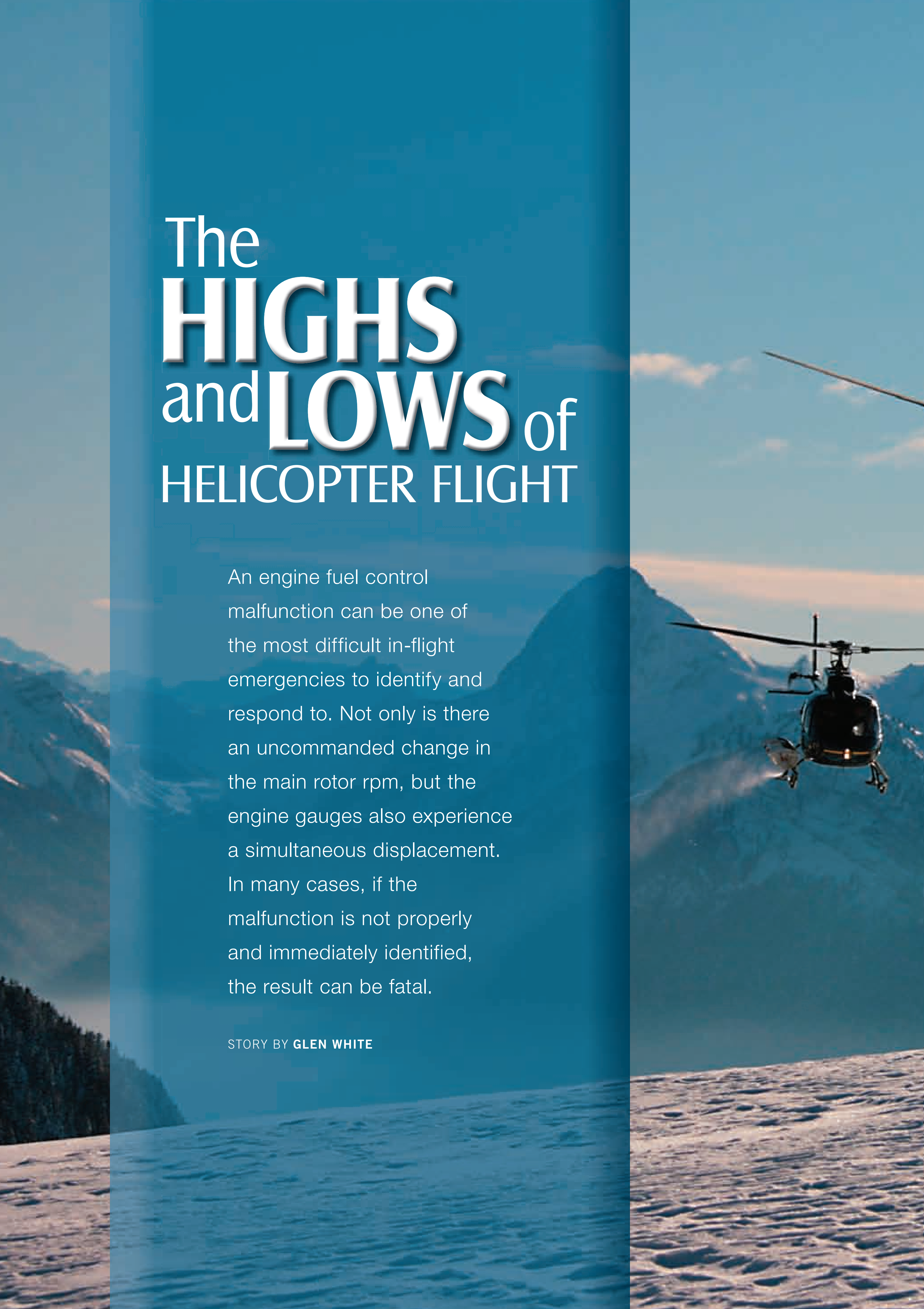


The HIGHS and LOWS of HELICOPTER FLIGHT

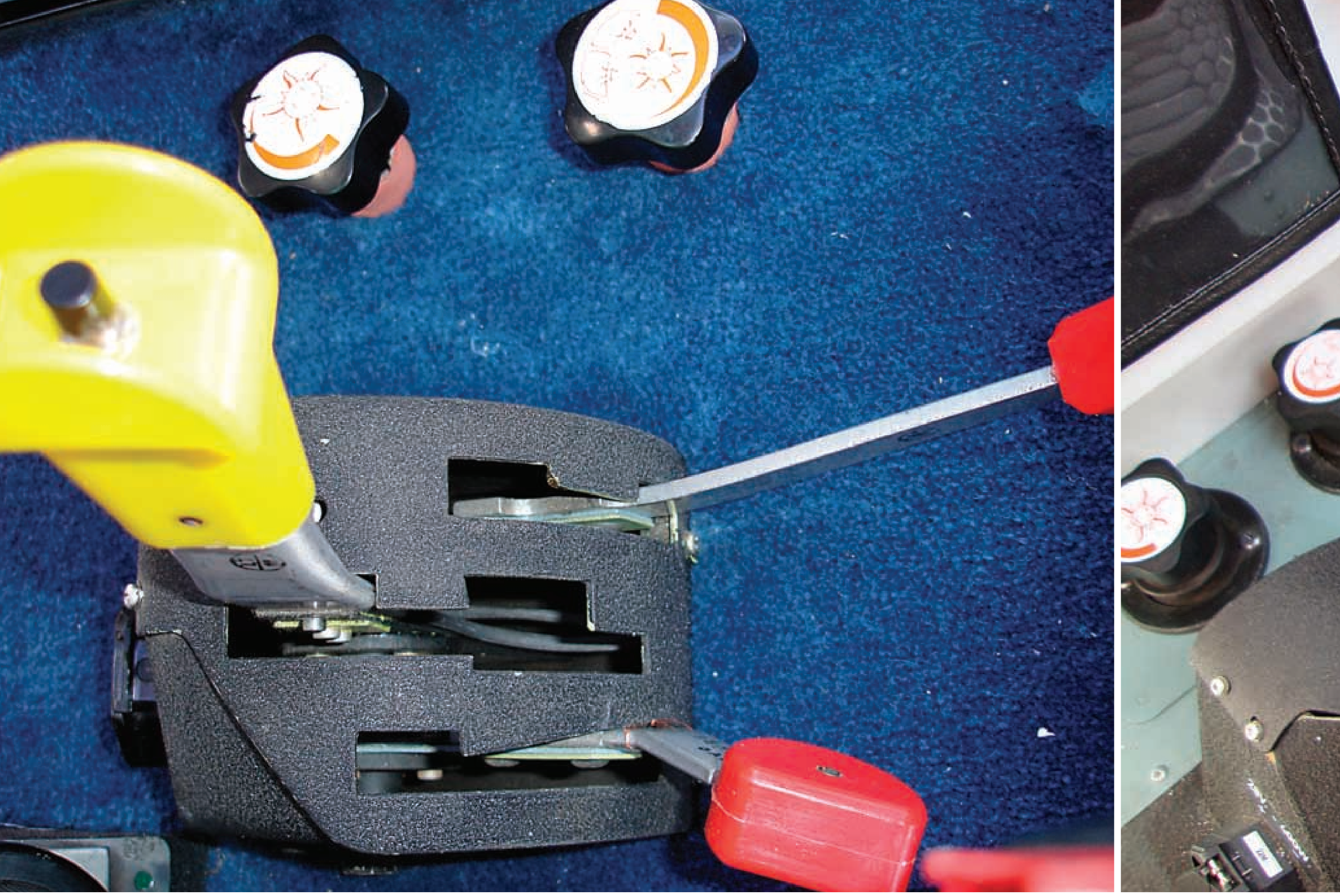
An engine fuel control malfunction can be one of the most difficult in-flight emergencies to identify and respond to. Not only is there an uncommanded change in the main rotor rpm, but the engine gauges also experience a simultaneous displacement. In many cases, if the malfunction is not properly and immediately identified, the result can be fatal.

STORY BY **GLEN WHITE**

AS355N Engine 1
Governor Failure

The failure of a fuel flow governing system is a malfunction that is not unique to any one manufacture or airframe model. It can occur in a single engine, multi-engine, FADEC or hydro-mechanically equipped helicopter. The pilot's knowledge of the system and emergency procedures associated with the malfunction dramatically affects the successful outcome of these failures.

