PROPULSE" 980: A Hydrogen Peroxide Enrichment System

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ABSTRACT

The PROPULSE" 980 unit is a transportable processing plant that enriches aerospace grade hydrogen peroxide from 90% to 98% final concentration. The unit was developed by Degussa-H ls, in cooperation with Orbital, NASA-Marshall Space Center and NASA-Stennis Space Center. The system is a self-contained unit that houses all of the process equipment, instrumentation and controls to perform the concentration operation nearly autonomously. It is designed to produce non-bulk quantities of 98% hydrogen peroxide. The enrichment unit design also maintains system, personnel and environmental safety during all aspects of the enrichment process and final product storage. As part of the Propulse 980 checkout and final buyoff, it will be disassembled at the Degussa-H ls Corporation plant in Theodore, AL, transported to the Stennis Space Center, reassembled and subjected to a series of checkout tests to verify design objectives have been met. This paper will summarize the basic project elements and provide an update on the present status of the project.

Project Objective

While hydrogen peroxide concentrations of 70% and higher (HTP) have had applications in propulsion systems, the specific impulse of the system is directly related to the concentration of the HTP. Many propulsion systems proposed are intended to operate using 98% wt. HTP, which is only available in small quantities commercially. To support current and future propulsion system development, development funds from NASA NRA8-21were provided to assure availability of 98% HTP propellant. Specifically the objective was to design, develop and demonstrate a transportable pilot plant to enrich hydrogen peroxide to 98% concentration.

Requirements

The project requirements established the design and operations parameters that were used to execute the detailed design of the unit. The major requirements were as follows:

Enrichment Range

The unit will use 90% wt. HTP feedstock, concentrating it to 98% (+/- _%). Initially the objective was to concentrate from 70% wt. HTP to 98% wt., however this would have required the use of two discrete chemical processes to perform the enrichment. In addition, 90% wt. HTP is now currently commercially available. This eliminates the need to perform this initial concentration step on site at a portable unit.

Capacity

The production goal for the enrichment unit is to safely and automatically produce a minimum of 1,000 pounds of 98% product per day. HTP, being a hazardous and energetic material requires care in handling, processing and storage. The enrichment unit was designed to operate automatically with a minimum of operator attention. Anomalous operation is detected by the units control system resulting in alarms and automatic corrective actions as required.

Transportability

A key design goal was to produce a unit that is within the size and weight envelope to be transportable by common commercial carrier. While it is possible to ship bulk and non-bulk quantities of 98% HTP, the ability to enrich the HTP at the point of use has certain advantages. In particular, the ability to enrich material immediately before use ensures that the required concentration will be available and eliminates the need to maintain a stock of enriched material produced off site.

The detailed design of the unit resulted in an assembly that meets the transportability requirements. The unit is formed from two modules that are transported separately and then stacked at the operations site. An access stairway and a platform with ladder provide two means of entrance and egress for the upper level.

Facility Requirements

The operations site provides utility services to the PROPULSE" 980 enrichment unit. These services include potable water, containment, instrument gas and electrical power.

The unit is designed to draw 90% HTP feedstock from either IM-101 top-unloading transport containers or from a fixed storage tank. Supply of feedstock to the unit using drums is possible, but not recommended.

While the unit has an integral finished product tank, this tank is intended primarily as a buffer — thus the facility should provide a finished product storage tank of suitable size constructed of a class 1 material for storing larger quantities.

Acceptance

The final step in the project will occur at NASA s John C. Stennis Space Center near Bay St. Louis, MS. The completed and tested PROPULSE" 980 unit will be brought to SSC, and set up. The unit s startup, operation, and shutdown processes fully demonstrated.

Development Team and Responsibilities

A team consisting of NASA, Orbital Sciences Corporation, and Degussa-H Is formed to realize the design, construction, and implementation of this project.

MSFC — Contracting Agency

MSFC is the organization pushing this technology development and is the contracting agency for this effort.

Orbital — Contract Oversight

Orbital is the contractor selected by NASA in NRA8-21 to oversee the enrichment unit development process. Orbital represents the launch vehicle integration and launch community to ensure the enrichment unit meets the needs of this group of future users. Orbital designs, fabricates, tests and provides launch integration of a family of small space launch vehicles. Currently, Orbital is in the development phase of a NASA/US Air Force Upper Stage Flight Experiment (USFE).

