TEST EQUIPMENT LIST

Test Report # ________
Page _____

NAME	MFR.	MODEL	SER.NO.	RANGE	ACCURACY	INV.#	CAL DATE
Pressure Gauge	US Gauge	1903	N/A	0 to 400 PSIG	± .5% span	PI456	
Pressure Transducer	Omega	PS906-500GV	150164	0 to 500 psig	±.4%	PI496	
Digital Temp. Indicator	Omega	199	19843	-245° F to 1999°F	±1.5°F	TI326	
Fluidized Bath	Teche	FB-07	1063-18	100 to 600C 212 to 1112°F	±1.°F	TI336	
Digital Temp. Indicator	OMEGA	650JX	None	-245°F to 1999°F	± 1°F	TI358	
Digital Temperature Indicator	Omega	650JX	None	-245 to 1999°F	±1.0°F	TI359	
Mercury Thermometer	Ertco	ASTM11C	45800	0 to 400°C	± 1°C	TI364	
Digital Temp. Indicator	Omega	650 JX	None	-245 to 1999°F	±1°F	TI375	
TC Temp. Indicator	Omega	650 JX	None	-245 to 1999°F	±1°F	TI376	
Thermocouple Probe	Omega	Type J	N/A	-300 to 1600°F	±2.2°C or ±.75%	TP324	
Thermocouple Probe	Omega	Type J	N/A	-300 to 1600°F	± 2.2°C or ± .75%	TP334	

TEST EQUIPMENT LIST

Test Report # ____________
Page _____

NAME	MFR.	MODEL	SER.NO.	RANGE	ACCURACY	INV.#	CAL DATE
Thermocouple Probe	Omega	Type J	N/A	-300 to 1600°F	±2.2°C or ±.75% whichever is greater	TP336	
Thermocouple Probe	Omega	Type J	N/A	-300 to 1600°F	±2.2°C or ±.75% whichever is greater	TP337	
Dual Thermocouple Probe	Omega	Type J	None	-300 to 1600°F	±2.2°C ±.75%	TP341	
Thermocouple Probe	Omega	Type J	None	-300 to 1600°F	± 2.2|°C ± .75%	TP343	
Thermocouple Probe	Omega	Type J	N/A	-300 to 1600°F	±2.2°C or ±.75%	TP344	
Dual Thermocouple	Omega	Type J	N/A	-300 to 1600°F	± 2.2°C or ± .75%	TP348	
Dual Thermocouple	Omega	Type J	N/A	-300 to 1600°F	± 2.2°C or ± .75%	TP349	

UNITED STATES OF AMERICA
UNITED STATES NUCLEAR REGULATORY COMMISSION

before the

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	
PUBLIC SERVICE COMPANY NEW HAMPSHIRE, et al.	Docket Nos. 50-443 OL-1 50-444 OL-1
(Seabrook Station, Units 1 and 2)	(On-site Emergency Planning and Safety Issues)

AFFIDAVIT OF GERALD A. KOTKOWSKI

I, GERALD A. KOTKOWSKI, being on oath, depose and say as follows:

1. I am the Electrical Engineering Supervisor at Seabrook Station. My responsibilities include the supervision of Electrical Engineering and Design activities and technical support of field/construction activities. I am familiar with the applications of cables at Seabrook Station and the cable characteristics which contribute to signal transmission. A statement of my professional qualifications is attached and marked "A".

2. As provided in the accompanying Affidavit of Richard Bergeron, paragraph 16, twelve (12) nonsafety-related RG-58 cables (now spares) are located in harsh environments within the Seabrook Station Unit 1 nuclear island. The purpose of my affidavit is to show that, for these 12 applications, the

RG-59 coaxial cable already purchased and qualified for use at Seabrook Station is a technically adequate substitute for RG-58 coaxial cable.

3. A review was performed to determine the applications of these twelve RG-58 cables and to determine if RG-59 cables were a technically adequate substitute for these 12 RG-58 cables. (See Engineering Evaluation Number 88-014, "Replacement of Coax Cable Type RG-58 By RG-59," Attachment B.) As a result of the review, these applications can be categorized into two nonsafety-related/non-essential groupings. The first application grouping is of cables connecting intelligent remote termination units (IRTU) to the main plant computer system Host CPU. The second application grouping is of cables connecting ultrasonic level sensors to electrical control units for certain level measuring instruments. In both cases the intended function of the cable is to transmit high frequency electrical signals.

4. In determining the acceptability of RG-59 coaxial cable for these applications, an evaluation was made to assess the degradation of signal due to insertion loss (attenuation) and variation in response time due to the change in the velocity of propagation. These are the primary specifications that determine the wave propagation characteristics of transmission lines.

