LOFT TECHNICAL REPORT LTR 1310-17

OCTOBER 27, 1977

IMPEDANCE CALCULATIONS FOR POWER CABLES TO PRIMARY COOLANT PUMP MOTORS

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DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

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LOFT TECHNICAL REPORT
LOFT PROGRAM

FORM EG&G-229
(Rev. 12-76)

TITLE	REPORT NO.
IMPEDANCE CALCULATIONS FOR POWER CABLES TO PRIMARY COOLANT PUMP MOTORS	LTR 1310-17
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ABSTRACT

The Primary System Motor Generator Sets are located in Room B-239 and are connected to the primary coolant pumps by means of a power cable. The calculated average impedance of this cable is 0.005323 ohms per unit resistance and 0.006025 ohms per unit reactance based on 369.6 kVA and 480 volts.

This LTR was written to show the development of power cable parameters that are to be used in the SICLOPS (Simulation of Loss of Fluid Test (LOFT) Reactor Coolant Loop Pumping System) digital computer program as written in LTR 1142-16 and also used in the pump coastdowns for the FSAR Analysis.

TABLE OF CONTENTS

1.0 INTRODUCTION

The primary coolant pump motors on the MTA (Mobile Test Assembly) are supplied from a generator several hundred feet away in Room B-239. With the long length the cable resistance and reactance may effect operation. To calculate the resistance and reactance it is necessary to know the length of each cable run, the size of the cable, the resistance per 1000 feet and that the cable is in steel conduit for its entire run. Also it is necessary to assume that the average temperature of the cable is approximately 25°C.

There are four separate cable runs from the generators to the primary coolant pump motors (see figure 1), two cable runs per motor-generator combination, and two generator motor pairs. Each separate run has a different overall length due to minor routing variances. To calculate the total values of resistance and reactance average values were found for each pair of cables.

2.0 CABLE SPECIFICATIONS

2.1 Type

1000 volt, 500 MCM, 37 strands of copper with 7/64 inches of insulation(1)

2.2 Resistance

DC Value - 0.0216 ohm/1000 ft.*
AC Value - 0.244 ohm/1000 ft.+
Reactance - 0.0271 ohm/1000 ft. # (2)

2.3 Length

Run #	Cable to Penetrator (feet)	Pen to Motor (feet)	Total (feet)
1	171	53	224
2	174	53	227
3	214	20	234
4	212	20	232 (3)

3.0 IMPEDANCE VALUES

The long length of power cable produces both resistance and inductive reactance. The resistance is found by knowing the length of the cable and multiplying it by the ohm /1000 feet. The reactance is calculated in a similar manner. These two values are then combined into an impedance. An equivalent value of impedance is found by combining both cables in parallel. This calculation results in 0.00264 ohm resistance and

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* Assuming cable temperature is averaged at 25° C.
\+ AC value found by multiplying DC value by 1.13
\# Entire length in conduit

0.00315 ohms reactance for generator-motor set number 1, and 0.00284 ohms resistance and 0.00316 ohms reactance for generator-motor set number 2.

The average value of resistance for the generator motor sets is 0.00274 ohms. Similarly the average value of reactance is 0.003155 ohms. Using 369.6 KVA as base KVA and 480 volts as base KV the per unit value or resistance and reactance for generator-motor number 1 is 0.00523 OHMS p.u. and 0.00602 ohms p.u. respectively. Also the same values for generator motor number 2 are 0.00542 ohms p.u. and 0.00603 ohms p.u. respectively.

