



NCSX

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# NCSX

## D.C. POWER CABLE SPECIFICATION

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REVISION 0

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RECORD OF CHANGES

Rev. #	Date	Changes
1		
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# NCSX D.C. POWER CABLE SPECIFICATION

## 1. SCOPE

This specification covers the design, construction, Quality Assurance and performance features of DC cables to be utilized for COIL POWER circuits of National Compact Stellerator Experiment (NCSX). The cable shall be constructed in accordance with the Seller's standard practices when such practices do not conflict with this specification. However, the cable shall, as a minimum, conform to acceptable industry standards for modern engineering, design and workmanship. The cable jacket may be either Vulcanized chloro-sulfonated polyethylene (CSPE) compound or PVC. [Note: Even though PVC cable may meet the IEEE 383 flame test, there is a concern about corrosion due to halogen outgassing from PVC jacketed cable. Seller shall address this concern and furnish comments] Quotes shall be provided for each of the two types.

Note that part of the cables to be supplied under this specification is duplexed. Duplexing requires verifications that the mechanical forces between the conductors under the maximum current shall not be destructive and shall not affect the cable life.

## 2. SERVICE CONDITIONS

- .01 The DC power cables shall be suitable for use in alternately wet and dry locations in conduit, cable tray and underground duct systems.
- .02 The cable shall be rated 105°C for normal operation, 140°C for emergency conditions, 250°C for short circuit conditions.
- .03 Estimated maximum and minimum ambient temperatures at project location are -24°C and +40°C.
- .04 The cable outer jacket shall be sunlight resistant.

## 3. APPLICABLE DOCUMENTS

The design of the DC Power Cable as well as the materials used in its construction shall be as recommended by Seller except where specified by Purchaser, and shall comply with the latest revision in effect at date of purchase order, or as mutually agreed to subsequent to date of order, of the following currently approved applicable regulations, safety codes, specifications and standards, including applicable technical definitions as acknowledged and accepted in the industry:

AEIC - Association of Edison Illuminating Companies

AEIC CS8-00 1<sup>st</sup> Edition – “Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46KV”

ASTM - American Society for Testing and Materials

ASTM B-8-1972 – “Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-hard, or Soft”.

IEEE - Institute of Electrical & Electronic Engineers

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IEEE 383-1974 – “IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations”, Section 2.5. Compliance with **UL-1277 is also acceptable.**

ICEA - Insulated Power Cable Engineers Association

ICEA S-93-639 (2000) – “5 – 46kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy”

UL - Underwriters Laboratories

UL-1072-1975-“Guide for medium Voltage Solid Dielectric Cable”.

## **NFPA-NFPA 70, NATIONAL ELECTRIC CODE (NEC)**

The above Standards and Codes, to the extent referenced herein, set forth the minimum requirements. They may be exceeded by Seller with written permission from Purchaser, if in his judgment superior or more economical designs or materials are available for successful and continuous operations, as required by the specification.

- a) Seller agrees, represents and warrants that all services, designs, equipment and material sold or otherwise provided to Purchaser by Seller comply with applicable Federal, State and local laws, regulations and codes, and all applicable specifications and standards including those specified above, in each case as in effect at the date of order placement. Seller shall advise Purchaser of the codes, standards and regulations complied with in the design and fabrication of his equipment.
- b) Seller represents and warrants to Purchaser that the material and services hereunder comply with the latest revisions of the Occupational Safety and Health Act of 1970 and **associated regulatory requirements in title 29 of the code of federal regulations.**
- c) In the event of any conflict, Seller shall refer the conflict to Purchaser.

## **4. REQUIREMENTS**

Cables shall be for Cable Tray use and meet the specific design requirements listed below:

### 4.1 Field Coil Power Connections – B/M D16-03 & 05

- a) Total Number of major Interconnecting Cables for DC Transmission: **26**
- b) Maximum pulsed current per cable: 30 kA for 1.4 seconds  
Equivalent Square Wave
- c) Maximum RMS Current per Cable: 1200 Amps\*
- d) Repetition Rate: Once every 900 seconds

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- e) Nominal Insulation Level: 5 kV AC
- f) Max. Operating Voltage: 6.0 kV DC, Line to Line
- g) Design Life:  
Normal Operation:  $3 \times 10^5$  full power pulses
- h) Load Current under shorted load: 120 kA DC Peak  
120 kA DC for 10 cycles
- i) Conductor Temperature:
  - i. Normal Operation: 105°C
  - ii. Fault Operation: Per ICEA S-68-516
- j) Length of each of 20 Interconnections: 600 feet or more TBD.

