# GAS TURBINE ENGINES INSTRUCTIONS FOR CONTINUED AIRWORTHINESS **WHY?**

For many years, Paul Harvey had a syndicated radio spot where he spoke about a topic that everyone knew about, and then said "AND NOW FOR THE REST OF THE STORY!" With apologies to Mr. Harvey, this article is in a similar vein. This is part one of a two-part series.

Gas turbine engine manufacturers make aircraft engines (i.e., turbo jet, turbo fan, turbo prop and turbo shaft.) These manufacturers provide instructions for continued airworthiness (ICAs), usually in the form of an overhaul manual, a maintenance manual, a service bulletin specifying the life limits for life-limited parts (e.g. compressor and turbine disks and sometimes turbine blades). Service bulletins also specify recommended engine overhaul intervals and recommended hot section inspection/repair intervals and possibly additional documents. These ICAs are then approved by the airworthiness regulatory authority of the country of engine manufacture (e.g., FAA, Transport Canada, et al.) The only alternative to this is to prepare your own ICA or have someone else do it for you. Then you provide a suitable (detailed) substantiation for your "instructions" and submit your ICA to your country's airworthiness regulatory authority for approval. As someone who has prepared alternative ICA, I can tell you that the preparation is difficult and the substantiation is worse. The final result is that the ONLY ICAs that are allowed to be used are the ones that have been approved by the appropriate airworthiness regulatory authority.

These ICAs tell you what to do, but often lack an adequate explanation of WHY. The purpose of this article is to explain why. Since I have spent the past 28 years working on Pratt & Whitney Canada PT6A turbo prop and PT6T turbo shaft engines, I will use those engines as examples, but these general principals apply to all gas turbine aircraft engines.

## Engine Start Carts

When a PT6A engine is started using the aircraft battery, and when that battery is in excellent condition (fully charged), the compressor can be brought up to 14 to 16 percent compressor speed BEFORE ignition and fuel are introduced during the starting cycle. With a battery that is not fully charged, the compressor speed could be as low as eight to 12 percent. An external start cart consists of either several large batteries or an engine driven generator. The use of an external start cart allows the compressor to be brought up to 18 to 20 percent before ignition and fuel is introduced. The faster the compressor is turning BEFORE ignition and fuel is introduced, the lower the peak starting temperature, AND the engine is subjected to that peak starting temperature for a shorter period of time. By reducing the peak starting temperature and reducing the amount of time the engine is subjected to that peak starting temperature, the hot section is subjected to less abuse and therefore lasts longer. I am well aware of the inconvenience of rolling out the start cart, connecting the start cart, disconnecting the start cart (after engine start), returning the start cart to its place of storage — and in the case of a battery start cart, reconnecting the start cart to its charger. Alternately, I am aware of an operator that never used a start cart and as a result prematurely destroyed three PT6A-20 hot sections BEFORE they learned how important the use of a start cart could be. At $25,000 to $30,000 per hot section, this was a very expensive lesson.

## Ground Idle

Normally ground idle is set at 52 percent compressor speed on PT6A engines. Pilots like the ground idle compressor speed to be as low as possible because it makes it easier to taxi aircraft on wet or snow-covered taxiways. On the other hand, the lowest inter turbine temperatures on PT6A engines occur at approximately 59 percent compressor speed. This means that as the compressor speed is reduced below 59 percent the inter turbine temperature increases. Obviously, higher temperatures mean shorter hot section lives. Ground idle should not be set at any value below the recommended speed, BUT whenever possible, increase the ground idle speed with the throttle(s) to reduce the inter turbine temperature(s). This is especially important when starting the second engine on a twin-engine aircraft.

