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FIRE PROPERTIES OF BUILDING MATERIALS AND THE EARLY FIRE HAZARD TEST

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ABSTRACT

In selecting materials for durability to water, abrasion, low temperature and the like, there is now an increasing emphasis on selecting for performance in a fire as well.

There are all sorts and sizes of fires, but the most useful way to catalogue them is in regard to increasing severity of radiated heat. Fire test methods for building materials have been developed at arbitrary points along the range of possible severity, each attempting to grade performance at a selected set of circumstances. The results of each method are thus limited, yet are sometimes attributed greater significance.

In current use in NZ is the Early Fire Hazard test method developed in Australia for examining the ignitability of wall linings. The equipment, method and index system of result expression are discussed. Results for materials commonly used in the food processing industry are summarised and guidance given on their interpretation.

KEYWORDS

Building materials; Coating materials; Early fire hazard; Fire; Fire-retardants; Fire risk; Fire properties; Fire tests; Linings; Thermal Insulating materials.

INTRODUCTION

Recent large fires in the food processing and storage industry with heavy losses of plant and production have contributed to a greater awareness of the potential for damage. On the economic front, a fire can mean lost production while repairs are made and, perhaps, a concurrent temporary loss of employment for a substantial workforce. It makes sense to consider the possibility of fire and the reaction of structure and contents to it, and to have set-up suitable preventative measures. But these matters are only one of many practical considerations which need to be taken into account by owners and designers when selecting materials. Fires occur infrequently so it is natural that the performance of materials to day-to-day wear and tear are foremost in design considerations, rather than fire.

Where 'Codes' exist specifying the performance of materials to fire, and test results are available, the selection of suitable materials is relatively straightforward. This paper sets out to describe the test method and criteria used in Chapter 5 of the New Zealand Model Building Bylaw, NZS 1900, (Standards Association of New Zealand (SANZ) 1963), to control the properties of wall and ceiling linings and how to locate materials with known properties. Where no control exists and there is a desire to incorporate better performance in a fire, solutions are not so clear and there is a danger of over-protecting selected areas while neglecting hazards elsewhere. Means of making logical deductions of fire hazards are outlined to assist those wishing to go further than the minimum requirements of the bylaw.

SELECTING MATERIALS TO MEET FIRE REQUIREMENTS IN CODES

The Fire Bylaw

Chapter 5, Fire Resisting Construction and Means of Egress, is the principal document for control of fire in buildings. A code relevant to the food industry is NZS 4216:1983 Code of Practice for Designing of Meatworks Complexes for Fire Safety, (SANZ 1983). this code is a means of compliance for meatworks complexes with the requirements of NZS 1900 Chapter 5 and a supplement to them. Also relevant but not enlisted by the bylaw is NZS 1340:1970 Specification for Thermal Insulating Materials for Buildings (SANZ 1970). Relatively few areas of wall and ceiling linings of NZ buildings are controlled for fire. Examples of control can be found in NZS 1900 chapter 5 under clauses 5.25, 5.52 and 5.67, and more particularly in NZS 4216:1983 under clauses 118 and 120.

The Test Method and Expression Of Results

Until 1978 New Zealand followed the United Kingdom example by using the 'surface spread of flame test'. The method was then changed by amendment 12 to the bylaw to become AS 1530,3-1976, (Standards Association of Australia (SAA) 1976, 1982). The latter is called the 'Early Fire Hazard' test (EFH), and was developed for Australian application. These two methods are quite different in how they rank the behaviour of materials. The principal differences are that the source for the UK test models exposure to a more severe fire, the Australian test includes smoke measurement, and the UK test measures spread of flame in a horizontal direction along a wall while the Australian test is for spread up a wall.

The EFH test subjects samples of materials to radiant heat from a red-hot refractory panel. The distance between the specimen and the heat source is progressively decreased. Decreasing the distance increases the radiation impinging on unit area of the specimen and this is done in such a way as to simulate the radiation received by a surface at a fixed distance from a fire which is steadily getting bigger and hotter. The size of the fire modelled is said to represent medium intensity when compared to a range of fires involving furniture.

Thus, this test is not used to decide how severe a fire has to be to cause ignition, rather it provides information on the way in which materials adjacent to a 'developing' fire would react and add to an existing fire which was on the verge of being out of control. It is important not to lose sight of the aims of the test when interpreting its results.

Results are expressed as indices (scale in brackets) to four parameters:

Ignitability (0-20)
Spread of flame (0-10)
Heat evolved (0-10)
Smoke developed (0-10)

In all cases, the higher the index the greater the hazard. A fuller explanation of the index system is available in the appendices to the 1982 edition of AS 1530,3.

