AEROSPACE INFORMATION REPORT

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POWER SOURCES FOR FLUIDIC CONTROLS

1. PURPOSE AND SCOPE

This AIR concerns itself with the end use of Fluidic (or Flueric) control hardware on aerospace vehicle applications. The fluidic control hardware application is viewed as a system comprised of the following subsystems:

Power Source
Power Conditioner
Fluidic/Flueric Control(s)

This AIR identifies potential power sources and relates the design of the fluidic/flueric controls to the nature of both the power source and, as required, the power conditioner. In the unlikely event that the power source yields a fluid which is always at the desired pressure level, temperature range and flow rate capacity and, further, is free of particulate or liquid contaminate, pressure pulsation, etc., no power conditioner is required. Experience has shown that the power conditioner is usually necessary to assure operability and reliability of the total control system. The functions of the fluidic power conditioner are analagous to those of the electrical power supply regulator circuit in an electrical control system or those of the hydraulic servo supply regulator in a hydraulic control system.

Examples of (fluidic) power sources are given along with the referencing of government or industry standards (or other documents) which are of interest. AIR 744A "Auxiliary Power Sources for Aerospace Applications" is an excellent, more broadly based document which may be utilized in conjunction with this AIR.

Input parameters and output parameters, relative to the power conditioner, are presented. Also, ambients affecting the design of the power conditioner are indicated.

2. POTENTIAL POWER SOURCES FOR FLUIDIC CONTROLS

Tables I and II list typically available power sources. Table I deals with Prime Propulsion Engine Sources; Table II with Secondary Power Sources. Both Tables show numbers in parenthesis which relate to a numbered listing herein of government and industry standards or documents.

3. PARAMETERS OF INTEREST FOR DESIGN OF FLUIDIC POWER CONDITIONER

Figure 1 shows the relationship of the fluidic power conditioner to its inputs from the fluidic power source. Also shown are interface parameters between the conditioner's outputs and the fluidic control. Environmental conditions affecting the fluidic conditioner are also indicated.

4. SURVEY (LIMITED) ON AEROSPACE FLUIDIC CONTROL APPLICATIONS

During 1971 a limited, partial survey was accomplished for the purpose of obtaining information on existing/planned fluidic control applications. The survey questionnaire was designed to obtain maximum data on the characteristics of the fluidic power source and on the fluidic power conditioner. These data are summarized on Tables IIIA, IIIB, and IIIC, attached. The survey summary included herein is not represented as necessarily being a typical profile of fluidic/flueric aerospace control applications. It is intended to give the control system/control hardware designer several real life examples which may assist him in the conceptual design of a functional and reliable fluidic control application.

Reliable operation of the fluidic control system is contingent upon the design/selection of a satisfactory power source.

