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ITT Electro-Optical Products Division

(NASA-CR-157061) WIDE TEMPERATURE RANGE FIBER OPTIC CABLE: CABLE DESIGN STUDY (ITT Electro-Optical Products Div., Roanoke) 6 p CSCL 20F

N78-24924

Unclas G3/74 20716

"WIDE TEMPERATURE RANGE FIBER OPTIC CABLE"

CABLE DESIGN STUDY

Contract No. 954843

(Subcontract under NASA Contract NAS7-100)

(Task Order No. RD-156)

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WIDE TEMPERATURE RANGE - FIBER OPTIC CABLE

Design Evaluation

1.0 INTRODUCTION

The design and fabrication of a single fiber optic cable intended for application in an invironment of temperature extremes from -160°C to +125°C presents a challenge to state-of-the-art of fiber optic cables. Applying the advanced technology of fiber optic cable production to selected materials capable of sustained operation over the desired temperature range will yield an acceptable cable.

The purpose of this paper is to address the considerations undertaken to arrive at the final design of the wide temperature range optical cable.

2.0 PERFORMANCE REQUIREMENTS

2.1 General

General requirements for the single fiber optic cable for spacecraft applications are abrasion resistance, low temperature flexibility, small size, low weight and overall temperature stability.

2.2 Specific Requirements

Specific requirements include:

1)	Fiber Core Diameter	50 μm ± 2 μ
2)	Fiber overall diameter	125 μm ±5 μ
3)	Fiber loss	≤10 dB/km @0.82
4)	Fiber NA	≥0.20
5)	Cable tensile load	≥80 lbs. @room temperature

3.0 SUBSTRATE SELECTION

3.1 Optic Fibers

Chemical vapor deposited (CVD) step index fibers will be used for the project. This fiber is a standard ITT EOPD product which has the required dimensions, optical losses less than 10 dB/km, and NA greater than .25.

3.2 Coating

A buffer of RTV silicone will be applied over the fiber to minimize the effect of vibrations and to reduce microbending losses at both low and high temperatures.

3.3 Fiber Jacket

Few polymers are available for protecting the fiber because of the extreme temperature range requirement. The best candidates are fluorocarbons, with Teflon PFA the optimum choice. Process experience at ITT with PFA plus its chemical inertness, heat resistance, toughness, flexibility, low coefficient of friction and self-extinguishment makes it the most attractive candidate as a jacket for the fiber.

3.4 Strength Members

To achieve the required tensile load for the single fiber optical cable, a material is needed that offers high tensile strength plus a high Young's Modulus: that material is "Kevlar" 49. At the safe allowable 1% strain limit of the glass fiber, Kevlar 49 exhibits tensile load capabilities of 170,000 psi which translates to more than 25 pounds strength per 1420 denier yarn.

The resistance of Kevlar 49 to cryogenic temperature is excellent, with increases in composite tensile strength and modulus at liquid nitrogen (-195°C) and liquid hydrogen (-253°C) temperatures. The slightly negative coefficient of thermal expansion can retard the positive thermal coefficient of other cable components to yield a dimensionally stable composite structure.

