

AEROSPACE INFORMATION REPORT

SAE AIR4391

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Industrial and Marine Gas Turbine Engine Starting Systems

1. SCOPE:

This SAE Aerospace Information Report (AIR) presents descriptions of several types of industrial and marine gas turbine engine starting systems.

1.1 Purpose:

The purpose of this document is to describe to the aerospace engineer the types of starting systems used on gas turbine engines employed in industrial and marine applications. It is believed that the aerospace engineer's ability to design starting systems for aircraft gas turbine engines will be enhanced by a knowledge of the lessons learned in nonaerospace applications.

2. REFERENCES:

- AIR1174 Index of Starting System Specifications and Standards
- NACE MR0175-96 Sulfide Stress Cracking Resistant Metallic Materials for Oil Field Equipment

3. DISCUSSION:

Industrial and marine gas turbine engine starting systems are very similar to those used on aircraft. However, there are a few important differences which are described herein. Basic requirements for aerospace engine starting and auxiliary power systems can be obtained from the documents listed in AIR1174, Index of Starting System Specifications and Standards.

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3.1 Gas Turbine Engine Applications:

3.1.1 Industrial: Industrial applications of gas turbine engines include fluid pumping, gas compression, electric power generation, and prime movers. Pumped fluids include water, natural gas, and petroleum products. Electric power is produced by fixed and mobile units for major power plants (usually through co-generation with steam power plants) and temporary or emergency systems (e.g., during outage of main utility supplies at hospitals and other large industrial facilities). Prime movers are used in transportation systems, primarily railway. There are many more industrial applications of gas turbine engines than marine.

3.1.2 Marine: Marine applications of gas turbine engines include ship propulsion and auxiliary power. Propulsion units are provided in all sizes to propel large ships and small boats. This includes both direct propeller drive and drive of water pumps for water jet propulsion. Auxiliary power generation includes electric power generation, fluid pumping (including fire pumps), and heat sources for ship service steam generation.

3.2 Types of Starting Systems:

Starting system types include gas (primarily air), hydraulic, and electric.

3.2.1 Gas: Gas systems include the use of air, natural gas, hot gas (solid propellant), and nitrogen. Air systems are the most common, followed by natural gas.

An example of a large marine multiengine bleed air manifold system, which provides cross-bleed starting capability, is shown in Figure 1. This system supplies air to a bleed air header to which is connected the starting air system shown in Figure 2. The starting system shown is for two main propulsion engines and one auxiliary electric generator engine. The auxiliary engine can be started by either the high pressure stored air system or engine bleed air. The high pressure system is recharged by a separate high pressure compressor system. Once started, the auxiliary engine can supply bleed air to start the other engines. A cooling air system is incorporated to cool the high temperature bleed air to an acceptable level for delivery to the starters. A reduced-pressure air regulator valve is incorporated in the main engine start circuit to limit the starter pressure to only that level required to accomplish engine motoring during water washing or purging. The starter air pressure is approximately 40 psig for normal starting and 21 psig for motoring.

Air storage pressures vary from 90 to 120 psig for typical shop air systems, to 450 psig for intermediate systems, and to 3000 psig for high pressure systems. Starter operating pressures can range between 40 to 225 psig.

Natural gas starters are used for cases where gas turbine engines are used for pumping of natural gas and a ready supply of the gas is available from the pipeline. An alternate stored energy system may be provided for times when pipeline pressure is inadequate.

