REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

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AUTH.NAME AUTHOR AFFILIATION
VAN BRUNT,E.E. Arizona Public Service Co.
RECIP.NAME RECIPIENT AFFILIATION
KNIGHTON,G. Licensing Branch 3

SUBJECT: Responds to 840725 request for addl info re isolation devices used within reactor protection sys & control sys failures due to high energy line breaks.

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	NRR/DE/SGEB 25	1	1	NRR/DHFS/HFEB40	1	1
	NRR/DHFS/LQB 32	1	1	NRR/DHFS/PSRB	1	1
	NRR/DL/SSPB	1	0	NRR/DSI/AEB 26	1	1
	NRR/DSI/ASB	1	1	NRR/DSI/CPB 10	1	1
	NRR/DSI/CSB 09	1	1	NRR/DSI/ICSB 16	1	1
	NRR/DSI/METB 12	1	1	NRR/DSI/PSB 19	1	1
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Arizona Public Service Company
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September 7, 1984
ANPP-30465 - WFO/MAJ

Director of Nuclear Reactor Regulation
Attention: Mr. George Knighton, Chief
Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2 and 3
Docket Nos. STN-50-528/529/530
File: 84-056-026; G.1.01.10

Reference: (1) Letter from G. W. Knighton, NRC, to E. E. Van Brunt, Jr., APS, dated July 25, 1984. Subject: Request for Information Concerning (a) Isolation Devices Used Within The Reactor Protection System, and (b) Control System Failures Due To High Energy Line Breaks.

Dear Mr. Knighton:

Reference (1) requested specific information relating to the isolation devices used within the PVNGS Reactor Protection System (RPS) and information concerning control system failures due to High Energy Line Breaks (HELB).

Attachment A to this letter provides the information requested by the Staff pertaining to the isolation devices used within the RPS and Attachment B addresses the control system failures due to HELBs.

If you have any further questions on these subjects, please call me.

Very truly yours,

E E Van Brunt/TBK

E. E. Van Brunt, Jr.
APS Vice President
Nuclear Production
ANPP Project Director

EEVBJr/MAJ/sp
Attachments

8409120335 840907
PDR ADOCK 05000528
A PDR

cc: E. A. Licitra (w/a)
A. C. Gehr (w/a)
R. Zimmerman (w/a)
B. Stevens (w/a)

B001
1/1

September 7, 1984
ANPP-30465 - TFQ/MAJ

STATE OF ARIZONA)
) ss.
COUNTY OF MARICOPA)

I, A. Donald B. Karner, represent that I am Assistant Vice President of Arizona Public Service Company, that the foregoing document has been signed by me for Edwin E. Van Brunt, Jr., Vice President, Nuclear Production, on behalf of Arizona Public Service Company with full authority so to do, that I have read such document and know its contents, and that to the best of my knowledge and belief, the statements made therein are true.

Donald B Karner
Donald B. Karner

Sworn to before me this 7th day of September, 1984

Nora E. Meador
Notary Public

My Commission Expires:
My Commission Expires April 6, 1987

Responses to NRC Questions Concerning Isolation Devices Used in the Reactor Protective System

Amendment 12 to the Palo Verde FSAR includes a revision to Section 7.2, "Reactor Protective System." The information states that the Core Protection Calculator (CPC) system and Core Element Assembly Calculators (CEAC) will provide their outputs and a number of their inputs to the Plant Monitoring System (PMS) which is considered to be nonsafety-related. Fiber-optic data links are to be used for this interface. The staff understands that this interface will be mono-directional (i.e., signals from the protection system CPCs to the PMS).

Paragraph 4.7.2 of IEEE 279-1971 permits the use of isolation devices to transmit signals from protection systems for use in nonsafety-related systems such as the PMS. Acceptance of the design interface described above will be predicated upon the satisfactory qualification of the electrical isolation devices that are to be used to maintain appropriate electrical independence. Information supplied to date is insufficient to determine whether the fiber-optic isolation devices are qualified for its application. Therefore, please provide information to ensure that any electrical failure applied to the isolation device output will not degrade, below an acceptable level, the operation of the circuit connected to the input. As a minimum, please provide:

1. Detailed information (including drawings) to describe the physical implementation of the subject isolation devices into the reactor protection system design. This should include specific information on the physical design and electrical characteristics of the isolation device itself.

APS

Response: The CPC/PMS Data Link System installed at Palo Verde Units 1, 2 and 3 is depicted in the figure on page 14. The four CPCs and the two CEACs in the DNBR/LPD Calculator System communicate individually to the Plant Monitoring System (PMS). The fiber optic modules at each end of the interface function as transducers; converting electrical signals to light pulses at the transmitting end, a CPC or a CEAC, and converting the light pulses to electrical signals at the receiving end, the PMS. Each of the six interfaces is accomplished over two fiber optic cables (reference the attached Pirelli data sheet (type S125C1)). The installed cable length varies with the channel involved but each is approximately 150 feet. The construction of the optic cable is such that the cable contains <u>no electrically conductive material</u>. The cable, rather than the modules, is the isolation medium. From an electrical point of view, it is as if the fiber optic cable were not even present.

