Appendix L
U.S. CODES AND STANDARDS ON OUTDOOR WARNING SYSTEMS

There are national model codes and standards applicable to outdoor siren–based communication systems for tornadoes (and other emergencies). A model code is a set of rules that is recommended for others to follow. A model code does not carry the force of law unless it is adopted. On the other hand, a standard is a technical document that contains more detailed description of how to measure, test, or satisfy the provisions of a particular code. As an example, a code may say that a community or a building must have an alarm system. The standard will provide more detailed information on how to meet the requirements of this code, including information about what kind of system must be installed and how the system must work (www.nfpa.org).

One national model code, NFPA 72, or the National Fire Protection Association's (NFPA) *National Fire Alarm and Signaling Code*[169], is specifically devoted to emergency communication systems, and can be applied to tornado siren systems. NFPA 72 contains a chapter (Chapter 24) specifically devoted to emergency communication systems (2013). This chapter establishes minimum requirements for the performance, reliability, and quality of installation for emergency communication systems. By definition, emergency communication systems are those that are intended to communicate information about emergencies, including (but not limited to) fires, accidents, and natural disasters. Chapter 24 provides requirements for in–building communication systems, namely one–way and two–way in–building fire emergency voice/alarm communication systems, in–building mass notification systems, two–way radio communications enhancement systems (in buildings), area of refuge emergency communication systems (in buildings), and elevator emergency communication systems (in buildings). For the category that is most applicable to a community–wide tornado siren system, namely wide–area mass notification systems, NFPA 72 specifies requirements for the wide–area systems' components, including the central control station, high–power speaker arrays, high–power speaker array enclosures and mounting, and speaker array structural loads for wind– and seismic–resistant design. Additionally, this code specifically states that these systems should not be used to provide mass notification inside any structures. In other words, these systems are to be designed and used only for outdoor alert or warning dissemination.

Whereas previous guidance was provided in the annex, the most recent revision of NFPA 72 (2013) begins to provide guidance on how to create and disseminate an emergency message, if the alert or warning system has that capacity. This revision suggests ways to improve intelligibility, the use of an alert tone in addition to a message, and the types of message content that will prompt a more efficient recipient response. This guidance is helpful for those communities with outdoor public address systems or visual signage; however, there is no mention in this model code about requirements for sound patterns, length of sounds, sound types, etc., or about the use of the siren system itself.

[169] Even though NFPA 72 has been a code for a number of years, it is a referenced standard in the model fire codes and is often administered and enforced in that manner.

All other current requirements that can be applied to tornado siren systems are standards. The first group of standards, listed below, focus on providing requirements for the construction, performance, and testing of the entire communication system.

- NFPA 1221 (2010), *Standard for the Installation, Maintenance, and Use of Emergency Services Communication Systems* (Chapter 14 on Public Alerting Systems)
- UL[170] 2017 (2011), *Standard for General–Purpose Signaling Devices and Systems*
- UL 1971 (2008), *Standard for Signaling Devices for the Hearing Impaired*
- IEC[171] 60849 (1998), *Standard for Sound Systems for Emergency Purposes*

NFPA 1221, or the NFPA's *Standard for the Installation, Maintenance, and Use of Emergency Services Communication Systems* has a chapter (Chapter 14) that focuses on public alerting systems. The standard states that such systems can be used to alert the public to natural or man–made events, including tornadoes. However, this standard provides very little in the way of requirements and even cites NFPA 72 for requirements on the audible alarm.

UL also has a standard on signaling devices intended for emergency or non–emergency use in both indoor or outdoor locations (UL 2017–2011), that can be applicable to tornado warning systems. The standard provides requirements for device construction and performance, as well as tests for evaluating the performance of particular components or capabilities. UL also has a standard on signaling devices for the hearing impaired (UL 1971–2008) that can be applicable to tornado warning systems. This standard covers the construction of the device's enclosure, cover, ventilation openings, corrosion protection, insulating materials, mounting parts, operating mechanisms, and wiring, cables, connections, and circuit boards (i.e., mainly the construction of the device). The standard also provides requirements for the performance of the system by specifying a series of tests. Installation and operating instructions are included as well.

Finally, IEC 60849 (1998) is another standard on sound systems for emergency purposes. The standard applies to sound reinforcement and distribution systems that are used to effect rapid mobilization of occupants in an indoor or outdoor area in an emergency. It specifies performance requirements for sound systems that use tone signals or voice announcements to broadcast information for the protection of lives.

All four of these standards focus on requirements for designing and installing the notification system, without providing much in the way of requirements for system use (other than intelligibility measurements, which will be described below). These standards do not address how the device should be used to disseminate information, such as the types of emergencies for which the system should be used, system activation procedures, sounding patterns, or guidance that should be provided to the community about the system.