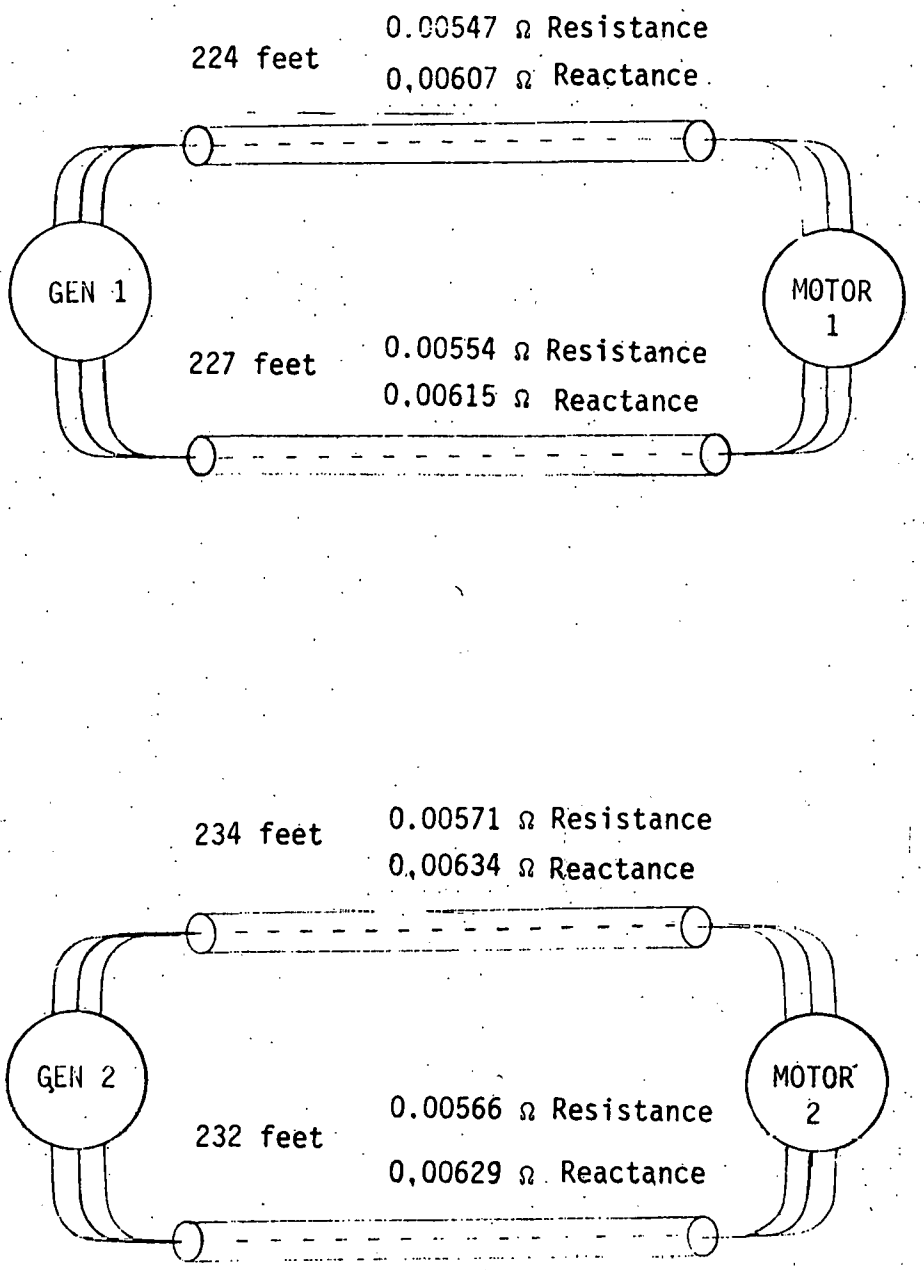
The overall average value of impedance for both generator-motor sets is 0.005325 ohms p.u. resistance and 0.006025 ohms p.u. reactance.

4.0 REFERENCES

1. Purchase Requisition #L500096, Aerojet Nuclear Company, dated 7-6-72.

2. National Fire Protection Association National Electric Code 1975 pp 70-567-8

3. Design Engineers Notes on Cable Length.



PSMG to PCP Cables
Fig. 1

APPENDIX A

RESISTANCE AND REACTANCE

FOR PSMG SET NUMBER ONE

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PAGE A ii OF iii PAGES

SUBJECT LTR 1310-17 DATE 12 JULY 1977

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RESISTANCE AND REACTANCE CALCULATION FOR PSMG SET NUMBER 1.

LENGTH: 224 feet, 227 feet.

RUN 1A;

$$R_{1A} = \left(\frac{0.0244 \text{ ohms}}{1000 \text{ feet}} \right) 224 \text{ feet} = \underline{0.00547 \text{ OHMS RESISTANCE.}}$$

$$X_{1A} = \left(\frac{0.0271 \text{ ohms}}{1000 \text{ feet}} \right) 224 \text{ feet} = \underline{0.00607 \text{ OHMS REACTANCE.}}$$

RUN 1B;

$$R_{1B} = \left(\frac{0.0244 \text{ ohms}}{1000 \text{ feet}} \right) 227 \text{ feet} = \underline{0.00554 \text{ OHMS RESISTANCE.}}$$

$$X_{1B} = \left(\frac{0.0271 \text{ ohms}}{1000 \text{ feet}} \right) 227 \text{ feet} = \underline{0.00615 \text{ OHMS REACTANCE.}}$$

