

NBSIR 74-455

Abstracts of Papers on Testing and Analysis of Flammable Fabrics October 1972 to October 1973

J. F. Krasny

Fire Technology Division
Institute for Applied Technology
National Bureau of Standards
Washington, D. C. 20234

March 1974



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NBSIR 74-455

**ABSTRACTS OF PAPERS ON TESTING AND
ANALYSIS OF FLAMMABLE FABRICS
OCTOBER 1972 TO OCTOBER 1973**

J. F. Krasny

Fire Technology Division
Institute for Applied Technology
National Bureau of Standards
Washington, D. C. 20234

March 1974

U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary
NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

Abstracts of Papers on Testing and Analysis
of Flammable Fabrics October 1972 to October 1973

Compiled by J. F. Krasny

This collection of abstracts covers papers on textile flammability testing and analysis of flame retardant fibers and finishes, for the period October 1972 to October 1973. It is hoped that this collection will facilitate research in this area in which there has been great interest in connection with the introduction of fabric and garment flammability standards by the Federal and several state governments. Similar collections appear in the Proceedings of the Annual Meetings of the Information Council on Fabric Flammability, available from the Council, Room 510, 1457 Broadway, New York, N.Y., 10036.

Testing and Standardization
General

Campbell, H. J. and Staples, M. L.

THE FLAMMABILITY OF TEXTILES.
Canadian Text. J., 90 (7) 85-89 (1973).

This is a review of fire injury data, flammability standards, and regulations, with emphasis on a comparison between the U. S. and Canadian approach to the problem of reducing losses from flammable fabric fires. A critical analysis of the 45° (CS 191-53) apparel fabric flammability test is presented. Ambiguities, especially those arising from the surface flash phenomenon encountered in napped cotton fabrics, are discussed, with modifications to the test suggested. The effect of R.H. and specimen orientation (vertical or horizontal) on ignition time is discussed, as well as the performance of double layers of fabrics.

Feikema, J. G.

THE COMBUSTION RATES OF VARIOUS TEXTILES
Melliand Textilberichte (Eng. Ed.), 54 (2) 179-184
(1973).

Flammability tests were conducted with the specimens in the horizontal, 45°, and vertical position with the flame spread rate measured at various distances from the point of ignition over a total specimen length of 44 cm. The major factors affecting flame spread rate were fabric weight and the dripping of molten polymer in the vertical tests. The latter ef-

fect is more obvious at distances farther from the point of ignition.

65/35 polyester/cotton blends did not produce melt drip. However, melt drip occurred in blends containing 75% or more polyester and in the acrylic fabrics. Initial flame spread was found to be considerably slower when ignition occurred in the body of the fabric than when the edge was ignited. There were some reversals in the relative ranking of the cotton and polyester/cotton fabrics. Smaller differences in ranking were observed when tests were conducted with point ignition than with ignition over the whole width of the sample: whole width ignition produced flame spread rates 1 to 1 1/2 times higher than the point of ignition.

Miller, B.

FLAMMABILITY TERMINOLOGY NEEDS VAST IMPROVEMENT
Amer. Dyestuff Rep., 62 (1) 25-27 (1973).

This paper attempts to point out certain inadequacies in the terminology used in the study of textile flammability. By citing specific examples it has shown how such terms as "flame-retardant", "self-extinguishing", "char length" and "flame propagation rate" must be used in a narrower sense than has been generally done in the past. At the same time, arguments were presented for the introduction of new terms and concepts, such as "thermal decomposition modifiers" and "ease of extinction".

It is hoped that this discussion will prove useful to those faced with the difficult problems that have arisen in the field of textile flammability.

Sharman, L. J., Tovey, H. and Vickers, A. K.

CURRENT STATUS AND NATIONAL PRIORITIES FOR FLAMMABLE FABRIC STANDARDS

Proc. 6th Annual Meeting ICFE, New York, 264-306
(Dec. 1972).

This paper covers the status of flammable fabrics standards development for mattresses, children's sleepwear sizes 7 to 14, upholstered furniture, and blankets, as well as the applicable sampling plans. The manner in which priorities for apparel standards are

determined is described: accident statistics are used to determine the more hazardous apparel item--sex-age grouping combinations, and availability of FR fabrics for such uses is considered.

Tribus, M.

DECISION ANALYSIS APPROACH TO SATISFYING THE REQUIREMENTS OF THE FLAMMABLE FABRICS ACT

Standardization News, STDNA 1 (2) 22-27 (1973).

In reference to the Flammable Fabrics Act of 1967, decision analysis is suggested as a method to specify "reasonable protection" from fabric flammability. Stress is given to the need for balance between cost and protection, higher cost encouraging the circumvention of standards and lower protection. The most advantageous trade off level to be found is with the probability theory using such factors as ignition levels, exposure to ignition, cost per garment and use of standard.

Yuill, C. H.

FIRE TESTS - THE CREDIBILITY GAP

Standardization News, STDNA, 1 (6) 26-28, 47 (1973).

Fire tests mean different things to different interests. Small-scale tests are needed for convenience and economy, but can be misleading if their limitations are not understood, particularly in relation to performance in actual fires. Materials that perform well by themselves may show poor performance when tested in combination with other materials. On the other hand, reports of large-loss fires frequently pin-point specific causes without supporting evidence.

Demonstrations of the reaction of materials to light fire exposure such as a match flame have been used to prove: (1) a greater hazard than that which actually exists or (2) a degree of safety that will be refuted by large-scale tests. Complaints against the "numbers game" ignore the necessity for the utility of specific end points. There is need for more large-scale testing in many areas to determine where to set end points.