3.5 Outer Protective Jacket

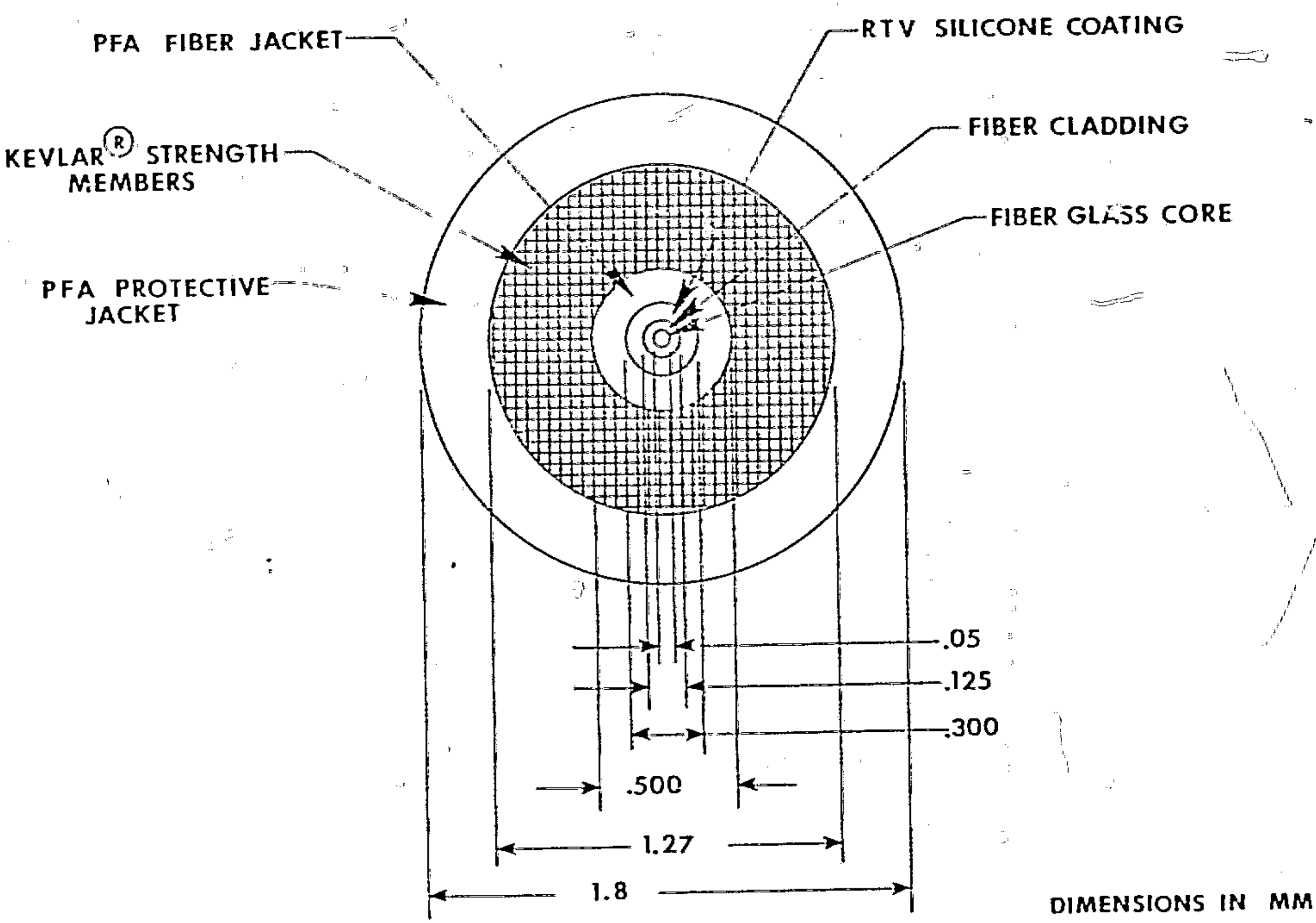
The reasons given for selecting Teflon PFA as the fiber jacket also apply for its selection for the outer protective jacket. A material that retains all its desirable properties from cryogenic temperatures to +250°C is very attractive for this demanding application.

4.0 CABLE DESIGN

The single fiber optic cable will be the design shown in Figure 1. A CVD Step Index fiber of .125 mm will be coated to .300 mm with RTV silicone and then extruded with a jacket of PFA to a diameter of .500 mm. Six yarns of 1420 denier unimpregnated Kevlar 49 with a helical lay of 1.3 inches will surround the jacketed fiber under an extrusion of PFA. The finished cable diameter will measure 1.8 mm. The weight of a one kilometer length will be approximately 4530 grams.

5.0 PROTOTYPE CABLE FABRICATION

Prototype cable fabrication will begin in late December 1977 and testing will be performed in early January 1978.



LOW TEMPERATURE OPTICAL FIBER CABLE