

2.1.3 Other Publications

Elkins, H.B. (1959). *The chemistry of industrial toxicology*. John Wiley and Sons.
<https://doi.org/10.1002/ange.19610731734>.

Gill, P. (1954). Chemical methods in industrial hygiene. *Journal of Chemical Education*, 31(7), 392.
<https://doi.org/10.1021/ed031p392.2>.

McCormick, W. et al. (1958). Hygienic Guides and Binders Available. *American Industrial Hygiene Association Journal*, 19(1), 71. <https://doi.org/10.1080/00028895809343547>.

Oesper, R.E. (1945). The Analytical Chemistry of Industrial Poisons, Hazards and Solvents. Second revised reprint (Jacobs, Morris B.). *Journal of Chemical Education*, 22(6), 311. <https://doi.org/10.1021/ed022p311.1>.

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

14 CFR Part 33 Airworthiness Standards: Aircraft Engines

3. GENERAL

3.1 Primary Purpose of Bleed Air

Bleed air on helicopter installations may be used as a source of heated air for the following purposes:

- a. Engine inlet deicing and anti-icing
- b. Cabin conditioning and pressurization
- c. Windshield defogging, defrosting, and anti-icing

3.2 Secondary Purpose of Bleed Air

A secondary use is for a small power source for driving one to two accessories and possible cross starting for multi-engine installation.

4. DISCUSSION

4.1 Bleed Extraction Limits

It is recognized that, in general, compressor bleed air is an inefficient source of power. It is necessary, therefore, to limit bleed extraction to those uses in which an overall advantage to the helicopter will accrue. As a source of energy for those applications listed in 3.1 and 3.2, bleed air performs a service that could otherwise require considerably more equipment with increased weight, cost, size, and complexity; otherwise, its use should be limited to the conditions where the reduction in engine power is not detrimental to helicopter performance. This document is not all-encompassing, and the engine manufacturer should consider specific bleed air requirements for engine ground idle operation with the helicopter rotor locked.

4.2 Effect of Hot Temperature

If the use of bleed air for cabin conditioning during hot weather proves desirable to overall helicopter optimization, it is recommended that engine designers consider anticipated compressor bleed air need.

5. BLEED ENERGY EQUATION

The bleed energy can be defined as:

$$E_{BL} = W_{BL} \times C_p \times (T_{BL} - T_a) \quad (\text{Eq. 1})$$

where:

E_{BL} = bleed energy, BTU (J)

W_{BL} = weight of bleed air, lb/h (kg/s)

C_p = specific heat at constant pressure, BTU/lb - °F (kJ/kg - °C)

T_{BL} = bleed port air temperature, °F (°C)

T_a = freestream air temperature, °F (°C)

NOTE: Assume sea level or note if otherwise.

6. QUALITATIVE OBJECTIVE

6.1 Contamination and Air Quality

To be acceptable for the purpose of cabin conditioning and pressurization, the bleed air must be free of detrimental contamination. The engine manufacturer should address the problem of bleed air contamination resulting from compressor bearing seal failures. This requirement is imposed on FAA certificated helicopters by 14 CFR 27.831(a), 29.831(b), and 29.831(d). Approved test methods for assaying air samples may be obtained from one of the following:

- a. McCormick, W. et al. (1958)
- b. Elkins, H.B. (1959)
- c. Oesper, R.E. (1945)
- d. Gill, P. (1954)
- e. MIL-E-8593A

7. QUANTITATIVE OBJECTIVE

7.1 Bleed Air Requirement

The primary requirement for bleed air is for environmental control. It is expedient to specify the requirement in terms of BTU per hour per horsepower. This leaves the pressure, temperature, and mass flow at which bleed air is supplied to the discretion of the engine designer. It is desirable to provide the same bleed energy determined from the curves in Figure 1 at all gas generator operating conditions down to flight idle power (i.e., 100% power turbine speed zero output torque). Specific stated engine operating conditions may require other considerations. Currently, helicopter environmental control units require bleed air at entry pressure levels of 3 to 4 atmospheres.

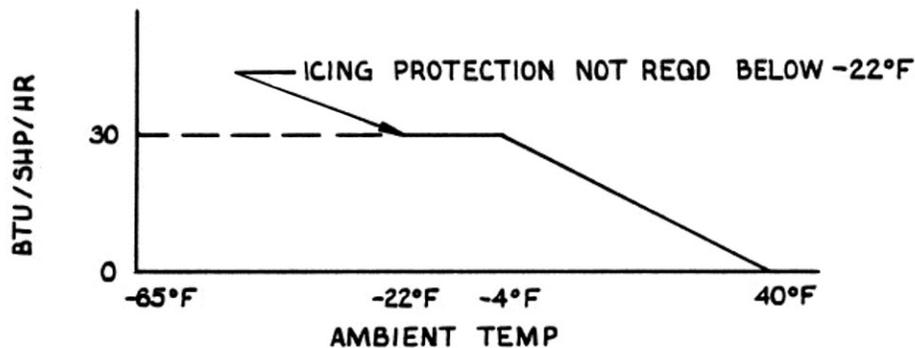


Figure 1A - Anti-icing engine cowls, inlet ducts (curve A)

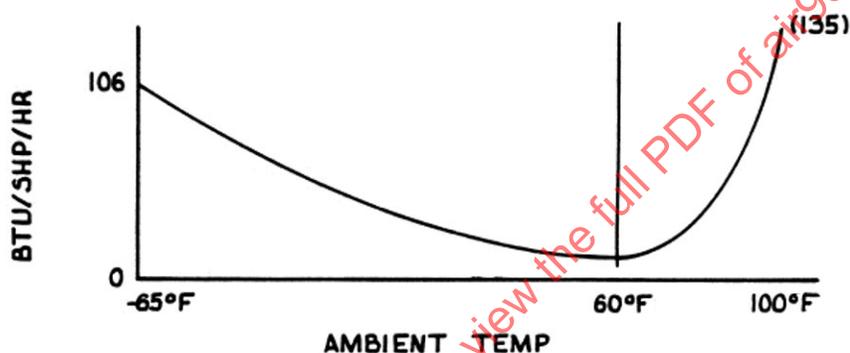


Figure 1B - Cabin conditioning (curve B)

Figure 1 - Helicopter bleed air requirements at 100% normal rated power (maximum continuous)

7.2 Deicing, Anti-Icing and Cabin Conditioning

Figure 1 shows a range of heat requirements as a function of the ambient temperature. Curve A is a minimum requirement for deicing or anti-icing for an airframe induction system. Curve B shows the relationship of bleed energy requirements for cabin conditioning.

7.3 Bleed Capacity

It is considered that the objective for future engine designs is to provide bleed capacity described by the total of curves A and B. The quantities of energy recommended by curves A and B may collectively amount to an impractically large flow of compressor bleed air when applied to certain low pressure ratio engines. In such cases, it is recommended that the engine designer provide at least sufficient air for curve A.

7.4 Bleed Air to Drive Accessories

Generally, the extraction of bleed air for the purpose of driving accessories is not recommended, principally because helicopter hot day performance is affected adversely. Satisfactory installation may be possible in the case of accessories requiring bleed air only while on the ground or where the power required is very small. It is not considered necessary to stipulate an additional increment of bleed air for these purposes beyond the heating requirements. Any continuous power demand for running accessories is considered an individual installation problem and beyond the scope of this information report.