

A STUDY OF TENSILE STRENGTH OF FIBER GLASS ROOFING FELTS AFTER ACCELERATED LABORATORY CONDITIONING

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A laboratory testing program was conducted to better understand the strength characteristics of fiber glass roofing felts used in built-up roofing membranes for IRMA (insulated roof membrane assembly). Fiber glass felts from nine different sources and one polyester roofing mat were tested for tensile strength after exposure to a wide range of laboratory conditioning.

Strength data, ranked on a scale of 1 to 10, indicated distinct differences between the felts obtained from different sources. Three felts were categorized as having high tensile strength, five felts demonstrated acceptable tensile strength and two felts had low tensile strength.

There are three different manufacturing processes for producing fiber glass roofing felts: steam, wet, and continuous strand. These processes have an important impact on tensile strength. All fiber glass roofing felts are not alike, although they all meet ASTM requirements for application in built-up roofing (ASTM D-2178 Type IV). A mat is made according to one of the aforementioned processes and then impregnated with asphalt. In some cases, a mat may be made by one company but impregnated with asphalt by another.

Felts were tested in the machine and cross-machine directions. The machine direction is parallel to the direction of the process, and the cross-machine direction is perpendicular to the process, as shown in Figure 1. This program of laboratory qualification of fiber glass roofing felts was divided into three major phases: conditioning variables, tensile testing, and data analysis.

CONDITIONING VARIABLES

Eight conditions of laboratory exposure were used.

Dry Control Condition

Specimens were cut and placed in a laboratory at 72F, 50 percent relative humidity (RH) for 40 hours prior to tensile testing.

Freeze/Thaw Condition

Specimens were cut, placed in sealed plastic bags, and then placed in a freeze/thaw apparatus for 40 hours. The unit was set for cooling and warming cycles between -20 and 10C. Felt specimens averaged 17 cycles. This exposure condition was used to simulate field conditions of freeze/thaw cycling and to estimate the effect of this cycling on the tensile strength of the felts. Felts were kept dry and tested dry after reaching ambient temperature (72F) to better simulate an asphalt encapsulated felt.

Wet Control Condition

Specimens were submerged in distilled water at 72F for 40

hours, then tested wet. Tensile strengths of wet specimens were compared to those of the dry controls. In addition, these data provided a wet control condition for comparison with other accelerated conditions that included moisture.

Room Temperature Wet/Dry Condition

Specimens were submerged in distilled water at 72F for 40 hours and then allowed to dry at 72F. These specimens were tested in tension to discover if strength is regained after drying.

High Temperature Condition

Specimens were kept in a hot-air oven at 160F < 10 percent RH for 40 hours and tested within one hour of removal.

Ultraviolet (UV) Exposure Condition

Specimens were exposed to UV using a QUV tester (fluorescent UV lights) for 40 hours, and then tested. This exposure condition was used to simulate accelerated aging due to sunlight. The temperature of the QUV tester was maintained at 50C.

High Temperature/High Humidity (Damp) Condition

Specimens were placed in an environmental chamber with humidity and temperature controlled at 160F and 90 percent RH for 40 hours. Damp specimens were tested promptly after removal from the chamber. This laboratory condition simulated conditions of high temperature and high humidity that can occur in the field. If felts are covered with clear polyethylene, for example, a "hot house" effect could generate high temperature with high humidity.

High Temperature/High Humidity (Dry) Condition

Specimens were placed in an environmental chamber with humidity and temperature controlled at 160F and 90 percent RH for 40 hours. Specimens were allowed to dry at 72F and 50 percent RH, and then tested after drying. Unlike the previous condition, this condition permitted detection of changes in strength after drying. It addresses the question: is strength loss due to moisture regained upon drying?

TENSION TESTING

Tensile properties were measured using a universal testing machine. Rectangular 12" x 1" strips were cut from the felts. Specimens were attached between two 1-inch jaws spaced 8 inches apart and pulled at a rate of 0.5 inch per minute. Five specimens of each felt were cut per conditioning variable from the machine direction (MD) and from the cross-machine direction (CD) for each felt. Testing consisted of replication phases, and each phase included five specimens in the MD, five specimens in the CD, for each of 10 felts and for each of 8 variables. Thus, a total of 80 tensile strips were

tested for each felt per phase, and a total of 800 tensile tests were conducted per phase. Five phases were conducted so that a total of 4,000 data points were generated. Recorded data included: breaking load, tensile stress, elongation, strain (percent), and retention of breaking load, as compared to the dry controls.

