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NFPA 77 Recommended Practice on Static Electricity Recommended Revisions

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Electrostatic Answers

ABSTRACT

The National Fire Protection Association (NFPA) develops standards for fire prevention and public safety through a consensus of experts. The 5-year revision cycle for NFPA 77 Standard Practice on Static Electricity begins in 2019. This standard practice includes recommended practices for web and sheet processes. This presentation reviews the existing 2019 standard that offers excellent information on substrates, coating solutions, various coating and converting processes, and offers good advice on the control of static electricity in web processes. The NFPA 77 Committee on Static Electricity is open to suggestions for revisions. I encourage your comments and suggestions. Recommended revisions currently include providing more examples of best practice static control, a description of measurements to verify that static is sufficiently controlled, and a description of the engineering methodology to implement fault tolerant static control where static control is sufficiently maintained to suppress sparks in solvent zones even when any single static control device fails.

1. INTRODUCTION

Table 1.1: Static Control Objectives in Webs Handling Systems
1. Eliminate static ignitions.
2. Prevent shocks.
3. Minimize deposition of airborne contaminates.
4. Prevent static damage to sensitive coatings such as release liners.
5. Prevent static problems such as sheet sticking and process jams.

Static causes a number of problems in web handling systems summarized in Table 1.1. When insulating films such as polypropylene or polyethylene terephthalate are conveyed through solvent zones, static sparks from the films risk igniting flammable solvent vapors. Static charges stored on winding rolls are a shock risk to operators. At least one worker has been electrocuted from static on a winding roll [1]. Static charges on films attracted airborne contaminates particularly during slitting and punching operations. Static sparks can damage thin coating such a silicone release layers or other sensitive coatings having chemical or electronic functionality. Once continuous films are chopped into individual sheets, static causes sheets to stick together in sheeting operations, packaging operations, or in customer applications.

These static problems may be prevented by installing static dissipators on the web handling system. However, dissipators must be installed properly in correct locations to achieve good static control. Information on identifying the correct locations and on properly installing static dissipators should be widely available to prevent fires and protect workers.

The National Fire Protection Association (NFPA) is a global nonprofit organization, established in 1896, devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards that helps save lives and reduce loss with information, knowledge and passion [2]. The NFPA develops codes, standards, recommended practices, and guides through a consensus of experts representing varied viewpoints and interests. One well known standard is NFPA 70 National Electrical Code (NEC). Adopted in all 50 states, the NEC is the benchmark for safe electrical design, installation, and inspection to protect people and property from electrical hazards [3]. The NFPA has acted as sponsor of the NEC since 1911. The original document was developed in 1897 as a result of the united efforts of various insurance, electrical, architectural, and allied interests.

NFPA 77 Recommended Practice on Static Electricity is another important document that offers guidance on identifying, evaluating, and controlling static electric hazards for purposes of preventing fires and explosions [4]. A tentative edition of NFPA 77 adopted in 1941 was further revised and officially adopted in 1947.

2. REVIEW OF NFPA 77 RECOMMENDED PRACTICE ON STATIC ELECTRICITY

Figure 2.1: NFPA 77 Table of Contents – Chapter 5 and Chapter 6

The 18 chapters in NFPA 77 are each devoted to a specific topic. The first four chapters focus on administrative information and definitions. Technical content in Figure 2.1 begins in Chapter 5 that provides an excellent review of electrostatic fundamentals. Chapter 6 focuses on assessing hazards. The fundament concepts reviewed in these two chapters lay the technical foundation for solving static problems.

Figure 2.2: NFPA 77 Table of Contents – Chapter 17 and Chapter 18.

Chapter 7 through Chapter 18 each focus on a specific technical area or application. Chapter 17 Web and Sheet Processes in Figure 2.2 on web conveyance operations is organized into 5 sections.

17.1 General provides only a short statement on the importance of static control.

"17.1.1 In web processes, such as printing, coating, spreading, and impregnating, static electricity is a frequent, annoying, and often expensive source of production problems. If flammable solvents are used in the process, static electric charges can constitute and ignition source."