Degussa-H Is — Propellant & System Hardware Developer & Manufacturer

Degussa-H Is is the 2nd largest supplier of hydrogen peroxide in the world and has been regularly producing HTP for the last several decades. Degussa-H Is maintains R&D facilities in Germany and the US along with process design, detailed engineering, and project construction services. Degussa-H Is R&D had performed several previous investigations which provided a scientific basis for the design of a production enrichment system for 98% HTP. This R&D experience, combined with engineering and manufacturing know-how, allowed the rapid design of a suitable processing unit.

This project was managed through Degussa-H Is Technical Services department, which focuses on providing engineering assistance to chemical consumers — however; the project involved efforts from virtually all of Degussa-H Is technology service groups along with several outside contractors.

SSC — Facility to provide checkout and test for aerospace community

Stennis Space Center operates its E-3 test stand as a dedicated hydrogen peroxide test site; the enrichment unit will be located near E-3. SSC will be providing a concrete burm area, which is required by state environmental laws. The concrete area will have enough space to encompass the enrichment skid, the feedstock bulk storage tank, by product storage tank and transfer area for off-loading the feedstock. Additionally along side the concrete area will be ~70,000 gallon capacity dilution pond. The pond will be utilized in dilution of HTP to less than 1% therefore allowing it to further be disposed in local sewage systems.

SSC will provide local GN_2 to skid for valve actuation, a phone line for a emergency dialing system, 480 VAC power for the enrichment skid and feedstock bulk storage tank, water for the safety showers and cleaning. Finally, an Ethernet connection will allow complete monitoring of the enrichment skid from the Test Control Center.

At a later date a larger class 1 vessel will be placed along side the enrichment skid to receive and store on hand a larger volume of 98% H2O2. Additionally a Class-1 completely enclosed

transfer system will be installed between the enrichment skid area and the test stand run tanks. The purpose for the transfer system will be to further minimize possible exposure to, or contamination of, the 98% H_2O_2 during test programs.

Current Status of Project

Presently the unit is at the Degussa-H Is Theodore, AL plant site being prepared for initial startup.

Test & Checkout Plan

Fabrication Site

Prior to delivery to Degussa-H Is site for process checkouts, the two modules were stacked to verify alignment of all inter-module piping and utility connections. Piping and vessels were pressure tested after the piping was completely installed.

Initial Startup: Degussa-H Is Theodore Site

A test location was prepared at the Degussa-H Is facility that had the necessary infrastructure to support the operation of the unit during process debugging and optimization. The unit will be transported to the site and erected.

Testing will include a final pressure test of all vessels and piping and checks of all instrumentation and electrical equipment. Prior to the introduction of HTP to the unit, all hydrogen peroxide piping and vessels will be flooded and allowed to soak overnight with 50% high-purity hydrogen peroxide, this will allow the internal surfaces to complete their passivation. After the soak, the hydrogen peroxide will be sampled for decomposition.

Prior to the processing of HTP, the process will be operated using a 50% concentration hydrogen peroxide solution. No enrichment will take place, but this step will allow verification of the process control and equipment integrity.
Once the process operating procedures have been demonstrated satisfactorily using dilute hydrogen peroxide, 90% HTP will be processed.

During the processing of 90%, the end product will be sampled and process parameters adjusted to obtain the desired result (98% – 0.5%). After demonstrating that the system can produce the rate and quality of product required, the process will be further adjusted to determine its maximum capacity. Sufficient 90% feedstock is on hand to allow extensive experimentation with the process parameters without recycling any of the processed materials.

Training: Degussa-H Is , Theodore Site

Once Degussa-H Is determines that the operation has been demonstrated to be safe and predictable, the system will be shut down. Personnel from SSC and Orbital will be oriented and provided training in the startup and operating procedures, and then participate in the startup, operation, and shutdown of the unit. The final shutdown of the unit will be used to prepare it for relocation to SSC.

Demonstration at SSC

After the PROPULSE" 980 unit completes its operational trials and process optimization, it will be disassembled and relocated to a site near the E-3 test stand.

The sequence of events after delivery to SSC will closely follow that used at the Degussa-H Is site. The pre-startup process can be abbreviated somewhat due to the experiences gained at Theodore.

Startup, normal operation, and shutdown sequences will be demonstrated to satisfy the acceptance criteria. The unit will then be placed in a condition in which it can remain idle until needed to support test activities.

Fabrication Status

Presently the completed PROPULSE" 980 unit is erected at the Degussa-H Is Corporation site in Theodore, Alabama where it is undergoing operations testing and optimization.

Program Outlook

The PROPULSE" 980 unit will be producing 98% HTP to satisfy SSC s requirements beginning 1st quarter 2001. The transportable nature of the equipment allows it to be relocated, if necessary, to other test or launch sites in support of future HTP projects.