

**ASTM E 119-00a Fire Tests
Of Building Construction
and Materials**
**Modified*

**SMALL-SCALE TEST OF
FIREBLOCKING MATERIALS**

Project No. 16094-111638

* At this time, no specific test for evaluating fireblocking exists. According to the 2000 International Building Code, certain wood fireblocking is accepted in combustible concealed locations (i.e. 2 - inch nominal lumber, two thicknesses of 1-inch lumber, 3/4 - inch particleboard, among others). The time/temperature curve from the ASTM E 119 test standard was used to compare the performance of currently accepted wood fireblocking materials and cellulose insulation.

COMPARATIVE FIRE RESISTANCE TEST OF CELLULOSE
INSULATION VERSUS WOOD FIREBLOCKING IN A WOOD STUD WALL

August 28, 2002

Prepared for:

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Abstract

This project was undertaken to compare the firestopping abilities of spray-applied cellulose insulation versus spruce-pine-fir wood fireblocking. Small-scale wood stud wall sections were constructed and divided into three sections. The fireblocking materials under evaluation were: two layers of 1 x 4 lumber, spray-applied cellulose insulation at a depth of 14-1/2", and one layer of 2 x 4 or 2 x 6 lumber. The wall sections were mounted in slots in a horizontal test frame, and the ASTM E 119 time/temperature curve was followed for a period of 60 minutes. The temperatures on the unexposed surface of the cellulose insulation remained well below those on the unexposed surface of the wood fireblocking throughout the test.

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INTRODUCTION¹

"The performance of walls, columns, floors, and other building members under fire exposure conditions is an item of major importance in securing constructions that are safe, and that are not a menace to neighboring structures nor to the public. Recognition of this is registered in the codes of many authorities, municipal and other. It is important to secure balance of the many units in a single building, and of buildings of like character and use in a community; and also to promote uniformity in requirements of various authorities throughout the country. To do this it is necessary that the fire-resistive properties of materials and assemblies be measured and specified according to a common standard expressed in terms that are applicable alike to a wide variety of materials, situations, and conditions of exposure.

Such a standard is found in the methods that follow. They prescribe a standard exposing fire of controlled extent and severity. Performance is defined as the period of resistance to standard exposure elapsing before the first critical point in behavior is observed. Results are reported in units in which field exposures can be judged and expressed.

The methods may be cited as the "Standard Fire Tests," and the performance or exposure shall be expressed as "2-h," "6-h," "1/2-h," etc.

When a factor of safety exceeding that inherent in the test conditions is desired, a proportional increase should be made in the specified time-classification period.

The ASTM E119 test procedure is identical or very similar to the following standard test methods:

UL 263
UBC 7-1
NFPA 251
ANSI A2.1

¹ ASTM E119-00a Standard Methods of FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS, American Society for Testing and Materials, Volume 04.07 Building Seals and Sealants.



1. Scope

1.1 These methods are applicable to assemblies of masonry units and to composite assemblies of structural materials for buildings, including bearing and other walls and partitions, columns, girders, beams, slabs, and composite slab and beam assemblies for floors and roofs. They are also applicable to other assemblies and structural units that constitute permanent integral parts of a finished building.

1.2 It is the intent that classifications shall register performance during the period of exposure and shall not be construed as having determined suitability for use after fire exposure.

1.3 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

Note 1 - A method of fire hazard classification based on rate of flame spread is covered in ASTM Method E84, Test for Surface Burning Characteristics of Building Materials.

1.4 The results of these tests are one factor in assessing fire performance of building construction and assemblies. These methods prescribe a standard fire exposure for comparing the performance of building construction assemblies. Application of these test results to predict the performance of actual building construction requires careful evaluation of test conditions.

2. Significance

2.1 This standard is intended to evaluate the duration for which the types of assemblies noted in 1.1 will contain a fire, or retain their structural integrity or exhibit both properties dependent upon the type of assembly involved during a predetermined test exposure.

