

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.

485 LEXINGTON AVENUE

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**AEROSPACE
RECOMMENDED PRACTICE****ARP 704**

HELICOPTER ENGINE-ROTOR SYSTEM COMPATIBILITY

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Revised

1. Helicopter and engine designers recognize that turbine engine governor-rotor system compatibility problems may exist. This problem is felt to be of mutual concern to both parties, and to be due to the introduction of automatic rotor speed governing.
2. The major compatibility problem is one of resonance, which can lead to instability at or near resonant frequency.
 - a. This resonance is not apparent in reciprocating or turboprop open loop control systems.
 - b. This resonance is apparent in shaft turbine closed loop control systems.
3. The critical dynamic parameters appear to be:
 - a. helicopter damping characteristics
 - b. helicopter component stiffness (rotor, shaft, gears, etc.)
 - c. helicopter rotor inertia
 - d. engine power train inertia
 - e. engine dynamic characteristics (time lags, transport phenomena, damping, engine operating limits, etc.)
 - f. engine governor dynamic characteristics (response time, damping, static gain)
 - g. helicopter lag hinge spring constant
 - h. lag hinge damper characteristics
 - i. helicopter rotor response requirements
4. To more effectively achieve satisfactory helicopter-engine system operational characteristics, the following procedures are recommended:
 - a. Phase I - Engine Design and Development
 1. Engine designer to conduct preliminary studies in advance of firm applications to provide greatest universality and adaptability in recognition of potential compatibility problems.
 2. Engine designer to design and develop a basic governor in light of Item 4.a.1 above.
 3. Engine designer to determine parameter range and transfer functions of the engine and its controls.
 4. Engine designer may supplement engine model specifications with information determined in Item 4.a.3 above, when required.

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4. (Continued)

b. Phase II - Engine Application - Preliminary Helicopter Design

1. Helicopter designer to supply estimated rotor system dynamic characteristics during design stage. (A typical form is spring-inertia diagram. See Figure 1.
2. Both helicopter and engine designers to carry out studies and coordinate results.
3. Both helicopter and engine designers to determine the possible methods for correcting problems as indicated.

c. Phase III - Helicopter Development

1. Helicopter designer to decide which of the solutions in Item 4.b.3 is to be implemented and negotiate accordingly.
 2. Helicopter designer to coordinate dynamic revisions required.
 3. Helicopter designer to establish compatibility test requirements in consultation with the engine designer.
 4. Helicopter designer to run official demonstration.
5. In order to accomplish effectively the objectives of the recommended practice, the eventual recognition of all the foregoing, and consequent specification action will be required by the cognizant agency. This shall include methods of data presentation. In addition, it is recommended that the compatibility requirements of turboprop and shaft turbine engines be properly differentiated by the cognizant agencies in their specifications.

NOTE: Although not officially part of this ARP it is recommended that a study be implemented to determine the feasibility of defining parametric limits for use as possible standards in establishing a compatibility specification.

PREPARED BY
JOINT E-21/S-2 HELICOPTER POWERPLANT SUBCOMMITTEE
OF
SAE COMMITTEE E-21, DESIGN & GENERAL STANDARDS
FOR AEROSPACE PROPULSION SYSTEMS &
SAE COMMITTEE S-2, HELICOPTERS