The relative permittivity or dielectric constant of a material is a measure of the material's isolation capability. The dielectric constant of a material is referenced relative to free space (a vacuum) and is a dimensionless number. Dry air possesses a dielectric constant of 1.00059. Glass possesses a dielectric constant in the range of 4.0 to 7.0 depending upon the specific type (Reference 1). The higher the dielectric constant, the greater the isolation that is provided. Thus, fiber optic cables have an isolation capability that is 4 to 7 times greater than dry air. NRC Regulatory Guide 1.75 recognizes six inches of air as sufficient isolation to meet separation criteria, and a 150 foot length of fiber optic cable provides significantly more isolation than six inches of air.

The voltage breakdown rating of a typical fiber optic cable is on the order of 250 KV per meter (reference the attached data sheet from EOTEC Corp. (page 15 and 16) on a cable of similar construction). One hundred and fifty feet of cable is approximately 46 meters which would provide a voltage breakdown of $250 \times 10^3 \times 46 = 1.1 \times 10^5$ volts. The maximum credible fault for the DNBR/LPD Calculator System is 480 VAC. The maximum credible fault for the PMS is 580 VAC. The isolation capability of the fiber optic cable is therefore orders of magnitude greater than any postulated maximum credible fault at either end of the CPC/PMS Data Link. A fault at either end of the data link might destroy the module but will not propagate over the fiber optic cable.

2. A description of the specific testing or analyses performed to demonstrate that the device is acceptable for its application. This description should include a discussion of the system mock-up considered including elementary drawings where necessary to indicate the design configuration and how maximum credible faults (including continuous phase-to-phase short circuits, phase-to-ground short circuits, and the application of continuous external high voltages) and voltage transients were applied or considered.

APS
Response: An analysis of the isolation characteristics of the data link is provided starting on page 5:

Physical Installation

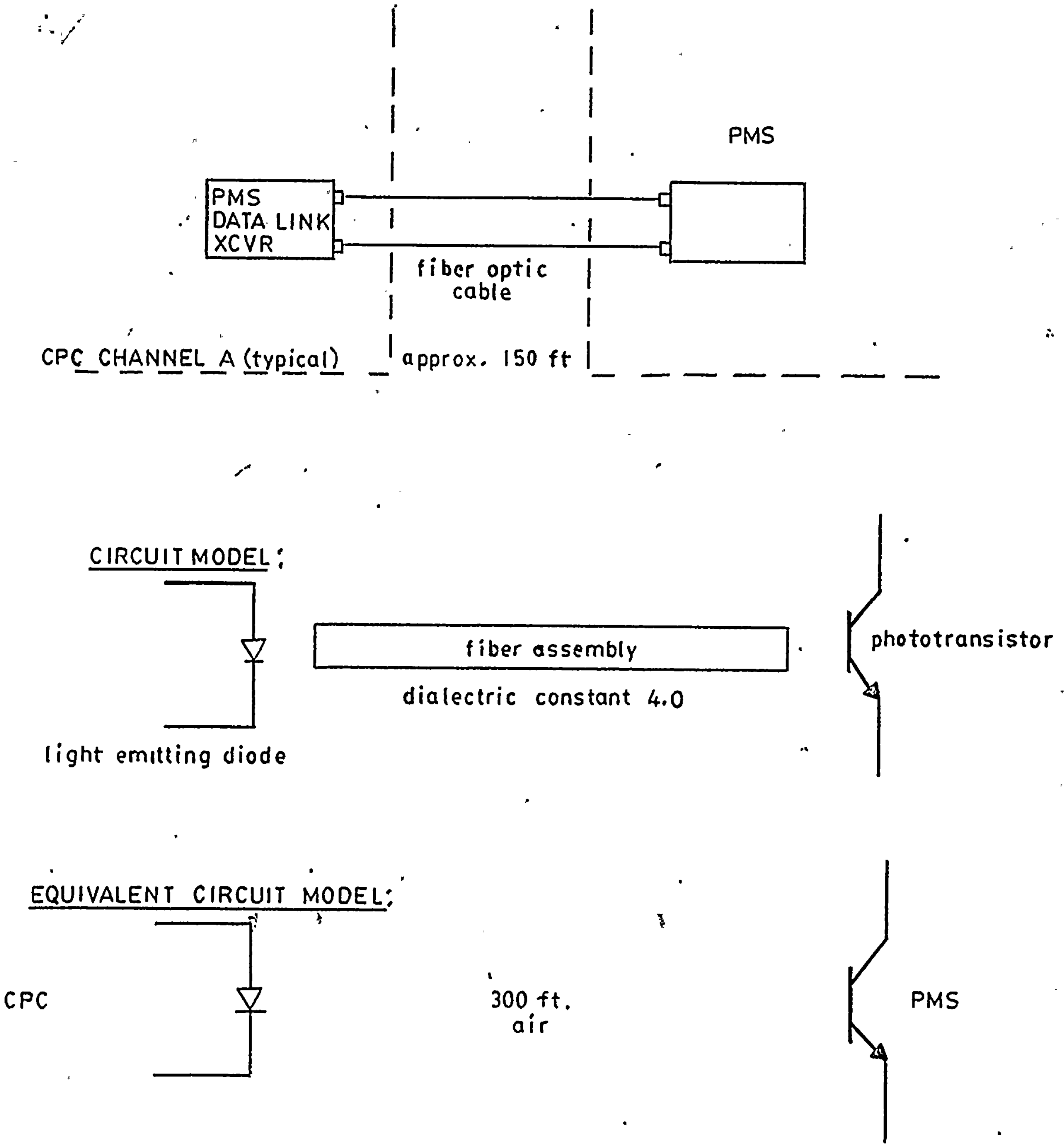


FIGURE-1

Analysis

Acceptance Criteria: A. Separation of 6" of air from R.G. 1.75

B. Withstand maximum credible fault

1. The interconnection of the protective channel to the plant monitoring system utilizes a non-conductive fiber optic cable.

dielectric constant 4.0

voltage breakdown = 250×10^3 volts/meter

cable length to PMS = 150 ft or 46 meters

A. Separation distance calculation:

$$D_S = 150 \text{ ft.} \times \sqrt{\frac{\text{dielectric constant 1}}{\text{dielectric constant 2}}} \quad \text{(reference 2)}$$

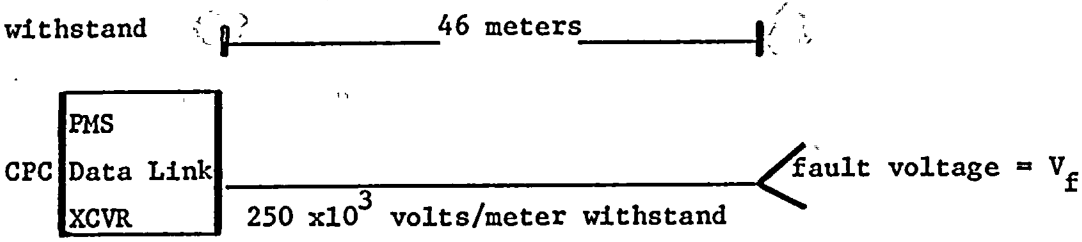
$$D_S = 150 \times 2.0 = 300 \text{ ft. equivalent in air}$$

Conclusion: D_s is greater than 6 inches, therefore Criterion A is met with a margin of greater than 100.

B. Maximum credible fault calculation

For a non-conductive medium, the fault voltage must exceed the breakdown voltage for the fault to propagate.

breakdown voltage characteristics of cable = 250 KV/meter



For the non-conductive medium to be an acceptable isolator, the withstand voltage V_W must be greater than the maximum credible fault voltage V_f.

$$V_W = 250 \times 10^3 \text{ V/M} \times 46 = 1.15 \times 10^7 \text{ volts}$$

The maximum credible fault voltage source - 580 VAC

This is equivalent to 580 x 1.2 VDC - 696 volts

A conservative assumption is to utilize 100% margin.

$$V_f = 696 \times 2 = 1392$$

Because the medium is non-conductive, it is conservative to assume the entire fault voltage is applied to the isolator, ignoring any attenuation in the circuit components of the transmitting device.

Since the isolator is a single conductor, there is only one transmission mode.

V_W = 1.15×10^7 volts

V_f = 1.392×10^3 volts

V_W = is greater than V_f by a margin of 8.26×10^3

Therefore, Criterion B is met and the isolator is qualified.

3. Data to verify that the maximum credible faults and transient voltages considered were the maximum voltage/current to which the isolation device could be exposed, and define how the maximum values were determined.

APS

Response: The fault voltage potential of this isolator was constrained by the application of interface criteria. Also, there does not exist any voltage in the plant greater than the isolator can withstand.

---

4. Information to verify that the maximum credible faults and transient voltages were considered in both the transverse (line-to-line) and common (line-to-ground) modes.

APS
Response: Line-to-line and line-to-ground transient voltage faults do not apply to a single conductor non-conducting optical cable medium. Refer to the response to question 2.

5. Data to define the pass/fail acceptance criteria.

APS
Response: The criteria for pass/fail for the analysis were to have an equivalent separation distance greater than 6 inches of air (R.G. 1.75) and to have a breakdown voltage greater than the maximum credible fault voltage.

6. Information to verify that the isolation device is classified as part of the protection system (i.e., verify that the device is safety-related; environmentally qualified in accordance with 10 CFR 50.49, and seismically qualified).