Another group of standards, listed below, focus primarily on sound and intelligibility levels (including how to measure each):

[170] Underwriters Laboratories.

[171] International Electrotechnical Commission.

- ANSI[172] S1.13 (2010), *Measurement of Sound Pressure Levels in Air*
- ANSI S1.26 (2009), *Method for the Calculation of Absorption of Sound by the Atmosphere*
- ANSI S12.14 (2007), *Methods for the Field Measurement of the Sound Output for Audible Public Warning Devices Installed at Fixed Locations Outdoors*
- ANSI S3.2 (2009), *Method for Measuring the Intelligibility of Speech over Communications Systems*
- ISO[173] 9921 (2003), *Ergonomic Assessment of Speech Communication*
- ANSI S3.5 (1997), *Methods for the Calculation of the Speech Intelligibility Index (SII)*
- IEC 60268–16 (2011), *Sound System Equipment* (Part 16: Objective Rating of Speech Intelligibility by Speech Transmission Index

First, ANSI S1.13 (2010), *Measurement of Sound Pressure Levels in Air,* provides an objective way to measure sound pressure, or pressure fluctuations, in the air. The greater the amplitude of pressure fluctuation, the "louder" the sound will be perceived. This standard presents a method that relies solely on physical parameters and not on subjective interpretation or opinion about volume. This relates specifically to emergency communication for tornadoes because it provides a standardized method of evaluating the performance of emergency sirens (i.e., whether the sound will reach specified areas of the community).

Similarly, ANSI S1.26 (2009), *Method for Calculation of the Absorption of Sound by the Atmosphere,* provides a method of calculating atmospheric absorption losses of sound from any moving or stationary source for a range of meteorological conditions. This becomes especially useful when evaluating whether siren tones will reach desired areas under the types of weather conditions expected during tornadoes.

The standard most relevant to tornado sirens is ANSI S12.14 (2007), *Methods for the Field Measurement of the Sound Output for Audible Public Warning Devices Installed at Fixed Locations Outdoors.* This standard provides procedures for measuring and reporting certain properties of sounds produced by audible public warning devices. ANSI S12.14 can be used, for example, by customers of public warning devices to verify the compliance of their systems with specific sound output specifications.

The last four standards listed above all relate to measuring or assessing speech intelligibility, i.e., the capability of being understood, comprehensible, and clear (NFPA 2010). Intelligibility measurements apply to mass communication or siren systems that allow for the dissemination of voice messages. ANSI S3.2 (2009), *Method for Measuring the Intelligibility of Speech over Communication Systems,* presents a standardized method for evaluating the intelligibility of a voice communication system. This method involves comparing the monosyllabic words trained listeners receive (and identify) with the words trained talkers or speech coders speak into a communication system. The communication system connects the talkers with the listeners, all of whom are required to be native speakers of English and have no speech or hearing defects. ISO 9921 (2003), *Ergonomic Assessment of Speech Communication,* standardizes

[172] American National Standards Institute.
[173] International Organization for Standardization.

ergonomic assessment of speech communication by recommending levels of speech–communication quality required for conveying messages in different applications, including when warning of a hazard or danger. Referenced within ISO 9921 are terms known as the "speech intelligibility index" and "speech transmission index." Both refer to objective measures for predicting the intelligibility of speech. ANSI recently updated its standard on one method, which is now entitled ANSI S3.5 (1997), *Methods for the Calculation of the Speech Intelligibility Index (SII),* and the IEC also updated their standard on a different method, which is referred to as IEC 60268, Part 16, "Objective Rating of Speech Intelligibility by Speech Transmission Index."

There are also standards that are devoted to the individual physical components that make up communication systems. Two examples follow:

- UL 1480 (2010), *Standard for Speakers for Fire Alarm, Emergency, and Commercial and Professional Use*
- UL 1989 (2010), *Standard for Standby Batteries*

The one most specific to emergency communication is UL 1480 (2010), *Standard for Speakers for Fire Alarm, Emergency, and Commercial and Professional Use.* This standard lists requirements for the construction of these types of speakers as well as various types of speaker performance tests. Similar standards are available for other components of communication systems, such as the UL 1989 (2010) standard on standby batteries.

In sum, no national codes or standards exist to provide requirements or standardization on the ways in which outdoor tornado siren systems should be used to disseminate emergency communications before or during tornadoes. Instead, as indicated above, current codes and standards focus on the construction, performance, and testing of the physical components of such systems. NFPA 72 has begun to provide guidance on the types of messages that should be disseminated via wide–area voice communication systems (typically used in communities); however, this guidance does not assist those communities that must rely on tone–based sirens (i.e., systems without the ability to send public address announcements).