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Volume III

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Office of
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U.S. Nuclear Regulatory
Commission

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Duress Alarms for Nuclear Fixed-Site Facilities

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Oak Ridge Y-12 Plant

Prepared for
U. S. Nuclear Regulatory Commission

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Duress Alarms for Nuclear Fixed-Site Facilities

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ABSTRACT

This report on duress alarm systems for fixed site nuclear facilities is prepared for use in the Safeguards program of the United States Nuclear Regulatory Commission. Information that will be useful to those responsible for the planning, design, and implementation of duress alarm systems is included. Basic system concepts, requirements, designs, and implementations are discussed. Techniques are presented that may be employed in duress alarm systems. Evaluation of the reliability or quality of specific vendor-supplied devices is not covered. An evaluation is included on various methods that can be incorporated into duress alarm systems. Comparison of these methods is given for specific applications.

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SUMMARY

The purpose of this report is to discuss the different types of duress alarm devices presently available for establishing effective duress alarm systems. The report also gives an overview of the important requirements inherent to duress alarm systems. Some devices are simple; others are costly and complex; and many more are still being developed. No two facilities are identical. A system that works well at one facility may not work as well at another. This report is a guide for decision making on tailoring appropriate devices into a viable duress alarm system for a given facility. Since any system can be defeated with the appropriate time and tools, one should decide what level of protection the system must provide for the facility.

References in this report to specific manufacturers are not intended to be an NRC endorsement of those particular firms, nor does the omission of any manufacturer imply a lack of endorsement by NRC. Manufacturers are identified to illustrate the types of equipment available and to assist designers in making initial identification of prospective suppliers.

1. INTRODUCTION

Attempts to breach the security of a nuclear reactor or fuel cycle facility may involve the use of duress on persons associated with the facility. Such persons may be compelled by threats to actively participate in an attempt, or to passively permit an attempt, to breach a facility's security.

Physical barriers, employee identification techniques, access control procedures, and other similar security measures are considered to have limited deterrent effects upon the use of duress. The assessment and response activities of conventional security system will be a limiting factor on the effective use of duress, provided the system is able to detect the duress and initiate an alarm signal. The conventional physical security safeguards will probably fail to detect the use of duress, especially with telephoned or mailed threats involving bodily harm, blackmail, or kidnapping. The neutralization of duress attempts will require the employment of additional countermeasures to those provided by conventional security systems, e.g., a duress alarm system.

A glossary is included as Appendix A which defines terms that are pertinent to duress alarm systems.

2. BUILDING BLOCKS OF DURESS ALARM SYSTEMS

The general structure of duress alarm systems will be discussed in this section. In addition, factors that can affect the effective employment of duress alarm systems will also be discussed. Human reactions to threats are discussed to determine the potential problems or aids that may be encountered with the systems.

2.1 Duress

The word "duress" is used to mean the involuntary response to stress placed on an individual. The stress is caused by an individual's perception of his environment, both real and imagined. The stress may be directly applied to the individual who perceives himself to be in trouble or indirectly applied to the individual who perceives another to be in trouble.

Stress applied to an individual can result in duress within the person. Stress or threats may be in the form of a gun, an oral threat, or an ominous-looking shadow at night. Duress encompasses the mental and physical changes that occur within an individual as a result of the stress, such as forgetting a familiar routine (mental) or increasing the heart rate (physical).

The typical person who may be subjected to duress is considered to be associated with a nuclear reactor or fuel cycle facility in a way that requires periodic communication between the person and the facility. This routine activity is diagrammed in Figure 1. The block labeled "Subject" represents the typical employee who may be subjected to duress. The block labeled "Facility" represents persons (other than the subject), mechanical devices, and electrical devices with which the Subject routinely interacts. The arrows indicate paths of interaction.

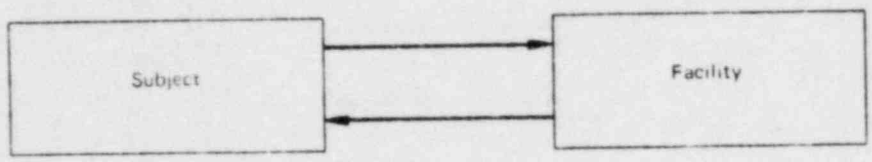

Figure 1. Subject-Facility Interaction

2.2 General Functions of Duress Alarm Systems

There are two basic functions of a duress alarm system--detection and alarm. The primary purpose of the system is to notify appropriate personnel that a duress condition exists.

A secondary purpose of the system is to provide information that will aid in the neutralization of the threat. Figure 2 shows the closed-loop relationship of the duress alarm system, the threat, and the actions necessary to eliminate that threat.

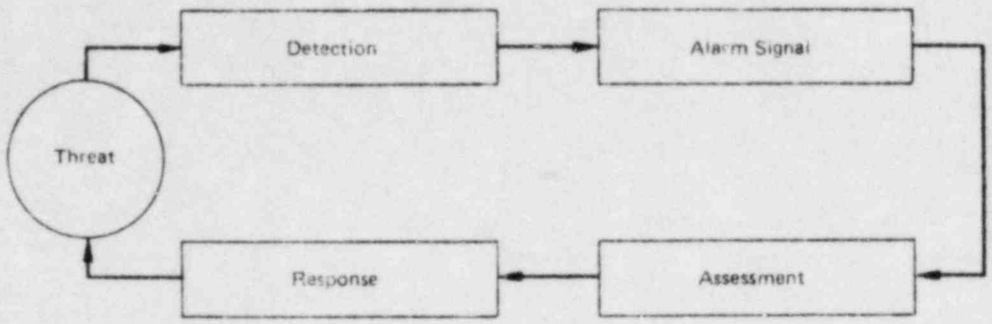

Figure 2: Duress Countermeasure System

Detection - The first primary function of a duress alarm is detection. Detection includes both the sensing and processing by a duress alarm device to determine that a duress alarm condition exists, whereupon an alarm signal is initiated. Detection also includes the recognition of coded words or acts that are predefined as calls for help. The existence of a duress alarm condition does not always mean that a threat exists, as in the case of nuisance alarms. The panic button can be used as an oversimplified example. Pressing the panic button is defined as the duress alarm condition. The tension spring within the panic button senses that the button has been pressed and in turn actuates a switch to initiate the alarm signal. The fact that the Subject did not intend to hit the button or did not know he hit the button does not prevent the switch from operating. In more sophisticated systems, the spring is replaced by complex electronics which perform the same function.

Alarm Signal - The "duress alarm signal" or "duress alarm" is that signal which is transmitted to the central alarm station (CAS) and all secondary alarm stations (SAS) to indicate that a duress alarm device has been activated. Along a single path to the CAS, the alarm may take on several different forms such as an electrical pulse in a wire, a specific radio frequency (RF) pattern, or the alarm annunciation at the CAS. The alarm signal is not just the lights flashing or buzzer sounding at the CAS, but includes all the intermediate transmission signal stages along a single alarm path.

Assessment - Two functions associated with, but not a part of, the duress alarm system are Assessment and Response. The secondary purpose of duress alarms is to provide information that will assist the Assessment and Response activities. Assessment is an evaluation functon performed at the CAS or SAS on information received from the alarm. Based on the received information, a judgment is made on the appropriate response. The evaluation may include checking the validity of the alarm through information from other sources.

> VERIFICATION OF A DURESS ALARM MUST NOT BE MADE BY CALLING AND ASKING THE SUBJECT IF HE IS REALLY IN TROUBLE. TO ASK THIS OR ANY SIMILAR QUESTION NEGATES THE ENTIRE DURESS ALARM SYSTEM. THE RESULT MAY BE THE SUBJECT'S DEATH REGARDLESS OF HOW HE ANSWERS THE QUESTION. COMMUNICATIONS FOR ASSESSMENT AND RESPONSE MUST BE DONE ON A SUITABLE NETWORK THAT DOES NOT ALERT THE AGGRESSORS. SYSTEM INTEGRITY IS BETTER MAINTAINED WHEN ALL DURESS ALARM SIGNALS RECEIVE DELIBERATE RESPONSE ACTION.

Response - The main function of the Response block in Figure 2 is the neutralization of the threat. The Response, as defined here, is performed by persons other than the Subject and is based on decisions made during assessment. Response to a duress alarm signal can range from an effective aid to tragic sacrifice. Poor Response to the alarm could arouse or antagonize the assailant before the assailant can be neutralized.

Source of Threats - Threats may come from local or remote sources. Threats to inflict bodily harm or to damage the facility with the use of weapons, explosives, or other obvious means for accomplishing the intended action are considered threats from local sources.

Threats made by mail or telephone involving bodily harm, property damage, blackmail, or hostages are threats which come from remote sources. Threats from remote sources may or may not include evidence that the threatened action can be accomplished.

In duress incidents involving threats from local sources, the Subject may proceed through the detection, alarm, assessment, and response phases to neutralize the threat immediately. This is not considered to be the typical situation and thus is not implied when using the terms Detection, Alarm, Assessment, or Response.

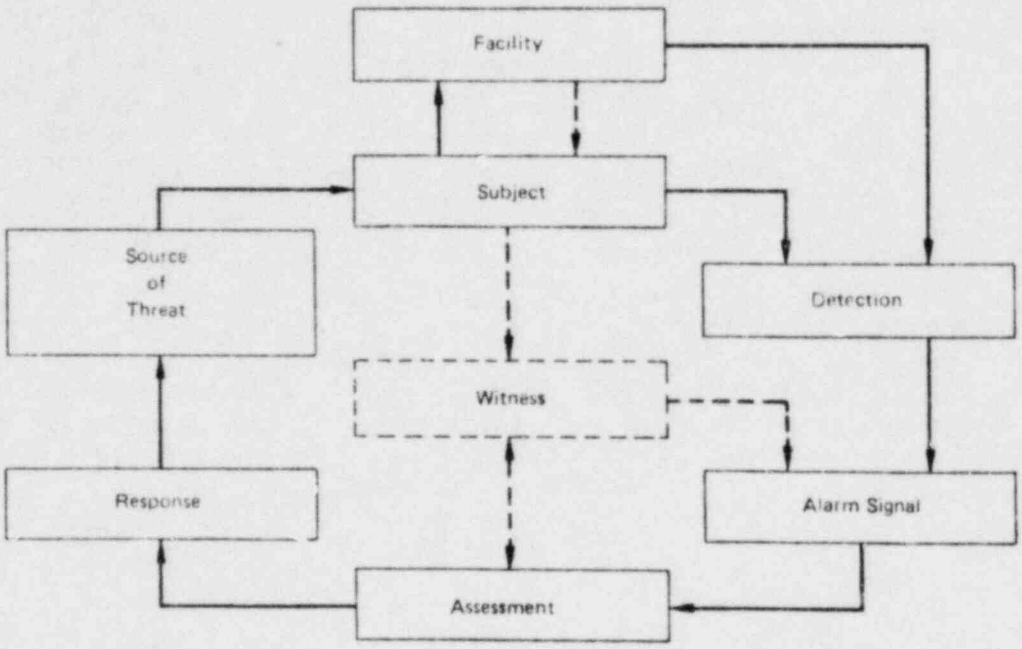

Figure 3. Subject Interaction with the Duress Countermeasure System

The relationship between the Subject and the duress countermeasure system is shown in Figure 3. Note that the Subject is the central block of the figure. The threat must be directed against a person for the alarm to be considered a duress alarm. Detection may involve inputs from various sources, including the Subject and Facility.

Witness - The Witness block has been added to Figure 3 as a possible source for duress alarm signals. The Witness is an individual who is aware of a threat against another person. In general, the Witness does not feel threatened; however, a concern for the threatened person may cause mental stress resulting in duress in the Witness. Witnesses need not be, but most likely will be, plant personnel. The Witness is more likely to notice a threat from a local source than from a remote source. The Witness block can be effective only if a strong training program is used to instruct appropriate personnel about signs of duress. Care must be used not to interfere unnecessarily with the privacy of employees. The Witness block is shown in a dashed line to indicate the difficulty in using this block effectively.

2.3 Reactions of the Subject to Threats

The reactions that a Subject can have to threats may be separated into voluntary and involuntary reactions. An understanding of these reactions will better enable security personnel to choose appropriate alarms for specific applications. Human limitations for response can be more important than any physical limitations an alarm device may have.

When considering the value of voluntary versus involuntary reactions in duress systems, certain human limitations must be kept in mind. Having a duress alarm available for voluntary use is no guarantee that the device will be used. The person subjected to duress may not have the will, the presence of mind, or the opportunity to voluntarily use the system provided. If the threat is from a remote source, especially one involving blackmail or kidnapping, the Subject may choose to exert every effort to conceal the existence of the duress. The reliability of voluntary acts as duress indicators is dependent on the Subject's ability to correctly perform the required acts. Involuntary reactions also have limitations for use as duress indicators. The physiological parameters used as duress indicators are also affected by physical exertion, personal problems, sexual arousal, etc. Much research is necessary to develop adequate parameter processing to eliminate nuisance alarms.

Voluntary Reactions - Voluntary reactions are those acts performed consciously by the Subject in response to an awareness of a threat. Such acts may be governed by the will of the Subject without regard to reason, or may be performed deliberately with a realization of the probable consequences.

When configuring a duress system for using a Subject's voluntary reactions as inputs, three basic alternatives are available. The subject may deliberately

1. fail to perform a routine act,
2. fail to perform a routine act correctly, or
3. perform a nonroutine act.

Routine acts are considered to be the typical work duties of the subject, whereas a nonroutine act may be the pressing of a panic button. The use of voluntary reactions of the Subject to initiate duress alarms requires precoding specific acts to indicate the presence of duress. When considering acts as candidates for the three categories, one should consider the level of visibility of the routine operations to potential aggressors. If the aggressor is allowed to see the routine operations during his planning stages, the aggressor will be able to recognize that the Subject is deviating from the routine operations.

Failure to Perform Routine Act - The Subject's failure to perform a routine act as an indication of a duress situation depends on the need for the routine act to be performed within a specific time period. The establishment of a predetermined schedule for routine acts of the Subject is a technique that has been used in patrols involving watchmen. Devices are installed at various stations along a patrol route that require resetting by an act of the subject in conformance with a predetermined schedule. Failure to reset a device on schedule will initiate a transmission of an alarm signal. Failure to report during routine radio roll calls can also be used to initiate an alarm. An important application for this category of reactions is the circumstance in which the Subject has been physically restrained.

Failure to Perform Routine Acts Correctly - The incorrect performance of one's routine duties to initiate a duress alarm must be done according to previously established rules. The violations of predetermined procedures or schedules must appear to be correct and routine to the outsider, i.e., the source of the threat. This system depends on either a trained Witness or a sensing device to detect the violation which indicates duress. The Witness must be trained to detect the incorrect act and to respond accordingly. Examples of routine duties incorrectly performed include the Subject punching a specific incorrect code into a numbered keypad or a guard on fixed patrol changing his route and reporting from the "wrong" reporting station.

Description of the Threat - The next important fact needed for Assessment and Response is the type of threat being made. Is it a local or remote threat? Local threats will usually require the immediate dispatching of a Response force, whereas remote threats such as blackmail or kidnapping may require several days of continuous Assessment and Response. The size of the threat can be critical. An all-out response is not needed when giving assistance to a guard who is being roughed up by one disgruntled employee. When two or more duress alarms are received at the same time, information is needed to decide which is the most critical. Terrorists may try diversionary tactics, attempting to draw all the Response forces to one area of the facility while the main terrorist force enters the facility at a different location.

Identification of Personnel Being Threatened - Knowledge of the number of hostages and who they are will give the Response team an indication of the type of help, if any, that the team can expect from the hostages. As an example, the Response team may expect more assistance from a trained guard than a secretary who is among the hostages. The assistance can be in the form of keeping the other hostages calm and sensible or in the form of direct actions for the Response team.

Any Other Helpful Information - There could be incidental information that may be helpful for Assessment if known, such as the objective of the threatening force. The subject of the threat may perceive that the present path of the threat is putting other plant personnel in imminent danger.

Duress alarm systems may be configured to automatically give portions of the desirable information. Some duress devices lend themselves better than others to supplying information. A "panic button" can only signal that someone is in trouble, but its isolated signal path to the CAS will pinpoint the location of the trouble (assuming that "panic buttons" from other areas are not included on the same signal path). Precoded messages could be used on a radio or with a pushbutton keypad. However, attention should be given to the possiblity that the Subject may be too upset to give the correct code. Audio or CCTV monitors may provide the most information through semicontinuous monitoring. Triangulation with multiple receivers may be used with RF to pinpoint the source of radio transmissions. When individual types of devices are discussed in later sections, the information transfer capability for the types will also be discussed.

Deliberate, Nonroutine Acts - The deliberate, nonroutine act is used to directly initiate a duress alarm signal. Nonroutine acts of the Subject may vary from pressing a "panic button" to dialing a telephone to call for help. The only purpose of the deliberate acts referred to in this category is to directly actuate a duress alarm device which in turn initiates a duress alarm signal.

Involuntary Reactions - Involuntary reactions to duress are actions or responses of a Subject that are not under the direct control of the will of the Subject. The reactions may be physiological, increased heart rate, faster breathing, etc. The involuntary reactions may also include psychological changes such as forgetting to do a routine function due to preoccupation with a threat made against the person.

The use of a Subject's involuntary reactions to indicate a duress condition requires knowledge of the Subject's involuntary responses to typical job routines. A maximum range of normal responses is set for the individual, and a response outside this range would indicate a duress alarm. Typical physiological parameters now being considered include pulse rate, blood pressure, skin conductance, and voice analysis. Sensing the Subject for involuntary duress reactions should be done automatically since the Subject does not take direct action to initiate the alarm.

2.4 Enhancement of Probable Duress Situations

Typically, there are some preconditions which must be met before a threat can be made which would cause duress. Recognition that the preconditions are being met may be used to alert a Witness or duress system that a threat may be imminent. The more isolated an individual is from the surroundings the less likely the individual is to be subjected to a threat. Obviously, if the person has no access to communication lines and has no means of physical approach, the person cannot be subjected to an external threat. If communication lines are introduced, the person may now receive threats from remote sources. Allowing individuals access to the vicinity of the subject introduces the possibility of threats from local sources.

Enhancement techniques can be used to alert a trained Witness, a duress device, or even a potential victim that a duress condition is temporarily more imminent. Electronically, the sensitivity of the duress device may be temporarily increased so that less effort by the Subject is needed to initiate the alarm. A time delay may be automatically started that will trigger an alarm, if not stopped, by the Subject to indicate "all is well". Lights or horns may be used to warn the Subject or a Witness that someone is approaching the post. When trained Witnesses are used with closed-circuit televisions (CCTVs) or speakers, the camera or microphone may be automatically turned on for personnel monitoring at the CAS.

3. JOB FUNCTIONS VULNERABLE TO THREATS

Any person employed at a nuclear facility could possibly be the victim of a threat, particularly from remote sources. For example, blackmail might be used to cause an employee to violate some company rule or federal regulation. Certain categories of employees are more likely to receive threats than others. These categories include security personnel, upper management, and receptionist or switchboard operator-type personnel who have much contact with persons not connected with the plant. Select individuals such as planning engineers and maintenance people who have access to critical special nuclear material (SNM) or Safeguard information are also more vulnerable to threats.

The discussion in this section will center on the typical types of duties performed by security personnel. There is little difference between the considerations that must be given to receptionists and switchboard operators and the considerations given to security personnel assigned to fixed posts. Similarly, the considerations for upper management and other select personnel are the same as those for security people whether on random patrol or fixed post assignment--random patrol when away from their private work stations and fixed post when at their private work stations, desks, etc.

In general, the security or guard activities will focus on patrols, fixed posts, and entrance portal monitoring. The various activities at these locations place constraints on the types of duress alarm systems that can be reliably used.

3.1 Patrols

Random Patrols - Personnel on foot or mobile patrols are the most difficult to monitor. Mobile patrols, i.e., those patrols made with vehicles, can cover much larger areas with greater distance between stops than foot patrols. In either case, the patrols may be predetermined or be completely random. Random patrols may be roving patrols that cover an area without specifying the paths taken--similar to police cruiser patrols. Guards that respond to alarms or make other nonroutine trips are also considered to be on random patrols. Foot patrols are made either indoors, outdoors, or both.

Random patrols are the most difficult and possibly the most expensive to monitor. Checkpoints for random patrols are of limited value except to indicate that the guard has passed designated locations. Tall buildings, metal superstructures, and receiver locations all adversely affect the ability of a radio to receive the transmitted signal. The bulk, weight, and battery power all limit the transmission power of portable equipment. Transmission and reception is less of a problem for

Numerous schemes may be used individually or in combination with each other to detect when a threat is more likely to be imminent. Weight sensors may be used to indicate personnel movement. Motion detectors could be used to indicate personnel or vehicle movement. Metal detectors could indicate potential weapons or indicate vehicle movement. Explosive detectors could be used to indicate hazardous materials. Detection may be simplified when physical barriers are used to restrict the avenues of approach for aggressors.

2.5 Secondary Purpose: Provide Information

A secondary purpose of a duress alarm system is to provide information that will guide the CAS personnel toward a proper Assessment of the alarm condition. The basic data inherent in any alarm system include the information that some nuclear facility employee somewhere within range of the CAS is in trouble. Increasing the information content of the alarm also increases the complexity of the system.

The ideal system would automatically indicate who was in trouble, the location of the trouble, a description of the threat, and would require negligible time to transmit all the data. Most devices that are presently available provide a negligible amount of assessment information. If time permits, the standard telephone or two-way radio can relay all the desirable data. If only a moment is available, the transmitted data will be limited. When transmitted information is limited by time, the order in which the information is given becomes important, beginning with the fact that a duress condition exists. The following list gives the types of data that are needed, starting with the highest priority first:

1. Personnel are threatened,
2. Location of personnel being threatened,
3. Description of the threat,
4. Identification of personnel being threatened, and
5. Any other helpful information.

Personnel are Threatened - Duress alarms are among the highest priority, if not the highest, security alarms that a central alarm station will receive. CAS personnel need to know immediately that the alarm is a "duress" alarm so that it can get immediate and full attention.

Location of Personnel Being Threatened - The second most important information to give is the location of the threat. Responding forces now have a place to converge on. If time did not permit giving more information, the responding forces can evaluate the situation for themselves when they arrive on the scene. There is little value in the knowledge that somewhere within the facility there are five terrorists with two hostages. Valuable time and possibly lives will be lost trying to find the location.

mobile patrols because mobile radio equipment is capable of higher transmission power levels. Coded relay transceivers for portable and mobile radio reception need to be placed at strategic locations throughout the facility. Once a duress signal is received at a relay transceiver, the transceiver can transmit by RF or landlines a coded signal back to the CAS, indicating the probable location of the duress.

Fixed Route Patrols - Fixed patrols follow predetermined paths. Checkpoints may be provided along the patrol routes or portable duress equipment may be carried. The guard may be told at the start of the patrol what his entire path will be, or he may be told only the first checkpoint from which he is to report; after reporting in from the first check point he is told the next checkpoint from which to report, etc. The effect of the latter method is to give a random appearance to the patrol.

A wider range of duress alarm options is available for mobile patrols than for foot patrols. When guards on mobile patrol are required to leave their vehicles, the guards temporarily simulate foot patrols. Checkpoints that require manual log-in are less convenient for mobile than for foot patrols. Vehicles used for patrols could be equipped to continuously transmit a unique identification code (ID) or to transmit when triggered. Signpost or triangulation methods can be used to locate the vehicle in case a duress alarm is initiated (refer to Section 4.13). The vehicle can be equipped with numerous types of alarm devices and high-powered radios. The guard that has stepped outside the patrol vehicle no longer has easy access to the alarm devices permanently mounted in the vehicle. When a guard leaves the vehicle with the appropriate equipment, he may use the powerful mobile radio as a repeater to retransmit his alarm signal to the CAS. Alarm devices that are suitable for particular types of patrols are discussed in detail in Section 4.

3.2 Fixed Posts

There are various types of fixed posts in which a guard may be stationed, such as a CAS or observation tower. Observation towers can see and be seen over greater distances than other posts, so they may be more likely candidates for attack. The CAS and SAS form the heart of all communications and alarm networks that are vital to the security of the nuclear facility and may be a crucial target for attack.

Much more flexibility of design for duress systems is possible when choosing alarm devices for fixed stations than was possible for partols. At fixed posts, the guards normally stay within a very limited area. One limitation which still exists for alarm signals is that body-carried devices must transmit the signals remotely via ultrasonics, RF, etc. Even though body-carried devices can be plugged into monitoring consoles, using cables, the method is not recommended. The cables would be an inconvenience to the wearer and prone to entanglement, particularly if more than one person worked at the post. The human factor of operator acceptance may also be difficult to achieve.

Hardening the post and restricting access to the post not only makes the post less vulnerable to attack but also makes the duress alarm system less vulnerable to compromise. Duress devices have little or no value if a surprise attack can be made, neutralizing the Subject's ability to activate the duress alarms. Devices that may be used at fixed posts range from panic buttons to highly sophisticated body-worn duress sensors. Alarm devices include telephones, high-powered radios, CCTV, and audio monitors.

3.3 Personnel and Vehicle Portals

Personnel and vehicle portals are special categories of fixed posts at which security personnel are stationed. At portals, interaction is required betwen guards and incoming/outgoing personnel or vehicles. All comments previously made on fixed posts also apply to portals.

To lessen the potential hazard to guards, direct contact with portal traffic should be minimized. As this contact is minimized, less sophisiticated duress devices are needed, and simple devices like the panic button become more effective. Using cameras and microphones, portal traffic on foot can be monitored remotely except when packages need to be checked. Stepping outside the portal control room to inspect a package would require the guard to carry a portable duress device or activate some type of timer. The timer would automatically initiate an alarm signal if not halted before timeout. If a drawer is provided through which the package is passed for inspection, the guards are still vulnerable to explosives and gas attacks. Each guard within the post should always be within easy reach of a duress device.

Drive-through portals are prime candidates for attack with the guards being extremely vulnerable as they inspect vehicles that enter or leave the facility. Several methods are being used to inspects vehicles which pass through a portal into a facility:

1. Guard inspects the vehicle in the noncontrolled area prior to opening the access gate,

2. Access gate is opened to allow the vehicle to enter the controlled area. The gate is again closed and the vehicle is inspected while already inside the controlled arca, and

3. Some facilities leaves the access gate open while inspecting the vehicle inside the controlled area.

The third method has the distinction of combining the worst of the two previous methods. The potential threat associated with vehicle inspection comes principally from enclosed vans and trucks. The guard has no idea what is inside the vehicle until it is opened, and by that time, there may be no chance to sound an alarm. Using locks (similar to those used for boats in a canal), a vehicle could be isolated from both the controlled area and the uncontrolled area. Remote-control cameras could then be used to assist the inspection and watch the guard for any signs of duress. Microphones could also be installed in the area to listen for indications of duress. Various types of timing devices may be used that would require the guard to return to the portal control room within a given time period. The timer automatically sends an alarm if allowed to timeout.

When access to a post is restricted, a wide range of duress devices can be used. For example, a panic button can be combined with the door unlock button, or weight sensors in the floor can be used to signal the presence or absence of someone. RF transmitters can be used at virtually every type of post if adequate receivers are provided.

4. DURESS ALARM TECHNIQUES AND DEVICES

A multitude of detection and transmission devices are available commercially, and additional devices are continuously being developed. Of the vast number of available devices, relatively few are practical for use in a duress alarm system at present. This situation is due to the limited number of techniques presently available for sensing duress, to the inherent constraints imposed on the system by the Source of the Threat, and to consideration for the Subject's comfort. The devices discussed in this section of the rep. . are presented as examples of types of devices that may be useful at present. As new duress sensing techniques are developed, devices that are presently experimental may become applicable; and new devices will certainly be developed.

4.1 Device Characteristics

When considering the design and installation of a duress alarm system, the designer should look at the characteristics of each alarm device, decide what he expects from the completed system, and choose the appropriate combination of devices that will meet the requirements.

Active Versus Passive Devices - All duress alarm devices will fall into one of two main groups, active and passive. Active units are continuously or temporarily sensing one or more parameters for indications of duress. When a duress indication is received, the device will automatically initiate an alarm signal. An obvious example is a device which monitors human physiological parameters, but another example is a timer. The timer automatically initiates an alarm if allowed to time out. Physiological devices will be only briefly mentioned, because they have not developed enough to be commercially available.

Passive devices require manual activation to initiate an alarm signal. The device cannot tell if the activation was intentional or accidental. As far as the device is concerned, activation is the duress condition necessary to trigger the alarm. A deliberate act is required by the Subject to initiate the alarm sequence.

Duress alarm equipment should possess the following characteristics:

A. Easily Activated - The device should be easily activated by the Subject when under duress. Whether alarm actuation is done using code words, depressing a sequence of buttons, or pressing a switch, the method of actuation should be kept simple--both mentally and physically. A Subject's ability to function is difficult to predict under actual duress conditions.

B. Quickly Activated - The device should not only be easy to activate, but it should also be quick to activate. The Subject then has his hands and mind free to perform other tasks with minimum delay during the emergency.

C. Reliable - High reliability and low false alarm rates require good sensitivity while inhibiting accidental and nuisance activations. The duress alarm system must maintain high integrity to ensure swift and decisive Response to the threat. If the system is prone to having many false alarms, the Response will become sluggish, and the duress alarm system will become ineffectual.

D. Provide Information - In addition to providing a duress alarm indication, some duress devices can provide information which can assist the Assessment and Response functions of the security system. Devices such as panic buttons give no information (although the unique lines connecting the buttons to the security system can give locations), whereas TV cameras or microphones are continuously transmitting information. Some devices such as RF transmitters give identification codes each time they are keyed.

The limitations of duress alarm equipment should be known for the following categories:

A. Portable, Mobile, or Fixed - When designing a system, consideration should be given to the mobility of the device. Any duress alarm device that can be used by personnel on foot or in a vehicle can also be used by personnel at a fixed post. The converse, however, is not true because the weight, size, or other factors may not allow a fixed device to be used in a portable or mobile situation. A "portable" device is normally one that is completely self-contained and can be carried on one's person. A "mobile" device is one that can be moved but not easily carried on one's person. Mobile units are usually considered to be those mounted or transported within a vehicle. Fixed-type devices are those devices which are either attached directly or via cables to a permanent structure.

B. Power Requirements - The power requirements of a duress device are a special case of the fixed, mobile, or portable considerations which deserve additional attention. The power requirements must be compatible with the intended use of the device. A device that has a high current consumption will quickly discharge most batteries that are designed for portable use. Units which operate on alternating current, although adaptable, would typically not be considered for a vehicle.

C. Susceptibility to Neutralization - The design of the duress devices is only one element of many which determine the overall susceptibility to neutralization. Tampering with telephone lines can disable systems that depend on commercial telephones. Redundant alarm signal paths and redundant control alarm stations both reduce the threat of compromise. The answer to the following question for any given system will give a good indication of the susceptibility of that system. If an aggressor is familiar with a system, how much time will be needed by that aggressor to defeat the system?

4.2 Device Categories

The categories of devices discussed range from the long-established devices to those still being developed. In most categories, an attempt has been made to reference at least one developer, manufacturer, or vendor. In categories with many vendors, no attempt has been made to list all the vendors. In general, the references are from those companies which contributed data sheets on their products or their studies. The references are meant only as a starting point and guide for searching out the most desirable combination of devices from all the applicable devices now on the market.

The types of duress alarm devices discussed in this section are listed below according to their modes of operation.

- Switch or Relay
- Telephone
- Two-Way Radio
- Closed-Circuit Television
- Audio Monitor
- Watchman Checkpoint
- Portal Cypher System
- Weight Monitor
- Biophysiological Monitor
- Cargo Monitor
- Automatic Vehicle Location
- Nondevice Methods

4.3 Switch or Relay

The simplest type of duress alarm device, in terms of hardware design, is the on-off switch or "panic" button. All types of alarms, even the most complex, when simplified to their very basic state take on the form of a switch; either "yes," an alarm conditon exists or "no," an alarm conditon does not exist. A relay is a switch that is actuated by a magnetic field set up by an electric current.

Characteristics of Switches

Manufacturers refer to the contact operations in various ways for switches and relays. In general, any one switch contact is said to be "normally open" or "normally closed". "Normally" means the inactive state with no manual or electrical force applied. "Energized" and "nonenergized" are terms commonly used to describe the switch as being in the activated or inactive states, respectively. Switches may be configured to include any number of normally open or normally closed contacts. For both types of contacts, there are only the two conditions possible, operated or nonoperated. Some switch positions are more advantageous than others in duress alarm devices.

Nonenergized, Open - When switch contacts are in the nonenergized and open condition, the switch neither requires any power nor does it allow the transfer of any power. Where low power consumption is required, as in battery-operated systems, this switch configuration is ideal. The disadvantage is that no indication is available to show a circuit is intact or even that the power supply is working until the switch is closed. This could be too late for duress alarm systems.

Nonenergized, Closed - When switch contacts are in the closed and nonenergized condition, the switch does not require any power but does allow the transfer of power. Power transfer is similar to that of an on-off power switch on electrical equipment. Using this switch configuration, the system can periodically or continuously verify that the electrical circuits are functioning properly. This type of self-testing cannot guarantee that the contacts will open when the switch is operated manually; only a manual test can verify the contact will open. When an alarm system uses closed contacts for the nonalarm condition, any break in the system, including switch contacts, will generate an alarm.

Energized, Open - Power is required to hold the switch open for the nonalarm condition. The presence of power at the remote site can be verified by using a normally closed switch in the energized open state to indicate nonalarm. If power is lost to the switch, the switch will return to the nonenergized condition and generate an alarm. Typically, the power which drives the remote device is not the same power that drives the transmission system for the alarm signal.

Energized, Closed - Since the switch uses the energized condition to mean nonalarm, the remote power can be monitored as described for the "energized, open" switch. Since the switch uses closed contacts to mean the nonalarm condition, the system can be tested as described for the "nonenergized, closed" switch. A duress alarm system using this switch configuration will usually consume more power than the other three methods.

In most applications, the system designer has the choice of using the energized closed, normally closed, energized open or normally open switch position to indicate the nonalarm condition. Closed contacts allow the supervisory loop to include the switch while monitoring for line tampering. The energized switch for nonalarm will drop to the nonenergized position, if power is lost, as an indication of system malfunction.

When choosing switches for various applications, the designer should consider the switch construction. Certain alarm applications commonly require low current for supervisory loops. For low currents, particularly in the microampere range, contact resistance in switches and relays must be kept to a minimum. The better switches have contacts which are plated with precious metals such as gold or silver. Power switches normally do not have very low contact resistances. Simple electrical equations will show what resistances in the circuits can be tolerated without degrading the signals.

Switch fatigue is another important area of consideration. Precision switch literature lists life expectancy (mean time before failure) as the number of operations before failure. Typical mean times are from one to five million operations. Although the emergency use of the switch will seldom occur, when the need does occur, the switch must not malfunction.

The reliability of switches may be increased by placing two or more switches in tandem in the circuit. The probability of two precision switches failing at the same time is extremely low, approaching zero. When the open condition is used to indicate an alarm, two switches may be placed in series and actuated by the same button. If either or both of the switches operate, the circuit will be opened to initiate an alarm. When the closed condition is used to indicate an alarm, two switches may be placed in parallel and actuated by the same button. If either or both of the switches operate, the circuit will be closed to initiate the alarm.

A switch type of duress device can do no more than indicate that a duress alarm condition exists. There are, however, ways that the system can be configured to provide more information. The simplest design method would have a unique signal path for each duress device all the way back to the CAS. An alarm received on a particular line shows the location of trouble to be at station "XYZ" because that is the only place to which the signal path is connected. A more complex method not requiring unique paths would have the switch activate a precoded transmission, giving the location of the persons in trouble. A more sophisticated method would count the number of times the Subject has pressed the panic button within a given time period, such as five seconds. Precoded messages could then be annunciated at the CAS according to the count the Subject entered. One count could imply an all-out response is needed, whereas four counts could mean that several unhappy employees are approaching the Subject with clubs. The methods available to annunciate the various coded messages will be discussed in Section 5.

Types of Switches for Duress Devices

There are numerous types of switches that may be used as duress alarm devices. If a particular type of switch is desired for use but has poor electrical characteristics that do not match the rest of the system, relays may be used. Relays are capable of transferring switching information while isolating high voltages and currents from low voltages and currents that may be used in supervisory loops.

Panic buttons may be concealed or they may be highly visible. Visible devices have questionable value. If the threat is a surprise to the Subject, it is doubtful that the Subject would be allowed to approach obvious duress devices. If the Subject has relatively free movement, but a comrade is being restrained by a threat, the Subject may be unwilling to risk the well being of the comrade to actuate the obvious duress alarm device. On the other hand, concealing or disguising devices will often make them more difficult to actuate.

The use of switches in duress alarm devices is limited by little more than one's imagination. Techniques employed at present in robbery alarm systems use footand knee-actuated devices under desks and counters and hand-actuated devices installed on desks and counter tops. Law enforcement vehicles are equipped with foot-actuated alarm devices concealed under the floor mats and with push-button alarm devices on the vehicles' radios. Portable radios are equipped with hand-actuated lanyards and push-buttons to initiate emergency signals.

Basic Panic Button - The basic panic button is a passive, voluntary device requiring manual actuation to initiate a duress alarm signal. The panic button may be made in a variety of different forms, using one of several different means of installation. An example of an effective use of panic buttons is given later in the Panic Button-Door Opener Example. The most common type of switch is the mushroom-type panic button. Listed below are the basic types of panic buttons.

Mushroom button switch - Has a large striking surface for easy operation by the Subject. Difficult to conceal. May be placed in any location for easy access.

Foot switch - May be used by the Subject while sitting or standing. Not immediately visible. May be difficult to find with foot when needed or may be accidentally stepped on when not needed. Shielded switches are available which prevent falling objects from accidentally depressing the switch.

Toe switch - Also called toe bar. Activated by raising toe of shoe to contact a toe bar. More difficult to use than the standard footswitch but has less chance for false alarms.

Knee switch - May have designs similar to the foot switch, mushroom button switch, etc. Placed in locations accessible for activation by the knee, such as under a desk.

Mat or pad switch - Usually placed on the floor. May be used to indicate the presence of someone (or something) at a door, work position, etc. Stepping on or stepping off the mat could be used to initiate a duress alarm signal. A mat switch along a walkway or passageway, when stepped upon by an approaching person, could: (1) alert the Subject to possible imminent danger, (2) turn on video recorders, (3) activate audio and video monitors, and (4) activate timers in portal cypher systems (section 4.9). Using a mat switch in vehicles to detect unexpected weight, a warning would be given to the driver that a stowaway is located in the trunk or on the floor in the back seat.

Ribbon switch - Built in the form of a ribbon. Pressure anywhere along its length actuates the contacts. May be installed under front edge of desk or work position for concealment.

Pressure switch - There are numerous types of pressure switches that may be concealed in many ways, such as under a book, magazine or paper.

The wafer-type pressure switches may be attached to desk or counter tops and require that only a light pressure be applied or removed to activate. Capacitive switches require only a light touch by the Subject. Using the same principles as in capacitance detection intrusion systems, almost any ferrous-type object may be used as a touch plate for capacitance switches. The Subject would only need to touch the object to send a duress alarm signal.

Tilt Switch

A tilt switch may be used as a passive, voluntary or active, involuntary device. The typical switch consists of a tube containing two electrical contacts and a small amount of mercury. When the tube reaches a given angle of tilt, the contacts are shorted together by the mercury. In the passive voluntary application, the switch is attached to an unobtrusive object that may be tilted to activate the duress alarm. The active involuntary application is used, when combined with a timer and radio transmitter, to make a "dead-man" alarm. The only known commercially available unit is marketed by Audio Intelligence Devices (AID).

The dead-man alarm marketed by AID is worn on the person of the Subject to sense incapacitation of the Subject. Should the Subject's body deviate more than a 30^{o} angle from the vertical plane, the unit will automatically transmit an identification coded duress alarm signal. A timer in the unit allows the unit to ignore body angles resulting from momentary bending or stooping. Transmitter options include either timed out or continuous one-way voice transmission following the alarm code transmissions. The alarm code is automatically retransmitted several times for each actuation of the dead-man alarm unit. The unit is also capable of functioning as a standard type RF panic button. One disadvantage of the unit is that the alarm signal is halted or not allowed to start when the power switch is turned off. An automatic alarm transmission upon loss of power to the unit would not allow an aggressor to neutralize the unit except by removing the unit from the Subject. Dead-man alarms based on measuring human biological parameters are discussed under "Biophysiological Monitor".

Flex Switch

The flex switch, commonly used to activate seat belt reminders in automobiles, may be used as a voluntary or involuntary, passive device. The flex switches may be concealed in chair seats or car seats to indicate the presence or absence of human bodies for automatic comparison with the expected occupancy. The expected occupancy may be a guard whose duties do not require him to leave his chair or a vehicle patrol which is made with precisely two personnel within the vehicle.

RF Panic Button

One need not assume that the various switches must all be connected by hardwire to the CAS. Radio frequency (RF) transmissions (only one-way transmision is required) may be used anywhere fixed devices can be used, most places where fixed devices cannot be used, or where the advantages outweigh the problems of frequency allocation, cost, etc. Using RF as a transmission medium, a panic button may be carried on the person of the Subject. Weight, size, and input power constraints limit the RF output power to a few watts or less. Enough remote receivers must then be installed to eliminate all dead spots from which the portable transmitter might otherwise not be able to communicate.

Low-powered transmitters along with a system of remotely located receivers may be used as an automatic locating system. Each receiver would be precoded to identify its location. Upon receipt of a coded duress alarm signal from a portable transmitter, the receiver (by RF again or by fixed wires) will retransmit the coded alarm along with its own unique precoded message to the CAS. Location is then given by the receiver, and the person in trouble is identified by the coded signal from the portable transmitter. This system for automatic location finding is called a sign post or proximity system. If two or more receivers simultaneously receive the distress signal, discrimination circuits may be used to determine which receiver got the strongest signal, implying closeness to the Subject. Further discrimination could be used to include precise timing of signal reception by the receivers to pinpoint the actual location of the Subject through triangulation. Both sign post and triangulation are discussed in Section 4.13.

RF panic buttons are commercially available from different sources but operate essentially in the same manner. A button(s) is actuated, and a coded transmission is initiated. The coded transmission, which may be repeated several times, identifies the alarm signal as duress and includes an identification code that is unique to the respective unit being keyed. Since the basic RF panic buttons have transmitters only, one-way voice communications may be included. RF panic buttons may be included on standard two-way radios (see Section 4.5.) Combining the RF panic button with a tilt switch makes an effective involuntary "deadman" alarm as described under "Tilt Switch." A device is being developed at Sandia Laboratories which has a toe-actuated switch within the shoe and a transmitter built into the heel of the shoe.

Ultrasonic Panic Button

Ultrasonic panic buttons are similar to the standard RF panic buttons except that ultrasonic transmission frequencies are used in place of radio frequencies. Two types of ultrasonic duress alarm transmitters are commercially available that differ greatly in internal design. When activated, the ultrasonic devices are capable of transmitting a nominal distance of ten meters. This distance varies greatly because of extraneous noises when used outdoors; therefore, the devices are recommended for indoor use only. A central control unit is used to annunciate the alarm and show the location of the receiver that responded to the ultrasonic device. A feature which is not particularly desirable for nuclear facilities is an indicator lamp on each receiver. The lamp turns on to show the Subject (and Aggressor) that the alarm was accepted by the receiver. The lamp will turn off again to show that the alarm has been acknowledged at the central control unit. Ultrasonic noise in the receiver area with the same frequency and sufficient amplitude will cause nuisance alarms.

Mechanical Ultrasonic Device - One type of ultrasonic device is all mechanical and marketed by Sentry Products, Inc. The device, called Silent Communicating Alarm Network (SCAN), simulates the appearance of a pen. The SCAN pen was developed by Sentry, in conjunction with NASA. A spring-loaded hammer, when released, strikes an aluminum bar that resonates at an ultrasonic frequency. The simple pen design requires no electrical power and is virtually maintenance free. A slight disadvantage is that the hammer must be manually pulled back before additional alarm signals may be sent during any one emergency. The device may be operated indefinitely, barring mechanical failure, without adjustments, battery replacement, etc.

Electronic Ultrasonic Device - The second type of ultrasonic device, marketed by UNISEC, Inc., is all electronic. When activated, the device transmits a three-second signal which substantially increases the probability of receiving the ultrasonic alarm signal. Potential maintenance (compared to the mechanical system) is a disadvantage along with battery replacement; however, repeated actuation of the switch will initiate subsequent alarm signals. The battery provides a minimum of 15 three-second signal transmissions. Battery replacement is designed to be difficult for those who are not familiar with the equipment. Without battery replacement, the transmitter would have a short life if it falls into unauthorized hands.

Panic Button-Door Opener Example

An example of an effective use of panic buttons is given in this subsection. Guard posts which have restricted access by way of electronic door locks are vulnerable during periods of authorized entry and exits. During these periods, door alarms are put in the access mode. Even a well-trained guard in a hardened post is not predictable when an intruder attempts to enter his post by holding a weapon on a fellow guard or associate. Even though he is safe within the post, he may or may not move to initiate a duress alarm and risk his associate's well-being.

A "black box" which contains both an electric door opening switch and a panic button would be an effective duress alarm device. This combination is not known to be commercially available but can be easily fabricated in an electrical shop. The box is completely enclosed except for a hole large enough for a hand to be inserted. Inside the box are either one or two (depending on preferred design) large mushroom-type momentary button switches. The black box allows the guard to actuate the door switch while also initiating a duress alarm. To gain entrance through threats without forcing the door, the intruder must allow the guard to insert his hand into the box. Assuming the guard does not make obvious movements, he can activate the door switch and panic button. If the intruder is aware of the panic button inside the box, the intruder's only recourse is to bluff the guard into not using the panic button. More important for the Subject's safety, the intruder would not know if the bluff worked or not.

In a single button design, a momentary push-pull switch is used; and in a dual button design, one is a momentary push button, and the other is a momentary pull button. Pulling a switch requires more finger movement than pushing; therefore, pulling should be used to open the door, and pushing should be used to actuate the alarm. In the dual button design, an option would be to have the push switch also operate the door. In no case should both switches be the pull type or both the push type. Identical switches add confusion and increase the probability of false alarms.

4.4 Telephone

A very common device often used in duress alarm systems is the telephone. An example of the use of telephones for duress is in cities where call boxes are installed along the sidewalks and used for reporting fires or other emergencies. In the home, the telephone becomes a duress device when it is used to call for emergency help. The telephone can be more difficult to actuate than the switches previously described. The telephone does, however, have the advantage of being able to transmit information by voice in addition to transmitting the alarm. There are several configurations in which the telephone may be used.

Standard Telephone Hookup - The simplest design of a telephone duress alarm configuration is the normal residential or commerical telephone installation. In an emergency, the Subject picks up the handset and manually dials an emergency number. The simplest design is not the most convenient for the guard. The guard may be unable to dial the complete number, may have dialed an incorrect number, or may get a "busy" signal. This system is totally dependent on commercial network switching. The calls can be routed anywhere. The lines are not secure from tampering.

Repertory Dialer - Another method combines a telephone set with a repertory dialer. A repertory dialer, when activated, will automatically dial a preprogrammed number. The Subject in trouble need only pick up the handset and wait for the CAS to answer at the other end. If the Subject is forced to hang up the handset before the called party answers, the circuit can automatically complete the dialing cycle and maintain the connection until the call is acknowledged by the called party. If the Subject has time, he may hold the handset and give the vital information directly. If the time is not available, a prerecorded message capability can be incorporated into the system to give the calling party's location. If several different messages are available, the Subject can select the messsage which best suits the situation. This method still uses commercial switching networks to reach the CAS unless the facility has a separate, private in-house system.

Dedicated Point to Point - A more restrictive use of the telephone employs dedicated lines that go between only two telephones; no switching networks are included. The "telephone" at the CAS may actually be a switchboard that terminates numerous dedicated lines to the CAS. In an emergency, the guard picks up the telephone; the telephone or switchboard at the other end immediately begins to ring. The setup cannot be used to call a different location unless new wires are installed. The lines may be kept totally within the secure area and may or may not be commercially installed and maintained.

Simulated Telephone Call - A duress alarm system being used by some retailers, e.g., liquor stores and all-night shops, incorporates a dummy telephone into the system. When a potential robber enters the shop, the proprieter depresses an unobtrusive button behind the counter. The button activates a preset timer. Upon time-out, a dummy telephone begins to ring, and a second timer is started. If the telephone is "answered" within a given time (or before a certain number of rings), the entire sequence is halted, and the system resets itself. If the proprieter does not or cannot "answer" the telephone within the given time period, a silent alarm is sent to the the local law enforcement headquarters. One such type of system is marketed by International Security Associates. This system may be used when the guard must leave the safety of his post or when persons approach a nonhardened post. If the guard is allowed to answer and the dummy telephone is connected to an alarm station, the guard may be able to provide vital information for Assessment. Another version of the timer system is discussed in Section 4.9. The advantage of these systems is that an alarm will be sent even if the Subject is incapacitated.

4.5 Two-Way Radio

Radio systems used for duress alarms are much more flexible than telephones but are more expensive and more complex to install.

Depending on the intended operation, a system designer may choose from low-powered portable radios (5 watts or less output), medium-powered mobile radios (range up to 80 watts output), and high-powered base radios (50 watts on up). Portable units are designed to operate on small disposable or rechargeable batteries. Mobile units are designed to operate on vehicle batteries or AC to DC converters. Base station radios usually operate on AC power.

Some of the major U.S. manufacturers of two-way radios which have duress alarm options are Aerotron, General Electric, and Motorola. Each of these companies sells radio equipment for use on all frequencies listed in Part 91 of the "FCC Rules and Regulations" and therefore can be used for voice communications, alarm signaling, data transmission, and remote control at nuclear facilities. AID also produces two-way radios, but the emphasis at AID has been to develop duress alarm devices with two-way radios being incidental to the devices.

Radio systems design is a complex field with many variables. In this report, radio system design is discussed only as the designs relate to the implementation of duress alarm systems. For more detailed radio system design information, refer to NRC's forthcoming report, Security Communication Systems for Nuclear Fixed Site Facilities.

The typical portable radio with limited power and minimum antenna capabilities has much shorter transmitting ranges than the other types. To compensate for the limited range, either a number of remote receivers may be installed at the facility or other radio sets should serve as repeaters. A repeater is needed, for example, when a guard steps away from his vehicle and transmits, via portable, to the mobile (vehicle-mounted) radio which relays the message to the base station. Remote receivers may be combined with portable radios to give automatic identification and approximate Subject location as discussed above under RF Panic Buttons.

Radios like telephones can be used in different ways for duress systems. The standard communications radio can be used to call for help. Additional information can be verbally given as with the telephone. This use is comparable to the use of emergency callboxes found along interstate highways in some states. Several options are available for radios which improve their effectiveness as duress alarm devices.

Voice-Operated Transmitter (VOX) - Hands-free keying of a transmitter may be accomplished through a voice-operated transmitter circuit. The transmitter is automatically keyed when the microphone detects a sound above a given threshold level. The threshold level may be adjusted up or down. The VOX option for transmitting is comparable to the squelch option for receiving. A realistic application of the VOX may be difficult to design. High background noise or conversations in the area may cause the transmitter to be unintentionally keyed, tying up the radio channel. VOX does free the Subject's hand for other tasks while calling for help.

Radio Identification (ID) Code - Radios are available which will automatically send a burst of data to identify the transmitting unit each time the unit is keyed to transmit. The digital burst of data is transmitted immediately after the radio is keyed and before the operator has a chance to speak. Each data burst contains several repetitions of the ID code. Each time a radio is keyed, a unique ID code is sent which identifies the transmitting radio and in turn identifies the operator to whom the radio is assigned. In time of emergency, the Subject is automatically identified, leaving critical transmission time for giving other information. Special words or phrases could also be used in conjunction with the ID code to initiate a duress alarm.

Panic Button - A natural progression in options on radios is to incorporate a panic button into the radio with the automatic ID code. The ID code is modified to indicate the panic button was actuated. When the proper control is actuated, the unit automatically transmits the ID/alarm code while the Subject's hands are free for other tasks. More important, the Subject has not had to compromise his position by speaking, assuming he is physically able to speak. The ID/alarm options are available on base, mobile, and portable radio equipment. Several methods have been developed for alarm activation, including pulling a ring, depressing a special button, or depressing a combination of buttons. The latter choice is usually a special button and the press-to-talk button that must be actuated simultaneously. The two-button requirement reduces the probability of false alarms below that for the single button actuation because the possibility of accidental tripping is decreased.

Power Switch Override - Special radios are designed with panic switches that will turn the entire unit on and off. Some manufacturers have designed a panic switch option that allows the ID/alarm code to be transmitted even with the power switch in the off position. The option not only enables duress alarm signals while the unit is turned off, but also prevents the aggressor from disabling the alarm signal. A side benefit of the option helps reduce horseplay on the radio by negating operator attempts to circumvent automatic transmission of the ID code.

Hands-Free Radio - A two-way radio made by AID gives completely hands-free operation and is designed to be worn under a shirt or jacket with no part of the radio exposed. The push-to-talk switch is operated by a slight inward pressure of the upper arm. The Subject is free to talk and listen while performing other tasks.

Other Options - Numerous other options may be included to integrate the radio into duress alarm systems. Radios, including portables, may be purchased to operate on one of several switch-selectable channels. Having several channels allows one to be designated as primary and the others as backup channels. Receive and transmit frequencies need not be the same frequency, thereby giving a limited amount of privacy to the communications. Digital radios are available which send numerical codes by depressing buttons on a key pad. Data can thus be sent without using voice communications. The digital radios may be used at remote checkpoints for guards on patrol where land lines could not be made secure or could not be installed.

4.6 Closed-Circuit Television (CCTV)

CCTV systems can be used as an active involuntary duress device by monitoring guard stations. Systems may be purchased that will consecutively scan a number of different cameras and display them on one or more displays. The cameras may also be connected to video recorders that become tools for Assessment when alarms are scheduled. The observers of the video monitors perform the function of Witness in duress alarm systems. Camera characteristics should be consistent with the light intensity levels encountered for a specific application during the respective operating time periods. Numerous options may either be built into the camera or included in the CCTV system:

1. Slow scan of multicameras.
2. Low-light or starlight intensity cameras.
3. Oneor two-way audio between camera and monitor.
4. Magnetic recorder for replay of crucial scenes.
5. Auto-iris control with spot density filters.
6. Remote control of pan, tilt, zoom, and iris.
7. Weatherproof camera housing for outdoor installation.
8. Concealed camera mount.
9. Auxiliary lighting in camera area.
10. Color camera and display.

Although a CCTV system can give an excellent view of the activity within a station, there are some potential pitfalls. An observer will find it difficult to watch a monitor(s) for any period of time without becoming "numb" to the scene(s). After a period of time, the observer will have difficulty maintaining active concentration. Similar to highway hypnosis, one "looks" but does not "see". The enhancement technique discussed in section 2.4, could be used to overcome much of this problem. The invasion of privacy and "big brother watching" syndrone are both potentially serious issues that may be raised by monitored personnel in objection to CCTV. Appropriate sensors could be installed to detect the approach of vehicles or persons to a guard station. When an approach is detected, the camera at the remote station and the video monitor at the monitoring station are both enabled. A video monitor has a scene displayed only during the periods of increased probability of danger. The scenes displayed will be only those that include the stations whose sensors have detected movement. Using a video recorder at the alarm station will allow the scenes at the source of the alarm to be recorded and saved. The video scenes may then be played back immediately as an Assessment tool. The video scenes may also be viewed later for alarm system analysis.

Transmission of video and control signals can be expensive if the distances are great and coaxial cables are used. There is a TEL-E-TEL unit on the market which enables the video signal to be transmitted over twisted pair wires for distances up to a mile. Little degrading of the video signal can be noticed visually; however, concern has been expressed about the occasional necessity of retuning the Tel-E-Tel units in adverse temperature environments.

CCTV can be effectively used to verify the existence of a valid duress alarm, when a duress alarm is initiated via some other device. As an Assessment tool CCTV would allow CAS personnel to observe the scene from which a duress alarm was received. The determination can be made whether or not the duress alarm was accidentally actuated.

4.7 Audio Monitor

Audio monitors can also be used as duress devices by listening to sounds and conversations that originate from a guard post. Several techniques are available or may be available in the near future that would be applicable to duress alarm devices. Audio monitors are classified as active, involuntary devices. As in CCTV, the invasion of privacy and "big brother listening" syndrone are both potentially serious issues that may be raised by those individuals being monitored.

Microphone-Speaker - The microphone-speaker is perhaps the simplest system to design and install. The microphone is installed in the area to be monitored, and the speaker is mounted in the CAS or some other station where the listener, or witness, is assigned. A listener who monitors audio signals has problems with concentration or "numbness" similar to the observer of video signals. The confusion factor increases dramatically for the listener when he must listen to simultaneous sounds from different sources. The effect is similar to being in the middle of two conversations and comprehending neither. Enhancement techniques similar to those discussed under "CCTV" may be used to overcome both of the above problems. The listener then only hears the conversations in the area in which activity is taking place that may lead to duress.

Voice Stress Analysis - Voice stress analyzers are audio devices that are used to monitor a Subject's voice to detect voice changes caused by stress. Voice changes induced by stress are characterized by a decrease in frequency modulation and an increase in amplitude modulation of the 8 to 14-Hertz components of the Subject's voice. One currently available unit monitors in real time and can actuate an alarm when stress is apparent. Another supplier's unit requires processing a tape recording of the voice during which a digital read-out will indicate the presence of stress. Both manufacturers agree that their respective units are designed to be used while the Subject is being interrogated (albeit unobtrusively) by a trained interrogator. Some speech analyzers are approaching the stage of development that is necessary for use in real-time situations. When used as a duress alarm device, the only output needed from it is an alarm signal, thus reducing the invasion of privacy of the Subject. The speech analyzer does not become "numb" to the conversation.

Computerized Analysis - The natural progression of voice analyzers could lead to computerized systems. If individual speech analyzers can be made reliable, then computer analysis can also be reliable. The computer would be capable of scanning many microphone inputs simultaneously.

4.8 Watchman Checkpoint

Using a computerized system, guards on routine foot patrols may be monitored for reaching specific points along the routes within expected time periods. Use with vehicle patrols would be cumbersome unless additional automation were employed of the type discussed in Section 4.13. The main purpose of the checkpoints in traditional (nonnuclear) institutions is to ensure that the guards are making their proper rounds according to schedule. Only as a secondary purpose do they function as duress alarm devices. As a duress device, the primary concern is that the guard has not been neutralized by a Threat or by physical incapacitation.

Several basic methods may be used for the guard to report from a checkpoint. American District Telegraph Co. (ADT) uses special keys to "log in". A simple button key pad and secret codes could also be used to log in. Secret codes would be more difficult to steal from guards than the special keys, but codes introduce possible confusion. A nonautomated reporting method could use microphones or CCTV systems that are routed back to a monitoring station. Persons within the monitoring station would manually acknowledge each guard who reports in from a checkpoint.

Patrols may be on fixed routes or they may be on a type of pseudo-random route, automatically controlled. A fixed route is one in which the entire path to be taken is known before the start of the patrol. In a pseudo-random patrol, the guard only knows one segment of the patrol at a time. From the checkpoint at the end of each segment, the guard is told the route of the next segment. The automated system would predetermine the entire route but inform the guard at each checkpoint of the identity of only the next checkpoint from which he should report. The guard could also be told the path that should be taken. This path may take him past other checkpoints before reaching the checkpoint from which he is to report. To the outsider, the patrol would appear to be completely random.

When the checkpoints are automated, the guard has several options available for initiating duress alarms. An automated checkpoint system would expect to receive a report from a patroling guard within a given time frame. The system would also expect a special key, a special code word, or combination of the two to be entered at the checkpoint. Finally, the system would expect the report to be made from the proper checkpoint. Using the above expectations of automated checkpoints, a guard may initiate a duress alarm in any of the following ways:

1. Fail to report within allotted time. The guard may voluntarily or through incapacitation fail to report to any checkpoint within a specific time frame. The "time frame" is the time allowed for the guard to walk from one checkpoint to the next.

2. Report to the wrong checkpoint. The guard may choose to report from the incorrect checkpoint as a means of initiating an alarm. False alarms will be generated with this option, if the guard unintentionally reports from the wrong checkpoint.

3. Incorrect Reporting Procedure. A predetermined code may be used to log-in at the checkpoint and to initiate a duress alarm. The code is "incorrect" in that the code is not the one which would be used for reporting all is well.

To prevent the watchman checkpoints from being compromised or neutralized by an aggressor, some verification checks may be made. As mentioned previously, secret codes or special keys could be used; however, an aggressor may be able to exert enough force to get both. Automatic means of identification could include any of several methods of finger-print analysis. Automatic voice print identification is a new fie [illegible] may be applicable. A manual CCTV-type verification could also be used to match the facial view of the guard with a photograph on file.

4.9 Portal Cypher System

A system has been developed which is marketed by International Security Associates for use by portal guards who must leave fixed posts to inspect vehicles passing through the portal. When the guard goes outside the post, he presses a button to initialize the cypher system. After a preset time elapses, a duress alarm is automatically sent to the CAS. If no duress condition exists, the guard must return inside the post and clear the system before the preset time has elapsed. The cypher system is cleared by depressing a unique pattern of buttons on a keypad. This system is designed for use at portals at remote locations. Variations of this system could be used to monitor guards who must temporarily leave their vehicles.

4.10 Weight Monitor

A duress alarm system can be designed for guard stations which have controlled entrances by monitoring the weight within the room. The entire guard station or CAS would be integrated into a high-capacity, weight-monitoring system. The principle of the system would be similar to the industrial or agricultual use which tells whether a storage bin has been filled, overfilled, or underfilled. Personnel movement within the guard station is essentially unrestricted.

This concept for an alarm device assumes that traffic in and out of the station is controlled so that the total weight of the station is stable about some nominal level. If an appreciable change of weight occurs from the current nominal, the system would assume that unauthorized passage has occurred and automatically initiate a duress alarm signal. During authorized entry or exit, the alarm would be disabled, reset to a new nominal weight, and enabled again.

Major manufacturers of weight scales have engineering staffs that can assist in designing systems to meet specific needs. No such system is known to be in use; however, the same concepts are used to monitor the storage of confiscated drugs for drug control agencies. A major disadvantage would be the typical cost, \$20,000 to \$40,000, of purchasing and installing the system.

4.11 Biophysiological Monitor

An area that is slowly getting more attention for use in duress alarm systems is the area of biophysiological responses to stress. Systems are now available that monitor critical hospital patients, that remotely monitor patients at home by telephone, or that remotely monitor emergency patients via paramedical equipment. The one major disadvantage common to all these systems is that none contains monitors and a transmitter in a single, lightweight package. Unless a system is capable of transmitting all needed data from the Subject by radio, the system's acceptance in security is highly doubtful.

An effective duress device must not only sense changes in human biological parameters, but the device must also be able to process the information immediately and transmit an alarm signal when a duress condition exists. NARCO Bio-Systems has a telemetry system that is designed to permit remote monitoring of physiological data from unrestrained subjects or from subjects in relatively inaccessible or hazardous locations. Research is being done at numerous institutions to determine the various effects of stress on the human body. The Lovelace Foundation for Medical Education and Research under contract to Sandia Laboratories has published several reports on development of biophysiological duress alarm devices (1-2).. Their conclusion is that a combination of heart rate and skin conductance can be used to detect abnormally high stress levels. Using these parameters, a reliable "dead-man" alarm is feasible, but more studies are necessary to determine if a reliable duress alarm is feasible

A biophysiological duress system has the advantage of being an active involuntary type of system. Through proper signal processing, false alarms are expected to be minimized from natural causes such as physical exertion, emotional problems, and sexual stimulations.

4.12 Cargo Monitor

Texas Instruments and Hoffman Information Identification have cargo protection systems which monitor drivers, cargos, and carrier trucks. The monitors include seat sensors, engine sensors, tire sensors, cargo door sensors, cargo sensors, panic buttons, and many more. Actuation of any one of the sensors will activate a homing signal from one or more radio transponders. A unique ID code is transmitted by the transponder for identifying the vehicle in trouble. Monitoring receivers pick up the emergency signals and annunciate the alarm. The transponder signal is also used as a homing signal to locate the truck and cargo. Hoffman also has a tracking system which may use both sign post and trilateration methods for automatic vehicle tracking. Vehicle tracking is discussed in Section 4.13. The tracking system gives periodic status reports and reports vehicle location even though no alarm has been actuated.

4.13 Automatic Vehicle Location (AVL)

Numerous companies have developed AVL systems with communications tecnniques that are accurate within a couple of hundred feet in large cities. The error can be decreased considerably when the area of interest is reduced to thr size of a typical nuclear facility.

The greatest advantage of AVL comes from integrating duress alarm devices into the system. Both Hazeltine Corp. and Boeing Company have designs with panic buttons mounted in the vehicle and an additional portable RF panic button for use when the officer must step outside the patrol car. Both types of panic buttons use the AVL system to relay the duress alarm signals. The dispatcher is capable of knowing who is in trouble (through use of a unique ID code) and at what location. The types of AVL systems can be generally grouped into one of three main categories.(3)

Dead Reckoning - The vehicle carries instruments to measure direction and distance of travel. Data is fed by radio to a central computer which determines the estimated vehicle position. Data may be compared with a computerized map to increase the accuracy.

Signposts (Proximity) - The system identifies a vehicle when it passes near a signpost. The signpost locations may be equipped with either sensors or emitters for one-way radio signaling between signpost and vehicle.

Radio Location - These systems use the unique characteristics of the radio transmission fields themselves to establish vehicle locations. This method is contrasted to the two other methods which use the radios only to report the vehicle locations. Radio location systems usually employ two or more fixed transmitters or receivers. Mathematical algorithms solved by computers use the signal variations that occur during transmission to estimate the vehicle location. (Signposts and dead reckoning use the actual transmitted messages to estimate location.) Trilateration, triangulation, and navigation systems are included in this category.

For typical size nuclear facilities, signpost and radio location would probably be the easiest to install. All systems depend on high-speed data transmissions for real-time updating of a fleet of patrol vehicles.

Although management may have other interests in AVL, the duress alarm interest is to know the location of the Subject when a duress alarm signal is activated. Therefore, a simplified version of AVL can be used, particularly with signposts or radio location. Using signposts, a vehicle would store data from the latest signpost passed for relaying with the duress alarm signal. Using radio location, two or more receivers may be used with triangulation to locate the source of a duress alarm signal. Triangulation requires that only ID/alarm-type radios be carried by guards and in vehicles with no other special equipment (for duress purposes only). Another simplified radio location method would require numerous receivers throughout the facility; the receiver which received the strongest signal is assumed to be closest to the Subject.

4.14 Nondevice Methods

Numerous methods may be used to initiate duress alarm signals, but all require human interpreters. The interpreter recognizes that a Subject has performed an act which has been prearranged to mean a covert call for help. The interpreter forwards the call for help to the CAS using any of the devices mentioned previously in this section. The prearranged act may be one of several possibilities.

Code Words - Code words or phrases are prearranged acts constructed to relay secret messages. The code words should be some combination of words that would not normally be used but yet sound natural to an aggressor.

Paperwork - Codes may be sent using routine paperwork. A specific location of paper clip, staple, rubber stamp or even type of rubber stamp may be used to indicate duress. If paperwork must be processed through a particular machine, a specific method of insertion may activate an alarm (the machine would actually be considered an alarm device).

Equipment Handling - A specific sequence of switch settings could be used to show duress. The handset of a telephone may be reversed in its cradle. (Transmitter is placed to the right side of the cradle instead of the more common left side of the cradle.) The telephone could even be modified with a switch to automatically detect the handset reversal.

Nondevice methods have a wide range of possible applications but they have several major disadvantages. An interpreter must be available to recognize within a reasonable time frame that a Subject has indicated duress. Assuming an interpreter is available, problems are still highly likely. A Subject who is under duress may not recall and use the proper code to signal duress. Regardless of how well one is acquainted with special codes, there is still a finite degree of human unpredictability when one is under stress. If the Subject manages to use the proper code, the interpreter may misinterpret the code or not even notice the code.

The codes should be changed periodically to prevent compromise. The codes should also be changed when knowledgeable personnel are removed from the rolls. Changing the codes to prevent compromise also introduces confusion to the Subject and interpreter as they attempt to stay current on the newest codes.

The Witness is another nondevice type of alarm source. A Witness is one who listens to an audio signal or watches a CCTV signal at another guard post or other sensitive station. A witness may be a security employee who becomes aware of abnormalities of a fellow security employee. A witness may be just any person that happens to be at the right place at the right time to observe a Threat being placed upon a Subject.

5. DURESS ALARM SIGNALS

The Detection function of a duress alarm system has been completed when transmission of an alarm signal is initiated. Alarm signals may assume one of several forms. Electronically, an alarm signal on a single path may assume various forms along that path. Annunciation is another form of signal transmission with a unique purpose. While the single purpose of all transmitted signals is to pass along information, annunciated signals must be able to convey information quickly, clearly, and dramatically to humans. To simplify the discussion within this section, annunciation will be treated separately from the other transmission media for alarm signals.

5.1 Transmission

To make a valid judgment on the type(s) of transmission media to be used, one must look at the entire path for each signal from origination to termination. Most likely, several types of transmission media will be required. To decrease the probability of neutralizing the duress alarm system, the alarm signal should be sent to the CAS and SAS along independent paths. Each type of transmission medium has its advantages and disadvantages.

<u>Radio Transmission</u> - Radio transmission systems are relatively simple to install. The transmitting pattern is determined by the type of antenna. Antennae are designed to receive and transmit in all directions or in restricted directions. Radios are essential when alarm signals must be sent through nonsecure or noncontrolled areas; however, radios can be monitored by anyone with the appropriate equipment and are susceptible to jamming. Jamming is the intentional transmission of radio signals designed to make the reception of intelligible signals impossible on a given frequency channel or group of channels. To be jammed is an indication to a nuclear facility that some aggressive action may be imminent.

Several modulation methods are available to the designer. Frequency modulation (FM) is normally used because of its immunity to atmospheric noises. Pulse code modulation (PCM) is becoming more popular because of its capability for sending a high volume of data in a short time period. PCM converts both data and voice information to digital form before the final conversion to FM for transmission.

A major disadvantage of RF communication is the channel congestion of the frequency spectrum. Various multiplexing schemes are available to allow many alarm signals to be placed on one RF signal. Time division multiplexing (TDM) and frequency division multiplexing (FDM) are both methods used to put more information on a single carrier frequency. Poling may be used at the CAS to allow each remote transmitter to send during a specific narrow time slot only. Multiplexing all or many alarms together allows the alarms to be remoted as a group to different locations such as the CAS, SAS, and local law enforcement headquarters, etc.

FM reception exhibits a major attribute that should not be overlooked by the system designer. When two or more FM signals are beamed at one receiver, the receiver must decide which signal it will accept. The receiver will exhibit the "capture effect" by locking onto the stronger signal. If the signals are equal in strength, the receiver may alternate between the two, receiving first one and then the other. Capture effect is an advantage when noise from more distant nonfacility transmitters is received. The designer should be aware that the capture effect can cause an emergency signal to be ignored by a receiver.

For more detailed radio system design information, refer to NRC's forthcoming report, <u>Security Communication Systems for Nuclear Fixed Site Facilities</u>.

Electrical Conductors - Virtually every transmission path will include electrical conductors or hardwire. The total length of hardwire within a single path may range from only a few feet to several miles. Hardwire has the advantage of privacy; no one can monitor the messages without having physical access to the wires. A major disadvantage is the total disruption of transmissions along that path if the wires are cut or broken. Cables may be placed in concrete to prevent tampering or damage. In many cases, twisted pair wires are adequate to carry the data transmissions. If modulation and multiplexing schemes are used, as described in Section 5.1, Radio Transmission, or if high-speed data are transmitted, coaxial cables will generally have to be used. Coaxial cables are considerably more expensive than twisted pair wires.

Fiber Optics Communications - A new transmission medium which is coming into greater use is fiber optics. Fiber optics are used as waveguides for modulated light signals. The major advantage is in high security. Stray signals radiated outside the fiber waveguides are essentially immeasurable as compared to electrical conductors. Waveguides may be placed in concrete encasements to prevent tampering and minimize damage. A fiber optic type of communication is ideal for high-density data transmissions, using various modulating and multiplexing schemes.

5.2 Annunciation

Annunciation is the final step of a duress alarm system. The purpose of annunciation is to alert human operators that an emergency exists and to convey as much information about the emergency as possible. General annunciations involving such tactics as the generation of loud sounds or the use of brilliant spot or flood lights to frighten or disorient aggressors are considered to be Response techniques rather than functions of a duress alarm system. Remote annunciation is inherent in all duress alarm systems, whereas local annunciation may not be desirable for any duress alarm system.

Local Annunciation - When considering the use of local annunciators, the designer should consider the effect the annunciation would have on the threatening party. Situations involving duress should not be treated the same as the general type of aggressor or intrusion action.

The following discussion describes a nonduress type of intrusion. The intruder is not warned that he has been detected when a silent alarm signal has been activated; therefore, the intruder is able to work at accomplishing his goals without any additional pressures which may have increased his chances of making critical errors. A publicized alarm signal tells the intruder that he has been detected. Having been warned that he was detected, the intruder is aware that additional constraints, including time, have been placed upon him. The additional constraints may cause frustration and increase the vulnerability to neutralization. If detection is anticipated, the intruder will have been warned by local annunciation to go to some alternate plan.

When a hostage is introduced into the scenario, the effects of local annunciation can be entirely different. The hostage is the Subject who has been placed in duress because of direct contact with the intruders, the Source of Threat. A publicized alarm signal jeopardizes the safety of the Subject, particularly if the Subject has initiated the alarm after being warned not to do so. It is doubtful that a serious aggressor would be dissuaded from his goals or be made more vulnerable to neutralization through the use of local annunciation.

Based on the above discussion, local annunciation is not recommended for duress alarm systems. Local annunciation not only includes an alarm bell or siren, but also includes the small indicator lights available with some alarm receiver units. Automatically switching on area lights after the receipt of an alarm is also a form of annunciation.

Remote Annunciation - Remote annunciation includes annunciation at the CAS, SAS, local law enforcement headquarters, and any other desirable location that is not in the immediate area of the Threat. In the CAS, the existing audio and visual annunciators may be used to attract attention to the alarm. A unique type of audible or visual alarm for duress alarms would alert the operators that a special priority alarm signal has been received.

5.3 Information Transfer and Display

Providing information helpful to Assessment and Response was earlier described as a secondary purpose of duress alarm systems. The transmission and annunciation portions of the system must be capable of transferring the information to the CAS and displaying the information in a form that is immediately understood by the operators. If codes are transmitted, the codes should be automatically interpreted before they are displayed for the operators.

A display board is a good method of showing the location of an emergency. The display could be a map of an area with specific guard stations designated by lamps. The appropriate lamp is switched on to indicate the location from which the emergency signal was received. When a device such as a panic button is activated, it could enable the transmission of a code to the display board. The display board decodes the signal to determine which lamp to light.

An alternative to the display board would be a slide viewer. Instead of decoding a signal to light a lamp, the signal is decoded to call up the appropriate slide for viewing. The slide may be only a map portion to designate the area of emergency. The slide may also contain much detailed information, such as possible methods of access into the area, strong points of the area, etc. If the Subject is able to transmit a code which describes the type of threat, an appropriate slide can be displayed. The slide would contain the interpretation of the code and the type of response required.

Information that can be displayed as alphanumeric characters could also be printed out on a computer type of line printer or video monitor. The line printer has the advantage of creating a permanent record.

There are two main methods of providing automatic information about the location for fixed stations. The first method would be to have a separate signal path between each alarm device and each alarm reporting station. The other alternative is to incorporate into each alarm device a unique identification code to designate its location. The code generator need not actually be in the device but should be inserted at some point prior to the signal path being joined by signals from other alarm devices.

6. DURESS ALARM SYSTEM DESIGN

The basic functions of a duress alarm system have been established. The primary function is to detect the condition of duress and bring the knowledge of detection to the attention of persons responsible for Assessment and Response. The secondary basic function is to transmit the maximum feasible amount of information that will assist Assessment and Response. Individual requirements will now be discussed to see how they may affect duress alarm systems.

6.1 Factors that Directly Affect the System

There are numerous factors which affect the way the system can be designed.

Actions by the Subject to Signal Duress - The type of device or code used to voluntarily activate a duress alarm sequence should be kept simple. Human behavior is unpredictable. The ability of a Subject to perform complex manual tasks is affected by stress. The actuation method must be kept reasonably simple, free from confusion, and free from false alarms. This is just as important for pushing buttons as for speaking a key phrase which translates into a call for help. The following is a guide for selecting reasonable methods for actuating duress alarm sequences. The guide is applicable regardless of whether the designer is selecting code words, alarm devices, or so forth.

1. The precoded action, to initiate an alarm, should be easily distinguished by the Witness or device and yet appear normal to the threatening person.

2. The precoded action should not be easily done by accident.

3. The action should be simple to perform and require no unusual skills.

4. The Subject should be able to quickly perform the precoded action.

Concealment of Alarm Device - Concealment of the devices and concealment of a Subject's attempts to use the devices are primary concerns of the alarm system. The danger to which a Subject is exposed by the Threat may be increased significantly if the threatening person becomes aware of any counteraction by the Subject. Concealment of the actuating device from the Threat may conceal the device from the Subject as well. The device should be installed so that it may be found and actuated by a nondiscernible act without being prone to accidental actuation. The subject should have ready access to the device. Where the Subject's routine activities require moving about a fixed duty station, several concealed devices may be needed to give accessibility.

Potential Targets for Duress - One of the first concerns for developing a system is to determine who should be protected with duress alarm devices. Guards would normally be protected. Receptionists or any other employees who have contact with nonfacility persons should be considered for inclusion in the duress alarm system. Key facility personnel such as top management may also be prime candidates for duress because of special privileges often given to them. Select individuals, such as planning engineers and maintenance personnel, who have access to critical SNM or Safeguard information may also be more vulnerable to threats.

Potential Methods of Exerting Threats - Once the decision has been made about who is to be protected, the next area to be considered is how the threats may be exerted against these individuals. Personnel such as guards and receptionists would normally be vulnerable only while on duty. Threats exerted on these people are more likely to be through direct contact from local sources, although some duties may require guards to go offsite. Key personnel such as top management may also be vulnerable when away from the facility. They are also more likely to receive threats from remote sources, which may include taking hostages, etc.

The designer should determine the periods of time during which threats should be detected, the activities the Subjects may be engaged in during these periods, and the locations that may be encompassed by these activities.

Level of Threat - An important consideration for any system is the level of Threat for which the system will give protection. The Source of Threat may be an outsider who is totally unaware that the facility uses duress alarms. On the other extreme, the Source of Threat may include an insider who has complete knowledge of the duress alarms. Ideally, the system should be configured so that knowledge of the system cannot compromise the system. Management decisions are needed to restrict information on the system to only those with a need to know.

Regulations to be Met - Applicable rules and regulations from various agencies need to be investigated to ensure system conformance with them. Two important sources of regulations are the NRC and FCC. Specific facilities may also need to investigate rules and regulations from state or local government agencies. Most facilities will have standard operating procedures of their own that the system must meet.

Line Supervision - An important consideration for any alarm circuit is line supervision which detects and annunciates tampering on the circuit. Line supervision will also detect that a line has been unintentionally broken. Supervisory circuits on land lines are more difficult to defeat than those on radio links because the aggressor must first have physical access to the correct cables. A broad range of supervisory systems is commercially available which range from simple and low cost to very complex and expensive. The following is a list of the types available in the order of decreased susceptibility to compromise.

1. DC Supervision - The simplest and least expensive supervisory method but relatively easy to defeat.

2. AC Supervision - More complex, more expensive, and only slightly more difficult to defeat than DC systems.

3. Multiplexed DC or AC - Combining several DC or AC loops together makes a system more difficult to defeat. It is more difficult to determine the condition of a given sensor and substitute a false signal.

4. Digital Supervision - The effort required to defeat this system is increased considerably over the other methods. Coding and modulation of alarm information is used. More expensive than previous systems.

5. Pseudo-Random Encoding - The signal is continuously changing according to a predetermined pattern. An encryption code is generated to continuously encode the incoming raw data. Pseudo-random codes are repetitive if allowed to run the full cycle.

6. Random Encoding - This method is the best defense against defeat because each random bit is unique. The major problem of this scheme is the generation and storage of the large quantity of random keys which would be required to encode the raw data.

7. Multiplexing Encoded Signals - As with DC and AC, multiplexing of several encoded signals appreciably decreases the vulnerability to defeat.

Once access to the signal lines has been gained, defeat times range from a few seconds for DC supervision to months or years for multiplexing encoded signals. Commercial supervisory systems are available. Wells Fargo offers point-to-point pseudo-random encoding systems. Many of even the most sophisticated systems still rely on the simple DC or AC supervision to monitor the actual alarm devices. Vikonics is one vendor that claims to have overcome this shortcoming by using a nonlinear feedback system in its local loops.

Environmental Factors - Environmental factors include a broad range of considerations. The size and type of terrain are critical to radio transmission and cable installation mountains and buildings limit radio reception from the commonly used low power, line of sight radios. Building materials will attenuate radio signals (especially from portable radios) being received or transmitted inside the building. The climate and terrain can dictate the methods and expenses of cable installation.

Body-worn devices have an additional set of environmental factors to contend with. Is the device susceptible to perspiration? Will the device corrode or become dislodged? Will the device withstand impacts due to handling, bumping and dropping? Is the device light weight, easy to wear, and nonobstrusive to appearance?

System Reliability - System reliability is concerned with a number of items, including each of the topics previously discussed in this section. Emergency backup power is also part of reliability. Does the duress alarm system remain operational if central power is lost? Preferably, each device should have its own emergency power supply. Multiple transmission paths for the alarm signals increase the reliability. If portions of the system go down, the speed at which they can be brought back up and the speed at which alternatives can be implemented affect reliability.

6.2 Factors that Indirectly Affect the System

There are some factors or problem areas that do not determine whether a particular device or system can work at a facility. They do determine, however, whether or not a system will be allowed to work at a facility.

Special Privileges of Management - The designer will need to determine possible weak spots in the proposed system that would result from the special privileges that may be accorded to the top levels of management. The more privileges taken by top management, the more likely they are to become the target of threats and the more vulnerable the duress alarm system is to compromise.

System Tests - An important consideration to the designer is how the system will be tested to ensure that no damage or tampering has occurred within the system. In some cases, automatic self-test can be built into the devices of the system. A simple method which would test each path in its entirety would be to individually actuate each device on a periodic schedule.

