OSHA 269 Transient Overvoltage Consideration

Transmission Transient Overvoltage

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Overview

OSHA 269 Background

Study Objectives

EMTP-RV Modeling Considerations

Mitigation

Definition of Arc-Flash and TOV

- *Electric Arc-Flashover* is defined as the passage of current between two electrodes through ionized gasses and vapors
- *Transient Overvoltage*- is defined voltage peak for a short duration commonly caused by switching and lightning strikes

Applicable Standards

- **OSHA 269-** Electric Power Generation, Transmission and Distribution
- **IEEE Standard 516-2003** - Guide for Maintenance Methods on Energized Power Lines
- **IEEE Standard 4-1995** – Standard Techniques for High Voltage

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Minimum Approach Distance vs Working Distance

OSHA 269 "The revised provisions on minimum approach distances include a requirement for the employer to determine maximum anticipated per-united transient overvoltages through an engineering analysis or, as an alternative, assume certain maximum anticipated per-unit transient overvoltages.

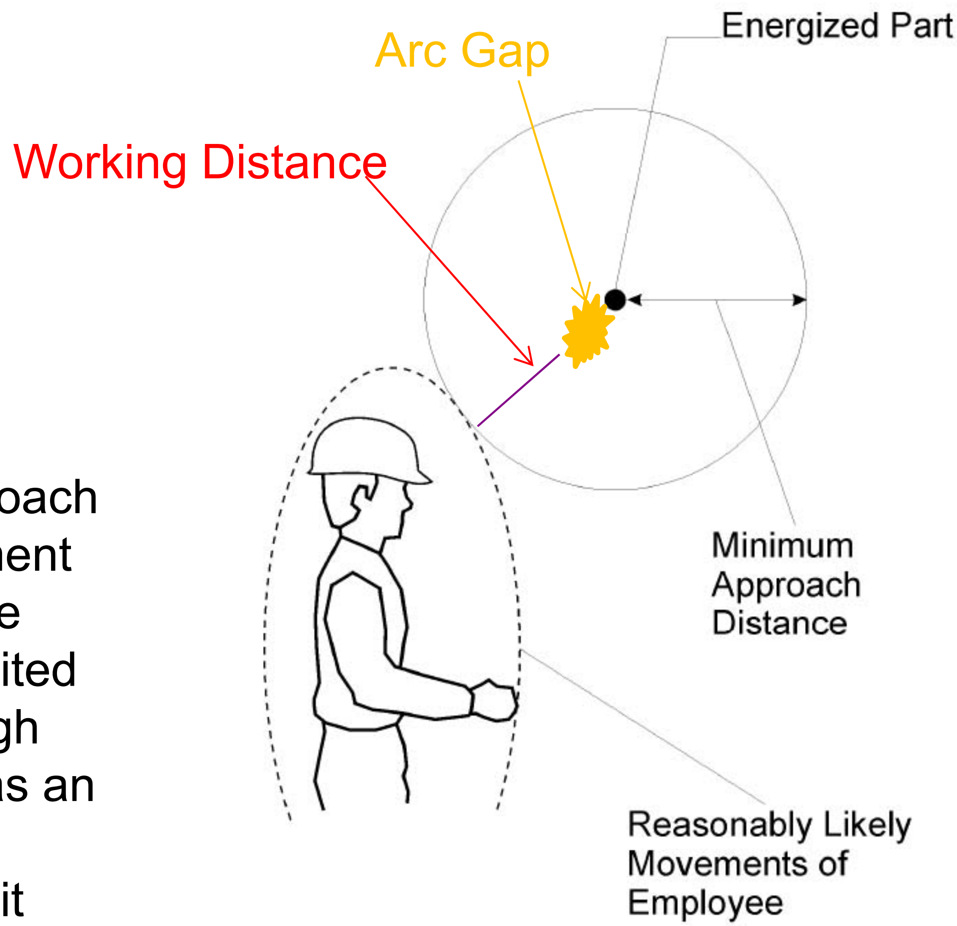

Figure 1—Maintaining the Minimum Approach Distance

Arc Flash Working Distance

Table 13—Selecting a Reasonable Arc Gap

Class of Equipment	Single-Phase Arc mm (inches)	Three-Phase Arc mm[1] (inches)
Cable	NA[2]	13 (0.5)
Low voltage MCCs and panelboards	NA	25 (1.0)
Low-voltage switchgear	NA	32 (1.25)
5-kV switchgear	NA	104 (4.0)
15-kV switchgear	NA	152 (6.0)
Single conductors in air, 15 kV and less	51 (2.0)[3]	Phase conductor spacing
Single conductor in air, more than 15 kV	Voltage in kV times 2.54 (0.1), but no less than 51 mm (2 inches)[3]	Phase conductor spacing

[1]Source: IEEE Std 1584a-2004.