Testing and Standardization
Test Development

Anon.

DEVELOPMENT OF A SEMIRESTRAINED VERTICAL FABRIC FLAMMABILITY TEST CONCEPT

Text. Chem. & Color., 5 (10) 27-33 (1973).

The Test Method Development Subcommittee of the Apparel Products Flammability Committee of the American Apparel Manufacturers Association evaluated a series of laboratory test method concepts in an effort to develop a bench test which would predict flame spread characteristics. The ultimate objective was to determine whether a small scale test would produce flame spread consistently similar to the flame spread observed with the same fabric in garment form on a mannequin. The method involves edge ignition (by a gas flame or a folded filter paper) vertical sample position, and moderate restraints of the sample to provide more realistic conditions for testing of thermoplastics than presented by metal frames.

Eisele, D.

FLAME RETARDANT TREATMENT OF NON-WOVENS

Melliand Textilberichte, 53 (10) 1167 (1973).

This is part of a series of papers on the materials and processes used to produce FR non-wovens. The author discusses methods for determining ease of ignition, flame spread rate, distance, intumescence, melting and dripping, afterglow, and extinguishability (by means of carbon dioxide). Ease of ignition and flame spread are measured by means of a modified semi-circular tester in which a Bunsen burner is moved 26 times per minute past the specimen. The number of cycles needed for ignition, and the flame spread along the arc are measured.

Gobeil, N. B.

ASTM TASK GROUP IS WORKING ON A NEW FLAMMABILITY TESTER

Text. Chem. & Color., 5 (2) 21-25 (1973).

During March 1970 an ASTM task group on apparel flammability began work on the development of a tester that could accurately measure both ease of ignition and rate of burning.

The experimental tester resulting from the project incorporates some of the principles of the 45° angle tester and others explored by the National Bureau of Standards. In the ease of ignition test the ignition flame impinges on the surface of the fabric with the specimen held at 62° from the horizontal. In the rate of burning test the specimen is held at a 45° angle with ignition forced at the lower edge. Test parameters can be changed by making minor engineering changes.

Griggs, D. I.

THE BRITISH EXPERIENCE

Proc. 6th Annual Meeting ICFE, New York, 230-237
(Dec. 1972).

The British fire death statistics for cases attended by fire departments are discussed briefly; they currently are apparently leveling out at somewhat above 800 deaths per year. Death due to asphyxiation appears more frequently than those due to burns. Experimental work with night clothing and dressing gowns led to development of vertical tests for ease of ignition, flame spread rate and distance, and heat evolved. The test for ease of ignition, and a test which classifies fabrics into those which spread flame, those with limited spread of flame, and those which melt, are applied first. The amount of flame spread, and sometimes heat transmission, are measured on fabrics which spread flames. At the time the paper was given an interlaboratory study was in process.

Miller, B., Goswami, B. C. and Turner, C.

THE CONCEPT AND MEASUREMENT OF EXTINGUISHABILITY AS A FLAMMABILITY CRITERION

Text. Res. J., 43 (2) 61-67 (1973).

Burning experiments in enclosed spaces have shown that oxygen depletion leading to flame extinction occurs even in a relatively large volume of air because convection is only partially effective in supplying air to a burning flame and removing products of combustion and pyrolysis. Quantitative evaluation of extinguishability through oxygen depletion determined under realistic burning conditions would, therefore, be a valuable indication of the hazard potential of a material.

Accordingly, a method has been developed for establishing a characteristic minimum-burning condition in terms of oxygen concentration which results in a more stringent criterion for the innate flammability of a material than the conventional oxygen index (OI) value. The TRI Flammability Analyzer is used to measure steady-state flame propagation rates at several oxygen concentrations high enough to support steady burning. Extrapolating the resultant linear burning rate-oxygen concentration relation to zero burning rate yields an intrinsic $(OI)_0$. With the analyzer, it is possible to determine intrinsic indices for the more common and vigorous upward directions of burning, and the upward indices obtained for a group of natural and synthetic fabrics, woven and knitted, are appreciably lower than the indices for the downward direction. Indeed, all fabrics studied, except Nomex, are found to be inherently capable of upward burning in air.

Testing and Standardization Apparel

Carter, W. H., Finley, E. L. and Farthing, B. R.

FLAME TEMPERATURE, HEAT RADIATION AND HEAT CONTENT
MEASURED FOR ALL-COTTON AND COTTON-POLYESTER FABRICS
J. Fire & Flammability, 4 (2) 106-112 (1973).

This research measured the heat radiation rate when full size A-line dresses made of all-cotton, 70/30 cotton-polyester and 50/50 cotton-polyester were burned on a life-size mannequin form. Radiation rates were evaluated in relation to surface temperatures measured on the mannequin and to the total heat content in cal/gram for the three fabrics. An Eppley pyrhelimeter placed at waist height and 18 inches out from the mannequin surface was used to measure heat radiation rate. The mannequin surface temperatures decreased as the polyester fiber content increased; whereas the total heat contents and radiation rates increased with increase in polyester fiber.

Duncan, A. J.

COMMITTEE E-11 ON STATISTICAL METHODS - REPORT
PERTAINING TO THE SAMPLING PLAN AMENDMENT TO THE
CHILDREN'S SLEEPWEAR STANDARD
Standardization News, STDNA, 1 (5) 26-27 (1973).

