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Fire Safety of Furnishings

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Abstract

The role of furnishings in fire safety is discussed, as well as ignitability tests of these furnishings.

Introduction

On a per capita basis, the Canadian record of fire-related deaths in buildings is among the worst in the industrialized world. Attempts to improve fire safety through building code requirements have been continuing for many years, but they affect only the design and construction of the building itself. However, furnishings also play an important role in fire safety. Newer synthetic materials used in furnishings are often more hazardous than traditional materials.

Restrictions on the use of synthetic materials are addressed under the provisions of the Hazardous Products Act or under provincial or municipal fire prevention laws, if they are addressed at all. The National Fire Code[1] also contains a limited number of requirements to regulate furnishings. These requirements, however, have no legal status unless adopted by a regulatory authority.

This digest provides an overview of the various test methods used to determine the ignitability of synthetic materials used in upholstered furniture. There is also a discussion of mathematical models for assessing fire risks.

Fire Death Statistics

In Canada, fire loss statistics are compiled by the provinces, territories and the federal government on an annual basis. A number of provinces (in which over 80% of the total population resides) now collect fire incidence data in conformance with an agreed format[2] that permits comparison of statistics and allows for much more detail in the collected data. These data have been used to characterize the role of furnishings in residential fires (Table 1).

Table 1. Fire Death Statistics 1979

	Number of Deaths				
Building Fire Deaths	Alberta	BC	Ontario	Quebec	% of Total

Residential*	49	108	181	100	79.1
Institutional	0	3	4	10	3.1
Other - known	23	14	30	32	17.9
Total	72	125	215	142	100.0
Residential, material first ignited					
Furniture and furnishings	27	46	50	22	33.1
Clothing, textiles	2	10	9	10	7.1
Flammable liquids	3	5	18	17	9.8
Others - known	11	28	33	30	23.3
Others - unknown	6	19	71	21	26.7
Total	49	108	181	100	100.0
Residential, furnishings first ignited					
Upholstered furniture	10	11	32	5	40.0
Bedding and mattress	17	20	16	11	44.1
Other	0	15	2	6	15.9
Total	27	46	50	22	100.0
Residential, furnishings, source of ignition					
Smokers' materials	25	35	41	18	82.1
Open flames	2	3	2	0	4.8
Others - known	0	6	2	3	7.6
Others - unknown	0	2	5	1	5.5
Total	27	46	50	22	100.0

*Residential occupancies include all buildings (other than institutional types) that provide sleeping accommodations, i.e., hotels, dormitories, mobile homes, one- and two-family residences, apartments and rooming houses.

As can be seen in this table, about 80% or more of the fire deaths in Canada occur in residential occupancies. In about a third of these cases furniture and furnishings were identified as the articles first ignited. Of these, upholstered furniture, bedding and mattresses were the most common items initially involved (over 80%). Smokers' materials were the source of ignition in about 80% of the cases.

Analysis of the data reveals that residential fires in which furnishings were the items first ignited by smokers' materials accounted for approximately 20% of fire deaths. A substantial reduction in the number of fire deaths is therefore possible by improving the ability of furniture and furnishings to resist ignition from small sources such as cigarettes and matches.

Ignitability

Several countries have or are considering regulations for assessing the resistance of mattresses and upholstered furniture to smouldering ignition.

A standard test method to determine the smoulder resistance of mattresses was first issued in Canada in 1968, and revised in 1979.[3] The test is performed on a small-scale mock-up of the mattress assembly, using a single lighted cigarette as the ignition source. The acceptance criteria are that charring or melting of the surface must not exceed 50 mm in any horizontal direction from the cigarette, and any combustion in the mattress assembly must cease within 10 minutes after the cigarette has stopped burning. Regulations based on this standard have been in force under the Hazardous Products Act since 1982.

Assessing the ignition resistance of upholstered furniture is much more complicated than in the case of mattresses. The materials used in their manufacture, and their geometries and constructions may be markedly different.

Many upholstery fabrics are a mixture of fibres. In addition to fibre composition, the variables known to influence combustion characteristics include fabric weight, construction method, backcoating, dye, sizing, and chemical finishes. Fabrics and filling materials made from natural substances are subject to a smouldering type of combustion. By comparison, synthetic fibres are primarily thermoplastic and tend to melt and shrink when subjected to smouldering ignition sources, but burn rapidly when exposed to flame.

At present there are no standard test methods in Canada to evaluate the fire performance of upholstered furniture. The United States and the U.K., on the other hand, have appreciable experience in this field.

The U.S. Consumer Product Safety Commission (CPSC) considered two principal methods for evaluating the resistance of upholstered furniture to cigarette ignition, one developed by the National Bureau of Standards (NBS) and another developed by the Upholstered Furniture Action Council (UFAC).

The NBS method[4] utilizes mock-up testing to determine the ignition resistance of upholstered furniture items when exposed to smouldering cigarettes. The individual materials such as cover fabrics, filling materials and welt cord are tested in the combination in which they will be used in practice. A fabric classification test was suggested as a means of avoiding the expense of carrying out tests with every combination of upholstery fabric and padding or filling materials.

