UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
Sheldon J. Wolfe, Chairman
Emmeth A. Luebke
Dr. Jerry Harbour

In the Matter of	
PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE, ET AL. (Seabrook Station, Units 1 and 2)	Docket No.(s) 50-443/444-OL-1 On-site EP October 11, 1988

STATEMENT OF MATERIAL FACTS IN DISPUTE

Pursuant to 10 C.F.R. § 2.749(a), tne Massachusetts Attorney General ("Mass AG") submits the following statement of material facts as to which he contends there exist a genuine issue to be heard. For the Board's convenience, the format used here is to follow the format of the Applicants by indicating which of the factual statements listed by the Applicants the Mass AG disputes and, where applicable, by adding other statements which the Mass AG contends are in dispute.

BASIS A.1

THe Mass AG does not dispute the facts listed in paragraphs 1, 2, 5, 6, 7, 8, 9, 16, and 18. The Mass AG does dispute the statements made in paragraphs 4, 10, 11, 17 and 19. With respect to the statement made in paragraph 3, the Mass AG believes that in the beach areas the siren public address or message mode must be used for alert and notification. The Mass AG believes that the statements made in paragraphs 12 to 15 are not relevant because these four areas do not comprise all of the areas in the Massachusetts EPZ uncovered by required siren coverage under the Applicants' system.

19a. It is not acceptable for each VANS siren to put out 134dB of sound output. Rather, FEMA-REP-10 requires that the sound output be limited to 123dB.

19b. If the VANS sirens put out only 123dB of sound output, under its existing configuration the VANS system will not provide coverage to essentially 100% of the population in the Massachusetts EPZ.

BASIS A.2

The Mass AG does not dispute the statements made in paragraphs 20, 21, and 22. The Mass AG does not dispute that the Governor of Massachusetts and the town officials of Amesbury will use their best efforts to protect the populace in response to a radiological emergency at Seabrook Station. The Mass AG does dispute that those best efforts will include allowing Applicants to activate VANS sirens.

BASIS A.3

THe Mass AG does not dispute the statements made in paragraphs 24, 26, 27, and 32. The Mass AG does dispute the statements made in paragraphs 29, 30 and 31. With respect to the statement in paragraph 25, the Mass AG does not dispute that the review mentioned was conducted but does dispute that it verified that there is sufficient room at each of the locations to deploy the outriggers and raise the boom. With respect to the statement made in paragraph 28, the Mass AG disputes that the VANS truck can be adequately set up on the incline at VL-06.

32a. With outriggers extended, a VANS truck parked at the side of the road at VL-12 will extend at least six feet into the road.

32b. The acoustic locations VL-06 and VL-07 are inclined where the trucks would set up. The crane manufacturer's instructions are clear and unequivocal not to operate the equipment on an inclined surface.

32c. The grass and dirt surface of VL-12 is uneven and inappropriate for operation according to the crane manufacturer's specifications.

32d. Acoustic locations VL-06, VL-07 and VL-12 are unpaved roadsides which will be blocked during substantial parts of the winter by piles of snow cleared from the roads. VL-03 will be similarly inaccessible during the wintertime. The Applicants have made no provision for prompt and effective clearing of these areas during snow conditions.

BASIS A.4

The Mass AG cannot dispute the statements made in paragraphs 33 through 41.

BASIS A.5

The Mass AG does not dispute the statements made in paragraphs 43, 46, 48, 49, 51, 53, 57, 58, 59 and 60. The Mass AG disputes the statements made in paragraphs 42, 50 and 52. With respect to the statements made in paragraph 44, the Mass AG contends that the relevant time for the Board's consideration is the maximum time which is approximately 54 seconds.

With respect to the statements made in paragraph 45, because the staging area facilities have not been constructed, there is no reason to expect no appreciable delay in exiting the facility. In other words, without construction of the staging areas and actual testing there is no basis for the statements made by the Applicants in paragraph 45.

With respect to paragraph 47, given the conservatism mandated by FEMA-REP-10, the maximum transit times for the acoustic locations are the relevant ones, not the average transit times. Therefore, the transit study of the Applicants does not show that the transit times for acoustic locations VL-02 through VL-15 are "well below the ten minute goal."

With respect to the statements in paragraph 54, winter weather conditions would delay 7 of the 16 VANS trucks beyond the ten minute objective. As indicated by the Mass AG's dispute of the statements made in paragraph 52, the Mass AG believes that the Applicants have understated the frequency of winter adverse weather conditions.

With respect to the statements in paragraph 55, again using the conservatism required for the calculations, the estimated adverse winter transit time to VL-16 is only slightly less than 20 minutes.

With respect to the statements in paragraph 56, the VANS system came into being because the Massachusetts fixed pole siren system was erected contrary to existing law.

60a. The Applicants' ten second period for driver alert does not include several actions required after staging area activation. Those actions will take at least 30 additional seconds to complete. Those actions are particularly important because only 16 VANS drivers will be available at any one time for the 16 VANS routes.

60b. Continuous snow coverage of at least one inch in the area has lasted as long as 109 days or 29% of the year.

60c. Acoustic locations VL-01, VL-12 and VL-13 cover areas within 5 miles of the Seabrook Plant.

60d. The Applicants' times of 1 minute for set up of the VANS trucks assumes that the set up time ceases when the crane is only partially extended - to a 25 foot height.

60e. The Applicants' conclusion that initial notification can be completed in the nonwinter months in 14 minutes and 50 seconds does not include the time necessary for an informational or instructional message. The Applicants intend to provide such messages by use of the EBS radio network.

60f. The initial EBS message used in the June 28 and 29, 1988 exercise took slightly over 2 minutes to read.

60g. With additions over the Applicants' calculations of 2 minutes for instructional messages, 30 seconds for driver alert and 15 seconds for driver dispatch, the following will occur:

> Acoustic locations VL-01, VL-12, VL-13, and VL-16 will exceed the 15 minute requirement based on the Applicants' average route transit times as indicated in Table 2 of the Desmarais Affidavit.
>
> Acoustic locations VL-01, VL-03, VL-08, VL-09, VL-10, VL-11, VL-12, VL-13 and VL-16 will exceed the 15 minute requirement based on the Applicants' maximum route transit times as indicated in Table 2 of the Desmarais Affidavit.
>
> Acoustic locations VL-01, VL-03, VL-08 through VL-13 and VL-16 will exceed the 15 minute requirement based on the Applicants' average wintertime route transit times as indicated at page 6 of the Leiberman Affidavit.

BASIS A.6

The Mass AG does not have information available to him to dispute the statements made in paragraphs 61 through 69.

BASIS A.7

The Mass AG does not dispute the statements made in paragraphs 71 and 73. The Mass AG does dispute the statements made in paragraphs 70, 72 and 74.

74a. The 123dB limit in NUREG-0654 was imposed to prevent discomfort as well as injury to individuals. The VANS sirens exceed the 123dB limit.

74b. Individuals around the VANS sirens will be subject to sound levels up to 133dB by virtue of the loudness of the sirens and reflections off of nearby buildings.