COMBINE TO AN IMPEDANCE

$$Z_{1A} = R_{1A} + j X_{1A} = 0.00547 + j 0.00607 = 0.00817 \angle 49.97^\circ$$

$$Z_{1B} = R_{1B} + j X_{1B} = 0.00554 + j 0.00615 = 0.00828 \angle 47.98^\circ$$

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(Rev. 4-76)

CALCULATION WORK SHEET

PAGE Aiii OF iii PAGES

SUBJECT LTR 1310-17 DATE 12 JULY 1977

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IMPEDANCE CALCULATION

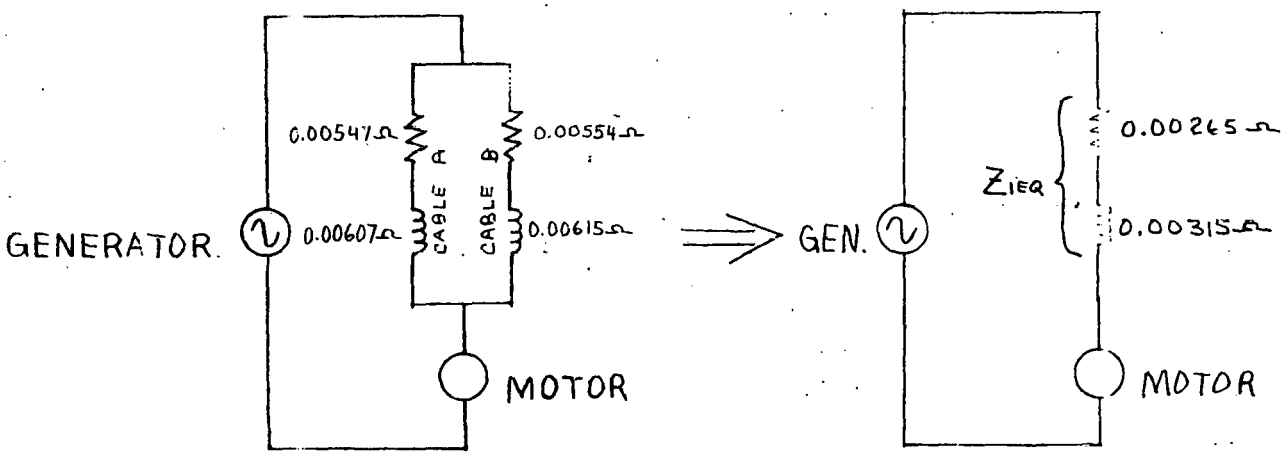
$$\bar{Z}_{IEQ} = \frac{(Z_{IA})(Z_{IB})}{(Z_{IA} + Z_{IB})}$$

$$= \frac{(0.00817\angle 49.97^\circ)(0.00828\angle 47.98^\circ)}{(0.00547 + 0.00554) + j(0.00607 + 0.00615)}$$

$$= \frac{6.76 \times 10^{-5} \angle 97.95^\circ}{0.01101 + j\,0.01222}$$

$$= 0.00411\angle 49.97^\circ$$

$$\bar{Z}_{IEQ} = 0.00265 + j\,0.00315$$



APPENDIX B

RESISTANCE AND REACTANCE

CALCULATION FOR PSMG

SET NUMBER TWO

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RESISTANCE AND REACTANCE CALCULATIONS FOR PSMG SET NUMBER 2.

LENGTH : 234 feet, 232 feet.

RUN 2A;

$$R_{2A} = \left(\frac{0.0244 \text{ ohms}}{1000 \text{ feet}}\right) 234 \text{ feet} = \underline{0.00571 \text{ OHMS RESISTANCE}}$$

$$X_{2A} = \left(\frac{0.0271 \text{ ohms}}{1000 \text{ feet}}\right) 234 \text{ feet} = \underline{0.00634 \text{ OHMS REACTANCE,}}$$

RUN 2B;

$$R_{2B} = \left(\frac{0.0244 \text{ ohms}}{1000 \text{ feet}}\right) 232 \text{ feet} = \underline{0.00566 \text{ OHMS RESISTANCE,}}$$

$$X_{2B} = \left(\frac{0.0271 \text{ ohms}}{1000 \text{ feet}}\right) 232 \text{ feet} = \underline{0.00629 \text{ OHMS REACTANCE,}}$$

COMBINE TO AN IMPEDANCE

$$Z_{2A} = R_{2A} + jX_{2A} = \underline{0.00571 + j\,0.00634 = 0.00853 \angle 47.99^\circ}$$

$$Z_{2B} = R_{2B} + jX_{2B} = \underline{0.00566 + j\,0.00629 = 0.00846 \angle 48.02^\circ}$$

