

- 2x6 steel stud wall + R-19 insulation (clear wall)

Description

2x6 steel stud wall

- 1/2-in. gypsum board

Thermal conductivity – 1.11 Btu-in/h-ft²-F

Density – 50 lb/ft³

Specific Heat – 0.26 Btu/lb-F

- 3.5-in. R-11 fiberglass batts

Thermal conductivity – 0.32 Btu-in/h-ft²-F

Density – 5.3 lb/ft³

Specific Heat – 0.23 Btu/lb-F

- 2x6 steel studs

Thermal conductivity – 314 Btu-in/h-ft²-F

Density – 490 lb/ft³

Specific Heat – 0.12 Btu/lb-F

- 1/2-in. plywood

Thermal conductivity – 0.8 Btu-in/h-ft²-F

Density – 34 lb/ft³

Specific Heat – 0.29 Btu/lb-F

COMPUTATION RESULTS

Three-dimensional model

Table 16.1
Resistance, transmittance and capacitance of the wall

| | <i>IP</i> | | <i>SI</i> | |
|-----------------|-----------|--------------------------|-----------|---------------------|
| R-value | 11.31363 | ft ² °F h/Btu | 1.99120 | m ² K/W |
| R ⁻¹ | 0.08839 | Btu/h ft ² °F | 0.50221 | W/m ² K |
| Capacitance | 1.53889 | Btu/ft ² °F | 31.4454 | kJ/m ² K |

Table 16.2
Dimensionless 3D z-transfer function coefficients

| <i>n</i> | <i>b_n</i> | <i>c_n</i> | <i>d_n</i> |
|----------|----------------------|----------------------|----------------------|
| 0 | 0.20008 | 6.90969 | 1.00000 |
| 1 | 0.48490 | -7.48203 | -0.37815 |
| 2 | -0.02034 | 1.26283 | 0.03605 |
| 3 | -0.00691 | -0.03276 | -0.00017 |

$$\Sigma c_n = 0.65773, E_1 = 0.00000$$

Table 16.3
3D response factors calculated with the help of the finite difference computer code HEATING 7.2 [Btu/h ft² °F]

| <i>n</i> | <i>X_n</i> | <i>Y_n</i> |
|----------|----------------------|----------------------|
| 0 | 6.1074037E-01 | 1.7684653E-02 |
| 1 | -4.3037835E-01 | 4.9548020E-02 |
| 2 | -7.3145370E-02 | 1.6301274E-02 |
| 3 | -1.4933781E-02 | 3.7702144E-03 |
| 4 | -3.0843690E-03 | 8.4654435E-04 |
| 5 | -6.4194183E-04 | 1.8782076E-04 |
| 6 | -1.3439510E-04 | 4.1394086E-05 |
| 7 | -2.8270463E-05 | 9.0842503E-06 |
| 8 | -5.9701368E-06 | 1.9877310E-06 |
| 9 | -1.2648723E-06 | 4.3396792E-07 |
| 10 | -2.6871695E-07 | 9.4578249E-08 |
| 11 | -5.7223992E-08 | 2.0583877E-08 |

Table 16.4
3D response factors ratio, dimensionless 3D response factors and transfer functions of the first order

| n | X_n/X_{n-1} | Y_n/Y_{n-1} | R^*X_n | R^*Y_n | $R^*X'_n$ | $R^*Y'_n$ |
|-----|---------------|---------------|----------|----------|-----------|-----------|
| 0 | | | 6.90969 | 0.20008 | 6.90969 | 0.20008 |
| 1 | -0.70468 | 2.80175 | -4.86914 | 0.56057 | -6.35677 | 0.51749 |
| 2 | 0.16996 | 0.32900 | -0.82754 | 0.18443 | 0.22077 | 0.06374 |
| 3 | 0.20417 | 0.23128 | -0.16896 | 0.04265 | 0.00921 | 0.00295 |
| 4 | 0.20654 | 0.22453 | -0.03490 | 0.00958 | 0.00148 | 0.00039 |
| 5 | 0.20813 | 0.22187 | -0.00726 | 0.00212 | 0.00025 | 0.00006 |
| 6 | 0.20936 | 0.22039 | -0.00152 | 0.00047 | 0.00004 | 0.00001 |
| 7 | 0.21035 | 0.21946 | -0.00032 | 0.00010 | 0.00001 | |
| 8 | 0.21118 | 0.21881 | -0.00007 | 0.00002 | | |
| 9 | 0.21187 | 0.21832 | -0.00001 | | | |
| 10 | 0.21245 | 0.21794 | | | | |
| 11 | 0.21295 | 0.21764 | | | | |

