Asbestos Substitute Fabrics for Safety Clothing

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Final Progress Report for
the Period 09/28/79 through 08/31/81

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by

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Summary Statement of Progress

More than seventy different heat-resistant fabrics that might be used in industrial safety clothing, or that might be considered asbestos substitutes in this application have been identified. Sample fabrics were obtained from various sources, and a systematic description and classification of these materials was developed. During the reporting period, many laboratory experiments were conducted to evaluate the fabrics acquired for this program. Tests completed include the measurement of thermal protective qualities; flammability, heat shrinkage, and resistance to molten metal. Other tests completed relate to the serviceability in an industrial environment. These tests include measurement of the fabric tensile strength, tearing strength, abrasion resistance, bending flexibility, air permeability, and thermal insulation value. Additionally, experimental apparatus was assembled for measuring the protection against radiant and convective heat. To assist in the interpretation of test data, information was accumulated and summarized concerning the use requirements of fabrics for industrial safety apparel. Computerized routines are being developed to manage the results of the laboratory experiments, and to permit a comparison of the asbestos substitute fabrics in various categories of performance.

List of Results

Identifying the Requirements for Heat-Resistant Fabrics in Industrial Safety Clothing

The following methods were used to obtain information needed to define performance criteria:

(1) A review was made of the available literature: technical papers, trade journals, and reports of private and government studies, on the needs and uses of high temperature fabrics. The contents of this literature were summarized and interpreted in light of the goals of this research.

(2) Industrial safety engineers were surveyed to obtain information concerning the thermal and physical performance requirements for textile materials in an industrial environment. Contacts were established with safety professionals in various industries, including Reynolds Aluminum, Alcoa, General Motors, American Motors, Ford Motors, United States Steel, National Steel, and the Corning Glass Works.

(3) Information on performance standards and materials specifications has been assimilated through active participation in the ASTM Committee F23.80 on Protective Clothing Materials for Exposure to Molten Substances.

(4) Manufacturers of protective clothing were surveyed to determine the types of protective clothing manufactured, to obtain product specifications, and to determine the criteria for selecting textile materials.

The results of these surveys are being analyzed. Certainly, they indicate a need for further communications with safety professions. The information obtained will be used to interpret the results of the laboratory tests made on the heat-resistant fabrics; and will influence the ultimate evaluation of the worth of these fabrics as materials for industrial protective clothing.

Identifying and Collecting Heat-Resistant Fabrics

The following methods were used to identify and classify the heat-resistant fabrics that are available, and to obtain samples of these fabrics for testing and evaluation:

(1) Heat-resistant fabrics that might be used in industrial safety apparel, or fabrics that might be considered asbestos substitutes in this application, were identified. These identifications were made through personal meetings and discussions with safety engineers, makers of protective clothing and manufacturers who are currently producing, converting, or promoting fabrics for industrial protective apparel.

(2) Samples of fabrics were obtained form various commercial sources having different heat-resistant fibers, blends of heat resistant fibers, fabric constructions, weights, weaves, refractive finishes, and multicomponent layers.

(3) These fabrics were identified, classified, labelled, and made ready for testing and evaluation.

Evaluating the Thermal Response of the Fabrics

An important goal of this research is to evaluate the ability of various asbestos substitutes to protect against burn injuries resulting from hazards encountered in an industrial environment. Aspects of thermal protection were measured incuding flammability, linear shrinkage and heat degradation, resistance to hot and molten materials, and ability to withstand radiant and convective heat assault. During the reporting period, the following studies were conducted:

(1) The ability of heat-resistant fabrics to resist heat transfer and thermal disintegration on impact with molten iron has been assessed. Maximum heat transferred through the fabrics was measured, and damage was evaluated in a controlled splash test. Ability to resist molten steel was correlated with fabric properties, including thickness and weight, air permeability, and the flammability characteristics. These tests represent an important industrial use of protective clothing against severe burn hazards.

(2) Flammability was measured using two different methods of testing. The first method involved subjecting the fabrics to a vertical flame, and measuring the char length and the after-glow time. The second method used a specialized flammability tester to measure the minimum concentration of oxygen required to burn. These data provide useful quantitative assessments of the tendency of protective fabrics to ignite, a significant hazard for workers exposed to open flames, to sparks, or to the splashing of molten materials.

(3) Thermal shrinkage and heat degradation was measured using a convection oven to expose test fabrics to temperatures of 300°C and 400°C for periods of 5, 10, and 15 minutes. These data provide an important basis for comparing protective values, since the potential for skin burn injury is greatly increased by thermal shrinkage even if the fabric does not burn.

Experiments to Measure the Fire Athermacy of the Fabrics

Various designs of laboratory apparatus can be constructed, and different experimental approaches can be used to measure the ability of a fabric to resist the transfer of heat and to protect against burn injuries. An objective of this research was to assemble equipment, and to choose experimental procedures with an emphasis on measuring the ability of the

fabrics to withstand heat hazards encountered in the work place. During the reporting period, the following steps were taken toward accomplishing this goal:

(1) A review of the scientific literature was made to accumulate detailed information on the design and construction of test apparatus and test procedures.

(2) Visits were made to laboratories and research centers, and communications were established with scientists knowledgeable in the testing of heat resistant fabrics; including scientists at Dupont, Cotton Inc., Fabric Research Laboratories, Clemson University, Southern Research Institute, the Materials Laboratories of the Armed Services, and the National Bureau of Standards.

As a result of these efforts, the next objective was accomplished, which was:

(3) to design and assemble apparatus, and to adapt experimental procedures to measure the transfer of convective heat and the resistance to an open-flame.

