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ANALYSIS OF SAC (SEPARATE AIR COOLED) DESIGN(U) ENERGY
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DRAK70-79-C-0249

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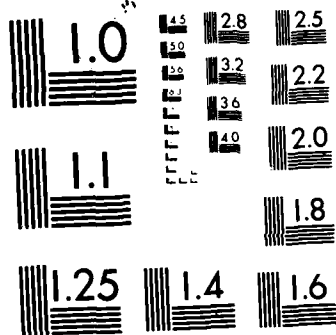


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Final Report on Analysis of SAC Design

Contract DAAK-70-79-C-024

CDRL ITEM A005

3kW/5kW Fuel Cell Power Unit

Component Name/Description:

Powerplant with SAC Stacks

References/Attachments:

None

Summary Of Data:

The SAC stack design for the powerplants and its incorporation into the current 3 and 5 kW program was analyzed and the findings are reported here.

MAR 17 1983

This document has been approved
by the Director and is hereby
certified as a true and correct
copy of the original.

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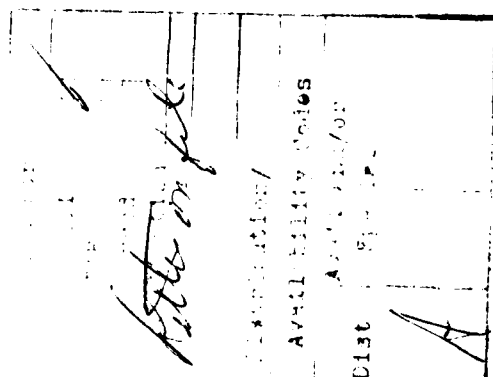
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INTRODUCTION

Two stacks incorporating the SAC (Separate Air Cooled) stack design were tested. These results were analyzed to evaluate the SAC design and the incorporation of SAC stack technology into the current 3.0 and 5.0 kW powerplant program. The findings are reported here.

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1. SAC DESIGN ANALYSIS

A. SYSTEM DESIGN

The powerplant schematic utilizing the the SAC stack design is shown in Figure 1. Note that the SAC stack design has been easily incorporated into the current 3 and 5 kW powerplant design (Figure 2) without major configuration or design changes.

The following benefits arise from employing the SAC stack design.

- The risk of acid dilution in the cell cathodes during startup is eliminated because burner flue gas does not contact the process gas channels. Fuel cell life is significantly enhanced.
- Startup time is reduced due to direct firing capability and higher inlet flue gas temperatures which are permissible since only the cooling side is exposed to flue gas.
- Cathode side sealing can be accomplished using passive elements that respond to stack temperature, opening when the stack reaches idle temperature.
- Approximately 15,000 BTU/hr heat is available from a 3 kW powerplant for direct use in space heating since the cooling air exhaust is dry and acid-free.
- More uniform current density and thermal distribution result from the counter-current flow of fuel and process air.
- Water recovery from the cathode exhaust gas is facilitated because the water concentration in the exhaust is greatly increased and the flow rate of the exhaust is small.
- The air recirculation loop is not exposed to phosphoric acid. Therefore, the duct work, blower, air exhaust valve, idle heaters, and bootstrap heater are not subject to acid corrosion. This results in increased system reliability and component life.

In the SAC design powerplant flow schematic, shown in Figure 1, the source of the cathode air is the high pressure side of the cooling air loop. The experimental pressure drop data from the 40 cell SAC stack, (0.2 inches of water corresponding to 3 stoich @150 mA/cm²) SAC-3, indicates that the pressure drop through the cathode process channel is low enough to draw sufficient process air from the cooling loop. In the event that sufficient air cannot be supplied to the cathode from the cooling loop, an auxilliary axial fan can be installed in the cathode inlet duct, shown in Figure 3.