Stations Chosen to Terminate Duress Alarm Signals - The CAS and SAS are obvious locations to which duress alarm signals should be routed within the nuclear fixed site. These alarm stations are manned around the clock and are equipped to immediately initiate the Assessment and Response phases. It may be desirable to route the duress alarm signals to other points as well. Such points may include the office of the security head, the medical emergency office, etc.

Notification of Duress Emergencies - Determine the persons that must be immediately notified in the event of a duress incident and the locations where they may be notified. Typical points to be notified may include certain law enforcement agencies. Communications paths for alarm signals would normally go directly to the CAS and SAS. From either or both the CAS and SAS, the alarms may be automatically routed or be relayed by alarm station personnel to city, county, and/or state law enforcement agencies. Other concerned agencies may also be included for notification.

Personnel Acceptance of Equipment - Determine the difficulties that may be encountered in getting personnel acceptance of the chosen duress alarm devices. Acceptance should not only be established for the devices themselves (e.g., body-attached sensors), but also for the concepts encompassing the entire duress alarm monitoring system. If the "big brother watching" syndrome is not anticipated and alleviated, much difficulty may be experienced in operating the system.

Radio Frequency Allocation - A very real problem that every facility faces is the crowded bands within the mobile radio frequency spectrum. There are many more ways of using radio communications than there are available transmitting frequencies. In most areas of the country, the lower bands are virtually filled to capacity, necessitating many new FCC frequency allocations to be made in the much higher frequency bands. Problems of operating on any one frequency is an entire report within itself and will not be discussed in this report. The designer must be aware that these problems can limit the effectiveness of radio-dependent duress alarm systems.

Growth Requirements - The system design and implementation should contain provisions to expand the system to keep pace with expansions that may occur in the facility which the system serves.

Support Requirements - A comprehensive system will contain provisions to ensure that the system can be maintained in a reasonable manner and without disabling a major portion of the system. An orderly resupply of expendable materials is necessary. Provisions should be made for any necessary training of appropriate personnel.

Administrative Approval - The design of a system may be the best in the world; but if it does not get administrative approval, the system is not likely to be used. A pragmatic approach must be taken to match a reliable system design with the monetary funds available and with the opinions and values of administrative personnel.

6.5 Assessment and Response

The success of any duress alarm system is dependent on the actions taken during Assessment and Response. Assessment personnel must not call up a Subject to ask if the received duress alarm signal is valid or false; to do so not only neutralizes the alarm system, but may also result in physical harm to the Subject during a valid emergency. Communications necessary to perform Assessment and Response should be through means that will not arouse the aggressor(s). Point-to-point intercoms rather than a radio net would be an example. A sudden reduction in the normal radio traffic may also be a tipoff that an alarm has been triggered.

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8. ACKNOWLEDGMENTS

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APPENDICES

A. Terms and Definitions for Duress Alarm Systems

B. Equipment List

C. Manufacturer's Literature

D. Bibliography

APPENDIX A

TERMS AND DEFINITIONS FOR DURESS ALARM SYSTEMS

APPENDIX A

TERMS AND DEFINITIONS FOR DURESS ALARM SYSTEMS

The following terms and definitions are in part based on "Terms and Definitions for Intrusion Alarm Systems," LESP-RPT-0305.00, October 1974, prepared by the Law Enforcement Standards Laboratory of the National Bureau of Standards. The definitions are also in part based on the "Proposed American National Standard: Standard Definition of Terms Associated with the Physical Protection of Nuclear Material and Facilities," October, 1978.

ACTIVE DETECTOR - See DETECTOR, ACTIVE.

ACTIVE DEVICE - See DETECTOR, ACTIVE

ACTUATING DEVICE - See ACTUATOR

ACTUATOR - A manual or automatic switch or sensor such as HOLDUP BUTTON, which causes a system to transmit an ALARM SIGNAL when it is manually activated or when it automatically senses an intruder or other unwanted condition.

ALARM - (1) As used in the block diagrams, see DURESS ALARM SIGNAL
(2) An ALARM SIGNAL
(3) An ALARM DEVICE

ALARM CONDITION - A threatening condition, such as an intrusion, fire, or holdup, sensed by a DETECTOR. As applied to Safeguards, this condition is called a Safeguards threat.

ALARM DEVICE - A device which initiates an ALARM SIGNAL in response to the DETECTION of an ALARM CONDITION.

ALARM, DURESS - A signaling device that can be operated manually or automatically by an individual who is in a threatening, coercive, or disabling situation.

ALARM, FALSE - An alarm signal generated by an unidentified input to a DETECTOR during the absence of an ALARM CONDITION. False alarm is sometimes used to include NUISANCE ALARMS also.

ALARM, NUISANCE - An alarm signal generated by an identified input to a DETECTOR during th absence of an ALARM CONDITION. Also see ALARMS, FALSE.

ALARM SIGNAL - A signal produced by a CONTROL UNIT indicating the existence of an ALARM CONDITION. Also see DURESS ALARM SIGNAL.

ALARM SYSTEM - An assembly of equipment and devices designed and arranged to signal the presence of an ALARM CONDITION, requiring urgent attention such as unauthorized entry, fire, temperature rise, etc. Also see DURESS ALARM SYSTEM.

ANNUNCIATOR - An electronically controlled monitoring device that emits visible and/or audible signals to indicate the current status of CONTROL UNITS within an ALARM SYSTEM.

ASSESSMENT - (1) As used in the block diagrams: like RESPONSE is incidental to a DURESS ALARM SYSTEM. Having received the information that a DURESS condition exists, assessment is done to determine what minimum level of response is needed.
(2) The investigation of an alarm signal to determine the characteristics of the event that caused it.

AUDIO MONITOR - see MONITOR, AUDIO

AWARENESS OF THREAT - Belief of an individual that he/she is being threatened.

CAS - See CENTRAL ALARM STATION.

CENTRAL ALARM STATION (CAS) - A control center to which alarm systems are connected, where circuits are supervised, and where personnel are maintained continuously to record and investigate alarm or trouble signals. Facilities are provided for the reporting of alarms to police departments and other outside agencies. A CAS is usually backed up by one or more SECONDARY ALARM STATIONS.

CODED ALARM SYSTEM - An alarm system in which the source of each signal is identifiable. This is usually accomplished by means of a series of current pulses which operate ANNUNCIATORS to yield a recognizable signal. This is usually used to allow the transmission of multiple signals on a common circuit.

CODED TRANSMITTER - A device for transmitting a coded signal when manually or automatically operated by an ACTUATOR. The actuator may be housed with the transmitter or a number of remote actuators may operate a common transmitter.

CONTACT DEVICE - A device which when actuated opens or closes a set of electrical contacts: a switch or relay.

CONTROL UNIT - A device, usually electronic, which provides the interface between the alarm system and the human operator and produces an ALARM SIGNAL when its programmed response indicates an ALARM CONDITION. Some or all of the following may be provided for: power for sensors, sensitivity adjustments, means to select and indicate access mode or secure mode, timing circuits, transmission of ALARM SIGNALS, etc.

COVERT - Hidden and protected.

DEFEAT - The frustration, counteraction, or thwarting of an ALARM DEVICE so that it fails to signal an alarm when a protected area is entered.

DETECTION - As used in the block diagrams, the sensing and processing by DURESS ALARM DEVICES to determine that a duress ALARM CONDITION exists, whereupon a DURESS ALARM SIGNAL is initiated.

DETECTOR - A unit designed to sense and signal a change in the environment in which it operates or it produces. Used to detect intrusion, equipment malfunction, etc.

DETECTOR, ACTIVE - (1) A detector that senses and signals changes in a self-produced environment. (2) A device which continually tests its environment for conditions which are indicative of DURESS. When DURESS conditions are sensed, an ALARM SIGNAL is automatically initiated. Also see DETECTOR, PASSIVE.

DETECTOR, PASSIVE - (1) A detector that senses and signals changes in the environment in which it is placed. (2) A device, such as a PANIC BUTTON, which cannot initiate a DURESS ALARM SIGNAL until the device is manually actuated by a SUBJECT under DURESS. See also DETECTOR, ACTIVE.

DIALER - See TELEPHONE DIALER, AUTOMATIC.

DIGITAL TELEPHONE DIALER - See TELEPHONE DIALER, DIGITAL.

DURESS - (1) An individual's involuntary biophysiological response to stress caused by the perception of his environment whether real or imagined; a) perceives one's self in danger or b) another to be in danger. (2) Involuntary responses of a SUBJECT when a threatening party attempts to compel the SUBJECT to conform to the will of the threatening party.

DURESS ALARM - See ALARM, DURESS.

DURESS ALARM DEVICE - A device which is activated in the event of a DURESS CONDITION, providing an electronic signal which annunciates at a CENTRAL ALARM STATION or other continuously manned security location. See ALARM DEVICE.

DURESS ALARM SIGNAL - Relayed information that indicates the presence or absence of a DURESS CONDITION. The signals may be voltages or radio frequencies (RF) as in transmission signals, or they may be visual or audio as in annunciation.

DURESS ALARM SYSTEM - An alarm system which uses DURESS ALARM DEVICES. System includes both DETECTION and ALARM.

FACILITY - (1) Plant personnel and equipment that routinely interact with the SUBJECT. (2) A fixed site where nuclear materials are located.

FALSE ALARM - See ALARM, FALSE.

FAIL SAFE - A feature of a system or device which initiates a trouble signal when the system or device either malfunctions or loses power.

FOOT RAIL - A HOLDUP ALARM DEVICE, often used at cashiers' windows, in which a foot, placed under rail, is lifted to initiate an ALARM SIGNAL.

FREQUENCY DIVISION MULTIPLEXING - See MULTIPLEXING, FREQUENCY DIVISION.

GUARD POST - A location where nuclear security personnel are either continuously or periodically stationed for purposes of surveillance or access control.

HOLDUP ALARM DEVICE - A device used to signal a holdup. It may be manually or automatically actuated, fixed or portable. See DURESS ALARM DEVICE.

HOLDUP BUTTON - See DURESS ALARM DEVICE.

INSIDER - A person with authorized access to some part or all of the site or facility; for example, employee, contractor, or maintenance person.

INTRUSION - Unauthorized entry into the property of another.

LINE SUPERVISION - The concept of electronically transmitting to ANNUNCIATORS, during alarm and nonalarm conditions, the status of DETECTORS, CONTROL UNITS, ALARM SIGNAL paths, etc. The purpose of line supervision is to determine if tampering occurs

LOCAL ANNUNCIATION - An alarm signal which is annunciated in the vicinity of the ALARM CONDITION.

LOOP - An electric circuit consisting of several elements, usually switches, connected in series.

MAT SWITCH - See SWITCH, MAT.

MECHANICAL SWITCH - See SWITCH, MECHANICAL.

MERCURY SWITCH - See SWITCH, MERCURY.

MOBILE - Associated with a vehicle as a mobile patrol that is performed from a vehicle. Mobile equipment is that equipment which is designed for mounting in vehicles. Mobile contrasts with PORTABLE.

MONITOR, AUDIO - An arrangement of amplifiers and speakers designed to monitor the sounds transmitted by microphones located in the PROTECTED AREA. Similar to an ANNUNCIATOR, except that supervisory personnel can monitor the protected area to interpret the sounds.

MONITOR, VIDEO - Similar to MONITOR, AUDIO, except that cameras and television screens are used in the place of microphones and speakers, respectively.

MONITORING STATION - See CENTRAL ALARM STATION and SECONDARY ALARM STATION.

MULTIPLEXING, FREQUENCY DIVISION (FDM) - The multiplexing technique which assigns to each signal a specific set of frequencies (called a channel) within the larger block of frequencies available on the main transmission path in much the same way that many radio stations broadcast at the same time but can be separately received.

MULTIPLEXING, TIME DIVISION (TDM) - The multiplexing technique which provides for the independent transmission of several pieces of information on a time-sharing basis by sampling, at frequent intervals, the data to be transmitted.

NORMALLY CLOSED SWITCH - See SWITCH, NORMALLY CLOSED.

NORMALLY OPENED SWITCH - See SWITCH, NORMALLY OPENED.

NUISANCE, ALARM - See ALARM, NUISANCE.

PANIC ALARM - See DURESS ALARM DEVICE.

PANIC BUTTON - See DURESS ALARM DEVICE.

PASSIVE DETECTOR - See DETECTOR, PASSIVE.

PASSIVE DEVICE - See DETECTOR, PASSIVE.

PATROL - A person or persons who traverse a route at irregular intervals to inspect the integrity of barriers, seals, or other security features.

PATROL, RANDOM - A patrol conducted in a manner such that the patrol's route at any specific time cannot be predicted.

PORTABLE - Equipment or activities that are associated with walking. Portable equipment is either carried on one's body or capable of being easily moved by a person on foot. Portable contrasts with MOBILE.

PORTABLE DURESS SENSOR - A device carried on a person which may be activated in an emergency to send an ALARM SIGNAL to the CAS and SAS.

PORTAL - An opening in a physical security barrier which has access controls applied to allow only authorized entrance and exit.

PORTAL CONTROL ROOM - The room or area which is manned by security personnel, who authorize and deny passage through the PORTAL.

PORTAL, HARDENED - A PORTAL which is constructed to withstand (and repel) a limited strength attack by aggressors while physically protecting personnel within the PORTAL CONTROL ROOM. Access to the portal control room is usually restricted.

PROCESSOR - The electronic circuitry which analyzes data collected by the ALARM DEVICE from its environment to determine the existence of ALARM CONDITIONS.

PROTECTED AREA - An area monitored by an alarm system or guards, or enclosed by a suitable barrier.

RANDOM PATROL - See PATROL, RANDOM.

REMOTE ALARM - An ALARM SIGNAL which is transmitted to a remote MONITORING STATION. See also LOCAL ANNUNCIATION.

RESET - To restore a device to its original (normal) condition after an alarm or trouble signal.

RESPONSE - As used in the block diagrams, it is incidental to the DURESS ALARM SYSTEM. Response is the action being taken, based on ASSESSMENT, to neutralize the threat which caused the DURESS condition.

SAS - See SECONDARY ALARM STATION.

SCC - Security control center; see CENTRAL ALARM STATION AND SECONDARY ALARM STATION.

SECONDARY ALARM STATION (SAS) - Alarm stations at a FACILITY that provide redundancy for essential duties performed at the CENTRAL ALARM STATION. The secondary alarm station acts as a central alarm station in event the actual central alarm station has been disabled.

SENSOR - See DETECTOR.

SILENT ALARM - A REMOTE ALARM without an obvious local indication that an alarm has been transmitted.

SUBJECT - Guard or any other person who may be the recipient of a DURESS threat.

SUPERVISED LINE - See LINE SUPERVISION.

SURVEILLANCE - Control of premises for security purposes through alarm systems, closed-circuit television (CCTV), or other monitoring methods.

SWITCH, MAT - A flat area switch used on open floors or under carpeting. It may be sensitive over an area of a few square feet or several square yards.

SWITCH, MECHANICAL - A switch in which the CONTACTS are opened and closed by means of a depressible plunger or button.

SWITCH, MERCURY - A switch operated by tilting or vibrating which causes an enclosed pool of mercury to move, making or breaking physical and electrical contact with conductors. These are used on tilting doors and windows, and on fences.

SWITCH, NORMALLY CLOSED - A switch in which the CONTACTS are closed when no external forces act upon the switch.

SWITCH, NORMALLY OPENED - A switch in which the CONTACTS are open (separated) when no external forces act upon the switch.

TAMPERING - The act of interfering with or compromising the validity of data and/or integrity of equipment such that the Safeguards system can no longer perform its intended function.

TELEPHONE DIALER, AUTOMATIC - A device which, when activated, automatically dials one or more preprogrammed telephone numbers (e.g., police, fire department) and relays a recorded voice or coded message giving the location and nature of the alarm.

TELEPHONE DIALER, DIGITAL - An automatic telephone dialer which sends its message as a digital code.

TIME DIVISION MULTIPLEXING - See MULTIPLEXING, TIME DIVISION.

ULTRASONIC - Pertaining to sound waves having frequencies above the audible range for most people. Ultrasonic sounds are used in ultrasonic detection systems.

ULTRASONIC FREQUENCY - Sound frequencies which are above the range of human hearing, approximately 20,000 Hz and higher.

VIDEO MONITOR - See MONITOR, VIDEO.

WATCHMAN REPORTING SYSTEM - A monitoring system designed for the transmission of a patrolling watchman's regularly recurrent reports from stations along his patrol route to a central supervisory agency.

WITNESS - An individual who perceives a SUBJECT to be the recipient of a threat which will cause DURESS. The perception may or may not cause the witness to be under duress. The witness may not be part of the FACILITY.

APPENDIX B

EQUIPMENT LIST

APPENDIX B

EQUIPMENT LIST

This equipment list is not intended to be a complete list of all vendors that supply particular types of devices that can be used in duress alarm systems. (In some cases, the only known vendors have been listed.) However, this list is intended to include at least one source for most types of devices that have been discussed, if vendors are available. In some cases vendors were not listed because they failed to respond to inquiries on their line of equipment.

No attempt has been made to substantiate specific claims by manufacturers about the quality or reliability of their products. The report to which this is appended is only concerned with matching guard functions with various generalized duress alarm designs.

AUTOMATIC VEHICLE LOCATION (See Cargo Monitors)

Boeing Company
Wichita Division
Wichita, KS 67210

E-Systems, Inc.
Garland Division
Dallas, TX 75222

Hazeltine Corp.
Greenlawn, NY 11740

Hoffman Electronics Corp.
4323 Arden Drive
El Monte, CA 91734

BIO-PHYSIOLOGICAL DEVICES (See Speech Analyzers)

NARCO Bio-Systems, Inc.
7651 Airport Blvd.
Houston, TX 77017

Nicolet Instrument Corp.
Madison, WI

Time Computer, Inc.
Lancaster, PA 17604

CARGO MONITORS (See Automatic Vehicle Location)

Hoffman Information Identification, Inc.
2908 Collen St.
P. O. Box 9797
Ft. Worth, TX 76107

Texas Instruments, Inc.
Dallas, TX 75222

CCTV

RCA Closed-Circuit Video Equipment
New Holland Ave.
Lancaster, PA 17604

Security Resources
P. O. Box 331
Westport, CT 06880

LINE SUPERVISION

Vikonics, Inc.
23-25 East 26th Street
New York, NY 10010

Wells Fargo Alarm Services
Government Systems Group
1004 6th Street, NW
Washington, D.C. 20001

PORTAL CYPHER SYSTEM

International Security Associates
1341 E. Pomona
Santa Ana, CA 92705

RF SWITCHES (See Two-Way Radios)

AID-Audio Intelligence Devices
Technical Systems Division
1400 NW 62nd Street
Fort Lauderdale, FL 33309

Security Chief, Nevada Test Site
Nevada Operations Office
Department of Energy
Las Vegas, NV

SPEECH ANALYZERS

Communication Control Systems, Inc.
605 Third Avenue
New York, NY 10016

Dektor Counter Intelligence and Security, Inc.
5508 Port Royal Road
Springfield, Virginia

Hagoth Corporation
12350-206th Place, SE
Isaquah, WA 98027

SWITCHES

Tapeswitch Corporation of America
320 Broad Hollow Road
Farmingdale, NY 11735

TWO-WAY RADIOS (See RF Switches)

Aerotron, Inc.
P. O. Box 6527
Raleigh, NC 27628

AID-Audio Intelligence Devices
Technical Systems Division
1400 N. W. 62nd Street
Fort Lauderdale, FL 33309

Spedcall Corporation
Haywood, CA 94545

General Electric Co.
Mobile Radio Department
Lynchburg, VA 24502

Motorola Communications and Electronics, Inc.
Schaumburg, IL 60172

Page Alert Systems, Inc.
Downey, CA 90244

Reach Electronics, Inc.
Lexington, NB 68850

ULTRASONIC TRANSMITTERS

Sentry Products, Inc.
245 Stockton Avenue
San Jose, CA 95126

UNISEC, Inc.
San Leandro, CA 94577

WATCHMAN CHECK POINTS

ADT-American District Telegraph Co.
One World Trade Center, 92nd Floor
New York, NY 10048

WEIGHT MONITOR

Toledo Scales
350 W. Wilson Bridge Road
Worthington, OH 43085

APPENDIX C

MANUFACTURER'S LITERATURE

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MANUFACTURER'S LITERATURE

The following is a list of manufacturers where information can be obtained on duress alarm systems.

Ademco
165 Eileen Way
Syosset, NY 11791

ADT
One World Trade Center
Suite 9200
New York, NY 10048
Ph. 212/558-1100

Advisor Security
Division of Aerospace Research, Inc.
130 Lincoln Street
Boston, MA 02135
Ph. 617/254-7200

AID Technical Systems Division
P. O. Box 23130
Fort Lauderdale, FL 33307
Ph. 305/776-5000

Alarm Device Mfg. Co.
Division Pittway Corporation
165-T Eileen Way
Syosset, NY 11791
Ph. 516/921-6700

Alarm Supply Company, Inc.
12551-T Globe Road
Livonia, MI 48150
Ph. 313/425-2500

Alarm Systems
2930 College Avenue
Costa Mesa, CA 92626

Alpha Electronics Mfg., Ltd
527 East Liberty Street
Ann Arbor, MI 48605

American Security
247 Walnut Street
Elmhurst, IL 60126

Anderson Research and
Design Corp.
1900 Hennepin Av. South
Minneapolis, MN 55403

Automatic Products Co.
1918 S. Michigan Avenue
Chicago, IL 60616
Ph. 312/842-1600

Belden Corporation
2000 S. Batavia Avenue
Geneva, IL 60134
Ph. 312/232-8900

BPG Security
5540 MacDonald Street
Hampstead, Quebec, Canada

Ed Chown Associates
56 Hampshire Drive
Nahua, NH 03060

Cincinnati Time Recorder Co.
1749 Central Avenue
Cincinnati, OH 45214
Ph. 513/241-5500

Conrac Corporation
Cramer Division
Mill Rock Road
Old Saybrook, CT 06475
Ph. 203/388-3574

Continental Instruments Corporation
170 Lauman Lane
Hicksville, NY 11801
Ph. 516/938-0800

Controller Systems Corporation
21363 Gratiot
East Detroit, MI 48021

Cooper and Associates
3248 Jellison Street
Wheat Ridge, CO 80033

Craftor, Inc.
Craft-Gard Divison
1237 Central Avenue
Albany, NY

Crusader Corporation
Knightguard Division
P. O. Box 1488
Salisbury, NC 28144

Dektor Counterintelligence & Sec., Inc.
5508 Port Royal Road
Springfield, VA 22151
Ph. 703/321-9333

Delta Products, Inc.
630 S. 7th Street
P. O. Box 1147
Grand Junction, CO 81501
Ph. 303/242-9000

Denney, Wagner, Wright, Inc.
4100 SW Barbur Boulevard
Portland, OR 97201

Design Controls, Inc.
111 Cantiague Rock Road
Westbury, NY 11590
Ph. 516/938-8000

Detectron Security Systems, Inc.
1 Bay Street
Sag Harbor, NY 11963
Ph. 516/725-2600

Detectronics, Inc.
130 Lincoln Street
Boston, MA 02135

Edwards Co., Inc.
90 Connecticut Avenue
Norwalk, CT 06856
Ph. 203/838-8441

Elan Industries, Inc.
2427 University Avenue
St. Paul, MN 55114

Faraday, Inc.
805 S. Maumee Street
Tecumseh, MI 49286
Ph. 517/423-2111

Federal Signal Corporation
Signal Division
136th and Western Avenue
Blue Island, IL 60406
Ph. 312/468-4500

General Automotive
Speciality Co., Inc.
460 Barell Avenue
Carlstadt, NJ 07072
Ph. 201/935-0222

Gould, Inc.
P. O. Box 3140
St. Paul, MN 55165
Ph. 612/452-1500

GTE Sylvania, Inc.
One Stamford Forum
Stamford, CT 06904
Ph. 203/357-2000

Hagoth Corporation
12350- 206th Place S.E.
Issaquah, WA 98027
Ph. 206/235-1020

Harrington Associates
1857 Old Freegold Road
Toms River, NJ 08753

Hoffman Identification, Inc.
4323 Arden Drive
El Monte, CA 91734

Imperial Screen Co., Inc.
5336 West 145th Street
Lawndale, CA 90260
Ph. 213/675-0337

Inter-check Security Systems
3390 Commercial
Northbrook, IL 60062

International Importers, Inc.
2242 South Western Avenue
Chicago, IL 60608

J.B.H. Electronic Systems, Inc.
95 Terrace Hall Avenue
Burlington, MA 01801

Johnson Controls, Inc.
509 E. Michighan Street
Milwaukee, WI 53201
Ph. 414/276-9200

Kenco, Inc.
2386 Wall Avenue
Odgen, UT 84401

Kolin Industries, Inc.
59T Pondfield Road
P. O. Box 357
W. Bronxville, NY 10708
Ph. 914/961-5065

F. G. Mason Engineering, Inc.
1700 Post Road
P. O. Box 309
Fairfield, CT 06430
Ph. 203/255-3461

Massa Corporation
280 Lincoln Street
Hingham, MA 02043
Ph. 617/749-4800

Master Lock Co.
2600 N. 32nd Street
Milwaukee, WI 53210
Ph. 414/444-2800

Monaco Enterprises, Inc.
14820 E. Sprague Avenue
P. O. Box 14129
Spokane, WA 99214
Ph. 509/926-6277

Morse Product Mfg. Co.
12960 Bradley Avenue
P. O. Box 4128
Sylmar, CA 91342
Ph. 213/367-5951

Moseley Associates
Santa Barbara Research Park
111 Castilian Drive
Goleta, CA 93107

Mosler Safe Co.
1561 Grand Boulevard
Hamilton, OH 45012
Ph. 513/867-4000

Mountain West Alarm Supply
4215 North 16th Street
Phoenix, AZ 85016
Ph. 602/277-3217

MRL, Inc.
7644 Fullerton Road
Springfield, VA 22153
Ph. 703/569-0195

NAPCO Security Systems, Inc.
6 DiTomas Court
Copiague, NY 11726
Ph. 516/842-9400

NCR Corporation
7700 S. Patterson Boulevard
Dayton, OH 45479
Ph. 513/449-2000

Newbrite Alarms, Inc.
166 Laurel Road
East Nortport, NY 11731

The Night Eye Corporation
Interstate 80 and North Dubuque
Rural Route 6
P. O. Box 260A
Iowa City, IA 52240
Ph. 319/351-5827

North American Philips Controls Corp.
Cheshire Industrial Park, Dept. T
Cheshire, CT 06410
Ph. 203/272-0301

Nova Industries, Inc.
263 Hillside Avenue
Nutley, NJ 07110
Ph. 201/661-3434

ONAN Corporation
1400 73rd Avenue NE
Minneapolis, MN 55432
Ph. 612/574-5000

Pembroke-Court Co., Inc.
P. O. Box 235
Highland Park, IL 60035

Photobell Company, Inc.
14 East 22nd Street
New York, NY 10010
Ph. 212/674-2121

Projects Unlimited
3681 Wyse Road
Dayton, Ohio 45414
Ph. 513/890-1918

Quadrex Corporation
2869 South Bumby Avenue
P. O. Box 14957
Orlando, FL 32807
Ph. 305/898-5810

Quam-Nichols Co.
234 E. Marquette Road
Chicago, IL 60637
Ph. 312/488-5800

Raymond Lee Organization
230 Park Avenue
New York, NY 10017

Receptors, Inc.
4203 Spencer Street
Torrance, CA 90503
Ph. 213/542-0501

Republic Steel Corporation
1441-T Republic Bldg.
P. O. Box 6778
Cleveland, OH 44101
Ph. 216/574-7100

Retawmatic Corporation
509 5th Avenue
New York, NY 10017
Ph. 212/687-0890

Rochester Instrument
Systems, Inc.
275 North Union Street
Rochester, NY 14605
Ph. 716/325-5120

RPI, Inc.
13740 Midway Rd., Suite 509
Dallas, TX 75246

Schlage Electronics
P. O. Box 122
Pitman, NJ 08071

Secure Controls, Inc.
5685 Lincoln Avenue
Chicago, IL 60659
Ph. 312/728-2435

Security and Research Corp.
425 W. 2nd Street
P. O. Box 4227
Davenport, IA 52808

Sentrol, Inc.
14335 NW Science Park
Portland, OR 97229

Sentron Mfg. Co.
142 Station Street
P. O. Box 312
Barrington, IL 60010

Sentry Technology, Inc.
Santa Cruz, CA 95066

Sigma Instruments, Inc.
170 Pearl Street
Braintree, MA 02184
Ph. 617/843-5000

The Silent Watchman Corporation
4861 McGaw Road
P. O. Box 7893
Columbus, Ohio 43207
Ph. 614/491-5200

Solfan Systems, Inc.
665T Clyde Avenue
Mountain View, CA 94043
Ph. 415/964-7020

Sonaguard, Inc.
100 Commerce Way
Woburn, MA 01801

SVS Surveillance Systems
2315 East 7th Avenue
Denver, CO 80206

Telco Products Corporation
44 Seacliff Avenue
Glen Cove, NY 11542

Underwood Service Associates
13238 S. Fiji Way
Marina Del Ray, CA 90291

Unicorp International, Inc.
7540 LBJ Freeway, Suite 917
Dallas, TX 75251

U. S. Controls Corporation
16608 West Rogers Drive
New Berlin, WI 53151

Universal Sentry Systems,
1907 W 39th Street
P. O. Box 1825
Vancouver, WA 98663
Ph. 206/694-4443

Varian Associates
Varian Corporate Division
611 Hansen Way
Palo Alto, CA 94303
Ph. 415/326-4000

Vicon Industries, Inc.
125 East Bethpage Road
Plainview, NY 11803
Ph. 516/293-2200

Video Tek, Inc.
8 Morris Avenue
Mountain Lakes, NJ 07046

Visi-Con
1650 North Elston Avenue
Chicago, IL 60622
Ph. 312/489-5800

Wackenhut Electronics Systems Corp.
1742 NW 69th Avenue
Miami, FL 33126
Ph. 305/592-3278

Waldon Electronics, Inc.
4639 West 53rd Street
Chicago, IL 60632
Ph. 312/585-1212

APPENDIX D

BIBLIOGRAPHY

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BIBLIOGRAPHY

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This report on duress alarm systems for fixed site nuclear facilities is prepared for use in the Safeguards program of the United States Nuclear Regulatory Commission. Information that will be useful to those responsible for the planning, design, and implementation of duress alarm systems is included. Basic system concepts, requirements, designs, and implementations are discussed. Techniques are presented that may be employed in duress alarm systems. Evaluation of the reliability or quality of specific vendor-supplied devices is not covered. An evaluation is included on various methods that can be incorporated into duress alarm systems. Comparison of these methods is given for specific applications.

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Safeguards Against Insider Collusion

Guide on the Design of Work Rules for Safeguarding Against the Employee Collusion Threat at Nuclear Fuel Facilities

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ABSTRACT

Guidance is presented for the development of work rules that will assist in protecting nuclear fuel facilities against the threat of employee collusion. Evaluation criteria for safeguards performance against this threat are discussed. Five types of work rules are presented: Area Zoning, Function Zoning, Team Zoning, Time Zoning and Operation Zoning. The strengths and weaknesses of each are discussed and examples are given. Methods for optimization of work rules are described.

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1. INTRODUCTION

Safeguards against the threat of employees at a nuclear facility colluding to commit theft or sabotage are required of nuclear material licensees by regulations in 10 CFR Part 73.20. This report provides guidance on designing the employee work rules so that collusion between individuals in any positions of responsibility will not result in a failure of the safeguards system.

The protection of nuclear fuel processing facilities against theft of nuclear material or radiological sabotage by adversaries who are not employees of the facility is provided by integrated safeguards systems composed of detection equipment, barriers and guard forces. The detection equipment detects covert actions with high probabilities, the barriers delay overt attempts to penetrate into the facility, and the guard forces respond to detection alarms so they can contain the nuclear material before it leaves the site. These safeguards systems alone do not provide an equivalent amount of protection against threats involving people employed by the facility because employees have access to nuclear material and vital equipment, they control the safeguards equipment and the penetrations through barriers, and they comprise the guard force called upon to respond. In fact, a group of employees acting in collusion are potentially capable of accomplishing theft or sabotage by misusing the authority given to them for performing their assigned duties.

Protection against this threat can be provided by properly structured work rules in conjunction with other safeguards measures. These work rules govern the access to nuclear material and the control of the safeguards system. It is necessary to integrate these work rules with other safeguards system components so that, after employees have made full misuse of their work privileges, some safeguards will remain undefeated.

The purpose of this guide is to describe generic work rule options, discuss their individual strengths and weaknesses, demonstrate their effectiveness in protecting against employee collusion by the use of sample problems, identify impacts on facility operation and recommend methods for optimizing work rule design. This guide is intended for use by nuclear material licensees in preparing a security plan that meets the requirements for protection against collusion between insiders who occupy any positions of responsibility at the facility. While the primary purpose is guidance on designing work rules, there is a discussion of performance criteria and methods for evaluating safeguards systems to determine if the criteria are met. The reader is encouraged to also make use of related reports on the analysis of safeguards against threats involving insider collusion.[1,2]

This guide is one part of a series of guidance documents that can be used in implementing the upgraded physical protection requirements in 10 CFR Part 73. Proper design of work rules can prevent a total compromise of the safeguards system by colluding employees, but it is equally important to follow guidance on the adequacy of the uncompromised safeguards components that remain for protection.

2. SAFEGUARDS PERFORMANCE AGAINST INSIDER COLLUSION

An important first step in designing work rules is to determine measures or criteria for the performance of the safeguards system against a range of threats. Performance criteria and factors to be considered in formulating work rules in response to a spectrum of threats are discussed below.

2.1 PERFORMANCE CRITERIA

The primary purpose of a safeguards system is to prevent theft and protect against sabotage. Prevention is not meant to be absolute but rather to mean a low risk or a low probability that theft or sabotage would be successful. However, there are no rigourous formulas or universally accepted probabilities for computing theft or sabotage risks against all threats. The following discussion explains a way to demonstrate a low risk against the threat of employee collusion and especially how the risk is affected by work rule design. Other guidance should be consulted for determining risks associated with the defeat of safeguards by force, stealth or deceit.

One criterion for performance is to establish a minimum number of safeguards that must be defeated by force, stealth, or deceit after all other safeguards have been compromised by misuse of work duties. Thus for every threat analyzed and for each theft or sabotage sequence at least some minimum number of safeguards elements remain in the adversary path to provide protection. For example, assume two employees collude to steal material. If the criterion is that two safeguards components must remain, then no matter how these two insiders misused their controls or authorizations, at least two safeguards components of any type must be available to detect the theft attempt. This criterion is the least complex of all the criteria and ignores some important considerations that are discussed next.

In the above example, the two safeguards components can be located anywhere along the path from the point where the first safeguard is encountered until the nuclear material leaves the facility. Intuitively, if the undefeated safeguards were located at the beginning of the path, the ability of response personnel to engage the adversaries is greater than if the safeguards elements were at the end of the path. This is due to the additional time available for response. Thus, detecting the adversaries early in the sequence provides additional protection. This indicates that the location of the remaining safeguards along the path should become a part of the criteria. It is conceivable that additional safeguards will be required if the uncompromised safeguards are all located at the end of the path.

Along the same lines, the effectiveness of the remaining safeguards must be taken into account in formulating criteria. For instance, safeguards that only provide detection of theft by remote surveillance may not provide adequate protection, whereas searches of personnel and packages may be considered quite adequate even if only one uncompromised safeguard remains. Thus the remaining safeguards should provide effective response or deterrence as well as detection capabilities in order to assure adequate protection.

In summary, the criteria for the performance of a safeguards system against the threat of employee collusion are: (1) the number of safeguards remaining after full misuse of work privileges; (2) the location of these safeguards along the path; and (3) the effectiveness of the safeguards in detecting and responding to theft or sabotage actions. It is not the purpose of this guide to define values for the criteria but, to illustrate, one possible set would be: (1) at least

2 safeguards remaining; (2) one remaining safeguard located so that the adversaries could be intercepted by the guard force if detection occurred; and (3) at least one remaining safeguard is a direct check for access authorization, a direct search for contraband, or a direct search for nuclear material. There are, of course, alternative sets of criteria. One additional requirement could be that the two remaining safeguards must be of different types. The rationale for this is to require that the adversaries devise two different tactics to defeat the safeguards by force, stealth or deceit.

2.2 THREAT

This guide addresses the threat of employee collusion. The following paragraphs discuss issues that must be considered in evaluating the insider threat.

The first issue is the number of employees who make up the adversary team. There is little argument that a single insider should not be capable of theft or sabotage. Presently, considerable emphasis is being placed on protecting against two insiders. Larger adversary teams may be considered but are not as likely because as more individuals become involved there is a higher probability that evidence of the conspiracy will be discovered.

A second issue is the capability of the employees to control safeguards and have access to areas and nuclear material. There are situations where an individual may not be physically able to control a safeguard and allow himself to pass by. For example, a guard may control a portal and yet be unable to allow himself to pass through the portal due to portal design. In other cases control of the safeguard may imply access. For example, the custodian of a storage room key would be able to enter that room at any time. A conservative approach to this problem is to assume every employee has full capability to gain access and allow himself and others to pass by safeguards he controls. If vulnerabilities exist then they can be reviewed one by one to uncover inconsistencies.

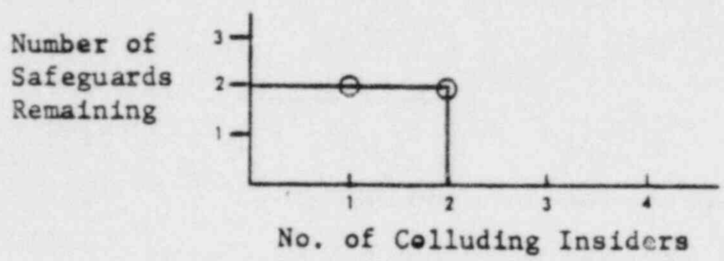
A third issue is the time span allowed for a credible theft or sabotage sequence to occur. This is especially important in facilities where personnel rotate between different job assignments. A sequence can be envisioned where material is moved to a different location within the facility and is hidden until job rotation and employee safeguards access and controls change. At that time, the material could then be recovered and removed from the facility utilizing the new authorizations. Although these long time sequences increase the adversary's risk of discovery, they are possible and should be considered. Any vulnerabilities should be examined to decide if the time span and number of plausable material hiding places provide a high enough risk of detection that such a sequence is adequately deterred.

In defining an appropriate time span for rotation of employee job assignments, two actions may be taken to reduce the risk of these partial theft sequences being successful. These are a search or facility sweep for hidden material and/or a physical inventory of material prior to job rotation. For example, if these were both conducted simultaneously at one month intervals with no evidence of hidden or missing material, personnel could then be freely rotated with some assurance that no partial theft sequence had taken place.

Another issue related to time and rotation is the number of different facility conditions that could exist during the theft or sabotage sequence. The safeguards system at the facility is dynamic and changes as the plant changes from normal day-shift to night-shift or to emergency conditions. It is possible that the optimum strategy for the employees would be to complete the theft or sabotage sequence in steps that occur during different plant conditions. Again, the most conservative approach is to assume this is possible and to review vulnerabilities for inconsistencies and incredible sequences.

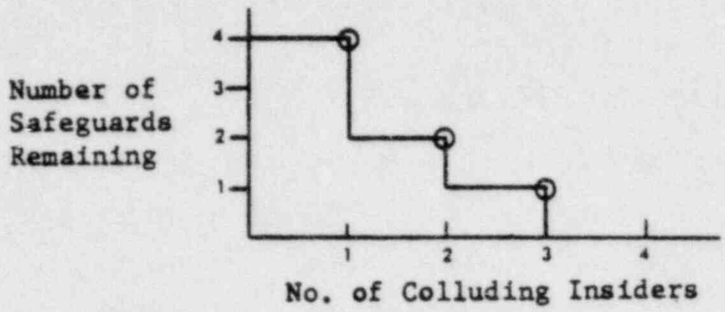
2.3 INTEGRATED PERFORMANCE

It is valuable to combine the threat spectrum with the safeguards performance criteria to measure the integrated performance of the safeguards system. That is, instead of taking a single criterion and applying that to all the threats, it may be more reasonable to have multiple criteria applied to the different threats. Assume, for example, a case where the criteria are stated only in terms of the number of remaining safeguards and the threat is stated only in terms of the number of colluding employees. The figure below shows a direct application of a single criterion to all the threats.



Two safeguards must remain for both the single and two insider threats and no safeguards are required against three or more insiders.

A graded or integrated performance measure would show variation in the criteria depending on the threat. This is indicated below.



In this case, the safeguards system performance is strongest against the most likely threats and decreases as the threat likelihood decreases.

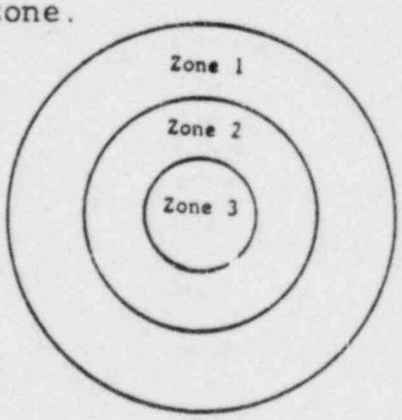
In the design of work rules, it is important to understand how changes in work rules impact these performance measures. The following table summarizes the six issues that must be considered.

Performance Criteria	Threat
1. Number of Remaining Safeguards	1. Number of Employees
2. Location of Remaining Safeguards	2. Capabilities of Employees
3. Effectiveness of Remaining Safeguards	3. Time Span and Facility Conditions

3. TYPES OF WORK RULES

An employee of a nuclear facility can be restricted in a number of ways in order to minimize his overall control of the safeguards system and his access to vital areas and nuclear material. He can be restricted as to <u>who</u> he can work with, <u>what</u> tasks he can perform, <u>when</u> he can enter and work in certain areas, <u>where</u> he can work, and <u>how</u> he performs his assignments. These <u>who</u>, <u>what</u>, <u>when</u>, <u>where</u> and <u>how</u> restrictions can be used to define a set of work rules. A number of work rule options are discussed below along with the safeguards hardware that is important in enforcing the rules.

One of the easiest work rules to apply is area zoning. This work rule restricts <u>where</u> people can work in an effort to provide "layers" or concentric shells of protection. Many facilities already use area zoning by restricting people to areas where they have responsibilities and not allowing them to enter areas where they do not have a need to go. Work areas can be created to actually form concentric shells in which a set of people are restricted to a specific shell and areas outside that shell but are not permitted into inner shells. For example, if a plant can be physically defined to have three concentric zones, with three real physical concentric barriers it can be represented by the figure below. It is assumed that the nuclear material resides in the inner or most protected zone.



Workers restricted to Zone 1 cannot enter Zones 2 and 3. Workers required to work in Zone 2 can enter Zone 1 but not work there and cannot enter Zone 3. Zone 3 personnel can enter any zone but can only work in Zone 3. The control of safeguards is done by the people who are restricted to that particular zone. Thus Zone 1 workers or guards control entrance and exit for Zone 2 and 3 workers. In this way no single or pair of individuals can bring contraband into Zone 3 or remove material from Zone 3. If there is an equivalent set of safeguards in each zone then this work rule prevents theft or sabotage requiring contraband by N-1 colluding individuals where N is the number of zones.

A second useful work rule is termed function zoning. This rule restricts what tasks a person can do. As in the above case of area zoning, most plants have inherent function zoning by the fact that guards have different responsibilities than process workers. Function zoning must be taken further than these general categories if it is to be useful for safeguards. For example, a portal may control who enters an area by checking identification, what is brought in the area by metal detectors and x-ray devices and what is removed from an area by SNM and metal detectors. By assigning these different functions to different groups of people and restricting these people to their specific functions, the single portal becomes a multiple barrier which requires collusion to defeat. Thus, a single portal guard cannot let himself through this barrier and then remove material because he either controls the entry aspects of the portal or the removal safeguards but not both. Therefore, the portal is functionally zoned.

Restricting who a person works with falls into a category of work rules called team zoning. This work rule can be used to specify people who must work together or people who must work separately. Its primary use for safeguards is to remedy specific problems rather than to be applied universally. The rule is enforced using entry portal safeguards systems and surveillance to assure teams are together.

Time zoning restricts when people can work and can be used to restrict personnel from plant entry or area except when they are required to be there. Plants may already employ time zoning techniques during late shift operations to prevent day shift workers from entering the plant during non-operation hours when guard forces may be small. This technique also uses entry portal safeguards and can employ such devices as intrusion detectors for certain areas in the plant.

The how category of restriction is covered in operations zoning which consists primarily of procedure specifications and checks. By zoning how a person does his work it may be possible to prevent the defeat of the system. This work rule is primarily used against a single insider but would affect every colluding team as well. Special tamper indicators or computer analysis of operational areas could be used to determine if the work is done properly. These safeguards fall into a closed-loop control system called operations control analysis.

Of the five work rule types discussed above, the first three - area zoning, function zoning, and team zoning - are the most universally useful and are the ones discussed in the remainder of the report.

4. DESIGNING EFFECTIVE WORK RULES

Many factors contribute to the formulation of an effective set of work rules. Details of the plant, its personnel, the safeguards system, and the existing work rules are needed to determine weaknesses of the existing systems and possible fixes using work rule techniques. This section discusses the basic considerations involved in establishing work rules.

One of the most important factors used in the formulation of work rules is the site geometry. Details of the walls, entrances, exits, and other features of the facility must be taken into account so that the designed work rules are effective. The location within the facility of guard stations, safeguards controls, and SNM will be integrated into the safeguards system. Since the objective of the study is to determine vulnerabilities to theft and sabotage, pathways into and out of the facility must be determined and evaluated. This requires that the site geometry be well defined.

Along with the site geometry, it is necessary to know what safeguards features exist in the plant and where they are located. This is important in not only determining vulnerabilities but also in design of the work rules. By knowing what safeguards are available, it is possible to integrate the work rules with the safeguards sytem. Work rules by themselves are not nearly as effective as when they are designed to utilize the existing safeguards features of the facility. Many of the work rules deal with people who control or maintain safeguards elements which means that the above information is needed just to evaluate what an individual may be capable of doing.

It may be necessary to correct certain situations with hardware rather than work rules. If this is the case, it is important to know what capabilities the facility may have in the area of safeguards. Also, additional personnel may be required in order to implement certain work rules. This is also part of the safeguards capabilities and must be taken into account when formulating the work rules for the plant.

Information is needed on personnel responsibilities and capabilities. Where people must go to perform their duties and what control they have over safeguards equipment are both very important considerations in work rule definition. It is these personnel characteristics that may be changed or redefined in the process of creating or revising the work rules. It is important that the work rules do not greatly impact the operation of the plant. Thus, the general responsibilities of the workers also need to be considered in the safeguards work rule system.

Other factors may enter into the analysis depending on special cases. Obviously, the work rules should hinder safety systems or responses to emergencies as little as is possible. The safety of plant employees is an important factor to consider in this process. Also, employee morale may become a factor for certain situations. Costs must be taken into account. These and possibly other considerations must not be ignored so that the final work rule definition is not only effective but also workable.

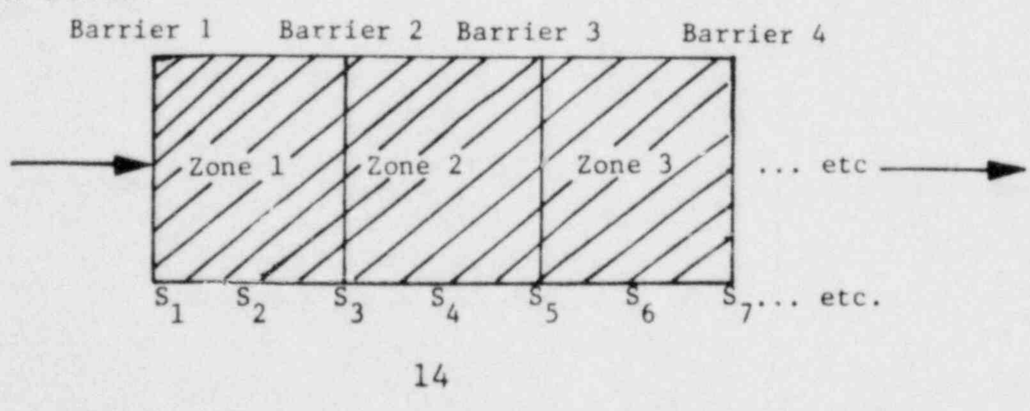
5. STRENGTHS AND WEAKNESSES OF WORK RULES

The design of work rules for an actual safeguards system usually involves the integration of three of the different types of rules: area zoning, function zoning and team zoning. This chapter presents the strengths and weaknesses of each type of rule and provides sample problems illustrating the use of these work rules in two simple models of a safeguards system. The two different models are used to demonstrate that the strength or weakness of a work rule depends on the design of the safeguards system. Thus, the rules that are most useful at one facility may have lesser value at another one.

5.1 AREA ZONING

Area zoning is a very useful work rule when the safeguard system can be modeled as concentric zones surrounding the special nuclear material (SNM) or vital area (VA) so that a number of zones must be crossed by the adversary to reach his target and to exit. It is, of course, necessary to have safeguards in each zone or at the barriers forming the boundaries between the zones. The effectiveness of area zoning is independent of whether these safeguards are the same type at each zone (redundancy of similar safeguards) or are different.

A simple diagram of a model of such a safeguards system is given below.



The diagram shows (at least) one safeguard at each zone or barrier. These safeguards are numbered sequentially to indicate their multiplicity, not that they are different types.

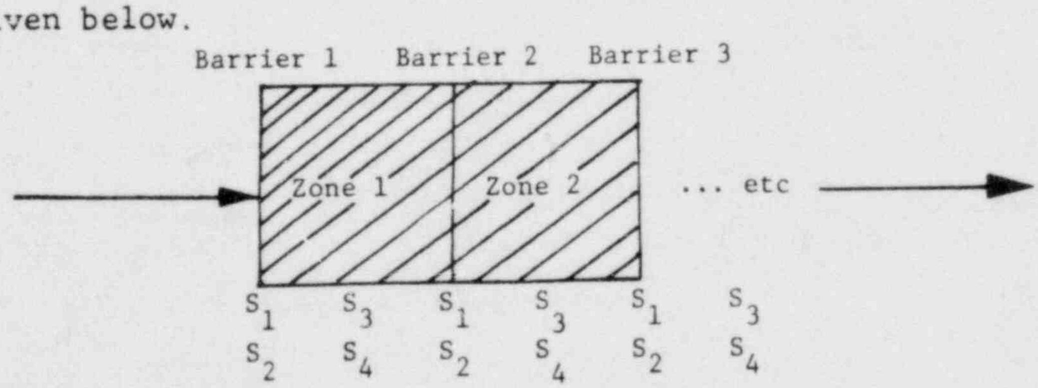
Using the area zoning concept, work rules would be established so that there would be a different class of employees who controlled the safeguards in each zone. Employees in any class could only control one zone and collusion among two classes would be unsuccessful if there are more than two zones.

If the safeguards system can be modeled as concentric zones as described previously, then area zoning is a very valuable work rule, not only because it can prevent theft or sabotage via collusion but also because it doesn't necessarily increase the number of guards or workers at the facility. This conclusion regarding numbers of personnel is based on the observation that there would be at least one person required in each zone to operate the safeguards in that zone. There is, of course, a sacrifice in terms of the amount of rotation that can be tolerated between classes or between zones. This is one of the major weaknesses of area zoning. The other is that the concept does not apply unless the system can be zoned.

5.2 FUNCTION ZONING

Function zoning is a very useful work rule when the safeguards system can only be modeled as a single zone or barrier having many diverse types of safeguards in the zone or at the barrier. It is also useful if the safeguard system can be modeled as concentric zones surrounding the SNM or VA provided there are diverse safeguards in each zone.

A simple diagram of this model of the safeguards system is given below.



The diagram shows (at least) two safeguards at each zone or barrier. The safeguards are numbered in sets of S_1 to S_4 to indicate that the safeguards in each zone are different types but that the sets at subsequent zones could be identical.

Using the function zoning concept, work rules would be established so that a different class of employee controlled each different type of safeguard, e.g. performed one type of duty or function. For example, Class 1 employees would control S_1 type safeguards, Class 2 employees would control S_2 type safeguards, etc. Employees in any class could control only one type of safeguard and collusion among classes would be unsucesful if there are more than two safeguards types in an adversary path.

If the safeguards system can be modeled as diverse safeguards that must all be encountered, then function zoning is very valuable; however, function zoning may increase the number of employees. This conclusion regarding number of personnel is based on the observation that a single person at each zone could be capable of controlling all the safeguards at that zone even if they are of different types. By function zoning more than one person is required to control these safeguards. If the safeguards system consists of a number of zones with diverse safeguards at each zone, then the application of this work rule does give the employees rotation among posts even though their duties remain the same.

5.3 TEAM ZONING

Team zoning is a very useful work rule when the safeguards system can be modeled in either of the two ways described above, but the number of zones or types of safeguards is few and additional safeguards are required. The use of the two-man rule alone would not prevent collusion if the same pair could rotate together to control all safeguards in the system. However, by judiciously establishing team zoning work rules the same pair of employees can be limited to work together only in one zone or only on one type of safeguard.

The rule is applied by treating each pair of employees as a single individual and forming classes as described above. The comments given for area and team zoning regarding the number of employees, the rotation possibilities, and the safeguards effectiveness also hold for team zoning.

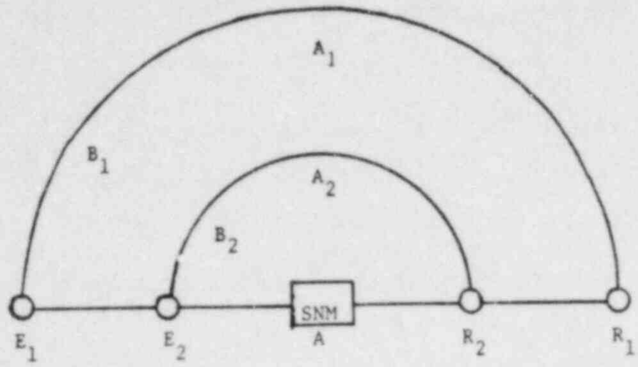
5.4 SAMPLE PROBLEMS

5.4.1 Model 1 - Concentric Zones with Redundant Safeguards

A simple model of a safeguards system consisting of concentric zones, each having an identical set of safeguards is shown in Figure 4.1, Model 1. This system has features that should make the application of both area and function zoning useful. Team zoning should also be valuable because there are only two zones (Zone A_1 and Zone A_2) and two types of safeguards (E type [entrance] and R type [removal]). The adversary moves from left to right on the figure encountering the entrance safeguards, the SNM (with an acquisition safeguard) and finally the removal safeguards.

Table 5.1 presents a summary of the possible work rules that can be used, the impact in terms of number of employees and their rotation, and the effectiveness of the safeguards system.

The table is interpreted in the following way. In the first column nine types of work rule combinations are listed. In the next two columns the work rule is defined by identifying the guard (G) or worker (W) who controls the E and R safeguards at the two portals. For example, in case 1 either the guard (G) or worker (W) can control all four safeguards, while for case 5 a different guard (G_1, G_2, G_3, or G_4) controls the different safeguards (E_1, E_2, R_1, and R_2). The symbol G^2 indicates two guards (G) are used in a team concept to control



A = Area

B = Barrier

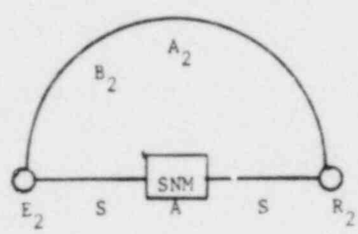
SNM = Special Nuclear Material

E = Entry Safeguard

R = SNM Removal Safeguard

A = Acquisition Safeguard

Model 1. Concentric Zones with Redundant Safeguards



A = Area

B = Barrier

SNM = Special Nuclear Material

E = Entry Safeguard

R = SNM Removal Safeguard

A = Acquistition Safeguard

S = Remote Surveillance Safeguard

Model 2. Diverse Safeguards Concentrated in a Single Zone

Figure 5.1. Models of Safeguards Systems Used to Demonstrate Strengths and Weaknesses of Work Rule Types

Table 5.1. Summary of Work Rules, Their Impacts, and the Safeguards Effectiveness for a System with Concentric Zones and Redundant Safeguards

TYPE OF WORK RULES	WORK RULES		IMPACT OF RULES		SAFEGUARDS EFFECTIVENESS MEASURED BY NUMBER OF SAFEGUARDS REMAINING (employee team)		
	FIRST PORTAL	SECOND PORTAL					
	E_1 Safeguard Control R_1 Safeguard Control	E_2 Safeguard Control R_2 Safeguard Control	Number of Guards* and Workers	Amount of Rotation	One Man	Two Man	Three Man
1. No Work Rules	G or W	G or W	3	Total	*(G or W)	N/A	N/A
2. Separation of Guard and Worker (Area or Function Zoning)	G G	G G	3	Post and Duties	1(G) 2(W)	*(GW)	N/A
3. Area Zoning	G_1 G_1	G_2 G_2	3	Single Post Rotate Duties	2(G_2) 2(W) 3(G_1)	1(All)	*(G_1G_2W)
4. Function Zoning	G_1 G_2	G_1 G_2	5	Single Duty Rotate Posts	2(G_2) 2(W) 3(G_1)	*(G_2W) 1(G_1G_2) 2(G_1W)	*(G_1G_2W)
5. Area and Function Zoning	G_1 G_3	G_2 G_4	5	None	2(W) 3(G_2 or G_4) 4(G_1 or G_3)	1(G_3W or G_4W) 2(G_1W or G_2W) 2(G_2G_4 or G_2G_3 or G_3G_4)	*(G_3G_4W)
6. Two-Man Rule	G^2 G^2	G^2 G^2	5	Posts and Duties	2(W) 4(G)	1(G^2) 2(W^2 or WG)	*(G^2W)
7. Area Zoning and Two-Man Rule	${G_1}^2$ ${G_1}^2$	${G_2}^2$ ${G_2}^2$	5	Single Post Rotate Duties	2(W) 4(G_1 or G_2)	2(W^2 or WG) 2(${G_2}^2$)	1(${G_1}^2W$ or ${G_2}^2W$)
8. Two-Man Rule with Area Zoning of Pairs (Team Zoning)	G_1G_2 or G_2G_3 G_1G_2 or G_2G_3	G_3G_4 or G_1G_4 G_3G_4 or G_1G_4	5	Single Post, Rotate Duties (G_2G_4) Posts and Duties (G_1G_3)	2(W) 4(G)	2(W^2 or WG) 2(G_1G_4 or G_3G_4)	1(G_1G_4W or G_3G_4W)
9. Function Zoning and Two-Man Rule	${G_1}^2$ ${G_2}^2$	${G_1}^2$ ${G_2}^2$	9	Single Duty Rotate Posts	2(W) 4(G_1 or G_2)	2(W^2 or WG) 2(${G_2}^2$)	*(${G_2}^2W$)

* Assuming each portal must be manned and one man is capable of controling both safeguards at each portal if this is authorized.

the safeguard. In the fourth and fifth columns the impact of the rule is given by the number of guards and workers needed to operate the system and the amount of rotation given the guards. We have assumed that each portal must be manned and that one man is physically capable of controlling the E and R safeguards at each portal. The last three columns give the safeguards system effectiveness against the one-man, two-man, and three-man threats. The effectiveness measure is the number of safeguards remaining and in parentheses the worst employee team is given. Only the most critical results are given, i.e., those with the fewest number of safeguards remaining. An asterisk indicates no safeguards remain.

Initially, if there are no work rules (case 1), any single person can defeat the system because there is total rotation. The most obvious work rule is to separate the guards and workers (case 2) so that guards are prevented from acquiring SNM and workers cannot control any safeguards devices except the acquisition safeguard which is a combination of material control procedures and surveillance. This separation is really an application of both area and function zoning; area zoning because only workers can enter area A_2 where nuclear material is handled, and function zoning because only workers have the authority to handle the SNM. This rule alone prevents one man theft but is vulnerable to any guard-worker two man pair. Throughout the remainder of this example we will maintain this division of guard and worker duties and focus on work rules for the guards to prevent collusion.

The application of the area zoning work rule (case 3) is to form two classes of guards, class one (G_1) to man the first portal and class two (G_2) to man the second portal. This presents two-man collusion by providing at least one safeguard remaining against all pairs. Guards are now fixed to a single post but have diverse duties. The number of employees is unchanged.

The application of the function zoning work rule (case 4) is to form two classes of guards, class one (G_1) to control E type safeguards and class two (G_2) to control R type safeguards. This prevents two-man collusion except for the pair G_2W, who are the worker and the guard who rotates to do all SNM removal searches. Obviously function zoning is not totally effective when there is a class of employees such as the worker who is authorized access through safeguards of two types (E and A) and must only collude with an employee in the class controlling the other type of safeguard. Function zoning also increases the number of employees from 3 to 5.

Combining the area and function zoning work rules (case 5) creates four classes of guards, one to control each of the four safeguards (E_1, E_2, R_1 and R_2). This only gives a minor improvement over area zoning alone and it has a major impact because there is no rotation and there is an increase in the work force size.

The two-man rule without team zoning (case 6) is accomplished with a single guard class but with two guards now at each portal. This prevents collusion only because we have already separated guards and workers. There is still no prevention of three-man collusion and there is still only a single safeguard remaining against two-man collusion.

Area zoning can be combined with the two-man rule (case 7) so that there are two guard classes and two guards of the same class at each portal or team zoning can be used so that there is a two-man rule with area zoning of the pairs (case 8). In this example of team zoning (case 8) we have four classes of guards, each class can be paried with two of the other three classes, and any pair can work at either the first or the second portal but not both. If either of these rules is applied we obtain double protection against two-man collusion and single protection against the three-man threat. Notice that the work force size is increased to 5 but there is some rotation, with team zoning giving more rotation than area zoning plus the two-man rule.

Function zoning and the two-man rule (case 9) is applied by forming two classes and having two guards of the same class controlling each safeguard. This does prevent two-man but not three-man collusion and it also results in a large increase in work force size from 3 to 9.

5.4.2 Model 2 - Diverse Safeguards Concentrated in a Single Zone

A simple safeguard system consisting of a single zone with diverse types of safeguards is shown on Figure 5.1, Model . This system has features that should make application of function zoning useful. Team zoning will probably not be as useful as for the Model 1 type safeguards system because there are four types of safeguards. Area zoning is not applicable. Notice that in Model 2, as in Model 1, there are a total of five safeguards so that the models and work rule evaluations can be compared. To accomplish this one entrance and one removal safeguard have been replaced by two surveillance(s) safeguards.

A summary of the work rules, their impact, and the safeguards effectiveness for this model is given in Table 5.2. This table is interpreted in the same way as Table 1 except that now there is a single portal and we show the control of the safeguards S and A that are within the area A_2.

Again we start by separating guards and workers only now in one case (case 2) we assign control of the surveillance safeguard (S type) to a worker class and in the other case (case 3) we assign this control to a guard class. The results are essentially independent of how this decision is made. Throughout the rest of this example there is a differentiation between these two possibilities.

Table 5.2. Summary of Work Rules, Their Impacts, and the Safeguards Effectiveness for a System with Diverse Safeguards Concentrated in a Single Zone

TYPES OF WORK RULES	WORK RULES		IMPACT OF RULES		SAFEGUARDS EFFECTIVENESS (Number of Safeguards Remaining)		
	PORTAL K_2 Safeguard Control R_2 Safeguard Control	SURVEILLANCE S Safeguard Control A Safeguard Control	Number of guards* and workers	Amount of Rotation	One Man	Two Man	Three Man
1. No Work Rule	G or W	G or W	3	Total	*(G or W)	N/A	N/A
2. Separation of Guard and Worker (W surveillance)	G G	W W	3	Rotate post and duties	1(W) 3(G)	*(GW)	N/A
3. Separation of Guard and Worker (G surveillance)	G G	G W	3	Rotate post and duties	1(G) 2(W)	*(GW)	N/A
4. Function Zoning (W surveillance)	G_1 G_2	W_1 W_2	4	None	2(W_2) 3(W_1) 4(G)	1(G_2W_2 or W_1W_2) 2(G_2W_1 or G_1W_2 or G_1W_1) 3(G_1G_2)	*($G_2W_1W_2$)
5. Function Zoning (G surveillance)	G_1 G_2	G_3 W	4	None	2(W) 3(G_3) 4(G_1 or G_2)	1(G_2W or G_3W) 2(G_2G_3 or G_1W or G_1G_3) 3(G_1G_2)	*(G_2G_3W)
6. Two-Man Rule (W surveillance)	G_2^2 G^2	W^2 W	5	Duties Only (G) Posts and Duties (W)	2(W) 5(G)	1(W^2) 2(GW) 3(G^2)	1(G^2W or W^2G)
7. Two-Man Rule (G surveillance)	G_2^2 G^2	G^2 W	5	None (W) Post and Duties (G)	2(W) 5(G)	1(G^2) 2(GW or W^2)	*(G^2W)
8. Function Zoning and Two-Man Rule (G surveillance)	G_1^2 G_2^2	G_1^2 W	7	None	2(W) 5(G)	2(W^2 or GW) 3(G_3^2) 4(G_1^2 or G_2^2) 5(G_xG_y)	1(G_2^2W or G_3^2W) 2(G_1^2 W)

* Assuming the portal and the remote surveillance station are manned and the man at the portal is capable of controling both safeguards if this is authorized.

There can be no area zoning in this system but function zoning can be applied (cases 4 and 5) to prevent two-man collusion. In case 4 two guard classes are formed, one to man E type and one to man R type safeguards, and two worker classes are formed, one to man S-type and one to man A-type safeguards. In case 5 one of these worker classes is replaced by creating a third guard class. Again results are independent of whether guards or workers control surveillance. Notice that there is an increase in work force size from 3 to 4 and there is no rotation. This is a much larger impact than in the previous model where area zoning alone was used to prevent two-man collusion.

The application of the two man rule is very effective if the workers control surveillance (case 6). The work force size is increased to 5 but now there is some rotation. The two man rule is not as effective if guards control surveillance. Function zoning and the two-man rule (case 8) must be applied if the guards have surveillance in order to get the same effectivenss as the two-man rule alone when workers have surveillance. However, there is a major impact in terms of increased work force size and no rotation.

6. IMPACTS OF WORK RULES ON THE FACILITY

Before implementing work rules it is important to understand the effects the rules may have on the personnel and activities in the facility.

One of the impacts of work rules is on the effectiveness of personnel, particulary guards. In some work rule schemes an employee may only be permitted to perform one function or to work at a single location due to functional or area zoning. The employee has a very well defined job but has little or no freedom to expand to other tasks. This type of environment tends to lead to less vigilance because of lack of variety, even though the employee may be better trained and better able to perform the job than if he had diverse duties. If possible, some sort of rotation scheme should be instituted to prevent this from happening. However, rotation allows adversary teams more capabilities and therefore,care must be taken in how the rotation is implemented.

Along a similar line, management will potentially have problems with scheduling. The rigidity of some of the work rule schemes may impact the ability of the plant to arrange reasonable schedules. This may be particulary true if the plant has little or no rotation of job responsibilities.

Some of the plant safeguards procedures such as close-out inspection, operability tests, quality assurance or quality control inspections and security tours may be impacted by work rules. The actual operations or procedures will not be impacted but additional personnel may have to be employed to prevent violations of the work rules. This impact should be small for large plants due to the large staff of available workers. Small facilities may need to employ additional high-level personnel (people capable of performing inspections or tests) to a greater extent than the large plants.

Work rules should have little to no impact on safety except for the following cases. If the two man rule is applied extensively, the number of people that can potentially be involved in accidents will increase and thus the risk increases. This impact should be minor for most situations If the work rules were not sufficient to meet performance objectives without the addition of safeguards elements which are intended to delay adversaries, safety problems may arise. If the adversary is delayed, so is a worker attempting to exit during an emergency or a response team may be delayed in getting to the hazard. Care must be taken in the placement of delaying safeguards to avoid this situation.

Other impacts may occur in specific cases but the above cases should cover most situations. The impact of work rules can be small if some of the above problems are considered in the work rule design process.

7. OPTIMIZING WORKING RULES

Optimizing the combinations of work rules utilizing area, function and team zoning is relatively straightforward for simple safeguards systems such as those presented in Chapter 5. There obviously is a world of difference between those simple models and the real and complex nuclear facilities that are in operation today. Two different methods appear to have merit for the analysis of real nuclear facilities. The first of these is more appropriate for designing new facilities while the second is more useful in analyzing older facilities where work rules have evolved over a long period of time and, as a result, have become very individualized.

7.1 FACILITY REDUCTION TECHNIQUE

The first technique is called the Facility Reduction Technique because the major task in the analysis is reducing the facility to a replica of one of the model facilities presented earlier. This also involves ascertaining that all employees are collected into classes for that model facility and that their access and control capabilities correspond directly to those in the model. Figure 7.1 is a schematic representation of this approach.

This does not mean that there can be only one removal path for material from the MAA in a real facility but rather, that all of the personnel controlling the removal safeguards at MAA exits have limitations analogous to those of the equivalent personnel in the model facility.

Once work rules similar to those presented in the problems have been designed it is appropriate to analyze the

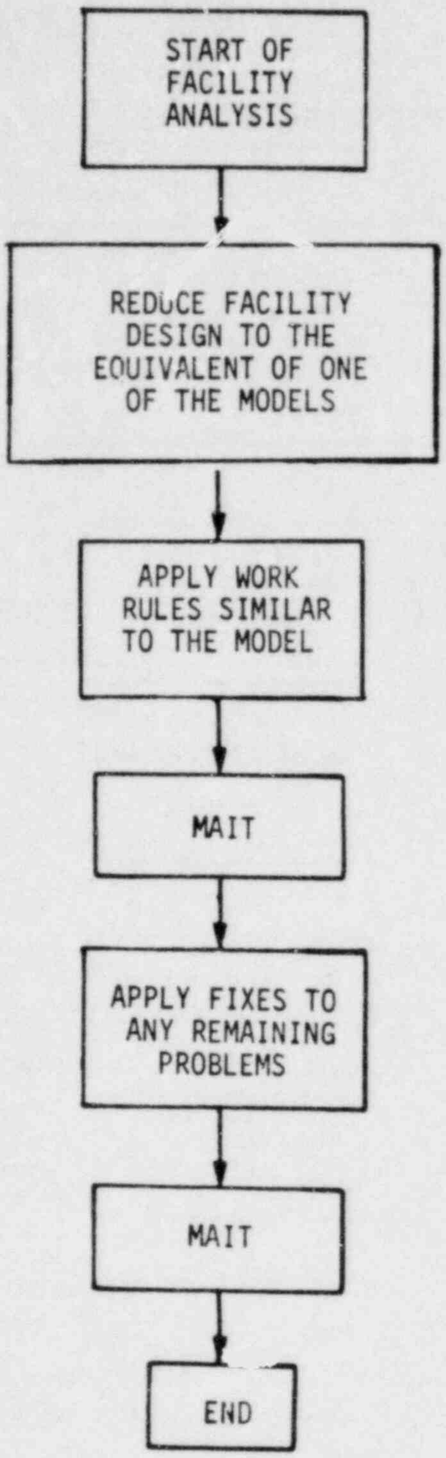


Figure 7.1 Facility Reduction Technique for Facility Design and Analysis

facility in detail to be certain that it is indeed resistant to insider collusion. The MAIT method of analysis[1,2] is specifically tailored to this type of problem.

If the facility has been precisely modeled after one of the simple demonstration facilities, the MAIT analysis (See NUREG-0532 Vol. 2) should show that, using the criteria developed in Section 2.1, the desired resistance to collusion does exist in the facility as described in the tables of Chapter 5.

In most cases, once supervisory or management personnel are added to the model facility and if they have a wide latitude of responsibilities and authorities certain problems could remain in the reduced facility. In this situation, some specific modifications may be required. These could include adding two-man rules for these personnel in critical plant locations or refining the safeguards functions of other personnel. These modifications could involve redefining the plant organization chart to provide more balanced safeguards coverage.

As a final verification that the safeguards system is adequate it is advisable to reanalyze using the MAIT method. This ensures that changes in responsibility brought about by the modifications have not caused problems in areas that were previously adequately safeguarded.

7.2 SAFEGUARDS SYNTHESIS TECHNIQUE

This analysis technique is capable of synthesizing an effective safeguards structure by employing and combining the elements of area, functional and team zoning. It is effective on facilities that cannot be easily reduced to an analog of one of the models discussed previously. Figure 7.2 shows schematically how the synthesis method would be employed to analyze and upgrade safeguards for a given facility. This approach is

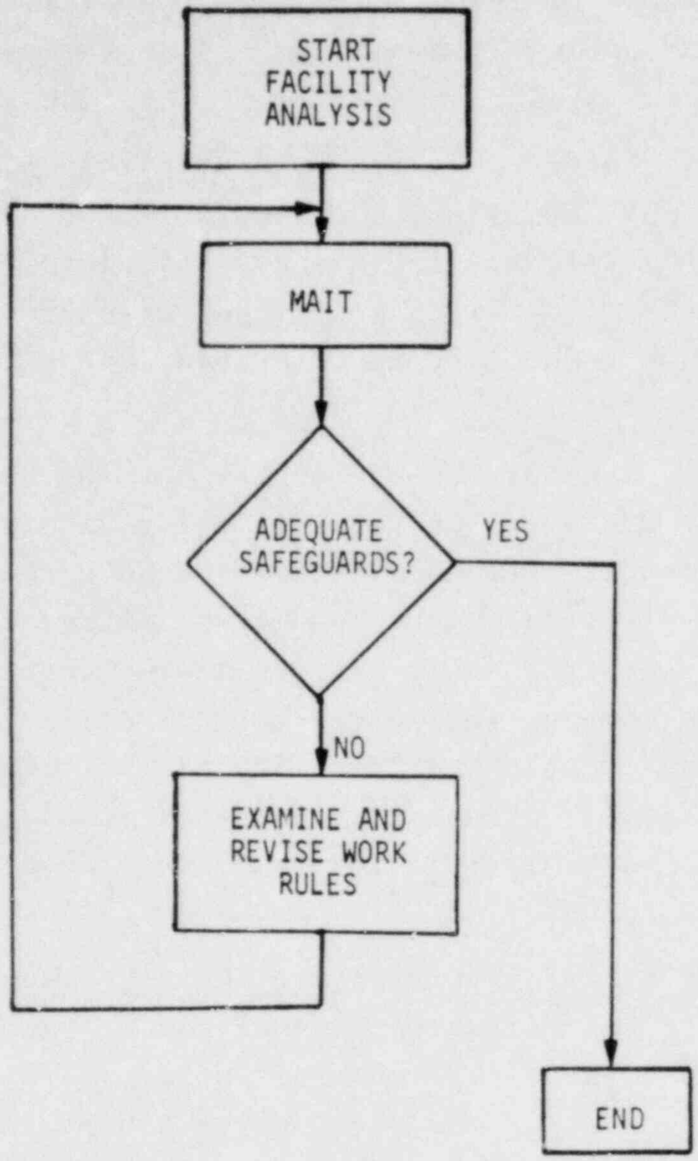


Figure 7.2 Safeguards Synthesis Technique for Facility Analysis

iterative rather than being a "straight through" analysis as the Facility Reduction Technique is.

The first step in the synthesis method is to determine the facility baseline. This is most easily done using a detailed analysis of floor plans, safeguards devices, personnel authorities and responsibilities, facility conditions to be expected and any other factors that impact on safeguards against the employee collusion threat. Again the MAIT method of facility analysis[(2)] is an ideal tool for this step of the assessment.

The results of the detailed analysis will possibly show weaknesses in one or more areas. These areas could include targets that are susceptible, adversaries or adversary pairs that can defeat all or most safeguards along a path, paths that many personnel can control or facility conditions that are poorly safeguarded. If weaknesses are observed, the analyst will draw from the techniques discussed in this report to solve them on a universal basis first. For example, if Person A is part of most of the scenarios that are successful for the adversaries a redesign of his work rules could be the only modification required. Another example would be that Safeguard B is in most paths that are successful for the adversary(ies). Here a redesign of the access authority and control responsibilities for this safeguard would be an appropriate universal fix. Of course certain weaknesses will probably surface that are individual problems for a certain specific situation. These must be dealt with individually.

It was assumed in developing Figure 7.2 that the inadequacy of the safeguards system could be corrected in every case by a modification of the work rules. This may or may not be true and it may or may not be the most appropriate solution in a given situation. This is generally assumed to be the most cost effective method of resolving a safeguards problem if it does not require the addition of extra personnel. Another potential solution is to add safeguards along critical paths. These safeguards would be controlled by personnel who are not members of the adversary groups that can defeat the other safeguards along the paths.

Once these upgrades have been designed on paper a second MAIT analysis is conducted on the upgraded facility. Evaluation of the results shows the progress made and any further problems. Changes followed by MAIT analyses can continue until satisfactory results are obtained.

REFERENCES

1. Glancy, et al., "Analysis of Nuclear Fuel Facility Safeguards Against Threats Involving Insider Collusion," Science Applications, Inc., SAI-78-547-LJ, April 1978.

2. McDaniel, et.al, Safeguards Against Insider Collusion, "The MAIT (Matrix Analysis of the Insider Threat) Method for Analysis of Facility Safeguards Against Insider Collusion - User's Manual" NUREG/CR-0532, Vol. 2, Science Applications, Inc. SAI-78-960-LJ, June, 1979.

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16. ABSTRACT (200 words or less)

This report provides guidance for the development of work rules (i.e., procedures) that will assist in protecting nuclear fuel cycle facilities against threats involving employee collusion. The work rules discussed in this report also have applicability to other sensitive technology environments such as automated industries, nuclear power reactors, communications networks and certain military-industrial complexes. Evaluation criteria for safeguards performance against the threat of insider-inspired crimes of collusion are discussed. The five types of work rules presented in the report include the following: area zoning, function zoning, team zoning, time zoning and operation zoning. The strengths and weaknesses of each are discussed and examples given. The report also presents methods for optimizing safeguards or security through the establishment of certain kinds and mixes of work rules.

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Central Alarm Station and Secondary Alarm Station Planning Document

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ABSTRACT

This report documents planning guidance for Central Alarm Stations (CAS) and Secondary Alarm Stations (SAS) as provided by the U.S. Nuclear Regulatory Commissions Upgrade Rules issued in final form in FR Vol. 44, No. 230, Wednesday, November 28, 1979. It provides basic considerations for sites licensed by the NRC to possess or process formula quantities of strategic special nuclear material relative to (CAS) and (SAS) siting, construction planning, intrusion detection systems, communications, operation considerations, miscellaneous equipment and information control.

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LIST OF FIGURES

1. INTRODUCTION

The purpose of this report is to provide basic planning information and guidance relative to Central Alarm Stations (CAS) and Secondary Alarm Stations (SAS) which are provided in the Code of Federal Regulations CFR-10, Part 73.20,"General Performance Requirements", 73.45, "Performance Capabilities for Fixed Site Physical Protection Systems and Part 73.46, "Fixed Site Physical Protection Systems, Subsystems, Components and Procedures". Specifically, planning information is provided for CAS and SAS siting, construction and support, intrusion detection, communications, operational considerations, miscellaneous equipment and information control at sites possessing or processing formula quantities of strategic special nuclear material.

The report does not cover the specific design or selection of site intrusion detection systems, communications or security operation except as related to interfacing with the CAS or SAS.

The report is a planning guide only and all designs or modifications of CAS or SAS facilities should be accomplished by a qualified architect or engineering group or firm or specific equipment specialist as required.

References and an appendix are provided to facilitate acquisition of additional information.

The application of the planning information and selection of options should also be reviewed with the NRC prior to significant investment or adaptation since the physical characteristics and operational requirements vary from site to site.

2. SITING

2.1 SITING, GENERAL

Part 73.46(e)(5) provides for "...a continuously manned central alarm station located within the protected area and at least one other independent continuously manned on-site station not necessarily within the protected area..." Additionally, it is provided that "The central alarm station shall be located within a building so that the interior of the central alarm station is not visible from the perimeter of the protected area."

It is recommended that the CAS and SAS not be co-located within the same building. However, if it is necessary or cannot be avoided, the building and CAS and SAS should be of fire-resistive construction Type A, B or a protected non-combustible construction per National Building Codes.

If the CAS or SAS is located within an existing building, the building should be Type A or B fire-resistive construction, protected non-combustible construction as defined by National Building Code, or the building at a minimum, should have a Class A roof and a sprinkler and fire alarm system.

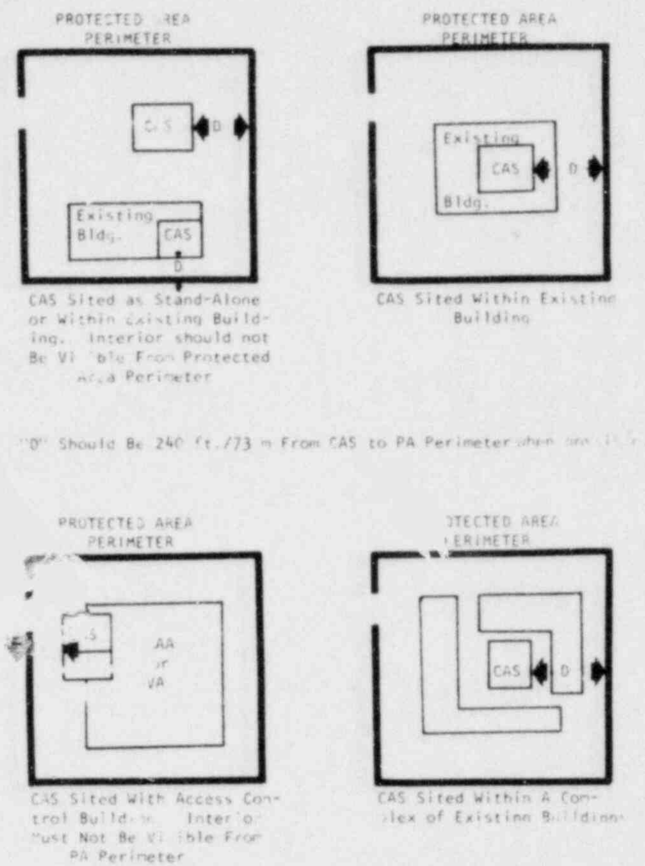
Physical separation of the CAS and SAS by a minimum of 240 feet (73 m) is a desirable planning feature. In no case should the CAS and SAS share a common wall.

2.2 CENTRAL ALARM STATION (CAS) SITING

The CAS should be located within the licensee's protected area. When designing and/or relocating the CAS, it is recommended that it be sited within the protected area perimeter by a distance of 240 feet (73 m) or more to minimize potential damage due to explosives which might be thrown into or placed within the protected area for sabotage purposes. This is equivalent to the protected distance required for up to 100 lbs. (45 kg) of Class 9 explosive to limit damage to "minor damage only". Reference Number 1. It is particularly important that either the CAS or SAS meet this criteria. See Figure Number 1 for Siting Options.