5. The velocity of propagation is the velocity of an electric wave governed solely by the properties of the dielectric medium and the permeability of the conductor through which it is transmitted. In a coaxial cable the velocity of propagation is the ratio of the speed of electromagnetic energy flow compared to the speed of light and is generally referred to herein as a percentage (%). The actual measured velocity of propagation provided in the typical factory cable test reports is 61.24% for RG-59 and 63.5% for RG-58. The actual field cable lengths for these twelve applications are much less (approximately 1/4) than the maximum allowable cable lengths for the applicable operating frequency as recommended by the equipment vendors. The minor decrease in the velocity of propagation (approximately 2.26%) in conjunction with the relatively short length of cable will not noticeably affect the rate of signal transmission.

6. A review of factory test results for both RG-58 and RG-59 coaxial cables showed that the attenuation (i.e., db/100 ft.) for the RG-59 cable is less than that for the RG-58 cable. (See Attachment B.) Thus the RG-59 cable will have less insertion losses and will retain equal or better signal quality than the RG-58 cable for these twelve applications.

7. In addition, the compatibility of an RG-59 cable with the connecting device/instrument was evaluated. In both

application groupings the characteristics impedance of the RG-59 is compatible with the requirements of the connecting device/instrument. In addition, the respective equipment vendors were contacted and they confirmed that the use of RG-59 was acceptable.

8. Based on the foregoing, I have concluded that an RG-59 coaxial cable would be an acceptable substitute for the twelve nonsafety-related RG-58 cables located in harsh environments and within the nuclear island.

Gerald A Kotkowski
Gerald A. Kotkowski

Dated: September 9, 1988

Then personally appeared Gerald A. Kotkowski, before and personally known to me, who, being first duly sworn, made oath that the foregoing statements are true to the best of his knowledge, information, and belief.

Notary Public

My Commission Expires: 4/23/93

KOTKOWSKI AFFIDAVIT
ATTACHMENT A

GERALD A. KOTKOWSKI
Electrical Engineering Supervisor

Education

B.S. Northeastern University
June, 1974

Mr. Kotkowski joined PSNH in June 1982 as a Senior Electrical Engineer in the Engineering Services Department. He was assigned to the Startup and Test Department as the System Test Engineer for the 13.8 KV, 4160 Volt, 125 Volt DC and Diesel Generator Electrical Systems and as the Lead Electrical Distribution Test Engineer. Specific accomplishments include the preparation and performance of the pre-operational acceptance tests for the DC Distribution and Diesel Generator Systems. Specific responsibilities included the review and approval of all design changes to the Distribution Systems and the subsequent implementation and testing of these changes.

Work Experience

In June 1986, Mr. Kotkowski was appointed to the position of Electrical Engineering Supervisor in the Engineering Department. His current responsibilities include the supervision of Electrical Engineering and Design activities and technical support of field/construction activities. He has overall responsibility for ensuring that the electrical design of the plant complies with the codes and regulations specified in the Seabrook FSAR.

Mr. Kotkowski came to PSNH from Power Technical Services where he was employed from June 1981 - April 1982 and was assigned as a Project Engineer to Boston Edison Company. While in this position he had the overall responsibility for implementing an Emergency Response Facility program for the Pilgrim 1 Nuclear Station. This program was designed to ensure technical adequacy and licensing compliance to current regulatory requirements, including NUREG-0696, NUREG-0700 and Regulatory Guide 1.97, Revision 2.

Between March 1978 and May 1981, Mr. Kotkowski was employed by Stone & Webster Engineering as an engineer in the Electrical Control Group. While at Stone & Webster Headquarters in Boston he was assigned to the Electrical

Control Group on the Shoreham Nuclear Power Station Project as the engineer responsible for providing post accident instrumentation to meet the requirements of Regulatory Guide 1.97, Revision 2. He also was designated as the cognizant engineer responsible for all controls associated with the Nuclear Steam Supply Systems as well as several other major modifications to Balance of Plant Systems.

While on a field assignment he was the only site representative for the Controls Division at the Shoreham Nuclear Power Station. He assumed complete responsibility for the resolution of construction and startup problems on all instrumentation and controls associated with an 850 MW Boiling Water Reactor. Specific responsibilities included: medium and low voltage switchgear, motor control centers, protective relaying, control and relay panels, electronic analog instrumentation, pneumatic control loops and instrumentation tubing. He was also designated as the Interface Engineer between Nuclear Steam Supplier and the Architect Engineer.

