Low Frequency Notification Appliances

SYSTEM SENSOR®

Low Frequency Notification Appliances

Contents

Introduction

The purpose of this guide is to provide information about low frequency 520 Hz notification appliance requirements used in fire alarm and carbon monoxide systems. It outlines the development of the NFPA 72, NFPA 720 and UL standard requirements. It also provides an overview and guidance for placement and usage of low frequency notification appliances within fire alarm and carbon monoxide systems.

Though this information is based on industry expertise, it is intended to be used only as a guide. The requirements of applicable codes and standards, as well as directives of the Authorities Having Jurisdiction (AHJ) should be followed. In particular, following the most current versions of NFPA 72 and NFPA 720 for installation and testing of systems is key to the effectiveness of low frequency notification appliances.

Section 1

Waking Effectiveness and the Development of Low Frequency Requirements

While fire alarm systems and smoke alarms provide life-saving value for people when they are awake, their greatest potential benefit may be when occupants are asleep. This is illustrated in a 2010 U.S. Fire Administration study[1] that reports 50 percent of fire fatalities in residential buildings occur between the hours of 10 p.m. and 6 a.m. – the time when most people are sleeping. Further, fatal fires peak between 4 a.m. and 5 a.m.[1]

Most unimpaired adults wake up quickly to the "standard" audible 3 KHz fire alarm signal, even at levels well below 75 dBA.[2] But according to the U.S. Fire Administration study, 13 percent of fire fatalities in residential buildings are occupants less than 10 years old. It is also suspected that over 27 percent of civilian fire fatalities in residential building fires are linked to alcohol (a sedative that can increase arousal thresholds), drug, or chemical influence.

If we know "most" adults wake up quickly to the "standard" audible fire alarm signal, the U.S. Fire Administration study results beg the following question: How effective is the "standard" signal at waking high-risk segments of the population, such as school age children, occupants experiencing some form of chemical or alcohol impairment, or people who are hard-of-hearing?[3]

Awakening of Sleeping People – a Decade of Research

In 2008, Dr. Dorothy Bruck released a compilation of a decade's worth of research at Victoria University on the effectiveness of various alarm signals for awakening people. During this study, Dr. Bruck ran numerous experiments using different types of signals to determine their waking effectiveness for healthy adults and high-risk groups.

Of all the signals tested, the low frequency signal with a fundamental frequency of 520 Hz was most effective at waking the majority of participants. Specifically, the low frequency signal was found to be 6 to 10 times more effective at waking people than the standard alarm signal. In adults with hearing loss, it was more than 6 times as effective as the standard signal and more effective than bed and pillow shakers.

NFPA-Funded Research on Waking Effectiveness

Many NFPA 72 Technical Committee members were concerned about the waking effectiveness of the standard 3 KHz alarm signal for people with hearing loss, the elderly, school-aged children, and the alcohol impaired. In 2006, NFPA petitioned the Fire Protection Research Foundation (FPRF) to carry out research studies to focus on the effectiveness of the standard fire alarm signal for certain high-risk groups. Working with Dr. Bruck, they funded two studies: "Waking Effectiveness of Alarms for Adults Who Are Hard of Hearing" and "Waking Effectiveness of Alarms for the Alcohol Impaired."

The goal of these studies was to optimize the performance requirements to meet the needs of these high-risk groups. Study participants were exposed to a range of signals across two non-consecutive nights while they were asleep. The six signals tested were:

1. 400 Hz square wave signal
2. 520 Hz square wave signal
3. Pure tone 3 KHz signal
4. Bed shaker
5. Pillow shaker

After testing these signals, the FPRF studies concluded:

- The low frequency 520 Hz square wave signal is the most effective by waking up 92 percent of hearing-impaired participants when presented at or below 75 dBA for 30 seconds.
- The standard 3 KHz signal woke up 56 percent at or below 75 dBA.
- The low frequency 520 Hz signal is superior to bed shakers and pillow shakers at waking hearing impaired participants.