17.2 Substrates and **17.3 Inks and Coatings** are each a paragraph long and make similar comments.

My assessment is that these general statements are true, and they offer little useful advice for solving static problems.

While **17.4 Processes** is longer, little useful information is presented. Following is an example.

"**17.4.5 Web Handling and Converting.** The path of the web through processing machinery often is guided over many rollers. Movement of the web over the rollers produces static electric charge due to friction."

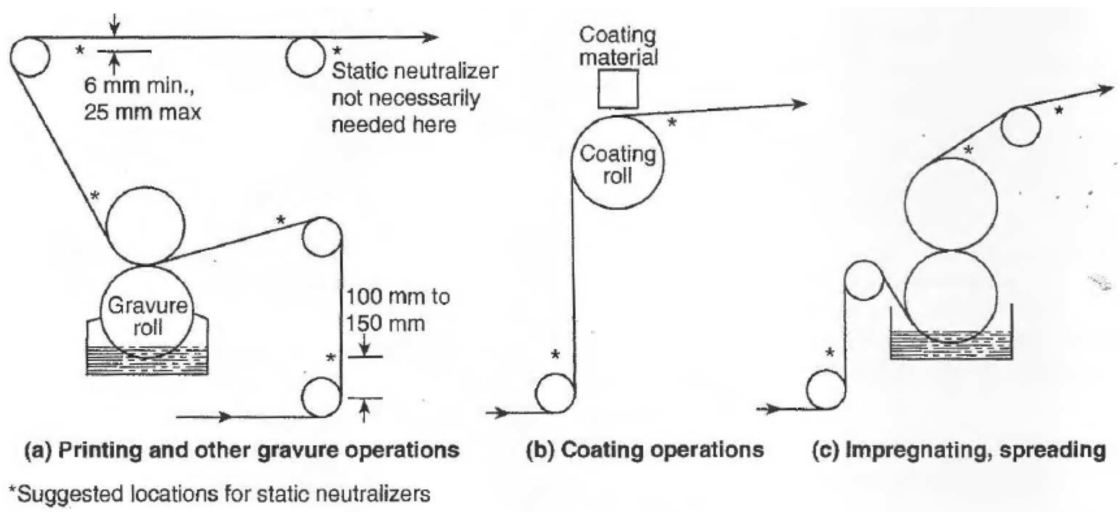


FIGURE 17.5.3.2.3 Typical Locations for Static Neutralizers.

Figure 2.3: Only figure in Chapter 17 on Web Handling.

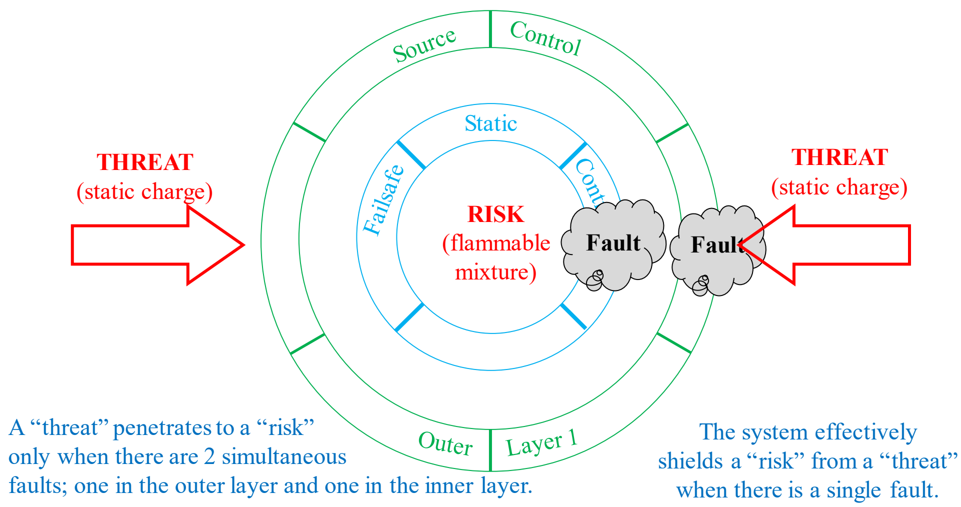
Figure 2.3 above shows the only figure presented in **Chapter 17 Web and Sheet Processes**. Showing these examples of "typical location" is helpful.