Between December 1974 and February 1978, he was employed by General Atomic Engineering Company. While on a field assignment he participated in the rise to power program at the Fort St. Vrain Nuclear Power Station. Specific accomplishments include: tuning the major plant controllers, modifying the Plant Protective System and Overall Plant Control System as required to pass Reactor Scram and Turbine Trip testing, coordinating a task force to resolve the Nuclear Regulatory Commission's concerns on cable segregation, and eliminating spurious control room alarms.

While at General Atomic Headquarters in San Diego he was assigned to the Control and Electrical Department. He was responsible for the design of instrumentation and controls for systems associated with the operation of a nuclear power plant. He prepared control and instrumentation diagrams, schematic diagrams, cable tabulations, and instrument specifications.

Between December 1970 and October 1974 he was employed by Stone & Webster on a student co-operative basis where he received various assignments in the Electrical Control Department.

In summary, Mr. Kotkowski has fourteen (14) years experience in the electrical design and testing of nuclear power plants.

KOTKOWSKI AFFIDAVIT

ATTACHMENT B

REPLACEMENT OF COAX CABLE TYPE RG-58 BY RG-59

CONTENTS

REPLACEMENT OF COAX CABLE TYPE RG-58 BY RG-59

By

Nirmal K. Bhowmik - NHY

May 2, 1988

Engineering Evaluation Number 88-014

Prepared By N. Bhowmik 5/11/88
N. K. BHOWMIK (Date)

Jim Martin 5/26/88
(Date)

Reviewed By K. J. Letourneau / [illegible] 5-12-88
(Date)

Approved By J. M. Varga 5/27/88
(Date)

1.0 PURPOSE

The purpose of this evaluation is to determine if Coax Cable Type RG-58 can be replaced by RG-59 for certain applications in the Seabrook Station design.

2.0 BACKGROUND

2.1 The non-vital plant cable numbers listed under paragraphs 2.2 and 2.3 are Coax Cable type RG-58. These cables have been routed in A-train associated raceways in harsh environments. Since the similarity qualification of RG-58 is being litigated for application in harsh environments, cable type RG-59 will be analyzed for replacement cable in this evaluation. Cable type RG-59 has been qualified by test for harsh environments.

2.2 Application # 1: Cables FM3-JW5, FM3-JW5/1, FM7-JX1, FM6-JW5/1, FM4-JX1, FM4-JX1/1, FM7-JX1/1, and FM6-JW5 (Ref. Dwg. 310181 shts. JW5 & JX1) are used between intelligent remote termination units (IRTUs) and the main plant computer system Host CPU. These cables transmit at a pulse rate of 93.7 khz (93.7, 16 bit kilo words per second).

2.3 Application #2: Cables GU4-Y59/2, 3, 4, & 5 (Ref.dwg. 310691 shts. E38/8) are used between ultra sonic level sensors and electric control units for National Sonics level measuring instruments, type 300S. The sensor consists of a transmitter and receiver transducers. The transmitter converts electrical signals (pulse @ 1 mhz) to ultrasonic signals and transmits across the sensor gap to the receiver. The signal at the receiver is converted to electrical signals (pulse @ 1 mhz) and transmitted to the control unit.

3.0 DISCUSSION

3.1 The intended function of the cable as described under paragraph 2.2 & 2.3 is to transmit high frequency electrical signals. The maximum length of the cable that can be used at this frequency as recommended by the vendor is 2,000 feet for application 1 and 1000 feet for application 2. The actual maximum lengths of the field cables are 425 feet and 253 feet respectively. Degradation of signal due to insertion loss (attenuation) and variation of response time due to the change in the velocity of propagation are the prime concerns to be evaluated. The attenuation and velocity of propagation are listed, compared, and evaluated under subsequent paragraphs 3.2 thru 3.8.

3.2 Refer to Specification No. 9763-006-113-19 Rev. 0 for the following information:

Parameters	RG-59	RG-58
Conductor Resistance (OHMS per 1000 ft. Max.)	25.2 *	6.3 *
Loop Resistance Center Conductor to Shield (OHMS per 1000 ft Max.)	25	26
Capacitance	25.7 pf/ft Max.	37 pf/ft Max.
Characteristic Impedance	75 ± 15 OHM	50 +3 -6 OHM
Velocity of Propagation	61.24% *	65% (63.5% per test report)
Attenuation in db/100 ft		
@ 10 MHZ	1.5 *	1.74 *
50 MHZ	3.18 *	4.31 *
100 MHZ	4.71 *	6.39 *
200 MHZ	7.55 *	11.02 *
300 MHZ	10.00 *	14.62 *
400 MHZ	11.92 *	15

* Not specified in the Reference Specification, data typical for cable type as documented in actual Factory Test Reports (Ref. P.O. 113-19 Site Data Packages).

