COMMUNITY WARNING FOR TOXIC RELEASES FROM INDUSTRIAL SITES

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ABSTRACT

Many industrial facilities such as refineries, chemical plants and paper mills handle toxic substances for their operations. In order to alert nearby communities surrounding these facilities in the event of an emergency, an effective method must be used. Depending on the wind conditions and the nature of the toxic release incident, the response time must be kept very short (a matter of a few seconds). It has been determined that the most effective alerting method is to use fixed high power directional speakers within the fenceline of these facilities. The US Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and Federal Emergency Management Agency (FEMA) require these facilities to provide a reliable method to safeguard these communities.

This paper describes a system implemented for a community near Houston, Texas. It will describe the system's design and computer modeling to ensure proper acoustic coverage for the effected community. System hardware and software will also be discussed in the paper. Continuous status monitoring for the installed equipment and the communication system design will also be addressed.

In summary, this paper will highlight important aspects used to alert communities against technological disasters associated with the release of toxic fumes.

INTRODUCTION

A community warning system is for the purpose of alerting the residents in the event of a chemical accident/emergency that may result in harmful concentrations within the community. As a result of the severe time constraints involved with an accident, a warning must be issued immediately and must be capable of both indoor and outdoor alerting and notification. The warning siren alert signal is intended as an initial attention getting signal instructing the population to take necessary protective actions. In most instances, the siren signal instructs the population to get indoors, close all window, turn off any air conditioning systems to avoid drawing the chemical indoors, and turn on their local Emergency Broadcast System (EBS) television or radio station for further information. The residents living within areas nearby to the industrial plant must be instructed on how to respond to a siren signal through a public education program.

SYSTEM DESIGN CRITERIA

The Nuclear Regulatory Commission (NRC) and the Federal Emergency Management Agency (FEMA) have established acceptable outdoor siren signal criteria for public notification in the vicinity of nuclear power plants in their document NUREG-0654, Appendix 3 -- "Means for Providing Prompt Alerting and Notification of Response Organizations and the Population." "As an acceptable criteria at most locations, 10dB above average daytime ambient background should be a target level for the design of an adequate siren system." The 10dB dissonant differential refers to the ambient in the octave band surrounding the siren tone and is a conservative use of the 9dB differential which is discussed in FEMA document CPG-1-17. Research has shown that a person is capable of being alerted by such a differential above the background ambient in the case of a predominantly narrow band siren tone. The achievement of a positive differential of 10dB has been a basic objective of most siren system designs for outdoor alerting.

Available data relating to investigations into the effect of waking people from sleep indicate that for the time of deep sleep, an indoor warning signal of 60dB was sufficient to awaken approximately 60 percent of the test subjects. This means that the outdoor siren warning signal must be at least 75dB if one can assume about a 15dB transmission loss for building wall, given the type of housing construction (wood and brick) and wall insulation levels expected in the south. This report also indicated that a decrease in loudness of 5dB resulted in a waking loss of about 7 percent. It was also determined that a time duration of 60 seconds was sufficient for emitting the signal for waking purposes.

Using this information, it was determined that an outdoor siren signal level of 75 dBC is an adequate design for indoor notification.

With regard to *nighttime indoor* notification for waking people during sleep, several factors tend to improve system's indoor warning capability. During the nighttime hours, ambient sound levels due to traffic and other outdoor activity as well as indoor noise levels (especially during sleeping hours) are substantially lower, which should help to make the warning signal more noticeable indoors.

Electronic, high power directional sirens for fenceline alerting have been chosen due to their capability of operating off a battery source which can be integrated with a solar power energy system.

ACOUSTIC COMPUTER ANALYSIS

Siren sound levels for siren locations are calculated by a computer model developed by ATI. This model is based on outdoor sound propagation theory used in conjunction with empirical factors to closely correlate the results with field test data. ATI has made extensive acoustic measurements at siren systems across the country in order to evaluate and perfect this model.

For siren system analysis, the primary inputs to the computer model are site specific topography (building and land elevations), ground cover and meteorological conditions. Topography and ground cover in the vicinity around each siren. Summer average temperature, humidity, wind speed and direction are computed from data gathered at local site weather monitoring station and the National Climatic Data Center. This information is used to calculate the sound attenuation due to the sources described in the following sections.