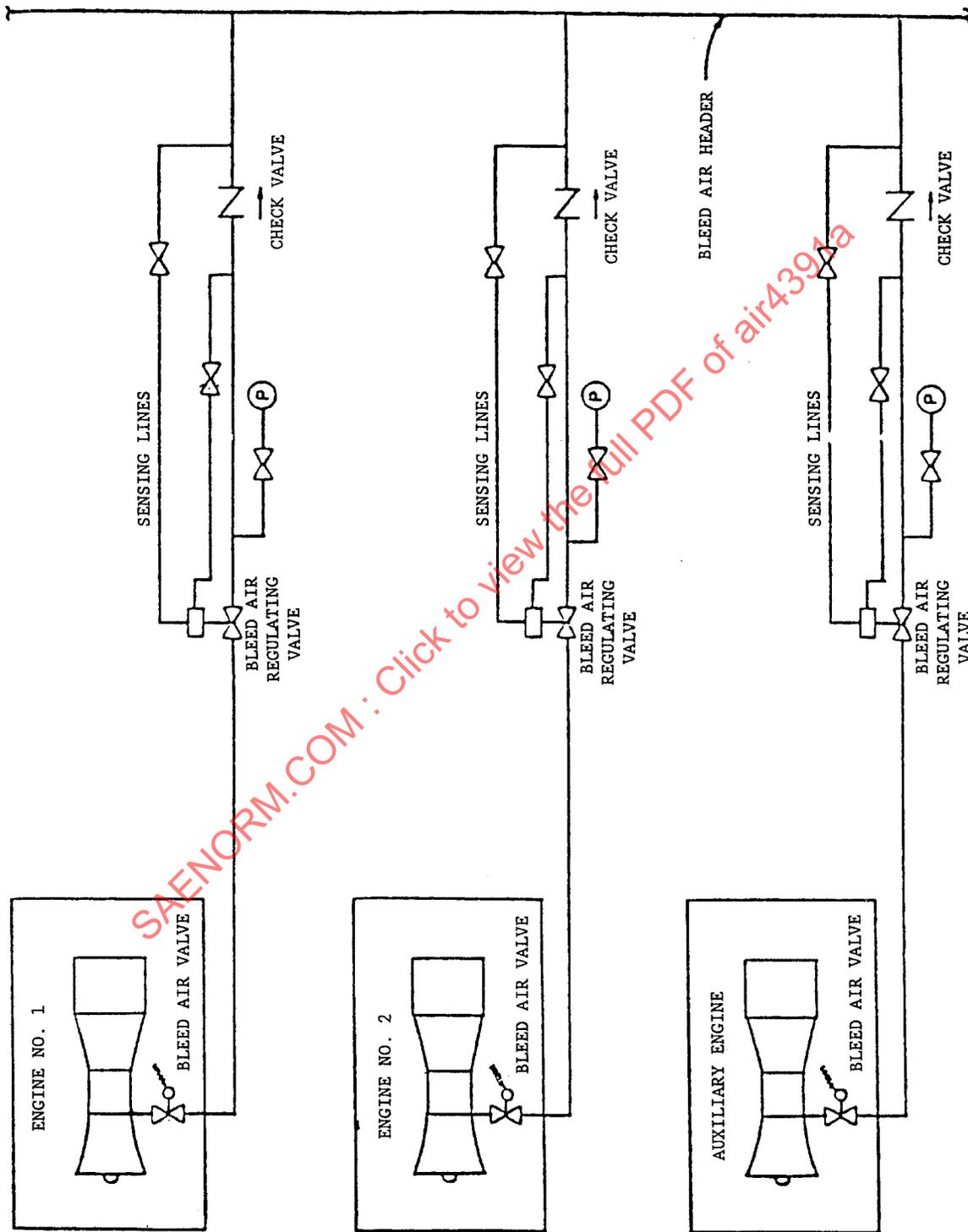


FIGURE 1 - Example Large Marine Multiengine Bleed Air Manifold System

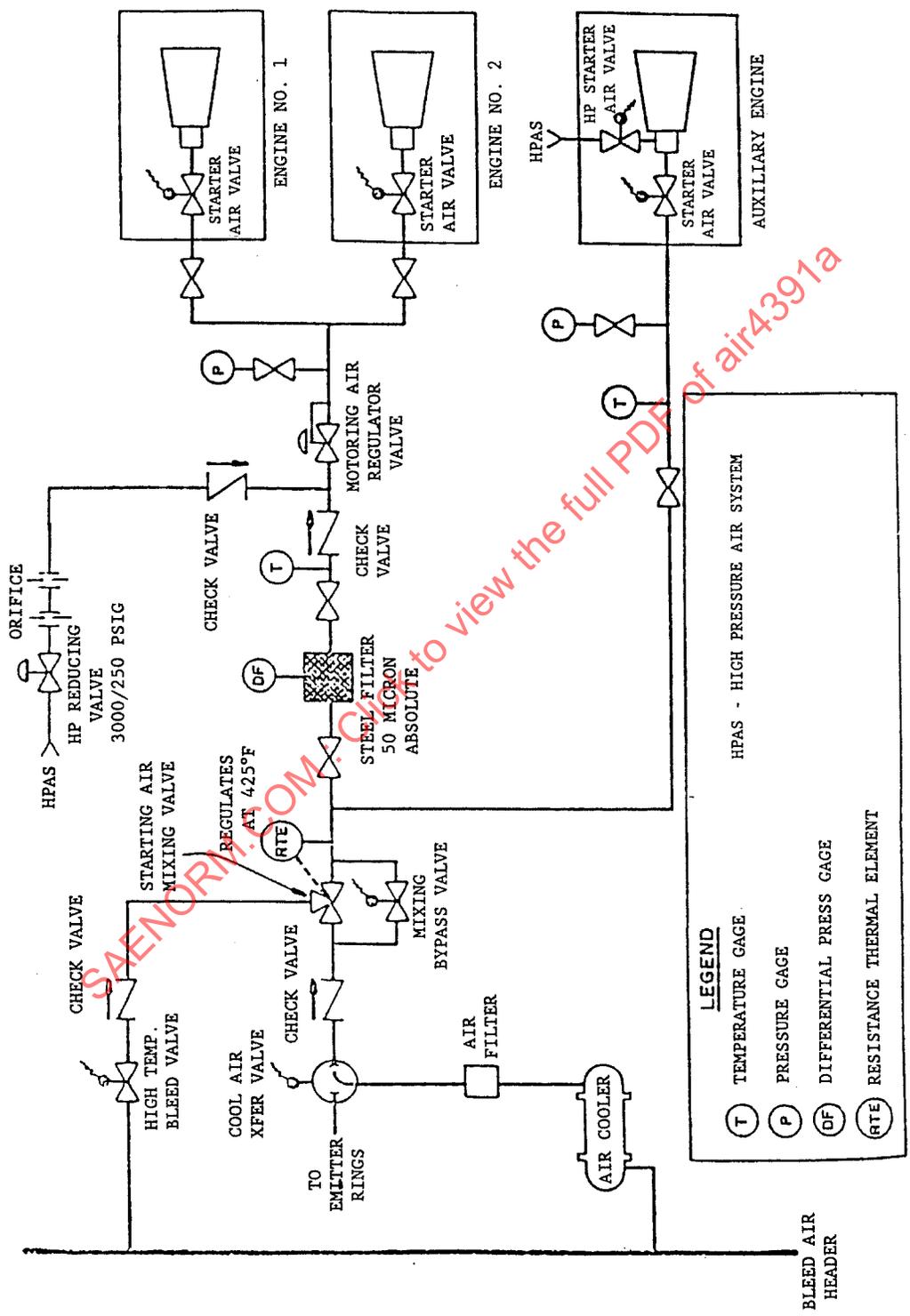


FIGURE 2 - Example Large Marine Multiengine Starting Air System

3.2.1 (Continued):

Solid propellant hot gas generators and nitrogen storage systems are sometimes used as energy sources to meet emergency starting requirements.

Where toxic gases are used for starter operation, it is necessary to collect the starter exhaust gases in a shroud and discharge them clear of any buildings.

Gas driven starters use vane, turbine, screw, or piston type motors.

3.2.2 Hydraulic: A typical hydraulic starting system incorporates a variable displacement hydraulic motor which receives flow from a variable displacement hydraulic pump. A separate drive system is required to power the hydraulic pump. A 5000 psi single-engine hydraulic starting system is shown in Figure 3. As shown, a pressurized accumulator could be another source of flow to the hydraulic motor. However, any number of engines could be connected to the system.

3.2.3 Electric: Electric start systems are normally used for starting small gas turbine engines such as those used for auxiliary electric generators and as prime movers. These systems are usually powered by storage batteries.

3.3 Detail Requirements:

The following basic detail requirements of industrial and marine gas turbine engine starting systems are similar to those for aircraft:

- a. Starter free-running capability to withstand a failed shear shaft
- b. Structural containment within the starter envelope of failed high energy rotating components
- c. Overrunning mechanism to prevent the engine from back-driving the starter
- d. Running engagement capability to permit restart attempts while the engine is still rotating
- e. Flexible plumbing and wiring connections in some cases
- f. Where lube oil is required, use the same oil as used in the engine
- g. Starter output shaft spline lubed by engine oil in some cases
- h. Use of corrosion resistant materials in some installations
- i. Long life (4000 starts and 3000 motorings without overhaul)
- j. Multiple-start duty cycles
- k. Ignition-proof (will not ignite an explosive mixture)
- l. Air or gas supplied to starter filtered to 50 μm absolute
- m. Consideration for sulfide stress cracking resistance (per NACE MR0175-96)

3.3.1 Some unique requirements are as follows:

- a. Use of special fluids such as natural gas and nitrogen
- b. Discharge of toxic gases clear of enclosed buildings
- c. Rapid start after extended nonoperating standby periods