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PUBLIC ADDRESS SYSTEMS FOR EMERGENCY USE: AUDIT AND PERFORMANCE ASSESSMENT IN THE OFFSHORE AND MARINE SECTIONS

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1. INTRODUCTION

Public Address (PA) and Alarm systems form part of the life saving and emergency equipment on offshore installations and passenger ships and assessment of these systems forms part of their certification requirements. The function of the alarm system is to provide a clearly identifiable audible warning of the occurrence and nature of an emergency. The alarm system should therefore have sufficient power and coverage to be distinctly audible in all manned areas. The PA system is then used to back up the standard emergency plans with specific instructions. In addition to having the same power and coverage requirements as the alarm system, the PA system must deliver speech with adequate intelligibility. Furthermore, the PA and alarm systems should themselves continue to operate, possibly with partial damage, under these very emergency conditions.

Current methods of testing are highly subjective and time consuming, and there are no formal assessment criteria. This paper presents procedures for direct measurement of PA and Alarm system performance and auditing. In particular the use of the Rapid Speech Transmission Index Method (RASTI) for PA intelligibility assessment and system diagnostics is discussed.

2. PA SYSTEM ASSESSMENT

2.1 Subjective assessment methods.

Determination of intelligibility using subjective methods involves a listener interpreting messages broadcast by an announcer. Intelligibility is then expressed in terms of the proportion of sentences understood. A suitable target is 95% sentence intelligibility. Accurate assessment can involve a large number of messages, and requires a minimum of two operators. Full-scale intelligibility tests on a large vessel or installation can be time-consuming. In addition, where the performance of the system is judged to be unsatisfactory, subjective assessment does not yield any diagnostic information.

2.2 Factors affecting intelligibility

2.2.1 Signal-To-Noise Ratio. Background noise will mask the broadcast speech. A basic measure of the audibility of a PA system is the signal-to-noise ratio. This can be determined by comparing the background noise levels with the noise levels produced by the PA system. Both measurements are taken at the same test point. The background noise level is measured with all normally running mechanical equipment operating. The PA system level is measured whilst operating at its standard output power levels. A more accurate measure of audibility is obtained by measuring signal-to-noise ratios in octave bands in the principal speech frequency bands from 250 Hz to 4000 Hz. A 'pink noise' source may be used as the test signal. A signal-to-noise ratio of 10 dB in each octave band ensures reasonable audibility. Relative performance between octave bands gives further information relating to the frequency response of the system. Mapping of the signal-to-noise ratios across all decks gives an indication of adequacy and evenness of coverage.

2.2.2 Echoes and Time Delays. These factors reduce intelligibility by confusing the direct sound, transmitted from the speaker to the listener, with additional unwanted delayed or 'spread' versions of the same sound. Echoes can be due to genuine reflections, or path length differences between speakers. Reverberation is a particular problem offshore, where large areas with sound reflective surfaces exist. Echoes and reverberation falling within the first 80 milliseconds can be tolerated as the ear is capable of integrating these with the original sound. However sound delayed or reverberating for longer intervals only serves to confuse the next part of the message. Using an impulsive sound source (e.g. tone burst) broadcast over the PA speakers, reverberation times, echoes and time delays can be measured from time-traces of the received signals.

2.3 RASTI Measurements.

The RASTI method combines elements of both the signal-to-noise ratio test and the reverberation, echo and time delay tests. The 'announcer' is replaced by an audio signal generator which is placed in front of the broadcast microphone. The audio output level is calibrated for average speech and provides a consistent source signal. The signal consist of bands of random noise centred on 500 Hz and 2000 Hz. These bands are in the main speech frequency range. These bands of random noise are then pulsed at a number of different rates - the result sounding something like a steam train. The RASTI analyser, which is placed at the test location, contains a calibrated sound level meter which records the 'signal' and 'noise' levels automatically. The RASTI analyser effectively compares the received pattern with the expected pattern and computes the degree of reverberation and echo.

2.4 Providing a single measure of performance.

In order to provide a single overall performance assessment value, the results for audibility, reverberation and echoes must be combined. The individual test results are however useful for further diagnostics. The RASTI analyser provides a single RASTI scale value from 0 to 1 which represents the proportion of the test signal accurately received. The human ear is particularly suited to the interpretation of speech. Our languages contain many expected patterns and a formal grammar which enables the listener to fill in missing information. As a result, the target of 95% sentence intelligibility can generally be achieved with an overall RASTI value of 0.45 (i.e. 45% transmission accuracy). Performance assessment based on overall RASTI values is as follows:-

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RASTI Value	Assessment Category
0.0 to 0.3	Bad
0.3 to 0.45	Poor
0.45 to 0.6	Fair
0.45 to 0.6	Good
0.75 to 1.00	Excellent

Based on this scale, satisfactory performance is achieved with RASTI values of 0.45 of better, i.e. Fair, Good or Excellent.

