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**PPL EU Requirements For Transmission Connected Facilities
To Be Owned And Operated By PPL EU: Attachment 1**

-2-083-

Revision: -02-

Effective Date: 9/29/2017

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**PPL EU REQUIREMENTS FOR TRANSMISSION CONNECTED
FACILITIES TO BE OWNED AND OPERATED BY PPL EU**

**Attachment 1
Technical Requirements**

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Location Codes	S	0	6	0											Sorts				
Rev	Date	Sponsor	Reviewer	SUBSTATION ENGINEERING INSTRUCTION PPL ELECTRIC UTILITIES CORPORATION															
0	9/19/14	NJM	SEH																
1	7/14/17	GJ	NJM																
2	9/29/17	NJM	LEL																
				Approved _____ Yves Nembo Mgr. Standards															



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Record of All Issued Revisions

Revision	Page(s)	Section(s)	Description	Issue Date
0	All	All	Initial Issue	9/19/14
1	6, 7, 8	6, 9, 10	Updated PJM references. General formatting corrections. Spacing and Clearances Table updated	7/14/17
2	10	10	Updated language regarding perimeter fences to "Perimeter Security System"	9/29/17

Distribution:

1. RC 0880 – T&S Standards
2. RC 0883 – Substation Engineering
3. RC 0601 – T&S Asset Management
4. RC 0878 – T&S System Engineering



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For all PDF documents refer to latest copy on PJM's website

- 1. Introduction - Technical Requirements and Design Philosophy (06.2002) (PDF)**
- 2. Transmission System Design Criteria (11.2001) (PDF)**
- 3. Substation Bus Configuration and Substation Design Requirements (06.2002) (PDF)**

Section B. Functional Criteria

- Item 5 should reference historic or grandfathered facilities only. Current PPL design standards require at least one breaker between the generation and the utility owned facilities.
- Item 6, this requirement effectively eliminates the use of a 3 breaker ring bus design, as any line dead-end termination failure will fall across a 'bus' element, and effectively remove another line from service.
- Item 8, where the balancing of generation and load across a bus would result in excessive line crossings, the bus should be upgraded, if necessary, to allow the generation to be placed with minimal line crossings.

Section C. Substation Arrangement

- Item 1, Accessibility and Layout, 3rd bull dot, in a 3 breaker ring bus, the catastrophic failure of any single breaker will require the tripping of the remaining two breakers. Physical separation should be adequate to prevent damage to other equipment, and motor operated disconnects should be provided to isolate failed equipment and restore undamaged equipment and lines to service.
- Item 1, Accessibility and Layout, 4th bull dot, the roadways must also incorporate sufficient turning radius for the equipment required to maintain the facilities.
- Item 5, Raceways, 4th bull dot, the raceways must be located in a manner to limit coupling to associated high voltage lines or buses. See item 7 with regard to control cubicle location.

4. Spare Equipment Philosophy (02.1999) (PDF)

5. Design, Application, Maintenance, and Operation Technical Requirements

NOTE: in some cases the PPL EU standard design goes beyond the PJM design. In these cases, a note has been included below to contact PPL EU to clarify the specific requirement.

- a. PJM Design and Application of Overhead Transmission Lines (01.2002) (PDF)
- b. PJM Design and Application of Power Cables (03.2002) (PDF)
- c. PJM Design and Application of Large Power Transformers (06.2002) (PDF)
- d. PJM Design and Application of Circuit Breakers (06.2002) (PDF)
- e. PJM Design and Application of Load Interrupting Switches (Circuit Switches) (06.2002) (PDF)
- f. PJM Design and Application of Disconnects and Switches (06.2002) (PDF)
- g. PJM Design and Application of Shunt Capacitors (08.1999) (PDF)
- h. PJM Design and Application of Instrument Transformers (02.1999) (PDF)
- i. PJM Design and Application of AC Station Service (06.1999) (PDF)
- j. PJM Design and Application of Substation Batteries and Chargers (04.1999) (PDF) The current PJM document is not clear on:
- k. The 8 hour minimum load capability, PPL EU uses 24 hour capability for Bulk Power facilities (230 kV and above).
- l. The initial battery is sized for the expected FUTURE facility arrangement during the lifetime of the battery, typically 20 years.
- m. PPL EU safety and operation requirements include:
 - Suitable covers over the terminals of racked batteries.
 - Center point DC breaker, with alarm contacts
 - Specific DC alarms and DC system monitoring
 - See section 11.8 below

