- 2x4 steel stud wall + 1” EPS + Brick (clear wall)

Description

2x4 steel stud wall + 1-in. EPS + brick

- ½-in. gypsum board
  - Thermal conductivity – 1.11 Btu-in/h-ft^2-F
  - Density – 50 lb/ft^3
  - Specific Heat – 0.26 Btu/lb-F
- 3.5-in. R-11 fiberglass batts
  - Thermal conductivity – 0.32 Btu-in/h-ft^2-F
  - Density – 5.3 lb/ft^3
  - Specific Heat – 0.23 Btu/lb-F
- 2x4 steel studs
  - Thermal conductivity – 314 Btu-in/h-ft^2-F
  - Density – 490 lb/ft^3
  - Specific Heat – 0.12 Btu/lb-F
- ½-in. plywood
  - Thermal conductivity – 0.8 Btu-in/h-ft^2-F
  - Density – 34 lb/ft^3
  - Specific Heat – 0.29 Btu/lb-F
- 1-in EPS foam sheathing
  - Thermal conductivity – 0.26 Btu-in/h-ft^2-F
  - Density – 1.5 lb/ft^3
  - Specific Heat – 0.29 Btu/lb-F
- 3 ¼-in brick
  - Thermal conductivity – 6.0 Btu-in/h-ft^2-F
  - Density – 120 lb/ft^3
  - Specific Heat – 0.19 Btu/lb-F

COMPUTATION RESULTS

Three-dimensional model

Table 15.1
Resistance, transmittance and capacitance of the wall

	IP		*SI*	
R-value	12.7916	ft^2 °F h/Btu	2.25132	m^2 K/W
R^{-1}	0.07818	Btu/h ft^2 °F	0.44418	W/m^2 K
Capacitance	7.276	Btu/ft^2 °F	148.67627	kJ/m^2 K

Table 15.2
Dimensionless 3D z-transfer function coefficients

n	b_n	c_n	d_n
0	0.01014	6.99557	1.0000
1	0.15042	-12.38192	0.96989
2	0.11515	7.07266	0.26922
3	0.00060	-1.50306	-0.02015
4		0.09593	

$\Sigma\, c_n = 0.27918$, $E_1 = -0.01032$

Table 15.3
3D response factors calculated with the help of the finite difference computer code HEATING 7.2 [Btu/h ft^2 °F]

n	X_n	Y_n
0	5.4688866E-01	7.9269069E-04
1	-4.3755333E-01	1.2527799E-02
2	-1.8696523E-02	2.0938732E-02
3	-6.8176278E-03	1.6998370E-02
4	-2.8966110E-03	1.1197589E-02
5	-1.3506981E-03	6.7756783E-03
6	-6.6758011E-04	3.9302827E-03
7	-3.4221124E-04	2.2276774E-03
8	-1.7953287E-04	1.2460164E-03
9	-9.5605897E-05	6.9155349E-04
10	-5.1414651E-05	3.8207612E-04
11	-2.7831555E-05	2.1053721E-04
12	-1.5132883E-05	1.1584079E-04
13	-8.2535753E-06	6.3686717E-05
14	-4.5119283E-06	3.5004851E-05
15	-2.4703359E-06	1.9237553E-05
16	-1.3540648E-06	1.0572345E-05
17	-7.4282368E-07	5.8106473E-06
18	-4.0775689E-07	3.1938954E-06
19	-2.2393386E-07	1.7557525E-06
20	-1.2302545E-07	9.6527952E-07
21	-6.7613606E-08	5.3079758E-07
22	-3.7169877E-08	2.9192198E-07
23	-2.0438002E-08	1.6056624E-07

Table 15.4
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			6.99558	0.01014	6.99558	0.01014
1	-0.80008	15.80415	-5.59701	0.16025	-9.44418	0.15467
2	0.04273	1.67138	-0.23916	0.26784	2.83887	0.17971
3	0.36465	0.81181	-0.08721	0.21744	0.04432	0.07014
4	0.42487	0.65874	-0.03705	0.14324	0.01091	0.02366
5	0.46630	0.60510	-0.01728	0.08667	0.00310	0.00790
6	0.49425	0.58006	-0.00854	0.05027	0.00096	0.00261
7	0.51261	0.56680	-0.00438	0.02850	0.00032	0.00085
8	0.52463	0.55933	-0.00230	0.01594	0.00011	0.00027
9	0.53253	0.55501	-0.00122	0.00885	0.00004	0.00008
10	0.53778	0.55249	-0.00066	0.00489	0.00001	0.00002
11	0.54132	0.55103	-0.00036	0.00269	0.00001	0.00001
12	0.54373	0.55022	-0.00019	0.00148		
13	0.54541	0.54978	-0.00011	0.00081		
14	0.54666	0.54964	-0.00006	0.00045		
15	0.54751	0.54957	-0.00003	0.00025		
16	0.54813	0.54957	-0.00002	0.00014		
17	0.54859	0.54961	-0.00001	0.00007		
18	0.54893	0.54966	-0.00001	0.00004		
19	0.54918	0.54972		0.00002		
20	0.54938	0.54978		0.00001		
21	0.54959	0.54989		0.00001		
22	0.54974	0.54997				
23	0.54985	0.55003				

