NUREG-0273
Four in a Series of
Five Reports

GUIDE FOR THE EVALUATION OF PHYSICAL PROTECTION EQUIPMENT

Book 2
Volumes IV-VIII

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GUIDE FOR THE EVALUATION OF PHYSICAL PROTECTION EQUIPMENT

Book 2
Volumes IV-VIII

Wolf Haberman, and Others

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The MITRE Corporation
P.O. Box 208
Bedford, MA 01730

Division of Safeguards, Fuel Cycle and Environmental Research
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ABSTRACT

A guide for evaluating the performance of commercially available physical protection equipment has been prepared in partial fulfillment of Task 2 of MITRE contract AT(49-24)-0376 for use by the U. S. Nuclear Regulatory Commission (NRC). Separate evaluation procedures are provided for each generic type of equipment contained in the companion document, Catalog of Physical Protection Equipment. Among the equipment parameters evaluated, as appropriate, are sensitivity, area/volume of coverage, false/nuisance alarm rate, resistance to countermeasures, environmental requirements, installation parameters and maintenance. Four evaluation techniques are employed (inspections, analyses, demonstrations and tests); standard test equipment (both commercially available as well as developmental) to be used in the evaluation are listed.

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PREFACE AND ACKNOWLEDGEMENTS

The Guide for the Evaluation of Physical Protection Equipment is a companion document to the Catalog of Physical Protection Equipment (NUREG-0274, MTR-3445). This document presents evaluation techniques and guidelines for use by NRC inspectors in the performance of both preoperational and operational physical protection equipment inspections in the field. It may also be useful to NRC licensing personnel during their evaluation of physical security plans and/or development of acceptance criteria for those plans.

For convenience of reference, the Evaluation Guide follows the same general format as the Equipment Catalog. An equipment reference by category is provided on the first page of each individual procedure; the reader may also refer to the cross-reference indices in the Reference Materials volume (NUREG-0272, MTR-3443).

Although each evaluation procedure is intended to be complete in itself, there are a few cases in which the methods contained in a procedure for one category of equipment may be applicable to equipment in other categories as well. Such methods can and should be adopted for use in these other categories as appropriate. Since comparison of data between preoperational and operational inspections is often required by the procedures, it is recommended that the inspector employ a notebook or a set of data sheets (not included in the Evaluation Guide) to record the results of equipment evaluations at each facility for future reference.

A final report (NUREG-0271, MTR-3458) has been prepared which describes the rationale and methodology used to create the Evaluation Guide. The final report also contains a summary of the test aids and measurement equipment referred to in the Evaluation Guide that are commercially available or that require development.

Drafts of the individual evaluation procedures contained in the Evaluation Guide were prepared by MITRE staff members as follows:

Volume I.		
	L. I. Egelson	Sections 1, 4, 5, 6, 7, 8, 9, 10
	R. G. Hansen	Sections 2, 3
Volume II.		
	J. L. Conway	Section 1
	R. D. Cotell	Section 2
	Z. Kohorn	Sections 11, 14
	R. N. Lawson	Sections 4, 5, 7, 9, 12
	J. O. Runkle	Sections 6, 8, 10, 13, 15
	G. O. Sauermann	Section 3
Volume III.		
	W. L. Parlee	
Volume IV.		
	G. O. Sauermann	
Volume V.		
	A. J. Graff	
Volume VI.		
	R. N. Lawson	
Volume VII.		
	C. E. Dolberg	
Volume VIII.		
	D. Stone	
	D. G. Willard	

The Evaluation Guide was revised and edited by A. J. Graff; W. Haberman had overall responsibility for its preparation. The editor gratefully acknowledges the efforts and assistance provided by the authors of the procedures and wishes to thank W. Haberman for his review of the document, and his helpful comments and suggestions. The editor also wishes to thank the secretaries of MITRE Department 81 and the Word Processing Center for their efforts in preparing the manuscript for publication.

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4. **Guide for the Evaluation of Physical Protection Equipmen**

   NUREG-0273

5. Catalog of Physical Protection Equipment

   NUREG-0274

THERMAL IMAGING SYSTEMS

Thermal imaging systems display an object's temperature contrasts in the form of a thermal picture, using natural infrared radiation, which varies with the object's surface temperature and a material constant, the emissivity. The camera scans over its field of view and focuses the infrared radiation on a detector which converts the infrared variations to an electronic signal. After amplification the signal is used to control the electron beam of a TV-type picture tube. The beam sweeps over the picture screen in synchronism with the camera scanner, forming a thermal image of the object in which the brightness variations represent details of differences in temperature. The result is a live, or real-time, thermal picture of the object on the monitor display screen. The system, consisting of a camera and a display unit operates independently of other sensors.

The scanning system, in contrast to standard TV systems, is optical-mechanical. Two prisms move at high speed -- one in the horizontal and one in the vertical direction -- to provide a raster scan. Interchangeable lenses offer various fields of view from wide-angle (45 degrees) to narrow-field (2 degrees) telephoto lenses. The thermal image can be displayed on either a black-and-white or a color television-type monitor. Since the scan rates of the thermal system differ from those of standard TV, the electronics of standard monitors have to be modified to display the thermal image. Different shades of gray represent different object temperatures. Alternatively, temperature differences can be displayed as different colors for easier identification. Temperature differences as low as 0.3^{0}F (0.2^{0}C) can be detected at object temperatures of 86^{0}F (30^{0}C). Several display modes are offered for each system, including an overall temperature map, temperature contours or both. Changing from one mode to another is done by simple switching. The most effective mode for a specific application has to be determined on location. Thermal imaging devices are offered as small hand-held units with a small portable display unit (monitor) and battery pack, or as larger tripod-mounted units with separate electronic control units.

One drawback of thermal imaging systems of this type is the need to cool the detector element with liquid nitrogen. One filling of the reservoir will keep the device operational for two to four hours, which means that liquid nitogen has to be available at all times, since when the detector warms up, the device ceases to function and becomes useless. The need for storage of liquid nitrogen and its transportation to the cameras can provide a difficult logistics problem.

Thermal imaging devices are very useful for detection of objects (intruders) showing very small visual contrast or during conditions of low visibility. People hidden in vegetation or camouflaged can be detected easily and with a high rate of confidence even if they cannot be seen with the unaided eye. The devices work equally well during day or night since no external lighting is required.

Thermal imaging systems are very difficult to spoof. Unless the intruder blends totally with the background, i.e., his body temperature and emissivity match the background over the whole spectral range, the intruder cannot hide within the field of view. If these thermal imaging systems are used in combination with closed circuit television, two detection systems with very different detection mechanisms must be spoofed simultaneously, a task which is generally considered to be impossible.

The cost, mechanical complexity and need for liquefied gas cooling, however, make thermal imaging devices less attractive as a general surveillance tool. However, as a gap filler, thermal imagers can be very helpful and sometimes essential where other devices fail completely.

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THERMAL IMAGING SYSTEMS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Thermal Imaging Systems	IV-1.a

Performance Characteristic/Measurement Procedure	Measurement Equipment
From a user's point of view, there are few differences in the operation of a passive thermal imaging system and standard closed circuit television, in spite of the fact that the information displayed on the monitors is quite different.	
Evaluation of proper installation, adjustments and operation of both systems can therefore follow the same guidelines. In the following paragraphs, evaluation procedures are listed for thermal imaging devices only where the procedures differ from those established for evaluation of standard television systems. In all other cases, reference is made to the specific guidelines for standard televisions contained in evaluation procedure IV-2.A (Video Surveillance Components).	
<u>INSTALLATION</u>	
The purpose of this evaluation is the verification of proper installation of equipment and proper mechanical mounting of components and cables as well as the determination that no corrosion and other mechanical deterioration of mounts, housings and other supports has occurred. In addition to the appropriate guidance provided in evaluation procedure IV-2.A, the following procedures should be followed.	
<u>INSPECTION/ANALYSIS</u>	
1. Inspect the coolant supply system to ensure that it is installed according to the manufacturer's recommendations so that the thermal imaging camera sensor will be cooled properly during operation.	Manufacturer's installation instructions.

Performance Characteristic/Measurement Procedure	Measurement Equipment
2. Check that loss of coolant will shut down the system and will cause an alarm.	
3. Review the licensee's maintenance schedule to ensure that the coolant reservoirs are replenished during periods of operation.	Licensee's maintenance schedule.
<u>SYSTEM PARAMETERS</u>	
The purpose of this evaluation is to measure system parameters and to verify that their numerical values fall within the range specified by the manufacturer.	
FIELD OF VIEW	
<u>INSPECTION</u>	
Ensure that no permanent obstacles such as trenches, fences, walls, small buildings, working huts, etc. are within the sensor's field of view other than those specified in the original survey layout.	
<u>ANALYSIS</u>	
Analyze the coverage provided by the surveillance cameras. Place emphasis on blind areas, such as the area immediately below and to the side of the cameras and assure that other cameras or other intrusion sensors cover these areas adequately.	
<u>DEMONSTRATION</u>	
1. Demonstrate that the area to be covered by the thermal imaging system is actually within the fields of view of the cameras. Refer to the licensee's camera plans. Depending on the terrain, fixed markers should be put on the sides of the coverage area so that they are observable on the monitor display.	Licensee's camera coverage plans.

Performance Characteristic/Measurement Procedure	Measurement Equipment
2. During the preoperational visit, or for newly installed or modified equipment, photograph the display on the monitors for the various areas of coverage for comparison with the results obtained during future inspections. Verify that no new obstructions are within the field of view and that the field of view has not been altered during operational inspections.	Polaroid camera with close-up lens set.
3. Have a member of the inspection team walk a grid pattern in the area under surveillance to verify the planned field of view. Make sure that no blind areas exist in which an intruder could escape detection by observation of the displayed image.	
THERMAL RADIATION SENSITIVITY	
ANALYSIS	
An analysis should be made to verify that the thermal sensitivity of the camera lens combination as specified by the manufacturer covers the temperature ranges (maximum and minimum values for both day and night and for different seasons) expected to be encountered during normal operation.	
DEMONSTRATION	
1. Demonstrate that the thermal imaging system is capable of obtaining clear pictures under all ambient illumination conditions (day, night, cloudy, rainy, etc.). It may be necessary to interview system operators to obtain information regarding performance under certain conditions.	
2. Demonstrate that a person wearing dark clothing standing at the end of the defined surveillance range can be observed clearly on the TV monitor.	
TEST	
Measure the dynamic range of the system with a calibrated thermal gray scale device. This device would consist of ten parallel bars each of which is heated or cooled to a different	Thermal gray scale test device (must be developed).

absolute temperature. The device is to be placed in the field of view of the imaging device in such a location that the image fills approximately one-fourth of the monitor screen. All shades of gray should be distinguishable.

Note: The gray scale response of the monitor display should be demonstrated independently prior to performing this test. See evaluation procedure IV-2.A.

RESOLUTION

DEMONSTRATION

Demonstrate that the image of a person at the far end of the planned surveillance range appears on the monitor screen to be of a size equivalent to at least 35 TV scan lines.

TESTS

Measure the resolution of the whole system with a resolution test device placed in the field of view of the camera. The resolution test device should consist of a series of parallel bars all of which are heated electrically 20°C above ambient temperature. A single modification of the gray scale test device would permit this mode of operation. The resolution test device is used in a manner similar to an optical bar chart (resolution chart) for standard TV cameras. Place the thermal resolution test device at various distances from the sensor as discussed below. Both horizontal and vertical orientation of the bars is required.

Thermal resolution test device (must be developed).

1. Move the bar pattern away from the camera along a line parallel to its axis to a distance at which the individual images of the bars on the monitor can no longer be resolved. Measure and record this distance (measurement of distance to a fixed landmark is sufficient). It [illegible] to be expected that two distances will be measured: one [illegible] the bars oriented horizontally and one for the bars orie[illegible] vertically (i.e., the distance associated with the vertical bar pattern will be greater than that associated with the horizontal bar pattern).

2. Repeat step (1) in both the right and left edges of the field of view.

3. Compare these measured distances with those made at the time of installation (the same resolution test device must be used). If there are discrepancies of more than ± 20 percent, request a careful mechanical and electrical realignment of the system.

These measurements should be performed during the day as well as at night under artificial illumination conditions.

SPOOFING AND TAMPERING

The purpose of this evaluation is to determine the resistance of the thermal imaging system to tampering (attempts to mechanically or electrically deactivate the system) and to spoofing (attempts to render the system incapable to react without any physical changes in the system itself). While it may be relatively easy to deactivate a thermal imaging surveillance system by tampering, spoofing is generally very difficult, except in cases of internal sabotage. For this reason careful inspection of the system to detect possible areas accessible to sabotage is of vital importance. Additional evaluation guidance is contained in evaluation procedure IV-2.A (Video Surveillance Components) which is applicable to Thermal Imaging systems.

INSPECTION

1. Inspect the control adjustments on all elements of the system to ensure that they are protected by tamperproof covers and/or are not accessible to the operators without authorization. Take note whether or not any of the following adjustment controls are accessible to the operators, record this fact as well as the justification given by the licensee. It should be noted that these adjustments should only be altered by trained technicians since they have an effect on system optimization.

(a) Cameras: horizontal and vertical scan adjustments, sensor supply voltages, electrical and mechanical focus.

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(b) Monitors: vertical and horizontal scan size, focus, termination impedance switches.

2. Note the control setting values and record for future reference. Any changes in values should be justified by the licensee.

SYSTEM OPERATION

The purpose of this evaluation is to verify that the entire system is operating properly as specified, including correct electrical and mechanical alignment, correct adjustment ranges of controls and appropriate accessibility of controls by the operators. See procedure IV-2.A.

MAINTENANCE

The purpose of this evaluation is to determine that the equipment is properly maintained and that required records are kept. See procedure IV-2.A.

POWER

The purpose of this evaluation is to ensure that the surveillance system is supplied by proper power sources and that in case of power failure auxiliary systems are available immediately. See procedure IV-2.A.

VIDEO SURVEILLANCE COMPONENTS

TELEVISION CAMERAS

Television cameras in principle consist of three major components which have clearly defined functions. The light-sensitive detector, usually referred to as the sensor or pickup device, converts the incoming light energy into an electrical signal. The optical lens system focuses the light from a given scene onto the sensor, creating an electrical charge pattern which is "read out" within the sensor by an internal electronic scan. The electronic support system provides all the necessary voltages, timing pulses and amplification of the electrical signal. The pickup tube is surrounded by a coil whose electromagnetic field deflects the electron scan beam within the tube. By varying the current in the deflection coil the electron beam is moved to create a raster scan identical to that used in home television sets. In the following paragraphs, technical terms specific to television cameras are explained in more detail.

A camera's <u>sensitivity</u> is measured in terms of the amount of light falling on the light-sensitive surface (faceplate) of the camera sensor. Usually two values are given. The first indicates the amount necessary to produce a usable picture, enabling an observer to identify familiar objects on a correctly adjusted monitor. This value is subjective and depends on circumstances. The second value gives the illumination necessary to produce ten distinctly discernible shades of gray. These levels and the camera response can be measured in the laboratory and constitute an objective method for evaluation of the camera.

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Signal transfer distance is defined as the maximum distance between camera and television monitors which can be used without amplifier repeaters.

The video signal itself has two components, one containing the picture content (raw video) and the other the timing information (horizontal and vertical synchronization pulses). The raw video and sync pulses are superimposed to form the composite signal.

The scan format defines the details of the scanning process. All television cameras designed to be used in connection with a monitor for visual observation scan the image in an "interlaced" mode. First all odd-numbered lines are scanned, defining field one, then all the even-numbered lines, defining field two. Fields one and two constitute the whole scan, called a frame. The standard rate in the U.S. is 60 fields (30 frames) per second; this scan format is called 2:1 interlaced. The scan timing can be controlled by the ac line frequency, by an internal oscillator or by an external synchronization (sync) pulse. If the starting times of the two successive fields are not locked together, the scan sequence is called 2:1 random interlaced. Minimum standards to make closed circuit television systems compatible are listed in Electronic Industries Association Standard EIA RS-170, which covers output and equipment standardization. More rigid standards for closed-circuit television cameras are defined in EIA RS-330 which specifies 525 scan lines per picture height and 30 frames (60 fields) per second. Some cameras are also equipped with an option to comply with CCIR standards which are the European equivalents to the US EAI RS standards, but based on a rate of 50 frames/sec and 625 scan lines per picture height.

Scan fail protection is provided by a special sensing circuit which turns the electron scan beam off in case the scan circuitry fails. This prevents possible severe damage to the sensor tube when the electron read beam stops moving.

Automatic gain control (AGC) enables the camera to provide a constant-output signal over a wide variety of illumination conditions, but only within the sensor's sensitivity range. The video amplifier gain is automatically comtrolled by a feedback circuit, which in turn is controlled by the video output signal. Most cameras can override the AGC when necessary.

If the illumination range exceeds the automatic gain control's sensitivity range, the camera's lens stop (iris) must be adjusted. Several cameras include provisions for automatic operation of a motor-driven lens stop -- an automatic iris -- to maintain a constant electrical output signal over a wide range of illuminations.

In many instances television cameras are provided with remote control of their own electronic adjustments (but not of their positioning). The camera controls available to an operator are electrical and mechanical focus, scan beam adjustment, and in some cases target voltage control. For more technical details, consult the camera servicing manuals.

Camera pickup tubes for closed-circuit TV usually come in two sizes, nominally 2/3 inch and 1 inch. Manufacturers specify the tube to be used with their cameras, but many tubes are interchangeable without any need to change electronic circuits. Tube interchangeability guides are provided by all major tube manufacturers.

Most cameras have interchangeable lenses with a standard threaded mount referred to as a "C Mount". Lens selection depends on the specific requirements for area coverage. Tables and diagrams to aide in the selection are available from various manufacturers. It is important to note that the size of the sensor itself (in the case of vidicons, 2/3 or 1 inch) is an important parameter in selecting the camera lens. Many camera lenses are also produced with a variety of additional features. Zoom lenses are available in good quality either for manual or motorized adjustment. Motorized lens stop (auto-iris) adjustments are very common, as is motorized optical focus adjustment for remote-control operation. Many lens systems provide all three motorized options in one unit.

A special feature provided by some manufacturers is the "one-cable" camera, in which power to run the camera, the video signal and camera control signals are transmitted over the same cable. Other features, usually provided on special request, include matching circuits directly attached to the camera for video rf signal transmission.

TV Cameras with Standard Vidicon Sensors

Most commercial closed-circuit television cameras use standard vidicon tubes as pickup devices. Vidicon pickup tubes are basically cylindrical glass vacuum devices between 1/2 and 2 inches in diameter and between 3 and 7 inches long. One of the flat ends of the cylinder holds the photosensitive material; the other is used for electrical feedthrough. The term "standard vidicon" refers to a tube using a particular type of photosensitive material, a homogeneous layer of antimonide trisulfide which responds to visible light only.

Vidicon tubes are inexpensive, rugged and of moderate sensitivity. They can be used under normal lighting conditions indoors, and outdoors during daytime. They have a relatively high range of sensitivity (dynamic range), but are very vulnerable to illumination overload. Very high illumination levels can burn out the photosensitive area and damage the tube permanently. At high light levels standard vidicons exhibit extensive blooming; very bright areas seem to flow into adjacent darker sections and obscure part of the scene. Furthermore, standard vidicons are susceptible to "burn-in" --

a memory effect. Closed-circuit television cameras equipped with standard vidicons exposed to the same scene for a long period can become completely insensitive and display part or all of a previously observed scene on a video monitor even when the camera lens is covered.

An advantage of the standard vidicon is the ability to control its sensitivity electronically by varying a single critical voltage. This allows for automatic sensitivity adjustment, widely used with these devices. It eliminates the lens stop (iris) adjustments similar to those used in film cameras.

TV Cameras with Silicon Diode Vidicon or Equivalent

High-performance closed-circuit television cameras are usually equipped with silicon diode vidicons as electronic pickup devices. Vidicon pickup tubes are basically cylindrical glass vacuum devices between 1/2 and 2 inches in diameter and between 3 and 7 inches long. One of the flat ends of the cylinder holds the photosensitive material; the other is used for electical feedthrough. The term "silicon diode" vidicon refers to a tube using a particular type of photosensitive material, an array of up to 500,000 individual silicon diodes. Interchangeable with these silicon diode vidicons are the newly developed Newvicons and Chalnicons, which are very similar to silicon diode vidicons in all important performance characteristics but use different electro-optical sensor materials, which make these vidicons less sensitive in the near infrared region than silicon diode vidicons.

Silicon diode array vidicons (silicon vidicons), Newvicons and Chalnicons are approximately ten times as sensitive as standard vidicons, and can be used during dusk and dawn without external lights. They are very rugged and can withstand very heavy illumination overloads without damage. They also exhibit no "burn in" image-retaining effects, even if exposed to the same scene continuously for many months. They do exhibit "blooming" to some extent, very brightly illuminated areas seeming to flow into darker sections of the picture. The sensitivity of silicon vidicons, Newvicons and Chalnicons cannot be controlled externally over any wide range; cameras equipped with these sensors therefore, like standard film cameras, require automatic lens stop (iris) adjustments to prevent overexposure. Silicon vidicons are also sensitive to the near-infrared region of the electromagnetic spectrum, which makes them very useful surveillance devices in fog, rain, and snow.

TV Cameras with Intensified Tubes

TV cameras used for surveillance under very-low-illumination conditions, called Low Light Level TV (LLLTV) cameras, are equipped with intensified pickup tubes. The actual sensor is a vidicon with an electro-optical intensifier stage attached to it. The incoming light is electronically amplified first and then the more intense light is directed to the vidicon for signal generation.

Vidicon pickup tubes are basically cylindrical glass vacuum devices between 1/2 and 2 inches in diameter and between 3 and 7 inches long. One of the flat ends of the cylinder holds the photosensitive material; the other is used for electrical feedthrough. Two types of vidicons are used in connection with light amplifiers: the standard vidicon and the silicon-diode vidicon.

The term standard vidicon refers to a tube using a particular type of photosensitive material, a homogeneous layer of antimony trisulfide. A silicon diode vidicon has as a sensor an array of a large number of photodiodes, which are about ten times more sensitive than the sensor material used in the standard vidicon.

Optical amplification in the LLLTV camera can reach a value of several hundred times normal illumination, with an equivalent increase in camera sensitivity. In some models the intensifier stage is external to the vidicon, the devices having individual vacuum housings. They are mechanically coupled, however, and cannot be separated without possibility of damage. In this case the pickup tube configuration is called an IV (intensified vidicon), or if two or three intensifiers are cascaded as I^2V or I^3V respectively, each step dramatically increases the sensitivity. Another configuration incorporates the first intensifier stage in the vidicon vacuum housing; in this case the pickup tube system is referred to as a SIT (Silicon Intensified Target) tube.

An external electro-optical intensifier stage can be combined with a SIT tube, making it an ISIT. As a rule of thumb, an ISIT is about as sensitive as an I^2V (double intensified vidicon). Intensified pickup tubes are sensitive only in the visible part of the electromagnetic spectrum. ISIT tubes are usually preferred over I^2V combinations where high resolution is required.

Intensifier stages require high voltages (up to 12,000V), which can be supplied by small power supplies specifically designed for this application. The voltage of the intensifier controls the amount of light amplification and is therefore often used for automatic exposure control to increase the camera's operating range. With automatic lens stop (iris) controls, these cameras can operate on very dark nights (moonless, cloud covered sky) with no artificial illumination as well as during broad daylight.

Intensified pickup tubes are susceptible to blooming, very brightly illuminated areas seeming to flow into the darker areas. For this reason good automatic exposure control is required. An exception is the SIT pickup tube, which is extremely rugged and shows very small blooming effects.

Cameras with Special Sensors

Special sensors used in closed-circuit television include the Isocon, the intensified Isocon, pyroelectric vidicons and solid-state self-scanning arrays. Isocons are cylindrical vacuum tube devices approximately 1 to 2 inches in diameter and up to 16 inches long. One flat end of the cylinder holds the photosensitive material, the other the feedthroughs. Special sensor devices combine high sensitivity with high resolution but are more complex in structure and operations than standard pickup tubes.

Isocons use the well-established principle of a scanning electron beam for signal generation, but employ a very sophisticated scheme for electronic signal output. Quite frequently Isocons are coupled to an electro-optical light intensifier, which increases the sensitivity of the device by as much as one hundred times -- the intensified Isocon. The Isocon or intensified Isocon pickup tube is surrounded by coils whose electromagnetic fields deflect the electron scan beam within the tube. By varying the current in the deflection coil, the electron beam can be moved to create a raster scan identical to that used in home television sets.

Another class of special sensors is the pyroelectric vidicon. These devices appear identical to other vacuum type pickup sensors, but respond only to thermal radiation, recording a thermal image. They require a shutter or panning motion, however; this makes the camera mechanically more complex. Deflection coils and electronic circuitry requirements remain the same, except for a special signal processing stage connected with the signal amplifier.

Another class of closed-circuit television cameras with special sensors employ all solid-state detectors, called Charge Transfer Devices (CTD). This light-sensitive device, a very small chip less than the size of a thumbnail, does not require electron beam readout as vacuum pickup tubes do. Scanning is done solely by timing pulses from an electronic clock, eliminating the bulky magnetic deflection coil. Thus the whole camera is much smaller and consumes much less power than standard TV cameras. On the other hand, solid-state cameras are lower in resolution than cameras with standard pickup tubes.

VIDEO CAMERA ENCLOSURES

Enclosures are used to protect a TV camera system from the elements, dust, corrosive materials and tampering, and in some cases to conceal the camera system itself. Except for special units, camera enclosures are sturdy rectangular metal boxes with provisions for camera mounting, cable feedthroughs, air vents and a window. For some models electrical heaters and air blowers are standard; in most cases they can be attached to the unit as accessories. Access to the cameras is usually through large doors protected in most cases by key locks, sometimes by electrical tamper switches. The windows are usually much larger than the camera lens aperture, so that careful adjustment of the camera position within the enclosure is not necessary.

Outdoor enclosures, usually called environmental enclosures, are sealed units with special cable feedthroughs for signal and power. They usually have a sunshade, and some models have windshield wipers as standard equipment. Heaters for the windshield and the camera itself are optional. Special explosive-proof, hermetically sealed units are available, as well as pressurized units for use in corrosive atmospheric environments. For deployment in high-temperature areas, special housings with refrigeration units are provided by several manufacturers. For deployment in extremely cold temperatures, manufacturers offer housings with special insulation for operation down to -100°F (-60°C).

VIDEO CAMERA POSITIONING EQUIPMENT

Video camera positioning equipment is used to remotely point a closed-circuit television camera. There are two classes: pan units, which provide horizontal sweep only, and pan and tilt units which can be operated vertically as well. Different classes of units are also distinguished by their mode of operation. They may operate automatically, scanning a predetermined angular range without operator assistance in an autoscan operation, or they may be operated as needed from a control center by manual remote control operation. A third distinction is in timing. Some units are designed for continuous operation, 24 hours a day without overheating or damage to the device. Others can be operated only intermittently, not operating at specified periods to prevent equipment overload or fatigue.

Units designed for smaller cameras and lightweight housing usually are controlled directly; that is, the voltages fed to the unit from the control center are also the operating voltages. Larger devices usually require their own attached power supplies, which in turn are controlled by command voltages from the control center. Maximum cable lengths for remote control are stated by the manufacturer based on the power requirements for a given unit.

Remote positioning equipment is manufactured either for indoor or for outdoor use, the latter having waterproof electrical connections and sealed moving mechanical parts. Provision for mounting is simple, usually a base plate with holes. Care has to be taken not to overload the positioning equipment keeping the total weight of the camera, lens and housing at or below the maximum rating for that positioning device. During installation, the camera and housing must be well balanced to prevent unnecessary backlash and wear and tear on the positioning units.

VIDEO MONITORS

Television monitors convert a video signal into a visible picture for observation. The central component is a cathode ray tube (CRT) in which a high-velocity electron beam strikes a phosphor, causing it to emit light.

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The electron beam is deflected by an electromagnetic coil to form a raster pattern of 525 horizontal lines. The scan starts at the upper-left-hand corner of the display. The intensity of the electron beam is modulated while the beam is scanning, causing the phosphor to radiate according to the intensity of the modulation. The raster scan is repeated 60 times each second (60 fields), one field scanning the odd-numbered lines of the raster and the following field scanning the even numbered scan lines. In this way the total scan is repeated 30 times (frames) per second. This scan format is called 2:1 interlaced.

Synchronization (sync) pulses contained within the video signal provide proper timing, which is essential to stablization of the picture. Only if the raster scan lines correspond directly to those from the video camera can a usable picture be displayed on the monitor; small departures from proper timing cause noticeable distortions on the visual display.

Electronic circuits provide the proper voltages for operation of the cathode ray display tube, signal amplification, signal synchronization and controls. The required video signal input is specified either for the composite video signal, which includes video information and sync pulses, or for the non-composite signal, which refers to the video information alone. The voltages always are measured as the differences between the highest positive and negative signals -- the peak-to-peak voltage. (The abbreviation used is usually ppc for the composite signal.)

Most video monitors are equipped with their own timing (signal) circuits, which lock on to the timing signals in the composite video signal. Some manufacturers also provide external synchronization options; in this case the monitors can be driven by external timing devices, if desired.

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Controls for operation of television monitors are basically the same as on a home television set. Contrast and brightness control knobs are usually mounted on the front for easy access, but some monitors have special lockable compartments for these controls. In addition there are control knobs for vertical and horizontal hold -- adjustments to the timing circuits to provide a proper lock onto vertical and horizontal timing pulses, thus preventing the display from shifting and rolling. Usually on the rear panel or inside the monitor cover are controls to adjust the height and width of the picture as it is displayed on the monitor, and to change the electronic focus of the electron scan beam to obtain a sharper picture. The acceleration voltage of the electron beam, measured in kilovolts (1000 volts), is an indicator of the maximum display brightness: the higher the voltage the brighter the picture.

A monitor's resolution is a measure of its capability to display fine details. Usually only the resolution for the horizontal direction is given. The basic unit is the TV line. If the resolution is 550 TV lines, 550 alternating black and white dots can be resolved across the monitor screen along a section of a horizontal scan line whose length is equal to the picture height. The resolution in the vertical direction is approximately 0.7 times the number of scan lines. This means that on a monitor with 525 scan lines, a series of 350 alternating black and white dots arranged in a vertical line will be separated. It is important to note that the horizontal resolution given in TV lines per picture height is independent of the number of scan lines in the raster, in contrast to the vertical resolution which is strongly dependent on the raster spacing. In some cases the term "active scan lines" is used, denoting the scan lines which can actually be seen on the display. This number is about 10% less than the number of scan lines in the raster (525). Fewer scan lines are displayed simply for convenience; the edges of the picture are cut off to eliminate any frayed edges. Monitors provide for underscan (display of the raster at a smaller than normal size). This mode of operation is used to check proper adjustment of camera and monitors.