2.2 The test exposes a specimen to a *standard fire exposure* controlled to achieve specified temperatures throughout a specified time period. In some instance, the *fire exposure* may be followed by the application of a *specified standard* fire hose stream. The exposure, however, may not be representative of all fire conditions which may vary with changes in the amount, nature and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment. It does, however, provide a relative measure



of fire performance of comparable assemblies under these specified fire exposure conditions. Any variation from the construction or conditions (that is, size, method of assembly, and materials) that are tested may substantially change the performance characteristics of the assembly.

2.3 The test standard provides for the following:

2.3.1 In walls, partitions and floor or roof assemblies:

2.3.1.1 Measurement of the transmission of heat.

2.3.1.2 Measurement of the transmission of hot gases through the assembly, sufficient to ignite cotton waste.

2.3.1.3 For load bearing elements, measurement of the load carrying ability of the *test specimen* during the test exposure.

2.3.2 For individual load bearing assemblies such as beams and columns: Measurement of the load carrying ability under the test exposure with some consideration for the end support conditions (that is, restrained or not restrained).

2.4 The test standard does not provide the following:

2.4.1 Full information as to performance of assemblies constructed with components or lengths other than those tested.

2.4.2 Evaluation of the degree by which the assembly contributes to the fire hazard by generation of smoke, toxic gases, or other products of combustion.

2.4.3 Measurement of the degree of control or limitation of *the passage of* smoke or products of combustion through the assembly.

2.4.4 Simulation of the fire behavior of joints between building elements such as floor-wall or wall-wall, etc., connections.

2.4.5 Measurement of flame spread over surface of tested element.

2.4.6 The effect of fire endurance of conventional openings in the assembly, that is electrical receptacle outlets, plumbing pipe, etc., unless specifically provided for in the construction tested."

TEST PROCEDURE

Test Furnace

The 7' x 7' test furnace is fitted with 25 uniformly located diffuse-flame natural gas burners providing an even heat flux distribution across the face of the test specimen. Furnace pressures are maintained at +0.04" W. C. to -0.20" W. C.



The temperature within the furnace is determined to be the mathematical average of thermocouples located symmetrically within the furnace and positioned twelve inches away from the horizontal face of the test specimen. The materials used in the construction of these thermocouples are those suggested in the test standard. During the performance of a fire exposure test, the furnace temperatures are displayed every 6 seconds for the furnace operator to allow control along the specified temperature curve. The fire exposure is controlled to conform with the standard time-temperature curve shown in Figure 1, as determined by the table below:

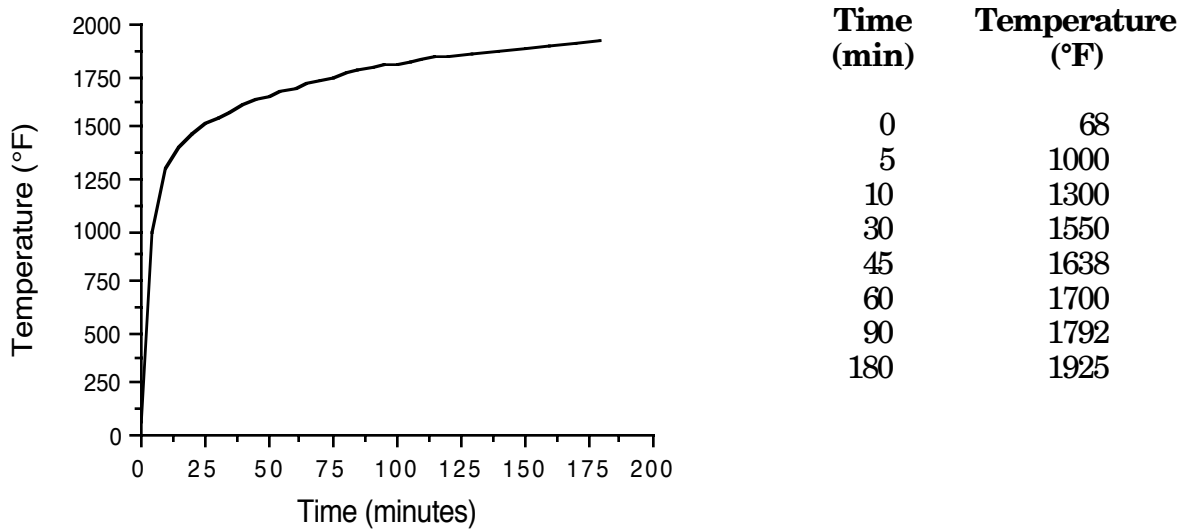


Figure 1

The furnace interior temperature during a test is controlled such that the area under the time•temperature curve is within 10% of the corresponding area under the standard time•temperature curve for 1 hour or less tests, 7.5% for those less than 2 hours and 5% for those tests of 2 hours or more duration.