$\alpha = 0.54994$, $\tau_1 = 1.67240$

Equivalent wall model: 3 layers plane wall

Table 15.5
Structure factors and time constants

Structure factors		*Time constants [h]*	
φ_{ii}	0.07198	$R \cdot C \cdot \varphi_{ii}$	6.699
φ_{ie}	0.03422	$R \cdot C \cdot \varphi_{ie}$	3.185
φ_{ee}	0.85959	$R \cdot C \cdot \varphi_{ee}$	80.003
		$R \cdot C$	93.072

Table 15.6a
Thermophysical properties of the equivalent wall - IP units

Layer *N*	R_n Ft^2-°F-h/Btu	C_n Btu/ft^2-°F	l_n in	k_n Btu-in/h-ft^2-°F	ρ_n lb/ft^3	c_{pn} Btu/lb-°F
1	0.42572	0.41667	0.5	1.175	40	0.25
2	11.63052	0.34297	5	0.430	3.58	0.23
3	0.73536	6.51637	3.25	4.420	126.63	0.19

Table 15.6b
Thermophysical properties of the equivalent wall - SI units

Layer *N*	R_n M^2 K/W	C_n kJ/m^2 K	l_n m	k_n W/m K	ρ_n kg/m^3	c_{pn} kJ/kg K
1	0.07493	8.51408	0.013	0.169	640	1.048
2	2.04697	7.00811	0.127	0.062	57.26	0.964
3	0.12943	133.15410	0.083	0.638	2026.14	0.796

Table 15.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

n	b_n	c_n	d_n	τ_n
0	0.00561	7.42267	1.00000	
1	0.15654	-11.50827	-0.70930	1.931
2	0.17776	4.80489	0.06866	0.441
3	0.01871	-0.36359	-0.00060	0.215
4	0.00013	0.00305		0.118

$\Sigma\, c_n = 0.35875$, $\alpha = 0.59576$

Table 15.8
Response factors for the equivalent wall [Btu/h ft^2 °F]

n	X_n	Y_n
0	5.802772E-01	4.385494E-04
1	-4.880822E-01	1.254853E-02
2	-1.040845E-02	2.276703E-02
3	-1.947857E-03	1.675036E-02
4	-7.227005E-04	1.033603E-02
5	-3.851264E-04	6.195065E-03
6	-2.247253E-04	3.694629E-03
7	-1.333919E-04	2.201503E-03
8	-7.941834E-05	1.311602E-03
9	-4.730873E-05	7.814002E-04
10	-2.818396E-05	4.655251E-04
11	-1.679073E-05	2.773400E-04
12	-1.000319E-05	1.652270E-04
13	-5.959468E-06	9.843524E-05
14	-3.550393E-06	5.864343E-05
15	-2.115172E-06	3.493726E-05
16	-1.260128E-06	2.081409E-05
17	-7.507299E-07	1.240015E-05
18	-4.472525E-07	7.387473E-06
19	-2.664539E-07	4.401136E-06
20	-1.587417E-07	2.622008E-06
21	-9.457143E-08	1.562079E-06
22	-5.634161E-08	9.306198E-07
23	-3.356589E-08	5.544227E-07

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

Table 15.9a
3-D model

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.97	-24°	1.39	39°
24	0.88	-46°	2.14	52°
12	0.66	-85°	3.75	56°
6	0.32	-140°	6.67	49°

Table 15.9b
Equivalent wall

	Transmittance		*Admittance*	
period	amplitude	Phase angle	amplitude	phase angle
48	0.97	-24°	1.35	41°
24	0.88	-46°	2.05	58°
12	0.68	-83°	3.65	69°
6	0.39	-137°	6.84	73°