Besides simple thermal exposures, the goal of this research called for the making of more sophisticated measurements to accurately simulate the type of radiant/convective heat hazard encountered in the work place. In this regard:

(4) technical problems were encountered in using devices assembled from separate components to conduct experiments that required controlled exposures to a combined radiant and convective heat source. Particular problems were identified in making these measurements with sufficient reliability and with safety at the intense levels of heat required to realistically simulate severe industrial burn hazards. A critical need was identified for specialized engineering controls, including a need for precision monitoring of heat flux levels, precise exposures, and special heat shielding. A commercial apparatus was identified that incorporates sophisticated electronic and mechanical control devices for the purpose of measuring the protective values of industrial safety fabrics. This equipment is being acquired and will be used for the completion of this phase of the project.

Experiments to Evaluate the Textile Properties of the Fabrics

Many laboratory tests designed to measure properties that control the durability and comfort of protective fabrics were conducted during the reporting period. The following testing was completed:

(1) Fabric weight, thickness, and density were measured using standard test methods. Additionally, lengthy test procedures were conducted to charaterize aspects of the fabric structure and weave design including threads per inch of fabric, cover factors, yarn size, yarn twist, and the amount of yarn crimp. Besides being useful in the

interpretation of performance, these basic data are of immediate value in the engineering design of protective fabrics.

Tests were carried out to measure the durability including:

(2) Tests of tensile strength and elongation, and tests of the fabric's tearing resistance. Due to the high strength and the composite nature of many high performance textiles, standard tests had to be modified and special experimental procedures were developed to generate meaningful test results.

(3) Using the Stoll Universal Wear Tester, the resistance to flexing and abrasion was measured by subjecting the sample to reciprocal folding and rubbing over a 1/16 inch thick bar under a tension of one-half pound. The number of cycles required to break the sample was recorded.

(4) Thermal transmittance and insulative values measured following ASTM Standard Test Method D1518-77, Thermal Transmittance of Textile Materials Between Guarded Hot-Plate and Cool Atmosphere.

(5) Air Permeability determined following ASTM Standard Test Method D737-75.

(6) Fabric stiffness, including bending length and flexural rigidity, determined using ASTM Standard Test Method D1388-64.

(7) Fabric drapeability measured using a drapemeter technique to determine coefficients of fabric draping.

These data are useful in evaluating the functionality of protective fabrics, particularly heat stress, a significant performance factor in hot environments.

Defining Performance Criteria for Heat-Resistant Fabrics

A considerable amount of information has been accumulated concerning the requirements and uses of high-temperature fabrics in industrial safety clothing. Through continuing contacts with safety engineers, makers of protective clothing, and professional organizations a logical set of performance criteria was defined, including performance requirements related to thermal protection, comfort and durability. Information was obtained on the demands placed on fabrics used to protect against molten steel or molten aluminum, significant hazards to workers in these industries. A systematic methodology is being developed for predicting from laboratory measurements the workplace performance of asbestos substitutes. This methodology will be used to compare the fabrics tested by this research in various categories of performance.

Computer Analysis

A sizeable volume of data has been generated as a result of many physical and thermal tests made on more than 70 test fabrics. A computer is being used to analyze these data, to organize information, generate graphs, and to do the statistical analysis that is required. In many cases, special programs are being developed to interpret results, rank fabrics in performance categories, or to analyze the results of special test measurements.

List of Publications

1. Barker, R. L. and M. Yener: "Evaluating the Resistance of Some Protective Fabrics to Molten Iron," Published in the Textile Research Journal, Vol. 51, pp 533-541, August 1981.

2. Barker, R. L. and M. Yener: "Protective Clothing: Evaluating the Performance of Some Asbestos Substitutes Against Molten Steel," a paper presented at the International Conference on Fire Safety, held in Menlo Park, California in January, 1981. Abstract published in the Proceedings of the International Conference of Fire Safety, Vol. 6, p. 190, January 1981.

3. Brewster, E. Pintauro and R. L. Barker: "Fabrics for Protective Clothing: Part I. Identifying the New Heat Resistant Fabrics," a prepared paper to be submitted for review and publication in the American Industrial Hygiene Association Journal.

4. Brewster, E. Pintauro and R. L. Barker: "Fabrics for Protective Clothing: Part II. A Review of Research on Heat Resistant Fabrics," a prepared paper to be submitted for review and publication in the American Industrial Hygiene Association Journal.

5. Brewster, E. Pintauro and R. L. Barker: "Bibliography of Published Information on Heat Resistant Fabrics for Protective Clothing," a prepared paper to be submitted for review and publication in the Journal of Fire and Flammability.

6. Barker, R. L. and E. Pintauro Brewster: "Evaluating the Flammability and Thermal Shrinkage of Some Protective Fabrics," a prepared paper to be submitted for review and publication in the Journal of Industrial Fabrics.

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16. Abstract (Limit: 200 words)

Surveys were conducted to develop criteria for heat resistant fabrics for use in industrial safety clothing. Requirements for heat resistant fabrics in industrial safety clothing were identified. Sample fabrics were obtained and identified, classified, labeled, and tested for thermal responses. The ability of fabrics to resist heat transfer and thermal disintegration on impact with molten iron (7439896) was assessed. Flammability, thermal shrinkage, and heat degradation were measured. Fire athermancy and textile properties were evaluated. Durability was measured by tests of tensile strength, tearing resistance, resistance to flexing and abrasion, thermal transmittance and insulative values, air permeability, fabric stiffness, and drapability. Performance criteria for heat resistant fabrics were defined. The author concludes that a systematic methodology is being developed for predicting from laboratory measurements the workplace performance of asbestos (1332214) substitutes. The methodology will be used to compare the fabrics tested by this research in various categories of performance, with the use of a computer for data analysis, information organization, graph generation, and statistical analysis.

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