\* The cables will be placed in Cable trays per NEC 318-13b-2. Thirteen single conductor cables **OR** seven duplexed cables may be routed in one 36" wide tray system.

### 4.2 Specific Requirements for Cables B/M # D16-03 & 05

- a) **Symbol – EPRSH (5kV)**
- b) Group D16 – Single Conductor 5000 volt Shielded power cables (CSPE / Hypalon\* or PVC Jacket)  
\* Trade name of Dupont Co.
- c) Application – Underground and aboveground applications in alternately wet and dry locations. In this specific application the Cables will be installed in open cable tray and will be randomly spaced.
- d) Conductor – Class B, compact **round** stranded, bare, annealed **copper** per ASTM B 8 and ASTM B-496, ICEA S93-639. 1000 kcmil
- e) Strand Shield – Extruded layer of semi-conducting **ethylene-propylene based** material compatible with the insulation, with volume resistivity not in excess of 10 ohm-m at 105°C.
- f) Insulation – Ethylene propylene rubber, meeting electrical and physical requirements of ICEA S-93-639, **Type III** and AEIC No. 8. The insulation shall be rated for continuous operation at a conductor temperature up to 105°C (221°F).
- g) Insulation Thickness – 5 kV (133% insulation level).
- h) Insulation Shielding – Extruded layer of black semi-conducting **ethylene-propylene based** compound compatible with the insulation. Peel strength

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of the extruded screen from insulation shall be between 4-18 lbs/0.5 inch width when tested per [ICEA S-93-639](#).

- i) Shielding - .005” coated\* copper shielding tape with 12.5% overlap per [ICEA S-93-639, Part 6](#). (\*Coated tape for CSPE/Hypalon jacket; bare tape for PVC jacket.)
- j) Tape – Bedding tape for CSPE/ Hypalon only, not required for PVC.
- k) Jacket – Black chlorosulfonated polyethylene (CSPE) jacket meeting the physical requirements of paragraph 7.1.4 of [ICEA S-93-639](#) for PVC or paragraph 7.1.10 of [ICEA S-93-639](#) for Hypalon with thickness in accordance with Table 7-3 of [ICEA S-93-639](#).

4.3 The following **Conductor** requirements shall apply:

B/M Number	Number of conductors	Conductor Size	Metal	Number of Strands	Insulation Thickness
D16-03	1/C	1000 kcmil	CU	61	115 mils
D16-05	2/C duplexed	1000 kcmil	CU	61	115 mils

4.4 The following requirements shall apply for single conductor 1000 kcmil cable (D16-03):

Cable						Reels	
Jacket Thickness Mils	Jacket Color	Nominal OD In.	Minimum Bending Radius In.	Max. Pulling Tension lbs.	Wt. Per foot	Reel Number	Linear Feet Per Reel
80	Black	OD**	**			RD1603-01/and seqtl.	TBD

\* Basket Grip Max. Tension = 1000 lbs.

\*\*Sub-contractor to fill this information. However the OD shall be less than 1.8".

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4.5 The following requirements shall apply for duplexed 1000 kcmil cable (D16-05):

<u>Cable</u>						<u>Reels</u>	
Jacket Thickness Mils of each condtr.	Jacket Color	Nominal OD In.	Minimum Bending Radius In.	Max. Pulling Tension lbs.	Wt. Per foot	Reel Number	Linear Feet Per Reel
80	Black	OD**	**			RD1605-01/and seqtl.	TBD

4.6 **Seller to furnish the following data:**

- ◆ **Dimensions (overall Cable, over shield, over insulation, etc. -- for termination selection)**
- ◆ **Weight per foot**
- ◆ **Minimum bending radius**
- ◆ **Maximum Pulling Tension**

4.7 Reels

Each reel shall contain a continuous run of cable without any joints. Exact number of Reels and length per reel will be determined and communicated later based on Seller's input and Purchaser's requirements. Reel footage is based on minimum wastage of cable based on run length of each circuit. Both ends of the cable in each reel shall be made available so that the reel of cable can be subjected to high potential tests.

4.8 Seller shall furnish evidence that the completed cable is free from unacceptable patches, flat spots or other faulty workmanship throughout its length. This may involve re-reeling, calipering and examination of one or more lengths if, in Purchaser's opinion, the situation warrants. Unless specifically stated to the contrary in the Purchase Order, there will be no extra charge to Purchaser for this work.

