



# AEROSPACE RECOMMENDED PRACTICE

**ARP704™****REV. A**

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Superseding ARP704

## Helicopter Engine-Rotor System Compatibility

### RATIONALE

ARP704A has been reaffirmed to comply with the SAE Five-Year Review policy.

A reaffirmed status is given to technical reports that have been reviewed by the technical committee and deemed to be current with no need for immediate revision. No changes have been made to this document as a result of this review.

### FOREWORD

Changes in this revision are format/editorial only.

#### 1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) recommends a methodology to be used for the design, analysis and test evaluation of modern helicopter gas turbine propulsion system stability and transient response characteristics. This methodology utilizes the computational power of modern digital computers to more thoroughly analyze, simulate and bench-test the helicopter engine/rotor system speed control loop over the flight envelope. This up-front work results in significantly less effort expended during flight test and delivers a more effective system into service.

The methodology presented herein is recommended for modern digital electronic propulsion control systems and also for traditional analog and hydromechanical systems.

#### 2. REFERENCES:

There are no referenced publications specified herein.

3. 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.
4. 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.

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5. 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
6. 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 6.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 6.a.3 above, when required.
  - 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.