My assessment is that a process engineer working on a film casting, coating, or converting line would find little in Chapter 17 that would help solve a static problem.

3. RECOMMENDED REVISIONS

I recommend that **Chapter 17 Web and Sheet Processes** be revised into 4 sections.

- **17.1 Design Principles**
- **17.2 Measurements**
- **17.3 Best Practice Static Control**
- **17.4 Manage Static Performance**



Protect risk areas with "2-layer," fault tolerant static control systems

Figure 3.1: Engineering strategy to achieve fault-tolerant static control.

17.1 Design Principles presents the over-arching engineering strategy in Figure 3.1 for implementing fault tolerant static control. When implementing static control, I find it helpful to think in terms of "risk" and "counter-measure." Begin with identifying areas of the operation that are at risk from static. The most common areas are solvent rated (C1D1 or C1D2) areas at risk of static ignitions and winding rolls that pose shock risks to operators. Usually, identifying risk areas is straightforward.

The first counter-measure or "line of defense" is to install as static dissipator on the web span entering the risk area. Install a static dissipator on the web entering a solvent rated area. This common practice is recommended.

The next step is to apply Failure Mode and Effect Analysis (FMEA). Consider the effect when the static dissipator fails. This single failure allows the static threat in Figure 3.1 to penetrate into the risk area. Fault tolerant static control protects the risk area even when there is a single failure.

Fault tolerant static control is achieved by installing the second, outer layer of protection in Figure 3.1. Identify the sources of static charging where static where the web first becomes charged. The second, outer layer of protection is to dissipate static at the source. With good "source control," the web entering the risk area is charge-free. Our first line of defense is redundant. Our first line of defense provides protection when there is a fault in the second, outer layer of protection.

The key enabler is to identify sources of static charging. This is accomplished by taking static measurements as describe in **17.2 Measurements**.

17.2 Measurements describes how to take reliable, meaningful static measurements to achieve two goals.

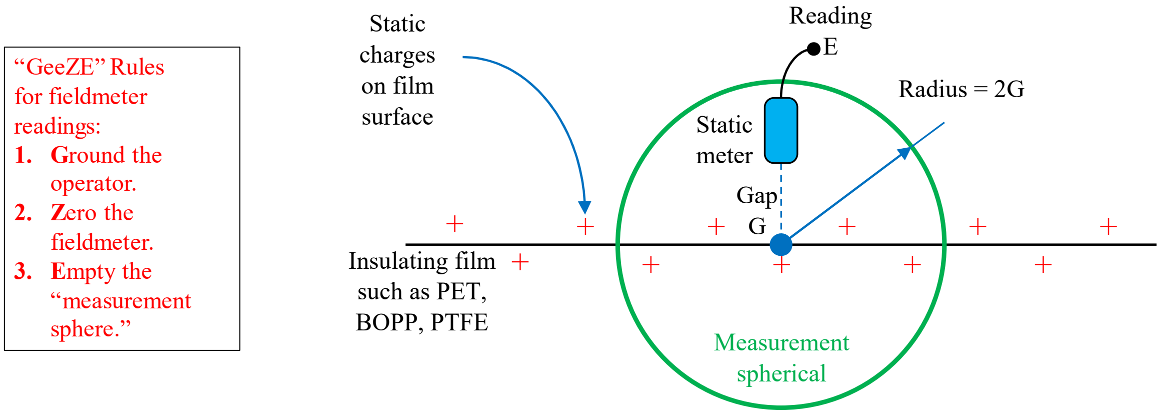
1. Identify sources of static charging.
2. Document static performance.

Identify sources of static charging using a hand-held electrostatic fieldmeter. Make repeatable, reliable static measurements using the "GeeZE" rules [5] summarized in Figure 3.2.

Rule 1: **G**round the operator taking measurements by touching the machine frame.

Rule 2: **Z**ero the static meter by measuring grounded metal such as the machine frame.

Rule 3: **E**mpty the "measurement sphere."



In your "mind's eye," draw a dot the web below the fieldmeter. The dot becomes the center of a sphere that expands to a radius of 2G. For reliable readings, the "measurement sphere" must be empty (except for the meter and your hand).