At its meeting in April 1973, Committee E-11 spent considerable time discussing the proposed sampling plan amendment to the Children's Sleepwear Standard. This is one of the initial standards issued under the Flammability Fabrics Act as amended in 1967 and is likely to set precedents for many other Federal Government standards to follow in the area of product safety. The introduction of a sampling plan into the standard is in itself a significant feature. It stands in sharp contrast to the policy recently proposed by the National Highway Traffic Safety Administration which refuses to allow permissive failure rates in its flasher standard. The E-11 discussion, which is summarized in this report, was concerned with the background of the sampling plan, its special features, interpretations needed for the computation of an operating characteristic curve and criticism of the test method.

Finley, E. L. and Butts, C. T.

GARMENT CONFORMATION ON A MANNEQUIN CHANGES FLAMMABLE
CHARACTERISTICS
J. Fire & Flammability, 4 (3) 145-155 (1973).

A-line dresses, with and without selfbelt, were burned on an adult size mannequin. Ignition was by exposure to six gas burners located at the hemline for 5 seconds. Fabrics used were all-cotton, 70/30 and 50/50 polyester/cotton, with and without THPOH-NH₃ treatment. The belts acted as flame-stops for about 3 minutes with the all-cotton, 2 minutes for the 70/30, and 1 minute for the 50/50 dresses. Unlaundered, FR treated dresses withstood 1 minute exposure to the gas burners but ignited after 20 launderings. Mean peak temperatures measured during the complete burning of the dresses were higher for the belted than the unbelted dresses. These temperatures became lower with decreasing polyester content (parts of the blend fabrics stayed intact and charred). Temperatures were relatively low where the fabric was in contact with the mannequin. Mean times to peak temperature varied from 8 to 33 seconds;

they decreased with polyester content, and were slightly shorter for the belted than the unbelted dresses.

Krasny, J. F. and Fisher, A. L.

LABORATORY MODELING OF GARMENT FIRES

Text. Res. J., 43 (5) 272-283 (1973).

In an attempt to model real-life burn accidents, garment assemblies were burned on adult-size mannequins and the temperature distribution over the mannequin surface determined. Anaesthetized, shaved rats were exposed in openings of the mannequins in the spatial arrangements encountered in real-life garment fires. The correlation between the depth of burn into the skin and the temperature observed on the mannequin surface near the exposed skin seemed fair. In other experiments, the interaction of burning fabrics and depth of burn was studied by means of simulated garments fitted to anaesthetized, shaved rats.

Garment geometry was found to affect the burn injury potential as much as fabric parameters. It is discussed in terms of initial fabric to skin, fabric to mannequin, and outerwear-underwear distance (these distances often change during the fire due to heat shrinkage of thermoplastic fibers, turbulence, etc); formation of chimney spaces between fabric layers and the mannequin surface; and firestops such as belts.

Other experiments covered the effect of combinations of various fabrics, such as dress-slip assemblies. Garments made from flame-retardant (FR)-treated cotton fabric and 100% thermoplastic fibers did not ignite in our experiments when used as single layers. When combined with polyester/cotton blends in outerwear/underwear assemblies, these fabrics caused smaller areas of the mannequins to be raised to elevated temperatures than the blend fabrics alone. This effect was particularly marked for the FR treated cotton.

In our experiments, polyester/cotton blends seemed to have more potential for causing injury than comparable, 100% cotton fabrics. 100% thermoplastic fiber fabrics appeared to have a low injury potential.

The effect of fabric weight on the area of the mannequin raised to elevated temperatures was not clear cut, though it was obvious that heavier fabric caused

more severe injury to exposed skin, and were more difficult to extinguish by beating out the flames than light fabrics.

Mandel, J., Steel, M. N. and Sharman, L. J.

NATIONAL BUREAU OF STANDARDS ANALYSIS OF THE ASTM INTERLABORATORY STUDY OF DOC FF 3-71 FLAMMABILITY OF CHILDREN'S SLEEPWEAR

Standardization News, STDNA, 1 (5) 8-12, (1973).

ASTM Committee D-13 on Textile Materials carried out an interlaboratory study on the test method given in DOC FF 3-71, Standard for the Flammability of Children's Sleepwear. Sixteen laboratories and eight fabrics were involved. Committee D-13's conclusions were that the study demonstrated that laboratories do not obtain the same "pass-fail" results when testing the same fabrics with DOC FF 3-71 as written and, in fact, gross differences in reproducibility were obtained. The same test data was analyzed at NBS. The analysis reported in this paper leads to conclusions contrary to those reported by D-13. The NBS report shows theoretically that with a go-no-go test, such as that for children's sleepwear, the probability of complete agreement between laboratories is attained only when the material under test is either so far superior to the test method requirements or so far inferior to them that unavoidable test method fluctuations have no effect on the outcome of the test. For a fabric that is only 2% defective, the probability of complete agreement between 16 laboratories is down to 72 percent. The data provide no evidence to support D-13's conclusion that gross differences in reproducibility are obtained.

Peach, R. W.

CONFORMANCE SAMPLING FOR CHILDREN'S SLEEPWEAR

Standardization News, STDNA, 1 (5) 13-15 (1973).

The DOC FF 3-71 includes a sampling plan, which though not specifically intended to be a quality control tool, is in effect just that. Thus, the standard will exert an influence on how a garment manufacturer conducts his business. Additionally, the position taken that the manufacturer's own test data is not acceptable places an unwarranted stricture on this industry. The author warns that despite

Congressional pressure, government agencies should exert more restraint before pushing through mandatory standards of this nature.