[2]"NA" = not applicable.

[3]Table 6 of Appendix E of final Subpart V uses a more conservative arc gap that equals the electrical component of the minimum approach distance rather than a value corresponding to the dielectric strength of air for the system voltage, which forms the basis for the values in this table.

Table 14—Selecting a Reasonable Distance from the Employee to the Arc

Class of Equipment	Single-Phase Arc mm (inches)	Three-Phase Arc mm (inches)
Cable	NA*	455 (18)
Low voltage MCCs and panelboards	NA	455 (18)
Low-voltage switchgear	NA	610 (24)
5-kV switchgear	NA	910 (36)
15-kV switchgear	NA	910 (36)
Single conductors in air (up to 46 kilovolts), work with rubber insulating gloves	380 (15)	NA
Single conductors in air, work with live-line tools and live-line barehand work	$MAD-(2\times kV\times 2.54)$ $(MAD-(2\times kV/10))^{\dagger}$	NA

*"NA" = not applicable.

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Safety(MAD) Working Distance Comparison

Voltage	Mid Sized IOU Present Distance (ft)	OSHA Calculated Phase to Ground (ft)	OSHA Calculated Phase to Phase (ft)	OSHA TOV Recommendation PU
12kV	2.16	2.13	2.23	
69kV	3.16	3.28	3.94	
138kV	3.58	4.30	5.40	3.5
230kV	5.25	5.60	8.40	3.5
500kV	11.25	16.6	27.00	3.0

Table V-8, which specifies the following maximums for ac systems:

72.6 to 420.0 kilovolts	3.5 per unit
420.1 to 550.0 kilovolts	3.0 per unit
550.1 to 800.0 kilovolts	2.5 per unit

Notes to Table 7 through Table 14:

1. The employer must determine the maximum anticipated per-unit transient overvoltage, phase-to-ground, through an engineering analysis, as required by §1926.960(c)(1)(ii), or assume a maximum anticipated per-unit transient overvoltage, phase-to-ground, in accordance with Table V-8.

2. For phase-to-phase exposures, the employer must demonstrate that no insulated tool spans the gap and that no large conductive object is in the gap.

3. The worksite must be at an elevation of 900 meters (3,000 feet) or less above sea level.

TOV Approach Distances-121.1 to 145.0 kV

Table 8—AC Minimum Approach Distances—121.1 to 145.0 kV

T (p.u.)	Phase-to-Ground Exposure		Phase-to-Phase Exposure	
	m	ft	m	ft
1.5	0.74	2.4	0.95	3.1
1.6	0.76	2.5	0.98	3.2
1.7	0.79	2.6	1.02	3.3
1.8	0.82	2.7	1.05	3.4
1.9	0.85	2.8	1.08	3.5
2.0	0.88	2.9	1.12	3.7
2.1	0.90	3.0	1.15	3.8
2.2	0.93	3.1	1.19	3.9
2.3	0.96	3.1	1.22	4.0
2.4	0.99	3.2	1.26	4.1
2.5	1.02	3.3	1.29	4.2
2.6	1.04	3.4	1.33	4.4
2.7	1.07	3.5	1.36	4.5
2.8	1.10	3.6	1.39	4.6
2.9	1.13	3.7	1.43	4.7
3.0	1.16	3.8	1.46	4.8
3.1	1.19	3.9	1.50	4.9
3.2	1.21	4.0	1.53	5.0
3.3	1.24	4.1	1.57	5.2
3.4	1.27	4.2	1.60	5.2
3.5	1.30	4.3	1.64	5.4