Linearity on a monitor specifies the tolerances allowed for horizontal and vertical displacement of parts of the picture with respect to other parts (i.e., the difference between the actual position of a given point on the display and the position this same point would occupy on an ideal display system).

Monitors are manufactured either for desktop operation or rack mounting. In some cases manufacturers provide twin or triple mounts, allowing monitors to be placed side by side for easier observation.

Performance limitations, vulnerability and the resistance to electromagnetic interference of TV monitors has to be considered in the context of the whole closed circuit television system. The cameras, camera control units, signal transfer systems, switching devices and monitors form a chain; a malfunction in any link will impede the system to a point where the system ceases to serve its purpose.

Electromagnetic interference can cause severe problems. Since the signal transmission lines can be several thousand feet long, they have to be carefully shielded and kept away from power lines to avoid picking up stray fields which can cause severe distortions of the TV picture even if the monitor is adjusted correctly. For this reason the proper routing of TV signal lines and the placement of switch boxes is not trivial. A careful analysis of the whole TV system layout is necessary to determine actual or possible trouble spots prior to system installation.

Circuits are available on some units that automatically detect loss of video signal, loss of sync and tampering with TV signal transmission lines. If these are provided, the resistance to spoofing and internal sabotage is high.

VIDEO TAPE RECORDERS

Video tape recorders are considered support equipment in closed-circuit television surveillance; nevertheless they are an important part of such systems. In the following paragraphs, technical terms specific to video tape recorders are explained.

Video tape recorders usually serve one or both of two functions. For real-time recording they are activated by an intrusion alarm to document events immediately following the alarm, aiding the alarm assessment function. In the time-lapse mode, video signals are automatically sampled and recorded to continually document activities within a given surveillance area. Time lapse video recording operates in a similar manner to time lapse photography: only one TV picture frame is recorded during a given time interval in contrast to the 30 frames which are generated by the camera every second. The ratio of recorded frames to those which are discarded can be preset by a manual switch. Most machines have several settings; ratios between 1:1 and 1:90 can be obtained.

In the time lapse mode only a fraction of the video information is recorded which results in more economical use of the tape but in loss of video information. In security surveillance systems this trade-off becomes critical, especially for high time lapse ratios where events that may take place between recorded frames cannot be observed during replay. Individual video picture frame recall (stop action) is provided in some video recorders with the time-lapse feature, permitting examination of individual frames which were originally exposed as much as three seconds apart.

Video tape recording systems for closed-circuit television are commercially available in two different versions, reel-to-reel and cassette machines. Though they differ in appearance, they operate on the same basic principle: the helical scan. The construction of the recording and playback system itself is the same except for minor mechanical details. In order to standardize the details of video recording and to be able to play back on one machine the recordings made on another, the EIAJ-1 standard was developed by the Electronic Industry Association of Japan. This standard covers all video tape recorders except those used for commercial broadcasting systems, which follow an entirely different principle of operation.

In a video tape recorder, the recording heads are not stationary (as they are in all audio recorders), but rotate within a recording drum approximately 4 inches (10 cm) in diameter at high speed (several thousand rpm). The video tape is pulled around the recording drum at speeds of 7.5 in/sec (19.1 cm/sec) in reel-to-reel machines and at speeds of 3.75 in/sec (9.5 cm/sec) in cassette machines. To reduce friction between the drum and tape, the tape rides on an air bearing, the air flow being provided by the rotating heads and their supports, which act like blades of an air blower.

Reel-to-reel type video recorders use either 1/2 inch, 3/4 inch, or 1 inch wide tapes, while cassette recorders use 1/2 inch and 3/4 inch tape cassettes. Recording durations are usually an hour for reel-to-reel machines which accept 7 inch reels with 2400 feet of tape. Cassettes are available for recordings of 15, 30 and 60 minutes duration. Some video tape recorders provide fast playback, permitting the video picture to be played back at faster speeds than the recording speed to save time during examination. Some units offer special features such as electronic editing.

The required video signal input is specified either for the composite video signal which includes video information and sync pulses or for the non-composite signal, which refers to the video information alone. The voltages always are measured as the differences between the highest positive and negative signals -- the peak-to-peak voltage.

A video tape recorder's resolution is a measure of its capability to record fine details which then can be displayed on a monitor. Resolution is a direct function of the electrical bandwidth -- the larger the tape recorder's bandwidth, the larger the achievable resolution. For use with closed circuit TV, a bandwidth of 4.5 MHz is required. Usually only the resolution for the horizontal direction is given. The basic unit is the TV line. If the resolution is 550 TV lines, 550 alternating black and white dots can be resolved across the screen of a monitor along a section of a horizontal scan line whose length is equal to the picture height. The resolution in the vertical direction is approximately 0.7 times the number of scan lines. This means that on a system with 525 scan lines, a series of 350 alternating black and white dots arranged in a vertical line will be separated. It is important to note that the <u>horizontal</u> resolution given in TV lines per picture height is independent of the number of scan lines in the raster, in contrast to the vertical resolution which is strongly dependent on the raster spacing.

Linearity specifies the tolerances allowed for horizontal and vertical displacement of parts of the picture with respect to other parts. The values given for linearity are the difference between the actual position of a given point on the display and the position this same point would occupy on an ideal display system.

Although simple in principle, a video tape recorder is a complex electro-mechanical device which has to operate at high speeds within very close mechanical tolerances. For this reason video tape recorders operate within their specifications only when carefully adjusted by experienced technicians. One of the problems most commonly encountered with video tape recorders is the deterioration of the recording heads either due to mechanical wear or due to dust and dirt. Periodic performance tests and inspections of the heads are mandatory. But video tape recorders are still susceptible to noise problems, either mechanical or electrical, that can manifest themselves in periodic bars visible on a monitor, or by "snowstorm" like noise superimposed on the display. If the mechanical scan is not completely stable, "rolling" of the picture or gross distortion, which can be observed as a "wavy" appearance of otherwise straight lines, may result.

The limitations encountered in video recorders are dictated by the degree of loss of resolution, and by the limits of interchangeability between different tape recorders in spite of the EIAJ-1 standard. Video tape recording machines still have individual differences which may introduce additional noise and distortion, even when they have been adjusted with extreme care. For this reason when a video surveillance system having video tape recorders is used, it is important that the system be designed with a considerable safety margin beyond the minimum specifications in order to accommodate these types of degradations.

VIDEO SURVEILLANCE COMPONENTS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Video Camera Equipment	IV-2.a
Video Monitors	IV-3.a
Video Tape Recorders	IV-4.a

Performance Characteristic/Measurement Procedure	Measurement Equipment

INSTALLATION/OPERATION

The purpose of this evaluation is to verify that video surveillance components are properly installed. The proper operation of various components is also verified. Separate procedures for cameras/mounts, camera housings, lenses, cables, monitors and video tape recorders are provided for convenience of reference.

CAMERAS/MOUNTS

INSPECTION

1. Check that all cameras/mounts are securely fastened onto the supporting structure (walls, poles, etc.) in accordance with the manufacturer's installation recommendations.

2. Check that all mounts and fasteners are free of rust, corrosion, etc.

ANALYSIS

Verify that the combined weights of the camera and housing do not exceed the load limits of the mounts specified by the manufacturer.

Camera mount specifications.

DEMONSTRATION

1. If pan/tilt camera mounts are used, demonstrate that the pan and tilt motion of the mounts follow control commands smoothly and without jerking motion (observe the monitor display

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Performance Characteristic/Measurement Procedure	Measurement Equipment
while exercising the controls). Deficiences may be due to improper installation.	
2. Verify that the pan/tilt mounts are equipped with appropriate limit stops and that the cabling is allowed to follow the camera movement freely.	
CAMERA HOUSINGS	
INSPECTION	
1. Verify that the camera housing(s) are properly installed and free of dirt and corrosion.	
2. For special environmental housings, inspect the enclosures to ensure that hatches and doors are properly installed and fastened with the specified hardware.	
3. Check that the housing windows are clean and, if equipped with a blower, check that the air filter is clean.	
4. Verify that the air blower operates properly and provides sufficient cooling for the electronic equipment.	
5. Inspect all seals on environmental enclosures (camera housings, cable boxes, etc.) for signs of deterioration, and proper fit.	
6. Open the enclosure and inspect for signs of corrosion, dirt and water leakage.	
7. If electrical heaters are employed in the environmental enclosures, check for proper installation; i.e., proper electrical insulation and mechanical placement. (Refer to housing manuals.)	Camera housing manuals.
8. If windshield wipers are provided on the camera housing, check that they are installed properly so that they cover the area in front of the camera lens.	
9. Inspect the windshield for scratches that may have been caused by a damaged wiper or abrasive action.	735 201

Performance Characteristic/Measurement Procedure	Measurement Equipment
10. Check that there are no obstructions which could prevent the air blower from rotating freely.	
ANALYSIS	
1. Assure that the temperature and humidity variations of the environment at the facility do not exceed the ranges specified by the manufacturer.	Housing specifications.
2. Determine that any heater system installed in the environmental enclosure is compatible with the enclosure and meets the manufacturer's requirements.	
3. Determine that the power cables are of sufficient gauge to carry the required current over the distance from the power source.	
4. Verify that provisions are made to protect the equipment from overheating due to heater thermostat or blower failure.	
DEMONSTRATION	
1. Demonstrate that the heating elements operate when the ambient temperature falls below a preselected value (refer to manufacturer's specifications). The following procedure may be used when the ambient temperature is above the preselected heater activation temperature:	Manufacturer's specifications.
(a) Connect a voltmeter across the heater terminals and observe whether or not voltage is applied to the heater (under the conditions specified above, no voltage should be present).	Voltmeter such as Simpson Model 260.
(b) Locate the temperature sensing element in the enclosure and cool it below ambient temperature with the spray from a quick-freeze aerosol.	Quick-freeze aerosol.
(c) Upon application of a quick-freeze spray the heater control circuit should supply current to the heater and the specified voltage should appear at the heater terminals.	

Performance Characteristic/Measurement Procedure	Measurement Equipment
2. If the ambient temperature is <u>below</u> the preselected value verify that the heater is operating by feeling the heater element or by noting that voltage is applied to the heater.	
3. Demonstrate that the windshield wipers keep the windshield free of streaks and water droplets. The judgment of proper operation is to be made by observing a scene on a TV monitor. The windshield should be sprayed with water to simulate driving rain. Make sure that the windshield is completely wet before activating the wipers.	Water spray can.
LENSES	
<u>INSPECTION</u>	
1. In preoperational inspections all lenses should be inspected to verify that their focal length and relative aperture (F-stop) agree with the installation specifications.	Installation plans and specifications.
2. In operational inspections, verify that the lenses are free of scratches, dirt spots, and fingerprints.	
3. Verify that the lenses are firmly attached to the cameras.	
4. Check that all external lens zoom control wiring is secure and that there are no signs of corrosion, water leakage or condensation at the connectors.	
<u>ANALYSIS</u>	
1. Determine from the licensee's maintenance records that the zoom lenses have performed properly and that any malfunctions which have occurred were corrected properly.	Licensee's maintenance records.
2. Review the licensee's maintenance records and/or security logs to determine if malfunctions of the iris have been observed. Compute and record the frequency of failures (preferably for each unit) over the period of time since the last inspection.	Licensee's maintenance records.

Performance Characteristic/Measurement Procedure	Measurement Equipment
DEMONSTRATION/TEST	
1. Demonstrate that all zoom lenses employed in the system can be operated over the specified zoom range. While the television is operating, an arbitrary but fixed target (tree, building, post, etc.) is to be observed on the monitor. Measure the size of this object on the monitor with a ruler for both extreme positions of the zoom. The ratio of these measurements should be the same as specified for the zoom range. If the ratio is significantly less than specified, the operation of the control is faulty or the wrong lens is installed.	Ruler or measuring tape. Zoom lens specifications.
2. Demonstrate that the iris control responds properly to artificially induced light level changes. Point the camera at a well illuminated area and observe the scene on the TV monitor. Place a neutral density filter of value 1.0 in front of the lens and observe the automatic iris compensation on the TV monitor. The brightness of the scene displayed on the video monitor should not be significantly different with the filter in place. Remove the filter and observe that the automatic iris again operates to produce a normal picture.	Neutral density filter of value 1.0 and approximately 4 in (10 cm) in diameter.
3. Observe the operation of the camera (i.e., quality of scenes produced) at night under artificial illumination conditions.	
4. Photograph day and night scenes produced by each camera for comparison with scenes observed in future inspections.	Polaroid camera with close-up lens set.
CABLES	
INSPECTION/ANALYSIS	
1. Check that all cables are installed according to the licensee's installation plans.	Licensee's cable installation plans.
2. Verify that all exposed cables are not damaged and there are no sharp bends or abrasions of the insulation.	
3. Check that cables are protected from damage caused by motion of the camera mount, etc.	

Performance Characteristic/Measurement Procedure	Measurement Equipment
4. Check that all cable feedthroughs and all cable ports have the proper covers or seals. These areas should be examined with special care since they are likely trouble spots at which cable damage can occur.	
5. Check that all signal cables are shielded. In order to reduce electrical interference pickup, the TV signal cables should be routed in separate conduit. TV signal cables should never be collocated in conduit with power cables.	
6. Verify that all power and signal cable are suitable for the facility environment. For example, all outdoor connectors should be of sealed, waterproof design.	
7. Carefully check the cable-connector interfaces for frayed or broken insulation, signs of corrosion and condensation.	
8. Check that screw-on type connectors are tight and do not show any marks indicating that they were tightened with pliers or similar tools unless the installation procedures call for the use of such tools.	
9. Check that all signal cables are protected from lightning/voltage surges by fuses, surge arrestors or other appropriate devices.	
10. If cable equalizers are employed on the video lines ensure that they are properly installed and adjusted according to the manufacturer's specifications.	Cable equalizer specifications.
MONITORS	
INSPECTION	
1. Verify that all TV monitors are installed in accordance with the manufacturer's installation recommendations. Ensure that adequate ventilation is provided.	Manufacturer's installation manual.

Performance Characteristic/Measurement Procedure	Measurement Equipment
2. Verify that sun shades or other devices are employed, as appropriate, to shield the face of the monitor from glare due to all sources of light in the monitoring station.	
3. Check that the monitors are installed in the position that is convenient for the security guard. See evaluation procedure VII-1.A (CRT Displays) for additional guidance in evaluating the installation of the monitor.	
4. Check that the termination impedance of the monitor (75 Ω or "high") is correct for the monitor application. Refer to the video system plans and manufacturer's operations manual.	Monitor operator's manual.
DEMONSTRATION	
Verify that all monitors are operational (including any spares and that a clear picture is produced without interference from glare under all possible lighting conditions.	
VIDEO TAPE RECORDERS	
INSTALLATION	
1. Verify that any video tape recorder used in the system is installed in accordance with the manufacturer's recommendations.	Manufacturer's installation manual.
2. Check that the location in which the recorder is installed has provisions for adequate ventilation.	
3. If the recorder is provided with a dust cover to protect the recording heads from contamination, verify that it is properly installed.	
DEMONSTRATION	
Have the licensee tape record scenes from all cameras used with the device. Play back the scenes and observe that the scenes are sharp and clear, and exhibit no tearing or synchronization difficulties.	735 206

Performance Characteristic/Measurement Procedure	Measurement Equipment
CONTROLS AND ADJUSTMENTS	
INSPECTION	
1. The controls available to the operators should be minimized as specified. The controls which should be accessible are brightness and contrast controls on the video monitors, pan, tilt and zoom controls for the cameras, and if applicable, switches for manual camera monitor or video tape recorder selection. Camera controls such as beam, focus, setup, and black level compensation and video tape recorder controls such as skew and tracking should be located behind tamper-proof covers, since they are used to optimize performance and should be adjusted only by qualified maintenance personnel.	
2. Take note of the position of these controls and determine whether or not they have been altered since the last inspection. All adjustments should be recorded in the licensee's maintenance records.	Licensee's maintenance records.
DEMONSTRATION	
1. Exercise all controls to demonstrate their proper function and range as specified in the appropriate operation manual. If any deficiencies exist, the equipment should be serviced by a qualified technician.	Manufacturer's operation manuals.
(a) Pan, tilt and zoom motions should be smooth and reversible; no visible backlash should be observed on the TV monitor. Deactivation of the controls should stop the motion within less than one second unless otherwise specified.	
(b) Contrast and brightness adjustments on the video monitor should produce a pleasing picture having good contrast under daylight conditions at their midpoint setting.	
(c) The field of the monitor should be able to be completely filled; no edges of the scan field should be visible.	
(d) The monitor picture should be free of double images or ghosts and of noise (snow). Posts, or similar vertical objects in the field of view, should not be distorted.	

CAMERA SWITCHING

DEMONSTRATION

1. Demonstrate that all the cameras can be switched either manually or automatically to the TV monitor or monitors.

2. Demonstrate that the pictures come on the display instantaneously (i.e., in less than the response time of the eye) and that there are no initial distortions. After switching, the picture should remain stationary without flicker or roll until a new switching sequence is initiated.

3. If an alarm trigger is provided, demonstrate that the camera or cameras surveying the sector in which the alarm has occurred are switched to the monitor immediately (less than the response time of the eye) and that the whole sector in which the alarm has occurred can be observed by the operator on either one or more monitors if necessary.

4. If video recording capability is provided, have the licensee demonstrate that it operates as described in the licensee's physical security plan (among the type of recording systems that may be encountered are time lapse and alarm triggered storage).

TEST

Test the automatic alarm trigger system (if provided) by having a person walk into the appropriate protected area to activate an alarm. This test should also be repeated by having the person run at different speeds in the near and far fields of the camera to ensure that the security guard can identify that an intruder is in the area.

If the cameras are on pan/tilt mounts (i.e., not on fixed mounts) then the time required for the observer to find the intruder should be measured. For example, measure the time required for the pan/tilt mount to move the camera from one extreme position to the other. Verify that the time falls within the limits specified in the manufacturer's specifications and that the access time is suitable for the security system. If the cameras are used for security alarm assessment, this access time has a significant impact on the ability of the security force to respond to the threat.

Stop watch timer.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
SYSTEM PARAMETERS	
The purpose of the evaluation is to measure the system operational parameters (i.e., field of view, resolution, gray scale, illumination levels) and to verify that they fall within the range specified in the physical security plan.	
FIELD OF VIEW	
INSPECTION	
Verify in operational inspections that no new obstacles such as trenches, fences, walls, small buildings, working huts, etc., have been placed in the field of view which produce blind areas.	
ANALYSIS	
Analyze the coverage provided by the surveillance cameras by reviewing the camera coverage plans. Determine whether or not blind areas such as the areas immediately below and to the side of the cameras exist, and ensure that other cameras or intrusion detection sensors cover these areas.	Camera coverage plans.
DEMONSTRATION	
1. Demonstrate that the area to be covered by the television surveillance is the same as the planned coverage. Have a member of the inspection team walk through the surveillance area in a systematic manner, such as in a grid pattern, to determine the extremes of the coverage area and the location of any blind areas. Fixed markers should be placed on the sides of the coverage area and should be observable on the TV monitor.	
2. Photograph the displays on the television monitors for the various areas of television coverage for comparison with results of future inspections.	Polaroid camera with close-up lens set.

Performance Characteristic/Measurement Procedure	Measurement Equipment
ILLUMINATION LEVELS	
DEMONSTRATION	
Demonstrate that the TV camera system is capable of obtaining clear pictures under all possible lighting conditions (both daylight and artificial lighting at night).	
ANALYSIS	
Verify that the light sensitivity of the camera/lens combination, as specified by the manufacturer, covers the range of light levels encountered during normal operation. The expected light levels should be available from records obtained and kept by the licensee (i.e., maximum and minimum values for both day and night). Use a faceplate illumination calculator to convert scene illumination values into camera faceplate illumination. (Select an appropriate scene reflection value from the table on the calculator.)	Licensee's illumination data. Faceplate illumination calculator such as that available from General Electric Co. Microwave and Imaging Division, PRODSEC, Syracuse, NY 130201.
TEST	
1. Measure the scene brightness (radiance) in the field of view of the cameras with a calibrated photometer. The measured values should be consistent with the values used in the Analysis above. Repeat these measurements at different times of the day and night as well as under different weather conditions.	Photometer such as United Detector Technology Model 40X equipped with a photometric filter and cosine-corrected foot-candle diffuser.
2. Verify that the measured scene illumination is sufficient to create the required faceplate illumination on the camera tube. The measured illumination values, appropriate values for the reflection coefficients and the lens parameters should be used in the equation:	
$\text{Faceplate Illumination} = \frac{\text{Scene Illumination} \times \text{Scene Reflectivity} \times \text{Lens Transmission}}{4 \times [\text{F-Number of Lens}]^2}$	
The resulting faceplate illumination should be well within the range given by the camera manufacturer.	
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Performance Characteristic/Measurement Procedure	Measurement Equipment
RESOLUTION	
ANALYSIS	
1. Determine by analysis that, with the existing camera/lens combination, the image of a person or object 6 ft (1.8 m) high at the far end of the planned surveillance range appears on the television monitor to be at least 35 scan lines high. For verification use the equations below. The calculated maximum surveillance range should be equal to or larger than the planned surveillance range.	Field of view nomograph for CCTV lenses such as that contained in Vicon Application Notes Sheet No. 205 and Tech. Note No. 245.
$\text{Maximum Surveillance Range (ft)} = 150 \times \frac{\text{Focal Length of Lens (in)}}{\text{Diameter of Vidicon (in)}}$	
or	
$\text{Maximum Surveillance Range (m)} = 45 \times \frac{\text{Focal Length of Lens (cm)}}{\text{Diameter of Vidicon (cm)}}$	
For zoom lenses, repeat the calculation for both the minimum and the maximum focal lengths available.	
2. Verify that the resolution (bandwidth) of any video tape recorder used in the system is compatible with the video system so that information is not lost in the recording process.	
DEMONSTRATION	
Demonstrate that the image of a person at the far end of the planned surveillance range appears on the screen to be of a size equivalent to at least 35 TV scan lines.	
TEST	
1. Measure the resolution of the TV monitors by replacing the camera input with a calibrated video tape recorder and playing a tape upon which a resolution chart has been recorded. Verify that the center and corner resolution observed is equal to or exceeds the monitor specifications. If any degradation in performance since the last inspection is observed, the monitor should be serviced by a qualified technician.	Portable video tape recorder. Prerecorded resolution chart test tape.
2. Measure the resolution of the real-time video system by placing a resolution chart in the field of view of the camera. The	Resolution chart consisting of a black and white

Performance Characteristic/Measurement Procedure	Measurement Equipment
resolution chart should consist of both equally spaced horizontal and vertical bars. The bar pattern is to be moved away from the camera to a distance at which the individual images of the bars can no longer be separated. Measure and record this distance (measurement of the distance to a fixed landmark is sufficient). It is to be expected that two distances will be measured: one for the horizontal pattern and one for the vertical pattern. Compare these distances with those obtained in previous inspection visits with the same bar chart. If there are discrepancies of more than ± 20 percent, a careful mechanical and electrical realignment of the system is required. Repeat these measurements during the night in order to ensure that illumination levels are sufficient to maintain the daytime resolution.	horizontal bar pattern and a vertical bar pattern (must be developed).
3. For video tape recorders, obtain a test pattern taper (available from the recorder manufacturer) and play it on the recorder. Verify that the observed resolution meets or exceeds the recorder specifications. Take note of the resolution observed for comparison with future results.	
GRAY SCALE	
TEST	
1. Measure the gray scale rendering capability of the TV monitor by replacing the camera input with a calibrated video tape recorder and playing a tape upon which a gray scale test chart has been recorded. Verify that the number of shades of gray (maximum of 10) discernible is equal to or exceeds the monitor specifications. If any degradation in performance since the last inspection is observed, the monitor should be serviced by a qualified technician.	Calibrated portable video tape recorder. Prerecorded gray scale test chart tape.
2. Measure the gray scale performance of the entire real-time video system by placing a gray scale test chart in the camera field of view in such a location that the image of the chart appears at the center of the monitor screen and that it is approximately one quarter of the width of the screen. The observed gray scale rendition should not be significantly different from that of the monitor (as measured in step (1) above). If it is, the	Gray scale test chart (must be developed).

TV camera and communications link should be examined by a qualified technician.

3. For video tape recorders, play a prerecorded gray scale test tape (available from the recorder manufacturer) on the machine and verify that its gray scale performance meets or exceeds the recorder specifications.

SPOOFING AND TAMPERING

The purpose of this evaluation is to determine the resistance of the TV surveillance system to tampering (attempts that mechanically or electrically deactivate the system) and to spoofing (attempts that render the system incapable of reacting without any physical changes in the system itself).

INSPECTION/ANALYSIS

1. Inspect all mechanical and electrical tamper protection devices including tamper switches on camera housings, cable distribution boxes, electronic cabinets and power supplies for proper installation.

2. Verify that all vital electronic components are protected by tamper proof locks, doors or covers and that no possibilities exist to bypass those devices. Signal rerouting should not be possible.

3. If automatic or manual switchover to video recorders is provided by the system, determine that there is no possibility that in case of automatic or manual activation of the TV system a tape recording will be displayed on the monitor and not the real scene.

DEMONSTRATION

1. Demonstrate that the opening of any door, cover or lock protected by a tamper switch will result in an alarm.

Performance Characteristic/Measurement Procedure	Measurement Equipment
2. Demonstrate that any switching of signal lines (i.e., by disconnecting and reconnecting) will cause an alarm as a result of either tamper protection or line supervision circuitry. 3. If the system has provisions to produce an alarm as a result of loss of video, demonstrate the feature as follows: (a) Disconnect a video cable completely to simulate complete loss of composite video signal. An alarm should be generated in video line supervised systems. (b) Cover the lens of a camera with an opaque object to simulate loss of video. An alarm should be generated in video line supervised systems. INTERFERENCE The purpose of this evaluation is to determine if visual obstructions and electrical noise interfere with the function of the system. IMAGE BURN-IN INSPECTION Check the camera for image burn-in. Cover the camera lens completely and observe the scene on the monitor. Any scene displayed on the monitor should disappear completely within 10 to 20 seconds. If not, the vidicon on the TV camera should be replaced. Note: Most video cameras equipped with standard vidicons are susceptible to burn-in. If ever such a camera views a specific scene without an occasional change in viewing angle, the vidicon develops a memory of the scene. This scene would be displayed on a monitor, even when the camera lens is covered for days or weeks.	

OPTICAL INTERFERENCE

INSPECTION

1. Inspect the surveillance area during the day and at night for possible optical interference such as:

(a) Sections of the field of view that may be obscured by permanent or temporary structures (fences, vehicles, small buildings, etc.).

(b) Sections within the field of view that may not be covered by the cameras (ditches, gullies, etc.)

(c) Bright lights that may interfere with the proper operation of the cameras, especially lights in parking lots and headlights of cars driving within or in the vicinity of the surveillance area. The surveillance area should not contain large areas of very low contrast where an intruder could pass undetected.

DEMONSTRATION

Demonstrate that during day and night no optical interference occurs in the surveillance areas. Give special emphasis to the examination of very bright sunlit areas as well as dark shadow areas. See the evaluation procedures for FIELD OF VIEW.

ELECTRICAL INTERFERENCE

INSPECTION

Inspect the surveillance area for possible sources of electrical interference such as transformer and power lines in close proximity to video cables and distribution boxes. (The video cables should be shielded and should not be in the same conduit as power cables.)

Performance Characteristic/Measurement Procedure	Measurement Equipment
DEMONSTRATION	
With all the electronic equipment operating, demonstrate that no electronic interference exists. The video picture should exhibit neither "herringbone" patterns (caused by high frequency radiation sources such as a nearby radio broadcasting station) nor vertically rolling black and white horizontal bar patterns (caused by power frequency induction). It is important that these demonstrations be repeated at different times during a 24-hour period in order to ensure that no noise sources are overlooked (i.e., street lights which are on only at night, power tools which are operated only during the day, etc.). In addition, there should be no evidence of multiple scenes being displayed on the monitor. If this condition exists, the licensee should correct the problem.	
MAINTENANCE	
The purpose of this evaluation is to determine that the equipment is properly maintained and that appropriate records are kept.	
ANALYSIS	
1. Verify that the equipment is serviced by properly qualified people.	
2. Verify that the licensee has incorporated the preventive maintenance procedures recommended by the manufacturer. Routine checks of cables, cable connectors, camera housings, lens and lens iris operation, camera operation, etc., should be made.	Manufacturer's maintenance manual.
3. Determine that the maintenance records reflect any maintenance work accurately and that proper care has been taken to keep these records up to date.	Licensee's maintenance records.

Performance Characteristic/Measurement Procedure

Measurement Equipment

POWER

The purpose of this evaluation is to ensure that, in case of power failure, auxiliary systems are immediately available to power the surveillance system.

INSPECTION

Ensure that an auxiliary power system exists. If batteries are used check that they are free of corrosion and that they are maintained in a full state of charge.

DEMONSTRATION

Demonstrate that the auxiliary power system actually takes over during the specified time by shutting down the prime power for the television surveillance system. The whole TV surveillance system should operate without any additional adjustments when on auxiliary power. Since operation on backup power for an extended period may not be feasible, a battery tester should be used to perform a short term load test to determine battery capacity.

Battery tester (must be developed).

SAFETY

The purpose of this evaluation is to ensure that the licensee has incorporated safety measures in the system.

INSPECTION

1. Verify that lightning protection is provided at each camera installation mounted higher than 18 ft (6 m).

2. Verify that lightning protectors are provided on all TV signal lines to protect the equipment from over voltage and surges in the event of a lightning strike.

3. Verify that the power system is properly fused and that all equipment is properly grounded.

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EXPLOSIVES DETECTORS

Gas chromatography is the most common method employed in explosives detectors for security applications. The principal components of a gas chromatograph are the air sample collector and concentrator, the carrier gas injection system, the chromatographic column and the electron capture detector and recorder.

The air sampling system draws a sample of the suspect air at a rate of several liters per minute over a metal surface which adsorbs the trace explosive constituents onto its surface. Vapor selectivity or specificity can, to a degree, be achieved by proper selection of metal. Since explosive effluents may be present in very low concentration, it may be necessary to sample a large volume of air in order to concentrate enough effluent on the adsorbing material so that an analysis can be made.

After the air sample has been taken, a neutral carrier gas (usually argon or helium) is passed over the adsorbing material. The adsorbing material may be heated during this process in order to ensure that the vapors are desorbed and transferred to the carrier gas stream.

The vapor-laden carrier gas then feeds into the chromatographic column. Each constituent has a characteristic retention time in the column which varies according to the vapor pressure of the sample constituents, their solubility in the column material, temperature, etc. The time required by the various constituents to reach the detector (electron capture type) at the selected operating temperature allows an analysis of the vapor to be made.

