GLA REPORT NO. 479
SUPPLEMENT NO. 1
SURVEY, ANALYSIS AND EVALUATION TEST
ON
HIGH VOLTAGE/CURRENT PULSE TRANSMISSION CABLES
FOR
NASA
HUNTSVILLE, ALABAMA
P.O. NAS8-21298

GENERAL LABORATORY ASSOCIATES, INC. SUBSIDIARY OF SIMMONDS PRECISION

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GAS TURBINE ACCESSORY SYSTEMS

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PRIME CONTRACT DCNI-8-40-82058(IF)+S-1(IF)

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A SUBSIDIARY OF SIMMONDS PRECISION PRODUCTS, INC.

I TABLE OF CONTENTS

II SUMMARY

1. Object

The object of this report supplement is to recommend an optimum cable-connector configuration with detailed information for procuring and/or fabrication of this optimum cable assembly.

2. Procedure

According to the discussion in GLA Report No. 479, the maximum cable length while maintaining the applicable voltage/current pulse characteristics and minimum size and weight is obtained with the triax type cable construction with an RFI shield added. Limiting ourselves to the diameter of the present output cable, .280" ± .030", the triax approach was investigated.

In order to meet the detonator 99.9% all-fire level, 95% confidence-logit analysis curve of Figure 1 in Report No. 479, the cable resistance, R, must be as low as possible while the cable inductance, L, remains relatively low. To meet these R and L requirements, it is clear from the expressions on page 5 of Report No. 479, that radii a, b1,b2 and c must be as large as possible, and at the same time, the ratios b1/a and c/b2 must be as close to the value of one as possible. However, for our high voltage application, these ratios are controlled by the required thickness of insulation and the overall diameter of the cable. Thus, with a fixed insulation thickness, as the overall diameter increases, the ratios approach the value of one. Apparently, as the overall diameter increases, the values of

$$\frac{1}{b_1} + \frac{1}{a} \quad \text{and} \quad \frac{1}{c} + \frac{1}{b_2}$$

decrease, thus decreasing R. The result is a longer cable.

Arbitrarily using the .280" ± .030" outside diameter because of the size and weight consideration, it is possible to work into the cable and determine the remaining dimensions. See Figure 1. Assuming a double RFI shield with a glass cord braid (G) between (as required in previous EBW output cables), the insulation (E) between the second braid (D) and the RFI braids (F&H) has an inside diameter of .165" and an outside diameter of .183". Therefore, the insulation (C) between the first braid (B) and second braid (D) has an inside diameter of .122" and an outside diameter of .140". This leaves an outside diameter of .097" and an inside diameter of .030" for insulation (A). If a center conductor is used, its outside diameter would be .030". Converting these diameters to radii and using the methods described in the main report, a maximum cable-connector length of twelve feet is calculated. Using the methods for coax type cable with RFI shielding described in the main report, a maximum cable-connector length of ten feet is calculated. All calculations take into account the effect of the two connectors and the tolerances on the cable diameters. It can be appreciated that the extra two feet obtained with the triax construction is expensive in extra weight (can use a glass cord or foam for insulation A) and complexity of cable terminations in the backshells. For these reasons, GLA elected to recommend the coax type cable with an RFI shield, using braid (B) as the "B" conductor and braid (D) as the "A" conductor. It can be seen from the expressions for the coax cable that there is a very large decrease in R of the cable by using a braid for the center conductor rather than a stranded wire. It can also be seen that the limiting factors on R and L, and ultimately on cable length, are the insulations (C) and (E). These were made as thin as possible while maintaining a good margin of safety with regards to dielectric strength.

Cable parameters are as follows:

Frequency KHz	Resistance Ω/ft.	Inductance μh/ft.	Capacitance pF/ft.	Zo ohms
150	.00685	.0186	157.3	11.8
200	.00791	.0209	157.1	13.3
300	.00975	.0214	159.0	13.5
400	.01263	.0209	157.1	13.3

3. Conclusions

In order to optimize a cable design, certain requirements, such as length, flexibility, weight, diameter, type of connectors and environmental capabilities must be specified. Therefore, the optimum cable-connector configuration being recommended takes into account the following major design considerations in the order listed:

a) Minimum size and weight of cable and connectors.

b) Increased length, in excess of 48 inches, of the cable while maintaining the pulse transmission characteristics of MSFC Specification 40M39515B, Figure 2.

c) Reliability.

d) Environmental capabilities.

e) Flexibility.

f) Ease of fabrication or assembly.

