# Hydrogen Separation from a Logistic Fuel Reformate Stream (N05-040)

## Need

Fuel cell systems are developing into a viable option for tactical and distributed power generation onboard Navy ships. However, fuel cells typically require hydrogen rich fuel with very low sulfur content to prevent performance degradation. Navy logistic fuels can contain up to 0.5% (by weight) sulfur which is beyond the tolerance levels. Current sulfur removal technology typically increases the size and complexity of the fuel reforming system which adds to the overall cost and maintenance.

A hydrogen separation membrane of sufficient permeability that is immune to sulfur concentrations in logistic fuels would simplify the desulfurization process and save significant cost, space and maintenance for a military fuel-to-hydrogen generation process.

## Technology Development

The Power & Energy (P&E) palladium membrane technology separates pure hydrogen from a reformate stream originating from a fuel reformation process. The pure hydrogen is used to power a Proton Exchange Membrane (PEM) fuel cell system for electricity generation at many power levels and applications. Because the reformer is fed sulfur-containing logistic fuel, P&E has developed highly sulfur tolerant separation modules. Hydrogen flux rates approaching that of industry standard Palladium-Silver (PdAg) are achieved with a Palladium-Copper (PdCu) alloy material operated at high temperature, which can be drawn to a slightly thinner wall thickness. The PdCu alloy exhibits a high degree of sulfur tolerance consistent with recent DOE studies. Membrane module housing materials were investigated regarding sulfur corrosion and compared with studies from the oil refinery industry. Empirical as well as reaction chemistry based metal-sulfide formation data is available for palladium, copper and different steels providing the temperature and Hydrogen Sulfide/Hydrogen ($H_2S/H_2$) ratios below which corrosion is absent. P&E is designing sulfur resistant hydrogen separation modules with conditions for good sulfur tolerance and high $H_2$ flux rates.

The P&E separation modules confine the reformer stream in a micro channel between the membrane and a wall which are made from materials with catalytic properties. Such wall-catalyzed membrane reactors have been investigated for the Water-Gas Shift (WGS) reaction that converts carbon monoxide into carbon dioxide to increase overall hydrogen production. The underlying scalable manufacturing technology currently used for P&E's commercial PdAg hydrogen purifiers is basically the same for PdCu separators and WGS membrane reactors.

## Technology Transition

Currently, ongoing transition collaboration with United Technologies Research Center (UTRC) exists including subcontracting on several DOE projects related to hydrogen recovery from coal derived syngas and renewable sources.

P&E has recently delivered a facility hydrogen purifier to the Hawaii Fuel Cell Test Center (supported by both ONR and DOE). The purifier will provide consistent hydrogen purity from multiple sources to eliminate hydrogen purity as a variable for the various test stations over time.

Additional hydrogen separation modules were delivered to Battelle and integrated with a steam reformer into a 5 kW net diesel fuel based PEM fuel cell auxiliary power unit for Army vehicles operating on diesel fuel. An experimental steam sweep separator has been delivered in support of a DOD Solid Oxide Fuel Cell program.

**Program Sponsor:** PMS 320 - ONR
**Point of Contact:** Don Hoffman

## Need

- Desulfurization process that is simplified, saving significant cost, space and maintenance.

## Benefits

- Extended mission capability: Increased electrical power can be generated per gallon of fuel using fuel processor and fuel cell vs. internal combustion-based generator.
- Reduced thermal and acoustic signatures with increased power density to support distributed power generation.

## Technology Transition

- Collaborating with UTRC on sulfur tolerant membranes for hydrogen from coal syngas, DOE has selected a UTRC/P&E team for a larger scale project demonstrating a megawatt capacity.
- P&E has shipped six high purity separators to both Battelle Columbus and PNNL for 5-10 kW APU systems for both Army and Air Force projects. P&E has been notified that it is a subcontractor an additional DOD.

## Project & Phase III Funding

| | | |
|---|---|---|
| SBIR | PEO Ships | $1,098,637 |
| Phase III | ONR | $1,915,014 |
| Phase III | United Technologies Research Center | |
| Phase III | Hawaii Natural Energy Institute | |
| Phase III | Battelle Memorial Institute | |


## Power & Energy, Inc.

106 Railroad Drive | Warminster, PA 18974
(215) 942-4600 | www.powerandenergy.com