74c. Twelve of the sixteen acoustic locations are in residential areas or other areas where members of the public can be expected to be outside of permanent structures and well within the discomfort range of the VANS sirens.

BASIS A.8

The Mass AG does not dispute the statements made in paragraph 77. The Mass AG does dispute the statements made in paragraphs 75, 76 and 78.

78a. The VANS siren loudspeaker has directional characteristics such that the loudspeaker produces its maximum signal output along its primary output axis and the output diminishes as the angular offset from the primary axis increases. As a result, Massachusetts residents will hear signals which vary by 26dB or more over short periods of time as the siren rotates. Therefore, the siren signal will not be a 3 to 5 minute steady signal as required by NUREG-0654.

78b. Because of the loudspeaker's directional characteristics the Applicants' map erroneously assumes that approximately circular coverages will exist for the sirens. In fact, oval coverages will exist. As the sirens rotate randomly the system will not meet the requirement for steady sound pressure levels exceeding 70dB where the population exceeds 2,000 persons per square mile and 60dB in other uninhabited areas.

BASIS A.9

The Mass AG does not dispute that the Applicants do not use the VANS sirens for voice messages but believe that in the beach areas they must.

BASIS A.10

The Mass AG does not dispute the statements made in paragraphs 80 and 81.

BASIS A.11

The Mass AG does not dispute the statements made in paragraphs 82 through 86.

86a. During periods of operation the Applicants intend to have only one driver per VANS truck at each staging area. Without redundant drivers available to fill in on a timely basis the Applicants' assumption of immediate notification to the drivers in the event of an emergency is erroneous.

BASIS A.14

The Mass AG does not dispute the statements made in paragraphs 87, 88, and 89. Again, the Mass AG believes that the Applicants must use the message or public address mode in the beach areas.

BASIS B

The Mass AG does not understand the Applicants' reference to "a backup to a backup." The Mass AG does not dispute the remaining portion of the statement in paragraph 90. Because the Applicants have not addressed any material facts with regard to the airborne system, the Mass AG similarly does not address any such facts.

JAMES M. SHANNON
ATTORNEY GENERAL
COMMONWEALTH OF MASSACHUSETTS

Stephen A. Jonas
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Public Protection Bureau
Office of the Attorney General
One Ashburton Place
Boston, MA 02108
(617) 727-2200

Dated: October 11, 1988

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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AFFIDAVIT OF STEPHEN A. JONAS

I, Stephen A. Jonas, depose and say as follows:

1. I am an Assistant Attorney General and Deputy Chief of the Public Protection Bureau for the Massachusetts Department of the Attorney General. I am familiar with the matters set forth in this affidavit.

2. Attached as Exhibit A hereto are true and accurate copies of pages 85 and 86 of the deposition I conducted of Edward Desmarais on July 28, 1988.

3. Attached as Exhibit B hereto is a true and accurate copy of the initial EBS message released by the New Hampshire Yankee Offsite Response Organization during the June 28-29, 1988 exercise.

3. Attached as Exhibit C hereto is a true and accurate copy of FEMA Publication No. CPG 1-17 as I received it from Jeffrey P. Trout of Ropes & Gray.

Signed under the pains and penalties of perjury this 11th day of October, 1988.

Stephen A. Jonas

Q. Would your purchasing people tell you or would you otherwise become aware of communications between them and Whelan with regard to dual sirens?

A. Normally they would contact us. However, there may be some minor negotiations, terms, communications, that I'm not aware of.

Q. But you are not aware of any communications between New Hampshire Yankee and Whelan within the last month?

A. No.

Q. Are the six staging areas operational?

A. Can you define that, please?

Q. Are they operational in the respect that they are ready for use as staging areas as contemplated in the design report?

A. They are not.

Q. What remains to be done to put them into that state?

A. There are certain physical modifications that we will make to the staging area, depending on each of the staging areas, depending on their existing conditions. We will also make these facilities available or brought up to the standards for a normal office environment and we will also put the communications equipment in place.

Q. Do you have any idea how long that will take for the last staging area to become operational in that sense?

A. Depends on when we start.

Q. If you start it today, how long would it take?

A. Again, depending on the priority of the task, it could conceivably be done in a range of times, but under a high priority, it could be done in a month or so.

Q. Are there any plans to start that work?

A. Yes.

Q. How specific are the plans in terms of a starting date?

A. Some of them are based on as a condition for the lease, so that the owner has to make physical modifications as a condition for the lease.

Q. Are all of these leased premises?

A. Yes.

Q. Who is the lessee and who is the lessor?

A. I'm not familiar with those terms.

Q. Is New Hampshire Yankee the lessee of all of these?

EXHIBIT B

ORO EBS MESSAGE

Massachusetts Offsite Response Organization of New Hampshire Yankee

THIS IS A DRILL *** THIS IS A DRILL *** THIS IS A DRILL

SITE AREA EMERGENCY
(SEASONAL CLOSURE OF BEACHES AND WILDLIFE REFUGE)
MESSAGE
(May 15 to September 15)

Date Message Released ~~06/28/88~~
Time Message Released ~~******~~ 12:22

Release # 03

Released by: _______________
NHY Offsite Response Director

The following Emergency Broadcast System message was released by the Massachusetts Offsite Response Organization of New Hampshire Yankee, under authority granted by the Governor of Massachusetts.

"A SITE AREA EMERGENCY has been declared at Seabrook Nuclear Power Station. A SITE AREA EMERGENCY means that some significant release of radioactive materials could occur, although any releases are not expected to go beyond levels set by the United States Environmental Protection Agency, except near the Seabrook Station site boundary.

The New Hampshire Yankee Offsite Response Organization has been notified and is responding to the problem. The New Hampshire Yankee Offsite Response Director is reviewing site conditions at this time, and is discussing the situation with Massachusetts government officials.

As a precaution, the Governor of Massachusetts has recommended the closing of beach and park areas, from Salisbury to Plum Island, including the Parker River National Wildlife Refuge. Persons at these beaches and parks or visiting the national wildlife refuge should leave those areas immediately.

The closings of the Wildlife Refuge, beaches and boating areas are precautionary measures based on policy adopted long before Seabrook Station was operational. It does not mean that a release of radiation has occurred or will occur."

"In addition, emergency information brochures are mailed annually to residents of the communities of Salisbury, Amesbury, Merrimac, Newbury, West Newbury and Newburyport. If you are in any of these towns, you should look

ORO EBS MESSAGE

Massachusetts Offsite Response Organization of New Hampshire Yankee

up that emergency information. If these are unavailable, information also can be found in area telephone books. English and French emergency information flyers also have been made available at beach facilities and recreation areas. This information could be helpful in understanding future messages.

If you know of any neighbors or co-workers with hearing or language problems, please inform them of this message.

Once again, Seabrook Station has declared a SITE AREA EMERGENCY.

This message will be repeated frequently on this station until new information is available. Stay tuned to this EBS station for the latest official information.

If you are in any of the New Hampshire eastern Rockingham County communities, you should tune to a local radio station in New Hampshire for news about your community.

Actions recommended in this message are intended only for persons in communities within ten miles of Seabrook Station."

