DIRECTIONAL CHARACTERISTICS OF AN OUTDOOR WARNING SIREN

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1. INTRODUCTION

A utility company installed an outdoor warning siren at one of its facilities to alert the surrounding community in the event of an emergency situation. The selected unit was a rotating, electromechanical siren supplied by a manufacturer of signaling devices. A single test of the system was conducted after it was installed and it was observed that siren noise was not clearly audible in some parts of the warning area. The siren is capable of various modes of operation and the utility company wanted to determine which operation mode would maximize the audibility of the siren throughout the warning area. Because of the potential public disturbance caused by further testing of the siren, a theoretical study of the siren noise was conducted to analyze the characteristics of the various operating modes.

2. SIREN OPERATION MODES

The siren is comprised of a single horn mounted on a motor that rotates the horn at a uniform speed. The speed of rotation is relatively slow (*i.e.* a few rpm) and is adjustable within a small range. The siren's electromechanical mechanism produces a steady primary tone when it is energized. The sound power of this tone is sufficient for the alarm to be normally audible up to a distance of about 3 kilometres if the siren is located in a semi-urban or rural area and is mounted well above the ground. The siren noise may be presented as a steady tone or as two types of modulating tones (*i.e.* fast and slow). The provision of modulating tones appears to be a feature designed to improve the urgency and 'attention-getting' aspects of the alarm. The various operating modes of the siren include selection of the type of tone emitted (*i.e.* steady or modulating) and the rotational speed of the horn.

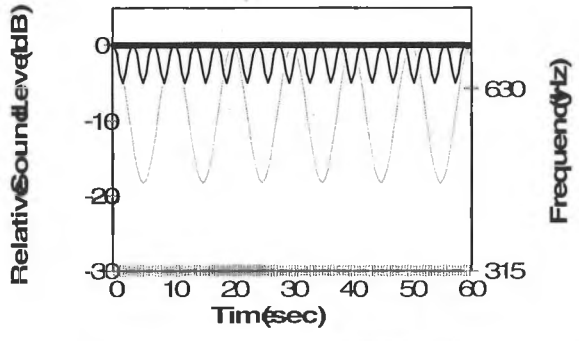

Figure 1. Siren modes: Steady tone ▬▬ ; Fast modulating tone ▬ ▬ ; Slow modulating tone – – – –.

The modulating tones are produced by periodically de-energizing and energizing the siren's electromechanical mechanism. For the fast mode, the unit cycles off and on at a rate of about 17 cycles per minute. For the slow mode, the unit cycles off and on at a rate of about 6 cycles per minute. During the 'off' interval of each cycle, the siren tone steadily decreases in both sound level and frequency. During the 'on' interval, the tone increases in sound level and frequency until the primary tone is again achieved. Figure 1 illustrates the sound of the 3 types of tones produced by the siren.

3. DIRECTIONAL CHARACTERISTICS

The manufacturer's data identifies the directional characteristics of sound radiation from the siren horn. Directivity plots of the radiation patterns were calculated [1] from the manufacturer's data. Radiation patterns for the 3 types of tones produced are shown in Figure 2. These patterns correspond to the sound radiation from the siren without rotation of the horn. The steady tone plot shows a single-lobe pattern directed along the axis of the horn. The fast and slow modulating tone plots show single-lobe patterns which correspond to the upper and lower limits of the envelope of each modulating tone. These are also directed along the horn axis.

Rotation of the horn provides 360 degree coverage of the siren tone. Since audibility of the alarm is its most important aspect, the directivity patterns of the maximum sound levels produced by the rotating horn were calculated. Maximum sound level results for each type of tone at two of the selectable rotational speeds are shown in Figure 3. For the steady tone mode, the sound level of the lobe remains constant as the horn axis sweeps through the circle. This results in a uniform distribution of the maximum sound level around the siren. At any location in the coverage area, the sound level of the tone is observed to increase to the maximum and then decrease with the passage of the lobe, repeating at the same rate as the rotational speed. This mode provides the best coverage (in terms of audibility) for a siren centrally located in a warning area.

