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Reliability Demonstration of Imaging Surveillance Systems

by

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Abstract

Security surveillance systems which employ closed circuit television are being deployed with increasing frequency for the protection of property and other valuable assets. A need exists to demonstrate the reliability of such systems before their installation to assure that the deployed systems will operate when needed with only the scheduled amount of maintenance and support costs.

This paper describes an approach to the reliability demonstration of imaging surveillance systems which employ closed circuit television. Failure definitions based on industry television standards and imaging alarm assessment criteria for surveillance systems are discussed. Test methods which allow 24 hour a day operation without the need for numerous test scenarios, test personnel and elaborate test facilities are presented. Existing reliability demonstration standards are shown to apply which obviate the need for elaborate statistical tests. The demonstration methods employed are shown to have applications in other types of imaging surveillance systems besides closed circuit television.

Introduction

Imaging systems using Closed Circuit Television (CCTV), as shown in Figure 1, are assuming an increasingly important role in the security of military installations. The design of meaningful reliability demonstrations which will help to assure the delivery of reliable equipment is essential. Military reliability test standards such as MIL-STD-781[1] can provide the basic accept and reject criteria, however, the detailed failure definitions required for these imaging surveillance systems are in need of development. Test methods which will allow 24 hour a day operation for sustained periods and do not require constant monitoring of equipment by operator or maintenance personnel were also subject to devlopment. Finally, attention was given to periodic checks of equipment in the presence of test stimuli.

The demonstration plan, although prepared for CCTV consisting of television cameras, coaxial cable communications, television control and switching equipment, monitor displays and external base perimeter lighting, should have applicability for other types of imaging systems such as those using thermal imaging or systems operating in an indoor environment.

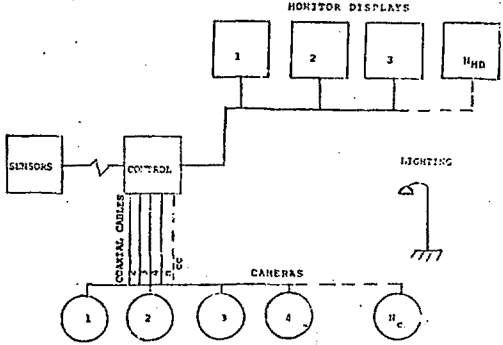


FIGURE 1. CCTV CONFIGURATION

Failure Definitions

The definition of relevant and non-relevant failures is essential to any reliability demonstration and care must be exercised in obtaining the required measure of preciseness. The individual definitions must relate to the CCTV system specification in a manner that ensures adherence to essential specifications during the entire test. Further this must be achieved by periodic measurement and demonstration. If this adherence is not met, a relevant failure must be charged.

The primary baseline performance requirements chosen for relevant failure assignment were resolution of detail and discrimination of shades of gray. Minimum values of resolution (a number of lines to be measured in the vertical and horizontal directions) and discrimination (the number of gray levels discernible) were determined in prior performance tests with simulated intruders approaching a perimeter fence and variable glimpse times for assessment. The resolution requirement for minimum number of TV lines was chosen to allow object coverage for detecting and assessing intrusion. The Johnson criteria[2] of two lines for detection of a target and eight lines for recognition were used as a guide in this determination. Both the resolution and gray discrimination requirements were determined for day and nighttime conditions and these minimum values became the basic definitions for relevant failures. However, since reliability demonstrations are a form of endurance test because of their longevity and can therefore last weeks or months on a continuous 24 hours a day, seven days a week basis, a need existed to use some form of test signal or test pattern in lieu of simulated intruders.

The solution was found in the Electronic Industries Association resolution chart[3] which is shown in Figure 2. This chart presents a selection of horizontal and vertical resolution lines, depending on the particular system requirements, as well as gray scales (10) from which the gray discrimination can be measured. The minimum values of resolution and gray discrimination established previously were used as the minimum standard and actual CCTV system values were measured from the chart and compared with these minimums.

Other measures of picture quality included the percent of picture coverage and the size, number, and spacing of camera blemishes. Picture coverage was measured to assess picture shrinkage, expansion, and/or shift. This measurement was performed with a non-metallic ruler and was referenced to photographs of the monitor screens taken at the start of the demonstration testing. A change in picture coverage of less than three percent was deemed acceptable. In the measurement of blemishes, reference targets equal to maximum acceptable blemish dimensions when projected on the monitor screen were affixed to the resolution charts. Actual blemishes were compared to these target blemishes to determine conformance with the size, spacing and quantity requirements.

Test Methods

Test Standards

It is appropriate to use an exponential distribution test plan such as MIL-STD-781 for the CCTV demonstration. This is acceptable since the large majority of the piece parts in such a system follow the exponential distribution. Those parts that exhibit a normal, log normal, weibull, etc. distribution tend to combine to an exponential failure rate when treated at the circuit and assembly level. In addition, they are in the minority and their failure rate contribution is small.

