

Choosing the Proper Audio Frequency

by Dean K. Wilson, P.E.

***Question:* Our firm has accepted a contract to install a fire alarm system in a residential group home care facility. The architect placed a note on the plans calling for an analysis of the appropriate audio frequency for the audible fire alarm notification appliances. Do audible notification appliance signals have to operate at any particular audio frequency?**

The simple answer: only in sleeping areas for systems using distinctive sound-based audible notification appliances, such as horns, bells, sirens, chimes, audio speakers reproducing warning sounds or tones, and other similar appliances installed after January 1, 2014.

Even though the actual requirement does not take effect until that somewhat distant date, if I were installing a new fire alarm system, I would incorporate the requirement now to take advantage of the best possible means of notification and assure compliance in the future.

In addition, the NFPA Standards Council issued Tentative Interim Amendment (TIA) 971 at its March 1-3, 2010 meeting. This action revises paragraph 24.4.1.4. Thus, requirements similar to those for the sound-based audible notification appliances will now apply to all voice message notification appliances, such as audio speakers reproducing the sound of a human voice, installed in sleeping areas as part of an Emergency Communications System.

Here's the background and supporting information. In NFPA 72-2010, *National Fire Alarm and Signaling Code*[®], you will find the requirements for the distinctive evacuation signal in Chapter 18, Notification Appliances. Paragraph 18.4.2 and its subparagraphs reads as follows:

18.4.2 Distinctive Evacuation Signal.

18.4.2.1* To meet the requirements of Section 10.7, the alarm audible signal pattern used to notify building occupants of the need to evacuate (leave the building) shall be the standard alarm evacuation signal consisting of a three-pulse temporal pattern. The pattern shall be in accordance with Figure 18.4.2.1 and shall consist of the following in this order:

- (1) "On" phase lasting 0.5 second ± 10 percent
- (2) "Off" phase lasting 0.5 second ± 10 percent for three successive "on" periods
- (3) "Off" phase lasting 1.5 seconds ± 10 percent

Exception: Where approved by the authority having jurisdiction, continued use of the existing consistent evacuation signaling scheme shall be permitted.

(Note: Due to space considerations, we have omitted the Figure referenced above.)

A.18.4.2.1 Paragraph 10.7 requires that alarm signals be distinctive in sound from other signals and that this sound not be used for any other purpose. The use of the distinctive three pulse temporal pattern fire alarm evacuation signal required by 18.4.2.1 became effective July 1, 1996, for new systems installed after that date. It is not the intent to prohibit continued use of an existing consistent evacuation signaling scheme, subject to approval by the authority having jurisdiction. It is also not the intent that the distinct pattern be applied to visible appliances.

The temporal pattern can be produced by any audible notification appliance, as illustrated in Figure A.18.4.2.1 (a) and Figure A.18.4.2.1 (b).

(Note: Due to space considerations, we have omitted the Figures referenced above.)

18.4.2.2 A single-stroke bell or chime sounded at "on" intervals lasting 1 second ± 10 percent, with a 2-second ± 10 percent "off" interval after each third "on" stroke, shall be permitted.

18.4.2.3 The signal shall be repeated for a period appropriate for the purposes of evacuation of the building, but for not less than 180 seconds. The minimum repetition time shall be permitted to be manually interrupted.

18.4.2.4 The use of the standard evacuation signal shall be restricted to situations where it is desired that all occupants hearing the signal evacuate the building immediately. It shall not be used where, with the approval of the authority having jurisdiction, the planned action during an emergency is not evacuation, but rather is the relocation of occupants or their protection in place, as directed by the building emergency response plan or as directed by emergency personnel.

18.4.2.5* The standard evacuation signal shall be synchronized within a notification zone.

A.18.4.2.5 Coordination or synchronization of the audible signal within a notification zone is needed to preserve the temporal pattern. It is unlikely that the audible signal in one evacuation/notification zone will be heard in another at a level that will destroy the temporal pattern. Thus, it would not normally be necessary to provide coordination or synchronization for an entire system. Caution should be used in spaces such as atriums, where the sounds produced in one notification zone can be sufficient to cause confusion regarding the temporal pattern.

