April 12, 2022

Loss of Engine Power due to Excessive Fuel Flow in Cirrus SR22T Aircraft

Introduction

The National Transportation Safety Board (NTSB) is providing the following information to urge Cirrus Aircraft and the Federal Aviation Administration (FAA) to take action on the safety recommendations in this report. They are derived from previous investigations of Cirrus SR22T accidents in which excessive fuel introduced to the engine during takeoff climb led to engine power loss. Our examination of these investigations suggests a lack of system safety assessments to identify the cause and reduce the potential of the hazard from occurring. The NTSB is issuing one safety recommendation to Cirrus and one safety recommendation to the FAA.

Background and Analysis

The NTSB has identified six accidents involving Cirrus SR22T airplanes in which an excessive fuel condition led to a loss of engine power during the takeoff climb (see the appendix to this report for more information on these accidents).[1] During the investigations of five of the accidents, fuel flow data were retrieved from the recoverable data modules (RDM) installed in the accident airplanes.[2] In each case, the fuel flow data indicated an excessively high fuel flow (ranging from 42.2 to 50.1 gallons per hour [gph]) to the engine just before the loss of power. According to

[1] The NTSB conducted the investigations of five of these accidents (NTSB case numbers WPR18FA093, WPR17FA150, WPR18LA256, ANC18LA004, CEN19LA002). More information about these investigations can be found using our CAROL (Case Analysis and Reporting Online) query tool. The Air Accidents Investigation Branch in the United Kingdom conducted the sixth accident investigation. More information about this accident investigation is available at https://assets.publishing.service.gov.uk/media/5f1ad574e90e074567f1f828/Cirrus_SR22T_2-RORO_07-20.pdf.

[2] The RDM could not be located during the United Kingdom investigation.

Cirrus, during takeoff climb, the electric fuel pump could deliver 19 gph (in the BOOST position) to 42 gph (in the HIGH BOOST/PRIME position).[3]

While excessive fuel flow was determined to be the cause for the engine failures in all six accidents, the cause for the excessive fuel flow could be determined in just three cases: two investigations determined that the suspected incorrect selection of the fuel pump's HIGH BOOST/PRIME position caused the excessive fuel flow, and the third investigation cited an improperly adjusted slope controller and fuel pump.[4]

The two accidents in which the selected fuel pump position was suspected to cause the excessive fuel flow occurred in Schellville, California, and Kennett, Missouri.[5] In the July 2017 accident in Schellville, California, RDM data revealed that the fuel flow peaked 6.5% higher than average during climbout just before the loss of engine power. Further, both the fuel flow and manifold pressure exceeded the manufacturer's parameters for takeoff, peaking about the time of the engine power loss. The RDM data were consistent with the electric fuel pump switch being selected to the HIGH BOOST/PRIME position, but, because the fuel pump switch position is not a recorded parameter on the RDM (and the cabin sustained impact damage), the investigation could not definitively determine the switch's position.

In the September 2018 accident in Kennett, Missouri, the investigation revealed that the pilot likely repositioned the fuel pump switch while attempting to untangle his headset cord, resulting in a loss of engine power at an altitude of about 200 ft. In this case, investigators observed the fuel pump switch in the HIGH BOOST/PRIME position after the accident.

The third investigation in which the cause for the excessive fuel flow could be determined occurred in October 2017 in Tuskegee, Alabama.[6] The postaccident examination revealed that when the throttle was advanced through a manifold pressure of about 36 inches of mercury, the fuel flow exceeded the engine manufacturer's full throttle high-side limit. After the slope controller was adjusted to reduce manifold pressure to that specified by Cirrus, the engine operated without any interruption in power. Thus, the excessively high fuel flow (and subsequent loss of engine power) experienced during the accident was likely caused by an improperly adjusted slope controller.