(NOTE: This message is also pre-recorded in French.)

Approved: [signature] Date/Time: 6/28/88 12:41

Approved: [signature] Date/Time: 6/28/88 12:42pm

Approved: [signature] Date/Time: ________

DRILL

EXHIBIT C

CPG 1-17
MARCH 1, 1980

OUTDOOR WARNING SYSTEMS GUIDE

federal emergency
management agency

CPG 1-17

OUTDOOR
WARNING SYSTEMS
GUIDE

FEDERAL EMERGENCY MANAGEMENT AGENCY
Washington, D.C. 20472

March 1980

NOTE TO USERS OF THE FEMA CPG 1-17

This publication supersedes the following portions of the Federal Civil Defense Guide

Part E, Chapter 1, Appendix 3

Part E, Chapter 1, Appendix 4, Annex 1

Also superseded are any other publications of FEMA and FEMA Regional Offices which are inconsistent with CPG 1-17

CPG 1-17

OUTDOOR WARNING SYSTEMS GUIDE

Abstract

This practical guide has been developed to aid public officials in determining the requirements for outdoor warning systems.

- The guide covers, in a simplified form, the principles of sound, outdoor warning systems and devices, propagation and detection of sound out of doors, avoiding hazardous noise exposures, and warning system planning, testing, and use.

- The guide is adapted from Report No. 4100, Bolt Beranek and Newman Incorporated, produced under Contract No. DCPA-01-78-C-0329, Work Unit No. 2234E. Report No. 4100 is based upon a survey of the current literature on the subject, and upon discussions with Civil Preparedness personnel and vendors. No experimental work has been performed.

- The guide is a replacement for Federal Guide, Part E, Chapter 1, Appendix 3, "Principles of Sound and Their Application to Outdoor Warning Systems," and Part E, Chapter 1, Appendix 4, Annex 1, "General Instructions for Determining Warning Coverage," both published in December 1966.

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LIST OF FIGURES

OUTDOOR WARNING SYSTEMS GUIDE

I. PURPOSE

The purpose of this guide is to set forth the basic principles of sound that are applicable to audible outdoor warning devices and to describe a method for planning and laying out an effective outdoor warning system. This guide concentrates on the selection, siting, and operation of audible outdoor warning devices.

II. INTRODUCTION

Audible outdoor warning systems (sirens, air horns, etc.) are an essential component of the Civil Defense Warning System (CDWS) established by the Federal Government to advise government agencies and the public of impending enemy attack or other disaster. Following the detection of an attack or other hazard, information is disseminated over the Federal Emergency Management Agency (FEMA) dedicated communication network -- The National Warning System (NAWAS) -- to more than 2,000 locations throughout the United States. From these locations, the public can be informed of a potential hazard through the Emergency Broadcast System (EBS), TV stations, the news media, and other means.

Outdoor warning systems can advise people that a hazard exists and that they should determine the nature of the hazard by listening to the radio, etc. For more information on other aspects of the CDWS, see CPG 1-14, "Civil Preparedness, Principles of Warning," June 30, 1977.

III. PRINCIPLES OF SOUND

A. Terminology - Since outdoor warning devices use sound to alert listeners to danger, this section starts with a brief introduction to the vocabulary and principles of sound.

- Sound is a form of mechanical energy that moves from a source (a voice, a musical instrument, a siren) to a listener as tiny oscillations of pressure just above and below atmospheric pressure. When people hear sounds, they can distinguish their loudness, their tone or pitch, and variations of loudness and pitch with time. The loudness and pitch variations of some sounds are recognized as having certain meanings, such as with speech sounds.

- Instruments used to measure sounds give the magnitudes of sounds in decibels (abbreviated here as dB(C)). This magnitude is closely related to what we hear as loudness. Thus, an audible warning device that produces 110 dB(C) at 100 ft. (30 m) away sounds louder than one that produces only 100 dB(C) at the same distance. All audible outdoor warning devices are rated in terms of their sound output at 100 ft. in dB(C).

• Instruments can also measure the frequency components of a sound in Hertz (Hz). They are closely related to what we hear as pitch. As discussed below, the frequency components of the sound from an audible outdoor warning device are important in determining how far that sound will carry through the air and how well it will be heard. Most audible outdoor warning devices produce sound within the frequency range from about 300 Hz to about 1,000 Hz.

B. Attenuation - It is well known that sound decreases in magnitude (in loudness and in dB(C)) at greater distances from its source. This decrease is called attenuation with distance, and it is caused by a number of factors described in Section V-A. The amount of sound available to warn a listener can be calculated simply with the following equation:

$$\begin{bmatrix}\text{Amount of Sound}\\ \text{Available to Warn,}\\ \text{in dB(C)}\end{bmatrix} = \begin{bmatrix}\text{Sound Output of}\\ \text{Audible Warning}\\ \text{device, in dB(C)}\end{bmatrix} \text{ minus } \begin{bmatrix}\text{Attenuation}\\ \text{with Distance,}\\ \text{in dB(C)}\end{bmatrix}$$

Thus, if it is known that an audible outdoor warning device produces 110 dB(C) at 100 ft. (30 m), and that the attenuation with distance is 25 dB(C), then the amount of sound left over to warn people is 110 - 25 dB(C), or 85 dB(C).

C. Hearing - Whether the amount of sound available to warn people will indeed be sufficient to do the job depends upon several factors. First, the warning sound must be audible above the ambient, or background, noises. These ambient noises change constantly in loudness and pitch, depending upon noise-producing activities in the vicinity of the listener. Second, the warning sound must get the attention of the listener away from what he is doing. Normally, people "close out" of their minds distracting sounds that are not pertinent to what they are doing. A warning sound must penetrate this mental barrier. Tests have shown that to attract a listener's attention away from what he is doing, a warning sound must be about 9 dB(C) greater than would be sufficient to make it audible to someone who was concentrating on listening for it, and not doing anything else.

All of these factors suggest that a warning sound must be loud: loud enough to overcome attenuation with distance, to exceed the background noise, and to attract attention. Yet it cannot be too loud, or there is risk of injuring the hearing of some people who listen to it. This risk, which is discussed in greater detail in Section V-B, can occur when people are exposed to audible warning sounds exceeding 123 dB(C).

I. OUTDOOR WARNING SYSTEMS AND DEVICES*

When a civil preparedness official buys an audible outdoor arning system for his community, he will be purchasing:

- The sound-making devices.
- The controls and equipment that operate the devices.

In this manual, the controls and equipment are not discussed. ese vary with the manufacturer and are completely described in ndors' literature. The civil preparedness official should be are, however, that the costs of the system will include both kinds f components, as well as installation costs.

The sound-making devices themselves can be of three different pes:

- Sirens.
- Electronic (loudspeaker) devices.
- Horns and whistles.

A. Sirens - Sirens are by far the most widely used sound-making vices for outdoor warning systems. Sirens are capable of producing ry intense sounds by chopping the flow of compressed gas (usually r). The fundamental frequency (pitch) of a siren sound is deter- ned by the rate at which the flow is chopped, in cycles per second.** rens are powered by electric motors, gasoline engines, compressed r, or steam. Electric-motor-driven sirens are the most common for vil preparedness purposes.