Pressley, T. A., Fincher, K. W. and Rowlands, R. J.

TEXTILE FLAMMABILITY TESTING

Text. J. Australia, 48 (2) 17-20, 38, 40 (1973).

This paper explains the background to Australian Standards 1176, "Methods for the Determination of Flammability of Textiles from which Clothing may be Made", AS 1248, "Fabrics Described as of Low Flammability", and AS 1249, "Safe Design Rules for Children's Night-clothes". Rather than adopting the British "Children's Nightdress Regulation 1964", the authors studied the apparel fire experience in conjunction with Australian hospitals, and related such garment parameters as fiber content, fabric construction, and weight, as well as garment fit, to the observed hazard. Unlike the U. S. statistics, which show a large incidence of nightwear fires, especially of females, Australian statistics show boys wearing day-time garments to be the foremost victims of fires.

In the ease of ignition test, hydrogen jet flames were chosen as ignition source because of flame stability. Samples are mounted horizontally and ignition is from below. This results in a convenient method and rates fabrics in the same manner as they were found in burn incidents.

The rate of burning test is vertical, and samples are held on needles (which are small heat sinks). Ignition is by means of a 7 jet gas burner across the full width of the sample. The use of glass threads to stabilize the position of thermoplastic fabrics in the flame is discussed, as is the effect of atmospheric pressure which was found to be significant. A method for measuring total heat output during each test, by means of recording the temperature rise in a standard copper rod in the chimney, is described but its use in rating fabrics is in abeyance pending further analysis of its significance.

Another method is used to measure surface burn of, e.g., chenille and flannel fabrics. Bone dry samples are used for this test because most such accidents seem to occur after the victim has been standing in front of heat sources for considerable time periods, and the

garments can be assumed to be fully dried. Surface burn is measured, in the downward direction. Methods for measuring ease of extinction are considered; the LOI test differentiates correctly between fibers but is independent of fabric weight while in real-life, heavier fabrics are harder to extinguish.

Testing and Standardization Floor Covering

Day, M. and Wiles, D. M.

CARPET FLAMMABILITY: AN OXYGEN INDEX MODIFICATION OF THE PILL TEST

J. Fire and Flamm., 4 (2) 165-173 (1973).

A simple, relatively inexpensive test method for determining the flammability of carpets has been devised based on the oxygen index concept and the timed burning tablet test. The combustion propensity of the carpet is determined by adjusting the proportion of oxygen in a mixed oxygen/nitrogen, constant total flow, supply fed into the test cabinet containing the carpet specimen. A methenamine tablet is used as a constant ignition source and rate of flame propagation is measured. The critical oxygen value is determined as the minimum concentration of oxygen which will just support combustion of the test specimen after ignition. Accurate and repeatable results have been obtained. The test method ranks carpets according to their limiting oxygen index value and rate of burning at an oxygen index of 21%.

Denyes, W. and Raines, J. W.

A MODEL CORRIDOR FOR THE STUDY OF FLAMMABILITY OF FLOOR COVERINGS

NBSIR Report 73-200, Nat. Bur. Stand. (U.S.), Washington, D. C. (1973).

A program was carried out to develop a laboratory test method that would measure the flame propagation characteristics of floor covering materials. A facility was designed which included a floor mounted specimen in a rectangular cross-sectional duct having a forced supply of air and a gas burner ignition source. The effects of variations in duct size, ignition source, and air flow were studied. Factors influencing repeatable test results were explored. Flame

spread was measured by an observer and temperature and heat flux measurements were recorded on an electronic digital data acquisition system.

Denyes, W. and Quintiere, J.

EXPERIMENTAL AND ANALYTICAL STUDIES OF FLOOR COVERING
FLAMMABILITY WITH A MODEL CORRIDOR

NBSIR Report 73-199, Nat. Bur. Stand. (U.S.), Wash-
ington, D. C. (1973).

The factors which control flame spread on carpets were studied in full scale experiments in a corridor. The predominant factor was found to be radiant preheating of the carpet surface ahead of the flame front. If a critical level of preheating is exceeded, an accelerating flame front will develop; if not, a decelerating flame front will develop. The intensity of radiant preheating depends on the energy supplied by the carpet and other sources, the dimensions of the corridor, and air velocity. Underlays provide insulation from the floor and increase carpet fire severity; bonded installation can reduce it. Mathematical modeling yields scale relationships which allow comparison of the results in the model corridor (with some qualifications) with the results of full-scale situation. A suggested test method is described.

Huggett, C.

CARPET FLAMMABILITY AND THE NBS FIRE CORRIDOR FIRE
PROGRAM

Standardization News, STDNA, 1 (5) 16-20 (1973).

Controversies over floor covering flammability test methods, the need for improved standards, and several recent fires involving floor coverings have focused special attention to the first phase of the NBS corridor fire program. The program is designed to study the effects of configuration, fuel loading and distribution, ventilation and other design parameters on the spread of fire through corridors in multiple occupancy buildings. The experimental program, observations, and correlation with real life hazards are outlined. Methods by which the results of flammability tests can be scaled to predict performance in full-scale buildings of different design are suggested.

Lee, T. G. and Huggett, C.

INTERLABORATORY EVALUATION OF THE TUNNEL TEST
(ASTM E 84) APPLIED TO FLOOR COVERINGS

NBSIR Report 73-125, NTIS COM 73-11189, Nat. Bur. Stand. (U.S.)., Washington, D. C. (1973).

