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REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 5.44

PERIMETER INTRUSION ALARM SYSTEMS

A. INTRODUCTION

Paragraph (b)(4) of §73.50 of the Commission's regulations requires that, at fuel reprocessing plants and certain other plants at which highly enriched uranium, uranium-233, or plutonium is used or processed, the isolation zone surrounding the physical barrier at the perimeter of the protected area be monitored to detect the presence of individuals or vehicles within the zone so as to allow response by armed members of the licensee security organization to be initiated at the time of penetration of the protected area. This guide describes five types of perimeter intrusion alarm systems and sets forth criteria for their performance and use as a means acceptable to the Regulatory staff of meeting the above requirement.

B. DISCUSSION

Perimeter intrusion alarm systems can be used to detect intrusion into or through the isolation zone at the perimeter of the protected area. A system generally consists of one or more sensors, electronic processing equipment, a power supply, and an alarm monitor. Detection of an intruder is accomplished by the alarm system responding to some change in its operating condition caused by the intruder, e.g., interruption of a transmitted infrared or microwave beam or stress exerted on a piezoelectric crystal. The choice of a perimeter alarm system is influenced by considerations of terrain and climate. At present, no single perimeter intrusion alarm system is capable of operating effectively in all varieties of environments.

The mode of installation of the perimeter alarm system influences the effectiveness of the perimeter intrusion alarm. In general, dividing the site perimeter into segments that are independently alarmed and uniquely monitored assists the security organization in response to an alarm by localizing the area in which the alarm initiated. Segmenting of the perimeter alarm system also allows testing and maintenance of a portion of the system while maintaining the remainder of the perimeter under monitoring. It is generally desirable that the individual segments be limited to a length which allows observation of the entire segment by an individual standing at one end of the segment.

Effective use of a perimeter intrusion alarm system is facilitated by a regular program of system testing. Testing for operability can be performed by a guard or watchman penetrating the zone protected by the alarm system during routine patrols. Functional performance testing, however, is usually more elaborate. In any case, testing can be meaningful without compromising security only if performed under controlled circumstances such as direct visual observation of the area being tested while a specified test is conducted.

The following discussion describes the operations, limitations, and environmental considerations of five basic types of commercially available perimeter intrusion alarm systems—microwave, ferrous metal detector, pressure-sensitive, infrared, and vibration- or stress-sensitive fence protection systems.

1. Microwave Perimeter Alarm System

Each link of a microwave perimeter alarm system is composed of a transmitter, receiver, and power supply. The microwave transmitter produces a beam-like pattern of microwave energy directed to the receiver, which senses the microwave beam. A partial or total interruption of the beam will cause an alarm condition. The microwave beam can be modulated to reduce interference from spurious sources of radiofrequency energy, to increase sensitivity, and to decrease the vulnerability to defeat from "capture" of the receiver by a false microwave source.

at least 3 meters from parallel running metal fences and at least 20 meters from public roads to minimize nuisance alarms.

d. **Pressure-Sensitive Perimeter Alarm Systems**

(1) **Performance Criteria.** A pressure-sensitive perimeter alarm system should be capable of detecting an individual weighing no more than 35 kilograms crossing the sensitive area of the system at a minimum speed of 0.3 meter per second whether walking, crawling, or rolling. The system design should employ techniques (e.g., electronic signal processing) to eliminate nuisance alarms from wind noise.

(2) **Installation Criteria.** The sensors should be installed at the depth below the ground surface stated by the manufacturer. To obtain a high probability of detection, the sensors should be in two separate parallel lines at a distance from 1.5 to 2 meters apart. The sensors and electronic circuitry buried in the ground should be of a durable, moistureproof, rodent-resistant material. When a pressure-sensitive perimeter alarm system is being installed in rocky soil, all rocks should be removed during backfilling to prevent damage to sensors.

