31 March, 2013

Assuring safe people reaction to public alarms

A Proposal for a New International Standard

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Contents

Forward

The Technical Committee (TC) for Usability Assurance is a Technical Committee of the Central Committee for Management and Quality of the Israeli Institute of Standards (SII).

This proposal is based on a technical report on Resilience-oriented Design (in Hebrew), developed by the Gordon Center for System Engineering of the Technion, Israel. It is optimized to fulfill the Israeli safety needs. Apparently, it can also be adopted, or at least adapted, for use also as an international standard.

Introduction

Public alarms are about hazards such as floods, storms, epidemics, environmental contamination, volcanic eruptions, building destruction, tsunami, meteorites, forest fire, earthquakes, land slide, avalanche, chemical and radiation threats, in-house fire, terror attacks and missile attacks.

Public alarms enable safety authorities to alert people about the hazards, so that they can prepare and act to mitigate the risks.

In emergency, people must respond quickly, and the time to communicate the information required for assuring proper reaction is often limited. This standard proposal provides guidance and instructions for helping people perceive and understand the significance of the alarm, in terms of risks and the time frame available for preparing to the hazard.

This standard proposal elaborates the general statements in ISO/DIS 22322,"Societal security -- Emergency management -- Public warning" regarding the need to consider human factors in the design and operation of the message dissemination function of alarm systems. It is based on knowledge published in the following articles:

- Harel, A., Alarm Reliability, User Experience Magazine, Vol 5., Issue 3., 2006
- Harel, A., Using Sound for Alerting: Lessons from the War with Hezbollah. User Experience Magazine, Vol 5., Issue 3. Postscript, 2006

- Harel, A., Designing war alarms: a multi-disciplinary approach. The Israeli Ergonomics Association on Human Factors Engineering for Military Systems, Netzer Sereny, Israel. 2012

- Harel, A., Towards families of resilient systems. (A. Zonnenshein, A. Harel) The Yossi Levin Conference, Technion, Haifa, Jan. 9th, 2013

- Stanton, N A, Stammers, R B, Alarm initiated activities: Matching formats to tasks, International Journal of Cognitive Ergonomics. 2 (4) 331-348, 1998

- Lars Benthorn, Håkan Frantzich, Fire alarm in a public building: How do people evaluate information and choose evacuation exit?, LUND, June, 1996.

- Robin Hattersley Gray, 7 Steps to Reducing False Fire Alarms, 2010

- McNeer RR, Bohórquez J, Ozdamar O, Varon AJ, Barach P., A new paradigm for the design of audible alarms that convey urgency information. J. Clin Monit Comput. 2007 Dec; 21(6):353-63. Epub 2007 Nov 1.

- Hagenouw RR., Should we be alarmed by our alarms? Curr Opin Anaesthesiol. 2007 Dec;20(6):590-4.

- Guillaume, A., Intelligent auditory alarms, in Thomas Hermann, Andy Hunt, John G. Neuhoff (eds.) The Sonification Handbook, Logos Publishing House, Berlin, Germany

- Edworthy J, Meredith CS. Cognitive psychology and the design of alarm sounds, Med Eng Phys. 1994 Nov; 16(6):445-9.

The standard proposal considers four types of risks to the public:

- Direct risks – due to the hazard itself,

- Unpredictable behaviour of people under trauma, due to being in stress during and following the warning,

- Psychological injuries, namely, PTSD

- Carelessness about safety

The main body of the standard proposal, following the Scope, Normative Reference and Terms and Definitions chapters, is arranged in two chapters, according to the way compliance with the standard can be verified:

- Chapter 4: assuring reliable alarm generation, compliance can be verified by review and usability testing of common failure modes in alarm generation
- Chapter 5: promoting safe people reaction to alarms, compliance can be verified by usability testing of the safety behavior of people at risk.

1 Scope

This standard proposal provides principles and guidelines for designing and managing public warning about hazards. This proposal does not deal with the ways the hazards are monitored or with evaluating their risks. It is applicable to any authority and organization responsible for public warning. It is applicable at both local and national levels.

2 Normative references

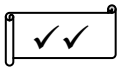
The following referenced documents are indispensable for the application of this document.

- ISO/DIS 22322, Societal security -- Emergency management -- Public warning

3 Symbols, terms and definitions

3.1 Symbols used in this proposal

Compulsory: This paragraph provides an instruction



Optional: This paragraph provides guidance, recommendations and examples

Testing: This paragraph is about compliance verification

3.2 Hazards

A hazard is defined here as an upcoming incident involving high risk for people.

