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COCKPIT INFORMATION REQUIRED FOR HELICOPTER TURBINE ENGINE OPERATION AND MAINTENANCE

1. **PURPOSE:** The purpose of this document is to provide the Propulsion Engineer's recommendations for the instrumentation that is required for the safe operation and maintenance of turbine engines as installed in helicopters. It should be used as a guide for cockpit layout, as well as a reference for maintenance considerations throughout the propulsion area. Propulsion instruments should receive attention early in the design phase of the helicopter. Maintenance and diagnostic recorders are not considered within the scope of this document. (See ARP 1587 "Aircraft Gas Turbine Engine Monitoring System Guide")
2. **RECOMMEND INSTRUMENTS:** Discussion:
 - 2.1 **Measured Gas Temperature:** This instrument may be analog and/or analog digital. Normally this instrument has a scale from 100 degrees C to 1000 degrees C or higher. It has coded on it the maximum operating temperature of the hot gas in the engine for the various modes of operation (i.e. starting temperature allowables, maximum short time temperature allowable, continuous temperature allowable, etc.). It may be advantageous to expand the scale in the higher region of operation to improve readability and/or accuracy.
 - 2.2 **Engine Torque:** Engine torque indication is extremely important to the pilot for safe operation of the helicopter drive train.

It is the only direct measurement of the power output (when used in conjunction with shaft speed) of the engine and it is used for engine thermodynamic health monitoring as well as drive train loading.
 - 2.3 **Gas Producer Speed Indicator:** This instrument also may be analog and/or analog digital. Its normal scale is from 0 to 110%. It is used by the pilot to monitor speed of the compressor rotor and maintain the operation of the engine within its approved limitations.

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- 2.4 Power Turbine Speed: The power turbine speed in some cases is not provided and the helicopter rotor speed is utilized in lieu of it. It can be used by the pilot to indicate function of the drive train freewheeling unit or as a backup in case of failure of the helicopter rotor speed indication. It may also be used to check the power turbine overspeed protection system.
- 2.5 Engine Oil Temperature: This parameter is normally used to indicate proper functioning of the oil temperature control system. Loss of cooling capability is usually obvious to the pilot; however, in many applications (especially civil), a high temperature warning device is provided. In some cases, abnormal increases indicate that a failure is in progress or has already occurred.
- 2.6 Engine Oil Pressure: Oil pressure provides the lubricant flow to the engine for good safe operation. Abnormally high or low oil pressure may indicate an unsafe or impending failure condition, thus forewarning the pilot that an engine failure is imminent. In certain applications, oil pressure only may be used to indicate proper lube system function and temperature indication is not required. However, the non-indication of oil temperature may be appropriate for certain systems, but it should be recognized that for civil applications this does not meet rotorcraft FARs, (i.e., FAR 29.1305).
- 2.7 Fuel Pressure: Fuel pressure indication provides the pilot with the knowledge that the airframe supply to the engine is functioning properly. With suction or lift systems, pressure measurement at the engine inlet port is of lesser importance and the pressure sense is sometimes extracted within the engine pumping system. A low pressure indicator light may be used instead of an instrument to indicate system malfunction. Fuel flow measurement has been substituted in place of a pressure gage with a suction system.
- 2.8 Engine Vibration: The most common method of measurement consists of mounting accelerometers at specified locations on the engine casing and comparing the values to a known baseline. As the reliability of vibration equipment improves, the vibration pick-ups may be permanently installed for inflight monitoring. To date, this has not been a widespread practice.
- 2.9 Fuel Flow: Fuel flow meters have been installed in helicopters for the primary purpose of inflight range and endurance optimization. This parameter is not essential, but can be useful as a backup for other instrumentation, i.e., torque indication.
- 2.10 Secondary/Advisory Functions: These items are usually displayed as caution or advisory light functions.
- 2.10.1 Anti-Icing Functions: Usually a light indicating that the engine anti-ice system is active.
- 2.10.2 Impending By-Pass Fuel Filter: A light that informs the pilot the fuel filter is about to go into by-pass flow and allow contamination to enter the fuel metering system. This function may also be a mechanical pop-up button located on or near the fuel filter. Also, pop-up buttons may indicate filter by-passed condition.

- 2.10.3 Impending By-Pass Oil Filter: A light that informs the pilot the oil filter is about to go into by-pass flow and allow contaminants to enter the lubrication supply system. This function may also be a mechanical pop-up button located on or near the oil filter. Also, sometimes pop-up buttons are used to indicate by-pass conditions.
- 2.10.4 Fuel Control Mode: Usually a light that tells the pilot he has selected the engine fuel control in a backup or secondary mode. Some systems may incorporate a warning light which indicates activation of an extra fuel flow control system for emergency purposes (one engine inoperative in multi-engine installation).
- 2.10.5 Electronic Fuel Control Failure: Advisory light that informs the operator that the electronic fuel control has malfunctioned or that automatic reversion has occurred. This function may operate with the fuel control mode as described in 2.10.4.
- 2.10.6 Chip Detector: Chip detectors may be located at selected positions within the engine lubrication system to provide warning of impending failure. This function is most often displayed as an advisory light in the cockpit. Fuzz burn off type chip detectors have been successfully employed to avoid nuisance indications.
- 2.10.7 Engine Failure Indication: This function provides the pilot with a positive indication that the engine has ceased to perform so that he can take the proper safety measures. This indication may be either a light or an audio signal.
- 2.10.8 Low Oil Pressure: In the event that the pilot does not notice a low oil pressure situation, a light on the master caution panel is provided.
3. DISCUSSION: As can be seen in the previous section, the various parameters necessary for engine operation have been discussed. As is the case of most items of this nature, there is always more than one way to accomplish the desired result.

Several problem areas must be addressed when selecting instruments and their location. Obviously, readability is every bit as important as accuracy. A poorly located but accurate instrument will not produce the desired result. Accuracy requirements are outlined in ARP 1217 Instrumentation Requirements for Turbohaft Engine Performance Measurement.

Another important feature of an instrument is time response. If the system response is too slow, then the pilot does not receive the information in time to perform the proper corrective action.

4. METHODS:

- 4.1 Analog Methods: The analog is the most traditional approach which is in current use today. Round indicators with needle cursors represent this approach. Some new hardware in the form of vertical tape instruments is beginning to come forth but as yet it has not completely replaced the round analog type instrumentation.