Fire Research Note No 1063

TEST PERFORMANCE OF AUTOMATIC FIRE ALARM EQUIPMENT

by

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JANUARY 1977

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SUMMARY

The results of type approval tests carried out on fire detection equipment are outlined, and the defects found in the equipment are discussed.

Many pieces of equipment failed to meet the requirements of the tests. Similar failures or deficiencies were found to occur in several different types of equipment.

Department of the Environment and Fire Offices' Committee
Joint Fire Research Organization

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INTRODUCTION

Since its formation in 1947 the Joint Fire Research Organisation has been responsible for carrying out tests on automatic fire detection equipment for the Fire Offices' Committee and some manufacturers.

Initially these tests have been ad hoc tests; the procedures being gradually altered in conformity to first the drafts of Standards and then published Standards.

Since 1959, heat detectors have been tested to BS 3116. Since 1970 control and indicating equipment has been tested to the draft BS 3116 : Part 4 and later to the published version (1974). Since 1974 heat and smoke detectors have been tested according to draft Comité Européen des Assurances (CEA) Standards.

The tests carried out to Standards have in general comprised more test requirements (eg the introduction of a vibration test for control equipment) than the ad hoc tests, and some requirements have also been made more stringent, particularly for smoke detectors.

This Note discusses tests carried out between 1970 and 1976 on a total of 22 different control equipments, and 25 detector types.

TESTS ON CONTROL EQUIPMENT

The BS 3116 tests include an examination of the design and construction; 10,000 cycle durability test, vibration-operational and vibration-endurance tests, temperature and humidity tests, and battery charging and capacity tests.

At the preliminary examination stage, a third or more were found not to meet the functional requirements of BS 3116 : Part 4 in some particular. Where the defects were serious, manufacturers were requested to modify their equipment before work was started. Many of the control equipments received were prototypes rather than production items.

BATTERY CHARGING AND CAPACITY

The standby battery is required to give a 24 or 72 hour standby, depending on the arrangements for remote fault signalling, and then power a two-zone alarm for one hour. The charger is required to recharge a discharged battery within 24 hours.

Half the equipments were found to have inadequate or barely adequate battery capacity or charging performance, although the nominal capacity of the battery was adequate in almost all cases.

In two cases where the equipments were otherwise satisfactory, they would not supply the full alarm loads when operated from the normal supply mains, with the battery disconnected.

In all cases the chargers were of the constant-potential type. These are suitable for lead-acid batteries particularly when fast charging is not required (the charge current falls considerably when the battery becomes partially charged), but are less suitable for alkaline batteries, which have quite different characteristics. A constant-potential charger will not float-charge an alkaline battery to more than two-thirds its capacity, and in fact underchargings much worse than this were found in some cases.

Five equipments were supplied with alkaline (nickel-cadmium) standby batteries, while others had auxiliary alkaline batteries for tertiary supplies. Some systems using alkaline batteries were satisfactory. It may be pointed out, however, that since alkaline batteries are expensive the cost of unused capacity in a large battery could be substantial.

10,000 CYCLE DURABILITY TEST

Durability tests have been carried out on control equipments since 1960. The results obtained prior to 1970 are not discussed here, since the details of these tests differ from the BS 3116 : Part 4 test.

A set of functional tests is repeated 10,000 times by an automatic tester. At least six genuine malfunctions were recorded. Four were caused by faulty relays, one by a zone module (cause unknown, possibly a relay or edge connector) and one, at 4288 cycles, was a transistor failure. Half of the malfunctions appeared after 1000 test cycles.

VIBRATION TEST

No failures in the vibrational-operational test (0.1 g swept from 5-60 Hz) were noted. The vibration-endurance test comprises sweeps from 5 to 60 Hz at 1 g for 6 hours. This test caused loosening of screw fastenings or other damage in most equipments. In two cases metal parts were fractured through fatigue.

Of the 13 control equipments subjected to this test, eight malfunctioned because of broken wires, shaken-out plug-ins, detached components etc, when power was reconnected.

The acceleration is controlled at the vibrating table, with the result that when the mounting points of the equipment are driven at 1 g, certain parts, particularly the front door panels, resonate violently at particular frequencies. Despite this we concluded that screw fastenings which vibrated loose were inadequately secured. This also applies to broken wires and detached components which generally were clearly inadequately secured.

A large polyester capacitor was detached by vibration; one of five identical capacitors. On examination it was concluded that one lead had been poorly soldered into a printed circuit board and had pulled loose; the other lead then broke. The test is designed to expose weaknesses in construction, and it seems most effective.

TEMPERATURE AND HUMIDITY TESTS

The equipments were given functional tests after operation at 40°C, 38% RH (16 hrs), 40°C, 90% RH (96 hrs) and - 10°C (2 hrs). Several malfunctions occurred, most of which cleared on recovery to ambient. The remainder were: a sticking relay, a poor relay socket contact, and a failed transistor.

No malfunctions were noted during the 40°C 38% RH test.

GENERAL COMMENTS

Many of the control equipments received were prototypes rather than production items. The chief fault areas were relays, connectors, poorly secured parts, and transistors.

Most equipments were soundly constructed but some were marred by lack of attention to detail. For example, in one unit, poorly sleeved buzzer tags touched the chassis, and some wires were crushed by the transformer, though the insulation was not broken. In an equipment intended to be earth-free, one terminal of a bell was in contact with the chassis.

There have been at least three instances in which electromechanical bells and buzzers stopped working, and two instances of trouble with International Octal sockets and plugs. In one case the trouble was traced to the socket contact forks not being sufficiently resilient or free to move.

