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"FILLING UP WITH HYDROGEN 2000"

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Abstract

The purpose of Stuart Energy's prototype deployment program "Filling Up with Hydrogen 2000" is to build on-site electrolytic hydrogen generators for refuelling gaseous hydrogen vehicles. The general objective of this prototype deployment program is to demonstrate that electrolysis based hydrogen generators can meet market cost and performance targets. The program is in year 3 of Phase 2.

In Phase 2 of the Stuart/DOE program Stuart Energy will deploy two types of appliances called Fleet Fuel Appliances and Personal Fuel Appliances. The Fleet Fuel Appliance is intended for use with buses, trucks and other centrally fuelled fleet vehicles where fuel production rates in excess of 400 SCFH (10 Nm^3/h) are required. The Personal Fuel Appliance is designed for use with consumer vehicles at the home or office, and can be sustained by the utility infrastructure of the typical North American home. The production rate of these units is in the range of 50 SCFH (1.5 Nm^3/h). Both types of appliances will be capable of delivering gaseous hydrogen at high pressure (up to 5000 psig) to the vehicle. The goals of the program are to demonstrate the performance and cost objectives projected in the Phase 1 commercialization plan while accomplishing a safe and convenient refuelling process.

Introduction

The objectives of the past year were to demonstrate operation of Stuart's new CST electrolytic cell stack technology in large-scale application as part of a hydrogen bus refuelling station at SunLine Transit in 1000 Palms, California, build and test two smaller fleet fuel appliances using a different but related cell stack technology, and on a smaller scale through the prototyping program for the personal fuel appliance deliver a fuel appliance to a major automaker for evaluation. The key to achieving the cost targets in both product lines is the CST cell stack. The knowledge gained from the demonstrations will provide an experience base for the cell stack technology for later commercialization, and is a cost effective approach to equipment testing being that the user picks up the operating costs.

Stuart's prototype development plan not only includes the testing of the cell technology, but also provides public exposure to the fuel appliance concept; introducing customers to the idea of distributed on-site hydrogen production as well as providing valuable precedents for the development of codes and standards and hydrogen project risk assessment. The operation of the bus fuel appliance (P3-1A) at SunLine Transit provides public access to the technology through SunLine. The low-pressure fueler (P3-1B LP) provides a demonstration of a system, which can refuel metal hydrides. The high-pressure fueler (P3-1B HP) demonstrates the concept of a distributed "community fueler". The prototyping of the personal fuel appliance (PFA P1 Model 25) at major automakers will provide the auto industry the opportunity to assess and evaluate the concept of a small onsite hydrogen generator and potential home based fuelling appliance.

While the design and manufacture of the P3 prototypes provides a proving ground for component technology, primarily the cell stack, the design emphasis in the next 12 months will be development of the P4 systems. The P4 prototypes will realize a projected 50% reduction in appliance footprint and will be the basis for achieving manufacturing cost targets.

Discussion

Stuart Fleet Fuel Appliance Program

The Fleet Fuel Appliance is directed at the refuelling needs of hydrogen buses, trucks and other centrally fuelled fleet vehicles. Conceived to be a scalable product, 1 to over 30 vehicles can be supported with one appliance. The progress and development of Fleet Fuel Appliance prototypes follows a four-phase product development program, which is now in its third phase. The 17.7 million-dollar program will be completed by 2003. The ultimate cost goal for the fleet fuel appliance is $3000 per SCFM hydrogen production/refuelling capacity. Relationships with bus operators and hydrogen bus companies will be developed during the prototype deployment period from 1999-2002. Commercialization will occur from 2002 to 2004 and will probably be led by fuel cell urban buses. Table 1 shows the deployment schedule for fleet fuel appliance prototypes and prototyping partners identified at this time.

Table 1. Schedule for Fleet Fuel Appliance Prototypes

PROTOTYPE	PROTOTYPING PARTNER	DELIVERY DATE
Fleet Fuel Appliance		
P3-1A	SunLine Transit	Q1 2000
P3-1B (High Pressure)	Powertech Labs	Q1 2001
	California Fuel Cell Partnership	Q3 2001
P3-1B (Low Pressure)	Fuel Cell Propulsion Institute*	Q4 2001
P4-1	TBA	Q3 2001
P4-10	TBA	Q2 2002
Personal Fuel Appliance		
PFA-P1-99	Ford Motor Company	Q1 2001

* Proposal under consideration

P3 Fleet Fuel Appliance Progress

Prototype P3-1A

P3-1A demonstrates Stuart's new MW-CST or multi-stack electrolyzer cell technology and is intended for use with bus fleets and large retail outlets. The appliance is capable of producing up to 1490 SCFH at full current (12000 amps). The unit has been operating at SunLine Transit in 1000 Palms, CA and is being used to fuel a fleet of buses including two Hythane buses and a Ballard fuel cell bus. A Ballard Fuel Cell Bus being fuelled is shown in Figure 1.

Figure 1 – Ballard Fuel Cell Bus being fuelled at SunLine.

The unit is connected to a high-pressure storage system (approx. 100,000 SCF) and an external dispenser, which is part of a public access hydrogen fuelling station, the first of its kind in North America. The dispenser was designed by Stuart and built by Fuelling Technologies Inc. High-pressure hydrogen is distributed through one hose and high pressure Hythane, a mixture of 20% by volume hydrogen in natural gas, from the other. General operating characteristics of the cell are summarized in Table 2.