Figure 3.2: Instructions for making reliable electrostatic fieldmeter measurements.

The "measurement sphere" is centered on the web directly in front of the static meter. The radius of the sphere is twice the distance to the meter. So, for a meter calibrated to read at a distance of 1 inch, the radius of the measurement sphere is 2 inches. This sphere must be empty (except for the meter and the operator's hand) to obtain a reliable reading. Any other object inside the sphere such as a roller or an element of the machine frame compromises the measurement. So, for a meter calibrated for a distance of 1 inch, there must be an empty sphere about the size of a soft ball to obtain a reliable, repeatable static measurement.

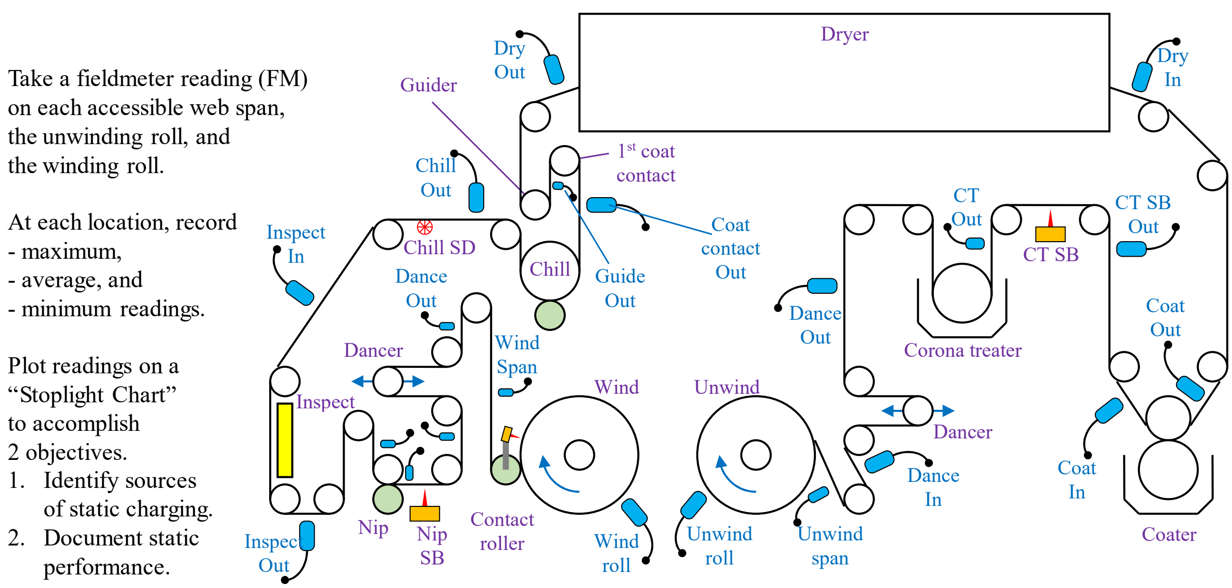


Figure 3.3: Advice for identifying static charging sources and documenting static performance.

To identify sources of static charging, complete a "static survey." Take an electrostatic fieldmeter measurement on every, safely accessible web span on the line. For example, shown in Figure 3.3 are 21 measurements taken on a one-station gravure coater. At each location, record the average, maximum, and minimum readings. This is best accomplished by using an electrostatic fieldmeter having an analog output and monitoring this output with a digital voltmeter having a "max-avg-min" function.

Identify Sources:
Look for
large changes
in readings.

Static Performance:
Keep reading in the
"Green Zone."