5. REFERENCES

1. MIL-H-5440 Hydraulic Systems, Aircraft, Types I and II, Design, Installation and Data Requirements for

2. MIL-P-5518 Pneumatic Systems, Aircraft, Design, Installation and Data Requirements for

3. MIL-H-8891 Hydraulic Systems, Manned Flight Vehicles, Type III, Design, Installation and Data Requirements for

4. MIL-H-25475 Hydraulic Systems, Missile, Design, Installation, Tests, and Data Requirements

5. MIL-P-5954 Pump Unit, Hydraulic, Electric Motor Driven, Fixed Displacement

6. MIL-P-5994 Pump, Hydraulic, Electric Motor Driven, Variable Delivery

7. MIL-C-6388 Compressor Unit, Air, Aircraft, Shaft Power Driven, General Specification for

8. MIL-C-6591 Compressor Unit, Aircraft, Electric Motor Driven, General Specification for

9. MIL-V-7909 Valves, Hydraulic, Pressure Reducer

10. MIL-P-19692 Pumps, Hydraulic, Variable Delivery, General Specification for

11. MIL-T-25363 Tank, Pneumatic Pressure, Aircraft, Gloss Fiber

12. MIL-C-26805 Compressor Units, Air, General Requirements for

13. MIL-A-5498 Accumulators, Aircraft Hydropneumatic Pressure

14. MIL-F-5504 Filters and Filter Elements, Fluid Pressure, Hydraulic Micronic Type

15. MIL-P-7858 Pump, Hydraulic, Power Driven, Fixed Displacement

16. MIL-C-7905 Cylinders, Compressed Gas, Nonshatterable

17. MIL-R-8572 Reducers, Pneumatic Pressure, Aircraft

18. MIL-F-8815 Filter and Filter Elements, Fluid Pressure, Hydraulic Line, 15 Micron Absolute, Type II Systems

19. MIL-A-8897 Accumulators, Hydraulic, Cylindrical, 3000 PSI, Type II

20. MIL-F-25682 Filter and Filter Elements, Fluid Pressure, Hydraulic, Absolute, 25 Micron, Minus 65 Deg. to plus 450 and plus 600 Deg. F.

21. MIL-F-27656 Filter, Fluid, Pressure, Absolute 25 Micron, Hydraulic

22. MIL-H-5606 Hydraulic Fluid, Petroleum Base, Aircraft and Ordnance

23. MIL-H-6083 Hydraulic Fluid, Petroleum Base, Preservative

24. MIL-P-8686 Power Units, Aircraft Auxiliary, Gas-Turbine-Type, General Specification for

25. MIL-H-8446 Hydraulic Fluid, Nonpetroleum Base, Aircraft

26.	MIL-H-46004	Hydraulic Fluid, Petroleum Base, Missile
27.	MIL-H-81019	Hydraulic Fluid, Petroleum Base, Ultra-low Temperature
28.	MIL-E-5007	Engine, Aircraft, Turbojet and Turbofan, General Specification for
29.	AIR 744A	Auxiliary Power Sources for Aerospace Applications

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POTENTIAL POWER SOURCES
- FOR -
AEROSPACE FLUIDIC CONTROLS

TABLE I

PRIME PROPULSION ENGINES:

GAS TURBINE

- Bleed Extraction From Flowpath At (See AIR 744A, Section 7.0)
  - Compressor Inlet (Inlet Diffuser)
  - Fan Discharge
  - Compressor Interstage (2, 17, 28)
  - Exhaust Nozzle
- Fuel at High Pressure
- Pressure Hydraulic Oil (9, 10, 14, 15, 18, 19, 20, 21, 28)
- Pressure Lubrication Oil

RECIPROCATING PISTON

- Bleed Extraction At
  - Inlet Manifold
  - Exhaust Manifold
- Fuel at High Pressure (9, 14, 18, 20, 21)
- Coolant System Pressure (9, 14, 18, 20, 21)
- Pressure Lubrication Oil

ROCKET ENGINES

- Bleed Extraction At
  - Combustor Discharge
  - Exhaust Nozzle
- Fuel (liquid at High Pressure)
- Pressure Hydraulic Oil (1, 3, 4, 5, 6, 9, 10, 13, 14, 15, 18, 19, 20, 21, 26, 27)

POTENTIAL POWER SOURCES
- FOR -
AEROSPACE FLUIDIC CONTROLS

TABLE II

SECONDARY POWER SOURCES:

AUXILIARY POWER UNIT

- Bleed Extraction At (24)
  - Turbine Gas Generator (7, 8, 11, 12, 13, 17)
  - Piston Compressor Discharge (7, 8, 11, 12, 13, 17)
- Pressure Lubrication Oil
- Turbine Driven Liquid Pumps

SERVO GAS GENERATORS (See AIR 744A, Sections 4.0 and 5.0)

- Solid Propellant (11, 16, 29)
- Liquid Propellant (11, 16, 29)

COMPRESSED STORED GAS (See AIR 744A, Section 6.0)

- Air Vehicle Pneumatic System (2, 11, 16)
- Propellant Tankage Boiloff
- Life Support Gas