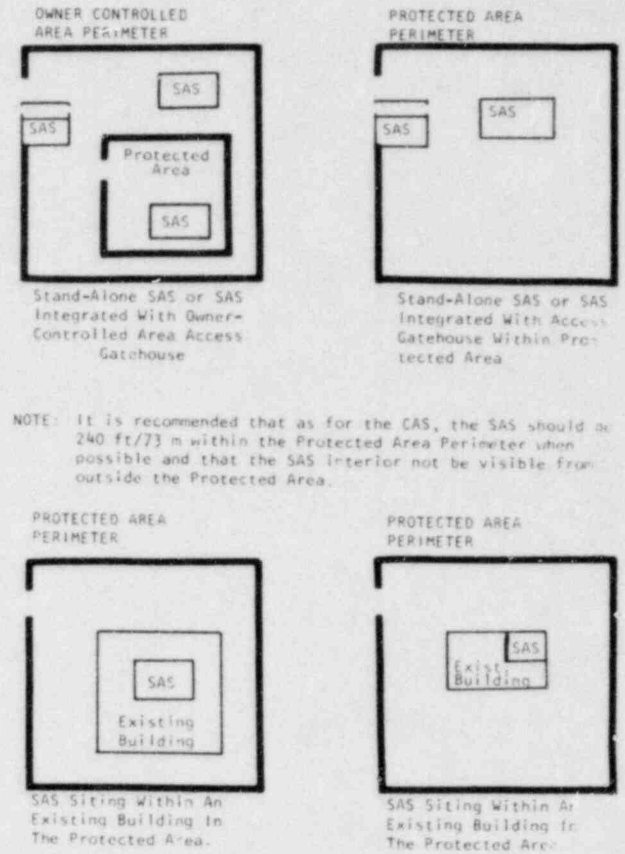
The interior of the CAS should not be visible from the protected area perimeter. This may be accomplished in several ways including:

- Windowless stand-alone structure with door opening on side not visible from protected area perimeter.
- Located within an existing building perimeter such that the interior is not visible from the protected area perimeter



TYPICAL CAS SITING OPTIONS

Figure 1



TYPICAL SAS SITING OPTIONS

Figure 2

- Located within an area not visible from the protected area perimeter (surrounded by buildings, structures, or geologic barriers).

- "One-Way Mirrored Windows" Note: Light must be balanced such that the interior is not visible under day, night or artificial lighting conditions. See Section 3.4.

- Indirect one-way observation devices such as peepholes, periscopes, or fiber optics. See Section 3.8.2 and 3.8.3.

2.3 SECONDARY ALARM STATION (SAS) SITING

Part 73.46 provides that a second independent alarm station (Secondary Alarm Station SAS) should be provided on-site. On-site is defined as within the owner-controlled area or outside, within or contiguous to the protected area. Typical SAS siting options may be the same as those noted for CAS in Figure 1 or those noted exclusively for the SAS in Figure 2. It is recommended that the SAS interior not be visible from the protected area perimeter if possible. If the SAS is also serving as a site observation post of significant security value, it is recommended that one-way or remote observation techniques be utilized. See Section 3.4 and 3.8.

For licensee sites with two protected areas within the contiguous licensee-controlled areas, it is suggested that each protected area have a separate and independent alarm station with one serving as a CAS and the other as the SAS. If more than two protected areas are in the same contiguous licensee-controlled area one CAS and one SAS are normally sufficient. Backup power distribution, wire type telephone and communications links, duress, CCTV links and intrusion alarm data gathering wire systems should be buried underground between protected areas.

3. CONSTRUCTION PLANNING

3.1 CONSTRUCTION PLANNING, GENERAL

This section provides basic planning guidelines for the adaptation/modification of existing facilities or construction of a new CAS or SAS facility. In some cases, typical information is provided and it is not meant to exclude other valid configurations which may meet NRC requirements. In all cases, before any significant investment is made by a licensee, it is recommended that specific site planning be accomplished with an experienced architect or engineering firm or group and that a review of the planning be provided by the NRC.

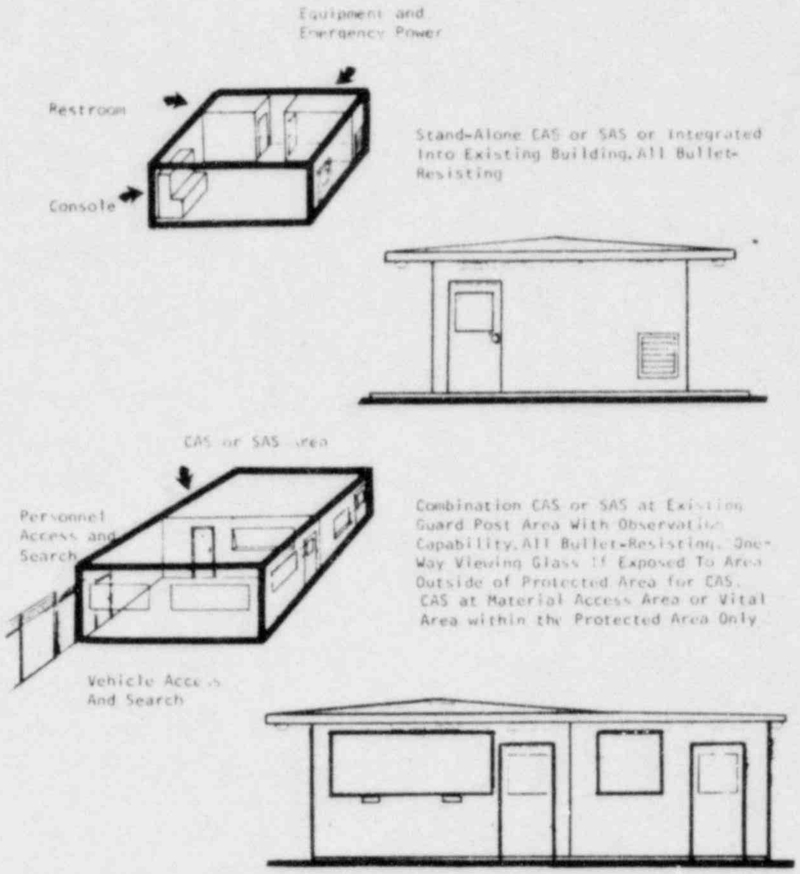
3.2 TYPICAL CONFIGURATIONS OF CAS AND SAS FACILITIES

Figures 3 and 4 provide several sketches of typical CAS and SAS configurations.

The CAS and SAS can be either a stand-alone facility or integrated into or on existing buildings. They may be windowless or have observation capabilities. Regardless of the construction configuration, siting should be in compliance with provisions noted in Section 2. They must also be bullet-resistant as noted in Section 3.3.

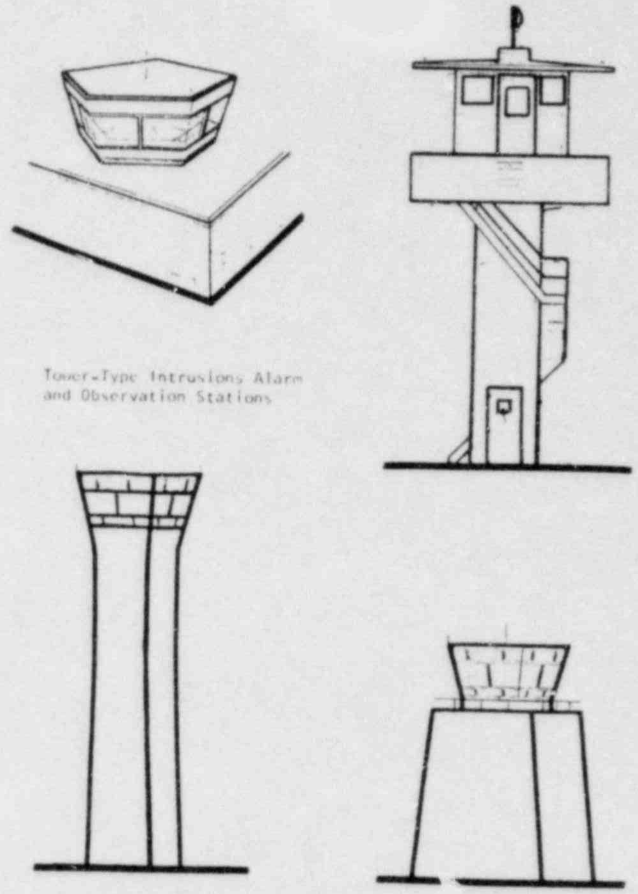
3.3 BULLET RESISTANCE

Part 73.46 (e)(5) provides that "the alarm stations shall be controlled access areas and their walls, doors, ceiling, floor and windows shall be bullet resisting". The bullet-resisting design and test criteria which is recommended is contained in the "Standard for Bullet-Resisting Equipment" UL 752, Fifth Edition, Reference Number 2. The defintion of "bullet-resisting" by UL "signifies protection against complete penetration, passage or fragments of projectiles, or spalling (fragmentation) of the protective material to the degree that no injury would be caused to a person standing directly behind the bullet-resisting barrier." It is used in conjunction with the rating of the bullet-resistant materials. The rating to be used for CAS and SAS is (High Power Rifle (HPR): .30-06 rifle; 24 inch barrel; 220 grain soft point ammunition; 2,410 fps muzzle velocity; 2830 ft-lb muzzle energy). Materials, or equipment procured for bullet-resisting purposes should be clearly marked with its UL rating. Figure 5 shows a typical marking. Criteria for performance testing bullet-resisting materials is included in the Appendix as taken from the December 8, 1976, update of UL 752. If the material utilized by the licensee is not UL listed, it will be necessary for the licensee to provide to the NRC documented evidence that the material used will meet the UL specification or certified test results. Note that Appendix B is provided for information and all of the materials do not meet the UL HPR rating level. Also many vendors are



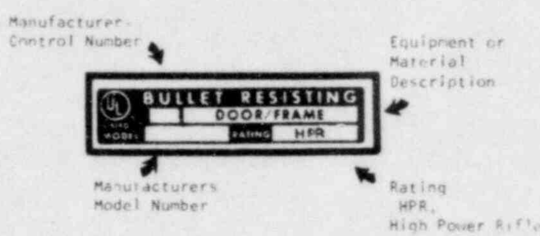
TYPICAL CAS AND SAS CONFIGURATIONS

Figure 3



TYPICAL CAS AND SAS CONFIGURATIONS

Figure 4



UL MARKING FOR BULLET-RESISTING MATERIAL

Figure

noted who do not necessarily provide UL listed materials to the HPR rated level or do not use the UL test criteria.

High-hardness armor steel is produced by several firms to Mil Specifications in thicknesses of 3/16 in. to 3/8 in. Standard armor steel is manufactured to Mil Specification MIL-A-12560. MIL-S-46100 is approximately 20-30% more effective than MIL-A-12560. (Reference Number 3). Dual hardness steel "Ausform Dual Property Steel Armour (DPSA)" is the lightest weight metallic armor available for defense against small caliber ball projectiles (Reference Number 3 and 12). Another DPSA is DHA-3 or DHA-2.

Ceramic armor is most effective when bonded to an aluminum or a glass reinforced plastic laminate. In this case the outer ceramic layer shatters the projectile and the inner layer catches the pieces. (Reference Number 3, 4, and 12). Its weight is quite a bit less than a dual hardness steel. For applications where weight is a key consideration ceramics may be effective as cost/weight trade-off, otherwise they are relatively expensive for "building" materials.

Most resin-filled fiberous glass and other laminates such as DuPont's Kevlar 29 or 49 are not designed to resist high power rifle projectiles. Contacts with DuPont representatives indicate that Kevlar is not specifically designed for high power rifle bullets (Reference Number 6). Most testing for glass and Kevlar laminates is done for light weight body armor designed for protection from fragments and other lower energy projectiles. (Reference Number 7 and 8). Kevlar 29 and 49 and woven glass also provide an effective backing for ceramic armor systems, such as B_4C. In these systems, the ceramic armor breaks up the projectile which is then caught by the glass or Kevlar. (Reference Number 9). With this in mind, it is possible that a fiberglass or Kevlar liner inside a concrete block building could provide adequate bullet resistance for walls. However, no test information is available. This liner could be in the form of a resin-filled laminate fastened to the wall or draped fabric, or attached with battens or located between the concrete wall and interior sheet rock or interior finished panel.

Bullet-resistant concrete walls, roofs, or floors can be provided with a minimum of 6-inch thick reinforced concrete. Floors can be poured on ground and raised to the proper position or poured in place over temporary forms. Walls and roofs can be poured in place or on the ground and raised to their final position. Walls should be reinforced with #4 rebars on 18-inch centers. Roof and floor reinforcing will depend on installation loads, span, etc. Typically, walls will utilize 3,000 PSI concrete and prestressed roofs, floors or walls (if a high rise observation post/tower is contemplated) will utilize 6,000 PSI concrete subject to specific design. Reference Number 10.

Other concrete, including cellular and fiber-reinforced cellular, have been tested (Reference Number 11). These materials were tested in configurations 6 inches thick of foamed concrete, both with and without

.9 lbs/cubic foot of glass fibers. Air made up .45 cubic feet/cubic foot of the concrete. Penetration of 7.62 mm projectiles was limited to 1 1/2 to 3 inches. This material merits further consideration in areas where weight is a limiting factor.

The standard transparent bullet-resisting material for a HPR rating is laminated glass. UL rated glass is available. Two inch thick glass should not be confused with two inch thick acrylic, polycarbonate or other plastic type material.

Many bullet-resisting materials are available off-the-shelf, can be fabricated to specification, built in place, added to existing facilities or complete prefab bullet-resisting alarm/guard stations can be procured. The following paragraphs describe some of the options. Military armor specifications, as a matter of interest, are included in Appendix D.

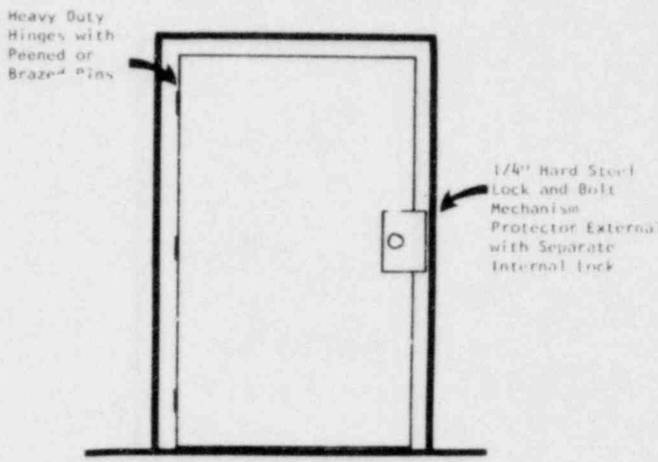
3.3.1 Doors

Bullet-resisting doors, frames, and hardware are typically steel-skinned with hardened steel, ceramic composites or reinforced laminate armor. Appendix I, Table I provides the identification of manufacturers of prefabricated doors. See Figure 6.

3.3.2 Walls, Ceilings and Floors

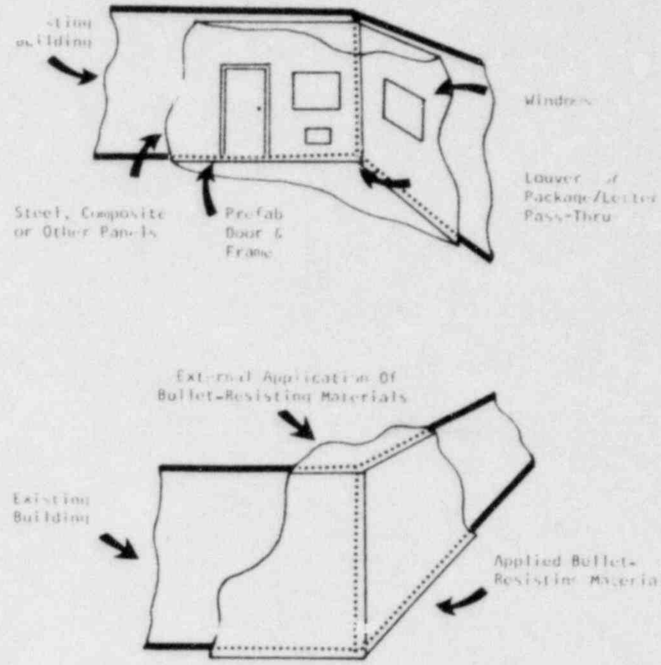
A partial list of suppliers is noted in Appendix B. Corners, doors, frames and other hardware should be continuously bullet-resisting. Cracks or weak spots which do not meet the UL standard should be avoided. Vision panels, "pass-thrus", gunports, etc. should be of the same bullet-resisting specification.

Materials for walls, ceilings, and floors may be high strength steel, reinforced laminate armor, ceramic composites, reinforced concrete or other materials. They may be applied in existing buildings or integrated during construction of the CAS or SAS. In both cases an architect should be involved in review and specification to assure proper ceiling, wall and floor structural integrity. Prefab bullet-resisting structures are also available. If floors are slab-on-grade, no bullet resistance treatment is required. See Figure 7. Trenches or a raised floor (computer room type) may be useful if extensive cables and junctions are required. Reference Appendix B, Table II.



CAS AND SAS DOOR CONCEPTS

Figure 6



APPLICATION OF BULLET-RESISTING MATERIALS TO EXISTING FACILITIES

Figure 7

3.3.3 Windows

Materials for transparent armor are typically glass, plastic or a laminated combination. Prefab windows made up as "teller windows" are available as well as window material made to specification. In most cases the supplier will have to cut the transparent armor to size prior to delivery as many difficulties can be encountered in cutting. See Section 3.3.7. Reference Appendix B, Table III.

3.3.4 Pass-Thrus

Bullet resistant pass-thrus are available and utilized by the banking industry for example. They provide bullet resisitant capabilities of transfering documents or packages through a protected device without having to provide access to the CAS or SAS. Many of these devices are manufactured and made ready for installation. Reference Figure 8. Reference Appendix B, Table IV.

3.3.5 Louvers

Louvers can be procured which meet physical and bullet resisting requirements. Louvers would be typically utilized for air conditioning, return air, etc. Reference Miscellaneous Openings Section 3.9 and Appendix B, Table V. See Figure 9.

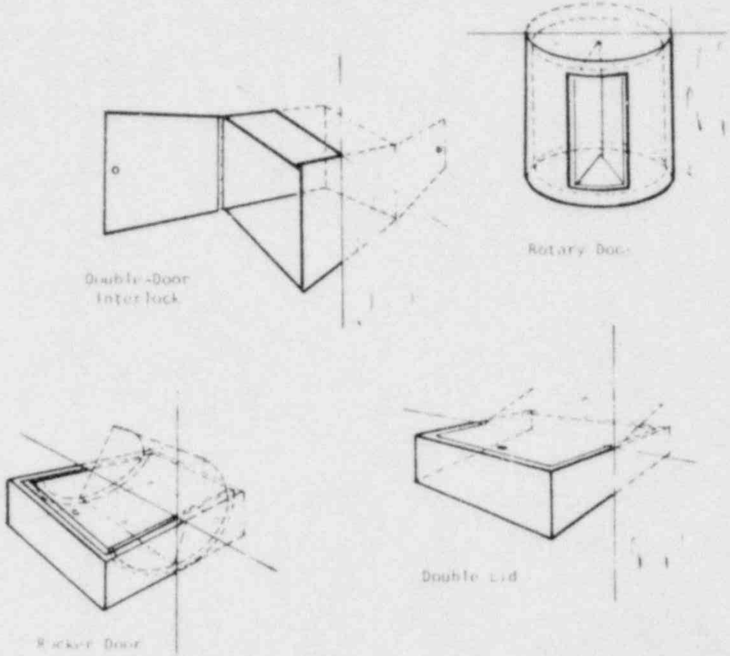
3.3.6 Gunports

The CAS or SAS is not to be used as an offensive response facility. For defensive purposes gunports may be desirable. Bullet-resisting gunports would be required if gunports are utilized. Also reference Appendix B, Table VI.

3.3.7 Bullet-Resisting Materials and Equipment Installation

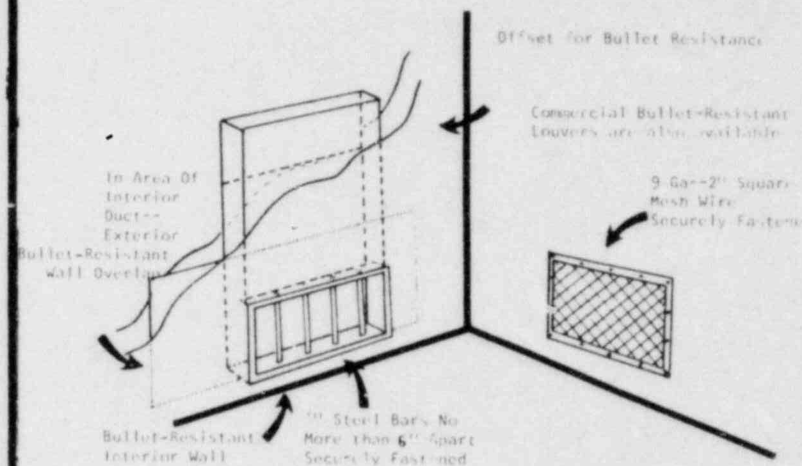
As noted, many bullet-resisting materials and fixtures can be procured raw, as a subassembly (a teller window, pass-thru, door, etc.) or a complete prefabricated building. When possible, finished component utilization may be the best method of acquiring bullet-resistant capability since it eliminates cracking, annealing and other problems which might be involved in custom installations and on-site fabrication.

In all cases strict adherence to the manufacturer's installation, use and maintenance requirements should be followed. Guidance of an experienced architect and/or engineering firm is recommended.



TYPICAL DOCUMENT AND P CKAGE PASS-THRUS

Fig. 8



NOTE: The above should be used openings of one square foot or more if the smallest dimensi ater than 6 inches.

PHYSICAL "ROTECTION SCELLANEOUS OPENINGS

igure 9

Many glasses and steels require cutting, fabrication and/or assembly prior to final processing or heat treating. Therefore in some cases drilling, cutting and/or welding can diminish the strength of the materials or cause failure if accomplished after factory processing.

Plastic transparent armor installation should take into consideration the exposure of the surface to chemicals and abrasion. Cutting, edge polishing, and forming of all transparent armor should be done to manufacturer's specifications. The use of counter-sunk screws, self-tapping screws, slots, and notches are discouraged as they can cause stresses and weaknesses in transparent armor.

Windows of transparent bullet-resistant material and one-way glass should be installed in accordance with the manufacturer's specification and hardware which has been appropriately UL approved. Windows should offer substantial intrusion resistance as well as bullet resistance. If, for some reason, it is not possible to provide a substantial mounting for the bullet-resistant window, then they should be fitted with solid one-half inch bars (separated by no more than six inches), plus cross bars to prevent spreading, or wire mesh securely fastened on the inside.

If the CAS or SAS serves as an observation post, the windows should be installed at an angle of approximately 15° with the top leaning out if a tower or second floor is used or leaning in or out if at ground level. This will minimize reflections from within the CAS or SAS and interferance with observation requirements. Consideration should also be given to designing the window such that the external layer is of glass to minimize maintenance and possibility of scouring from fire or chemical application. One-way glass should be installed on the inside of the bullet-resisting glazing.

3.4 VISUAL ISOLATION OF WINDOWS

Part 73.46 (e)(5) provides that "the central alarm station shall be located within a building so that the interior of the central alarm station is not visible from the perimeter of the protected area." If it is necessary for the CAS or SAS operations to have direct visual observation through windows, and as a result this makes the interior of the CAS or SAS visible from outside of the protected areas, "one-way" mirrors may be utilized to prevent observation of the interior. Large panes of one-way mirrored glass are commercially available in clear, gray or bronze. They are known by various trade names such as "Duovue", "Mirror Pane" or "TransView" for example. Thicknesses available range from 1/8 inch to 3/4 inch. Light transmitted through the glass is approximately 8% for clear and 4.5% for gray or bronze. Other reflective glass not specifically designed for one-way viewing could possibly be utilized and has 7 to 30% transmittance. One-way glass requires a higher light level on the unsecured side than on the secured or observer side. Typically for the clear one-way glass this ratio is 8:1 to 10:1. For bronze or gray glass, it is typically 4:1 Reference Lighting Section 3.5. Note that windows also should be bullet-resisting as recommended in Section 3.3.3.

As noted in Section 3.3.7, observation windows of a relatively large size should be installed at an angle to minimize internal reflection problems which are particularly troublesome at night or during periods of low external light levels. The use of both transparent, bullet-resisting material and one-way viewing mirrors will further compound this problem. If it is intended to view the protected area or protected area perimeter which at night, may have only .2 footcandles of light available, it may be found to be impractical to use this combination since the interior of the CAS or SAS would only be "seeing" an equivalent of .01 to .025 footcandle through the window. See Figures 10 and 11. This will require near darkness in the CAS or SAS. Experimentation at the specific site is suggested prior to major commitments. External lights in the close proximity of the exterior window could be directed to "wash" the window without shining into the CAS or SAS.

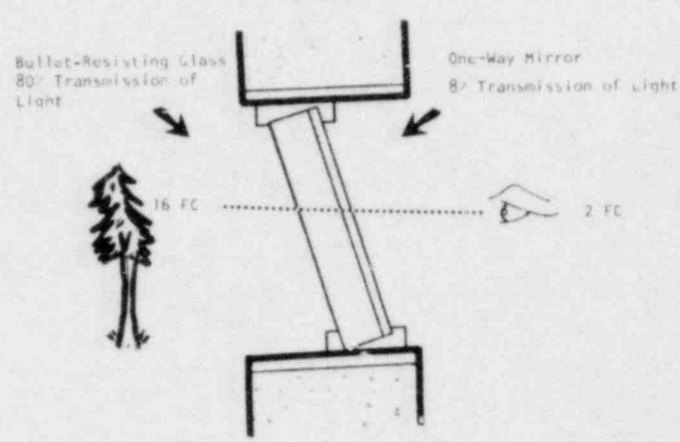
At the door to the CAS, if one-way mirrors and bullet-resisting transparent armor are utilized, the exterior light in the door area should be bright enough to preclude viewing from the protected area perimeter.

3.5 LIGHTING

3.5.1 Interior Lighting

Reference Section 3.4 if one-way viewing mirrors are to be utilized. Since most CAS's and SAS's will contain closed circuit television (CCTV) monitors as well as intrusion alarm console lights, consideration must be given to lighting levels which will not degrade significantly the ability to view these devices. The overall lighting should be kept low with a separate circuit for high level lighting for maintenance or other purposes. It is possible to provide high intensity local lighting for reading, etc. with desk/drafting-type lamps where required, therefore avoiding high intensity room wide. It is important not to have light placements which cause reflections on the CCTV screens. High level lighting for maintenance purposes can range from 50 to 100 footcandles. For security operation purposes, it is recommended that a variable lighting level (rheostat-contolled) be installed on a separate circuit. Since the CAS and SAS design, console design, CCTV monitor designs and sizes are quite variable, the variable lighting level will allow the operator to adjust to a comfortable level. To assure reasonable contrast on CCTV monitors, the room light level may be as low as 1 footcandle. The suggested level is from 1 to 10 footcandles at the

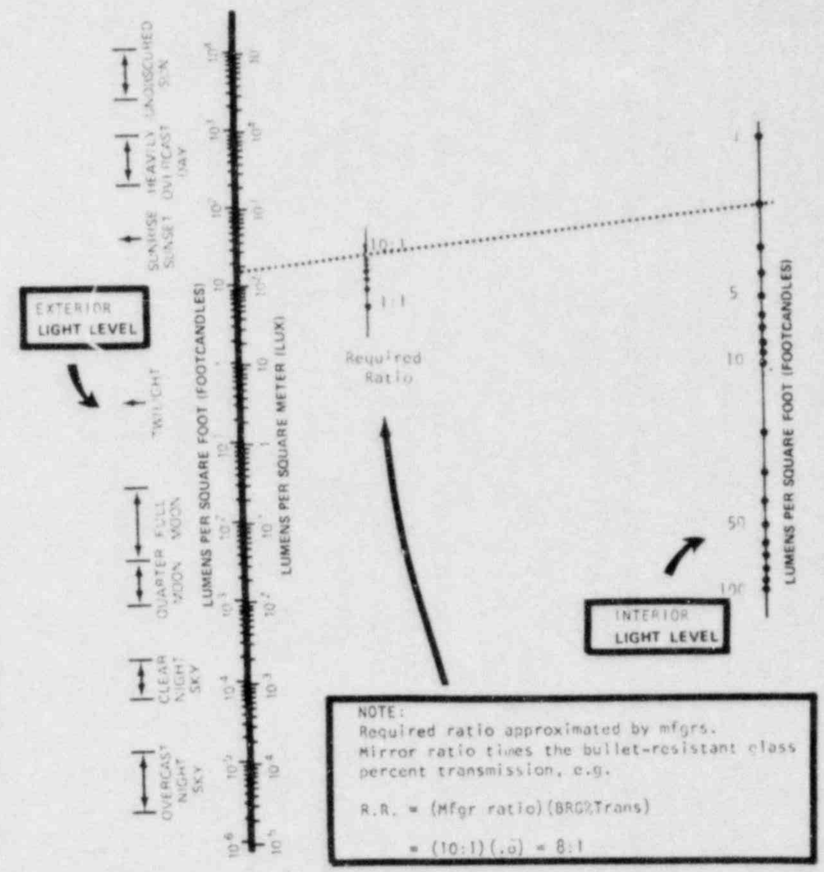
EXAMPLE



If There Are FC's Outside	Inside There Will Be FC's
16	2
.2	.025
800	100

ONE-WAY VIEWING MIRROR LIGHT RATIOS

Figure 10



APPROXIMATE EXTERIOR/INTERIOR LIGHT RATIOS FOR ONE-WAY MIRRORS

Figure 11

CCTV console. Reference air traffic control room lighting levels, Reference Number 13. Variable intensity lights work best if of an incandescent type since fluorescents tend to flicker at low levels and should be installed in a recessed ceiling fixture or other area which will provide indirect light for the CAS or SAS interior. Low cost, wall-mounted emergency light (continuous charge) are also recommended. If the CAS or SAS is utilized as a windowed observation post, ceiling lights should be recessed and/or have a parabolic type lens which provide vertical light only.

3.5.2 Exterior Lighting

If the CAS or SAS is in the proximity of an access control gate or perimeter fence, the lighting levels will be from .2 footcandle to 2 footcandles. If the CAS or SAS is a stand-alone building, it is recommended that the exterior lighting should be designed for a 2 footcandle level to provide illumination for security patrol purposes. These lights should be installed such that they do not shine in the eye of approaching vehicle drivers, etc. causing a hazardous situation. Whether the CAS or SAS is within a building or stand-alone, it is important to have lighting at the access door which is adequate for personnel identification prior to entry. This lighting level should be 30 footcandles minimum and/or the level required for the selected remote identification system (CCTV, fiber optics, peepholes, etc.)

3.5.3 Interior/Exterior Lighting

Consideration for external and internal lighting ratios will depend on whether or not one-way mirrors are utilized. Reference Section 3.4.

3.6 PHYSICAL SECURITY OF DOORS

The recommended physical security level for doors and hardware is noted in UL 1034 Reference Number 14. This level is designated as a relatively high level of physical security. Other applicable standards include UL 437, "Key Locks" (Reference Number 15); UL 768, "Combination Locks" (Reference Number 16); DOD 5200, "Industrial Security Manual for Safeguarding Classified Information" (Reference Number 17); Regulatory Guide 5.12, "General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials", 1973, (Reference Number 18) and Federal Specification FF-P-110F, "Padlock, Changeable Combination (Resistant to Opening by Manipulation and Surreptitious Attack)" (Reference Number 19).

A summary of planning guides follows:

- The locks, lock bolt, door bolt operating cam, and bolt operating linkage connected thereto should be protected by a tempered steel alloy hardplate located in front of the parts to be protected. The hardplate should be at least 1/4 inches in thickness and be in the Rockwell hardness range of C-63 to C-65. It should cover an area such that tampering with the bolt is precluded without removal of the plate.

- Door assemblies and components should incorporate no screw, bolt, pin, or other mechanical factor which is accessable from the outside and whose removal would permit entry by disassembly. Hardware accessible from outside the area should be peened, brazed, or spot welded to preclude removal.

- Heavy-duty builders' hardware should be used in construction and all screws, nuts, bolts, hasps, clamps, bars, hinges, pins, etc., should be securely fastened to preclude surreptitious removal and assure visual evidence of tampering.

- In addition to the lock accessible from the exterior of the CAS and SAS, doors should be secured from the inside with a panic bolt, a dead bolt, or a rigid wood or metal bar (which should preclude "springing") extending across the width of the door and held in position by solid metal clamps. This should be constructed of heavy duty hardware consistent with the class of security noted above. When this is used, an alternate route of emergency entry or method of forceful entry should be provided in case the operator becomes ill or incapacitated.

3.7 ENVIRONMENTAL CONSIDERATIONS

3.7.1 HVAC

Heating, ventilation and air conditioning (HVAC) is an important aspect of the CAS and SAS planning. It is recommended that air conditioning and heating be sized to provide a comfort range of 68° to 72° F. Due to the general monotony of the CAS and SAS job assignment and the need to maintain alertness at a level greater than many other assignments, the area should not be subjected to "economy" temperature measures.

Ducting into and out of the CAS and SAS should be intrusion resistant as noted in Section 3.9. Additionally it is recommended that a switch within the CAS and SAS be available to the operator to allow shutdown of the air circulation system and that ducts be designed to facilitate closing by the operator to prevent the introduction of smoke or irritants if required. An alternate, concealed source of fresh air may be considered.

Air conditioning and air handling equipment should consider the heat load generated by the alarm station and communication console, battery charging equipment, etc. Ventilation consideration for gas generated by battery chargers should be considered. See Section 3.11.

If equipment is temperature or humidity (static electricity) sensitive (as many computers and solid state devices are), it is necessary to assure emergency power and air conditioning to provide 8 hours of emergency back up environmental control. All equipment within the CAS and SAS should have manufacturer's specifications reviewed for temperature and humidity tolerance levels.

3.7.2 Noise

If alarm console and equipment (such as ventilating fans, computer disc operations, computer printer operations, etc.)are noisy, consideration should be given to interior accoustic treatment on the ceiling and/or walls or a separate room for noise generating equipment. Emergency generators will require significant accoustic and vibration isolation. Transformers, solid-state power supplies and battery chargers can also cause significant and distracting noise and should be soft-mounted with consideration for accoustic isolation.

3.7.3 General Finish

General interior equipment, walls, ceiling etc. should have a non-reflective surface to avoid distractions. If the CAS or SAS is utilized as an observation post (with angled windows) the ceiling and fixtures as well as the walls should be painted a dark flat color to minimize internal reflections during both daytime and night time observation.

3.8 OBSERVATION CAPABILITIES

3.8.1 Observation Capabilities, General

If properly protected (i.e. bullet resistant), the utilization of a CAS or SAS as an observation post is not inconsistent with its operational purpose. However this is only true if all intrusion detection devices provide an audible alarm (including CCTV devices) when violated, upon failure, or when tampering occurs.

3.8.2 Remote Observation Concepts, Access

Remote observation capabilities from the CAS and SAS can be accomplished by CCTV, peepholes, bullet-resistant glass, fiber optic devices, or periscopes. The remote observation method should not degrade the bullet resistance of the CAS or SAS. Figure 12 provides typical configurations which may be utilized.

Planning guidance for CCTV systems is provided in NUREG 0178, "Basic Consideration for Assembling a Closed Circuit Television System", Reference Number 20 and "Intrusion Detection Systems Handbook Volume II", Reference Number 21. Specific guides for CCTV systems which monitor material access areas and vaults are covered in Section 4.8. CCTV may be installed to provide access verification prior to entry into the CAS or SAS. For this purpose lenses are available which will provide an image of the individual as well as a close-up of the individual's badge at the same time.

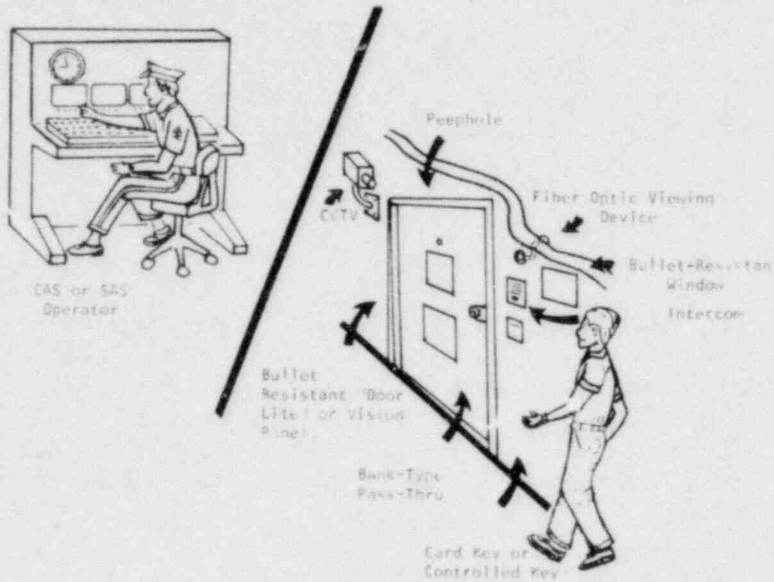
Bullet resistant one-way viewing mirrors are covered in Sections 3.3, 3.4 and 3.5.

Fiber optic devices provide an indirect viewing device which does not have to go straight through the wall or door but can be offset to provide bullet resistance. Conduits can be installed in places which form a "S" near the door. They can remain plugged except during use when a flexible fiber optic viewing device can be inserted. Fiber optic devices could also be installed permanently. Reference Figure 12.

3.8.3 Observation Concepts, Area

Several methods for observation from the CAS or SAS, in addition to bullet-resistant glazing, are available as noted in Section 3.8.3. Zoom, pan and tilt CCTV cameras may be utilized if additional area coverage is required as shown in Figure 13.

Fiber optic viewing systems can be installed in the wall or door which provide an indirect line-of-sight. This may assist in minimizing problems with bullet-resistant observation capability.



CAS AND SAS ACCESS AUTHORIZATION IDENTIFICATION OPTIONS

Figure 12

Periscopes may be fabricated utilizing prisms or mirrors as shown in Figure 13 or procured (such as military surplus or hunting spotting scopes). Installation should provide an indirect line-of-sight which is inherently bullet-resistant.

Standard hardware peepholes may be installed in either the door or wall. Also bullet-resistant "lites" or windows may be installed in doors or walls. See Sections 3.3, 3.4 and 3.5.

3.9 MISCELLANEOUS OPENINGS

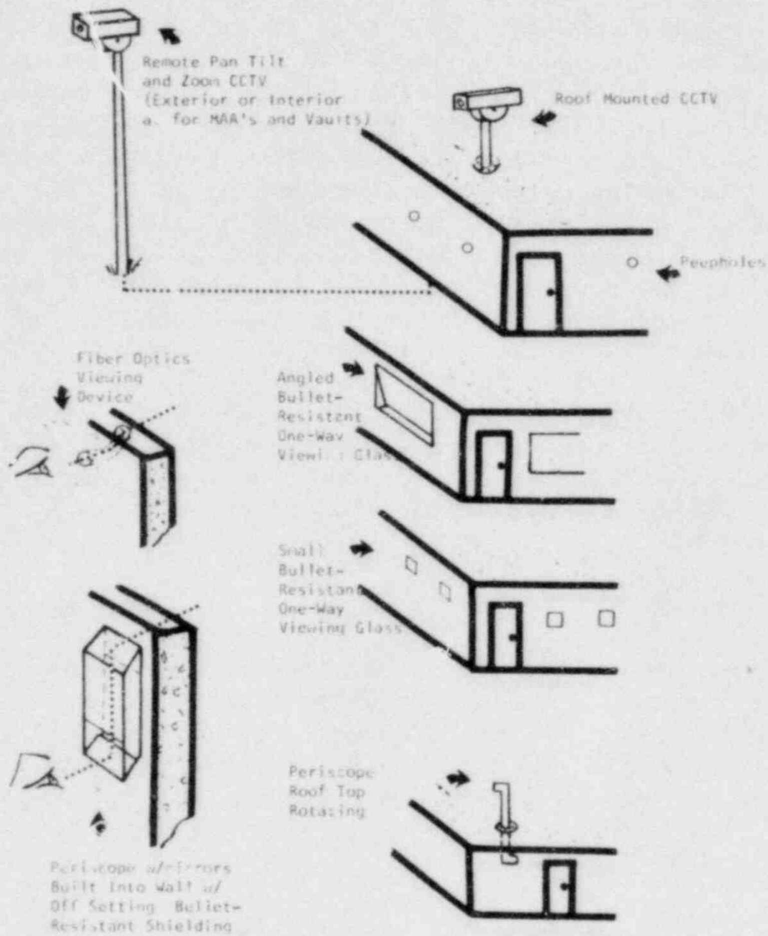
Where ducts, registers, sewers and tunnels are of such size and shape as to permit unauthorized entry, (areas greater than 1 square foot unless one dimension is less than 6 inches) they should be equipped with man-safe barriers such as wire mesh (No. 9 gauge, 2-inch square mesh-Fed. Spec. RR-F-191d, Reference Number 22) or solid steel bars of at least 1/2 inch in diameter extending across their width with a maximum space of 6 inches between the bars. The steel bars should be securely fastened at both ends to preclude removal, with cross bars on 6-inch centers to prevent spreading. Where wire mesh or steel bars are used, care should be exercised to insure that equipment and material within the room cannot be removed or tampered with the aid of any type of instrument. Reference Figure 9.

Bullet-resistance should be continuous in the areas of ducts and openings. Figure 9 shows an overlapping bullet-resistant material to accomplish this. Bullet-resisting and access-resisting louvers are commercially available. Reference Appendix B, Table V.

3.10 PLUMBING

Plumbing will typically be required if a restroom is included within the CAS or SAS. If restrooms are available, the relief and/or operator rotation period may be extended. Additionally the availability of a restroom within the CAS or SAS secured area could provide for an extended siege or continuous emergency coverage. If a restroom is not provided, an emergency "camp-type" portable toilet is recommended for availability.

Additionally, plumbing is required for fire protection purposes in accordance with standard fire protection codes. U.S. Nuclear Regulatory Commission Regulatory Guide 1.120 (for comment), "Fire Protection Guidelines for Nuclear Power Plants", June 1976, (Reference Number 23) and "General Fire Protection Guide for Fuel Reprocessing Plants",



REMOTE EXTERNAL OBSERVATION CONCEPTS

Figure 13

NUREG Guide 3.38 (for comment), Reference Number 24, provide basic guidelines and planning criteria. Adequate drainage for fire protection water should be provided to assure that emergency exit can be accomplished without jamming doors, etc.

A water cooler within the CAS or SAS will require plumbing for water and drainage if tied in with the site water system. If a water bottle type is used, only drainage will be required. Since a water bottle type provides an independent supply of water for emergency use, it is recommended. As an alternative, plastic bottles (1 gallon) can be stored within the CAS or SAS for emergency use.

3.11 EMERGENCY POWER

Provisions cited in Part 73.46 (e)(6) state that "All alarms required by this section shall remain operable from independent power sources in the event of the loss of normal power. . .Switch-over to standby power shall be automatic and shall no cause false alarms on annunciation modules." The CAS and SAS can share a common emergency power system or they can have independent emergency power systems. The emergency power systems should provide power for CAS and SAS lighting, HVAC, alarm and communication subsystems for a minimum of 8 hours of continuous operation.

This may require a parallel power source which can be either a separate independent generator power source, uninterruptable power supply (UPS), a constantly charged battery source or a constantly charged battery source with automatic or manual starting generators. Starting capability should be considered for location within the CAS or SAS.

It may be desirable to have the radio/microwave communication system operate from separate emergency batteries within the CAS or SAS as well as internal lights (wall-mounted emergency lights).

The intrusion alarm system should normally run on commercially supplied AC power. Should this supply fail, an alarm indicating that it has done so should annunciate in the CAS and SAS both visually and audibly.

Note that power supply planning should include air conditioning required to keep communications and alarm equipment within operational temperature and humidity tolerances.

It is recommended that physical security protection (controlled access area) be provided for the emergency electrical power system and that power cables/lines into the CAS and SAS be underground to minimize tampering possibilities. If it is necessary to have emergency power routed between protected areas, this should be installed underground as well.

Outdoor generators and fuel supplies can be protected with a barrier of sandbags or a reinforced concrete wall (6 inches).

Other criteria for installation is included in:

- Regulatory Guide 1.108 "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants", August, 1977.
- Regulatory Guide 1.6, "Independence Between Redundant Standby (On Site) Power Sources and Between Their Distribution Systems (Safety Guide 6)", March, 1971.
- Regulatory Guide 1.9, "Selection, Design and Qualification of Diesel-Generated Units Used as Onsite Electric Power Systems at Nuclear Power Plants", November, 1978.
- Regulatory Guide 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Power Plants."
- Regulatory Guide 1.93 "Availability of Electric Power Sources," December 1974.
- Regulatory Guide 1.118 "Periodic Testing of Electric Power and Protection Systems." June 1976.
- Regulatory Guide 1.128 "Installation, Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants" (for comment) April 1977.
- Regulatory Guide 1.129 "Maintenance, Testing and Replacement of Large Lead Storage Batteries for Nuclear Power Plants," February 1978.
- Regulatory Guide 1.137 "Fuel-Oil Systems for Standby Diesel Generators" (for comment) January 1978.
- Regulatory Guide 5.44 "Perimeter Intrusions Alarm Systems", June 1976.
- NUREG 0320 "Interior Intrusion Alarm Systems" February 1978.
- NUREG/CR 0509, "Emergency Power Supplier for Physical Security Systems" (1979).

Backup and emergency power systems should be maintained in accordance with the manufacturer's specifications. Preventive maintenance and inspections should be scheduled accordingly, accomplished, documented and verified.

Power generators (diesel, gas or other) should be performance tested in accordance with references noted above. Operational tests (starting) the unit and operating it for a time adequate to bring it to operating power and temperature) should be accomplished weekly with or without load and monthly with load. It should be accomplished more frequently if recommended by the manufacturer. The security staff supervisor should confirm operation of all intrusion alarm, communication, security lighting, etc. during the test and subsequent to the test. These tests should be logged and records kept for two years. Vibration and accoustic isolation should be provided for generators.

Battery systems should be maintained in accordance with the manufacturer's specifications. Preventive maintenance and inspections should be scheduled accordingly, accomplished, documented and verified. Periodic testing should be accomplished as noted for generators (i.e. notification of security; operational test by security; post test of security equipment; and logging of the test).

3.12 FIRE PROTECTION, ELECTRICAL AND OTHER CODES

All construction and/or modification design, equipment selection, construction and operation shall be in accordance with appropriate standards and codes and/or special requirements noted in this planning document or elsewhere. This document is not intended to provide standard construction details or codes.

Particular attention should be given to lightning protection for the intrusion detection and alarm systems and console, emergency power systems and communications systems (antennas, etc.).

Fire protection design should conform to Fire Resistive Construction Type A, B or Protected Non-Combustible Construction as defined by National Building Codes.

Switchboards and consoles should be provided with water sheds permanently installed over the equipment if it is subject to flooding from fire sprinklers. Other systems, such as Halon, may be utilized.

Two portable fire extinguishers with a total of 20 B:C rating and one 2A should be located in the CAS and SAS.

The CAS and SAS should also be tornado and earthquake resistant.

3.13 DEFENSE CAPABILITIES

It is not intended that the CAS or SAS operator be a part of the response force. Additionally, bullet-resisting CAS or SAS facilities with physical hardening and other options recommended in this document provide significant operator defense capabilities. Although the CAS or SAS operator is not a part of the response force, it is recommended that side arms be provided and that the operator be qualified in their use for defensive purposes.

The use of gunports is optional and they should be utilized only for the defense of the CAS or SAS and not the site as a whole. Gunports can be used for defensive firing to keep adversaries away from the CAS or SAS or they can be used to eject irritant emitting canisters. It is a common practice at some prisons to have this capability at sally ports. Note that the use of such devices is subject to various federal, state and local laws. The gunport should meet bullet-resistance requirements as noted in Section 3.3.6.

Other defensive strategies could include a piping system around the perimeter of the CAS or SAS to dispense irritants, intense external sound or electric shock devices which could be activated when required (Reference Number 25).

Although none of the above unusual methods are required, they are available for consideration. Other than the gunports, detailed information on the above will require licensee research and investigation.

4. INTRUSION DETECTION

4.1 INTRUSION DETECTION, GENERAL

Provisions in 10 CFR Part 73.46, "Fixed Site Physical Protection Systems, Subsystems, Components and Procedures", Section (e), describes the intrusion detection provisions for nuclear fixed site facilities. Reference Numbers 20, 21, 26, 27 and 28 provide general guidance on exterior and interior alarm systems.

It is not the purpose of this document to define the various alarm systems except to the extent noted below:

- All intrusion alarms required should terminate at both the CAS and SAS.
- They should annunciate visually and audibly upon activation by an intruder.
- They should have an independent power supply capable of 8 hours of continuous operation.
- The independent power supply should not cause false alarms upon activation.
- The status of all alarm systems should be displayed at all times.
- Activation of the independent power supply should cause both a visual and audible alarm in both the CAS and SAS.
- All alarm systems should be tamper-indicating and self-checking or have self-checking capability.
- All indicators of tampering or failure should be annunciated at both the CAS and SAS both visually and audibly.
- All alarm annunciations should indicate the location of the alarm (by zone, building, door, room, etc.)
- Duress alarms should annunciate visually and audibly at both the CAS and SAS. Exceptions: If roving patrols utilize portable radios as a duress communication device, a visual alarm is not essential.

- All alarm systems should be repaired and maintained by two individuals working as a team. The security shift supervisor should be notified before maintenance begins and upon completion and should conduct operational verification tests.

- All alarm systems should be tested at the beginning and end of each use period, not to exceed 7 days.

4.2 INTRUSION ALARM REDUNDANCY

All intrusion alarms required should terminate at both the CAS and SAS so that a single act cannot remove the capability of monitoring, controlling, calling for assistance or responding to an alarm. Redundancy is defined to mean that both the CAS and SAS independently receive and annunicate the same alarm signal and monitor and control each alarm signal source/zone in the alarm reporting system. This requires that, at some point before the alarm signal reaches the CAS or SAS, it must be split or divided such that each receives an independent signal, which cannot be interrupted or incapacitiated by the other alarm station. For a simple system, this is illustrated in Figures 14 and 15 in concept. The redundancy requirement does not mean that identical equipment is required in both stations, but that each station can independently perform the same functions.

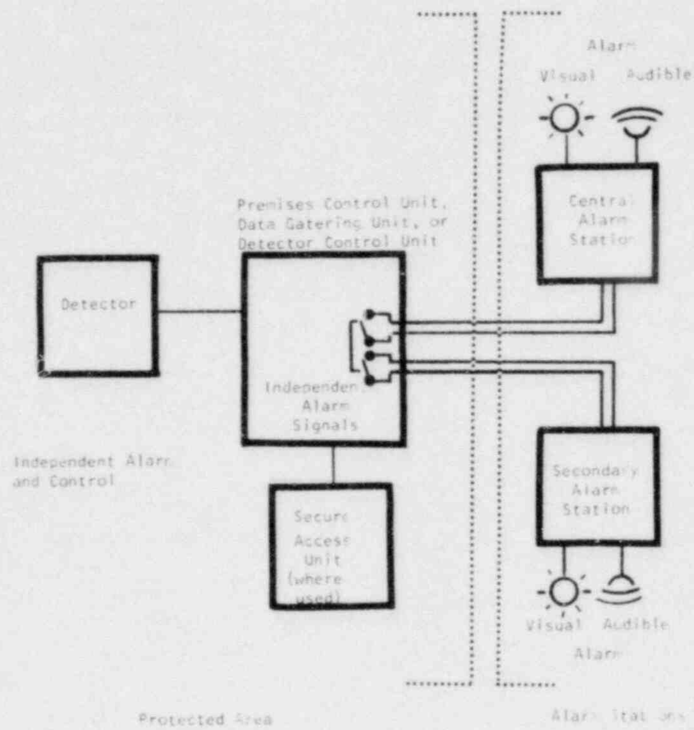
If the alarm systems is a more sophisticated system using multiplexed systems, computerized systems, or microwave transmission, the design should comply with the concept illustrated in Figure 14, even though the method may be somewhat different.

Note that the third observation post shown in Figure 15 is optional.

4.3 STATUS DISPLAY

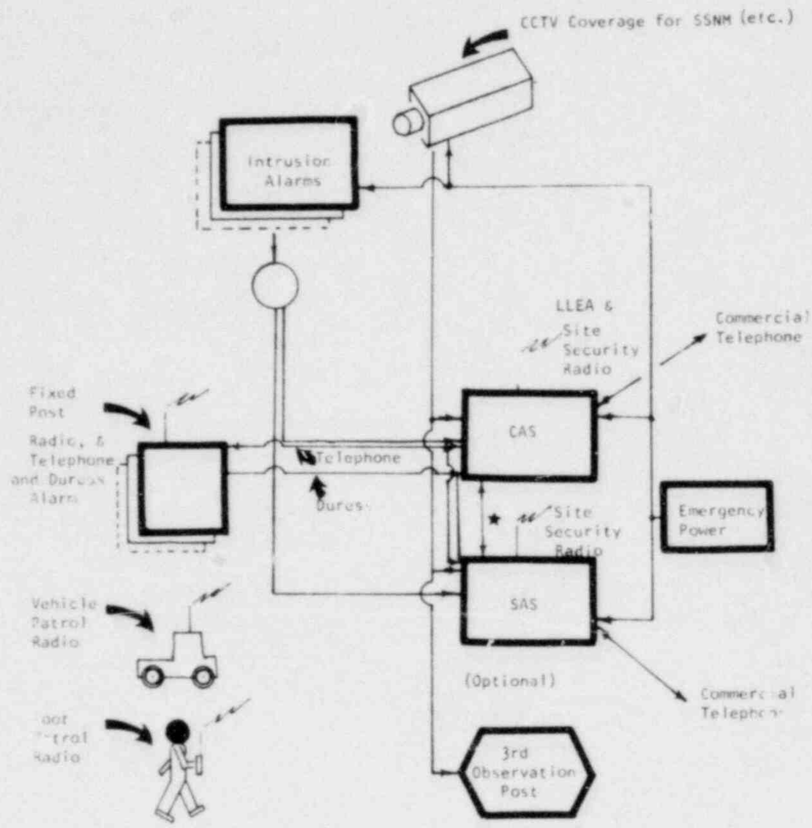
The status of each alarm intrusion detector should be displayed at all times. Typically this will be "secured" (alarm operational), "access" (alarm turned off) or "alarm" (alarm activated), It is not necessary that the CAS and SAS use the same status display scheme or type of equipment. When activated, the alarm system should provide the geographic location, time and date and the new status (alarm, false alarm, failure). The audible alarm should provide 85 db at a distance of 10 feet. A redundant audible unit should be provided.

All building and alarm openings and closings should be logged and verified by telephone or radio if scheduled or an assessment response should be initiated for unscheduled, non-verified alarms.



REDUNDANT INTRUSION ALARM CONCEPT

Figure 14



* Intrusion Alarm, Door
CCTV/Intercom
Duress Alarm
Telephone

CAS AND SAS CONC

Figure 15

4.4 TAMPER-INDICATING AND SELF-CHECKING

All alarm systems should be tamper-indicating and self-checking. Tampering or failure should cause an alarm at both the CAS and SAS (see Intrusion Alarm Redundancy, Section 4.2) in the same format as other alarm systems. Control boxes, junction boxes, lines, detectors and consoles, for example, are all included. Terminal boxes and junction boxes additionally should be secured in a closed position by welding or locked and sealed.

4.5 DURESS ALARMS

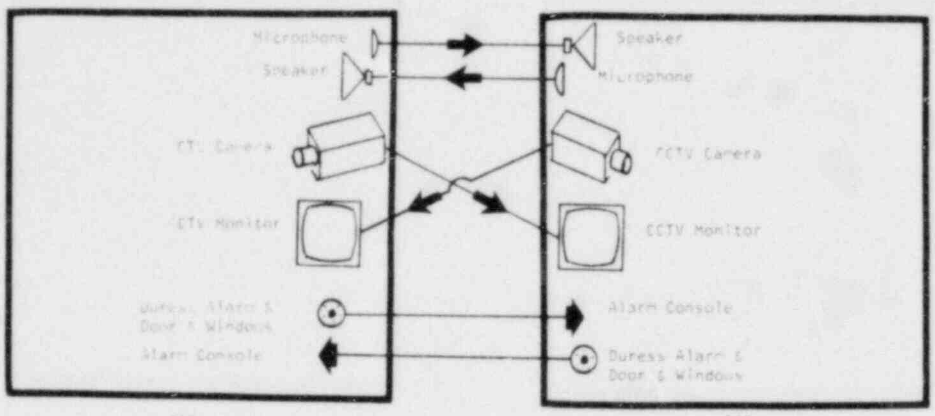
Duress alarms should be provided for all fixed security posts including the CAS and SAS. These alarms should annunciate visually and audibly at both the CAS and SAS. They should be redundant and have the same reporting format as intrusion alarms. For guards on roving patrol either a radio frequency linked alarm or a portable radio should be provided to call in alarm or duress codes. The duress alarm at the CAS should annunciate only at the SAS and the SAS duress alarm at the CAS. Reference Number 28.

4.6 CAS AND SAS INTRUSION ALARMS

Both the CAS and SAS should have intrusion alarms on doors and windows. The CAS intrusion alarm should annunciate at the SAS and SAS alarm at CAS. A continuous audio and/or CCTV link between the CAS and SAS is recommended. Reference Figure 16. A floor trap (pressure sensitive switch, etc.) external to the door of the CAS and SAS is useful to inform the operator of approaching personnel.

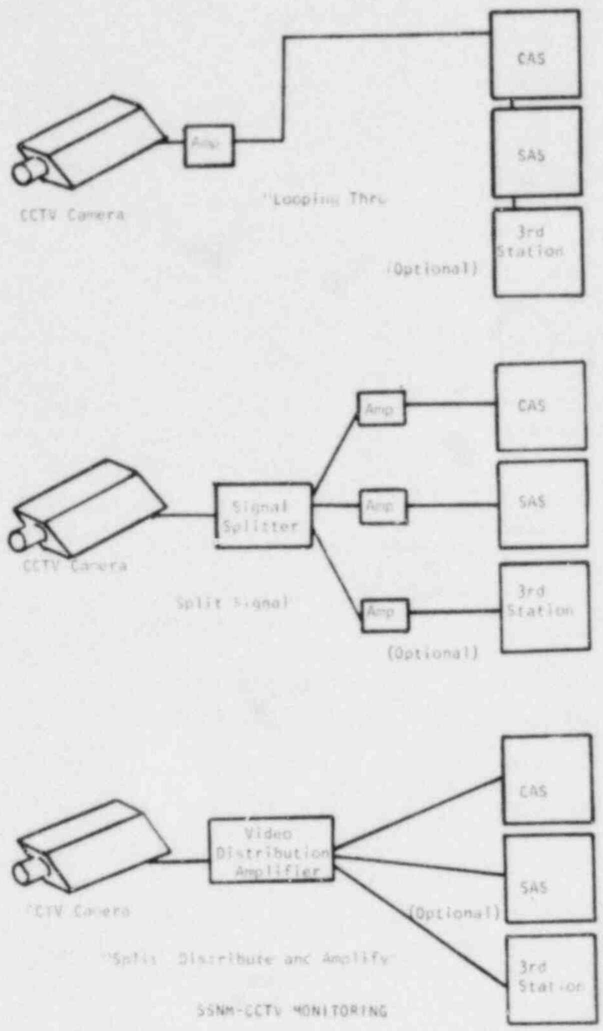
4.7 SSNM/CCTV COVERAGE

Vaults and process areas containing unencapsulated or unalloyed SSNM should be under the surveillance of closed circuit television that is monitored in both alarm stations. Additionally, means should be employed which require that an individual other than an alarm station operator be present at or have knowledge of access to such unoccupied vaults or process areas. The CCTV monitors can operate from a single camera (fixed) with a distribution amplifier, signal divider or looped-thru, provided that no individual in the CAS, SAS or third location can redirect the camera, turn it off or turn off the lights in the camera field of view. Reference Figure 17 for typical configurations. Note that the 3rd station is optional and the requirement for and location of a line amplifier is dependent upon the type of equipment utilized. CCTV signals may also be transmitted via microwave or non-coax wire system such as telephone lines, etc. Reference Number 20, 21 and 30. Reference Number 30 provides information on a tamper-resistant CCTV system.



CAS/SAS ALARM INTERFACE CONCEPTS

Figure 16



"Split, Distribute and Amplify"

SSNM-CCTV MONITORING

Figure 17

POOR ORIGINAL

4.8 INTRUSION DETECTION ALARM TRANSMISSION SYSTEMS.

It is recommended that intrusion detection systems which utilize cable or wire transmission have these cables and wires buried, where external to buildings and obstructions, concealed in protected inaccessable areas or open to visual surveillance within the buildings to minimize tampering potential. Junction boxes should be welded in a secured position or locked and sealed. Cables and wire systems should be enclosed in rigid conduit or metal per UL 681.

4.9 INSPECTIONS AND MAINTENANCE

Alarm equipment and circuits should be thoroughly inspected by qualified service personnel annually. They should also be thoroughly tested and inspected after maintenance, failure or system modification or expansion by the security organization. Maintenance should be accomplished in accordance with manufacturer's specifications. Spares should be considered for key areas and items which may require removal for repair purposes. Record of all maintenance activities should be kept for two years after occurance. A preventive maintenance schedule for inspection adjustment and calibration should be established. All maintenance and repair on-site will be accomplished by two trained individuals working as a team. All items repaired or provided from off-site will be inspected and tested by the two trained individuals before releasing them for use. Operation test procedures should be prepared for each alarm system and/or detector. Each alarm system should be tested at the beginning and end of each use period. If it is used continuously in excess of 7 days, it should be inspected each 7 days. If spare equipment is not online such that it can be activated by the CAS or SAS operator, it is recommended that call-out maintenance personnel be available within one hour.

5. C MMUNICATIONS

5.1 COMMUNICATIONS, GENERAL

Provisions in 10 CFR Part 73.46, "Fixed Site Physical Protection Systems, Subsystems, Components and Procedures", paragraph (f) "Communications Subsystems", provide that:

- "Each guard, watchman or armed response individual on duty shall be capable of maintaining continuou. communication with an individual in each continuously manned alarm station required by paragraph (e)(5). . . who shall be capable of calling for assistance from other guards, watchmen, and armed reponse personnel, and from law enforcement authorities."

- "Each alarm station required by paragraph (e)(5) of this section shall have both conventional telephone service and radio or microwave transmitted two-way voice communications, either directly or through an intermediary, for the capability of communication with the law enforcement authorities".

- "Non-portable communications equipment controlled by the licensee and required by this section shall remain operable from independent power sources in the event of the loss of normal power."

- "The licensee shall have a test and maintenance program for. . . communications equipment. . ." Test and inspections should be accomplished during installation and construction. Preoperational test and inspections, and routine operation test and inspection should also be accomplished. Communications equipment for on-site utilization should be tested at least once at the beginning of each shift. Off-site communications equipment should be tested at least once during each 24-hour day.

- A preventive maintenance procedure should be established for all communications equipment.

- All repairs and maintenance should be accomplished by two individuals working as a team and the security organization shall be notified prior to and after service and should conduct performance verification test.

5.2 FIXED CAS AND SAS COMMUNICATIONS

5.2.1 Telephone and Intercom

The CAS and SAS should each have a telephone. This telephone system may have intra-site intercom and telephone capabilities and intermediary switchboards, but at least one dedicated line/number for the CAS or SAS which is to be utilized for off-site and emergency communications only is recommended. This number should be unlisted.

Either a telephone or intercom communication capability should be available between all fixed security posts including the CAS and SAS. It is recommended that telephone and communication lines between the CAS or SAS and security post facilities be buried underground to minimize tampering possibilities or enclosed in cable trays which are not accessable.

Telephone power is normally provided by the telephone company, however switchboards and push button lights are powered by local power. The licensee should verify that telephone communications for security purposes are either on an independent power source or tie the system into a backup power system as required to provide communication between all security posts and from the CAS and SAS to the law enforcement authorities. Normally calls can be made from a phone during a power outage but in-coming calls may not annunciate.

Maintenance will normally be performed by the telephone company. This is not a required two man operation. However, maintenance should not be performed on-site without the explicit cognizance of the site security shift supervisor. The security shift supervisor should be notified upon beginning and completing the service. Upon notification of completion all security phones should be performance checked including a test call to the law enforcement authority.

5.2.2 Radio/Microwave

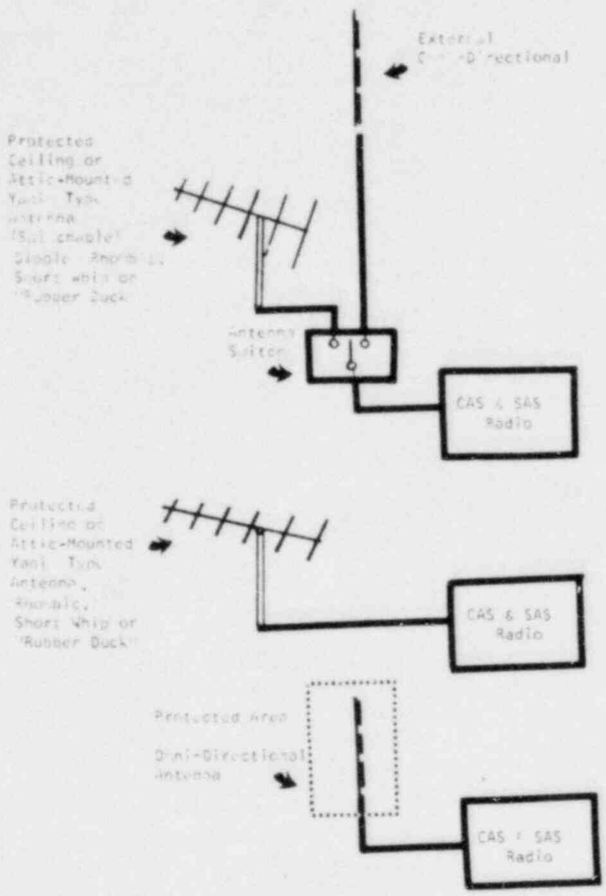
Both CAS and SAS should have radio/microwave communication capabilities for on-site security and off-site communications. A minimum of two frequencies should be available including the law enforcement authority frequency and a security dedicated on-site frequency. The law enforcement authority frequency should not be used for other than daily test and emergencies as required. Additional channels may be utilized for operations and maintenance, etc. However, these extra channels should not be used for security purposes except as backup emergency. The on-site fixed and portable security radios should have a range capable of communicating to any point within the owner-controlled area. The CAS and SAS radios should additionally be capable of communicating with the local designated law enforcement authorities fixed and continuously manned station. All security radios (portable and fixed) should have both the on-site frequency and law enforcement authority frequency.

Although external antennas may be utilized, they are subject to disablement by an adversary or perhaps weather extremes. Therefore, it is recommended that both the CAS and SAS have protected antenna or a backup protected antenna which can provide for communication both on-site and with the law enforcement authorities. Typically, omni-directional antennas are used for base stations. Generally, these are vertical antennas which are difficult to protect. As Figure 18 depicts, it is recommended that perhaps an attic, in-room ceiling, or non-visible low roof profile antenna be utilized as the antenna or backup. A yagi type may suit this purpose. The Yagi could be directed toward the law enforcement base station and at the same time radiate enough non-directional energy for on-site use. Other options include small in-room dipoles, rhombic, short whips or "rubber ducks". Consult with an appropriate communications engineer.

A backup power supply should be provided for CAS and SAS radio communication systems. This power source may be shared with the intrusion protection backup system or may be isolated and dedicated to each CAS and SAS fixed radio (utilizing a small separate battery system). Backup power should provide for a minimum of 8 hours of continuous communication. It is recommended that the manufacturer of the communications equipment be contacted to provide advice and possibly the equipment required. Radio failure should be detectable both visually and audibly.

5.2.3 INSPECTIONS AND MAINTENANCE

Intercom, radio and microwave equipment should be tested, inspected, calibrated and maintained in accordance with the manufacturer's recommendations. A routine preventive maintenance and inspection schedule should be established and utilized. A record of this maintenance should be kept for a period of two years. Planned maintenance for the CAS and SAS radios should not be done simultaneously. It is recommended that a spare fixed base radio for either the CAS or SAS be retained on-site by the licensee or available from the radio maintenance company or vendor to preclude CAS or SAS downtime during extended maintenance requirements. Maintenance should not be accomplished on communication systems without the explicit approval of the security organization shift supervisor. Although it is not essential that radio maintenance be accomplished by two individuals, it is essential that, upon completion of repair and return to service, that the performance of the unit be tested. Fixed radios at the CAS and SAS should be checked both for on-site communication as well as law enforcement authority communication. Range and voice clarity for both transmit and receive should be verified by an operational radio check.



TYPICAL PROTECTED ANTENNA CONFIGURATIONS

Figure 18

If spare equipment is kept available and on-line, it is recommended tha it be utilized 8 hours out of the 24 hour day to provide continuing assessment of its usability and status. If redundant spare equipment is not available which can be utilized by the operator, it is recommended that call-out maintenance be available within one hour.

6. OPERATIONS CONSIDERATIONS

6.1 OPERATIONS CONSIDERATIONS, GENERAL

It is the purpose of the following paragraphs to provide some operational considerations for the CAS and SAS. However, it is not intended to provide detailed orders or procedures as provided by 10 CFR Part 73.46. "The Standard Format and Content of Safeguards Contingency Plans for Fuel Cycle Facilities", Regulatory Guide 5.55, provides additional operation recommendations. (Reference Number 31).

- Written procedures including the operation of the CAS and SAS should be provided. Those pertaining to the CAS and SAS operation should be readily available at the respective stations and for emergency use and periodic review.

- Part 73.46 (b)(5) states that "within any given period of time, a member of the security organization may not be assigned to, or have direct operational control over, more than one of the redundant elements of a physical protection subsystem if such assignment or control could result in the loss of effectiveness of the subsystem". Therefore it is recommended that operators assigned to the CAS not be rotated to the SAS or those assigned to the SAS not be rotated to the CAS unless or until a complete cycle of alarm system, communication system and backup power for the same have been routinely performance checked.

- It is recommended that access to the CAS and SAS be limited to the operator, maintenance personnel as required and emergency personnel during emergencies. It should not be utilized for other general purpose security operations, meetings, training, etc.

- It is recommended that procedures be established such that the doors to both the CAS and SAS are not open concurrently. They should be kept closed and locked from the inside at all times. Before admission is granted the operator should assure that the other alarm station door is not open (via radio, telephone, CCTV or intercom).

- A specific list of personnel authorized for CAS and SAS access should be maintained. All other personnel requiring access should require specific approval of the shift security supervisor and be escorted to minimize distractions of the CAS or SAS operator.

- Keys to the CAS should not be available to the SAS operator and SAS keys should not be available to the CAS operator.

- Before access is granted by the CAS or SAS operator, access authority should be verified remotely (before opening the door) via CCTV, peephole, etc.

- A log sheet of visitors should be maintained and a record kept for two years. (Operator assignment records are kept in logs.)

- The function of the CAS and SAS operators is intrusion detection, monitoring, communication and observation. Functions should be limited to these and only other assignments which must be carried out from a bullet-resistant, controlled-access area (such as remote control of electric or powered gates or locks). The CAS should not be used as an arsenal or staging area for response personnel as these functions can cause periodic or continuous disruptions and distractions.

- To assure post and patrol integrity, the CAS operator should conduct a "roll-call" at least every 1/2 hour. The post or patrol number should be called over the phone, intercom or radio. A reply is required which indicates status "O.K." The security log should reflect these checks.

- The CAS and SAS should be continuously manned. Shift changes or rotations should not cause any discontinuance or distractions. The CAS and SAS operators are not to be considered as response personnel.

- Once each 24-hour period, telephone and radio checks should be made with the law enforcement authorities. This assignment should alternate between the CAS and SAS. The security log should reflect these checks. If acceptable by the LLEA, once per shift is preferable.

- Once within each 7 days, all alarm and CCTV systems should be performance checked. This may be accomplished in part during normal facility opening procedures (work start-up). The security log should reflect these checks.

See Appendix E for a typical operation function list.

6.2 SEALS

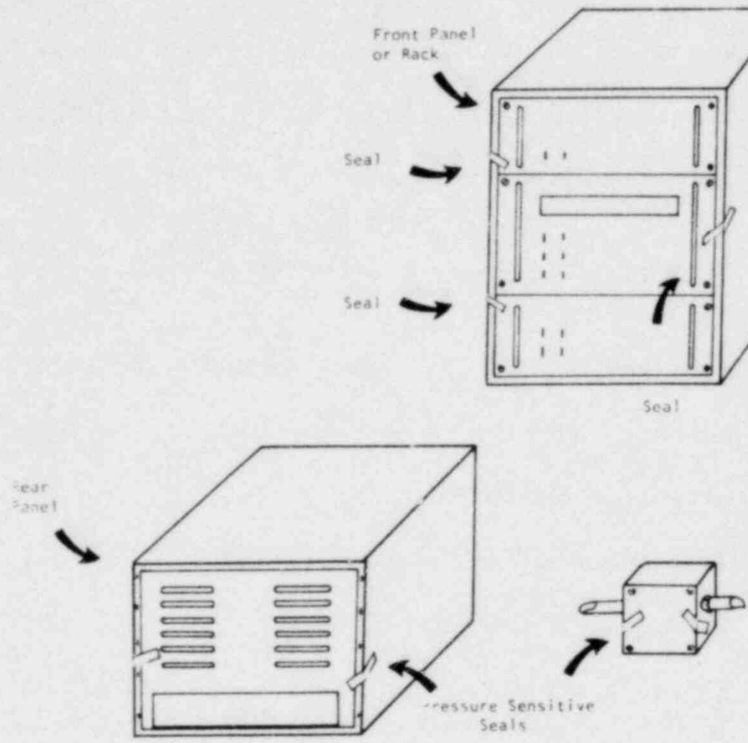
In order to assist in assuring the calibration and operational integrity of emergency power systems, alarm system and communications equipment between calibration and service periods, it is recommended that seals be utilized. Type E seals, pad lock or pressure sensitive seals should be applied to equipment access panels, junction boxes, rack mounting screws, etc. Controls should be established to assure they are opened/broken only by authorized personnel. Appropriate controls include a monthly inspection and security organization designee observation of any seal breaking for maintenance and seal application upon completion of maintenance. NRC Regulatory Guides describing the approved methods of seal utilization are noted below. Note that the references are for information, technique and methods which may be applied.

- Regulatory Guide 5.10 "Selection and Use of Pressure Sensitive Seals on Containers for Outside Storage of Special Nuclear Material."

- Regulatory Guide 5.12 "General Use of Locks in the Protection and Control of Facilities and Special Nuclear Material."

- Regulatory Guide 5.15 "Security Seals for the Protection and Control of Special Nuclear Material."

Figure 19 illustrates several typical application areas for effective sealing.



CAS/SAS EQUIPMENT SEALING CONCEPTS

Figure 19

7. MISCELLANEOUS EQUIPMENT

7.1 MISCELLANEOUS EQUIPMENT, GENERAL

Other equipment to be considered for availability within the CAS and/or SAS includes:

- Portable camp toilet for emergency use only
- Drinking water supply (1 gallon jugs)
- Flashlights
- Gas mask adequate to protect against irritants within the CAS or SAS
- Fire Extinguishers (two or more for a total of 20 B:C and one 2A)
- Independent emergency light (wall type) with independent battery
- Tear gas, CS, MACE or other defensive gas (assure legality)
- Standard AM/FM radio (emergency monitoring only).
- Weather radio
- Lightning detector
- Wind speed and direction indicator
- Thermometer (indoor-outdoor)
- Binoculars and/or night seeing devices if utilized as an observation post concurrently.
- Quick reference emergency procedure indicator (microfilm or computer information retreival and display).
- Spotlight (if used for nighttime surveillance), can be mounted on the roof and remotely controlled from within the CAS or SAS.
- Emergency warning horns (civil defense type) for site alerts for security, safety or weather or national defense purposes.
- Sitewide PA/intercom link

- Clock (battery or mechanical power option)
- Time and date clock stamp

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13. "Lighting Handbook", Illumination Engineering Society, 5th Edition, 1972.

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15. "Standard for Safety--Key Locks", UL 437, Underwriters Laboratory, Inc.

16. "Standard for Safety--Combination Locks", UL 768, Underwriters Laboratory, Inc.

17. "Industrial Security Manual for Safeguarding Classified Information", Department of Defense, DOD 5220. 22-M, Ocotber, 1977.

18. "General Use of Locks in the Protection and Control of Facilities and Special Nuclear Material" Regulatory Guide 5.12, U. S. Nuclear Regulatory Commission, November 1973.

19. "Padlock, Key Operated (Resistant to Opening by Force, Pick and By-Pass Techniques)", Interim Federal Specification, FF-P-001480 (GSA-FSS) and FF-P-110.

20. "Basic Considerations of Assembling a Closed-Circuit Television System", NUREG 0178, U. S. Nuclear Regulatory Commission.*

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24. "General Fire Protection Guidelines for Fuel Reprocessing Plants" (for comment), NUREG Guide 3.38, U. S. Nuclear Regulatory Commission, June 1976.

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27. "Interior Intrusion Alarm Systems", U. S. Nuclear Regulatory Commission, NUREG 0320, February 1978.*

28. "Duress Alarm for Nuclear Fixed Site Facilities", U. S. Nuclear Regulatory Commission NUREG Guide CR/0510, 1979.*

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APPENDIX A

Excerpts from UL 752 Standard for Bullet-Resisting Equipment. Note that this Standard is equivalent to ANSI SE 4.6-1973. The HPR rating is based on a .30-06 Springfield Rifle with a 220 gr. soft point bullet with muzzle velocity of 2410 ft/sec and muzzle energy of 2830 ft./lbs.

PERFORMANCE--BULLET-RESISTING MATERIALS

8. General

8.1 Test samples and materials shall be of commercial construction. The thickness of each part of the assembly subjected to tests shall be no greater than that which is produced for field use. The types of materials tested shall also be identical to those which are used in commercial production.

8.2 Five samples of each type of bullet-resisting material shall be available for tests.

8.3 Each assembly of bullet-resisting glazing material tested shall be finished to the degree that there are no visible imperfections in the materials such as delaminations.

8.4 Each test sample shall be available in a 12 by 12-inch (304.8 by 304.8 mm) size. If bullet-resisting glass, plastic, or any combination thereof is produced with a lateral dimension smaller than test sample size, then the smallest section sample shall also be tested. If test results indicate that a more severe condition would involve the testing of a larger size test sample, then the larger size samples up to the maximum overall size commercially produced shall be tested.

9. Ballistics Test

General

9.1 Balistics tests shall be conducted at close range (15 feet (4.57 m) or less) using weapons and ammunitions specified in Table 2.1 of this Standard.

9.2 Each test sample shall be mounted in a rigidly fixed frame. For each test, corrugated cardboard indicators shall be placed a distance of approximately 18 inches (467.2 mm) behind the protected side of each test sample.

9.3 Each type of bullet-resisting material shall be tested in accordance with the weapon-resisting rating assigned to it by the manufacturer.

9.5 Bullet-resisting material with a high power rifle rating shall resist one shot in the approximate center of the test sample.

9.6 These tests are to be conducted at normal room temperature, $22\pm3^{\circ}$ C ($71.6\pm5.4^{\circ}$F). There shall be no penetration of the projectile through the test sample, and there shall also be no spalling of material on the protected side of the test sample to the extent that fragments imbed into or damage the cardboard indicators.

9.7 A separate sample of each type of bullet-resisting material which is intended to have a small arms rating shall also be subjected to a test in which two shots are fired at the approximate center of the test sample with the shots spaced 1-1/4 to 1-3/4 inches (31.8 to 44.5 mm) apart. Spalling of bullet-resisting material from the protected side of the test sample will be accepted under this test condition but there shall be no penetration of the projectile through the material. This test is to be conducted at normal room temperature conditions, $22\pm3^{\circ}$ C ($71.6\pm5.4^{\circ}$ F).

9.7A A separate sample of each type of bullet-resisting glazing material shall be subjected to an unsupported edge test. The sample shall be mounted in a frame with the lower edge unsupported and struck with a single shot placed midway between the vertical supports and 1 to 1-1/2 inches (25.4 to 38.1 mm) from the free edge. Spalling of bullet-resisting material will be accepted under this test condition but there shall be no penetration of the projectile through the material. This test is to be conducted at normal room temperature conditions, $22\pm3^{\circ}$ C ($71.6\pm5.4^{\circ}$ F).

(Added Paragraph 9.7A effective May 12, 1977)

9.8 Bullet-resisting material which is intended for indoor use only shall be subjected to the spalling hazard test described above with one sample thoroughly cooled to a temperature of 13° C (55.4° F) for three or more hours and another sample shall be tested after it has been subjected to a temperature of 35° C (95° F) for three or more hours. There shall be no penetration of the projectile during the tests and there shall also be no spalling of the protected side of the test sample to the extent that fragments are imbedded into or damage the cardboard indicators.

9.9 Bullet-resisting materials intended for outdoor use such as in armored cars, windows for tellers' fixtures, etc. shall also be tested for spalling hazard with a separate sample at each of the temperature extremes anticipated in service. One sample of the material shall be tested immediately after exposure of one side to minus 31.7° C (minus 25° F) with the other side of the material at ordinary room temperature for a period of 3 hours or more. Another sample shall be tested with the entire sample subjected to a uniform temperature of 49° C (120° F). There shall be no unacceptable spalling of material or penetration of the projectile as described above.

10. Ballistics Specifications

10.1 The tests shall be conducted with the use of equipment to record the velocity of the projectile. Each test shot shall be not less than 90 percent nor more than 105 percent of velocity rating of the ammunition used. See Table 2.1 for the velocity ratings of each type of ammunition used for test purposes. Each test shot which involves a deviation of greater than minus 10 percent of the ammunition rating shall cause the results for that particular test sample to be rejected. If the velocity rating for the ammunition used is exceeded by more than 105 percent, and there is no hazard as a result of the tests, the data can be accepted.

Note: These excerpts are not all inclusive (Acquire a current copy of complete Standards from Underwriters Laboratory).