APS

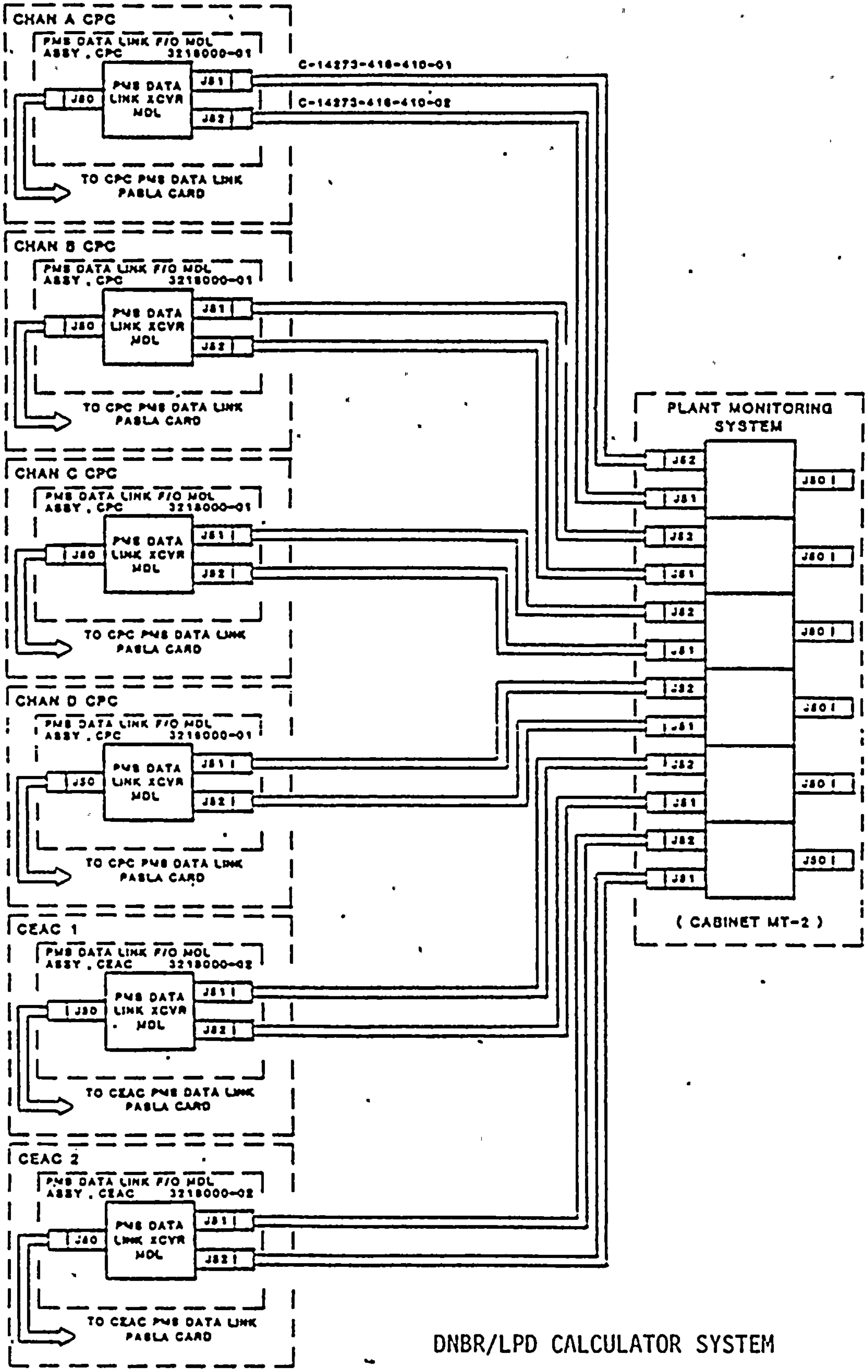
Response: Qualification data for the modules and cable is provided in the DNBR/LPD System Environment Program documentation and is available for review at either C-E's Windsor facility or at APS offices.

7. Data to verify that the effects of electrostatic coupling and electromagnetic interference were considered.

APS

Response: As described in the response to question 1, the optical cables in use contain no electrically conductive material and function more effectively as an isolating dielectric than air.

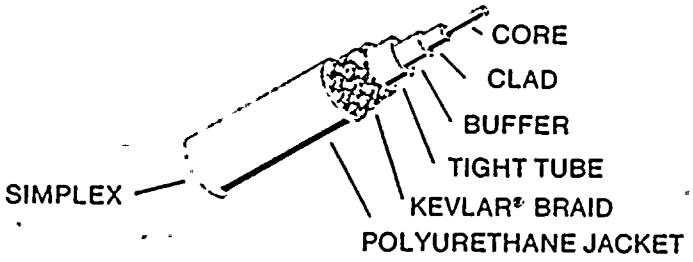
Therefore, no electrostatic coupling is enabled by use of such cables. Similarly, there are no electrical effects resulting from electromagnetic radiation in optical cables, nor is the optical transmission (especially of digital communication in multimode fiber) affected by plant electromagnetic interference.

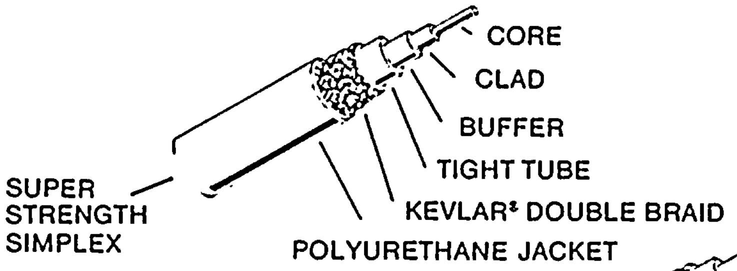


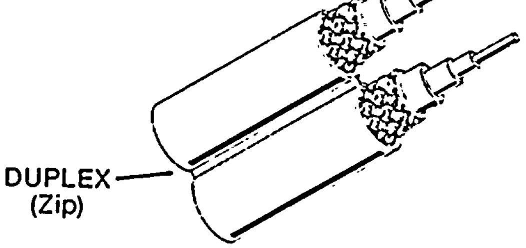
DNBR/LPD CALCULATOR SYSTEM
FIBER OPTIC INTERFACE CABLE ASSEMBLIES

FIBER OPTIC CABLE

High Voltage Performance







APPLICATIONS

- Extreme high voltage environments
- Thyristor triggering
- Electrical power plants
- Motor and switch control