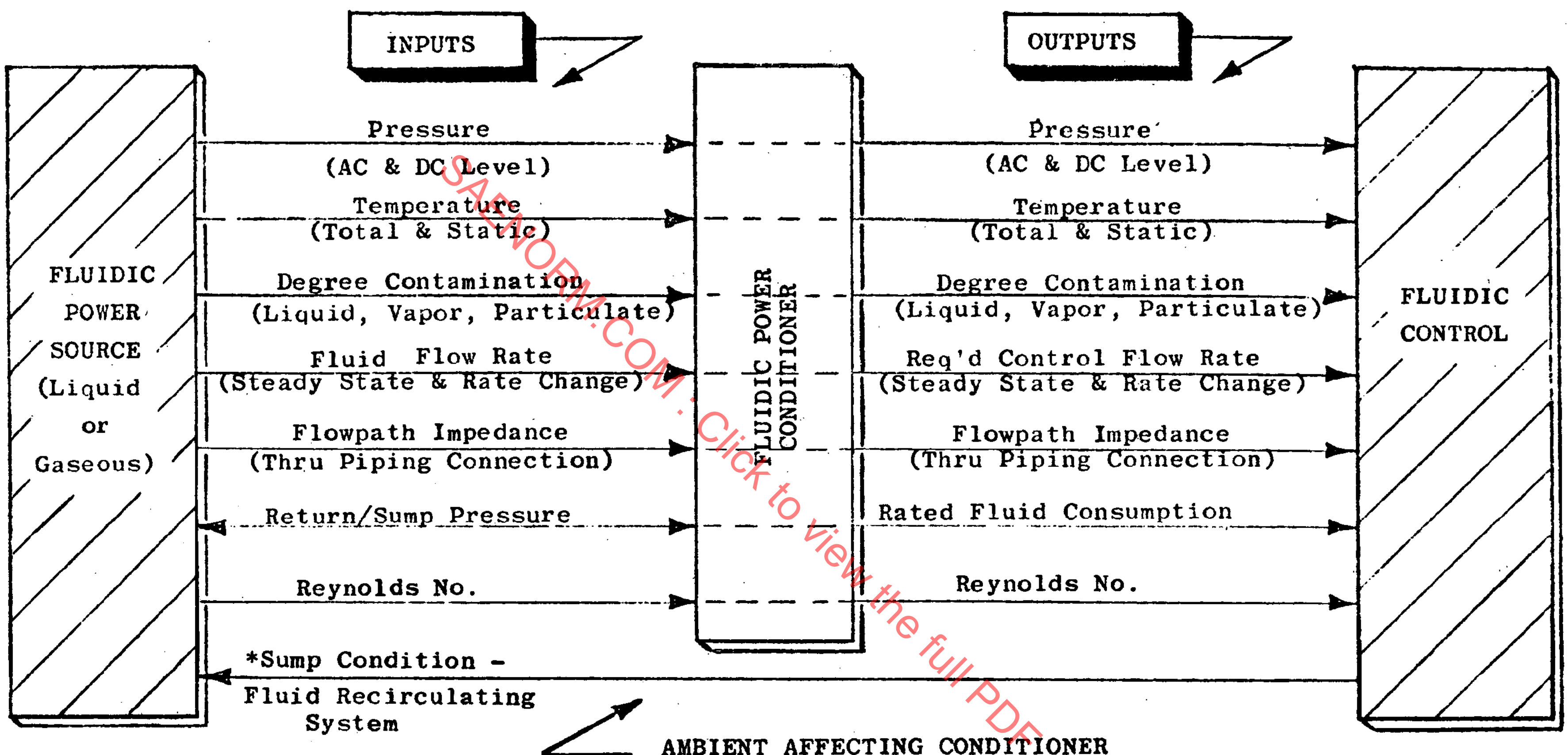
RAM AIR VENTURI TUBE

-

AIR VEHICLE SYSTEMS

- Flight Control System, Utility Power System (1, 3, 5. 6, 9, 10, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 25)
- Environmental Control System, Types A & B Servo Air (2, 11, 13, 17)

PARAMETERS OF INTEREST FOR DESIGN OF FLUIDIC POWER CONDITIONER



AMBIENT AFFECTING CONDITIONER

- Pressure
- Temperature of Air
- Temperature of Mounting Points
- Oil, Fuel, Grease Contamination (External)
- Water and Salt Spray (External)
- Vibration, Shock, Sustained Maneuver Loads
- Radiation Level
- Acoustic Noise
- Thermal Shock

Figure 1.