Fire Endurance Test

The fire exposure is continued on the specimen until failure occurs, or until the specimen has withstood the test conditions for the desired fire endurance rating.



TEST SPECIMEN CONSTRUCTION

The test specimen identification is as provided by the client and Omega Point Laboratories, Inc. accepts no responsibility for any inaccuracies therein. Omega Point did not select the specimen and has not verified the composition, manufacturing techniques or quality assurance procedures.

A 7' x 7' wood stud frame was constructed from 2 x 4 lumber to fit on the laboratory's small-scale horizontal furnace. The exposed surface was clad with three layers of 5/8" thick Type X gypsum wallboard. Three slots were cut out of the gypsum for mounting the test samples. Two of the openings were large enough to house a 2 x 4 stud wall section, and the other was cut to house a 2 x 6 wall section. The wall sections consisted of spruce-pine-fir wood studs spaced either 16" or 24" o.c. fastened to a top plate using 1-7/8" long galvanized steel roofing nails. The total height of each assembly was 19-1/2", with an overall length of 48". The fireblocking materials under evaluation were: a single 2 x 4, single 2 x 6, two layers of 1 x 4 with a broken lap joint, wet-spray cellulose insulation (nominal 3 pcf), and dry-fill cellulose insulation (density unknown, but visually greater than 3 pcf). The cellulose insulation was installed at a depth of 14-1/2". Each of the fireblocks was installed 2" from the bottom of the studs. The inside of the outer two studs of the assembly were covered with a piece of 5/8" thick Type X gypsum wallboard, and each end cavity was also separated from the middle cavity by a piece of 5/8" thick Type X gypsum wallboard. After the fireblocking was installed, each surface of the wall assembly was covered with a single layer of 5/8" Type X gypsum wallboard, fastened to the studs using 1-1/2" long self-tapping drywall screws. The wall assemblies were then fitted into the slots in the horizontal test frame with the bottom of the studs flush with the exposed surface of the frame. Construction drawings are located in Appendix A.

THERMOCOUPLES

All temperatures monitored were measured using 24 GA., electrically-welded, Type K Chromel-Alumel, glass-glass insulated (Special Limits of Error: $\pm 1.1^{\circ}\text{C}$) thermocouples, purchased with calibration certifications and lot traceability.

Thermocouples were located in each cavity of the test sample. The thermocouples in the wood fireblocking cavities were located on the unexposed side of the fireblocking, and the thermocouples in the cellulose-insulated cavities were



located on the unexposed surface against the top plate. Additional thermocouples, for information only, were located within the cellulose insulation 1-1/2" from the bottom to give a direct comparison between the wood and the cellulose insulation. A drawing of the thermocouple locations can be found in Appendix B.

TEST RESULTS AND OBSERVATIONS

The test assembly was mounted on the laboratory's small-scale horizontal test furnace on February 13, 2001. The lab ambient temperature at the time of the test was 90°F, with a relative humidity of 65%.

Observations made during the test are as follows:

Time (min:sec)	Observation
0:00	Furnace fired at 2:45 p.m.
1:30	Light smoke issuing from the test assembly
5:00	The damper was closed to create positive pressure (+0.01" W.C.) at the sample location
5-60	No visible changes occurred throughout the test
60:00	The furnace was extinguished and the test samples were removed from the frame. After the sample had cooled for a few minutes, one layer of gypsum wallboard was removed to inspect the fireblocking materials. The wood fireblocking was either completely charred or burned away, and the cellulose-insulated cavities still had 10-11" of virgin material remaining.