Results of an interlaboratory evaluation of the ASTM E-84 tunnel test method involving eleven laboratories and nine materials; including four carpets, are reported. Data on flame spread, smoke, and fuel contribution are analyzed statistically. Selected physical characteristics of each tunnel are tabulated and compared relative to specifications in the test method. The between-laboratory coefficient of variation (reproducibility) in flame spread classification (FSC) was found to range from 7 to 29% for the four carpets and from 18 to 43% for the other materials tested. The between-laboratory coefficients of variation for smoke developed and fuel contribution ranged from 34 to 85% and from 22 to 117% respectively for all materials tested. The causes of higher variability in smoke and fuel contribution measurement between laboratories is not definitely known but may be reasonably attributed to variations in tunnel construction, maintenance, and operation, in the location of photometers, and in the mounting of thermocouples in different laboratories. Some variability of results may possibly be due to variation in test specimens. Variation in construction and measurement techniques among tunnels may be minimized by updating the test method standard.

Sanders, R.

A SMALL SCALE BURNING TEST FOR SHAG CARPETS

Text. Chem. & Color., 5 (3) 34-37 (1973).

The objective of this work was to develop a small scale burning test which would correlate with the tendency for a flame to propagate through the pile of shag carpets. A method was devised to test flame propagation through the pile of shag carpets by using the oxygen index tester. A small swatch of carpet was mounted in the test chamber in the horizontal pile-side-up position. Stainless steel rods, 1/8-inch in diameter, were placed between tuft rows in order to prevent interference due to ignition of the backing, and the oxygen index designated as the Pile Burn Index (PBI) of the carpet was determined. It was

found that shag carpets which did not meet the acceptance criterion of the methenamine tablet test (U. S. Department of Commerce Flammability Standard) due to propagation of the flame through the carpet pile had PBI's in the range of 18-20, while those which passed the test had PBI's of 22 or greater. The shag carpets with PBI's between 20 and 22 were found to exhibit marginal behavior in the tablet test. The PBI's of both polyester shag and nylon shag carpets were decreased when certain chemical residues from the dye bath (especially silicone) were on the carpet specimens.

Segall, W. M.

CARPET FLAMMABILITY UPDATE

Amer. Dyestuff Rep., 62 (6) 36 (1973).

A brief description of the flammability regulation of carpets; the citations by FTC for violation of the standard by numerous manufacturers; the definition of addition of alumina trihydrate used in lattices or foams as a fire retardant treatment and the need to launder such carpets before testing; and the presentation by industry to FTC of evidence that the laundering procedure of FTC was unrealistic and substitution of a better procedure.

Segall, W. M.

EFFECT OF FLAMMABILITY STANDARDS ON THE CARPET INDUSTRY

Standardization News, STDNA, 1 (5) 21-22, 68 (1973).

The experience of the carpet industry with the first flammability standard developed under the amended Flammable Fabrics Act has demonstrated the need for a statistical approach to the enforcement of government regulations based on mandatory safety standards. Recognition of the inherent variability of manufactured products and the lack of precision of test methods can be established by the incorporation of valid sampling plans in future standards.

Stamm, G.

EVALUATION OF THE FLAMMABILITY OF TEXTILE FLOOR AND WALL COVERINGS

Textilveredlung, 8 (6) 326-340 (1973).

This paper describes the work leading to a new Swiss Standard "Determination of Flammability Properties of Textile Floor and Wall Covering" (SNV 198,897, draft May 1973). A number of carpets were tested by four methods, all using a 20 mm gas flame. Flame spread, burn, and afterglow times were measured. Samples were tested in the vertical position, and ignition time was varied. Flammability classifications based on flame spread and burn time are discussed.

Thomm, E. C.

EFFECTS OF CARPET VARIABLES ON THE METHENAMINE PILL TEST

J. Fire & Flammability, 4 (2) 197-209 (1973).

Polyamide carpets were "pill-tested" in accordance with the ASTM D-2859-70T test method. Effects of the different carpet variables and components such as face yarn arrangement, backing materials and adhesive materials were compared and analyzed. It was found that carpets with longer loops, polypropylene primary backing, urethane foam secondary backing and ordinary adhesive burned most readily. The use of jute as primary or secondary backing and the incorporation of alumina trihydrate in the adhesive latex exhibited beneficial effects.

Testing and Standardization
Mattresses

Anon.

CALIFORNIA SETS STANDARDS

Bedding Magazine, 100 (11) 21 (1972).

The California Assembly Bill 1522 sets the effective date for the manufacture of flame retardant mattresses for June 7, 1973 and requires that the Bureau of Home Furnishings adopt regulations for the flammability of upholstered furniture by April 1, 1975.

The California mattress standard requires a vertical flame test for all components labelled "fire retardant".

McKee, C. J. L.

FLAMMABILITY: HISTORY, CIGARETTE TEST, STANDARD, ALTERATIONS, PRODUCT SAFETY
Bedding Magazine, 101 (5) 41-43, 66-68, 81 (1973).

The history of the Flammability Standard for Mattresses (DOC FF 4-72) is described. Lighted cigarettes are used as the ignition source in the test. They are placed on the bare surface as well as between two pieces of cotton sheeting on the mattress, in smooth areas, in quilted channels and tufted depressions (if any), as well as at the taped edge. The criterion for failure is a char extending for more than two inches from the cigarette. Several sampling plans cover the number of failures permissible in prototype and production testing.

Roe, R.

THE IMPACT OF THE NEW FLAMMABILITY STANDARDS ON THE BEDDING INDUSTRY
Standardization News, STDNA, 1 (5) 23-25 (1973).