TOV Approach Distances-169.1 to 242.0 kV

Table 10—AC Minimum Approach Distances—169.1 to 242.0 kV

T (p.u.)	Phase-to-Ground Exposure		Phase-to-Phase Exposure	
	m	ft	m	ft
1.5	1.02	3.3	1.37	4.5
1.6	1.06	3.5	1.43	4.7
1.7	1.11	3.6	1.48	4.9
1.8	1.16	3.8	1.54	5.1
1.9	1.21	4.0	1.60	5.2
2.0	1.25	4.1	1.66	5.4
2.1	1.30	4.3	1.73	5.7
2.2	1.35	4.4	1.81	5.9
2.3	1.39	4.6	1.90	6.2
2.4	1.44	4.7	1.99	6.5
2.5	1.49	4.9	2.08	6.8
2.6	1.53	5.0	2.17	7.1
2.7	1.58	5.2	2.26	7.4
2.8	1.63	5.3	2.36	7.7
2.9	1.67	5.5	2.45	8.0
3.0	1.72	5.6	2.55	8.4
3.1	1.77	5.8	2.65	8.7
3.2	1.81	5.9	2.76	9.1
3.3	1.88	6.2	2.86	9.4
3.4	1.95	6.4	2.97	9.7
3.5	2.01	6.6	3.08	10.1

TOV Approach Distances-420.1 to 550.0 kV

Table 13—AC Minimum Approach Distances—420.1 to 550.0 kV

T (p.u.)	Phase-to-Ground Exposure		Phase-to-Phase Exposure	
	m	ft	m	ft
1.5	1.95	6.4	3.46	11.4
1.6	2.11	6.9	3.73	12.2
1.7	2.28	7.5	4.02	13.2
1.8	2.45	8.0	4.31	14.1
1.9	2.62	8.6	4.61	15.1
2.0	2.81	9.2	4.92	16.1
2.1	3.00	9.8	5.25	17.2
2.2	3.20	10.5	5.55	18.2
2.3	3.40	11.2	5.86	19.2
2.4	3.62	11.9	6.18	20.3
2.5	3.84	12.6	6.50	21.3
2.6	4.07	13.4	6.83	22.4
2.7	4.31	14.1	7.18	23.6
2.8	4.56	15.0	7.52	24.7
2.9	4.81	15.8	7.88	25.9
3.0	5.07	16.6	8.24	27.0

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TOV Approach Distances-550.1 to 800.0 kV

Table 14—AC Minimum Approach Distances—550.1 to 800.0 kV

T (p.u.)	Phase-to-Ground Exposure		Phase-to-Phase Exposure	
	m	ft	m	ft
1.5	3.16	10.4	5.97	19.6
1.6	3.46	11.4	6.43	21.1
1.7	3.78	12.4	6.92	22.7
1.8	4.12	13.5	7.42	24.3
1.9	4.47	14.7	7.93	26.0
2.0	4.83	15.8	8.47	27.8
2.1	5.21	17.1	9.02	29.6
2.2	5.61	18.4	9.58	31.4
2.3	6.02	19.8	10.16	33.3
2.4	6.44	21.1	10.76	35.3
2.5	6.88	22.6	11.38	37.3

MAD Equations

C. Voltages of 72.6 to 800 kilovolts. For voltages of 72.6 kilovolts to 800 kilovolts, this subpart bases the electrical component of minimum approach distances, before the application of any altitude correction factor, on the following formula:

Equation 1— For voltages of 72.6 kV to 800 kV

$$D = 0.3048(C + a)V_{L-G}T$$

Where:
- D = Electrical component of the minimum approach distance in air in meters;
- C = a correction factor associated with the variation of gap sparkover with voltage;
- a = A factor relating to the saturation of air at system voltages of 345 kilovolts or higher;[4]
- V_{L-G} = Maximum system line-to-ground rms voltage in kilovolts—it should be the "actual" maximum, or the normal highest voltage for the range (for example, 10 percent above the nominal voltage); and
- T = Maximum transient overvoltage factor in per unit.

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OSHA 269-Employee to the ARC

Voltage	OSHA Single-Phase Arc inches	Mid Size IOU Single-Phase Arc inches
34.5 kV	15.0	N/A
69 kV	31.4	37.9
115 kV	31.1**	N/A
138 kV	35.6	27.0
230 kV	52.6	36.4
500 kV	141.4	111.3

Notes:
*Single conductors in air, work with live-line tools and live-line, bare-hand work
MAD −(2×kV ×2.54)
(MAD − (2 × kV /10))
**Used 69 kV working distances

Study Objectives

- Meet regulatory requirements (OSHA 269)
- Use available resources to determine hazard levels
- Evaluate hazard reduction methods
- Provide basis for Utilities to:
  - Develop operating procedures
  - Determine equipment needs