The purpose of a powerplant's governing system is to maintain a set and constant rotor rpm by electrical reference or by gear/air pressure input to the fuel control system. A failure of this system can cause a high, low or fixed fuel flow to the engine. Depending on the rotorcraft model, this may require everything from manipulating the fuel flow manually to performing an auto-rotational landing.



The United States National Transportation Safety Board (NTSB) publishes a report for every aircraft accident in the country. It is filled with both successful and tragic reports of the aftermath of governing system failures. Between January 2000 and August 2010, there were more than 40 helicopter accidents in the United States that involved malfunctions of helicopters' fuel governing systems. In addition to the 40 resulting from malfunctions, another two accidents ensued during governing system failure training. This means that within the US, there was an average of a helicopter accident every three months caused by a fuel governing system malfunction.

Besides the reported occurrences found within the NTSB reports, there are numerous unreported successful governor failure landings. These were situations where the pilot properly identified the failure and performed the proper actions. Generally, because of their successful outcome, these occurrences received very little attention.

A fuel control failure is generally predicated by a failure or malfunction of a component within the governing system. In May 2003, a Bell 407 was in cruise flight at approximately 800 feet over the Gulf of Mexico when the FADEC FAIL aural warning sounded, followed closely by the sound of the LOW ROTOR RPM horn. Simultaneously, the LOW ROTOR RPM, FADEC FAIL, and FADEC FAULT cockpit caution lights illuminated. As the rotor speed began to decay through 90%, the pilot attempted to regain rotor rpm by lowering the collective – with little result. The pilot then depressed the AUTO/MANUAL button and switched to the MANUAL mode. He then increased the throttle above the 90% detent in an attempt to regain rotor rpm. During the manipulation of the throttle, the Litton gauges recorded several engine temperature exceedences and a total failure of the power-plant followed. The pilot then entered an autorotation, deployed the skid mounted emergency float system and landed upright on the water. A post-accident investigation revealed that the engine failure was due to extreme over-temperature operation during the manual manipulation of the throttle and a short in the electronic control unit (ECU) caused the initial failure of the governing system.

An over-speed or under-speed of the rotor system can also be a self-induced situation. In April 2008, an AS350B2 crashed in Chickaloon, Alaska due to the fuel flow control lever being inadvertently placed into its emergency range. The NTSB surmised that a child sitting in the front passenger seat had inadvertently dropped his backpack onto the fuel control lever. The ensuing over-speed of the engine caused a shedding of the power turbine wheel and, judging by the position of the fuel shut-off lever, the pilot had used it to shut down the engine. Because of the helicopter's low altitude and airspeed, the impact was fatal to all occupants except the young front passenger.

THE FAILURE OF A FUEL FLOW GOVERNING SYSTEM IS A MALFUNCTION THAT IS NOT ISOLATED TO ANY ONE MANUFACTURE OR AIRFRAME MODEL. IT CAN OCCUR IN A SINGLE ENGINE, MULTIENGINE, FADEC OR HYDRO-MECHANICALLY EQUIPPED HELICOPTER.

LEFT: AS350B3 Throttle.

OPPOSITE PAGE: AS350B2 Fuel Flow Control Lever.

Engine Engine Low Side Governor Failure.

DURING A LOW SIDE GOVERNOR FAILURE THE FUEL CONTROL UNIT DOES NOT ROUTE SUFFICIENT FUEL FLOW TO THE POWERPLANT.

FUEL CONTROL DESIGN

For the most part, helicopter turbine engines utilize one of four types of fuel governing systems. They are classified as hydro-mechanical units (HMU), full authority digital engine control units (FADEC), engine electronic control units (EEC, EECU, DECU, ECU or DCU), or hydro-mechanical units, which are manipulated by an electronic engine control unit (HMU/EEC).

There is a variety of different designs for each type of fuel control unit. The most common type of hydro-mechanical variant utilizes high-pressure fuel whose flow into the engine is manipulated using compressor discharge pressure and N1/N2 flywheel speed. A manual control is included in this design for engine acceleration and fuel flow manipulation after a unit failure. The hydro-mechanical design can be found on such airframes as the AS350B2 and the BH206.