In the electron capture detector the vapor laden carrier gas is exposed to electrons from a radioactive source (such as tritium

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or nickel-63) and they tend to attach with high probability to the trace constituents* which have high electron affinity. The normal operating current flowing in the detector is reduced in proportion to the concentration of the trace constituents. The signature of the vapor is obtained by recording the detector current as a function of time on a strip-chart recorder. A more practical mode of operation permits automatic programming by providing a time window which is on the order of several seconds duration and which can be located within a retention time interval between zero and 99 seconds. If a particular constituent reaches the detector during the selected time period, a visual or audible alarm is activated. The response of the instrument can be optimized by varying the temperature of the chronatographic column and the pressure of the carrier gas.

The usefulness of a detector of explosives effluents in a practical security system depends on the following instrument characteristics:

- Sensitivity -- the minimum detectable concentration of a trace gas in air.
- Response Time -- the period of time between sample injection and measurable instrument response.
- Specificity -- the uniqueness of the instrumental signature -- the absence of false alarms due to innocuous constituents in air such as perfumes,

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*Molecules containing halogen or nitro-groups typically have a high electron affinity. In the case of dynamite, the major effluent is ethylene glycol dinitrate (EGDN). In the case of TNT, the major constituent is trinitrotoluene, but mononitrotoluene and dinitrotoluene (DNT) are also present in the effluent. Hydrocarbons, such as are found in gasoline or jet fuel, produce no effect.

shaving lotions, shoe polish, and others commonly found in the environment in which the detector is used.

- Convenience -- including portability, warmup time, power consumption, operator training required and frequency of adjustment.

- Cost -- capital investment, operational and maintenance expenditures.

Sensitivity is determined by injecting measured quantities of air saturated with explosives effluent into the airstream sampled by the instrument during normal operation. From the magnitude of the response of the detector to a certain vapor, and from separate determination of the background response (i.e., determination of the signal-to-noise ratio), the minimum detectable concentration can be estimated. Lack of sensitivity would yield a low probability of detecting a well-wrapped, concealed parcel of explosives. The response time clearly is important for security applications of explosive detectors, since it governs the rate at which traffic can flow through the inspection area. Generally the higher the concentration of the effluent, the shorter the response time. However, once an instrument has been exposed to an unduly high concentration of effluent, it may require a recovery time of several minutes or even longer to regain its full sensitivity.

PORTABLE EXPLOSIVES DETECTION COMPONENTS

Most explosives detectors for security applications on the market today are of a portable configuration. In most cases the device can fit into a suitcase. A hand-held sampling probe is used to search the suspect person or object. The primary advantage of the portable explosives detector is that it can be used anywhere, and the location of the explosives can be precisely determined. Specificity of these devices to various explosives effluents varies from manufacturer to manufacturer and, where available, this information has been included in the Catalog data sheet. Some of the portable explosives detectors contained in the Catalog have been evaluated by the Department of Transportation, Transportation Systems Center, Cambridge, MA and the U.S. Army MERADCOM.

WALK-THROUGH EXPLOSIVES DETECTION COMPONENTS

Walk-through explosives detectors employ an "air curtain" within a confined area or portal in order to obtain a sample of the suspect vapor. In general, they are designed for surveillance in fixed installations such as controlled access gateways and are compatible for use with other types of contraband detection devices. Some of the walk-through explosives detectors contained in the Catalog have been evaluated by the Department of Transportation, Transportation Systems Center, Cambridge, MA.

PORTABLE EXPLOSIVES DETECTION COMPONENTS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Portable Explosives Detection Components	V-1.a

Performance Characteristic/Measurement Procedure	Measurement Equipment
SENSITIVITY The purpose of this evaluation is to verify the sensitivity of the detector to various explosive vapors. The licensee should have test targets (samples of various types of explosives) that are used for routine testing.	
DEMONSTRATION	
1. Conceal a 1/2 lb (250 g) stick of 40 percent dynamite anywhere on the body and verify that the detector can precisely pinpoint its location.	Stick of 40 percent dynamite, 1/2 lb (250 g).
2. Perform this demonstration with any other samples of explosive compounds the licensee uses for routine testing. Verify that these samples as well as the stick of dynamite can be located when concealed on the body or in a package or suitcase.	
TEST	
1. In order to perform a quantitative test of sensitivity, a means of introducing a known volume concentration of explosive effluent (calibrated vapor source) must be developed. Several different types of military and commercial explosives should be used to verify claimed sensitivity to various compounds.	Calibrated explosive vapor source(s) for various types of explosives (must be developed).
2. Perform step (1) or (2) of the Demonstration above. After an alarm is obtained measure the length of time it takes for the detector to "clear down" and be able to continue to search. Compare the measured time to the time specified in the manufacturer's data.	Stop watch timer.

Performance Characteristic/Measurement Procedure	Measurement Equipment
OPERATION/SPOOFING	
The purpose of this evaluation is to ensure that the explosives detector operates properly and is used properly as well as to ensure that procedures have been established to reduce the likelihood that "masking" agents could be used to disguise the presence of explosives.	
DEMONSTRATION	
1. Verify that all operators have been trained in the use of the detector and that they are knowledgeable in the expected detector response to both explosive and non-explosive vapors.	
2. Have the detector operator demonstrate the start-up and operating procedure for the device. Verify that this procedure conforms to the procedures in the operating manual.	Manufacturer's operating manual.
3. Have the operator demonstrate the search procedure and the manner in which all positive responses (alarms) are handled. Verify that the procedures used conform to those recommended in the operating manual.	
MAINTENANCE	
The purpose of this evaluation is to verify that the detector is maintained in good operating condition.	
INSPECTION	
1. Inspect the detector for signs of physical abuse or damage (pay particular attention to the sampling probe).	
2. Inspect the battery pack and verify that the electrical connections are clean, free of corrosion and tight, and that the battery is in good condition (no leaking electrolyte, etc.).	
3. Verify that all meters and other indicators respond properly and that all control markings are legible.	
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Performance Characteristic/Measurement Procedure	Measurement Equipment
4. Verify that all controls are in a good state of repair and that they function properly.	
ANALYSIS	
1. Review the licensee's schedule for battery replacement and charging for conformance with the manufacturer's recommendations.	Licensee's battery charging/replacement schedule.
2. Review the licensee's schedule of preventive maintenance as recommended by the manufacturer.	Licensee's maintenance schedule. Manufacturer's operating/maintenance manual.
ENVIRONMENTAL REQUIREMENTS	
The purpose of this evaluation is to ensure that the environmental characteristics of the detector will not be exceeded under normal operating conditions.	
ANALYSIS	
Review the environmental specifications of the detector, particularly humidity requirements (see the appropriate Catalog sheet as well as the manufacturer's operating manual), and verify that the detector is operated only when the conditions are within the specified tolerances.	Manufacturer's operating manual.
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WALK-THROUGH EXPLOSIVES DETECTION COMPONENTS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Walk-through Explosives Detection Components	V-1.b

Performance Characteristic/Measurement Procedure	Measurement Equipment
INSTALLATION/MAINTENANCE	
The purpose of this evaluation is to ensure that the walk-through explosives detector is properly installed and maintained in good operating condition.	
INSPECTION	
1. Verify that the detector is installed according to the recommendations contained in the manufacturer's installation instructions.	Manufacturer's installation instructions.
2. Verify that all electrical and mechanical connections made between the portal and the control console or other components are secure. Also check any electrical connections made to central alarm monitoring equipment and automated response devices.	
3. Check that the detector is free of signs of physical abuse and that all control labels and markings are legible. Take special notice of wear of silk screened information on control panel surfaces.	
4. Verify that the proper carrier gas is used and that the pressure regulator is properly adjusted.	Manufacturer's operating manual.
5. Check that there are no obstructions in the vicinity of the portal which would inhibit or interfere with the operation of the air sampling device. Also check that the unit is located away from fans, ventilators, etc., which could disturb the air sampling system.	
6. Ensure that smoking is prohibited in the vicinity of the detector.	

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Performance Characteristic/Measurement Procedure	Measurement Equipment
ANALYSIS	
1. Verify that the licensee has established a schedule for carrier gas replenishment that is consistent with the manufacturer's recommendations and frequency of use of the system.	Licensee's maintenance schedule.
2. Verify that the licensee has established a schedule of preventive maintenance as recommended by the manufacturer.	Manufacturer's operating/ maintenance manual.
3. Verify by analysis of specifications that any external alarm devices connected to the detector will not exceed the voltage and current ratings of the output relay.	
SENSITIVITY	
The purpose of this evaluation is to verify the sensitivy of the detector to explosive vapors. The licensee should have test targets (samples of various types of explosives) available at the facility that are used for routine testing.	
DEMONSTRATION	
1. Conceal a 1/2 lb (250 g) stick of 40 percent dynamite anywhere on the body under one layer of clothing and enter the detector portal. An alarm should be generated. If no alarm sounds, exit the portal, wait five minutes then enter again. The system should respond positively to approximately 90 percent of the trials.	Stick of 40 percent dynamite, 1/2 lb (250 g).
2. Perform step (1) with any other test targets available from the licensee.	Licensee's test targets (samples of explosive compounds).
TEST	
1. In order to perform a quantitative test of sensitivity, a means of introducing a known volume concentration of explosive effluent (calibrated vapor source) must be developed for field use. Several different types of military and commercial explosives should be used to verify claimed sensitivity to various compounds.	Calibrated explosive vapor source(s) for various types of explosives (must be developed).

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Performance Characteristic/Measurement Procedure	Measurement Equipment
2. Perform step (1) or (2) of the DEMONSTRATION above. After an alarm is obtained, measure the length of time it takes for the system to "clear down" and be able to continue screening personnel. Compare the measured time to the time specified in the manufacturer's data.	Stop watch timer.

OPERATION/TAMPERING

The purpose of this evaluation is to ensure that the explosives detector operates properly and that any provisions for tamper protection function properly.

DEMONSTRATION

1. Verify that all operators have been trained in the use of the system.

2. Observe the operation of the device under normal working conditions. Verify that the operator's controls and detector prompting devices for the entrants operate properly. Make sure that the entrants are held within the air sampling curtain for the amount of time specified by the manufacturer.

3. Verify that the licensee has established procedures for responding to all explosives detector alarms and have the operator demonstrate these actions. At a minimum a manual search of the person as well as any parcels or packages should be included in the procedure.

4. If the device is equipped with tamper protection switches, activate these switches to ensure that an alarm is generated. If the detector is connected in a line supervised monitoring system, perform this demonstration in both the "secure" and "access" modes.

5. If any cabinets or consoles are protected by locks, ensure that the lock functions properly.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
FALSE/NUISANCE ALARM RATE/SPOOFING	
The purpose of this evaluation is to determine the frequency of spurious alarm activation and to ensure that procedures have been established to reduce the likelihood that "masking" agents could be used to disguise the presence of explosives.	
ANALYSIS	
1. Review the operating log or security alarm log and note any spurious alarms by the explosives detector. Calculate the frequency of false/nuisance alarms over the period of time since the last inspection. If false alarms frequently occur, ascertain if the licensee has attempted to determine the cause of the alarms (note that some explosives detectors are sensitive to certain types of shoe polish, after shave lotions, etc.). Verify that the operator is knowledgeable in the expected detector response to both explosive and non-explosive vapors.	Licensee's security alarm log and/or equipment operating log. Manufacturer's operating manual.
2. Review the licensee's procedures for responding to false/nuisance alarms. At a minimum, a hands-on search of the subject should be made.	
ENVIRONMENTAL REQUIREMENTS	
The purpose of this evaluation is to ensure that the environmental characteristics of the facility, or location of the portal, are within the tolerances of the manufacturer's specifications.	
ANALYSIS	
Review the environmental specifications of the system (see the appropriate Catalog sheet as well as the system operating manual) and verify that the conditions at the location of the equipment are within the specified tolerances.	Manufacturer's operating manual.
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FERROUS METAL DETECTORS

All commercial devices that detect only ferrous or magnetic materials operate on the same principles, though the sensor elements in the instruments may differ in shape and use different materials. The characteristics of these devices depend on the sensor element which may be either a magnetometer or gradiometer. A typical magnetometer configuration consist of an oscillator, a cylindrical saturable core wound with two coils (primary and secondary) and a detector circuit, though other core/coil geometries may be used. The primary coil is connected to the oscillator, and the current flowing in the coil drives the core into saturation during a portion of each half-cycle of the driving frequency. As a result of the changing flux in the core, voltage pulses are induced in the secondary coil. The polarity and magnitude of these pulses vary with the rate of change of magnetic flux in the core. When no external field is present, the voltage pulses induced in the secondary coil are evenly spaced in time, and their frequency spectrum contains only odd harmonics. As ferrous metal is brought into the vicinity of the coil the magnetic field is altered, and unevenly spaced voltage pulses are produced in the secondary circuit. When this occurs, the secondary voltage waveform has a frequency spectrum which contains a detectable and measurable second harmonic component (a component at twice the frequency of the oscillator). To improve detection of the second harmonic component, a special circuit tuned to this frequency may be employed in the secondary circuit. A device of this type is called a second harmonic magnetometer.

Another common second harmonic magnetometer configuration consists of a ferrite torroidal core wound with an excitation

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coil (primary coil); a secondary coil is wound diametrically around the core and is called a flux-gate magnetometer. The principles of operation are similar to those discussed above.

When magnetometers are used as weapons detectors, two identical sensor elements are often used and are configured so that only the field gradient (difference) between the elements is detected and measured. This arrangement is called a gradiometer. In all configurations the detection of ferrous metal objects depends on the fact that such objects distort the earth's magnetic field or, if magnetized, provide their own external field.

The principal advantages of magnetometers are their low cost and light weight. Their basic disadvantages are their extreme sensitivity to permanently magnetized materials and their relative insensitivity to ferrous metal objects which are oriented with their major axis at right angles to the earth's field. Of course these devices cannot detect non-ferrous materials; thus they do not protect against weapons made of non-magnetic stainless steel, aluminum, beryllium-copper or plastic.

Many of the hand-held ferrous metal detectors contained in the Catalog are configured in the form of a night stick or club and are rugged enough to be used as such. A few concealed models are available which are strapped onto the body of a guard and are very convenient for covert searches. Hand-held detectors are relatively insensitive to large ferrous metal objects in their vicinity because of their limited range of sensitivity. In addition, they are able to precisely locate ferrous metal objects on the person being searched.

Walk-through ferrous metal detectors can be of very compact size because of their inherent simplicity. A problem that frequently arises in their use is sensitivity to moving ferrous metal (especially if magnetized) in their vicinity. As a result, a great deal of care must be exercised in the selection of a suitable installation location in industrial environments. Many of the devices can be made less sensitive to external effects by proper orientation with respect to the metal object, and the portal itself can be used to determine the best orientation by adjusting its orientation until external effects are minimized.

Because of the fundamental weakness of ferrous metal detectors (their inability to detect weapons or other devices made of nonferrous metal) procedures for follow-up manual search or search with a hand-held detector are generally recommended.

Some of the ferrous metal detectors contained in the Catalog have been evaluated by the Department of Transportation, Transportation Systems Center, Cambridge, MA.

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FERROUS METAL DETECTORS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Hand-Held Ferrous Metal Detection Components	V-2.a
Walk-Through Ferrous Metal Detection Components	V-2.b

Performance Characteristic/Measurement Procedure	Measurement Equipment
Evaluation procedures for ferrous metal detectors will be provided by the U.S. Army MERADCOM in a document prepared under a separate NRC technical assistance contract (AT(49-24)-0260).	

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ALL-METAL DETECTORS

Detectors of all metals measure the disturbances in an alternating electromagnetic field caused by the presence of any metallic object. The field may be characterized by its frequency and uniformity; beyond this, the various manufacturers of these devices use different configurations. Some of the confiugurations/techniques employed are listed below.

- Single coil -- inductance change measured by phase of amplitude variations.
- Dual oscillator -- measurement of beat frequency.
- Dual coils -- measurement of changes in mutual coupling.
- Transmitter/receiver loops -- measurement of transmission losses.
- Marginal oscillator arrangements using feedback changes to vary oscillator output.
- Pulsed field -- eddy current decay detection and analysis.

In a typical walk-through active field all-metal detector, two coils, primary and secondary, are located several feet apart. The primary coil is energized by an oscillator and produces an electromagnetic field which is coupled to the secondary coil. Under quiescent operating conditions the detector circuit, typically a balanced bridge circuit, maintains a zero signal condition at the indicator device. If a metalic object is introduced between the coils, the coupling between the primary and secondary coils is altered, the detector becomes unbalanced and the indicator displays the signal. Magnetic and non-magnetic metals each alter the couling in a different way, and they can be differentiated by noting the polarity of the displayed signal. If the change in field coupling measured by the device exceeds a preselected threshold, an alarm circuit can be actuated.

The simplest form of all-metal detector consists of a single coil of wire which forms one element of an alternating current impedance bridge circuit. A metal object in or near the plane of the coil changes the circuit impedance, unbalances the bridge and results in a signal indicating the presence of the object. Commercial all-metal detectors use many variations of this basic concept.

For maximum effectiveness the all-metal detectors must have high field strength uniformity. Otherwise, performance will vary greatly with the location of a metal object relative to the primary coil. However, the direction of the field should not be uniform, because the orientation of a weapon with respect to the field determines the strength of the interaction. Also, the excitation frequency must not be too high, or the device will be too sensitive to foil wrappers, etc., and will have a high nuisance alarm rate. Many of the less expensive single-coil models operate at high frequencies (20 kHz or higher) and also produce nonuniform fields. The more costly units use multiple coils to improve field uniformity and operate at lower frequencies to improve detection performance. At frequencies below 200 Hz, however, it is difficult to detect weapons made of high-resistivity metals such as stainless steel.

The operation of the most advanced pulsed-field detectors involves the detailed interaction between electromagnetic fields and metal objects. When an object is immersed in an electromagnetic field, circulating currents (eddy currents) are induced in it which give rise to losses and secondary electromagnetic fields which affect the primary circuit both of which are detectable and measurable. The respective magnitudes of these two effects vary with the geometry of the object, its resistivity thickness, and orientation in the field as well as the frequency of the field. As a result, it is possible to determine the "signature" of specific metal objects and to use logic circuitry to identify them. These devices can be optimized by adjustment of the pulse and detection circuitry to discriminate target objects from background objects in order to reduce the occurrence of nuisance alarms.

Walk-through all metal detectors typically consist of a portal, the sides of which contain the search coils, and an electronics console. In most cases the equipment can be operated in the vicinity of other equipment such as x-ray inspection gear. If several units are employed in a confined area it is generally recommended that they be synchronized with each other in order to eliminate mutual interference.

Various levels of search can be made with these devices depending upon the sensitivity setting selected. The usual practice in using walk-through detectors is to require the persons to be screened to divest themselves of all metal objects before entering the portal in order to reduce the incidence of nuisance alarms. If an alarm condition results, hand scanner or manual inspection is required. Among the causes of nuisance alarms are metal supports in shoes (which may be a particularly troublesome source in licensee facilities) and metal foil such as that found in cigarette packages and candy bars. Manual search procedures should be established and adhered to in order to protect against "masking" of a concealed weapon by a known nuisance alarm source.

Hand-held all-metal detectors are compact in size and may be shaped in the form of a club (and are rugged enough to be used as such). These units typically have balance adjustments and provide an audio alarm presentation. The primary advantages of hand-held detectors is that they can precisely locate a metal object concealed on a person's body without hands-on search, and they are insensitive to large metal objects in the nearby vicinity because the detection range is limited to the immediate vicinity of the search coil. Some of the all-metal detectors have been evaluated by the Department of Transportation, Transportation Systems Center, Cambridge, MA.

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ALL-METAL DETECTORS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Hand-Held All-Metal Detection Components	V-3.a
Walk-Through All-Metal Detection Components	V-3.b

Performance Characteristic/Measurement Procedure	Measurement Equipment
Evaluation procedures for all-metal detectors will be provided by the U.S. Army MERADCOM in a document prepared under a separate NRC technical assistance contract (AT(49-24)-0260).	

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SNM DETECTION COMPONENTS

Special nuclear material (SNM) monitors sense the presence of gamma radiation produced both by radioactive decay occurring in soil, rocks and air (natural background radiation) and by radioactive decay occurring in SNM or other radioisotopes which may be within the monitor's field of view. Both sources of radiation can be highly variable. The natural background radiation varies geographically from a few microroentgens per hour in some regions, such as the southeastern United States, to as high as approximately 25 microroentgens per hour in Rocky Mountain cities. The gamma radiation from SNM includes not only the intrinsic radiation from the uranium or plutonium isotopes but also from radionuclides, particularly in the case of spent or recycled material.

The basic problem in the detection of SNM is to distinguish the presence of a significant quantity of SNM from a background that may include natural radiation and radiation from stored SNM, other radioactive material or waste. The amount of background radiation sensed by the monitor is a constraint on its ability to determine that a signal caused by SNM is present. Quantitatively, the magnitude of the variation in the background radiation count is proportional to the square root of that count. False alarms are minimized by setting the alarm level high enough so that the variation in the background count is unlikely to exceed this threshold. The false alarm rate then will remain reasonably constant as the background radiation changes. As the SNM that is to be detected produces a signal or net count that is greater than the square root of the background radiation, it is more likely to be detected. The alarm condition occurs then when the background plus signal is equal to or greater than the background plus the expected variation in the background count.

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Commercially available SNM detectors are configured as walk-through portals and have five basic elements: gamma detector, portal occupancy monitor, signal conditioning electronics, analyzer and logic/control unit. The types of gamma detectors used are solid, liquid and crystal scintillators and Geiger tubes. In a scintillator light pulses are produced as gamma radiation and absorbed by the material. These pulses are converted to electrical signals by means of a photomultiplier. Liquid, plastic and sodium-iodide (NaI) crystal scintillating materials are available which have adequate sensitivity to accumulate a significant signal count in a short period of time. Geiger tube detectors convert the incoming radiation directly to an electrical signal. These devices are, however, much less sensitive than scintillators and are used primarily for radiological health monitoring.

The signal pulses produced by the detector are examined with an analyzer, then transmitted to the control unit, where they are counted and processed by logic circuitry which determines if an alarm condition exists. The portal occupancy monitor allows the logic/control to determine if it is processing background signals or background plus source signals. In this way the background can be updated continuously, and separate alarms can be generated if the background exceeds a preselected threshold.

In choosing the location for an SNM monitor it must be kept in mind that the signal count will be essentially the same for the same amount of SNM to be detected independent of where the monitor is located, but that the background may vary from one location to another. At some location the variation in the background may be large enough so that the signal is no longer detectable, and the monitor will no longer have adequate sensitivity. If the sensitivity of a given monitor configuration is found to be background-limited, it may be possible to increase the signal by modifying the configuration (e.g., by decreasing the distance between the target material and the detector, or by adding shielding in an appropriate way). In any case it is best to select a monitor location that has a background low enough for proper operation. Increases or other variations in background radiation at the monitor location might be caused by the storage or movement of process materials in its vicinity, and could produce nuisance alarms.

Another means of reducing the sensitivity of a SNM monitor is to reduce the signal. This may be done by transporting the source (target) material around the monitor (circumvention); by moving the source rapidly through the monitor (for example, by throwing it or swinging it through the monitor so that it spends little time within the detector's field of view); or by shielding the source with an appropriate material. To prevent circumvention and rapid transport, some combination of barriers and supervision of the traffic flow is required.

Shielding by means of lead or other metals is particularly effective in hiding uranium 235. Small quantitites of uranium 235, perhaps up to 200 grams, shielded by 0.32 cm of lead might not be detected by an SNM portal monitor. Such a shielded source might also be undetectable by means of a metal detector unless special provision is made to operate the metal detector at very high sensitivity. In order to reduce the ease of transporting such shielded material, a separate search of hand baggage, parcels, etc., may be necessary and/or a high sensitivity all-metal detector should be used in conjunction with the SNM detector.

SNM DETECTION COMPONENTS

EQUIPMENT CATEGORY	CATALOG REFERENCE
SNM Detection Components	V-4.a

Performance Characteristic/Measurement Procedure	Measurement Equipment
Evaluation procedures for SNM detectors are being prepared by the Los Alamos Scientific Laboratories (LASL) under a separate NRC technical assistance contract. The procedures will appear in a separate document prepared by LASL.	

X-RAY INSPECTION EQUIPMENT

An X-ray package inspection system has four principal components: X-ray source, image converter, protective enclosure and parcel-transport mechanism. In operation, the package to be inspected is placed in front of the image converter and illuminated with X-rays. To an extent depending on the mass and X-ray absorbing properties of the package materials and its contents, the X-rays are attenuated, producing a shadow on the image converter. The converter, a fluoroscopic screen, converts the X-ray shadow pattern to a visible image. This may be viewed directly or may first require amplifcation by an image intensifier. The image may also be scanned by a television camera and displayed on a monitor. The components are enclosed within a shielded cabinet or housing which protects the operator from X-ray exposure.* The transport mechanism for exposing single or multiple objects may be either a simple manual loading arrangement or a mechanized conveyor system.

The primary parameters of an X-ray system are dosage, exposure time, resolution and contrast. Three levels of X-ray dosage are commonly discussed in the literature: high-dose, low-dose and film-safe-dose. A high-dose system is one which operates at an X-ray flux rate at the fluorescent screen on the order of 10,000 to 100,000 R/hr. At such a high-flux rate the image produced on the fluorescent screen can be viewed with the naked eye. High-dose systems are characterized by their "refrigerator-type" cabinets, which are heavily shielded. They are typically used to inspect large parcels or dense objects.

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*The maximum permissible level of X-ray leakage from cabinet X-ray systems is 0.5 milliRoentgens per hour (mR/hr). The regulatory authority for X-ray equipment of this type is the Bureau of Radiological Health, Rockville, MD.

In low-dose systems the X-ray flux is less than that of high-dose systems by four or five orders of magnitude, less than 10 R/hr. As a result, the fluoroscopic image intensity is much less, and a light-amplifying device (image intensifier) is incorporated to provide compensation. As a result of the low-flux rate and attendant low X-ray scattering, these low-dose units require only lightly shielded cabinets, making it possible to use high throughput transport mechanisms. Low-dose units are also smaller, lighter and more easily used than high-dose units. Most X-ray systems used in security applications are of the low-dose type.

A film-safe system is one in which the X-ray exposure per article inspection is less than 1 mR (0.001 R)*. By comparision, in a high-dose system an article would receive a dose of several Roentgens during a nominal inspection time of a few seconds. All photographic film is sensitive to X-ray exposure. At the film-safe level, however, the amount of film fogging produced by as many as five exposures will be undetectable on amateur-type photographic emulsions. Most low-dose X-ray systems used in security applications today meet the film-safe exposure specification.

There are three basic low-dose X-ray techniques: continuous, pulsed and scanning X-ray. A continuous X-ray system operates with a low-level X-ray beam which, when activated, illuminates the parcel. The image produced on the screen is of low intensity and must be amplified by a multistage light amplifier. The image produced by the amplifier may be viewed directly, or can be scanned by a closed-circuit television camera and displayed on a monitor either at the system control console or at any other remote location.

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*The film-safe exposure limit is specified by the National Association of Photographic Manufacturers, Inc., Harrison, NY.

In a pulsed X-ray system, the article being inspected is illuminated by a low-level, short-duration pulse of X-rays, and the shadow image is formed on a fluoroscopic screen. During the short time that the screen is illuminated, the shadow image is intensified and then scanned by a closed-circuit television camera. The video image is stored in an electronic storage device and is available for display on a television monitor. Before another article is scanned, the stored television image must be cleared from the storage device.

Scanning X-ray beam systems use a combination of X-ray beam scan along one axis and parcel motion along an axis at 90° to the scanning beam to produce a two-dimensional image of the parcel. The scanning beam is produced by a slotted rotating disk and detected by a sodium iodide (NaI) scintillator detector. The electrical signal produced in this fashion is converted to a television image signal and displayed on a monitor.

A given X-ray system's ability to enable an operator to identify weapons, contraband, explosives, etc., depends on the X-ray optics design (X-ray energy spectrum, uniformity of package coverage, distortion); on the method of transport and operator control; and most importantly, on the viewed image quality (brightness, resolution, contrast, etc.). X-ray systems for security applications should be capable of resolving a 24-gauge (0.02 in(0.5 mm) diameter) copper wire and be capable of distinguishing 10 shades of gray. In general low-dose units produce poorer-quality images than high-dose units, but have superior display systems and may have better detection than the high-dose units.

X-ray systems should be considered as screening systems rather than detection systems, because combinations of circumstances prevent them from fully imaging all the contents of a package. For example, items can be concealed in the metal frame of a handbag; items can be concealed within heavy-metal containers of various shapes; and low-atomic-number materials (substances composed of carbon, oxygen and nitrogen) may not always be clearly imaged. Therefore, it is often necessary to perform a hands-on inspection of suspect articles rather than to rely solely on viewing an X-ray image.

X-RAY INSPECTION EQUIPMENT

EQUIPMENT CATEGORY	CATALOG REFERENCE
X-Ray Inspection Equipment	V-5.a

Performance Characteristic/Measurement Procedure	Measurement Equipment

INSTALLATION/MAINTENANCE

X-ray inspection systems are sold as self-contained units and as such require a minimum amount of preparation for installation. It is essential, however, that the unit be assembled in accordance with the manufacturer's recommendations in order to ensure that the radiation leakage levels specified by the Bureau of Radiological Health will not be exceeded. Due to the sophistication of X-ray systems, service and maintenance contracts are available from the manufacturers. The Bureau of Radiological Health requires that cabinet X-ray systems be tested annually for radiation leakage. The purpose of this evaluation is to ascertain that the equipment has been installed and maintained in accordance with the manufacturer's recommendations.

INSPECTION

1. Inspect the X-ray unit and control console (if separate) for signs of physical abuse, damage, or excessive wear (especially in the vicinity of the X-ray source and package loading area).

2. Verify that the electrical wiring between the X-ray unit and control console (if separate) is protected from damage (e.g., ensure that it is in a protective enclosure or stored away from moving parts). Verify that all wiring insulation is free of cuts and abrasions.

