DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

AND

FIRE OFFICES' COMMITTEE

JOINT FIRE RESEARCH ORGANIZATION

FIRE RESEARCH NOTE

NO. 549

THE EXAMINATION OF FIRE DETECTOR CONTROL EQUIPMENT

by

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September, 1964.

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F.R. Note No. 549

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SUMMARY

The basis on which fire detector control equipment is examined and assessed for reliability is described. Possible developments in the test procedure are discussed.

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1. Introduction

Tests on fire detectors are described in B.S. 3116 : 1959, Heat Sensitive Detectors for Automatic Fire Alarm Systems in Buildings. Detectors complying with this specification not only have response times which ensure early warning of a fire but they have a high degree of reliability by virtue of their resistance to the effects of corrosion and vibration. In order to take full advantage of the reliability offered by such detectors, it is clear that the control equipment to which they are connected must be at least equally reliable. In fact, the reliability of the control equipment should be greater than that of the detectors themselves, for while a failure of a single detector could be tolerated where a number are spaced beneath the ceiling of a building, the failure of the control equipment would render the whole installation useless.

In this note the present procedure used in examining fire detector control equipment is described and possible developments are discussed. The most commonly occurring faults in control units already tested are listed in Appendix A.

2. Description of control equipment

The control equipment of a fire detection system is primarily a means by which a warning of the abnormal conditions sensed by a detector are communicated to the occupants of the building by audible alarms and local zone indicators and to the fire brigade by direct G.P.O. link.

To perform this function, which is one of switching, the system requires an adequate and reliable source of power. In addition further switching facilities are usually provided in order that the system may be tested at regular intervals to ensure its correct functioning and in order that the occurrence of certain faults may be indicated automatically.

A typical system might consist of a circuit of detectors continuously monitored by a small current passing through them; a power supply comprising a 24 volt lead-acid battery floated across the output of an automatic charger connected to the mains; test arrangements by which the effect of a detector operation can be simulated causing operation of the alarm system and fire station link, and fault indication by lamps and/or a buzzer to indicate such faults as failure of part of the power supply, failure of monitoring current, etc.

More sophisticated systems working off higher voltages might use transistorised converters to supply power from a low-voltage battery, and future developments in this field can be expected in which the properties of semi-conducting materials and transducers of various kinds are more widely used, leading to more complex systems.

3. Present tests

The examination of control equipment is at present based on the assumption that the apparatus will be in service in a building for periods of 10, 20 or more years and will have little other than superficial inspections and routine operating tests during that time. It should, therefore, be capable of with-standing any adverse conditions likely to occur.

The condition of the equipment should be such as to always be able to give a warning of a fire but if this condition is not met then the equipment should indicate that a fault exists.

The examination, which can conveniently be divided into three parts, is carried out partly in accordance with a British Standard Code of Practice for Electrical Fire Alarms, No. C.P. 327.404/402.501 (1951). Although it is not possible to give an exhaustive account of all the factors considered due to the diversity of equipment submitted, some of the main features are listed below.

3.1. Quality of workmanship

Under this heading the manufacture, assembly and layout of equipment are examined. The system is examined for the quality and adequacy of the materials used for any manufacturing faults such as sharp or jagged edges which could abrade wiring, for security in fixing components with adequate locking to prevent loosening under vibration and to ensure electrical continuity for proper earthing. Soldered connections and their associated wiring are examined. There should be no dry joints and solder should have flowed properly on component tags and wiring. Leads should be properly secured against vibration and should be sleeved where practical at soldered connections. There should be no nicks or broken strands due to careless stripping of insulation which would lead to premature failure under vibration.

The positions of high dissipation components are noted and, if necessary, measurements of the temperatures reached inside the casing are made to ensure overheating of other components does not occur. Due regard is also paid to the position of components so that accidental movement, of tags for example, would not lead to short circuits or unwanted connections.

In all assemblies a high standard of electrical safety is expected.

3.2. Operation under normal and fault conditions

The equipment is tested to ensure that it is capable of carrying out its stated function under normal conditions. In addition the effects of various faults are examined.

Measurements are made to ensure that each component is operating within the manufacturers rating, and where practicable the effect of tolerances and production spreads is calculated. The effect of an open-circuit fault of each component in turn is noted, both under stand-by and fire conditions. This type of fault also gives the effect of a lead failure. The battery, mains supply and detector leads are also open-circuited in turn. The effect of an earth fault of the detector leads and of any other part of the circuit where this could occur in practice is noted. Under certain conditions components such as capacitors, rectifiers, transistors, etc., are liable to short-circuit. Such faults are simulated in the equipment and their effects observed.

The design of the equipment should be such that any of the above faults can be recognised, either by an automatic fault signal or during the course of a routine test.