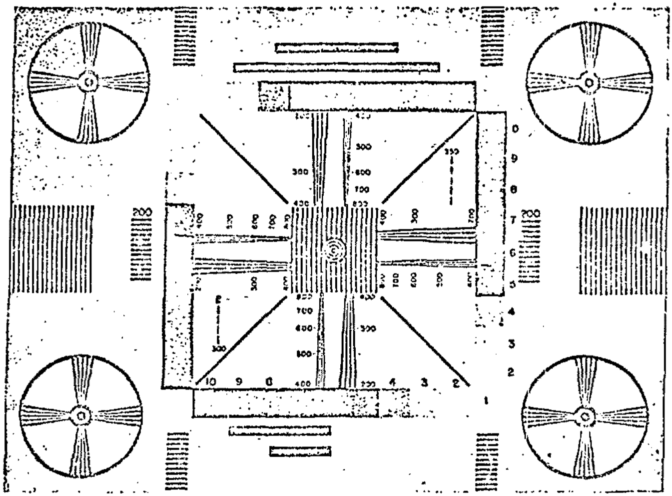
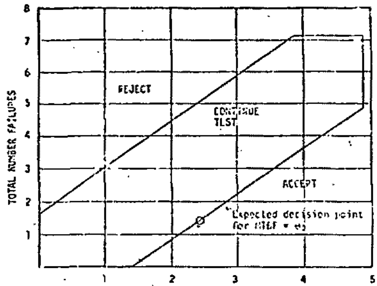


Figure 2. RS-170 Resolution and Shades of Gray Chart

A test plan from MIL-STD-781, "Reliability Tests: Exponential Distribution"[4] is shown below in Figures 3 and 4.

4.2.8.4 Accept-Reject Criteria for: Test Plan IV
Decision Risks 20%
Discrimination Ratio 2.0 : 1



No. of Failures	Total Test Time* Reject (Equal or less)	Accept (Equal or more)
0	N/A	1.40
1	N/A	2.09
2	.35	2.79
3	1.04	3.46
4	1.73	4.17
5	2.43	4.87
6	3.12	4.87
7	3.81	4.87
8	4.27	N/A

Figure 3.

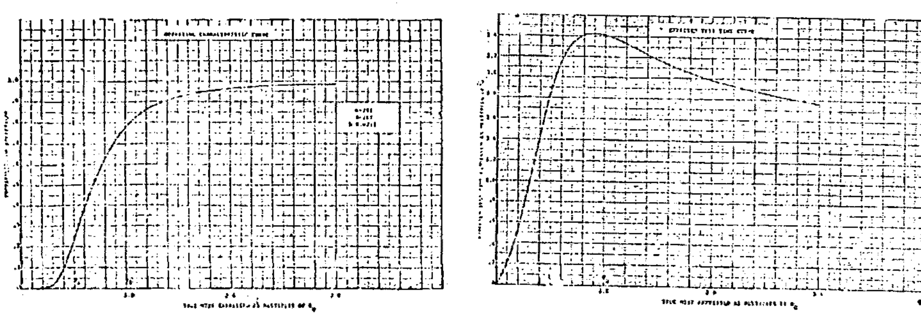


Figure 4. Test Plan Characteristics Curves

Test Stimuli

The test stimuli consisted of simulated intrusions as selected from a test set by a test operator. After an intrusion, normal operator response was taken as if a real intrusion had been detected. Various camera sectors, as associated with the blind zones of the selected intrusions, were input to the microprocessor logic for display as appropriate. All possible sectors associated with the system were displayed at least once per test sequence. As in real world assessments, alarms were allowed to "stack up", that is some alarms were being assessed, awaiting to be assessed, and noted as having been previously assessed. As these alarms were entered and ultimately reset, every logical combination of alarm processing was checked.

Another stimuli consisted of camera faults. The power was routinely interrupted to the cameras to simulate loss of video and/or cable tampering. These alarms were processed as if the cause of the alarm was unknown. The system was shown to prevent alarm reset until such time as the camera fault had been cleared. In addition it was shown that these alarms could be inhibited by an ACCESS mode. (This mode allows for camera removal, repair or extended shutdown in a real installation.)

The test stimuli were exercised at least twice daily to assure that the system was operational under various external lighting conditions. To assure that the cameras were continuously performing their function during unmonitored time periods, the cameras were monitored by built-in video presence detector latches. Any momentary loss of video resulted in a camera fault alarm that had to be manually reset. Any such fault not associated with power line disturbances was classified as a relevant failure.

Test Installation

Rather than establish a test site consisting of external fence perimeters, lighting and internal control and monitoring equipment, a relatively simple, low cost installation was chosen. The external silicon vidicon cameras were all installed in close proximity and focused on charts of the types previously explained. Because of the close proximity of the cameras and their respective charts, the external power required for nighttime viewing was only 300 watts. A light sensor was used to trigger the power turn-on and turn-off each day.

The monitor displays for presentation of video and the control equipment, including a microprocessor, were installed inside a building, immediately adjacent to the camera location.

Conclusions

Based on the test methods previously described, a successful reliability demonstration was performed on the CCTV surveillance system. The necessary realism was perserved throughout by the use (twice daily) of the test stimuli. Further, the external location of cameras in the outdoor environment, operating 24 hours each day, seven days a week also added realism to the test conditions. The simplicity of the test installation, the use of natural environmental inputs, and the elimination of the need for continual operator monitoring, makes this type of reliability demonstration a low cost, short duration effort with applicability to a variety of imaging surveillance systems.

Acknowledgement

This work was performed under the sponsorship of the Base and Installation Security System Program Office, Electronic Systems Division, Hanscom AFB, Bedford, MA.

References

1. MIL-STD-781B, 15 November 1967, Military Standard, Reliability Tests: Exponential Distribution
2. Imaging Intensifier Symposium (1958), Ft. Belvoir, VA; AD #220260
3. EIA Standard, RS-170, Electrical Performance Standards - Monochrome Television Studio Facilities, November 1957
4. Same as reference 1.