The diameter of the recommended cable, over the outside RFI braid is .280" ± .030", the same as the diameter of the present output cable. The connector used on the detonator end is essentially the same RB connector as used on the present output cable. The only differences are the backshell used, the crimp contacts instead of solder type, and the elimination of the cadmium plating. The backshell on this RB connector is slightly longer to accommodate the terminations of this coax type cable. The connector used on the EBW box end is a modified triax connector. This amphenol connector is not suitable for the environmental requirements of the output cable, but was used for electrical evaluation of the cable design. It appears that a special triax connector would be required, since there are no suitable connectors available at the time of this study. However, any special triax connector obtained would be of approximately the same physical size. The backshell used on this connector is the same size as that used on the RB connector, and is longer than the termination used on the present EBW box-cable assembly. Because of the larger backshell on the detonator end, the additional connector on the box end, and the increased copper used in the "A" and "B" conductors, the recommended cable is slightly heavier than the present output cable.

The detonator 99.9% all-fire level, 95% confidence-logit analysis curve of Figure 2, MSFC Specification 40M39515B, was used as the minimum value for peak current and time to peak. The maximum length of the present output cable (pendent-twisted pair) is seven feet. The maximum length of the recommended optimum cable-connector configuration (detachable-RB connector and triax connector) is ten feet. It should be noted that if all conductor and insulation diameters in the proposed cable were increased by .100" and all tolerances remained the same, the maximum cable length would be twenty feet.

The reliability of the overall cable-connector configuration is improved. The larger backshells allow for better, more reliable terminations of the cable, with long creepage distances and large area for bonding of potting compound to the cable insulation. The new method of attaching the RFI braids to the backshells assures a good RFI seal with much less heat required during soldering. The use of crimp contacts in the RB connector assures the integrity of the conductor-contact joint during the application of any excessive heat to that connector.

The environmental capabilities of the recommended cable-connector configuration are greater than those of the present output cable. The cable assembly is designed for operation to 985,000 feet altitude. The teflon insulation between the "A" and "B" conductors and between the "B" conductor and the first RFI shield provide a double altitude seal. The connector backshells on each end of the cable are sealed with a potting compound. All teflon insulation in the cable and connectors is etched prior to potting. Rubber gaskets or O-rings are used to seal the connector faces when mated. The cable assembly is also designed for a temperature range of -120° F to +250° F. The cable will be quite stiff at -120° F, but can be wrapped around a mandrel whose diameter is ten cable diameters. The salt spray, vibration, shock, acceleration and acoustical noise requirements are also well within the capabilities of the recommended cable design. In addition to all these required environmental capabilities, this cable will also meet the outgassing requirements of MSFC Specification 50M02478 by virtue of the materials specified in this program, and tested in the Phase II material survey.

The flexibility of the cable is as good, or better than the flexibility of the present output cable, especially at -120° F. The proposed cable is capable of a bend radius at room temperature of four diameters and at -120° F of ten diameters with no cracking or deterioration of the insulation. Some flexibility directly in back of the connectors is lost due to the longer backshells.

There are two methods of fabrication, or assembly of the proposed cable. The first is to use etched TFE shrinkable tubing and in-house braiding capability. Cables would be built in the required lengths and then assembled to the connectors. The second method would be to purchase extruded cable, apply the RFI braids, cut to length, and assemble connectors. The RB connector is a standard purchased part, while the backshell and accessories are within in-house capability. A suitable triax connector for this application would have to be developed, or possibly one of the GLA triax connectors could be modified. In any case, all fabrication and assembly work, with the exception of the extruded cable manufacture, could be done with GLA in-house capability.