3.3. Other Code of Practice recommendations

Paragraph 202 of the Code of Practice states that the quality of materials and finishes and the performance of all components, apparatus and equipment (other than cables) should be adequate to meet certain specified test requirements and to ensure satisfatory operation of the system throughout the life of the building or the period for which the

installation is designed. The test requirements include a durability test, in which each component is operated 10,000 times. This is usually achieved by an external switching circuit which gives the effect of a detector operation, a battery failure and a mains failure in turn. Where temperature sensitive components, such as transistors, are used, one half of the durability test is carried out at a temperature of 40°C. Also specified is an insulation test by which the insulation resistance at 500 V d.c. is measured after the application of a 1000 V r.m.s. test voltage; and an operating test, made to verify that the equipment functions satisfactorily at any specified limits of current or voltage. Although a vibration test is required, no limits or conditions of vibration are specified and at present no such test is made.

Other sections of the Code of Practice define the types of power supplies accepted, their capacities, connection and protection, and describe the types of indicators which may be used, the delineation of sections, marking, terminals, covers etc.

One of the recommendations of the Code of Practice is that the materials and finishes of all components and appliances should be such as to resist effectively corrosion by moisture or any vapours likely to be encountered. At the present time no tests are made to assess the resistance of the equipment to corrosion.

4. Developments in test procedure

Present developments are concerned first with the specification of design and materials of the equipment, and second with extending the mechanical methods of testing.

The function of an automatic fire detection system is to give sufficiently early warning of fire to permit the escape of any occupants of the building and to bring fire-fighting facilities into action as quickly as possible. Ideally, therefore, the system should always be capable of giving an alarm. This ideal is, unfortunately, impossible in practice due to the fact that the components of any system - resistors, capacitors, relays, wiring, etc. - are not themselves completely reliable. It is possible, however, to design systems such that in the event of the failure of a component which would prevent a fire alarm being given a fault is immediately indicated by the equipment, and any other failure in the system should become evident during a routine test. A specification including these requirements would of course limit the equipment to closed circuit, continuously monitored detector systems.

Reliability can also be improved by using only those components which are known to be of a high standard, and to this end services and other specifications and standards might be used. Components would also be required to operate well within the manufacturers stated limits; de-rating by as mush as 50 per cent might be considered. For example, a resistor rated at 1 watt by the manufacturer might be allowed to dissipate not more than ½ watt in the circuit.

The methods of testing used at present are somewhat time-consuming, and so experiments are being made to determine whether it is possible to reduce the time now spent on visual examinations by substituting purely mechanical tests. The effect of conducting the 10,000 cycle durability test whilst the equipment is being subjected to a temperature of 40°C and a relative humidity of 95 per cent is being studied, and a vibration table capable of testing control units up to 100 lb in weight is being constructed. Time spent in studying the circuit could be reduced if manufacturers were required to supply full details of their design, including the calculations and reasoning by which the value of each component was determined and by which the effect of component tolerances and production spreads were taken into account. This requirements would not only

reduce the time spent in testing but would help to ensure that the equipment was properly designed.

5. Conclusions

Fire detector control equipment is examined to ensure that it is capable of carrying out its stated functions reliably under various practical conditions. The procedure by which the reliability of this type of equipment is assessed has been described and possible developments have been discussed.

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Appendix A

Analysis of faults

An analysis has been made of the faults which have been found in the seven fire detection control units most recently examined. A list of those faults which have occurred in two or more systems is given in Table I; a more detailed explanation of them is given below.

Table I Most commonly occurring faults in fire detection control units

Type of fault	No. of control units exhibiting fault
Security, routing or termination of leads	6
Rating of components	6
Indication of component failure	6
Battery capacity or charging arrangements	5
Earthing	4
Design faults	4
Mechanical security	3
Soldering	2
Positioning of components	2

Security, routing or termination of leads

Under this heading have occurred instances of excessive lengths of unsupported leads which might result in fatigue failure at joints under conditions of vibration; weakening caused by 'nicks'; leads passing directly over spikes of solder on joints, over edges of tags and being crushed by chassis members after assembly; and inadequate protection against fracture in terminal blocks.

Rating of components

Certain components have been found to carry more than their manufacturers recommended maximum current or to be subjected to more than the recommended maximum voltage. Other components, particularly relays, have been used which were not designed to meet the Code of Practice insulation test.

Indication of component failure

Those cases where the failure of a component would not be indicated automatically or during a routine daily test and which would prevent a warning of a fire being given should a detector operate.

Battery capacity or charging arrangements

One reason for the manufacturers not meeting the Code of Practice recommendations for battery capacity has been a failure to consider the relatively high power consumption of fault warning bells, lamps or buzzers which switch on when the mains supply of a floating battery system fails.

Earthing

Paint and varnish has been the chief cause of earth faults, insulating one chassis from another or insulating components from chassis.

Design faults

These include failure of the system to operate at reduced voltage, and failure of the designer to provide certain essential parts of a system, such as maintaining a fire warning should the detector leads burn through during a fire.

Mechanical security

Instances have occurred where locking arrangements were not provided for screws on moving parts, and where an insufficient number of fixing points for components were used.

Soldering

This has been due to a failure to heat both parts of a joint sufficiently to allow solder to adhere and flow.

Positioning of components

In units where an attempt has been made to save space the parts of some components, relay terminals for example, have been positioned so close to a chassis or to other components that a slight movement has resulted in an unwanted connection through the chassis or other component.