Listings and plots of the furnace control temperatures and specimen unexposed surface temperatures may be found in Appendix C. A photographic documentation of the test has been included in Appendix D.



CONCLUSIONS

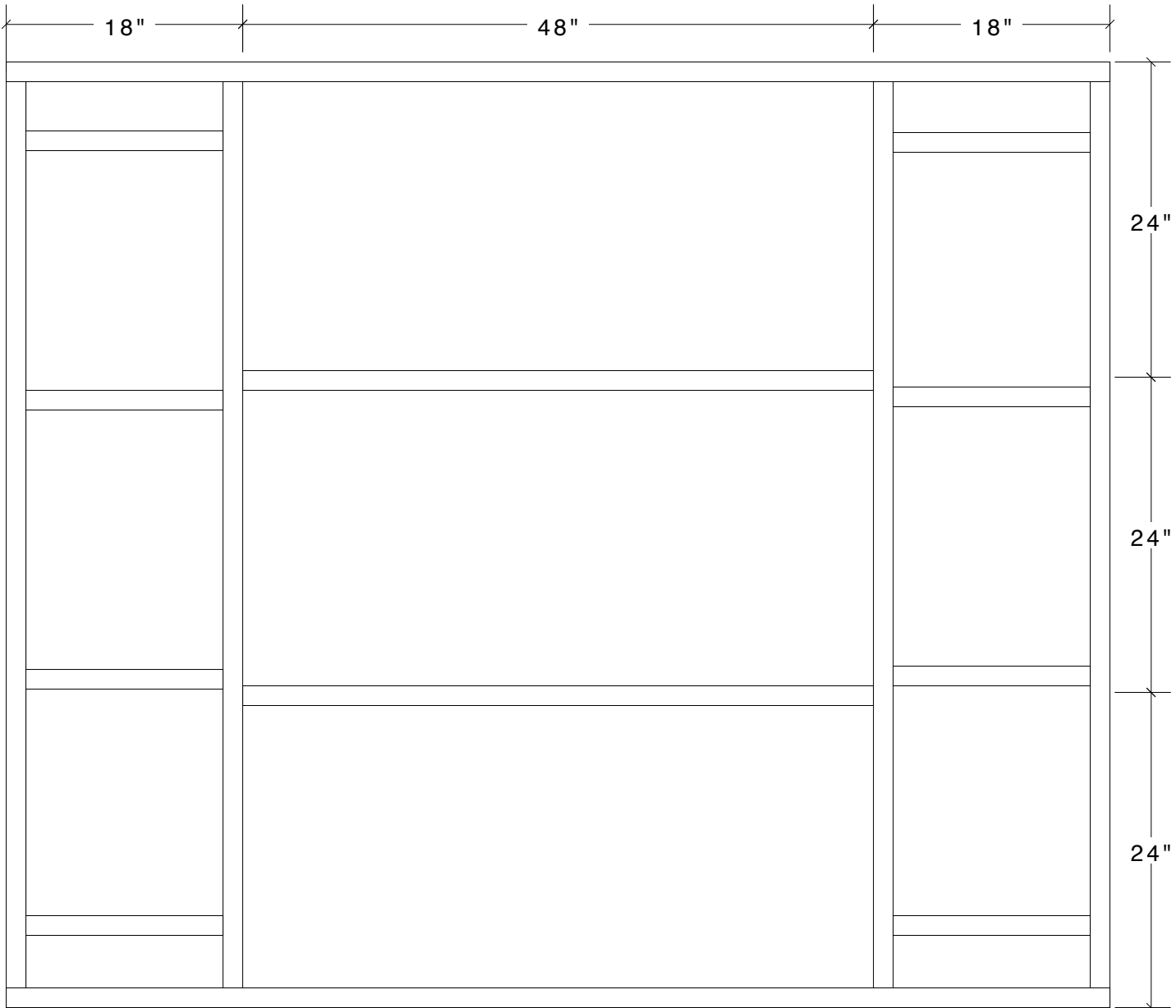
The test specimen identification is as provided by the client and Omega Point Laboratories, Inc. accepts no responsibility for any inaccuracies therein. Omega Point did not select the specimen and has not verified the composition, manufacturing techniques or quality assurance procedures.