Section 2

Low Frequency Requirements in NFPA 72

The low frequency 520 Hz requirements were fully adopted into the 2010 edition of NFPA 72 and subsequent editions. The compliance date for the new requirement was set for January 1, 2014, which provided a five-year window for Nationally Recognized Test Laboratories (NRTLs), such as UL, FM, and ETL to develop test requirements for product standards. This time frame also gave manufacturers time to develop products to comply with the product standards.

The new NFPA 72 low frequency 520 Hz requirements are found in Chapters 18, 24, and 29. The following provides an overview for the low frequency requirements in each of these chapters.

Chapter 18

Chapter 18 covers the audible alarm signal requirements that are part of a protected premises fire alarm system. The requirements in Chapter 18 do not cover the audible alarm signal produced by a smoke alarm or a household fire alarm system.

Section 18.4.5.3 under Sleeping Area Requirements, took effect on January 1, 2014. This section establishes that the audible fire alarm signal in sleeping spaces must be low frequency.

In the 2013 edition of NFPA 72, the text was slightly modified to clarify that the low frequency 520 Hz requirement is only for sleeping spaces and for the purpose of awakening occupants.

Some examples of spaces covered by this requirement are hotel guest rooms and college and university dormitory sleeping rooms.
The Chapter 18 Committee chose to apply the requirement to all sleeping areas, not just those where occupants have self identified as having a hearing impairment. This was done for the following reasons:

- Many people are not aware they have a hearing impairment.
- The low frequency signal has also proven to be very effective at waking people impaired by alcohol third bullet
- The low frequency signal is effective at waking up school age children.

Chapter 24

Chapter 24 covers Emergency Communications Systems (ECSs), such as in-building fire emergency alarm communication (EVAC) systems and mass notification systems (MNSs). Chapter 24 requirements cover occupancies that use a voice system for occupant notification instead of horns as part of an ECS.

NFPA 72:2010 Section 24.4.1.2.1 under Voice Evacuation Messages establishes that sleeping spaces must include a low frequency (520 Hz square wave) pre-alert tone to accommodate hearing impaired individuals.

In NFPA 72: 2013, the section was changed to Section 24.4.2.4.2 and the text was modified to the following:

24.4.2.4.2* *Except as specified in 24.4.2.4.3, 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 18.4.5 shall be used.*

This section states that if you are using speakers in sleeping spaces as part of your ECS, the low frequency 520 Hz signal is required to play first to wake people who could be asleep, followed by a voice message, except in occupancies listed in 24.4.2.4.3. The reason for this provision is to comply with the NFPA 72 and UL 864 requirement for the voice evacuation message to be preceded by two cycles of the temp 3 audible alarm signal.

Section 24.4.2.4.3 does not require a low frequency 520 Hz signal in occupancies where the voice system is used to communicate to occupants who are awake. 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 could include waking and relocating patients who could be in danger.

Chapter 29

Chapter 29 covers all occupancies that are required to install smoke alarms or household fire alarm systems. Low frequency 520 Hz requirements have been added for household fire alarm systems and single and multiple-station smoke alarms.

Section 29.3.8.1 of NFPA 72: 2010 establishes that in these applications, notification appliances provided for hearing impaired individuals must produce a low frequency alarm signal “where required by governing laws, codes, or standards” and “where provided voluntarily for those with hearing loss.” It mirrors the Chapter 18 square wave and 520 Hz frequency requirements and also establishes a minimum 75 dBA at the pillow, 15 dB above average ambient, or 5 dB above maximum sound level (whichever is greater). Duration of the signal must be at least 60 seconds.
The NFPA 72: 2013 was modified to clarify that low frequency alarm signals are only required in the sleeping spaces.

The Chapter 29 committee took a different position than Chapter 18 and decided to only require the low frequency signal in sleeping spaces for those that are classified to have mild-to-severe hearing loss.

Section 3
Impact on NFPA 720

NFPA 720 is the Standard for the installation of Carbon Monoxide (CO) Detection and Warning Equipment. The 2012 and 2015 editions of NFPA 720 has also incorporated low frequency 520 Hz requirements in Chapters 6 and 9. Compliance for NFPA 720 was set for January 1, 2015.