To address the potential for engine power loss due to excessive fuel flow during takeoff caused by the incorrect selection of the electric fuel pump switch in the

[3] The BOOST position is used for vapor suppression during takeoff, climb, and landing and when switching fuel tanks; the HIGH BOOST/PRIME position is used for priming the engine before start and suppressing vapor formation at flight altitudes above 18,000 ft.

[4] The slope controller limits oil flow, through a wastegate, on a turbocharged engine.

[5] Accident numbers WPR17FA150 and WPR18LA256, respectively.

[6] Accident number ANC18LA004.

HIGH BOOST/PRIME position, Cirrus took several steps. First, on May 7, 2018, Cirrus issued Service Advisory SA18-02 applicable to SR22T airplanes. The advisory provided the following information:

> In accordance with, and as a reminder about, the language in the Pilot's Operating Handbook, the intended use of the fuel pump HIGH BOOST/PRIME position is priming prior to engine start and suppressing vapor formation in flight above 18,000 feet with hot fuel. The fuel pump must be set to BOOST – but not HIGH/BOOST/PRIME – for takeoff, climb, landing, and for switching fuel tanks. The pilot should monitor fuel flow during takeoff. Fuel flow should never exceed 41 gallons per hour (GPH) at 36.5 inches of manifold pressure. Higher fuel flow rates may result in a rough running engine and/or loss of power.

Also in May 2018, Cirrus implemented software changes intended to prevent improper operation of the electric fuel boost pump on the SR22T. The approach consisted of a software-controlled lockout feature for in-service SR22T airplanes and was explained in two service bulletins (SBs) that differed slightly as a function of whether the airplanes were equipped with the "Perspective" or "Perspective Plus" avionics platforms.[7] This feature locks out the high boost function of the pump (if HIGH BOOST/PRIME is selected) until the airplane reaches a pressure altitude of 10,000 ft; this prevents an engine power loss at low altitudes due to improper selection of the pump to the HIGH BOOST/PRIME position. The software changes included an updated HIGH FUEL FLOW crew alerting system message on the primary flight display.[8] All subsequent new production Cirrus airplanes were equipped with the lockout software.

Following pilot reports of the lockout feature not operating as intended, on January 22, 2019, Cirrus issued Service Advisory SA19-01, which stated:

> Cirrus has been made aware of a Garmin software condition where the HIGH BOOST/PRIME altitude lockout feature is not functional in [software version] 2647.N1. This condition allows HIGH BOOST/PRIME fuel pump mode to be enabled below 10,000 feet. Use of HIGH

[7] Perspective Plus-equipped airplanes were first addressed by SB2X-42-14, issued on May 30, 2018, and superseded by SB2X-42-18R3, issued on September 12, 2019 (updated June 3, 2020). Perspective-equipped airplanes were first addressed by SB2X-42-15, issued on November 14, 2018, and superseded by SB2X-42-17, issued on March 18, 2019.

[8] According to Cirrus, the HIGH FUEL FLOW warning is triggered by a flow rate greater than 41 gph. As indicated in SA18-02, if fuel flow exceeds 41 gph, "further flight operations should be discontinued until the engine fuel pump is serviced in accordance with the manufacturer's approved Instructions for Continued Airworthiness." Part of the engine inspection, per the engine manufacturer, includes checking and adjusting manifold pressure via the slope controller.

> BOOST/PRIME fuel pump mode in flight below 10,000 feet is not recommended and should be avoided.

SA19-01 further stated that until a software update is released to address this condition, the use of "HIGH BOOST/PRIME fuel pump mode should only be required, in flight, above 18,000 feet on hot days with warm or hot fuel to maintain fuel flow in the green arc or to suppress vapor formation." The FAA did not mandate compliance with the service advisories or any of the SBs for in-service airplanes.