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FORM INEL-1592
(Rev. 4-76)

CALCULATION WORK SHEET

PAGE B''' OF ''' PAGES

SUBJECT LTR 1310-17 DATE 12 JULY 1977

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IMPEDANCE CALCULATION

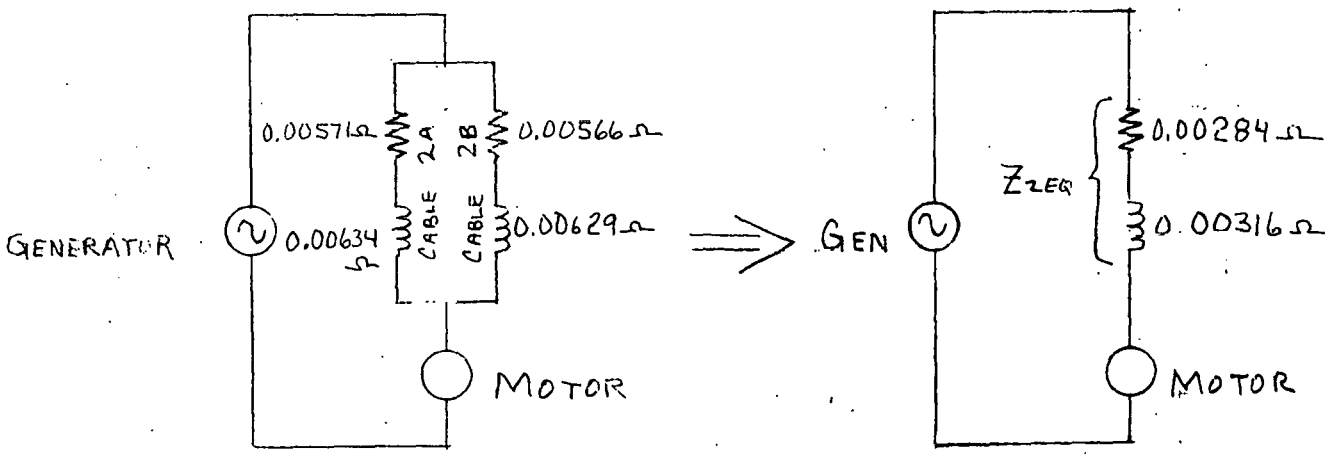
$$Z_{2EQ} = \frac{(Z_{2A})(Z_{2B})}{(Z_{2A} + Z_{2B})}$$

$$= \frac{(0.00853 \angle 47.99^\circ)(0.00846 \angle 48.02^\circ)}{(0.00571 + 0.00566) + j(0.00634 + 0.00629)}$$

$$= \frac{7.22 \times 10^{-5} \angle 96.01^\circ}{0.01137 + j\,0.01263}$$

$$= 0.00425 \angle 48^\circ$$

$$= 0.00284 + j\,0.00316$$



APPENDIX C

BASE CONVERSIONS

PER UNIT VALUES OF IMPEDANCE

AVERAGE IMPEDANCE VALUES

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FORM INEL-1592
(Rev. 4-76)

CALCULATION WORK SHEET

PAGE ii OF iii PAGES

SUBJECT LTR 1310-17 DATE 12 JULY 1977

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BASE CONVERSIONS

$$\text{BASE OHMS} = \frac{(\text{BASE VOLTS})^2}{\text{BASE KVA} \times 1000}$$

$$= \frac{(440)^2}{(369.6)(1000)}$$

$$= 0.52381$$

PER UNIT VALUES OF IMPEDANCE

$$Z_{1EQ\ p.u.} = \frac{0.00265}{0.52381} + j\,\frac{0.00315}{0.52381}$$

$$= \underline{0.00505 + j\ 0.00601}$$

$$Z_{2\,EQ\ p.u.} = \frac{0.00284}{0.52381} + j\,\frac{0.00316}{0.52381}$$

$$= \underline{0.00542 + j\ 0.00603}$$

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FORM INEL-1592
(Rev. 4-76)

CALCULATION WORK SHEET

PAGE Ciii OF iii PAGES

SUBJECT LTR 1310-17 DATE 12 JULY 1977

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THE AVERAGE PER UNIT VALUE OF BOTH PSMG SETS

IS

0.00523 OHM RESISTANCE PER UNIT

0.006025 OHM REACTANCE PER UNIT