

Balloon Safety in the Sky: Testing and Evaluating Dielectric Performance in Contact with Overhead Power Lines

Christian Henderson, Dean Borchardt, & Anil Poda
Members of IEEE PES DRWG Task Force for IEEE P2845

Agenda

- Problem Statement
- What is IEEE 2845?
- Powerline design review
- How does a balloon affect the powerline?
- Balloons
- Review of the standard
 - Testing apparatus
 - Test specimen
 - Sampling
 - Testing method
 - Acceptance criteria
 - Marking
- Status of the standard

Problem Statement

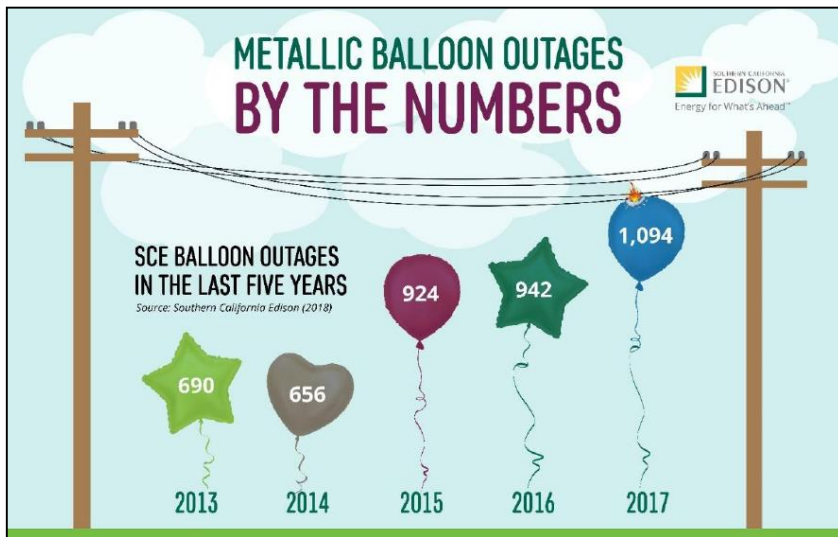


Figure 1 – 2019 GB DRWG Presentation

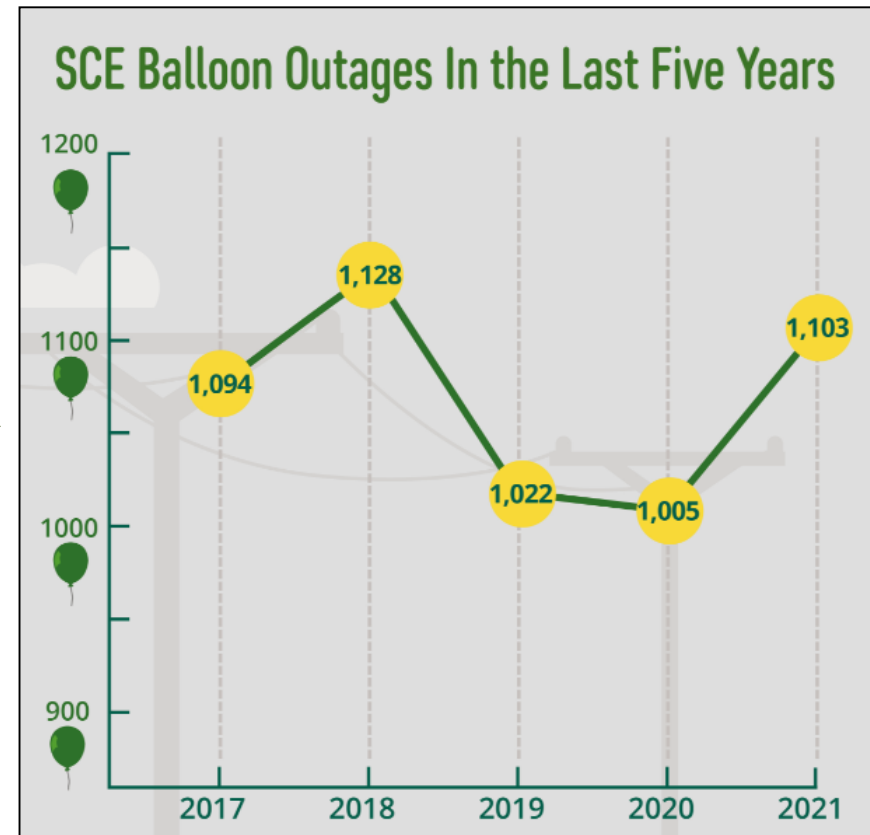


Figure 2 – 2022 Data

<https://energized.edison.com/stories/metallic-balloon-hazards-graduate-too-from-bad-to-worse>

Problem Statement

In 2021, metallic balloons that drifted into PG&E power lines caused more than 600 outages, a **27 percent increase** from the previous year and the highest number of balloon-related outages that PG&E has seen in a decade.