If the frost line exceeds 10 cm, a buried pressure-sensitive system should not be used unless the soil is specifically prepared to eliminate freezing above the sensor.

e. **Infrared Perimeter Alarm Systems**

(1) **Performance Criteria.** An infrared perimeter alarm system should be a multibeam modulated type consisting of a minimum of three transmitters and three receivers per unit. An alarm condition should be generated when 90% of the beams are blocked for a period of 75 milliseconds or more or when any one beam is blocked for a period of 1.25 seconds or more. Furthermore, the system should be able to operate as above with a factor of 20 (13 dB) insertion loss due to atmospheric attenuation (e.g., fog) at maximum range (100 meters).

(2) **Installation Criteria.** An infrared perimeter alarm system should be installed so that, at any point, the lowest beam is no higher than 21 cm above grade. The distance between transmitters and receivers of a unit should not exceed 100 meters.

The transmitters and receivers should be mounted rigidly (e.g., installed on a rigid post or concrete pad) to prevent nuisance alarms from vibrations. Installation should provide "overlap" of adjacent units. The maximum distance between transmitter and receiver should be selected to permit proper operation during conditions of severe atmospheric attenuation that are typical for the site, generally a maximum of 100 meters.

The infrared perimeter alarm system should be installed outside of and parallel to a fence or wall so that the transmitter and receiver units are positioned between 0.3 and 1.0 meter from the fence or wall. If the infrared alarm system is installed inside and parallel to a fence, the transmitter and receiver units should be positioned between 2.0 and 2.5 meters from the fence to prevent an individual from jumping over the infrared beams from atop the fence or sprinting through the beams. Installation of the infrared alarm system inside and adjacent to a wall should be avoided since the wall provides a solid base from which an intruder can jump over the beams into the protected area.

f. **Vibration or Strain Detection**

(1) **Performance Criteria.** Vibration- or strain-detection systems used for fence protection should detect an intruder weighing no more than 35 kilograms attempting to climb the fence. The system should also detect any attempt to cut the fence or lift the fence more than 15 cm above grade. The system should not generate alarms due to wind-produced vibration of the fence.

(2) **Installation Criteria.** The vibration or strain sensors should be attached firmly to the fence (post or fabric, as appropriate) so that the vibration or stress caused by an intruder climbing, cutting, or lifting the fence will generate an alarm.

2. **Testing Perimeter Intrusion Alarm Systems**

a. **Routine Testing**

Perimeter intrusion alarm systems should be tested at least once each seven days. Testing may be accomplished during routine patrols by the members of the licensee security force. The alarm systems should be tested in segments at random with only one or two segments tested per patrol. However, every segment should be tested at least once every seven days. The testing should be conducted by crossing the isolation zone where the alarm system is located or by climbing the fence to which the system is attached. Where appropriate, a specific test procedure should be followed. Prior to making the test, the individual making the test should notify the central alarm station that a test is about to be conducted. The area under test should be maintained under visual observation by a guard.

b. **Performance Testing**

At least quarterly, the perimeter intrusion alarm system should be tested against its functional performance specifications. The test procedure recommended by the manufacturer should be followed. While the test is being conducted, the area under test should be maintained under direct visual observation by a guard.

Successive microwave links can be overlapped to form a protective perimeter around a facility. However, as the transmitter/receiver link is a line-of-sight system, hills or other obstructions will interrupt the beam, and ditches may provide crawl space for an intruder. Moreover, objects such as tumbleweeds, paper, and bushes moving in the path of the beam can cause nuisance alarms. Systems utilizing the Doppler shift for motion detection are especially sensitive to the motion of trees and grass and to falling rain and snow.

The maximum and minimum separation of the transmitter and receiver usually is specified by the manufacturer. Typically, a microwave perimeter alarm system will operate effectively in the range between 70 and 150 meters.

2. Ferrous Metal Detector Perimeter Alarm System

A ferrous metal detector system consists of buried electrical cables, amplifiers, inhibitors, and a central alarm unit. The system is passive and is susceptible to changes in the ambient magnetic field. Such changes are caused either by electromagnetic disturbances such as lightning or by ferrous metal being carried over the buried cables. The change in the local magnetic field induces a current in the buried cable which is filtered and sensed by the electronics. If the change exceeds a predetermined threshold, an alarm is generated. To reduce nuisance alarms from external electromagnetic sources (e.g., electrical power transmission lines), the electrical cable is laid in loops which are transposed at regular intervals. The inhibitor, which operates on the same principle as the cable loops and is buried near a cable loop, senses strong temporary electromagnetic interference (e.g., lightning) and disables the alarm system for approximately one second, thus reducing nuisance alarms.