APPENDIX B

The following tables provide information on various manufacturers or vendors who have been noted to provide bullet-resisting and/or physical security equipment. The list does not include intrusion alarm, or communications equipment or other miscellaneous equipment. Other equipment listings can be found in "Catalog of Physical Protection Equipment", NUREG 0274, December 1976; "Intrusion Detection Systems Handbook - Vol. I & II, Sandia Laboratories, SAND 76-0554 November 1976; various other references included in this report; or commercial catalogs and brochures.

The inclusion of any manufacturers name or product in this report does not constitute an endorsement but only provides a lead to additional information. Also this listing is not meant to exclude any supplier or manufacturer who may have equipment or materials which will meet the specifications.

In all cases the licensee should utilize professional assistance in determining the specific design criteria and concepts for the specific site.

Tables Included

Note: Other suppliers of UL listed materials can be found in "Accident, Automotive, Burglary Protection Equipment Directory", Underwriters Laboratory, Inc.

UL also list companies which have shown that they are sufficiently familiar with UL requirements to be listed as one or more of the following.

1. Central Station Alarm Company
2. Local Alarm Company
3. Police Station Connect Alarm Company

Companies so listed can install and provide a certificate of installation which indicates the type of installation and the extent of protection that is installed.

A catalog of all UL Standards can be ordered which shows all of the UL Standards by title and number along with cost and ordering procedures.

Underwriters Laboratories Inc.
Publication Stock
333 Pfingsten Road
Northbrook, Illinois 60062

APPENDIX B -- TABLE 1 BULLET-RESISTING AND SECURITY DOORS

MATERIAL OR COMPONENT	BULLET RESISTANCE	MANUFACTURER OR SOURCE
Bullet-Resisting Doors		
DR-4 (30-70) (Appx $1400-$1600)	UL-HPR Listed	Chicago Bullet Proof
DRP-4	UL-HPR Listed	Chicago Bullet Proof
Model Not Listed	UL-HPR Listed	Americraft
DA-4	UL-HPR Listed	D-F-W Co.
DAX-4	UL-HPR Listed	D-F-W Co.
BR-4	UL-HPR Listed	Johnson Fireproof Door
Model Not Listed	UL-HPR Listed	Protective Materials
Other Manufacturers of Security Doors		Dibold Mosler Safetvue Fries Correctional Equipment Midwest Architectual Metals Overly Southern Steel Gary Safe LeFebure Schwab Insulgard

APPENDIX B -- TABLE 11 BULLET-RESISTING WALLS, CEILINGS AND FLOORS

MATERIAL OR COMPONENT	BULLET RESISTANCE	MANUFACTURER OR SOURCE
Bullet-Resisting Materials and Panels		
Shot Tex 131 Steel ($24/sq. ft.)	UL-HPP Listed	Chicago Bullet Proof
Shot Tex 131S Steel	UL-HPR Listed	Chicago Bullet Proof
Shot Tex 4A Steel ($22/sq. ft.)	UL-HPR Listed	Chicago Bullet Proof
Shot Tex 4A1 Steel	UL-HPR Listed	Chicago Bullet Proof
Shot Tex 1221 Steel	UL-HPR Listed	Chicago Bullet Proof
Types BRSP-3,4	UL-HPR Listed	D-F-W Company
Types HPR 1, RR	UL-HPR Listed	Overly
Model Not Listed	UL-HPR Listed	Protective Materials
Other Materials Not UL Listed		
Steel DHA-2, $25-30/sq. ft., 9.2 lbs/ft^2	.30-06 V_{50} at 2750 fps	Avco
DHA-3, $25-30/sq. ft, 12 lbs/ft^2	.30-06 V_{50} at 2700 fps	Avco
Kaisaloy, $6-8 sq. ft. 5.2 lbs/ft^2	.30-06 V_{50} at 2382 fps	Kaiser Steel Co.
DPSA-6, $25-30/sq. ft. 10 lbs/ft^2	Ballistically certified for .30-06 ball	U.S. Steel, Armco, Philco Ford
Tiannium, $65-85/sq. ft., 14.1 lbs/ft^2	.30 ball	
Aluminum 7039, $12-18/sq. ft., 15.6 lbs/ft^2		
Ceramics		
B4C-W.R. Fiberglass 6.6 lbs/ft^2, 8 in. thick, $300-400/ft^2	Resisted Penetration by .30 caliber AP Projectiles	Norton, Corborundum

APPENDIX B -- TABLE [illegible] (CONT.)

MATERIAL OR COMPONENT	BULLET RESISTANCE	MANUFACTURER OR SOURCE
SiC-W.R. Fiberglass 8.5 lbs/ft^2, .8 in. thick, \$150-200/ft^2	Rated for .30 Ball	Norton, Carborundum
85 AL_2O_3 Fiberglass 8.5 lbs/ft^2, .7 in. thick, \$40-50/ft^2	Rated for .30 Ball	Norton, Carborundum
85 AL_2O_3 Aluminum 8.5 lbs/ft^2, .7 in. thick, \$35-45/ft	Rated for .30 Ball	Norton, Carborundum
Ceramic-Glass-Plastic (PP-600) 9.? $lbs/ft.^2$	.30-06 AP at 2750 fps	AVCO
Other Ceram		Aerojet General French Town Ceramics, Coors Porcelain, Skyline Industries San Bernadino Materials Co. KDI-Composite Technology Inc.
Concrete Reinforced Concrete, 6 in. w/#4 rebars on 18 in centers, 3000 lbs test Cost Approx \$15/sq. ft.	HPR Resistant	
Cellular Concrete	Reference Number 11	
Cellular Concrete w/fibers	Reference Number 11	

APPENDIX B -- TABLE II (CONT)

MATERIAL OR COMPONENT	BULLET RESISTANCE	MANUFACTURER OR SOURCE
Prefab Structures		
Various Custom & Std. Designs 24x24, $21,000 to 25,000	UL-HPR Listed	Chicago Bullet Proof
Various Custom & Std. Designs	UL-HPR Available	Protective Materials
Various Custom & Std. Designs	UL-HPR Available	Overly
Other Low Co. Materials		
1 in. pine - 6 in. sand - 1 in. pine	.30 Caliber Ball Resistant	Reference Number 32
1 in. pine - 5 in. trap rock - 1 in. pine (1 1/2 - 3 in. crushed rock)	.30 Caliber Ball Resistant	Reference Number 32
Burlap Sack - 7 in. trap rock	.30 Caliber Ball Resistant	Reference Number 32
Burlap Sack - 8 in. sand	.30 Caliber Ball Resistant	Reference Number 32
Burlap Sack - 16 in. earth	.30 Caliber Ball Resistant	Reference Number 32
Bricks, Common Baked Clay, 3 5/8 in., 4 lbs/ft² (stacked on end with 1 3/8 in. wood backing).	.30 Caliber Ball Resistant	Reference Number 32

APPENDIX B -- TABLE III BULLET-RESISTING WINDOWS (TRANSPARENT ARMOR)

MATERIAL OR COMPONENT	BULLET RESISTANCE	MANUFACTURER OR SOURCE
Bullet-Resisting Glazing and Windows		
SCS-4	UL-HPR Listed	Chicago Bullet Proof
SCSII-4	UL-HPR Listed	Chicago Bullet Proof
STW-4 (3240) (Appx $1,500-1,800)	UL-HPR Listed	Chicago Bullet Proof
VWF-4	UL-HPR Listed	D-F-W Company
VW-4	UL-HPR Listed	D-F-W Company
BR4W	UL-HPR Listed	Johnson Fireproof Door
ASG-HPR	UL-HPR Listed	ASG Industries
M 36	UL-HPR Listed	Buchmin Industries
M 39	UL-HPR Listed	Buchmin Industries
AS-10	UL-HPR Listed	Chromalloy-Safetee Glass
RR 200	UL-HPR Listed	Chromalloy-Safetee Glass
BR-200	UL-HPR Listed	Globe-Amerada Glass
RR	UL-HPR Listed	LOF
Model Not Listed	UL-HPR Listed	PPG
RR	UL-HPR Listed	Texas Tempered Glass
Plexiglas	Not HPR Rated	Rohm & Hass
Lucite	Not HPR Rated	DuPont
Lexgard Laminate System RC 750	**UL-HPR Listed**	General Electric

APPENDIX B -- TABLE III (CONT)

MATERIAL OR COMPONENT	BULLET RESISTANCE	MANUFACTURER OR SOURCE
One-Way Mirror (Not Bullet-Resisting)		
Mirror Pane		
Clear, 1/8-1/2 in. thick light ratio 10:1 to 5:1, $6-12/ft²	Not Bullet-Resisting	LOF
Laminated, 1/4-1/2 in. thick, light ratio 10:1 to 5:1, $6-12/ft²	Not Bullet-Resisting	LOF
Gray, 1/4 in. thick, light ratio 4:1 to 2:1, $6-10/ft²	Not Bullet-Resisting	LOF
One-Way Mirror		
Transview		
Clear 1/4-3/4 in. thick, light ratio 8:1, $6-15/ft²	Not Bullet-Resisting	Environmental Glass Products
Gray, 1/4-3/4 in. thick, light ratio 4:1, $6-15/ft²	Not Bullet-Resisting	Environmental Glass Products
Bronze, 1/4-3/4 in. thick, light ratio 4:1, $6-15/ft²	Not Bullet-Resisting	Environmental Glass Products
Duovue		
Clear, Light Ratio 8:1, $6-10/ft²	Not Bullet-Resisting	ASC Industries
Gray, Light Ratio 4:1, $6-10/ft²	Not Bullet-Resisting	ASC Industries
Bronze, Light Ratio 4:1, $6-10/ft²	Not Bullet-Resisting	ASC Industries
Other Security Window Sources	Various	Diebold Mosler The William Bayley Co. Midwest Architectual Metals Overly Mfg. Southern Steel Co. Federal Laboratories Rowland Products Insulgard

APPENDIX B -- TABLE IV BULLET-RESISTING PACKAGE AND DOCUMENT PASS-THRUS

MATERIAL OR COMPONENT	BULLET RESISTANCE	MANUFACTURER OR SOURCE
Parcel Passers Model PP/PP-4 ($1,350-1,650)	UL HPR Listed	Chicago Bullet Proof
Other Parcel Passers		Protective Materials Diebold Creative Industries Mosler Overly Insulgard

APPENDIX B -- TABLE V BULLET-RESISTING LOUVERS

MATERIAL OR COMPONENT	BULLET RESISTANCE	MANUFACTURER OR SOURCE
Louvers Model LVU-4, 2424 ($425)	UL-HPR Listed	Chicago Bullet Proof
Other Louvers and Air Guards		Diebold, Mosler

APPENDIX B -- TABLE VI BULLET-RESISTING GUNPORTS

MATEP AL OR COMPONENT	BULLET RESISTANCE	MANUFACTURER OR SOURCE
Gunports		
Model		
GP3A-4, ($505)	UL-HPR Listed	Chicago Bullet Proof
GP4-4	UL-HPR Listed	Chicago Bullet Proof
Other Gunports		Protective Materials Overly

TABLE VII

MANUFACTURERS ADDRESSES

ASG Industries Inc.
P. O. Box 929
Kingsport, TN 37662
615-254-0211

Aerojet General Corp.
Azuza, California

Amerada Glass Co.
2001 Green Leaf Avenue
Elk Grove Village, IL 60007

Americraft
Irving, CA 92714

Armco Steel
Houston, TX

Avco Speciality Materials
Lowell Industrial Park
Lowell, MA 01851

Buchmin Industries
Reedley, CA 93654

The Carborundum Co.
Armor Systems Division
P. O. Box 339
Niagra Falls, NY 14302

Chicago Bullet Proof Equipment Co.
2250 Western Avenue
Park Forest, IL 60466

Chromalloy Safetee Glass
250 King Manor
King of Prussia, PA 19406

Coors Porcelain Company
Golden, CO

Creative Industries, Inc.
959 N. Holmes
Indianapolis, IN 46222
317-632-7471

Diebold, Inc.
Canton, OH 44702
216-489-4083

Environmental Glass Products
4815 Cabot Avenue
Detroit, MI 48210
313-582-6200

Fargo Company
1162 Bryant Street
San Francisco, CA 49103
415-621-4471

Federal Laboratories, Inc.
Saltsburg, PA 15681

Frenchtown Ceramics
French Town, NJ

Fries Correctional Equipment, Inc.
102 Pleasant Street
Bromley, KY 41016
606-431-3313

Gary Safe Co.
City of Industry, CA 91746

General Electric
Plastic Business Division
Sheet Products Section
1 Plastics Avenue
Pittsfield, MA 01201

Globe-Amerada Glass Co.
Elk Grove Village, IL 60007

Great Lakes Steel
Detroit, MI 48229

Insulgard, Corp
98-34 Samaica Avenue
Richmond Hill, NY 11418
212-849-9000

Johnson Fireproof Door Co., Inc.
Rosemont, IL 60018

LOF
811 Madison Avenue
Toledo, OH 43624

LeFebure Corp.
Cedar Rapids, OH 52406

Midwest Architectual Metals, Inc.
35601 Curtis Boulevard
East Lake, OH 44094
216-942-6700

Mosler
Hamilton, OH 45012

Norton Company
Noroc Armor Products
Worchester, MA 01606

Overly Manufacturing Co.
574 W. Otterman Street
Greensburg, PA 15601
412-834-7300

Philco-Ford Corp.
Aeronautronic Division
Ford Road
Newport Beach, CA 92663

Protective Material
Holly Mill
Seabrook, NH 03874
603-474-5523

ROHM & HAAS
Independence Mall West
Philadelphia, PA 19105
215-592-3000

Rowland Products, Inc.
Kensington, CT 06037

Safelite Industries
P. O. Box 1879
Wichita, KS 67201
800-835-2092

Safetvue
152 Dwight
River Rouge, MI 48218
313-843-4600

Schwab Safe Co., Inc.
3000 Main Street
Layfayette, IN 47902
317-447-9740

Security International
San Antonio, Texas
512-661-8331

Sierracia Sylmar
12780 San Fernando Road
Sylmar, CA 91342

Southern Steel Co.
Box 2021
San Antonio, TX 78297
512-533-1231

Viracon, Inc.
800 Park Drive
Owatonna, MN 55060
507-451-9555

APPENDIX C

UL AND ANSI SECURITY RELATED STANDARDS

Safety Standard for Anti-Theft Alarms and Devices. UL 1037, ANSI S.E. 2.2-1975.

Safety Standard for Central Station Burglar Alarm Units and Systems. UL 611, ANSI S.E. 2.2-1972.

Safety Standard for Connectors and Switches for Use with Burglar Alarm Systems. UL 634, ANSI S.E. 2.6-1973.

Safety Standard for Holdup Alarm Units and Systems. UL 636, March 1973.

Safety Standard for Household Burglar Alarm System Units. UL 1023, ANSI S.E. 2.4-1972.

Safety Standard for Installation and Classification of Mercantile and Bank Burglar Alarm Systems. UL 681, ANSI S.E. 2.3-1972.

Safety Standard for Local Burglar Alarm Units and Systems. UL 609, ANSI S.E. 2.1-1972.

Safety Standard for Proprietary Burglar Alarm System Units. UL 1076, ANSI S.E. 2.9-1974.

Safety Standard for Access Control System Units. UL 294, ANSI S.E. 2.10-1975.

Safety Standard for Bullet Resisting Equipment. UL 752, ANSI S.E. 4.6

Safety Standard for Burglar Resistant Electric Door Strikes. UL 1034, ANSI S.E. 2.11-1974.

Safety Standard for Relocking Devices. UL 140, ANSI S.E. 4.4-1972.

Safety Standard for Surveillance Cameras. UL 983, ANSI S.E. 2.5-1973.

Safety Standard for Combination Locks. UL 768, ANSI S.E. 4.2-1972.

Safety Standard for Burglar Resisting Glazing Material. UL 972, ANSI S.E. 4.5-1972.

Safety Standard for Central Stations for Watchmen, Fire-Alarm and Supervisory Services. UL 827, ANSI S.E. 3.1-1972.

Safety Standard For Key Locks. UL 437.

APPENDIX D

MILITARY ARMOR SPECIFICATIONS

Military Armor Specifications which may be of interest are listed below. Reference Numbers 24, 28 and 29. It is notable that most military reports providing specific armors and performance characteristics are classified.

Steel	Wrought Homogeneous	MIL-S-12560
	Rolled Homogeneous	JAN-A-256
	Rolled Non-Magnetic	MIL-A-13259B or JAN-A-434
	Wrought High-Hardness	MIL-S-46100
	Cast	MIS-S-11356
	Face-Hardened	JAN-A-784 or MIL-A-07784
	Rolled Bonded Dual-Hardness	MIL-S-46099
Light Metal	Aluminum (2024-T4)	MIL-A-7169
	Aluminum (2039-T6)	MIL-A-46063
	Aluminum (2219-T81)	MIL-A-46118
	Aluminum (5083)	MIL-A-46027
	Titanium Alloy (Weldable)	MIL-T-46077
	Titanium Alloy	MIL-A-23556
	Magnesium Lithium Alloy	MIL-A-21648
Organic		MIL-A-17856
Non-Metallic Armor		MIL-C-12369
Ceramic Composite		MIL-A-46103
Transparent Glass		MIL-G-5485
Transparent Glass-Faced Plastic		MIL-A-46108
Armor Plate Finishing		MIL-STD-171

APPENDIX E

TYPICAL OPERATIONAL FUNCTIONS FOR THE CAS AND SAS

1. Monitor Alarm Systems

    1.1 Intrusion Alarms

        1.1.1 Protected Areas
        1.1.2 Material Access Areas and Vaults
        1.1.3 Vital Areas
        1.1.4 Controlled Access Areas
        1.1.5 CCTV Monitoring/SSNM and Other Areas

    1.2 Duress Alarms

        1.2.1 Patrols
        1.2.2 Posts
        1.2.3 CAS and SAS

    1.3 Emergency Power Alarm
    1.4 Criticality and Other Sensitive Equipment Alarms
    1.5 Fire Alarms
    1.6 Alarmed Use Areas Operating Schedule Maintenance
    1.7 Alarm Stations (CAS & SAS)
    1.8 Alarm System Control (Access, Active, Activated)
    1.9 Alarm Test and Operational Status Verification
    1.10 Alarm Maintenance Scheduling, Control and Post Maintenance Check
    1.11 Site Observation

2. Alarm or Abnormality Assessment

    2.1 CCTV Monitoring
    2.2 Visual Observation
    2.3 Dispatch of Assessment Personnel

3. Communications

    3.1 Site Security Channel Operation
    3.2 Local Law Enforcement Channel Operation
    3.3 Emergency and Security Telephone Operation
    3.4 Other Intercom and Communication
    3.5 Site Civil Defense and Disaster Warnings
    3.6 Communications Equipment Test Operational Status Verification
    3.7 Communications Equipment Maintenance Scheduling and Control
    3.8 Control and Distribution of Emergency Communication Equipment
    3.9 Post and Patrol Status Checks

4. Access Control

4.1 Personnel (Protected, Vital Material and Controlled Access Areas as Required)
4.2 Vehicle (Protected, Vital Material and Controlled Access Areas as Required)
4.3 CAS and SAS Access
4.4 Emergency Vehicle and Personnel Control
4.5 Access Authority Verification
4.6 Escort Coordination as Required
4.7 Off-Shift Access Logs
4.8 Remote Entry Control as Required

5. Contingency and Emergency Coordination

5.1 Serve as Contingency Control Center
5.2 Contingency Plan Activation and Coordination

5.2.1 National Emergencies
5.2.2 Fire
5.2.3 Natural Disaster (Flood, Tornado, Earthquake, Hurricane, etc.)
5.2.4 Radiological Incident
5.2.5 Theft or Sabotage Attempt
5.2.6 Civil Disturbance (Riot, Demonstration, etc.)
5.2.7 Bomb Threat
5.2.8 Site Closure
5.2.9 Personnel Injury and Incidents
5.2.10 Other

5.3 Mobilization of Response Force and Coordination
5.4 Local Law Enforcement Assistance Notification and Coordination
5.5 Fire and Emergency Aid Assistance Notification and Coordination
5.6 Personnel Accountability Coordination
5.7 Public Information Control
5.8 Chain of Command Notification

6. Records

6.1 Security and Communications Maintenance
6.2 Security and Communications Test
6.3 All Alarm Status Changes
6.4 CAS and SAS Access
6.5 Events and Incidents Log and Reports
6.6 Others as Required

7. Storage, Control and Distribution of Contingency Equipment

7.1 Riot Control Equipment
7.2 Fire Arms
7.3 Emergency Radiological Equipment
7.4 Other Emergency Equipment

NOTE: It is not recommended that the CAS or SAS be used for this purpose. If it is necessary, however, only the CAS or SAS should be used and not both.

8. General

8.1 Perform Periodic Drills Utilizing All Security Equipment, Personnel and Plans
8.2 Cognizance and Control of SSNM Shipments and Receipts
8.3 Emergency Power Control as Required and Fuel/Charge Monitoring

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H. J. Wait

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9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
Mason & Hanger - Silas Mason Co., Inc.
Systems Division
200 West Vine Street
Lexington, KY 40507

6. *(Leave blank)*

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12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
Office of Standards Development
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

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This report documents planning guidance for Central Alarm Stations (CAS) and Secondary Alarm Stations (SAS) as provided by the U.S. Nuclear Regulatory Commissions Upgrade Rules issued in final form in FR Vol. 44, No. 230, Wednesday, November 28, 1979. It provides basic considerations for sites licensed by the NRC to possess or process formula quantities of strategic special nuclear material relative to (CAS) and (SAS) siting, construction planning, intrusion detection systems, communications, operation considerations, miscellaneous equipment and information control.

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Security Lighting Planning Document for Nuclear Fixed Site Facilities

Prepared by H. J. Wait, M. W. Manning, D. R. Page

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Washington, D.C. 20555
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ABSTRACT

This document has been prepared as an aid in planning security lighting at nuclear fixed site facilities. While the recommendations enclosed cover the minimum requirements established in Title 10, Code of Federal Regulations (CFR), Part 73, additional suggestions are made for further enhancing a facility's security lighting and related security capabilities. Planning considerations and information are provided for lighting of the isolation zones, protected areas, portals, vital areas and material access areas. Recommendations are made relative to indoor, outdoor, fixed, portable and other unique applications of security lighting.

TABLE OF CONTENTS

LIST OF FIGURES

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Mr. Bill Batzel, Representing Quality Lighting

Mr. Dennis Lohman and Ms. Carol Cramer, Representing Johns-Manville, Holophane

I. INTRODUCTION

This planning document is a reference guide of security lighting considerations. The minimum requirements of 10 CFR Part 73 are covered with examples of lighting equipment and configurations to meet them. Additionally, recommendations are made to improve the security lighting at nuclear fixed sites. The basic philosophy, concepts and goals of security lighting are covered as well as light sources, equipment and configurations. Auxiliary equipment, portable systems and backup equipment are included. Operation, maintenance and testing recommendations are provided.

It is important to recognize that this document is intended as a planning guide to illustrate basic security lighting considerations and requirements. It is recommended that any actual site lighting design be accomplished by a qualified engineering organization or company.

This document is organized to first discuss security lighting philosophies in Section (2) and is followed with information in Sections (3) and (4) on the characteristics of light and vision which contribute to the visibility of objects or persons in security lighting situations. Section (4) is concluded with a brief summary of recommended lighting levels at various areas within a protected site. Section (5) provides information on the use of lighting to the disadvantage of an intruder. Section (6) covers other general equipment for security lighting purposes. Installed or fixed lighting application configurations are provided in Section (7) which cover a range of lighting levels for perimeters, protected areas and portals. Lighting for CCTV systems is also discussed in this section. Sections (8) and (9) address the use, operation, maintenance, and testing of lighting systems. Summary recommendations are listed in Section (10).

2. SECURITY LIGHTING PHILOSOPHY

2.1 General

Security lighting is accepted as an integral part of a security system. Many references can be cited that explain the benefits and cost effectiveness of security lighting. Unfortunately, most lighting requirements are based solely upon illumination level. The design of a security lighting system generally gives little consideration to the impact of various lighting techniques upon intruder and response force behavior. Three distinct psychological/behavioral processes have been found to be relevant to security lighting system design: (1) psychological deterrence, (2) visual detection and identification, and (3) visual incapacitation. These established processes should be applied in the design of an optimum security lighting system. (Reference No. 1.)

2.2 NRC Requirements

Present NRC security lighting guidelines require that isolation zones and all exterior areas within the protected area be provided with illumination sufficient to detect the presence of unauthorized persons, vehicles, materials, or unauthorized activities, determine whether or not a threat exists and assess the threat, if any. The guidelines require a capability of observing the isolation zones and the physical barrier at the perimeter of the protected area, preferably by means of closed circuit television or by other suitable means which limit exposure of responding personnel to possible attack. Isolation zones and all exterior areas within the protected area shall be provided with illumination not less than 0.2 footcandles measured at ground level. (Reference No. 2.) Additionally, NRC general guidance for lamp restrike time (time to restart lamps after a power interruption) is 60 seconds maximum for these areas.

2.3 Goals

Security lighting is necessary for night time surveillance of indoor and outdoor areas. Proper illumination levels are expected to discourage would-be intruders and render them visible to guards during general surveillance or alarm assessment should they attempt entry. Security lighting requires adequate light, glaring light in the eyes of the intruder, and minimum light on the patrolling or observing guard.

Two basic methods or a combination of both may be used to provide practical and effective security lighting. The first method is to light the boundaries and approaches; the second, to light the area and structures within the general boundaries of the property. The Nuclear Regulatory Commission requires both.

The goals of an effective security lighting system are:

1. Discourage or deter entry attempts by intruders.
2. Maximize the probability of intruder detection should entry be attempted.
3. Provide glare effective in handicapping the intruder and avoid glare which handicaps guards or other personnel authorized to be in the immediate area of the security lighting system.
4. Provide additional illumination for areas most susceptible to intrusion.
5. Provide adequate illumination levels for intruder detection.
6. Provide adequate illumination levels and suitable light to dark ratios for the determination of false alarm causes on existing or planned perimeter intrusion detection systems.
7. Provide convenient switch and control access.
8. Provide supplementary portable lighting or searchlights to permit exploration inside and outside the protected area, and to backup fixed lighting systems during emergencies.
9. Provide protection for luminaires, supports, distribution systems and auxiliary equipment by locating them within the protected area where they are not readily accessible.
10. Provide an adequate maintenance program to assure lighting reliability.
11. Provide an adequate testing program to assure lighting capability and performance to specification.
12. Provide for operating procedures for use during normal and emergency situations.

The guidelines presented should be incorporated in the security lighting system design or upgrading to achieve optimum conditions for intruder: (1) psychological deterrence, (2) visual detection and identification, and (3) visual incapacitation. (Reference Nos. 1 and 3.)

3. DETERRENCE CHARACTERISTICS

3.1 General

An important objective of security lighting is the deterrence of potential intruders from initiating an intrusion attempt. A major deterrent for intruders is a high probability of their being detected and apprehended. Security lighting systems should be designed to increase this probability. As a result, the intruder has a greater estimate of his apprehension probability and is more likely to be deterred from initiating an intrusion attempt.

The security lighting system can be considered the first line of defense due to its serving as a deterrent to both the amateur and experienced intruder. (Reference No. 4.) This is not to imply that the deterrent effect of security lighting alone will suffice to provide protection.

3.2 Physiological/Psychological Effects

A significant physiological effect in security lighting is adaptation. Adaptation level is the average luminance of objects and surfaces in the immediate vicinity of an observer and is important when considering deterrence. As a fully dark-adapted person approaches security lighting perimeters, the brighter lights enter into the visual field and the person's adaptation level begins to change. The change in adaptation level reduces the ability to see low-luminance low-contrast objects such as observers within the perimeter. The potential intruder now has a difficult task of studying the terrain immediately ahead and watching for more distant patrolling security guards. This undesirable situation places the potential intruder in a physiological disadvantage and possibly a psychological disadvantage. As the potential intruder advances closer to the lights, the adaptation level may be high enough that the person is virtually blind to dark objects behind the lights. The psychological disadvantage of not knowing whether or not observation is taking place causes tension or fear which could increase the adrenalin flow which causes pupil dilation and an increase in the effect of glare. This, of course, will heighten the deterrence value of the security lighting. (Reference No.5.)

3.3 Effectiveness

The reduction of crime in urban, industrial and residential areas as a result of security lighting has been studied and documented on numerous occasions. Approximately 75 percent of all urban burglaries against commercial establishments occur during the hours of darkness against facilities having either little or no lighting (Reference No. 1). The incidence of crime has a direct relationship with the number of hours of darkness in a given 24-hour period. (Reference No. 1.) Comparisons of urban crime patterns before and after new street lighting was installed show that increased illumination levels result in a reduction of crime in the lighted area. The above mentioned trends are not to imply that urban crime and the threat to a nuclear facility are exactly the same. It is apparent that when properly motivated individuals plan a criminal act they are not deterred by security lighting or even security forces in many cases. In these situations, a well-planned security lighting system can aid in detection and apprehension of intruders. It can however, be concluded that security lighting is an effective deterrent to many potential intruders.

4. VISUAL DETECTION CHARACTERISTICS

4.1 General

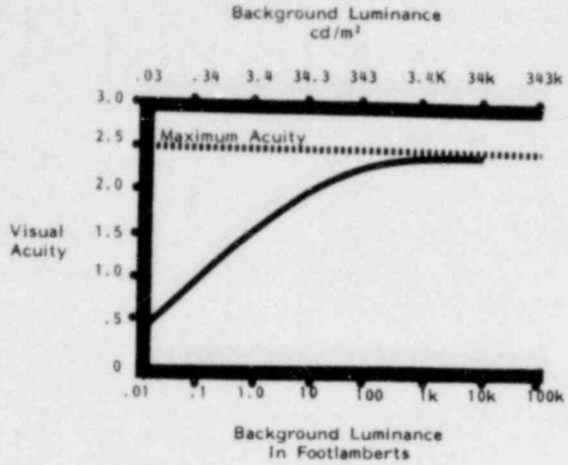
There are several significant factors relative to the effectiveness of security lighting not the least of which is how the human eye responds to various light sources and stimulus. Some of the most important considerations include the lighting intensity and area contrast, the frequency of the light or color, lighting uniformity, exposure time of the intruder and the size of the image of the intruder or target. These factors are very important in planning a lighting system. It is also difficult to integrate these factors into a definitive specification. Therefore, it is necessary to attempt to optimize as many of the conditions as possible.

4.2 Lighting Intensity and Contrast

As noted in the Illuminating Engineering Society Lighting Handbook (Reference No. 6), visual acuity is the ability to distinguish details. Visual acuity is a function of the brightness of the background. As the illumination decreases, the visual acuity diminishes. For dark objects on light backgrounds with a luminance of approximately .34 cd/m^2 (.1 footlamberts), the acuity is 50 percent of maximum. At 6.9 cd/m^2 (2 footlamberts), visual acuity is approximately 90 percent of maximum. Figure 1 describes the basic relationship (Reference No. 1). The units of measure used to describe illumination and luminance are:

	English	SI
Illumination	Footcandle	Lux
Luminance	Footlambert	Candela/Meter^2 (cd/m^2)

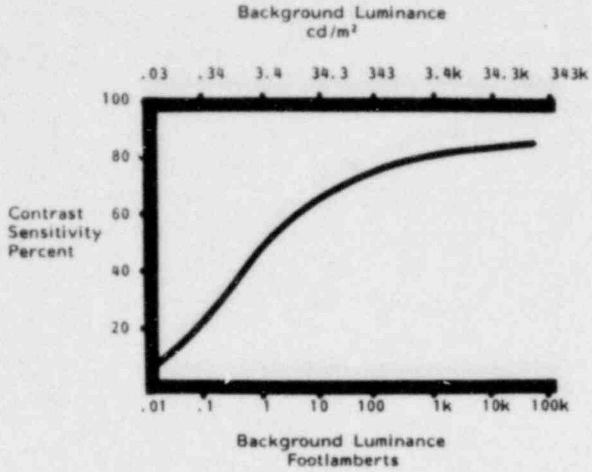
Illumination is essentially the amount of light available at any point or flux and luminance is the amount of light reflected from or emitted from an object at its surface. Note that a footlambert is a measure of luminance equal to $1/\pi$ candle per square foot. A one foot square emitting or reflecting light at one lumen per square foot would be one footlambert. The SI equivalent is cd/m^2.



VISUAL ACUITY RELATED TO BACKGROUND LUMINANCE

Figure 1

Contrast sensitivity is the ability to detect contrast area borders. The probability of intruder detection is greatly increased as the contrast between the intruder and background increases. At low light levels where the contrast is relatively low, dark on light targets seem to have the advantage over light on dark for detection. (Reference No. 7.) Also at very low luminance levels, color will always enhance visibility of the intruder. These observations and observations by others would tend to indicate that for detection or assessment purposes as much of the background as possible should be white or of a light color or illuminated to as high a level as practicable. This would include isolation zones, building faces, etc. Figure 2 (Reference No. 6) illustrates this concept. Figure 3 illustrates the fact that for areas of higher luminance, less task/target/intruder to background contrast is required for detection of a specific sized target. (Reference No. 8.)



CONTRAST SENSITIVITY RELATIVE TO
BACKGROUND LUMINANCE

Figure 2

Contrast, as used in Figure 3, is an absolute value of target luminance less background luminance divided by the larger of the two numbers. Background luminance is measured as horizontal for these purposes and will provide a conservative estimate. Target luminance, on the other hand, is measured vertically and can be approximated by multiplying the horizontal illumination by the distance from the light source and dividing by the source mounting height.

$$\text{Illumination Vertical} = \frac{\text{(Illumination Horizontal) (Distance)}}{\text{(Mounting Height)}}$$

As an example, if a 9m (30 ft.) pole is set back 6m (20 ft.) from an 18m (60 ft.) isolation zone, the intruder is at the outer edge of the isolation zone and the illumination is 2 lux (.2FC) horizontal then:

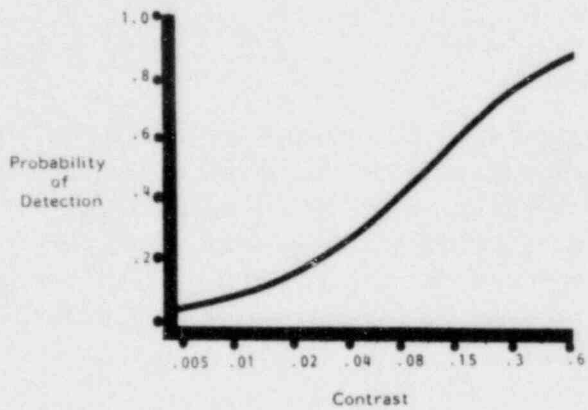
$$Iv = \frac{(.2FC)\,(80\ ft.)}{(30\ ft)} = .5FC$$

If the intruder is wearing olive drab clothing and the isolation zone is grass then:

L_t = Luminance of the Target = (.5FC) (.11 reflectivity) = .055 foot-lamberts

L_b = Luminance of the Background = (.2FC) (.17 reflectivity) = .03 footlamberts

$$C = \text{Absolute Contrast} = \frac{L_t - L_b}{\text{(Larger of two)}} = \frac{.055 - .03}{.055} = .45$$



PROBABILITY OF DETECTING TARGETS AS A FUNCTION OF CONTRAST

Figure 3

Utilizing this type of information and the reflectance factors in Figure 4, it is possible to determine relative effective illumination levels. This was accomplished in Reference No. 9 where it was concluded that:

1. "The prone target represents the most difficult visual target. This is true at all levels of illumination but particularly so at the currently recommended level of 2.1 lux (.2 footcandles)."

2. "Although vertical illumination determines target luminance, variations in vertical illumination have only a minimal effect on target detectability."

3. "The currently specified 2.1 lux (.2 footcandles) illumination will not assure detectability of all potential targets."

4. "A background luminance of no less than .24 cd/m^2 (.07 footlamberts) is required to provide an acceptable environment for detection of a variety of targets."

REFLECTIVITY OF VARIOUS GROUND COVERINGS

Material	Reflectivity
Light Sand	.15
Sandy Soil	.11
Asphalt	.04
Concrete	.36
Crushed Stone	3-.65
Grass/Vegetation	.17

REFLECTIVITY OF VARIOUS COLOR CLOTHES

Material	Reflectivity
Black	.03
Gray	.52
Dark Green	.10
Sand/Beige	.40
Olive Drab	.11

REFLECTIVITY OF VARIOUS WALL MATERIALS

Material	Reflectivity
Aluminum	.6 - .7
Aluminum Paint	.6 - .7
White Plaster	.9 - .92
White Paint (Mat)	.75- .9
Limestone	.35- .65
Mirrored Glass	.8 - .9
Stainless Steel	.55- .65
Red Brick	.30- .40

REFLECTIVITY OF VARIOUS MATERIALS

Figure 4

The .24 cd/m^2 (.07 footlamberts) luminance is a function not only of the light source and level but also of the reflectance of the background. As an example of determining a rough approximation of the lux (footcandles) required to yield .24 cd/m^2 (.07 footlamberts), the following equation can be used.

$$\text{Illumination (footcandles horizontal)} = \frac{\text{Luminance (footlambert)}}{\text{Reflectance}}$$

$$\text{e.g., Footcandles} = \frac{.07\ \text{Footlamberts}}{.04\ \text{Reflectance (Asphalt)}} = 18.8\ \text{lux (1.75 footcandles)}$$

Therefore approximately 20 lux (2 footcandles) is required on an asphalt isolation zone or protected area to yield .24 cd/m^2 (.07 footlamberts). This is consistent with recommendations for major expressways, bikeways and pedestrian ways. (Reference No. 10.)

Reviewing the other potentially utilized protected area and isolation zone material reflectance factors, the level of recommended illumination can be approximated. For horizontal surfaces, these are shown in Figure 5. It is necessary to recognize that these are only estimates and there are many variables such as differences in materials, vegetation changes between seasons, the color of light used, the texture/roughness of the materials, position and proximity to the luminaire and observer.

		Horizontal** Illumination		Background* Luminance at 2.2 lux (.2 FC)	
Material	Reflectivity	Lux	FC	cd/m^2	FL
Light Sand	.15	5.0	5	.1	(.03)
Sandy Soil	.11	6.8	.6	.07	(.02)
Asphalt	.04	18.8	1.8	.03	(.008)
Concrete	.36	2.0	.2	.24	(.07)
Crushed Stone	.3-.65	1.2-2.5	.1-.2	.2	(.06)
Grass Vegetation	.17	4.4	4	.1	(.03)
Red Brick	.35	2.2	.2	.24	(.07)

*These numbers are the expected background luminance obtained if the present lighting guidelines of .2 footcandles are used for illumination.

**These numbers are the illumination levels required to yield .24 cd/m2 (.07 footlamberts).

APPROXIMATE LIGHTING REQUIREMENTS FOR VARIOUS MATERIALS TO YIELD .24 cd/m^2 (.07 Footlamberts) BACKGROUND LUMINANCE

Figure 5

Even at these levels of illumination certain combinations of backgrounds and intruder clothing will not provide either adequate illumination or contrast levels to meet the minimum threshold in some cases.

As an example and somewhat of a saving factor, if a minimum of 21.5 lux (2 footcandles) is utilized, certain areas within the illuminated area will have a higher degree of illumination since the minimum specified illumination is normally on the edge of the zone. Illumination closer to the luminaire can normally exceed this by a factor of 3:1 (average to minimum) or 6:1 (as a maximum to minimum ratio). Therefore, for certain limited segments of the zone the illumination may be as much as 108-130 lux (10-12 footcandles) or given a variety of background surfaces, 1.4-27 cd/m^2 (.4-7.8 footlamberts).

For vertical surfaces which can be painted white, the quantity of illumination required is significantly reduced. If a horizontal illumination of 2 lux (.2 footcandles) is provided at a minimum the luminance of the wall should readily exceed .26 cd/m^2 (.075 footlamberts).

4.3 Color of Light

Another significant characteristic which is notable is the color availability. A highly monochromatic light such as that from low pressure sodium lamps which consist of light almost entirely at 589 and 589.6 nanometers wavelength, does not permit discrimination of colors. Therefore, where color discrimination is required such as at access portals, for emergency equipment or emergency egress points, another source of light should be used or mixed. Heterochromatic light (such as most light sources other than low pressure sodium) provide a greater depth of focus, but monochromatic light (such as low pressure sodium) provides a sharper image. (Reference No. 11.)

Research by the Illuminating Engineering Society (Reference No. 6) has shown that on the whole the visibility of objects in roadways or in the proximity of roadways is generally the same regardless of the color of light when the distribution and intensity are similar. Therefore, there seems to be no strong color preference for intruder detectability.

4.4 Lighting Uniformity

Since the observer's head and eyes are constantly changing fixation points, the retinas are subjected to light/dark adaptation. For this reason and to reduce any discomfort, strain or excessive adaptation time, it is important to provide lighting which is uniform with a minimum of potential glare sources in the eyes of security personnel.

Uniformity of illumination (uniformity ratio) is the ratio of the average lux (footcandles) of illumination to the point of minimum illumination. A maximum to minimum ratio is often specified. General recommendations for highway use are for an average to minimum ratio of 3:1 to 4:1 (Reference No. 10). The U. S. Air Force is specifying a 3:1 ratio in the clear/isolation zone for single fence configurations as noted in Reference No. 9. The U. S. Navy has specified an 8:1 light to dark maximum to minimum ratio. "The American Standards Practice for Protective Lighting" (Reference No. 3) recommends a maximum to minimum ratio in critical areas of 6:1.

It is anticipated that an average to minimum ratio of 3-4:1 or maximum to minimum of 6-8:1 of illumination measured horizontal would be appropriate for planning purposes at nuclear fixed site facilities.

It is obvious that at points where illumination levels differ in requirements such as at portal or interfaces with areas within the protected area that are illuminated to high levels for operational or maintenance purposes, that these ratios will be difficult to maintain. However, they should be utilized in areas not subject to illumination pollution from other sources.

For planning purposes, guard patrol routes and post locations should be such that they are exposed as little as possible to areas creating glare or causing constant light to dark observation adaptation.

4.5 Intruder Speed

Although the site's security system or personnel have no way to influence the speed of which an intruder might move in most areas, target speed significantly influences detectability (Reference No. 12). The faster a target is moving, the more probable will be its detection up to a limit well above the speed with which a human can run. If there are areas where long shadows of an intruder can be created such as up against a building, both the size and speed of the shadow may be a greatly amplified image of the intruder, therefore making the intruder more detectable.

4.6 Intruder or Target Size

Target size or intruder profile influences detectability (Reference No. 8). Smaller or more distant targets require either higher levels of illumination, higher contrast levels, closer observation points or seeing aids to increase visible detectability. Figure 6 (Reference No. 8) illustrates these relationships for various visual angles (size of targets), contrast and illumination levels. The visual angle of 2.67 degrees is equivalent to a person standing at a distance of 39m (138 ft.) or crawling at 6.4m (21 ft.). The angle of 1.33 degrees represents a person at 79m (260 ft.) standing or 13m (43 ft.) crawling. The angle of .67 degrees represents a person at 156m (513 ft.) standing or 26m (85 ft.) crawling. The angle of .33 degrees represents a person standing at 317m (1040 ft.) or crawling at 53m (173 ft.). It can be seen that both higher contrast levels and illumination enhance the probability of detection of still targets. These factors should be considered when planning lighting, patrols and alarm assessment strategies.

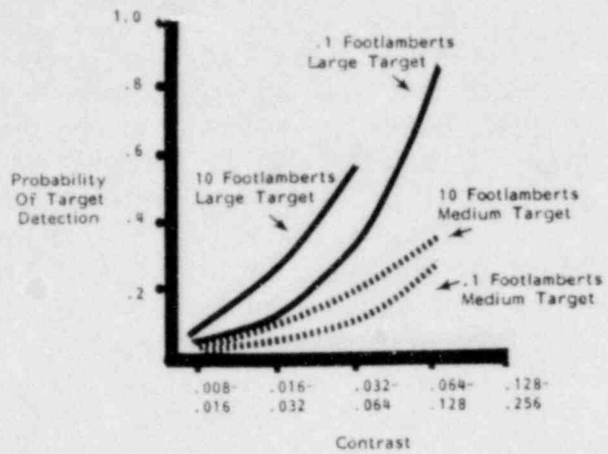
4.7 Target Search Time

Figure 7 derived from Reference No. 8 provides an indication of the time to search and find a still target. Notice that in areas of high target to background contrast, a search time of 20 or more seconds is required to achieve a reasonable probability of target detection. At lower contrast levels, the probability of detection is inadequate. This emphasizes the consideration for lighting strategies which provide either greater contrast levels, illumination levels or both.

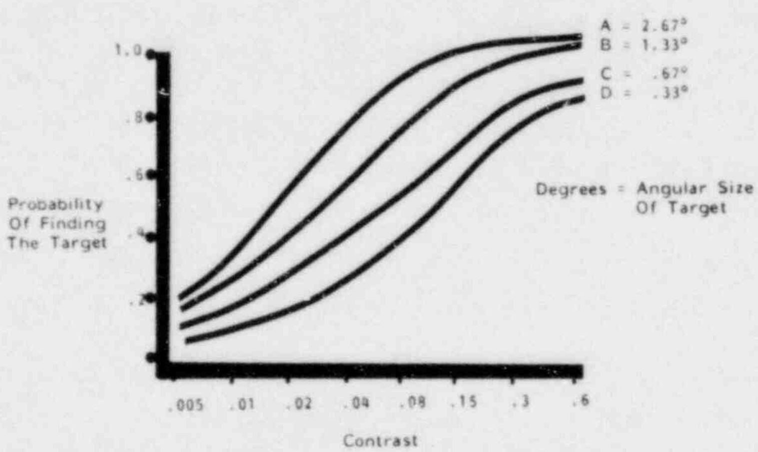
4.8 General Lighting Recommendations

As a result of the previous discussion, it is noted that while a minimum of 2.15 lux (.2 footcandles) is required by NRC, there are situations which would be significantly improved with an increased lighting level. It is recommended that the increased levels be considered when designing or updating the security lighting system for direct visual surveillance and assessments. Additionally, higher levels should be considered if CCTV systems are planned. Due to the number of variables it is difficult

Contrast, Size and Luminance

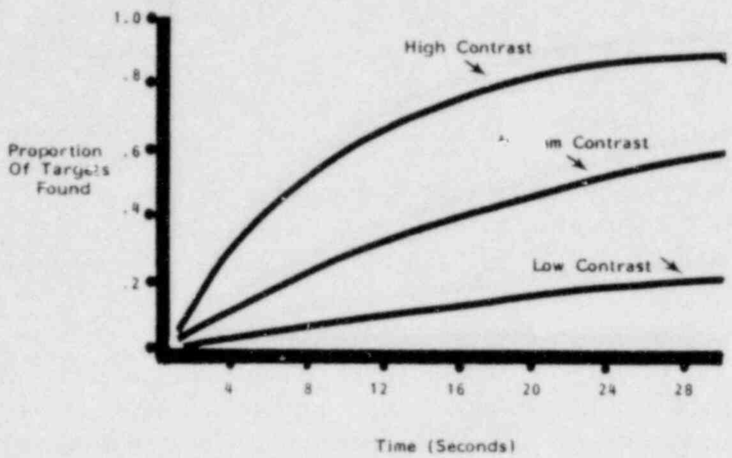


Contrast and Size



PROBABILITY OF FINDING TARGETS AS A FUNCTION
OF CONTRAST, SIZE AND LUMINANCE

Figure 6



SEARCH TIME FOR TARGET DETECTION FOR
THREE CONTRAST LEVELS

Figure 7

to specify an exact level of illumination. However, the following minimum ranges of security lighting are recommended with the higher levels being preferred.

- Exterior Protected Area Isolation Zone (2.15 to 21.5 lux) (.2 to 2 footcandles)
- Exterior Protected Area in the Area of Vital and Material Access Areas (2.15 to 21.5 lux) (.2 to 2 footcandles)
- Exterior Protected Area Between Isolation Zones and Vital and Material Access Areas (2.15 lux) (.2 footcandles)
- Exterior Vehicle and Pedestrian Access Areas (21.5 lux) (2 footcandles)

- Interior and Exterior Badge and Credentials Check Areas (323 lux) (30 footcandles)

- Interior Area Lighting (May be Existing Lighting System) Used Only During Assessment Except Areas Requiring Continuous Surveillance (21.5 lux) (2 footcandles)

The above are measured horizontal and may be increased for CCTV or other operational purposes. A maximum to minimum ratio of 8:1 with 6:1 preferred and an average to minimum light to dark ratio of 4:1 with 3:1 preferred should be uitlized.

Note that the recommendation for the general protected area is for 2.15 lux (.2 footcandles) which is the minimum required by NRC. However, the planner should keep in mind that this provides a very minimum of detection capability and puts the burden of detection and assessment on areas with higher illumination levels. For example, if intrusion detection in the isolation zone is assessed either with instant direct visual or CCTV capability it is less important for the general protected area to have higher levels of illumination. On the other hand, if the isolation zone cannot be assessed within 2-3 seconds (depending on the location of the intrusion detection device), it is quite possible that the intruder has progressed into the general protected area and a higher level of illumination, say 21.5 lux (2 footcandles), would be more appropriate.

5. INCAPACITATING CHARACTERISTICS

5.1 General

Lighting can cause seeing disabilities. If the lighting system is not properly designed, this can cause problems for security personnel on patrols or assessments. While this section is discussed in the context of visual incapacitation of intruders, the planner should recognize problems which might be created for security personnel.

The use of illumination as an intruder incapacitation device has some applicable potential. Certain lighting techniques are inherently incapacitating or are capable of degrading human performance. Four major effects of lighting technique which may alter human response are (1) glare, (2) flash blindness, (3) stroboscopic, and (4) phototropism. Other effects also warrant consideration.

5.2 Glare

Glare is the technique of directing high intensity light into the eyes of an intruder. Its effect is to (1) obscure the intruder's visual target (disability glare), or (2) produce discomfort on the part of the intruder (discomfort glare). The source of disability or discomfort glare may be directly from illumination sources or indirectly from highly reflective objects. (Reference No. 1.)

Disability glare is a result of the retina being peripherally exposed to illumination sources considerably brighter than the luminance level to which the eye is foveally centered. The exposure to a brighter luminance level reduces foveal visual performance capability and therefore obscures the visual target. The magnitude of the effect depends upon the intensity of the glare source and the location (angular distance from the line-of-sight) of the glare source. The effects of two or more glare sources are completely additive. (Reference No. 1.)

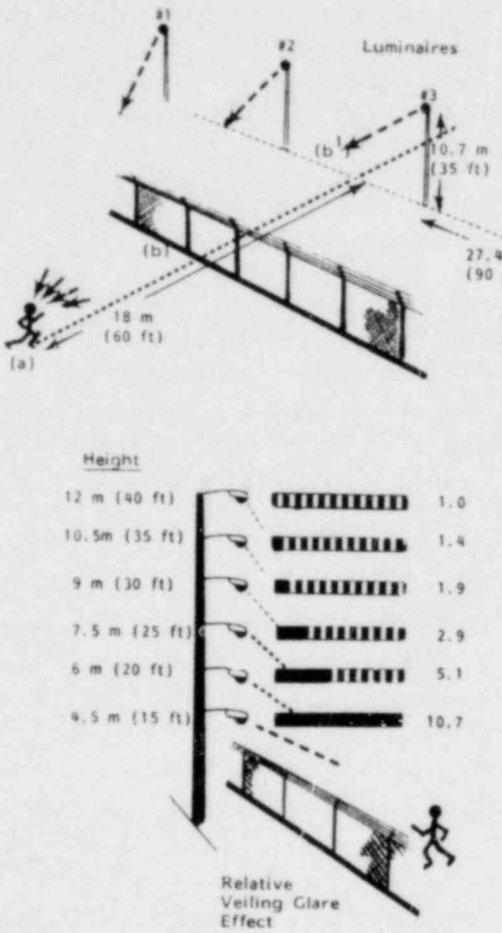
Disability Veiling Brightness (DVB) is a method utilized to determine the veiling glare effect of lighting systems (Reference No. 13). The formula for computing DVB is:

$$DVB = \frac{30\ EV}{\theta(1.5 + \theta)}$$

Ev = Vertical Footcandles at the Eye

θ = Angle in degrees between the "normal" line of sight and the glare source. The angle must consider not only the height of the luminaires but also the angle to the left or right of the line of sight.

DVB will be the sum of these effects from all sources of light in the view of an intruder. Figure 8 illustrates this type of situation. An intruder at point (a) will be visually disabled by the veiling brightness of all four luminaires. If the intruder is at the edge of the isolation zone, attempting intrusion at point (b) to (b¹), the primary DVB sources will be luminaires 2 and 3.



DISABILITY VEILING BRIGHTNESS (DVB)

Figure 8

Assuming, for example, that the intruder is at a distance of 18 m (60 feet) from the luminaire pole, the angle from the intruder's eye level to the luminaire is approximately 42°. If the vertical illumination at that point is 4.3 lux (.4 fc) then:

$$DVB = DVB_2 + DVB_3$$

$$DVB = \frac{30\ (.4)}{42\ (1.5 + 42)} + \frac{30\ (.4)}{42\ (1.5 + 42)}$$

$$= .0066 + .0066 = .0132$$

The configu-ation of luminaires 1 and 4 are very small contributors in this particular case because their distance significantly reduced their brightness and the angle to the line of sight is quite large.

If the height of the luminaires is lowered to 4.6m (15 feet) and the same illumination level is maintained then:

$$DVB = \frac{30\ (.4)}{38\ (1.5 + 38)} + \frac{30\ (.4)}{38\ (1.5 + 38)}$$

$$= .008 + .008 = .016$$

If the luminaires are spaced at 13.7m (45 feet) then:

$$DVB = \frac{30\ (.4)}{32\ (1.5 + 32)} + \frac{30\ (.4)}{32\ (1.5 + 32)}$$

$$= .011 + .011 = .022$$

If both the height and spacing reduction is accomplished then:

$$DVB = \frac{30\ (.4)}{22\ (1.5 + 22)} + \frac{30\ (.4)}{22\ (1.5 + 22)}$$

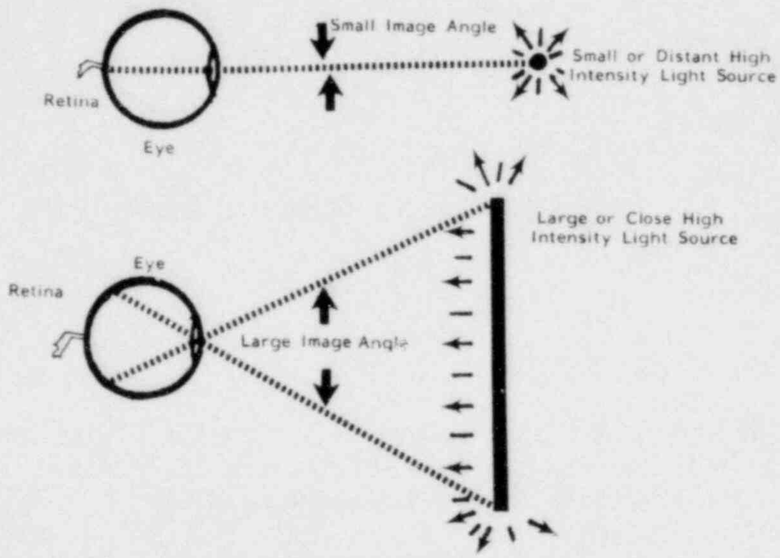
$$= .023 + .023 = .046$$

As a result of the above, it can be seen that the closer the luminaires are to the line of sight of an intruder the greater the glare deterrent and disability veiling brightness will be.

The above can be utilized to estimate the glare effectiveness of various lighting configurations. This can be used in evaluating glare as an intruder incapacitation device or to evaluate glare as a potential hazard to site security and other personnel. Figure 8 provides the relative veiling glare effect for a head-on approach to luminaires at various heights.

5.3 Flash Blindness

Flash blindness is the effect of high intensity flashes of light which cause substantial visual after images (Reference No. 9). After a "brief" super-adaptational-intensity burst of illumination to the eyes, there exists a period of visual insensitivity. The effect of the insensitivity is defined in terms of the time required for complete recovery to normal visual sensitivity levels. The magnitude of the effects of flash blindness depends primarily upon (1) flash duration, (2) intensity, (3) wave length composition, and (4) the visual angle of the flash relative to the line-of-sight. Severe effects can last up to several minutes for a single flash and may be repeated with additional flashes. Reference No. 14 provides a summary of various tests conducted to determine the variables relative to flash blindness. From this information, it is indicated that high intensity light sources can cause a period of flash blindness up to 210 seconds.

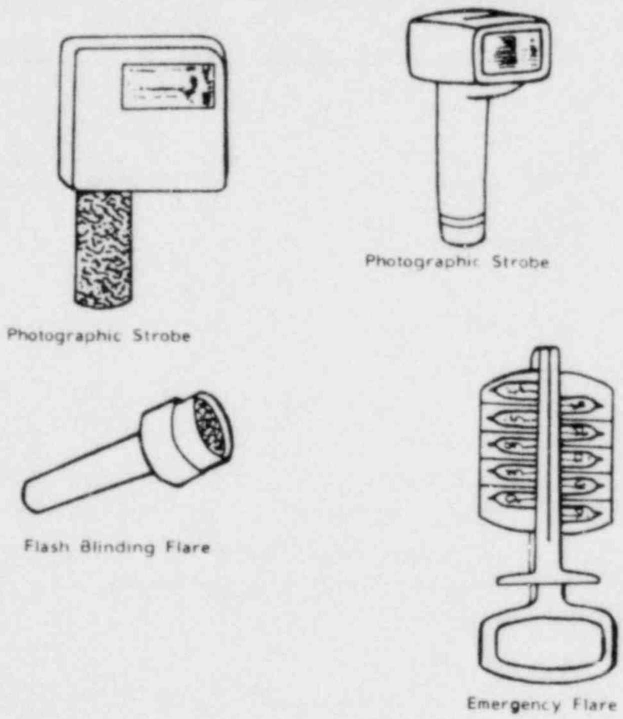


FLASH BLINDING EFFECT

Figure 9

As illustrated in Figure 9, high-intensity light flashes imaged on the retina produce residual images with the same shape as the light sources. A large close-up flash will create a very large residual image which will be difficult to see through until or unless the image or images provide a highly detectable contrast. A small flash or high intensity flash at a significant distance will create only small residual images therefore having very little residual effect since a large portion of the retina is not directly exposed. For example, a high intensity spotlight at a distance may provide a flash blinding source of only 20 minutes of arc. Therefore, while it will provide significant glare, flash blindness will be minimized. A strobe at a distance of 10 feet will provide approximately 2 degrees of arc and at 4 feet approximately 5 degrees which becomes more significant and potentially useful at closer range.

Flash blindness can be created to some extent with off-the-shelf, available devices. Some of these include photographic flash devices, photographic flash bulbs and emergency flares, special intruder flares or sweeping of high intensity flashlights or searchlights. Figure 10 illustrates some of these items. Note that the use of these items may also hinder the vision capability of the guard using them. The items listed in Figure 11 provide light of various intensities and durations. A 15,000 candlepower flashlight might be expected to cause 10 seconds of flash blindness if gazed at for a



FLASH BLINDNESS DEVICES

Figure 10

fifth of a second at very close range. A high intensity spotlight of 200,000 candlepower might cause 40-50 seconds of flash blindness if gazed at for one-fifth of a second at very close range. A searchlight of 3,000,000 candlepower might be expected to create flash blindness for 100-120 seconds if gazed at for one-fifth a second at close range. Flashlights, searchlights and spotlights normally have a highly concentrated beam. However, the further away the intruder is from the source of the light the less light available, therefore reducing the effectiveness of flash blindness.

	Portable	Duration	Intensity Candle Power	Cycle Time	Cost
Intruder Flare	Yes	Less Than 1 Second	6,000,000	Not Available*	$100
Flashlights	Yes	Continuous	2,000-15,000	None	$5-20
Spot/Searchlights Vehicle	Vehicle Only	Continuous	30,000-200,000	None	$15-60
Searchlights	No	Continuous	3,000,000	None	
Photographic Strobe	Yes	1/1,000 Second	1,000,000-6,000,000	.2-.10 Second	$20-400
Hand Flare**	Yes	Less Than 1 Second	Not Available	Fraction of Second	$5-10

*Requires Bulb Replacement

**Similar to Small Flashbulb

FLASH BLINDING DEVICE INFORMATION

Figure 11

Strobe/photographic equipment provides a very short duration flash (on the order of 1/1,000 second or less). Particularly in this case as well as in the case of continuous light, a slight deviation of gaze, turning away or blinking by the intruder during the flash or sweep of light will appreciably reduce the flash blindness effect.

Strobe lights are not only of very short duration but also they are not normally focused into a concentrated beam. Their range without a modification of beam covergence is limited by the fact that the light will diminish very quickly after 2-4m (10-13 feet). At close range or with a highly concentrated beam at a short distance, a small strobe or flashbulb device could create seconds of flash blindness. A larger strobe range could cause 10-30 seconds of flash blindness.

The advantages of using flash blinding devices are:

- Reasonably low cost
- Will work if used carefully at very close range
- No long term damaging effects to the eye of the intruder

The disadvantages of using flash blinding devices are:

- They must be used at very close range
- They will not in themselves immobilize an intruder
- The person utilizing the device can suffer some temporary vision degradation
- The intruder can avoid exposure by blinking or looking away

5.4 Stroboscopic

Stroboscopic effect is the use of periodic pulsating light to cause disorientation, confusion, or anxiety. (Reference No. 9.) The continuous flickering of lights is known to have physiological or psychological effects on certain individuals such as the onset of seizures. The effects of stroboscopic illumination are illusory motions, colors, or patterns which normally lead to distressful feelings of confusion or anxiety. (Reference No. 1.)

Research for this planning document has not revealed any practical applications of this effect for security lighting purposes. Since it is known that strobosopic lighting affects different people in different ways, there is no consistency noted for an application basis. Some people are known to work under stroboscopic lighting effects and have adapted readily.

A stroboscopic effect created by a relatively slow light pulsation could cause difficulties in the manner of light to dark adaptation. However, if the intruder has a flashlight available, the effect would be limited.

Stroboscopic lighting could also degrade the security guard's performance as well as the intruders.

Fluorescent and most high intensity discharge lamps have an inherent stroboscopic effect. This is not usually an obvious effect except around some rotating equipment, for example. This is discussed in subsequent sections.

For the above reasons additional consideration is not given to stroboscopic lighting effects for security lighting purposes.

5.5 Phototropic

Phototropic effect is the technique of using light to direct movement. A natural tendency of the human eye to orient toward light may result in a subsequent movement of the individual toward the source of light (Reference No. 9). This natural tendency is only slightly evident in humans and may be consciously avoided. It is thought that the proper placement of light within the facility perimeter may guide an intruder to a particular area which could be designed for higher apprehension probability. (Reference No. 1.) The absence of light in certain areas might also attract the intruder to utilize trapped (intrusion detection) routes or dead-end routes. Areas of low visibility or obscured vision should be reviewed for this reason.

5.6 Permanent Eye Damage From High Intensity Light

From an incapacitation standpoint, it is possible not only to utilize light sources to create effects of flash blindness and light/dark adaptation problems but also permanent effects such as chorioretinal burns. The extent and duration of these effects depends on exposure conditions and because the eye may focus on the radiant energy source, the hazard can be extreme even at long range (Reference No. 15). Both the irradiance (energy per unit of area per unit of time) incidence on the eye and the area of the irradiance source on the retina are inversely proportional to the square of the distance from the source. This is valid for open lamps or sources without concentrating reflectors or lenses or other mechanisms of concentration. A nuclear blast fire ball, for example, follows this rule. Devices such as searchlights or lights with reflectors or lenses or lasers however are primarily attenuated by scatter and reflection caused by atmospheric conditions and do not necessarily follow the same criteria, but are more dependent on focus patterns.

Permanent damage is caused by heat generated in the retina and adjacent structures by the radiant energy. If the rate at which the heat is generated is greater in an area than that which can be dissipated, the temperature will build up (Reference No. 15). The temperature above a certain threshold can cause injury to the rods and cones, optical nerve tissue, and other structures in the retina and choroid. Currently there is little reliable quantitative information on this threshold. Vision loss from such burns, although permanent and uncorrectable does not normally take the form of total blindness but rather creates blind spots. The extent of the impairment depends upon the size, severity and location of the burn. To cause extensive blindness would require either a small severe burn of the nerve fiber area (disc) which is not in the fovea and therefore would be exposed more by remote chance or by a very large/close high intensity source which would expose a very large portion of the retina. Neither of the above would seem to have practical application.

For many reasons, including marginal effectiveness, public acceptance and inherent hazards, permanent incapacitation via permanent blindness is not considered to be a recommended practice. Normal lighting equipment used for security purposes should not create any hazards.

5.7 Intense Light Source Incapacitation

Laser systems are capable of being utilized as antipersonnel and material devices. None, as such, are known to be used for protective or security purposes other than for military development, communication or intrusion detection. These are, therefore, not further considered in this planning document.

6. SECURITY LIGHTING EQUIPMENT

6.1 General

This section provides information on a variety of lamps, luminaires, supports, ballasts, distribution systems and related backup power systems. Combinations of these equipment items can be selected to provide the most cost effective security lighting which will meet the requirements at individual nuclear facilities.

6.2 Lamps

Many light sources and fixtures can supply the proper illumination for security lighting. Figure 12 shows representative lamp efficiencies and other information for light sources considered for security lighting. The light sources chosen will, of course, be those which fulfill the necessary requirements of illumination, and those which are cost effective. The characteristics for each lamp depends not only on the type lamp but also its size (rating), ballast type (if any), luminaire used and other considerations.

CHARACTERISTICS						
Lamp Type	Mean Lumens Per Watt	Start	Restrike	Nominal Life Of Lamp Hrs	% Lumen Maintenance At Rated Life	Color Discrimination
Incandescent	4(21)22*	Instant	Instant	750-1,000	85-90	Excellent
Fluorescent	35(62)100	Rapid	Rapid/Instant****	7,500-10,000	70-90	Excellent
Metal Halide	68(80)100	3-5 min.	10-20 min.	10,000-15,000	65-75	Excellent
Mercury Vapor	20(48)63	3-7 min.	3-6 min.	16,000-24,000	50-75	Good
High Pressure Sodium	95(127)140	4-7 min.	Instant**	16,000-24,000	75-85	Fair
Low Pressure Sodium	131(183)183	8-10 min.	Instant**	16,000-24,000	Basically Constant*****	Poor
Xenon Arc	***	Rapid/Instant	Instant	1,500	----	Excellent

*4(21)22 (4)--Minimum Mean (21)-Nominal Rating For Most Protective Lighting Applications 22-Maximum Mean

**Instant for most lamps if less than one minute of power interruption but at a reduced lumen output

***Use for searchlights only

****Low temperature ballast must be considered

*****Current increases until end of lamp life to keep lumen output consistant.

LAMP SELECTION INFORMATION

Figure 12

6.2.1 Incandescent

The incandescent lamp or "light bulb" produces a clean, color-true light. The lamp is a very reliable starter. It starts instantly and will restrike instantly. The incandescent lamp produces 21 lumens/watt which is very low when considering a cost effective method for illuminating a large area. The life expectancy of incandescent lamps is quite variable depending on the type and size of lamp, fill gas used, and operating voltage. Nominally 750-1000 hours is an accepted standard service life but some lamps such as projector lamps or searchlight lamps may last only 10-25 hours and other special long-life lamps may last several thousand hours. Voltage deviations from the rated voltage will cause diminished lumen output if the voltage decreases and increases output if it increases. Lumen maintenance at rated life is approximately 85 percent. Incandescent lamps do not require a ballast, do not normally cause stroboscopic effects, do not create radio interference and do not make audible noise.

"Halogen Lamps," "Iodine-Quartz," "Tungsten-Halogen" and "Krypton" lamps are all variations of incandescent lamps. Some of these may have a rated life of up to 12,000 hours with very high lumen maintenance factors.

The primary disadvantage of incandescent lamps is their relative inefficiency.

6.2.2 Fluorescent

Fluorescent lamps are cylindrical and long in shape. There is an electrode at each end with a "pool" of metallic mercury on the inside of the tube. A current flow between the electrodes vaporizes the metal and causes a gas arc. There is a thin coating of phosphor on the inside of the tube which fluoresces and gives off visible light due to the large quantities of ultraviolet radiation from the gas arc. The efficacy of fluorescent lamps is approximately 62 lumens/watt. The temperature sensitivity makes these lamps most useful as an indoor lighting source. Fluorescent lamps are rated at approximately 10,000 hours for outdoor lamps and ,500 hours for indoor lamps. Some lamps are rated as low as 6000 hours and as high as 24,000 hours. Voltage deviations reduce the lamp efficiency and shortens the life of the lamp. Low voltage can cause starting and restrike difficulties as well. Typically a 10 percent decrease or increase in voltage will cause 5 percent decrease or increase respectively in lumen output. Depending on the ballast used, the lamp will tolerate a dip in voltage from 50 to 80 percent. Ballasts are required for fluorescent lamps. A variety of lamp color outputs are available and all will provide good color discrimination. Lumen maintenance (lumen output) at rated life may vary from 70 to 90 percent. Ballasts, even though functional, can make audible noise if defective. Under certain conditions fluorescent lamp systems can also cause electromagnetic radiation or interference. Fluorescent lamps are also subject to flicker and stroboscopic effects. As a result, rapidly moving objects may give a blurred image and rotating equipment may appear to be moving in a direction opposite to or slower or faster than it actually is rotating. The stroboscopic effect can be minimized by using lead-lag type ballasts or by using 3-phase operation of 3 adjacent lamps or pairs of lamps or by operating at a higher frequency (400 Hz or higher). Normally, rapid start lamps will start or restrike within 1 second.

6.2.3 Mercury Vapor

Mercury vapor lamps produce light by passing current through a vapor or gas rather than through a tungsten wire. The lamp consists of an inner arc tube and an outer glass envelope. The outer envelope filters ultraviolet radiation which would otherwise be harmful. If the outer envelope breaks, some lamps will automatically extinguish to prevent this hazard. These types are recommended for open luminaires which are not enclosed with glass or plastic lenses. The efficacy of mercury lamps is 48 lumens per watt depending on the lamp size and ballast selection. The life expectancy rating varies from 16,000 to 24,000 hours. The response of mercury vapor lamps to voltage changes is dependent on the type of ballast used. A 10 percent change in voltage using a typical high reactance ballast will cause a 30 percent change in lumen output. If a constant wattage ballast is used, lumen output will remain relatively stable. With an auto-regulator type ballast, power dips of 40-50 percent can be tolerated without creating drop-out and restart requirements. Typically a mercury vapor lamp will reach near maximum lumen output in 3-7 minutes. Restrike time is from 3-6 minutes after a power interruption as short as 1/120 second. An interruption in the power supply or a sudden voltage drop may extinguish the arc. Most ballasts are designed to permit a voltage drop which varies with the type of ballast used. Before the lamp will restrike it must cool sufficiently to reduce the vapor pressure to a point where the arc will restrike at the voltage available. Restrike will not be at full rated output until the warm-up cycle is completed. When the lamp is an enclosed fixture, the restrike time may be slightly longer. Lumen maintenance at rated life varies widely from 50 to 75 percent. Mercury vapor lamps can create stroboscopic effects. In locations where this is a problem, pairs of lamps can be operated on lead-lag ballast or 3 lamps can be operated on 3-phase power supply systems. Lamps are also available as self ballasted or can have remote ballast. The ballasts are prone to create an audible hum. Where this is a problem they can be set up remotely. Electromagnetic radiations causing interference with certain instrumentation should also be considered. Power loss to the ballast may vary from 4-25 percent with the greatest loss attributed to the smaller lamps.

6.2.4 Metal Halide

Metal halide lamps are similar in construction and concept to the mercury vapor lamp. The lamp contains a solid inside the tube which vaporizes when current flows between the electrodes. The lamp has high intensity and very clean light with respect to color. The efficacy of a metal halide lamp is approximately 80 lumens/watt. The life expectancy rating for metal halide lamps is from 10,000 to 15,000 hours. The metal halide lamp is similar to mercury vapor lamps except that additional metal compounds including metals such as thallium, indium, and dysprosium are a part of the system. These additives help produce more white light. The response of metal halide lamps to voltage changes is dependent on the type of ballast used. A typical high reactance ballast with a 10 percent line voltage charge will cause a 30 percent plus or minus change in lumen output. With a constant wattage ballast the lumen output change will be insignificant. With an auto-regulator ballast power dips of 40-50 percent can be tolerated without drop-out and restriking required. The time required to start metal halide lamps depends on the ballast used but normally requires 3-5 minutes. Restrike time is very poor and 10-20 minutes may be required. Lamps will not restrike at full rated output and will require cool down as well as warm up time. Drop-out with restrike required will occur if the power source is interrupted for as little as 1/120 second. Lumen maintenance at rated life is from 65-75 percent. Metal halide lamps provide only minor stroboscopic effects. Power loss to the ballast depends on the type of ballast and lamp size. It varies from 5-17 percent with the greater loss on the smaller lamps. This is because the ballast requires a certain amount of power regardless of lamp size. For larger lamps the ballast consumes a smaller percentage of power. Electromagnetic radiation from the metal halide lighting systems can cause interference in certain instrumentation and sould be considered.

6.2.5 High Pressure Sodium

High pressure sodium lamps use xenon gas as the inert gas which starts the lighting arc for the lamp. An amalgam of mercury and sodium vaporizes as a result of the starting xenon gas and gives off light. The light produced is amber in color. The high pressure sodium lamp has a tube that encloses the gases and then a tube which encloses the device. During operation the inside tube containing the gases reaches a temperature of approximately 1100^{o}C. The high temperature produces a higher pressure inside the tube. Due to the high pressure, the high pressure sodium tube is made of sintered aluminum oxide. The lamp will start in 3-7 minutes. The lamp has an efficacy of approximately 127 lumens/watt. The life expectancy rating of the lamp is from 16,000 to 24,000 hours. High pressure sodium lamp lumen output only varies slightly with line voltage changes. For example, a 10 percent decrease in line voltage will cause only a 1 percent decrease in lumen output depending on the ballast used. Voltage dips which require restriking vary from 15 to 50 percent. With reactor type ballast, 12-20 percent dips can be tolerated. With auto-regulator type ballast, 40-50 percent dips can be tolerated. Most high pressure sodium lamps will restart within one minute after a power interruption. A power interruption of only 1/120 second will cause restrike. When lamps do restrike they will not be at full rated output until the warm-up cycle is completed. Lumen maintenance at rated life is 75-85 percent. Power loss to the ballast varies from 16-21 percent. High pressure sodium lamps will cause stroboscopic effects. These can be minimized by operating pairs of lamps on lead-lag ballast or by arranging 3 lamps on separate phases of 3-phase power distribution systems. High pressure sodium lamps are available in self-ballasting configurations. High pressure sodium lamps provide adequate color discrimination but produce an amber/yellow color light. Electromagnetic radiation from high pressure sodium systems may cause interference with certain instrumentation or alarm systems and should be considered. The slight audible hum of ballast should also be considered.

6.2.6 Low Pressure Sodium

Low pressure sodium lighting utilizes pure metal sodium in an inert gas combination of neon-argon. The ignition of the lamp is by means of a gas discharge through a neon-argon gas mixture. Because the lamp need not vaporize a substance to initiate the arc, they are considered very reliable starters. The efficacy of the lamp is approximately 183 lumens per watt. Low pressure sodium lamps require approximately 8-10 minutes to reach full lumen output. Manufacturers indicate that 90 percent of low pressure sodium lamps will reliably restrike after power interruptions of up to 5 minutes. The remaining 10 percent of the lamps will restrike in less than 1 minute. The life expectancy rating is from 16,000 to 24,000 hours. Low pressure sodium lamp output varies only slightly with line voltage changes. A 10 percent decrease in line voltage will cause only a 2 percent decrease in lumen output. The low pressure sodium lamp provides a highly monochromatic yellow light. Color discrimination is poor. There is no appreciable lumen depreciation during the lamp's expected life which minimizes over-specification requirements. Since the lamps are highly efficient, significantly smaller cables and lower power requirement distribution systems can be used, however, consideration must be given to sizing the system for the end of life cycles since the lamps have a higher operating current at the end of their life.

6.2.7 Xenon Lamps

High pressure short-arc xenon lamps are used where high lumen output is required from a small source. It is very appropriate for searchlight applications. Xenon lamps will reach full rated lumen output in a few seconds. Other short-arc lamps such as mercury - mercury-xenon require several minutes to reach rated output. Xenon lamps require ballasts/power supplies to provide the high voltage starting pulse. Xenon lamps would normally be used for searchlights but not for other applications relative to security lighting. They are available in the range from 100 watts to 2500 watts. Typical searchlight applications include 1000 and 2500 watts. These would be specified where very high lumen ratings are required (35,000,000 - 90,000,000 candlepower).

6.2.8 Carbon Arc Lamps

A carbon arc lamp is an electric discharge lamp in which light is produced by an arc discharge between carbon electrodes. A carbon arc source radiates because (1) incandescence of the electrodes, and (2) the luminescence of vaporized electrode material and the surrounding gaseous atmosphere. The choice of different electrode materials results in changes in brightness, total radiation, and spectral energy distribution. The most practical application of carbon arc lamps for security lighting purposes is in searchlights. Although carbon arc lamps do not require ballast, they do require power supplies. It is likely that for searchlight applications, an incandescent lamp would be more appropriate and lower in initial and continuing cost.

6.2.9 Infrared Lamps

Infrared lamps are typically variations of the incandescent lamp. They are designed to operate at a very low filament temperature to minimize visible light and maximize the infrared. These lamps would require additional light filtration for security lighting applications. They are available in a range from 125-2500 watts. Reference Section 6.6.7.

6.2.10 Ultraviolet Lamps

Ultraviolet lamps producing "blacklight" have applications in security lighting. The blacklight can be produced by both incandescent and fluorescent lamps which are appropriately filtered. Their use is most appropriate for close range inspection and a variety of lamp types, sizes and fixtures are available. Reference Section 6.6.9.

6.2.11 Other Lamps

There are a variety of other types of lamps available for highly specialized applications. None of these however seem to have application to security lighting.

6.3 Luminaires and Supports

6.3.1 General

Lighting systems require luminaires and support for the luminaires. The luminaire is generally considered to be the lamp and fixture for the lamp.

Supports for the luminaires include poles, wall brackets, ceiling brackets or ground mounting fixtures.

Factors to be considered in selecting luminaires include lamps, beam spreads, luminaire efficiency, type of fixture, designs for dirt depreciation control, designs for hazardous locations, indoor vs. outdoor applications and environmental exposure.

Supporting structures must be selected for each application. Typically pole, wall, or ground mounting of the luminaire will be specified. Material types for poles as well as height and number of luminaires per pole must be selected.

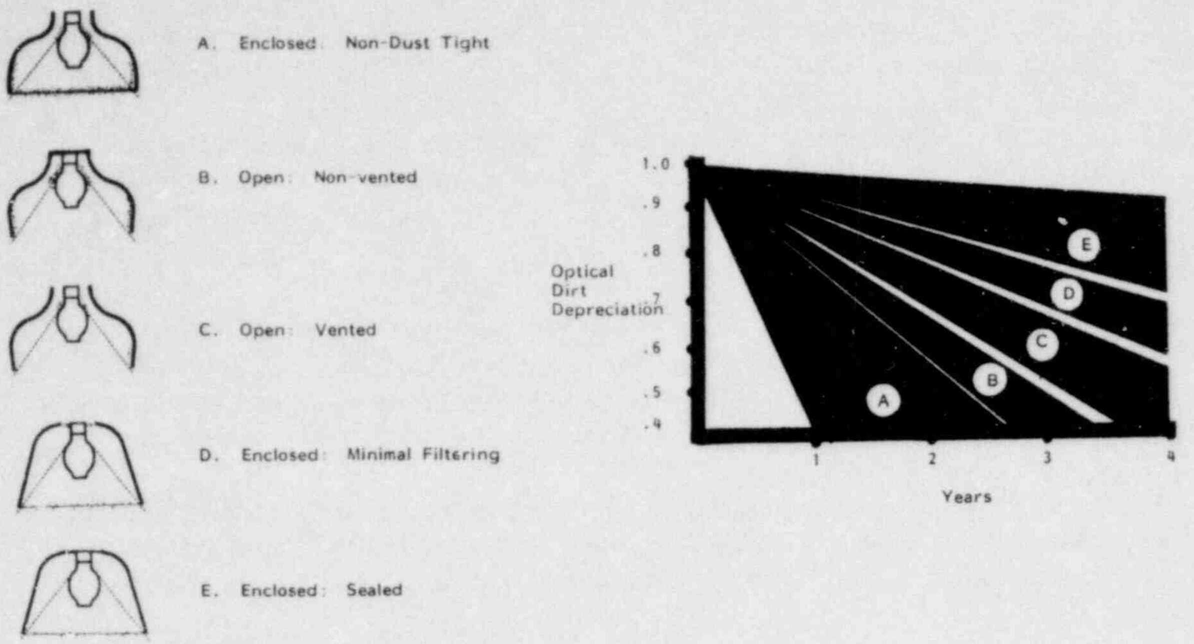
A very wide variety of systems are commercially available. Manufacturer's information is available on specific items and systems selection. Planning and design by an experienced illumination engineer is recommended.

6.3.2 Luminaires

Luminaires are designed for indoor or outdoor applications. Luminaires combine various lamps with fixtures which are either open with or without ventilation or enclosed.

The selection of luminaires relative to whether they are open or enclosed depends largely on the exposure of the luminaire to dirt and dust. For indoor lighting, open ventilated luminaires are utilized more than open non-vented luminaires because the dirt and dust will not accumulate as rapidly. Where there is a high dirt content in the air or fumes, etc., enclosed sealed luminaires can be utilized. Outdoor luminaires are normally of an enclosed type for weather protection and to minimize cleaning and maintenance but also may be open and ventilated. Figure 11 illustrates the fixture types relative to open, enclosed and ventilation configurations. Although dirt depreciation varies widely because of exposure and luminaire design, Figure 13 provides an indication of the relative dirt depreciation from dirt and dust. Notice how the accumulation of dirt and dust on the lamps, reflectors and lenses significantly reduces the lumen output of the luminaire.

Luminaires for wet locations, underwater and hazardous gas or dust locations may also be considered. Sealed luminaires are readily available for this purpose. Performance specifications are included in Underwriters Laboratories Standards Numbers 781, 676, 595, 844 and 57.



RELATIVE LUMEN DEPRECIATION FROM DIRT AND DUST

Figure 13

In selecting luminaires, consideration should be given to ease of maintenance. Access to the luminaire, ease of lens removal, lamp removal, ballast access and cleaning ease should be reviewed.