After modification by the manufacturers, most of the control equipments tested were eventually approved by the FOC for use as part of a heat or smoke detecting system.

SUMMARY OF FAULTS

	Vibration	Durability	Temp and Humidity	Preliminary/ Functional standby	Battery charging	Totals
Relays	1	4	1	4		10
Connectors		2	2		1	5
Transistors		1	1	3		5
Breakages	8					8
Other	1	1	2	3		7
Totals	10	8	6	10	1	35

Approximately 40 failures and malfunctions were observed during the tests. The most common causes of trouble were relays, connectors and transistors. All but one of the failed relays was performing a logic or low-level switching function. Most were the miniature cradle or 'continental' style with snap-on dust covers, and most were soldered in. One relay stuck in the operating position, apparently because of residual magnetism. One relay's coil became open-circuit.

All the failed transistors were used near or above their design limits in some way. In one case a suppressing diode across a relay coil was omitted, either by design or by accident, causing a high voltage pulse on the collector. The other transistors were in invertors or power supplies.

An Octal relay socket gave trouble because of a defective fork.

Wires, components and mechanical parts and screw fastenings broke away or were loosened during the vibration test of most equipments.

SMOKE AND HEAT DETECTORS

Detectors are rarely faulty when received, and few develop faults. However, many types fail to meet all the requirements of the BS and CEA tests - even, in some cases, after redesign and resubmission.

HEAT DETECTORS

Heat detectors usually failed either because they responded too slowly, or because they were damaged by the corrosion test. In several cases the sensing element became coated by corrosion products which increased its response time. Electronic-type detectors were more vulnerable to attack, suffering bridging by conducting corrosion products, and breakage of corroded wire leads. In one case, closed circuit elements were bridged by conductive corrosion products, which prevented the control equipment from responding.

SMOKE DETECTORS

Smoke detectors were subjected to smoke tunnel tests, and fire tests. None of the optical scattering type detectors tested were satisfactory with the fast-burning wood fires specified in the CEA draft unless their sensitivity was much greater than normal. Ionisation types responded least well to smouldering wood fires. (This particular test defines the minimum sensitivity allowable on ionisation detectors).

In the form in which they were submitted most smoke detectors were so damaged by the corrosion test, that they ceased to work at all, or their performance fell outside acceptable limits. Where an exact cause of failure could be ascribed, it was one of the following:

(a) Corrosion deposits shorted out chamber electrodes or bridged other parts of circuit.

(b) Corrosion deposits reduced radioactive emission (ionisation detector). This increased the sensitivity, often causing a false alarm.

(c) Corrosion deposits on optical surfaces reduced the light transmission of optical systems. In optical scatter detectors this led to a reduction in sensitivity to smoke.

(d) Corrosion caused open-circuit of connecting leads.

Most of the failures were overcome by appropriate modifications. Ionisation detectors with effective potting and long leakage paths showed little change in performance after corrosion. The damp sulphur dioxide atmosphere heavily attacks unprotected copper and steel parts, and affects some plastics.

HUMIDITY TEST

Only 9 smoke detector types have been subjected to the CEA humidity test (90% RH at 40°C for 10 days).

Four types showed a substantial fall in sensitivity after this test, and another gave false alarms during the test. The detectors were found to recover after prolonged drying at ambient temperature. In two cases the manufacturers submitted modified detectors which overcame the problem.

Certain detectors performed poorly in fire tests held when the humidity was high, and the temperature low. The results were consistent with the above laboratory test, since these detectors showed a substantial fall in sensitivity after the 10-day humidity test. One detector was later re-submitted with improved potting which overcame this problem.

EFFECT OF TEMPERATURE

The sensitivity of one optical detector was found to fall substantially with increasing temperature. This feature was thought to cause its poor performance in certain fire tests.

An optical smoke detector whose sensitivity increased with temperature would have certain advantages; however, none with this feature have been tested.

SHOCK, IMPACT, VIBRATION TESTS

Detectors of conventional designs are not much affected by these tests. Optical beam detectors pose problems in test since it is not practicable to test an aligned source-receiver pair.

SEMICONDUCTOR SMOKE/GAS DETECTORS

We have performed fire tests and smoke tunnel tests on detectors incorporating various semiconductor smoke/gas sensors. These respond poorly to CEA and other test fires, indicating that the amount of combustible gas released by the fires is rather small. The sensors are very sensitive to flammable vapours (eg petrol). It appears to be difficult to design a detector using these sensors so that it responds satisfactorily to the various types of fire whilst avoiding false alarms due to flammable vapours, and drift. The sensitivity of the sensors varied with time, not necessarily in a reproducible way.

CONCLUSIONS

1) At least a third of the control equipments did not meet the functional requirements of BS 3116 : Part 4 when initially submitted.

2) Most equipments developed some faults and malfunctions during test.

3) The durability, environmental and battery charging and capacity tests are valuable in exposing weaknesses in control equipments.

4) Most of the fire detectors submitted, when tested in their original form, failed to meet the BS or CEA standard requirements.

REFERENCES

1. BS 3116 : Part 1. Heat Sensitive Detectors for Automatic Fire Alarm Systems - 1959.

2. BS 3116 : Part 4. Automatic Fire Alarm Systems in Buildings - Control and Indicating Equipment - 1974.

3. Groupe de Travail Incendie du Comité Européen des Assurances - Comité Technique Permanent. Test Methods for heat-sensitive (Point) Detectors - November 1973.

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Printed in England for Her Majesty's Stationery Office by Studio Trade Plates Ltd.