Some sirens are nondirectional -- that is, they continuously oduce the same sound in all directions horizontally from the source. e most powerful sirens, however, use a horn that radiates a beam sound in a single direction. The horn is then rotated several mes a minute, so that the beam sweeps through the entire area ound the siren. For a stationary listener, the sound from such a ren goes up and down in loudness as the horn sweeps around.

B. Electronic Loudspeaker (or Voice/Sound) Sources - Loud- eaker sound sources have the advantage that they can broadcast ices as well as siren-like sounds. Therefore, they can be used to sue messages as well as warning sounds to the public. However, eir sound-output capability is less than that available from siren urces, so that more sources may be required to cover the same area.

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hile in the past there were Federal matching funds for this purpose, he current FEMA budget contains no such funds and future budgets ay not include such funds.

Some sirens, known as two-tone sirens, generate two frequencies simultaneously by using two airflow chopping rates.

Furthermore, sound reflections from large surfaces or simultaneous messages from several loudspeaker sources at different distances may "garble" the signal so badly that some listeners will not be able to understand voice messages.

C. Horns and Whistles - Air horns have the advantage that the sounds they produce cannot be confused with those of emergency vehicles or fire department sirens. When a suitable air supply is already available, the cost of a horn installation is very low. In addition, the air horn requires a minimum of maintenance and, because it weighs very little, is easily installed.

In the absence of an air supply or commercial storage cylinders, a compressor, storage tanks, and related appurtenances are necessary. These increase costs substantially, for horns require more power than many outdoor warning devices of the same decibel (dB(C)) rating.

In general, the comments on air horns apply to steam whistles as well. However, steam supplies are even more expensive than air supplies. It is generally not practical to install steam whistles unless an adequate steam supply is already available.

D. Ratings and Specifications - The sound outputs of acoustic outdoor warning devices are given in terms of their maximum decibels (dB(C)) measured at 100 ft. (30 m) from the device. The siting guidelines in this manual are based upon this figure.

The fundamental sound frequencies of almost all outdoor warning devices are in the range from 300 to 1,000 Hz. (Some devices "warble" up and down in pitch within this frequency range. See Subsection E.) Below 300 Hz, reduced human hearing sensitivity and higher background noise levels combine to restrict warning ranges. Above 1,000 Hz, sounds are more rapidly attenuated in the atmosphere, so the warning range is again restricted.

The sounds from audible outdoor warning devices are generally focused into the horizontal plane surrounding the device. Sound radiated upward would be wasted, and sound radiated downward close to the device is unnecessary and may be hazardous. (See Section VI-B.) As indicated above, some sirens may radiate a "beam" of sound in one direction horizontally, and have a mechanical means for rotating this beam around a vertical axis.

E. Warning Signals - Different cities and towns use their outdoor warning systems in different ways. Most local governments, however, follow the Federal Emergency Management Agency (FEMA) guidance and use a certain signal to warn people of an enemy attack, and a different signal to notify them of a peacetime disaster. These warning signals are:

Attack Warning - This is a 3- to 5-minute wavering (warbling itch) tone on sirens, or a series of short blasts on horns or r devices. The Attack Warning signal shall mean that an actual ck against the country has been detected and that protective on should be taken immediately. The Attack Warning signal shall epeated as often as warnings are disseminated over the National ing System or as deemed necessary by local government authorities btain the required response by the population, including taking ective action related to the arrival of fallout. The meaning of signal "protective action should be taken immediately" is appro- te for the initial attack warning and any subsequent attacks. signal will also be used for accidental missile launch warnings.

Attention or Alert Warning - This is a 3- to 5-minute steady al from sirens, horns, or other devices. This signal may be as authorized by local government officials to alert the public eacetime emergencies. In addition to any other meaning or require- for action as determined by local government officials, the ntion or Alert signal shall mean to all persons in the United es, "Turn on radio or TV. Listen for essential emergency informa- ."

A third distinctive signal may be used for other purposes, such local fire signal.

BASIC FACTS ABOUT SOUND OUT OF DOORS

A. Attenuation with Distance - As sound moves away from an or warning device toward potential listeners, it can be greatly ed by the atmosphere. For example, everyone knows that the ess of a sound decreases as the listener gets further from the e. Also, beyond a few hundred feet from a steady sound source, oudness varies with time, being unnoticeable at some times and pronounced at others. Such effects, which are characteristic e propagation of sound out-of-doors, are caused by the factors ibed below.

1. Divergence - As sound radiates away from a source, its sity decreases with distance because its energy is spread over ger and larger area. From a point-source, this decrease is d "spherical divergence" or "inverse square loss," because the intensity decreases inversely with the square of the distance the source to the receiver (sound level decreases 6 dB for each ing of source-receiver distance).

2. Attenuation Caused By Ground Effects - The ground pro- a number of effects on the propagation of sound over its surface. ps the simplest of these is the interferometer effect, which s when sound is propagated over a hard, flat surface. For any

given source and receiver height, there are two sound-wave paths between the source and the receiver: one direct, and the other - somewhat longer - reflected off the ground surface. Under some conditions, the sound waves arriving at a listener along these two paths interfere with each other, and cancel out. The opposite effect can also occur: the two sound waves can add, and a "gain" (negative attenuation) is observed. When the ground is soft and absorbs some sound, this effect becomes even more complicated.

3. Barriers - A barrier is any large solid object that breaks the line of sight between the sound source and the listener. In general, a barrier can introduce up to 20 dB of attenuation. The sound available behind the barrier comes from diffraction around the barrier, or from sound energy scattered into the region behind the barrier from other wave paths.

4. Effects of Vertical Temperature and Wind Gradients: Atmospheric Refraction - The speed of sound in air increases with temperature. Furthermore, when the wind is blowing, the speed of sound is the vector sum of the sound speed in still air and the wind speed. The temperature and the wind in the atmosphere near the ground are frequently nonuniform. This atmospheric nonuniformity produces refraction (bending) of sound wave paths. Near the ground, this refraction can have an effect on the attenuation of sound propagated through the atmosphere.

During the daytime in fair weather, temperature normally decreases with height (lapse), so that sound waves from a source near the ground are bent upward. In the absence of wind, an "acoustic shadow," into which no direct sound waves can penetrate, forms around the source. Large attenuations are observed at receiving points well into the shadow zone - just as if a solid barrier had been built around the source. On clear nights, a temperature increase with height is common near the ground (inversion) and the "barrier" disappears.

Wind speed almost always increases with height near the ground. Because the speed of sound is the vector sum of its speed in still air and the wind vector, a shadow zone can form upwind of a sound source, but is suppressed downwind.

The combined effects of wind and temperature are usually such as to create acoustic shadows upwind of a source, but not downwind. Only under rare circumstances will a temperature lapse be sufficient to overpower wind effects and create a shadow completely surrounding a source. It is less rare, but still uncommon, for a surface inversion to be sufficiently strong to overcome an upwind shadow entirely.