3. Verify that all external electrical and mechanical connectors are tight, clean and free of corrosion.

4. Verify that all control knobs and panels are clean and that any labels or markings are legible. Take special notice of wear of silk screened control setting information on control panel surfaces.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
5. Check that internal wiring is free of dust, spilled substances or other foreign objects.	
6. Check that the system display is located such that it is not subject to glare from natural or artificial light sources.	
7. For systems which employ a remote console ensure that the cable length (signal transmission distance) has not been exceeded.	
ANALYSIS	
1. Determine how the licensee maintains the equipment (i.e., by service/maintenance contract with the manufacturer or by specially trained in-house technicians). If in-house technicians are used, review their records of training and experience to ensure that they are qualified to maintain the equipment.	
2. Review the licensee's schedule of maintenance for the equipment and verify that all the manufacturer's recommended preventive maintenance procedures are incorporated in the schedule.	Licensee's test/maintenance schedule.
3. Examine the licensee's maintenance log to ensure that scheduled maintenance has been performed. In addition, note the date of the last radiation leakage test (and the results of this test) and determine from the licensee's schedule when the next test is to be performed.	
RESOLUTION/GREY SCALE	
The purpose of this evaluation is to ensure that the resolution of the operating X-ray equipment meets or exceeds the manufacturer's specifications. Resolution is a measure of the system's ability to produce an image of a small object (usually a wire). Grey scale performance is a measure of the ability of the system to produce usable images of objects of different density. Both characteristics are important indicators of overall system performance. Note that there are several different types of X-ray systems -- some	

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Performance Characteristic/Measurement Procedure	Measurement Equipment
permit direct visual inspection of a fluoroscopic X-ray image; others provide a televised picture of the fluoroscopic X-ray image. The complexity of the imaging system and controls for image optimization are greatest in the televised image systems. The evaluation procedures which follow are intended to indicate overall system performance and do not address the performance of individual components.	
Note: This evaluation is intended to determine system performance under normal operating conditions. Therefore, it is recommended that the inspectors test the system immediately upon arrival at the facility. No internal adjustments of the system should be allowed prior to the test; only those adjustments available to the operator under routine operating conditions to optimize the image should be permitted.	
<u>TEST/ANALYSIS</u>	
A. RESOLUTION	
1. Place a resolution test chart in the inspection area and observe the image produced on the X-ray system display. 2. Determine the smallest size wire that can be clearly distinguished. Verify that this wire size is equal to or less than the manufacturer's specified minimum resolvable wire size (usually 24 gauge copper wire to meet FAA requirements).	Resolution test chart which consists of 6.3 in (15 cm) length of both bare and vinyl insulated copper wire of 24, 26, 28, 30, and 32 gauge and mounted on an appropriately sized 1/8 inch thick sheet of plexiglass (must be fabricated; refer to NILECJ-STD-060.00).
3. Photograph the display of the chart and record all operator control settings, ambient lighting conditions and photographic exposure data on the reverse side of the photograph. Compare this photograph and data to photographs made in previous inspections. There should be no substantial differences in the equality of the images produced by the X-ray system.	Polaroid camera with close-up lens set.
B. GREY SCALE	
1. Place a grey scale test chart in the inspection area and observe the image produced on the X-ray system display.	Grey scale test chart (such as the X-ray test pattern available from

Performance Characteristic/Measurement Procedure	Measurement Equipment
2. Determine the number of discrete grey scale steps that can be clearly distinguished. Compare this number to the value specified by the manufacturer; the system should be capable of distinguishing a number equal to or greater than that specified.	Phillips Electronic Instruments, Model 650-903-01, cost $50.00).
3. Photograph the display and record all operator control settings, ambient lighting conditions and photographic exposure data on the reverse side of the photograph. Compare this photograph and data to photographs made in previous inspections. There should be no substantial differences in the quality of the images produced by the X-ray system.	Polaroid camera with close-up lens set.
Note: If the system performance is found to be inferior to that specified by the manufacturer or observed in previous inspections, then corrective actions should be taken by the licensee.	
<u>OPERATION/SPOOFING AND TAMPERING</u>	
The purpose of this evaluation is to ensure that the X-ray system operates properly. Depending upon the type of X-ray system various modes of operation are available (e.g., automatic or manual parcel transport; various display modes). It is also important that the licensee has adopted inspection procedures in which all suspect articles are thoroughly inspected by hand.	
<u>DEMONSTRATION</u>	
Note: Perform the following under normal operating conditions.	
1. For manual package loading systems observe that the packages are inserted properly and that the X-ray scan does not begin until the operator is clear of the inspection area (that is, verify that any safety interlocks function properly).	Manufacturer's operating manual.
2. For conveyor loading systems, observe that start and stop controls function properly (in some systems, the conveyor is automatically controlled).	
3. For direct viewing systems, observe that the image can be optimized to compensate for variations in ambient lighting.	735 249

4. For systems equipped with a television display:

(a) Observe that there is no perceptible image jitter in either the horizontal or vertical directions.

(b) Verify that the horizontal hold and vertical hold controls have sufficient latitude to produce a stable picture (the controls should be at approximately mid-range in a properly adjusted system).

(c) Verify that the brightness and contrast controls have sufficient range to produce a usable image under all illumination conditions. If the manufacturer specifies optimum settings for these controls verify that these settings are used.

5. If any cabinets in the system are protected by tamper switches, verify that a tamper alarm is generated when the cabinet is opened.

TEST

Place a standard test target in the inspection area and observe that the operator can identify all the contents that are not purposely obscured by other objects. For those objects that are concealed (i.e., contained within a metal box) the operator should request that the package be opened for a detailed manual search.

Standard test target:
An attache case containing the following objects:

- paper clips,
- razor blades,
- folding pen knife,
- .22 caliber pistol (or similar metal shape -- see NILECJ-STD-0602.00),
- plastic molding clay (to simulate plastic explosives), and
- metal box capable of holding the pistol.

Performance Characteristic/Measurement Procedure	Measurement Equipment
ENVIRONMENTAL REQUIREMENTS	
The purpose of this evaluation is to ensure that the environmental characteristics of the facility, or at the location of the X-ray equipment, are within the tolerances of the manufacturer's specifications.	
ANALYSIS	
Review the environmental specifications of the system (see the appropriate Catalog sheet as well as the manufacturer's operating manual) and verify that the conditions in the location of the equipment are within the specified tolerances.	Manufacturer's operating manual.

SIREN, BELL AND AUTOMATIC ILLUMINATION CONTROLS

Siren and bell controls are designed to activate auditory signaling devices, while automatic illumination controls are designed to activate lights. This is usually done in the vicinity of an intrusion to scare the intruder into fleeing and to attract personnel/security forces to the location of the intrusion. A siren control typically is an electronics module (usually a printed-circuit card), either self-contained or suitable for mounting inside a security control panel enclosure. A loudspeaker capable of handling the driver output characteristics (power, frequency, impedance) must also be provided in an enclosure suitable for the environment. A bell control is usually a simple switch closure, provided either by an alarm security control panel relay closure or by a sensor with a normally open (NO) switch configuration (e.g., a pressure mat) and a latching relay. No operator intervention is required. Automatic illumination controls include a light source and an activation circuit -- usually a relay driver circuit and a realy intended for external activation, although built-in sensors could be employed. Self-contained batteries may be supplied.

Installation considerations for siren, bell and illumination controls fall into two groups, the first relating to the method of providing the triggering signals, the second relating to the control itself. If triggering signals from equipment external to the automated response device (sensors and alarm controls) are to be relied on, selection of the triggering signal must ensure that the intruder will generate those signals when entering the protected area. No operator intervention is required. Automated response devices with self-contained sensors may offer more installation flexibility, since their coverage parameters may be optimized for each location instead of relying on existing sensors or sensor zones. For example, when installing a bell control triggered by a single pressure mat dedicated to the bell control, the mat may be placed at the specific location desired. In the case of a bell control triggered from a sensor zone containing pressure mat and additional sensors, extra triggering signals may be produced by the additional sensor, thus creating a higher nuisance activation rate. Devices which include built-in sensors must be evaluated component by component (e.g., sensor, communications) using procedures suitable for each.

Locations of siren, bell, or illumination controls are typically chosen based on considerations of device security, wiring installation flexibility and security, and requirements for location of the siren, bell or illumination control so that the intended audience can hear the signal or the lighting it provides will be appropriate. Since the controls for sirens and bells are usually very small, they can be conveniently located near, or preferably inside, the security alarm control panel, or inside the bell or siren enclosure. Wiring is usually mounted inside conduit or reinforced cable to hinder tampering attempts. Some devices also offer line supervision circuitry that will automatically activate the auditory alarm if tampering is detected. Consideration should also be given to the properties of the siren or horn itself. Specifically, location, audio frequency and sound pressure level should be consistent with the environment (e.g., background noise levels, weather conditions) to ensure that auditory alarms from sirens or horns will be suitable. Locations for lighting should be chosen so that an intruder will not be able to block the light or destroy the device. If devices are available with line supervision, so that line tampering results in activation of the devices, these should be considered for use. As before wiring mounted in conduit or armored cable will hinder tampering. Consideration should also be given to the properties of the lighting source itself (e.g., ambient lighting levels, orientation and location of the source) to ensure that the response will be suitable to the environment.

SIREN, BELL AND AUTOMATIC ILLUMINATION CONTROLS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Siren and Bell Controls Automatic Illumination Controls	VI -1.a VI -2.a

Performance Characteristic/Measurement Procedure	Measurement Equipment

RESPONSE MECHANISM

The purpose of performing this evaluation is to ensure that the response occurs when the device is activated, and that the auditory or visual response is appropriate to the environment.

INSPECTION

1. For a siren driver or portable flashing light, check that wiring between the security control panel and the device (as well as between the siren driver and speaker as appropriate) is free of cuts or abrasions, sharp bends, or any other mechanical strains that might cause failures.

2. For a siren driver, check that it is mounted either inside the security control enclosure or inside an optional metal enclosure in a protected location. The driver itself is best suited to an indoor environment. (The speaker used with the siren driver, and the portable flashing light, should be contained in weatherproof enclosures that may be used indoors or outdoors.)

3. Check that the auditory signal of the siren or visual signal of the portable flashing light is directed toward the intended recipient.

4. For a bell control:

(a) Check that wiring between the pressure mat, or other sensor,and bell module is free of cuts or abrasions, sharp bends, or any other mechanical strains that might cause failures.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
(b) Check that the sensor used for bell module activation is located so that persons entering the protected area must encounter it. Check if there are any objects in the vicinity which could be used by an intruder to bypass the sensor.	
(c) Check that the auditory signal is directed to the intended recipient.	
ANALYSIS	
1. Review the licensee's security logs to determine that these devices were activated and performed their intended function when actual intrusions or periodic testing occurred.	Licensee's security alarm logs.
2. Review licensee maintenance records relative to the operability of these devices (especially the sensor associated with the bell control). Take note of any problem that appears to occur consistently, and attempt to correlate it with weather conditions or with licensee operational procedures.	Licensee's maintenance records.
DEMONSTRATIONS	
1. Provide the required stimulus to activate the response device as follows:	
(a) For a siren driver or a portable flashing light, either activate the TEST function on the security control panel (if so equipped) in order to activate the response device, or physically stimulate a sensor connected to the security control panel loop that interfaces with the response device.	
(b) For a bell control activated by a switch mat, have a person step on the integral switch mat, or use a weight having a base no larger than 3 in^2 (7.6 cm^2). This procedure is based on requirements in the Interim Federal Specification (GSA-FSS) for pressure mats. (Since the control is a self-contained unit, no additional input terminals are available to use a more standardized stimulus for activation. The inspector should realize that the procedure of using a human subject to demonstrate the operation of this device will necessarily introduce a variance into the measurement.) For other types of sensors, use an appropriate stimulus to activate an alarm.	Person weighing at least 80 lb (36 kg), or an equivalent weight having a base of 3 in^2 (7.6 cm^2).

Performance Characteristic/Measurement Procedure	Measurement Equipment
2. Determine that the auditory or visual response signal is produced by the device upon sensor activation.	
3. Assess that the auditory or visual response signal is suitable for the local environment. For example, is the auditory response signal loud enough to be heard over the ambient noise level? Can it be discriminated from the sound of other auditory alarm signals used in the area? Is it so directional that it cannot be heard in any required area such as a guard station? Can it be heard in all necessary areas, both indoors and outdoors? For the visual response signal, is the light bright enough to be useful under all conditions in which it may be used? Is it too directional so that it cannot be seen in certain required areas?	
4. If the device incorporates an automatic reset feature, demonstrate that it operates in the required time as specified in the Catalog sheet (e.g., determine whether or not the auditory alarm included in the portable flashing light automatically resets after two minutes).	Stop watch timer.
<u>FALSE/NUISANCE ALARM RATE</u>	
The purpose of this evaluation is to help ensure that siren, bell and illumination controls are installed and used properly. These devices are not expected to exhibit inherent false alarms. Nuisance alarms could reasonably be expected to occur only as a result of spurious activity of the sensors used to activate the siren driver, portable flashing light or bell control.	
<u>INSPECTION</u>	
1. Determine that the bell control integral sensor response device is not located in an area of normal employee traffic, where it could be susceptible to nuisance activation.	
2. For externally activated response devices, inspect the installation of external sensors for conditions which might be conducive to false/nuisance alarm activity, using the methods	735 256

Performance Characteristic/Measurement Procedure	Measurement Equipment
provided in the evaluation procedure for the specific type of sensor employed.	
3. For any response devices located outdoors, determine whether or not anticipated environmental conditions (especially temperature) are compatible with device characteristics.	
ANALYSIS	
1. Review the licensee's security alarm logs for the sensor loop used to activate the externally activated devices (siren driver and portable flashing light). Take note of any apparent discrepancies in correlation between security alarm activation and response device activation. Excessive nuisance alarms may require reconfiguration of the sensor loops or relocation of the sensor responsible for response device activation.	Licensee's security alarm logs.
2. Calculate the frequency of false/nuisance alarms over the period of time since the last inspection visit and compare the results to those previously obtained. A gradual increase in frequency could be indicative of system or device deterioration.	
SPOOFING	
The purpose of this evaluation is to determine whether or not the sensor used to activate the automated response device can be avoided by an intruder. Susceptibility to spoofing should be evaluated in detail using the methods provided in appropriate evaluation procedures contained in Volume II of this Guide.	
TAMPERING	
The purpose of this evaluation is to determine whether or not the device's response may be inhibited by tampering.	
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Performance Characteristic/Measurement Procedure	Measurement Equipment
INSPECTION 1. For siren drivers, check that it is either mounted inside the security control panel (which should be equipped with a tamper protection switch) or in its own optional metal enclosure equipped with a tamper switch. 2. Check if any enclosure for the siren, bell or light has a tamper switch. 3. Check that the sound and/or light-producing devices are not within reach, and that objects which could be used to mute the auditory response or mask the flashing light are not available in the area.	
ANALYSIS Review licensee's security log to ascertain whether or not these devices have ever been affected by tampering attempts. If so, determine what compensatory measures have been taken.	Licensee's security alarm log.
DEMONSTRATION For any enclosure equipped with a tamper sensor, open the enclosure and verify that a tamper alarm is sounded.	
POWER SYSTEM The purpose of this evaluation is to ensure that power supplied to these devices is adequate for proper operation.	
INSPECTION 1. Examine the power supply configuration for each device, as described in the appropriate Catalog sheets, to determine that the correct supply voltages are available, and that the device is supplied with uninterrupted power during power outages by the security system backup power supply.	
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Performance Characteristic/Measurement Procedure	Measurement Equipment
2. If batteries are used, check that they are free of corrosion, leaking electrolyte, and that there are no loose or broken wires, or faulty connections that could degrade performance.	
<u>ANALYSIS</u>	
1. Review the licensee's schedule for recharging or replacing the batteries, if used.	Licensee's maintenance schedule.
2. Determine that the batteries are maintained in a continually charged state (for example, that they are trickle-charged during periods of storage).	
<u>DEMONSTRATION</u>	
1. Demonstrate that the response device operates on the standby source of power. This is done by removing the prime source of power from the device if it is equipped with a self-contained backup, or if not, by testing the transition of the security system to standby power.	
2. Activate the device and determine how long the device will provide useful illumination or sound before battery capacity is exhausted. Determine whether or not this time is consistent with the claims made by the manufacturer in the appropriate Catalog sheet.	

AUTOMATIC PHOTOGRAPH CONTROLS

Automatic photograph controls are designed to detect an intruder and take a series of photographs, using available lighting, to be used in identifying the intruder. They do not provide immediate security alarm data. A self-contained sensor (acoustic, etc.) can be incorporated in the design to detect intruder motion and to trigger a camera that takes pictures at a slow rate (typically two frames per second) on a film magazine that must then be processed. A self-contained battery may be supplied to provide installation flexibility. Several properties of the device are constrained by the characteristics of the sensors. For acoustic devices these include susceptibility to environmental noise and to wind motion (generally limiting usefulness to indoor locations), inability to detect targets moving tangentially to the ultrasonic beam, maximum range limitation due to the power handling limitations of the ultrasonic transmitter, maximum azimuth coverage limitations due to the size and wavelength of the ultrasonic transmitter, and masking of the intruder by large objects in the coverage volume such as a desk and file cabinets. Other sensor types could also be used. A fuller treatment of properties of sensor characteristics may be found in Volume II (Intrusion Detection Components).

The camera is not usually provided with an integral source of scene illumination; hence external lighting is required for adequate film exposure. Both the sensor coverage pattern and the camera field-of-view should be consistent with the intended coverage volume (typically a room about 20 ft (6m) square in which the automatic photograph control is mounted in one corner near the ceiling). The units should be mounted in a place inaccessible to an intruder, so as to preclude the possibility of such tampering techniques as covering the camera lens with a heavy cloth or knocking the control module

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with a pole to change its field of view both of which would make the camera ineffective. There is no protection against individuals wearing a mask to preclude identification, hiding behind objects or carrying an obscuring shield.

AUTOMATIC PHOTOGRAPH CONTROLS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Automatic Photograph Controls	VI-3.a

Performance Characteristic/Measurement Procedure	Measurement Equipment

SYSTEM PARAMETERS

The purpose of this evaluation is to establish whether or not the photographic system is effective in recording pictures whenever any stimulus is detected by the system's sensor. The camera orientation and lens focal length selected for the application should provide photographic coverage of the sensor's area of sensitivity. Since a system may not have its own light source and the minimum light level may not be specified, the inspector may encounter external artificial light sources of site-specific design and light level. The inspector should refer to the appropriate evaluation procedures of Volume II (Intrusion Detection Components) for the sensor used to activate the photograph control. Note that the automatic photographic system is intended only to help identify intruders; it is not used as an intrusion detector.

INSPECTION

1. Inspect the coverage area for objects which are large enough to conceal an intruder from being photographed, or which might limit the effectiveness of the detection device.

2. Inspect the photographic system installation, using applicable procedures presented in the Evaluation Guide for the applicable sensor as referenced above. Pay particular attention to any external artificial lighting provided within 20 ft (6 m) of the photographic system, and to the operating procedures for the lighting system. For example, determine if the lighting is available continuously or only during normal working hours, and whether or not this lighting has a backup power supply to ensure operation in the event of prime power failure.

Performance Characteristic/Measurement Procedure	Measurement Equipment
3. Inspect any self-contained battery to ensure that there are no signs of corrosion or leaking electrolyte.	
4. Inspect the film magazine to ensure that a film type compatible with requirements of the system is installed (see the applicable photographic system Catalog sheet for the film type recommended by the manufacturer).	
ANALYSIS	
1. Review any photographic data taken during previous NRC inspections, the licensee's regularly scheduled operational tests, or actual intrusion attempts, to determine whether or not the photographic system was effective as an aid in identifying intruders or test personnel.	Previously exposed films.
2. Review the licensee's schedule for film and battery replacement. Any battery used in this system should be replaced at regular intervals consistent with normal use of the device.	Licensee's maintenance schedule.
3. Review the licensee's schedule for maintenance of any external artificial lighting installed in the coverage area of this device. Note that a minimum illumination level, dependent upon the film type, lens aperture and shutter speed must be maintained for proper device operation.	
DEMONSTRATION	
1. In preoperational inspections:	
(a) Activate the photographic system by approaching it from the farthest location in the room in which it is mounted that lies along the axis (center line) of the sensor's detection coverage. The axis may be assumed to be perpendicular to the system enclosure. A slow walking speed of about 3 ft (1 m) per second should be used. Ensure that all lighting in the room that is intended to be operational while the photographic system is in use is working.	
(b) Repeat step (a) at angles of approach of 20 and 40 degrees to each side of the center line of the sensor's detection coverage. These approach paths should allow direct surveillance by the system and not allow one to pass behind file cabinets or other objects that might obscure the sensor or field of view of the camera.	Protractor. 735 263

(c) Process the photographic film according to the procedures normally used by the licensee. Take note of the amount of time required for processing.

(d) Review the processed film to determine the distance of the intruder from the camera when the system was first activated for each angle. Ensure that the photographic quality is adequate to permit intruder identification at these distances.

(e) Retain the film made during this demonstration for use during future system evaluation.

(f) Determine the limits of the camera's field of view; ensure that all access routes to the protected area are covered.

2. In operational inspections:

(a) Activate the photographic system by approaching the device at a slow walking speed of about 3 ft (1 m) per second. Stay within the area of coverage determined during the preoperational demonstration.

(b) Process the photographic film according to the procedures normally used by the licensee.

(c) Review the processed film to determine whether or not photographic quality is adequate to permit intruder identification.

(d) Compare the field of view of the current photographs with that obtained in the preoperational evaluation, to ensure that the field of view has not changed.

FALSE/NUISANCE ALARM RATE

The purpose of this evaluation is to determine whether or not the photographic system operation may be affected by external sources of interference capable of causing activation of the sensor and erratic activation of the camera subsystem.

INSPECTION

Check the area in which the photographic system is installed for the presence of potential sources of sensor interference.

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Refer to the appropriate evaluation procedure contained in Volume II for the sensor employed in this system.

ANALYSIS

1. Review any photographic records (i.e., previously exposed and processed films) to determine the extent (if any) of false activations or nuisance responses by comparing the photographic record with the licensee's security alarm log. Attempt to correlate the incidence of any false or nuisance activations with the licensee's normal facility operation.

2. Calculate the frequency of false/nuisance alarms over the period of time since the last inspection and review the results of previous NRC inspections for spurious alarm activity to determine if a persistent problem exists. Increasing frequency of spurious alarm activity may be indicative of sensor deterioration.

SPOOFING

The purpose of this evaluation is to determine the resistance of the photographic system to attempts at avoiding activation. Note that an intruder could prevent recognition by employing a mask or other disguise.

INSPECTION

Inspect the area in which the device is employed for objects which could be used to cover the lens or for objects which would enable an intruder to gain access to the equipment.

TAMPERING

The purpose of this evaluation is to ascertain how well the photographic system resists attempts to disable or destroy it. These systems typically have no tamper sensor and are not intended to be connected to the licensee's central security alarm system.

Performance Characteristic/Measurement Procedure	Measurement Equipment
Consequently the system is completely vulnerable to actions against it unless it is protected by sensors connected to the central security alarm system. Expected tampering attempts include efforts to "blind" the system or to render it inoperative by covering it or displacing it from its usual mounting position, efforts to remove the film magazine from the enclosed camera, or efforts to destroy it.	
<u>INSPECTION</u>	
1. Examine the photographic system layout to estimate how accessible all parts of the system are to an intruder. Check for the presence of objects which could place this equipment within reach or be used to displace the camera from its mounting position.	
2. Determine that the surveillance area of the photographic system is protected by intrusion detection sensors connected to the central security alarm system. For example, determine that the access doors to the room in which the photographic system is used are equipped with intrusion detection sensors.	
3. Inspect the device for visible signs of tampering.	
<u>ANALYSIS</u>	
1. Consider whether or not other schemes to disable the photographic system without being photographed such as knocking it off its mounting bracket with a broom, mop, etc., might be effective. Compare records of device orientation from previous inspections with current findings -- that is, compare previously filmed scenes with filmed scenes obtained in the current evaluation and note whether or not the field of view of the camera has changed.	Previously exposed films.
2. Determine whether or not the lighting necessary for proper camera operation can be disabled by an intruder.	

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AUTOMATIC DIALERS

Automatic telephone dialers are designed to dial a preprogrammed telephone number and deliver a prerecorded message over existing telephone lines to an instrument at the receiving end of the telephone line. This instrument may be either a conventional telephone handset (in which case a person must answer the ringing telephone, listen to, and understand the prerecorded message) or a special-purpose receiving device that includes an alarm signal (auditory, visual, or both), a display of alarm data and a printer for long-term hardcopy logs.

Automatic dialers are triggered from security alarm control panels which receive alarm data from zones of sensors. Messages transmitted by these units are intended to alert someone, typically local law enforcement agency (LLEA) personnel, who will make some form of response. The messages are prerecorded and intended to convey enough information to ensure that the anticipated response will in fact occur. The recording mechanism is a magnetic tape configured either as a commonly available tape cartridge or cassette or as an open tape loop. The telephone number and message can usually be programmed at the facility using a tape programmer available from each dialer company. Some dialers provide for multiple messages, depending on which alarm zone provides the trigger. These units are said to have a multi-channel capability; they can be used, for example, to report messages requiring fire and/or LLEA responses. The channels are assigned on a priority basis, so that if two alarms occur simultaneously, the message relating to the high-priority channel will be sent first, and then the lower-priority channel message will be sent.

Dialers usually have an automatic re-dial feature, so that the dialer will repeatedly (usually up to a preset number of attempts) place a call to a busy number. To minimize lost time, the telephone dialer should be programmed to dial an in-coming line that is reserved only for high-priority business. Dialers also should be equipped with a line seizure feature, when available, that will prevent a call on an extension to the dialer's outgoing line from inhibiting dialer action. An anti-jam feature, breaking the connection of an incoming call to the dialer line at the moment a trigger signal is received, should also be used if available. These three options are intended to minimize spoofing attempts against the dialer. Some dialers also permit a listen-in feature so that the call recipient can hear, through a microphone built into the dialer, any sounds, such as might be caused by an intruder, in the vicinity of the dialer. Dialer options are listed in the Notes section of each sheet.

Dialers are usually mounted in reinforced enclosures with locks and tamper alarms, and usually offer line supervision on the trigger input line to increase tamper resistance. However, the connection between the dialer and the intended call recipient may not be resistant to tamper attempts unless special procedures, such as mounting internal lines in conduit and guarding access to telephone lines outside the facility, are employed.

The utility of a telephone dialer also depends upon the characteristics of several associated items. The telephone line used is most often a non-conditioned dial-up line which may have varying levels of background noise. The recipient of a dialer voice message has to understand it quickly (it might not be repeated), and the messages sent to central station monitors must be read correctly by an operator. In both cases a correct response must then be effected. Since the dialer operation could result in a response by local law enforcement agency personnel, the false activation and nuisance alarm rates of this equipment must be considered. Care must be taken to ensure that installed equipment is acceptable by local law enforcement agencies for connection to their lines or end instruments.

AUTOMATIC DIALERS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Automatic Dialers	VI-4.a

Performance Characteristic/Measurement Procedure	Measurement Equipment

INSTALLATION/OPERATION

The purpose of this evaluation is to determine whether or not the automatic dialer will correctly dial the pre-programmed telephone number and transmit a usable message either to someone who answers the dialed telephone (analog systems) or to someone who reads a display (digital systems). Since these dialers typically operate commercial dial-up telephone lines, the quality of transmitted messages may be expected to vary greatly in the course of normal operation. Consequently there will be some variation limiting evaluation of message utility. This is a known characteristic of these devices. Dedicated telephone lines may be necessary to improve transmitted message quality to acceptable levels at certain licensee facilities. Automatic dialers typically have a multichannel capability in that more than one input channel is available. Each input controls a different message; a mechanical tape recorder mechanism is common to all messages. Each channel is assigned a priority in the event that input activation signals occur simultaneously. When a call is made to a busy line, the dialer typically will re-initiate the call until the connection is completed. This evaluation concerns only the automatic dialer output, since telephone line quality is variable.

INSPECTION

1. Examine the automatic dialer installation to determine that the dialer and its associated wiring (input from security control, output to telephone lines, and prime/backup power) are correctly installed according to the licensee's installation plans and are, in the inspector's judgment, adequately protected from overt and covert efforts to compromise proper operation. Note that the dialer would typically be located at the central alarm monitoring station or secondary station where it would be protected by the presence of security personnel rather than by electronic means such as tamper switches.	Licensee's installation plans.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
2. Examine wiring to any extension telephones on the same line as the dialer for adequate protection against compromise.	
3. Check that any extension telephones on the same line are located where ready access is not available to unauthorized personnel.	
4. Examine telephone line wiring from the dialer to the telephone junction box and from there to telephone company circuits for any protection against efforts to inhibit responses. For example, check for wires in conduit or other protective enclosures, locked telephone junction boxes, interconnections between facility and local law enforcement agency (LLEA) monitored for taps, wires inaccessible to unauthorized personnel (e.g., mounted on poles surrounded by fence or buried underground), and protection of telephone company switching facilities from unauthorized access. Telephone company technicians may be required to help perform this evaluation.	
ANALYSIS	
1. Review both licensee and LLEA logs of security alarm data to ascertain whether the automatic dialers were effective in transmitting usable messages in response to actual or test alarm activations.	Licensee's and LLEA security alarm logs.
2. For digital dialers, obtain any printer listings of dialer signals that may have been generated either as a result of actual security alarm activity or during routine testing of security control equipment.	
3. Assess the operation of printers (see step (2) above) using the techniques presented in evaluation procedure VII-2.A (Printers).	
4. Ascertain that the number dialed by the dialer is safeguarded (not generally known to the public).	
DEMONSTRATION	
1. Attach the instrument described at right to the telephone line output terminals of the telephone dialer. In some cases, depending on licensee location, local tariffs require that dialers be attached to telephone company equipment through a coupler. This procedure considers the coupler performance to be the responsibility	Automatic dialer verification instrument capable of displaying dialed numbers visually, and reproducing recorded

Performance Characteristic/Measurement Procedure	Measurement Equipment
of the telephone company (which owns the coupler), and therefore addresses only dialer performance. The equipment described at right may also be used to check coupler performance, using procedures described in the instruction manual accompanying the test equipment, if desired. 2. Activate the telephone dialer by an appropriate means as described below: (a) Activate the TEST function (if available) on the security control panel from which the dialer receives its activation signal, or (b) Activate an intrusion detection sensor which is used to activate the dialer, or (c) Short-circuit the normally open (N.O.) input terminals to the dialer, or (d) Activate the TEST function on the dialer, if so equipped. 3. Copy the display of dialed numbers from the test instrument. These numbers will be presented serially (one after the other). 4. For analog dialers listen to the audible presentation of the recorded message; for digital dialers, refer to the evaluation procedure described under Analysis (2), above. Determine that the message is quickly and easily understood. 5. Compare the telephone number data from the instrument with the actual number to be dialed. Note: If the Automatic Dialer Verification Instrument is not available, replace steps (1) and (5) above with the following procedure. This procedure also evaluates any coupler attached to the line, as well as telephone company lines, circuits, and equipment. 1'. Notify the intended recipient of the dialer message (usually LLEA) that dialer operation is to be tested and evaluated. Coordinate evaluation with the recipient continually during subsequent steps (e.g., by another telephone line or by radio link) to preclude inappropriate responses. 2'. Same as (2) above.	voice messages audibly. (such as Bodine Model VF-400 Verifier at a cost of $126 from Bodine Company, P.O. Drawer B, Collierville, TN 38017).