Tensile strength of the felt specimens was measured after exposure to the eight laboratory conditioning variables. The felts were then ranked according to breaking load, tensile stress (load per unit area), and percent retention of control strength values. Over 400 points were generated for each brand of felt to identify the means and standard deviations for the tensile properties of these fiber glass roofing felts. These data are reported in Table 1.

The quality of the felts cannot be depicted fairly in a single figure. For example, one may consider the breaking load (Figure 2) to be the most important property, whereas another may regard retained strength (Figure 5) as the most important property. A ranking procedure was devised for each property and has been included in this report. The felts were ranked for three property categories, breaking load, tensile stress, and percent retained strength, according to a simple point system. Highest rankings received 10 points, and the felt with the lowest ranking in a category received one point. These points were then added together to establish an overall ranking.

DATA ANALYSIS

Data were entered into a computer after averaging the five specimens for each felt brand, each direction, each variable, and each phase. A computer program produced graph sets for the following:

1. Breaking load for each variable by felt brand (Figure 2)
2. Tensile stress for each variable by felt brand (Figure 3)
3. Strain for each variable by felt brand (Figure 4)
4. Percent retention of dry control breaking load for each variable by felt brand (Figure 5).

CONCLUSIONS

For every fiber glass felt brand, the most adverse conditions were those which involved moisture. The dry conditions of high temperature, freeze/thaw, and short-term UV exposure affected the tensile strengths of the felts very little relative to the controls. Fiber glass felts lose tensile strength when exposed to moisture, and although some felts regained some tensile strength after drying, many did not. Some of the felts tested while wet lost as much as 50 percent of the original tensile strength. Even though glass felts are considerably stronger than organic felts when wet, it is advisable to protect fiber glass felts from moisture.

Some distinct differences in tensile strength were observed between the felt specimens tested after exposure to laboratory conditioning. A ranking system was devised to provide a relative comparison of the various brands of fiber glass roofing felts. A felt that performed poorly in this investigation may have a higher risk for failure in the field. However, these data are not necessarily indicative of field performance. Many built-up roofs using the lowest ranked felts are performing quite well. Likewise, some failures have been noted with felts having the higher rankings. Nevertheless, some conditions affected all felts adversely, and applicable protection methods should be taken.

