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AEROSPACE INFORMATION REPORT

SAE AIR4152

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RECIPROCATING ENGINE PNEUMATIC STARTERS

1. SCOPE:

The purpose of this SAE Aerospace Information Report (AIR) is to present a brief discussion of pneumatic starters for reciprocating engines. This AIR also provides a general analysis guide for preliminary sizing of pneumatic starter systems for reciprocating engines.

2. REFERENCES:

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J476a Dryseal Pipe Threads
SAE J516 JUN91 Hydraulic Hose Fittings
SAE J542 JUN91 Starting Motor Mountings
SAE J543 JUN88 Starting Motor Pinions and Ring Gears

2.2 Definitions:

STARTING TORQUE: Torque required to initiate engine flywheel rotation.

CRANKING TORQUE: Torque required to crank the engine until the engine reaches self-sustaining rotation.

3. PNEUMATIC STARTER:

Pneumatic starters are a category of starters which are driven by a pressurized gas source. The pressurized gas energy is converted to mechanical shaft power for engine starting by the pneumatic starter.

For the wide range of reciprocating engine starting requirements, pneumatic starters typically operate on gas pressures of 15 to 200 psig at output speeds up to 5000 rpm, and provide output power up to 100 HP.

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SAE AIR4152

3. (Continued):

Generally, pneumatic starters provide higher cranking speeds than electric, hydraulic, or mechanical systems, and the pressurized gas source loses less energy at low temperatures.

Current pneumatic starters convert the stored energy into mechanical energy by one of three methods.

3.1 Vane Type:

In this type, pressurized gas is expanded between vanes that slide within rotor body slots forming seals between an elliptically offset rotor body and a cylindrical casing. The resulting force on the vanes converts rotation of the rotor to the engine flywheel.

3.2 Gear Type:

This type usually incorporates two spur, helical, or lobed gears closely meshing inside a housing. Pressurized gas is swept from inlet to outlet of the housing. The resulting forces on the gears convert rotation to the engine flywheel.

3.3 Turbine Type:

This type converts the stored energy of a pressurized gas into mechanical energy by the expansion of the compressed gas. The expanded gas at high velocity is directed through a rotor. The change of gas velocity through the rotor is translated into rotation to the engine flywheel.

4. PNEUMATIC STARTER/RECIPROCATING ENGINE SYSTEMS:

Figure 1 shows the basic elements found in a typical pneumatic starter system.

Pneumatic starter mounting is defined for reciprocating engines per SAE J542.

All starters are required to provide sufficient torque to initiate the starting sequence and to crank the engine until engine firing speed is reached. When the engine fires consistently, its rotation is self-sustaining and the starter torque is no longer needed. A means of disengaging the starter is then provided.

SAE AIR4152

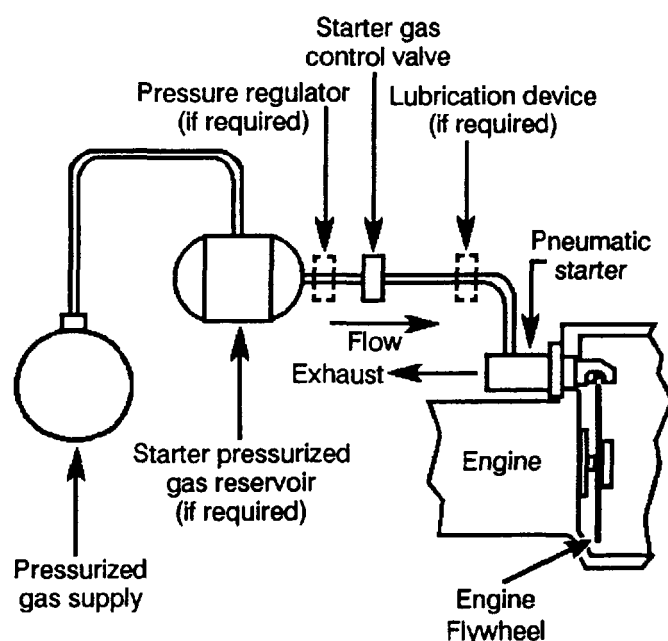


FIGURE 1 - Basic Components of Pneumatic Starter System

5. PNEUMATIC STARTER INTERFACING:

The mechanical energy of the pneumatic starter is transmitted to the engine flywheel through a driving pinion in mesh with a ring gear on the engine flywheel. The driving pinion and ring gear should conform to SAE J543. The cranking ratio is defined as the number of teeth on the ring gear divided by the number of teeth in the starter pinion (see Equation 1).

$$\text{Cranking Ratio} = \frac{\text{number of ring gear teeth}}{\text{number of starter pinion teeth}} \quad (\text{Eq.1})$$

The starter pinion must engage and mesh with the engine flywheel to initiate a start. The driving pinion must also disengage from the ring gear at or after each engine start to prevent damage to the starter and ring gear. Currently, two methods are utilized to provide pinion engagement and disengagement.

5.1 Inertial Method:

The starter pinion is mounted on a helical support shaft. Acceleration of the starter inertially thrusts the pinion mass outward for meshing. Usually a minimum acceleration of 600 rad/s per second is required. Disengagement occurs when the pinion is accelerated by the ring gear (starting engine) combined with the deceleration of the starter. The pinion is inertially spun out of mesh. Inertially operated starters generally will incorporate an energy absorption device (such as a friction clutch) to diminish the shock loading on starter components after pinion/ring gear engagement.