The NTSB recognizes that Cirrus has attempted to mitigate, through the service advisories, SBs, and avionics software updates, the hazard of excessive fuel flow to the engine when the HIGH BOOST/PRIME fuel pump mode is inappropriately selected. While these updates will lockout HIGH BOOST/PRIME fuel pump mode during takeoff, we do not have evidence that this is what caused the excessive fuel flow in three of the accidents cited in this report. Thus, it is unclear whether the software updates will adequately address all excessive fuel conditions during takeoff. Additionally, Cirrus did not consider pilot performance related to recognition, reaction time, and recovery from an engine power loss at low altitude. For example, do pilots know what to do when they receive a crew alerting system message at low altitude so that they can recover the airplane?

As stated above, the NTSB was only able to identify the cause of the excessive fuel flow in three of the SR22T accidents we investigated. We believe that all the potential causes for these failures need to be identified to fully address this hazard. A functional hazard assessment (FHA) is a top-down process that can be used to examine system functions to identify all potential failure conditions and classify the associated hazards.[9] An FHA is normally performed early in the development and certification of an aircraft but should also be updated as new functions or failure conditions are identified. Once an FHA is completed, a system safety assessment associates a probability to each failure condition. Although Cirrus performed many FHAs during the initial certification process of the SR22T, as of December 15, 2021, Cirrus had not performed an FHA for excessive fuel flow during takeoff and climb resulting in a loss of engine power.

The NTSB is concerned that, because there may be additional potential causes for excessive fuel flow-related engine failures that have not yet been identified, they will continue to occur despite Cirrus' software updates. Therefore, the NTSB concludes that the Cirrus SR22T can experience a loss of engine power due to excessive fuel flow and some causes of excessive fuel flow during takeoff and climb may have not been identified and mitigated. The NTSB recommends that Cirrus

[9] FAA Advisory Circular 23.1309-1E, System Safety Analysis and Assessment for Part 23 Airplanes, dated November 17, 2011, provides guidance and information for demonstrating compliance with the requirements for equipment, systems, and installations in airplanes manufactured under 14 *Code of Federal Regulations* Part 23 (normal-category airplanes).

conduct an FHA to identify the causes, effects, and severity levels for the SR22T excessive fuel flow hazard condition during takeoff and climb phases of flight and, based on the FHA, update the system safety assessment.

The NTSB notes that while identifying the failure modes for excessive fuel flow in Cirrus SR22T airplanes during takeoff and climb is a safety improvement, more needs to be done to prevent the condition from occurring. The next step in the system safety process and, arguably, the most important, is identifying mitigating actions—such as design modifications, operational procedures, and/or guidance to operators—for each failure mode. Although Cirrus Aircraft can implement mitigating actions for the SR22T, unless Cirrus Aircraft and the individual operators are required to implement the mitigations, the actions may not be performed.[10]

The NTSB concludes that until the FAA requires implementation of appropriate mitigating actions to prevent the loss of engine power due to excessive fuel flow in the SR22T, additional accidents may occur due to this hazard. Therefore, the NTSB recommends that the FAA review the FHA recommended in Safety Recommendation A-22-7 and ensure it meets the objectives of Advisory Circular 23.1309-1E. Upon approval of the FHA, work with Cirrus to identify necessary mitigating actions and require their implementation through the appropriate means, such as an airworthiness directive.

Conclusions

Findings

The Cirrus SR22T can experience a loss of engine power due to excessive fuel flow and some causes of excessive fuel flow during takeoff and climb may have not been identified and mitigated.

Until the Federal Aviation Administration requires implementation of appropriate mitigating actions to prevent the loss of engine power due to excessive fuel flow in the SR22T, additional accidents may occur due to this hazard.