$\alpha = 0.21530, \tau_1 = 0.64654$

Equivalent wall model: 3 layers plane wall

Table 16.5
Structure factors and time constants

| <i>Structure factors</i> | | <i>Time constants [h]</i> | |
|--------------------------|---------|-----------------------------|--------|
| ϕ_{ii} | 0.41464 | $R \cdot C \cdot \phi_{ii}$ | 7.219 |
| ϕ_{ie} | 0.06376 | $R \cdot C \cdot \phi_{ie}$ | 1.110 |
| ϕ_{ee} | 0.45784 | $R \cdot C \cdot \phi_{ee}$ | 7.971 |
| | | $R \cdot C$ | 17.410 |

Table 16.6a
Thermophysical properties of the equivalent wall - IP units

| <i>Layer</i> | R_n | C_n | l_n | k_n | ρ_n | c_{pn} |
|--------------|---------------------------|-------------------------|-------|------------------------------|--------------------|-----------|
| <i>n</i> | ft ² ·°F·h/Btu | Btu/ft ² ·°F | in | Btu·in/h·ft ² ·°F | lb/ft ³ | Btu/lb·°F |
| 1 | 0.42846 | 0.52500 | 0.75 | 1.750 | 35 | 0.24 |
| 2 | 10.30390 | 0.40556 | 5.25 | 0.510 | 3.86 | 0.24 |
| 3 | 0.58127 | 0.60834 | 1 | 1.720 | 30.42 | 0.24 |

Table 16.6b
Thermophysical properties of the equivalent wall - SI units

| <i>Layer</i> | R_n | C_n | l_n | k_n | ρ_n | c_{pn} |
|--------------|--------------------|---------------------|-------|-------|-------------------|----------|
| <i>n</i> | M ² K/W | kJ/m ² K | m | W/m K | kg/m ³ | kJ/kg K |
| 1 | 0.07541 | 10.72774 | 0.019 | 0.253 | 560 | 1.006 |
| 2 | 1.81349 | 8.28707 | 0.133 | 0.073 | 61.8 | 1.006 |
| 3 | 0.10230 | 12.43061 | 0.025 | 0.248 | 486.67 | 1.006 |

Table 16.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

| <i>n</i> | b_n | c_n | d_n | τ_n |
|----------|---------|----------|----------|----------|
| 0 | 0.15407 | 7.98220 | 1.00000 | |
| 1 | 0.59877 | -8.02308 | -0.15560 | 0.532 |
| 2 | 0.09164 | 0.88796 | 0.00046 | 0.171 |
| 3 | 0.00039 | -0.00222 | | 0.111 |

$$\Sigma c_n = 0.84487, \alpha = 0.15257$$

Table 16.8
Response factors for the equivalent wall [Btu/h ft² °F]

| n | X_n | Y_n |
|-----|---------------|--------------|
| 0 | 7.055381E-01 | 1.361779E-02 |
| 1 | -5.993728E-01 | 5.504392E-02 |
| 2 | -1.510011E-02 | 1.665802E-02 |
| 3 | -2.268062E-03 | 2.600758E-03 |
| 4 | -3.459347E-04 | 3.969669E-04 |
| 5 | -5.277769E-05 | 6.056427E-05 |
| 6 | -8.052094E-06 | 9.240067E-06 |
| 7 | -1.228478E-06 | 1.409722E-06 |
| 8 | -1.874243E-07 | 2.150760E-07 |
| 9 | -2.859462E-08 | 3.281335E-08 |
| 10 | -4.362573E-09 | 5.006210E-09 |
| 11 | -6.655815E-10 | 7.637785E-10 |

**Frequency response for the three-dimensional model and equivalent wall;
dimensionless amplitude and phase angle**

Table 16.9a
3-D model

| period | <i>Transmittance</i> | | <i>Admittance</i> | |
|--------|----------------------|-------------|-------------------|-------------|
| | amplitude | phase angle | amplitude | phase angle |
| 48 | 0.99 | -8° | 1.44 | 41° |
| 24 | 0.98 | -17° | 2.28 | 54° |
| 12 | 0.91 | -33° | 4.07 | 56° |
| 6 | 0.72 | -62° | 7.05 | 44° |

Table 16.9b
Equivalent wall

| period | <i>Transmittance</i> | | <i>Admittance</i> | |
|--------|----------------------|-------------|-------------------|-------------|
| | amplitude | phase angle | amplitude | phase angle |
| 48 | 1.00 | -8° | 1.39 | 43° |
| 24 | 0.99 | -17° | 2.17 | 60° |
| 12 | 0.96 | -33° | 3.95 | 70° |
| 6 | 0.85 | -64° | 7.45 | 73° |