4.9 The Seller shall verify and certify that duplexed cable is capable of withstanding a) the normal pulse current of 30kA for 1.4 seconds and b) the maximum current of 120kA for 10 cycles, without any damage to the cable or reduction in life of cable, due to the mechanical forces between the conductors.

*Note: If the Seller cannot satisfy this requirement, they may furnish alternatives including two single conductor 1000 mcm cables.*



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## 5. TEST AND ACCEPTANCE CRITERIA

5.1 Seller shall provide documentation that the cable provided meets the requirements of 4.1 e) & g), 4.2 e), f), g), h), & k), and 4.8.

5.2 All cables shall be tested in accordance with [ICEA S-93-639 \(2000\)](#), and [AEIC CS8-00 1<sup>st</sup> Edition](#).

5.3 Vertical tray flame test is required in accordance with Section 2.5 of IEEE-383-1974, using a ribbon type burner. Seller may provide, in lieu of actual flame test, test results previously performed on identical cable configurations.

### 5.4 Factory Inspection

Seller shall inspect cables to verify the minimum lengths specified in Tables 4.4 & 4.5 and to ensure compliance with paragraph 4.7. Inspection results shall be documented and provided to Purchaser.

Tests on completed cables shall be performed on the shipping reel lengths before shipment in accordance with the applicable standards as shown in Paragraph 3. Purchaser shall have the right to witness these tests and reject any portion of the order which does not meet specified requirements. Seller shall furnish certified test reports.

### 5.5 Field Tests

Voltage tests will be performed by the Purchaser on the terminated cables after installation. The cables shall pass these tests when conducted in accordance with the latest applicable ICEA and AEIC Standards. In the event of a failure, Purchaser will ask Seller to join in the investigation to determine the cause of failure. Should failure be determined due to a manufacturing defect, Seller shall be responsible for replacing cable(s) without extra charge to Purchaser.

## 6. QUALITY ASSURANCE

### 6.1 Quality Program Requirements

The end item(s) furnished in compliance with this specification shall be produced under a system of controls which meets the requirements of this subparagraph. Seller's quality assurance program shall be described in a written manual or plan and shall be subject to Purchaser's review and approval prior to start of work.

- a) **Organization:** The Seller's organization, to be represented on an organizational chart, shall demonstrate that personnel responsible for quality assurance functions have sufficient authority and independence to identify quality problems, verify conformance of supplied items to specified requirements, control nonconformance and obtain satisfactory resolution of conflicts involving quality.

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- b) Design Control: Where Seller is responsible for design of item(s) for Purchaser, Seller's Quality Assurance Program shall provide for a system of controls over such design activities. Seller shall implement procedures which provide for review and approval of specifications, drawings and other significant engineering documents, as well as changes thereto, prior to issuance for use. Such reviews shall be conducted to verify completeness, correctness and adequacy with respect to contract requirements and intended application.
- c) Document Control: Seller's Quality Assurance Program shall provide for a system of distribution and control of approved engineering and procurement documents (including specifications, drawings, procedures, purchase order, and other critical documents) as well as changes thereto. Such a system shall provide for control of superseded or voided documents by such means as recall, clearly marking as "VOID", or other effective means of assuring that superseded documents are not inadvertently used.
- d) Procurement: Sellers Quality Assurance Program shall provide for planning and executing of procurement activities in accordance with documented instructions and/or procedures.
  - i. Provisions shall be made for defining the requirements for review of procurement documents and changes thereto, for technical requirements as well as inclusion of appropriate quality assurance requirements.
  - ii. Provision shall be made for method of evaluation and selection of supplier; basis for approval shall be documented.
  - iii. Seller's procurement system shall provide for verification of conformance of purchased items to procurement document requirements. Such verification may be in the form of receipt inspection for simple, non-critical items or in-plant surveillance at the sub-supplier's facilities in the case of complex and/or critical items.
- e) Manufacturing, Inspection, Installation and Test: The seller's Quality Assurance Program shall provide for manufacturing planning, material and process control, inspection and testing, nonconformance control and objective evidence documentation.
  - i. A system of process sheets, shop travelers, or equivalent means shall be used to define the sequence of manufacturing, inspection, installation and test activities to be performed. "Hold" or "witness" points shall be designated on such flow sheets where required by the Purchaser and/or Seller. Flow sheets, or equivalent, shall provide for sign-off by designated inspection

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personnel at specified inspection and test points, to assure completion as well as proper sequencing of required operations.