5. Foliage - Large amounts of dense foliage (100 ft. (30 m) or more) can attenuate sound somewhat, although small amounts of foliage have no effect.

6. Absorption of Sound in the Atmosphere - Sound is absorbed in the atmosphere in a way that depends upon the humidity. In general, this loss is most pronounced at high frequencies and is of lesser importance at the sound frequencies produced by outdoor warning devices.

7. Summary - The combination of all the factors that cause sound to be attenuated in the atmosphere is both complicated and unpredictable. If one were to observe the sound from a warning device 1,000 ft. (300 m) or farther away, he would find that it varies with time as much as 20 to 30 dB, depending upon the conditions of the atmosphere and the ground. This manual provides (Section V-C) a simple and conservative method for estimating warning ranges. It is important to realize, though, that this is an estimate which -- like the weather -- cannot be guaranteed.

B. Hearing - The most important factors determining the ability of a warning sound to alert a potential listener are the barriers to sound in the listener's immediate vicinity, and the background or masking noise at his location.

1. Local Barriers - A potential listener indoors or inside a motor vehicle is much less likely to be alerted by a warning sound of a given loudness than someone out of doors. This is, of course, because of the attenuation of the sound as it comes through the walls of the structure surrounding him. In general, an outdoor warning device cannot be counted on to alert people in vehicles or buildings unless they are very close to the device.

It is interesting to note that the current activity toward improving the energy-conservation properties of buildings will have the concomitant effect of increasing their sound-attenuating properties. Thus, it is even less likely in the future that people indoors will be alerted by outdoor audible warning devices.

2. Background Noise and Detectability - The most important factor that determines the detectability of a sound is the signal-to-noise ratio measured over a range of frequencies around the signal frequency. The "noise" portion of this ratio is the background noise at the listener's location. Thus, for a given level of warning signal, the background noise is critical to determining warning signal effectiveness.

Recent studies have shown that the outdoor background noise in a community is strongly correlated with local population density. This correlation presumably results from the fact that outdoor noise levels are almost always caused by motor vehicle traffic, which correlates well with population density. Thus, population density is a better metric of background noise than zoning or land-use patterns like "residential," "business," and "heavy industrial."

Recent studies have also shown that the level of sound from a warning device must be about 9 dB higher than the level detectable under laboratory conditions in order to attract the attention of otherwise preoccupied observers.

3. Deleterious Effects of Warning Sounds - When audible warning devices are used "in earnest" to alert a population of impending disaster, it seems surprising that anyone would be concerned about any deleterious effects of the sounds themselves. Indeed, many local noise ordinances specifically exempt warning sounds from noise-level restrictions. Nevertheless, in some communities sirens are operated so frequently (such as to provide tornado warnings in midwestern towns) that complaints about their noise level have been reported. Furthermore, the warning devices must be tested from time to time, and the resulting high noise levels could be viewed as disturbing and/or damaging under these circumstances.

4. Hearing Damage - For test purposes, audible warning devices should be so located and operated that no person is likely to be subject to a sound level great enough to cause hearing damage. A suitable limit for this purpose, based upon recommendations of the Committee on Hearing, Bioacoustics and Biomechanics (CHABA) of the National Academy of Sciences, is 123 dB(C).

Loud sounds, even if not potentially damaging, can be viewed as a disturbance by some residents of a community. Operators of audible outdoor warning systems should realize this fact, and should:

- Minimize the frequency and duration of tests of outdoor warning devices. Alternatively, "growl tests" can be conducted (see Section VII) when the source is a siren.

- Refrain from conducting tests at night when people are relaxing and sleeping.

- Avoid locating warning devices too close to noise-sensitive activities.

5. Summary - The detectability of an auditory warning signal is a function of the level of the signal at the potential listener's ears relative to the background noise at his location.

Because of local barriers, it is probable that a much smaller proportion of the potential listeners indoors or in vehicles can be alerted by an audible warning system, relative to the proportion that could be alerted out of doors.

No person should be exposed to the sound of an outdoor warning device if it exceeds 123 dB(C).

C. Estimating Range of Coverage - All of the factors in the previous two subsections -- on propagation losses and on signal detection -- have been combined to obtain the warning effectiveness ranges illustrated in Figure 1. The range, or radius, of coverage of any audible outdoor warning device can be determined from Figure 1 on the basis of the rated output of the warning device at 100 ft. Figure 1 indicates, for example, that a warning device rated 120 dB(C) will have a range of about 3,700 ft. (1.1 km) in suburban and rural areas, when mounted above the rooftops. In an urban area, when the device is mounted below the rooftops, its effective range will be about 1,200 ft. (0.35 km).

The upper curve in Figure 1, applicable to suburban and rural areas, is very close to 10 dB per doubling of distance for a 70-dB warning signal level. The lower curve of Figure 1, that applicable to urban high-rise areas, takes into consideration the greater attenuation caused by shielding and the higher background noise levels existing in downtown areas.

Two important features of Figure 1 should be emphasized. The first is the "NOTE" in the caption, which makes clear the uncertainties associated with the range prediction process. The second important point is embodied in the parenthetical remarks "over rooftops" and "below rooftops" in the labels of the curves. It is strongly recommended that warning devices be mounted above the prevailing rooftop height in areas where buildings are less than 3 to 4 stories high. In urban high-rise areas, of course, the opposite may be advisable.

VI. PLANNING AN OUTDOOR WARNING SYSTEM

A. <u>Determining Warning Coverage</u> - The basic tools for planning an outdoor warning system are a good topographic map of the community, a drafting compass, knowledge of the sound output ratings of the warning devices to be used, and Figure 1 from this manual.

Planning itself can be broken down into the following steps:

1. The civil preparedness official should locate, on the map:

- Downtown areas that contain tall buildings .
- Hills or any other barriers that would obstruct the flow of sound .
- Residential (suburban) or rural areas with low buildings over which sound can move freely .

2. The official should locate the public or business buildings that would be good sites for a warning device. (The community civil preparedness officer will, of course, have to double-check the usefulness of the site and obtain permission from the owner to install the device.)