Underwriters Laboratories Standards covering luminaires, lamps and ballasts are listed below:

- Ballasts, Fluorescent Lamps #935-1978
- Ballasts, High Intensity Discharge Lamps #1029-1976
- Emergency Lighting and Power Equipment #924-1977
- Fixtures, Electric Lighting #57-1972
- Fixtures, Electric Lighting for Use in Hazardous Locations #844-1972
- Fixtures, Electric Lighting, Marine Type #595-1974
- Fixtures, Electric Lighting, Underwater, for Swimming Pools #676-1977
- Lampholders, Edison Base #[illegible]-1975

- Lampholders, Starters, and Starter Holders for Fluorescent Lamps #542-1974
- Lamps, Portable Electric #153-1976
- Lighting and Power Equipment, Emergency #924-1977
- Lighting Units, Portable Electric, for Use in Hazardous Locations, Class I, Groups C and D, and Class II, Group G, #781-1978

6.3.2.1 Outdoor Luminaires

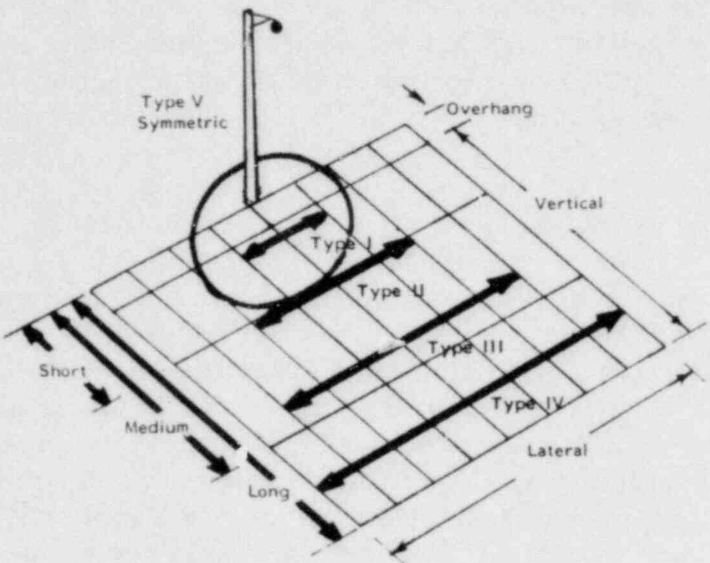
Outdoor luminaires are generally of two types, a roadway luminaire or floodlight luminaire. Either of these types can be used for both isolation zone illumination or other protected areas by utilizing various configurations of supports and luminaires. Outdoor luminaires are normally weatherproof by enclosure or open ventilated. Outdoor luminaires should be manufactured from aluminum, galvanized metal, plastics, other alloys or be appropriately coated with a protective finish to assure minimal maintenance and maximum service life.

6.3.2.1.1 Roadway Luminaires

The Illuminating Engineering Society has established luminaire classifications for roadway types by vertical light distribution, lateral light distribution and control of light distribution above maximum candle power (Reference No. 16). Figure 14 illustrates these criteria. Vertical light distributions are divided into short, medium and long. These refer to the relative reach of illumination from the luminaire (for example, in the direction of across the road). The lateral illumination refers to the distribution parallel to the roadway. The con[illegible] of light describes the amount of illumination falling outside of the speci[illegible] design area. "Controlled" is less than or equal to 10 percent, "semi-con[illegible]" or "semi-cutoff" is not more than 30 percent and "non-cutoff" provi[illegible] limitation. As shown in Figure 14, the roadway luminaire is normally de[illegible]ed to hang over the illuminated area. Applications for this type luminaire are covered in Section 7. As an illustration, a typical specification or desicription for a 7.3 m (24 foot) wide roadway would be as follows (Reference No. 16):

Light Distribution -	Type	III
	Vertical	L (Long)
	Control	Semi-Cutoff

Lamp Data	Designation	Mercury 700w Clear
	Output (Lumens)	39,000
Pole Data	Height	10.7m (35 ft.)
	Overhang	1.2m (4 ft.)
Arrangements	-	One Side
Spacing	-	61m (200 ft.)
Illumination	Average	1.49 Horizontal
	Minimum	.51 Horizontal
	Uniformity	2.9:1 Avg. to Minimum



ROADWAY LUMINAIRE LIGHTING DISTRIBUTION

Figure 14

An additional consideration for roadway luminaires is the luminaires' coefficient of beam utilization. This is the fraction of lumens from the lamp which reach the illuminated area. It is a function of the luminaire design including configuration, reflectivity of materials used, lens material, and lamp utilized.

To complete the information required to determine the luminaire configuration design, the luminaire dirt depreciation (LDD) factor and lamp lumen depreciation (LLD) factor and other factors such as equipment factors or external factors must be considered.

Normally, manufacturers provide complete photometric data on their luminaires for planning and design purposes. Most manufacturers and distributors will provide a complete computer analysis of configurations and cost for a client's application as a customer service.

6.3.2.1.2 Floodlight Luminaires

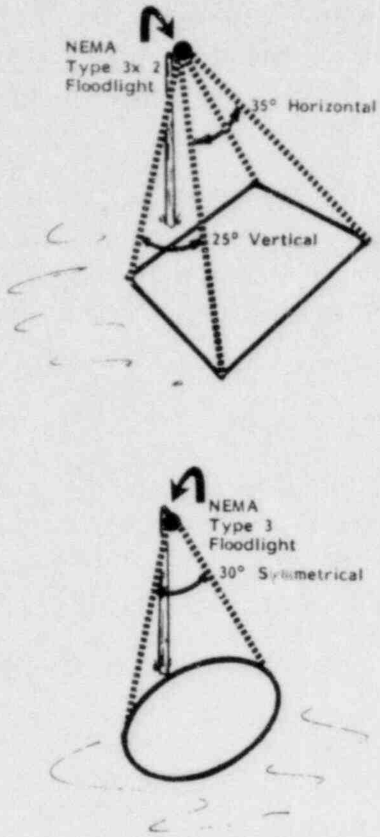
The National Electrical Manufacturer's Association and the Illuminating Engineering Society have designated criteria for floodlight luminaires. These are described by NEMA types which define 7 beam spread degrees (Reference No. 6) as shown below.

NEMA Type 1	10-18 Degrees Spread
NEMA Type 2	18-29 Degrees Spread
NEMA Type 3	29-46 Degrees Spread
NEMA Type 4	46-70 Degrees Spread
NEMA Type 5	70-100 Degrees Spread
NEMA Type 6	100-130 Degrees Spread
NEMA Type 7	130-Up Degrees Spread

These designations refer to a symmetrical (circular) beam. However, the designations can be utilized to define "rectangular beams." This would be designated, for example, by Type 6x4 Floodlight. The 6x4 designates the type of horizontal spread and vertical spread respectively. A $110^{\circ} \times 50^{\circ}$ floodlight would be a Type 6x4. Obviously, a wide variety of flood configurations can be defined and are available commercially. Figure 15 illustrates several configurations which describe the NEMA type designations.

Floodlight luminaires can be utilized for both "roadway type" of isolation zone illumination or protected area illumination.

As in the case of roadway luminaires, several factors must be considered in planning or designing. Such factors include the luminaire utilization factor, luminaire dirt depreciation factor (LDD), the lamp lumen depreciation factor (LLD), other equipment or exterior factors, luminaire height and luminaire aiming point.



NEMA TYPE FLOODLIGHT DESCRIPTIONS

Figure 15

Manufacturers provide complete photometric information on their luminaires and will normally assist in the planning and design as a customer service. It is recommended that the design of illumination systems be accomplished by an experienced illumination engineer.

6.3.2.2 Indoor Luminaires

A wide variety of indoor luminaires are commercially available. In high bay areas, high intensity discharge luminaires, or high wattage incandescent or fluorescent luminaires are normally utilized. Although enclosed luminaires can be utilized and are appropriate in hazardous or wet areas, ventilated open luminaires are becoming more common. In high bays, glare is not usually a problem since the luminaires can be mounted high in the ceiling. In low bay areas and offices, lamps used in luminaires are usually shielded by louvers, baffles or diffusers to minimize glare problems. Primarily, fluorescent and incandescent and low wattage high pressure sodium luminaires are utilized in low bay or office areas.

As in the case of outdoor illumination, many factors must be considered in planning or designing indoor luminaire configuration. General indoor illumination considerations and criteria for nuclear power plant lighting are provided in Reference No. 17, "Nuclear Power Plant Lighting." Indoor illumination for nuclear power plants is predominantly continuous and an integral part of operational requirements. However, several recommendations are made which relate to luminaire selection and in some cases apply to other nuclear fixed sites. These include:

- Refueling Floor - Enclosed and gasketed luminaires, wall mounted.
- Crane Illumination - Enclosed and gasketed high bay luminaires.
- Pools - Underwater luminaires in pools, mounted around pools on wall.
- Bridge Crane - Enclosed and gasketed luminaires mounted on crane as required.
- Decontamination and Waste Areas - Enclosed and gasketed luminaires.

The luminaires for the above should be of a heavy duty industrial type with high impact globes or covers and vibration proof. Luminaires used in the pool areas should be of stainless steel or low zinc bronze alloys. The use of zinc galvanized and aluminum luminaires and related fixtures should be avoided in the PWR reactor containment areas. Luminaires and related fixtures should be located and designed to minimize the potential of items falling into pools.

Design and planning for general indoor illumination is beyond the scope of this document due to the wide variety of luminaires and operational illumination requirements within nuclear fixed sites. Section 7 does address several applications where security/safety illumination may be required as a minimum if operational illumination levels are not otherwise available.

6.3.2.3 Special Luminaires

"Pit Lights" are protected luminaires which can be installed in the ground or in wells of wet and harsh environmental areas. These luminaires are ideal for installation in roadways at vehicle portals and inspection stations. They are weather protected and have a durable protective lens.

Underwater luminaires for use in reactor pools are commercially available. For security lighting purposes these would normally already be installed for operational lighting purposes.

6.3.3 Luminaire Structural Supports

6.3.3.1 General

Indoor and outdoor luminaires are supported by wall mountings, ceiling mountings, light standards, poles, high mast structures and a variety of other methods. This section reviews some of the basic considerations for planning and design.

6.3.3.2 Outdoor Luminaire Structural Supports

6.3.3.2.1 General

Luminaire support structures include wall mounting, common light standards, pole top standards and high mast/tower systems. Design standards which will aid in preparing specifications on designs are noted in Reference No. 10 and "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" by the American Association of State Highway and Transportation Officials (Reference No. 18).

Primary design and selection considerations include the local environment, selected luminaire system, structural support loads, materials selection, soil conditions, cost, space available, maintenance and other unique site requirements.

6.3.3.2.2 Poles and Masts

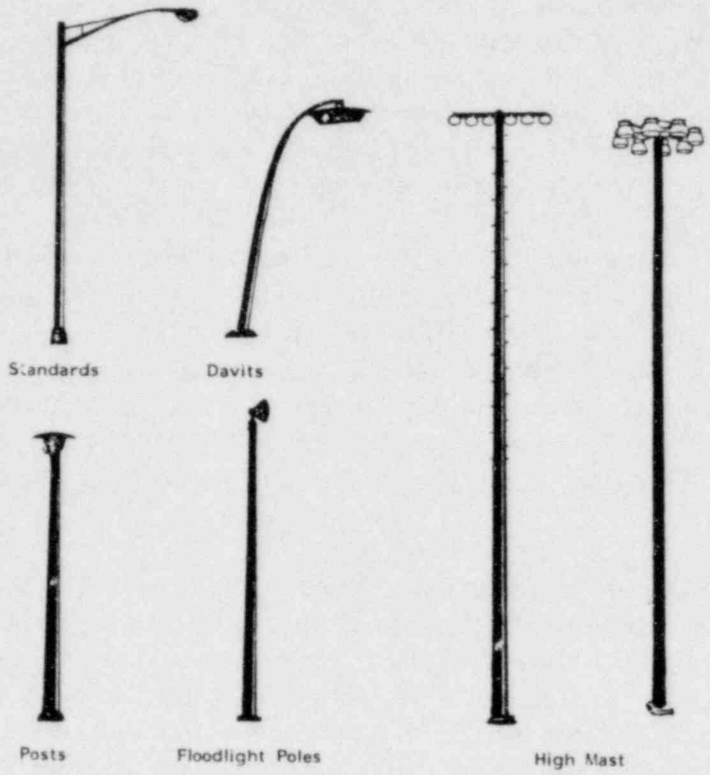
6.3.3.2.2.1 General

Poles and masts for luminaire support are commonly made from treated wood, steel, aluminum or reinforced concrete. Pole and mast heights of up to 46 meters (150 feet) are available. Poles and common light standards are used for perimeter illumination. For this purpose, the luminaire height is usually 12 meters (40 feet) or less. Generally each pole will have 1 to 4 luminaires depending on design requirements. High masts or towers are used to illuminate large areas and may utilize up to 12 or more luminaires. While shorter poles can usually be serviced from a "bucket truck" which is currently available with working heights up to approximately 18 meters (60 feet), taller masts will require either climbing aids (cables or pegs, for example) or luminaire lowering devices. A variety of pole and mast configurations are shown in Figure 16.

Pole and mast loads must be considered for planning and design purposes. These loads consist of dead loads (the weight of the luminaires, supports, lowering devices, and other fixtures including CCTV devices, if appropriate), ice loads (as determined for the installation area) and wind loads (based on regional maximum wind speeds on a 50-year mean recurrence with special consideration given to exposure to gusts; high winds or turbulence). Reference No. 19 provides computational details and regional information.

If luminaire support structures are to be utilized for CCTV cameras as well as luminaires, particular attention should be given to structure flexure resulting from wind loads and its effect on image quality. The slightest camera movement may cause a very distracting video image movement. At sites where this is likely to be a consideration, an analysis of the anticipated windloads, camera movement and impact on the video image should be completed.

High mast systems are more economical when large areas require illumination. High mast systems reduce glare at ground level which is desirable within the security area. Poles at a relatively low level along the isolation zone create glare for the intruder, selective higher intensity illumination in key areas and can be aimed away from the protected area thereby eliminating glare in the eyes of the security force.



TYPICAL OUTDOOR LUMINAIRE SUPPORTING STRUCTURES

Figure 16

6.3.3.2.2.2 Steel Poles and Masts

Steel poles and masts are one of the most expensive options from the standpoint of initial cost as indicated in Figure 17. However, they are durable if properly protected against corrosion. This can be accomplished by specifying galvanized steel, stainless steel, painting or other pretreatment. Stainless steel is very expensive but requires a minimum of maintenance. Aluminized steels will also require a minimum of maintenance.

Steel masts are available in heights up to 46 meters (150 feet) or more if required.

6.3.3.2.2.3 Aluminum Poles and Masts

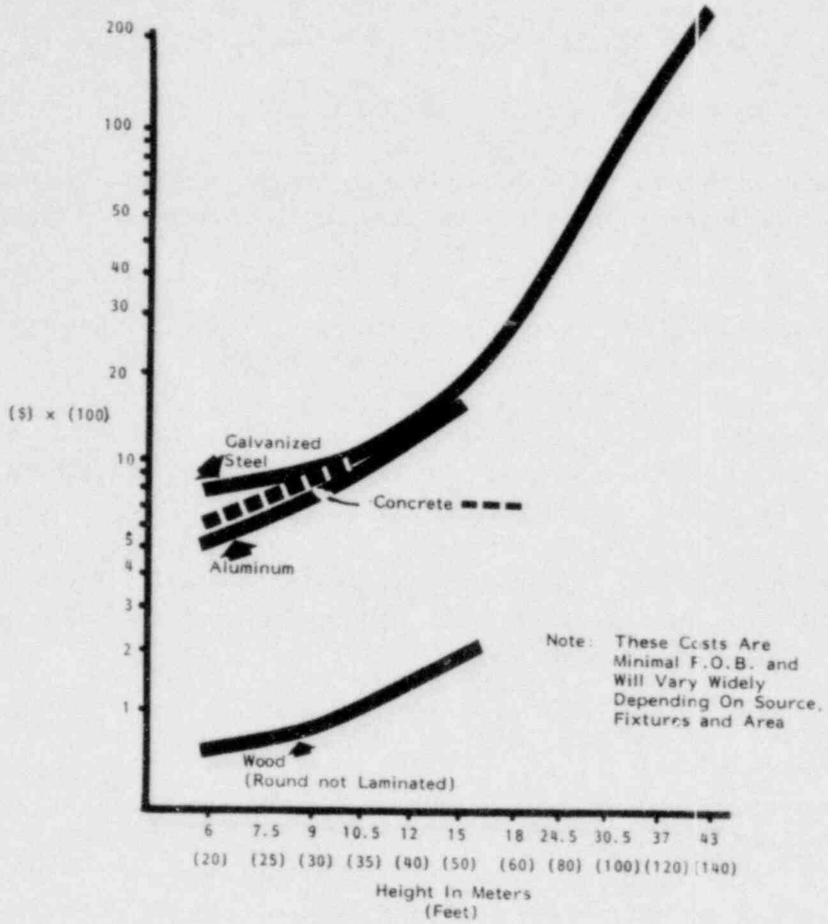
Aluminum poles and masts are very close in cost to steel poles of equal height. They have very long service lives and require a minimum of maintenance.

If aluminum poles or other fixtures are utilized, precautionary measures should be taken where they come in contact with wood or dissimilar metals. The purpose of this is to minimize the effects of corrosion and electrolysis (Reference No. 18). Surfaces which come in contact with wood, masonry or concrete can be protected by application of a coating of alkali-resistant bituminous paint.

Additional information on aluminum structures is available in "Specifications for Aluminum Bridge and Other Highway Structures," The Aluminum Association, New York, April, 1969.

6.3.3.2.2.4 Wood Poles

Treated wood can be utilized for luminaire supports with heights of up to 15-18 meters (50-60 feet). Wood poles should be pressure treated with either creosote or pentachlorophenol type preservatives. Depending upon environmental exposure at the installation, a service life of 20-30 years can be anticipated. As shown in Figure 17, wood poles have a relatively low initial cost. Wood poles require a minimum of maintenance and foundation expense. The aesthetics of wood poles is limited due to the requirement of external conduit and fixtures and non-existent architectural



COMPARATIVE POLE AND MAST COST

Figure 17

stylization. Wood poles are more subject to fire damage. They are appropriate for use where aesthetics are not significant and high masts are not required. They should provide excellent service as isolation zone and perimeter luminaire supports. Wood laminated poles which may be somewhat more aesthetically designed as well as round poles are available. The laminated poles may have internal raceways and therefore not require external conduit and fittings. Laminated poles are available in heights of up to 9 meters (30 feet). The cost of laminated wood poles ranges from approximately $650 for 6 meters (20 ft.) to $1400 for 9 meters (30 ft.) poles.

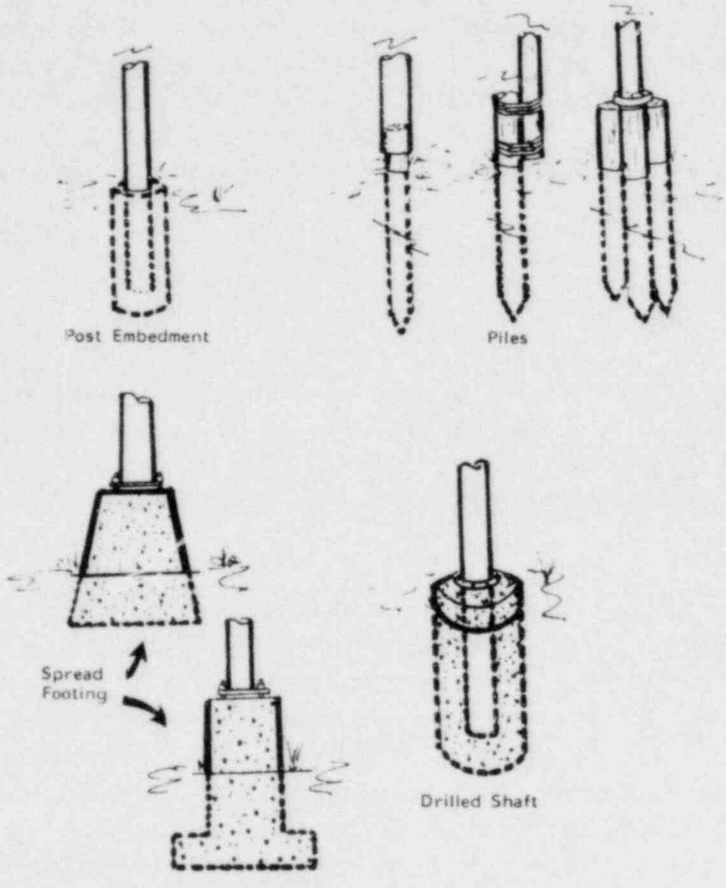
6.3.3.2.2.5 Concrete Poles

Concrete poles are available in a range of from 3 meters (10 feet) to 12 meters (40 feet). The poles are prestressed and manufactured usually by centrifugal casting processes or non-centrifugal processes. Aggregate surface options with a polished Terrazzo finish make the poles aesthetically attractive. Maintenance should be minimal since the poles, with the exception of miscellaneous fixtures, are basically inert. Extensive exposure to salt spray or splash should be avoided.

6.3.3.2.2.6 Foundations

Foundation requirements for luminaire supporting structures depend upon the type of pole utilized, height and weight of the pole and luminaires, pole wind and ice loads, and soil conditions. Soil information including type, density and ground water conditions should be investigated by the foundation designer.

Generally foundations will be either of a post embedment, piles, drilled shaft or spread footings type. These are illustrated in Figure 18. Post embedment can be utilized for relatively short poles in relatively dry and stable soil conditions. This is a common foundation for wood poles (telephone poles, etc.). Piles may be used when soils are constantly wet at shallow depths or caving of sides precludes use of drilled shafts or spread footings. Drilled shafts can be utilized for "deep" foundations which are desirable where horizontal loads or cantilevered loads are prevalent. Spread footings provide a larger vertical bearing surface for heavy loads or unstable soil conditions.



TYPICAL LUMINAIRE SUPPORT STRUCTURE FOUNDATIONS

Figure 18

Soils such as loose sand and soft clay will require foundations which are larger or deeper or both. Soils such as hard clay may permit smaller foundations. Foundations should be deep enough to be well below the frost line to prevent frost heaving.

Foundations should be designed by an experienced engineer to assure that all appropriate design requirements are considered.

6.3.3.2.3 Wall Mounts

Fixtures and luminaires designed for wall mounting are readily available. They normally add little if any cost to the luminaire and avoid the cost of poles or masts. Floodlight luminaires are available with brackets which require attachment using several bolts.

6.3.3.2.4 Ground Mounts

In some instances it may be desirable to mount luminaires at ground level to floodlight a building or sign. This can be accomplished by utilizing an appropriate embeded spike or post or a small spread footing. Luminaires with mounting brackets can be bolted directly to the support.

6.3.3.3 Indoor Luminaire Structural Supports

Indoor luminaires are normally suspended from the ceiling area or wall mounted. Standard hardware is available for this purpose or mounting features are offered as an integral part of the luminaire. Brackets usually require attachment with several bolts. Ceiling suspended units may either be clamped or bolted on to roof support structures.

6.4 Ballast Systems

6.4.1 General

Ballast systems are required for high intensity discharge (HID) lamps and fluorescent lamps to provide power to the lamp at the proper voltage and current levels. Generally the ballast is an integral part of the luminaire but in some cases can be separated from the lamp by as much as 1-46 meters

(3-150 feet). High pressure sodium and mercury vapor lamps are also available as self-ballasted (with the ballast built into the lamp). Self-ballasted lamps are not as efficient as those with regular ballasts. Generally the efficiency of a ballast increases with the output rating of the lamp used. Since the ballast consumes power as well as the lamp, they must be added together including power factor to determine total power requirements.

6.4.2 High Intensity Discharge (HID) Lamp Ballasts

6.4.2.1 General

There are several important factors to be considered when selecting ballasts for security lighting systems. These include efficiency, crest factor, range of temperature exposure, fusing, grounding, voltage regulation, extinction voltage (drop-out or dip-voltage) and power factor.

The efficiency of a lighting system or luminaire is based not only on the power consumed by the lamp but also the ballast. In computing the net lumens per watt the number of watts should include both the lamp and ballast. Generally the higher powered lamps and ballast are more efficient.

The crest factor is the ratio of maximum lamp current to R.M.S. (root-mean-square) current. A maximum crest factor (approximately 2.0 for mercury vapor and 1.8 for metal halide and high pressure sodium lamps) must be maintained by the ballast to assure maximum lamp life.

Mercury vapor and metal halide lamps have minimum specified starting temperatures for given starting voltages. Lower temperatures may require higher voltages. It is important to assure that the specified ballast will meet the minimum requirements.

Some manufacturers do not recommend fusing of high intensity discharge lamp ballasts and indicate that a reactor type ballast should never be fused. Since ballast normally fail in an open circuit condition, the value of fuses is diminished. If fused, interruptions will be minimized by using fuses or breakers with a rating of 3 times maximum current. Grounding of lamp sockets should be considered only if primary and secondary ballast transformers are isolated from each other.

Ballasts must assist in controlling lamp voltage over a range of line voltage deviations. Voltage dips causing extinction or drop-out should also be controlled. Most ballast will tolerate dips up to 15-20 percent with some tolerating dips of up to 50-60 percent.

Power factor ratings of ballasts are important from an economic standpoint. Ballasts with power factors of 50 percent use approximately twice as much power as a 90 percent power factor rating. Utility companies may charge a premium for power consumed at a low power factor. Figure 19 illustrates several common ballast types.

6.4.2.2 Reactor Ballast

The reactor ballast is small and low cost and applies to mercury vapor and sodium vapor lamps. A voltage of plus or minus 5 percent of ballast rated operating voltage is required for mercury vapor and plus or minus 10 percent for sodium vapor. The reactor ballast generally has a power factor of 50 percent, however, it can be corrected to 90 percent with the addition of an expensive capacitor across its lines. Starting current is higher than operating current. Use of a mercury reactor ballast for high pressure sodium lamps will cause a very short lamp life.

6.4.2.3 Lag Type Ballast

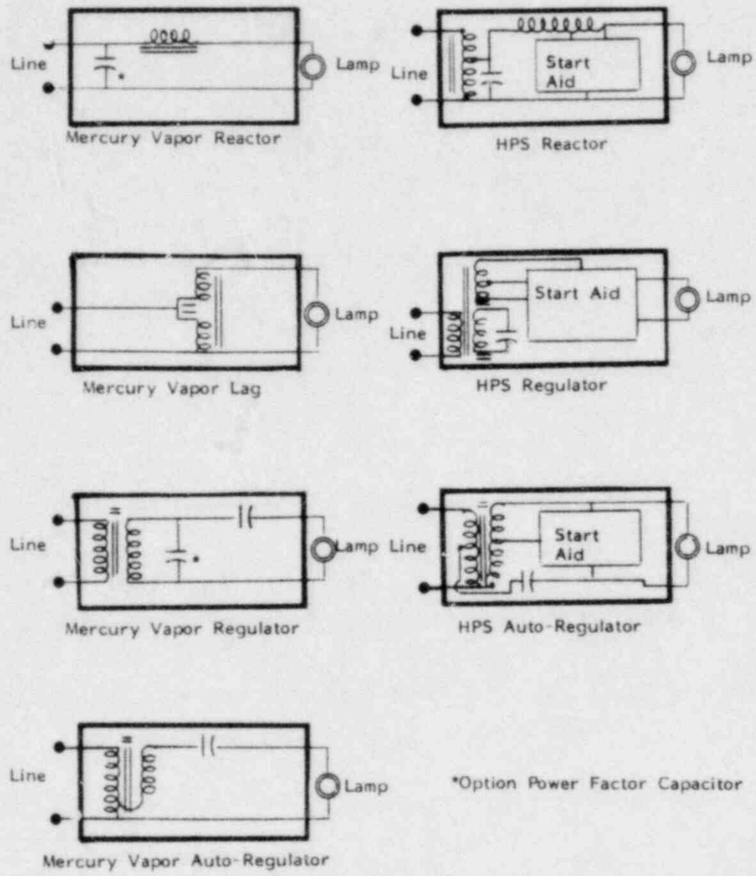
Lag type ballasts have low power factor ratings of 50 percent and can tolerate voltage dips of only 15-20 percent. They have a crest factor of 1.4 and require a closely regulated line voltage (plus or minus 5 percent). They are only used on mercury vapor lamps. The ballast losses are greater than the reactor ballast. Starting current is higher than operating currents.

6.4.2.4 Regulator Type Ballast

The regulator ballast has a crest factor of 1.8 and a power factor of 95 percent. It can tolerate large voltage dips of up to 50-60 percent and line voltage deviations of plus or minus 13 percent. It has among the highest ballast losses. It is only used for mercury vapor lamps.

6.4.2.5 Auto-Regulator Ballast

The auto-regulator ballast is low cost and relatively efficient. It has a crest factor of 1.6 and power factor of 90 percent for mercury vapor and metal halide and 95 percent for high pressure sodium. It can tolerate voltage dips



BASIC BALLAST TYPES FOR HID LAMPS

Figure 19

of 40-50 percent and line voltage deviations of plus or minus 10 percent. It is commonly used on mercury vapor, metal halide and high pressure sodium with the addition in manufacturing of a lamp voltage transformer and starting aid.

6.4.2.6 Auto Transformer Ballast

This ballast is used for low pressure sodium lamps. It will start lamps in temperatures as low as -34°C (-30°F). It has a power factor rating of 95 percent and requires that line voltage be controlled to plus or minus 10 percent.

6.4.3 Fluorescent Lamp Ballast

Ballast for fluorescent lamps should be an instant starting type with a high power factor rating. Both of these features are common.

6.4.4 Xenon Arc Lamp Ballast

Xenon arc lamps require power supplies designed specifically for the type and rating of the lamp used. These are normally provided by the manufacturer of the searchlight or luminaire.

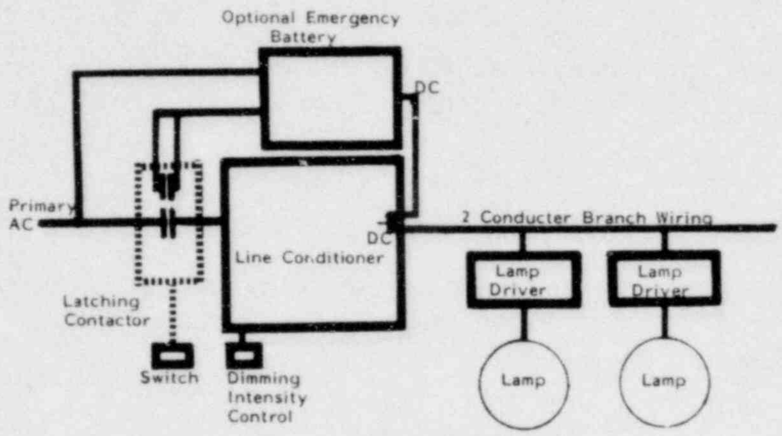
6.4.5 Other Ballast Systems

6.4.5.1 General

Several newer types of ballast and ballast features have been recently developed. These systems are discussed in the following paragraphs.

6.4.5.2 Transistorized Arc Control

The transistorized arc control system made by Wide-Lite utilizes solid state components and provides features such as built-in dimming, potential to be tied directly in with a D.C. battery bank for use as an emergency power supply, silent operation, stroboscopic effect free and it can provide power for several power cycles which may prevent drop-out and restrike after very brief power interruptions. (Reference Figure 20.) This system is available for 175 watt and 400 watt metal halide and mercury vapor lamps and 150 watt and 360 watt high pressure sodium self-starting lamps. An energy savings of 7-10 percent is claimed when used with metal halide lamps. Line voltage variations of plus or minus 10 percent will not cause lamp power to vary more than plus or minus 1 percent. The dimming feature permits adjusting the lumen output to the minimum required. Dimming from 100 to 60 percent of rating is claimed. Additional savings can be realized by allowing lamps to operate at partial output until higher levels of lighting are desired for increased visual or CCTV assessment (savings of approximately 40 percent).



TRANSISTORIZED ARC CONTROL

Figure 20

6.4.5.3 GE Steadilux (Trademark)

The GE Steadilux is a hybrid design which combines a conventional core and coil and capacitor with an electronic control. It achieves a plus or minus 1 percent regulation of lamp watts for plus or minus 10 percent line voltage variation. The power control features keep the lamp output almost constant over the life of the lamp. This minimizes the need to overspecify or plan for excessive lamp lumen depreciation. Improved energy efficiency of at least 10 percent is claimed. This ballast is available for 150, 250 and 400 watt high pressure sodium lamps. This feature adds approximately 68 dollars to the cost of the luminaire.

6.4.5.4 "Hot Lamp Restart"

General Electric manufactures a "Hot Lamp Restart" feature. Although most high pressure sodium lamps will restrike within one minute, two to three minutes may be required to achieve full lumen output. The "Hot Lamp Restart" will restart the GE Lucalox (Trademark) lamp instantly without significant lumen degradation after outages of up to 10 seconds. If the power outage is less than 30 seconds but more than 10 seconds it will restrike instantly but lumen output will be slightly diminshed. Presently, this is available as an option on reactor ballast for 50, 70, 100 and 150 watt lamps only. This feature adds approximately 65-76 dollars to the ballast cost. Although not stated by the manufacturer, this method of restart may decrease the life of the lamp.

6.4.5.5 Automatic Auxiliary Lamp Switching Ballast

High intensity discharge luminaires and ballast are available which during power interruption will automatically switch power to an auxiliary lamp (usually tungsten halogen) which will provide immediate light. When the main lamp restrikes and reaches output from 40 to 60 percent, the auxiliary lamp extinguishes. When this system is used in conjunction with an auxiliary power source, emergency lighting can be provided.

Manufacturers who provide these systems include Wide-Lite (LiteMatic - 250, 400, 1,000 watt HID plus 150 watt tungsten halog auxiliary) and GE (400, 1,000 watt HID plus 250 watt quartz auxiliary; 250 watt and smaller HIDs plus 150 watt quartz auxiliary). These systems add approximately 55-109 dollars to the cost of each luminaire not including the auxiliary lamp. Caution in designing systems such as these is necessary in determining the total circuit load for all the lamps simultaneously.

6.4.5.6 Dimmers

Dimmers are available for incandescent, fluorescent and high intensity discharge lamps. Dimmers may be manually controlled or automatically controlled. The purpose of dimmers is to allow adjustment of lumen output to specific levels. Their use is appropriate for taking advantage of ambient light (reducing the lumen output to provide minimum net levels) or for compensating for lamp and dirt depreciation (by automatically increasing lumen output only as required).

A wide variety of commercial and industrial dimmers are available for fluorescent and incandescent lamps. Since these are not used primarily for security lighting except in isolated areas, they are not covered in detail.

One system, the Automatic Energy Control (AEC) manufactured by Wide-Lite, provides an automatic dimming system which monitors the light available and adjusts the luminaire output to a specified level. This system is available for 400 and 1,000 watt high intensity discharge lamps. As an indoor system, it can compensate for lamp and dirt depreciation and ambient light. As an outdoor system, it can compensate for lamp and dirt depreciation, ambient light and ambient atmospheric conditions such as rain, fog, etc.

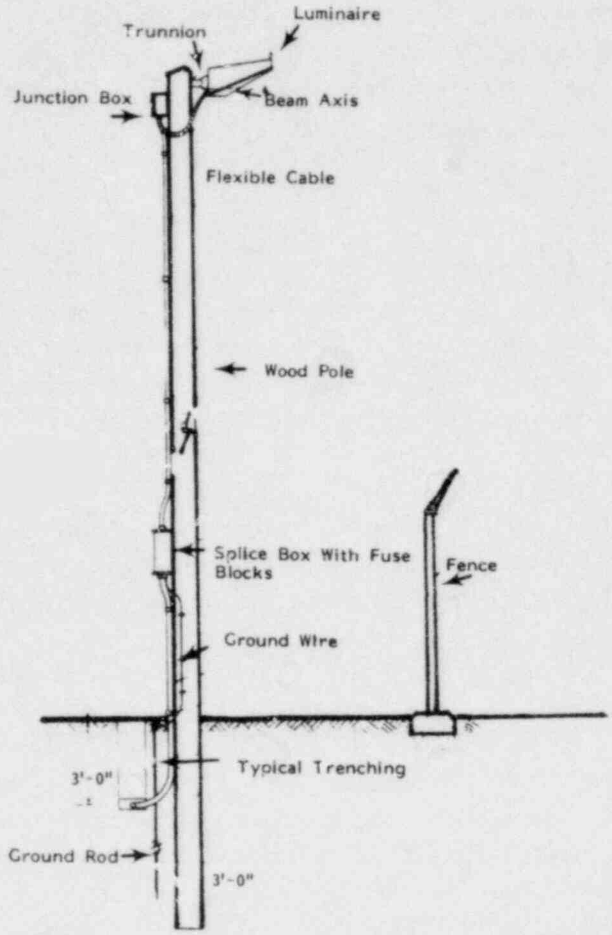
6.5. Power Systems and Distribution

6.5.1 General

The purpose of this section is to highlight unique factors relative to security lighting system power systems and distribution.

6.5.2 Primary Distribution

There are a variety of circuits suitable for various kinds of security lighting systems. There is also a choice to be made between overhead and underground distribution systems. While overhead systems are generally more accessible for maintenance, they are more susceptible to damage by ice, storms and adversaries. When choices are available, it is recommended that an underground system be utilized. A typical installation is illustrated in Figure 21. Note in the figure that the electrical conduit is located on the backside or secured side of the pole (wooden in this case) and that each luminaire is fused. The fuse box should be kept as close to the ground as possible to minimize the quantity of exposed non-fused circuit. It is recommended that the security lighting distribution system and related substation systems be located within the protected area and out of the line-of-sight from off-site as much as possible.



TYPICAL SECURITY LIGHTING POLE CIRCUIT

Figure 21

There are many circuit options for security lighting systems. Caution should be utilized to assure that each luminaire is independent from others. Damage to one pole should not affect other poles nor cause large segments of the security lighting system circuit to open. Separate pole fusing will prevent this in case of luminaire malfunction or pole/luminaire damage.

Lighting circuits should be planned to avoid overloading or blowing fuses or breakers which will affect total lighting reliability. Separate conduits and feed circuits are desirable whenever possible. Having all or large segments of luminaires on one circuit significantly reduces the overall security lighting reliability and alternatives should be considered. Separate lighting systems for portals (vehicle and personnel), protected area outdoor lighting, material access areas, vital areas and security alarm stations are recommended. Refer to Figure 22 as a partial typical example.

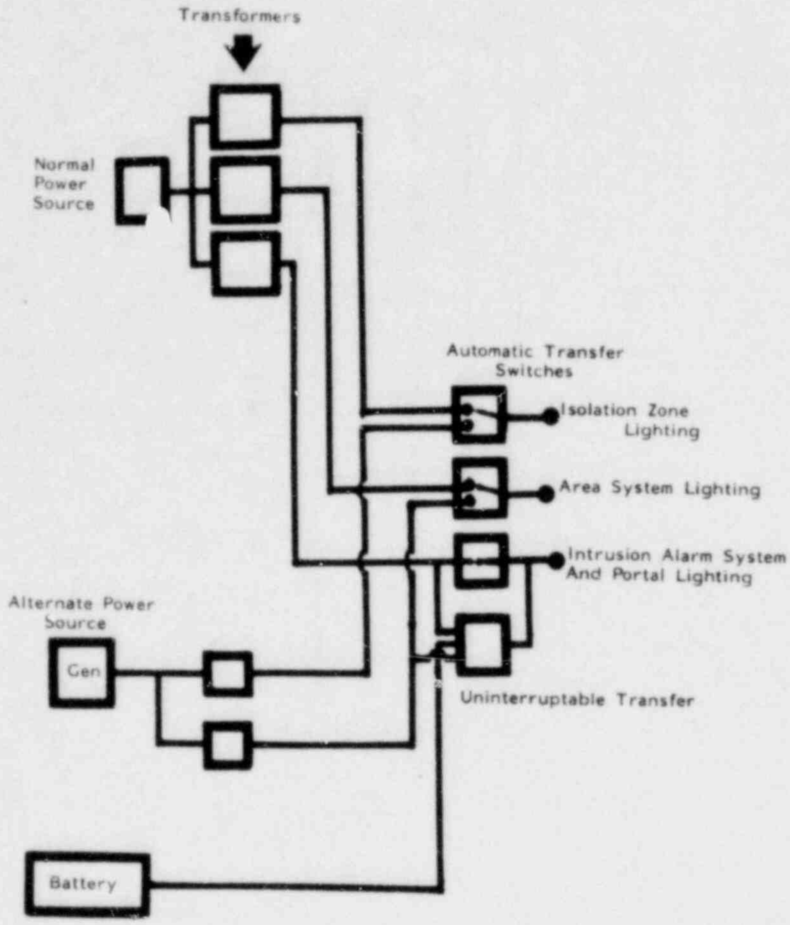
Where 3-phase power distribution systems are planned, it is possible for alternate luminaires to utilize separate phases of the 3-phase system. This method will provide some continuous illumination in case of a failure of a single phase. This approach also minimizes stroboscopic effects which are common to most high intensity discharge lamps and fluorescent lamps.

As shown in Figure 23, poles with 3 luminaires may use 2 phases alternating on each pole. Poles with one luminaire may alternate phases on each pole. If poles have more than 3 luminaires, other combinations can be worked out to assure load distribution and best assurance of continuous illumination.

Similar systems can be worked out utilizing single-phase by alternating off neutral if the luminaires are selected for 1/2 of the single phase voltage. However, it may not be advisable to either mix or lower the voltage for maintenance and economy reasons. (Reference Figure 24.) Isolation switches should be provided at each pole to manually transfer a damaged circuit to an alternate feed. This can be accomplished by feeding a row of fixtures from both ends and sizing either circuit to carry the full load at an increased acceptable voltage drop.

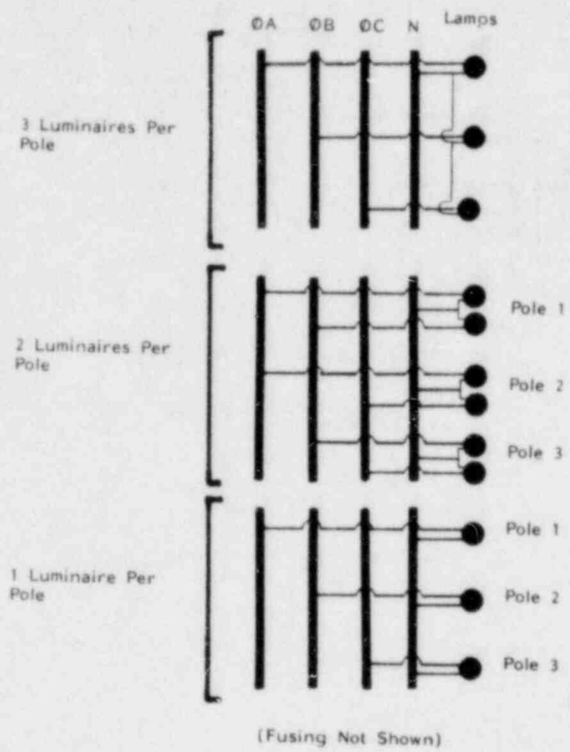
6.5.3 Power Surges and Losses

As noted in the sections on lamps and ballasts, luminaires are sensitive to power surges and losses. Voltage drops due to "brown outs" or other causes can result in diminished illumination in some cases or cause certain



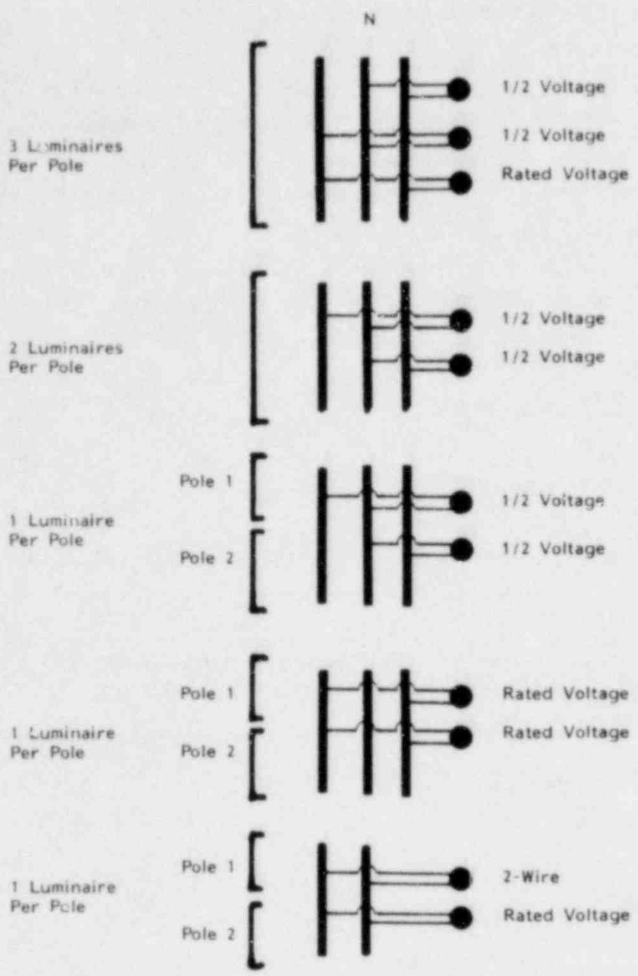
PARTIAL TYPICAL LIGHTING SYSTEM POWER DISTRIBUTION

Figure 22



3-PHASE LUMINAIRE WIRING DIAGRAMS

Figure 23



SINGLE PHASE LUMINAIRE WIRING DIAGRAMS

Figure 24

types of luminaires to drop-out or reduce output. Complete failure of a momentary or long-term type can be caused by adversaries, equipment failure, accidents, lightning strikes or other storm damage.

Tests run by the National Bureau of Standards (Reference No. 19) indicate that a person can penetrate a perimeter chain-link fence in 6 to 47 seconds. Intruders in a running mode can cover from 15-25 feet per second. This would indicate that a 60 foot isolation and fence zone at a protected area perimeter could be penetrated and cleared in from 8.4 to 51 seconds. If the intruder continues to run into the protected area, penetration of up to 135 to 1,290 feet could be accomplished within one minute. If the intruder initiated the power outage, access to the proximity of vital or material access areas could readily be accomplished for the purpose of sabotage or threatened sabotage. Using this rationale, it is recommended that lighting systems for the isolation zone provide for a maximum of 10 seconds outage. The backup power supply should be of an uninterruptable type or a generator type with luminaires which will reliably restrike within 10 seconds. To accomplish this would mean that an independent power source would have to come on within 10 seconds and instantly restrike the lamps or that an uninterruptable power supply will be required to sustain the lighting system until power is either returned or the backup system is activated.

Power changes beyond the tolerance limits of various luminaires can have several detrimental effects. If the voltage drops marginally, lamps may not operate at rated output or cease to operate until restarted with the proper power level.

Typical effects of power changes are summarized by type of lamp below:

- Incandescent lamp output varies with voltage applied to the lamp. Start and restart time to full output is almost instantaneous. Power dips do not cause restart delays.

- Fluorescent luminaires are usually of an instant or rapid start design. They will restrike almost as quickly as incandescent lamps.

- Metal halide lamps require a 3-5 minute startup cycle to reach 80 percent of rated light output. If the power is interrupted for more than 1/2 cycle or 1/120 second, restart will be required. Restart for metal halide requires 10-20 minutes. If an auto-regulator type ballast is uitlized, power dips of 40-50 percent can be tolerated without drop-out. To avoid the restrike time requires use of an uninterruptable power supply. Reference No. 9.)

- Mercury vapor luminaires typically start in 3 - 7 minutes. Restarting is required if the lamp's power is interrupted for more than .008 seconds. It must cool down before restarting. Cool down and restart can take from 3 to 6 minutes. (Reference No. 9.) To avoid 3 to 6 minutes outages would require an uninterrupted power system. Significant power dips can be tolerated to the extent of 60 percent depending upon the type of ballast used. The dip-voltage which can be tolerated without causing drop-out or restrike are shown below:

Regulator Type	50-60% DIP
Lag Type	15-20% DIP
Auto-Regulator Type	40-50% DIP
Reactor Type	15-20% DIP

- High pressure sodium (HPS) lamp restart capabilities are similar to mercury lamps in that if the power source is interrupted for more than 1/120 second reignition is required. (Reference No. 9.) However, since they do not have to cool down as much, the restrike time is from 1/2 to 1 1/2 minutes with a nominal time of 1 minute claimed by most manufacturers. Initial start requires 3 to 4 minutes for 80 percent output. Voltage dips can be tolerated without drop-out or requiring restrike to the extent of 15-50 percent depending on the type of ballast used as shown below:

Reactor Type	15-20% DIP
Regulatory Type	40-50% DIP
Auto-Regulator Type	40-50% DIP

- HPS lamps in a luminaire of German design (Reference No. 9) used by the U.S. Air Force in Europe provide a ballasting system which will allow instant restart with outages of up to 60 seconds and requires a 30 second restart time if the outage is for no more than 120 seconds. Otherwise, it is necessary to accept a minute outage or provide an uninterruptable power supply.

- General Electric manufactures a "Hot Lamp Restart" feature as an option on ballasts for 50, 70, 100 and 150 watt high pressure sodium lamps which will provide instant restart with outages of up to 10 seconds and instant restart with outages of up to 30 seconds at slightly reduced lumen output. In this case, an interruptable power source could provide rapid restrike illumination (such as a generator with a 10 second power up time).

- Low Pressure Sodium (LPS) lamp output varies slightly with line voltage changes. Start time for low pressure sodium lamps requires about 10 minutes. If power is interrupted, the lamp stays hot enough to restart instantly within the normal time frame necessary to start a generator. Therefore, service could be expected to be restored within 10 seconds with a generator or continuous service can be provided with an uninterruptable power source. Since the LPS lamps will instantly restart with only momentary power interruptions, momentary power dips in line voltage do not cause drop-out or restrike. Manufacturer's claims for restrike time for low pressure sodium lamps as noted in Reference No. 9 are as follows:

  "35 and 55 watt lamps will re-ignite immediately following a power drop out with a reliability factor of plus 95%."

  "90, 135, and 180 watt lamps will re-ignite immediately following a power drop out with a reliability factor of plus 75%."

  "Lamps that do not restrike immediately will strike within a maximum of 2 minutes."

  "The amount of light provided when lamps re-ignite will be dependent upon the duration of the outage. In general, if power is restored within 30 seconds those lamps which re-ignite immediately will provide 90% plus of their maximum light output." Note that lamps which have been extinguished in excess of the 30 seconds will require additional time to reach rated output.

  "The latest information from the lamp manufacturer is that 90% of the lamps will restrike immediately with interruptions up to 5 minutes. The other 10% will take 58 seconds to restrike."

In summary:

An uninterruptable power supply will provide continuous power to all luminaires.

An interruptable power supply will provide power to restrike incandescent and fluorescent luminaires instantly, metal halide luminaires in 10-20 minutes, mercury vapor luminaires in 3-6 minutes, high pressure sodium luminaires in 1 minute (instantly with optional ballast features) and low pressure sodium lamps 90 percent instantly if within 58 seconds.

It is recommended that luminaires and backup power supplies be combined such that isolation zone illumination will restrike within 10 seconds, that protected area illumination will restrike within 60 seconds, that portal area illumination is continuous and that vital and material access area illumination is continuous. Note that the general requirement recognized by NRC is for a 60 second restrike maximum time in the protected area.

6.5.4 Backup Power System

6.5.4.1 General

The backup power supply for the security lighting systems should be on site within the protected area, considered a vital area and additional to the primary or preferred power system. It does not have to be exclusively for the purpose of lighting. The security lighting backup power can be derived from systems designed to provide backup power for purposes other than security if the system is on site within the protected area and has adequate capacity and appropriate activation criteria.

Typical systems and combinations of systems to be selected from include:

- Uninterruptable Power Supplies
- Interruptable Power Supplies
- Generator Sets
- Special Ballast Systems

U. S. Nuclear Regulatory Guides provide a significant amount of information on backup and emergency power systems. Several of these guides are listed below:

Regulatory Guide 1.108; August 1976 (For Comment); Periodic Testing of Diesel Generators Used as On-Site Electric Power Systems at Nuclear Power Plants.

Regulatory Guide 1.118; June 1978; Periodic Testing of Electric Power and Protection Systems.

Regulatory Guide 1.128; October 1978; Installation Design and Installation of Large Lead Batteries for Nuclear Power Plants.

Regulatory Guide 1.129; April 1977 (For Comment); Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants.

Regulatory Guide 1.137; Fuel-Oil Systems for Standby Diesel Generators.

Regulatory Guide 1.30; Quality Assurance Requirements for the Installation, Inspection and Testing of Instrumentation and Electrical Equipment.

Regulatory Guide 1.32; Use of IEEE Std 308; Criteria for Class IE Power Systems for Nuclear Power Generating Stations.

Regulatory Guide 1.41; Pre-Operational Testing for Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments.

Regulatory Guide 1.47; Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.

Safety Guide 1.6; Independence Between Redundant Standby (On-Site) Power Sources and Between Their Distribution Systems.

Regulatory Guide 1.75; September 1978; Physical Independence of Electrical Systems.

Regulatory Guide 1.81; Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants.

Regulatory Guide 1.9; November 1978 (For Comment); Selection, Design, and Qualification of Diesel-Generator Units Used as On-Site Electric Power Systems at Nuclear Power Plants.

Regulatory Guide 1.93; December 1974; Availability of Electric Power Sources.

Regulatory Guide 5.3; June 1974; Materials Protection Contingency Measures for Uranium and Plutonium Fuel Manufacturing Plants.

Branch Technical Positions, BTP ICSB6; Capacity Test Requirements of Station Batteries Technical Specifications.

Branch Technical Position, BTP ICSB-11, Stability of Off-Site Power Systems.

Safety Guide 9; March 1971; Selection of Diesel Generator Set Capacity for Standby Power Supplies.

NUREG Report, CR-0509; Emergency Power Supplies for Physical Security Systems (details planning information for backup power systems).

Minimum requirements for emergency or standby systems which are vital to protection of human life or safety in public facilities are covered in the National Electrical Code, NFPA (National Fire Protection Association) 101-Life Safety Code, and in the National Uniform Building Code.

Another excellent source is the IEEE's Recommended Practice for Emergency and Standby Power Systems. Std 446-1974.

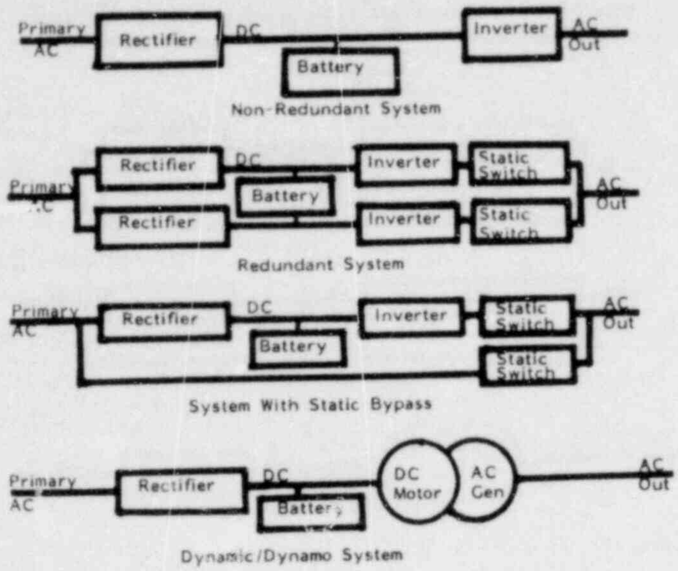
6.5.4.2 Uninterruptable Power Supplies

For the purposes of security lighting backup power systems, uninterruptable power systems (UPS) are systems which provide constant power to protect equipment against power outages or voltage variations and assure continuity of operation. A system typically consists of storage batteries, power inverters and related controls. Several typical systems are shown in Figure 25. Redundancy built into the uninterruptable power systems provide much greater reliability. However, since the uninterruptable system itself is a redundant system, it is not necessary to provide extra assurances for security lighting.

The cost of various sizes of uninterruptable power systems are shown in Figure 26. These costs vary depending on type of system, shipping and installation requirements. The costs shown include only the equipment cost and not the cost of a facility for the equipment.

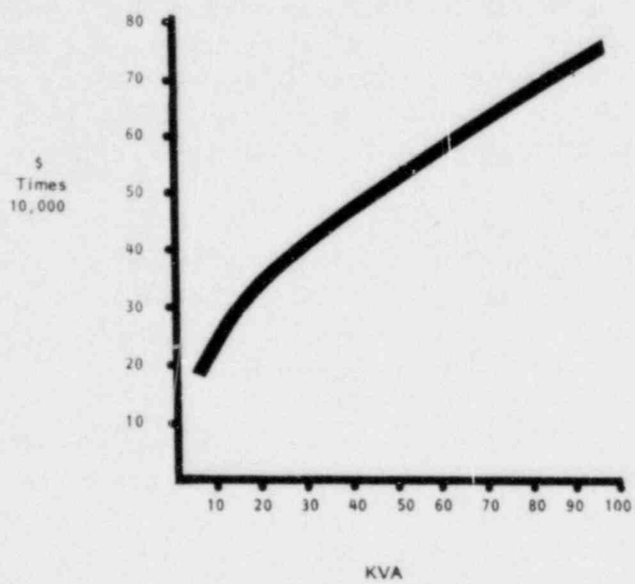
Typically UPS's will be designed to provide about 15 minutes of power for security lighting systems. Therefore, generator sets are required or other power sources for continuous operation when the failure of the primary power source exceeds 15 minutes.

In specifying a long life UPS/Battery System, the user should consider use of the lead-calcium/lead-acid batteries instead of lead-antimony/lead-acid to provide an approximate service life of 20 years in float use, up to 30 percent reduction in water servicing and no equalize requirements with proper float (Reference No. 20). With these battery systems, the user should also



TYPICAL UNINTERRUPTABLE POWER SYSTEMS

Figure 25



RELATIVE COST OF UPS SYSTEMS
(With 15 Minute Backup)

Figure 26

be aware that some capacity is lost after 15-18 years. IEEE Standard 450-1975 recommends that batteries be replaced when they reach 80 percent capacity. This early replacement can be avoided if a 125 percent capacity rating is specified at installation. Typically, a monthly test for 30 seconds of discharge and an annual full discharge test would be appropriate. Reference Numbers 21 and 22 provide systems planning details.

6.5.4.3 Interruptable Power Systems

For the purpose of security lighting backup power systems, interruptable power systems are those which do not provide continuous power during an interruption of the primary power source. This results from either time required to start a generator set or mechanically switch to a backup source such as a battery inverter system or other sources. Figure 27 illustrates several typical systems.

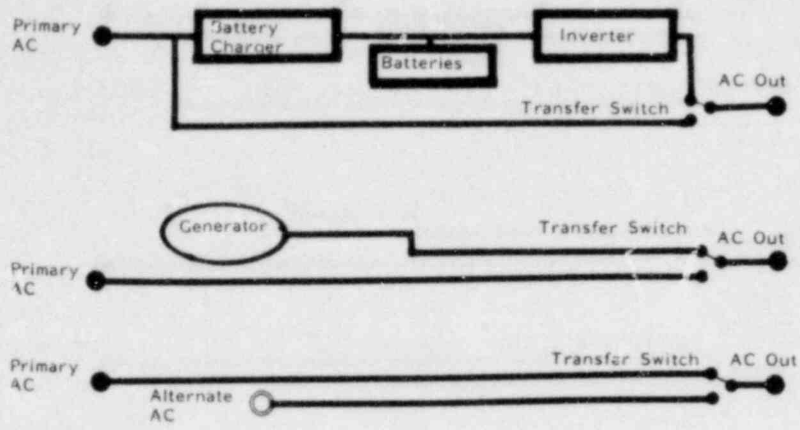
Generators for backup power supplies are available in a wide range of outputs. They can be powered by steam, gas, propane/butane, gasoline or diesel fuel. Figure 28 shows the relative approximate cost of several types and various sizes of systems. This cost includes equipment only and not a facility for the equipment.

Generators cannot start fast enough and switch into the power grid to avoid a momentary void in current flow. Depending on the size, condition, and ease of starting, the interruption may be from a nominal time of 10 seconds to several minutes. Diesel powered sets may require a longer period to start if additional time is necessary for "glow plugs" to heat up (in the order of 1 minute extra).

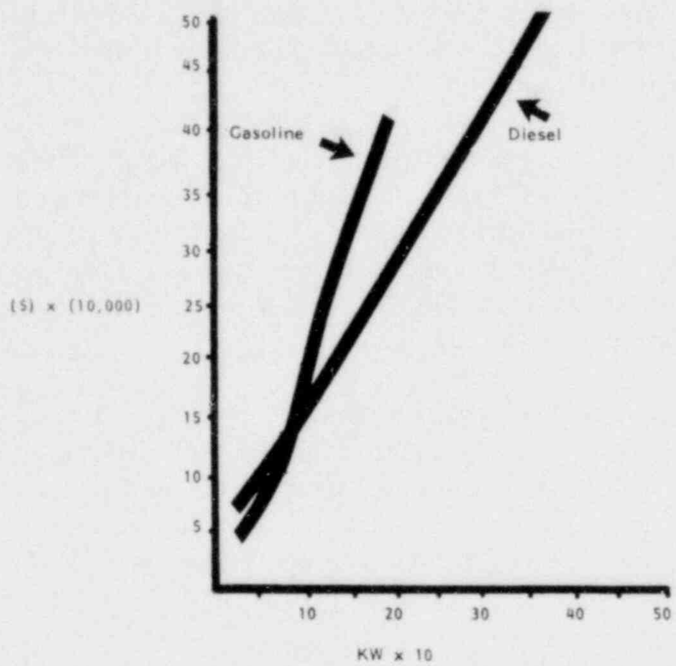
If a generator set is installed along with a UPS system, it may not be necessary to have a 15 minute battery system for the UPS. If the generator set is highly reliable, the battery capacity of the UPS system can be reduced.

Generator set installations should be planned with the following considerations in mind:

- radio interference shielding
- exhaust muffling
- vibration controls
- engine or fuel heating



TYPICAL INTERRUPTABLE POWER SYSTEMS
Figure 27



RELATIVE COST OF GENERATOR SETS

Figure 28

- multiple fuels and fuel storage quantities
- unit location and space available
- careful load analysis
- security protection of the unit and switchgear
- environmental protection of the unit (weather, rodents, etc.)

Gasoline engine generators are normally lower in initial cost for smaller units, start more rapidly, require more maintenance and are available in sizes up to 150-200 KW.

Diesel engine generators are generally more expensive initially for smaller units, more economical to operate, have less maintenance and are good for continuous operation.

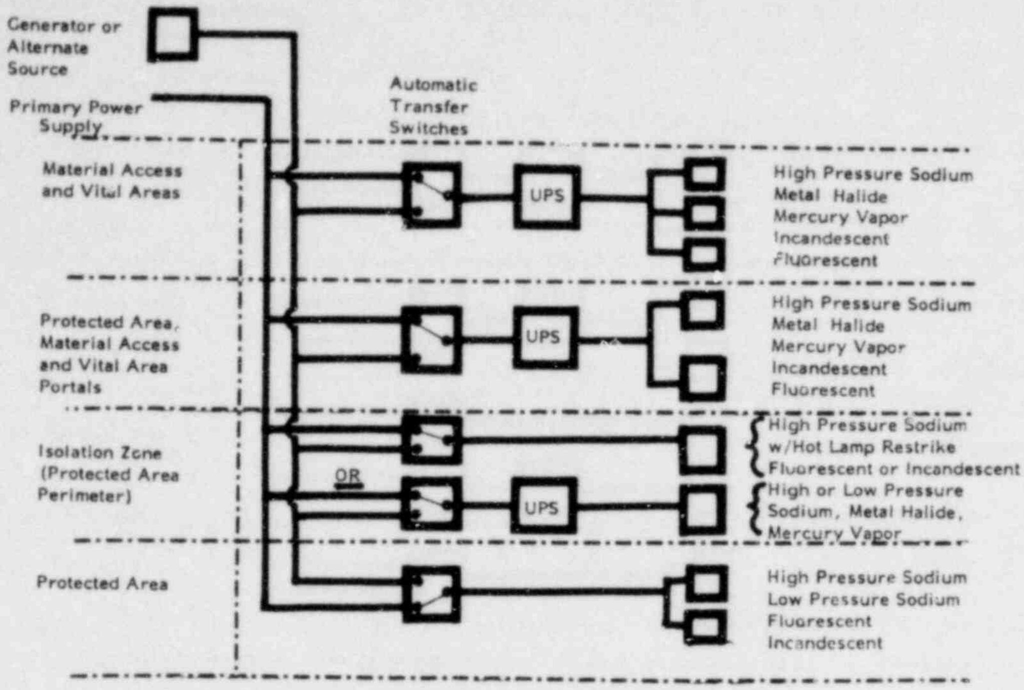
Gas powered engine generators start quickly and have relatively low maintenance cost due to clean running of gas or propane.

Gas turbine driven generators are available but less common in use. They operate on gas or oil fuel and are relatively compact but require noise control and do not start as quickly as gasoline engine powered generators.

Reference Numbers 21 and 22 provide systems planning details.

6.5.4.4 Typical Power Systems for Security Lighting

With all of the various kinds of luminaires and backup power systems, there are many combinations which will meet the recommended criteria. Figure 29 outlines several combinations utilizing uninterruptable power systems (UPS) and one or more backup generators. Note that the material access and vital areas are on an UPS to assure no lapse in illumination. Since the UPS is used, there is a variety of luminaire types which can be selected. The portals are provided with the same features as the material access and vital areas. The UPS need only provide power long enough to get the generator started and on line. The isolation zone can tolerate illumination lapses of up to 10 seconds. Therefore, either instant start luminaires with a 10 second start time for the generator or an UPS with any luminaire is appropriate. The general protected area can have illumination lapses of up to 60 seconds. Therefore, the generator with the noted luminaires should be adequate. In the case of area illumination, metal halide or mercury vapor will not restrike in time unless an UPS is provided.



TYPICAL SECURITY LIGHTING POWER SYSTEM

Figure 29

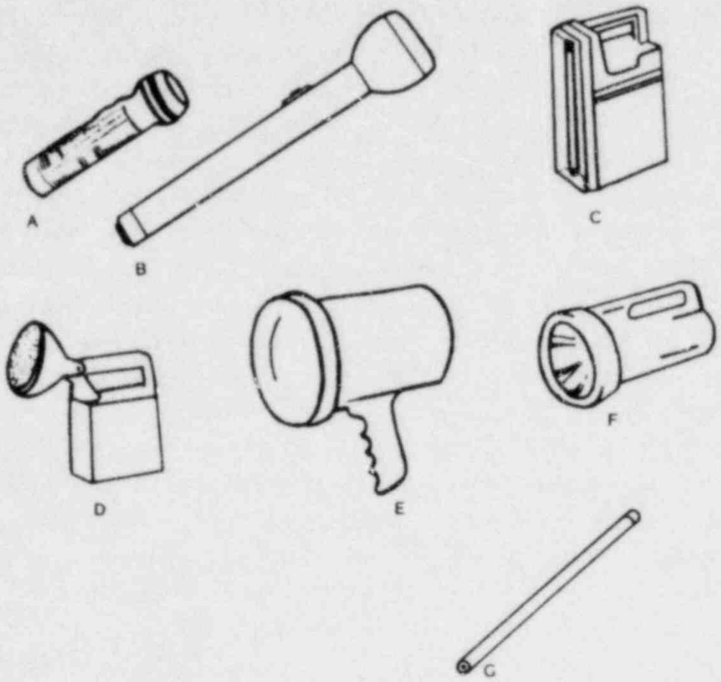
6.6 Portable Security Lighting Equipment

6.6.1 General

Portable security lighting primarily consists of hand-held, vehicle supported, self-sufficient or portable floodlights. Hand-held lights normally support foot patrols. Vehicle support lights enhance vehicle patrol and contingency support. Portable floodlights and self-sufficient units are used normally to support an unlighted or insufficiently lighted area in emergency or contingency situations.

6.6.2 Hand-Held Portable Lights

Hand-held portable lights of the flashlight or lantern type provide effective patrol support both indoors and outdoors. Typically these units are available with incandescent, fluorescent or quartz-halogen bulbs. They may also be either rechargeable or operate from one-time use disposable cells. Units should preferably be weatherproof. Figures 30 and 31 illustrate some of these types of units. Note that fluorescent units "C" do not provide an effective beam. A minimum of 4,000 CP rating is recommended. (Most 6 volt or 5 cell units meet this rating.)



HAND-HELD PORTABLE LIGHTS

Figure 30

Hand-Held Unit	Output Candlepower	Cost Dollars
A. 2-Cell Flashlight	2,000 Beam	3 - 30
B. 5-Cell Flashlight	4,000-7,000 Beam	4 - 30
C. Fluorescent	500, Diffuse	20 - 50
D. Lanterns	15,000-95,000 Beam	20 - 450
E. Lantern	22,000 Beam	12 - 35
F. Lantern	15,000-40,000 Beam	10 - 35
G. Chemical Flare	Not Available, Diffuse	2 - 3 each

HAND-HELD PORTABLE LIGHTS CHARACTERISTICS

Figure 31

Alkaline or rechargeab' cells/batteries are recommended due to their extended service life. . ˜aline cells will last several times longer than standard carbon cells. Rechargeable cells can be recharged several hundred times. "D" size cells of the nickel-cadmium type are available with several power ratings. Typical rechargeable cells available in hardware stores are rated at approximately 1.2 amp-hours. They are also available with 3.5-4.5 amp-hour ratings which extends the use period by a factor of three. The higher rated cells may have to be acquired through a battery shop or electronics store. In addition to nickel-cadmium "D" size cells, battery packs of various voltages, sizes and power ratings are available. Sealed lead-acid batteries are available in "D" size cells which have a rating of 2.5 amp-hours. It is notable that the voltage of different "D" size cells varies by type of battery. Carbon and alkaline "D" cells are nominally 1.5 volts per cell. Sealed lead-acid "D" cells are 1.8-2.0 volts per cell. Multi-cell flashlights normally have bulbs installed for 1.5 volt cells. Higher voltage cells will increase the light output but decrease the life of the bulb. Lower voltage cells will decrease the light output but increase the life of the bulb. When replacing or substituting cells and bulbs, care should be taken to match total cell voltage with the properly rated bulb. Note that NiCad cells require an exercising program to prevent the cells from establishing a "memory effect." That is, they should be intentionally discharged to varying levels of discharge and, at least on an annual basis, to a complete discharge.

Gel-type cells are available for various lantern configurations with 6 and 12 volt requirement-. These are sealed, maintenance-free batteries which can be recharged several hundred times.

Chemical Lights or Chemiluminescent devices are a recent innovation. These are in the configuration of small plastic containers in the shape of a cigar. When activated they provide a yellow-green light for approximately three hours. During the first hour of use they provide a rather bright light which degenerates to a marker status. They are subsequently discarded. Typical uses would be for marker flares. The cost of each unit is from $2.00 to $3.00 each. Reference Figure 30 C. Different units provide varying amou :s of light for varying durations of up to 12 hours. The level of illuminat on provided is low and they would provide light over only a few square meters.

6.6.3 Vehicle Mounted Lights

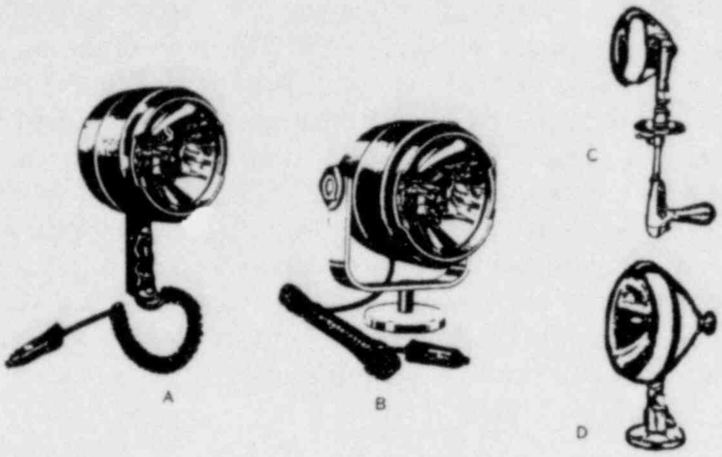
Vehicle mounted lights for security purposes are recommended for all security assigned and backup vehicles. The lights operate by plugging into the vehicle's cigarette lighter, special plugs or permanently fixed to the vehicle and wiring. Units with a minimum of 75,000 candlepower are recommended. Figures 32 and 33 provide information on several configurations of vehicle mounted fixtures. The advantage of "A" and "B" is that they can be moved by hand. In addition, "B" with a magnet or clip on base can be directed and left unattended. The fixture described by "D" can be directed but not readily moved. The fixture illustrated in "C" can be directed from within the vehicle and minimizes exposure of the security personnel to weather or adversaries.

6.6.4 Portable and Self-Sufficient Floodlights

Portable and self-sufficient floodlights are available in many configurations. They would be utilized to provide security lighting at locations where the permanent lighting has been temporarily incapacitated due to damage or failure, for area maintenance purposes or for coverage of gates and areas which are experiencing protest, picketing or other related activities. The type and size of the units depend on the application. Equipment illustrated in Figure 34 "A" and "B" would be used in locations where power was available within reach of extension cords. Units illustrated in Figure 34 "C", "D" and "E" are typical of those which can operate either on available power or motor generators integral to the lighting unit. The motor generators normally operate from either gasoline or diesel fuel. Typically, with previous notice, equipment such as this can be rented. However, for emergencies, available on-hand equipment is recommended. Figure 35 provides characteristics of several types of portable, self- sufficient floodlights.

6.6.5 Fixed Directable Lighting

Fixed, directable lighting for security purposes includes searchlights and beacons. Security lighting of this type can, in certain situations, significantly enhance the security force's capability of nighttime alarm assessment and intrusion deterrence. It is of particular value when a significant portion of the protected area, isolation zone and perimeter of the protected area is visible from the guard post. Figure 36 illustrates



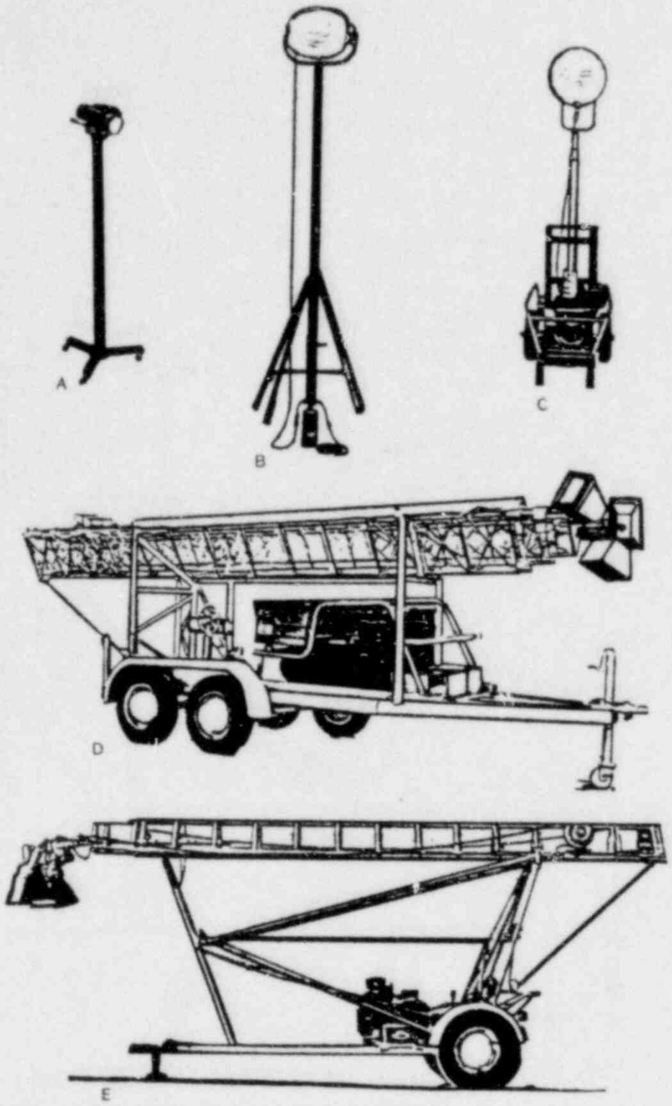
VEHICLE MOUNTED LIGHTS

Figure 32

Vehicle Mounted Unit	Output Candlepower	Cost Dollars
A	30,000-360,000	15-30
B	200,000	40-50
C	20,000-75,000	40-50
D	20,000-75,000	40-50

VEHICLE MOUNTED LIGHTS CHARACTERISTICS

Figure 33



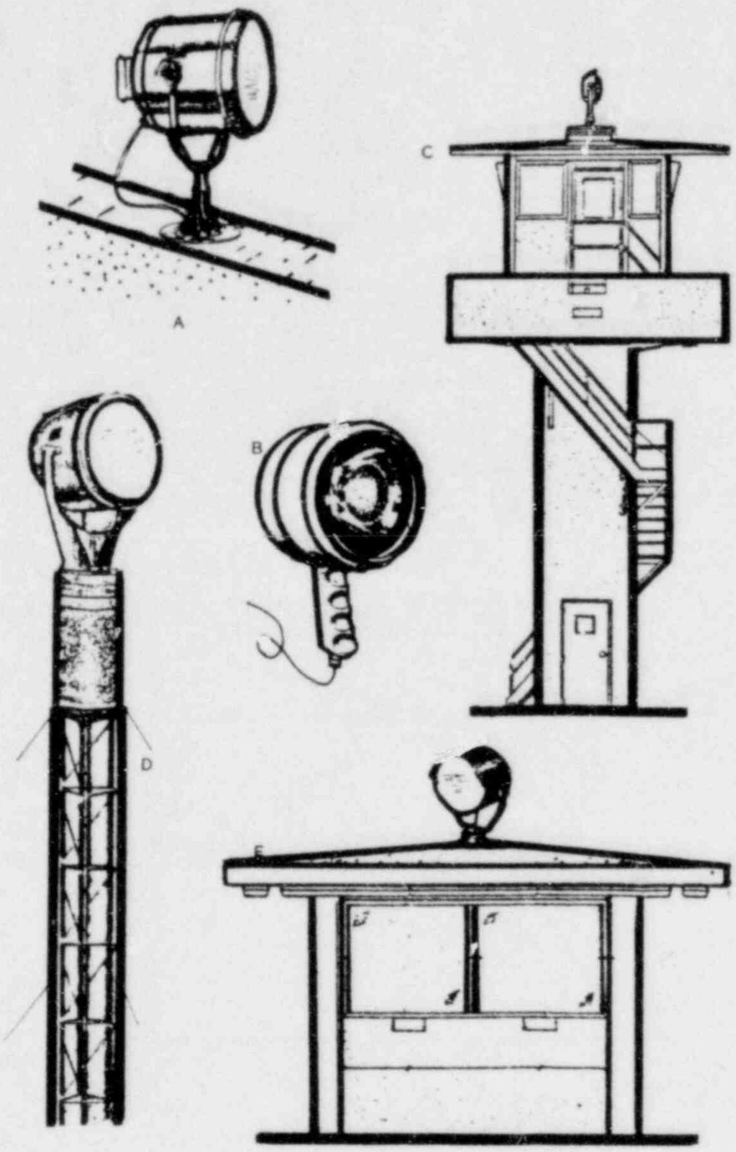
PORTABLE AND SELF SUFFICIENT FLOODLIGHTS

Figure 34

	Power	Cost
Type A or B	1,000 Watt Metal Halide, Quartz or Other Options	$1,000- 2,000
Type C	1.5 kw; 1,000 Watt Metal Halide	$2,000- 6,000
Type D	2.4 kw; Quartz or HID	$3,500- 7,000
Type E	2.4 kw; Quartz or HID	$7,500-13,000

PORTABLE AND SELF-SUFFICIENT FLOODLIGHT CHARACTERISTICS

Figure 35



FIXED DIRECTABLE LIGHTING

Figure 36

several possible installation concepts for searchlights. The illustration "A" is of a hand directable searchlight which could be mounted in many locations. Another hand-held light configuration for fixed locations shown in "B" is a spotlight with a connecting cord to the power source. Illustrations "C" and "E" are of the pilot house type with controls within the guardhouse or tower. Illustration "D" depicts a tower mounted searchlight which is remotely controlled by a distant electric control or "joy stick." The lights in "C", "D" and "E" can be controlled by a "joy stick." A single searchlight can also be controlled from more than one post if it has remote electric controls. Other remote controlled installations might include searchlights mounted high on existing towers, walls, buildings, antennas or CCTV towers. Special equipment for this purpose or adaptations of CCTV pan and tilt equipment can be used. The availability of lighting systems of this type permit the security personnel at a fixed post or a protected environment to explore within or without the protected area or to supplement existing lighting when and where required.

Light sources for these purposes include incandescent, xenon short arc, and carbon arc. Power ratings for searchlights of 20 cm (9 inches) in diameter to 90 cm (36 inches) vary from 200,000 candlepower to several hundred million candlepower. Figure 37 provides some of the various sizes, power and ratings of searchlights and approximate costs based on models manufactured by The Carlisle and Finch Company.

An additional consideration for fixed searchlights is the effective range of lights of different intensities during different atmospheric conditions. As derived from Reference No. 6, Figure 38 illustrates the effective range for relatively small targets such as a vehicle (4-wheel) or small group of men in a variety of weather conditions.

Figure 39 provides an approximation of the searchlight beam spot size considering different degrees of beam divergence. For example, if a spot is desired to have a minimum size of 6 m (20 feet) and a maximum size of 15 m (50 feet) a divergence of approximately 6 degrees would provide this at a distance between 58 m (190 feet) and 145 m (475 feet).