- n. PJM Design and Application of DC Substation Service (06.1999) (PDF)
- o. Substation Operation and Maintenance (12.2003) (PDF)
- p. PJM Design and Application of Carrier Current Line Traps (06.2002) (PDF)
- q. PJM Insulation Coordination and Surge Protection (06.2002) (PDF) Refer to table 2 in section 3 below.
- r. PJM Relay and Control Building Requirements (06.2004) (PDF) See section 8 below

6. Rating Guides

- a. Bare Overhead Transmission Conductor Ratings (03.2012) (PDF) - Contact PPL EU for confirmation of bare overhead conductor ratings.
- b. Power Transformers (03.2012) (PDF) - Contact PPL EU for current specification.
- c. Circuit Breakers (03.2012) (PDF) - Contact PPL EU for current specification.
- d. Air Disconnect Switches (03.2012) (PDF) - Contact PPL EU for current specification.
- e. Outdoor Substation Conductor Ratings (103.2012) (PDF) - Contact PPL EU for confirmation of bare overhead conductor ratings.
- f. Current Transformers (003.2012) (PDF)
- g. Line Traps (003.2012) (PDF)

7. Installation and Commissioning (12.2003) (PDF)

8. Inspection, Testing and Acceptance (12.2003) (PDF)

Annexes

- A. System Phasing Diagrams (01.2002) (PDF)
- B. Definitions (06.2002) (PDF)



9. Protection and Control

The PJM Relay Subcommittee (Relay-sub) posted documents shall be followed in design of protection and control systems. These documents are posted on the PJM website.

PPL has recently updated our standard protective relaying requirements for Bulk Power Facilities. Specifically these requirements deal with:

- Approved relay vendors and models
- Approved routers and communication equipment
- Approved communications processors
- Approved substation computers
- The overall interconnection of all of the above equipment
- The required software and settings for all of the above equipment

Due to Cyber Security concerns, some aspects of this design will be either entirely by PPL EU or the final programming will be by PPL EU. Please contact PPL EU to discuss further.

Facilities associated with generation in excess of 250 MVA will also need to have a Digital Fault Recorder installed. PPL EU will advise if this equipment will be programmed for PMU capability.



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10. PPL Standard BIL, Spacings, and Clearances

Operating kV	500	230	138	69
Rated Maximum Voltage	550	245	145	72.5
Basic Impulse Insulation Level (BIL) kV	1550	900 ¹	550	350
Rigid Bus	1550	900	550	350
Disconnecting Switches	1550	900	550	350
Circuit Breakers	1800	900	650	350
Transformers	1425 ²	750	450	350
Current Transformers	1800	1050	650	350
Potential Transformers / CCVTs	1800	1050	650	350
Capacitor Banks	1800	900	650	350
Surge Arresters				
Nameplate rating ² in kV (duty cycle)	396	180	132/108	72
MCOV	318	144	104/84	57
Spacings				
Phase-to-Phase (inches)				
Rigid Bus	300"	144"	96"	96"
Strain Bus	N/A	180"	120"	120"
Bay conductors and disconnect switches	300"	144"	96"	96"
Minimum Clearance ³ for Rigid Parts (inches)				
Phase-to-Phase	216"	99"	63"	63"
Phase-to-Ground	144"	82"	50"	50"
Temporary Closeness (conductor swing)	110"	49"	29"	29"
Minimum Clearance for live parts (feet)				
to grade inside substation	20.5	13.75	11.7	11.7
to roadway inside substation	26	23	20.5	20.5
to perimeter security system (*per NESC)	20*	15*	15*	15*
¹ Use 1050kV BIL tie bus insulators at old stations				
² Arrester ratings are for metal oxide varistor (MOV) types only. Stations with extensive underground cable or shunt capacitor banks shall be evaluated individually.				
³ Clearance is the metal-to-metal distance between conducting parts.				