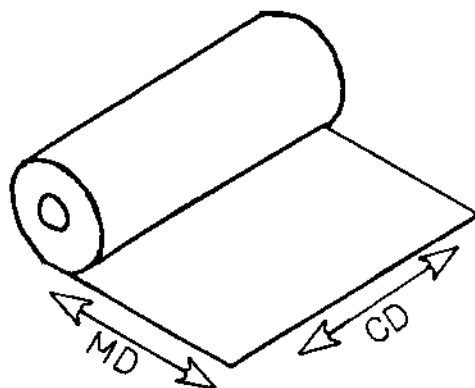


Figure 1

Average Breaking Strength for Each Sample

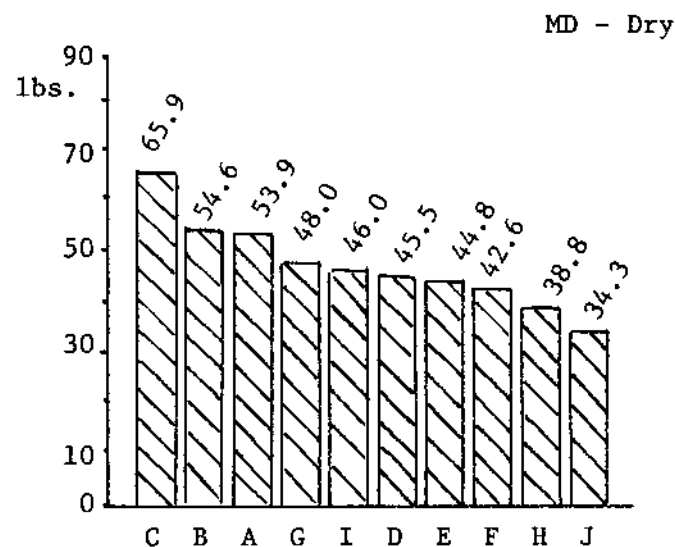


Figure 2

Average Breaking Strength for Each Sample

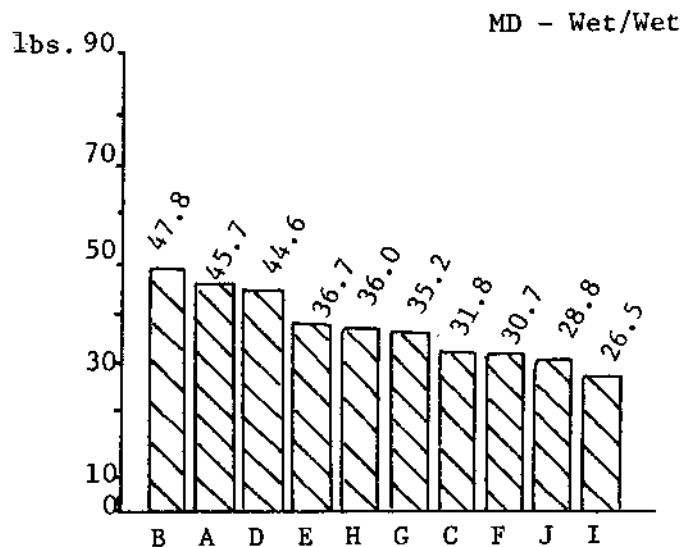


Figure 3

Average Breaking Strength for Each Sample

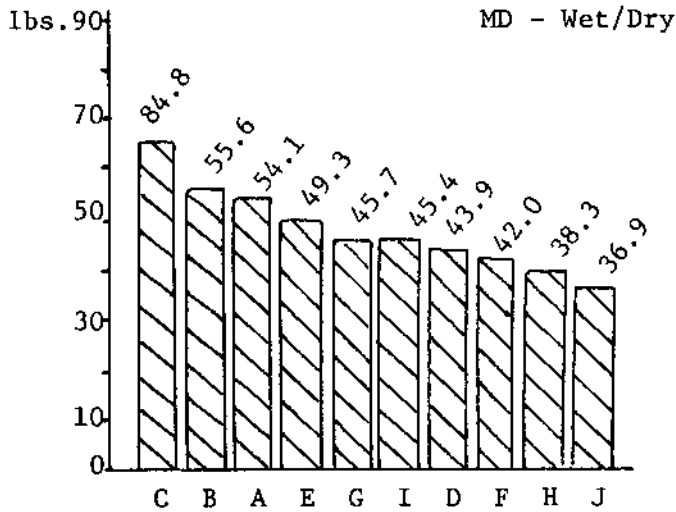
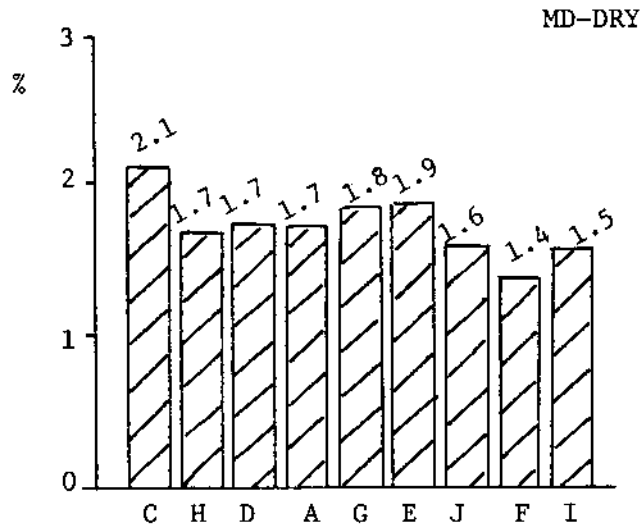


Figure 4

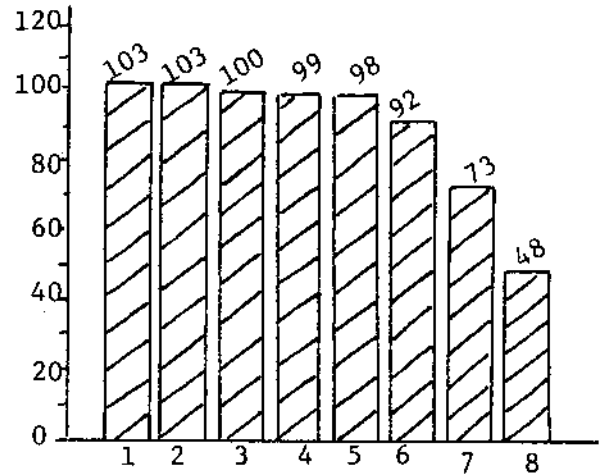
Average Breaking Strain for Each Sample



note: Sample B = 37.9%

Figure 5

% Retention of Breaking Strength for Each Condition by Sample Sample C - MD



KEY:

- 1 = Dry Control
- 2 = Wet Control
- 3 = Wet/Dry
- 4 = High Temperature
- 5 = High Temp/High Humid - wet
- 6 = High Temp/High Humid - dry
- 7 = UV
- 8 = Freeze/thaw

Figure 6