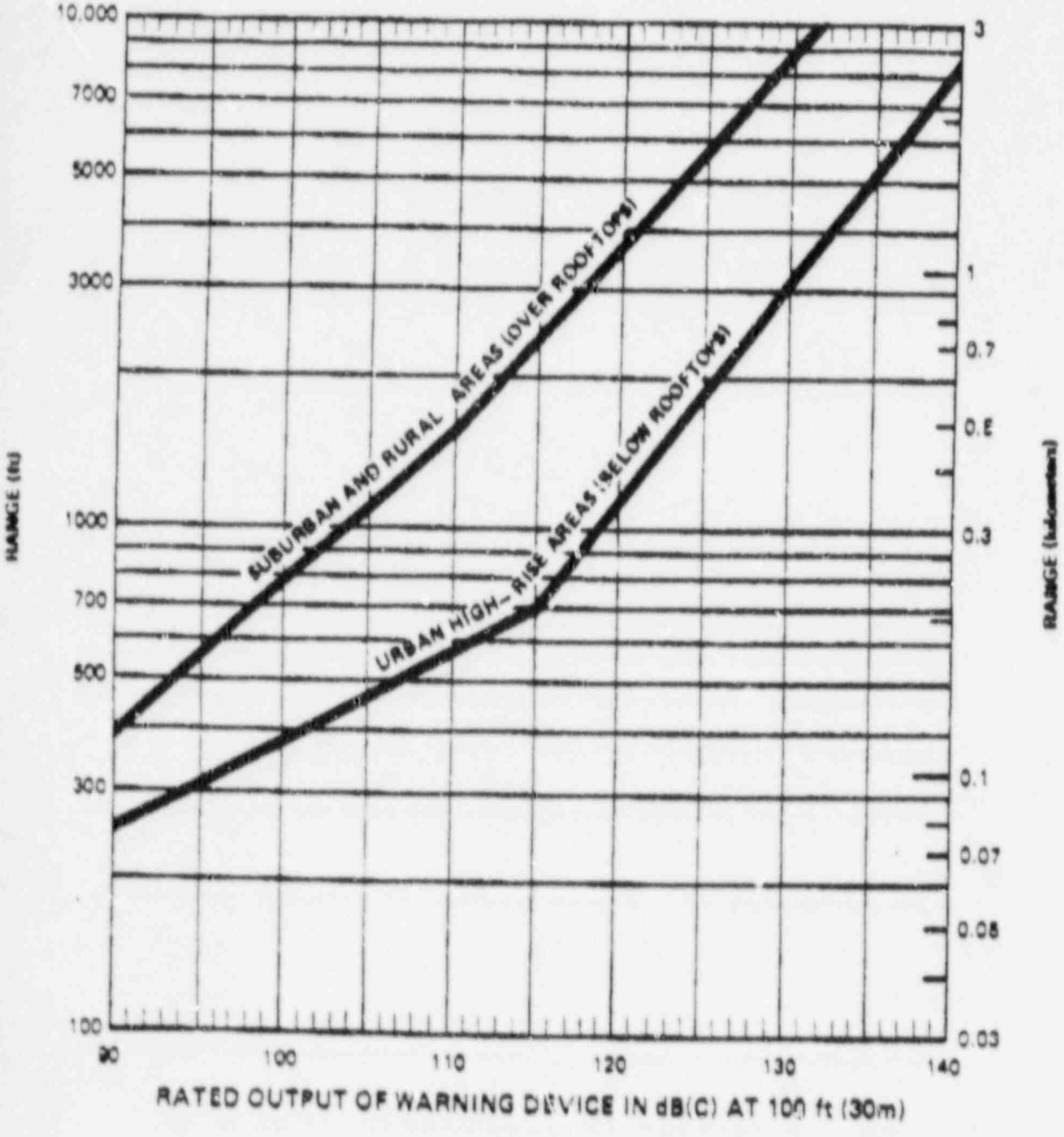

Figure 1

Effective Ranges of Outdoor Warning Devices As a Function of Their Rated Sound Output in dB(C) at 100 ft (30m)

Note: Differences less than ± 2dB(C) in rated output, and differences less than ± 15% in range, are not generally significant

3. The official should circle, on the map, the area in which each device will be effective, using ranges read from Figure 1.

It is a good idea to start the layout with the obvious warning device locations, such as:

- Noisy places (freeway interchanges, rail yards, etc.).
- Locations with good line-of-sight coverage (hilltops, centers of radial street patterns).
- Locations where permission to install the devices can be readily obtained (public buildings, parks).

Noise-sensitive locations (hospitals, schools, residential buildings) should be avoided.

Many layouts are possible for most communities, and several trials may be necessary to obtain a layout with the minimum number of devices.

The product of this planning effort should look like Figure 2, a map covered with interlocking circles, each centered on a single warning device. (Note that the circles do not overlap to any major degree.) This layout attempts to make maximum use of warning devices rated 120 (dB(C)), so that the minimum number of different types of devices will be required.

The finished planning map can help answer a major question: What will the entire outdoor warning system cost? The number of circles indicates the number of devices needed and is a clue to the costs of installation and maintenance, as well as to the costs of control circuits for the system.

If the total cost, as estimated during planning, is too high, civil preparedness officials may want to redesign the system, perhaps decreasing the total number of devices by increasing the sound level rating of each device to be used.

B. <u>Siting to Avoid Hazardous Exposure</u> - Detailed siting of each device should take into consideration the factors desirable to maximize coverage, described in Section VI-A. Installations should also be sited to avoid exposing anyone to sound levels exceeding 123 dB(C). In general, this second requirement can be achieved by mounting the device high enough above ground level so that the sound is directed mostly over the heads of people standing on the ground near the device. The minimum height needed to meet this requirement, as calculated for one type of siren with a well-designed horn, is illustrated in Figure 3. This figure indicates, for example, that a device rated at 120 dB(C) should be mounted at least 32 ft. (10 m)