#1 Goal: Employee Safety

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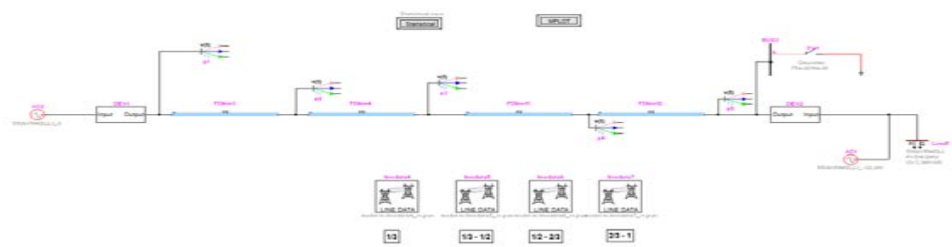
Network Model

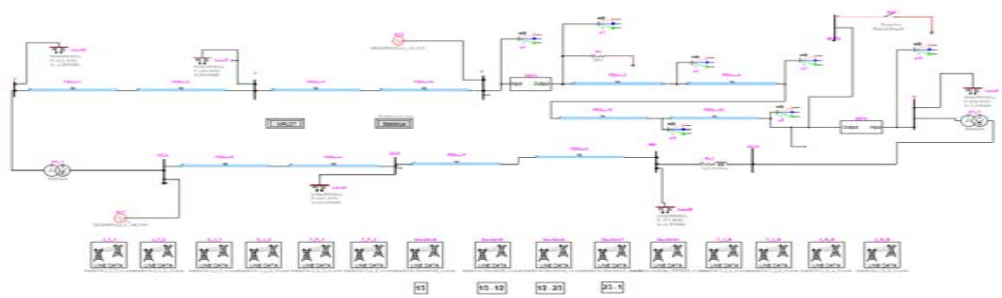
- PSSE or PSLF
  - In order to obtain the equivalent generation and load
- CAPE or Aspen
  - In order to obtain line constant data
- Topology in EMTP-RV
  - How much to model in EMTP-RV

Network Model

- Simple Model



- Loop Model

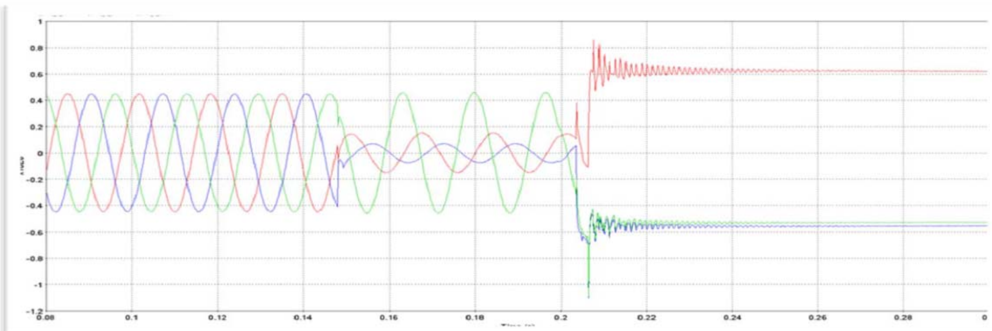


Type of studies and Assumptions

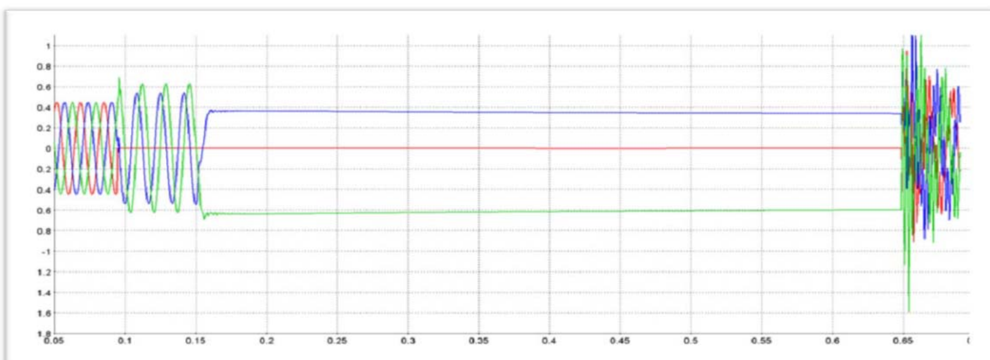
- Measurement
  - Local or remote of the substation
  - Different lengths of the line
- Scenarios
  - Single-Line-to-Ground (SLG)
  - Double-Line-to-Ground (DLG)
  - Line De-energization
  - Reclose and Non-Reclose