Recommendations

To the Federal Aviation Administration:

Review the functional hazard assessment (FHA) recommended in Safety Recommendation A-22-7 and ensure it meets the objectives of Advisory Circular 23.1309-1E. Upon approval of the FHA, work with Cirrus to identify

[10] According to the FAA, airworthiness directives are legally enforceable rules issued by the FAA in accordance with Title 14 *Code of Federal Regulations* Part 39 to correct an unsafe condition in a product. A product is defined as an aircraft, aircraft engine, propeller, or appliance.

necessary mitigating actions and require their implementation through the appropriate means, such as an airworthiness directive. (A-22-6)

To Cirrus Aircraft:

Conduct a functional hazard assessment (FHA) to identify the causes, effects, and severity levels for the SR22T excessive fuel flow hazard condition during takeoff and climb phases of flight and, based on the FHA, update the system safety assessment. (A-22-7)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

BRUCE LANDSBERG
Vice Chairman

THOMAS CHAPMAN
Member

Report Date: April 12, 2022

Appendix

Cirrus SR22T Accidents Involving a Loss of Engine Power due to Excessive Fuel Flow

Accident	Date	Injuries	Probable Cause
Schellville, CA (WPR17FA150). During takeoff, witnesses heard the engine "sputter" or "pop" a few times and, shortly after, observed the deployment of the airplane's parachute system. The airplane descended and impacted a wheat field.	7/13/2017	2 Fatal, 1 Serious, 1 Minor	The pilot's failure to maintain adequate airspeed after a loss of engine power, which resulted in an aerodynamic stall at a low altitude from which the pilot was unable to recover. The loss of engine power resulted from the pilot's improper selection for the electric fuel pump setting during climbout, which caused an excessively high fuel flow to the engine. Contributing to the accident was the pilot's failure to follow the airplane manufacturer's emergency procedures for a low-altitude loss of engine power.
Tuskegee, AL (ANC18LA004). Shortly after takeoff, during the initial climb, the pilot noticed the airplane slow and the climb rate diminish. A witness observed gray smoke being emitted from the airplane's exhaust. The pilot performed a forced landing to a sod field.	10/15/2017	3 None	An improperly adjusted slope controller and fuel pump that resulted in an excessively high fuel flow, an extremely rich mixture, a rough-running engine, and a subsequent partial loss of engine power.
San Diego, CA (WPR18FA093). During takeoff, witnesses heard the airplane's engine lose power at low altitude and described a sequence of events consistent with an aerodynamic stall/spin.	2/21/2018	1 Fatal	The pilot's exceedance of the airplane's critical angle of attack during an attempted return to the runway following a total loss of engine power after takeoff, which resulted in an aerodynamic stall. Contributing to the accident was the excessive amount of fuel being delivered to the engine for reasons that could not be determined based on the available information.

Accident	Date	Injuries	Probable Cause
Kennett, MO (WPR18LA256). During takeoff, at an altitude about 200 ft above ground level, the pilot engaged the autopilot, then leaned down to try to free his headset cord that had become stuck between his seat and the center console. A few seconds later, he noticed a decrease of engine noise and power. The pilot deployed the airplane's parachute, and the airplane impacted the ground shortly after.	9/7/2018	2 Minor	The pilot's inadvertent activation of the fuel pump control rocker switch, which resulted in a loss of engine power shortly after takeoff. Contributing to the accident was the pilot's distraction with an entangled headset cord.
Midland, TX (CEN19LA002). Shortly after takeoff, about 500 ft above ground level, the airplane's engine "surged." The pilot turned the airplane back toward the airport; however, the engine lost power. The pilot deployed the airplane's parachute, and the airplane descended into a parking lot where it impacted a vehicle.	10/12/2018	2 Minor	The loss of engine power due to excessive fuel flow.
Abergavenny, Wales, United Kingdom (UK) (CEN19WA254). During takeoff the airplane's engine started to produce varying amounts of power, which the pilot and witnesses described as the engine "surging." The airplane contacted power lines before pitching down and striking a highway. The aircraft came to rest inverted and was consumed by fire.[1]	5/12/2019	3 Minor	The loss of engine power was probably caused by too much fuel being delivered to the cylinders. Due to the significant damage to the aircraft and parts of the engine, the investigation was unable to determine the cause of the over-fueling.

[1] This investigation was conducted by the Air Accidents Investigation Branch of the United Kingdom.