



TP-7000-23

VOLTAGE CRITERIA and VOLTAGE CONTROL on the BULK ELECTRIC SYSTEM (BES)

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Table of Contents

Revision History	i
1.0 Purpose	1
2.0 Voltage Criteria	1
2.1 Steady-state and Post-contingency Voltage Limits	1
2.2 Post-contingency Voltage Deviations	1
2.3 Transient Voltage Response	1
3.0 Voltage Control Rules	2

Revision History

Version	Date	Revisions
23	12/13/2019	Section Voltage Control Rules <ul style="list-style-type: none"> ➤ Eastview 138 kV Shunt Reactor R1 (Priority 1) was permanently retired ➤ The Priority of the Gowanus 345 kV Shunt Reactor R16 was changed from 1 to 2
22	05/15/2019	Section Voltage Control Rules <ul style="list-style-type: none"> ➤ Dunwoodie South 345/138 kV transformer S1 does not have workable LTC ➤ Fixed title of Table 4
21	02/22/2019	Section Voltage Control Rules <ul style="list-style-type: none"> ➤ East 13th Street 345/138 kV transformers 10 and 11 were replaced with a workable LTC ➤ East 13th Street 138/69 kV transformer 112 is currently unavailable for voltage control ➤ Farragut 345 kV Shunt Reactor R11 is currently unavailable for voltage control
20	12/14/2018	Section Voltage Control Rules <ul style="list-style-type: none"> ➤ Eastview 138 kV Shunt Reactor R3 (Priority 3) was permanently retired as a result of internal failure evidenced by high combustible gases.
19	05/09/2018	Section Voltage Control Rules <ul style="list-style-type: none"> ➤ The Priority of the Eastview 138 kV Shunt Reactor R3 was changed from 1 to 3

Version	Date	Revisions
18	01/03/2018	Section Voltage Control Rules <ul style="list-style-type: none"> ➤ Note 2, pertaining to Dunwoodie Shunt Reactor R1, was removed since the delayed tripping scheme is always in service for breakers 2N and 3N at the Dunwoodie North 138 kV substation ➤ The prior Note 3 became Note 2, and so forth... ➤ New Note 4, pertaining to Sprain Brook Shunt Reactor S6A was expanded to provide more operational clarity
17	04/01/2017	Section Voltage Control Rules <ul style="list-style-type: none"> ➤ The Priority of the Pleasantville 345 kV Shunt Reactor R1 was changed from 2 to 1 ➤ Note 1 that was associated with the Pleasantville Shunt Reactor R2 was updated and is applicable to Shunt Reactor R1
16	11/04/2016	Global <ul style="list-style-type: none"> ➤ The information contained within TP-7000 has been benchmarked against SO16-1 <i>Voltage Control – Bulk Power System</i> and all duplications have been removed from this revision of TP-7000 ➤ Revision 16 of TP-7000 addresses Voltage Criteria and Voltage Control Rules utilized in the <u>design</u> of the Con Edison Bulk Electric System (BES)
15	09/29/2016	Global <ul style="list-style-type: none"> ➤ References to a retired Specification TP-4292 have been removed ➤ Section's # (i.e. extra 4.0) has been fixed
14	09/09/2016	Global <ul style="list-style-type: none"> ➤ Designation "EP-7000" changed to "TP-7000" ➤ The overall template of the specification has been changed Section Revision History <ul style="list-style-type: none"> ➤ Added a new Section: <i>Revision History</i>

1.0 Purpose

This document specifies, for the Con Edison Bulk Electric System (BES), the criteria for steady-state and post-contingency voltage limits, post-contingency voltage deviations and transient voltage response. In addition, this document lists voltage control rules utilized in the design of the Con Edison BES.

2.0 Voltage Criteria

2.1 Steady-state and Post-contingency Voltage Limits

Voltages on the Bulk Electric System (BES) must satisfy both steady-state and post-contingency limits, as follows:

Minimum: 500 kV (1.00 p.u.) < **500 kV system** < Maximum: 550 kV (1.10 p.u.)
Minimum: 328 kV (0.95 p.u.) < **345 kV system** < Maximum: 362 kV (1.05 p.u.)
Minimum: 219 kV (0.95 p.u.) < **230 kV system** < Maximum: 242 kV (1.05 p.u.)
Minimum: 131 kV (0.95 p.u.) < **138 kV system** < Maximum: 145 kV (1.05 p.u.)

In addition, voltages on the non-BES 69 kV electric system must satisfy both steady-state and post-contingency limits, as follows:

Minimum: 65.6 kV (0.95 p.u.) < **69 kV system** < Maximum: 72.5 kV (1.05 p.u.)