The remaining types of fuel control units are often generically referred to as FADEC fuel governing systems. They all use some sort of electronic manipulation of the fuel metering system to maintain a constant rotor rpm. However, a true FADEC system controls fuel flow solely through sensor reference to manipulate a metering valve electronically and has no form of manual override. If a failure of the system occurs, the pilot cannot adjust the fuel flow manually so these systems typically have at least one backup FADEC channel. The FADEC design can be found in such helicopters as the EC130B4 and the S-92.

An EEC-controlled power-plant consists of a computer which receives reference signals from sensors and determines what fuel flow is needed to the engine. Then, through an electrical signal, adjusts the setting of the electronic fuel valve (metering valve). EEC designs also include the ability to adjust the fuel flow manually with a control lever or throttle after an EEC failure. The EEC design can be found on such airframes as the AS350B3 and the AS365N3.

The HMU/EEC design is generally a hydro-mechanical fuel control whose engine compressor discharge pressure is manipulated by an electronic control unit. This design includes a throttle or control lever for engine acceleration and fuel flow control after a unit failure. The HMU/EEC design can be found on such airframes as the A119 and the S76B.

Multi Engine Low Side Governor Failure Engine 2.

GOVERNOR FAILURE IDENTIFICATION

Fuel control system malfunctions are classified as "low side", "high side" or "fixed flow" governor failures. High side and low side governor failures are more likely to occur in helicopters with hydro-mechanical or HMU/EEC fuel control units. A fixed failure is more likely to occur in an EEC or FADEC-equipped helicopter.

On a single engine platform, the identification of the type of governor failure is self-evident by the actions of the engine and rotor parameters. Some models are also equipped with caution and warning lights to assist the pilot in identifying the failure.

In a single engine helicopter, if the rotor rpm decreases (with the engine still producing power), the failure is confirmed as a low side governor failure. If the rotor rpm increases (outside a flight profile that would induce a high rotor rpm), the failure is identified as a high side governor failure. If the NR increases only when the collective is reduced and increases when the collective is lowered, the most likely failure is a fixed fuel flow (anticipator failures can also produce the same indications momentarily).

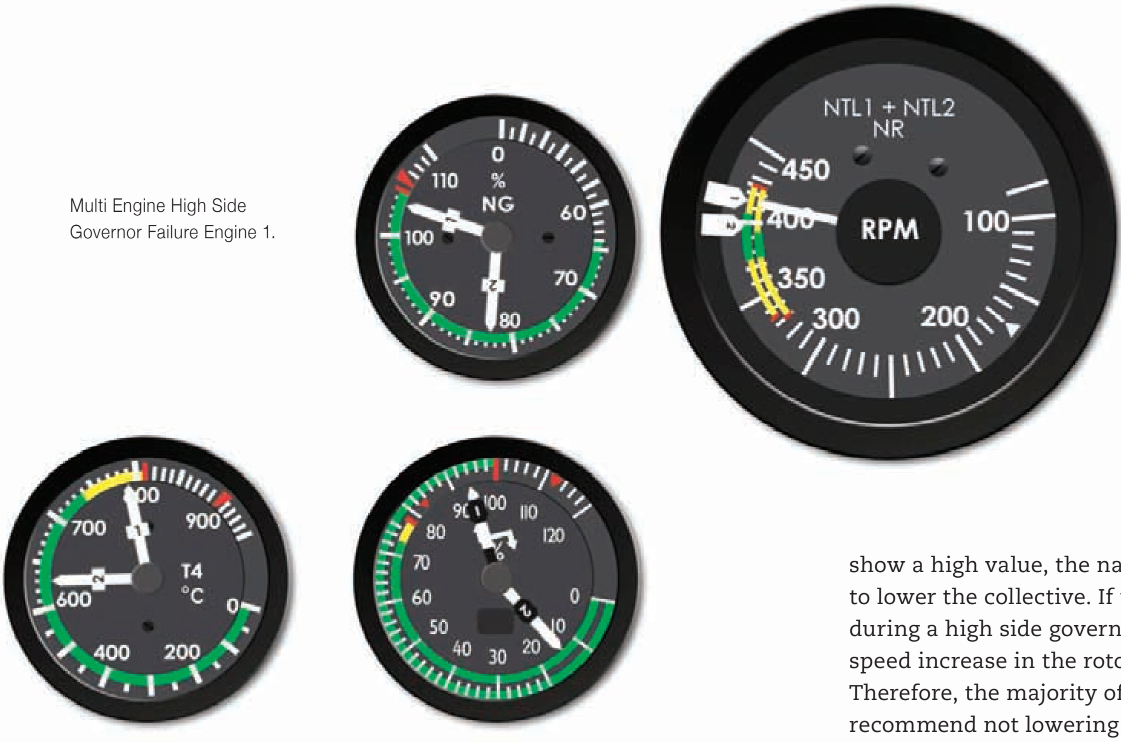
A governor failure in a multi-engine helicopter can be far more difficult to analyze and causes a split on the engine parameter gauges. Some models of multi-engine helicopters are also equipped with caution and warning lights to help assist the pilot in identifying the malfunction. In other models, the pilot must analyze the instrument panel gauges to determine the malfunction, and to determine which engine is affected.