Examples of expected hazards include: floods, storms, epidemics, environmental contamination, volcanic eruptions, building destruction, tsunami, meteorites, forest fire, earthquakes, land slide, avalanche, chemical and radiation threats, in-house fire, terror attacks and missile attacks.

3.3 Safety information

Range	A hazard may apply to several areas, each with its special safety information. For example, a hurricane might arrive from the south, threatening southern areas first. The range is the area to which the safety information apply
People at risk	People staying at the range
Neighbors at risk	People staying in high-risk areas about the range
Expected loss	Forecast about the costs of casualties, injuries and property of people at risk, due to the hazard
Reaction Time Frame	An estimate of the time left until the hazard is expected
Risk information	A combination of the expected loss, the reaction time frame and hazard specific optional risks
Impact	The hazard actual set off time
Emergency	A situation in which the expected loss is high and the reaction time frame is short

3.4 Alarms

Alertness	The likelihood of an alarm to attract the people attention to the risks
Attractor	A visual and/or audio means to alert, namely, to attract the people attention to the risks
Alarm message	Information about the hazard risk, the emergency, and available safety measures
Advance notice	A message to the public in the range, notifying them about the upcoming hazard
Media	Channels, such as internet, TV and newspapers, public and home announcement system, used to disseminate the alarm message
Earcone	An audio symbol used to represent the risk information in audio media
Icon	A visual symbol used to represent the risk information in visual media

3.4.1 Alarm performance

Emergency recognition	The ability of people to recognize risky situations
Emergency perception	The ability of people to perceive the risk information
Emergency compliance	The ability of people to use the safety measures

3.4.2 Alarm reliability

Latent failure	Failure, such as hardware problems and operational problems, not detected until there was a need for the safety function
Fault Detectability	Means to detect potential latent failures.

4 Assuring reliable alarm generation

4.1 Types of alarm generation

4.1.1 Manual

Manual alarm generation is applicable to areas with sufficient advance warming. Examples of such hazards include floods, storms, epidemics, environmental contamination, volcanic eruptions, building destruction, tsunami, meteorites, forest fire, etc.

Manual alarm generation enables thorough estimation of the risks, evaluation of safety measures and warning methods, and deciding on the best way to warn the people at risk

4.1.2 Automatic

Automatic alarm generation is applicable to imminent hazards, or hazards with short notice, when the people at risk should be warned immediately. Examples of such hazards include earthquakes, land slide, avalanche, chemical and radiation threats, in-house fire, terrorist attacks, missile attacks, etc.

In such cases, safety authorities do not have sufficient time for activities such as real-time risk estimation, method evaluation or decision making. Therefore, the alarms are generated automatically, optimized for risk mitigation based on to pre-defined scenarios.

4.2 Assuring manual alarm generation

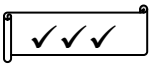
Manual alarm generation is applicable to areas with sufficient advance warming.

4.2.1 Training the operators of the alarm system

The operators of the alarm system should be trained to cope with both expected and unexpected threats. Training to handle expected hazards is based on learning the operational and maintenance procedures and on routine practice. Training to handle unexpected events should be based on special skills, acquired in event-response training sessions.

The responsible organization should prepare a plan for both types of training.

Compliance verification

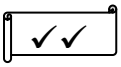


Compliance with this part of the standard may be verified by review of the training program and its schedule.

4.2.2 Detecting operator malfunction

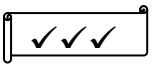
According to the Human Factors version of Murphy's Law statement, if the system enables the operators to fail, eventually they will. Operator might be absent, incompetent, sleepy, sick, confused, ect.

The system design should include backup means to detect that this happens.



Examples of such means include utilities for remote supervision of the alarm control, and supervisor-level safety warnings.

Compliance verification

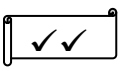


Compliance with this part of the standard may be verified by usability testing of the backup solutions, namely, the supervisors in their control rooms.

4.2.3 Responding to unlikely hazards

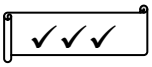
People typically hesitate before generating an alarm about unlikely hazards.

The system design should include means to automatically warn higher levels in the decision making about such hesitation.



For example, the system can warn a local safety supervisor when the delay before the alarm activation is 10% from the time-to-impact, it can warn a national-level safety supervisor when the delay is 20%, etc.

Compliance verification



Compliance with this part of the standard may be verified by usability testing of the higher levels of decision making by the local and national supervision system.

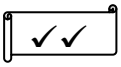
4.3 Assuring automatic alarm generation

Automatic alarm generation is applicable to imminent hazards, or hazards with short notice, when the people at risk should be warned immediately.