3'. Determine whether or not the intended recipient received the call.

4'. Ascertain whether or not the message was intelligible to the recipient by requesting that he repeat the message or summarize its contents. Remember that this procedure uses a telephone line which is not under licensee control, and that variations in telephone line quality are to be expected.

5'. Notify the intended recipient that the test has been concluded and resume this demonstration at step (6) below.

6. If the telephone line to which the dialer is connected has an extension telephone, and if the dialer is fitted with an optional line seizure relay, pick up the receiver on the extension telephone and repeat steps (2) through (5) of the appropriate method above. (The purpose of the line seizure relay is to prevent the automatic dialer from being unable to make an outside call, due to someone's use of the telephone line being used by someone either inadvertently or intentionally as an attempt to defeat the system.)

7. Demonstrate that the dialer will continue to dial if the recipient's line is busy by placing a call (call "A") to the recipient using an independent phone line, holding the line open and repeating step (2) above. After the dialer is observed to be activated, terminate the call "A" to the recipient and verify that the dialer satisfactorily completes its call (steps (3) and (4) above). In preoperational tests, the number of times the dialer attempts its call should be determined. Ensure that the licensee safeguards this information.

8. If the dialer is programmed to deliver a message to more than one telephone number, or to different telephone numbers depending on type of alarm, repeat the steps above as applicable for the various alarm conditions.

FALSE/NUISANCE ALARM RATE

The purpose of this evaluation is to aid in determining whether or not the telephone dialer may be activated by unintended external sources. A device exhibiting this characteristic could be saturated by an intruder prior to an entry attempt; if LLEA personnel could be led to believe that the device was defective, they might take valuable time verifying a call before responding. Acceptable levels of false/nuisance alarm activity must be negotiated with the LLEA who receives the call and must respond. Fales and nuisance alarms would usually be caused by sensor activity in the zone activating the dialer. Excessive spurious alarms may necessitate examination of the sensors.

ANALYSIS

1. Review the licensee's security alarm log and the logs kept by the LLEA for any reported incidents of false activations. Discrepancies between the licensee and LLEA logs should be investigated.

Licensee's security alarm log.
LLEA logs.

2. If excessive false/nuisance alarms are found to occur, try to determine the cause by analyzing the results of the test for EMI VULNERABILITY below.

EMI VULNERABILITY

The purpose of this evaluation is to ascertain if the magnetic tapes used in the telephone dialers may be affected by the presence of strong magnetic fields produced by high currents on wires in the vicinity of the dialers, and to ascertain whether or not surges, transients, etc. on these wires, or radio transmissions originating in the vicinity of the dialer, may degrade transmitted message quality or produce false activation. The susceptibility of the dialer to EMI strongly depends on the shielding provided by its protective enclosure. For example, a metal enclosure provides more shielding or protection against EMI than a non-metal one.

A. SUSCEPTIBILITY TO MAGNETIC FIELDS

Note: The feasibility as well as the utility of measuring magnetic field strengths requires further analysis.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
INSPECTION	
Check whether or not dialers have been located in the vicinity of wires carrying heavy currents (power lines, etc.). If so, the inspector should be especially critical in reviewing the results obtained in the remainder of this procedure.	
ANALYSIS	
1. Review licensee service or periodic test logs and LLEA logs to determine whether or not unexplained tape erasure or message degradation has ever been observed. If so, it may be necessary to relocate the dialer and/or associated wiring as an attempt to alleviate the problem.	Licensee's service/ test logs. LLEA logs.
2. Review applicable dialer and magnetic tape manufacturer data for information on the maximum permissible magnetic field strength in the vicinity of the magnetic tape before degradation of the recorded message may be expected to occur. The maximum field must not be exceeded in the vicinity of the magnetic tape.	
DEMONSTRATION	
Repeat the Demonstration for INSTALLATION/OPERATION under worst-case conditions (when all machinery, lights, etc., are in operation). The performance of the dialer is acceptable if no false activations occur when the various loads are switched on or off and no tape erasure or message degradation is observed.	
TEST	
1. Measure the magnetic field strength inside the dialer enclosure in the vicinity of the magnetic tape. Record results.	Hall Effect Magnetic Field Strength Meter such as: RFL Industries, Inc. Boonton, NJ Model 505, approx. $455, or F. W. Bell, Inc. Columbus, OH Model 600, approx. $400
2. Compare with the specifications used in Analysis (2) above.	

B. SUSCEPTIBILITY TO RADIO FREQUENCY INTERFERENCE

INSPECTION

1. Check whether or not portable or base-station radio equipment is operated in the vicinity of the dialer.

2. Check whether or not the input and output lines of the dialer are shielded or are in conduit.

ANALYSIS

If radio equipment is not typically used or permitted to be used in the vicinity of the dialer, determine whether or not it is possible to carry a portable unit into this area.

DEMONSTRATION

1. Operate a portable radio (walkie-talkie) or base-station radio in the vicinity of the dialer. This action should not result in false activation of the dialer.

Walkie-talkie - either a unit used by the licensee guard force (preferable) or the unit specified for NRC use.

2. While operating a walkie-talkie or base-station radio in the vicinity of the dialer, carry out steps (1) through (4) of the appropriate Demonstration procedure used for INSTALLATION/OPERATION. The message transmitted by the dialer should not become garbled or degraded.

POWER SYSTEM

The purpose of this evaluation is to determine whether or not the operation of the dialer is affected by loss of prime power.

INSPECTION

1. Inspect backup batteries furnished with dialers for signs of corrosion, loose connections, damage, abuse, or any other characteristic that may affect service life.

2. Check that the backup battery is located inside the dialer cabinet, or in some other location that would protect it from compromise.

3. Inspect any exposed wiring between the battery and the dialer for signs of cutting, abrasion, etc.

Performance Characteristic/Measurement Procedure	Measurement Equipment
4. Determine that battery wiring is protected against accidental or deliberate damage.	
ANALYSIS	
1. Review the power requirements of the dialer recommended in the manufacturer's specifications, if available.	
2. Determine whether or not the power requirements can be satisfied by the backup power source. If batteries are used in this supply, determine that the proper type of batteries are installed and note the ampere-hour capability of the supply. (The current drain of the dialer expressed in amperes multiplied by the number of hours the dialer is expected to operate from the supply should be less than the ampere-hour figure for the supply.)	
DEMONSTRATION	
To determine whether or not the backup battery source can supply the dialer for a period of time specified in the licensee's physical security plan in the event of a prime power failure, disconnect the dialer from prime power and demonstrate dialer performance at the end of the time period using steps (1) through (4) of the Demonstration procedure for INSTALLATION/OPERATION. The device should not become activated as a result of power switchover transients.	
Note: A battery checker, capable of being set to reflect the power supply rating, would provide a more convenient and feasible test.	Battery tester (must be developed).
DATA/COMMUNICATIONS	
The purpose of this evaluation is to determine the availability of backup communications to the LLEA in the event of telephone line failure.	
ANALYSIS	
Determine what backup communications (alternate telephone line, or a radio link, etc.) the licensee has adopted for implementation to notify the LLEA in the event of failure of the primary telephone line.	

CATHODE RAY TUBES (CRT)

A great variety of CRT displays, meeting many different requirements, is readily available. Their use in physical security systems is outlined in Catalog Volume VIII, Section 1 (Alarm Signalling Systems). CRT displays may interface with a computer or a similar display, or may operate as a keyboard-send-receive (KSR) or a receive-only (RO) teletype. The degree to which the displays meet requirements is determined by their intrinsic operational capabilities and the number and type of peripheral devices that support them or are supported by them. Such peripherals may include parallel displays, hard-copy output devices such as printers, and additional memory in the form of magnetic tape cassette record/playback devices.

The CRT display is comprised of five principal elements: The CRT with its associated display/deflection electronics; character-generating or display-forming circuitry; display memory; display control device(s', and circuitry for interfacing the display to external equipments. These elements may be either physically integrated into a single console/cabinet or interconnected by appropriate cables.

The character generating or display forming circuitry accepts binary coded characters from the local keyboard or communications interface and converts them into deflection signals. Basic character generators produce 64 upper-case alphanumeric characters including a few special symbols. Extended generators can form more characters as well as many combinations of special symbols, upper and lower case alphanumerics and line drawing graphics.

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The memory in CRT displays provides storage for refreshing the display image and supports the display controls and external and local interfaces. The refresh memory is used to sustain the character image on the face of the CRT at a refresh rate sufficient to prevent "flicker". The memory is usually large enough to store at least one "page" or screen full of data. If additional refresh storage is provided, the CRT display has a "paging" capability that permits the user to index lines that have rolled off the screen. The memory provides sufficient "buffering" to match the operational communications interface, and supports local cursor indexing, character/line insert/delete, tab, and format controls.

The CRT display control devices usually consist of a keyboard augmented with special function keys. The function keys provide cursor control and edit controls such as erase and insert/delete character/line. Some CRT displays for special applications may have limited or augmented key input capabilities. For example, some displays may only have a numeric key pad, or may have a numeric key pad in addition to a complete keyboard. Other display controls, similar to those of conventional TV sets, are display brightness and contrast. These are separate from the keyboard but are generally accessible to the operator.

The interfacing circuitry couples the CRT display to external devices. These interfaces may include a teletype-compatible current loop, or may conform to the electrical and logic specifications of the Electronic Industry Association (EIA) RS-232 standards, or may provide Diode Transistor Logi ansistor-Transistor Logic (DTL/TTL) signal levels. Some displays have built-in data sets or modems (modulator-demodulator) which not only convert the transmitted binary character code voltages into audible tones or frequencies that are acceptable to the communications lines, but also convert the received tones or frequencies to the binary signal needed by the display electronics. Many CRT displays provide switch-selectable input/output characteristics to permit a variety of data rate, electrical, and logic interfaces.

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Data transmission and reception between the display and interconnected devices can occur simultaneously (full-duplex mode) or alternatively in one direction at a time (half-duplex). Other transmission modes are echoplex (keyboard-to-interconnected device simultaneously with interconnected device-to-display) and simplex (display-to-display only).

In some respects CRT displays are similar to conventional television receivers. Generally a medium-short-persistence phosphor (50 microseconds to 100 milliseconds) is used in the CRT, the same type of phosphor employed in conventional monochromatic TV receivers. In many cases the deflection circuitry for CRT alphanumeric displays is also the same as that used in the home TV sets (i.e., raster scan or "video deflection"). CRT alphanumeric displays generally use a raster scan or video deflection method. In this mode (the one used in conventional TV sets), an electron beam sweeps continuously from left to right through a series of 525 horizontal lines over the entire screen area. A limited number of suppliers offer displays that have up to 1000 horizontal lines. These are generally special purpose devices and are substantially more costly than the conventional 525-line devices. All odd-numbered lines are scanned in one pass (one-sixtieth of a second), then the even-numbered lines are scanned in the next one-sixtieth of a second. This "interlace" of the scan lines completes the entire image or frame in one-thirtieth of a second. In a video or raster scan device the displayed characters are composed of dot patterns, which are formed with the electron beam "on" or unblanked for each dot.

The performance parameters of CRT displays generally fall into one of two major interrelated areas: those that affect the "legibility" of the presented information, and those that are related to the particular operational mode(s) in which the display is employed.

Legibility performance depends on many factors, including the contrast between the displayed image and the background; screen luminance and ambient illuminance; display screen characteristics

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such as screen blemishes, ion and/or pattern burns, and screen noise which creates elemental variations in radiant emission across the screen; spot and character/symbol size and spacing; character/symbol flicker; and jitter of the displayed characters/symbols. Measures of overall legibility are determined by statistical methods. However, if the above aspects are satisfactory, and the operational mode performance needs are met, the display is generally suitable.

The operational performance capability also depends on the capabilities of the basic elements. Certain factors, however, have more impact than others in determining operational capability. Some of these are the size of the screen or viewing area, the number and types of characters/symbols displayed; interface characteristics such as data rates, signal levels and types; information transfer capabilities; block, page, line or character transfer rules and procedures. In addition, the physical operational environment in regards to ambient lighting and the position of the display (viewing angle/distance) with respect to the operator both impact on the overall performance of the CRT displays for their intended uses.

The degree of maintenance capability required depends on the complexity of the CRT display. The simpler displays (such as the KSR and RO teletype equivalent) depend on scheduled maintenance activities. Faults or degradation in performance occurring between scheduled periods are usually detected visually, backed up by visual "trouble" light indications. The more sophisticated displays that are interconnected to a computer may have periodic offline/online diagnostic checks made automatically to indicate faults and confirm satisfactory operation. These diagnostics range in capability from simple "go-no-go" tests up to canned/simulated operational tests which exercise the entire display.

Inasmuch as the general purpose CRT displays are manufactured for a wide range of applications, tamper switches are not incorporated therein. However, the displays have incorporated provisions for reducing effects of RFI and EMI because they are normally collocated with other equipments, e.g., computers, memory devices.

The display should be positioned so that the nominal viewing distance is 16 inches (41 cm) for a display screen size of 13 x 41 in (33 x 35.6 cm). If the viewing distance is much greater than 16 inches, (41 cm), displays should be selected that have larger character/symbol sizes, greater brightness ranges, and larger character, word and line spacing.

ALPHANUMERIC CRT DISPLAYS

Most CRT alphanumeric displays use both the CRT and the deflection circuitry contained in conventional TV sets. In fact, many display manufacturers obtain the basic TV chassis containing the CRT and deflection electronics from TV set manufacturers and incorporate their own character generator, memory, display controls and interface logic. Conventional TV set deflection electronics together with the beam control circuitry form the characters/symbols using a dot matrix. The most common matrix is a 5 x 7 pattern; some displays use a barely legible 3 x 5 dot matrix, while others use more precise matrices ranging up to a 9 x 13 or 9 x 14 dot matrix. These last two matrices are usually incorporated in displays that provide closer to 1000 scan lines. The total number of displayed characters/symbols not only depends on the dot pattern selected but also on the total number of resolvable lines. With the conventional TV set type of deflection, the spacings between characters, words and lines are fixed. Statistical tests have shown that for good legibility the spacing between characters should be at least equivalent to one-sixth the character height, the spacing between words at least equivalent to one character width, and the spacing between lines at least equivalent to one-half the character height.

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ALPHANUMERIC WITH LIMITED GRAPHICS CRT DISPLAYS

CRT alphanumeric displays with limited graphics use one of three deflection methods. Some use the video or raster scan deflection method. To permit greater flexibility in displaying various formats (variable character, word and line spacing), a substantial number of these displays use the sawtooth scan method. In this method the beam is deflected to a character position, then guided through a series of short horizontal and vertical strokes to define the characters. These may be comprised of dot or stroke patterns whose width, height, spacing and line-to-line spacing can be separately adjusted. In the third method, which uses programmed or directed beam scan, the beam is deflected to the appropriate positions on the screen under the direction of control logic. Once positioned, the character or graphics is fashioned as in the sawtooth scan method by a series of dots or strokes.

CRT displays which are alphanumeric with limited graphics can display horizontal and vertical lines in conjunction with alphanumerics. Prescribed lines with associated alphanumeric notations, commonly termed a "format", usually are stored in the local display memory. This memory can be internal, or can be provided in the form of an interconnected device such as a magnetic tape or cassette transport. The format is recalled from memory by keyboard action (function key) and usually is protected in that it cannot be erased or altered by ordinary keying. Furthermore, format control allows the operator to transmit to other devices (printers and computers) the variable data entered at the keyboard. This feature may be identified as "split screen" by some display manufacturers. In addition to augmenting the memory capabilities to retain the format, the character generator element of the displays can generate line and bar symbols needed for establishing the format.

GRAPHICS CRT DISPLAYS

Some CRT graphic displays use the video or raster scan deflection method. In addition, two other basic types of deflection methods are commonly employed in CRT graphic displays. In the sawtooth scan method, the beam is deflected to an addressed position, then guided through a series of short horizontal and vertical strokes to define the characters or graphic elements (lines) which may be comprised of dot or stroke patterns or a combination of the two whose width, height, spacing and length can be separately adjusted manually or by computer control. In the programmed or directed beam scan method, the beam is deflected to the appropriate positions on the screen under the direction of control logic. Once positioned, the character or graphics is fashioned as in the sawtooth scan method by a series of dots or strokes.

The CRT graphic displays are the most versatile of the general purpose CRT displays. Their versatility is due to use of the programmed or directed beam deflection method, extended character generators, substantial augmentation of the display memory (both integral with the display and in the form of interconnected memory devices), substantial increases in the number of devices used to control the display (light pen, joystick, track ball) and a keyboard with added numeric pads and function keys. Furthermore, the CRT graphic displays can be interconnected with a large variety of devices which have more expanded capabilities and functions.

The graphic displays can generally display more information than the other displays by generating a spot size that is on the order of one-half the radius of that generated in the other displays and by controlling the deflection/positioning of the beam to a precision approaching 0.1% of full screen deflection. When more information is to be displayed, the local refresh memory must be expanded. The "flicker" on the face of the tube depends on both the amount of total

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information displayed and the memory access/vector computing time. Therefore, the refresh rate is usually a variable and longer-persistance phosphors are employed. In fact, some CRT graphic displays incorporate a storage type of CRT whose phosphor can store an image for long periods of time, reducing the need to use memory to refresh the display. Most storage tubes use a focused high-energy electron beam to form the displayed image, and a lower-energy diffuse beam that floods the entire screen area to refresh the display. This dual-beam mode of generating and refreshing the display usually reduces the contrast between the image and the background, lessening legibility. In addition the image "write" time is longer than that of the standard type of CRT, due in part to the need for a high-energy "write" electron beam.

CATHODE RAY TUBES (CRT)

EQUIPMENT CATEGORY	CATALOG REFERENCE
Alphanumeric CRT Displays	VII-1.a
Alphanumeric with Limited Graphics CRT Displays	VII-1.b
Graphics CRT Displays	VII-1.c

Performance Characteristic/Measurement Procedure	Measurement Equipment
PREREQUISITES	
The display should be interconnected with the other components of the security system. These other components should be operational and be capable of transferring appropriate signals to the display from activated sensors. If the security system includes the capability of providing machine (computer) generated simulated intrusion signals, then the necessary tapes, machine storage, etc. should be available and ready for use.	
CHARACTER STRUCTURE	
The purpose of this preoperational evaluation is to determine if the displayed characters conform to established and generally accepted criteria for size, spacing and font (MIL-STD-1472B).	
Note: A series of at least 5 separate machine simulated intrusion signals or signals generated by actual sensor activations are required to be displayed prior to performing the following evaluation.	
TEST	
1. Measure and record the character sizes and stroke widths of the symbols, and the spacing between characters, words and of the displayed messages.	Comparator such as Edmund Scientific Company Catalog No. 41,055.
2. Determine the normal viewing/reading distance between the displayed information and sec system operators and record.	Steel tape calibrated in feet/meters.

ANALYSIS

1. Analyze the results of the data collected in Test (1) above to determine if the structure of the displayed characters conforms to the following criteria:

(a) Letters: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except letters "I" = one stroke width = 1/6 H, and "W" and "M" = 4/5 H).

(b) Numerals: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except numbers "1" = one stroke width = 1/6 H, and "4" = 3/5 H + 1/6 H).

(c) Spacing: Between characters = 1/6 H minimum; between words = one normal character (4/5 H) minimum; between lines = 1/2 H minimum.

2. Since the above characteristics are based on a nominal viewing distance of 20 in (510 mm), the results to Test (2) above should be analyzed to determine if the characteristics are in consonance with accepted standards in MIL-STD-1472B for greater viewing distances. For 20 to 36 in (51 to 97.4 cm) viewing distances, the minimum character height, H, should be 4.3 millimeters and for distances from 36 to 72 in (97.4 to 195 cm), H should be 8.6 millimeters.

3. If the results of the analysis show a disparity, the legibility of the displayed messages is impaired, and corrective measures may be required.

MESSAGE FORMAT

The purpose of this preoperational evaluation is to assess the ability of the display to present the information in a directly usable form with minimal requirements for decoding, transposing, interpolation or mental translation by members of the security force.

Performance Characteristic/Measurement Procedure	Measurement Equipment

INSPECTION

Examine a series of displayed intrusion messages, paying particular attention to the means of identifying each message type (i.e., sensor, tamper, line monitor, power emergency, etc.), the description of the status or event and the accuracy of the date/time indication.

1. Verify that sharp lines of demarcation exist between each message, either by appropriate spacing between words/lines/ symbols or by lines/graphics.

2. Determine that the number of characters in the character set is sufficient to display all types of messages used in the security system.

DEMONSTRATION

A series of either machine simulated intrusions or real intrusions made by cooperating security personnel are required to be made using appropriate portions of the system. The simulated or actual activations should include at least three of each type of event the security systems monitors (i.e., tamper, line fault, power emergency, access, intrusion, etc.). Verify that the monitoring personnel are able to check the response of the display against the stimuli and quickly identify the type of event and location without consulting other members of the security force.

ANALYSIS

1. Review the messages to ascertain that the displayed information complies with the requirements of 10 CFR 73.50 or 73.55 as appropriate and that it is in a usable format.

2. Verify that the identification and understanding of the messages by the monitoring personnel agree with the event provided.

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Performance Characteristic/Measurement Procedure	Measurement Equipment

"BLINKING" DISPLAY

If the licensee employs a display with "blinking" messages, this evaluation has the purpose of determining the operation of that type of display.

DEMONSTRATION

Verify the response of the display to several of the alarm conditions that will cause a blinking message to appear.

DISPLAY SCREEN CHARACTERISTICS

The purpose of this evaluation is to determine if the display screen has developed any defects. A series of separate machine simulated intrusion signals, a standard test pattern or a series of signals generated by actual sensor activation should be displayed. The displayed information should fill the entire usable screen area; the focus control should be set properly and the brightness control set at about 70 percent of full scale.

INSPECTION

1. Examine the entire screen area to determine if any of the following faults are visible:

(a) Screen blemish - any localized variation in light emission.

(b) Screen noise - any elemental variation in radiant emission from the screen due to phosphor imperfections.

(c) Mottled screen - any areas of 6.4 to 25.4 millimeters in diameter whose broad, diffuse boundaries form a mosaic of variable light output.

Scale calibrated in millimeters.

(d) Spots - any dark flaw with discrete boundaries.

(e) Ion burn - a centrally located dark area with diffuse boundaries that becomes more pronounced with continued operation.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
(f) Pattern burn - an area of higher or lower light output with sharp boundaries corresponding to the size and location of the previously used excitation pattern.	
2. Photograph the display for comparison with the results of other operational inspections.	Polaroid camera with close-up lens set.
ANALYSIS	
The appearance of display screen defects impairs the legibility of the display. Therefore, if defects are found, not only should the CRT be replaced, but also the performance of the electron beam generating, deflection, brightness and contrast circuits must be examined (and repaired if needed). This should be performed only by skilled technicians.	
DISPLAY STABILITY	
The purpose of this evaluation is to determine if the displayed information exhibits any flicker, jitter or drift. A series of separate machine simulated intrusion signals, a standard test pattern or a series of signals generated by actual sensor activation should be displayed. The displayed information should fill the entire usable screen area; the focus control should be set properly and the brightness control set about at 70 percent of full scale.	
INSPECTION	
1. Examine the displayed messages or patterns to determine if any detectable flicker or jitter of the display is present (allow a 30 minute warm-up period if the display has not been running continuously).	
2. Examine the displayed information to verify that the presentation does not drift (move) more than 3.2 millimeters from the geometric center of the display surface, along either the horizontal or vertical axis, during the first 30 minutes after power is applied to the unit. The center of the display presentation should not drift more than 6.4 millimeters along either axis during any 12 hour period of operation.	Scale calibrated in millimeters. 735 289

Performance Characteristic/Measurement Procedure	Measurement Equipment
TEST	
Tape a transparent gauge to the display screen so that the engraved axial lines are registered at the geometric center of the screen. Determine if the drift exceeds the requirements identified in Inspection (2) above.	Display stability gauge (must be developed). Watch.
ANALYSIS	
Flicker, jitter or drift are indications of deterioration in the performance of the display device. Examine the licensee's maintenance plans to ascertain how any corrective actions would be made and to verify that full display capability is maintained while repairs are made.	Licensee's maintenance plans.
SCREEN BRIGHTNESS	
The purpose of this evaluation is to determine the brightness of the display. At least two separate machine simulated actual intrusion messages or a standard test pattern should be displayed. The focus control should be set properly and the brightness control set at full scale.	
TEST	
1. Examine the physical position of the display to determine that the location of the display with respect to the operator is such as to minimize the effects of reflected light from external ambient light sources.	
2. With the display turned off, measure and record the ambient lighting level at the surface of the display as well as in its immediate vicinity.	Light meter such as United Detector Technology Model 40X with photometric filter and foot-candle diffuser.
3. With the display turned on and messages displayed, measure and record the spot or line brightness on the display through any glare shields that may be employed over the screen.	Test pattern generator (if the system provides this capability). Spot meter such as Photo Research Corp., Model UBD-1/4°.

ANALYSIS

The ambient illumination of the screen should not contribute more than 25 percent of the total screen brightness through diffuse reflection and phosphor excitation. The screen luminance should be at least 25 foot-lamberts in an ambient lighting of 30 foot-candles. Any degradation observed during successive periodic evaluations will provide an indication of deterioration in the capability of the CRT.

SPOT SIZE

The purpose of this evaluation is to measure the spot size or line width of the displayed image. At least two separate machine simulated intrusion signals, a standard test pattern or a series of signals generated by actual sensor activations should be displayed. The focus control should be set properly and the brightness control set to produce 50 percent screen brightness.

TEST

Measure and record the spot size or line width at various points over the viewing area.

Comparator such as Edmund Scientific Company Catalog No. 41,055.

ANALYSIS

The spot size or line width measured at 50 percent screen brightness should not exceed 0.02 in (0.51 mm) at any location. If the spot size is observed to increase during successive periodic evaluations, the CRT display may be deteriorating.

MAINTENANCE PROCEDURES

The purpose of this evaluation is to ascertain that a comprehensive maintenance procedure has been developed and implemented by the licensee. The maintenance may be performed by the lessor in a lease arrangement or by properly skilled technicians in the employ of the licensee.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
ANALYSIS Examine the planned maintenance procedures and the display manuals to determine that preventive maintenance schedules contain features such as: 1. A complete cleaning every 300 to 500 hours to remove dust from the internal components. 2. A complete check of the operation of electronic circuits every 1000 to 2000 hours. In particular, the deflection, focus and character generating circuits should be examined/tested.	Licensee's maintenance plan. Lessor's maintenance procedures (if applicable). Manufacturer's instruction. operation and maintenance manuals.
DIAGNOSTIC EXERCISE The purpose of this evaluation is to assess the suitability of any machine (computer) generated diagnostic tests of the display that might be available in the system.	
INSPECTION Review the set of diagnostic programs being used; compare the set contained in the maintenance plan and identify any differences. DEMONSTRATION Exercise the set(s) of available diagnostics in accordance with the display instruction manual and/or maintenance plan and verify that the display functions properly. ANALYSIS 1. Determine if any changes have been incorporated in the set(s) of programs since the previous inspection visit. Changes may indicate a simple upgrading of the maintenance actions. However, they also may indicate the need to perform more maintenance because the display is deteriorating. 2. Examine the results of the demonstration and compare with the results of previous inspection visits. Any differences indicate either inadequate maintenance or deterioration in the display.	Licensee's maintenance plan. Lessor's maintenance procedures. Display instruction, operation and maintenance manuals. Descriptions of diagnostic programs, and appropriate tapes/storage device(s) and machine (computer). 735 292

PRINTERS

Printers are almost universally employed to create visual records of a display of information. Even though a number of types are readily available with wide ranges of capabilities, all printers include four generic elements: print and ink mechanism, paper feed controls, printer operation controls, and interfacing elements. The use of printers in physical security systems is outlined in Volume VIII, Section 1 (Alarm Signalling Systems).

Many printers can interface with a wide range of devices (CRT displays, computers, magnetic tape transports), while others can only interface with a very limited number. Some printers have a keyboard that permits local entry of information and interchange of information with other interconnected devices, while others can only receive and print information derived from other sources. Among the wide choices of interfacing capabilities there is also the opportunity to select different printer information input/output data rates, print speeds, numbers of characters and fonts, numbers of characters per line, type of paper, paper feed, and so on.

By far the most widely used type of print mechanism is the impact type. However, with technical advances, and with the need to reduce the noise level in operating environments, more non-impact printers of various types are becoming available. Impact printers operate much like a conventional typewriter. An impression is transferred from a type slug on a ball, drum, chain or wheel to the paper. Ink is provided by a ribbon or a roller, or is incorporated in the paper itself. Some printers are equipped with dual color (red and black) ink ribbons to distinquish critical information. Multiple copies may be obtained, as with a typewriter. Another type of impact mechanism uses a solenoid-driven matrix of points instead of a type slug, forming a dot matrix character on the paper. Different sizes of dot matrices are provided with different machines. The 5 x 7 dot matrix is most common, but other matrices offering a higher degree of legibility are available: 7 x 7, 7 x 9, 5 x 9.

There are three varieties of non-impact print mechanisms: electrode, electro-optical and spray. In an electrolytic printer the electrodes form the image by the transfer of metal ions from the positively charged metal electrode to chemically-treated electrosensitive paper. The electrodes charge the surface of the paper, and the latent image formed by the charge attracts a toner which is developed by either heat or solvent to produce the character. In a thermal printer, the electrodes are resistive and are heated by current pulses to form the image on heat-sensitive paper. The second class of mechanisms uses electro-optics to flash an optical image on photosensitive paper, forming the character. The third class is the "video-jet" type that sprays controlled jets or drops of ink onto the page, generating a dot matrix that has very good legibility -- the dots are so close together that the character appears to be composed of straight lines. None of the non-impact-type printers makes copies or prints in two colors.

Ribbons for some impact printers are mounted on spools whose width is equal to the column width; the ribbon travels in the same direction as the paper. Other printers use a narrow (3/4 in/1.9 cm) ribbon that travels perpendicular to the paper motion, as in conventional typwriters. Only the latter type of ribbon drive is capable of two-color printing.

In the impact type of printers, the paper and the ribbon, when used as the inking mechanism, should not move during the print cycle. However, excessive dwell time, the time it takes the impact component to make contact between the paper and the ribbon, can cause the printed character to be smeared in the direction of paper travel. To reduce smearing, some printers use type slugs having character sets with thinner lines in the segments of the character that are perpendicular to the paper travel. Both the "smearing" and the specially designed characters tend to affect the legibility of the printed information.