CHARACTERISTICS

- *Tested at 250KV/meter. Actual rating will be application dependent
- Extremely rugged construction for tough environments
- Large core insures high power optical transmission with low loss
- Dielectric immunity and abrasion resistance
- Orange polyurethane jacket for identification
- Braided Kevlar® for increased tensile and pulling strength
- Tight tube construction for increased flexibility and handling capability
- Operating temperature: −20°C to +80°C
- Available in Simplex, High Strength Simplex, and Duplex Zip constructions
- Fiber nominally proof tested at 50k psi. Available at proof test levels up to 200k psi
- High radiation resistance
- High numerical aperture
- EMI/RFI immunity
- Easily terminated with all connector devices

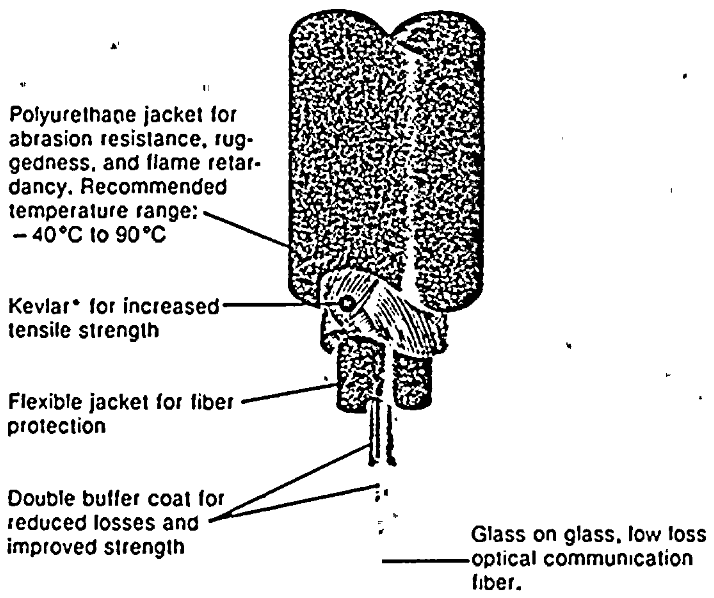
	Part Number	NA	Attenuation at 820 nm (dB/km)	Core/Clad Diameter (µm)	Cable Dia. (mm)	Min. Bend Diameter Unloaded cm (in)	Maximum Pull Load Nt (Lb)	Bandwidth (MHz-km)
Simplex	434001	0.29	6	100/140	3.0	4.75 (1.90)	400 (90)	100
	444001	0.40	10	200/380	3.0	4.75 (1.90)	400 (90)	20
	454001	0.40	10	400/560	3.5	9.50 (3.75)	400 (90)	15
	464001	0.40	10	600/850	3.0	27.00 (10.0)	400 (90)	10
Super Strength Simplex	434003	0.29	6	100/140	3.5	4.75 (1.90)	666 (150)	100
	444003	0.40	10	200/380	3.5	4.75 (1.90)	666 (150)	20
	454003	0.40	10	400/560	4.0	9.50 (3.75)	666 (150)	15
	464003	0.40	10	600/850	3.5	27.00 (10.0)	666 (150)	10
Duplex (Zip)	434002	0.29	6	100/140	3.0x7.0	4.75 (1.90)	600 (135)	100
	444002	0.40	10	200/380	3.0x7.0	4.75 (1.90)	600 (135)	20

All parameters are nominal.

*Note: Tested at 250KV/meter in accordance with electrical requirements for 100R series non-conductive hydraulic hose outlined in Society of Automotive Engineers (SAE) specification J343 report number ET83-208-P. Report on simplex cable 444001 available upon request.

OPSYCA®

OPTICAL SYSTEMS CABLE GLASS FIBER AND CABLE



S80C1 and C2
S100C1 and C2
S100RC1 and C2
S125 C1 and C2

STEP INDEX LOW LOSS OPTICAL FIBERS IN SINGLE AND DUAL CHANNEL CABLES

APPLICATIONS

- Remote Military Communications
- Oceanography
- Process Control
- Data and Communication Links

ADVANTAGES

- Very Low Propagation Loss
- Immunity from Electromagnetic and Radio Frequency Interference
- Complete Electrical Isolation
- Excellent Abrasion Resistance and Flexibility

Optical communications fibers combine the wide bandwidth of waveguide systems with the flexibility of wire at a substantial weight savings. In addition, their complete electrical isolation eliminates spark and fire hazards.