The light available which is perpendicular to the searchlight beam can be approximated by the following formula:

$$\text{Light Available} = \frac{\text{Beam Candlepower}}{(\text{Distance})^2}$$

For a 3 million beam candlepower rated searchlight, the illumination available at 610 m (2,000 feet) would be estimated by:

$$\text{Light Available} = \frac{(3{,}000{,}000)}{(2{,}000)^2} = \frac{3{,}000{,}000}{4{,}000{,}000} = .75 \text{ footcandles}$$

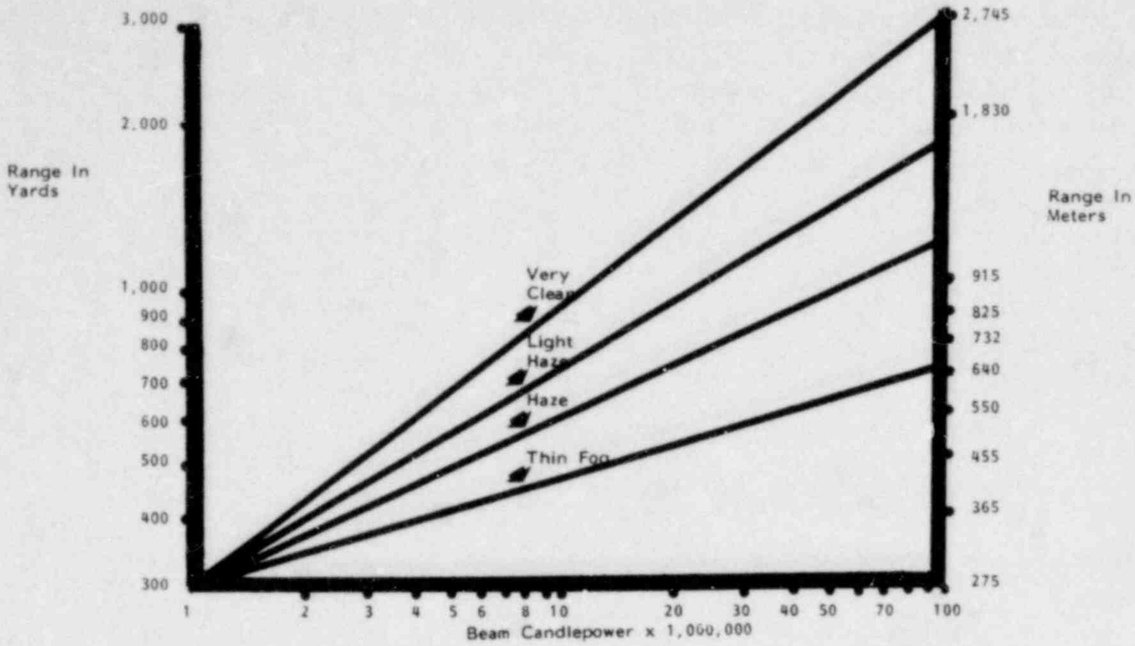
Note that this may vary depending on the rating method used by the manufacturer.

Searchlights are also available with focus and remote focus devices. With these accessories, it is possible for the beam to vary from a few degrees of divergence to 20 degrees.

			Cost (Dollars)		
Searchlight Size	Power Watts	Beam Candlepower	With Manual Controls	With Electric Controls	Power Supplies
10 in. Incandescent	100 — 600	350,000 — 780,000	400 — 1,100	1,000 — 1,000	—
12 in. Incandescent	100 — 1,000	560,000 — 1,650,000	400 — 1,200	1,050 — 1,200	—
15 in. Incandescent	100 — 1,000	940,000 — 3,280,000	500 — 1,300	1,200 — 1,400	—
19 in. Incandescent	500 — 1,500	1,540,000 — 4,750,000	800 — 1,400	1,700 — 2,300	—
19 in. Xenon	1,000 — 2,500	36,000,000 — 90,000,000	3,800	4,700	1,800
24 in. Incandescent	1,000 — 3,000	2,750,000 — 7,660,000	3,000	3,700	—
5-6 in. Hand-Held	—	—	15-50	—	25.75

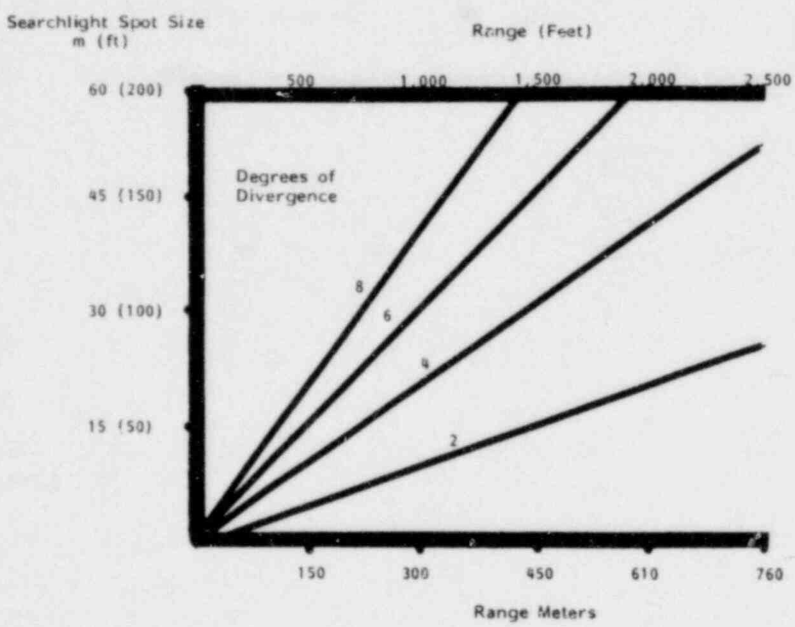
SEARCHLIGHT CHARACTERISTICS

Figure 37



SEARCHLIGHT RANGE

Figure 38



SEARCHLIGHT DIVERGENCE AND RANGE SELECTION

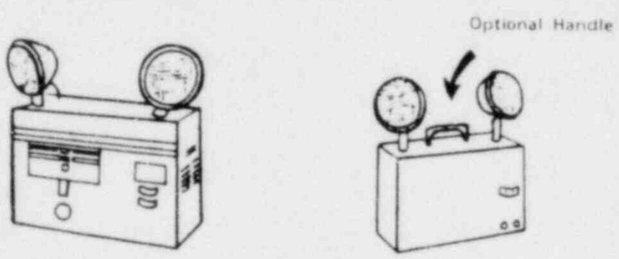
Figure 39

Lamps utilized in searchlights are either "projection type" or "tungsten-halogen type" for searchlights in the smaller size range. The life expectancy of the projection type lamp is from 25-50 hours in most cases with some lamps with life expectancies of up to 200 hours. The life expectancy of tungsten-halogen types is approximately 500 hours. In all cases, spare lamps should be in stock and the lights utilized only when necessary. Xenon lamps are available in 1,000 and 2,500 watt ratings and have an average life of 1,500 hours.

Since searchlights are normally utilized outdoors, it is important to assure that they are of weatherproof and corrosion resistant design.

6.6.6 Unitized Emergency Lighting Units

Unitized emergency lighting units can be effectively utilized to provide a backup lighting system for critical areas, as "portable" emergency lights or even as a third level of backup where deemed appropriate. Figure 40 illustrates several of the most commonly used types of units.



UNITIZED EMERGENCY LIGHTING UNITS

Figure 40

These units usually consist of a diffused lens or lamp, a storage battery or set, a battery charger, and a power failure sensor. The units in operation are on continuous charge. If the primary power source fails, the lights are automatically switched on.

Units are available which will provide continuous light from 1 to 12 hours. The cost of single units varies from approximately $150 to $400 each.

Since the units are rather heavy and have options which include acid electrolyte, they are normally permanently mounted on walls or on a shelf. With the installation of one or more handles however, they can be quite portable and, in an emergency, can be relocated to the emergency site or area of need.

Ceiling mounted units, flush units, explosion proof units and units which have central battery and charging systems are also available.

6.6.7 Infrared Seeing Aids

6.6.7.1 General

The primary application of infrared light for security lighting is for surveillance. Infrared light or the IR region of electromagnetic radiation is that portion of the spectrum located between the visible wavelengths and the microwave wavelengths. The IR band is divided into three regions:

- Near IR (between .72 - 1.2 microns)
- Intermediate IR (between 1.2 - 7.0 microns)
- Far IR (between 7.0 - 1,000 microns)

Sometimes the 8.0 - 30 micron region is also referred to as the long wavelength (LWL) region.

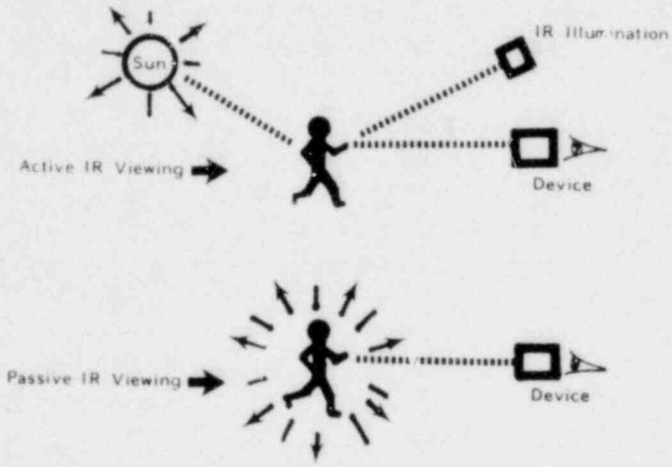
The first IR development for practical surveillance application was that of the IR imaging tube which converted IR radiation into visible light. During WW II these were called sniperscopes.

Although some IR seeing aids can be used with IR illuminators, their biggest advantage is that many can operate in the passive mode. Reference Figure 41. This results from the fact that most natural objects radiate in the IR region and therefore do not require illuminators or transmitters. The advantages of passive IR systems are:

- Relatively small and lightweight
- Relative low cost (as compared to active systems)
- Capable of passive or active operation
- Effective against camouflaged targets and the cover of darkness
- Day or night operation
- Greater angular accuracy than radar
- No minimum or maximum range limits
- Minimum auxiliary equipment

Disadvantages to IR systems are:

- Line of sight use only
- Atmospheric conditions such as fog, clouds, etc., can obscure target
- Can be decoyed
- Some systems require cryogenic cooling during operation



ACTIVE AND PASSIVE IR VIEWING

Figure 41

With the above in mind, it is obvious that an IR seeing aid device could be useful for periodic scanning during nighttime surveillance of dark areas beyond the lighted isolation zone, continued surveillance during power outages, or intrusion alarm assessment assistance (particularly in looking for camouflaged or low profile intruders). Infrared radiation from ground targets under surveillance with passive devices is due to thermal emissions or reflected solar or illuminating device energy. Most ground targets such as vehicles and personnel may be much warmer than their surroundings. Although special low-emissivity paints and insulations could be used it will usually be difficult to camouflage against visual and IR detection simultaneously (Reference No. 23).

6.6.7.2 IR Lamps

Most lamps produce IR radiation. Standard tungsten filament and quartz-iodine lamps are commonly utilized. Filters or dichroic mirrors are necessary to block visible radiation in applications where IR radiation only is required. (Reference No. 23.) Sources of this type range from hand-held units to truck-mounted night driving devices to tank mounted 1,800 watt searchlights. The systems are primarily utilized for military purposes. Smaller systems can be made utilizing a Kodak Cold Mirror Filter No. 310 or equivalent which will transmit light in the .9 to 1 micrometer range (Reference No. 24). Argon, krypton, xenon, cesium, mercury and rubidium gaseous arc lamps can also be utilized. At the present time, for larger systems, xenon arc lamps are predominantly used for near infrared night vision equipment (Reference No. 23). Input power for these lamps varies from 150 w to 30 kw. More than 10 percent of the light output of the xenon lamp is in the IR region.

Various flashlamps and flashtubes can also be utilized with filters and would be appropriate for surveillance photography where pictures are to be taken without the knowledge of persons at the scene.

The criteria for filtering visible light from the lamp's total spectrum of output would include:

- No transmission less than .8 micron with IR optimized
- No white light pinholes
- High temperature tolerance (as required)

6.6.7.3 IR Seeing Aid Devices

Presently, most of the military IR devices utilize thermal imaging with scanning systems in the 3-5 and 10 micron region (Reference No. 23). However, the systems used most frequently for sights and viewing devices utilize image tubes and screens.

From a current commercial standpoint, an infrared viewer manufactured by Hughes Aircraft Company is available. The cost of this hand-held portable unit is $8,000 - $10,000. It utilizes a rechargeable power supply and a small cylinder of argon gas provides the cryostat coolant which must be refilled after about four hours of operation. The registered trade name is Probeye. This device works on passive emissions of IR and does not require an IR illumination source. Therefore its range is unlimited. Reference Figure 42.

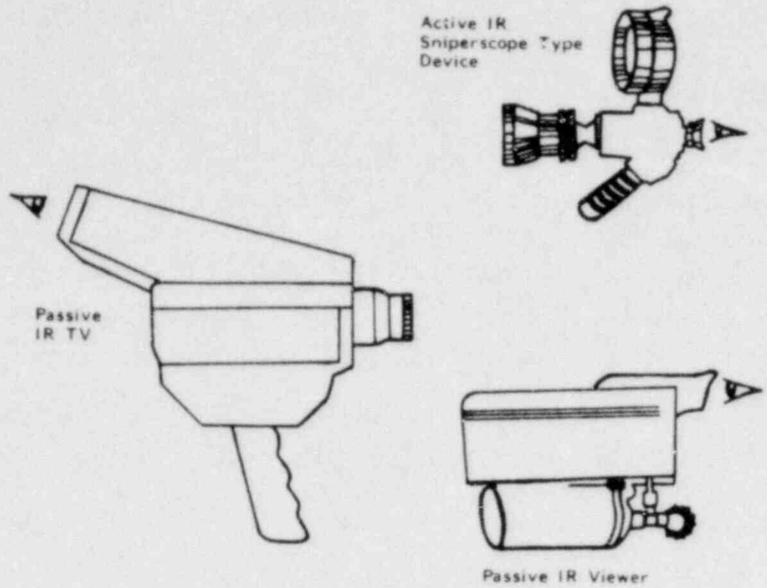
An infrared viewer is also available through Law Enforcement Associates. This device uses active IR provided by a beam from the unit. Its range is 50-150 meters. It costs approximately $1,450 and is called the Nite-Site Infrared Viewer. Reference Figure 42. Surplus Army M3 Sniperscopes which operate from 6 volt battery packs are available from Edmund Scientific at a cost of approximately $400 each. This system also utilizes an active IR source which is an integral part of the unit.

An infrared TV system is available from Xedar Corporation which operates in the 8-14 micron region. It weighs about 7 pounds and is utilized by direct viewing. The cost is approximately $9,000. Reference Figure 42. Units are available for fixed locations as well as portable units.

Considerable eye and search fatigue can develop if these devices are utilized for direct veiwing over an extended period of time.

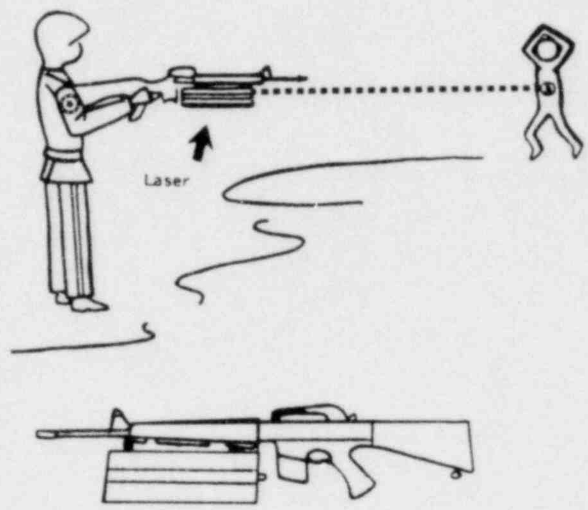
6.6.8 Laser Target Designators

Small light weight lasers are available as target designators for light weapons. These can be quite effective for nighttime use when standard gunsights are difficult to see. (Figure 43 illustrates this concept.) Equipment is available through York Arms (Laser Lok Sight), for example, at an approximate cost of $500 per unit.



IR SEEING DEVICES

Figure 42



LASER TARGET DESIGNATORS FOR SMALL ARMS

Figure 43

Other weapon sight systems have been developed for military purposes utilizing infrared and "starlight" seeing aids. These include "starlight" devices such as the AN/PVS-2, AN/PVS-4 and M9821. Infrared aiming devices similar to the laser target designator in function which are rifle mounted such as the AN/PVQ-4 Infrared Aiming Light project a spot which can be seen with special night vision sensors such as the AN/PVS-5 goggles. Although mentioned in this guide, the use and availability of systems such as these may be controlled by state and federal law.

6.6.9 Ultraviolet Light Equipment

Combinations of ultraviolet light and ultraviolet sensitive tracing materials can be utilized for protective purposes. The primary use of these materials would be to detect tampering or theft attempts, for example. This is accomplished by marking items which require special control with "invisible" (to visible light - but sensitive to ultraviolet light) powders, ink, crayons, pastes or paints. Ultraviolet lamps (black light) are then used at check points to detect any of the marked materials. The marked materials will appear in fluorescent colors when exposed to the ultraviolet light.

Fluorescent powders can be dusted on items or areas requiring no access or controlled access. Persons tampering with these items or areas are then detected at the check point when the fluorescent material appears on hands or clothing.

Small portable lamps cost $40 - $100. Bottles of powders, inks, etc., cost $5 - $15 each. They can be procured at a local police officer supply company.

7. SECURITY LIGHTING APPLICATIONS

7.1 General

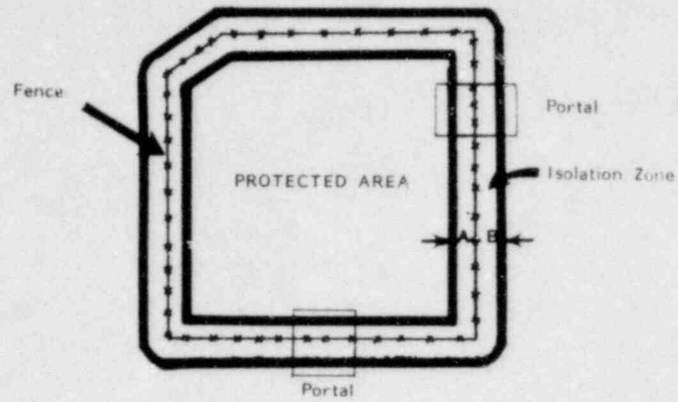
Based on the foregoing reviews of requirements, goals, lighting effects and equipment, this section provides information on specific applications, concepts and configurations. Outdoor lighting of isolation zones, protected areas and portals as well as indoor concepts are covered. The information provided is conceptual only and should not be construed as design information. It is recommended that any security lighting application be designed by a properly qualified and experienced engineering firm or organization. Some of the application information will reference specific manufacturer's products. It should be noted that this in no way is meant to exclude other manufacturers' equipment with equivalent features and quality. It is necessary to use specific manufacturer's information due to the unique photometric data on each specific luminaire.

Except where there are special requirements, luminaires reviewed in detail will include only high and low pressure sodium. This is because of their higher efficiency ratings and better restrike characteristics. Costs noted in this chapter are for comparative purposes only and do not include design, contractor markup, contingencies, or costs common to all systems unless otherwise noted. Isolation zone and portal lighting costs include wood poles. Area lighting costs include steel galvanized poles.

7.2 Security Lighting for the Protected Area Isolation Zone

7.2.1 General

The isolation zone is the area at the protected boundary on either side of the fence designated as a clear zone. Figure 44 illustrates this area. Specific NRC requirements are for a minimum illumination of 2.15 lux (.2 footcandles) for the entire protected area. Recommendations for the illumination of these areas are: for measurements to be made horizontally at .15 meters (6 inches) above the ground; levels increased to those noted in Section 4.6 as appropriate; lighting to be provided a minimum of 9.1 meters (30 feet) both inside and outside of the protected area fence or 18.2 meters (60 feet) from a protected area boundary building wall; and with an average to minimum illumination ratio not to exceed 4:1 with less than 3:1 recommended and maximum to minimum ratio of 8:1 with less than 6:1



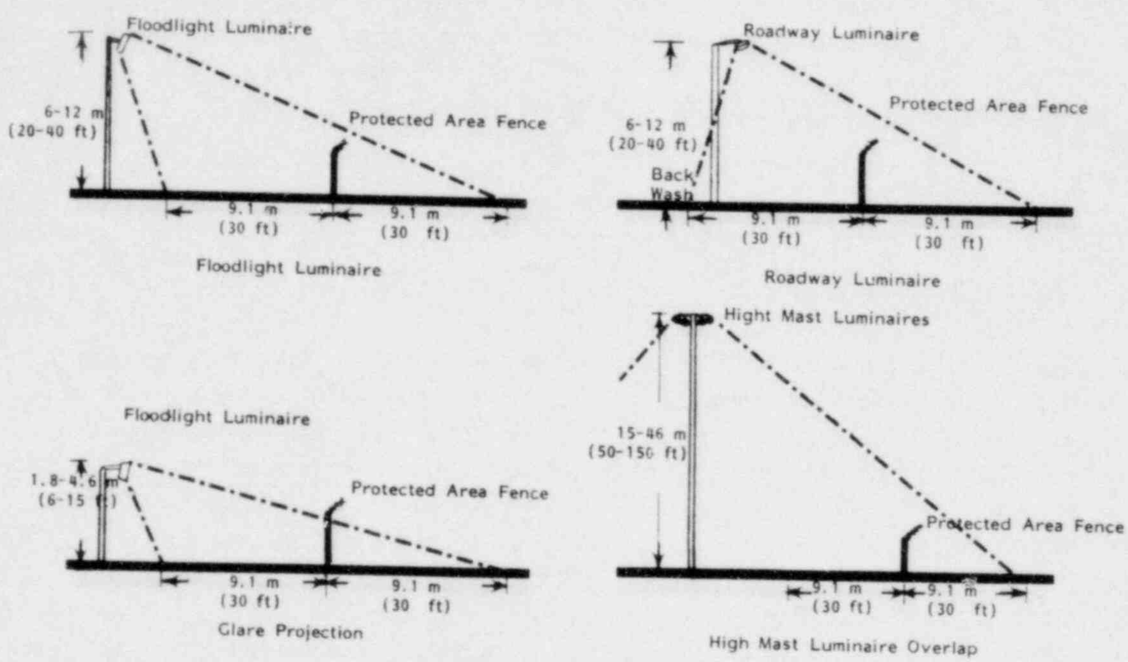
A = Minimum of 9.1 meters (30 feet)

B = Minimum of 9.1 meters (30 feet)

Minimum illumination of 2.15 lux (.2 footcandles) horizontal with average to minimum ratio not to exceed 4:1 with less than 3:1 recommended.

SECURITY LIGHTING OF THE ISOLATION ZONE

Figure 44

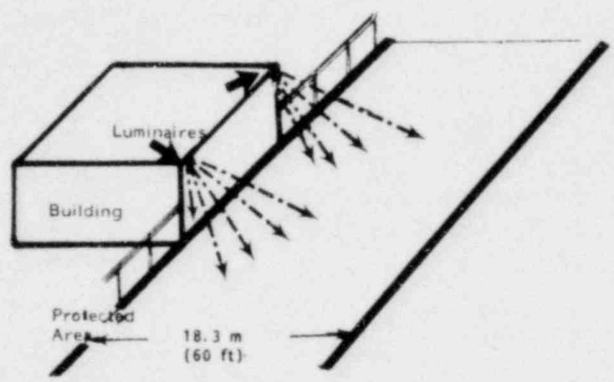


ISOLATION ZONE LIGHTING CONFIGURATIONS

Figure 45

recommended. If double fences are utilized, the isolation zone should include 9.1 meters (30 feet) minimum inside the inside fence and 9.1 meters (30 feet) minimum outside the inside fence.

Illumination of the isolation zone can be accomplished in four basic ways--these include floodlight luminaires, roadway luminaires, floodlights in specific glare configurations and with high mast or "parking lot" illumination. Figure 45 illustrates these concepts. Note that in all cases the poles or masts should be set back into the protected area at least 2.4 meters (8 feet) from the fence to preclude utilizing poles as an aid in climbing the fence. Figure 46 illustrates the isolation zone concept if a building wall is utilized as the protected area barrier. In this case, floodlights can be located on the building.



BUILDING USED AS A PROTECTED AREA BARRIER

Figure 46

Floodlights for glare projection have been utilized by the USAF (Reference No. 9). This consisted of 250w HPS lamps mounted in pairs approximately 4.6 meters (15 feet) high and 35 meters (115 feet) apart. However, due to poor uniformity of lighting which affects both direct visual and CCTV observation capability, the concept has been abandoned. Other tests (Reference No. 5) indicate that the glare in the eye of the intruders was optimized when 500 w tungsten-halogen lamps in symmetric floodlights were used at a height of 3 meters (9.8 feet) and spaced at 10 meters (32.8 feet). These were setback 10 meters (32.8 feet) from the fence. However, no measure of lighting uniformity was provided. Illumination uniformity is a problem when luminaires are mounted close to the ground and at the same time are required to provide uniform illumination as far as 18.2 meters (60 feet) away (isolation zone) plus any setback distance. Simulations run by Independent Testing Laboratories, Inc. (Reference No. 25) indicate that uniformity (maximum to minimum) gets worse as an inverse function of the pole height. That is, a 6 meter (20 foot) pole may have 4 times a maximum to minimum illumination ratio as a 12 meter (40 foot) pole with other factors held constant. As a result, no specific glare projection configurations are included in this planning guide although some systems shown have poles only 6.1 meters (20 feet) high. This is not meant to preclude a licensee from investigating such a configuration.

Figure 47 provides a summary of basic isolation zone lighting configuration characteristics which are detailed in subsequent figures.

7.2.2 Floodlight Lighting of the Isolation Zone

The advantage of utilizing floodlights is the ability to direct light away from the protected area without creating glare within the protected area. The disadvantage is that they do not provide as wide a spread of light as roadway luminaires. Figures 48 through 51 include several configurations of poles, heights, luminaires, lighting levels and spacing. Note that corners or other irregularities in the isolation zone require separate computations. Cost estimates are based on 1979 dollars and may vary considerably due to local conditions. The cost estimates do not include design cost, contractor markup, other contingencies or items common to all systems. They are provided for comparative purposes only. Many other lighting configurations reviewed did not meet the lighting uniformity criteria and are not included.

No	Lamp	Luminaire	Min FC	Avg-Min FC	Units/ Pole	Height (Ft)	Set Back (Ft)	Spacing (Ft)	Annual Cost ($/Ft)	Initial Cost ($/Ft)
1	400w HPS	Roadway	.19	2.8	1	40	40	350	.71	3.01
2	400w HPS	Roadway	.23	2.3	1	50	40	350	.75	3.23
3	400w HPS	Flood	.19	3.76	1	40	40	200	1.15	4.62
4	400w HPS	Flood	.32	2.49	1	40	40	180	1.28	5.14
5	250w HPS	Flood	.26	2.52	1	30	30	140	1.25	5.42
6	180w LPS	Flood	.458	2.28	1	50	0	140	1.51	7.11
7	400w HPS	Roadway	.5	1.8	1	50	40	225	1.16	5.02
8	400w HPS	Roadway	.52	2.8	1	40	20	175	1.43	6.02
9	400w HPS	Roadway	.53	2.58	1	40	20	120	2.12	7.99
10	180w LPS	Flood	.769	2.4	2	50	0	160	2.22	9.62
11	180w LPS	Roadway	1.0	2.3	1	40	10	80	2.73	13.00
12	400w HPS	Roadway	1.07	2.4	1	40	20	100	2.50	10.54
13	400w HPS	Roadway	1.27	1.77	4	37	20	170	3.67	10.38
14	180w LPS	Flood	2.0	1.9	1	21	10	50	3.14	13.43
15	180w LPS	Flood	2.07	1.44	2	40	6	90	3.36	14.07
16	400w HPS	Roadway	2.15	1.46	2	35	5	80	3.86	12.34

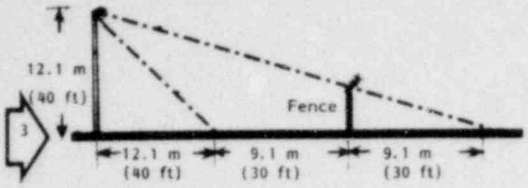
Cost Shown is Per Linear Foot

(Feet); (3.28) = (Meters)

(FC) (10.76) = (Lux)

ISOLATION ZONE LIGHTING CONFIGURATION SUMMARY

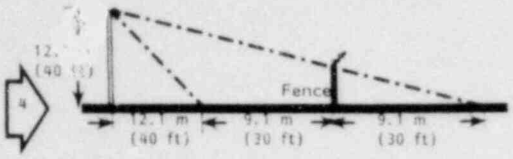
Figure 47



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12.1 m (40 ft)
Pole Height: 12.1 m (40 ft)
Spacing: 61 m (200 ft)

Luminaire: Floodlight GE P-400C
Min FC: .19
Avg-Min: 3.76
Max-Min: 7.59

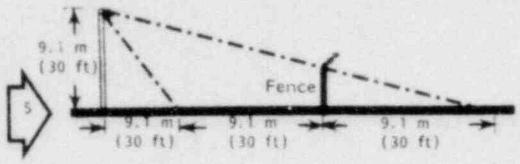
Initial Cost Per Meter (Foot): $15.18 ($4.62)
*Annual Cost Per Meter (Foot): $ 3.77 ($1.15)
Photometric data provided by G.E.



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12 m (40 ft)
Pole Height: 12 m (40 ft)
Spacing: 55 m (180 ft)

Luminaire: Floodlight GE P-400C
One Per Pole
Min FC: .32
Avg-Min: 2.49
Max-Min: 4.57

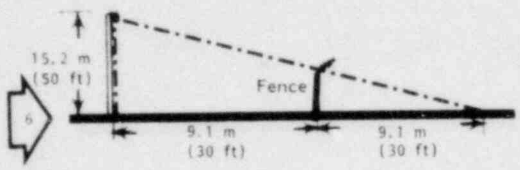
Initial Cost Per Meter (Foot): $16.87 ($5.14)
Annual Cost Per Meter (Foot)*: $ 4.19 ($1.28)
Photometric data provided by G.E.



Lamp: 250w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 9.1 m (30 ft)
Pole Height: 9.1 m (30 ft)
Spacing: 43 m (140 ft)

Luminaire: Floodlight GE P-400C
One Per Pole
Min FC: .26
Avg-Min: 2.52
Max-Min: 5.35

Initial Cost Per Meter (Foot): $17.78 ($5.42)
Annual Cost Per Meter (Foot)*: $ 4.10 ($1.25)
Photometric Data Provided by G.E.



Lamp: 180w LPS
LDD: .81
LLD: 1.05
Maintenance Factor: .85
Set Back: 0
Pole Height: 15.2 m (50 ft)
Spacing: 42.7 m (140 ft)

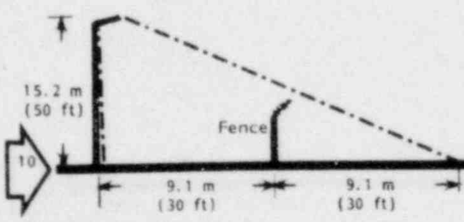
Luminaire: Cutoff Assymmetrical
Quality Lighting 9718
One Per Pole
Min FC: .458
Avg-Min: 2.285
Max-Min: 4.101

Initial Cost Per Meter (Foot): $23.3 ($7.11)
Annual Cost Per Meter (Foot)*: $ 4.94 ($1.51)
Photometric data provided by Quality Lighting

*$.04/kwh

ISOLATION ZONE FLOODLIGHT CONFIGURATIONS FOR 2.15 LUX (.2 FC)

Figure 48



Lamp: 180w LPS
LDD: .81
LLD: 1.05
Maintenance Factor: .85
Set Back: 0
Pole Height: 15.2 m (50 ft)
Spacing: 48.8 m (160 ft)

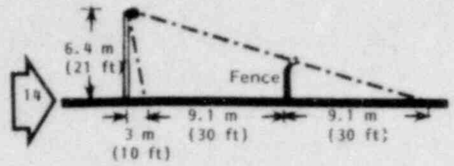
Luminaire: Assymetrical Cutoff
Quality Lighting 9718
Two Per Pole
Min FC: .769
Avg-Min: 2.406
Max-Min: 4.73

Initial Cost Per Meter (Foot): $31.57 ($9.62)
*Annual Cost Per Meter (Foot): $ 7.29 ($2.22)
Photometric data provided by Quality Lighting

*$.04/kwh

ISOLATION ZONE FLOODLIGHT CONFIGURATION FOR 5.4 LUX (.5 FC)

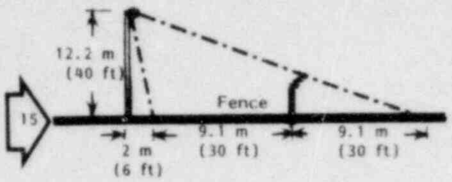
Figure 49



Lamp: 180w LPS
LDD: .8
LLD: 1.05
Maintenance Factor: .84
Set Back: 3 m (10 ft)
Pole Height: 6.4 m (21 ft)
Spacing: 15.2 m (50 ft)

Luminaire: Flood Norelco SFL-33885
One Per Pole
Min FC: 2
Avg-Min: 1.9
Max-Min: 3.13

Initial Cost Per Meter (Foot): $44.04 ($13.43)
Annual Cost Per Meter (Foot)*: $10.32 ($3.14)
Reference No. 25



Lamp: 180w LPS
LDD: .8
LLD: 1.05
Maintenance Factor: .84
Set Back: 2 m (6 ft)
Pole Height: 12.2 m (40 ft)
Spacing: 27.4 m (90 ft)

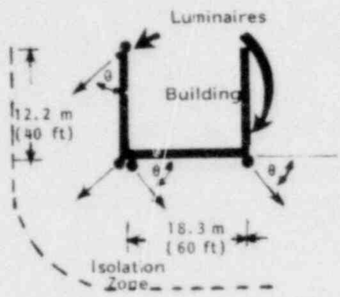
Luminaire: Flood Norelco SFL-33885
Two Per Pole
Min FC: 2.07
Avg-Min: 1.44
Max-Min: 1.95

Initial Cost Per Meter (Foot): $46.16 ($14.07)
Annual Cost Per Meter (Foot)*: $11.03 ($3.36)
Reference No. 25

* $.04/kwh

ISOLATION ZONE FLOODLIGHT CONFIGURATIONS FOR 21.5 LUX (2 FC)

Figure 50

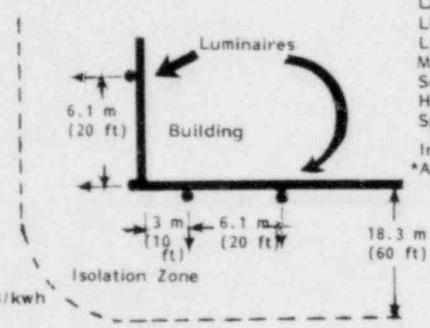


Lamp: 400w HPS
LDD: .73
LLD: .86
Maintenance Factor: .63
Setback: 0
Height: 9.1 m (30 ft)
Spacing: as shown

Luminaire: Flood NEMA 4 x 4
GE P400C Powerflood
One Per Mounting
Min FC: .71
Avg-Min: 2.94
Max-Min: 15.1

Initial Cost/Meter (Foot): $119.00 ($35.61)
*Annual Cost/Meter (Foot): $ 29.70 ($ 8.91)

$\theta = 45°$



Lamp: 250w HPS
LDD: .73
LLD: .86
Maintenance Factor: .63
Set Back: 0
Height: 4.6 m (15 ft)
Spacing: 6.1 m (20 ft)

Luminaire: Flood GE Versa Flood 2
One Per Mounting
Aimed Perpendicular to Building Face
Min FC: .6
Avg-Min: 3.4
Max-Min: 8.5

Initial Cost/Meter (Foot): $46.50 ($14.16)
*Annual Cost/Meter (Foot): $12.93 ($ 3.94)

*$.04/kwh

SECURITY LIGHTING FROM A BUILDING -- 5.4 LUX (.5 FC)

Figure 51

In configurations with more than one luminaire per pole, the luminaires are aimed at different locations. In these cases, there will be some glare within the protected area if the security guard is in a position which requires looking down the row of luminaires. Any luminaire which has a lens which protrudes beyond the plane of the opaque part of the fixture will also create some side or backwash glare.

7.2.3 Roadway Lighting of the Isolation Zone

The advantage of roadway type lighting for the isolation zone is that it normally is more economical since roadway luminaires are designed for this purpose. The disadvantage is that roadway luminaires project a backwash light (light to the side and rear of the luminaire) which is undesirable from the standpoint of glare projected into the eyes of security personnel on patrol. Figures 52 through 56 provide several configurations of luminaires and spacing for consideration.

Roadway luminaires with "cutoff" features or flat lenses may create significantly less side or backwash glare. "House side" shields are available as an option on many roadway luminaires which minimize backwash glare into the projected area. These shields cost from $25 to $30 each.

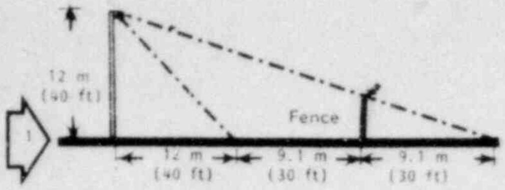
The costs shown in the figures are for comparative purposes only and do not include design, contractor markup, items common to all systems and other contingencies. Many other configurations were reviewed which did not meet the lighting uniformity criteria and therefore are not included.

7.2.4 Area Lighting of the Isolation Zone

The use of area lighting for the isolation zone is possible by adjusting the location of the protected area lighting to include the isolation zone. Configurations of area lighting are included in Section 7.3. The locations of the poles and masts illustrated can be adjusted to include the isolation zone.

The advantage of doing this is that the overall cost of lighting may be reduced by using high mast configurations.

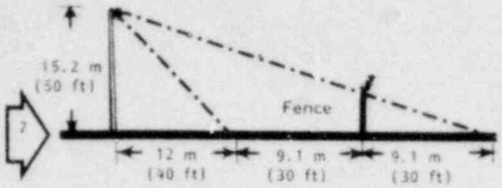
The disadvantage is that glare projection away from the protected area is not possible. Selective higher lighting levels at the isolation zone may be



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12 m (40 ft)
Pole Height: 12 m (40 ft)
Spacing: 107 m (350 ft)

Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: .19
Avg-Min: ?.8
Max-Min: f.79

Initial Cost Meter (Foot): $9.85 ($3.01)
*Annuz Cost Met- (Foot) $2.34 ($ .71)
Photon etric data provided by Johns Manville



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12 m (40 ft)
Pole Height: 15.2 m (50 ft)
Spacing: 107 m (350 ft)

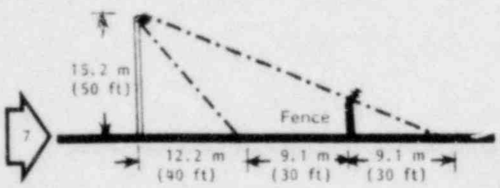
Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: .23
Avg-Min: 2.3
Max-Min: 5.96

Initial Cost/Meter (Foot): $10.57 ($3.23)
*Annual Cost/Meter (Foot): $ 2.44 ($ .75
Photometric data provided by Johns Manville

*$.04/kwh

ISOLATION ZONE ROADWAY LIGHTING FOR 2.15 LUX (.2 FC)

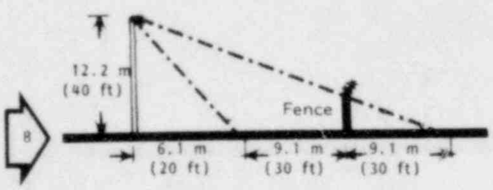
Figure 52



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12.2 m (40 ft)
Pole Height: 15.2 m (50 ft)
Spacing: 68.6 m (225 ft)

Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: .5
Avg-Min: 1.8
Max-Min: 3.1

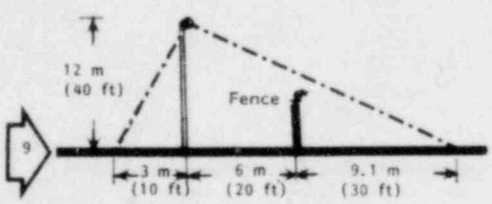
Initial Cost/Meter (Foot): $16.48 ($5.02)
*Annual Cost/Meter (Foot): $ 3.80 ($1.16)
Photometric data provided by Johns Manville



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 6.1 m (20 ft)
Pole Height: 12.2 m (40 ft)
Spacing: 53.3 m (175 ft)

Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: .52
Avg-Min: 2.8
Max-Min: 5.7

Initial Cost/Meter (Foot): $19.77 ($6.02)
*Annual Cost/Meter (Foot): $ 4.69 ($1.43)
Photometric data provided by Johns Manville



Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 6 m (20 ft) from fence
Pole Height: 12 m (40 ft)
Spacing: 36 m (120 ft)

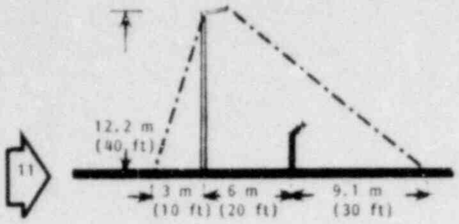
Luminaire: Roadway GE M400A (Cutoff)
One Per Pole
Min FC: .53 fc
Avg-Min: 2.58
Max-Min: 6.15

Initial Cost/Meter (Foot): $26.64 ($7.99)
*Annual Cost/Meter (Foot): $ 7.06 ($2.12)

*$.04/kwh

ISOLATION ZONE ROADWAY LIGHTING FOR 5.4 LUX (.5 FC)

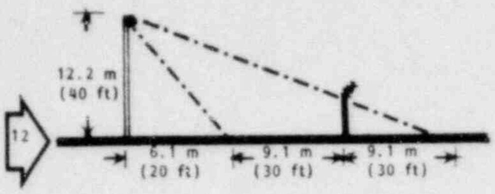
Figure 53



Lamp: 180w LPS
LDD: .9
LLD: 1.0
Maintenance Factor: .9
Set Back: As Shown
Pole Height: 12.2 m (40 ft)
Spacing: 24.4 m (80 ft)

Luminaire: Roadway QL-SOX 180
One Per Pole
Min. FC: 1.0 (approx)
Avg-Min: 2.3 (approx)
Max-Min: 4.0 (approx)

Inital Cost Per Meter (Foot): $42.64 ($13.00)
Annual Cost Per Meter (Foot)*: 8.94 ($ 2.73)

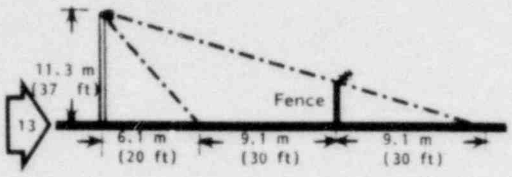


Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor:
Set Back: 6.1 m (20 ft)
Pole Height: 12.2 m (40 ft)
Spacing: 30 m (100 ft)

Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: 1.07
Avg-Min: 2.4
Max-Min: 4.26

Initial Cost Per Meter (Foot): $35.13 ($10.54)
Annual Cost Per Meter (Foot)*: $ 8.33 ($ 2.50)

Photometric data provided by Johns Manville



Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 6.1 m (20 ft)
Pole Height: 11.3 m (37 ft)
Spacing: 51.8 m (170 ft)

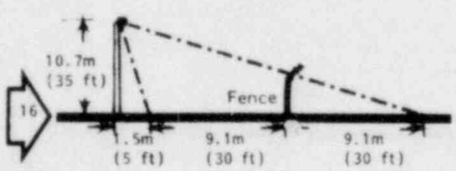
Luminaire: Roadway GE M400
Four Per Pole
Min FC: 1.27
Avg-Min: 1.77
Max-Min: 4.50

Initial Cost Per Meter (Foot): $34.06 ($10.38)
Annual Cost Per Meter (Foot)*: $11.87 ($ 3.62)

*$.04/kwh

ISOLATION ZONE ROADWAY LIGHTING FOR 10.76 LUX (1 FC)

Figure 54



Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 1.5 m (5 ft)
Pole Height: 10.7 m (35 ft)
Spacing: 24 m (80 ft)

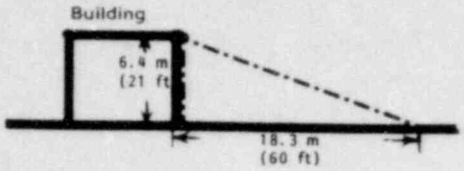
Luminaire: Roadway GE M400
Two Per Pole
Min FC: 2.15
Avg-Min: 1.46
Max-Min: 2.08

Initial Cost Per Meter (Foot): $40.47 ($12.34)
Annual Cost Per Meter (Foot)*: $12.66 ($3.86)
Reference No. 25

*$.04/kwh

ISOLATION ZONE ROADWAY LIGHTING FOR 21.5 LUX (2 FC)

Figure 55



Lamp: 250w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 0
Height: 6.4 m (21 ft)
Spacing: 18.3 m (60 ft)

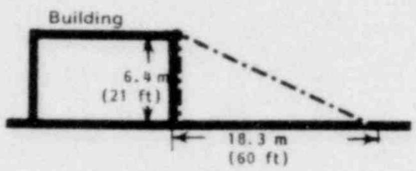
Luminaire: Roadway GE M400A
Two Per Mounting
Min FC: 1.01
Avg-Min: 1.6
Max-Min: 3.4

Initial Cost/Meter (Foot): $34.16 ($10.41)
Annual Cost/Meter (Foot)*: $11.61 ($ 3.54)

*$.04/kwh

SECURITY LIGHTING FROM A BUILDING -- 10.7 LUX (1 FC)

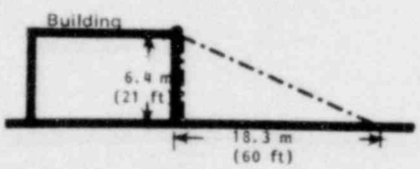
Figure 56



Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Setback: .0
Height: 6.4 m (21 ft)
Spacing: 18.3 m (60 ft)

Luminaire: Roadway GE M400A
Two Per Mounting
Min FC: 2.0
Avg-Min: 1.5
Max-Min: 3.4

Initial Cost/Meter (Foot): $39.25 ($11.96)
Annual Cost/Meter (Foot)*: $18.14 ($ 5.53)



Lamp: 180w LPS
LDD: .8
LLD: 1.05
Maintenance Factor: .84
Setback: 0
Height: 6.4 m (21 ft)
Spacing: 15.2 m (50 ft)

Luminaire: Floodlight Phillips 180w LPS
One Per Mounting
Min FC: 2.0
Avg-Min: 1.5
Max-Min: 3.1

Initial Cost/Meter (Foot): $38.57 ($11.76)
Annual Cost/Meter (Foot)*: $ 9.51 ($ 2.89)

*$.04/kwh

SECURITY LIGHTING FROM A BUILDING -- 21.5 LUX (2 FC)

Figure 57

difficult if not impossible to achieve without large parts of the protected area having more light than necessary.

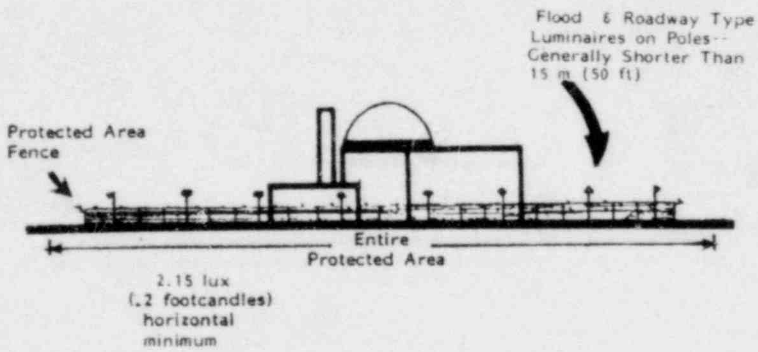
Figures 62 through 67 illustrate a variety of configurations. Note that the costs shown are for comparative purposes and do not include design, contractor markup and items common to all systems and other contingencies.

7.3 Security Lighting for the Exterior Protected Area

7.3.1 General

The NRC requires that all exterior areas within the protected area shall be monitored or periodically checked to detect the presence of unauthorized persons, vehicles, materials or unauthorized activities and provided with sufficient illumination to accomplish this. Figure 58 illustrates this concept.

The protected area requires a minimum illumination level of 2.15 lux (.2 footcandles). As noted in the previous sections, depending on the type of surface being illuminated, the level of illumination should be increased to provide additional assurance of intruder detection.



FLOOD AND ROADWAY LUMINAIRE
SECURITY LIGHTING FOR OUTDOOR PROTECTED AREAS

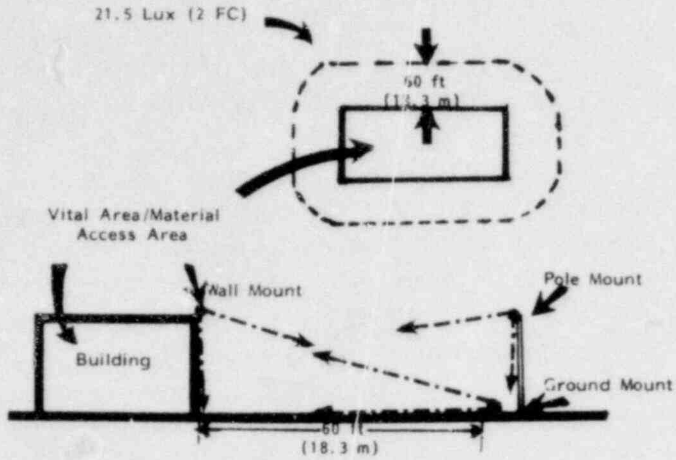
Figure 58

Depending on the site configuration, the security area lighting can be accomplished with floodlights or roadway luminaires (in parking lot illumination configurations), high mast systems or combinations of these.

It is normally not important to have a significant degree of color discrimination in this area. Exceptions can be covered with appropriate lamps in areas required.

Uniformity of illumination within the protected area is perhaps not as critical as in the isolation zone. The uniformity will also be affected by lighting around vital and material access areas, portals and other operating areas which may require illumination well in excess of minimum security requirements. Even so, it is recommended that, where possible, the average to minimum ratio be less than 4-3 to 1 and the maximum to minimum ratio be less than 6-8 to 1.

Figure 59 illustrates the recommended increased illumination levels around vital and material access area buildings. The increased level of illumination in the proximity of these areas will increase the probability of intruder detection and increase the deterrent effect. Although this is not a requirement, it is a practice which is recommended for consideration. As shown in the figure, the illumination can be accomplished from the building wall or roof, the ground level away from the building, or poles mounted away from the building. Section 7.2 provides configurations for building mounted luminaires. The disadvantage of these is that glare is projected away from the building into the eyes of intruders and possibly security guards. Low mounting heights will also cause illumination uniformity problems. Ground mounted luminaires cause glare if security personnel are looking out of the building, make horizontal illumination difficult to achieve, and cause poor uniformity. Ground mounted luminaires do create large shadows if an intruder is in the light beam and standing up. However, this cannot be assured. Lighting of buildings from poles set away from the building can be accomplished with the same configurations of lighting as used for the isolation zone with the building wall assumed to be the outer edge of the zone. This will provide good illumination uniformity. The only disadvantage of this is the glare in the eyes of security guards who may be in the building looking out. This can be minimized by selecting configurations which use poles at least 12.2 m (40 feet) high.



OPTIONAL VITAL AND MATERIAL ACCESS AREA SECURITY LIGHTING

Figure 59

Figure 60 provides a summary of basic security area lighting configuration characteristics which are detailed in subsequent figures.

7.3.2 High Mast Lighting of Protected Areas

High mast or tower lighting for an area generally consists of groups of luminaires mounted on free standing masts or towers at heights of 18 meters (60 feet) to 55 meters (180 feet) or more (Reference Figure 61). There are several significant advantages to high mast lighting: high uniformity of illumination can be achieved with high masts; the number of poles using high mast lighting is significantly reduced which minimizes hazards and maintenance; area as well as perimeter (isolation zone) lighting can be provided with high mast systems; illumination of roofs and other tall structures in the protected area can readily be accomplished with high mast lighting;

No.	Lamp	Luminaire	Min FC	Avg-Min FC	Units/ Pole	Height (Ft)	Set Back (Ft)	Spacing (Ft)	Annual Cost ($/Ft²)	Initial Cost ($/Ft²)
17	1000w HPS	High Mast	.22	3.0	4	90	0	600	.006	.028
18	1000w HPS	High Mast	.22	2.2	5	120	0	700	.007	.032
19	250w HPS	Parking Lot	.26	2.5	2	50	0	150x250	.016	.082
20	1000w HPS	High Mast	.27	2.5	4	140	0	450	.021	.110
21	1000w HPS	High Mast	.53	3.0	12	120	0	700	.011	.043
22	1000 w HPS	High Mast	.52	2.63	4	100	0	450	.016	.081
23	400w HPS	Parking Lot	.71	1.74	2	50	0	150x250	.016	.088
24	250w HPS	Parking Lot	.68	2.1	4	50	0	200	.023	.109
25	1000w HPS	High Mast	1.04	2.5	8	100	0	450	.023	.097
26	1000w HPS	High Mast	1.24	2.15	4	80	0	400	.020	.101
27	400w HPS	Parking Lot	1.13	2.1	4	50	0	200	.026	.113
28	1000w HPS	High Mast	2.55	2.53	12	80	0	450	.029	.115
29	1000w HPS	High Mast	2.4	2.15	12	100	0	400	.038	.147
30	400w HPS	Parking Lot	2.17	1.88	4	40	0	150	.038	.148
31	400w HPS	Parking Lot	2.9	1.3	4	50	0	150	.046	.201

Cost Shown is Per Square Foot

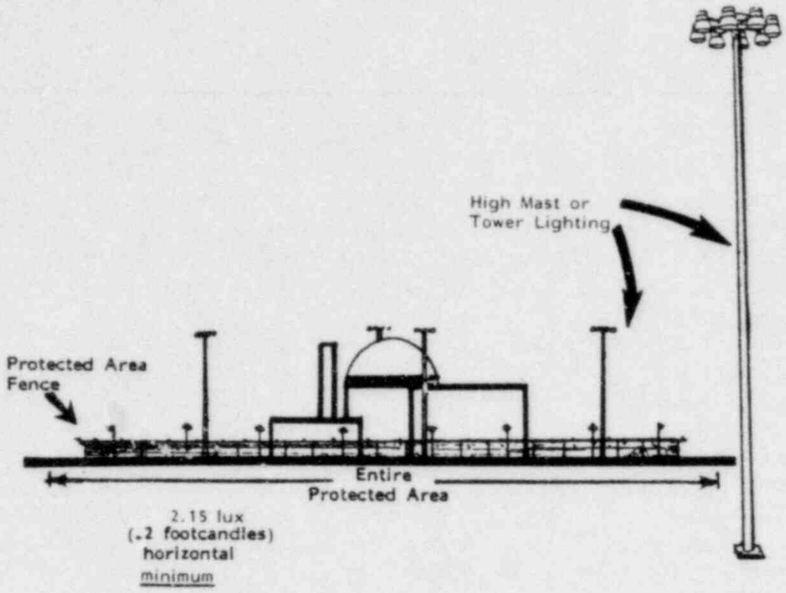
(Feet) (3.28) = Meters

(FC) (10.76) = Lux

PROTECTED AREA LIGHTING CONFIGURATION SUMMARY

Figure 60

glare is almost non-existent at ground level when high mast units are used; the tendency for observation of bright lights and bright areas is minimized and dark adaption and transition problems are minimized when high mast lighting is used.



HIGH MAST LUMINAIRE
SECURITY LIGHTING FOR OUTDOOR PROTECTED AREAS

Figure 61

Since so much illumination dependence is dedicated to single poles, care should be taken to locate them in areas of minimal damage hazards and maximum observation by security posts. The luminaries and lowering devices can be more complex and maintenance of the units may require special considerations.

Typically, high level illumination lamps are utilized (generally either 400 to 1,000 watt high pressure sodium, 1,000 watt metal halide or 180 watt low pressure sodium). The use of 24-30 meter (80-100 foot) masts is common for large area illumination.

Generally, the cost of high mast illumination decreases as higher masts are utilized. Even though the cost of the mast goes up significantly, the area covered goes up as a function of the square of the mounting height. The break-even point varies between 18-30 meters (60-100 feet). For example, a 12 meter (40 foot) pole will illuminate 3700 square meters (1 acre) and a 45 meter (150 feet) mast will illuminate 37,000 square meters (10 acres). A mast system will cover in width at least 4 to 4.5 times its height and the spacing between masts will be at least 4 to 4.5 times the mast height.

Figures 62 through 65 provides several high mast lighting configurations for consideration. Many other configurations reviewed did not meet the lighting uniformity criteria and therefore were not included.

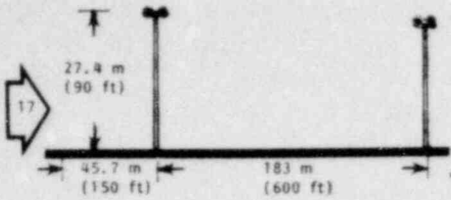
Height and marking (beacon) limitations or requirements should be checked with the local Federal Aviation Administration (FAA) office as a part of high mast illumination planning.

7.3.3 Non-High Mast Lighting of Protected Areas

Non-high mast lighting of protected areas is similar to "parking lot" lighting. Although more poles are required for this type of lighting, it can be more efficient for smaller areas. Luminaires are more widely spread and therefore they do not have illumination dependence on only a few poles. Lower level luminaires are generally easier to maintain and service. A disadvantage is that the lower level luminaires create glare within the protected area which can be a distraction to security personnel on patrol. For this reason, a minimum height of 12.2 meters (40 feet) is recommended (Reference Figure 58). Figures 66 through 69 provide several configurations of luminaires and spacings which will provide the 2.15 lux (.2 footcandles) required as a minimum within the protected area. Several configurations are also provided for higher levels should they be desired.

7.4 Security Lighting at Personnel and Vehicle Access Portals

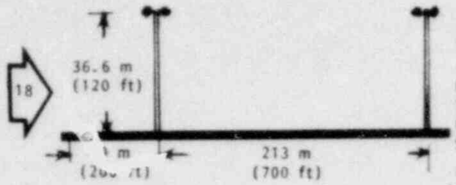
Since security functions other than just surveillance are required at site portals, it is necessary to increase the quantity and quality of light in these areas. Therefore an intensity level of 21.5 lux (2 footcandles) horizontal minimum is recommended of a light type which will permit accurate color distinction. Figure 70 illustrates the areas over which this



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 27.4 m (90 ft)
Spacing: 183 m (600 ft)

Luminaire: High Mast Holophane HMS #1171
Four Per Pole
Min FC: .22
Avg-Min: 3.0
Max-Min: 8.04

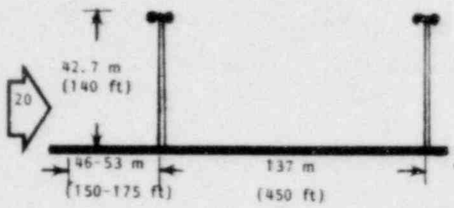
Initial Cost Per m² (ft²): $ .29 ($.028)
*Annual Cost Per m² (ft²): $ .069 ($.006)
Photometric data provided by Johns Manville



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 36.6 m (120 ft)
Spacing: 213 m (700 ft)

Luminaire: High Mast Holophane HMS #1171
Five Per Pole
Min FC: .22
Avg-Min: 2.2
Max-Min: 5.6

Initial Cost Per m² (ft²): $ .424 ($ .032)
*Annual Cost Per m² (ft²): $ .074 ($ .007)
Photometric data provided by Johns Manville



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 42.7 m (140 ft)
Spacing: 137 m (450 ft)

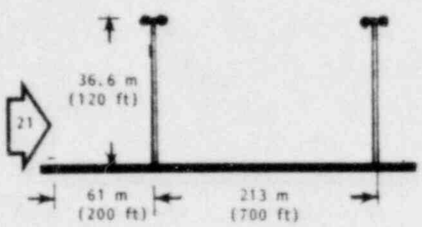
Luminaire: High Mast GE HM-1000 S
Four Per Pole
Min FC: .27
Avg-Min: 2.5
Max-Min: 5.1

Initial Cost Per m² (ft²): $1.19 ($.110)
*Annual Cost Per m² (ft²): $ .223 ($.021)
Photometric data provided by G.E.

*$.04/kwh

HIGH MAST PROTECTED AREA LIGHTING 2.15 LUX (.2 FC)

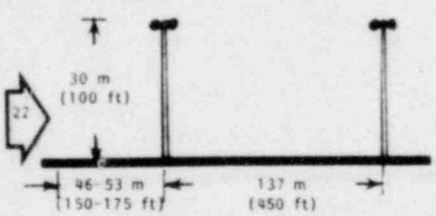
Figure 62



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 36.6 m (120 ft)
Spacing: 213 m (700 ft)

Luminaire: High Mast Holophane HMS #1171
Twelve Per Pole
Min FC: .53
Avg-Min: 3.
Max-Min: 5.63

Initial Cost Per m² (ft²): $ .589 ($.043)
*Annual Cost Per m² (ft²): $ .123 ($.011)
Photometric Data provided by Johns Manville



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 30 m (100 ft)
Spacing: 137 m (450 ft)

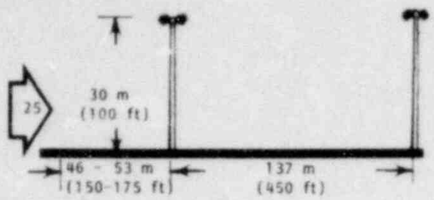
Luminaire: High Mast GE HM 1000 S
Four Per Pole
Min FC: .52
Avg-Min: 2.63
Max-Min: 5.39

Initial Cost Per m² (ft²): $.874 ($.081)
*Annual Cost Per m² (ft²): $.175 ($.016)
Photometric Data provided by G.E.

*$.04/kwh

HIGH MAST PROTECTED AREA LIGHTING 5.4 LUX (.5 FC)

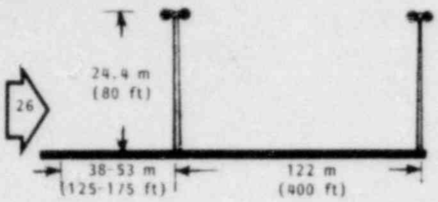
Figure 63



Lamp: 1,000w HPS
LDD: .99
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 30 m (100 ft)
Spacing: 137 m (450 ft)

Luminaire: High Mast GE HM-1000 S
Eight Per Pole
Min FC: 1.04
Avg-Min: 2.5
Max-Min: 5.19

Initial Cost Per m² (ft²): $1.05 ($.097)
*Annual Cost Per m² (ft²): $ .246 ($.023)
photometric data provided by G.E.



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 24.4 m (80 ft)
Spacing: 122 m (400 ft)

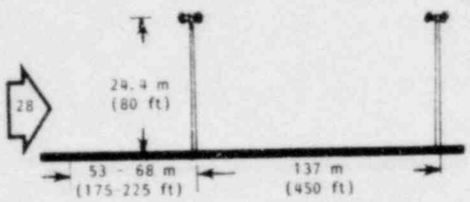
Luminaire: High Mast GE HM-1000 S
Four Per Pole
Min FC: 1.24
Avg-Min: 2.15
Max-Min: 3.62

Initial Cost Per m² (ft²): $1.082 ($.101)
*Annual Cost Per m² (ft²): $ .213 ($.020)
Photometric Data provided by G.E.

*$.04/kwh

HIGH MAST PROTECTED AREA LIGHTING 10.76 LUX (1 FC)

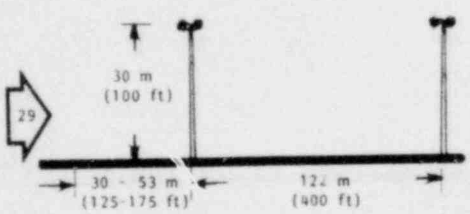
Figure 64



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 24.4 m (80 ft)
Spacing: 137 m (450 ft)

Luminaire: High Mast GE HM 1000 S
Twelve Per Pole
Min FC: 2.55
Avg-Min: 2.53
Max-Min: 5.18

Initial Cost Per m² (ft²): $1.23 ($.115)
*Annual Cost Per m² (ft²): $ .319 ($.029)
Photometric Data Provided by G.E.



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 30 m (100 ft)
Spacing: 122 m (400 ft)

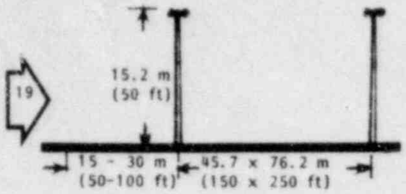
Luminaire: High Mast GE HM1000 S
Twelve Per Pole
Min FC: 2.4
Avg-Min: 2.15
Max-Min: 3.6

Initial Cost Per m² (ft²): $1.58 ($.147)
*Annual Cost Per m² (ft²): $ .405 ($.038)
Photometric Data Provided by G.E.

*$.04/kwh

HIGH MAST PROTECTED AREA LIGHTING 21.5 LUX (2 FC)

Figure 65



Lamp: 250 HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 45.7 x 76.2 m (150 x 250 ft)

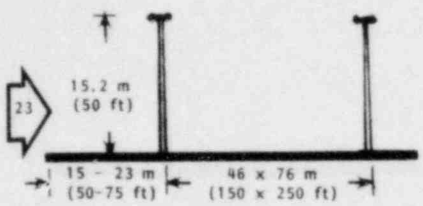
Luminaire: Roadway GE M400
Two Per Pole
Min FC: .26
Avg-Min: 2.5
Max-Min: 6.42

Initial Cost Per m² (ft²): $.902 ($.082)
*Annual Cost Per m² (ft²): $.170 ($.016)
Photometric Data Provided by G.E.

*$.04/kwh

"PARKING LOT" LIGHTING-PROTECTED AREA 2.15 LUX (.2 FC)

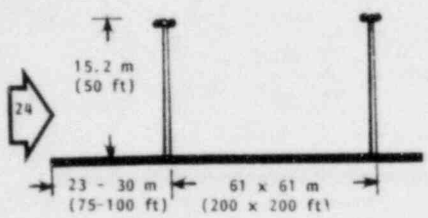
Figure 66



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 46 x 76 m (150 x 250 ft)

Luminaire: Roadway GE M400
Two Per Pole
Min FC: .71
Avg-Min: 1.74
Max-Min: 3.97

Initial Cost Per m² (ft²): $.951 ($.088)
*Annual Cost Per m² (ft²): $.169 ($.016)
Photometric Data Provided by G.E.



Lamp: 250w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 61 m (200 ft)

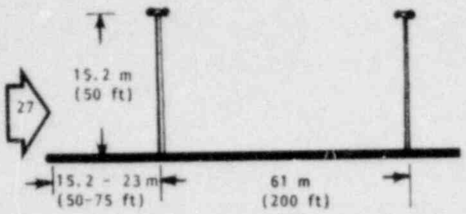
Luminaire: Roadway GE M400
Four Per Pole
Min FC: .68
Avg-Min: 2.1
Max-Min: 4.9

Initial Cost Per m² (ft²): $1.18 ($.109)
*Annual Cost Per m² (ft²): $ .247 ($.023)
Photometric Data Provided by G.E.

*$.04/kwh

"PARKING LOT" LIGHTING-PROTECTED AREA 5.4 LUX (.5 FC)

Figure 67



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 61 (200 ft)

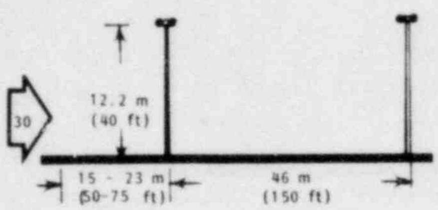
Luminaire: Roadway GE M400
Four Per Pole
Min FC: 1.13
Avg-Min: 2.1
Max-Min: 5.5

Initial Cost Per m^2 (ft^2): $1.[illegible] ($.113)
*Annual Cost Per m^2 (ft^2): $ [illegible] ($.026)
Photometric Data Provided by G.E

*$.04/kwh

"PARKING LOT" LIGHTING-PROTECTED AREA 10.76 LUX (1.0 FC)

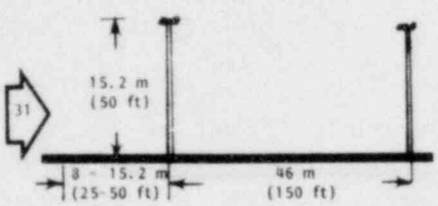
Figure 68



Lamp: 400w HPS
LDD: .95
LLD: .75
Maintenance Factor: .69
Set Back: 0
Height: 12.2 m (40 ft)
Spacing: 46 m (150 ft)

Luminaire: Roadway GE M400
Four Per Pole
Min FC: 2.17
Avg-Min: 1.88
Max-Min: 4.08

Initial Cost Per m^2 (ft^2): $1.59 ($.148)
*Annual Cost Per m^2 (ft^2): $ .406 ($.038)
Photometric Data Provided by G.E.



Lamp: 400w HPS
LDD: .95
LLD: .75
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 46 m (150 ft)

Luminaire: Roadway CE M400
Four Per Pole
Min FC: 2.9
Avg-Min: 1.3
Max-Min: 2.17

Initial Cost Per m^2 (ft^2): $2.160 ($.201)
*Annual Cost Per m^2 (ft^2): $ .49[illegible] ($.046)
Photometric Data Provided by G.E.

*$.04/kwh

"PARKING LOT" LIGHTING-PROTECTED AREA 21.5 LUX (2 FC)

Figure 69

level should be applied. The vehicle gate is illuminated to provide complete coverage of a tractor/trailer for search purposes. The area includes 15.2 meters (50 feet) either side of the center of the roadway, 30.5 meters (100 feet) into the protected area and 30.5 meters (100 feet) outward from the gate. If a "sally port" gate is used, the area will be 30.5 meters (100 feet) square. The pedestrian gate/door is illuminated in an area which will allow viewing and identification of small groups of people. This area is 9.1 by 9.1 meters (30 x 30 feet).

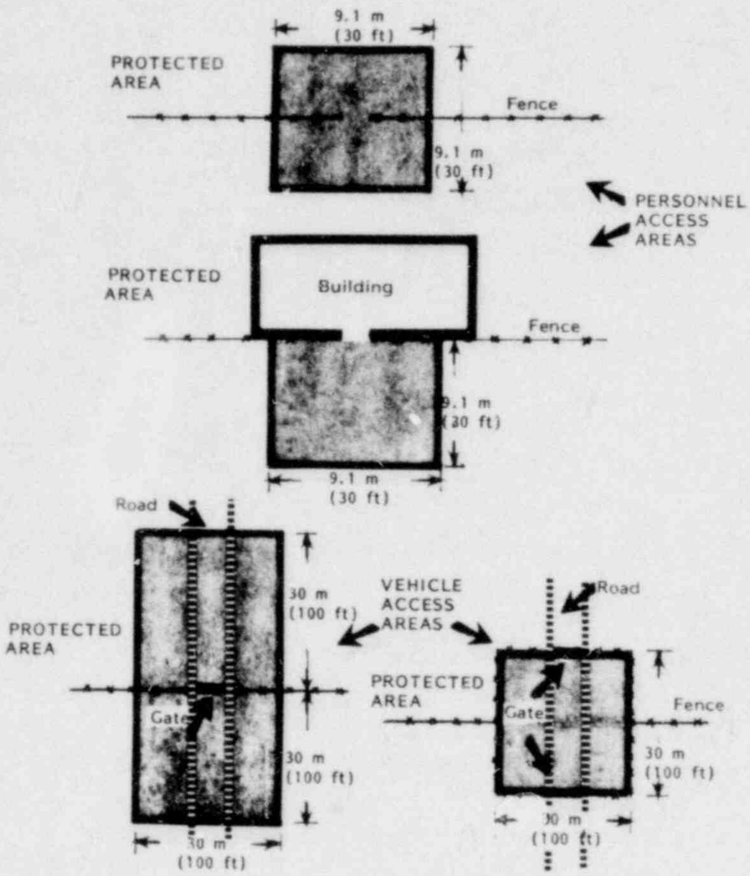
At gate areas where vehicles are to be searched, concrete with or without reflective beads embedded can be used or the road surface can be painted white to assist with lighting available for inspection/search of the underside of vehicles. Reflective paint such as that utilized for highway marking should last up to two or more years. Both the area inside and outside the gate or the area between gates ("sally port") should be painted the full width of the pavement or at least 7.3 m (24 feet) and for a distance of 30.5 m (100 feet). See Figure 71. As shown in Figure 71, recessed lighting ("pit lights") can also be installed for this purpose.

Lighting at gate areas should not create glare for the security personnel. The security personnel's position should utilize the concepts shown in Figure 72.

It is very important to have color discrimination capability at gate areas. Typical lighting configurations to accomplish this are shown in Figure 73. Note that the small quartz floods on the building are aimed not to create a dangerous level of glare in the vehicle area but to provide illumination for document checking and personnel identification. Other combinations of luminaires and distribution configurations may also be acceptable.

7.5 Security Lighting for Interiors

It is not important to continuously illuminate the interior of all buildings within the protected area perimeter for security purposes. Lighting for areas requiring continuous direct visual surveillance should be illuminated from 21.5 to 54 lux (2-5 footcandles) minimum. This is not only adequate for personnel identification but also for safety as recommended in Nuclear Power Plant Lighting (Reference No. 17). Areas requiring CCTV or utilizing other electro-optical detection, surveillance or assessment devices may require additional illumination. Interior security lighting for safety purposes should permit accurate identification of colors. If a security



21.5 Lux (2 FC) in Hatched Areas

SECURITY LIGHTING AT ACCESS PORTALS

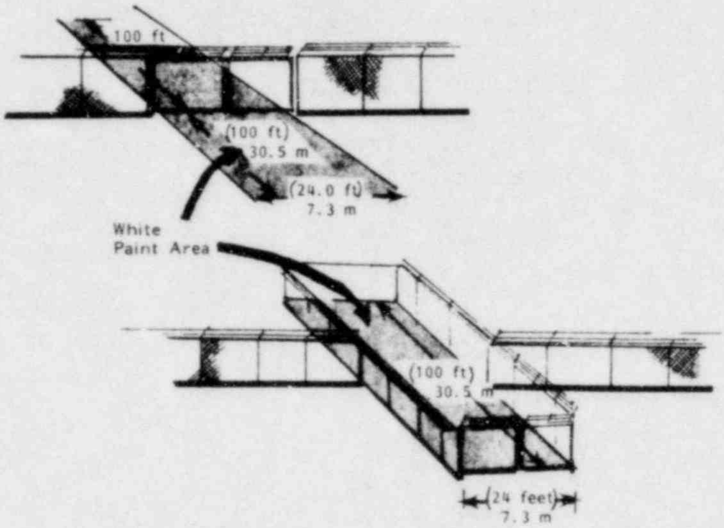
Figure 70

IMAGE EVALUATION
TEST TARGET (MT-3)

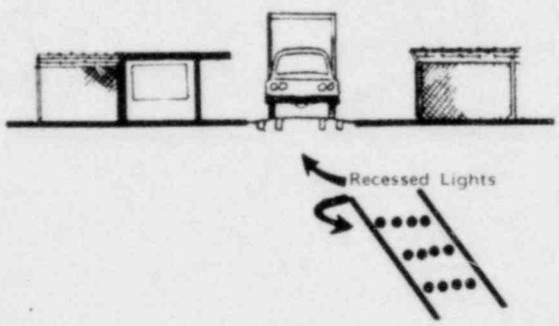
6″

IMAGE EVALUATION
TEST TARGET (MT-3)

6″

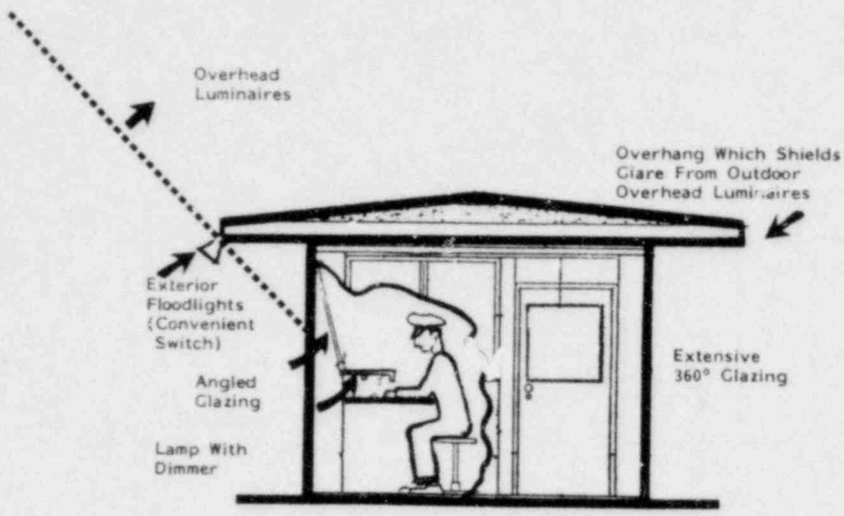


VEHICLE GATE AREA WITH WHITE SURFACE



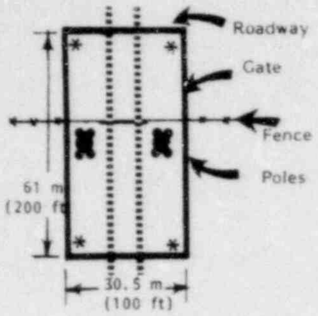
VEHICLE GATE AREA RECESSED LIGHTING

Figure 71



PROTECTED AREA GATEHOUSE LIGHTING

Figure 72

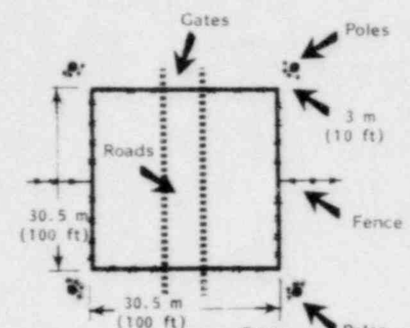


Lamp: 1500w Quartz
LDD: .96
LLD: .8
Maintenance Factor: .77
Set Back: 8 ft/Fence
Height: 9.1 m (30 ft)
Spacing: 24.4 m (80 ft)

Luminaire: Floods
2 NEMA 6 x 2/pole
2 NEMA 6 x 5/pole
Four Per Pole
Min FC: 2.0 (approx)
Avg-Min: 2.24 (approx)
Max-Min: 5.07 (approx)

Initial Cost/Meter² (Foot²): $1.22 ($.113)
Annual Cost/Meter² (Foot²): $1.50 ($.140)

* Note: One each quartz 150w Flood can be installed in each of the four corners with a switch within the Protected Area. These are used for illuminating the back of vehicles.

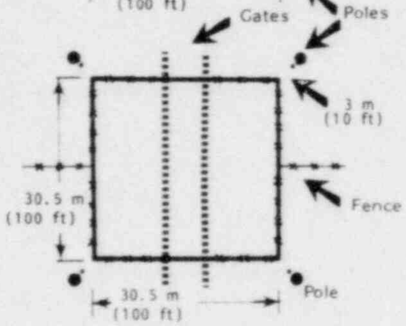


Lamp: 150w HPS
LLD: .73
LDD: .86
Maintenance Factor: .63
Set Back: 3 m (10 ft)
Height: 9.1 m (30 ft)
Spacing: (as shown)

Luminaire: Flood GE Versa Flood
NEMA 6 x 7
Four Per Pole
Min. FC: 2.18
Avg-Min: 1.98
Max-Min: 4.36

Initial Cost/Meter² (Foot²): $8.74 ($.813)
* Annual Cost/Meter² (Foot²): $2.02 ($.187)

Note: Hot Restrike Feature Should Be Used



Lamp: 1500w Quartz
LDD: .96
LLD: .8
Maintenance Factor: .77
Set Back: 3 m (10 ft)
Height: 12.2 m (40 ft)
Spacing: (as shown)
Initial Cost/Meter² (Foot²): $2.88 ($.268)
* Annual Cost/Meter² (Foot²): $1.75 ($.163)

Luminaire: Flood GE 1500A
Quartz NEMA 6 x 4
One Per Pole
Min FC: 2.67
Avg-Min: 2.08
Max-Min: 3.37

*$.04/kwh

SECURITY LIGHTING FOR VEHICLE ACCESS AREAS 21.5 LUX (2 FC)

Figure 73

guard is expected to patrol the area in the protective low light environment, low pressure sodium luminaires may not be appropriate in some areas. Switches are normally available which provide full working illumination for the security guard to use on scheduled or random patrols or alarm assessment responses.

Additional cautions on the use of lighting for security or other purposes in material access or vital areas include:

- Count Rooms--Equipment in these areas may be sensitive to line feedback or direct radiation from fluorescent luminaires (Reference No. 17).

- Count Rooms and Other Areas--Security lighting should not be of such intensity that it washes out low output neon, LED or other small instrumentation luminaires.

- Critical lighting circuits wherever possible should be run in different conduits and raceways to maintain integrity of backup capability.

- Aluminum and galvanized zinc use in reactor containments is restricted. (Reference No. 17.) This is because of potential hydrogen production resulting from reactions with deluge chemicals. Substitute materials or coatings may be required for lighting fixtures in environments subject to these chemicals in critical areas.

- High pressure sodium, mercury vapor, metal halide and fluorescent lamps all contain certain quantities of mercury. Mercury and its compounds have been known to be restricted in areas such as reactor buildings, fuel handling buildings, and auxiliary buildings to minimize the possibility of contaminating and corroding primary stainless steel piping systems. (Reference No. 17.)

- Polyvinyl chloride use may also be restricted in the containment area. (Reference No. 17.)

- Some facilities are concerned with the use of materials with a flame spread rating of greater than 25 (Reference No. 17). Plastics commonly used in lighting such as acrylic and polystyrene may require substitute materials such as steel or glass.

If there are areas in which continuous lighting for security purposes only is desired, this can be accomplished with separate circuits providing low cost low level illumination. Information is provided which illustrates these possibilities. They are based on using a luminaire with wide angle light distribution (spacing to mounting height ratio of 1.8 - 2.0 to 1). The information provides for the spacing of the luminaires as shown in Figure 74.

	CEILING HEIGHT			
	3.8 m (12.5 ft)		9.1 m (20 ft)	
	21.5 lux (2 fc)	54 lux (5 fc)	21.5 lux (2 fc)	54 lux (5 fc)
70w HPS	7.6 m (25 ft)	4 m (13 ft)	7.6 m (25 ft)	4 m (13 ft)
175w MV	—	—	—	8.2 m (27 ft)
100w HPS	—	—	—	8.8 m (29 ft)

HPS = High Pressure Sodium
MV = Mercury Vapor

INTERIOR SECURITY LIGHTING SPACING CONFIGURATIONS

Figure 74

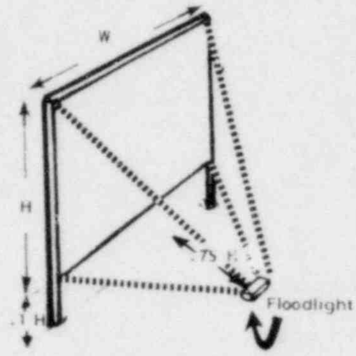
Systems are also available to turn on lights remotely through hardwire switching, radio control, remote control or by utilizing the alarm system to activate lights.

7.6 Sign Illumination

Security related signs at vehicle and pedestrian gates should be illuminated to assure they can be read. The American Association of State Highway and

Transportation Officials (Reference No. 10) recommend a minimum illumination of 108-215 lux (10-20 footcandles) at the sign's surface. Sign illumination should be arranged such that it does not create glare for security posts or patrols.