- https://www.pge.com/en_US/about-pge/media-newsroom/news-details.page?pageID=19db7e8c-2975-4a8e-bdb2-e9c1a0ddd14f&ts=1644863643108

PG&E had 21 ignitions in 2019, 22 in 2020 and 31 in 2021: a total **increase of 48 percent** from 2019.

- <https://goldrushcam.com/sierrasuntimes/index.php/news/local-news/38564-pg-e-says-help-graduates-celebrate-safety-by-securing-balloons-with-a-weight-metallic-balloon-caused-power-outages-on-the-rise>

According to FirstEnergy, 132 outages in 2020 were attributed to foil balloons across the company's six state service area, **up 25% from 2019**

- <https://www.cleveland.com/news/2021/02/fly-away-foil-balloons-caused-132-firstenergy-power-outages-in-2020.html>

Problem Statement



NEETRAC testing facility: Metalized balloon creating an arc between the conductors as soon as the balloon contacts both conductors (12.5kV @ 13.625" separation and 26 A fault current)

IEEE 2845

Trial Use Standard for Testing and Evaluating the Dielectric Performance of Celebratory Balloons in Contact with Overhead Power Distribution Lines Rated up to 38 kV System Voltage

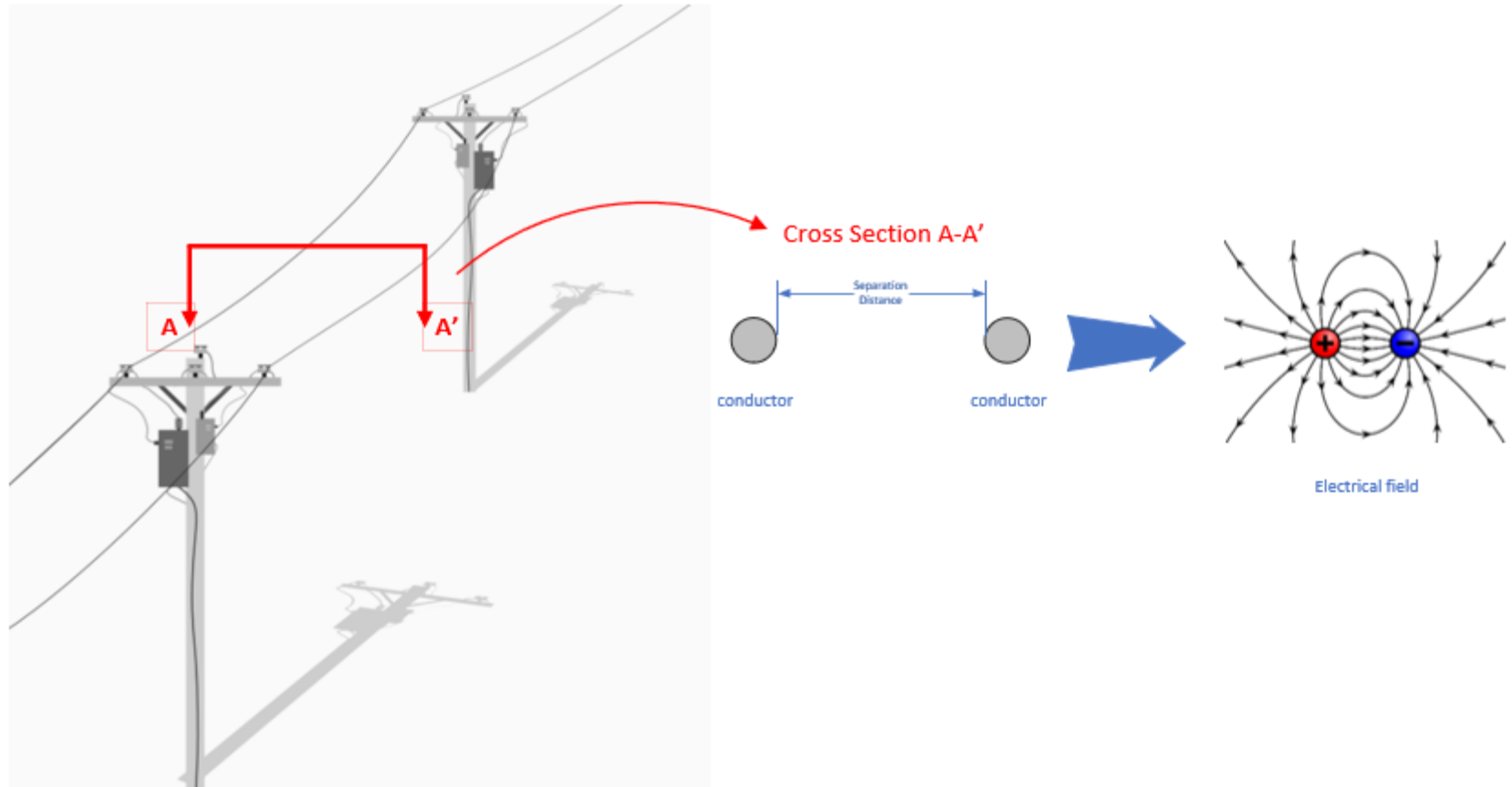
IEEE 2845: Scope

This standard is applicable to celebratory balloons that are comparable in size and shape to what are commonly referred to as foil balloons, which are available in retail stores and are filled with helium or a gas that is lighter-than-air. **The test procedures evaluate the dielectric performance of celebratory balloons in contact with simulated energized overhead distribution power lines with the intent of minimizing balloon caused power system outages (or electrical faults).** The scope is limited to distribution system voltages of 38 kV or less and only single balloons. The effects of having any string or ribbon attachments to the balloon(s), moisture, and contaminants are not investigated under this procedure.