3.3 Conductor Resistance:

The total resistance based on allowable cable lengths with RG-58 for application Number 1 is $\frac{6.3}{1000}$ X 2000 = 12.6 OHMs.

Application Number 2 is $\frac{6.3}{1000}$ X 1000 = 6.3 OHMs.

Resistance based on actual lengths with RG-59

Application Number 1 - 25.2/1000 X 425 = 10.7 OHM

Application Number 2 - 25.2/1000 X 253 = 6.37 OHM

Conductor resistance contributes to the characteristic impedance as discussed under paragraph 3.6.

3.4 Loop Resistance:

Loop Resistance also contributes to characteristic impedance as discussed under paragraph 3.6. The loop resistance for RG-59 is 25 OHMs/1000 ft. compared to 26 OHMs/1000 ft. for RG-58.

3.5 Capacitance:

Reference specification specifies maximum capacitance per foot for the cable. Actual capacitance, less than the maximum specified is acceptable. The specified capacitance for RG-59 is 25.7 pf/ft max. which is less than the specified value of 37 pf/ft max. for RG-58. The value of the capacitance contributes to the characteristic impedance and velocity of propagation as described under paragraph 3.6 and 3.7.

3.6 Characteristic Impedance:

The characteristic impedance, Zo is a complex number and is defined as:

$$Zo = \frac{Z}{Y}$$

[Reference Schaum's outline of theory and problem of transmission lines, Chapter 5]

Where Z = Line impedance per unit length
Y = Line admittance per unit length

Line Impedance $Z = R + jWL$

Where, R = Conductor Resistance in OHMs [See para. 3.3 of this evaluation]
W = 2 F, F = frequency in HZ
L = Induction in Henries

Line Admittance Y = G + jwc

Where, G = Conductance in MOHs, reciprocal of the loop resistance (see paragraph 3.4)

C = Capacitance in farads (see paragraph 3.5)

Therefore, characteristic impedance Zo can be written as

$$Zo = \sqrt{\frac{R + jWL}{G + jWC}}$$

Inductance, L is not specified in the specification. However, the capacitance, loop resistance, conductor resistance, and the value of the characteristic impedance have been specified (for both type of cables). These values are listed under paragraph 3.2 of this evaluation. This impedance contributes to the velocity of propagation and attenuation as discussed under paragraph 3.7 and 3.8.

3.7 Velocity of Propagation (VP)

The velocity of propagation (VP) is the velocity of an electric wave governed solely by the properties of the dielectric medium and the permeability of the conductor through which it is transmitted. In free space the electromagnetic energy will travel with a speed of 3 X 10^8 meters per second or a 100 percent VP. In a coaxial cable with a uniform dielectric and a conductor with a relative permeability of 1, the VP is always less than 100 percent. Hence, the VP of a coaxial cable is the ratio of the speed of electromagnetic energy flow compared to the speed of light.

$$VP = \frac{\text{Velocity of energy in a cable dielectric medium}}{\text{Velocity of energy in free space}} \times 100$$

Velocity of propagation is inversely proportional to the product of characteristic impedance in OHMs (Zo) and capacitance in PICO Farads per ft. (C).

[Reference IPCEA S-69-530, NEMA WC 41, January 21, 1975 and MIL-C-17F Amendment 2 February 18, 1986].

i.e., $VP \propto \frac{1}{Zo \times C}$

The actual measured value of VP is available from the test report for the cables. These values are 61.24% for RG-59 and 63.5% for RG-58. The impact due to the increased value of characteristic impedance Zo of RG-59 (see paragraph 3.6) is mostly compensated by decreased value of the capacitance "C" (see paragraph 3.5).

The velocity of propagation determines the speed of transmission of the signal thru the cable. A decrease in VP by 2.26% (63.5 - 61.24) will not create a time delay in signal transmission due to the fact that the actual field cable length is much less (about 1/4) than the max. allowable cable length for the applicable frequency of operation.

3.8 Attenuation:

For high frequency applications the attenuation (α) can be expressed as follows:

$$\alpha = 1/2 \ \frac{R}{Zo} + 1/2 \ GZo$$

[Reference, Schaum's outline of theory and problems of transmission lines Chapter 5].