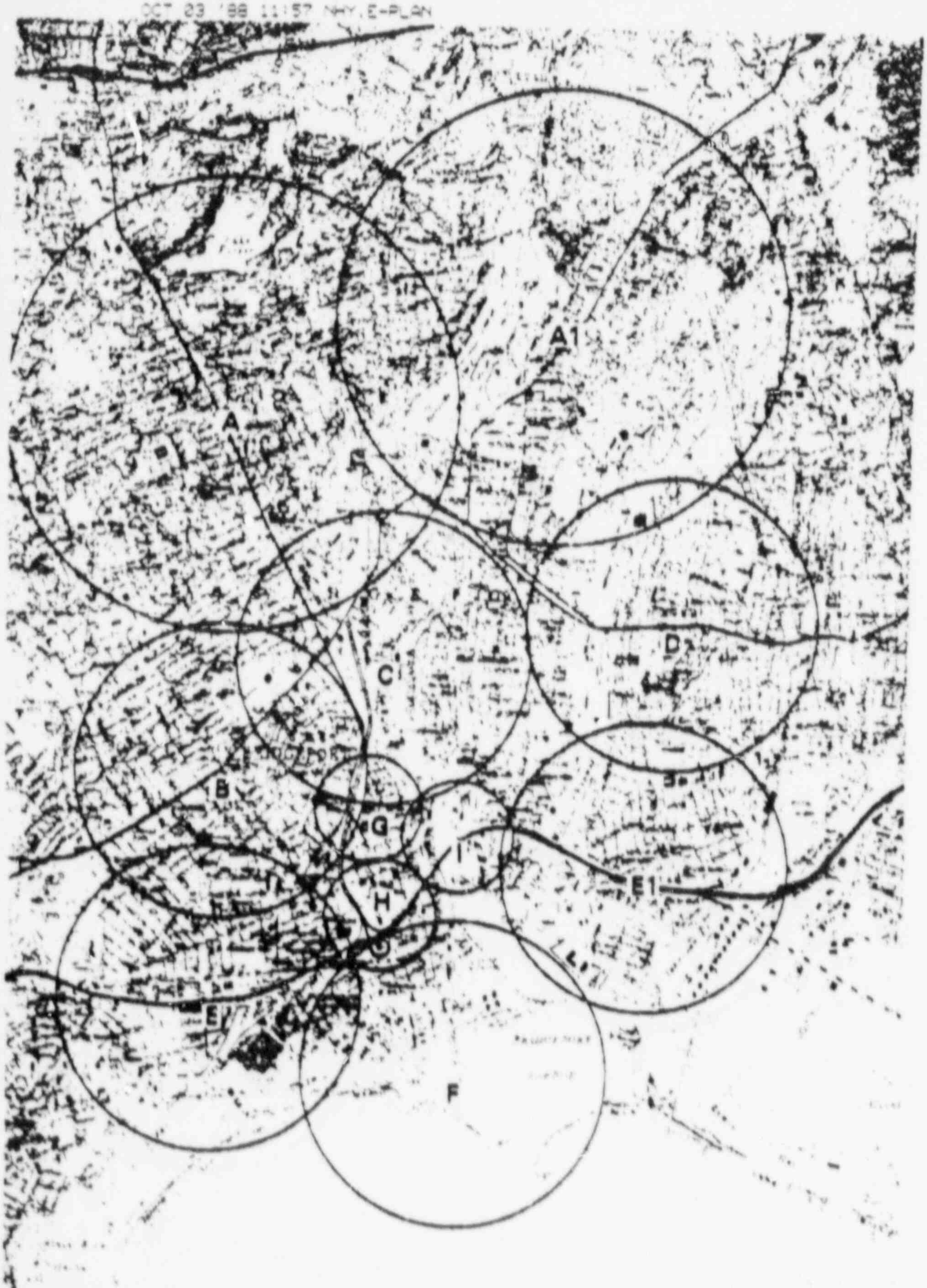

FIGURE 3. MAP WITH CIRCLES CENTERED ON SINGLE WARNING DEVICES

LEGEND

SOURCE	
A	125 dB(C) mounted in suburban area at fire station: Range 5900 ft. (1.8 km)
A-1	125 dB(C) mounted in suburban area at fire station: Range 5900 ft. (1.8 km)
B	120 dB(C) mounted at major road intersection: Range 3700 ft. (1.1 km)
C	120 dB(C) mounted in industrial area: Range 3700 ft. (1.1 km)
D	120 dB(C) mounted on hilltop: Range 3700 ft. (1.1 km)
E	120 dB(C) mounted at turnpike interchange: Range 3700 ft. (1.1 km)
E-1	120 dB(C) mounted at turnpike interchange: Range 3700 ft. (1.1 km)
F	120 dB(C) mounted in park: Range 3700 ft. (1.1 km)
G	120 dB(C) mounted in high-rise area at city hall: Range 1200 ft. (0.36 km)
H	120 dB(C) mounted in high-rise area at highway interchange: Range 1200 ft. (0.[illegible] km)
I	120 dB(C) mounted in high-rise area on highway bridge: Range 1200 ft. (0.36 km)

(Map With Circles Centered on Single Warning Devices) above the ground. Of course, a higher mounting may be desirable to place the source above the prevailing rooftop height.

Note that Figure 3 has been established for just one type of source. It may not be applicable to other products. The public official should ask the vendor about the proper mounting height to limit the exposure of people standing on the ground to 123 dB(C) or less.

In those cases where it is impossible to mount the device high enough to achieve a safe sound level on the ground, large signs should be prominently displayed on the device, reading:

CIVIL PREPAREDNESS WARNING ____________ (horn, siren, etc.)
CAUTION!
THIS ____________ (siren, horn, etc.) OPERATES AUTOMATICALLY. ITS SOUND CAN BE DANGEROUS TO YOUR HEARING. WHEN IT STARTS TO OPERATE, COVER YOUR EARS AND MOVE AT LEAST 200 FEET AWAY.

In some urban areas, it may be necessary to mount warning devices in such a way that the main sound beam is directed at adjacent buildings. When this occurs, the devices should be mounted no closer than indicated in Figure 4. A much greater separation than indicated by Figure 4 would be desirable for the comfort of building occupants.

VII. SYSTEM TESTING AND USE

Once an outdoor warning system is installed, civil preparedness officials must ensure that the system does indeed alert residents of the community. A system is successful only if:

- Residents of the community know how the signal sounds and why it is being sounded
- Residents can differentiate between system testing and a true alert
- Each device is operating as it should

A. Knowledge of Warnings - Americans are almost two generations removed from the days of World War II, when the voice of the air raid siren, the information it carried, and the proper reaction to it were familiar to everyone in the community. Though the potential of