Generally, either of two types of feed mechanism is employed: sprocket (including tractor-mounted pins) or friction. The sprocket/pin type requires edge-perforated paper. Some printers can use either perforated or unperforated paper in different widths, giving the user a wide choice. Since the sprocket/pin type provides more positive control of the paper, the higher-speed printers use that type of feed.

Some printers employing the non-impact type of mechanism, such as the electrostatic, electrolytic and thermal types, do not need to stop paper during the print cycles.

Associated with the paper feed are controls that advance the paper between print cycles. The timing and coordination between the printing action and paper movement are crucial to good legibility. Some printers can advance the paper at two different speeds; a slow speed for normal line-to-line stepping, and a higher speed for slewing when several lines are skipped. The skipping of lines (vertical formatting) can be controlled by operator action, by components incorporated within the printer or by control signals from an interconnected device. In addition to the controls for paper advance, other controls are incorporated such as end-of-paper (forms) stop, paper-jam stop, and ribbon-jam stop.

Printer controls fall into two broad categories: those that are internal, and those that are accessible to the operator. The former may be integrated with the printer mechanism or the paper control mechanism, or may have provision in the interfacing logic to accept control signals from interconnected devices. The controls accessible to the operator range from simple panel controls (OFF/ON, PRINT) to full keyboards augmented with special function keys. Many printers have both very complex local operator control features and sophisticated internal logic that accepts control signals from interconnected devices.

The interface logic couples the printer to external devices. These interfaces may include a teletype-compatible current loop, or may conform to the electrical and logic specifications of the Electronic Industry Association (EIA) RS-232 standards, or may provide Diode Transistor Logic/Transistor-Transistor Logic (DTL/TTL) signal levels. Some printers have built-in data sets or modems (modulator-demodulators) which convert the transmitted binary character code voltages into audible tones or frequencies that are acceptable to the communications lines and which convert the received tones or frequencies to the binary signal needed by the print mechanisms. Many printers have switch-selectable input/output characteristics, permitting a variety of data rates and electrical and logic interfaces. Synchronous or asynchronous data transmission and reception between the printers and interconnected devices can occur simultaneously (full-duplex mode) or, by switch selection, in one-way transfer at a time (half-duplex). Many printers operate in a receive only (RO) or simplex (interconnected device-to-printer only) mode.

The performance parameters of printers generally fall into one of two major interrelated areas: those that affect the legibility of the presented information, and those that are related to the particular operational mode(s) in which the printer is used. Both areas rely on comprehensive planned/programmed and fault correction maintenance activities.

The legibility performance is dependent on many factors, including the contrast between the printed characters and the background, the ambient illumination, the character size/spacing/font, the method of forming the characters and the printing speed. The type of paper used is a determinant of contrast; in general the sensitized papers provide less contrast than the non-sensitized. The amount of ambient illumination may or may not be a serious factor; some printers incorporate internal illumination of the printed paper. Of course, the contrast between black characters and the background is different than that of red characters. Measures of overall legibility are determined statistically.

The operational performance capability of printers also depends on the capability of the basic elements, with certain factors having a greater impact than others. These include the paper width, the print mechanism (impact or non-impact), the availability of two-color printing to differentiate between alarm and non-alarm data, the number of printed characters/line (columns), the number of character types that can be printed, the accessibility of the printed paper for viewing of information as it is being printed or for annotation during operation if required and ambient lighting.

The amount of maintenance required primarily depends on the type of print and ink mechanism and the operating speed. Some non-impact printers require addition of liquids (toners, ink) or storage of sensitized paper in controlled environments such as refrigerators. Hence, all printers depend on scheduled maintenance. Faults or degradation in performance between scheduled maintenance periods usually are detected visually, backed up by "trouble" light indications -- out-of-paper, out-of-ink, paper-jam, ribbon-jam, smearing, etc. The more sophisticated printers may have periodic internal or interconnected computer-generated off-line/on-line diagnostic checks.

Inasmuch as printers are manufactured for a wide range of users and applications, tamper switches are not incorporated therein. However, printers do incorporate provisions for reducing the effects of RFI and EMI since they normally operate in an environment with other equipments, e.g., computers, memory devices and CRT displays.

SERIAL AND RECEIVE-ONLY PRINTERS

Serial and receive only (RO) printers generally have a common set of characteristics that distinguish them from other general purpose printers: they can only receive and print information derived from other sources, they print one character at a time, and they can print at least 80 characters per line. Although these printers present a wide range of printing speeds and information acceptance rates, most serial and RO printers in general use have printing speeds between 10 and 30 characters per second and information acceptance rates between 75 and 150 bits per second. The units capable of the higher rates usually have a one line buffer memory capacity. The devices in this category present a wide range of choices in such features as number of characters and fonts, type of paper, and paper feed and print mechanisms.

DATA LOGGING, DIGITAL AND LIST PRINTERS

The data logging, digital and list printers have a common set of characteristics that distinguish them from other general purpose printers: they operate in a receive only (RO) mode of information transfer, they print one line at a time, almost all of them ar limited to printing 32 or less characters per line, and they usually have a numeric only or limited alphanumeric printing capability. Some printers in this category have impact print mechanisms that use field replaceable print wheels, allowing the user to select or change fonts. For the most part this selection feature is provided by printers with less than 16 characters per line. In other respects, such as printing speed, ink supply, paper selection and type of print mechanism the data logging, digital and list printers vary widely in capability.

KEYBOARD TELEPRINTERS

In addition to the obvious distinguishing characteristic of keyboard teleprinters, they all have a keyboard, these devices have other features in common as well. They all permit local entry of information and interchange of information with other devices. Their other characteristics are similar to those for serial and receive-only printers in that they generally have modest printing speeds (most range between 10 and 30 characters per second), they print one character at a time, and they can print at least 80 characters per line. In other respects such as number of characters and fonts, type of paper, paper feed and print mechanisms, the keyboard teleprinters vary widely in capability.

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PRINTERS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Serial and Receive-Only Printers	VII-2.a
Data Logging, Digital and List Printers	VII-2.b
Keyboard Teleprinter	VII-2.c

Performance Characteristic/Measurement Procedure	Measurement Equipment

PREREQUISITES

The printer should be interconnected with the other equipments of the security system. These other equipments should be verified to be operational and be capable of transferring appropriate signals to the printer from activated sensors. If the security system includes the capability of providing machine storage, etc., these capabilities should be available and ready for use.

PRINT STRUCTURE

The purpose of this preoperational evaluation is to determine if the printed characters conform to established and generally accepted criteria for size, spacing and font (MIL-STD-1472B).

A series of at least 5 separate machine simulated intrusion signals or signals generated by actual sensor activations are required to be printed out prior to performing the following evaluation.

TEST

1. Measure and record the character sizes and stroke widths of the print, and the spacing between characters, words and lines.	Scale calibrated in millimeters or a comparator such as Edmund Scientific Company Catalog No. 41,055.
2. Determine the normal viewing/reading distance between the printed information and security system operators and record.	Steel tape calibrated in feet/meters.

ANALYSIS

1. Analyze the results of the data collected during Test (1) above to determine if the print structure conforms to the following criteria:

(a) Letters: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except letters "I" = one stroke width = 1/6 H, and "W" and "M" = 4/5 H).

(b) Numerals: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except numbers "1" = one stroke width = 1/6 H, and "4" = 3/5 H + 1/6 H).

(c) Spacing: Between characters = 1/6 H minimum; between words = one normal character (4/5 H) minimum; between lines = 1/2 H minimum.

2. Since the above characteristics are based on a nominal viewing distance of 20 in (510 mm), the results of Test (2) above should be analyzed to determine if the characteristics are in consonance with accepted standards in MIL-STD-1472B for greater viewing distances. For 20 to 36 in (51 to 97.4 mm) viewing distances, the minimum character height, H, should be 4.3 millimeters; and for distances from 36 to 72 in (97.4 to 195 cm), H should be 8.6 millimeters.

3. If the results of the analysis show a disparity, the legibility of the printed messages is impaired, and corrective measures may be required.

MESSAGE FORMAT

The purpose of this preoperational evaluation is to assess the ability of the printer to present the information in a directly usable form with minimal requirements for decoding, transposing, interpolation or mental translation by members of the security force.

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INSPECTION

Examine randomly selected printed intrusion messages, paying particular attention to the means of identifying each message type (i.e., sensor, tamper, line monitor, power emergency, etc.), the description of the status or event and the accuracy of the date/time indication.

1. Verify that sharp lines of demarcation exist between each message, either by appropriate spacing between words/lines or by preprinted forms.

2. Determine that the number of characters in the character set is sufficient to print all types of messages used in the security system.

DEMONSTRATION

A series of either machine simulated intrusions or real intrusions made by cooperating security personnel are required to be made using appropriate portions of the system. The simulated or actual activations should include at least three of each of event the security system monitors (i.e., tamper, line fault, power emergency, access, intrusion, etc.). Verify that the monitoring personnel are able to check the printer response against the stimuli and quickly identify the type of event and its location without consulting other members of the security force.

ANALYSIS

1. Review the messages to ascertain that the printed information complies with the requirements of 10 CFR 73.50 or 73.55 as appropriate and that it is in a usable format.

2. Verify that the identification and understanding of the messages by the monitoring personnel agree with the events provided.

Performance Characteristic/Measurement Procedure	Measurement Equipment
BACKGROUND CONTRAST	
A critical factor in obtaining a high degree of legibility is the luminance contrast between the printed message and the background (paper). It is the purpose of this evaluation to ascertain that the output of the printer provides a luminance contrast within acceptable standards as defined in MIL-STD-1472B.	
TEST	
A printed message should be compared to the contrast gauge to attempt to match the printed characters with an acceptable standard contrast level on the reticule. This matching process is to be conducted under all conditions of ambient lighting (including emergency lights) and internal illumination of the printer, if the device is so equipped, to preclude masking by lights similar to the colors of the print. Record results for future comparison. If a suitable contrast is not observed, corrective action must be taken.	Comparator such as Edmund Scientific Company Catalog No. 41,055 with reticule Catalog No. 30,539.
ANALYSIS	
1. In operational inspections compare the current installation ambient lighting conditions and contrast results of the Test above with the findings from previous inspections to determine that no deterioration in performance has occurred. Corrective measures are necessary if the contrast has degraded below minimum standards.	
2. Review the licensee's maintenance logs to determine the periodicity of resupplying paper and ink as well as the sequence of conducting preventive maintenance. Any deterioration in contrast would indicate such procedures may need to be conducted at more frequent intervals.	Licensee's maintenance logs.
TWO COLOR PRINTING	
If the licensee employs a printer capable of two color printing (red and black) this evaluation has the purpose of verifying the operation of the two color printing capability and that the print is legible.	735 303

ANALYSIS

Determine that the luminance contrast between each of the two colors and the background during the evaluation of BACKGROUND CONTRAST above is suitable under all illumination conditions. Pay particular attention if red ambient illumination is used at any time.

DEMONSTRATION

Have at least 1/10 of the total number of messages of each color printed out. Check the response of the printer to appropriate types of activations that will cause the two message colors to be printed, and determine that the proper colors appear for the proper stimuli.

PRINT, INK AND PAPER FEED MECHANISMS

The purpose of this evaluation is to ascertain that the print, ink and paper feed mechanisms are in proper synchronism and to determine if any deterioration has occurred.

INSPECTION

1. Examine a randomly selected series of printed messages to verify that the print lines are straight, the characters show no signs of "smudging", there is no overprinting of characters on lines, no omitted characters or lines, and the textual message is in registration with the paper and with any preprinted forms.

2. If the printer is capable of printing at different speeds -- characters per minute or lines per minute -- repeat step (1) above for each of the speeds available and note any discrepancies. Since the discrepancies would tend to impair the legibility of the printed messages, any noticeable ones should be corrected. Furthermore, a recurrence of the discrepancies during successive periodic examinations will provide evidence of deterioration of the printer.

Printer manufacturer's operation manual.

Performance Characteristic/Measurement Procedure	Measurement Equipment
ANALYSIS	
Review licensee maintenance logs to determine the frequency of adjustments to the print, ink and paper feed mechanisms. Calculate and record the frequency of such adjustments for the period of time since the last inspection visit. Consistent increase in frequency of adjustments indicates possible deterioration in the mechanisms.	Licensee's maintenance logs. Lessor's maintenance procedure.
NOISE	
Impact printers create higher levels of noise than do the non-impact types. However, both types have noise created by paper feed mechanisms. The purpose of this evaluation is to determine the noise level of the printer in operation.	
TEST	
A sufficient series of test messages should be printed to permit the sound level to be measured and recorded.	Sound level meter such as a General Radio Type 1565-A.
ANALYSIS	
1. Examine the test results. The maximum noise level should not exceed 65 dB above 0.0002 dynes/cm^2. Increases in the noise level detected during subsequent periodic evaluations will indicate a possible degradation in the performance of the printer.	
2. Review the licensee's maintenance logs to ascertain that the preventive maintenance procedures have been conducted according to the established plan.	Licensee's maintenance logs.
OPERATION INDICATIONS	
The different printers provide various numbers of indicators of printer operation. Fault indicators such as paper-jam, ink-ribbon jam and need for material replacement (paper and ink)	

Performance Characteristic/Measurement Procedure	Measurement Equipment
generally provided. The purpose of this evaluation is to determine that the indicators operate properly as defined in the printer manuals.	
INSPECTION	
Examine the printer to determine that the material replacement indicators perform satisfactorily. The indicators should become activated prior to the need to replenish supplies or should provide an indication of amount of remaining material. Use the test procedures recommended by the manufacturer.	Licensee's operation plan. Printer manufacturer's operation manual.
DEMONSTRATION	
Simulated faults should be introduced into the printer to activate each fault indicator. Correspondence between each simulated fault and indication should be obtained; otherwise, corrective measures are necessary.	
ANALYSIS	
1. Compare the results obtained from this demonstration with the findings from the previous inspection visit to determine that the performance has not degraded.	
2. Examine the licensee maintenance logs to determine the frequency of occurrence of fault indications. Calculate and record the frequency. Consistent increases in the incidence of fault indications may be due in part to inadequate maintenance as well as deterioration in the printer.	Licensee's maintenance logs.
MAINTENANCE PROCEDURES	
The purpose of this evaluation is to ascertain that the licensee has developed and implemented a comprehersive maintenance schedule/procedure. The maintenance may be performed by the lessor in a lease arrangement or by properly skilled technicians in the employ of the licensee.	

Performance Characteristic/Measurement Procedure	Measurement Equipment
ANALYSIS Examine the planned maintenance schedule/procedures and the manufacturer's printer manuals and determine that preventive maintenance schedules contain, as appropriate to each type of printer, features such as: 1. A complete cleaning to remove all dust, paper particles, ink residue and oil every 300 to 500 hours. 2. A complete examination of mechanism and controls to detect any needed adjustments or wear every 300 to 500 hours. 3. A complete overhaul of the mechanisms by replacing worn components, lubricating bearings, linkages, ratchets, etc. every 2000 hours.	Licensee's physical security plan and/or maintenance plan. Printer manufacturer's instruction, operation and maintenance manuals.
DIAGNOSTIC EXERCISE If the security system has the capability to provide machine (computer) generated diagnostic tests of the printer, this evaluation concerns the conduct and assessment of such diagnostics.	
INSPECTIONS Review the set of diagnostic programs being used; compare the set contained in the maintenance plan and identify any differences. DEMONSTRATION Exercise the set(s) of available diagnostics in accordance with the printer instruction manual and/or maintenance plan and verify that the printer functions properly. ANALYSIS 1. Determine if any changes have been incorporated in the set(s) of programs since the previous inspection visit. Changes	Licensee's physical security plan and/or maintenance plan. Lessor's maintenance procedures. Printer instruction, operation and maintenance manuals. Descriptions of diagnostic programs, and appropriate tapes/storage device(s) and machine (computer).

may indicate a simple upgrading of the maintenance actions. However, they also may indicate the need to perform more maintenance because the printer is deteriorating.

2. Examine the results of the demonstration and compare with the results of previous inspection visits. Any differences indicate either inadequate maintenance or deterioration in the printer.

OTHER DISPLAYS

EVENT DISPLAYS AND RECORDERS

Event recorders usually use a transilluminated display in combination with a printer to indicate and record a change or an occurrence detected by a sensor or transducer. The transilluminated display may involve a series of indicator lights, either conventional incandescent, light-emitting diodes (LEDs), or a series of "flags". The flags may be "shutters" over incandescent bulbs. The printer is usually of the data logging or digital family, using impact printing with either a ribbon or roller ink mechanism (see Volume VII, Section 2).

The major functional elements of event recorders include the receiver, scanner, display, printer, and interface logic. Some devices have separable elements which include a remote transmitter at one location that sends received indications over long distances via telephone lines to the display and recording elements of the event recorder at a remote location.

Event recorders are often interconnected to each sensor or transducer, or to a zone covered by such devices, through a separate line. For certain event recorders this is a conventional 600-ohm telephone line, while other event recorders can only be interconnected by direct hardwire lines. Event recorders that utilize telephone lines have digital-to-analog and analog-to-digital (D/A/D) converters, sometimes used in conjunction with a modem, incorporated in the receiver element. Recorders that depend on hardwire interconnections have simple receivers that sense a change of state (voltage) of the line. The incoming signals from the D/A/D usually are placed in a memory, and the scanner element repeatedly scans the memory for signals. When the scanner detects the presence of a signal, appropriate messages are sent to the display and to the printer. In recorders that are hardwired to the sensors, the scanner examines each line, and when a change of state is noted, proper messages are sent to the display and the printer.

Most event recorders provide for modular growth through the addition of printed circuit (PC) boards or expander units. Some event recorders can accept signals from as many as 1000 sensor zones.

Two primary performance areas determine the suitability of an event recorder for a particular application: (1) the legibility of the display and of the printed information; and (2) the response time of the display and printer to stimuli at the sensor or transducer. Legibility is affected by the size, spacing, and font of the legends on the display and the printed information, the positioning of the legends with respect to the indicators (bulbs, LEDS, or flags), the ambient illumination color of indicators, and the resultant contrast. In general the legibility of displayed or printed characters is within acceptable limits of MIL-STD-1472B (Human Engineering Design Criteria), since most devices provide characters at least one-eighth inch in height, properly spaced and positioned. The colors of lights may be critical if the display is operated in high ambient light, for example in bright sunlight, since under such conditions red is not readily apparent and green and blue lights are hard to distinguish from each other.

Response time is a critical parameter in some installations and is a function of scanner speed, memory size, number of zones, and printer response time. Typical event recorders have an overall response time of about one second per line per stimulus. However, some have response times approaching 30 seconds per line per stimulus, and these would be unsatisfactory in particular applications. Since many event recorders have long signal lines to the sensors, other provisions for line monitoring or physical hardening should be provided to maintain security and reduce vulnerability to tampering.

The event recorders generally incorporate maintenance aids, such as indicator light tests (manually or automatically tested), faulty power indicators, and end of paper/ink warnings in the printer element.

TRANSILLUMINATED DISPLAYS

Transilluminated displays employ backlighting on clear, translucent or fluorescent material, or use single and multiple legend/indicator lights or light-emitting diodes (LEDs) to present information upon receipt of signals. Such displays depend on other devices or elements (sensors, transducers, or signal processing logic) to provide signals to actuate the display.

Some transilluminated display devices are hardwired to the external elements with an individual line/wire to each transillumination display component (indicator bulb), and the individual line carries the "sense" signal (voltage) to actuate the display component. Other transilluminated displays incorporate an analog-to-digital (A/D) converter, sometimes in conjunction with a modem, to permit interconnection with external devices via telephone lines. For the latter kind of displays, the digital signal from the A/D is transformed into a "sense" signal by internal logic that will actuate the display component(s).

The primary performance parameter of the transilluminated display is legibility. Legibility is determined by the positioning, number and colors of the display components, the character size, the spacing and positioning of associated legends and ambient lighting. Most transilluminated displays operate best in areas where the luminance of the display is at least ten percent greater than the surrounding lighting. The characters of the identifying legends should be readable at a minimum distance of 28 inches (71 cm) in the operating environment and should have a height of at least one-eighth inch (0.3 cm). If viewing at greater distances (D) is required, the height should be increased by the factor D/28.

Some transilluminated displays that employ incandscent bulbs use dual-filament bulbs so that when one filament burns out, the decrease in intensity is apparent but not so much as to keep the user from noting an event until the bulb can be replaced. Furthermore, most displays of this category have a "press-to-test" feature which permits the user to periodically check the operation of the indicators.

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EVENT DISPLAYS AND RECORDERS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Event Displays and Recorders	VII-3.a

Performance Characteristic/Measurement Procedure	Measurement Equipment
PREREQUISITES	
The event recorder should be interconnected with the other equipment of the security system. This equipment should be operational and be capable of transferring appropriate signals to the event recorder.	
PRINT STRUCTURE	
The purpose of this preoperational evaluation is to determine if the recorded characters conform to established and generally accepted criteria for size, spacing and font (MIL-STD-1472B).	
NOTE: A series of at least 5 separate intrusion signals generated by actual sensor activations are required to be printed out prior to performing the following evaluation.	
TEST	
Measure and record the character sizes and stroke widths of the print and the spacing between characters, words and lines.	Comparator such as Edmund Scientific Company Catalog No. 41,055.
ANALYSIS	
1. Analyze the results of the data collected above to determine if the print structure conforms to the following criteria:	
(a) Letters: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except letters "I" = one stroke width = 1/6 H and "W" and "M" = 4/5 H).	

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(b) Numerals: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except numbers "1" = one stroke width = 1/6 H and "4" = 3/5 H + 1/6 H).

(c) Spacing: Between characters = 1/6 H minimum; between words = one normal character (4/5 H) minimum; between lines = 1/2 H minimum.

2. If the results of the analysis show a disparity, the legibility of the recorded messages is impaired and corrective measures may be required.

MESSAGE FORMAT

The purpose of this preoperational evaluation is to assess the ability of the printer to record the information in a directly usable form with minimal requirements for decoding, transposing, interpolation or mental translation by members of the security forces.

INSPECTION

Examine randomly selected recorded intrusion messages, paying particular attention to the means of identifying each message type (i.e., sensor, tamper, line monitor, power emergency, etc.), the description of the status or event and the accuracy of the date/time indication.

1. Verify that sharp lines of demarcation exist between each message either by appropriate spacing between words/lines or by preprinted forms.

2. Determine that the number of characters in the character set is sufficient to print all types of messages used in the security system.

DEMONSTRATION

A series of intrusions against the safeguards system should be made by cooperating security personnel. The activations should include at least three of each type of event that the security system monitors (i.e., tamper, line fault, power emergency, access, intrusion, etc.). Verify that the monitoring personnel are able to check the printer response against the stimuli and quickly identify the type of event and its location without consulting other members of the security force.

ANALYSIS

1. Review the messages to ascertain that the printed format complies with the requirements of 10 CFR 73.50 or 73.55 as appropriate.

2. Verify that the identification and understanding of the messages by the monitoring personnel agree with the stimuli provided.

BACKGROUND CONTRAST

A critical factor in obtaining a high degree of legibility is the luminance contrast between the recorded message and the background (paper). It is the purpose of this evaluation to ascertain that the output of the recorder provides a luminance contrast within acceptable standards as defined in MIL-STD-1472B.

TEST

A recorded message should be examined through the comparator in order to match the printed characters with a contrast level indicator on the reticule. This matching process should be conducted under all conditions of ambient lighting (including emergency lights) to preclude masking by lights similar to the colors of the print. Record results for future comparison. If a suitable contrast is not observed, corrective action must be taken.

Comparator such as Edmund Scientific Company Catalog No. 41,055 with reticule Catalog No. 30,539

ANALYSIS

1. In operational inspections compare the results of the Test above with the findings from previous inspections to determine if degradation has occurred. Corrective measures are necessary if the contrast has degraded below minimum standards.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
2. Review the licensee's maintenance logs to determine the periodicity of resupplying paper and ink as well as the sequence of conducting preventive maintenance. Any deterioration in contrast would indicate such procedures may need to be conducted at more frequent intervals.	Licensee's maintenance logs.
PRINT, INK AND PAPER FEED MECHANISMS	
The purpose of this evaluation is to ascertain that the print, ink and paper feed mechanisms are in proper synchronism and to determine if any deterioration has occurred.	
INSPECTION	
Examine a randomly selected series of recorded messages to verify that the print lines are straight, the characters show no signs of "smudging", there is no overprinting of characters or lines, no omitted characters or lines, and the textual message is in registration with the paper. Since the discrepancies tend to impair the legibility of the recorded messages, any noticeable ones should be corrected. Furthermore, reoccurrence of the discrepancies during successive periodic examinations provide evidence of deterioration of the recorder.	
ANALYSIS	
Review licensee's maintenance logs to determine the frequency of adjustments to the print, ink and paper feed mechanisms. Calculate and record the frequency of such adjustments for the period of time since the last inspection visit. Consistent increase in frequency of adjustments indicates possible deterioration in the mechanism.	Licensee's maintenance logs. Manufacturer's maintenance procedures.
NOISE	
Impact printers create higher levels of noise than do the non-impact types. However, both types have noise created by paper feed	735 316

Performance Characteristic/Measurement Procedure	Measurement Equipment
mechanisms. The purpose of this evaluation is to determine the noise level of the printer in operation.	
TEST	
A sufficient number of messages should be recorded to permit the sound level to be measured and recorded.	Sound level meter such as General Radio Type 1565-A.
ANALYSIS	
1. Examine the results. The maximum noise level should not exceed 65 dB above 0.0002 dynes/cm^2. Increases in the noise level detected during subsequent periodic evaluations will indicate a possible degradation in the performance of the printer.	
2. Review licensee maintenance logs to ascertain that the preventive maintenance procedures have been conducted according to the established plan.	Licensee's maintenance logs
INDICATOR LABELS	
The purpose of this evaluation is to determine if the characteristics of the indicator labels conform to established criteria (MIL-STD-1472B) for size, spacing and font.	
TEST	
1. Measure and record the characters on the labels to determine the character sizes, the stroke width, and the spacing between characters, words and lines.	Comparator such as Edmund Scientific Company Catalog No. 41,055.
2. Measure and record the normal viewing/reading distance between the display information and operating security personnel.	Steel tape calibrated in inches/centimeters.
ANALYSIS	
1. Analyze the results of the data collected in Test (1) above to determine if the structure of the characters conforms to the following criteria:	735 317

(a) Letters: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except letters "I" = one stroke width = 1/6 H and "W" and "M" = 4/5 H).

(b) Numerals: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except numbers "1" = one stroke width = 1/6 H and "4" = 3/5 H + 1/6 H).

(c) Spacing: Between characters = 1/6 H minimum; between words = one normal character (4/5 H) minimum; between lines = 1/2 H minimum.

2. Since the above characteristics are based on a nominal viewing distance of 28 in (71.1 cm), the results of Test (2) above should be analyzed to determine if the characteristics are in consonance with accepted standards in MIL-STD-1472B for greater viewing distances. If the viewing distance (D) is greater than 28 in (71.1 cm), the minimum character height (H) should be increased by the factor D/28 or D/71.1 (for measurements made in inches or centimeters respectively).

3. If the results of the analysis show a disparity, the legibility of the labels is impaired, and corrective measures may be required.

RESPONSE TIME

The purpose of this evaluation is to determine the response time of the event recorder.

TEST

A series of at least ten separate actual intrusion alarms should be generated by cooperating security personnel. The time between the receipt of the intrusion signal at the input of the event recorder and the illumination of the visual indicator should be measured and recorded. The electronic counter should be started by the initiation of the alarm signal at the input to the event recorder and be stopped by the voltage appearing across the visual indicator.

Electronic counter such as Hewlett Packard 5245 L/M.

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ANALYSIS

Calculate the average of the response times; the result should be less than five seconds to ensure effective guard force response. A steady increase in response time over previous inspections indicates that degradation may have occurred.

DISPLAY/RECORD CORRELATION

The purpose of this preoperational evaluation is to ascertain that the visual signals appearing on the display correspond to the appropriate recorded messages.

TEST

A number of actual security alarms should be generated by co-operating security personnel. At least five alarms for each type of signal (i.e., sensor, tamper, line monitor, power emergency, etc.) should be generated and the results recorded.

ANALYSIS

The correspondence between the alarm indicated and the recorded message should be verified and any discrepancies corrected.

INDICATOR VISIBILITY

The purpose of this evaluation is to determine that the visual indicators provide sufficient light output, as defined in MIL-STD-1472B, that they can be readily observed within the operational ambient lighting of the monitoring station.

INSPECTION

Examine the physical location of the visual indicators to determine that their position with respect to the operator has not changed and is such as to minimize the effects of reflected light from external (ambient) light sources.

Performance Characteristic/Measurement Procedure	Measurement Equipment
TEST	
1. Measure and record the light output from each type of indicator lamp.	Spot meter such as Photo Research Corp. Model UBD-1/4°.
2. Measure and record the ambient light level (including emergency lighting).	Light meter, such as United Detector Technology, Model 40X with photometric filter and footcandle diffuser.
ANALYSIS	
To be acceptable the alarm indicator lamps should produce a minimum of 50 foot-lamberts in an ambient lighting of 30 footcandles. In other ambients, a ratio of lamp brightness to ambient illumination of 5/3 should be maintained.	
MAINTENANCE PROCEDURES	
The purpose of this evaluation is to ascertain that a comprehensive maintenance procedure has been developed and implemented by the licensee. Maintenance may be performed by the lessor in a lease arrangement, or by properly skilled technicians in the employ of the licensee.	
ANALYSIS	
Examine the planned maintenance procedures and the event recorder manuals. Determine if the preventative maintenance schedules contain, as appropriate to each type of recorder, features such as:	Licensee's physical security plan and/or maintenance plan. Event Recorder instruction, operation and maintenance manuals.
1. A check of all indicator lights and switches for proper operation every shift.	
2. A complete cleaning every 300 to 500 hours to remove all dust, paper particles, ink residue and oil.	

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Performance Characteristic/Measurement Procedure	Measurement Equipment
3. A complete examination of the mechanisms and controls to detect any needed adjustments or wear every 300 to 500 hours. 4. A complete overhaul of the mechanisms by replacing worn components, lubricating bearings, linkages, ratchets, etc. every 2000 hours.	

TRANSILLUMINATED DISPLAYS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Transilluminated Displays	VII-3.b

Performance Characteristic/Measurement Procedure	Measurement Equipment
PREREQUISITES	
The display should be interconnected with the other equipment of the security system. This equipment should be operational and be capable of transferring appropriate signals to the display from activated sensors.	
LABEL CHARACTER STRUCTURE	
The purpose of this evaluation is to determine if the label characters conform to established and accepted criteria for size, spacing and font, (MIL-STD-1472B).	
TEST	
1. Measure and record the sizes and the stroke widths, of the characters on the labels, and the spacing between characters, words and lines.	Comparator such as Edmund Scientific Company Catalog No. 41,055.
2. Measure and record the normal viewing/reading distance between the display and operating security personnel.	Steel tape calibrated in feet/meters.
ANALYSIS	
1. Analyze the results of the data collected during Test (1) above to determine if the structure of the characters conforms to the following criteria:	
(a) Letters: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except letters "I" = one stroke width = 1/6 H and "W" and "M" = 4/5 H).	