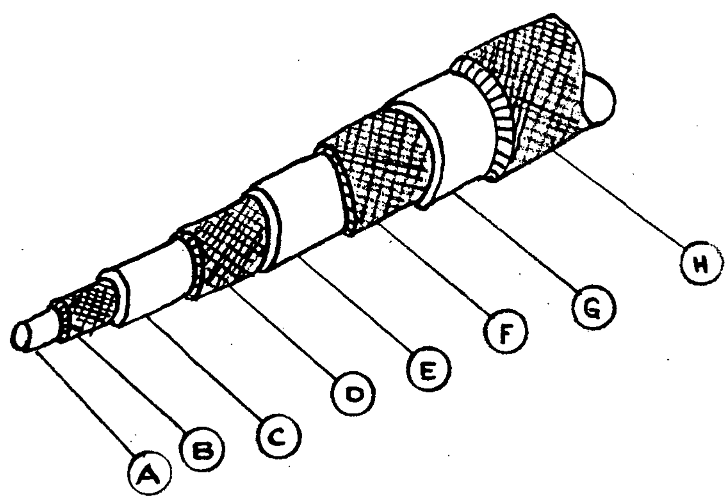

Figure 1

POS.	NAME	PART NO.OR DESCRIPTION
1.	CORE	GLASS CORD
2.	CONDUCTOR "B"	METAL BRAID: #34 GA.TINNED COPPER WIRE
3.	SLEEVE,INSULATING	TEFLON
4.	CONDUCTOR "A"	METAL BRAID: #34 GA.TINNED COPPER WIRE
5.	SLEEVE,INSULATING	TEFLON
6.	WIRE,BRAIDING	31323: SILVER PLATED COPPER WIRE
7.	GLASS CORD,TEFLON COATED	150-1/2 DENIER (3 END)
8.	WIRE,BRAIDING	31323: SILVER PLATED COPPER WIRE
9.	SLEEVE,CABLE	82136: ALUMINUM
10.	GROMMET,SPACER	79428: TEFLON

POS.	NAME	DESCRIPTION
11.	FERRULE,CABLE	79427: ALUMINUM
12.	RING	.100 WIDE W/.010 WALL: COPPER BRASS OR NICKEL
13.	ADAPTOR,CABLE	79426: ALUMINUM
14.	WIRE,ELEC.#18 GA.	MIL-W-16878,TYPE E
15.	SLEEVING,INSULATING	22640: TEFLON
16.	CONNECTOR,ELECTRICAL	BENDIX #10-473089-3S (INCLUDES COUPLING NUT)
17.	CONNECTOR,PLUG,MODIFIED	AMPHENOL #53150
18.	SCREW,PLUG	79429: ALUMINUM
19.	COMPOUND	PRODUCT RESEARCH #PR 1535