Chapter 6

Chapter 6 covers audible alarm signal requirements that are part of a protected premise carbon monoxide or fire alarm detection system. The requirements in Chapter 6 do not cover audible alarm signals produced by a carbon monoxide alarm or a household carbon monoxide system.

Like Section 18.4.5.3 of NFPA 72: 2010/2013, NFPA 720 Section 6.4.4.3 under the sleeping area requirements establishes low frequency alarm signal requirements centered around a 520 Hz square wave. The new low frequency requirements become effective January 1, 2015.

Chapter 9

Chapter 9 covers all occupancies that are required to install carbon monoxide alarms or household carbon monoxide detection systems. Low frequency 520 Hz requirements have been added for household carbon monoxide detection systems and single- and multiple-station carbon monoxide alarms.

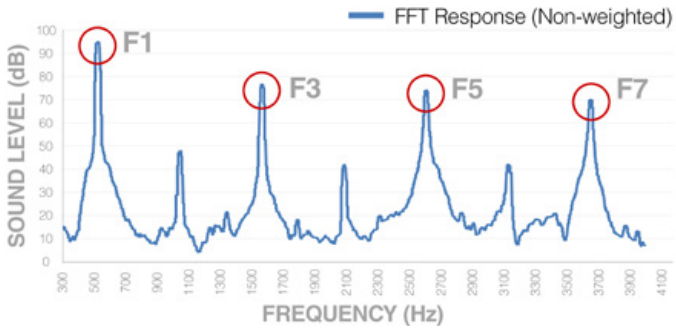
Section 9.4.2.2.1.1 establishes requirements for notification appliances provided for the hearing impaired and mirrors those requirements established in NFPA 72: 2010/2013 Chapter 29, Section 29.3.8.1.

Section 4
Impact on UL Standards

In 2012, UL incorporated performance requirements into two product standards. The first standard of significance to low frequency requirements is ANSI/UL 464, Standard for Audible Signal Appliances, which is primarily used for horns and sounders. The second is ANSI/UL 217, Standard for Single and Multiple Station Smoke Alarms, to which residential smoke alarms are listed.

The determination of the low frequency signal format is the same within ANSI/UL 464 and ANSI/UL 217. Per ANSI/UL 464, Section 24.3 describes the signal format requirements. These consist of analyzing the odd harmonics (F1,F3,F5,F7) using a spectral analysis to ensure that the signal is of a square wave format. While evaluating the odd harmonic profile, UL is looking to ensure that the first harmonic is within 520 Hz 10% at its highest dB output.

Each subsequent harmonic must follow a sequence of 5 dB less than the highest peak but no less than 20 dB at its third harmonic, no less than 30 dB at its fifth harmonic, and no less than 50 dB at its seventh harmonic. (See FFT Response of Low Frequency (520 Hz) Notification Appliances).



FFT Response of Low Frequency (520 Hz) Notification Appliances

The evaluations of these new product requirements are very similar to the profile of speakers for fire alarm systems but with a very specific focus within the 520 Hz frequency range.

Products that are evaluated and listed to the low frequency requirements shall be permanently marked on the housing as a "low frequency sounder" for ANSI/UL 464 compliance or a "low frequency alarm" for ANSI/UL 217 compliance. The marking requirements were added to distinguish the low frequency notification appliance from traditional devices that do not use a 520 Hz frequency.

Section 5

Voice Evacuation Requirements

The use of speakers and amplifiers with fire alarm systems is another way to meet the new low frequency 520 Hz requirements. For a voice system to be listed for low frequency applications, the low frequency alert tone needs to be tested as compatible with the voice system and evaluated per the low frequency requirements defined in UL 464, Section 24.3.

This means that the Fire Alarm Control Panel (FACP) manufacturer must list in its literature the compatible manufacturers of speaker(s), amplifier(s), as well as a specific low frequency sound file that has been approved and listed as compatible with the low frequency 520 Hz requirement.