The UFAC program,[5] in contrast, evaluates individual component materials for use in any item of furniture by exposing them to lighted cigarettes in combination with standard materials representative of other components. Several tests are used, each employing a simple mock-up, to rate cover fabrics, filling materials, interliners, welt cords, and decking materials.

In 1979 the CPSC opted for the UFAC voluntary program, and since then it has worked closely with the industry in improving the reliability of this program.

The Upholstered Furniture (Safety) Regulations of the U.K.[6, 7] have requirements on assemblies of cover and filling materials to resist ignition by both lighted cigarettes and lighted matches. The ignition source is placed at the junction of the seat and back surface of a mock-up assembly of actual cover and filling materials. The test specimen passes the cigarette test if progressive smouldering or flaming of the components does not occur. A butane flame is used to simulate a lighted match in the open flame test; resistance criteria are the same as for the cigarette test. Upholstered furniture coming on the market in the U.K. since the end of 1982 has had to pass the cigarette test. A requirement to pass the simulated match test is being considered.

The use of slightly larger flaming sources has also been considered in order to reduce the number of upholstered furniture fires in the U.K. A graded series of seven flaming ignition sources has been developed for specifying ignitability requirements for particular applications. The series consists of small gas flames and wooden cribs, with the largest crib producing approximately the same heat as four double sheets of newspaper.

Post-Ignition Performance

The control of products based on ability to resist flaming ignition sources will have some effect on improving fire safety but is not expected to fully solve the problem. It is known that materials and products of similar ignition potential can have widely varying burning rates. Furthermore, testing of assemblies of materials for ignitability alone, is not sufficient for the complete assessment of the fire hazard of these products. Other fire characteristics such as surface flame spread, heat release, smoke obscuration and toxicity of combustion products also contribute to the hazard. It is known from observations of fires that with flaming ignition of furnishings the time from detection to untenable conditions is very short; consequently the rates of production of heat, smoke and toxic gases need to be considered for a more complete assessment of the hazard.

Traditionally, the results of small-scale fire tests have been employed to regulate the use of combustible materials in buildings. Unfortunately, the ranking of products developed by many of these tests does not give a reliable measure of the potential hazard in building fires. More meaningful techniques of hazard assessment are needed.

Room Fire Tests

The behaviour of burning furnishings has usually been studied in full-scale experimental rooms using common ignition sources. The growth of a fire in such studies is monitored by measuring the gas temperature, and from it the time to flashover. The development of smoke and the changes in gas composition are measured at selected locations.

At present, there is considerable interest in the development of standard room fire tests. Although the initial efforts are directed towards standardizing a test for wall and ceiling materials, the room fire facility and the instrumentation are designed in such a way that it can be adapted to tests on furnishings. The test being considered by both the American Society for Testing and Materials and the International Organization for Standardization utilizes an instrumented exhaust system for the measurement of the rate of production of heat, smoke and toxic gases in the entire room. The rate of heat release is determined by a technique which is based on the finding that the heat released per kg of oxygen consumed is approximately the same for most combustibles to be found in buildings. The only measurements required for determining the rate of heat release are the oxygen concentration in the exhaust duct and the volume flow rate of gases through the duct.

The room fire test has one disadvantage which, however, is common to most fire tests: the fire performance of materials obtained under a chosen set of conditions cannot always be assumed to be representative of all conditions. A large number of full-scale experiments will be necessary to investigate the many factors that affect the fire performance of products. The expense of such tests and the rapid advances in computer technology has led to increasing interest in mathematical modeling of fires.

Mathematical Modeling of Fires

The ultimate aim of fire modeling is to provide a comprehensive tool for the assessment of fire risk. Of major interest is the understanding of the fire growth in a compartment from ignition to full-room involvement. Computer programs have been written which use either factual data or assumptions regarding the key constituents of the fire (the burning item, the flame, the hot upper spaces, the lower spaces, non-burning surfaces, unburnt items) and their interactions. The main objective is to predict the time to flashover which is related to the ultimate time available for escape or rescue. Although substantial progress has been made in modeling compartment fires, accurate predictions of time to flashover cannot yet be made.

Mathematical models that employ the results of small-scale fire tests are being developed for practical applications. A simplified model has been developed for predicting the role of room lining materials and furnishings in the growth of compartment fires. Another model has been developed for predicting whether an upholstered furniture burning in a compartment without contribution from other combustible items would lead to flashover. It appears now that the development of control strategies for furnishings, using mathematical models, will soon be feasible.

Summary

An appreciable reduction in fire deaths is theoretically possible if bedding and upholstery materials are made more resistant to ignition by smokers' materials. Some materials such as mattresses are currently regulated. Test methods are available for assessing the suitability of many other products.

The fire behaviour of furnishing materials in the presence of strong ignition sources warrants attention. Until suitable small-scale tests are available, full-scale testing is necessary for product evaluation.

Mathematical modeling of fires using small-scale fire tests to predict room fire growth appears to be a promising tool for the future control of furnishings.

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