This test has shown that temperatures on the unexposed side of spray-applied cellulose insulation, installed at a depth of 14-1/2", remained lower than the temperatures on the unexposed side of wood fireblocking materials when exposed to the ASTM E 119 time/temperature curve for a period of 60 minutes. The wood fireblocking materials in this comparative test were 1) two layers of 1 x 4 spruce-pine-fir installed with a broken lap joint, and 2) a single piece of 2 x 4 or 2 x 6 spruce-pine-fir. The wet-spray cellulose was installed at a nominal 3 pcf. The dry-fill density was unknown, but visually was greater than 3 pcf.



APPENDIX A
CONSTRUCTION DRAWINGS

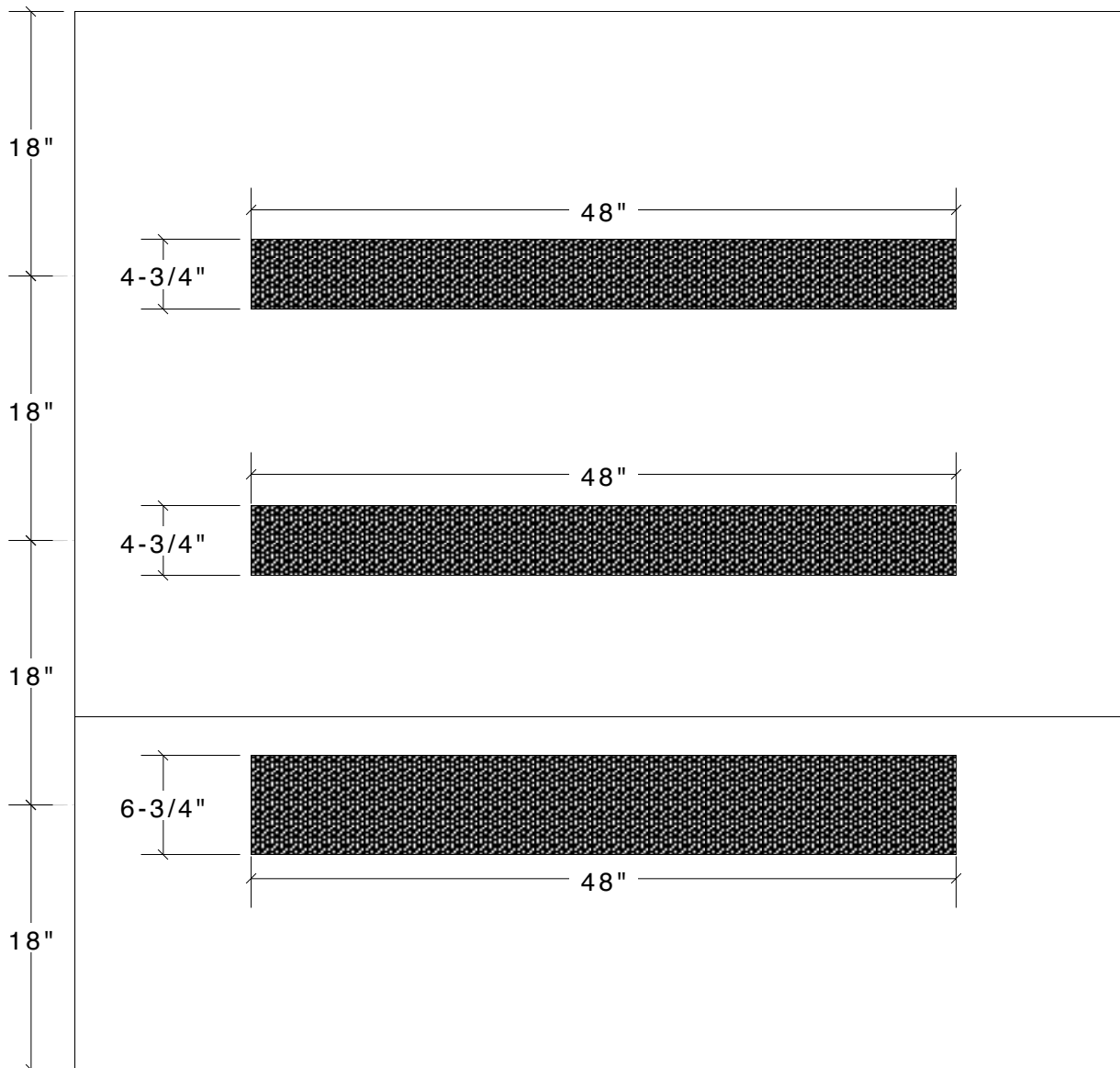




Note: A 7' x 7' wood stud frame was constructed from 2" x 4" lumber as shown. The exposed surface was covered with three layers of 5/8" Type X gypsum wallboard. Three slots were cut out for mounting each of the three wall sections.

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CIMA
Fig. 1 Stud Frame Detail

Scale: 1"=1'



Note: The exposed surface was covered with three layers of 5/8" Type X gypsum wallboard. Three slots were cut out for mounting each of the three wall sections. Two of the openings were large enough for a 2"x4" stud wall with a layer of 5/8" Type X gypsum on each side, and the third opening was large enough for a 2"x6" stud wall with a layer of 5/8" Type X on each side. The bottom of the outside studs of each wall section were be fastened to the stud framework in Fig. 1.