This has caused some confusion because many speakers and amplifiers are approved within a frequency range of 400-4,000 Hz and some manufacturers market products with wider frequency ranges. The reason for the compatibility requirement is that historically speakers listed to ANSI/UL 1480 and amplifiers listed to ANSI/UL 1711 can only be listed within a frequency range of 400-4,000 Hz. Nationally Recognized Testing Laboratories (NRTLs) such as UL, will perform their test requirements across these manufacturers' listed frequency ranges and they will take an average response across the range. They will not focus on any one specific frequency during their evaluation, which is very different from the requirements defined in 24.3 of ANSI/UL 464 and ANSI/UL 217, which have specific testing requirements on the 520 Hz ± 10% frequency range.

Section 6

Impact on the International Building (IBC) and Fire Code (IFC)

Section 907.2 in the 2012 and 2015 edition of the IBC/IFC requires a fire alarm system to be installed in new buildings in accordance with NFPA 72 and to provide occupant notification in accordance with Section 907.5.

The basic purpose of a fire alarm system is to alert all occupants in the building. Section 907.5 requires the activation of a fire alarm system to send a signal to the control unit and then provide occupant notification throughout all occupied areas of building, including both common and tenant spaces.

Common spaces are the corridors, lobbies, or meeting rooms. Tenant spaces are dwelling units within apartment buildings, guest rooms of hotels, or dormitory sleeping rooms.

The NFPA 72: 2010 is referenced in Chapter 80 of the IFC and Chapter 35 of the IBC. The requirements in NFPA 72 and section 907.2 of the IFC do not apply retroactively to existing systems. However, there are situations when an AHJ may require an existing system to be brought up to current criteria even though the system still meets the minimum requirements of the version of the code in effect at the time of the original installation.

Section 7

Impact on Occupancies

The low frequency requirement applies to new sleeping spaces across several residential Group R occupancies, including lodging or rooming houses, hotels and motels, and dormitories, apartment buildings, and residential board and care facilities.

Group R	Description	Examples
1	Occupancies that are transient in nature	Hotels and Motels
2	Occupancies containing sleeping units or more than two dwelling units where occupants are more permanent in nature	College and University Dormitories, Boarding Rooms
3	Congregate living facilities with 16 or fewer occupants that provide accommodation for five or fewer persons of any age for less than 24 hours	Daycare Facilities
4	Intended for occupancy as residential care/assisted living facilities including more than five but not more than sixteen occupants, excluding staff	Assisted Living Facilities

Group-R1/R2

The low frequency 520 Hz signal is required to be installed in sleeping units of motels and hotels where there is a protected premises fire alarm system to activate the occupant notification system. The purpose of the protected premises fire alarm system is to alert all occupants in the building, including those in sleeping units. However, exception 1 of 907.2.8.1 exempts a protected premises fire alarm system in buildings not more than two stories where all individual sleeping units have an exit directly to a public way.

The low frequency 520 Hz signal is also required to be installed in sleeping units of college and university dormitories where there is a protected premises fire alarm system to activate the occupant notification system.

The protected premises' fire alarm system is required to produce the low frequency 520 Hz signal in the sleeping unit. The smoke alarm is required to produce the low frequency signal as well, either by activating the protected premises fire alarm system or by activating the integral low frequency notification appliance.

Group-R3

This occupancy is only required to install smoke alarms in sleeping units. A protected premises fire alarm system is not required.

- The low frequency 520 Hz signal is not required if there is trained staff to wake up people who are sleeping.
- The low frequency 520 Hz signal is required if there is not trained staff to wake up people sleeping.

Group-R4

This occupancy is intended for residential care/assisted living facilities including more than 5 but not more than 16 occupants, excluding staff.

- If there is no trained staff, see the requirements for Group-R1/R2 for the low frequency 520 Hz requirements.
- The low frequency 520 Hz signal is not required if there is trained staff to wake up people sleeping.

Section 8
Power Supply Considerations

Because of the comparatively high current draw of low frequency 520 Hz devices, the selection of the power supply and accurate voltage drop calculations are critical to ensuring adequate current to the loop.