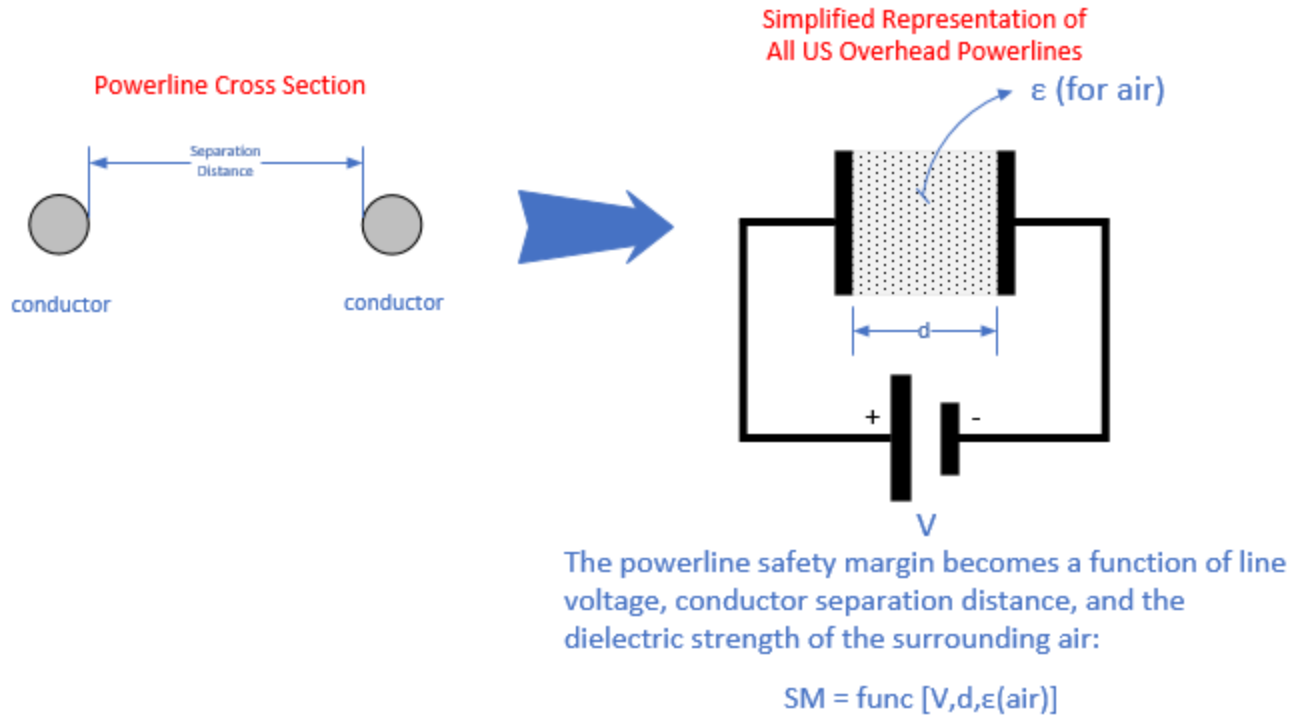
IEEE 2845: Purpose

This standard specifies the test conditions under which a celebratory balloon should be tested in order to determine whether the balloon design is likely to cause a fault when the balloon comes in contact with overhead electric distribution power lines. The common “foil” or “celebratory” balloon is widely available in retail stores and may have a thin layer of metal in the balloon material. Celebratory foil balloons are usually inflated with helium or a lighter-than-air gas which causes them to rise and may drift into overhead power lines. **When these celebratory balloons come into contact with energized distribution power lines, a system fault can occur, either from a short across the metal layer or from ionization of the lighter-than-air gas inside the balloon.** New celebratory balloon designs have been created which have non-continuous metalized designs or are without any metallization or have a different blend of gas. This standard provides the means to evaluate the effectiveness of these new balloons towards not causing distribution system outages.