The ferrous metal detector system is not a line-of-sight system and therefore can be installed on uneven ground and need not be laid in a straight line. The loops formed by the cables must be fairly regular, however. As the system will detect only ferrous metal, animals, birds, or flying leaves will not initiate alarms. However, electromagnetic interferences can cause nuisance alarms or even disable the alarm system if the interference is severe.

Each sensing cable (and amplifier) can monitor a line up to 500 meters in length. Multiple cables and amplifiers can be used to extend the monitoring length.

3. Pressure-Sensitive Perimeter Alarm System

Buried pressure transducers detect small variations in the mechanical stress exerted on the surrounding soil by the presence of an individual passing above the sensor. The signals produced by the transducers are amplified and compared with a preestablished threshold. If the signal exceeds the threshold, an alarm occurs. The transducer may be a set of piezoelectric crystals, a fluid-filled flexible tube, or a specially fabricated electrical cable.

Like the ferrous metal detector system, the pressure-sensitive system does not require line-of-sight installation and can be sited on uneven terrain. However, installation in rocky soil may result in damage to the pressure transducers either during installation or as a result of soil settlement after installation. High winds can produce pressure waves on the ground surface which can be sensed by the transducer and could necessitate operation at reduced sensitivity to avoid nuisance alarms; however, features to compensate for wind-generated noise can be designed into the equipment. Pressure systems also may lose sensitivity if the buried sensors are covered with snow, by snow with a frozen crust that will support the weight of a man, or by frozen ground. Other natural phenomena such as hail and rain can cause nuisance alarms.

The sensitive area consists of a narrow corridor, usually about one meter in width. A greater degree of security can be achieved by employing two such corridors to prevent an intruder jumping over the buried transducers. Typical maximum length monitored by a transducer (i.e., a set of piezoelectric crystals, a liquid-filled tube, or an electrical cable) is about 100 meters.

4. Infrared Perimeter Alarm Systems

Like the microwave system, each link of an infrared system is composed of a transmitter, receiver, power supply, and alarm annunciator. The transmitter directs a narrow beam to a receiver. If the infrared beam between the transmitter and receiver is interrupted, an alarm signal is generated. As with the microwave system, the infrared system is line of sight. In addition, the infrared beam is usually modulated. Since the infrared beam does not diverge significantly as does the microwave beam, multiple infrared beams between transmitter and receiver can be used to define a "wall". If this "wall" is then penetrated by an individual, an alarm will result.

Fog both attentuates and disperses the infrared beam and can cause nuisance alarms. However, the system can be designed to operate properly with severe atmospheric attenuation. Dust on the faceplates also will attenuate the infrared beam as will an accumulation of condensation, frost, or ice on the faceplate.

Like the microwave system, vegetation such as bushes, trees, grass, etc., will interfere with the infrared beam, and ditches, gullies, or hills will allow areas where the passage of an intruder may be undetected.

The typical maximum distance between transmitter and receiver is about 100 meters.

5. Vibration or Stress Detector

A variety of devices which detect strain or vibration are available for use as fence protection systems. Although the devices vary greatly in design, each basically detects strain or vibration of the fence such as that produced by an intruder climbing or cutting the ace. In the simplest devices, the vibration or strain makes or breaks electrical continuity and thereby generates an alarm.

Vibration- or strain- detection devices for fence protection generally are susceptible to nuisance alarms generated by wind-produced vibration of the fences to which they are attached. Rigid mounting of the fence will lessen the propensity of the fence to vibrate and therefore will reduce the frequency of nuisance alarms. However, making the fence too rigid will render the alarm system insensitive to an intruder. This situation is especially common with post-mounted switch-contact-type alarm systems. The utilization of electronic signal-processing equipment in conjunction with signal-generating strain or vibration transducers can effectively reduce nuisance alarm rates without sacrificing sensitivity to climbing or cutting the fence.