In order to meet the new Federal Flammability Standards for Bedding, the industry will have to redesign all mattress products to meet necessary resistance to ignition from cigarettes. Each mattress manufacturer must also provide space and equipment to perform required test procedure, conduct destructive tests on mattresses prior to beginning production in order to certify compliance with the standards, conduct further on-going tests according to a work sampling plan and maintain certain record keeping for Federal enforcing agencies.

Testing and Standardization
Miscellaneous

Anon.

FLAME RETARDANTS UNDERGO CHECK

Amer. Dyestuff Rep., 62 (5) 28 (1973).

A short description is given of testing according to procedures specified by the Board of Standards and Appeals, City of New York, "Rules for Tests for Fire-Resistive Flameproofed Materials". Ignition is by means of a gas burner; the fabric sample is unrestrained; there shall be no more than 3 seconds after-flame time or 20 seconds afterglow time; and there shall be no flashing at any point on the specimen. The test applies to decorative and acoustical materials used in places of public assembly and special occupancy. Chemical systems which produce cotton, cotton/polyester, 100% polyester and triacetate fabrics that satisfy the requirements are mentioned.

Feller, I., Richards, K. and Crane, K.

THE ROLE OF FLAMMABLE FABRICS IN SEVERE BURN INJURIES

Proc. 6th Annual Meeting ICFE, New York, 167-174 (Dec. 1972).

Data collected by the National Burn Information Exchange show that clothing ignited in 86% of 4,596 flame-burn cases and were compared with those in which no clothing item ignited. In the former, mortality was 3 times higher and there were very substantial increases in the average areas of total and of full thickness burns, days of hospitalization and cost.

Hendrix, J. F., Drake, G. L., Jr. and Reeves, W. A.

SOME FACTORS AFFECTING FABRIC FLAMMABILITY AS MEASURED BY THE OXYGEN INDEX (OI)

Text. Chem. & Color., 5 (8) 13-17 (1973).

The use of oxygen index (OI) for determining relative flammabilities of textile materials is discussed in terms of variables inherent in the technique and artificial variables introduced for the purpose of this

study. OI values were found dependent on size and construction of the sample holder, temperature of the testing environment, weight, construction, moisture content and purity and the sample being tested.

Lehman, H. H.

A REVIEW OF THE FLAME RETARDANT FABRICS STUDY CONDUCTED AT THE NEW ORLEANS PHS HOSPITAL

Proc. 6th Annual Meeting ICFE, New York, 178-198 (Dec. 1972).

Untreated cotton fabrics and cotton fabrics treated with experimental FR treatment, polyester/cotton blends, fiberglass, modacrylics, X-400, and Nomex fabrics were used in hospital sheets, pillow cases, bedspreads, blankets, mattress covers, curtains, and gowns, for a period representing 200,000 patient bed days. No dermatological effects of FR materials could be detected, nor were there any significant differences in bacteriological growth on ordinary and FR materials. There was a 50% reduction in fire loss when the FR items were employed. Nomex sheets were disliked by the nursing staff because of slippage and color. Laundering conditions were adjusted for the FR cotton fabrics, which resulted in good resistance of the treatments to laundering.

Ignition, Heat Developments,
Combustion Products

Birky, M. M. and Yeh, Kwan-nan

CALORIMETRIC STUDY OF FLAMMABLE FABRICS. PART I. INSTRUMENTATION AND MEASUREMENTS

J. Appl. Polym. Sci., 17 (1) 239-253 (1973).

A calorimeter has been designed, calibrated, and tested to measure the total amount of heat released and the rate of heat released from the combustion of fabrics in air. Calibration of the calorimeter gave a reproducibility of $\pm 3\%$ for total heat measurements and $\pm 5\%$ on rate measurements. Consideration of systematic errors gives an expected accuracy of $\pm 7\%$ for total heat and $\pm 10\%$ for combustion rate measurements. Measurements on cotton show that 90% of the standard heat of combustion is released when cotton is burned in air. The rate of heat release for cotton is independent of fabric weight. The constancy of rate of

heat release as determined calorimetrically confirmed the result implied by the 45° test measurements on flame spread rate. The rate and amount of heat release of other commercial fabrics and blends were also measured.

Birky, M. M.

COMBUSTION PRODUCT ANALYSIS FROM FULL SCALE FLOOR COVERING FIRES

Polymer Prepr., Amer. Chem. Soc., Div. Polym. Chem., 14 (2) 1011-1016 (1973).

Smoke and gas measurements were conducted during fires in which carpets were burned in a 30 foot corridor. Gas sampling was at the ceiling where the concentrations were highest. Maximum tolerable concentration of CO and CO₂ and minimum concentrations of O₂ as well as visibility attenuation due to smoke were discussed. Typical times to reach these concentrations during the fire were listed.

Chouinard, M. P., Knodel, D. C. and Arnold, H. W.

HEAT TRANSFER FROM FLAMMABLE FABRICS

Text. Res. J., 43 (3) 166-175 (1973).

An instrumented mannequin was constructed to measure the general heat transfer from single- and multi-layer garment systems after ignition by a flame source. A range of weights in fabrics of cotton, polyester/cotton, acrylic, wool, nylon, and polyester has been studied.

Due in large measure to the melt-drip phenomenon, garments of polyester or nylon were found to burn relatively slowly over a limited area and self-extinguish, resulting in little heat transfer to the mannequin. To supplement the mannequin data, an instrument was developed to record all modes of heat transfer, including that from melted polymer. This paper deals with its application to both single and double fabric layers.