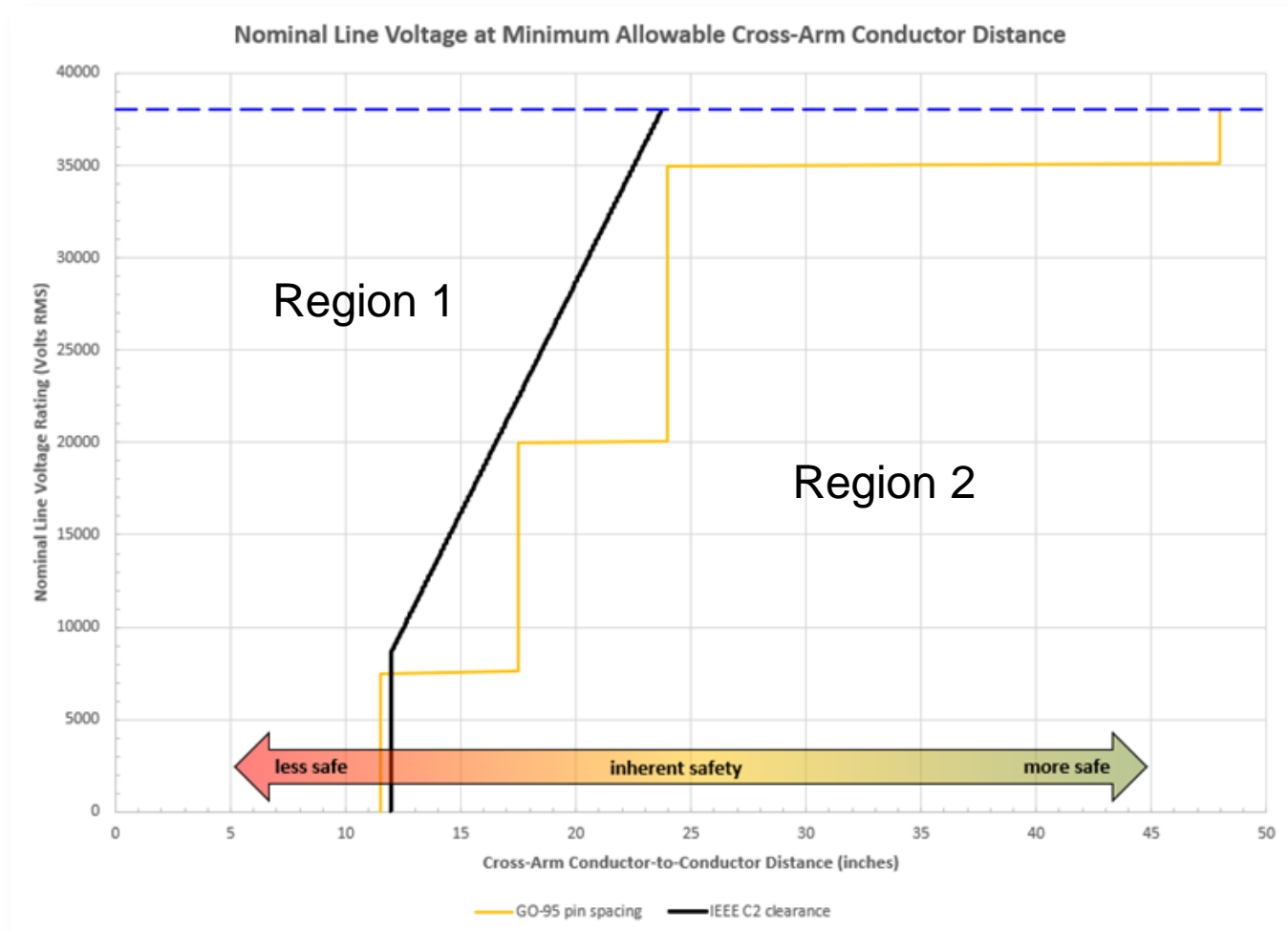
Representation of a powerline



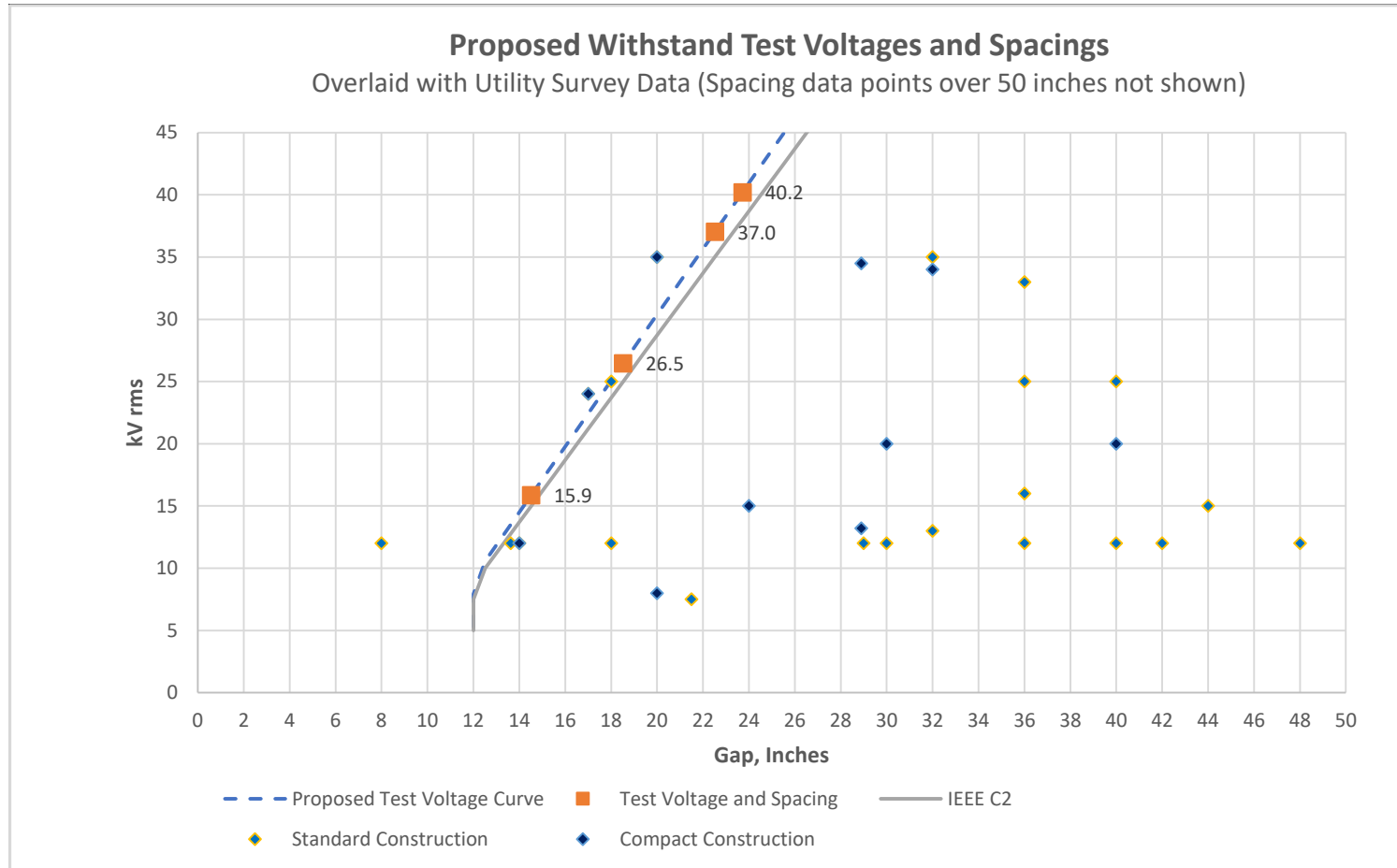
Safety of the powerline



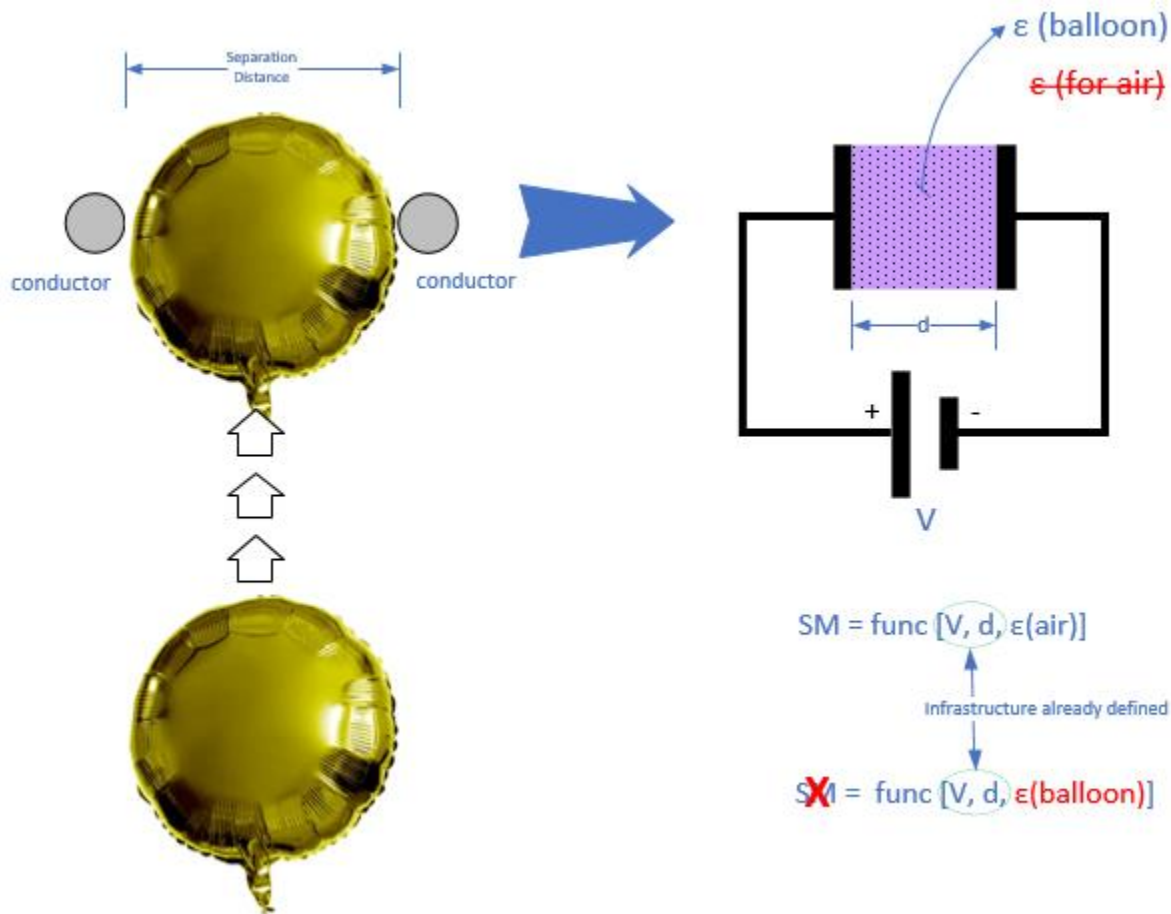
IEEE C2 vs GO-95 Pin Spacing



Utility Survey Results



Foreign body across powerline



Potential Electrical Pathways

The dielectric of the balloon can be different depending on the electrical path of the breakdown:

1. Across the surface of the balloon
2. Within the interior of the film layers of the balloon
3. Within the inflation gas of the balloon

Balloon Differences

- Non-Latex Balloons
 - Metalized balloons
 - Partial metal containing balloons
 - Non-metalized balloons
- Latex Balloons
- Existing Testing on Balloons
 - Quality
 - Safety
 - *Conductive Test*



In a nutshell...