2.5 RASTI survey procedure.

The test procedure is relatively simple, and may be carried out by a single engineer. The RASTI signal generator is placed in front of the main broadcast microphone. The signal may be left running continuously or may be switched on and off by remote control. Note that ambient background noise at the broadcast station will affect the signal to the same degree as per normal system use. Other points of input into the PA system may via the telephone system, or by direct electrical signal connection. The object is not to test reception close to each speaker. The test locations are chosen to represent normally manned locations, escape routes and muster stations. At each test location, the complete RASTI analysis can be completed in 8 seconds. The results, including overall RASTI value and detailed diagnostic information can be printed out directly.

2.6 Making Recommendations

Where performance is unsatisfactory, the recommendations for modifications can be made using the detailed RASTI data as a guide. Firstly, any global problems should be addresses, e.g. lack of audio power at all locations, or generally unsuitable orientation of speakers. Secondly problems at individual locations may be addressed. Poor audibility at individual locations may be tackled by background noise reduction measures, additional speakers, or individual speaker power tapping increases. Reverberation and echo problems may be overcome by increasing the incidence of direct line-of-sight to speakers, by adding speakers at strategic locations. Generally it is preferable to add speakers rather than increase existing speaker power.

3. ALARM SYSTEM ASSESSMENT

3.1 Alarm assessment criteria

The principal requirement for the alarm system is that the various types of signals should both audible and distinguishable from one another. Audibility is based on the signal to noise ratio.

between background noise levels and the alarm tone levels at each location. Background and alarm tone levels should be measured in the octave bands which contain the alarm tone frequencies. Satisfactory performance will be achieved with octave band signal-to-noise ratios of 8 dB or better. Signals will be more easily distinguishable if their tone frequencies are well separated, or the signals consist of different patterns.

3.2 Survey procedure

Background octave band sound level measurements are required in the bands containing the alarm tone frequencies. Further octave band measurements are then made with the alarms sounding. Where the alarm signals consist of intermittent patterns, 'slow' or L_{eq} levels will average out the 'on' and 'off' periods; it is preferable to record L_{max} levels, indicating the levels during the audible 'on' part of the signal.

3.3 Other factors influencing Alarm system performance.

Alarm signalling systems come in two principal forms. In the first, alarm signals are generated by a central tone generator, and broadcast over a common PA/Alarm system. In this case recommendations to improve PA audibility will also benefit alarm audibility. In the second type of system, alarm tones are generated by individual sounders or bells. It is important that any alarm tone patterns are synchronised between sounders, otherwise signals will not be so easily distinguishable. Higher signal levels or greater coverage can only be achieved by adding further sounders.

4. SYSTEM AUDITS

4.1 Audit criteria

Audits are aimed at examining the operational status, fault determination systems and maintenance planning for the systems. In addition the auditor may assess the ability of the system to operate in a real emergency situation, possibly with damage to one or more components. The audit criteria used by the author consist of basic questions and response levels which indicate the degree of compliance with a notional ideal.

4.1.2 Operational status. The operators will be questioned as to how many speakers/speaker loops/amplifiers/microphones are faulty. Answers will reveal whether the operator carries out any formal inspections, and whether any fault-finding diagnostics are available.

4.1.3 Maintenance. The operators will be questioned about typical faults, fault turn-round times and spares holdings. Answers will reveal whether the system components are reliable, and whether the operator is planning for appropriate inspection and maintenance.

4.1.4 Redundancy. The system design drawings will indicate the ability of the system to operate with partial damage. Important points include;

the division of the systems into independent A/B systems, each capable of providing satisfactory coverage

the provision of dual routed wiring to each A and/or B system

the provision of dual amplifier and control systems, located in separate fire zones, each with the ability to feed A and/or B system

the provision of several microphones in separate fire zones.

5. CONCLUSIONS

Public address and alarm systems form an important part of the lifesaving and emergency equipment offshore or at sea. Whilst their correct operation is a certification requirement, inspection of systems is frequently no more than cursory. Historically, the difficulty of carrying out intelligibility surveys using subjective methods has precluded detailed assessment. However, the availability of the RASTI technique has made quantitative PA system surveys a practicality, and such surveys are now increasingly being carried out on offshore installations. Alarm systems are generally included in such surveys, particularly where common components are used for PA and Alarm functions. Recommendations made following surveys can be specifically tailored to global system problems or local faults. The inclusion of system audits give further indication to the operators as to ability of the system to perform under real emergency situations.