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(b) Numerals: Height (H) = 2.3 millimeters minimum; Width (W) = 3/5 H (except numbers "1" = one stroke width = 1/6 H and "4" = 3/5 H + 1/6 H).

(c) Spacing: Between characters = 1/6 H minimum; between words = one normal character (4/5 H) minimum; between lines = 1/2 H minimum.

2. Since the above characteristics are based on a nominal viewing distance of 28 in (71.1 cm), the results of Test (2) above should be analyzed to determine if the characteristics are in consonance with accepted standards in MIL-STD-1472B for greater viewing distances. If the viewing distance (D) is greater than 28 in (71.1 cm), the minimum character height (H) should be increased by the factor D/28 or D/71.1 (for measurements made in inches or centimeters respectively).

3. If the results of the analysis show a disparity, the legibility of the labels is impaired and corrective measures may be required.

INDICATOR VISIBILITY

The purpose of this evaluation is to determine that the visual indicators provide sufficient light output, as defined in MIL-STD-1472B, that they can be readily observed in the operational ambient lighting of the monitoring station.

INSPECTION

1. In preoperational inspections examine the physical location of the visual indicators to determine that the positioning of the indicators with respect to the operator is such as to minimize the effects of reflected light from external (ambient) light sources.

2. In operational inspections verify that neither the physical location of the visual indicators nor the position of the indicators with respect to the operator have been altered.

Performance Characteristic/Measurement Procedure	Measurement Equipment
TEST	
1. Measure and record the light output from each type of indicator lamp.	Spot meter such as Photo Research Corp. Model UBD-1/4°.
2. Measure and record the ambient lighting (including emergency lighting).	Light meter such as United Detector Technology, Model 40X with photometric filter and foot-candle diffuser.
ANALYSIS	
1. To be acceptable the alarm indicator lamps should produce a minimum of 50 foot-lamberts in an ambient lighting of 30 foot-candles. In other ambients, a ratio of lamp brightness to ambient illumination of 5/3 should be maintained.	
2. Compare the results of Tests (1) and (2) above with results obtained in previous evaluations and determine if any degradation has occurred.	
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ALARM SIGNALLING SYSTEMS

The basic objective of an alarm signalling system is to convey to a central monitoring facility that alarm/status information which has been generated by a remotely located sensor device. Equipment configurations and method of operation can vary considerably from installation-to-installation; however, some basic functional characteristics can be identified. One means of characterizing alarm signalling systems is by the techniques used to convey the alarm information. The following subparagraphs paraphrase definitions for four types of alarm signalling systems as specified in Underwriters Laboratories Standard UL-611.

Direct Wire Systems

A direct wire system shall form one or more fully supervised protection circuits so arranged that an alarm will be initiated at the central station from the effect of an open circuit, short circuit, ground, or other significant change of resistance or current flow in the lines. Direct wire lines require an instrument, usually a milliammeter, in the individual receivers located in the central control panel to continuously monitor the line current that indicates the circuit condition. If more than one receiver is present, monitoring jacks in the other protection loops and a common current-measuring meter may be used.

Transmitter Systems

A transmitter system shall provide for the connection of more than one subscriber's protection circuit to the central station by means of coded signals transmitted by a code transmitter via wire, telephone lines or radio.

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Multiplex

Multiplexing is a method of signalling (transmitting protection circuit information) characterized by the simultaneous and/or sequential transmission and reception of multiple signals over a single communication channel with means of positively identifying each signal. The signalling may be accomplished over a wire path, radio or telephone lines.

Combination Transmitter and Local Systems

Combination systems are systems provided with a grounding device at the subscriber's premises and in addition, employ a code transmitter to send alarm signals to the central station. Most systems fall in this category.

Alarm signalling systems are usually composed of five serially connected segments: The Central Station, which is connected to the remote Transmitters by means of the Communications Link; and the Sensor Devices, which are connected to the transmitters by the Initiating Lines (Figure 1). The sensor devices are described in Volume II (Intrusion Detection Components).

The Central Station is composed of various categories of equipment that provide the functional capability for alarm monitoring, remote test and reset, access and secure switching, and operation logging. An alarm signalling system might use all or only a few of the items that are discussed briefly below.

The Processor/Computer

This element generally provides continuous monitoring of all analog and digital signals. It also annunicates non-normal conditions, initiates programmed start-stop operations, and permits operator signal selection, visual display selection, and command generation through the console keyboard. The processor consists of a power supply and several electronic logic cards containing transceivers (or repeaters), processor function cards, and memory for systems requiring programmed control or analog alarm limit comparison. A computer interface is also included for systems using a computer.

Annunciators

This element is used in one form or another by many systems to provide a visual display of the zone or building that has originated an alarm signal. Annunicators may also monitor the prime power applied to the alarm system, switchover to standby power, and whether an area is in a secure or access mode. They sometimes incorporate a single audible tone to draw attention to the fact that an alarm signal is being received on the annunciator. Annunciators are of two general types: the drop and the lamp. The drop type causes a metal flag to move into view behind a small window; the lamp type lights a light. Annunicators may incorporate a number of colored lamps to indicate specific alarm conditions or power failure.

Alarm Receiver

This is an element used by many systems to receive and process sensor alarm signals and responses from other monitoring and control devices. The receiver is an annunicator that also provides supervision of the alarm line. It may or may not include an audible alarm device. Various circuit and contact arrangements are usually available to provide auxiliary functions upon receipt of an alarm signal.

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Printers

This element is often used in computer-controlled systems and some processor-controlled systems to record the change of state of sensors and to note changes in system control functions. Other central station receiving equipment may have built-in printers or may have optional connections to an external printer for logging all the activities of the alarm-signalling system.

Basically, all printers should provide hard copy, preferably in two colors, red for alarm conditions and black for a return-to-normal or normal condition. The printer should record the time, date, address of remote point, control command, and alarm type and condition. Printers use mnemonics (abbreviated words that are easily identifiable) to increase speed and capacity. The operator of the system must be thoroughly familiar with this method of communication. In large alarm systems, a "logging printer" (used to make itemized breakdowns of alarm system activity) may be used as a backup printer. For a thorough discussion of specific printers, see Catalog Volume VII (General Purpose Displays).

Cathode Ray Tube (CRT) Display

This element is sometimes used in computer-based systems to provide visual alpha-numerical output of single-point data or messages (see Volume VII-1). The display outputs data received from the processor in standard ASCII code and has on, off, and erase controls. The data to be displayed is selected on the console keyboard. For a more complete description, see Catalog Volume VII (General Purpose Displays).

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Video Monitors

These are sometimes provided as optional equipment with some alarm systems, but may also be part of a closed-circuit television (CCTV) system incorporating video cameras and monitors for surveillance and intrusion alarm source identification. Video switching may be provided for several monitors, and a number of cameras may be switched to the same monitor. Cameras may include some or all of the following capabilities: pan, tilt, zoom, focus and iris control. The CCTV controls are usually located at the control console. For a more complete discussion, see Catalog Volume IV (Surveillance Components).

Intercom

This element is generally used in systems requiring constant communication with personnel in remote areas and provides two-way audio communications between the central station (or its backup) and the remote areas. It may also be used to audibly monitor remote areas, to page and communicate with personnel such as guards on tour and to provide for all-station announcements and paging. Intercoms may be of the push-to-talk type and/or use hands-off operation.

Graphic Displays

This is an optional element used to display areas of concern from a random-access projector on a rear-projected viewing screen, using the console keyboard. For a more complete discussion, see the Catalog volume for General Purpose Display Components, Volume VII.

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Access/Secure Control

This control enables an area within a protection loop to be put in a secure or accessible mode. Figure 2 is a schematic diagram of the basic protection loop, showing the connection of the access/secure control. The access/secure control unit, which may be located at the operator's console or at the controlled area, operates by a secure keyswitch. The access/secure control connects to a substitute ECLC (end-of-the-line component) when the access control unit is energized. This places a substitute EOLC across the protection loop at a selected point, disconnecting the remainder of the protection loop serving the area which is to be made accessible.

Console Keyboard

This device provides another form of man-machine interface used to control a system by enabling the operator to manually select an address, to perform a manual command or demand function, and to select a system operating mode, such as displaying summaries or printing logs.

Control Console and Operator's Terminal

In a less sophisticated alarm signalling system, a single control console is used and may be as simple as a tabletop model with built-in visual/audible display. It could possibly use a printer to handle the limited number of alarm signal points. In more sophisticated systems the main man-machine interface is the operator's terminal which may provide selection buttons to address the sensor device for test or other purposes, a series of function buttons, a key-operated lockout capability and a digital readout. This console is often a tool for on-site manual computer programming and system checkout.

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In a large computerized system one or more operator's control terminals or consoles may be used and assigned to control or communicate with a specific section of the alarm and control system. Each terminal would be under specific assignment by computer software for controlling building automation, supervision of sprinklers, elevators, etc., in addition to controlling the facility security system.

The <u>Communications Link</u> and <u>Initiating Lines</u> include the various types of communication media used to deliver sensor status signals to the transmitters (initiating lines) and from the transmitters to the receiving equipment located at the central station (signalling lines). Because of electrical variances between systems, the information presented here may only be valid for specific applications.

Alarm communication links (the signalling lines and the initiating lines) may fall into either of two classes of operation: Class A or Class B. They must also observe certain rules and regulations to maintain a given quality of communications operation as specified in the Interim Federal Specification. On the requirements for Class A operation, the National Fire Prevention Association standard for the installation, maintenance and use of proprietary protective signalling systems (NFPA 72D) states that "each signalling circuit and the services connected to it shall be capable of operating in their intended signalling services during a single break or single ground fault of any signalling line circuit conductor". Class B operation does not include the Class A emergency operating feature.

For the signalling line circuit to meet the Class A requirements, a redundant transmission path must be used, with an automatic switchover capability to ensure uninterrupted transmission through a single fault, as specified.

For the initiating line circuit to meet the Class A requirements, a four (4)-wire direct current loop is used with a loop transfer relay (or circuit conditioning relay) to reestablish the circuit. Figure 3 shows the basic 2-wire loop, which does not have this capability unless the second alarm contact to occur happens to be electrically closer to the control panel than the first alarm contact in the circuit. Figure 4 shows how the 4-wire loop circuit functions through a single fault. Assume that there is a break in the wiring at point 'A'. One side of the alarm contacts becomes isolated from the end-of-line resistor (EOLR). A trouble signal results, but at the same time circuit conditioning relay contact 'A' closes. This action connects the alarm contacts that were previously isolated by the break to the EOLR. A subsequent alarm contact closure will short out the EOLR and cause an alarm to be annunciated.

Transmitters are alike in their basic function; they accept and transmit sensor status signals to the receiver, but vary widely in the number of inputs they can handle. They also differ in the method used to gather information from the system's many sensors and to process and transmit it to the central station receiver.

Alarm systems may also be characterized by the protection offered (Line Supervision) by electromechanical means to ensure that the system is in a state of readiness and to signal an alarm if it is not. Most circuits are self-checking in that any change from the normal will cause an alarm.

Signalling Line

Line supervision is sometimes accomplished by providing a dual transmission signal path over direct wire, coaxial cable or telephone lines, depending on system application. By alternating from one line to another, or by comparing data sent by two routes,line operation may be assured.

Digital systems which operation in an interrogate/respond mode provide constant assurance that the transmission path is intact.

On direct-wire systems "ring back" or "handshake" techniques are used on the transmission line to ensure that the receivers and transmitters are talking with one another.

Other types of alarm systems continually send tones, coded tones, random, or high speed, digital interrogate/respond-type signals for line supervision.

Initiating Line

The two-wire loop with the end-of-line resistor is an accepted form of circuit supervision for many applications. Line supervision functions by monitoring the change of current or resistance in the loop circuit, and may have one or all of the following characteristics:

Break or cross sensitive -- A general type of line supervision, which detects a very high resistance for an open line and a very low resistance for shorted lines, is accepted by industry as being adequate for an alarm circuit, say, between a protected area and a police station.

Direct current supervision -- This method detects an increase or decrease in loop current as a percentage of its normal rated receiver input value. The normal current value is selected by adjusting the current limiting and end-of-line resistances. supervision sensitivity is the percentage of current change and normally ranges between 50 and 10 percent. The more sensitive, 10 percent, systems called high line supervision require receivers using a balanced Wheatstone bridge.

Single or double supervision is another consideration for line supervision. Single supervision means that a trouble signal will be given if there is either a break or a short in the circuit. Double supervision means that a trouble signal will

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be given if the power to the source of the first trouble signal is interrupted. This configuration requires two power sources, as an auxilliary means for maintaining the normal operation of the system following the trouble indiciation.

Direct wire lines are limited in length by the line resistance and the particular alarm system application, due to the level of electrical current limitations. These wire lines may be two- or four-wire, depending on the class of service required. Four-wire is needed for Class A operation. A dc "Break" and "Cross" circuit is usually accepted for a basic security alarm system. Alarm systems using coaxial cable for their signalling lines are usually systems that are installed within a single location. The transmission distance of alarm information on telephone lines is unlimited, since the entire Bell Telephone System is available.

Transmission lines of any type that are exposed to the elements (outside runs) degenerate in performance due to humidity and temperature. Lines to be extended between buildings should run through underground conduits or through protected raceways between buildings to reduce these effects.

Computers and processors should be located in an environmentally controlled area to operate under the temperature and humidity conditions specified by the equipment manufacturer.

Lightning and overvoltage protection should be installed on all cables and conductors extending between buildings, whether direct burial, underground conduit or overhead runs are used. Lightning arrestor networks should be installed at both ends. Both primary protection devices, such as a gas tube protector, and secondary protectors should be used to reduce voltages to non-destructive levels. Devices offering both fuse protection and gas discharge lightning protection for telephone lines are typical of the type that should be employed.

To be tamper-resistant all alarm signal wiring should be kept within secure areas or else run through conduit and secured raceways in unprotected areas. Wiring between buildings should preferably be run underground. In addition, where alarm signal panels are mounted in unprotected areas, the panels themselves must be tamper-protected. UL-approved tamper-proof steel boxes and switches should be used.

It is unrealistic to consider any telephone or other off-premise line to be free of the possibility of compromise. Direct-wire systems are more susceptible to compromise by the use of resistors, batteries and other devices. The more sophisticated systems, using complex waveform and digital communication techniques, make compromise quite difficult even by the sophisticated intruder. Noise jamming is generally effective with time division multiplex systems, but is unlikely to be successful in compromising a tone (frequency division) multiplex system because of the narrowband channel filtering used and the band limiting done in telephone line interface units.

Noise warning devices are available from at least one manufacturer to monitor the incoming lines at the central station for attempts to compromise the system by introducing noise. This unit senses noise, sounds an audible/visual alarm, and cuts in an audio speaker which enables the operator to listen to what is being received.

Rechargeable storage batteries are generally used for standby operation and are installed in circuits incorporating a trickle charger to keep the battery ready for immediate service. When primary power fails, automatic transfer of power to the battery should provide at least 24 hours of continuous operation without recharging. If a second source of power is available from a standby generator, battery capacity may be reduced to 4 hours without recharge.

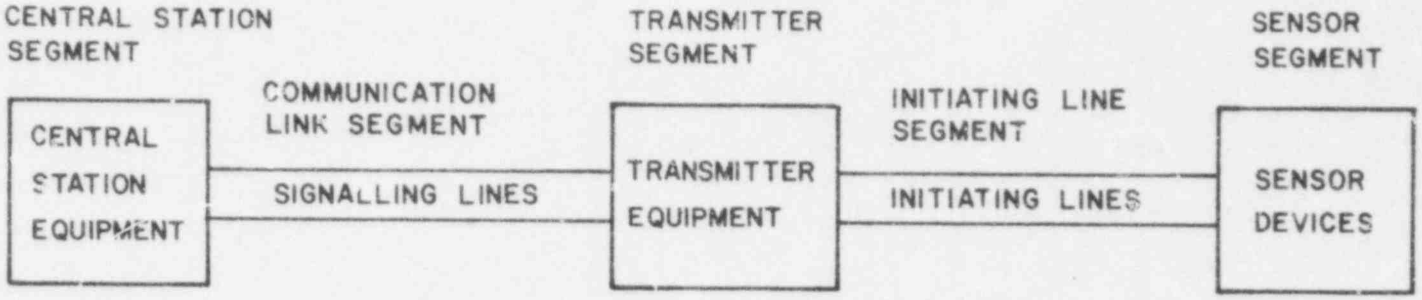


FIGURE I ALARM-SIGNALLING SYSTEMS—BLOCK DIAGRAM

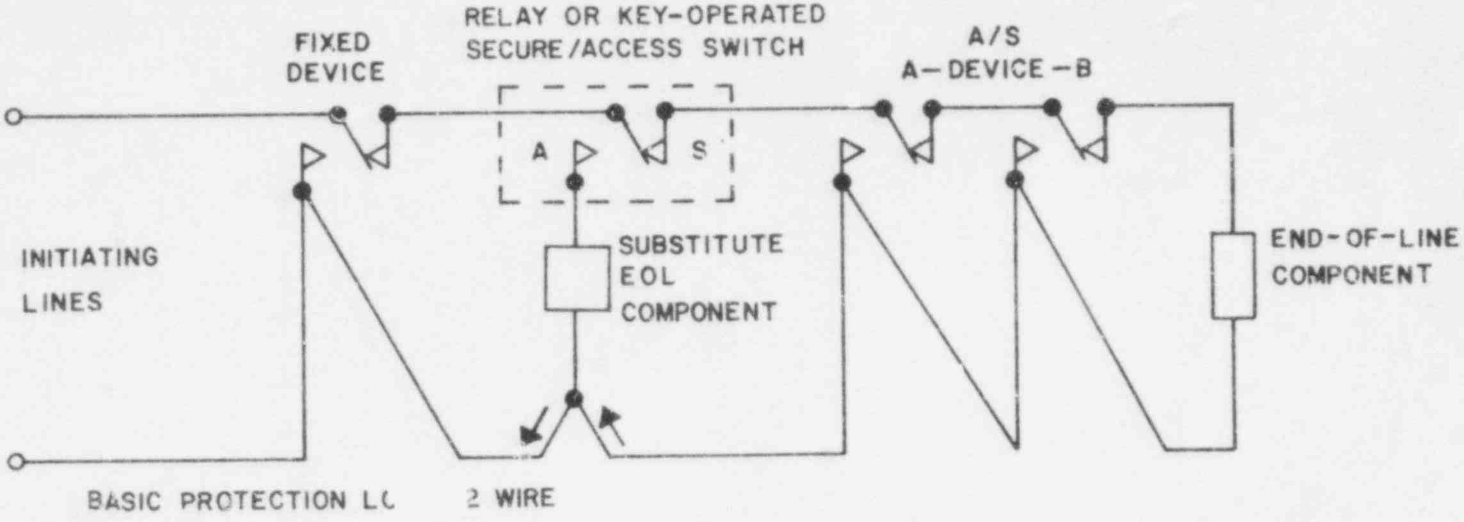
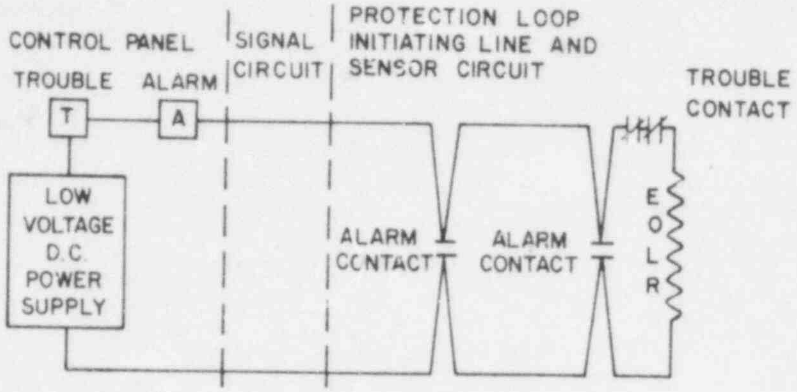


FIGURE 2 BASIC PROTECTION LOOP WITH ACCESS / SECURE CONTROL

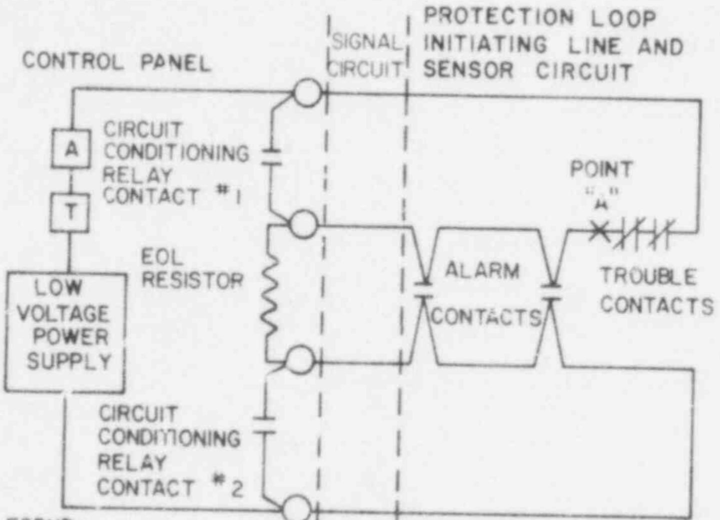


LEGEND:

T TROUBLE (BREAK) SENSITIVE DEVICE

A ALARM (CROSS) SENSITIVE DEVICE

FIGURE 3 BASIC 2-WIRE LOOP FIRE DETECTION AND ALARM CIRCUIT



LEGEND:

T TROUBLE (BREAK) SENSITIVE DEVICE

A ALARM (CROSS) SENSITIVE DEVICE

FIGURE 4 BASIC 4-WIRE LOOP FIRE DECTECTION AND ALARM CIRCUIT

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ALARM SIGNALLING SYSTEMS

EQUIPMENT CATEGORY	CATALOG REFERENCE
Alarm Signalling Systems	VIII-1.a

Performance Characteristic/Measurement Procedure	Measurement Equipment
ALARM SIGNALLING SYSTEMS	
Computer based alarm signalling systems can be very complex and a thorough evaluation can be time consuming. It is recommended that the inspector obtain a user's manual for the system to be evaluated well in advance of the inspection visit in order to become more familiar with the unique features of the system. The evaluation procedures which follow have been divided into four sections: computer operation, alarm display, alarm transmission and line supervision. These procedures should be supplemented with evaluations of a specific nature as recommended, for example, in the operational checkout and preventive maintenance portions of the individual system's operations and maintenance manual.	
COMPUTER OPERATION	
The purpose of this evaluation is to ensure that the computer is properly installed and to verify that it functions properly.	
INSPECTION	
1. Verify that the computer has been installed properly in accordance with the manufacturer's recommendations. Pay particular attention that environmental requirements (temperature and humidity) have been satisfied.	Manufacturer's installation manual.
2. Inspect the computer for signs of physical abuse and mechanical defects. Any defect which may interfere with the operation of the system (such as faulty switches, etc.) should be repaired.	

Performance Characteristic/Measurement Procedure	Measurement Equipment
3. Inspect all controls and indicator lights for damage and obstructions. 4. If the machine is paper tape programmed, verify that the program tape is installed in the tape holder, and that it is in good condition (the tape should not be torn, worn or mutilated in any way). 5. Check that the licensee maintains a full complement of spare parts and components for routine maintenance as recommended in the system maintenance manual. 6. Check that all the required circuit cards/modules are installed and firmly seated in the computer. It is recommended that a means of "sealing" the electronics enclosure and/or circuit modules be used to protect against tampering. (For example, a wire attached to the card and chassis and sealed with a metal crimp-type connector, which would have to be irreparably damaged to gain access to the circuit cards, might be employed.) After routine maintenance operations are performed on the equipment, a member of the licensee's security force should verify that all circuit modules are in place, and seal the enclosure. 7. Inspect the interior of all electronics consoles to ensure that there is no foreign material (such as spilled substances) and that there is no accumulation of dust or dirt. 8. If cooling fans are incorporated in the electronics enclosure verify that they are operating, and inspect the air cleaning filters. The filters should be free of excessive accumulated dirt. In addition, verify that there is adequate space between the air intake ports and any structures surrounding the enclosure, and that the enclosure is not installed in the vicinity of heat generation sources (such as baseboard heaters). 9. Verify that the computer is properly grounded by means of the power cord or by a separately attached ground strap. If the latter means is employed, verify that the strap is firmly connected to a bare metal ground and that all connections are clean and tight. 10. Check that all labels or printed messages on the computer enclosure (such as silk screened control setting information) are clearly legible.	

Performance Characteristic/Measurement Procedure	Measurement Equipment
ANALYSIS	
1. Review the system design parameters (number of sensors, type of alarm signal input, wiring requirements, maximum cable length requirements, etc.) to ensure that the computer used in this application has sufficient capacity and flexibility to meet the system needs. (Potential for system expansion may be estimated by noting the number of spare plug-in module positions remaining in the electronics enclosure which would be used to accept additional zone cards.)	
2. Review the licensee's test and maintenance records and plans to ensure that all of the manufacturer's preventive maintenance recommendations are incorporated and performed on schedule. Also verify that the test plan meets the requirements of 10 CFR 73.50 or 73.55 (as appropriate) regarding frequency of performance testing. In some cases, the licensee may have a service contract with the manufacturer to maintain the equipment.	Licensee's test/maintenance plans and records.
3. Review the system logs to determine if any persistent problems have been encountered since the last inspection visit. If so, determine whether or not the problems are severe enough to warrant the use of compensatory measures to ensure an adequate level of security. Short MTBF periods for any component should result in replacement of the component and a detailed system checkout.	
DEMONSTRATION/TEST	
1. Refer to the system operating instructions and follow the system operator through the system start-up/checkout procedures. If the system employs two computers (primary and backup) verify that both operate properly. For example, switch the lock-type "Enable/Disable" switch to the Enable position to activate the processor electronics. The power-on indicator lamp should come on. Should the system not operate after applying power, and if the processor is suspected, have the licensee initialize a program load to reload the program into the memory. The normal operating indicators should illuminate if no further trouble exists. Verify that the printer, or other system display, records the identification of the processor that was put into service.	
2. If the computer system has the capability of self test by means of a programmed diagnostic routine, have the system	

Performance Characteristic/Measurement Procedure	Measurement Equipment

operator exercise this routine and verify that no faults occur.

3. Perform a lamp test to ensure that all lamps are working.

4. Observe the "Scan" indicator for evidence of processor activity. Normally, this indicator blinks as data is processed. Most processors include a method for interrupting sequential scanning. Activate this control momentarily and observe automatic restoration of the scanning function.

5. As a demonstration of processor operation, one or more alarm zones should be triggered and the appropriate audible/visual annunciation should occur with proper identification of the sensor(s).

6. Request that the licensee pull a randomly selected circuit board. The processor should indicate a fault condition. When the card is placed back into the processor, the system should return to normal operation (verify this by activating several randomly selected sensors and observing the response of the system).

7. Request that the licensee remove the primary source of power from the processor. The system should respond with an immediate transfer of power to the standby source and both audible and visual indications of loss of prime power should appear at the control console. No loss of information should occur during the power transition. Verify that the system operates properly on the backup source by activating several randomly selected sensors and observing the response of the system.

8. Show that all of the system control functions associated with the particular control panel or operator's terminal are operational by performing the following: exercise a number of functions, in turn, by enabling the associated control. Each operation should be recorded on the printer. Return to normal system operation (i.e., reset the control) after each test.

9. If the system employs two computers, exercise the automatic system control transfer switch by disabling the main computer. The disablement of the main computer should result in an alarm and in automatic transfer of the protection system to the standby computer (the transfer should be indicated on the

control panel). Reset the system to quiet the audible alarm. Perform Demonstration (5) above to verify standby computer operation.

Note: The backup computer should always be on-line and functioning as though it were in control.

ALARM DISPLAY

The purpose of this evaluation is to ensure that the proper alarm presentation is provided by the system in response to actual sensor activations as well as computer generated diagnostic routines. Detailed evaluation procedures for display components such as printers, CRT's, event recorders and transilluminated displays are provided in Volume VII.

INSPECTION

1. Inspect all visual indicators for mechanical defects such as broken lamp covers and check all identification markings for clarity and legibility.

2. If audible alarms are provided, ensure that the speakers are in good condition and free from foreign matter. If a volume control is available, verify that it is set such that the signal can be heard above the ambient sound level in the room and that the control cannot be turned down so low that the sound is inaudible.

DEMONSTRATION

1. In the preoperational inspection demonstrate that a sensor activation in each zone of protection is properly processed by the system and the appropriate alarm printout or display is obtained. (Have a person activate each sensor/zone in the system.)

In operational inspections, spot check the annunciation of alarms by activating a randomly selected sample of 20 percent of the sensor zones. This demonstration may be performed in parallel with the evaluation of the sensors.

2. Verify that the alarm annunciation and recorder printout are in agreement.

3. Reset each alarm using the acknowledge button and verify that the proper indicator/recorder actions are obtained.

4. Actuate each of the system control functions in each zone (e.g., the access/secure function) and note that the correct indicator/recorder action is obtained (e.g., when the system is placed in "access", the printout should indicate that fact, and should provide a separate indication when returned to the "secure" mode).

5. Show that the annunciator panel will operate from the standby source of power. Disconnect power to the annunciator panel by pulling its circuit breaker and observe that the indicators for loss of prime power and transfer to standby power become illuminated. Push the acknowledge button to quiet the audible alarm. Return the system to prime power by resetting the circuit breaker. Normal operation indicators should illuminate, and the printout should record end-of-test. (Note: UL-611 recommends that the standby power supply for "Central Station" operation be capable of operating the system for at least 24 consecutive hours without recharging.)

ALARM TRANSMISSION

The purpose of this evaluation is to ensure that the alarm transmission equipment (transmitters and receivers) are fully operational and function properly.

INSPECTION

1. Inspect the transmitter and receiver enclosure panels for mechanical soundness and determine that the panel door locking mechanism is functional.

2. Check that the licensee maintains an adequate supply of spare parts as recommended by the manufacturer.

3. Check that any indicator lights are not damaged and that they are operating. If the transmitter is of the zone monitoring type, it may have LED indicators which indicate loss of input from a sensor location.