This product class includes various step index optical fibers. The core diameters range from 80 to 125 microns. Urethane is the standard jacketing material with Kevlar* used to provide tensile strength in a completely dielectric cable design. PVC jacketing is available for minimum cost.

These glass core-glass clad fibers are low loss flexible waveguides with bandwidths of 10-45 MHzkm. Data links to 2 km and beyond are readily achieved.

S100R is a large core fiber with enhanced radiation hardness for military and nuclear power plant requirements. It has a radiation sensitivity of approximately 2 dB/km per kilorad — 10 times better than conventional CVD low loss fiber. Other fiber sizes can be ordered with enhanced radiation hardness as well.

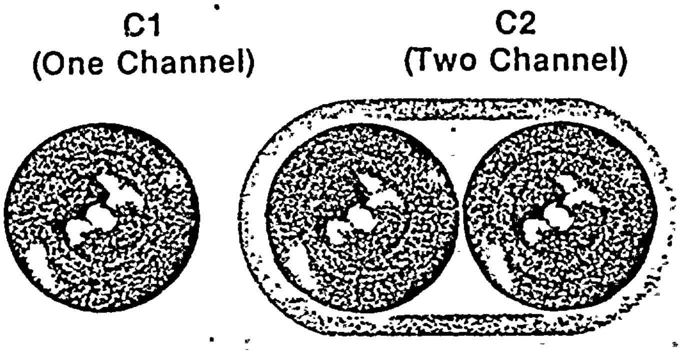
Single and dual channel cables are standard designs, available for rapid delivery in lengths up to 2 km. Multiple channel constructions are also available. Special designs can be provided for critical high-temperature applications, hybrid constructions combining electrical and optical wires. For other particular requirements, consult the factory.

---

*Registered E.I. DuPont Trademark

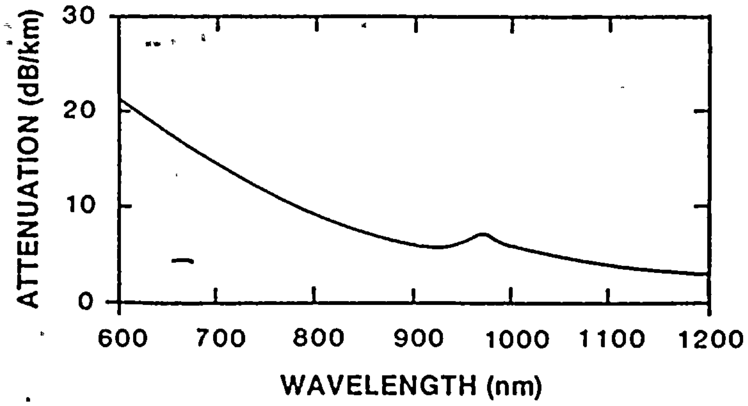
PIRELLI
CABLE CORPORATION
SPECIAL CABLE DIVISION
2 Tower Drive • P.O Box 50 • Wallingford, Ct. 06492 • Phone (203) 265-5533 • TWX: 710-476-0764 • Wats: 800-243-3959

CABLE DESIGNATION



TY[illegible]CAL ATTENUATION

OPSYCA* LOW LOSS FIBERS



FIBER OPTICAL AND DIMENSIONAL CHARACTERISTICS

	S80	S100 S100R	S125
Maximum Attenuation (db/km @ 850nm)	6	6	6
Numerical Aperture 99% Intensity 95% Intensity	.30 .24	.30 .24	.30 .24
Maximum Acceptance Cone Angle	35°	35°	35°
Bandwidth (MHzkm)	10-20	20-45	10-20
Core Diameter (mm)	0.080	0.100	0.125
Fiber Diameter (mm)	0.125 ± .004	0.140 ± .004	0.200 ± .006
Buffered Dia. (mm) (nominal)	0.50	0.50	0.50
Proof test level (psi)	50,000	75,000	50,000

CABLE CHARACTERISTICS	CABLE CONSTRUCTION	
	C1	C2
Jacket Material	Polyurethane Jackets passes IEEE 383 Flame test Kevlar* strength members	
Cable Dimension (mm)	3.0 ± 0.2	4.5x7.5 ± .2
Outer Wall Thickness (mm)	0.50mm	0.75mm
Operating Temp. (°C)	−40 to +90	−40 to +90
Min. Bend Radius (mm)	20	20
Cable Break Strength (Kg)	175	350

*Registered E.I. DuPont Trademark

CABLE IDENTIFICATION	PHYSICAL CHARACTERISTICS			
Catalog Part Number	Fiber Core/Clad Diameter (mm)	Number of Channels	Cable Dimension (mm)	Cable Weight (kg/km)
SCD-O-S80C1	0.080/0.125	1	3.0	8.0
SCD-O-S80C2	0.080/0.125	2	4.5x7.5	31.0
SCD-O-S100C1	0.100/0.140	1	3.0	8.0
SCD-O-S100C2	0.100/0.140	2	4.5x7.5	31.0
SCD-O-S125C1	0.125/0.200	1	3.0	8.0
SCD-O-S125C2	0.125/0.200	2	4.5x7.5	31.0
SCD-O-S100RC1	0.100/0.140	1	3.0	8.0
SCD-O-S100RC2	0.100/0.140	2	4.5x7.5	31.0

END TERMINATIONS AND CABLE ASSEMBLIES

Items available include bulkhead connectors, splices, and cable terminations such as the optical SMA connectors. Other connectors from different manufacturers will be quoted on request. Pirelli maintains an efficient optical cable assembly manufacturing facility. Quotations will be made for specific cable assemblies to simplify optical system installations.