Typical Results

Some results of selected paint finishes on various substrates are listed in Table 1 to illustrate some generalisations, the relevance of which is discussed where applicable:

1. The results are dependent on the finish.

2. Coatings with a high resin content (often glossy) are more reactive to fire. These coatings are usually more desirable because of their ease of cleaning.

3. An 'ignitability index' of 12,13 or 14 is quite common when the system contains cellulose-based materials, eg. paper, wood fibre.

4. The results of a normal coated system are rarely better than those of the bare board. For improved performance fire-retardant paints are required.

5. The results of a finish on one substrate should not be attributed to another. If in doubt have it tested.

TABLE I. SELECTED EFH RESULTS OF PAINTED PANELS

	I	S	H	Sm
Glass-reinforced gypsum plaster				
uncoated	0	0	0	0
+ PVA paint	0	0	0	0
+ gloss acrylic paint	0	0	0	4
Paper-faced gypsum plasterboard				
uncoated	12	0	1	4
+ PVA paint	0	0	0	3
+ gloss acrylic paint	13	10	4	4
+ fire-retardant paint	0	0	0	2
Hardboard				
uncoated	13	7	7	5
+ PVA paint	13	9	9	5
+ gloss acrylic	14	9	10	5

Legend: I - Ignitability index (0to 20) H - Heat evolved index (0 to 10)
S - Spread of flame index (0 to 10) Sm - Smoke developed index (0 to 10)

Other observations that have been made by the Building Research Association of New Zealand (BRANZ), but which are not illustrated by the limited examples in Table I include:

1. Few materials have a 'spread of flame' index between 2 and 7. They tend to be at the extremes of the scale.

2. Systems with fire-retardants added can delay or inhibit ignition but at the expense of smoke evolution as measured by this test. Thus these systems could be more accurately thought of as ignition retardants.

3. The thickness of combustible coatings is important. The extra fuel of thicker combustible coatings makes reaction more energetic. In this respect, if the tested paint system was used to decorate a surface, then care is needed with any recoat applied at a future date. In extreme cases the coating may have to be removed before redecorating and this is a significant cost factor.

4. To achieve adequate protection of combustible substrates with fire-retardant paint finishes, relatively thick coatings are required. The extra coats add to the cost. Many fire- retardant finishes are water-sensitive and have to be protected by an impermeable top coat. This limits their durability.

Results for Materials of Interest to the Food Processing Industry

Some results for non-painted systems are listed in the appendices to AS 1530,3-1982, of which the following may have interest for the food industry:

Glass Fibre Reinforced Polyester (GRP): without fire-retardant additives GRP is readily ignited and contributes to flame spread by direct flame contact and through flaming droplets. This latter point is required to be noted on test reports to AS 1530,3 and should be considered where combustible material is placed below GRP. Fire-retardant grades are available but these suffer from high 'smoke developed' indices and they have limited durability. Gel coats are invariably not fire-retarded.

Polyvinyl Chloride (PVC): the reactivity of PVC is directly related to the proportion of plasticiser it contains. Flexible films are more reactive than rigid material used in plumbing. In fact unplasticised PVC pipes behave quite well in a fire since they first soften and generally slump to seal penetrations in walls etc. This property affects EFH tests where the specimen is restrained as a flat sheet behind chicken netting. In a real fire the netting would not exist and behaviour could be quite different. However, the test standard requires the use of the netting to achieve consistent results. PVC is an example of a thermoplastic material and it is as well to know what lies behind it, since when the PVC softens and falls away the backing will be next in line to be attacked by the fire.

Melamine: fire-retardant melamine veneers are available and give good results. With heating the veneer splits and exfoliates. It is not known if any of the durability properties of normal melamine veneers are lost by using fire-retardant additives. The performance of a veneer is influenced by the method of attaching it to a substrate. During heating, contact adhesives fail, and the premature loss of protection afforded by the veneer could result in the substrate catching fire. Care should be exercised that the correct grade of adhesive and application rate, as recorded in the test report, are used.

Flooring Materials: while Australia relies on the EFH test to rank carpets and other flooring materials, this practice is not recommended in NZ except where the material is to be used on a wall, say to dado height. There are no controls on flooring in New Zealand but where information is required tests to the 'hot nut', 'pill test' or 'NBS critical radiant flux' methods are more relevant. The Wool Research Organisation of New Zealand (WRONZ) is equipped to perform these tests and the Building Research Association may soon offer the same service.