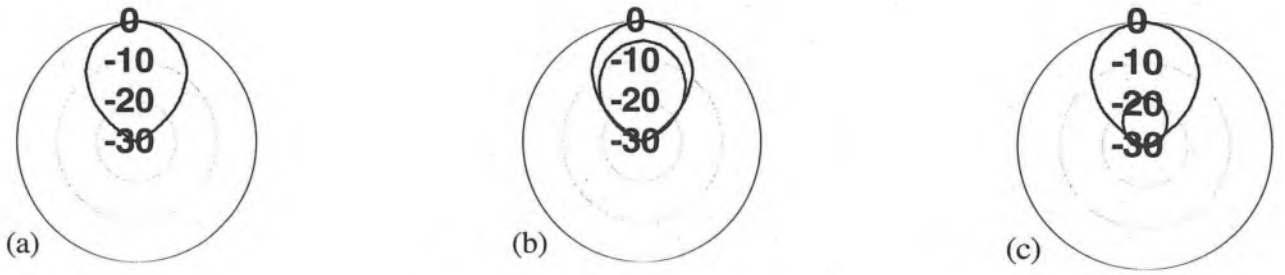

Figure 2. Siren directivity without rotation: (a) Steady tone; (b) Fast modulating tone; (c) Slow modulating tone.

For the modulating tone modes, the sound level of the lobe changes as the horn axis sweeps around the circle. This results in maximum sound levels that vary with angular position around the siren and causes the siren to display directional characteristics. These directional characteristics become most pronounced when the rotational frequency of the horn approaches the modulation frequency of the tone, which occurs for this siren when it operates in the slow modulation mode.

When the rotational speed is fast, the rotational frequency is equal to the modulation frequency. It is apparent from the directivity patterns in Figure 3(c) that the poorest coverage occurs when the frequencies of the modulation tone and the rotational speed are equal. In the areas of poorest coverage, the maximum sound level of the siren diminishes to the minimum sound level produced by the modulating tone.

4. CONCLUSION

These directional characteristics are not identified in the product literature for the siren and may not be apparent to the manufacturer. Moreover purchasers, possibly having minimal opportunity to test the siren because of potential community disturbance, may intuitively think that the modulating tone mode is the best way to operate the siren, but would be unaware that this mode could result in uneven coverage of the warning area.

REFERENCES

Kinsler, L.E. et.al. "Fundamentals of Acoustics", (page 180) John Wiley & Sons, 1982.

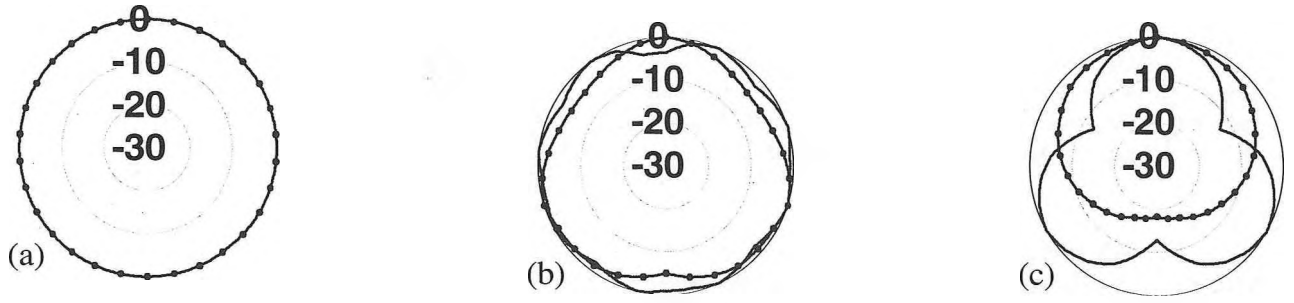

Figure 3. Maximum siren sound levels with slow rotational speed ▬, and fast rotational speed ▬ :(a) Steady tone; (b) Fast modulating tone; (c) Slow modulating tone.