SURVEY ON POWER SOURCES FOR FLUIDIC CONTROLS

CONDUCTED AUGUST 1971 BY
FLUIDIC PANEL OF SUBCOMMITTEE A-6D

- SURVEY OBJECTIVE - OBTAIN INFO ON INDUSTRY/GOVERNMENT EXPERIENCE WITH FLUIDIC CONTROL SYSTEM APPLICATIONS

- SURVEY QUESTIONNAIRE SENT TO 15 SELECTED INDIVIDUALS (12 Companies/Government Facilities)

- RESPONSES FROM SEVEN INDIVIDUALS (Five Companies/Government Facilities)

- % RESPONSE TO SURVEY

  By Individual, 7/15 = 47%
  By Employer, 5/12 = 42%

SUMMARY OF RESULTS

- TOTAL OF 22 APPLICATIONS DESCRIBED

CONCEPTUAL	9
DEVELOPMENT	9
OPERATED	3
STATUS UNKNOWN	3
	24

- ANALYSIS AS TO FLUIDIC POWER SOURCE

  PRIME PROPULSION -

  Gas Turbine (6)

  - Pressure Hydraulic Oil
  - Compressor Bleed (5)

  Rocket Engine (2)

  SECONDARY POWER SOURCES -

  Auxiliary Power Unit (4)
  Ram Air Bleed
  Servo Gas Generators (6)
  Compressed Stored Gas (5)

TABLE IIIA

1971 SURVEY (LIMITED) ON AEROSPACE FLUIDIC CONTROL APPLICATIONS

POWER SOURCE			POWER CONDITIONER	CONTROL APPLICATION	FLUID POWER SOURCE ADVANTAGES	FLUID POWER SOURCE DISADVANTAGES
PRIME PROPULSION ENGINES		ROCKET ENGINE BLEED	• 1000 psi; 0.3 pps typical • Filtration only provided	Fluidic reaction controls (2)	Already on-board	Solid propellant oxidation products are dirty
PRIME PROPULSION ENGINES	GAS TURBINES	COMPRESSOR BLEED	• 250 psi supply; 25 psig regulation • 40 micron filter • 4 SCFM	Power turbine overspeed control	• Redundant (control operates without electrical or hyd) • Engine self-contained	Requires sensing line protection
PRIME PROPULSION ENGINES	GAS TURBINES	COMPRESSOR BLEED	• 50 psig regulator • 13 SCFM • 25 micron filter	3-axis SAS	Separate source	Temp. stabilization time
PRIME PROPULSION ENGINES	GAS TURBINES	COMPRESSOR BLEED	• 20 micron filter • finned cooling tube • 12 SCFM	Fan speed/vibe limiter	Redundant (as above)	(none stated)
PRIME PROPULSION ENGINES	GAS TURBINES	COMPRESSOR BLEED	• 150 psi supply; 50 psig regul. • 10 SCFM • 40 micron filter	Approach control power compensator	• Fewer interfaces • Reliability	(none stated)
PRIME PROPULSION ENGINES	GAS TURBINES	COMPRESSOR BLEED	(not defined)	Engine inlet door control	• Allowed all pneu. system • Environment tolerant • Readily available	(none stated)
PRIME PROPULSION ENGINES		HYD. PUMP	(utilized existing regulated hyd. pres.)	Landing gear sequencing	• Common source • No interfaces • Less cost	(none stated)