LOW SIDE GOVERNOR FAILURE

During a low side governor failure, the fuel control unit does not provide sufficient fuel to the engine. In a single engine helicopter, this would result in a loss of rotor rpm and can progress slowly or rapidly into the low flow rate.

If the failure occurs rapidly, the most likely initial prognosis would be an engine failure. After entering an auto-rotational state, the pilot may notice that the engine is still producing power. If the collective were to be reintroduced at this point, the engine fuel flow would not be great enough to maintain NR and the rotor would droop. The proper procedure in this situation would be to either complete the landing in an auto-rotational state, or if the helicopter were so equipped, to adjust the fuel flow control lever or throttle above the flight position to manipulate fuel flow manually.

If the low side occurs slowly, the pilot may recognize the failure immediately. If the aircraft is equipped with a throttle or fuel flow control lever that allows manipulation above the flight position,



Multi Engine High Side Governor Failure Engine 1.

IF THE LOW SIDE OCCURS SLOWLY THE PILOT MAY RECOGNIZE THE FAILURE IMMEDIATELY.

the pilot can adjust it immediately to maintain rotor rpm. If the airframe is not so equipped, the only recourse is to enter an auto-rotational flight profile.

If a low side governor failure occurs on one engine in a multi-engine helicopter, a split develops on the engine parameter gauges. Depending on the power demand, the rotor rpm may also droop. If the rotor rpm does droop, the failure is identified as a low side on the engine whose engine parameters show low.

If the rotor rpm does not droop, the failure must be analyzed to determine if the failure is a low side or high side governor failure. Many manufacturers recommend lowering the collective slightly – while keeping all parameters within limits – to identify the failure. If the engine gauges producing the most power follow the collective movement, the malfunction is identified as a low side on the engine whose engine parameter needles show low.

HIGH SIDE GOVERNOR FAILURE

During a high side governor failure, the fuel control unit supplies the engine with an excessive amount of fuel.

In a single engine helicopter, a high side governor failure would result in an increase in rotor rpm. Because the engine parameter gauges would show a high value, the natural reaction would be to lower the collective. If the collective is lowered during a high side governor failure, a catastrophic speed increase in the rotor rpm can occur. Therefore, the majority of rotorcraft flight manuals recommend not lowering the collective initially if a high side governor failure occurs.

The proper reaction by the pilot is to reduce the fuel flow by utilizing the fuel flow control lever or throttle. Care must be taken when reducing the power to avoid inadvertently stopping the fuel flow completely. Once the airframe parameters are adjusted to their proper levels, a combination of fuel flow and collective movements are utilized to control power management.

If a high side governor failure occurs on one engine in a multi-engine helicopter, a split develops on the engine parameter gauges. Depending on the power demand, the rotor rpm may also increase. If the rotor rpm increases, the failure is identified as a high side on the engine whose engine parameters show high.

DURING A HIGH SIDE GOVERNOR FAILURE THE FUEL CONTROL UNIT SUPPLIES THE ENGINE WITH AN EXCESSIVE AMOUNT OF FUEL FLOW.

If the rotor rpm does not droop, the failure must be analyzed to determine if the failure is a low side or high side governor failure. Many manufacturers recommend lowering the collective slightly – while

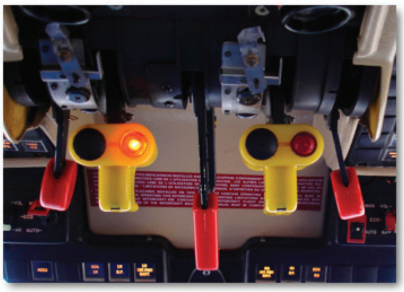
Single Engine High Side Governor Failure.