The various factors (see Figure 1) considered in the sound propagation analysis by the computer model are summarized as follows:

a. Hemispherical Wave Divergence
b. Atmospheric Absorption
c. Wind Shadows
d. Ground Cover Absorption
e. Barrier Attenuation Effects

The extensive program of field testing has proven the ATI siren computer model to be an accurate and reliable estimator of siren acoustic coverage for all siren types and models to which it has been applied, as well as a wide variety of topographic and ground surface conditions.

FEMA guidelines suggest that average summer daytime weather conditions be used to calculate siren sound contours.

SYSTEM CONFIGURATION AND DESIGN

The portion of the community targeted for fenceline siren alerting is a significant area within the Community Emergency Planning Zone (EPZ). The industrial plants within the community have been grouped into 3 major zones: the East Zone, the North Zone and the West Zone. The optimum system design consists of fifteen fenceline siren sites for the three zones. The fifteen sirens were determined to be sufficient to acoustically cover the fenceline areas within the EPZ. These locations require sirens with directional horns to optimize the alert coverage within the community.

Each fenceline siren is located on one of the industrial plant's property. In most cases, this means that access to the site for installation and future maintenance of the siren will be through the designated plant. The extent of the sound coverage from the fenceline sirens is shown on Figure 2.

Additional Community Siren Coverage: If blanket coverage of the entire community Emergency Planning Zone (EPZ) is required at a future time, additional community sirens can be installed. ATI designated tentative locations for additional community sirens.

Maximum Noise Level Exposure Analysis: In order to insure that there is no public risk to excessive noise exposure, a computer analysis was performed to determine the maximum noise exposure to any residence in the immediate proximity of the siren. This computer analysis was based on the following general assumptions:

1. The siren may be modeled as a point source;
2. The receiver lies in the far field;
3. The atmosphere is still, isothermal, and homogeneous; and,
4. The ground is a perfect reflector.

The predicted sound pressure level was determined by considering the effects of ground reflection, hemispherical divergence, atmospheric absorption, and directivity pattern on the propagation of sound between source and receiver.

From this analysis, a maximum sound pressure level of 117 dBC at a distance of 100 feet from the siren pole (in the direction that the siren horns are pointing) was determined. This value is less than 123 dBC, the level considered to cause discomfort to an individual. These results strongly indicate that the sirens are safely located with regard to noise exposure criteria.

Figure 3 illustrates the system configuration. Each zone has an independent controller to control its' zone sirens. Also there is a central controller located at the city police station. This central controller can activate individual sirens, a group of sirens, or the entire system. The siren system uses a radio frequency (RF) communication infrastructure for status monitoring and activation of the sirens.

Radio Frequency Propagation Study: In order to determine actual radio signal strength and to identify potential system problems for the community siren system, a radio frequency propagation study was performed during the system design phase. Radio signal propagation losses were compared to expected losses to determine attenuation effects of man-made structures as well as vegetation. Finally, the radio system design constraints were confirmed. The survey confirmed the feasibility of using the licensed frequency, 154.980 MHz, with 25 watts effective radiated power (ERP) with 15 watts maximum output power which is given by the license. Also confirmed were the type of antenna and configuration that were needed to achieve reliable radio communications.

The fenceline siren system was installed and is maintained by the local industrial plants. The system design includes a user-friendly software package running on the personal computers at each control station. The siren system software package provides status monitoring and maintenance information for operators and after siren activations, verification information on the success or failure of the sounding.

CONCLUSIONS

The results of ATI's site survey and radio propagation survey provided enough data to enable a highly reliable design of an Industrial fenceline community warning system. The system of fifteen sirens described in this paper sufficiently covers the area immediately around the various industrial plants.

The following main conclusions can be drawn from this paper:

1. Adequate 75 dBC for indoor and 65dBC for outdoor acoustic coverage is provided by 15 stationary high power electronic sirens for the fenceline community near the industrial sites.

2. Placement of sirens did not pose any environmental noise impact to humans or animals in the near field of the sirens.

3. The central and zone controller stations transmit and receive radio signals reliably with the siren's controller utilizing the 154.980 MHz radio frequency.

4. The warning system and its radio control system will provide adequate means for prompt alerting of the nearby public in case of an emergency at the industrial facilities.

