Technical Report

Calculated R-Values for Hybrid Insulation Assemblies that Contain Hy-Fi Reflective Insulation

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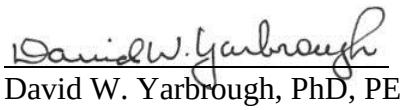

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Introduction

Thermal resistances (R-values) with units $ft^2 \cdot h \cdot °F/Btu$ have been calculated for hybrid insulation systems consisting of a layer of mass insulation partially filling a wall cavity and Hy-Fi reflective insulation in the remaining part of the cavity. Figure 1 is a top view of a wall cavity that illustrates the assembly.

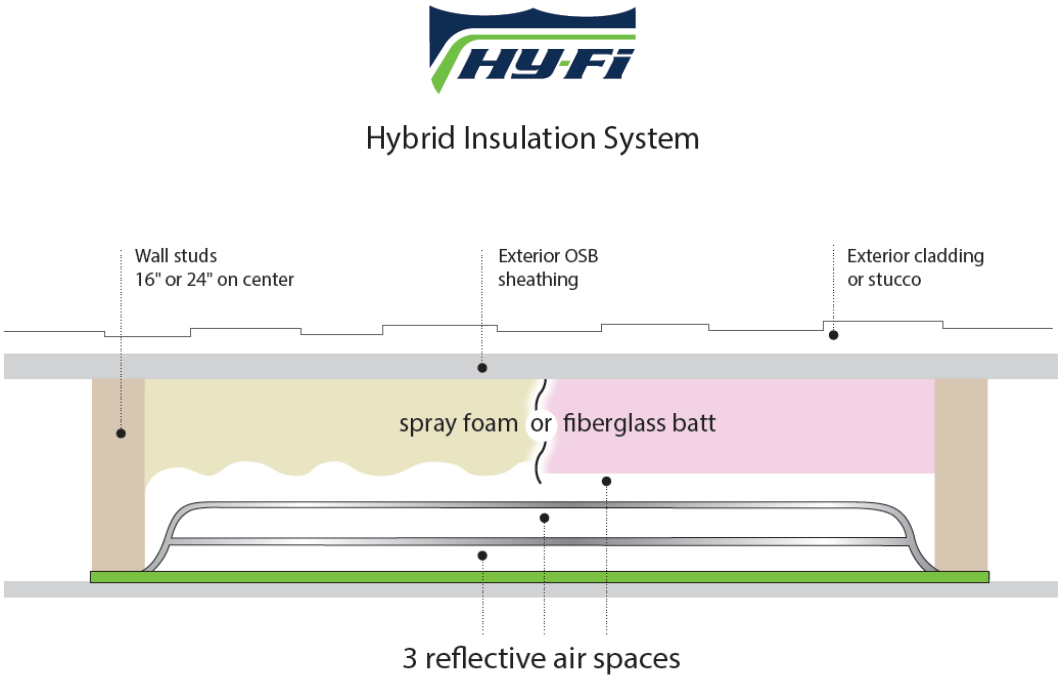


Figure 1. Wall Cavity with Mass Insulation and Hy-Fi Reflective Insulation

The region labeled "Mass Insulation" in the above figure will be characterized by a thermal resistivity (R per inch of thickness). The mass insulation can be cellulose, fiberglass, rock wool, cellular plastic, cotton or any insulation that can be installed in the cavity and provide the stated thermal resistivity.

Details of the Calculation

The boundary conditions for the thermal resistance calculations are 100 °F for the cavity surface on the exterior side (behind the mass insulation) and 70 °F for the air space on the interior side of the wall. These temperatures are representative of summer conditions. The interior side of the wall will be enclosed with ½-inch thick dry wall. The thermal resistances used in the calculations are contained in Table 1. Hy-Fi reflective insulation consists of three enclosed reflective air spaces. Two of the air spaces are taken to be ½ inch wide while the third air space dimension is the total cavity depth minus the thickness of mass insulation and one inch for the two enclosed reflective air spaces. The aluminum surfaces are taken to have emittance 0.034 and the non-reflective surfaces are taken to have emittance 0.9. This provides an effective emittance of 0.0339.