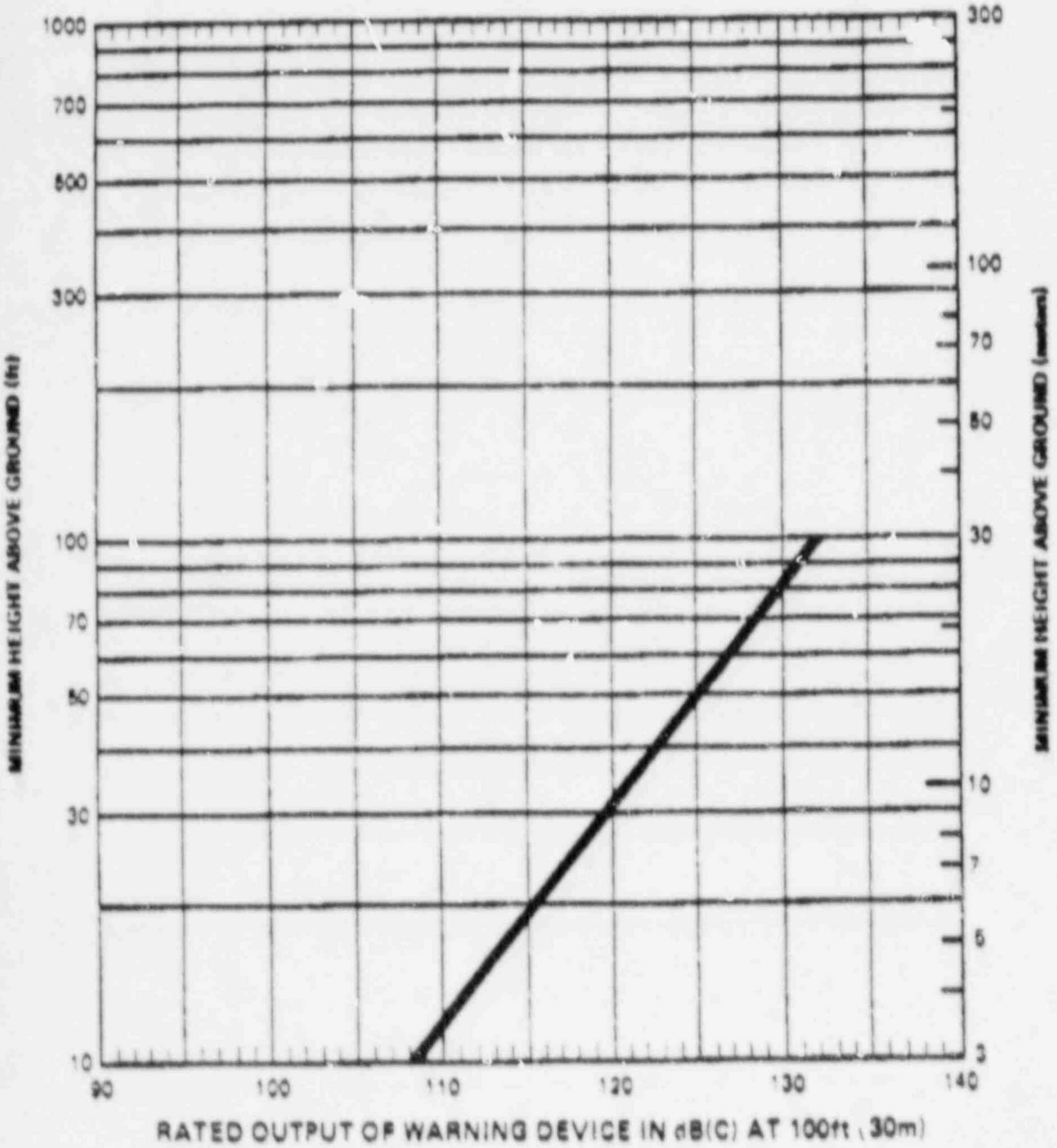

Figure 3

Minimum Mounting Height of a Typical Warning Device to Avoid Risk of Hearing Damage to Pedestrians (for horizontal beam)

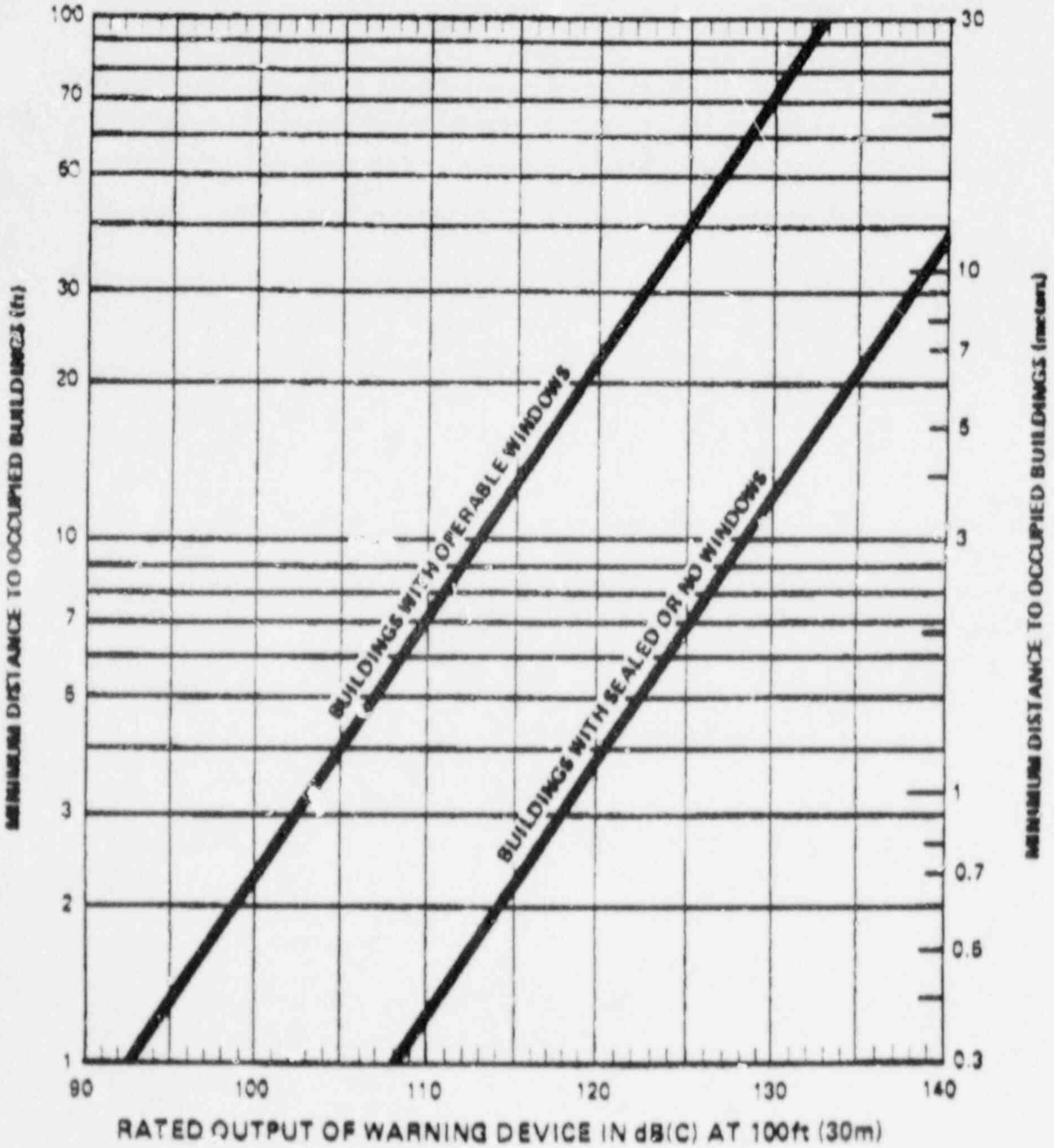

Figure 4
Minimum Distance to Avoid Risk of Hearing Damage
to Occupants of Adjacent Buildings Located in Sound
Beam of Warning Device

enemy attack remains, the usefulness of outdoor warning systems may have dwindled. If so, civil preparedness officials can turn the situation around, primarily through a controlled program of testing and a well-planned public information campaign.

B. Testing/Alert - Detailed information on the testing of outdoor warning systems is given in CPG 1-14 which includes recommendations that local officials:

- Test the outdoor warning system approximately once a month.
- Publicize the testing day and time each month.
- Test by sounding the "Attention" or "Alert" signal (the steady sound) for no more than 1 minute.
- Follow with 1 minute of silence.
- Finish by sounding the "Attack Warning" (rising/falling signal or series of short blasts) for no more than 1 minute.
- Emphasize, in all public announcements, that testing signals are sounded for less than 1 minute only, while in an actual emergency, all warnings would be sounded for 3 to 5 minutes and would probably be repeated.

When sirens are used, and must be tested more frequently than once a month, a "growl test" is acceptable. In a growl test, the siren is sounded for so short a time that it never produces significant sound output, yet long enough so that officials can determine that it is working.

C. Public Information Campaign - The civil preparedness official who must create a public information campaign has two advantages as he starts. First, the information he must communicate is neither lengthy nor hard to understand and, second, he is talking to people about their own safety. He should involve all community media, such as newspapers and radio/television stations, in his campaign; he should not overlook such useful forms of communication as posters in public buildings, newsletters sent out by community organizations, flyers enclosed in utility bills, and opportunities to address school assemblies.

The message must be straightforward, and the best campaign will repeat the same announcement, in the same words, again and again. Suggestions for conducting a public information campaign are contained in "Ideas for Conducting Awareness Campaigns," MP-83.