4.3.1 Detecting alarm malfunction

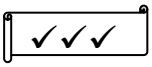
The system might fail to provide audible alarm signals for various reasons, such as due to setting the amplifier to low volume, disconnected speakers, unintentional shut down or switching to mute mode, or failure to reset properly after power failure. Also, the alarm system might be set to the 'Off' position for maintenance or testing.

The system design should include means to detect and provide salient warning about such situations.



For example, the alarm system may generate continuous or periodic hardly-audible alarms, and an electronic signal detector, operated using a different power supply, may warn the operator when an alarm signal is not generated.

Compliance verification



Compliance with this part of the standard may be verified by usability testing of the operator's behavior in the control room, in various malfunction scenarios.

5 Promoting safe people reaction to alarms

5.1 Public risks

Typical risks due to hazards include:

- Direct risks imposed by the potential hazard
- Risks due to the people failure to behave safely

Depending on their personality and duties, eventually, they might regard taking refuge as a waste of time, and prefer continuing with their routine activities. Depending on their personality and the circumstances, they might become stressful, and respond hysterically. Alternatively, they might decide to disregard the alarm, as a way to cope with the stress. Depending on their personality and impact outcome, they might develop PTSD

5.1.1 Mental tasks of people at risk

Typical mental tasks involved in responding to a hazard include:

- Be alerted
- Become aware of the potential hazard
- Get an estimate about the risk level
- Decide whether to change routine behavior
- Decide on a best protection

5.2 Alarms

An alarm has two functions:

- Alerting, namely, attracting the people attention, and
- Informing about the risk and availability of safety measures.

Accordingly

 An alarm consists of two components: an attractor and a message.

5.3 Alerting

5.3.1 Sources of people carelessness about safety

People might disregard the warnings, due to:

- Reliability problems, such as due to high rate of irrelevant alarms or of nuisance alarms or
- Confusion about the way they should react to the alarm

5.3.2 Attractor design

People might fail to distinguish the alarm from common, daily information.

The alarms should be designed using dedicated format, such that they are easily distinguished from common messages.

The alarms should be designed so that people's attention is attracted to the message.

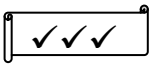
- Printed messages should use special icons, using bold colors and high contrast.
- Media messages should use Special dissonant, annoying earcones and animation, so that people cannot ignore them
- Flashing lights may be used as backup to sound alarms, and as a primary means for the deaf

Distinction assurance

The safety authorities should prohibit replay of sound alarms in the new, or in ads used for business promotion.

Replication of visual alarms should use a special format, so that people can easily distinguish an acute alarm from replications of previous alarms.

Compliance verification



Compliance with this part of the standard may be verified by review of the publication guidelines.

5.4 Informing the public about the reaction time frame

When people look for a safe place to stay during the impact, they may choose the one nearest to their location, or, if they have enough time, they may look for another one which is more convenient.

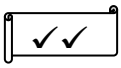
Knowledge of the reaction time frame is important for making the proper decision about which option to choose. If the system does not provide this information, people hesitate,

and subsequently, they get into a stress situation. Consequently, many people react carelessly the alarms. Some hesitate before entering a shelter, some disregard the alarms altogether and become careless about safety.

To mitigate these risks, the alarm message should include information about the reaction time frame.

5.4.1 Visual messages

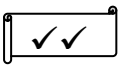
To enable fast perception of the reaction time frame, it should be codified in the icon.



For example, the icon may include an image of a calendar and a clock showing the reaction time frame.

5.4.2 Sound messages

To enable fast perception of the reaction time frame, it should be codified in the earcone.



For example, the earcone dissonance and properties of pitch, loudness, duration, and time intervals may induce sensation of emergency levels.

5.5 Informing the public about the risk level

When the alarms do not reflect the actual loss due to the hazard, people might perceive the alarm system as unreliable. Typical problems of alarm reliability include:

- Irrelevant alarm, when the hazard impacts a remote location
- False alarms, when the hazard does not materialize or fade away before reaching the range
- Missing notification, when the impact on neighbors at risk was not preceded by an alarm.
- Unexpected impact, when the alarm similar to previous alarms, but the impact is significantly different

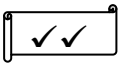
When the alarm system is perceived as unreliable, people often become stressed, because they cannot estimate properly the risk to which they are exposed. Many people become

careless about the alarms. Some hesitate before looking for a shelter, some disregard the alarms altogether.

To mitigate stress development and to assure prudent behavior, besides information about the risk level at their range, the alarm message should also include information about neighborhoods with similar or higher risk.