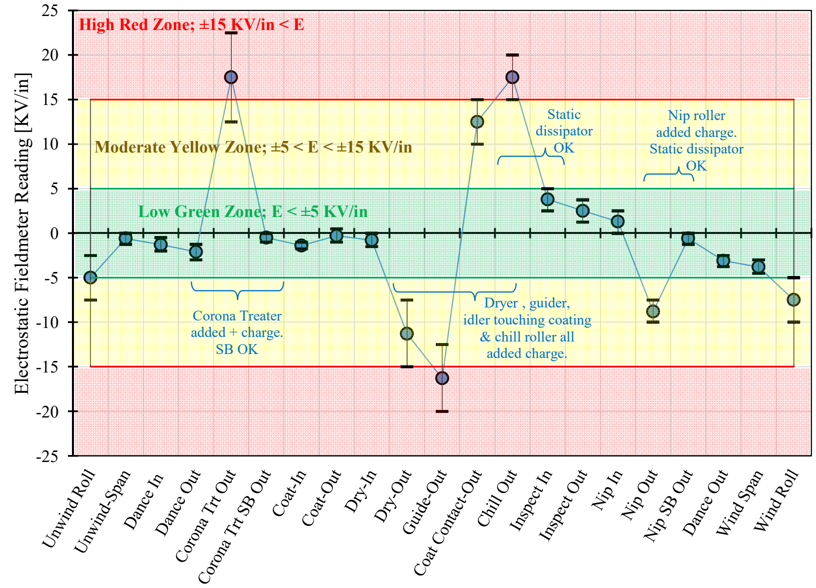


Figure 3.4: Plot fieldmeter measurements to identify charging sources and document static performance.

The readings are plotted in Figure 3.4 that provides a good, visual summary of the static performance. For good performance, all reading will be less than ±5 KV/in keeping them in the "Low Green Zone."

A large change in sequential readings indicates that the web static increased from a source of static charge between the readings. For example, fifth reading in Figure 3.4 indicates that the web gained a large amount of positive static from the corona treater.

NOTE:
We don't need a static dissipator after every roller!

Sparks occur when charge > ±5 μC/m²

Neutralize static at each charging source that deposits ±5 μC/m² or more.

Source	Charge (μC/m²)
Lamination Nips	±250
Corona Treaters	±50
Unwinding Rolls	±20
Polymer Nip Rollers	±15
Drive / Pull Rollers	±15
Heated / Cooled Rollers	±15
Spreader / Bowed Rollers	±10
Dryer / Oven Idler Rollers	±10
Web Guides	±5
Registration Compensation Rollers	±4
Dancer Rollers	±2
Metal Idler Rollers	±0.2

Figure 3.5: Examples of common charging sources.

The electrostatic fieldmeter reading is proportional to the static charge density on the web. Applying Gauss' Law results in (1) where ε_0 is the permittivity of free space, a physical constant ($\varepsilon_0 = 8.854\times10^{-12}$ F/m).

$$\sigma_{WEB} = \varepsilon_0 E \tag{1}$$

From (1), working through the units results in (2) that I use to estimate the static charge density σ_{WEB} from fieldmeter readings E.

$$\sigma_{WEB}\left[\frac{\mu C}{m^2}\right] = (0.885)\,E\left[\frac{KV}{cm}\right] \tag{2}$$

The common sources of static charging in Figure 3.5 are listed in descending amounts of charge deposited on the web. The top two sources, lamination nips and corona treaters, can deposit very large amounts of static on web. To achieve good static control, install a static dissipator on the web exiting each static source that deposits ±5 $\mu C/m^2$ of static or more.