Insulating Materials: foamed polyurethane (PU) and expanded polystyrene (EPS) have both been associated with disastrous fires. The results of the EFH test on them give a false impression of their relative contributions in a fire. The apparent better performance of EPS could in fact give licence to its use as a wall lining, in 'places of assembly' for example. Commonsense on the part of the manufacturers of EPS has prevailed and there are no such installations. In the test, EPS melts into a liquid pool remote from the heat source. In a real fire this pool would catch fire (see BS 6203:1982). There are installations where EPS does not significantly add to the fire hazard, one of which is its use as ceiling tiles attached by spots of adhesive to a non-combustible substrate. As a result of full-scale fire tests, the Building Research Association has issued advice on their use (1980).

PU and EPS are likely choices for insulating pipes where condensation could render non-combustible fibre types thermally less effective. Methods are available to protect these foams from fire. In one case, a fire-resistance test (ie. exposed to direct heating in a furnace) was used to demonstrate the integrity of a NZ manufactured system where the foam was encased in sheet steel cladding. The fire property of thermal insulation is required to be known by clause 5.1 of NZS 1340:1970 and the test methods are AS 1530 parts 2 and 3. However, the New Zealand Standard does not specify pass/fail criteria. A thorough examination of the fire hazard of insulating materials is given by Malholtra, Sutcliffe, Rogowski and Ramaprasad (1980).

Where to look for Test Results

By reviewing some published lists of materials suitable for use in the food processing industry, the author deduced that about half of the recommended systems had been tested for reaction to fire. For example, 14 out of a list of 30 had been tested and 8 of these had been granted an 'approval' by the SANZ Fire Ratings Committee. The usual starting point of a search for such information is the SANZ publication MP9, (SANZ 1980). This is a register of approved fire rated systems. It includes fire-resisting doors, walls etc, and a large section on wall and ceiling linings. In the case of the latter, the substrate and the components are detailed and should be closely followed. Results, however, are expressed in terms of 'spread of flame' and 'smoke developed' indices for use in NZS 1900 chapter 5. If evidence of compliance with NZS 4216 is needed, test reports for each candidate system, listing all four indices, must be obtained. Some systems are taken for granted as being unreactive, eg. sheet stainless steel.

IDENTIFYING FIRE HAZARDS AND USING FIRE TEST RESULTS IN AREAS NOT COVERED BY CODES

First Principles

The bylaw is a minimum level of compliance. If it is desired to extend controls on the fire properties of materials into areas not designated in the bylaw then consideration must be given to their cost-effectiveness. It is seen from the foregoing description of the EFH test and results that the bylaw/code requirements are relatively simple. Simplicity is often desirable but there are a few examples, such as EPS, where the criteria fail to provide adequate protection. While it is tempting to simply extend the bylaw requirements for surface linings, this does not address all the fire hazards present in areas where there are any combustible contents. Contents are often more reactive than the structure and produce the greater contribution of hazard. Clearly, if one wants better performance in a fire then all the hazards need to be identified and dealt with in a balanced manner. Identification of hazards are discussed in the commentaries to the British Standards BS 6336:1982 and BS 476:10:1983.