Table 2. General Operating Characteristics of the Cell

OPERATING CHARACTERISTIC	SPECIFICATION
Maximum Output	1490 SCFH
Maximum pressure	4000 psig
Cell Voltage efficiency @ 70 C & 95% maximum output	83% wrt HHV
Gas purity (ex. moisture)	99.65%

Over the period from mid-July 2000 to March 31, 2001 the unit operated for 960 hours (cells and compressor) producing 1,200,000 SCF of hydrogen fuel. The demonstration is planned to continue until March 31, 2003. The P3-1A Fleet Fuel Appliance at SunLine Transit is shown in Figure 2.

Figure 2 – The P3-1A Fleet Fuel Appliance at SunLine

Prototype P3-1B LP

The low-pressure Fleet Fuel Appliance, P3-1B LP, delivers a rated hydrogen output of 400 SCFH at 200 psig. In May 2000, P3-1B successfully completed 3000 hours of in-house testing. In the upcoming year, hydrogen generated from the prototype will be used to demonstrate refuelling hydrogen vehicles in underground mining applications. The unit (a solid model shown in Figure 3) uses two single-stack H-CST electrolysers and two compressors (one duty and one stand-by).

Prototype P3-1B HP

P3-1B HP Fleet Fuel Appliance successfully passed factory tests (750 hours) and has been delivered to Powertech Laboratories in Vancouver BC. Based on the same platform as P3-1B LP the unit uses H-CST single stack electrolyzer technology.

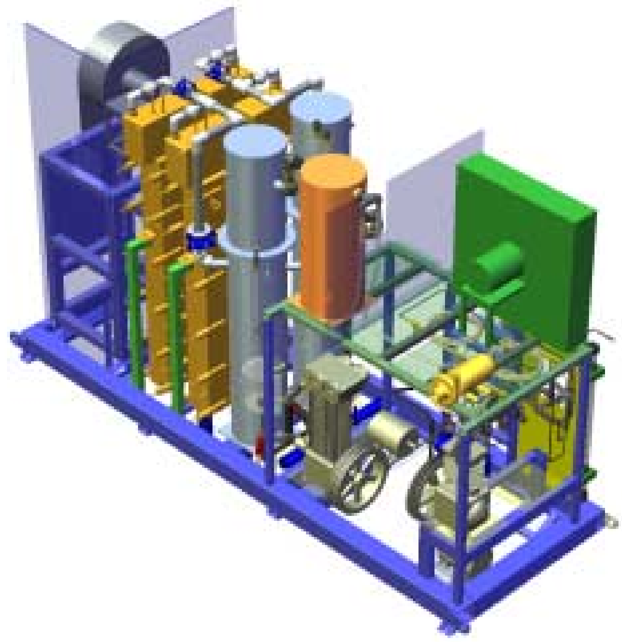

Figure 3 – Model of P3-1B (LP)

The unit incorporates the power conditioning system, two cells and two compressors in a linear designed platform that can be readily scaled to large sizes, up to six cells. The unit has both a catalytic purifier as well as high performance dryer, which is, installed inter-stage. The hydrogen production rate is rated at 400 SCFH at a maximum pressure of 5000 psig with plans to increase pressure to 6000 psig. Since arriving at the site the unit has run over 300 hours. The unit is being used to test and certify storage tanks for hydrogen vehicles. A photograph of the unit at Powertech is shown in Figure 4.

Figure 4 – The P3-1B (HP) at Powertech Labs, Surrey, BC

A summary of the operating characteristics of the high and low-pressure units is summarized in Table 3.

Table 3: Operating characteristics of P3-1B Prototypes

OPERATING CHARACTERISTIC	P3-1B (HP) SPECIFICATION	P3-1B (LP) SPECIFICATION
Production Rate (max)	450 SCFH	400 SCFH
Pressure	5000 psig	200 psig
Hydrogen Purity	99.993%	99.994%
Moisture (dew point temperature)	-65 C	-70 C

Prototype P3-5 Cell Stack Assembly

The P3-5 fuel appliance, capable of fuelling 5 buses or approximately 10000 SCFH was taken to the design stage of the cell stack assembly only. The cell stack assembly is designed to be assembled in 2- block cell platforms, with each block consisting of 6 stacks. The modules are aligned in a row to form a "U" shaped bank, which can be assembled inside an enclosure. The cell stack assembly design will be used in future bus fueler prototypes. A 3-D model of the P3-5 Cell Module is shown in Figure 5.

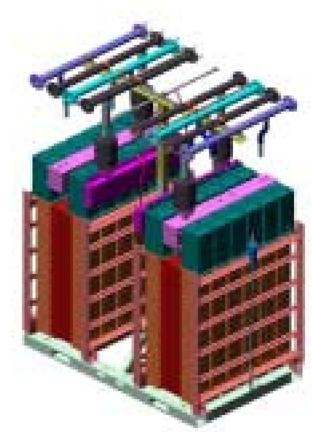

Figure 5 – 3-D Model of P3-5 Cell Module

The modules as assembled stand approximately 12 feet tall, 8 feet wide, by 6 feet long and weigh 13,000 lb. Installed the entire cell battery, with gas and feedwater headers connected, will be 14 feet high, 8 feet wide and 30 feet long. The unit will be capable of generating 10,000 SCFH.

Although a number of proposals for supplying bus filling stations have been made to Europe, California and Brazil, there have been no confirmed projects. As a consequence the plan for this prototype has been modified to include only the design and construction of the prototype. A photograph of the P3-5 Cell Prototype is shown in Figure 6.