17.3 Best Practice Static Control

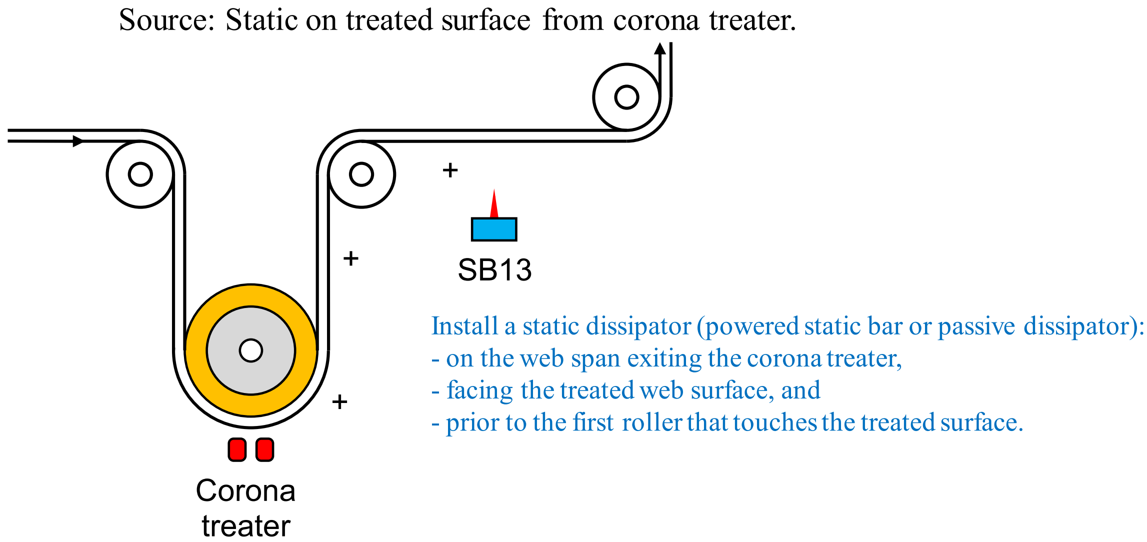


Figure 3.6: Best practice static control example

This section shows the best practice static control for each source in Figure 3.5. For example, for the corona treater in Figure 3.6, the best practice is to locate a static dissipator on the web span exiting the treater facing the treated web surface.

17.4 Manage Static Performance

#	Description
R1	When static is important, devote ~2% of scheduled work hours to static control.
R2	Train operators annually (or on an appropriate schedule) on static electricity awareness.
R3	Install each static dissipator to have good neutralization efficiency.
R4	Energize active static bars only when the line is running.
R5	Make a checklist identifying the location of each static dissipator (photo?).
R6	Visually inspect each static dissipator periodically (weekly?) to ensure that each is fit-for-use. By "fit-for-use," I mean 3 things: 1. The dissipator is in place and properly spaced. 2. The pins of static bars are clean. Passive dissipators are in good physical condition. 3. Power is applied to active bars.
R7	Measure periodically (quarterly?) the neutralization efficiency of each static dissipator.
R8	Periodically inspect (monthly?) rollers to verify that they are fit-for-use. By this, I mean 4 things. 1. The roller surfaces are clean. 2. The roller bearings are functioning properly. 3. The rollers are aligned properly. 4. The web path is free of debris that might touch the moving web.
R9	Audit the static levels on incoming rolls.
R10	Audit the static levels on finished rolls.
R11	Perform a static survey to qualify lines for service after major maintenance operations.
R12	Perform a static survey as part of Management of Change.

Table 3.7: Management recommendations for maintaining good static control.

Once good static performance is achieved, good management ensures that performance is maintained. The 12 recommendations in Table 3.7 help maintain static performance. For example, R2 is that operators should receive annual "static awareness" training. R5 and R6 are that static dissipators should be regularly inspected to ensure that each is "fit-for-use."

4. SUMMARY

The National Fire Protection Association (NFPA) develops standards for fire prevention and public safety through a consensus of experts. NFPA 77 Standard Practice on Static Electricity recommends practices for web and sheet processes. The NFPA Committee on Static Electricity is open to suggestions for revisions. Recommended revisions currently include providing more examples of best practice static control, a description of measurements to verify that static is sufficiently controlled, and a description of the engineering methodology to implement fault tolerant static control where static control is sufficiently maintained to suppress sparks in solvent zones even when any single static control device fails.

5. REFERENCES

[1] United States Department of Labor, Occupational Safety and Health Administration, Reports of Fatalities and Catastrophes – Archive, https://www.osha.gov/dep/fatcat/dep_fatcat_archive.html, FY10 (Incident dates between Oct 1, 2009 - Sep 30, 2010):
05/15/10, "Worker was electrocuted by static electricity built up on a plastic film roll line."

[2] National Fire Protection Association, https://www.nfpa.org/About-NFPA.

[3] NFPA 70 National Electric Code, https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70.

[4] NFPA 77 Recommended Practice on Static Electricity, https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=77.

[5] K. Robinson, "Static Beat | GeeZE' Rules for Static Readings," http://www.pffc-online.com/surface-prep/14478-static-beat-geeze-rules-for-static-readings, 24 May 2017.