IEEE 2845 is:

- **Withstand testing**
- **On a set of inflated balloons**
- **At known voltage and conductor separation distances representative of a “minimum” overhead distribution powerline.**
 - At voltage/conductor distances in accordance with *IEEE C2-2017 NESC®*, *Table 235-1, Rule 235B1a Clearance for wires, conductors, or cables carried on the same supporting structure*;
 - With test voltages limited to 15kV, 25kV, 35kV, and/or “38kV” voltage classes;
 - And with testing voltages adjusted for:
 - Allowable overvoltage line tolerance, *ANSI C84.1-2011, Table 1, Voltage Range B*, and
 - Environmental testing conditions, *IEEE Std 4™-2013 Clause 13.2.1*

IEEE 2845: Outline

1. Overview
 2. Normative references
 3. Definitions
 4. Introduction
 5. Safety awareness
 6. Testing apparatus
 7. Prevailing conditions for testing
 8. Test specimen
 9. Sampling
 10. Test procedure
 11. Acceptance criteria
 12. Marking and reporting
- Annex A – The need for a testing methodology
- Annex B – Development of spacing and withstand voltage
- Annex C – Example of balloon testing
- Annex D - Bibliography

IEEE 2845: Outline

1. Overview
2. Normative references
3. Definitions
4. Introduction
5. Safety awareness
- 6. Testing apparatus**
7. Prevailing conditions for testing
8. Test specimen
9. Sampling
10. Test procedure
11. Acceptance criteria
12. Marking and reporting

Annex A – The need for a testing methodology

Annex B – Development of spacing and withstand voltage

Annex C – Example of balloon testing

Annex D - Bibliography

6. Testing apparatus

Simulated powerline

1. High voltage test set

- 45-65 Hz AC
- **≥ 3 A fault current**

2. Voltage measurement device

3. Test conductors

- 1" diameter rigid bars or tubes
- Ability to change conductor clearances

4. Positioning device

- Hands-free device to lift inflated balloon into **energized conductors**
- Ability to affix balloon in desired orientations

IEEE 2845: Outline

1. Overview
2. Normative references
3. Definitions
4. Introduction
5. Safety awareness
6. Testing apparatus
7. Prevailing conditions for testing

8. Test specimen

9. Sampling
10. Test procedure
11. Acceptance criteria
12. Marking and reporting

Annex A – The need for a testing methodology

Annex B – Development of spacing and withstand voltage

Annex C – Example of balloon testing

Annex D - Bibliography

8. Test specimen

A balloon envelope retaining a slightly pressurized lighter-than-air gas

1. Balloon shape and size

- *Class A*: standardized format
- *Class B*: any shape and size as long as it spans the conductors

2. Lighter-than-air gas

- **95% helium 5% oxygen admixture**
- At normal inflation pressure for the balloon

IEEE 2845: Outline

1. Overview
2. Normative references
3. Definitions
4. Introduction
5. Safety awareness
6. Testing apparatus
7. Prevailing conditions for testing
8. Test specimen

9. Sampling

10. Test procedure
11. Acceptance criteria
12. Marking and reporting

Annex A – The need for a testing methodology

Annex B – Development of spacing and withstand voltage

Annex C – Example of balloon testing

Annex D - Bibliography

9. Sampling

The test sample consists of a set of “like” balloon specimens

- **Sample is based on the same balloon characteristics**
 - Polymer composition
 - Metal or conductive content and its configuration on/in the balloon
 - *Class B*: the size and shape of the inflated balloon
- **Number of test specimens making up the sample**
 - **Two voltage levels** are tested
 - i. Minimum voltage class
 - ii. Maximum voltage class
 - The **physical dimensions** of the inflated balloon will drive which principal orientation will be tested for each voltage level.