- ii. Material and equipment identification shall be maintained throughout the manufacturing process, either on the material or equipment, or on records traceable to the material or equipment. Status of acceptability of materials and equipment with respect to inspections and tests shall be readily discernible through the Seller's use of tags, stamps, routing cards or other positive means.
- iii. Inspections and tests shall be performed in accordance with approved written procedures; such procedures shall include or reference criteria for acceptance or rejection. Adequate records shall be maintained of all inspections and tests. These records shall include observations made, inspection or test results (accept or reject) and identification of the inspection or test personnel.
- iv. Inspection and tests shall be performed using properly calibrated measuring and test equipment. Seller's Quality Assurance Program shall describe a system which provides for:
  1. Calibration procedures, including frequency and proper environmental conditions.
  2. Calibration status indicators on measuring and test equipment where physically possible.
  3. Serialization of measuring and test equipment.
  4. Traceability to National Bureau of Standards or equivalent.
  5. Calibration records for all measuring and test equipment as well as reference and transfer standards.
- v. Seller's Quality Assurance Program shall provide for qualification of personnel, equipment, and/or procedures for the performance of certain special processes such as welding, soldering, heat treatment, nondestructive examination, or others as may be required by Contract.
- vi. The Seller shall enforce a system of documentation whereby objective evidence of required inspections, examinations and tests is systematically compiled. Such objective evidence includes material test reports, certifications, inspections, examination and test reports, which shall be complete, legible and validated by responsible Seller's personnel. Documentation shall be traceable to particular material or equipment.

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vii. The Seller's system shall provide for completely documenting the configuration of the delivered end items, using drawing revisions, specification revisions, unique part numbers, or other suitable means.

f) Nonconformance Control

Seller's Quality Assurance Program shall provide for prompt identification and control of nonconforming items. Nonconforming material or equipment shall be positively identified, and segregated where physically possible, to prevent use. Seller shall document the condition, propose a disposition, and obtain Purchaser's concurrence prior to implementing the disposition.

g) Packaging, Shipping and Storage

i. Seller's Quality Assurance Program shall provide for procedures which assure adequate protection of material and equipment during shipment and while in storage. Such protection shall include special environmental packaging requirements where appropriate.

ii. Procedures for packaging and storage shall provide for adequate marking or labeling in order to clearly and readily identify the material or equipment.

iii. Seller's Quality Assurance Program shall provide for adequate control and protection of in-house stores (raw material, parts or components) in order to prevent damage, deterioration or unauthorized use.

h) Audits

Seller's Quality Assurance Program shall provide for planned, periodic audits of the various aspects of the Program by persons not directly responsible for implementation of the area being audited. Such audits are for the purpose of determining compliance with Program requirements as well as determining need for modification of the Program.

### 6.3 Test Procedures

The test procedures required to demonstrate ability to satisfy Contract requirements shall be prepared by Seller and submitted to Purchaser for review and approval prior to use of such procedures.

### 6.4 Manufacturing/Inspection/Test Plan

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Seller shall prepare and submit for Purchaser review prior to fabrication a manufacturing/inspection/test plan for the items to be produced which satisfies the following:

- a) Identification of parts and sub-assemblies showing integrated flow into end item(s).
- b) Identification of critical manufacturing operations as well as inspection and test checkpoints.
- c) Plan may be a single document, or may make use of existing “travelers” or other suitable planning and control documents.
- d) Revisions or changes to the Plan are subject to Purchaser’s review.

### 6.5 Purchaser Witness Points

Purchaser reserves the right to designate, based on the above Plan, selected manufacturing, inspection and/or test operations as “witness” points. Seller shall provide the Purchaser with five (5) working days notice in advance of such witness points.

### 6.6 Special Process Procedures

Seller’s procedures for special processes such as duplexing, shall be available for review by Purchaser.

- 6.7 Instruction Manuals Seller shall provide for Purchaser review, prior to delivery of purchased equipment, copies of required Seller’s instruction manuals for equipment installation, operation, maintenance and repair of the type, format and number of copies as required by the Contract.

### 6.8 Release for Shipment

Prior to any shipment of items, Seller shall obtain a signed "Product Quality Certification and Shipping Release" form from PPPL's Quality Assurance Representative. PPPL reserves the right to refuse to accept shipment unless accompanied by a signed "Shipping Release Form" (See Attachment 1). A full documentation package shall accompany the request for release for shipment.