Type of studies and Assumptions

- DLG Fault – Measurement at line side – Voltage reach 2.42pu



- SLG Fault with 30 Cycles reclose– Measurement at line side – Voltage reach 3.55pu



TOV Approach Distances-420.1 to 550.0 kV

Table 13—AC Minimum Approach Distances—420.1 to 550.0 kV

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2.0	2.81	9.2	4.92	16.1
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2.2	3.20	10.5	5.55	18.2
2.3	3.40	11.2	5.86	19.2
2.4	3.62	11.9	6.18	20.3
2.5	3.84	12.6	6.50	21.3
2.6	4.07	13.4	6.83	22.4
2.7	4.31	14.1	7.18	23.6
2.8	4.56	15.0	7.52	24.7
2.9	4.81	15.8	7.88	25.9
3.0	5.07	16.6	8.24	27.0

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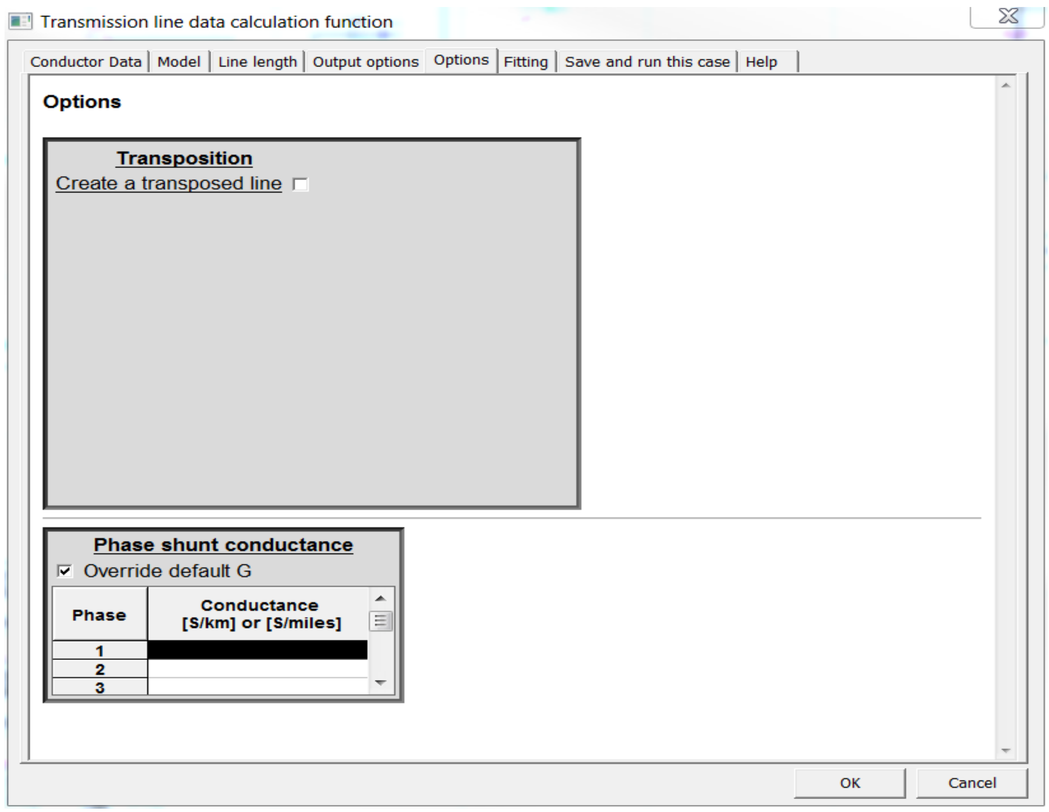
Shunt Conductance

– EMTP-RV default value: 2*10E-10 S/Km



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Mitigation

- High TOV may require some mitigation
  - Review the high-speed reclose time and the need of it
  - Consider installations of line arresters
  - Consider pre-insertion resistor
  - Utility can change transmission system to mimimize the effect of switching operations
- All mitigations need to be evaluate to determine the best approach for each scenario

Questions?

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