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General Discussions—Session I

Some Problems Concerning the Corrosion Tests of Cellulose Insulating Material

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We have studied the corrosiveness of cellulose insulating materials with a variety of chemical add-ons. I would like to discuss some of the problems we have experienced in carrying out the ASTM Specification for Cellulosic Fiber (Wood-Base) Loose-Fill Thermal Insulation (C739-77) and the General Services Administration (GSA)-HHI-515D corrosion test.

Extrusion of Air Pocket—In both the ASTM C-739 and GSA 515D procedures, a large amount of water was used. Extrusion of air pockets in the water-saturated specimen dish appears to be very critical. Many specimens showed early signs of corrosion at the interface of air pocket, metal coupon, and aqueous phase.

Edge Corrosion—We have experienced a high incidence of edge corrosion with certain types of add-ons. Whether this is considered as corrosion is yet to be determined. Mechanistically, this probably should not be considered as perforation.

Dry Test and Wet Test—Both ASTM C-739 and GSA 515D are considered as wet tests since the specimen is almost saturated with water. When we placed the coupon in dry cellulose which was then put in the humidity chamber under the same temperature and humidity, a much more severe corrosion was observed with cellulose-insulating material containing hygroscopic add-ons. It is believed that an hygroscopic add-on could pick up moisture and form a highly concentrated and localized add-on solution on the metal surface which is responsible for the corrosion.

Chloride Content in Cellulose—As expected, we have found a great variation of the chloride content in cellulose (17 to 350 ppm). Since chloride is detrimental in crevice corrosion, cellulose with high chloride content should be avoided.

Statistical Significance—Generally speaking, specimens with general surface corrosion gave more consistent results. On the other hand, for those specimens with localized pitting or crevice corrosion, triplicate specimens or even more are necessary to give a statistically significant result.

Preconditioning of Specimen—No preconditioning of the specimen was

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indicated in either the ASTM C-739 or the GSA 515D procedures. Preconditioning of a specimen could be critical in certain corrosion tests.

Our corrosion tests were run in a humidity chamber made from Plexiglas and equipped with a mechanical convection; the entire chamber was placed inside a temperature-controlled oven. The humidity was controlled by a saturated aqueous potassium sulfate solution [ASTM Recommended Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions (E 104-51)]. It is very economical (material cost ~ $180.00), easy to operate, and we believe it performs more consistently than strictly electromechanical equipment.

Effects of Moisture on Thermal Performance of Cellulose Insulation

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We have studied the effects of moisture on the thermal performance of cellulose fiber insulation in typical wall and attic applications both qualitatively and quantitatively.

Procedure

For the qualitative study of the possible degrading effects of total moisture pickup and of cyclic moisture migration, a typical cavity wall and ceiling panel combination was built centrally within a heavily insulated chamber. The wall and attic sections were insulated with commercial Class I cellulose insulation at the appropriate densities.

The combination test panels were instrumented with surface and air thermocouples, and calibrated heat flowmeters were placed in selected mirror-image postions on each of the insulated and stud sections to provide relative heat flow measurements during any tests.

The interior side of the test panel combination was maintained at approximately 23°C and a relative humidity of 40 $\pm$ 3 percent and the cold side at −15°C for 57 days. Measurements of temperatures and heat flowmeter outputs were recorded daily during this time. After this period the sections were examined and specimens of cellulose were taken from each for measurements of moisture content.

In the second part of this phase the combination panels were subjected to cyclic temperature conditions for 70 days. The cycle consisted of switching off the refrigeration on the cold side on three days of each weekly period for approximately 9 h and then switching on again once the cold side

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temperature had reached 5°C. As before, temperature and heat flow measurements were taken daily. On completion of this cycle the sections were reexamined once more and other specimens taken for moisture content measurements.

For the quantitative study typical separate cavity wall and ceiling panels were built and assembled in a guarded hot box. Measurements of thermal conductance of each panel were made separately for the appropriate heat flow direction according to standard procedures outlined in the ASTM Test for Thermal Conductance and Transmittance of Built-Up Sections by Means of the Guarded Hot Box (C 236-69).

After the baseline value had been obtained for each system, each was then subjected to the continuous moisture gradient conditions of the qualitative test for a total period of 12 days. Following this, a measurement of thermal conductance was attempted. It was found in each case that after 2 days the value of conductance, although it was at an equilibrium value within the criteria of the method, continued to decrease regularly but very slowly. Measurements were made for a further 5 days. On completion of the test the panels were examined and specimen taken from each for moisture content measurements.

Results

Qualitative Study—In both cases the heat flowmeter readings in the various sections of each panel increased and the temperature differences across the panel decreased, indicating that the thermal conductance and transmittance of the panels increased due presumably to the pickup of moisture mainly by the cellulose insulation. The relative thermal conductance increased on the order of 28 percent for the wall and 15 percent for the ceiling. Once cyclic conditions were started, however, the thermal conductance of each started to decrease significantly, indicating that a drying procedure had begun. Moisture contents of the cellulose rose from approximately 11 to 13 percent at the start of the measurements, over 40 percent at the end of the constant moisture gradient conditions, but fell again to between 16 and 25 percent after the cycling.

Quantitative Study—In both cases the measured thermal conductance increased from the original value by some 20 percent at the end for the moisture gradient conditions. In each case the value started to decrease once absolute measurements were started. Moisture contents were approximately 11 percent at the start, 20 percent after the moisture gradient conditions, and 17 percent after the limited drying procedure provided by the measurement conditions.

An analysis of the results for the ceiling section indicated that for a 10 percent increase in moisture content of the cellulose the thermal conductance increased by approximately 15 percent. Once drying conditions were established, the thermal conductance started to decrease and approach the starting value.

It is believed that the stringent moisture conditions enforced on the typical building section under consideration were far in excess of the most which would apply within the United States. No catastrophic changes in thermal performance were noted nor were any serious problems noted with the appearance of the various structural members of the panels.

The present study has been a limited one to evaluate gross effects of moisture pickup. While no serious effects were noted, the results are sufficient to indicate that further study is required on the mechanism and effects of moisture pickup in all thermal insulations.

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