FLAME RESISTANT FIBROUS MATERIALS DEVELOPMENT

Contract No. NAS9-13673
Final Report

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1. DAWN, F.S. / ES5

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Prepared by

3 Robert J. Coskren

for

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Crew Systems Division
Houston, Texas

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4. Albany International Research Co.
1000 Providence Highway
Dedham, Massachusetts

Introduction

Since 1973, Albany International Research Co. has been engaged by NASA-JSC under Contract No. NAS9-13673 to conduct studies aimed at developing fibers and flexible structures made therefrom which would provide improved flame resistance over existing commercially available materials in oxygen-enriched atmospheres. A portion of the crew bay area life support system and crew equipment for the Space Shuttle was initially designed to function at a 30% oxygen, 70% nitrogen atmosphere at 9 psia pressure. This oxygen concentration imposed certain fire safety and smoke generation requirements which could not be completely met by commonly accepted textiles. The purpose of this program was to investigate potentially useful new polymers, both for fire safety and mechanical properties, spin fibers and produce sufficient quantities of qualified flexible materials for use in upcoming Shuttle flights. During the course of the work, three candidate fibers have been studied and evaluated and the results of each of these efforts are summarized below.

CTFE/E Fiber Development Program (1973-1975)

The first fiber study was initiated based upon the success of preliminary spinning trials made by Allied Chemical Corporation under NASA Contract No. NAS9-12257. At the end of the two year period in which the work was carried out at AI Research Co., the following goals were achieved:

1. Production of an experimental quantity of CTFE/E continuous filament yarn. (Tenacity = 2.0-2.5 grams per denier, Rupture Elongation = 8-11%, Limiting Oxygen Index = 51).

2. Production and lab evaluation of prototype woven and knitted fabrics from this yarn.

3. Dyeing and finishing of woven and knitted fabrics such that end items could be fabricated for use by NASA flight personnel in various applications where flammability hazards might exist.

Polyimide Fiber Development Program (1974-1979)

With the advent of Upjohn 2080 polyimide resin in mid-1974, a separate study was initiated to assess the merits of a polymer developed by the Upjohn Company, their 2080 polyimide. This material is known to have good flame resistance and high temperature tensile strength retention, and in addition, its specific gravity is less than that of CTFE/E making it potentially useful in many NASA applications. Its Limiting Oxygen Index is 40 making it also more flame resistant than any of the fiber-forming polymers commercially available at the time. During the period of performance of this phase of the contract, the following was accomplished:

1. Production of pilot plant quantities of continuous filament yarn in various deniers and a quantity of cut staple fiber. (Tenacity = 2.0-2.5 grams per denier, Rupture Elongation = 30-35%, Limiting Oxygen Index = 40).

2. Spinning of staple fiber into spun yarn on commercial equipment.

3. Production of tapes, braids, knitted and woven fabrics in sufficient quantity for in-service evaluation by JSC personnel. One of the braided cords developed was ultimately adopted by JSC for use in the cargo bay area of the Space Shuttle.

4. Application of dyes and finishes to woven fabrics in an attempt to provide a range of colors suitable for use in clothing by NASA flight personnel.

PBI Fiber Development Program (1979-1982)

Early in 1979 the Celanese Corporation announced plans to construct a fiber plant capable of producing commercial quantities of their new high temperature and flame resistant fiber, PBI. From 1965 through 1973, Celanese had been producing this fiber on a pilot facility built and owned by the U. S. Air Force. In 1973 when the Air Force no longer chose to produce this fiber for use in flight crew clothing, the plant was shut down and fiber production ceased. PBI is known to have an LOI of 40-45 and has been used extensively by NASA in Apollo and Skylab missions. However, when its production was halted, the search for a suitable replacement was initiated by NASA-JSC. This search led to CTFE/E and polyimide fibers which, while adequate, did not offer as much as PBI in many Shuttle applications. Therefore, when PBI was reactivated by Celanese in 1979, the emphasis in the program was shifted back to this fiber and the list of products made was increased to include webbings, tapes, braids, sewing threads and various spun fabrics. In fact, the outer layer of the Ejection Escape Suit (Launch and Landing Pressure Suit) worn by Astronauts of STS-1 through STS-4 missions of the Space Shuttle Columbia was a fabric woven from PBI yarns developed during this phase of the program. Moreover, many of the items used on subsequent flights were designed and developed under this program. Such things as oxygen hose coverings, restraint harness webbings, tie-down cords and sewing threads have all been delivered to NASA and its various contractors. With the Celanese plant scheduled to be completed early next year, it is expected that this fiber will be suitable for many of NASA's future requirements.