Measurements were related to possible physiological effects, using data from the literature and a supplementary pathological study.

McCarter, R. J.

A NEW TECHNIQUE FOR THERMAL ANALYSIS OF VAPOR PRODUCING REACTIONS

J. Appl. Poly. Sci., 17 (6) 1833-1846 (1973).

An apparatus was developed for measuring the rate at which vapors are evolved during the thermal degradation of materials and thereby deriving the kinetics of such reactions. Requisite to the operating scheme of the apparatus is the provision of a high-temperature zone to convert condensable or tarry vapors into non-condensable form. The apparatus yields a direct measure of reaction velocity, rather than the integrated indication obtained with thermogravimetric analysis. This simplifies the identification and calculation of kinetic parameters. Increases in sensitivity and operating range are also achieved. Flexibility in operation is obtained that permits the separate recording of reactions that tend to overlap. Although the apparatus principally has been operated using a combustible gas indicator to meter the evolved vapors, a number of options are available for the latter function, including flowmeters and various continuous gas analyzers. Examples of results obtained with untreated and FR treated cellulose are given.

Wulff, W., Alkidas, A., Hess, R. W. and Zuber, N.

FABRIC IGNITION

Text. Res. J., 43 (10) 577-588 (1973).

The burn injury hazard of fabrics has been conceptually related to laboratory test methods. The relation is to be derived from the description of the relevant processes which lead to burn injury. Among these processes stand out the ignition, the burn and the tissue denaturalization processes as predominately deterministic because of predictable fabric response.

Presented here are the results of an experimental and analytical investigation into the fabric ignition process. Thermophysical fabric properties relevant to the description of the ignition process have been presented. Fabric ignition times were measured under radiative heating. Modeling rules for the ignition process are presented.

Yeh, Kwan-nan, Birky, M. M. and Huggett, C.

CALORIMETRIC STUDY OF FLAMMABLE FABRICS. PART II.
ANALYSIS OF FLAME RETARDANT-TREATED COTTON
J. Appl. Polym. Sci., 17 (1) 255-268 (1973).

Efficiencies of three flame retardants for cellulose, (phosphoric acid, diammonium phosphate, and THPOH ammonia finish) have been evaluated based on the heat release value and the rate of heat release of treated fabrics burning in air measured with the isoperibol calorimeter. The results were compared and correlated with those obtained previously with the bomb-calorimetric technique. Complete heat balances were obtained for the systems studies by correlation of the calorimetric data and the measurement of combustible gases evolved from the fabric burning in air. The rate of heat release was found to correlate with the flame propagation rate measured at a 45° angle. The results from the heat, rate, and combustible gas measurements were interpretable in terms of existing mechanisms of flame-retardant action.

Effect of Laundering on FR Characteristics of Fabrics

Anon.

DETERGENTS AND FLAMMABILITY
Text. Chem. & Color., 4 (12) 20-21 (1972).

Nearly 100 persons attended a three-hour meeting of the Ad Hoc Committee on Detergents of AATCC. The entire meeting was devoted to the influence of washing procedures upon the flammability properties of fabrics and garments which initially meet the requirements of DOC FF 3-71. Extensive discussion reviewed the effects of hard water (calcium and magnesium ions) on washing with sodium soap, sodium carbonate-built detergents, low phosphate detergents and high phosphate detergents. It was the consensus that the use of soap with water hardness above 100 ppm would result in a significant loss of flame resistance on most if not all of the major fabrics being considered for garments which meet the standard initially.

Anon.

EFFECT OF SOIL ON FLAME RETARDANCE

Text. Chem. & Color., 5 (3) 25 (1973).

Committee RA56, Stain Resistance, of The American Association of Textile Chemists and Colorists (AATCC), is planning a study on the effect of soil redeposition and unremoved soil on the effectiveness of flame retardant fabrics. An attempt will be made to use a modification of the currently proposed redeposition methods utilizing the automatic home washer. Co-operative participation in the study by two other committees has been invited (Committee RA82, Flammability and Fire Resistance, and Committee RA83, Soiling of Household Textiles other than Floor Coverings).

Defosse, T. C.

THE INFLUENCE OF DETERGENT ADDITIVES ON FLAMMABILITY

Paper at Meeting of AATCC, Atlantic City, N. J.,
(Sept. 1973).

The purpose of this study was to present experimental results obtained when a variety of fire retardant fabrics were laundered with a series of detergent types under varying water hardness conditions. The main objective of the work was to define the effects of these detergents on a number of representative fire retardant fabrics and to identify cause of fire retardant impairment where applicable. Analytical data relating to detergent effects and photomicrographs of washed fabrics are presented. Fibers and finishes included in the study are acetate, cotton, high temperature nylon, modacrylics, PVA-PVC matrix fiber and rayon, all fire retardant, either inherently or by chemical finishing.

LeBlanc, R. B. and LeBlanc, D. A.

EFFECTS OF CALCIUM DEPOSITS ON FIRE RETARDANT COTTON

Amer. Dyestuff Rep., 62 (3) 50 (1973).

This paper is a follow-up to the previous citation. Calcium chloride was deposited on FR treated cotton fabrics which were then soaked in trisodium phosphate or sodium carbonate solutions. Fire retardance was not lost by deposition of calcium phosphate in situ

at a 1% level nor by deposition of calcium carbonate at the 1% level, or deposition of calcium chloride when 1% calcium is present.