Figure 75 illustrates typical arrangements for floodlight illumination of signs. (Reference No. 16.)



Sign Size	107.6 Lux (10 Footcandles)
3 x 3 m 10 x 10 ft	(1) 175 Watt Mercury Vapor Flood
3 x 5 m 10 x 15 ft	(1) 175 Watt Mercury Vapor Flood
3 x 6 m 10 x 20 ft	(2) 175 Watt Mercury Vapor Floods

SIGN LIGHTING CONFIGURATIONS

Figure 75

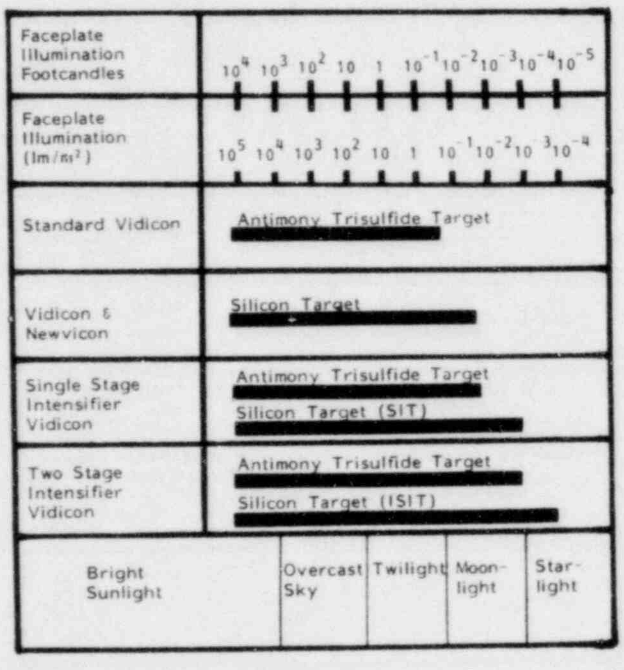
7.7 CCTV Lighting

7.7.1 General

Closed-circuit television (CCTV) plays an important role in the security field. The lighting requirements for human observation are not necessarily adequate for CCTV. It is important to choose the more cost-effective combinations of lighting and CCTV cameras. NUREG 0178, Basic Considerations for Assembling a Close-Circuit Television System (Reference No. 26) provides an excellent guide for CCTV planning. If CCTV Systems are to be installed in the future, it is best to recognize the CCTV lighting requirements in designing lighting systems to minimize future cost and problems. This should include type of lighting fixtures, width of the isolation zone, pole placement, etc.

Key planning factors for CCTV lighting include camera selection, lens selection, lighting level, lighting color and placement of lights and cameras.

As shown in Figure 76, camera systems have different sensitivities to light.



FACEPLATE ILLUMINATION FOR COMMON CCTV CAMERAS

Figure 76

Lens selection determines the amount of available light reaching the light sensing part of the camera imaging device. This is determined by the lens transmission efficiency, focal length of the lens and the maximum lens opening.

The lighting level must be measured as scene reflectance or luminance. Figure 4 provides the reflectance factors for various surfaces. These factors multiplied by the available illumination as measured horizontally provide an approximation of the scene luminance.

CCTV cameras are selectively sensitive to light color. Figure 77 illustrates the relative sensitivity of cameras to the light spectrum. Figure 78 illustrates the relative signal strength per watt of electrical power for various lamp and camera combinations. This takes into account luminaire efficiency and camera sensitivity to the lamp's lumen output and color spectrum (Reference No. 25). Note the greater sensitivity of cameras to light provided by low pressure sodium lamps.

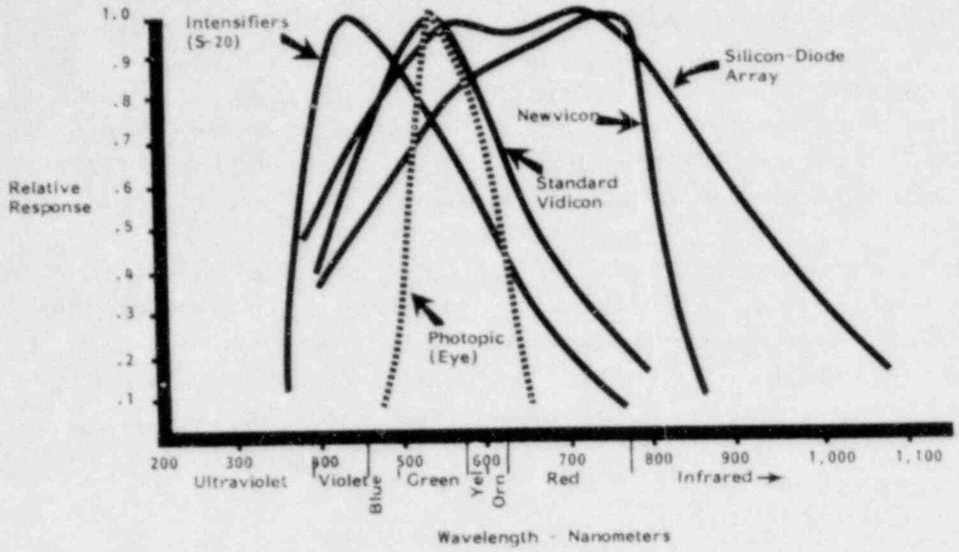
7.7.2 Outdoor CCTV Lighting Application Configurations

The security lighting system must provide light levels high enough to illuminate the scene, reflect from the scene and maintain the level required for the faceplate illumination necessary for the CCTV system to register a useful image. The scene illumination required to provide the faceplate illumination can be calculated by:

$$\text{Scene Illumination} = \frac{(4)\,(\text{Required Faceplate Illumination})\,(\text{Lens Speed})^2}{(\text{Scene Reflectance})\,(\text{Transmissibility of Lens})}$$

For a came a which requires 0.2 lux (0.02 footcandles) faceplate illumination (an average Low-Light-Level silicon array camera), that has a lens speed of 1.4 (F/1.4), a scene reflectance of .25 (graded and smooth background) and .7 transmissibility of lens (average lens value), a scene illumination of 9.6 lux (.896 footcandle) is required to provide sufficient illumination for good Low-Light-Level camera resolution.

A light/dark ratio (the ratio of illumination level between the brightest area in the scene and the darkest area) of less than 6 to 1 is recommended for exterior lighting. The light/dark ratio should apply as much as possible to the full field of view of the camera and not just the area of interest.



CCTV CAMERA SENSITIVITY TO THE LIGHT SPECTRUM

Figure 77

Camera	LAMPS				
	LPS 180w	HPS 400w	Tung. Halogen 500w	Clear Mercury 400w	Metal Halide 400w
Silicon Diode Vidicon	1.54	1.29	1.00	.57	1.36
New Vicon	2.25	1.90	1.14	.774	1.20
Standard Vidicon	.243	.202	.066	.122	.244
(SIT) Silicon Target	188.0	165.0	59.0	127.0	239.0
(ISIT) Two Stage Silicon Target	6903.0	6095.0	2323.0	3838.0	7821.0

Source Reference No. 25

RELATIVE SIGNAL STRENGTH PER WATT OF ELECTRICAL POWER FOR CCTV CAMERAS

Figure 78

A report of The Engineering and Economics of Lighting for Closed Circuit Television (CCTV) Security Alarm Assessments was recently completed for the Department of Energy (Reference No. 25). This study reviewed combinations of lighting sources for perimeter CCTV systems (Reference Figure 79) including low pressure sodium, high pressure sodium, metal halide, mercury vapor and tungsten halogen with cameras including silicon diode array vidicon, new vicon, standard vidicon (sulphide), silicon intensified target and intensified silicon intensified target. The applications studied were for perimeter surveillance and assessment of alarms using CCTV. From this study, several optimum lighting configurations were derived as shown in Figure 80. The minimum specification was for 10.76 lux (1 footcandle) horizontal, uniformity of 3:1 average to minimum and 6:1 maximum to minimum. Note that the importance of lighting uniformity for CCTV systems should not be underestimated. The "C" system shown is provided as an indication of the most economical high pressure sodium floodlight configuration and has the advantage of minimal backwash glare into the protected area which is distracting to security personnel. The "B" system has a higher initial cost than "A" or "C" but becomes competitive from an annual operating cost basis when power cost is just over $.04 per kwh. At $.06 per kwh "B" has an annual cost of 5 percent less than "C" and at $.10 per kwh its annual cost is 16 percent less than "C". This analysis was based on multiple fixed CCTV cameras located along the perimeter. The silicon vidicon was the selected camera since it is relatively inexpensive and capable of operation in daylight as well as low light (Reference Nos. 25, 26, and 27). Note that the isolation zone for CCTV lighting is 25 meters (83 feet) to provide better camera/lense adaptation.

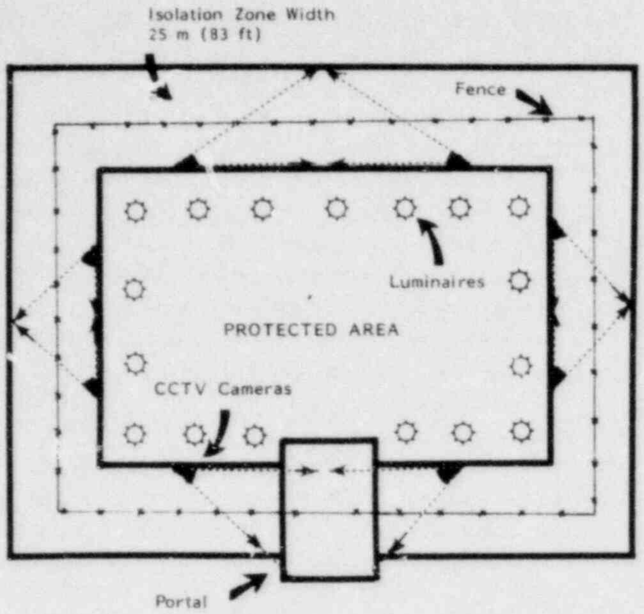
If surveillance is to be accomplished from one or more pan-tilt-zoom cameras, it may be economical to install a more sensitive and expensive camera (5 to 10 times the cost of a silicon diode vidicon) without providing the minimum of 10.76 lux (1 footcandle). In this case, if the illumination available is 2.3 lux (.2 footcandle), then for a zoom lens set-up the faceplate illumination minimum can be computed by:

$$\text{Faceplate Illumination} = \frac{(\text{Scene Illumination})\ (\text{Reflectance})\ (\text{Transmission})}{4\ (\text{Lens Opening})^2}$$

$$= \frac{(.2)\ (.25)\ (.7)}{4\ (2.5)^2}$$

$$= .0014 \text{ Footcandle } (.015 \text{ lux})$$

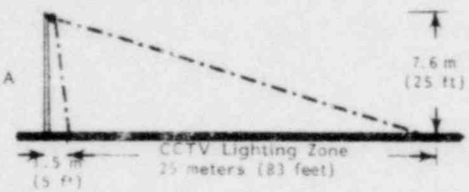
This is a very marginal amount of illumination for a silicon target vidicon camera (.01 footcandle required) and would therefore require a more sensitive silicon intensified target camera or equivalent. This assumes that the isolation zone and all other protected area zones have



ISOLATION ZONE CCTV AND LIGHTING CONCEPT

Figure 79

A

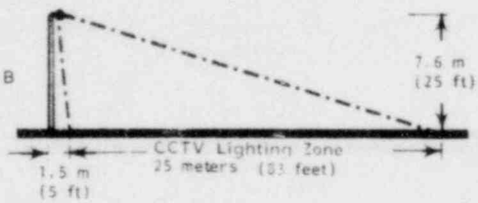


Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 1.5 m (5 ft)
Pole Height: 7.6 m (25 ft)
Spacing: 24 m (80 ft)

Luminaire: Roadway
GE M400
Two Per Pole
Min FC: .996
Avg-Min: 2.61
Max-Min: 5.94

Initial Cost Per Meter (Foot): $36.37 ($11.09)
Annual Cost Per Meter (Foot)*: $12.66 ($3.86)
Reference No. 25

B

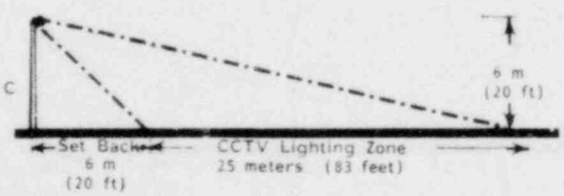


Lamp: 180w LPS
LDD: .8
LLD: 1.05
Maintenance Factor: .84
Set Back: 1.5 m (5 ft)
Pole Height: 7.6 m (25 ft)
Spacing: 27 m (90 ft)

Luminaire: Flood
Norelco SFL-53885
Two Per Pole
Min FC: 1.116
Avg-Min: 2.39
Max-Min: 5.89

Initial Cost Per Meter (Foot): $46.15 ($14.07)
Annual Cost Per Meter (Foot)*: $11.03 ($3.36)
Reference No. 25

C



Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Pole Set Back: 6 m (20 ft)
Pole Height: 11.3 m (37 ft)
Spacing: 61 m (200 ft)

Luminaire: Flood
Infranor Sterner
535-N-400 S
Four Per Pole
Min FC: 1.054
Avg-Min: 1.73
Max-Min: 5.94

Inital Cost Per Meter (Foot): $31.90 ($9.73)
Annual Cost Per Meter (Foot)*: $10.58 ($3.22)
Reference No. 25

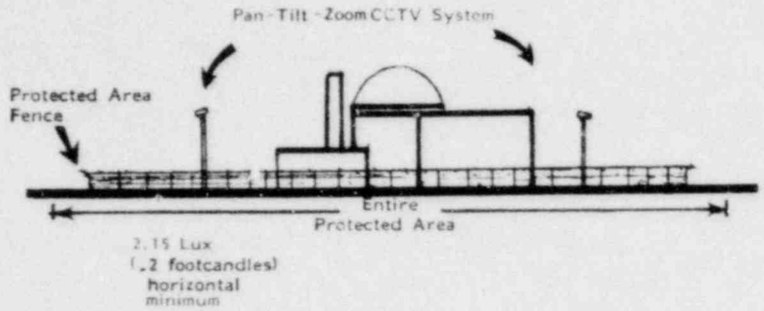
*at $.04/kwh

CCTV PERIMETER LIGHTING CONCEPTS

Figure 80

POOR ORIGINAL

a minimum of 2.15 lux (.2 footcandles) measured horizontal. This concept is illustrated in Figure 81. Lighting systems to provide this level of illumination are covered in the previous section.



PAN-TILT-ZOOM CCTV LIGHTING OPTION

Figure 81

Other combinations of illumination levels and cameras for outdoor use can be selected using the camera sensitivity, the previous equation and other illumination levels as provided in the previous section. Due to the variety of areas and requirements it may be appropriate to utilize several combinations and configurations.

When utilizing pan-tilt-zoom cameras to cover large areas it is important to keep in mind that the camera may have to function with a wide variety of illumination levels. Additionally, a fixed camera can provide immediate assessment and pan-tilt-zoom camera may require several seconds to minutes to aim at a suspect area. Even systems which are alarm system computer directed require time to aim or reaim.

7.7.3 Indoor CCTV Lighting Applications

Indoor lighting for CCTV is usually based on the available illumination. It is usually much more constant and uniform as well as having a higher illumination level than outdoor nighttime illumination. As such, standard vidicon cameras can be utilized as long as a minimum of 54-108 lux (5-10 footcandles) is available. If lower levels of light are available, cameras can be selected to match. If a continuous minimum of illumination for patrol and CCTV coverage is required in relatively small areas such as vault doors, access points, or other areas, high efficiency, high pressure sodium or low pressure sodium luminaires can be installed as wall or ceiling mounts.

8. OPERATION/CONTROL

8.1 General

To be effective, a security lighting system must be properly operated. Operational considerations include the use of lighting fixtures and security personnel lighting support during routine and contingency conditions. A coordination of properly maintained fixtures and trained, alert security personnel insures a more effective protective lighting and security system.

8.2 Routine

8.2.1 General

Routine operation is classified as the regular effort extended under normal circumstances. This includes start-up, operation and shutdown of the lighting fixtures and the visual tasks of the security personnel during nighttime post and patrol assignments.

8.2.2 Start-up and Shutdown

Outdoor lights will be switched on approximately 15 - 30 minutes after sunset and remain on until about 15 - 30 minutes before sunrise. The lighting schedule will vary depending on site location. This may be accomplished manually, by use of a timing system, or by use of a photoelectric system. If photoelectric switches are utilized they should be located such that they cannot be accessed and deactivated by an adversary's light. Manual override switches should be available for emergency use. The switching system should be located in a secure area. Only those personnel necessary to insure effective practices should have access to the switch area. Switches should be lockable. Consideration should be given to the time required for HID luminaires to reach adequate light output level (Reference Section 6). On and off schedules should be set such that minimum illumination requirements are met at all times.

8.2.3 Operation/Visual Search

With the lighting fixtures on and properly maintained, the observer is able to complete his visual tasks. There are several standard techniques used in the visual search task which include: (1) fixating one's vision on predetermined locations in a set pattern over the observation area, (2) random visual search over the observation areas, and (3) a combination of both. The observer should use a technique that will avoid eye fatigue. The assumed physiological and psychological characteristics of the observer are that they be healthy, alert, without visual impairments, highly motivated and possess a positive attitude toward the visual task (Reference No. 1)

Observers can be used in a fixed location to insure constant surveillance over a particular area or they can be on patrol to perform random observations of particular areas. The higher the risk of intrusion and the higher the potential danger from a successful intruder, the greater should be the observation effort.

The work of the observer at night can be repetitious and boring. If the visual task is boring and does not stimulate the security guard, the guard will fail to extend eye focus. A dark adapted observer typically focuses at a distance of about 2 m (6 feet) in front of the eyes. Physiologically, this is normal. It is called night myopia. The dark adapted observer will possess a higher sensitivity for peripheral vision and therefore will possess an extended range of observation area (Reference No. 5).

For visual search, it has been experimentally found that if the visual field is reasonably free from glare sources, the peripheral and general visual alertness of the dark adapted observer is greater without the use of a directable searchlight. The use of the searchlight raises the adaptation level of the observer which conditions the observer to the higher luminance of the beam and prevents seeing low contrast objects outside the beam. The peripheral vision of the observer is far more acute when dark adapted than when light adapted (Reference No. 5). The general approach to night visual search would therefore be to observe without searchlight aid until there exists reason to investigate an area with use of more illumination.

As shown in Figures 6 and 7 in Section 4.6 and 4.7, to perform a good visual search for targets which include still targets, the person should patrol within 80 m (260 feet) of areas included for casual patrols and within 15 m (50 feet) during assessment patrols to assure good search coverage. The time of search is also important, particularly in areas with low level illumination. Typically normal or casual patrols should spend 20 to 25 seconds observing each "scene" before continuing on to the next observation point. When an alarm assessment patrol is being performed, a search of a minute or more will be required for an effective search of each "scene."

Training, motivation and fatigue are some factors that effect the visual performance of an observer in the performance of duties (Reference No. 28). The degree of training can, of course, be determined by facility policies and the attentiveness of those who are responsible for the security of the site. The motivation of an individual cannot be estimated at a particular point in time, but steps may be taken to choose an individual for the observer position who will be generally motivated. This can be accomplished, as an example, in the hiring process. Fatigue also has the potential to be controlled. When a high standard of security lighting is used, the observer is less likely to experience extremes in luminance, glare or other eye fatigue circumstances.

8.3 Security Lighting Contingencies

U.S. Nuclear Regulatory Commission Regulatory Guide 5.55, March 1978, "Standard Form and Content of Safeguards Contingency Plans for Fuel Cycle Facilities" covers events which may require security lighting considerations. These events include acts of adversaries of all types, "Acts of God" (weather, etc.) or other incidents and accidents. Lighting is a very important aspect of contending with situations such as these during nighttime operating hours. (Reg.Guide 5.54 covers power plants.)

For contingency assessment and management the following are recommended:

- Each guard should have available a portable flashlight or lantern as described in Section 6.6.2.
- Each vehicle should have available a search/spot light as described in Section 6.6.3.
- Each fixed post (gate/mobile/observation) should have a searchlight/ spotlight. A flashlight or lantern for each guard should be available at the post.
- Guards should know where all light switches are located and the switches should be properly labeled.
- Guards should know where all emergency light sources are located, have access to them and know how to operate them.
- All facilities/buildings should have emergency lighting in accordance with State, Federal and NRC requirements.
- Isolation Zones, Protected Areas, Vital Areas and Material Access Areas should be provided with security lighting systems having backup power supplies as noted in Sections 4 and 7.

- Each site should have a portable floodlight system which is self-sustaining for 12 hours of operation (truck or trailer mounted typically).

- Each site should have emergency flares or strobe beacons available.

- Each site should have an inventory of lighting equipment available from other sources such as rental agencies, mutual use agreements, power and utility companies, etc. which can be drawn upon short term as well as extended basis. These items should include floodlight systems, self-sustaining portable floodlight systems and emergency generator sets.

8.3.1 Adversary Contingencies

Adversary contingencies include events such as an attack threat, bomb threat, civil disturbance, attempted or accomplished intrusion, evidence of an intrusion or suspect intrusion, intrusion alarm annunication, or suspicious personnel observation. In most of these cases, it is essential to dispatch a patrol toinvestigate or control the situation or assess the situation with other remote visual means such as CCTV or direct observation from a fixed post.

For lighting, adversary related contingencies should be assessed and illuminated as noted below:

- Patrols with flashlights or vehicle spotlights should be dispatched to assess the contingency or the assessment should be accomplished by CCTV or direct observation from fixed post if the contingency is within the visual range of observation.

- Patrols should travel in the least lighted areas and use their flashlights, vehicle lights and spot/searchlights as little as possible to minimize highlighting themselves as targets and to remain as dark adapted as possible.

- If a group of demonstrators collect at any point along the protected area perimeter, portable floodlights may be moved to the area to enhance observation capability or photographic capability.

- If pickets are established because of labor relations problems, portable floodlights in the area of picketing can minimize hazards and potential destruction and harassment.

- If hazards are found to exist such as downed power lines, ruts, obstructions, etc., flares, blinking caution lights or floodlights should be installed to mark or illuminate the hazard.

- If there is any interruption in security lighting continuity, patrols should be dispatched to perform a check of the material access areas, vital areas, protected areas and protected area fence/barrier to assure security. Although no adversary action may have occurred, it is necessary to assume that it may have until properly assessed.

- If contingency situations have the appearance of persisting or if there are additional lighting needs, lighting equipment from alternate sources should be brought in.

8.3.2 Acts of God Contingencies

Contingencies resulting from Acts of God would include damage resulting from floods, storms, earthquakes or reduced security capability due to vision limitation resulting from snow, rain, fog or dust. Backup power systems provide power for protection when the primary or off-site power source is interrupted. However, there may be some situations where no primary power supply is available for the basic security lighting circuits or the lighting circuits may be damaged. In these types of situations, some of the following actions may be appropriate.

- Dispatch the portable security lighting equipment to the points of greatest need. This may be a site of dire emergency or the main gate/portal.

- Utilize vehicle lighting systems at points of greatest need. Vehicles can illuminate emergency areas, gates or fence line. A vehicle and guard positioned in a corner of the fence/isolation zone can illuminate a significant length of fence with headlights in one direction and with a spotlight in another direction.

- Increase patrols and establish temporary post as required. This is also appropriate when visibility is limited by rain, snow or dust.

- If the need for lighting persists, equipment should be brought in from alternate sources.

- Include the above appropriate actions in the site security and contingency plan, guard orders and guard training.

8.3.3 Fire and Incident Contingency Lighting

When fires or other incidents occur during nighttime adequate lighting is most essential.

- Portable self-sustaining floodlight systems are most valuable at incident sites.

- Vehicles may be used effectively to provide incident site auxiliary lighting.

- If the need for lighting persists, equipment can be called in from the alternate sources.

- Fire and incident planning and training should address lighting use and availability.

9. MAINTENANCE AND TESTING

9.1 General

Security lighting systems require maintenance and testing to assure contingency readiness and day-to-day performance to specification. Scheduled preventive maintenance and testing is as important as breakdown or repair type maintenance. A complete maintenance program would include poles or standards, mast arms and hangers, lamp-housings and fixtures, wiring and controls, ballast, lamps, power supplies (backup/emergency) and application areas.

Factors which directly effect the general lighting level available at any point in time include:

- Luminaire Dirt Depreciation (LDD)--Light performance degraded by dirty lamp, lenses or reflectors.
- Lamp Lumen Depreciation (LLD)--Light output reduction resulting from normal in-service aging.
- Equipment Factors--Light output variables based on low voltage, or accumulation of various component performance tolerances.
- External Factors--Lighting output performance degrading resulting from weather conditions, vegetation growth, reflective background changes (paint peeling) or other indirect factors.
- Alignment and Leveling--Misalignment due to wind loads, damage or erosion.
- System Failure--Lighting system component failure or breakdown.

Considerations which assure continued operation and maximum economic service life of lighting equipment include:

- Mechanical Inspection--Inspection and protection of mechanical components.
- Electrical Inspection--Inspection and protection of electrical components.

9.2 Maintenance Scheduling

Security lighting maintenance will be normally scheduled as a result of routine and casual observations, a preventive maintenance and inspection specific schedule or as a result of a major lighting system breakdown. The quality and type of equipment, the service requirements and exposure will influence the frequency of maintenance. In all cases the manufacturer's recommendations should be followed at a minimum.

9.2.1 Routine and Casual Observations

Routine and casual observations are the responsibility of all of the site's employees as well as the maintenance and security organizations. Deficiencies noted in the security lighting system by any employee should be brought to the attention of the security organization to provide for timely review and correction. Maintenance personnel are normally observant of not only what they may be servicing but also peripheral equipment and should report any security lighting system deficiencies.

Since guards, regularly or at random, patrol areas which utilize security lighting, it is appropriate for their orders to include observation of the security lighting systems. Any deficiencies should be called in to the designated shift security supervisor for immediate action or follow-up maintenance as appropriate. The guard's daily log should record the observation.

9.2.2 Repair or Breakdown Maintenance Scheduling

Major breakdowns in security lighting systems may require immediate correction which may or may not require application of premium guard or maintenance personnel services. All repairs should be of a quality at least equal to National Electrical Code requirements.

9.2.3 Preventive and Scheduled Maintenance

Preventive and scheduled maintenance programs are required to assure the most economical operation of specified security lighting systems. Predetermined schedules, procedures and good records are essential to preventive maintenance programs. Schedules and procedures can be derived from the manufacturer of the lighting equipment.

Some components of the security lighting system may require periodic inspection. Othersmay not require attention until output becomes marginal as determined by testing, for example. The following describes some of the recommended activities.

9.2.3.1 Cleaning

The accumulation of dirt or other particulate material on lamps, lenses and reflectors will vary depending upon the type of fixture and its locale with respect to dirt roads and agricultural or industrial activity. Besides attenuating the light output, excessive accumulation can cause abnormal heating resulting in failure of components or cracking of glass.

The frequency of cleaning various types of fixtures can be established as a somewhat arbitrary level until experience or surveys determine the actual expected loss of lighting relative to time. The schedule might also be influenced by the frequency of relamping (lamp replacement). Cleaning during normal relamping may be adequate. The effect of cleaning is illustrated in Figure 83. The American Association of State Highway Transportation Officials (Reference No. 29) recommends that luminaires other than those with mercury vapor lamps may be cleaned each time they are relamped at a minimum and mercury vapor luminaires be cleaned at midlife and relamping time. Unusually dirty environments or non-sealed luminaires will require more frequent cleaning. Luminaire dirt depreciation for sealed and filtered fixtures is estimated at 95 percent and 80 percent for unfiltered units between relamping.

Most modern fixture lenses can be removed with relatively simple clamps. When this is the case, the lens can be taken down for safer and more convenient cleaning. If a spare is available, a clean unit can be installed at the same time without an extra trip up the pole (if this is required).

Cleaning of lenses and reflectors should be in accordance with the manufacturer's recommendations. Generally, the unit can be immersed in a container of detergent solution with scrubbing accomplished with a soft sponge or brush. A large "plastic" trash can may work well and minimize potential damage to the glass components. Simply wiping out the lens and reflector with a soft cloth or brush may suffice in many cases.

Strong chemicals, acids or alkaline solutions should not be used on aluminum reflectors. Gritty cloths, steel wool, or abrasive cleaning powders should not be used on glass lenses or reflectors since permanent hazing and transmission or reflective degradation may result.

When fixtures cannot be removed, a glass cleaning agent which does not require rinsing and a soft cloth may be used to clean the fixture in place (or simply a soft cloth or brush).

9.2.3.2 Relamping

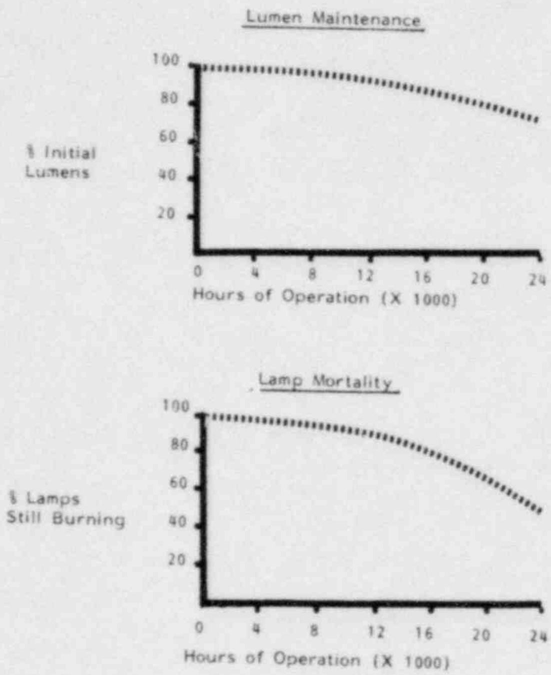
A relamping program should be developed for the site's specific security lighting system. The selected strategy will depend upon the type of lighting utilized, how it is applied, access to maintenance equipment or services and other unique installation or cost factors. Relamping may result from measured lamp output, lamp failure, or a schedule which anticipates the economic breakeven for replacement. In all cases, burned out lamps in high intensity discharge luminaires should be replaced as soon as possible. High pressure sodium lamps should be replaced to avoid possible damage to the ballast starting aid.

Manufacturers of lamps usually provide performance information relative to lamp lumen depreciation or lumen maintenance as shown in Figure 82. This is normally the average for a specific sample of lamps and individual lamps may vary somewhat. They also provide a lamp mortality curve or rated average life. The rated life is an indication of the life of 50 percent of the lamps, as shown in Figure 82. Obviously many of the lamps do not reach the rated average life.

Relamping must also consider the effects of cleaning if dirt and lumen depreciation are both allowed to accumulate. The lamp output will reach an unacceptable level very quickly (after for example 14,000 hours) as illustrated in Figure 83. Two cleanings will allow the lamp to reach its rated average life.

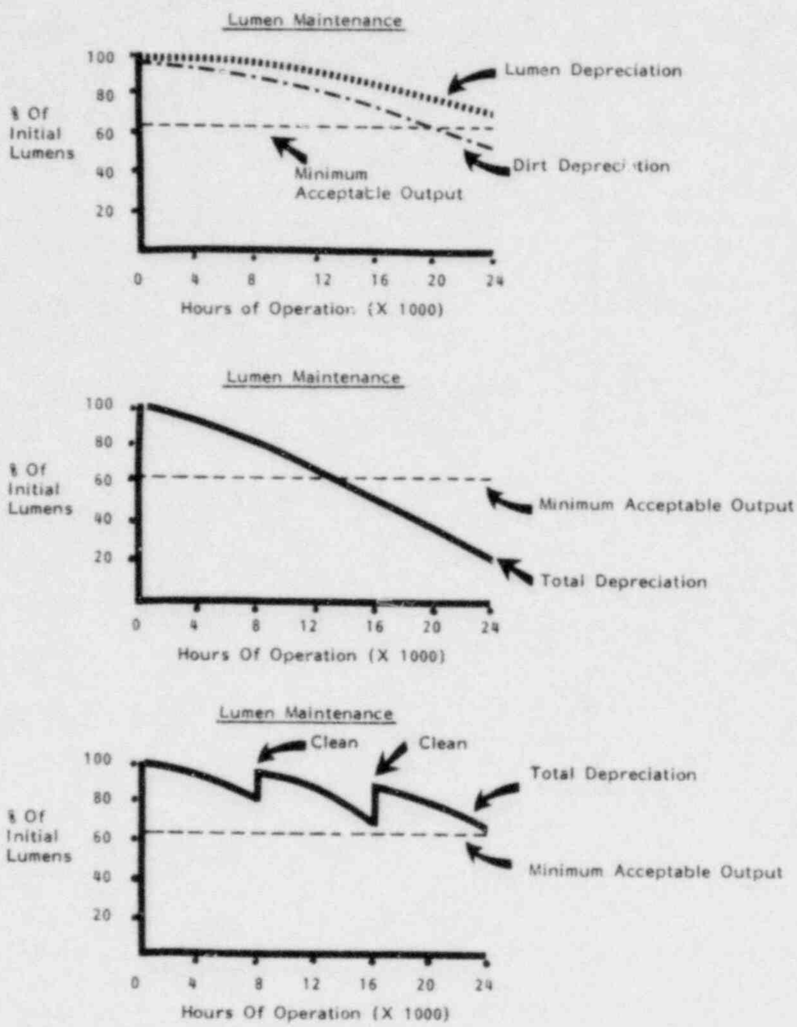
Relamping strategies include spot replacement and group replacement. Spot replacement would occur when the lamp fails or when by testing the area lamp it is determined to have a lumen output which is below the minimum acceptable level and cleaning is not an adequate corrective measure. Group replacement strategies are those in which all of the lamps in a specified area are replaced at one time at regular intervals. Group replacement can significantly reduce the number of failures between replacements. Group replacement would permit a more consistent level of illumination and thereby minimize consumption by eliminating some overspecification to compensate for deterioration but would require more lamps for replacement and more replacement labor. Without testing and a group replacement program, it is possible for incandescent and some high intensity discharge lamps to operate at a level far below their rated output and far beyond their rated average life. (Reference No. 29)

Far more important from a security standpoint is to minimize holes in the security lighting system due to failed lamps. The American Standard Practice for Protective Lighting (Reference No. 3) recommends that lamps should be group replaced at 70-80 percent of normal rated life which should reduce the number of random replacements



TYPICAL HPS LAMP MORTALITY AND
LUMEN MAINTENANCE CURVES

Figure 82



LUMEN AND DIRT DEPRECIATION

Figure 83

between group replacements to about 15 percent of the total installation.

The American Association of State Highway and Transportation Officials Maintenance Manual (Reference No. 29) recommends that fluorescent and halide lamps in a group replacement program should be replaced every two years; sodium vapor lamps every two and one-half to three years; and mercury vapor every five years (based on 24,000 hour rated lamps). AASHTO further recommends other types of lamps to be replaced at 90 percent of their average rated life. For security lighting purposes the AASHTO recommendations would be considered a minimum requirement. FM-19-30 (Reference No. 30) recommends group replacement schedules based on 80 percent of the lamps rated life. It is also noted that functional lamps removed from security lighting circuits can be used in less sensitive locations.

For security lighting purposes at the isolation zone, portals to the protected area, and material access and vital areas where the loss of one lamp could significantly degrade the security lighting, it is recommended that a program be established to replace lamps at 80 to 90 percent of their rated life. In other areas where multiples of lamps/luminaires are available and loss of a single lamp does not significantly reduce the illumination level, a relamping program which is economically justified should be utilized by the licensee.

9.2.3.3 Mechanical Inspection

At the same time lamps are replaced or cleaned or on an established separate schedule, the luminaire should be inspected for mechanical problems. This inspection should include:

- Gaskets--Missing, worn or broken gaskets should be replaced or repaired to minimize cleanliness and moisture problems.
- Hardware-- Fasteners, springs, clips, screws and bolts should be inspected to assure operability. Assure mountings are tight and secure.
- Insulators--Broken, cracked or otherwise deteriorated insulators should be replaced or repaired.
- Glass--All glass and transparent enclosures should be checked for cracks, discoloration or deformation (primarily plastic components).
- Electrical--Check sockets, receptacles and wiring. Check for loose connections, damaged insulation, corroded terminals and cracked sockets or receptacles.

- Poles and Brackets--Check paint or coating for indications of rust, corrosion or rot as appropriate. Clean, prime, repaint as appropriate.

- Periodically an aiming guide should be utilized to assure proper fixture alignment. This quite often is a major problem in maintaining lighting uniformity and levels in specified areas.

9.2.3.4 Circuits and Controls

Circuits and controls should be maintained in accordance with manufacturer's recommendations at a minimum.

- Constant Current Transformers--Clean, adjust and check mechanical operation. Check oil for moisture and sludge and replace oil if required. The inspection should be accomplished annually.
- Relays--Annually check contacts for excessive corrosion or burning. Burnish contacts if required. Check and clean the magnets and assure magnets lack of excessive noise.
- Oil and Other Switches--Check leads for corrosion and tightness. Check gaskets and inspect parts for cracks. Check oil level and dielectric strength. Filter oil or replace as required for oil switches. These inspections should be accomplished annually.
- Photoelectric Controls and Time Clocks--Annually check time clocks, terminals and contacts. Clean or burnish as required. Clean the photoelectric control "windows" semiannually and recalibrate. Experience with certain units and areas may indicate that annual servicing of the photoelectric controls is adequate.
- Power Circuits--Underground power circuits should have a megohm test annually to assure there is no leakage, shorting and deteriorating condition.

9.2.3.5 Backup Power Supplies

Backup power supplies both battery and generator based should be maintained in accordance with the manufacturer's specifications. Maintenance procedures should be prepared and included in the site's maintenance system. Refer to Regulatory Guides listed in Section 6.5.4, Backup Power Sources.

- Internal Combustion Engine Driven Generators--Basic checks of coolant, oil, fuel, heaters, lubrication and starting power source (batteries) should be made during normal test operation (See Section 9.3). Other maintenance relative to coolant, filters or oil changes, etc. should be accomplished in accordance with manufacturer's specifications.

- Battery and Uninterruptable Power Supplies should be checked during testing operations (See Section 9.3). Normally they will be inspected for charge level, electrolyte level and potential corrosion problems. Maintenance should be in accordance with manufacturer's recommendations.

- Switch Gear should be inspected during each test exercise (see Section 9.3) and in accordance with the manufacturer's recommendations.

9.2.3.6 Maintenance of Lighted Zones

Maintenance of the lighted zone should consist of at least an annual inspection to assure that vegetation (tree limbs, weeds, etc.) are not blocking luminaires such that the protected area is not illuminated to specification. Vegetation changes, can also cause significant changes in reflectance of both horizontal and vertical surfaces. Impairments should be trimmed and removed. Additionally, an inspection should be made to assure that clear areas have not been turned into parking lots, storage areas or otherwise reassigned such that security lighting is degraded.

9 2.3.7 Maintenance Safety

In addition to standard electrical maintenance practices, the following should be considered.

- When maintaining the system, remember that the voltages to start high pressure sodium vapor lamps are in excess of 4,000 volts AC. Assure that the main power, as well as any backup power source, is turned off and locked off. Do not remove lamps with power on.

- Remember that local photocell control at the fixture or elsewhere does not assure that the total system is turned off. The photocell switch should not be relied upon as shut off.

- Mercury vapor lamps contain mercury. A disposal program keeping this in mind is recommended to eliminate environmental or health hazards. High pressure sodium, fluorescent and metal halide lamps also contain small quantities of mercury.

- Sodium lamps contain small quantities of sodium which develop heat when in contact with moisture. As a result some lamps are provided with disposal instructions. These instructions typically require breaking the lamps, no more than 20 at a time, in a steel bucket or container. The container is then filled with water from a rubber hose with the operator at a safe distance. After soaking for a few minutes the sodium is rendered harmless. (Reference No. 25)

9.3 Testing

9.3.1 Testing Illumination Levels

Most luminaires commonly used for security lighting, including high intensity discharge lamps, do not deteriorate in lumen output rapidly. Fixture design and environmental consideration such as dust varies from site to site. Except in perhaps the most severe conditions, it would not be anticipated that lumen depreciation would be more than 25 percent per year. It is therefore recommended that the light levels in the protected lighting areas be tested at least once each year at a minimum and more frequently if lighting levels are very marginal or the combined dirt and lumen depreciation is particularly high. In areas with vegetation or other unusual problems, certain aspects of testing and inspection may be more frequent.

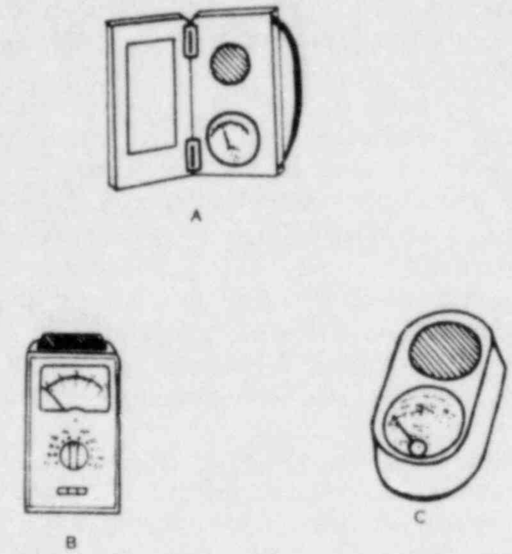
9.3.2 Testing Procedure

The overall inspection program should consider instrumentation used, methods of measurement, location of measurements and records of measurement.

9.3.2.1 Illumination Testing Instruments

Portable instruments for photometric measurements are available which were developed primarily for roadway illumination evaluation. Since security lighting requires measurement to levels as low as 2.15 lux (.2 footcandles) the choice is somewhat limited. A meter with a range of 2.15 to 54 lux (.02 to 5 footcandles) would be appropriate for most exterior security lighting measurements. This can be augmented with a low cost meter for illumination levels above 54 lux (5 footcandles).

Figure 84 illustrates several illumination test instruments which can be used for testing. Item (A) is a Weston Model 615 broadrange light meter. It has scales of 0-1.2, 3, 12, 30, 120 and 300. Color and cosine filters are included. The unit costs approximately $450 to $500. Many other light meters are available which cost from $50 to $200. However, they may not include color correction or cosine correction and may not have scales which are effective in the range of a few lux (fractions of a footcandle). Figure 85"B" and"C" illustrate typical lower cost units which may be sensitive enough for low light level testing above 21.5-54 lux (2-5 footcandles).



ILLUMINATION LEVEL TEST INSTRUMENTS

Figure 84

The color correction filters filter the light and correct it to match the sensitivity of the human eye. When working with high intensity discharge luminaires in particular, it is important to recognize that the color of the light varies significantly between lamps. Therefore it may be necessary to have a special filter for each type of lamp if the lighting levels are to be critically tested for licensee performance. Another option is to have the instrument which has a common color correction filter calibrated for each type of lamp. In this case the correction factor would be applied to the direct instrument reading. Still another option is for the licensee to provide illumination with a significant safety factor of 50-100 percent to assure minimal problems in any case.

Since the light at some measurement locations will be from relatively large angles of incidence, the meter should be of a cosine corrected type and the light sensing device leveled accurately before each reading.

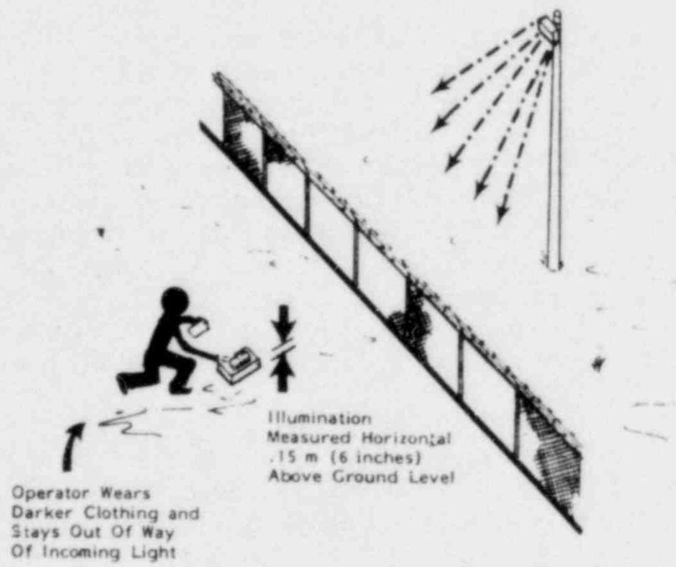
9.3.2.2 Method of Measurement

Illumination measurements should be horizontal and taken .15 meters (6 inches) above the ground. The reading should be color corrected and angle of light incidence corrected if not already compensated by the instrumentation.

The person taking the measurement should be sure that his or her body and clothing does not influence the meter reading by reflecting or interferring with the light source/sources. The use of darker colored clothing would be appropriate. (Reference Figure 85).

Testing in the proximity of buildings and other facilities should be accomplished in a manner which will not block reflected light from the building. This is because reflected light from fixed facilities is an actual or preplanned part of the available illumination.

Fences will exert some shadow effect especially if luminaires are mounted at low levels or have extensive set back. Testing in this area (fence shadow) should be accomplished in a manner which does not put the test device in the shadow of a fence post or small sign.



ILLUMINATION LEVEL MEASUREMENT

Figure 85

Points within the areas to be tested should be predetermined and noted on a site map. Records of the readings may be useful to help ascertain cleaning or relamping schedules. Points designated for measurement can be marked with small steel or plastic stakes in the soil, nails in the pavement or other unobstrusive marking. Other points can be checked at random to test for luminaire light depreciation problems.

If the lighting system was properly designed, the uniformity of illumination should not require periodic testing (that is, the ratio of average illumination level in the area to the minimum level).

Areas which are particularly sensitive and which should be measured include points on the extreme boundary of the designated protected lighted area, corners, mid-points between luminaires and other general points in the area (Reference Figure 86).

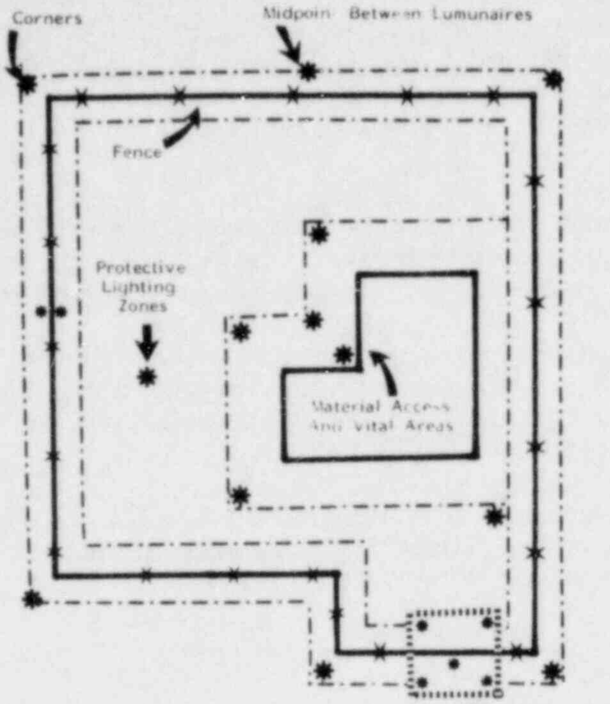
Test results which indicate the illumination level to be below the minimum requirements can be caused by a variety of factors several of which may not be a result of a deficient system. Some of these include:

- Inappropriate testing procedure
- Instrument out of calibration
- Line voltage other than rated
- Random lamp manufacture deficiencies
- Random lamp excessive depreciation
- Random ballast manufacture deficiencies
- Mis-aimed luminaires
- Height or spacing of luminaires not to specification
- Lamp replacement or cleaning required
- Luminaire damage
- Luminaire focus or reflectivity not to specification

Any apparent system deficiencies should be studied closely to determine the cause and most economical corrective measure.

9.3.2.3 Testing Support Equipment

Testing of the support equipment primarily applies to testing backup power supplies and other auxiliary lighting equipment.



ILLUMINATION TEST POINTS

Figure 86

9.3.2.3.1 Testing of Backup Power Supplies

The testing of backup power supplies or sources is covered in existing regulatory guides. The applicable guides are listed in Section 6.5.4.1.

Other applicable information may also be found in Section 6.5.4 which covers backup power in general. Generator sets used for security lighting should be tested (started) weekly and run under load at least once a month. (including a test of any switching and transfer functions). Generally, the weekly test includes running until operating temperature is reached.

9.3.2.3.2 Testing Auxiliary Lighting Equipment

Backup lighting equipment such as trailer mounted power generators, search and spot lights and other portable lighting equipment should be tested monthly. The testing should be functional and assure that the equipment operates to specification. As appropriate, the test should be on the security or maintenance organization's preventive maintenance/inspection schedule.

10. SUMMARY AND RECOMMENDATIONS

Security lighting is a requirement at nuclear fixed site facilities. As a result of a wide selection of lighting concepts and equipment, the requirements can be met in a variety of ways. Sites have different physical characteristics and may already have established security lighting. Other sites may be in the planning, design or improvement stage. This planning guide highlights application methods and considerations which will result in meeting or exceeding the NRC requirements. Comparative cost estimates for the various lighting configurations allow the security planner to select basic concepts which will provide security lighting for a specific site in the most economical manner.

As noted in several sections, due to site configuration differences, a variety of the provided concepts may be required to best utilize existing lighting or accommodate unique site features. Lighting concepts and designs for sites will ordinarily be highly customized and will require design by qualified and experienced engineering organizations or personnel.

Lighting equipment is being improved and made more efficient as a result of energy cost and availability limitations. It is important that security lighting users remain aware of new developments and take advantage of them at every opportunity.

In summary:

- At present, high and low pressure sodium lamps are the most efficient available.
- Low pressure sodium lamps do not provide light which allows color discrimination, but when properly controlled,provide better CCTV illumination as energy costs increase.
- Glare in the eyes of on-site security guards can be minimized by using floodlights at the protected area perimeter (isolation zone) with protected area lighting using poles which are as high as economically and practically possible.
- The minimum of 2.15 lux (.2 FC) horizontal required by NRC is not generally adequate to assure good detection capability. For this reason, it has been recommended that within the isolation zone, portal areas and in the proximity of vital and material access areas, the lighting level should be increased to 21.5 lux (2 FC) horizontal.
- All lighting plans should consider the present or future use of CCTV systems and related requirements.

- HID luminaires, including high and low pressure sodium, do not start instantly and do not necessarily restart (restrike) instantly. This must be taken into account where continuous illumination is required. It is recommended that lighting at portals and in material access and vital areas have instant restrike and continuous lighting capability. In the isolation zone, restrike should not require longer than approximately 10 seconds. In the protected area, in general, interruptions should not exceed 60 seconds. Generally, the NRC accepts 60 seconds restrike time for protected area and isolation zone lighting. However, the recommended restrike times will improve assessment and detection capability.

- Backup power systems or emergency power supplies should be available for security lighting at protected areas, material access areas, vital area portals, the protected area isolation zone, in the proximity of material access and vital areas, and general protected area.

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*Also available for purchase from the NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

APPENDIX

Partial List of Equipment Suppliers

Emergency Power Systems and Generators

Allis Chalmers	Box 563 Harvey, Illinois 60426 312-339-3300
Caterpillar Tractor Co.	Peoria, Illinois 61629 309-578-6859
Detroit Diesel Engine Div.	Detroit, Michigan 48228
Dual Lite Inc.	P. O. Box 468 Newtown, Connecticut 06470 203-426-2585
Emerson Electric	8106 W. Florissant Avenue St. Louis, Missouri 63136 314-553-2000
Exide	101 Gibraltar Road Horsham, Pennsylvania 19044 215-674-9500
Generac Corp.	Waukesha, Wisconsin 53186
General Electric	Schenectaday, New York 12345
Homelite-Textron	14401 Carowinds Blvd. Charlotte, North Carolina 28217
Kohler	Kohler, Wisconsin 53044 414-457-4441
Obrien Machinery Co.	206 Green Street Dowington, Pennsylvania 19335 215-269-6600
Onan	1400 73rd Avenue, N.E. Minneapolis, Minnesota 55432

Teledyne	290 E. Prairie Street Crystal Lake, Illinois 60014 815-459-6100
Topaz Electronics	3855 Ruffin Road San Diego, California 92123 714-279-0831
Westinghouse Electric Corp.	Pittsburgh, Pennsylvania 15222
Winco Division Dyna Technology	Sioux City, Iowa 51102
Worthington Corp.	Harrison, New Jersey 07029

Flash Blindness Devices

GTE Sylvania (Distress Flash)	West Main Street Hillsboro, New Hampshire 03244 606-464-5533
Law Enforcement Associates, Inc. (Intruder Flare)	88 Holmes Street Belleville, New Jersey 07109 201-751-0001
Local Photographic Equipment Suppliers	

Lighting (Lamps, Luminaires and Poles)

Alco Electronic Products, Inc.	North Andover, Massachusetts 01845
Arrem Plastics, Inc.	502 Vista Avenue Addison, Illinois 60101
Benjamin Electric Manufacturing Co.	P. O. Box 180 Sparta, Tennessee 38538
Bright Star Industries	600 Getty Avenue Clifton, New Jersey 07015
Burkey Colortran	1015 Chestnut Street Burbank, California 91502

Crouse-Hinds Co.	Syracuse, New York 13221
Electro Life, Inc.	P. O. Box 396 131 N. Island Avenue Batavia, Illinois 60150
GE Lighting Systems Department	Spartanburg Highway Hendersonville, North Carolina 29739
GE Lamp Division	Nela Park Cleveland, Ohio 44112
Hubbell Lighting Division Harvey Hubbell, Inc.	Electric Way Christianburg, Virginia 24073
ITT Landmark Lighting	P. O. Box 100 Southhaven, Mississippi 38671
Johns-Manville Holophane Division	Greenwood Plaza Denver, Colorado 80217
Joslyn	4000 E. 116th Street Cleveland, Ohio 44105
Justrite Mfg. Co.	2061 Southport Avenue Chicago, Illinois 60614
Killark Electric Mfg., Co.	P. O. Box 5325 St. Louis, Missouri 63114
Lesair, Inc.	8859 Balboa Avenue Suite C P. O. Box 23053 San Diego, California 92123
Lightron of Cornwall	195 Hudson Street Cornwall-on-Judson, New York 12520
Logitek, Inc.	40 Dentral Avenue Farmingdale, New York 11735
Lustra Lighting Corp.	180 Getty Avenue Clifton, New Jersey 07013
Luxor	Empire State Building 350 Fifth Avenue New York, New York 10001

Moldcast Lighting	Interstate 80 at Maple Avenue Pine Brook, New Jersey 07058
Optronics, Inc.	350 N. Wheeler St. Ft. Gibson, Oklahoma 74434
Perfect-Line Mfg. Co.	80 East Gates Lindenhurst, New York 11757
Permavolt, Inc.	P.O. Box 2582 1901 South Lafayette Blvd. South Bend, Indiana 46613
Power-Lite Industries, Inc.	Lindenhurst, New York
Quality Outdoor Lighting	3535 Commercial Avenue North Brook, Illinois 60062
Siltron Illumination, Inc.	1960 W. 139th St. Gardena, California 90249
Spectronics Corp. BLE Division	29 New York Avenue Westbury, New York 11590
Sterner Lighting Systems	Winsted, Minnesota 55395
Streamlight Inc.	1010 W. 8th Avenue Suite C King of Prussia, PA 19406
Sylvania Lighting Center	Danvers, Massachusetts 01923
Tork Inc.	Mount Vernon, New York 01551
Ultra-Violet Products Inc.	5100 Walnut Grove Avenue San Gabriel, California 91778
Verd-A-Ray Corp.	615 Front Street Toledo, Ohio 43605
Vicon Industries Inc.	125 East Bethpage Road Plainview, New York 11803
Voight Lighting Industries	135 Port Lee Road Leonia, New Jersey 07605

Westinghouse Electric Corp. Lamp Division	Bloomfield, New Jersey
Widelite Corp.	P. O. Box 606 San Marcos, Texas 78666

Laser Target Designator

York Arms	50 W. State Street Hurricane, Utah 84737 801-635-4867

Portable and Mobile Lighting and Power Systems

Alliance Electric Products Co.	6272 W. North Avenue Chicago, Illinois 60639 312-626-8454
American Construction Equipment Company	Los Angeles, California 90016
Appleton Electric Co.	1701 Wellington Avenue Chicago, Illinois 60657 312-327-7200
Carpenter Lighting Products	Charlottesville, Virginia 22901
Cregier Electric Mfg. Co.	New Orleans, Louisiana 70130
Emergency Lighting Systems Inc.	Hingham, Massachusetts 02043
Kato Engineering Co.	1415 First Avenue North Mankato, Minnesota 56001 507-625-4011
Koehler Mfg. Company	Marlboro, Massachusetts 01752
Lincoln Electric Co.	22810 St. Clair Avenue Cleveland, Ohio 44117 216-481-8100
Majol Portable Power Systems	Nanuet, New York 19054
McCulloch Mite-E-Lite	Wellsville, New York 14895

Speciality Lighting Co.	926 Arlee Place Anaheim, California 92805 714-778-1840
Sun Electric Corp.	Chicago, Illinois 60631

Searchlights

Brass Products	Marblehead, Massachusetts 01945
Carlisle & Finch Co. (Complete Line of Searchlights)	4562 W. Mitchell Avenue Cincinnati, Ohio 45232 513-681-6080
Crouse-Hinds Co.	Syracuse, New York 13201
Gulf & Western Mfg.	23100 Providence Drive Southfield, Michigan 48037 313-424-4313
Rowe Co., Inc.	66 Holton St. Woburn, Massachusetts 01801 617-729-7860
Spectrolab	12500 Gladstone Avenue Sylmar, California 91342 213-365-4611
Teledyne	290 East Prairie Street Crystal Lake, Illinois 60014 815-459-6100
Varian Associates	611 Hansen Way Palo Alto, California 94303 415-591-1627
Local Automotive and Industrial Equipment Suppliers	

Unitized Emergency Lights

Chloride Systems	Mallard Lane North Haven, Connecticut 06473 203-624-7837

Direct Safety Co.	511 Osage Kansas City, Kansas 66110 800-255-4416
Dual Lite Inc.	Newtown, Connecticut 06470 203-426-2585
Elan Industries, Inc.	1024 Shary Circle Concord, Connecticut 94518 415-671-7260
GTE Sylvania	21 Penn Street Fall River, Massachusetts 02724 617-678-3911
Sentry-Lite	P. O. Box 199 Rockville Center, New York 11570 516-678-2272
Teledyne	290 East Prairie Street Crystal Lake, Illinois 60014 815-459-6100

Infrared Scopes, Lights and Devices

Eastman Kodak Company	Kodak Apparatus Division Special Products Sales 901 Elmgrove Road Rochester, New York 14650 716-726-3579
Edmund Scientific	1887 Edscorp Building Barrington, New Jersey 08007 609-547-3488
F.S.W. Industries	215 East Prospect Avenue Mount Prospect, Illinois 60056 312-259-8100
Hughes Aircraft Company	P. O. Box 92927 Los Angeles, California 90009 213-534-2121
Law Enforcement Associates Inc.	88 Holmes Street P. O. Box 128 Belleville, New Jersey 07109 201-751-0001

Spectrolab	12500 Gladstone Avenue Sylmar, California 91342 213-365-4611
Xedar Corporation	2500 Central Avenue Boulder, Colorado 80301 303-443-6441
Local Industrial Equipment Suppliers	

NOTE: The above lists are not meant to exclude other manufacturers or suppliers but are provided as typical sources of information and hardware.

GLOSSARY

ADAPTATION - The process by which the eye adapts itself to changes in light.

BALLASTS - A circuit element used to produce the starting voltage and to limit the electric current in electric discharge lamps.

BRIGHTNESS - The characteristic of light that gives the visual sensation of more or less light. Also known as luminance.

CANDELA - The unit of luminous intensity.

CANDELA PER METER SQUARED (Cd/m^2) - SI equivalent of footlambert. Is equal to 3.426 footlamberts.

CANDLEPOWER - The luminous intensity expressed in candelas.

CHEMILUMINESCENCE - The emission of light as a result of chemical reaction.

CONTRAST SENSITIVITY - The ability to detect the presence of a contrast border.

CREST FACTOR - The ratio of the maximum lamp current to root-mean-square current.

DISABILITY VEILING BRIGHTNESS (DVB) - A method used to determine the veiling glare effect of lighting systems.

EFFICACY - The ratio of the total luminous flux (lumens) to the total power input (watts).

Ev - The vertical footcandles at the eye.

FLASH BLINDNESS - The disabling effect of the eye's ability to see due to a short exposure of a much higher intensity light.

FOOTCANDLE - A unit of illuminance on a surface that is everywhere one foot from a uniform point source of light of one candle and equal to one lumen per square foot.

FOOTLAMBERT - The English unit of luminance (brightness). The uniform luminance of a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square foot. It is equal to $1/\pi$ candela per square foot.

GLARE - A brightness within a visual field which causes discomfort or vision impairment.

HETEROCHROMATIC - Light of different color or wavelengths.

HIGH INTENSITY DISCHARGE (HID) - Lamps which operate by passage of electric current through a gas or vapor (such as mercury vapor, metal halide, high pressure sodium or low pressure sodium).

HORIZONTAL FOOTCANDLES - Illumination measured on the horizontal plane. Normally measured .15 m (6 in.) above the ground.

ILLUMINANCE - Luminous flux or light per a given area from a given point in a given direction.

INCANDESCENT - Light produced by a filament heated by current flow.

IRRADIANCE - The density of radiant flux on a given surface.

LAMP DIRT DEPRECIATION (LDD) - Lumen output decreases due to dirt accumulation on lamps and lenses.

LAMP LUMEN DEPRECIATION (LLD) - Change in lumen output of a lamp during its lifetime.

LIGHT - Visually observed radiant energy.

LUMEN - Luminous flux equal to one candle.

LUMINAIRE - The lighting fixture including lamp, reflector, mounting and electrical socket and wiring.

LUX - A unit of illuminance on a surface that is everywhere one meter from a uniform point source of light of one candle and equal to one lumen per square meter.

MATERIAL ACCESS AREA - Areas in which strategic quantities of special nuclear material are located.

MONOCHROMATIC - Light of a single wavelength or color.

PHOTOTROPIC - Tendency for the eye to direct itself to the brightest object or area.

PORTALS - Gate or access areas into material access areas, vital areas or protected areas.

POWER FACTOR - The ratio of active power to the product of volts and amperes. A measure of power use efficiency.

PROTECTED AREA - The area inclusive of vital and material access areas requiring controlled access.

REFLECTANCE - The ratio of light (flux) reflected by a surface to the incident light.

REFLECTORS - Devices used to reflect or direct light

SECURITY LIGHTING - Lighting utilized for security purposes as required by 10CFR Part 73.

STROBOSCOPIC - Pulsed light. Light which varies in output such as a blinking light. Undulating or oscillating light.

UNIFORMITY - The uniformity of brightness of areas within the visual field. Maximum to minimum ratio is the ratio of the maximum brightness to the minimum brightness in the visual or measured field. Average to minimum ratio is the average brightness to minimum brightness in the visual or measured field.

VERTICAL FOOTCANDLES - Illumination measured on the vertical plane.

VISUAL ACUITY - The ability to define details

VITAL AREAS - Areas which contain vital equipment.

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This document has been prepared as an aid in planning security lighting at nuclear fixed site facilities. While the recommendations enclosed cover the minimum requirements established in Title 10, Code of Federal Regulations (CFR), Part 73, additional suggestions are made for further enhancing a facility's security lighting and related security capabilities. Planning considerations and information are provided for lighting of the isolation zones, protected areas, portals, vital areas and material access areas. Recommendations are made relative to indoor, outdoor, fixed, portable and other unique applications of security lighting.

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ABSTRACT

This report provides guidelines to aid NRC licensees in evaluating existing strategic special nuclear material storage facilities, discusses typical tools that could be employed to penetrate such facilities, and provides simple and cost effective hardening techniques. The report was developed to provide guidance in support of the Physical Protection Upgrade Rule, effective March 25, 1980.

TABLE OF CONTENTS

LIST OF DIAGRAMS

1. INTRODUCTION

This report provides initial guidance to licensees in their efforts to meet the provisions of the Physical Protection Upgrade Rule for Fixed Sites, (10 CFR 73.20, 73.45, and 73.46). The reference system within the Physical Protection Upgrade Rule describes vaults used to protect SSNM as being capable of preventing entry by a single action in a forced entry attempt, except as such single action would both destroy the barrier and render contained SSNM incapable of being removed, and shall provide sufficient delay to prevent removal of stored SSNM prior to arrival of response personnel capable of neutralizing the design basis threat stated in § 73.1. It is recognized that existing licensee SSNM storage facilities are constructed of various materials and provide varying levels of security. Many licensees will have to address the question of how to meet these new requirements for SSNM storage vaults and what can be done to upgrade their present SSNM storage facility.

This document is a preliminary report on an NRC-sponsored study on Vault Design Guidance. It provides guidelines which aid licensees in evaluating existing SSNM storage facilities, discusses typical tools that could be employed to penetrate such facilities, and provides simple cost effective hardening techniques. The results of further validation testing of the hardening techniques contained herein will be incorporated into a final report, at a future date.

The following limitations have been placed on the scope of this effort:

1. This report will address the physical barriers of existing SSNM storage facilities (i.e., walls, floor, roof, doors and various apertures);
2. This report will provide hardening techniques to increase penetration resistance of SSNM storage facilities against the threat of 10 CFR Part 73.1.

   (Scenarios involving the use of explosives in such quantities that SSNM in vaults is rendered unusable by the adversary are expressly excluded);
3. This report will not consider other physical barriers adjacent or close to the SSNM storage facilities;
4. This report will not consider health and safety or other environmental factors that will be of consideration to the licensee in the handling and storage of special nuclear material.

For the purposes of this report, an SSNM storage vault is defined as a windowless enclosure with walls, floor, roof, and door(s) designed and constructed to delay penetration from forced entry. Penetration resistance time is defined as the time required to make an approximately 18-inch entry opening into an SSNM storage vault structural component and includes preparation time such as setting up mechanical or power tools and/or placement of explosives.

2. GUIDELINES FOR SSNM STORAGE FACILITY EVALUATION

The NRC is interested in increasing the level of security provided by SSNM storage facilities in the licensed nuclear fuel cycle industry. The licensee, in determining if his SSNM storage facility meets the proposed upgraded level of security, must first evaluate his present structure. The report provides the following guidelines for accomplishing this task:

1. Examine the Existing Construction

   Using the Sandia Barrier Handbook, referenced in the Fixed Site Physical Protection Upgrade Rule Guidance Compendium, barrier penetration data provided in Appendix 5.1, or any other data on materials penetration such as Engineering Handbooks, etc., determine the penetration resistance of the material utilized in the walls, floor, roof, door(s), and other apertures. Consider the weakest part of each component, such as joints, casing, hinges, and locks.

2. Evaluate Existing Apertures

   Determine if utility ports or electrical, heating, ventilation, and air-conditioning ducts would allow entry into the vault. Determine if existing apertures are constructed such that, although preventing physical entry, would allow mechanical arms/grabbers to be used to remove material. (It should be noted that windows are not permitted in SSNM storage vaults in the Physical Protection Upgrade Rule.)

3. Evaluate the Location

   How accessible is the SSNM storage facility from outside the building? Determine if relocating the SSNM storage facility closer to or away from existing walls would improve the penetration resistance.

4. Determine the Location of Electrical Power

   Electrical power should not be readily available to the adversary.

After the present SSNM storage facility is evaluated, list the components in order from the shortest to the longest penetration resistance time provided.

Compare this penetration resistance time to the time estimated for arrival of response personnel who are capable of neutralizing the design basis threat stated in 10 CFR Part 73.1. Identify the components whose penetration resistance time is less than the response force reaction time. These components become the vulnerable components of the existing SSNM storage facility that will require upgrading.

Once having identified the vulnerable components of his SSNM storage facility, the licensee should refer to Section 4 for upgrading guidance. Section 4 of the report, HARDENING TECHNIQUES, addresses typical components of SSNM storage facilities, evaluates a variety of structural material presently utilized in these components, and provides techniques for improving their penetration resistance.

3. PENETRATION TOOLS

Tools and materials that are considered available to the adversary in penetration operations include (1) hand tools, (2) power tools, (3) thermal tools, and (4) explosives. A brief description of the most commonly used tools, together with their relative effectiveness against barriers, is presented in Appendix 5.2. It can reasonably be expected that penetration attempts will mostly frequently use explosives or man-operated hand tools weighing less than 100 pounds. Consequently, only tools and materials in these categories are considered herein. Appendix 5.3 includes a list of penetration tools by category and associated weight. The licensee should also be aware, however, of the potential penetration tools he is providing at his facility. A forklift left unattended with ignition keys would provide a convenient penetration tool to an adversary.

4. HARDENING TECHNIQUES

The hardening techniques described in this section are provided as guidance for simple and cost effective ways of increasing the penetration resistance time of existing SSNM storage facility structural components. The application of these hardening techniques should be reviewed with the NRC prior to significant investment or adaptation since the physical characteristics and operational requirements may vary from site to site.

The design goal of these hardening concepts was to require the adversary to make more than one penetration attempt and to use more than one penetration tool. To accomplish this task, concepts such as using multiple barriers of different materials were employed. To minimize the effects from a single explosive charge, concepts were incorporated which provide space between barriers to dissipate blast effects, thus requiring more than one charge for multiple barriers. The concept of a suppressive shield, which breaks up the explosive shock wave and vents gases to minimize the energy applied to the solid portion of the structure, was also utilized where possible to minimize the effects from explosives. Approximately one inch of steel when used in a suppressive shield configuration is considered equal to a one foot reinforced concrete barrier with respect to minimizing the effects from blast and fragmentation. Concepts are also incorporated that deny initial access to such vulnerable components as door hinges, jambs and locks.

The information for each hardening technique is presented in two parts - data sheet and diagram. The data sheet describes the existing structural component and the time and tools required for penetration. Hardening action is then provided as step by step instructions utilizing simple and cost effective materials that in many cases could be fabricated in the licensee maintenance shop. Validation testing of all of the techniques presented has not been completed to date. Increased penetration resistance times provided have been estimated based on inputs from a variety of sources, including structural engineers, welders and demolitionists. A diagram showing the hardening technique applied to the existing structural component is provided to supplement the data sheet.

The hardening techniques are organized by specific structural components. Techniques 1 to 6 address walls and ceilings; Techniques 7 to 9, apertures; Techniques 10 and 11, doorways; Techniques 12 and 13, doors; and Techniques 14 to 16, door jambs, hinges, and locks.

Technique No. 1 - Hardening Chain Link Fence Wall

EXISTING STRUCTURE - Chain-link fabric supported by 3" diameter pipe.

TOOLS REQUIRED FOR PENETRATION - Boltcutter

PENETRATION TIME - 32 seconds

HARDENING ACTION -

1. Add to exterior of fence fabric 2"x4" studs on 18" centers.
2. Attach 2" thick rough cut oak wooden shield to studs thus providing 3½" space between the fence fabric and the wooden shield.
3. Attach ¼" ribbed, pierced steel planking to wooden shield.
4. Build an 8" solid concrete block wall directly against planking.

INCREASED PENETRATION RESISTANCE TIME - Approximately 15 minutes

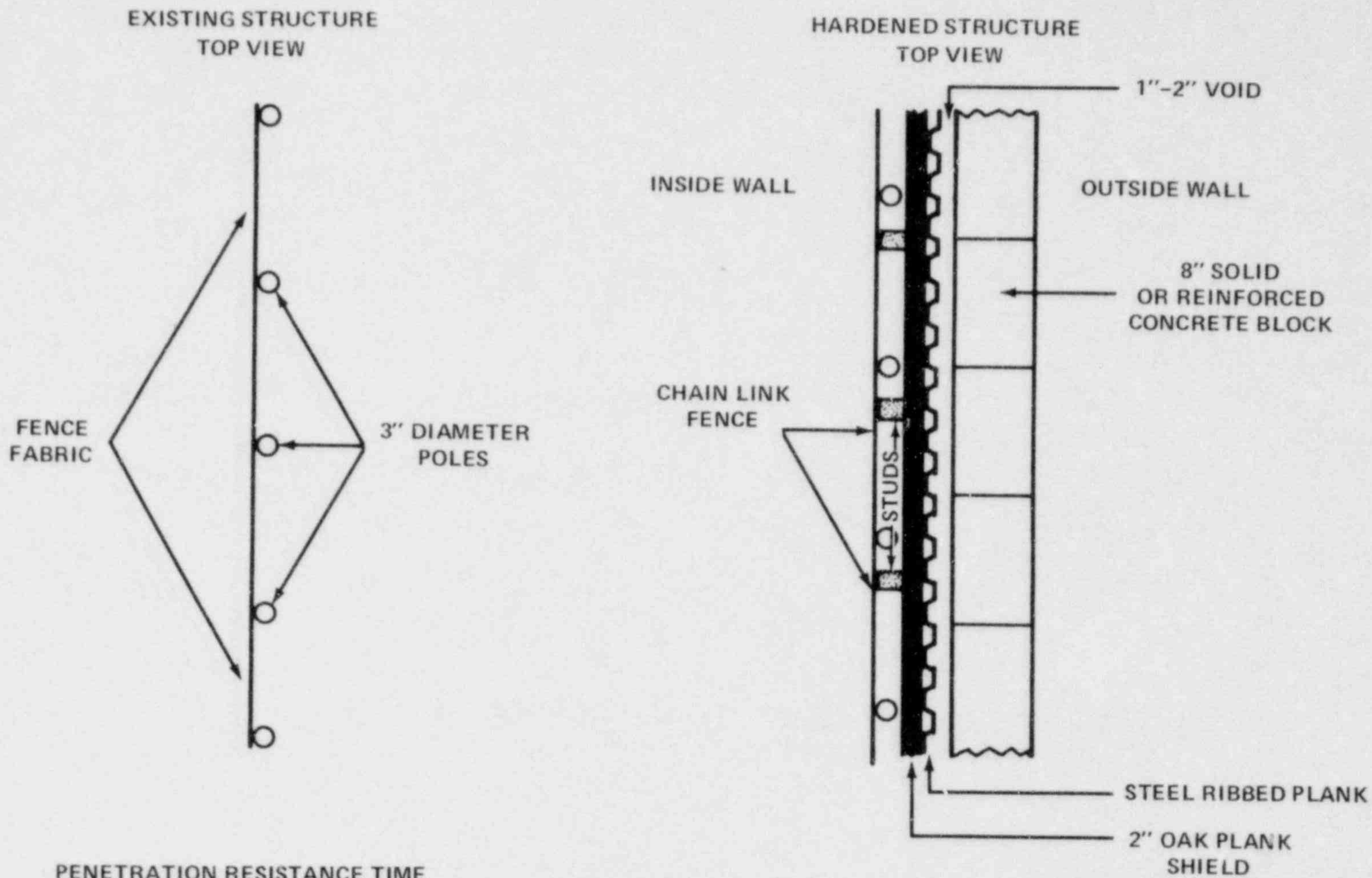
INCREASED THICKNESS OF WALL - Approximately 16"

ADDITIONAL TOOLS REQUIRED - Boltcutter
Sledgehammer
Cutting torch
Saw
Explosives

ADVANTAGES OF TECHNIQUE -

1. Requires multiple penetrating tools
2. Requires multiple breaching explosive charges

DIAGRAM 1 — Hardening Chain Link Fence Wall



PENETRATION RESISTANCE TIME

32 SECONDS

PENETRATION RESISTANCE TIME

APPROXIMATELY 15 MINUTES

Technique No. 2 - Hardening Fiberboard or Plasterboard Wall

EXISTING STRUCTURE - Standard fiberboard or plasterboard wall

TOOLS REQUIRED FOR PENETRATION - Fire axe

PENETRATION TIME - 30 seconds

HARDENING ACTION -

1. Add to both sides of existing wall 3/4" to 1" thick good grade plywood panels.

2. Attach 2"x2" or 2"x4" good grade wood studs at 16" centers and at plywood panel seams with screw type nails.

3. Attach 3/4" to 1" thick good grade plywood panels to studs with panel seams offset from previously applied panel.

4. Attach expanded metal mesh type fabric of at least 3/16" thickness to plywood.

5. Add another layer of 2"x2" or 2"x4" good grade wood studs equidistant between studs added in step 2.

6. Add a layer of plywood similar to step 3.

INCREASED PENETRATION RESISTANCE TIME - Approximately 15 minutes

INCREASED THICKNESS OF WALL - Approximately 11"

ADDITIONAL TOOLS REQUIRED - Metal and wood saw, or combination blade

- Explosives

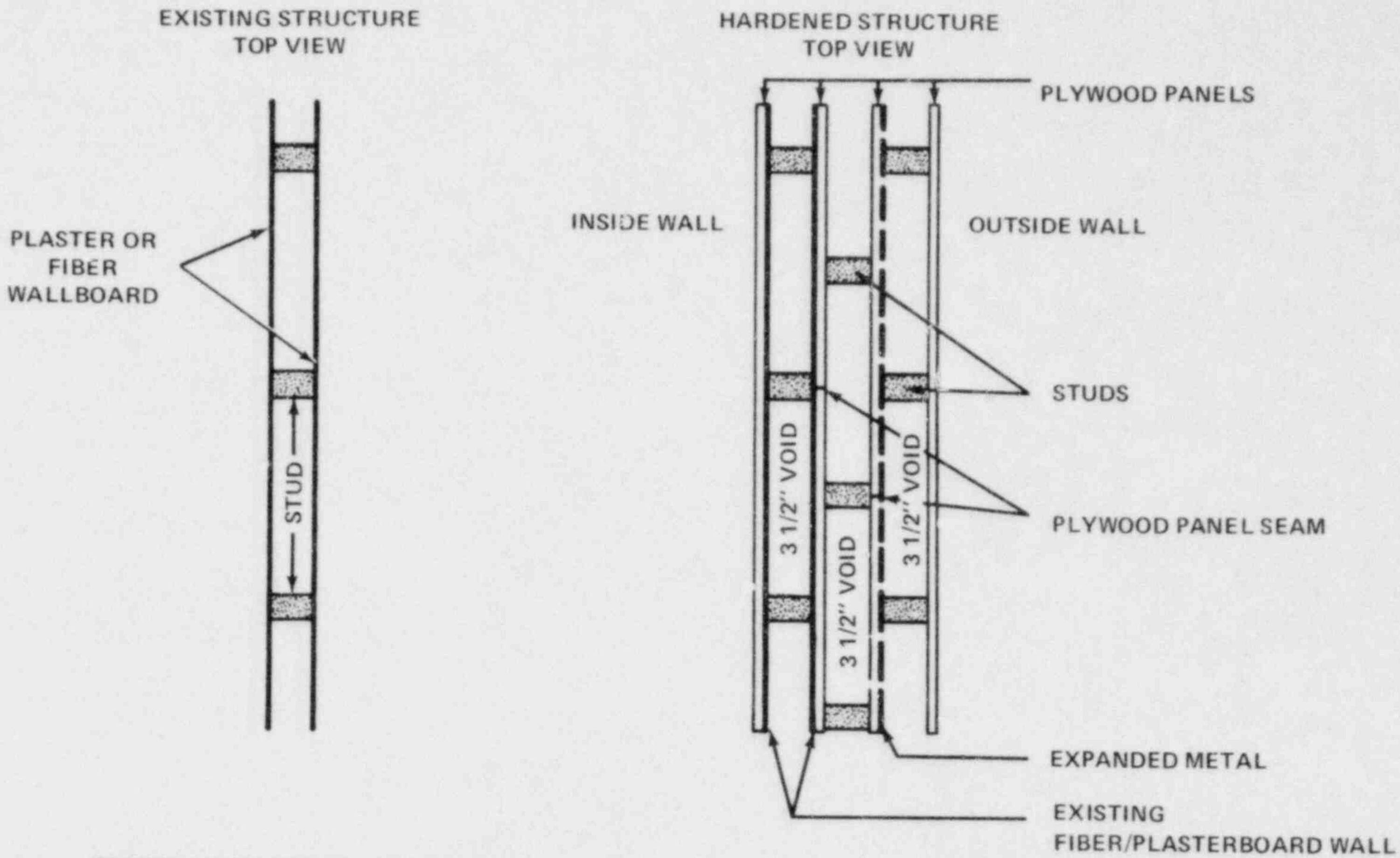
ADVANTAGES OF TECHNIQUE -

1. Multiple types of material require different types of saw blade or combination blade.

2. Void between panels increases thickness of wall forcing the use of a larger saw blade.

3. Void between panels vents and dissipates explosive gases and pressures requiring multiple charges.

DIAGRAM 2 – Hardening Fiberboard or Plasterboard Wall



PENETRATION RESISTANCE TIME

30 SECONDS

PENETRATION RESISTANCE TIME

APPROXIMATELY 15 MINUTES

Technique No. 3 - Hardening Hollow Concrete Block Wall

EXISTING STRUCTURE - 8" hollow, non-reinforced concrete block

TOOLS REQUIRED FOR PENETRATION - Sledgehammer

PENETRATION TIME - 1½ minutes

HARDENING ACTION -

1. Install 2" x 4" studs at 16" centers at least 2" from existing wall.
2. Attach two layers of 1" good grade plywood to studs.
3. Add layer of #5 or higher rebar grate with a minimum of 4" grid to plywood. Imbed grate into floor and ceiling and weld at intersections.