During the start cycle, the pilot's attention is concentrated on the engine that is being started. However, the engine that has already been started is at ground idle, and has a very large load applied to its (starter) generator by the starter on the engine that is being started. During this time, it is easy to have the generator load draw the idling engine below 52 percent ground idle. If this were to happen, the fuel control will automatically go into the start acceleration schedule and increase fuel flow in an attempt to accelerate the engine up to ground idle. This increase in fuel flow significantly increases inter turbine temperature, thereby shortening hot section durability. A similar condition can occur on a hot day with the aircraft air conditioning system running at maximum while attempting to cool a hot cabin and passengers. I am aware of an operator who was operating an engine at ground idle while refilling the Freon in the aircraft air conditioning system. The Freon was introduced fast enough that the ground idle was drawn below flight idle, the increased fuel flow could not accelerate the engine back up to idle, and the engine hung in a sub-idle condition for a long enough period of time to destroy the hot section. Another expensive lesson was learned.

## In Flight, Cruise Engine Temperatures

Many models of gas turbine engines have a higher allowable hot section temperature during the five minute take-off time period than the lower maximum continuous allowable temperature. Some models of gas turbine engines, like the PT6A turbo prop engine, have identical maximum allowable hot section temperatures during both take off and maximum continuous operation. There is a safety benefit, especially during emergencies, to have the takeoff and maximum continuous temperature limits the same. On the other hand, operation at or near the maximum continuous temperature limit significantly shortens hot section life. The following table shows the maximum allowable temperatures for takeoff and maximum continuous operation, and also provides suggested lower cruise temperatures that the experience of several operators has shown will increase hot section longevity. (Note all temperatures are in degrees Celsius).

| MODEL | MAX T5 LIMIT | SUGGESTED CRUISE T5 |
|---|---|---|
| PT6A-20 | 750 | 700 or less |

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| PT6A-11 | 700 | 680 or less |
| PT6A-21 | 695 | 680 or less |
| PT6A-27 | 725 | 680 or less |
| PT6A-28 | 750 | 680 or less |
| PT6A-34 | 790 | 740 or less |
| PT6A-36 | 790 | 740 or less |
| PT6A-114 | 805 | 740 or less |
| PT6A-114A | 805 | 740 or less |
| PT6A-41 | 750 | 725 or less |
| PT6A-42 | 800 | 725 or less |

There is an example that illustrates this concept. PT6A-11, PT6A-21 and PT6A-28 engines all have the same: compressor, combustor, CT vane ring, CT blades, PT vane ring and PT blades. The maximum allowable inter turbine temperature on the PT6A-11 and PT6A-21 engines are 700 C and 695 C respectively. The maximum allowable inter turbine temperature on the PT6A-28 is 750 C. Hot sections on PT6A-11 & 21 engines frequently operate 2,500 to 3,000 flight hours before hot section repair is necessary. Conversely, PT6A-28 engines frequently operate only 1,800 to 2,000 flight hours before hot section repair is necessary. This illustrates the benefit that can be obtained by using lower cruise power settings.

## Summary & Conclusion

The older and more experienced engine mechanics are already familiar with the topics in this article. Hopefully these more experienced mechanics will consider this article a helpful refresher course. As for the younger and less experienced engine mechanics, it is hoped that the lessons provided in this article will be used to prevent the kinds of problems that cause prematurely gray hair. This can be said another way. There is a very old cliché, "Pay me now or pay me later." The choice is yours! Look for part two of this series in our next issue of HeliMx magazine. ◀

*Ralph Hawkins is the Chief Engineer for MORE Company, Minden NV. MORE Company holds eight FAA Supplemental Type Certificates (STCs) providing alternative Instructions for Continued Airworthiness for PT6A engines. These STC(s) prescribe an enhanced inspection methodology that allows the operator and their mechanics to recognize engine problems in their early stages and to correct them promptly. In turn, the prompt correction of engine problems allows the engine overhaul interval to be safely extended to 8,000 flight hours. These eight MORE STCs include several of the techniques mentioned above, as well as several additional techniques that are especially well suited to the PT6A turbo prop engines. The MORE Company STCs apply to PT6A-11 through PT6A-45R and PT6A-110 through PT6A-135A engines. MORE Company began providing the use of their alternative Instructions for Continued Airworthiness to operators in the autumn of 1993. As of January 20, 2011, there were 1,782 PT6A engines operating in 39 countries that are now or had been using MORE Company's STCs. MORE's web site is www.morecompany.net*