Depending upon the variety of sensor, each sensor can monitor a length of fence ranging from about one meter to several hundred meters.

C. REGULATORY POSITION

1. Minimum Qualification for Perimeter Intrusion Alarm Systems

a. General

(1) **Electrical.** All components--sensors, electronic processing equipment, power supplies, alarm monitors–should be approved by the Underwriter's Laboratory (UL) for fire safety. If alarm power is furnished by public utility, the system should contain provisions for automatic switchover to emergency battery or generator power without generating alarms in the event primary power is interrupted. Emergency power should be capable of sustaining operation for a minimum of 24 hours without replacing or recharging batteries or refueling generators. If sufficient battery or fuel capacity is not attainable for 24-hour operation as stated above, additional batteries or fuel should be stored on site expressly for augmenting the emergency power supply. If emergency power is furnished by battery, all batteries (including stored batteries) should be maintained at a minimum of 90% of full charge by automatic battery-charging circuitry.

(2) **Tamper Indication.** All enclosures for equipment should be equipped with tamper switches or triggering mechanisms compatible with the alarm systems. The electronics should be designed so that tamper-indicating devices remain in operation even though the system itself may be placed in the access mode.* All controls that affect the sensitivity of the alarm system should be located within a tamper-resistant enclosure. All signal lines connecting the alarm relays with alarm monitors should be supervised; if the processing electronics is separated from the sensor elements and not located within the detection area of the sensor elements, the signal lines linking the sensors to the processing electronics should also be supervised.*

All key locks or key-operated switches used to protect equipment and controls should have UL-listed locking cylinders (see Regulatory Guide 5.12, "General Use of Locks in the Protection of Facilities and Special Nuclear Material").

(3) **Environment.** Perimeter intrusion alarm systems should be capable of operating throughout the climatic extremes of the environs in which they are used; as a minimum, the systems should be capable of effective operation between -35° and +50°C. Components that necessarily must be located out of doors should be protected from moisture damage by such methods as hermetic sealing or potting in an epoxy compound.

(4) **Alarm Conditions.** Perimeter intrusion alarm systems should generate an alarm under any of the following conditions:

(a) Detection of stimulus or condition for which it was designed to react,
(b) Failure of emergency power to properly operate the system in the event of loss of primary power,
(c) Indication of tampering (e.g., opening, shorting, or grounding of the sensor circuitry) that can render the device incapable of normal operation,
(d) Indication of tampering by activation of a tamper switch or other triggering mechanism,
(e) Failure or aging of any component(s) to the extent that the device is rendered incapable of normal operation.

An automatic and distinctly recognizable indication should be generated by the alarm monitor upon switchover to emergency power, if primary power is supplied from the central alarm station. In addition, for emergency power supplied by battery from the central alarm station, an automatic and distinctly recognizable indication should be generated if, at any time during operation on primary power, the available emergency battery power is below 80% of rated capacity.

Loss or reduction of power (either primary or emergency) to the degree that the system is no longer operating properly should result in an alarm condition or be otherwise indicated in the central alarm station.

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*Access mode means the condition that maintains the system sensitive to intrusion but that inhibits the audible (and in some cases visible) annunciation of an alarm.

*Signal supervision will be discussed in a regulatory guide currently under development on interior intrusion alarm systems.

Placement of any portion of a perimeter intrusion alarm system into the access mode should be indicated automatically and distinctly by the alarm monitor. Moreover, the segment(s) of the system placed in the access mode should be indicated clearly.

(5) **Installation.** Perimeter intrusion alarm systems generally may be located on either side of the perimeter physical barrier. If, however, installation is outside the perimeter barrier, a second barrier or fence (e.g., a cattle fence), should be erected so that the alarm system is located between the barriers. The second barrier or fence will serve to reduce the incidence of nuisance alarms from animals and passersby. Of course, fence protection systems must be located on a fence.