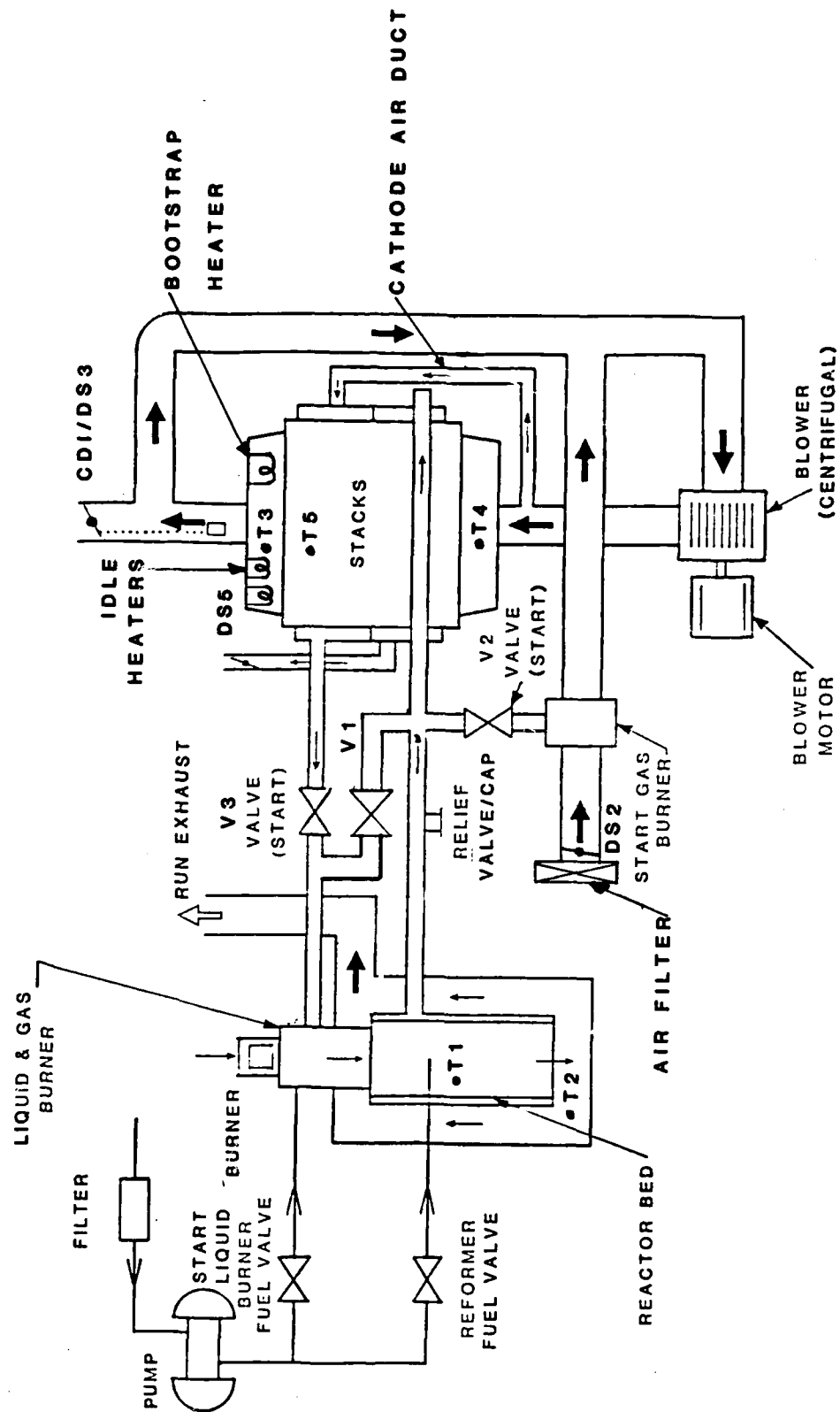


FIGURE 1. Powerplant Flow Schematic : SAC Design

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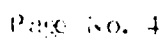


FIGURE 2 POWERPLANT FLOW SCHEMATIC : DIGAS DESIGN

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B. MECHANICAL LAYOUT

The mechanical layout of the major powerplant components (reformer, fuel cell stack, microprocessor, power conditioner etc.) is unaffected by the incorporation of an SAC stack. The minor plumbing modifications associated with the new design can be accommodated without increasing the overall powerplant volume or weight.

C. ANCILLARY COMPONENTS

No ancillary components are deleted in adopting the SAC design stack excepting that the hydrogen manifolds will be significantly smaller. The additional components to make the design change of the scheme shown in Figure 1, and the alternate scheme shown in Figure 3, are listed in Table 1.

TABLE 1 ADDITIONAL ANCILLARY COMPONENTS FOR SAC DESIGN

Figure 1 (SAC Design)	Cathode inlet manifold Cathode exit manifold Cathode exit valve DS5 Cathode ducting
Figure 3 (Alternate SAC Design)	Cathode inlet manifold Cathode exit manifold Cathode exit valve DS5 Cathode ducting Cathode fan

D. START TIME

The powerplant starting time will be reduced by incorporating a SAC design stack. Since the burner flue gas passes through the cooling channels only, a higher inlet gas temperature can be tolerated. Using the SAC design, an increase in the inlet gas temperature of 100°F (from 500°F to 600°F) can be tolerated without damaging cell edge seals or components. Startup preheating of the SAC stack from -65°F was accomplished in 15 minutes.

E. CONTROLLER INTERFACE

The basic controller logic will remain unaffected by the SAC design change. The only difference is that, as stated in the previous section, the set point of the temperature in the cooling air inlet manifold, T4, will be raised from 500°F to 600°F.

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F. PERFORMANCE

Performance of the fuel cell stack is expected to be enhanced by using the SAC design. Qualitatively, the SAC design will result in more uniform current density and thermal distribution due to the counter-current flow of fuel and process air. Increased average oxygen concentration in the process air in the case of the SAC stack will also contribute to higher fuel cell performance.

G. COST

Because of additional component requirements, the price of a mobile fuel cell powerplant incorporating SAC stack is expected to be \$15 - \$25/kW more than the DIGAS design. However, the life-cycle cost of such a powerplant will be reduced significantly as a result of increased fuel cell life.

2. INCORPORATION OF SAC TECHNOLOGY INTO CURRENT CONTRACT

The highlights of the analysis performed for incorporating SAC technology into the current 3 and 5 kW units are summarized in Table 2.

TABLE 2. SAC TECHNOLOGY FOR THE CURRENT 3 and 5 kW PROGRAM

Design	All subsystem designs excepting the fuel cell stack remain unchanged. Manifold design in 12 inch flow direction need to be changed.
Layout Modifications	Powerplant layout remains essentially unchanged.
Additional Ancillary Parts List	Given in Table 1
Preliminary Cost Factors	Total increase in cost for the 3 and 5 kW power-plant program will be \$90,000.
Projected Performance	At least same or better than the DIGAS power-plant.