R-values for the enclosed reflective air spaces were calculated using the procedure contained in ASTM STP 1116[1]. A correction for two-dimensional radiation published by Glicksman[2] has been included.

Table 1. Input Data for the Analysis

Component	Dimension (in.)	R-Value ($ft^2 \cdot h \cdot °F/Btu$)	Emittance
Interior air film	-	0.68	-
Dry wall (gypsum)	0.5	0.55	0.900
Low-emittance surfaces	-	-	0.034
Mass insulation surface	-	-	0.900

Calculated R-values ($ft^2 \cdot h \cdot °F/Btu$)

Table 2 contains calculated R-values for a hybrid insulation system installed in the cavity of a wall with nominal 2 by 6 inch wood framing. The insulation system consists of a four-inch thickness of mass insulation with the indicated R-per-inch of thickness (R*). The remaining 1.5 inches of space in the cavity contains the reflective insulation, Hy-Fi. The Hy-Fi insulation is taken to be three 0.5 inch thick enclosed reflective air spaces. Results are shown for mass insulation R* values of 3.0 to 4.2. This range of R* values includes open-cell foams, cellulose insulation, cotton, fiberglass, and rock wool. Additional values for R total can be calculated using the following equation.

$$R_{total} = 7.126 + 4.030 \cdot R^* \qquad (1)$$

$$2.5 < R^* < 4.5$$

Table 2. R-values for Hybrid Insulation System in 2 by 6 in. Frame Wall Cavity

R* for Mass Component	R for Mass Component	R Hy-Fi	R Total
3.0	12.0	7.220	19.22
3.4	13.6	7.230	20.83
3.5	14.0	7.232	21.23
3.6	14.4	7.234	21.63
3.7	14.8	7.236	22.04
3.8	15.2	7.238	22.44
4.2	16.8	7.250	24.05

Table 3 contains calculated R-values for a hybrid insulation system installed in the cavity of a wall with nominal 2 by 4 inch wood framing. The insulation system consists of a two-inch thickness of mass insulation with the indicated R-per-inch of thickness (R*). The remaining 1.5 inches of space in the cavity contains the reflective insulation, Hy-Fi. The Hy-Fi insulation is taken to be three 0.5 inch thick enclosed reflective air spaces. Results are shown for mass insulation R* values of 6.0 to 6.75. This range of R* values includes closed-cell spray-applied polyurethane foam insulations. R total for additional R* values can be calculated from the following equation.

$$R_{total} = 7.123 + 2.016 \cdot R^* \qquad (2)$$

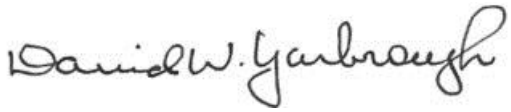
$$5.5 < R^* < 7.5$$

Table 3. R-values for Hybrid Insulation System in 2 by 4 in. Frame Wall Cavity

R* for Mass Component	R for Mass Component	R Hy-Fi	R total
6.00	12.0	7.221	19.22
6.25	12.5	7.224	19.72
6.50	13.0	7.227	20.23
6.75	13.5	7.230	20.73

Summary

R-values have been calculated for hybrid insulation assemblies intended for nominal 2 by 4 inch or nominal 2 by 6 inch wood-frame construction. The results of the calculation can be used to obtain the R-values for the hybrid insulation in the wall cavity for a range of thermal resistivities that includes most of the available mass-insulation products.



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References

[1] Desjarlais, A. O. and Yarbrough, D. W., "Prediction of the Thermal Performance of Single and Multi-Airspace Reflective Insulation Materials" , *Insulation Materials: Testing and Applications*, 2nd Volume, ASTM STP 1116, R. S. Graves and D. C. Wysocki, Eds., American Society for Testing and Materials (1991).

[2] Leon R. Glicksman, "Two-Dimensional Heat Transfer Effects on Vacuum and Reflective Insulations", *Journal of Thermal Insulation* 14 281-294 (1991).