Where possible, the perimeter should be segmented so that an individual standing at one end of a segment will have a clear view of the entire segment. In no case should any segment exceed 200 meters in length. Each segment should independently and uniquely indicate intrusion and should be capable of placement into the access mode independently of the other segments.

b. *Microwave Perimeter Alarm System*

(1) **Performance Criteria.** A microwave perimeter alarm system should be capable of detecting an intruder passing between the transmitter and receiver at a rate between 0.15 and 15 meters per second, whether walking, running, jumping, crawling, or rolling. The microwave beam should be modulated, and the receiver should be frequency selective to decrease susceptibility to receiver "capture". Generally, because of susceptibility to motion beyond the area to be protected, Doppler microwave systems should not be used as perimeter intrusion alarms.

(2) **Installation Criteria.** The transmitters and receivers should be installed on even terrain clear of trees, tall grass, and bushes. Each unit should be mounted rigidly at a distance of about 1 meter above the ground. The distance between a transmitter and its receiver should be at least 70 meters. Neither the transmitter nor the receiver should be mounted on a fence. To prevent passage under the microwave beam in the shadow of an obstruction, hills should be leveled, ditches filled, and obstructions removed so that the area between transmitter and receiver is clear of obstructions and free of rises or depressions of height or depth greater than 15 cm. The clear area should be sufficiently wide to preclude generation of alarms by objects moving near the microwave link (e.g., personnel walking or vehicular traffic). Approximate widths of the microwave pattern should be provided by the manufacturer.

If the microwave link is installed inside and roughly parallel to a perimeter fence or wall, the transmitter and receiver should be positioned so as to prevent someone from jumping over the microwave beam into the protected area from atop the fence or wall. Typically, a chain link security fence with an overall height of 8 feet will necessitate a minimum of 2 meters between fence and the center of the microwave beam.

Successive microwave links and corners should overlap three meters to eliminate the dead spot (areas where movement is not detected) below and immediately in front of transmitter and receivers. The overlap of successive links should be arranged so that receiver units are within the area protected by the microwave beam.

c. **Ferrous Metal Detector Perimeter Alarm System**

(1) **Performance Criteria.** A ferrous metal detector perimeter alarm system should be able to detect a 400-pole-centimeter (CGS units) magnet moving at a rate of 0.3 meter per second within 0.3 meter of a sensor cable. The detection system should be equipped with inhibitors to minimize nuisance alarms due to electromagnetic interference. Multiple inhibitors should be used to prevent undetected simultaneous desensitizing of the entire system.

(2) **Installation Criteria.** To determine if the ferrous metal detection system will operate in the proposed environment, a preengineering site survey should be made using an electromagnetic detection survey meter. This survey meter can be furnished by the manufacturer. If the electromagnetic disturbances are within the limits prescribed by the manufacturer, this type of system can be used effectively. Special looping configurations can be made in areas of high electromagnetic interference to reduce the incidents of nuisance alarms.

The sensing loops of electrical cable should be buried in the ground according to the manufacturer's stated depth. Multiple units (cable and amplifier) should be used to protect a perimeter. All associated buried circuitry should be buried in the detection zone of the sensor and packaged in hermetically sealed containers. The cable should be laid in accordance with the manufacturer's recommended geometrical configurations to reduce nuisance alarms from external sources. When cable is being installed in rocky soil, care should be taken to remove sharp rocks during backfilling over the cable.

Inhibitors should be buried in the ground at least 6 meters from the cable inside the protected perimeter.

Continuous electromagnetic interference obstructs the detection of an intruder carrying metal over the buried cable by keeping the inhibitor activated, thereby preventing the alarm unit from responding to a change in flux. The device should therefore be used only where the environment is relatively free of severe man-made electromagnetic interference. The cable should never be installed close to overhead power transmission lines. Moreover, the cable should be placed

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the Regulatory staff's plans for utilizing this regulatory guide.

Except in those cases in which the applicant proposes an alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of submittals in connection with special nuclear material license, operating license, or construction permit applications docketed after August 1, 1975.

If an applicant whose application for a special nuclear material license, an operating license, or a construction permit is docketed on or before August 1, 1975, wishes to use this regulatory guide in developing submittals for applications, the pertinent portions of the application will be evaluated on the basis of this guide.