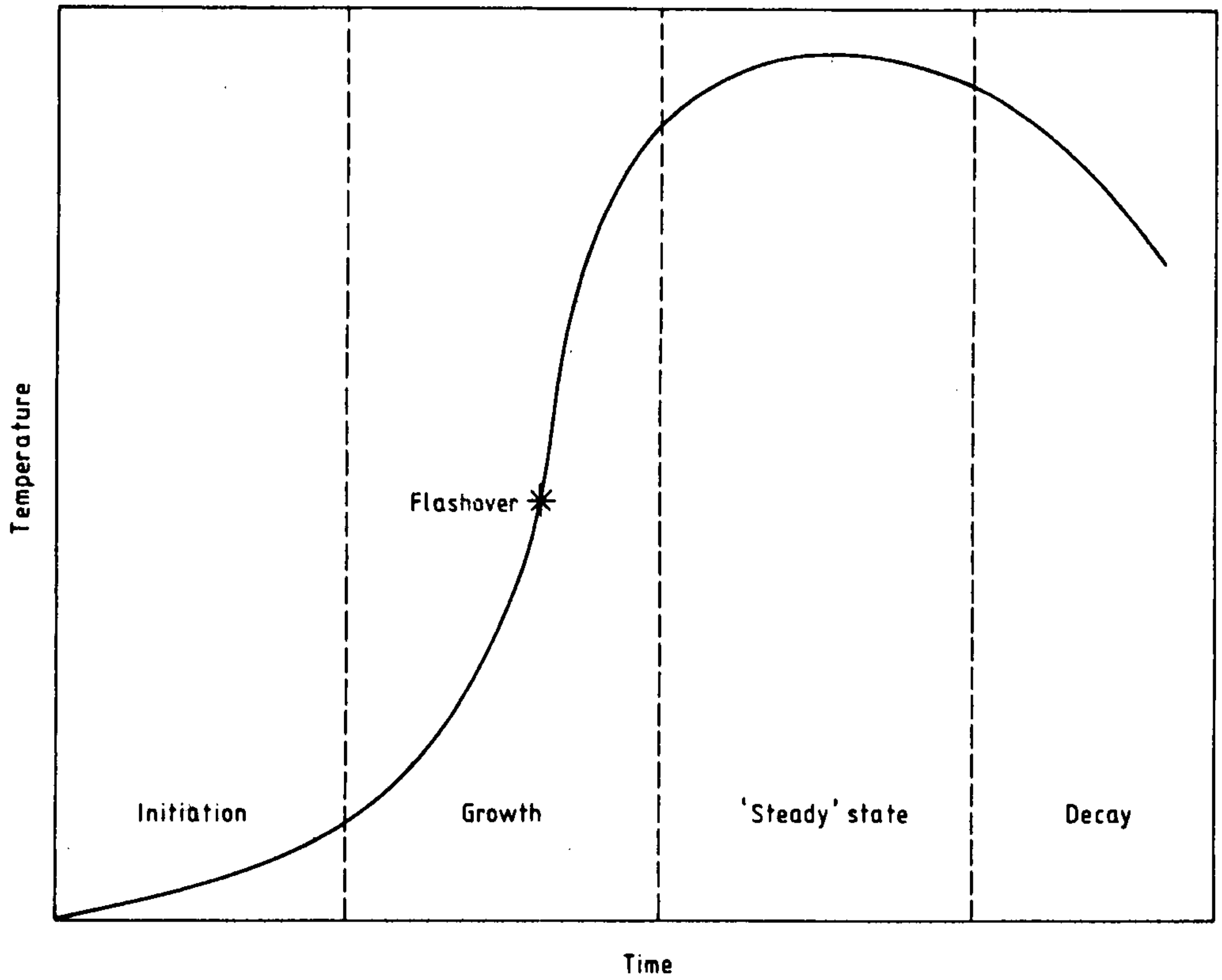
An example of identifying fire hazards which illustrate the approaches discussed by the above standards concerns insulating material. Questions to be addressed are:

> What are the likely sources of ignition present in ascending order of severity?
>
> What is the reactivity of each material present to graduated sources of ignition spanning the range of possibilities?

This information allows the selection of a pass/fail criterion which includes the majority of risks and, if necessary, back-up protection is provided by sprinklers.

Ranking the Severity of Fire Tests

Some fire tests gauge reactivity to a match while others use a much more energetic source of heat. Each test method models a particular area of development of a fire which can be visualised on an idealised graph of 'temperature at the scene of the fire' versus 'time' (Figure 1). Four phases are recognised.



NOTE. The scales from the two axes of the graph have been deliberately omitted because the rate of development and the severity of fires differ greatly although the general relationship varies very much less.

Figure 1. Relationship between temperature and time and the stages of a typical uncontrolled fire in a compartment

Initiation: this could include smouldering.

Growth: where the fire finds fresh fuel to spread to. This is also referred to as a 'developing fire' and the EFH test is an example of a test modelling one possible risk.

Steady state: all the available surfaces of fuel are burning and the rate of heat release is governed by oxygen supply and surface geometry. Also known as a 'developed fire'.

Decay: running-out of fuel and cooling.

When faced with unfamiliar fire test information on a product seek advice on the severity of the test. For example, many plastics are tested to UL 94. Underwriters

Laboratory Inc. 1973) which is a quality control test that subjects a wafer of material to a Bunsen burner flame. Such a test result will not tell you what the material will do in a 'developing fire'. Likewise, an EFH test will not provide the reactivity of a material to a 'developed fire'. A 'fire resistance' test is more usual for behaviour in a developed fire but even this is inadequate for exposure to a liquid fuel fire (crashed aircraft). In such cases, the severity of exposure to heat and radiation steadily increases.

SUMMARY

The fire bylaw and other codes of practice require wall and ceiling linings in certain areas of buildings to have a minimum performance to the Early Fire Hazard test.

In areas where the bylaw does not control the EFH properties of materials, there are logical means of identifying fire hazards and, by using suitable test information, arriving at meaningful and practical improvements.

Care should be exercised in comparing the systems used in specific installations to the one described in the fire test report.

In selecting materials to comply with the bylaw, a useful starting point would be to inspect the SANZ publication MP9. The manufacturers of candidate materials should also be approached.

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