Performance Characteristic/Measurement Procedure	Measurement Equipment
4. Check that all electrical wiring to and between the receiver and transmitter is protected from mechanical damage and tampering (for example by conduit) and that all electrical connections are clean, tight and free of corrosion.	
ANALYSIS	
1. Review the licensee's maintenance logs for indications of repairs made on any receiver or transmitter. If the MTBF for a particular unit is short, the licensee should thoroughly evaluate the portion of the system in which the component operates.	Licensee's maintenance records.
2. Review the licensee's security alarm logs to identify sensor zones which have excessive spurious alarm activity. If the evaluation of the sensor itself does not reveal the cause of the alarm activity, the licensee should thoroughly test the communication link between the sensor and the central processor.	Licensee's security alarm log.
3. Verify that the channel capacity of the transmitter has not been exceeded by checking the number of inputs and reviewing the number of sensors monitored in each security loop. One or more sensors in each loop should be activated to ensure transmitter operation.	
DEMONSTRATION/TEST	
1. For transmitter and receiver enclosures equipped with tamper switches demonstrate that, when the enclosures are opened, a tamper alarm signal is displayed at the central alarm monitoring station.	
2. Demonstrate the operation of the transmitter by actuating a sensor in the loop or by simulating a sensor actuation using a clip lead to short out the sensor contacts. Either type of actuation should result in the correct annunciator display.	Clip leads.
3. Demonstrate that the alarm receiving equipment correctly processes the incoming alarm signals and provides the proper signal output for the alarm status monitoring equipment.	
(a) For direct wire systems monitor the current in the signalling loop by means of the built-in multimeter (if available) or by connecting a multimeter across the series current limiting	Multimeter such as Simpson Model 260.

Performance Characteristic/Measurement Procedure	Measurement Equipment
resistor in the supervised loop to verify the change in current/voltage upon sensor activation.	
(b) Tone coded and single digital input receivers [illegible] be checked using an oscilloscope to observe the input signals (frequency shift keying (FSK) or coded tones). Some systems using coded tones in a telephone channel may be monitored by connecting a pair of high impedance earphones across the telephone line to identify the states of the transmitted tones. (The licensee should have a set of earphones for performing preventive maintenance.)	High impedance earphones (from the licensee). Portable oscilloscope such as Tektronix Model 323.
(c) In complex digital systems, the signal structure should be monitored with an oscilloscope (both the receiver input and output signals can be checked). Some of the more sophisticated receivers may have built-in LED indicators that may be used to identify the condition of the input signal.	Portable oscilloscope such as Tektronix Model 323.
Note: Steps (2) and (3) above may be performed simultaneously by noting that the correct display is obtained for a given sensor activation.	
4. Primary power to energize the transmitter may be supplied by a locally available prime power source or via the signalling lines themselves from the central alarm monitoring station. In either method, standby power is obtained from batteries located in the remote transmitter panel. Demonstrate that power is automatically transferred from the prime source to the standby source in the event of prime power failure.	
Note: Transmitters employing an uninterruptable power system must use a UL-listed transfer array that switches power in less than 10 milliseconds.	
LINE SUPERVISION	
The purpose of this evaluation is to enable the inspector to test the line supervision provisions of the alarm signalling system. Line supervision may be provided for the "signalling line", which is the transmission path between the remote transmitter and the	735 346

receiver at the central alarm monitoring station, and the "initiating lines" which provide the transmission path from the sensor to the transmitter (i.e., part of the protection loop). (The signalling line may be constructed utilizing a radio link -- these systems are not evaluated here.) When provided, line supervision should conform to the requirements of the Interim Federal Specification (GSA-FSS) paragraph 3.5. There are four basic methods of supervision for signalling lines and one general method for initiating lines. In addition, the supervisory system must provide for "access" and "secure" modes of operation.

SIGNALLING LINES

INSPECTION

1. Check that the signalling lines extending between buildings are equipped with lightning arrestors and fuses to protect against voltage surges.

2. Check that the licensee maintains an adequate supply of spare fuses for immediate repairs.

DEMONSTRATION/TEST

1. Redundant Paths Technique -- Manually or automatically cause the system to transfer from the primary signalling line to the standby line (e.g., short each line). Verify that the transfer occurs by actuating the sensor serviced by that line and noting the display of sensor actuation. Check that failure of the primary line is annunciated by the system.

2. Digital Interrogation Technique -- Observe that the processor is functioning (for example as evidenced by the blinking "scan" indicator). Momentarily pull the processor line output card (this action removes the digital interrogation signal from the line) and verify that an alarm is generated. The loss of digital signal, which can be monitored by means of an oscilloscope connected across the signalling line, should cause the "scan" indicator to be extinguished. A processor alarm condition should be observed on the annunciator and printer.

Portable oscilloscope such as Tektronix Model 323.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
3. Continuous Tone Technique -- Observe that the system is not initially in an alarm condition by noting that all "system normal" lamps are on. If telephone lines are used for the signalling lines, connect a pair of high impedance earphones across the line and listen to the tones being received (an oscilloscope may also be used). Lift a line fuse on the line, or disconnect an input wire to the receiver, simulating loss of supervisory signal. An alarm should be annunciated.	High impedance earphones (from the licensee). Oscilloscope such as Tektronix Model 323.
Note: Individual channel alarms may not be annunciated in a multiplexed system since the channel identification information may be lost when a complete line is lost.	
4. "Ring-Back" or "Handshake" Technique -- Verify that the system is in a normal condition. Initiate an alarm test by triggering a sensor in the field. Listen on the receiver monitor speaker or use high impedance earphones across the signalling line to hear the alarm signal and the acknowledgment tone. Verify that the transmitter continues to send the alarm signal when the ring-back tone is inhibited.	High impedance earphones (from the licensee).
INITIATING LINES	
<u>INSPECTION</u>	
1. Verify that the proper value end-of-line (EOL) resistors are installed (they may be found in the control panels, transmitter panels or in the access/secure panel).	
2. Check that the resistors are free from discoloration or any other sign of overheating or damage.	
Note: In some systems, diodes are used instead of EOL resistors to establish circuit reference voltage levels.	
3. Check if the circuit is a two- or four-wire type and verify that the EOL device is properly installed for the particular configuration.	735 348

Performance Characteristic/Measurement Procedure	Measurement Equipment
TEST	
1. For systems employing EOL resistors, place a decade resistance box across a randomly selected resistor. Start with a decade resistance at least 1000 times the EOL resistor value and decrease the decade resistance until an alarm is generated. The percent change in supervisory current when the alarm occurred may be calculated as follows: Current Change (in percent) = $\frac{\text{EOL Resistance } (\Omega) + \text{Decade Resistance } (\Omega)}{\text{Decade Resistance } (\Omega)} \times 100$ The percent change should be within the tolerances specified by the manufacturer. Repeat this test on approximately 10 percent of the EOL resistors in operational inspections (all should be tested during the preoperational inspection).	Decade resistance box (six decades, 10MΩ maximum resistance).
2. For systems employing EOL diodes place a diode of the same type in series with the EOL diode. An alarm should be generated when the EOL circuit is opened and remain in an alarm state when the circuit is restored with the extra diode in place. The addition of the extra diode results in a 100 percent increase in the end-of-line voltage, an amount which should not be tolerated by the supervisory system.	Diode of the same type as the EOL diode.
ACCESS/SECURE OPERATION	
INSPECTION	
Check that the access/secure switches and indicator lights are not worn or damaged.	
DEMONSTRATION/TEST	
The access/secure provision is intended to allow a sensor zone to be deactivated during authorized periods of access or maintenance operation. Demonstrate that in the secure mode, both an actual intrusion or actuation of the sensor and tamper switch cause an alarm.	735 349

Performance Characteristic/Measurement Procedure	Measurement Equipment
In the access mode, sensor actuation should not cause an alarm to be annunciated. However, if the tamper switch protecting the sensor is actuated or the initiating line is cut or tampered with, an alarm should be annunciated. Demonstrate this feature by placing the system in "access" and removing a tamper protected cover and/or performing the test for initiating lines provided above.	

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PORTABLE VOICE COMMUNICATIONS

Portable UHF and VHF voice communications equipment is available in three configurations, portable (handheld transceivers), vehicular (mobile transceivers), and Mobile/portable combinations. These units are designed to operate within the Ultra High Frequency (UHF) band or Very High Frequency (VHF) high and low bands. For specific operational application, radio units are required to operate on channels which fall within the frequencies assigned by the Federal Communications Commission (FCC) to the type of radio service being performed, in this case Power Radio Service.

The better-quality transceivers, in which both receiver and transmitter elements are incorporated, have aluminum frames and a high-impact polycarbonate case. All switches have rubber-sealed gaskets, permitting use in severe weather conditions.

Such transceivers use the latest integrated plug-in circuit modules, increasing the equipment reliability and facilitating maintenance. Power is supplied from a twist-lock battery pack which is usually attached to the base of the radio unit.

The transmitter segment frequency-modulates the carrier with the operator's voice and provides means to propagate the signal into free space via a built-in antenna. The antenna is typically omnidirectional. When the transmitter segment is keyed, the integral receiver segment is automatically disconnected from the antenna by the antenna switching relay. This action protects the receiver from damage by the transmitter's high-output signal, since both the transmitter and receiver segments normally share the same built-in antenna.

The receiver segment normally operates in a standby mode. Until the receiver is disconnected by the action of the antenna

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switching relay, it is ready to receive all incoming signals on its assigned frequency. Receivers equipped with Continuous Tone Coded Squelch (CTCS) circuitry will respond only to transmissions with the proper tone code, except when they are operating in the squelch "override" mode.

Mobile transceiver radio units, designed for operation in mobile vehicles, receive power directly from the vehicle's power system. These radio units are usually capable of operating at higher radio frequency (RF) power output than handheld units. This higher power, together with the more efficient vehicle-mounted antennas, provide a greater operating range than is possible with the handheld units. In all other respects their operation and electronic construction is similar to handheld units. However, their protective enclosures are constructed more ruggedly, using sheet steel with aluminum extrusions, and they are waterproofed.

The combination handheld and mobile transceivers are very versatile units, ruggedly constructed to operate in a dual environment as either a handheld portable or vehicle-mounted mobile radio unit. When used as a portable, the radio unit is self-contained with its built-in battery and antenna; when installed in its vehicle-mounted cradle, the unit operates from the main vehicle power system and uses the vehicle-mounted antenna, while the built-in battery automatically recharges. Electrical and mechanical construction is similar to that previously described for handheld units.

Some radio networks employ "repeaters" to extend the range of communications. The repeater employs one frequency for receive and another for transmit; typically a repeater station communicates with the base station on its own unique frequency, and with the handheld/vehicular stations on the standard network frequency.

Some networks provide for communications with telephone subscribers through a Radiotelephone Common Carrier (RCC) service consisting of a base station equipped with appropriate telephone system interface. (Many RCCs offer "repeater" service for extended handheld/vehicular to handheld/vehicular service. One manufacturer offers a special variation which allows direct telephone interface through the base-station transceiver associated with the plant security.)

Manufacturers provide a variety of optional functions in order to provide a specific service or to extend the capabilities of the basic radio unit.

The choice of functions offered is:

<u>Number of Channels</u> - Up to 6 selectable channels

<u>RF Power Output</u> - Up to 10 watts (handheld units)
- Up to 50 watts (mobile units)

<u>Continuous Tone Coded Squelch</u> - Opens receiver on receiving a specific (CTCS) tone from the net transmitter

Part 91 (Subpart F, Power Radio Service) of the FCC rules covers the authorizations required for operating a radio station in a power generating facility. The operator of the fixed master or base station must be licensed for any of the specified frequencies. However, the operators of handheld or vehicular units working in the radio net do not require a license. Radios operating on frequencies assigned to power radio service are not capable of direct communication with the LLEA or with public safety radio services.

The operating range of a UHF radio system depends on the type of terrain, RF output power, antenna efficiency and environmental factors, and is more susceptable to obstacle interference than VHF. The prediction of nominal range performance requires certain assumptions; a reasonable set is as follows:

1. The base station antenna is located 100 feet above the local terrain, uses low-loss transmission coaxial cable, and incorporates a high-gain antenna.

2. There is average ground conductivity, a smooth earth and "typical urban" man-made noise conditions.

Under these conditions, the operating ranges for a 2-watt UHF handheld radio, operating with a 70-watt base station using a 10-dB antenna are:

1.4 miles	Portable-to-portable
11 miles	Portable-to-base
22 miles	Base-to-portable

For 2-watt UHF vehicular radios operating in the same net, assuming the same operating conditions, the range will be:

2.7 miles	Portable-to-mobile
14 miles	Mobile-to-base
28 miles	Base-to-mobile
5.5 miles	Mobile-to-mobile

Under the average conditions specified above the operating ranges for a 2-watt VHF handheld radio operating with a 90-watt base station using a 6-dB antenna are:

1.5 miles	Portable-to-portable
14 miles	Portable-to-base
26 miles	Base-to-portable

Increasing the handheld radio power to 6 watts would increase the operating range as follows:

1.7 miles	Portable-to-portable
14.75 miles	Portable-to-base
26 miles	Base-to-portable (remains the same)

For 2-watt VHF Vehicular radios operating in the same net, assuming the same operating conditions, the range will be:

2.8 miles	Handheld portable-to-mobile
17 miles	Mobile-to-base
30 miles	Base-to-mobile
5.8 miles	Mobile-to-mobile

EQUIPMENT CATEGORY	CATALOG REFERENCE
UHF Portable Voice Communications	VIII-2.a
VHF Portable Voice Communications	VIII-2.b

Performance Characteristic/Measurement Procedure	Measurement Equipment

OPERATION/MAINTENANCE

The purpose of this evaluation is to ensure that the portable voice communication equipment in the licensee's facility is maintained in a good state of repair and that it functions properly. In preoperational inspections all units should be evaluated; in operational inspections, randomly select 10 to 25 percent of the units for evaluation. Select units that are ready for use at the distribution point as well as units which have been in use in the field for several hours.

INSPECTION

1. Inspect the physical condition of the radio unit. Check that all controls are intact and that the antenna is in a satisfactory state of repair and is securely fastened. No defective controls or knobs, antennas, plug-in modules or unit housings should be observed.

2. Check that antennas (depending on radio type) and all plug-in modules, including power supplies and other optional equipment that are interchangeable, are free from signs of excessive wear or abuse.

3. Verify that carrying cases, belt supports and carrying straps are in good condition.

4. Inspect for the addition of any options such as tone coded squelch modules for proper tone frequency selection.

5. Ensure that battery charging and checking equipment operate properly and review the battery charging records to ensure that worn batteries are recycled or replaced promptly.

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Performance Characteristic/Measurement Procedure	Measurement Equipment
6. Check the reserve battery holders and plug-in modular units for proper seating in the radio housing and for worn or corroded connections.	
7. Observe whether or not SCAM (Service, Calibration and Maintenance) stickers are employed on the radio. These stickers are attached to radios, etc., to record expiration date of current calibration, frequency of use, and the dates on which routine preventive maintenance recommended by the manufacturer has been performed. Verify that the information on the stickers shows proper calibration and preventive maintenance.	
ANALYSIS	
1. Review the licensee's procedures for placing a radio unit into service. At a minimum, daily radio performance checks should be accomplished to ensure that radios are in good operating condition and to reduce the possibility of a radio failure while on tour duty. An example of a daily routine which should be followed is provided under Demonstration methods below.	Licensee's radio operating procedures.
2. Determine whether or not the licensee maintains/services this equipment in-house, and if so, assure that the maintenance personnel are trained and qualified.	
3. Refer to the radio station log book to determine the frequency of unit and/or module failures. Those units that experience continuous problems and marginal operation should be replaced. In addition, verify that the routine maintenance and calibration checks (required by FCC) have been performed as scheduled.	Licensee's radio maintenance and test records.
DEMONSTRATION	
1. Turn on the radio unit and manipulate each control listed below. Observe that each control functions properly. Refer to equipment instruction manual to determine function of controls. • Power on-off switch. • Frequency selector. (Ensure that the portable unit is adjusted to the base station frequency.) • Volume control. • Squelch control. • Tone squelch override switch.	Manufacturer's operating manual. 735 357

Performance Characteristic/Measurement Procedure	Measurement Equipment
2. If the unit is equipped with a battery level indicator, verify that the reading is within the operable range. (A later section deals with the evaluation of battery charges.) 3. Perform a radio check with the local base station as follows: (a) Select a check point in the vicinity of the radio distribution room. (b) Turn on the radio and adjust the squelch control so that the background noise is just muted. For tone squelch units no adjustment is necessary. Evaluation of squelch is treated in more detail in a later section. (c) Key the transmitter and transmit a radio check message to the base station. The base station should receive the transmission loudly and clearly. (d) Instruct the base station operator to acknowledge the transmission. The base station message should break squelch in the portable unit and be heard loudly and clearly. 4. Perform a radio check with a randomly selected sample of approximately 20 percent of the units in the possession of members of the licensee's security force. Do not make any adjustments before performing the check. If the units do not operate properly with the adjustments made by the user, determine whether or not the security force member has been instructed in the proper use of the device. 5. Repeat the radio check on all available channels. Note: the licensee should adopt a regular radio check schedule to assure that each unit operates properly during the shift (for example, have the base station contact each unit every hour). TEST	
To ensure that the radio units are operating properly monitor the carrier frequency accuracy during the communication check using special monitoring equipment available for this purpose. Instructions for the use of the test equipment are provided by the manufacturer.	Communication monitor such as the Cushman Model CE-6A, Lampkin Monitor 107C or Motorola Service Monitor 1200A.

CONTROL ADJUSTMENTS

The purpose of this evaluation is to ensure that the radio unit controls (specifically frequency select and squelch) operate properly.

INSPECTION

1. Check that the channel select knob or pushbutton (if so equipped) is in a good state of repair and that once a channel is selected it cannot be inadvertently changed.

2. Check that the squelch control knob is not broken and that it is securely fastened to the control shaft.

3. Most radio receivers have squelch controls that function on the level of the audio received. By adjusting the squelch control to a point that 'quiets' the receiver, no sound will be heard from the radio speaker until a modulated carrier arrives with an audio level that 'breaks' squelch and audio is received. Care must be taken that not too much squelch is used; otherwise the receiver loses sensitivity. Check that the squelch control is adjusted to a point at which it just quiets the receiver noise.

Note: Selective tone squelch is offered on most radio units as an option. When tone squelch is used, the audio squelch circuitry is disabled. Tone squelch keeps the radio receiver quiet until it receives a modulated carrier plus a discrete tone which activates the tone squelch circuitry and 'opens' the receiver. The tone is received with the arriving transmission and remains during the entire length of the transmission. The tone squelch option applies to all channels in the hand-held unit.

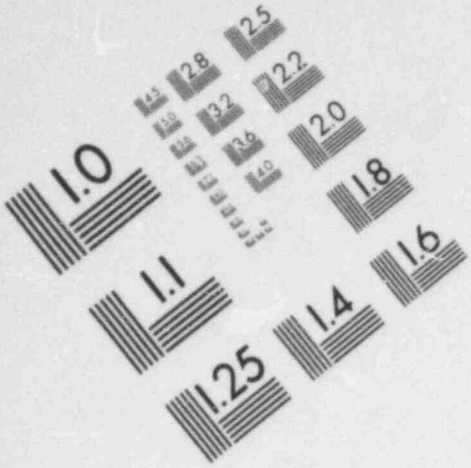
DEMONSTRATION

1. Perform a radio check with each unit selected for evaluation using each available channel.

2. While listening to a receiver tuned to the base station frequency, back off the squelch control for maximum receiver noise. Then slowly increase squelch to a point at which the receiver noise is no longer heard. (This step must be accomplished during a time when the base station is <u>not</u> transmitting.)

Performance Characteristic/Measurement Procedure	Measurement Equipment
3. Contact the base station for a radio check. Acknowledgment from the base station should break squelch and be clearly heard on the radio speaker. If tone squelch is used, no adjustments are to be made; the acknowledgment from the base station of radio check should break tone squelch and be heard on the radio speaker. 4. For units equipped with tone squelch, a tone squelch override switch is part of the tone squelch option. This control is used to monitor other stations on the receiving channel. This switch is also used for pre-transmission monitoring to avoid transmission interference. Demonstrate that the control operates properly by having radio transmissions broadcast by other units and monitoring these transmissions with the radio unit under evaluation. TEST	
For units employing tone squelch verify that the proper tone is broadcast using the communication monitor test equipment.	Communication monitor (see above). Manufacturer's operating manual.
OPERATING RANGE The purpose of this evaluation is to ensure that all units are capable of transmitting and receiving messages within the licensee's facility. ANALYSIS Personal or hand-held units operating with an RF output power of 2 watts or less and communicating with other personal units, can communicate over a range of approximately 1.5 miles depending on terrain features. Communications within a building is a function of the building materials and construction. Personal radios communicating with a base station that has an antenna located on the roof of a building (up to 100 feet high) can communicate over a range of approximately 14 miles.	735 360

Performance Characteristic/Measurement Procedure	Measurement Equipment
It is therefore, reasonable to assume that the hand-held radios of approximately 2 watts output or more can be utilized within the building(s) and out to the perimeter of a facility with good radio performance, provided the base station antenna is located high enough and the receiving section of the portable transceivers are sensitive enough.	
Obtain a map of the facility and verify that the maximum range of the units (as specified in the manufacturer's data) is not exceeded.	Facility map.
Verify that alternate means of communication are provided in all "dead" areas such as shielded areas or screen rooms from which radio communications would be impossible.	
DEMONSTRATION	
1. Obtain a map of the facility and select pairs of locations for communications checks as follows:	Facility map.
(a) Two exterior locations having maximum separation.	
(b) One exterior and one interior location having maximum separation.	
(c) Two interior locations having maximum separation.	
Perform a communications check between units operating at these locations.	
2. If areas are known to be shielded, the provisions for back-up communications to these areas should be demonstrated.	
BATTERY CHARGER	
The purpose of this evaluation is to ensure that the battery charger is able to maintain the batteries in an operable condition. Record keeping of battery charge cycles for all batteries is of the	



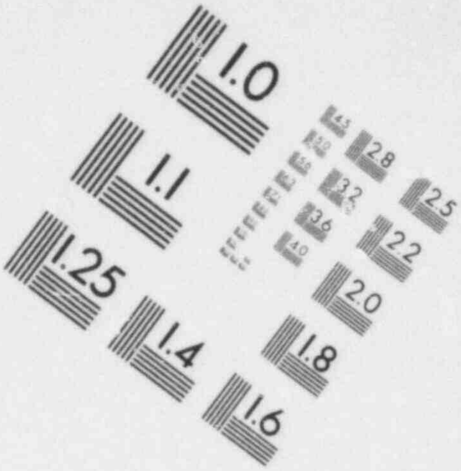
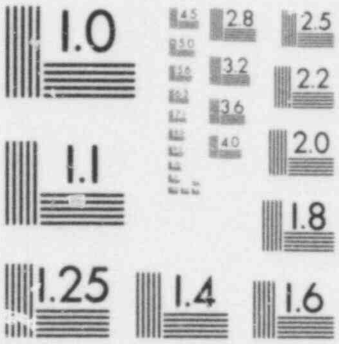
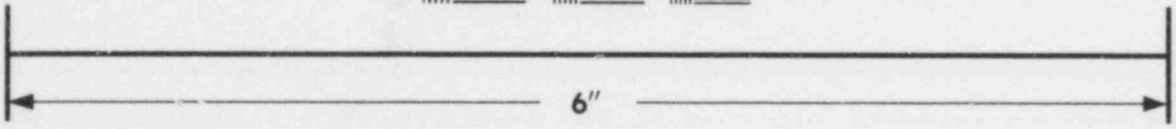
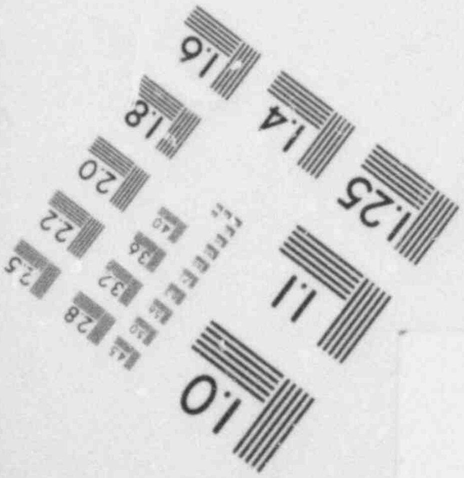
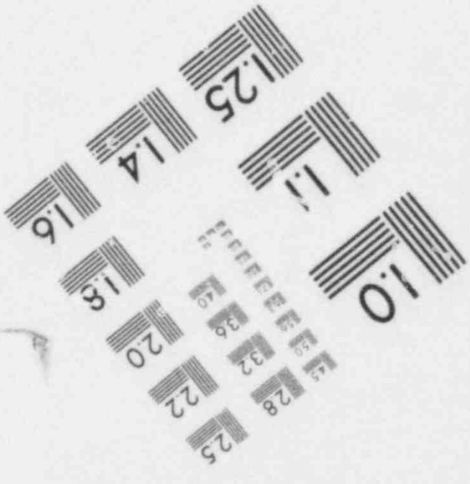


IMAGE EVALUATION TEST TARGET (MT-3)









Performance Characteristic/Measurement Procedure	Measurement Equipment
utmost importance to determine when to replace age-expired or malfunctioning batteries and ensure that the batteries are fully charged for immediate service. Caution must be observed in charging NiCad batteries since they may retain a 'memory' of lower than rated potential from previous discharge cycles and therefore might not recharge to full potential. A full discharge of the NiCad battery must be performed periodically prior to any further attempt at recharging.	
INSPECTION	
1. Observe that the battery charger indicator lights function when the charger selector switch is switched to 'trickle' charge or 'fast' charge.	
2. Check the battery charge indicating voltmeter, if so equipped, to verify that proper potential is applied to battery terminals when the battery voltage is being charged.	
3. Check that the licensee maintains records of operational battery charge cycles, age of batteries in use and condition of batteries held in ready reserve.	
4. Check that the batteries are in good condition (i.e., that the cases are not cracked, that the terminals are free of dirt, oil film and corrosion).	
ANALYSIS	
1. Review the battery charging/replacement schedules to ensure that they conform with manufacturer's recommendations.	Licensee's maintenance records. Manufacturer's maintenance manual.
2. If NiCad batteries are used, verify that they are periodically discharged completely in order to ensure that they will maintain full capacity. (Some battery manufacturer's have discharging devices available.)	
DEMONSTRATION	
1. Actuate the selector switch on the battery charger and observe that the indicator lamp (if so equipped) operates.	736 001

Performance Characteristic/Measurement Procedure	Measurement Equipment
2. Use a voltmeter to check the charging voltage. Refer to the charger manufacturer's specification for required voltage levels.	Multimeter such as Simpson Model 260.
TEST	
Check several batteries in different stages of the charging cycle (those in chargers, those ready for service, those in units in the field and those in ready reserve) for full battery potential. The potential may vary between types of batteries. The battery should be under a suitable current load condition when measuring battery voltage.	Battery checker such as Motorola HT220 which has provisions for testing under high and low current loads.

SPECIAL PERFORMANCE TESTS

The following procedures are included as background information to enable the inspector to ensure that the portable voice equipment is adequately maintained.

Hand-held transceivers operating in the UHF and VHF frequency ranges must meet the requirements contained in the following FCC rules and regulations:

Part 21. Domestic public radio services (other than maritime mobile radios).

Part 81. Stations on land and in maritime services, and Alaska - public fixed stations.

Part 91. Industrial radio services.

Part 93. Land transportation radio services.

The following is a list of Electronic Industries Association (EIA) standards of measurement techniques applicable to radio equipment:

RS-204. Land mobile communications FM or PM receivers.

936 002

Performance Characteristic/Measurement Procedure	Measurement Equipment
RS-152A. Land mobile communications FM or PM transmitters 25-470 MHz.	
RS-220. Continuous tone-controlled squelch systems (CTSS).	
The following tests below are recommended to be performed by trained technicians such as those who might be available at the licensee's facility.	
1. FREQUENCY AND RF OUTPUT	
The FCC requires that the carrier frequency be stable within ± 0.0005 percent (for radios operating from 50 to 1000 MHz) and the power output must be within ± 10 percent of rated power. Measurement equipment sufficiently accurate to satisfy FCC accuracy requirements must be used.	
TEST	
Using a wattmeter in conjunction with a frequency counter, both RF power output in watts and frequency in MHz can be measured. Make a direct connection from the hand-held radio unit antenna terminal to the input of the wattmeter and frequency counter. Operate the radio and measure the carrier frequency and RF output power indicators on the meters.	Frequency counter such as Hewlett-Packard 5383A (10 Hz to 520 MHz). Communication monitor such as Motorola service Monitor Model 1200A, Lampkin Model 107C or Cushman CE-6A.
2. RECEIVER SENSITIVITY	
The receiver must be able to distinguish the weakest signal specified by the manufacturer (in conformance to FCC rules and regulations), and provide a distortionless output.	
TEST	
Apply a standard modulated test signal to the antenna input of the receiver, and connect a standard test load and a distortion meter across the receiver's output terminal. Adjust the receiver's volume control for the rated audio output and adjust the signal generator to provide a ratio of [signal + noise + distortion] to [noise + distortion] of 12 dB. At this point, at least 50 percent	Communication monitor (see above). Distortion analyzer such as Hewlett-Packard Model 332A.

436 003

of the rated audio output should be obtained with minimum distortion. The RF signal level used to produce this condition is the receiver sensitivity in microvolts and should agree with the manufacturer's specifications.

3. NOISE SENSITIVITY

The ability of the receiver to override receiver noise is determined by measuring the amount of signal required from an unmodulated source to produce 20 dB of noise quieting at the receiver audio output. This test is used to verify compliance with FCC regulations and applies only to those receivers which use one or more noise limiters and a discriminator (most modern radio equipment employ these items).

TEST

Apply a standard unmodulated test signal to the receiver antenna terminal. Connect a standard test load and communications monitor across the audio output terminal and adjust the receiver volume control to provide noise level of 25 percent of the rated audio output. Adjust the signal generator output for the minimum RF signal level required to produce 20 dB of noise quieting. The measured value should agree with the manufacturer's specifications.

Communications monitor (see above).

TROUBLE SHOOTING EQUIPMENT

If the licensee maintains the equipment in-house, then it is necessary that the appropriate equipment be available (such as the measurement equipment specified in this procedure).

In order to ensure that faulty plug-in modules can be located and repaired the proper equipment should be available. Examples of such equipments are:

Aerotron, Test Kit No. 810-167-01 -- This unit includes a 25 ohm load resistor and alignment tools and a battery substitution pack with instructions for its use.

736 004

Performance Characteristic/Measurement Procedure	Measurement Equipment
Repco No. 817-012-(XX) -- This unit is used to monitor test points in radio sets in an attempt to localize trouble in faulty plug-in modules. Federal Signal Corp. No. R167 -- Simplifies test and maintenance similar to Aerotron No. 810-167-01 Test Kit.	

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