5.5.1 Visual messages

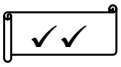
To enable fast perception of the risk, it should be codified in the icon and the earcone.



For example, the icon color may represent the risk level. When the hazard is imminent, the icon should flash.

5.5.2 Sound messages

To enable fast perception of the risk, it should be codified in the icon and the earcone.

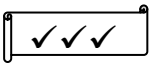


For example, the earcone may be based on three similar tunes, corresponding to the risk levels.

5.6 Informing the public about hazard information updates

The alarm system should notify the people about significant changes in the forecast of the impact location or of the risk level at the impact location.

Compliance verification



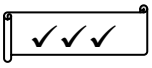
Compliance with this part of the standard may be verified by review of the procedures for message dissemination.

5.7 Safety information

Besides information about the hazard, the alarm messages should also include information about the way people should react to the alarm.

The alarm message design should support proper perception of the safety information, for example by graphical illustration and video clips.

Compliance verification



Compliance with this part of the standard may be verified by review of the message template

5.8 Message design

5.8.1 Message structure

Visual messages should include an icon and printed text. The icon should enable people to perceive the risk and the emergency at a glance.

Audio messages should include an earcone and spoken text. The earcone should enable fast perception of the risk and emergency using the audio channels.

5.8.2 Types of alarm messages

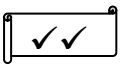
When the hazard is still flimsy, the messages can provide many details about the expected location, time and loss. When the hazard is more acute and concrete, the message should be concise, highlighting the most significant risk factors.

When the reaction time frame is of only few seconds, assuming that the people are already familiar with the safety information, the message should focus on countdown.

When the hazard is imminent, the alarm should continue until it impacts.

5.8.3 Designing the message content

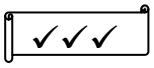
The safety administration should specify the content and format of the various message types.



The message content may be defined as in the following example:

Message type	Reaction time frame	Risk level	Safety measures
General notice	Expected day	General	Detailed guidance
Detailed	Expected time	by location	Detailed guidance
Concise	Seconds	by location	Concise guidance
Countdown	Seconds	Irrelevant	-
Flashing	Imminent	Irrelevant	-

5.8.4 Compliance verification



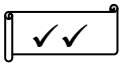
Compliance with this part of the standard may be verified by review of the message information structure and the dissemination procedures.

5.9 Scheduling the alarms

It is quite reasonable that people miss the first alarm message.

Alarms should be repeated regularly, to enable people memorize the expected hazard, and internalize (be familiar with) the new risks.

The design should include a detailed schedule of repeated alarms and the accompanied information.



The schedule may be as in the following example:

Reaction time frame	Media	Message type	Schedule
More than 24 hours	Public media, such as news	General notice	Every news session
1-24 hours	Alarm system	Detailed message	Every hour
10-60 minutes	Alarm system	Detailed message	Every 10 minutes
1-10 minutes	Alarm system	Detailed message	Every minute
10-60 seconds	Alarm system	Concise message	Every 10 seconds
1-10 seconds	Alarm system	Countdown	Every second
Imminent	Alarm system	Flashing	Continuous

5.9.1 Avoiding nuisance

Frequent alarms are disturbing. When the alarms are too frequent, people might fail to prepare for the hazard.

The alarms should not be repeated too often, in a way that might disturb other mental activities.

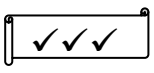
5.10 Training people

5.10.1 Understanding the alarms

When hearing an alarm in the first time, people might not understand its meaning, and might not know how to respond. People should experience the alarms, learn to recognize the meaning of the associated information, and understand how they should react to the alarms.

The responsible organization should prepare a training program for the public, enabling people to experience the alarms.

Compliance verification

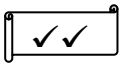


Compliance with this part of the standard may be verified by usability testing following the initial training.

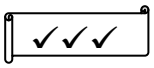
5.10.2 Practicing the alarms

Besides learning, the training program should also include rehearsal, to enable mental retention of the alarm information, and to enable new comers to learn and experience the alarms, and to practice the desired actions.

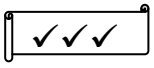

The responsible organization should prepare a rehearsal plan and schedule.

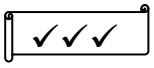

For example, a rehearsal may be scheduled for the first Tuesday of every month, at 10:00 am.

Compliance verification


Compliance with this part of the standard may be verified by review of the rehearsal schedule and by usability testing following rehearsals

5.11 Compliance verification of the people behavior


Compliance with this clause may be verified by testing the reaction of a large sample of people to alarm generated in various circumstances, including various risk levels and various emergency situations.


The icons and earcones should be fine-tuned and tested in pilot studies.