Orientation	Min. Voltage Class	Max Voltage Class
A	5	5
B	5	5
C	5	5

Principle testing orientations

	Test Apparatus Front View	Test Apparatus Side View
<p>Orientation A Perpendicular Orientation</p> <p>The plane of the balloon seam is perpendicular to the test conductors and perpendicular to the ground plane when both test conductors contact the balloon seam.</p>		
<p>Orientation B Flat Orientation</p> <p>The plane of the balloon seam is parallel with the test conductors and parallel to the ground plane when both test conductors contact a single balloon panel or face.</p>		
<p>Orientation C Longitudinal Orientation</p> <p>The plane of the balloon seam is parallel to the test conductors and perpendicular to the ground plane when each test conductor contacts a different balloon panel or face.</p>		

IEEE 2845: Outline

1. Overview
2. Normative references
3. Definitions
4. Introduction
5. Safety awareness
6. Testing apparatus
7. Prevailing conditions for testing
8. Test specimen
9. Sampling

10. Test procedure

11. Acceptance criteria
12. Marking and reporting

Annex A – The need for a testing methodology

Annex B – Development of spacing and withstand voltage

Annex C – Example of balloon testing

Annex D - Bibliography

10. Test Method

1. Inflate balloon with admix
2. Determine the balloon's dimensional length
3. Determine the maximum voltage class
4. Test balloons at the minimum and maximum voltage class for each orientation
5. Set proper clearance of the test conductors
6. Calculate the applied test voltage
7. Properly affix balloon to the lifting device
8. Energize the test conductors
9. Lift the balloon into the energized conductors
10. Observe test until expiration of the withstand duration
11. Make test apparatus safe

Voltage Class

Table 1—Voltage class and conductor clearance

Test specimen dimension	Voltage class	Test conductor clearance ^a
≥ 385 mm (15.5 inches)	15 kV rms	360 mm (14.5 inches)
≥ 485 mm (19.5 inches)	25 kV rms	460 mm (18.5 inches)
≥ 585 mm (23.5 inches)	35 kV rms	560 mm (22.5 inches)
≥ 615 mm (24.7 inches)	38 kV rms	590 mm (23.7 inches)

NOTE 1 - The utility industry recognizes voltage classes of 5 kV, 15 kV, 25 kV, and 35 kV. However, the 38 kV class is an industry un-recognized voltage class. This standard includes a 38 kV pseudo voltage class for the expressed purpose of distribution voltage inclusiveness defined in the scope of this standard.

NOTE 2 - The voltages within this table shall be considered as the nominal rated line voltages.

NOTE 3 – Conductor clearance shall be the clear distance between the conductors and measured at the nearest facing conductor surfaces.

^a Defined and calculated from IEEE C2-2017 NESC®, Table 235-1, Rule 235B1a.

IEEE 2845: Outline

1. Overview
2. Normative references
3. Definitions
4. Introduction
5. Safety awareness
6. Testing apparatus
7. Prevailing conditions for testing
8. Test specimen
9. Sampling
10. Test procedure

11. Acceptance criteria

12. Marking and reporting

Annex A – The need for a testing methodology

Annex B – Development of spacing and withstand voltage

Annex C – Example of balloon testing

Annex D - Bibliography

11. Acceptance criteria

Any specimen creating a disruptive discharge during the withstand test is considered a fail and the sample fails this electrical standard, in short (no pun intended):

Any disruptive discharge fails this standard!

Deflated or deflating balloons during a withstand test will not necessarily indicate a failed sample.

IEEE 2845: Outline

1. Overview
2. Normative references
3. Definitions
4. Introduction
5. Safety awareness
6. Testing apparatus
7. Prevailing conditions for testing
8. Test specimen
9. Sampling
10. Test procedure
11. Acceptance criteria

12. Marking and reporting

Annex A – The need for a testing methodology

Annex B – Development of spacing and withstand voltage

Annex C – Example of balloon testing

Annex D - Bibliography

12. Marking

Manufactured balloons successively passing this electrical standard can be permanently marked with its electrical rating.

Such balloon markings will be in the following format:

1. Manufacturer's mark or logo if not located elsewhere on the balloon
2. Designation of this standard, i.e., "IEEE 2845"
3. Designation of the geometrical type of the balloon, i.e., balloon class: "Class A" or "Class B" or alternatively "A" or "B"
4. The maximum tested Voltage Class, i.e., "15kV", "25kV", "35kV", or "38kV"
5. Designation of the inflation gas, i.e., the 95% helium 5% oxygen admixture

Examples:

- *Manufacturer* IEEE 2845 Class A 38kV 95He/5O₂
- IEEE 2845 A 38kV 95/5 He/O₂

Should be looking for this type of labeling on the balloon

Current Status of Standard

- The trail standard sent to New Standard Committee for approval.
- Once approved, Editorial Staff review for another 3 months.
- The trial standard will be active for three years from the date of publication.
- Once published the Task Force Chair will need to submit for a PAR using the same PAR number, but for a full use standard.