DO NOT SCALE — WORK TO DIMENSIONS GIVEN

REL. NO.				REVISIONS			
ZONE	CHANGE NO.	SYM CHG	SYM REV	DESCRIPTION	DATE	D'MAN	APP'D

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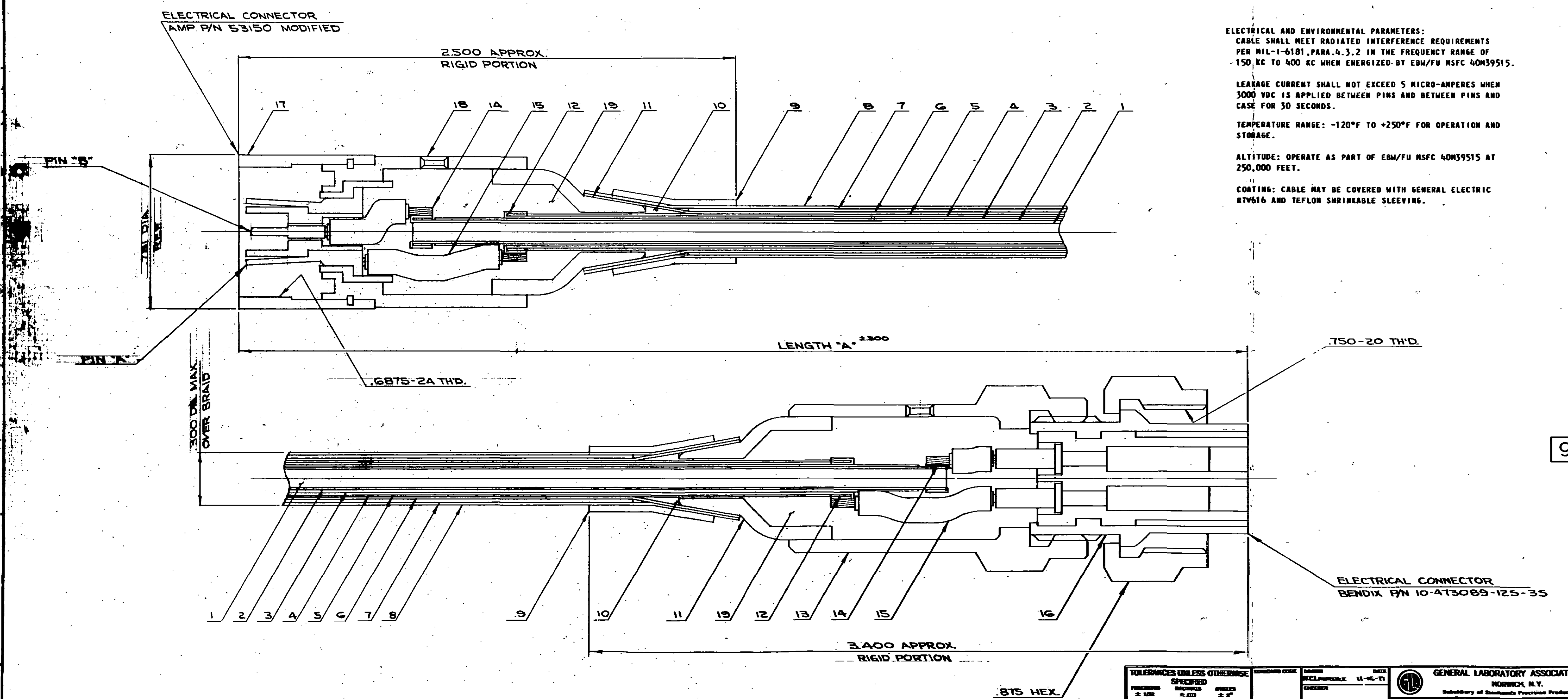
SUPPLEMENT NO. 1



ELECTRICAL AND ENVIRONMENTAL PARAMETERS:
CABLE SHALL MEET RADIATED INTERFERENCE REQUIREMENTS PER MIL-I-6181,PARA.4.3.2 IN THE FREQUENCY RANGE OF 150 KC TO 400 KC WHEN ENERGIZED BY EBW/FU MSFC 40M39515.

LEAKAGE CURRENT SHALL NOT EXCEED 5 MICRO-AMPERES WHEN 3000 VDC IS APPLIED BETWEEN PINS AND BETWEEN PINS AND CASE FOR 30 SECONDS.

TEMPERATURE RANGE: -120°F TO +250°F FOR OPERATION AND STORAGE.

ALTITUDE: OPERATE AS PART OF EBW/FU MSFC 40M39515 AT 250,000 FEET.

COATING: CABLE MAY BE COVERED WITH GENERAL ELECTRIC RTV616 AND TEFLON SHRINKABLE SLEEVING.

98938

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/32 DECIMALS ±.010 ANGLES ± 2°

MATERIAL SPEC

PROCESS SPEC

ENGINEERING SPEC

DRAWN W.C.LAWRENCE DATE 11-16-71

GENERAL LABORATORY ASSOCIATES, INC.
NORWICH, N.Y.
Subsidiary of Simmonds Precision Products, Inc.

PROPOSED OUTPUT CABLE OPTIMUM DESIGN CONFIGURATION

CODE IDENT NO 83311 | SIZE D | PART NO 98938

SCALE | WT. | REF. | SHEET OF