ORDER INFORMATION

Order should include: catalog part number and specify total length. Maximum continuous length 2 km. Shipping tolerances ±10%. Cable assemblies must specify unit length, type of cable, type of connector and number of assemblies.

PIRELLI
CABLE CORPORATION
SPECIAL CABLE DIVISION

References

1. "Electronic Engineer's Reference Book 5th Edition", edited by F. Mazda; Published by Butterworth & Co., Ltd.; London' 1983; Section 13.1.

2. "Handbook of Chemistry and Physics", 40th Edition, Chemical Rubber Publishing Co., 1959.

Responses to NRC Questions Concerning Control System Failures Due to High Energy Line Breaks (HELBs)

The staff requests that the following specific information be provided:

1. Detailed elementary drawings and electrical schematics to show the interaction of the Reactor Regulating System (RRS) and Steam Bypass Control System (SBCS) output signals with the Control Element Drive Mechanism - Control System (CEDMCS). This should clearly show the interface of the SBCS Automatic Withdrawal Prohibit (AWP) signal with CEDMCS which is to be used to block the RRS demand for withdrawal of control element assemblies (CEAs). The drawings should be highlighted and/or annotated as necessary for clarity.

APS
Response: The event scenario of concern is the failure of the SBCS such that a quick open signal is generated in combination with the RRS generating a CEA withdrawal signal during a steam line break inside the containment building. This scenario is being reviewed because of the potential increase in positive reactivity insertion above that reported in the PVNGS FSAR and the impact on the consequences. The following discussion explains why the combined actions of the SBCS and RRS need not be considered since an AWP signal will block a CEA withdrawal signal from the RRS, or terminate an automatic withdrawal if the withdrawal is already in progress. Enclosure (A), Page 6, is the CEDMCS Group Raise/Lower Logic Diagram.

The SBCS generates an AWP signal whenever a SBCS demand for opening the turbine bypass valves exists. This signal is generated for both the quick open and the modulate open signals. The AWP signal is sent to the CEDMCS (Input "D" on Enclosure (A)).

The RRS may generate an Automatic Raise (AR) signal due to a normal or faulted input. This signal is sent to the CEDMCS (input "A" on Enclosure (A)). The RRS generates other signals which do not impact this discussion since they do not result in the uncontrolled withdrawal of CEAs.

The CEDMCS also receives a Manual Raise (MR) signal from the CEDMCS control panel in the control room. This signal is given when the operator requests rod withdrawal. There is no MR signal for this discussion since no operator action is assumed. There are other input signals to the CEDMCS, however, these signals do not impact the RRS/SBCS interlock.

If an AWP is generated and the RRS is requesting CEA withdrawal then the inputs to the CEDMCS will have the following values; A = "1", D = "0", and MR = "0" (no operator action). Tracing these inputs through the CEDMCS logic diagram (Enclosure (A)) yields the following:

A. Since the AWP signal, input D, is "0", the output of NAND gate "W" will be 1, regardless of the value of inputs B and C.

B. The output of NAND gate "X" will be 1 since the MR input is "0" regardless of the value of the other input to the gate.

C. The output of Exclusive OR gate "Y" will be "0" since both of its inputs will be "0". Both of the NAND gate outputs have been inverted by the amplifier/inverters.

D. The output of NAND gate "Z" will be 1, since the output of the Exclusive OR gate is "0", regardless of the other inputs to the NAND gate.

E. Finally, the output of the CEDMCS logic is "0" for the "control group raise" portion of the diagram. The "control group lower" portion is not of interest since CEA withdrawal is the malfunction of concern.

From the above discussion, it can be concluded that in the presence of both an automatic raise signal from the RRS and an AWP signal from the SBCS, there will be no "control group raise" signal from the CEDMCS. As a matter of interest, the override of the RRS request occurs in what has been labeled NAND gate "W" of the attached diagram.