LeBlanc, R. B. and LeBlanc, D. A.

FLAMMABILITY OF SLEEPWEAR LAUNDERED WITH VARIOUS DETERGENTS

American Dyestuff Rep., 62 (1) 28-30 (1973).

The present work was done to study the effects of laundering variables on flame retardant fabrics. The fabrics were laundered in soft and hard water, (the rinse water in all cases was approximately 35 ppm) and with high-phosphate detergent, low-phosphate detergent and soap. Flame retardance was evaluated by the Children's Sleepwear Standard DOC FF 3-71.

It was proven that fabrics did not pick up measurable calcium phosphate during laundering in phosphate detergents and the fire retardance was not lost.

Calcium soaps did deposit on the fabrics laundered in hard water with soap, and this caused a loss in fire retardance.

Calcium salts were padded onto FR cotton and it was found that these calcium salts did not cause a loss in fire retardance.

It was also found that stearic acid affected the fire retardance of FR cotton as much as did calcium stearate.

FR Fiber and FR Finish Identification

Ellzey, S. E., Jr. and Connick, W. J., Jr.

GASOMETRIC ANALYSIS OF THPC

Amer. Dyestuff Rep., 62 (6) 47-48 (1973).

A procedure was developed for the analysis of commercial solutions of THPC. The method involves the collection and measurement of the volume of hydrogen evolved from the reaction of THPC and excess NaOH. The measurement requires inexpensive equipment and is reasonably rapid and precise. Accuracy with solutions of known concentrations is quite good.

Morris, R. N., McCall, E. R. and Tripp, V. W.

IDENTIFYING FINISHES BY INFRARED SPECTROSCOPY:
FLUORO-CHEMICALS AND FLAME RETARDANTS

Text. Chem. & Color., 4 (12) 39-42 (1972).

An extraction procedure to successively remove various additives from the fabric undergoing analysis is described. The resulting extracts are examined by infrared spectroscopy and identified by comparison with a catalog of infrared spectra. In this study fluorochemical and flame retardant finishes are added to the functional categories previously examined. A comparison of extraction techniques is discussed and the need for a reliable catalog of reference spectra is emphasized.

Nelson, K. H. and Kelly, H. J., Jr.

NONDESTRUCTIVE DETERMINATION OF PHOSPHORUS FLAME
RETARDANTS

Text. Chem. & Color., 5 (6) 29-31 (1973).

Woven and knit polyester, polyester/cotton and cotton fabrics can be analyzed for phosphorus flame retardants by nondispersive x-ray fluorescence. Commercial instrumentation incorporating an Fe-55 isotope source, a helium atmosphere, a proportional counter and a single channel analyzer is used. The fabric is placed over the irradiation source and counted. A background correction count is obtained with untreated fabric and the milligrams phosphorus is read from a current calibration curve prepared with permanent fabric standards. Then the percent phosphorus is calculated after the weight of the counted area is derived from the total fabric area and weight. After analysis, the intact fabric is available for burning rate studies or further tests. With an alternative procedure, disks cut from the fabric with a circular die can be analyzed. Errors from chlorine and other elements are eliminated with a balanced filter.

Perkins, W. S.

A METHOD FOR QUANTITATIVE ANALYSIS OF COTTON/KOHJIN
BLENDS

Text. Chem. & Color., 5 (8) 18, 19 (1973).

Blends of cotton and Kohjin fibers are analyzed quantitatively by dissolution of the Kohjin portion by successive treatments with 40% (w/w) formic acid and N,N-dimethylformamide. Analysis of the moisture regain of the blend also gives an indication of the blend composition, since the moisture regain is directly proportional to the percentage of cotton. The accuracy of the dissolution method appears to be about $\pm 1\%$, that of the moisture determination about $\pm 3\%$.

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR 74-455	2. Gov't Accession No.	3. Recipient's Accession No.
4. TITLE AND SUBTITLE Abstracts of Papers on Testing and Analysis of Flammable Fabrics October 1972 to October 1973		5. Publication Date March 1974	6. Performing Organization Code
7. AUTHOR(S) John F. Krasny	8. Performing Organ. Report No. NBSIR 74-455		
9. PERFORMING ORGANIZATION NAME AND ADDRESS NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234	10. Project/Task/Work Unit No. 4903390		
	11. Contract/Grant No.		
12. Sponsoring Organization Name and Complete Address (Street, City, State, ZIP) same as no. 9	13. Type of Report & Period Covered		
	14. Sponsoring Agency Code		
15. SUPPLEMENTARY NOTES			
16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) This collection of abstracts covers papers on textile flammability testing and analysis of flame retardant fibers and finishes, for the period October 1972 to October 1973. It is hoped that this collection will facilitate research in this area in which there has been great interest in connection with the introduction of fabric and garment flammability standards by the Federal and several state governments. Similar collections appear in the Proceedings of the Annual Meetings of the Information Council on Fabric Flammability, available from the Council, Room 510, 1457 Broadway, New York, N.Y., 10036.			
17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons) Burn injuries; carpets; clothing; fabrics; fire retardants; flammability testing.			
18. AVAILABILITY <input checked="" type="checkbox"/> Unlimited <input type="checkbox"/> For Official Distribution. Do Not Release to NTIS <input type="checkbox"/> Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13 <input checked="" type="checkbox"/> Order From National Technical Information Service (NTIS) Springfield, Virginia 22151	19. SECURITY CLASS (THIS REPORT) UNCLASSIFIED	21. NO. OF PAGES	
	20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED	22. Price	