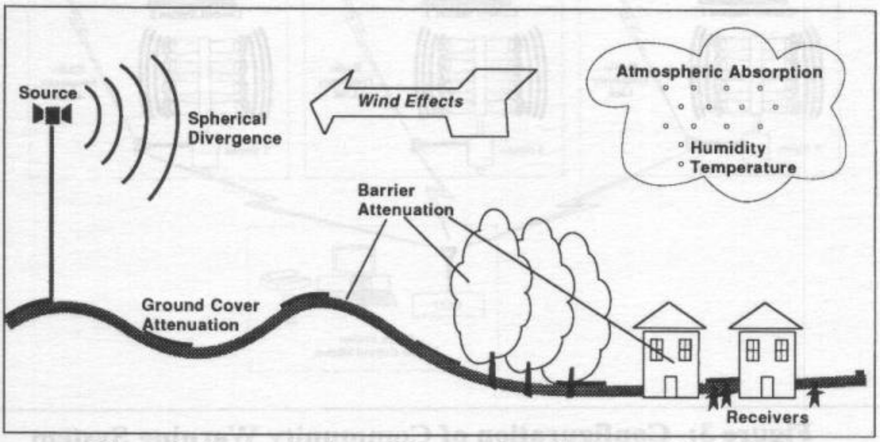

Figure 1: Factors in Sound Propagation Computer Modeling

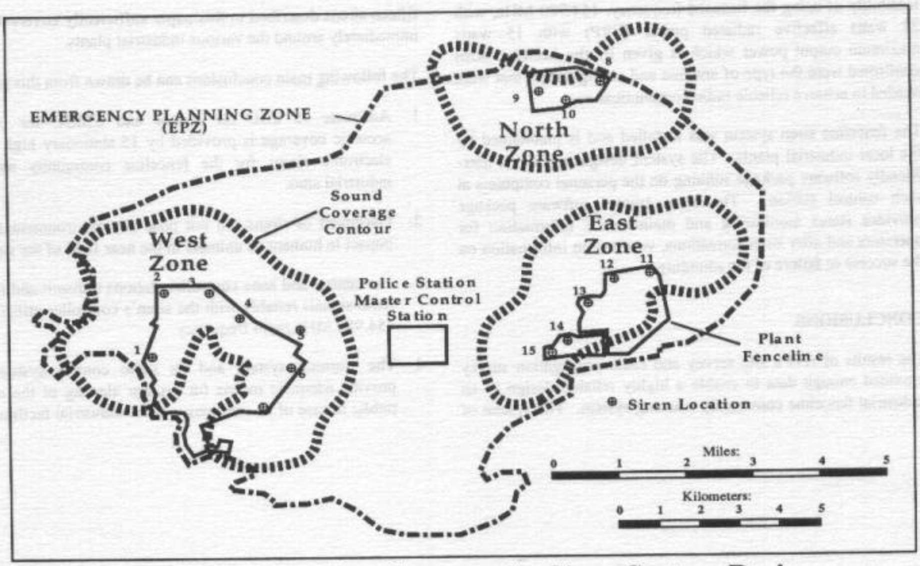

Figure 2: Fenceline Community Siren System Design

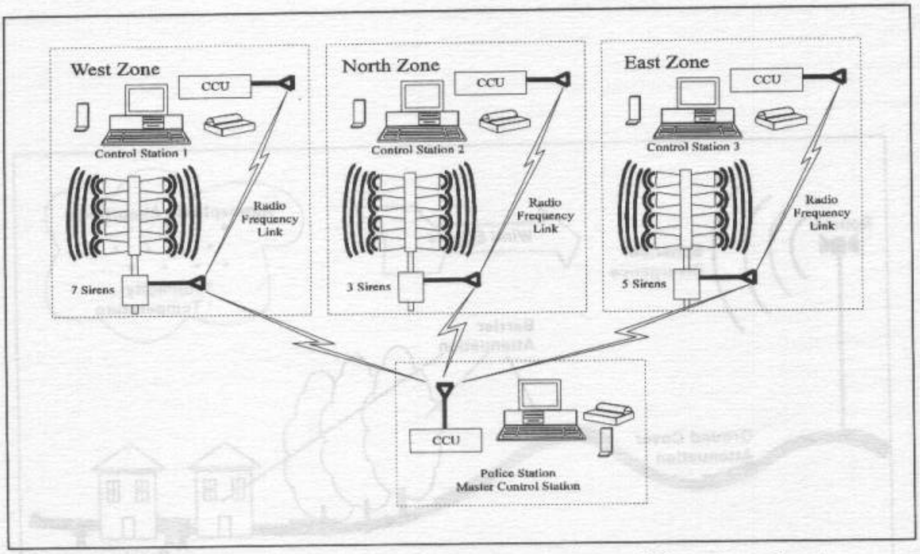

Figure 3: Configuration of Community Warning System