2.2 Post-contingency Voltage Deviations

The voltage deviation must be such that the post-contingency voltage remains within the applicable voltage limits. The permissible voltage deviation is from pre-contingency voltage to the post-contingency voltage limit.

2.3 Transient Voltage Response

The transient voltage must recover to 0.9 per unit of the nominal voltage within 5 seconds after a fault has cleared. This criterion excludes conditions where a fault reoccurred (restrike) within this 5 second period.

3.0 Voltage Control Rules

For design purposes of the Con Edison Bulk Electric System (BES), the following voltage control rules are utilized (these rules are also applicable to the non-BES 69 kV electric system):

1. Manual load shedding or implementation of voltage reduction is not permitted.
2. All available generation resources can be committed and dispatched in order to obtain additional reactive power (Mvar) control.
3. Generator terminal voltages can be adjusted within the range of 0.95 to 1.05 per unit.
4. Generator Step-up (GSU) transformers equipped with Load-Tap-Changers (LTC) can be used to control voltage. On the Con Edison BES, Table 1 lists GSU transformers that are equipped with LTC.

Table 1: GSU equipped with LTC

Substation	Generator	GSU Transformer
Astoria West 138 kV	Astoria 3	3N
		3S
	Astoria 5	5S
		5N
Astoria East 138 kV	Astoria 3	3S
	Astoria 5	5S
		5N
Vernon 138 kV	Ravenswood 1	1W
		1E
	Ravenswood 2	2S
		2N
Fresh Kills 138 kV	Arthur Kill 2	N
		S

5. GSU no-load (fixed) tap settings shall not be adjusted. If an adjustment could potentially address an identified violation a separate analysis shall be conducted per Specification TP-7720.

6. BES transformers equipped with Load-Tap-Changers (LTC) can be used to control voltage. On the Con Edison BES Tables 2 and 3 list transformers that are equipped with LTC.

Table 2: BES transformers equipped with LTC

Substation	Autotransformer	Associated Feeder
Ramapo 345 kV	1500	5018
Buchanan 345 and 138 kV	TA5	95891
Millwood 345 and 138 kV	TA1	96921
	TA2 does not have LTC	96922
Sprain Brook 345 kV and 138 kV	S6	99941
	N7	99942
Dunwoodie 345 kV and 138 kV	S1 does not have LTC	W73
	N1	W74
Academy 345 kV	T1	331
	T8	332
Tremont 345 kV	11	X28
	12	
Rainey 345 kV	5E	36187
	8W	36312
	8E	36311
West 49 th Street 345 kV	1 ⁽¹⁾	38M72
Astoria Annex 345 kV	TR-1	34091
Farragut 345 kV	8: "x" winding	32078
	9: "x" winding	32711
	10: "x" winding	32077
East 13 th Street 345 kV and 138 kV	10	37376
	11	37377
	12	37372
	13	37373
	14	37374
	15	37375
	16	37378
	17 (non-BES)	44371L/M
	111 (non-BES)	37041
	112 - Unavailable	37042
	113 (non-BES)	37043
	114 (non-BES)	37044
	9 ⁽²⁾ (non-BES)	44372

Note (1): West 49th Street 345 / 138 kV transformer No. 1 shall not be utilized for the sole control of the Vernon 138 kV substation voltage; loading balance on the West 49th Street 345/138 kV transformers 1, 2, 3, 4 and 5 shall be maintained.

Note (2): East 13th Street 138 / 69 kV transformer No. 9 is associated with an Emergency Tie 44372; a feeder normally modeled as out-of-service.

Table 3: BES transformers equipped with LTC

Substation	Autotransformer	Associated Feeder
Gowanus 345 kV	T2	42231
	T14	42232
Goethals 345 kV	1N	A2253
Fresh Kills 345 kV and 138 kV	TA1 does not have LTC	21191
	TB1 does not have LTC	21192

7. SVC and FACTS devices will be set to 0 Mvar pre-contingency and allowed to operate to their full reactive range post-contingency.
8. The East Fishkill 345 kV Shunt Capacitors (C1 and C2; 135 Mvar each) and the Millwood 345 kV Shunt Capacitors (C1 and C2; 120 Mvar each) may be removed or placed in-service to assist in maintaining adequate BES voltages.
9. Con Edison area station Shunt Capacitors may be removed to assist in maintaining adequate BES voltages for off-peak load conditions only.
10. Priority 1 Shunt Reactors shall be modeled in-service for all conditions. The Priority 2 and Priority 3 Shunt Reactors may be removed or placed in-service to assist in maintaining adequate BES voltages. Priority 4 Shunt Reactors shall be modeled as out-of-service for all conditions, except system restoration. The Con Edison Shunt Reactor priority list is as follows:

Priority 1: Shunt Reactors must be in-service at all times (however, for operating purposes, System Operations can decide to switch out).