Manufacturers cannot meet the low frequency 520 Hz requirements using the traditional electro-mechanical piezo element because it cannot effectively produce the harmonics needed to comply with the 520 Hz requirements as defined per UL 464, Section 24.3. Instead, a speaker element, which inherently draws more current than a traditional piezo element, is used to acoustically meet the 520 Hz requirements. As a result, current draw for low frequency devices when compared to devices with a standard alarm tone can be higher.

The low frequency 520 Hz signal is only required for the sleeping spaces, not hallways or corridors. The code does not preclude the use of low frequency devices throughout a building, including non-sleeping spaces, but the high current draw of the devices can make this a higher cost approach. Correspondingly, some designers and installers may be concerned that using traditional devices in non-sleeping spaces like hallways with low frequency devices in the sleeping spaces will create different tones between the sleeping room and the hallway. However, the code does not require that tones throughout a building sound the same. What it does require is that the tones synchronize within the same notification zone.

Section 9
System Applications

Given that in a hotel guest room you may encounter smoke alarms or combination alarms in conjunction with horns or speakers, there is confusion on how systems need to be designed to comply with the requirement. As with any new standard, time is needed for every product in a sleeping space to comply with the new requirement. Below are some recommendations for low frequency applications based on what is available in the market.

Local vs. General Notification

Using a low frequency notification appliance in each room that is connected to the fire alarm panel's notification appliance circuit is required to give general evacuation notice. In most sleeping spaces, especially in R-1/R-2 occupancies, installers and designers should provide local notification before general notification, in case someone burns popcorn or smokes in the space, for example. Given that many smoke alarm manufacturers in the industry have not released products that comply with the low frequency requirement that can give local notification, installers and designers can utilize a control module to tie a number of rooms together to provide general evacuation.

In sleeping spaces, it is recommended to use a smoke detector or a combination detector with no audible sounder base with the low frequency notification appliance, providing general notification only. The current required by the low frequency devices being used will determine how many rooms you can connect to the control module.

The use of low frequency sounder base with a system-connected smoke detector or combination detector can provide both local and general notification without the use of additional modules.

Household Fire and Carbon Monoxide Systems

If you are using a low frequency notification appliance in conjunction with a household fire alarm or carbon monoxide system with a smoke or CO alarm, then the traditional 3 KHz tone may go off for local notification. If the situation requires general evacuation, then the low frequency tone may go off from the notification appliance in addition to the 3 KHz tone of the smoke or CO alarm.

Note: System Sensor does not approve, inspect, or certify any installations, procedure, equipment, or materials. In determining the acceptability of installations or procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for current production of listed items. The information in this guide has been provided in an attempt to assist in making this decision and should in no way be constructed as a formal approval or certification.

References

1 Topical Fire Report Series- Volume 13, Issue 1/February 2012- Civilian Fire Fatalities in Residential Buildings (2008-2010).

2 In a 2008 study (Comparison of the Effectiveness of Different Fire Notification Signals in Sleeping Older Adults - Fire Technology 2008) conducted by Dr. Dorothy Bruck of Victoria University, the "standard" audible fire alarm signal was classified as a 3 KHz signal. The majority of fire alarm horns in the industry produce an alarm signal with a frequency range between 2 KHz and 4 KHz. Also, the integral sounders in nearly all residential smoke alarms produce a signal with a frequency of 3 KHz.

3 According to Cruickshanks et al, 1998, there were more than 34.5 million people in the U.S. who were classified as hard of hearing in 2007, and 12 percent of people aged 45 years or more are unaware of their hearing problem. This number was expected to increase as the population ages. www.systemsensor.com/en-us/Documents/AV-AlarmEffectiveness-AlcoholImpaired.pdf

4 Awakening of Sleeping People – a Decade of Research, Ian Thomas and Dorothy Bruck July 2008

5 www.systemsensor.com/en-us/Documents/AV-AlarmEffectiveness-HardofHearing.pdf

6 www.systemsensor.com/en-us/Documents/AV-AlarmEffectiveness-AlcoholImpaired.pdf

7 The System Sensor Voltage Drop Calculator application for SpectrAlert® Advance notification appliances can be accessed at: http://www.systemsensor.com/en-us/Pages/Voltage-Drop-Calculator.aspx

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