### 6.9 Documentation Package

The Seller shall provide three complete Documentation Packages, one with the request for Shipping Release and two with the completed item. This package shall be complete, legible, indexed and traceable to the item(s) supplied and shall contain the following, at minimum:

- a) Copies of reports of all required inspections, examinations and tests, properly validated by Seller’s authorized personnel.

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- b) A listing of the as-built configuration of each delivered item; may be defined by use of drawing numbers and revision, unique parts lists or other such means of positive identification.
- c) Copies of material test reports for the conductor and insulation materials, showing mechanical and chemical properties.
- d) A Manufacturing Certificate of Compliance, signed by Seller's Quality Assurance/Control Manager, stating that the supplied item(s) conform in every respect to physical configuration and functional requirements as specified in the Contract.

### 6.10 Progress Reports

The Seller shall furnish biweekly progress reports for the duration of the job. The report shall include any schedule updates and address any quality issues.

### 6.11 Test and Measuring Equipment

Inspections and tests shall be performed using properly calibrated measuring and test equipment. Calibration standards shall be traceable to the National Institute for Standards and Technology (NIST) or equivalent.

## 7. SCHEDULE

Seller shall include design, fabrication, test and delivery schedule with quotation.

## 8. SHIPPING AND HANDLING

SPA to be shipped FOB Destination freight prepaid and included.  
Ship to:

US Department of Energy, C/O  
Princeton Plasma Physics Laboratory  
US Route 1 North,  
Princeton University, Forrestal Campus  
Receiving 3, Princeton, NJ 08543

## 9. WARRANTY

Seller is to state their warranty at the time of quotation.

## 10. DELIVERABLES

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## 10.1 At time of Quotation

### 10.1.1. Technical Proposal and test procedures

Technical proposal shall be submitted with quotation. The following information shall be included, along with any other supporting information to establish that proposed design will conform to requirements of this specification.

- *Acceptance Tests – Objectives & Summary*
- *Exceptions to this specification, along with justification of same*
- *Duplexed cable – Capability to withstand the mechanical forces when a) normal pulsed currents up to 25kA for 3 seconds, and b) currents up to 120kA for 50 milliseconds flows through the conductors.*

### 10.1.2 QA Manual

### 10.1.3 Provisions of standard warranty

### 10.1.4 Schedule

## 10.2 With the request for release for shipment:

### 10.2.1 Documentation package per Par. 6.9

### 10.2.2 Instruction manuals per par. 6.7

## 10.3 With Delivery

### 10.3.1 Documentation package per Par. 6.9 (2 Copies)

### 10.3.2 Product Quality Certification and Shipping Release

PRINCETON UNIVERSITY  
 PLASMA PHYSICS LABORATORY—PPPL

<b>PRODUCT QUALITY CERTIFICATION AND SHIPPING RELEASE</b>					
PROJECT	ITEM DESCRIPTION			SHIPMENT NUMBER	
PPPL SUBCONTRACT/ ORDER NO.	REV.	ITEM NO.	SUPPLIER REFERENCE NO.	REV.	QUANTITY SHIPPED
<u>SUPPLIER'S CERTIFICATION</u>					
<p>This is to certify that the products and services identified herein have been produced under a controlled quality assurance program and are in conformance with the procurement requirements including applicable codes, standards and specifications as identified in the above-referenced documents unless noted below. Any supporting documentation will be retained in accordance with the procurement requirements.</p>					
SIGNED: _____			DATE: _____		
TITLE: _____		COMPANY: _____			
<u>PPPL (AUTHORIZED REPRESENTATIVE) SHIPPING RELEASE</u>					
<p>This is to certify that evidence supporting the above Supplier's Certification statement has been audited and no product/service non-conformances from procurement requirements have been found unless noted below. This product/service is hereby released for shipment.</p>					
<p>This section serves as the Quality Assurance release for the above described product for shipment. It does not constitute an acceptance thereof and does not relieve the Vendor, Manufacturer or Contractor of any and all responsibility or obligation imposed by the purchase contract. It does not waive any rights the Purchaser may have under the purchase contract, including the Purchaser's right to reject the above described material upon discovery of any deviations from requirements of the purchase contract, drawings and specifications.</p>					
NONCONFORMANCES FROM PROCUREMENT QUALITY REQUIREMENTS:					
REMARKS/PRODUCT SERIAL NUMBERS:					
BY PPPL QA REPRESENTATIVE (OR DESIGNEE)				DATE	



Specification  
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