---

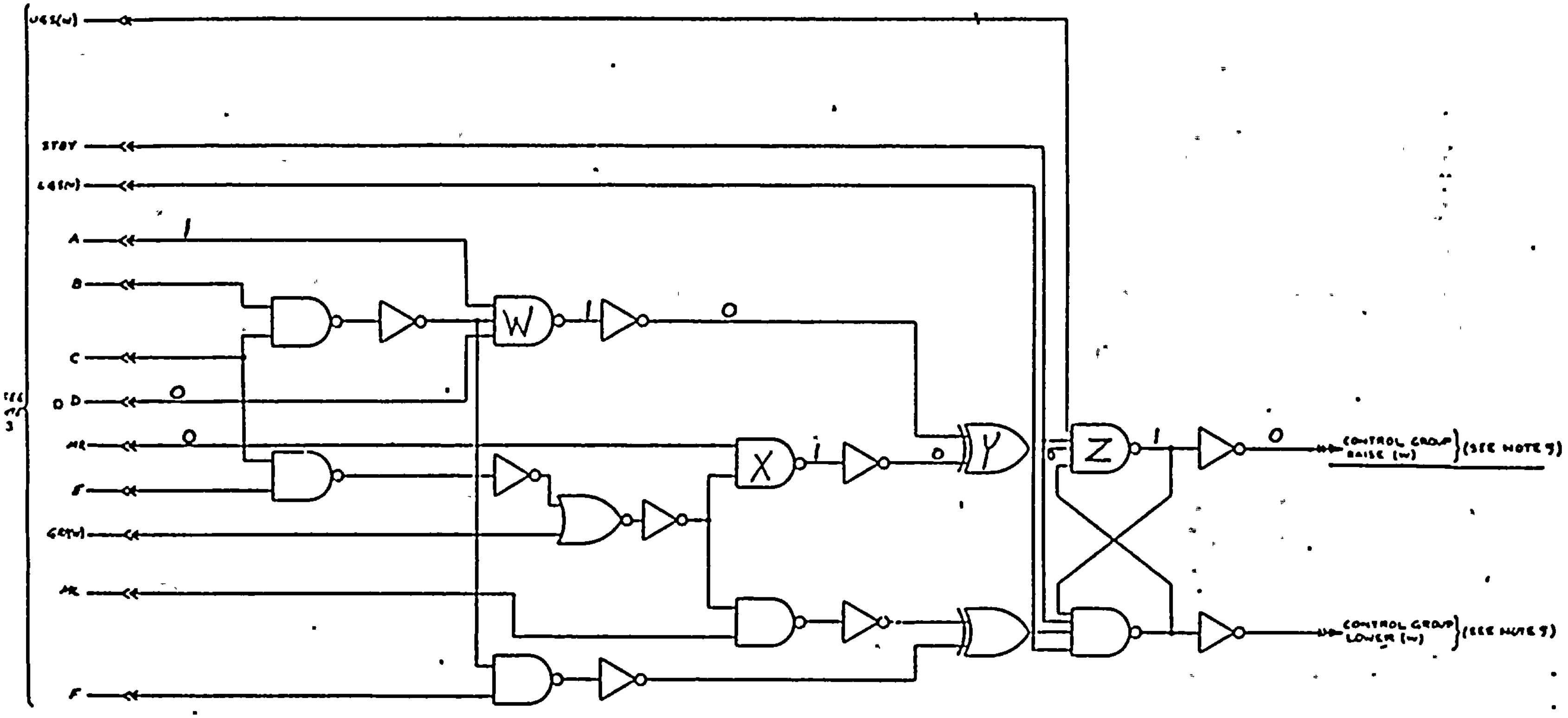
2. Information to verify that, should the RRS demand for withdrawal signal exist, a subsequent SBCS AWP signal will block the RRS demand signal and will result in the discontinuation of CEA withdrawal. Drawings to be provided as part of item 1 above should clearly show this. Again, please highlight and/or annotate where necessary.

APS
Response: The response to question (1) applies to a CEA withdrawal in progress when an AWP signal is generated. The logic is not latched. When signal "D" is zero, the automatic withdrawal will be terminated.

3. Clarify the statement (Reference 2) that "The SBCS generates an AWP signal whenever a SBCS demand for opening the turbine bypass valves exists..." as it relates to the quick opening signal (i.e., will any open command signal - Modulation Mode, Quick Open Mode - give AWP or just the Quick Open Mode signal).

APS
Response: For the SBCS malfunctions, only the quick open is of concern. The SBCS will generate an AWP signal in both the Quick Open Mode and Modulation Mode.

Enclosure A



5. REF. DWG D-SYS80-414-479
4. TYPICAL FOR 12 GROUP LOGIC CARDS.
3. REF DWG D-SYS80-414-460.
2. THIS DWG IS TO BE USED AS A LOGIC DIAGRAM AND IS NOT INTENDED TO BE USED FOR HARDWARE IMPLEMENTATION
1 ALL INPUTS THAT INHIBIT MOTION ARE LOGIC "0".

D-SYS80-414-472
01

APPROVED REFERENCE DESIGN

CONTROL GROUP TYPE	INPUT DESIGNATION					
	A	B	C	D	E	F
SHUTDOWN	LOGIC 0	LOGIC 0	LOGIC 0	LOGIC 0	LOGIC 0	LOGIC 0
REGULATING	AR	AS	SP(W)	AWP •	MS	AL
POWER SHARING	LOGIC 0	LOGIC 0	LOGIC 0	LOGIC 0	LOGIC 0	LOGIC 0

• SEE NOTE 1

Inputs

D - Automatic Withdrawl Prohibit From SBCS
MR - Manual Withdrawl Signal From CEDMCS Control Panel
A - Automatic Raise From Reactor Regulating System

CONTRACT NO SY000

REVISED DRAWING UPGRADED TO "ABD" PER REV NO [illegible]

SYS 80

CEDMCS
GROUP RAISE/LOWER
LOGIC DIAGRAM

D-SYS80-414-472 01