In order to recognize that a significant percentage of the population has impaired hearing, especially in the upper frequency range, NFPA 72-2010 has added the following requirement:

18.4.5.3* Effective January 1, 2014, where audible appliances are provided to produce signals for sleeping areas, they shall produce a low frequency alarm signal that complies with the following:

- (1) The alarm signal shall be a square wave or provide equivalent awakening ability.
- (2) The wave shall have a fundamental frequency of 520 Hz \pm 10 percent.

A.18.4.5.3 It is not the intent of this section to preclude devices that have been demonstrated through peer reviewed research to awaken occupants with hearing loss as effectively as those using the frequency and amplitude specified in this section.

Fundamental frequency: 520 Hz \pm 10 percent. Odd harmonic frequency components 3, 5, 7 and 9 times the fundamental frequency should be present in appropriate magnitude defined by the Fourier transform of a square wave (see below) \pm 20 percent.

On a linear scale where X is the peak magnitude of the fundamental frequency component, the harmonic frequencies should have the following peak magnitudes with the tolerance defined above:

- (1) 520 Hz X
- (2) 1560 Hz 1/3 X
- (3) 2600 Hz 1/5 X
- (4) 3640 Hz 1/7 X
- (5) 4680 Hz 1/9 X

(Note: Due to space considerations, we have omitted the remainder of this Annex section, A.18.4.5.3, which contains detailed formulas and Figures.)

And, for your reference, the revised text from TIA 971 adopted by the NFPA Standards

Council reads as follows:

24.4.1.4 Tones. The tone preceding any message shall comply with 24.4.1.4.1 through 24.4.1.4.4.

24.4.1.4.1 The tone preceding any message shall be permitted to be part of the voice message or to be transmitted automatically from a separate tone generator.

24.4.1.4.2* Except as specified in 24.4.1.4.3, in occupancies where sleeping accommodations are provided and the voice message is intended to communicate information to those who could be asleep, a low-frequency tone that complies with the following shall be used:

- (1) The tone shall be a square wave or provide equivalent awakening ability
- (2) The square wave shall have a fundamental frequency of 520 Hz \pm 10 percent.

A.24.4.1.4.2 The intent of this low frequency tone is to accommodate those with mild to severe hearing loss. See also 18.4.5, A.18.4.5 and A.29.3.8.2. The effective date listed in Chapter 18 for using a low frequency signal has not been allowed in this section (24.4.1.4) because voice systems are easily adapted to comply, whereas the requirements of 18.4.5 also apply to stand-alone tone signaling appliances.

24.4.1.4.3* In areas where sleeping accommodation are provided, but the voice communication system is used to communicate to occupants who are awake, the low frequency tone shall not be required.

A.24.4.1.4.3 Sleeping accommodations are provided in occupancies such as healthcare, detention and correction, and other occupancies where it would not be necessary to utilize a low frequency tone that awakens those sleeping. For example, in a hospital, the voice message is used to notify staff members who are already awake. The staff will then respond to the appropriate location in the hospital to carry out their duties which may include awakening and relocating patients who may be in danger. In addition, fire drills are required to be conducted on a regular basis and providing a low frequency tone could unnecessarily awaken patients, which would be detrimental to their care.

24.4.1.4.4 Audible signal tones for alert or evacuation shall meet the audibility requirements of either 18.4.3 (Public Mode Audible Requirements), 18.4.4 (Private Mode Audible Requirements), 18.4.5.1 and 18.4.5.2 (Sleeping Area Requirements), or 18.4.6 (Narrow Band Tone Signaling for Exceeding Masked Thresholds), as applicable.

Typically the frequency range of most speaker notification appliances exists in the range of 400-14,000 Hertz. Thus, currently available speaker-type audible notification appliances can reproduce the required square wave signal when the requirement takes effect as detailed above.

In working with a qualified system designer for this project, you must incorporate the requirements in the above sections. Most of the time, this will particularly apply to sleeping areas within your particular application. Since residential group homes do have sleeping areas, you will need to pay attention to these requirements.

This situation points out the need to pay attention to changes in each new edition of NFPA 72. And, you must pay particular attention to the actions the NFPA Standards Council may take on Tentative Interim Amendments (TIA) between the issuance of various editions of the *Code*.

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