INCREASED PENETRATION RESISTANCE TIME - Approximately 10 - 15 minutes

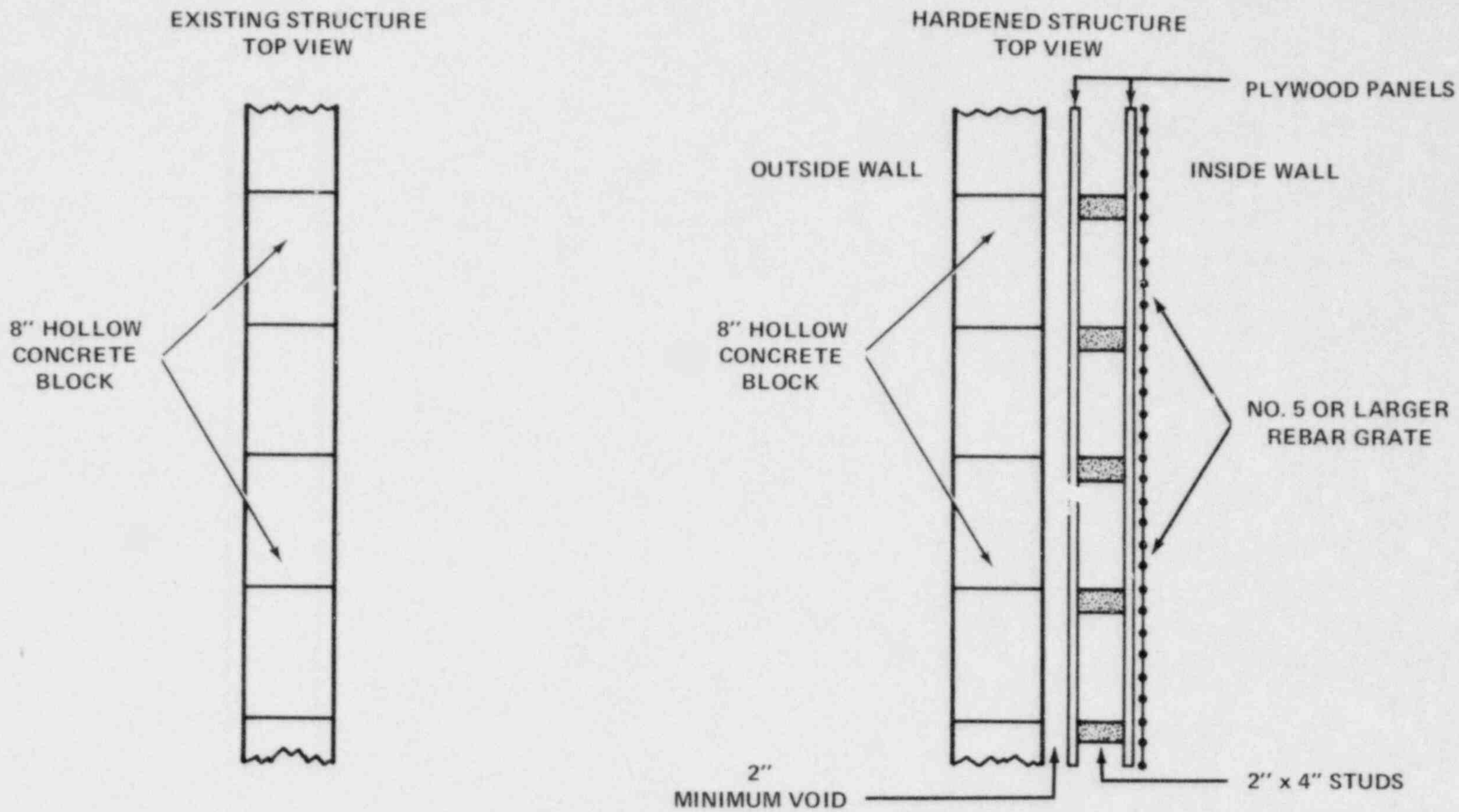
INCREASED THICKNESS OF WALL - Approximately 8 inches.

ADDITIONAL TOOLS REQUIRED - Saw
Hydraulic boltcutter
Explosives

ADVANTAGES OF TECHNIQUE -

1. Different penetration tools required
2. Requires considerable time to place separate explosive charges

DIAGRAM 3 – Hardening Hollow Concrete Block Wall



<u>PENETRATION RESISTANCE TIME</u>

1 1/2 MINUTES

<u>PENETRATION RESISTANCE TIME</u>

APPROXIMATELY 10–15 MINUTES

Technique No. 4 - Hardening Hollow or Reinforced Concrete Block Wall

EXISTING STRUCTURE - 8" hollow or reinforced concrete block.

TOOLS REQUIRED FOR PENETRATION - Sledgehammer
Boltcutters

PENETRATION TIME - 1½ minutes

HARDENING ACTION -

1. Layer tires on inside of vault wall.

2. Secure tires by inserted and interwoven grate of #5 or #6 rebar. Rebar should be welded at each intersection and penetrate through tire material.

3. Add layer of 2" solid oak plank or two 1" panels of 9 good grade plywood supported by 2"x 4" studs on 16" centers. If plank is used, it should be separated by the studs.

INCREASED PENETRATION RESISTANCE TIME - Greater than 30 minutes

INCREASED THICKNESS OF WALL - Approximately 13 inches

ADDITIONAL TOOLS REQUIRED - Cutting torch
Saw
Explosives

ADVANTAGES OF TECHNIQUE -

1. Utilizes easily obtained material.

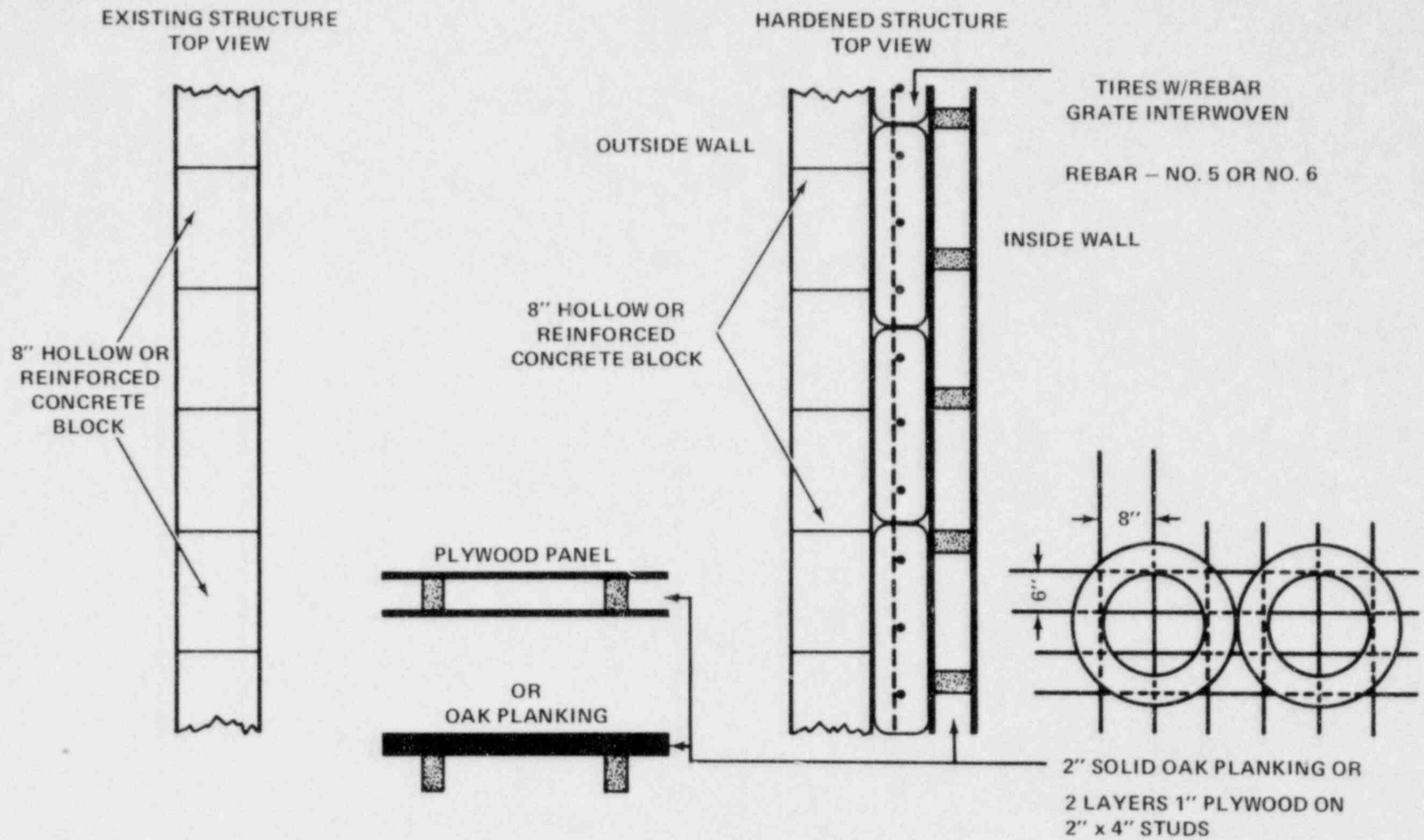
2. Tires help absorb explosive pressures.

3. Void around tires helps vent and dissipate explosive gases.

4. Different penetration tools required.

5. Tires delay access by thermal or mechanical cutting tools.

DIAGRAM 4 – Hardening Hollow or Reinforced Concrete Block Wall



<u>PENETRATION RESISTANCE TIME</u>

1 1/2 MINUTES

<u>PENETRATION RESISTANCE TIME</u>

GREATER THAN 30 MINUTES

Technique No. 5 - Hardening Any Type Wall or Ceiling

EXISTING STRUCTURE - Any type wall or ceiling

TOOLS REQUIRED FOR PENETRATION - Depends on existing wall or ceiling

PENETRATION TIME - Depends on existing wall or ceiling

HARDENING ACTION -

1. Anchor I-beam vertically in concrete base.

2. Interlock as many additional I-beams as necessary for length of wall.

INCREASED PENETRATION RESISTANCE TIME - Approximately 2-4 hours

INCREASED THICKNESS OF WALL - Approximately 8 inches

ADDITIONAL TOOLS REQUIRED - Cutting torch (large unit)
Multiple explosive charges
Oxy-lance

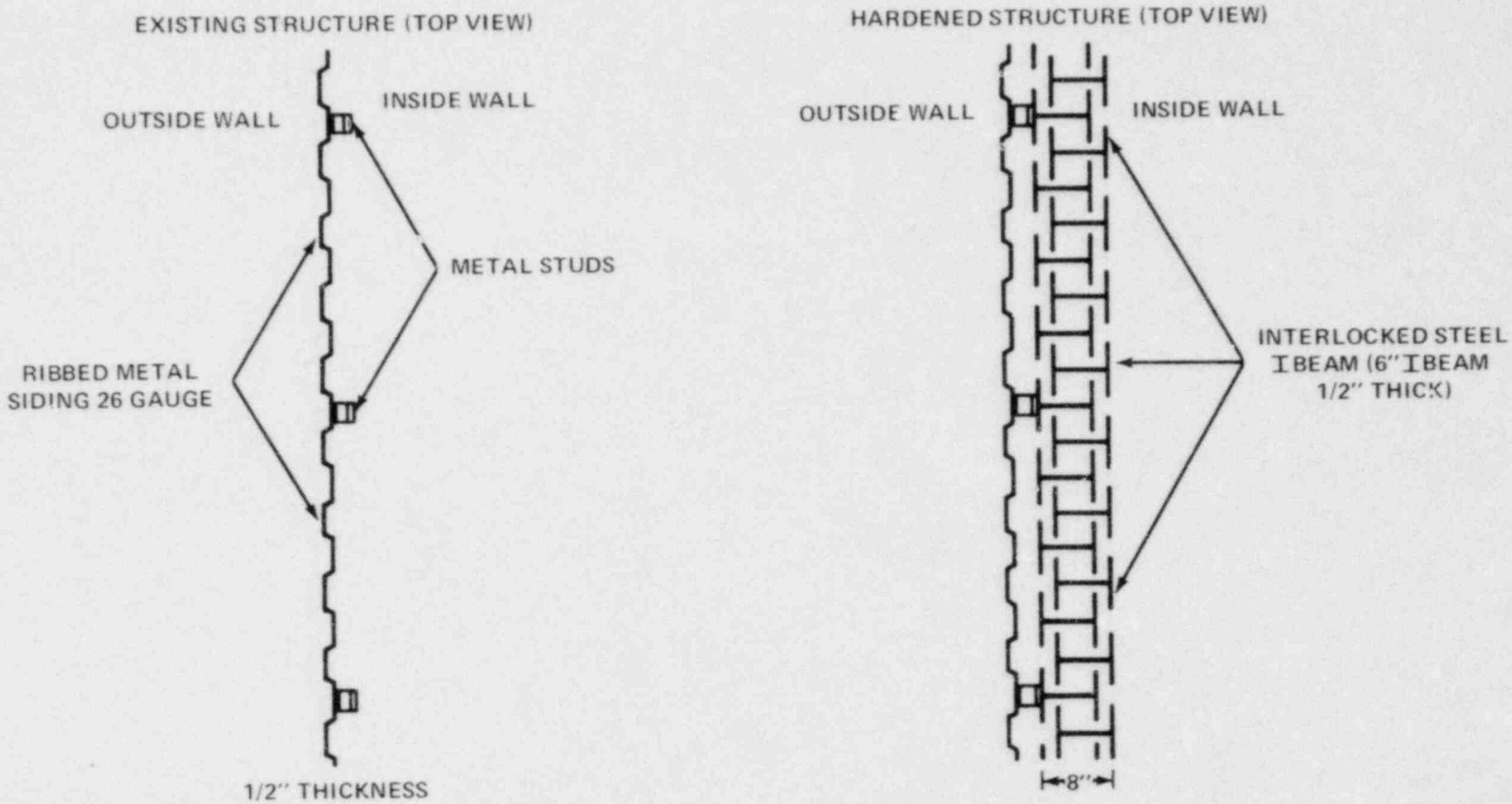
ADVANTAGES OF TECHNIQUE -

1. Utilizes principle of suppressive shielding.

2. Relatively easy to construct.

3. Can be used for roofs and ceilings as well as walls.

DIAGRAM 5 – Hardening Any Type Wall or Ceiling



PENETRATION RESISTANCE TIME

30 SECONDS

PENETRATION RESISTANCE TIME

APPROXIMATELY 2–4 HOURS

Technique No. 6 - Hardening Opening in Ceiling or Wall

EXISTING STRUCTURE - Opening in Ceiling or Wall

TOOLS REQUIRED FOR PENETRATION - Depends on existing opening

PENETRATION TIME - Depends on existing opening

HARDENING ACTION

1. Add strong steel jamb to opening
2. Form 3 separate grates by welding #4 rebar into 4" grids. Weld grates to inside center and outer lips of jamb. (Another method is to weld 6 separate layers of rebar alternating vertical and horizontal and off set from each other.)

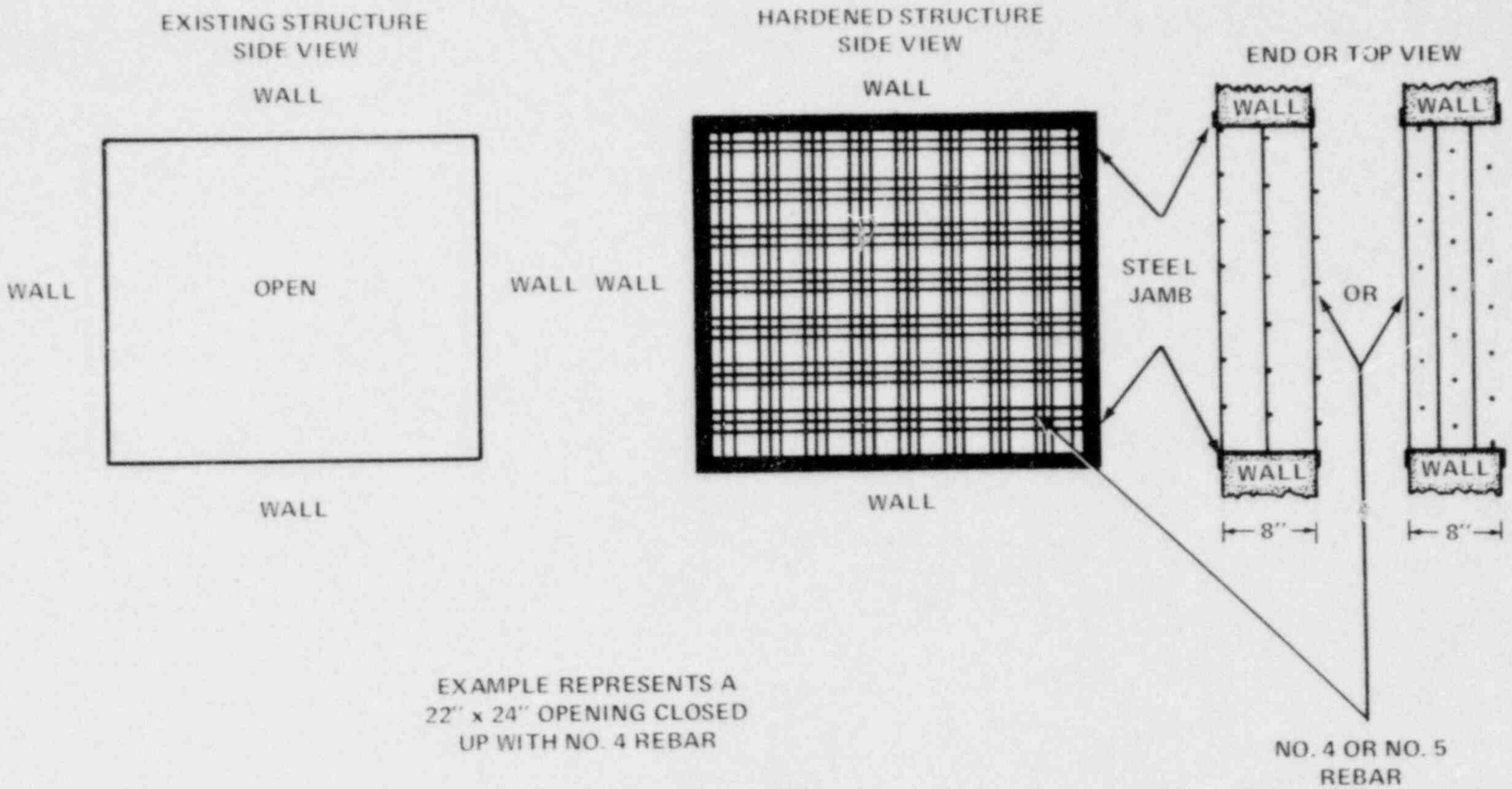
INCREASED PENETRATION RESISTANCE TIME - Approximately 15 minutes

ADDITIONAL TOOLS REQUIRED - Boltcutters

ADVANTAGES OF TECHNIQUE -

1. Multiple layers to penetrate
2. Delay time can be increased by either increasing size of rebar or numbers of rebar.

DIAGRAM 6 – Hardening Opening in Ceiling or Wall



EXAMPLE REPRESENTS A
22" x 24" OPENING CLOSED
UP WITH NO. 4 REBAR

PENETRATION RESISTANCE TIME	PENETRATION RESISTANCE TIME
0	17 MINUTES

Technique No. 7 - <u>Hardening Opening in Ceiling or Wall Where Air Flow is Required</u>

EXISTING STRUCTURE - Opening in ceiling or wall where air flow is required and opening is too small to allow complete body access

TOOLS REQUIRED FOR PENETRATION - Depends on existing opening

PENETRATION TIME - Depends on existing opening

HARDENING ACTION -

1. Bolt ¼" metal shield to inside of vault wall shaped as shown in Diagram 7.

INCREASED PENETRATION RESISTANCE TIME - Approximately 1-2 minutes (for a 4"x 4" opening)

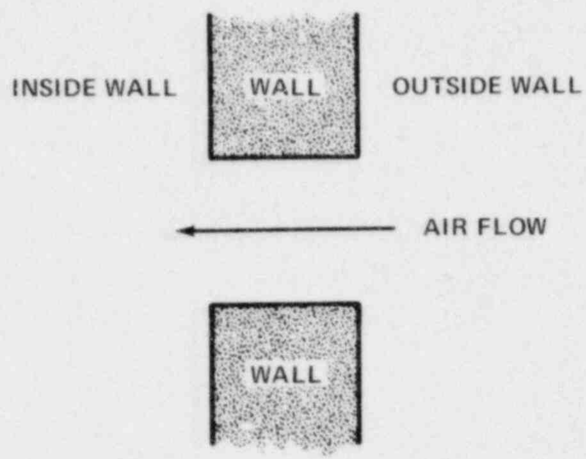
ADDITIONAL TOOLS REQUIRED - Cutting torch

ADVANTAGES OF TECHNIQUE -

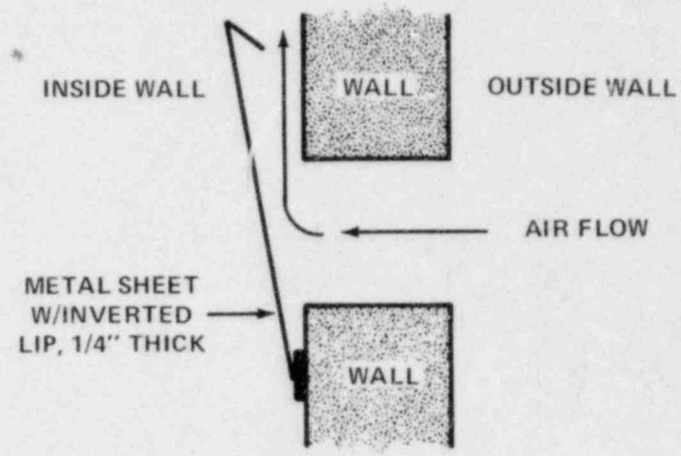
1. Prohibits visual observation of vault interior.
2. Allows air flow.
3. Obstructs insertion of arms or grabbers.

DIAGRAM 7 – Hardening Opening in Ceiling or Wall Where Air Flow is Required

EXISTING STRUCTURE



HARDENED STRUCTURE



PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING OPENING

PENETRATION RESISTANCE TIME

4" x 4" OPENING = 1–2 MINUTES

Technique No. 8 - Hardening Opening in Ceiling or Wall Where Air Flow is Required

EXISTING STRUCTURE - Opening in ceiling or wall where air flow is required and bodily access is possible

TOOLS REQUIRED FOR PENETRATION - Depends on existing opening

PENETRATION TIME - Depends on existing opening

HARDENING ACTION

1. Partially fill opening with material equivalent to or same as existing wall.

2. Bolt a heavy metal pipe elbow on inside of opening

INCREASED PENETRATION RESISTANCE TIME - Approximately 4-6 minutes to completely remove pipe

ADDITIONAL TOOLS REQUIRED - Cutting torch

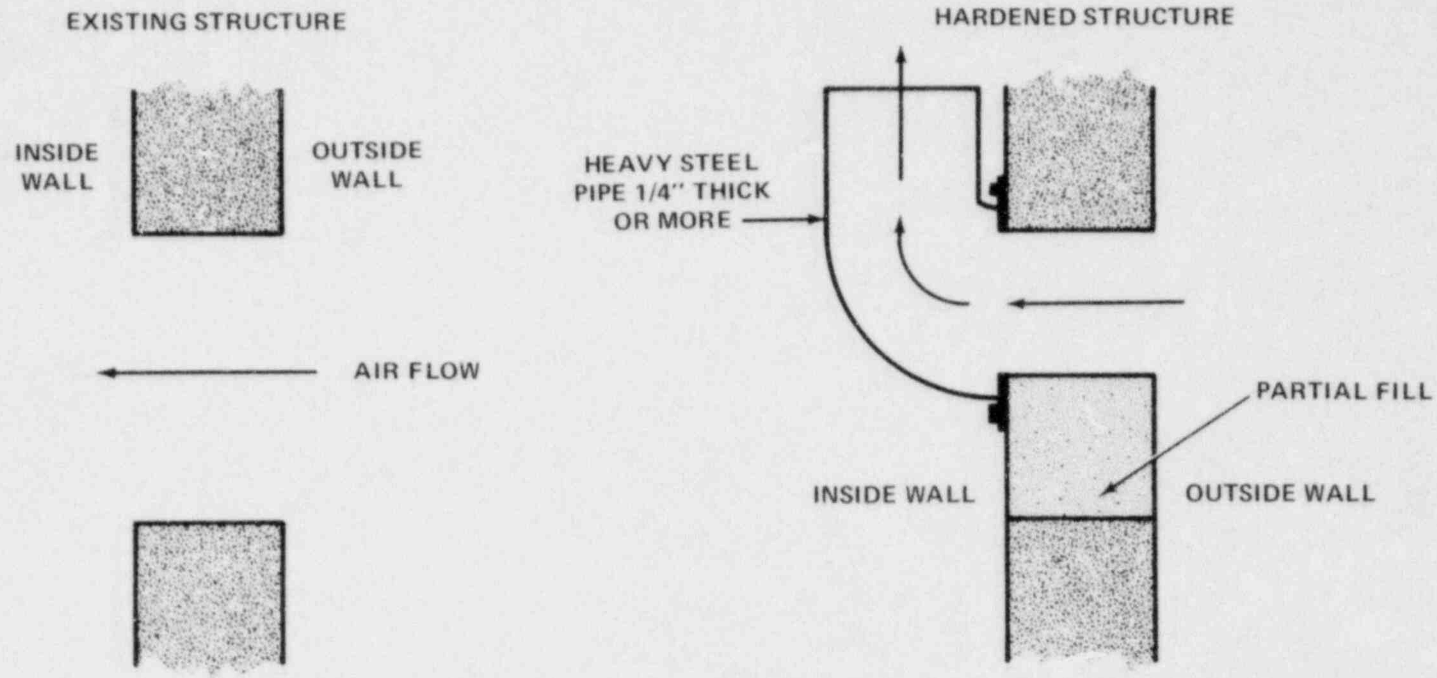
ADVANTAGES OF TECHNIQUE -

1. Reduces bodily access area.

2. Allows air flow.

3. Obstructs observation of vault interior.

DIAGRAM 8 – Hardening of Opening in Ceiling or Wall Where Air Flow is Required (Large Opening)



EXAMPLE: 8" PIPE, 1/4" THICK

PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING OPENING

PENETRATION RESISTANCE TIME

COMPLETELY REMOVE PIPE – 4–6 MINUTES

Technique No. 9 - Hardening Opening in Ceiling or Wall Where Air Flow is Required

EXISTING STRUCTURE - Opening of any size

TOOLS REQUIRED FOR PENETRATION - Depends on existing opening

PENETRATION TIME - Depends on existing opening

HARDENING ACTION -

1. Add strong steel jamb to opening.
2. Weld steel pipes of 3" diameter or less together and then weld to steel jamb.

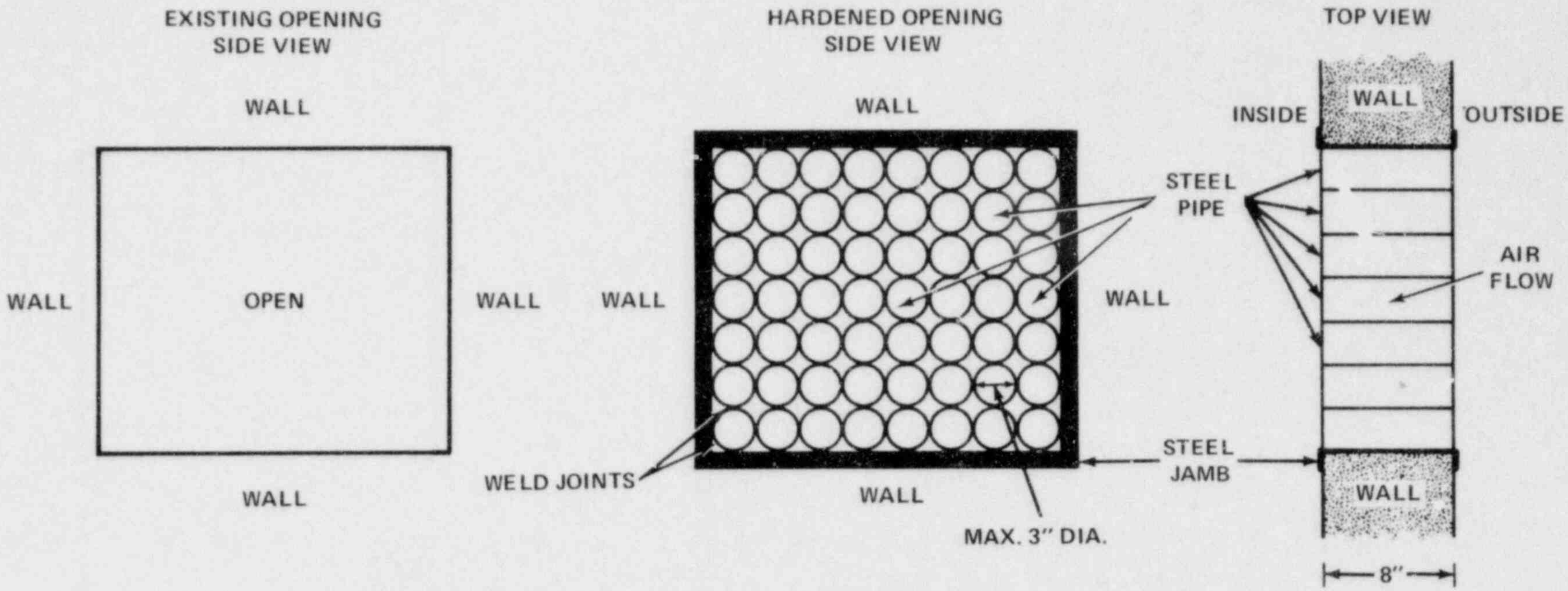
INCREASED PENETRATION RESISTANCE TIME - More than 15 minutes

ADDITIONAL TOOLS REQUIRED - Cutting torch

ADVANTAGES OF TECHNIQUE -

1. Allows air flow.
2. Reduces bodily access.

DIAGRAM 9 – Hardening Opening in Ceiling or Wall Where Air Flow is Required



PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING OPENING

PENETRATION RESISTANCE TIME

MORE THAN 15 MINUTES

Technique No. 10 - Hardening Vault Doorway

EXISTING STRUCTURE - Vault doorway

TOOLS REQUIRED FOR PENETRATION - Depends on existing door

PENETRATION TIME - Depends on existing door

HARDENING ACTION -

1. Weld grate of angle iron or #5 rebar with 4" grid at least 2 feet wider and 1 foot higher than existing vault door.

2. Attach door to inside of vault by either overhead roller track, swinging hinges, or on floor roller track. Hinges, track, and locking system must be unaccessible to the adversary in event vault door was breached.

INCREASED PENETRATION RESISTANCE TIME - Approximately 6-10 minutes

ADDITIONAL TOOLS REQUIRED - Hydraulic boltcutters
Steel cutting saw
Explosives
Cutting torch

ADVANTAGES OF TECHNIQUE -

1. Provides surprise barrier.

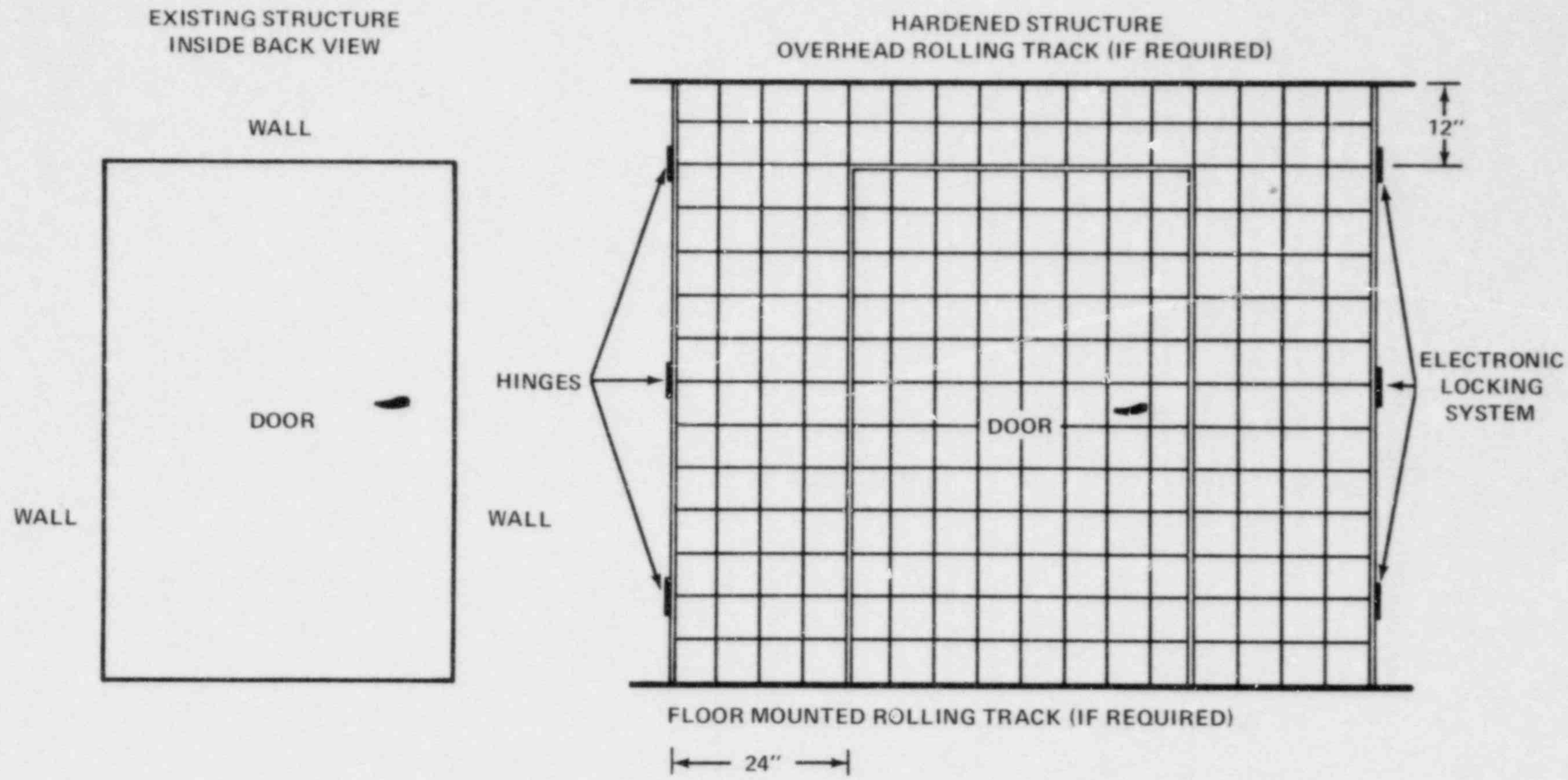
2. Provides an additional barrier.

3. Requires additional tools to penetrate.

4. Can be used for both personnel and vehicle doors.

5. Penetration time can be lengthened by utilizing more or larger rebar.

DIAGRAM 10 – Hardening Vault Doorway



PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING DOOR

PENETRATION RESISTANCE TIME

GRATE OF NO. 5 REBAR – 6–10 MINUTES
GRATE OF ANGLE IRON – APPROXIMATELY 20–30 MINUTES

Technique No. 11 - Hardening Doorway No Longer Required

EXISTING STRUCTURE - Vault doorway no longer required

TOOLS REQUIRED FOR PENETRATION - Depends on existing door

PENETRATION TIME - Depends on existing door

HARDENING ACTION -

1. Weld #5 rebar or angle iron to the door jamb or implant into concrete through the jamb. Rebar can be welded at each intersection to form one solid grate or welded as two separate layers (horizontal and vertical) using a 4" grid.

2. Place a hollow core steel door on the outside portion of the door jamb and spot weld in place.

3. Weld a 4" steel lip of approximately ¼" thickness over entire length of door/jamb seam.

4. Repeat step 2 on the inside portion of the door jamb.

INCREASED PENETRATION RESISTANCE TIME - Approximately 8-30 minutes, depending on material used.

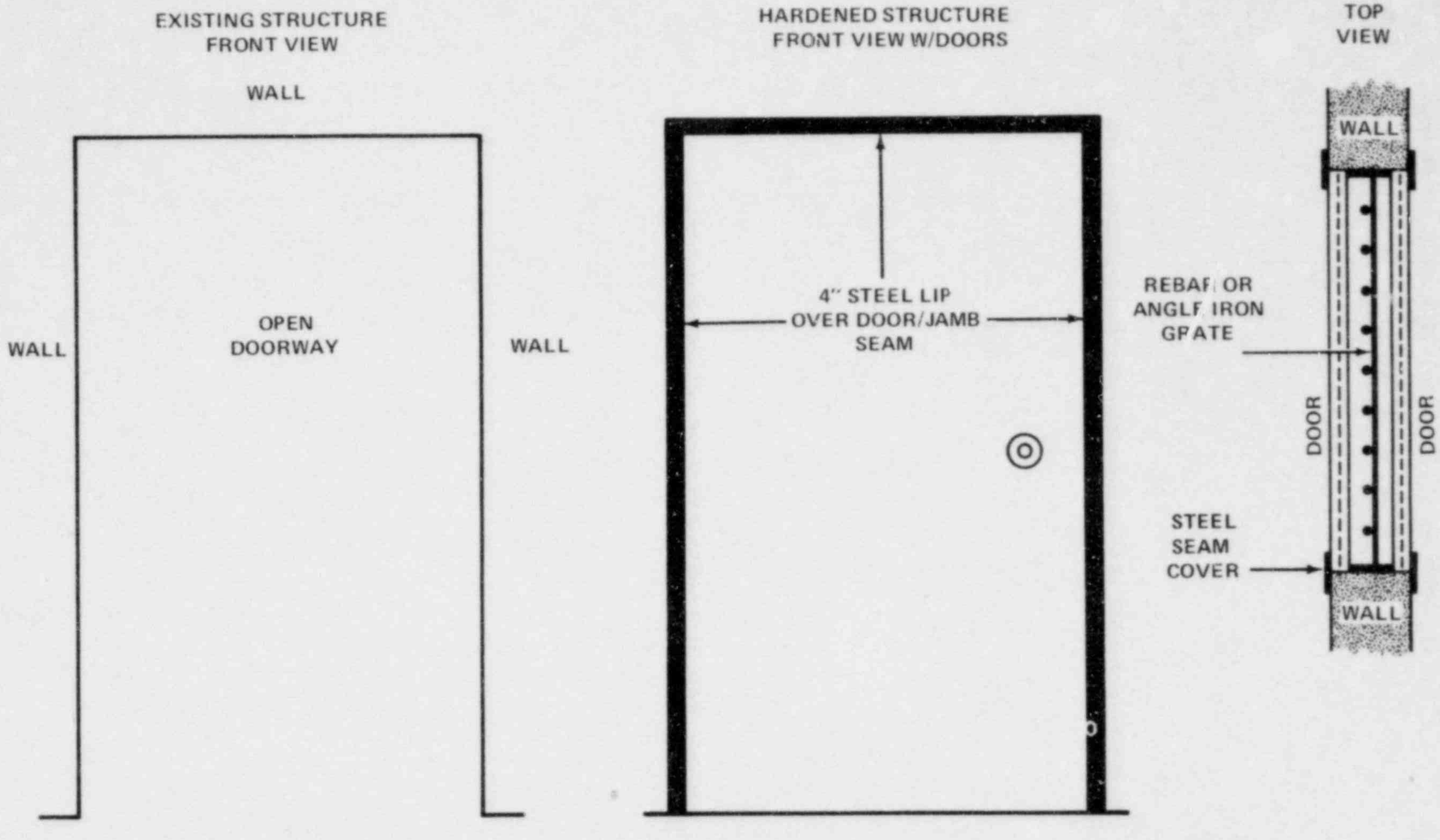
ADDITIONAL TOOLS REQUIRED - Boltcutters
Cutting torch
Explosives
Steel cutting saw

ADVANTAGES OF TECHNIQUE -

1. Vents pressures from explosive penetration attempt.

2. Further penetration resistance can be added by filling inside of doorway with a fill material, adding more rebar, or reinforcing or strengthening doors prior to permanently welding to jamb.

DIAGRAM 11 – Hardening (Seal Up) Doorway No Longer Required.



PENETRATION RESISTANCE TIME

REGULAR HOLLOW CORE DOOR – 30 SECONDS

PENETRATION RESISTANCE TIME

REBAR GRATE – 8–10 MINUTES
ANGLE IRON GRATE – 20–30 MINUTES

Technique No. 12 - Hardening Fire Class or Improving Security Class Doors

EXISTING STRUCTURE - Fire or security class door

TOOLS REQUIRED FOR PENETRATION - Simple explosive charge or cutting torch (back pack portable)

PENETRATION TIME - Approximately 1-2 minutes

HARDENING ACTION -

1. Remove metal panel from back of door and remove existing insulation material.

2. Weld heavy angle iron or small structural I-beam to form a 14" or smaller grid on inside of front panel of door. (The additional metal reinforcement must not interfere with locking system or interlocking pin systems.)

3. Replace insulation or "fill" material as appropriate.

4. Replace metal panel to back of door.

5. Basic skeleton of door, door jamb, or hinges may have to be further hardened to support added weight of door.

INCREASED PENETRATION RESISTANCE TIME - Approximately 20-30 minutes

ADDITONAL TOOLS REQUIRED - Explosives (multiple charges)
Cutting torch (heavier equipment)

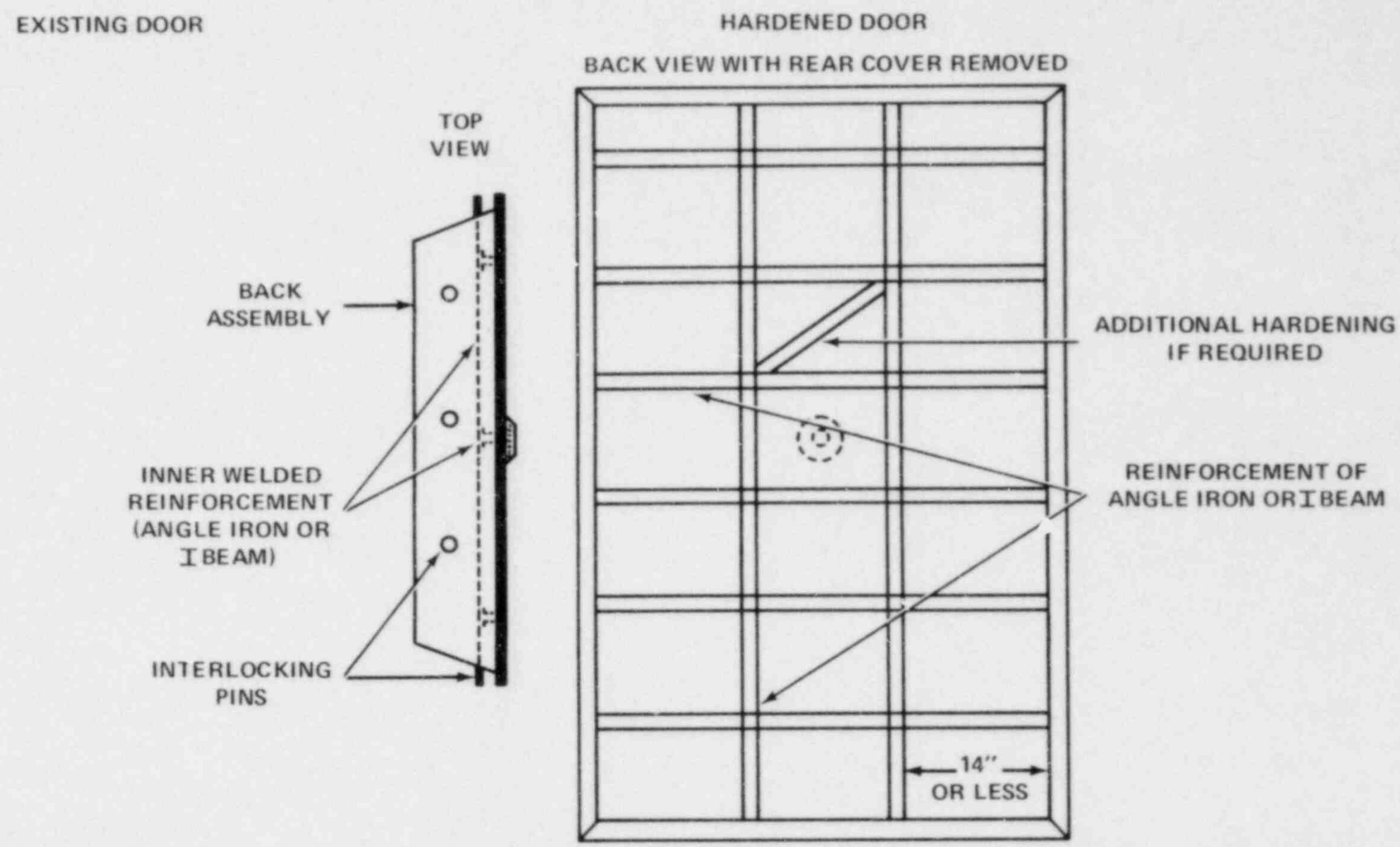
ADVANTAGES OF TECHNIQUE

1. Increases penetration delay time.

2. Requires different or heavier penetration tools.

3. Easily constructed.

DIAGRAM 12 – Hardening Fire Class or Improving Security Class Doors



PENETRATION RESISTANCE TIME

DEPENDS ON DOOR

PENETRATION RESISTANCE TIME

APPROXIMATELY 20–30 MINUTES

Technique No. 13 - Hardening of Door Utilizing Suppressive Shield Concept

EXISTING STRUCTURE - Common hollow core metal door

TOOLS REQUIRED FOR PENETRATION - Simple explosive charge (less than ½ lb)

PENETRATION TIME - Approximately 30-60 seconds

HARDENING ACTION -

1. Remove metal panel from back of door.
2. Weld ¼" steel louvers on inside of front panel of door 3"-4" apart from top to bottom.
3. Replace back panel of door. (The door frame may have to be reinforced to support the added weight of the door.)

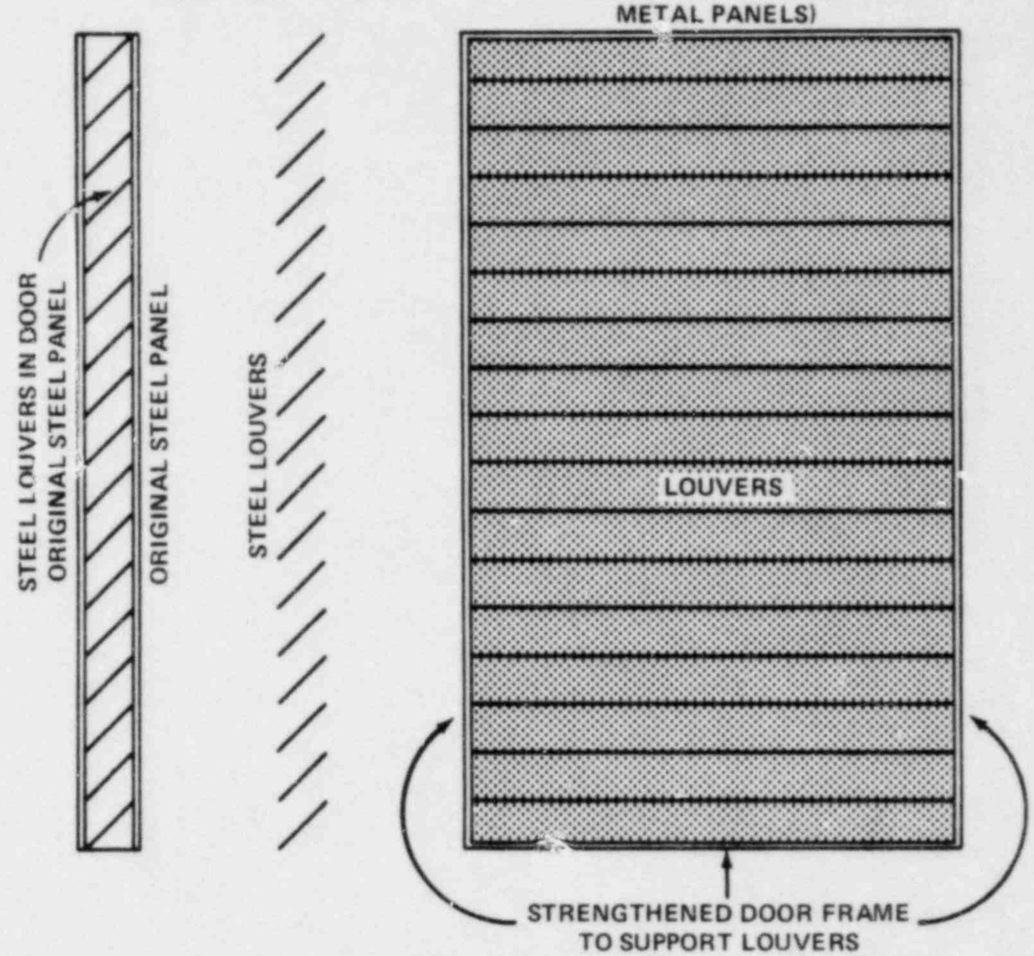
INCREASED PENETRATION RESISTANCE TIME - Approximately 10-15 minutes.

ADDITIONAL TOOLS REQUIRED - Cutting torch
Multiple explosive charges

ADVANTAGES OF TECHNIQUE -

1. Utilizes principle of suppressive shielding.
2. Door can be refitted with heavier exterior panels to provide more resistance.
3. Technique can be used for local construction of new blast-resistant door with only limitation being size of existing door jamb.

DIAGRAM 13 – Hardening of Door Utilizing Suppressive Shield Concept



PENETRATION RESISTANCE TIME

APPROXIMATELY 30–60 SECONDS
TO PENETRATE THROUGH DOOR

PENETRATION RESISTANCE TIME

APPROXIMATELY 10–15 MINUTES
TO PENETRATE THROUGH DOOR

Technique No. 14 - Hardening Door/Jamb Seam, Hinges and Locking Devices

EXISTING STRUCTURE - Any type of door

TOOLS REQUIRED FOR PENETRATION - Hydraulic prying tool

PENETRATION TIME - Approximately 30 seconds

HARDENING ACTION -

1. Weld at least ¼" thick steel strap iron to outer panel of door covering door/jamb seam by at least 2" on all sides.
2. Remove existing hinge from door.
3. Attach a piano or tubular type hinge the entire length of the door to the inner edge of door and jamb.
4. Weld a case hardened steel hinge attached to a case hardened steel cap to the door jamb to cover the door locking device. (The cap should completely cover the locking device.)
5. Weld a case hardened steel hasp to the door to interface with the cap and secure with a high security lock with recessed shackle.

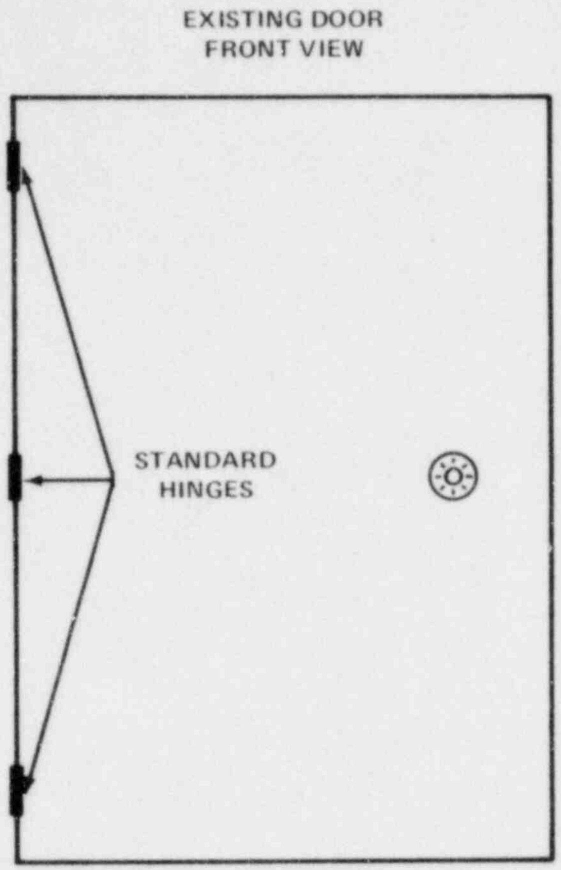
INCREASED PENETRATION RESISTANCE TIME - Approximately 10-15 minutes

ADDITIONAL TOOLS REQUIRED - Cutting torch
Multiple explosive charges
Steel cutting saw

ADVANTAGES OF TECHNIQUE -

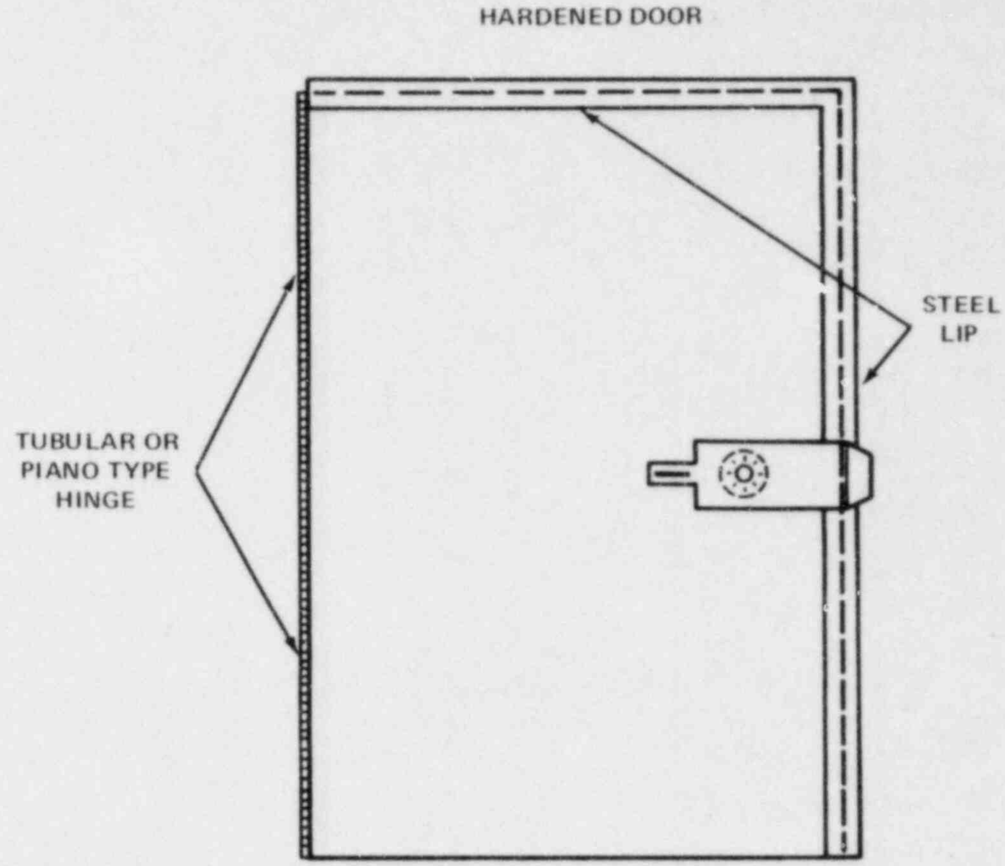
1. Prevents insertion of prying devices.
2. Requires time corsuming placement of explosives or use of different tools.
3. Easily constructed.

DIAGRAM 14 – Hardening Door/Jamb Seam, Hinges, and Locking Device



PENETRATION RESISTANCE TIME

APPROXIMATELY 30 SECONDS



PENETRATION RESISTANCE TIME

APPROXIMATELY 5–10 MINUTES
(DEPENDING ON TYPE OF DOOR)

Technique No. 15 - Hardening Jambs

EXISTING STRUCTURE - Commonly used wood or light metal jambs

TOOLS REQUIRED FOR PENETRATION - Pry or wrecking bar

PENETRATION TIME - Approximately 5 minutes or less depending on jamb.

HARDENING ACTION -

1. Completely remove existing jamb.

2. Place horizontal and verticle portions of heavy metal structural components into existing opening and weld joints at corners.

3. If wall is concrete block or solid concrete, the structural T or combination jamb should be imbedded in concrete.

4. Structural channel iron can be further reinforced by imbedding pins in concrete and welding to wall side portion of jamb.

5. Install hardened door.

INCREASED PENETRATION RESISTANCE TIME - With hardened jamb it would be easier to penetrate door or wall (no time given)

ADDITIONAL TOOLS REQUIRED - Cutting torch (large)
Burn bar
Wrecking bar
Multiple explosive charges

ADVANTAGES OF TECHNIQUE -

1. Provides strong jamb for hardened door.

2. Requires considerable time to remove, thereby encouraging penetration through door or wall.

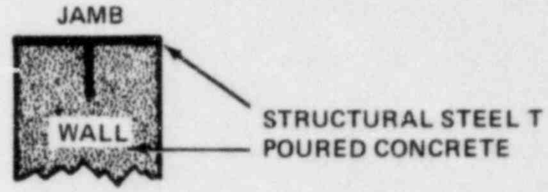
3. Easily and inexpensively fabricated locally.

DIAGRAM 15 – Hardening Jambs

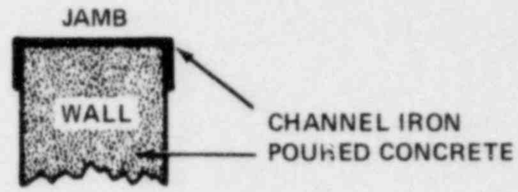
EXISTING STRUCTURE
COMMONLY USED WOOD
OR LIGHT METAL JAMB

HARDENED STRUCTURES
TOP OR SIDE VIEW

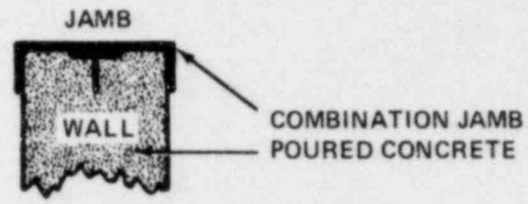
EXAMPLE 1.
STRUCTURAL STEEL T
IMBEDDED IN CONCRETE



EXAMPLE 2.
STRUCTURAL CHANNEL
IRON/STEEL



EXAMPLE 3.
COMBINATION OF
STRUCTURAL T AND
CHANNEL IRON



PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING JAMB

PENETRATION RESISTANCE TIME

DIFFICULT TO ESTIMATE BUT CONSIDERABLY MORE
TIME THAN COMPLETE OR PARTIAL DOOR REMOVAL

Technique No. 16 - Hardening Door Jambs, Hinges, and Locks

The following are additional general guidelines that apply to hardening door components:

Jambs

1. Use case hardened jambs or ones of superior strength.
2. Set jambs into concrete or other barrier material.

Hinges

1. Use multiple hinges (more than the average 3-4).
2. Use single tubular or a piano hinge running the entire length of the door.
3. Provide external covers to hinges to prevent immediate access to hinge.
4. Use hidden hinges (internal to door and jamb).
5. Use case hardened hinges.
6. Attach hinges to the inner edge of door and jamb.
7. Add mechanism that holds door to jamb after hinge failure.

Locks

1. Use multiple locking systems.
2. Use hardened locks with inaccessible internal functions.
3. Use high security locks of case hardened steel or recessed shanks.
4. Use case hardened hasps.
5. Use electrically operated locking devices internal to the vault or door.
6. Locally fabricate internal interlocking pin system.

5. APPENDICES

5.1 BARRIER PENETRATION DATA

WALLS

Type Construction	Personnel Required	Equipment (Wt. lb.)	Average Penetration Time (Min.)(18"D)
4" Cinder Block w/1/2" mortar seam.	1	Sledgehammer (10)	.4
8" Concrete Block, hollow, non-reinf, 1/2" mortar seam.	1	Explosive-Ribbon Charge (3)	.3
8" Cinder Block, hollow, with #5 rebar on 14" center, mortar bond, mortar filled.	1	Sledgehammer, boltcutters (19)	1.5
12" Cinder Block, hollow.	1	Sledgehammer (10)	1.2
Fence fabric, 9 gauge, 2" mesh.	1	Boltcutters (5)	.32
8-inch hollow cinder block, 4-inch ferro-cement with six layers of 11-gauge fence fabric.	3	Sledgehammer, cutting maul, manual boltcutters, wrecking bar	21.8
	3	Sledgehammer, cutting maul, manual oltcutters, wreckin, bar, abrasive blade ircular saw	9.4
	3	Sledgehammer, cutting maul, manual boltcutters, wrecking bar, cutting torch	14.7

WALLS

Type Construction	Personnel Required	Equipment (Wt. lb.)	Average Penetration Time (Min.)(18"D)
4-inch clay brick, 8-inch hollow cylinder block 1-inch from brick wall with ties every other course, block is mortar-filled with No. 5 rebar on 14-inch centers.	1	Sledgehammer	3.1
12-inch hollow cinder block, cores filled with mortar, No. 6 rebar on 8-inch centers.	2	Sledgehammer, hand hydraulic boltcutters	5.2
3/4-inch wood shingles over 3/4-inch wood siding on 2x4 studs, 3/8-inch gypsum board and a solid 5.5-inch layer of wood on opposite side.	2	Sledgehammer, cutting maul, wrecking bar, sabre saw, drill	18.0
	1	Sledgehammer, carbide-tipped circular saw	10.2
Concrete--3000 psi, one layer No. 4 rebar, 8-inch centers.	1	Sledgehammer, hand boltcutters	7.2
	2	Explosives, linear shaped charge (0.35), sledgehammer, hand boltcutters	3.0
	1	Explosives (3) tamper plate, hand boltcutters	2.0
	1	Explosives (4), hand boltcutters	2.2

WALLS

Type Construction	Personnel Required	Equipment (Wt. lb.)	Average Penetration Time (Min.)(18"D)
Concrete--3000 psi, one layer No. 5 rebar, 6-inch centers.	2	Rotohammer, drills sledgehammer, chisel, punch, cutting torch	14.0
	2	Explosives (0.35), sledgehammer, hand hydraulic boltcutters	3.5
	2	Explosives (4), tamper plate, hand hydraulic boltcutters	2.5
	2	Explosives (6), hand hydraulic boltcutters	2.7
	1	Explosives (20), platter	2.0
Concrete--3000 psi, two layers, No. 5 rebar, 6-inch centers.	2	Explosives (6), tamper plate, hand hydraulic bolt-cutters	4.2
	2	Explosives (9), hand hydraulic boltcutters	4.4
	2	Rotohammer, sledge hammer, punch, hand-held power hydraulic boltcutters	30.0

CEILINGS

Type Construction	Personnel Required	Equipment (Wt. lb.)	Average Penetration Time (Min.) (18"D)
Plaster lath ceiling on gypsum board attached to wood studs with fiberglass insulation.	1	Fire axe (5)	1.0
Celotex laying in suspended channels.	1	None	0.2
Plaster lath ceiling on gypsum board attached to bottom of 4-inch concrete floor with 6-inch, no. 10 wire mesh.	1	Tin snips, roto-hammer drill, roto-hammer chisel (30)	15.0
		Explosives (0.3), sledgehammer, bolt-cutters, tape (26.3)	2.0

ROOFS

Type Construction	Personnel Required	Equipment (Wt. lb.)	Average Penetration Time (Min.) (18"D)
Asphalt--built-up roof with gravel, 2-inch rigid insulation, high rib steel decking, 16-gauge.	2	Fire axe, shovel (15)	3.00
	2	Fire axe, shovel, circular saw (50)	2.40
	1	Explosives (0.2),	1.00
Asphalt--built-up roof with gravel, 2-inch celotex rigid insulation on poured 2.5-inch concrete roof.	3	Sledgehammer, fire axe, shovel (25)	2.00
	1	Explosives (25)	1.20
Asphalt--Built-up roof with gravel, 3-inch concrete with vermiculite aggregate, 2-inch celotex rigid insulation, precast T-beam, 2 to 4-inch taper.	3	Sledgehammer, fire axe, shovel (25)	4.7
	3	Sledgehammer, fire axe, shovel, circular saw (60)	12.7
	1	Explosives (3)	1.2

FLOORS

Type Construction	Personnel Required	Equipment (Wt. lb.)	Average Penetration Time (Min.) (18"D)
3-inch concrete topping on top of 2.5-inch concrete slab with 6-inch square mesh of no. 10 wire floor on grade.	2	Sledgehammer, bolt-cutters (20)	4.0
	1	Explosives (0.3), sledgehammer, bolt-cutters (50.3)	2.5
8-inch concrete with 1/2-inch rebar on 12-inch centers each way.	2	Tamped explosives (4), hand hydraulic bolt-cutters (32)	2.0
4 1/2-inch concrete with 3/8-inch rebar on 18-inch centers poured on steel decking.	2	Sledgehammer, fire axe (20.0)	4.0
	1	Explosives, linear shaped charge, fire axe (40.6)	2.0

DOORS

Type Construction	Personnel Required	Equipment (Wt. lb.)	Average Penetration Time (Min.)(18"D)
1/4-inch steel plate	1	Explosives, bulk (5.1)	1.00
1/2-inch steel plate	1	Explosives, bulk (10.2)	1.40
1-inch steel plate	1	Explosives, bulk (20)	1.80
Personnel, standard hollow core, 18 gauge, butthinge with non-removable pins	1	Linear shaped charge explosive (.3)	1.0 (charge preparation included)
Igloo door, 3/8-inch steel, 3-inch void, 1/4-inch steel plate, two Fichet locks	1	Explosives, tamped charge-6 (15)	1.20
	1	Circular saw (35)	3.00
	2	Sledgehammer, cutting torch, oxy-lance (75)	4.40
Igloo door upgraded with redwood center, 3/8-inch steel, 3-inch redwood, 0.036-inch steel	2	Sledgehammer, cutting torch, oxy-lance (75)	12.4
Class 5 vault door	1	Thermal tools	4.00
	1	Hand tools	4.00
	1	Hand tools, thermal tools	2.20

UTILITY PORTS

Type Construction	Personnel Required	Equipment (Wt. lb.)	Average Penetration Time (Min.) (18"D)
Sheet metal igloo vent with grill of rebar at bottom	3	Cutting torch (55)	3.3
36-inch dia. roof exhaust, 18- to 24-gauge sheet metal	1	Sledgehammer, axe, chisel, tin snips, rope (20)	2.3
36-inch dia. roof exhaust with 1/2-inch dia. security bars	1	Explosives, linear shaped charge (0.3), sledgehammer, chisel, rope (14.35)	2.0
	1	Sledgehammer, chisel, rope, cutting torch (69)	1.7
	1	Sledgehammer, chisel, hacksaw, rope (14.50)	3.0
	1	Sledgehammer, bolt-cutters, rope (20)	2.2

Type Construction	Personnel Required	Equipment (Wt. lb.)	Average Penetration Time (Min.) (18"D)
		HINGES	
Standard 4" door hinge (3 each)	1	Linear shaped charge explosive (.75)	.3
		LOCKS	
Padlock, high security, case hardened	1	Explosive C-4 (.1)	.10

5.2 COMMONLY USED PENETRATION TOOLS

Sledgehammer

The sledgehammer is an effective tool for forcible entry. It can be used singularly or in conjunction with other tools. The most effective sledgehammer is in the 6 to 16 pound range; the 10 pound hammer is preferred by most users. In sustained penetrations on a reinforced concrete wall, a sledgehammer user averages approximately 2 seconds per blow. For penetrations requiring 10 to 15 minutes, users usually rest 3 minutes for each minute of work. Small sledgehammers in the 3 to 4 pound range can be used effectively against concrete block construction (non-reinforced) for quick, loss-obtrusive penetrations.

Maul or Axe

The cutting maul or fireman's axe can be used on weaker materials. Both the maul and axe weigh approximately 6 pounds and are used at the rate of 2 seconds per blow. They are very effective in penetrating composite walls, wood or thin metal pedestrian doors, and built-up roofs consisting of corrugated metal, rigid insulation, and bituminous materials.

Boltcutters

Boltcutters are used for cutting chains, locks, chain-link mesh fabric, grill-work, and rebar. The size of boltcutters range from 12-42 inches in length. Twelve inch boltcutters are used against lighter materials, while the 42-inch size is used against cables, heavy chain, and #3 to #4 rebar. The rate of use per minute ranges from 30 cuts for chain-link mesh or flattened expanded metal to four cuts for #4 rebar.

Wrecking Bar

Wrecking bars are used to jimmy doors and to lift vents or covers. Common sizes range from 12 to 30 inches in length. About 1 minute is required to pry a door open, while less than 30 seconds is needed to forcibly open a simple vent.

Cutting Torch

Oxygen-acetylene is commonly used for gas welding or cutting. Flame cutting of ferrous metals requries only basic manual skills. One tank of oxygen and one tank of acetylene, together with pressure regulators, hoses, a torch, and cutting attachment, are all that are needed to penetrate most existing metal doors and utility ports. A small backpack model weighing 46 pounds and having a cutting rate of approximately 20 inches per minute for 1/4-inch thick mild steel can be operated for 1 hour. Larger equipment (120 cubic feet) can be utilized at the same rate, but for a period of time exceeding 3 hours.

Oxy-Lance (Burn-Bar)

The oxy-lance or burn-bar is another thermal tool used only for cutting. It can burn through most existing barriers including concrete. The burn-bar consists of a metal tube packed with a number of treated wires coupled to a level control handle, which is connected to an oxygen source. Once the tip of the lance is heated to approximately 1500 degress Fahrenheit by an acetylene torch and oxygen is supplied, the lance begins to burn at temperatures up to 10,000 degrees Fahrenheit. The lance is self-consumable. A 10-foot long lance will be consumed in approximately 3.5 minutes and a standard tank of oxygen (120 cubic feet) can supply oxygen for 3-1/2 units. Typical cutting times per linear inch are 2 seconds for 1/4-inch thick steel plate and 4 seconds for 1-inch thick steel plate. The burn-bar can also remove reinforced concrete at the rate of approximately 4 seconds per cubic inch.

Explosives

Explosives can be used effectively in penetrating a variety of barriers. Although a number of explosive materials such as dynamite, TNT, etc. are commercially available, it is considered that an adversary would more likely utilize a high efficiency, military explosive such as composition C-4. Large quantities of composition C-4 have been stolen from military depots and it is considered readily available to terrorist groups. Composition C-4 can be easily molded into a variety of shapes, and its use reduces the amount of explosive material required. The adversary must carefully evaluate using explosives because the results could damage material contained within the vault or trigger unwanted chemical or thermal side effects.

Explosive material can be packaged into a variety of charges that are designed to penetrate in specific ways. The following charges are typical of those that may be employed by an adversary.

Linear Shaped Charges are designed to cut through doors, walls and similar barriers. The V-shaped charge cuts a narrow slot along its entire length and can be formed to cut out any sized contour.

Platter Charges are best suited for making penetrations through barriers that are not directly accessible. The platter charge is positioned at a pre-determined distance from the barrier in such a manner that the explosive detonation propels the plate at optinum velocity into and through the barrier.

Satchel or Bulk Breeching Charges are used primarily in breaching barriers where shaped charges are not required. Satchel charges usually consist of a large quantity of bulk explosives packaged in a canvas bag or case.

5.3 PENETRATION TOOL WEIGHTS

HAND TOOLS	WEIGHT (POUNDS)
Hammer	<6
Suction Cup	1
Sledgehammer	5-10
Sledgehammer	10-16
Sledgehammer	>16
Cutting Maul	<6
Cutting Maul	≥ 6
Axe	2-5
Fire Axe	10
Lock-Picking Tools	0.5
Punch	<0.5
Chisel	0.5
Saw, Wood (Carpenters)	1
Saw, Metal (Hacksaw)	0.5
Boltcutters, <24 inches	5-10
Boltcutters, ≥ 24 inches	10-20
Hand Hydraulic Boltcutters	10
Strap Wrench	0.5
Pliers, <8 inches	0.5
Pliers, ≥ 8 inches	0.5
Pliers, Vise Grip, Med.	1.0
Shears, Sheet Metal	0.5
Tin Snips	0.5
Brace and Bit	2
S-Hook, 18-inch, Made of Rebar	0.5
6-foot Pry Bar	15
Wrecking Bar	<18
Wrecking Bar	≥ 18
Wrecking Bar, <35 inches	3
Battering Ram	50
Hydraulic Pry Bar	20
Shovel	5
Pick	5-10
Posthole Digger	5
Auger	10-50
Grappling Hook, 3 barbs	3

POWER TOOLS	WEIGHT (POUNDS)
Saw, Circular, Steel Blade, 8-inch Blade	20-30
Saw, Circular, Steel Blade, 8 to 12-inch Blade	20-30
Saw, Circular, Steel Blade, ≥12-inch Blade	20-30
Saw, Circular, Abrasive Blade, <12-inch Blade	20-30
Saw, Circular, Abrasive Blade, ≥12-inch Blade	20-30
Saw, Circular, Diamond Blade, <12-inch Blade	20-30
Saw, Circular, Diamond Blade, ≥12-inch Blade	20-30
Chainsaw, <16-inch Bar	10-15
Chainsaw, ≥16-inch Bar	15-30
Saw, Circular, Hubless, Steel Blade	20-30
Saw, Reciprocating (Sabre Saw)	3
Electric Powered Hydraulic Boltcutters	17
Gas Powered Hydraulic Boltcutters	30
Drill, 0.25-inch Chuck	2
Drill, 0.375-inch Chuck	3
Drill, 0.5-inch Chuck	6
Drill, Cordless 0.25-inch Chuck	4
Drill, Cordless 0.375-inch Chuck	6
Drill, Cordless 0.5-inch Chuck	8
Drill, Diamond Core	90
Rotohammer, Drill	15
Rotohammer, Chisel	15
Jackhammer, Pneumatic, with Bits	100
Saw, Circular, Carbide-Tipped Blade, Gasoline-powered	35

THERMAL TOOLS	WEIGHT (POUNDS)
Powder for Powder Lance	0-100
Cutting Torch with Tanks, Oxyacetylene	55
Cutting Torch with Tanks, Mapp	55
Cutting Torch Hand, W/Powder Attach, Linde C-63	100
Oxy-Lance, Small Tank, Gauge, Hose, Two Bars	100

EXPLOSIVES	WEIGHT (POUNDS)
Explosives, Bulk	0-100
Explosives, Satchel Charge	0-75
Explosives, Detonating Cord, <100 Grains per foot	
Explosives, Detonating Cord, ≥100 Grains per foot	
Explosives, Linear Shaped Charge, <100 Grains per foot	
Explosives, Linear Shaped Charge, 100 to 500 Grains per foot	
Explosives, Linear Shaped Charge, 500 to 2000 Grains per foot	
Explosives, Linear Shaped Charge, ≥ 2000 Grains per foot	
Explosives, Linear Shaped Charge, Jet-Axe, Ja-1, 3.5 oz, 250 Grains per foot	19
Explosives, Linear Shaped Charge, Jet-Axe, Ja-2, 1.9 oz, 250 Grains per foot	9
Explosives, Linear Shaped Charge, Jet-Axe, Ja-3, 5.6 oz, 250 Grains per foot	27
Explosives, Linear Shaped Charge, Jet-Axe, Ja-4, 5.6 oz, 550 Grains per foot	26
Explosives, Linear Shaped Charge, Jet-Axe, Ja-5, 3.4 oz, 550 Grains per foot	11
Explosives, Conical Shaped Charge	<2->20
Explosives, Platter Charge	<10-100
Explosives, Bangalore Toredo	20
Tamping Material (Typical)	2 to 3 times weight of explosives

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16. ABSTRACT *(200 words or less)*

This report provides guidelines to aid NRC licensees in evaluating existing strategic special nuclear material storage facilities, discusses typical tools that could be employed to penetrate such facilities, and provides simple and cost effective hardening techniques. The report was developed to provide guidance in support of the Physical Protection Upgrade Rule, effective March 25, 1980.

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LICENSEE SAFEGUARDS GUIDANCE GROUP INFORMATION BULLETINS

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Question:

Are two alarm systems required at a fence line which is the boundary to a protected area?

LSGG Response:

The regulation intends for licensees to provide intrusion alarm protection against penetration through the isolation zone into the protected area. Such systems should satisfy the performance standards considered acceptable by the staff as indicated in R.G. 5.44, Revision 2 (Perimeter Intrusion Alarm Systems) and in appropriate effectiveness tests of the "Design Methodology Document" (NUREG 0508). A single intrusion detection system would be acceptable if it can meet these performance standards. In some situations, an additional system may be needed in order to achieve the prescribed performance.

The use of redundant or diverse alarm systems in order to meet the performance guidelines of R.G. 5.44, Revision 2 might also aid in satisfying the General Performance Requirement of 10 CFR 73.20(b)(2).

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Questions:

(a) Is the closed circuit coverage described in 73.46(h)(6) intended to be continual coverage of all areas of an isolation zone?

(b) Will coverage of a fence line satisfy this provision in cases where roof mounted cameras fail to cover the base of a protected building?

LSGG Response:

The answer to (a) is yes; the answer to (b) yes, except for the case of a building wall which is used as a part of the perimeter barrier (see last paragraph).

The best application of CCTV is to accomplish an initial assessment of an alarm and its seriousness. NUREG 0508, "Design Methodology Document" and NUREG 0178, "Basic Considerations for Assembling a CCTV System," provide guidance on system specifics.

When using CCTV systems to achieve initial assessment of an intrusion indication, immediate monitoring of the sensitive area via CCTV is preferred. If immediate monitoring is not provided, then monitoring by camera movement should generally be rapid enough to allow an effective assessment of an alarm condition.

CCTV monitoring of only a fence line without camera coverage of the exterior base of a building within a protected area is conditionally acceptable. The referenced section 73.46(h)(6) intends that licensees have the capability of observing the entire isolation zone as well as the physical barrier at the perimeter of the protected area. Therefore, fence line protection by use of CCTV cameras for remote rapid assessment, exclusive of the protected building, would normally be adequate, provided adjacent isolation zones can also be monitored by CCTV.

An exception to this is under circumstances where the building's exterior walls themselves are considered part of the perimeter barrier. In those situations, CCTV coverage should include the entire area from the base of the perimeter wall through the isolation zone.

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Question:

Does the CAS and SAS have to have the same control function as well as display function?

LSGG Response:

Yes. Either the CAS or SAS should be able to continue operation in the event that the other alarm station is destroyed and/or totally inoperative. Additionally, an alarm station should not be denied alarm systems information (status and location) if the operator of the other alarm station injects a signal into the system, cuts lines, shorts lines, induces destructive voltages/currents into lines or otherwise attempts to disrupt the other alarm station's capability. Intrusion alarms should be capable of being controlled (activated or deactivated) from either the CAS or SAS thereby assuring no functional subservience of one alarm station over the other.

For additional information on this topic, refer to NUREG/CR-0543, entitled CAS/SAS Planning Document.

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Question:

Do telephones qualify as duress alarms?

LSGG Response:

No. One of the important features of duress alarms is the ability to rapidly send an emergency signal to others without the knowledge of an adversary. This feature would be lacking in the use of conventional telephones for duress situations. Telephone usage would prevent quick, covert action by a guard needing assistance thereby possibly affecting, in an adverse way, the resolution of the problem or incident.

Fixed duress alarm initiating devices should be installed at locations where they will be readily accessible to posted guards in the event of an attack or other reason to alert the security force.

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Question:

What documented evidence is required to show that bullet resistant enclosures conform to NRC-prescribed guidelines?

LSGG Response:

References: UL-752 - Bullet-Resisting Equipment. NUREG/CR-0543, CAS/SAS Planning Document.

Licensees should consider the following guidance in providing certification that bullet resistant enclosures meet standard UL-752.

1. If material utilized by the licensee is not UL listed, it will be necessary for the licensee to provide to the NRC documented evidence that the material used will meet the UL specification by certified test results.

2. "Bullet resisting" as used by UL and adopted by the NRC means protection against complete penetration, passage of fragments of projectiles or spalling (fragmentation) of the protective material to the degree that injury would be caused to a person standing directly behind the bullet resisting barrier.

3. Performance tests for bullet resisting materials should be conducted by a qualified ballistic's laboratory. The test results should certify that the materials are bullet resisting as defined above when tested against a High Power Rifle; cal. 30-06; 24 inch barrel; 220 grain soft point ammunition; 2410 fps; 2830 ft. lb muzzle energy.

4. Proper installation of bullet resistant materials, in accordance with the materials manufacturer's instructions, is important in achieving the desired protection results. Installation of bullet resistant materials and all related construction should be accomplished only by reputable construction firms employing experienced qualified personnel. The construction firms and their personnel should demonstrate substantial experience in building bullet resistant structures.

5. The entire structure, once finished, is expected to withstand the performance tests mentioned above and should be certified by the builder as meeting these performance tests.

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Question:

Ref. §73.46(c)(5)(iv), locking process equipment such as furnaces and grinding-mixers is not practical. What is the requirement?

LSGG Response:

The intent of 73.46(c)(5)(iv) is to provide protection against unauthorized access for relatively concentrated SNM that may accrue in quantity at locations within process MAAs such as the ADU drying ovens in a scrap recovery operation. 73.2(ii) defines "undergoing processing" as performing active operations on material such as chemical or physical transformation or transit between such operations. As such, the furnaces and grinding-mixers should be considered a part of normal processing and the SNM in them should be provided an appropriate degree of protection when unattended. This means that this equipment should be locked or inherently provide an equal level of protection.

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Question:

Reference 73.46(d)(10), with respect to the two individuals who perform searches of waste, what are the time limits for allowing them to move from a search function to one requiring access within an MAA?

LSGG Response:

73.46(d)(10) states that the team designated for drum scanning and tamper sealing of waste containers "not have access to material processing and storage areas." The purpose of this is to isolate the function of generating the waste from the functions of searching for unauthorized SNM and shipping the containers for ultimate disposition.

This requires assuring that individuals performing these functions do not have the opportunity to shift between an MAA assignment to a searcher assignment concurrent with the flow of waste material. The intent is to avoid a situation in which an individual has access to a given waste container in the MAA, and then is responsible for searching the same waste container for SNM. This should not be permitted so that the opportunity for diversion is lessened. Using the above criteria, an individual may shift from a search detail to the MAA without delay, but the reverse has to be determined on a case-by-case basis depending on the timing of material movement.

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Question:

Does paragraph 73.46(d)(9) refer to non-contaminated material and paragraph 73.46(d)(10) and (11) refer to contaminated material? If not, how do we resolve the 73.46(d)(10) and 73.46(d)(11) requirement to search after sealing?

LSGG Response:

The difference between sections 73.46(d)(9) and (10) with respect to searches for SNM is that in 73.46(d)(9), SNM is not expected to appear and in 73.46(d)(10) and (11), it is, although in reasonably predictable amounts. In this respect, paragraph 73.46(d)(9) would apply to trash and waste material that had not been knowingly contaminated. This normally non-contaminated material does not require sealing.

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Questions:

(a) Do CAS/SAS operators and entry control point operators have to be armed guards if they are not part of the response force?

(b) Can they be watchmen?

LSGG Response:

(a) No. Entry control point (ECP) operators should explicitly not be armed if their duties involve personnel search functions using hand held detection equipment. ECP operators whose duties do not involve search functions may be armed but are not required to be so. CAS/SAS operators need not be armed as a consequence of their job duties. Licensees may find it desirable to train and arm CAS/SAS operators.

(b) CAS/SAS operators must have as their primary duty protection of SNM and the facility. Therefore they cannot be watchmen (Ref. §73.2(d)). ECP operators may be watchmen.

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Question:

Are we to interpret the words on page 31 of the Intent and Scope Guide that the individuals performing the sealing not do the moving? Note that if the container is sealed there is no merit to restricting who moves it to the MAA exit point.

LSGG Response:

No, the Intent and Scope Guide does not mean to imply that those individuals who have completed the waste packaging, NDA measurement, sealing and attestation as to contents cannot subsequently relocate the container within the MAA to a position closer to the exit point for later pickup by shipper personnel.

The Intent and Scope Guide states that: "confirmation" of contents occurs at the time the packaged material crosses the MAA barrier. This means that the recipients at the MAA barrier should, as a minimum, check the seals to verify they are intact along with other checks on quantities presented vs. transfer forms.