The tested values for the attenuation at different frequencies are listed under paragraph 3.2 of this evaluation. These test results show that the attenuation decreases with the frequency of application. The lowest frequency available from the test results is 10 MHZ. At this frequency, RG-59 has an attenuation for 1.5 as compared to 1.74 for RG-58. Therefore, RG-59 has less attenuation than RG-58. The impact of attenuation on the input and output of the signal transmitted is as follows:

$$\frac{\text{Signal Output}}{\text{Signal Input}} = e^{-\alpha X}$$

Where, e = 2.71828
α = Attenuation in db/100 ft.
X = Length of the cable (in 100's of ft)

For comparison purposes, $e^{-1.5} = 0.22$ for RG-59, whereas, $e^{-1.74} = 0.17$ for RG-58. This shows that cable type RG-59 having an attenuation of 1.5db/100 ft. has less insertion loss and will retain better signal quality than RG-58 cable.

3.9 Adjustment of Signal:

Deviation of signal, if any, due to replacement of cable RG-58 by RG-59 can be compensated by adjustment of potentiometer R1 (Reference MODCOMP drawing 515-A00009, R A) for application 1 and by adjustment of gain potentiometer (Referenc V.P. 53758-09, Section 16) for application 2.

3.10 Vendor Confirmation:

In addition to above, the subject was discussed with the respective equipment vendor representatives. The confirmation from the vendors is documented in notes of telephone conversation attachment A & B.

4.0 CONCLUSION

4.1 Cable type RG-58 can be replaced by cable type RG-59 for the application mentioned under paragraph 2.

5.0 REFERENCES

5.1 Specification 9763-006-113-19 Rev. 0

5.2 Computerized Conduit & Cable Schedule Program (CASP), Dwg. 310994, Rev. 20

5.3 Drawing 310181, Rev. 34

5.4 Drawing 310891, Rev. 26

5.5 Site Data Packages for P.O. 113-19-01

5.6 IPCEA S-69-530, NEMA WC-41, January 21, 1975

5.7 Modular Computer System Technical Manual 225-900006-00

5.8 Foreign Print FP 51796-06

5.9 Operation - Maintenance Instructions for Nuclear Degasifier, FP 53758-09

5.10 Schaum's outline series on theory and problems of transmission lines by Robert A. Chipman

5.11 Telephone Conversation Notes, Attachment A & B

ATTACHMENT A

ENGINEERING EVALUATION NUMBER 88-014

FORM 3516 REV. 1/74

CALL FROM: V. C. Patel, Plant Eng., Seabrook Station, P.O. Box 700, Seabrook NH 03874

DATE April 29, 1988

TIME 3:30 p.m.

TO: Bob Booker, Modcomp, 1650 West McNab Road, P.O. Box 6099, Ft. Lauderdale, FL 33310

JOB NO.

SUBJECT: "Replacement of Cable Type RG-58 By RG-59"

ORDER NO.

In response to the inquiry on subject replacement, Mr. Booker checked Modcomp Engineering Dwg. No. 502-100018, Rev. A and verified Modcomp Part No. 535-100112 for Coax Cable Type RG-195 with characteristic impedance of 95 Ω (nominal). Therefore, Cable Type RG-58 having characteristic impedance 50 Ω can be replaced safely by Cable Type RG-59 having characteristic impedance of 75 Ω without replacing 51 Ω terminating resistor (Ref. Modcomp Dwg. 515-A00009, Rev. A).

NOTES PREPARED BY V C Patel

Vasant C. Pat /30/88

cc: J. M. Vargas 01/62

R. Bergeron 01/62

G. A. Kotkovski 01/62

Bob Booker/Modcomp

ATTACHMENT B

ENGINEERING EVALUATION NUMBER 88-014

FORM 3516 REV. 1/74

CALL FROM: N. K. Bhowmik, Plant Eng., Seabrook Station, P.O. Box 700, Seabrook, NH 03874

DATE April 29, 1988

TIME 2:15 p.m.

TO: Tom Blake, Neponset Control, Inc. 13 Mechanic St., Foxboro, MA 02035 (617) 543-4801

JOB NO.

SUBJECT: "Replacement of Cable Type RG-58 By RG-59"

ORDER NO. 233-3

In response to the inquiry on subject replacement, Mr. Blake consulted Mr. David Kotliar, Customer Service Manager, National Sonics, New York and confirmed that cable type RG-59 with characteristic impedance 75 Ω (nominal) can be used for customer wiring be[illegible] the level sensor and the control unit of National Sonics' level measuring un[illegible]e 300S.

NOTES PREPARED BY N.K. Bhowmik

Nirmal K. Bhowmik, 04/30/88

cc: J. M. Vargas 01/62

R. Bergeron 01/62

G. A. Kotkowski 01/62

Tom B[illegible]e, Neponset Control, Inc.