# SELF-INFLATING MOVABLE INSULATION

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REASONS FOR UNDERTAKING WORK

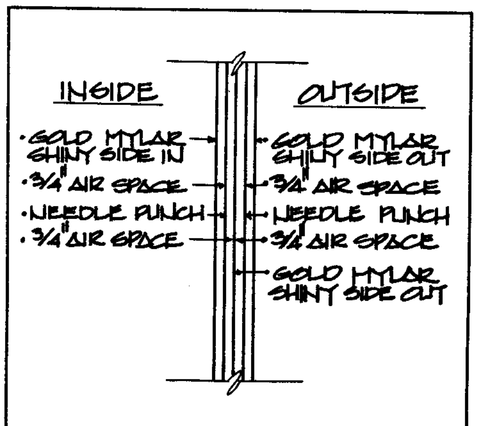
A passive solar greenhouse has been constructed at the Colorado Rocky Mountain School in the lower Roaring Fork Valley. There was a need for a movable insulation that could be easily automated, in order to keep nighttime temperatures high enough for the plants to live. A multi-layered curtain that was constructed of reflective materials seemed to be a good solution for that particular greenhouse. It became apparent that the curtain, if successful, would have many practical applications. Applications for vertical south wall passive systems were further investigated and the unique self-inflation facet of the system was realized. The unique ability of a series of layers having a high reflectivity and low emissivity to separate from one another due to radiant energy is the principle of operation of this curtain. Radiant energy from thermal mass (winter mode) or direct solar gain (summer mode) heats air which rises in the curtain and "blows it up".

Curtains 24 feet long by 16 feet high have been constructed (380 square feet of movable insulation). Storage requirement of the curtain is a space measuring 7 3/4 inches in diameter by 24 feet long. Another unique feature is the ability to cover large areas with effective insulation while keeping the linear feet of crackage (infiltration leakage) at a bare minimum.

This is the first disclosure of the s¥stem to the public (patents are being applied for both in the U.S. and abroad). In order to judge the success of the curtain,' the insulation values needed to be determined.

PRESENT WORK AND TESTING

The testing of the curtain has not, by any means, been completed. It is still in the experimental stages and will be for some time. However, enough data has been collected in order for us to make some safe conclusions. In determining the insulation values of the curtain, comparative values were stressed, rather than the R-values. This was done because R-values have been misused so much that they have become confusing. In order to get a comparison, two identical boxes were built. They were constructed of 2" thick Dow SM foam ,and 3/8" plywood. Each box had two sides that were open. On these openings, glass was placed along with the material to be tested. When the tests were run, a 5-gallon drum of hot water was placed within each box. The rate of temperature decline was charted over a certain time period, but more important, at the end of each test the water temperature of each can was checked to see which was hottest. The air temperatures of the hotter boxes were consistently higher, while the glass remained consistently cooler.




| Figure 1 | Section of curtain |
|---|---|

In each test, some form of the curtain was raced against a material with a known R-value, " By testing this way we could say that one material was better than another, In each test, a five-layer curtain was used.

The different materials used were gold colored aluminized mylar, *polyslim* mylar needle punch, and a vacuum deposited foil on a nylon scrim (commonly called foylon). In the first test, a curtain with the following *profile:* gold mylar (shiny *side in),* 3/4" air space, needle punch, 3/4" air space, gold mylar *(shiny* side *in),* 3/4" air space, needle punch, and gold mylar (shiny side out) was raced against a 1" piece of foam with an R-value of 4.1. After six hours, the curtain's water was hotter, containing 150 more Btu's.

In the second test, the needle punch was replaced with foylon and the curtain raced the same piece of foam. After seven hours, the curtain's water was hotter, 350 more Btu's. In the third, fourth, fifth and sixth tests, the middle sheet of mylar was replaced with foylon. In the third test, the curtain was raced against the same 1" piece of foam. After seven hours, the curtain's water was hotter, containing 500 more Btu's. In the fourth test, the same curtain was raced against a 1 1/2" piece of foam with R-value of 6.15. After nine hours the curtain's water was hotter, containing 350 more Btu's. In the fifth test, the same curtain was raced against a 2 1/2" piece of foam with an R-value of 10.25. After six hours, the curtain's water was hotter by 200 Btu's. In the sixth test the same self-inflating curtain raced a 4" piece of Johns-Manville fiberglass batt insu lation with an R-value of 14. After *six* hours, the curtain's water was hotter, containing 100 more Btu's.

| Experiment | Time (hrs. ) | Curtain vs. Control | Margin (Btu) |
|---|---|---|---|
| 1 | 6 | 5 layers vs. 1" foam | 150 |
| 2 | 7 | 5 layers vs. 1" foam | 350 |
| 3 | 7 | 5 layers vs. 1" foam | 500 |
| 4 | 9 | 5 layers vs, 1 1/2" foam | 350 |
| 5 | 6 | 5 layers vs. 2 1/2" foam | 200 |
| 6 | 6 | 5 layers vs, 4" fiberglass | 100 |

Table 1.

1 Curtain Test Data

METHOD OF CALCULATIONS

Hq = heat loss, Btu/hr/ft $^2$/F

U = heat transfer coefficient, Btu/hr/ft $^2$/F

A = surface area, ft $^2$

dT = change in temperature

Hq/Btu (5 gallon can) (Thermal Mass) (dT)

To find insulation values:

Hq (Foam box) = (U) (Area of Box) (dT air)

Hq water - Hqfoam box = Hq unknown material

Hq unknown material = (U) (Area of unknown material) (dT air)

$$U = \frac{\text{Hq unknown material}}{\text{(area unknown material) (dT air)}}$$

CONCLUSIONS

In the tests, the comparative values were stressed. Each curtain tested was a sandwich of four 3/4" air-spaces and five layers of material. The foylon proved to be a better insulator than the needle punch. In all of the tests, the curtain proved better than the control. In the last test, the curtain proved to be a small amount better than 4" of fiberglass insulation with an R value of 14, which agrees with the value supplied by the ASHRAE Handbook of Fundamentals. The tests prove and confirm that the curtain will be a successful movable insulation.

BIOGRAPHICAL SKETCH

Ron Shore is a solar consultant and teacher at the Colorado Rocky Mountain School (Solar Applications Laboratory) in Carbondale, Colorado. Ron is also a member of the Board of Advisors of the Roaring Fork Resource Center. James Gronen is a student of Ron's.