IN A SINGLE ENGINE HELICOPTER A HIGH SIDE GOVERNOR FAILURE WOULD RESULT IN AN INCREASE OF THE ROTOR RPM. BECAUSE THE ENGINE PARAMETER GAUGES WOULD SHOW A HIGH VALUE THE NATURAL REACTION WOULD BE TO LOWER THE COLLECTIVE. IF THE COLLECTIVE IS LOWERED DURING A HIGH SIDE GOVERNOR FAILURE A SPEED INCREASE IN THE ROTOR RPM TO CATASTROPHIC LEVELS CAN OCCUR.

keeping all parameters within limits – to identify the failure. If the engine gauges producing the most power do not follow the collective movement and the NR increases, the malfunction is identified as a high side on the engine whose engine parameter needles show high.

FIXED FLOW GOVERNOR FAILURE

During a fixed flow governor failure, the fuel control unit supplies the engine with a constant fuel flow regardless of collective position. Helicopters that this is generally associated with also give pilots indication of governor failures with caution or warning lights.



Multi Engine Fixed Flow Governor Failure Engine 1.

DURING A FIXED FLOW GOVERNOR FAILURE THE FUEL CONTROL UNIT SUPPLIES THE ENGINE WITH A CONSTANT AMOUNT OF FUEL FLOW REGARDLESS OF COLLECTIVE POSITION.

When a fixed failure occurs, the rotor rpm will only change its given value if the collective is manipulated. If the collective is lowered, the NR will increase and if the collective is increased, the NR will decrease.

In a single engine helicopter, a combination of throttle and collective are then utilized to maintain proper rotor rpm.

In a multi-engine helicopter, the affected engine is generally adjusted to a lower level, which will assist with rotor rpm, but not great enough to overspeed the NR if the collective is lowered. This power setting is generally recommended to be a 40% torque value.

WHAT DOES THIS MEAN TO ME?

The key to dealing successfully with a governor failure is a thorough knowledge of the fuel control

AS350B3 Governor Failure Indication.

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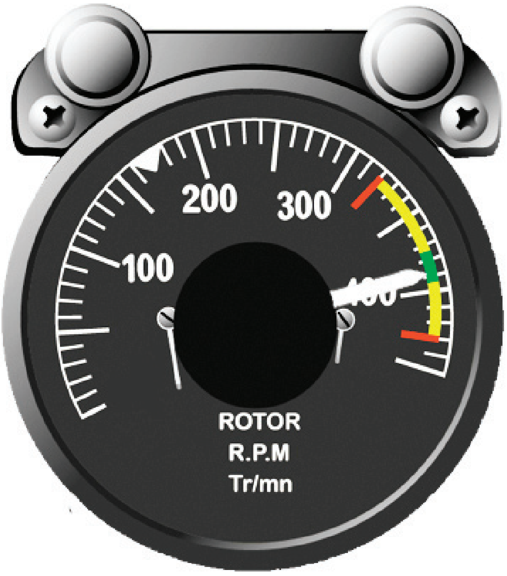

DECU Single Engine Fixed Flow.

THE KEY TO SUCCESSFULLY DEALING WITH A GOVERNOR FAILURE IS A THOROUGH KNOWLEDGE OF THE FUEL CONTROL SYSTEM AND THE EMERGENCY PROCEDURES ASSOCIATED WITH IT.

system and the emergency procedures associated with it. Confusion during a governor failure can lead to an engine or rotor speed that is outside the safe margin.

Many helicopters, such as the AS355N and the AS350B3 2B, allow for a method of training for these failures in flight. In these aircraft, the pilot has the opportunity to gain a high level of proficiency in executing the recommended malfunction procedures. For airframes that do not have the ability to practice the procedures, it is even more imperative for the pilot to have a thorough understanding of the system and emergency procedures.

Remember, you are the sovereign of your aircraft, the final source of authority, the master of your domain. You hold your and your passengers' lives in your hands with your abilities and knowledge. You WILL get your helicopter safely to the ground. ■