Priority 2: Shunt Reactors must generally be in-service, but may be removed as required for voltage support (some risk involved).

Priority 3: Shunt Reactors may be switched in-service or out-of-service as required for voltage control.

Priority 4: Shunt Reactors on transformer tertiary shall be used only for system restoration purposes (however, for operating purposes, System Operations can decide to switch in).

Table 4: Shunt Reactor Priority List

Priority	Substation	Reactor ID	Associated Feeder	Mvar (Nameplate)
1	Eastview 138 kV	R2	38W32	40
		R4	38W34	40
	Gowanus 345 kV	R4	41	150
	Pleasantville 345 kV	R1 ^{Note 1}	Y86 (F38)	20
2	Pleasantville 345 kV	R2	W90 (W74)	20
	Gowanus 345 kV	R16	42	150
	Dunwoodie 345 kV	R1	Y50	150
	Sprain Brook 345 kV	2N1 ^{Note 2}	Y49	150
		2N2 ^{Note 2}		150
		4S1 ^{Note 3}	M52	150
		4S2 ^{Note 3}		150
	Sprain Brook 345 kV	5S1 ^{Note 3}	M51	150
		5S2 ^{Note 3}		150
	Rainey 345 kV	1E	Q11	150
		5W	Q12	150
	Farragut 345 kV	R11 - Unavailable	B3402	60
		R12	B44 (C3403)	60
	Astoria Annex 345 kV	R1	Q35L (44371L/M)	150
		R2	Q35M (37376)	150
	Goethals 345 kV	R25	25	150
		R26 (FIXED)	26	150
3	Sprain Brook 345 kV	S6A ^{Note 4}	X28	150
	East 179 th Street 138 kV	5W	Bus Section 5W	75
		6E	Bus Section 6E (15155)	75
	Greenwood 138 kV	2S	42231	75
		3N	42232 (42G13)	75
	Goethals 345 kV	TN-1 ^{Note 5}	A2253 (Transformer 1)	70
		TN-2 ^{Note 5}	A2253 (Transformer 1)	70
4	Rainey 345 kV	2E	Transformer 2E	67.5
		7E	Transformer 7E	67.5
		8E	Transformer 8E	67.5
		8W	Transformer 8E	67.5
	East 13 th Street 345 kV	T-11	Transformer 11	76.8
		T-13	Transformer 13	76.8
		T-14	Transformer 14	76.8

- Note 1: If Pleasantville 345 kV Breaker B1 delayed tripping scheme is not in-service then Priority should be 1. The delayed tripping scheme is intended to be used for the Pleasantville 345 kV Breaker 1 whenever Shunt Reactor R1 is out of service on a long-term outage. If the delayed tripping scheme is in-service then Priority should be 2.
- Note 2: If Y49 series reactor R49 is out of service, then only East Garden City 345 kV Shunt Reactors R3 and R4 are required to be in-service. If Y49 series reactor is in-service, then in addition to East Garden City 345 kV Shunt Reactors R3 and R4 either Sprain Brook 345 kV Shunt Reactor 2N1 or 2N2 is required to be in-service. Whichever Sprain Brook 345 kV Shunt Reactor is used (2N1 or 2N2) becomes Priority 1.
- Note 3: If M51, M52, 71 and 72 series reactors are out-of-service, the Priority becomes 3.
- Note 4: If delayed tripping scheme for Sprain Brook 345 kV breakers RNS6, RS6, or RSB6 is not in-service, then Priority should be 1. If delayed tripping scheme is in-service, then Priority is 3. The delayed tripping scheme is intended to automatically delay tripping for 345 kV breakers RNS6, RS6, and RSB6 so that Shunt Reactor S6A can be taken out of-service.
- Note 5: Existing feeder A2253 end surge arresters at Goethals and PSEG limit over-voltages. If surge arresters are out-of-service, at least 1 Shunt Reactor on the A2252 Transformer 1 tertiary becomes Priority 1.

11. Voltage can be controlled by adjusting Phase Angle Regulators (PARs). Reactive power drops off quickly as it travels across high impedance paths, so from a voltage control view, voltage can be increased when the highest impedance paths have the lowest current flowing across them or voltage can be decreased when the highest impedance paths have the highest current flowing across them.
12. BES elements shall not be removed from service for the purpose of voltage control.
13. Con Edison and its neighboring Transmission Planners and/or Transmission Owners are each entitled to one-half of the reactive requirement of a tie-line. The reactive requirement is based on the line charging and the Mvar losses associated with power transfer across a tie-line.
14. Series Reactors shall not be by-passed, or placed in-service, for the sole purpose of voltage control. The status of the Series Reactors shall be based on the appropriate Series Reactor Operating Protocol.