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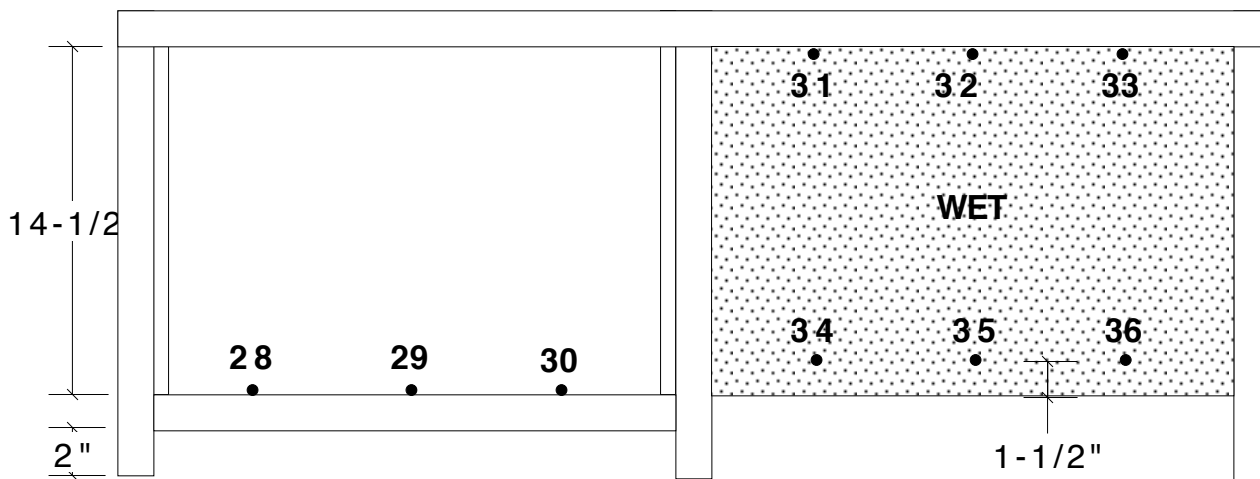
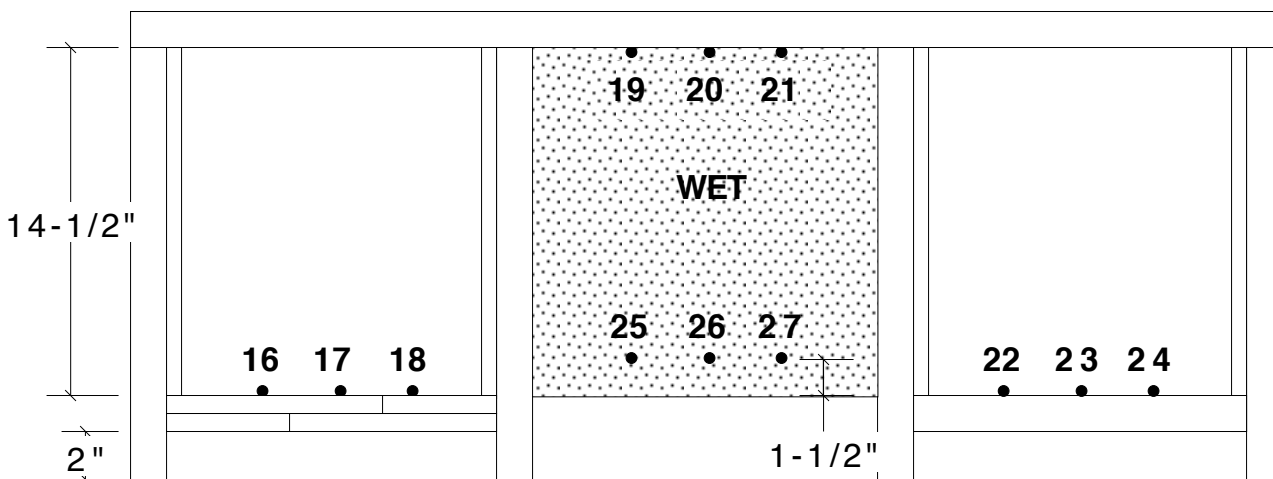
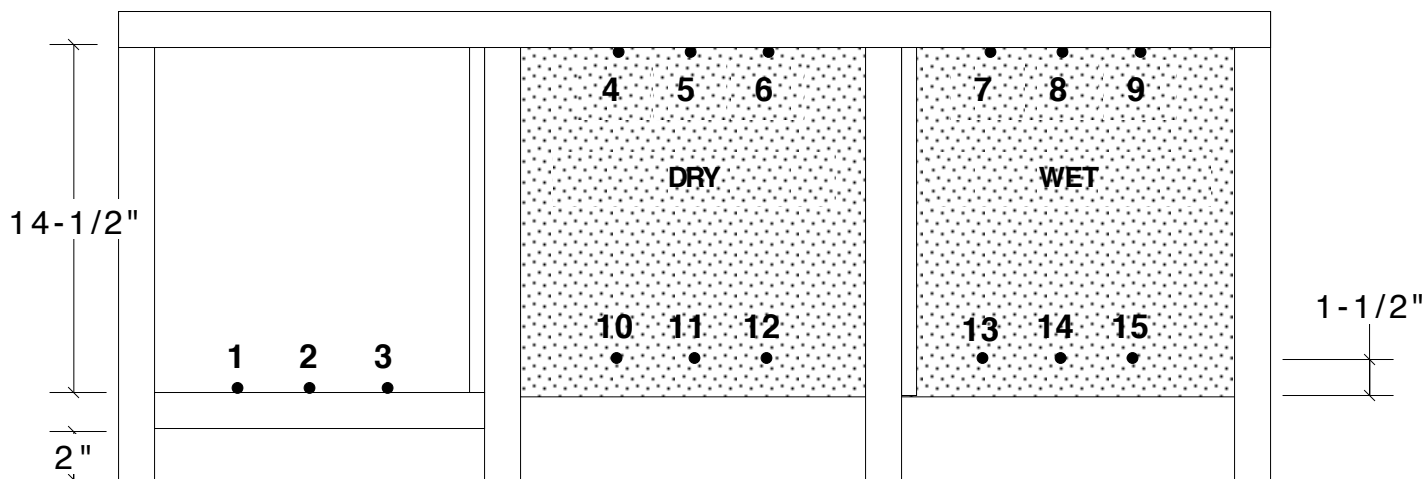
CIMA

Fig. 2 Wall openings

Scale: 1" = 1'

APPENDIX B
THERMOCOUPLE LOCATIONS





All temperatures monitored inside the stud cavities were measured using 24 GA., electrically-welded, Type K Chromel-Alumel, glass-glass insulated (Special Limits of Error: $\pm 1.1^{\circ}\text{C}$) thermocouples, purchased with calibration certifications and lot traceability.

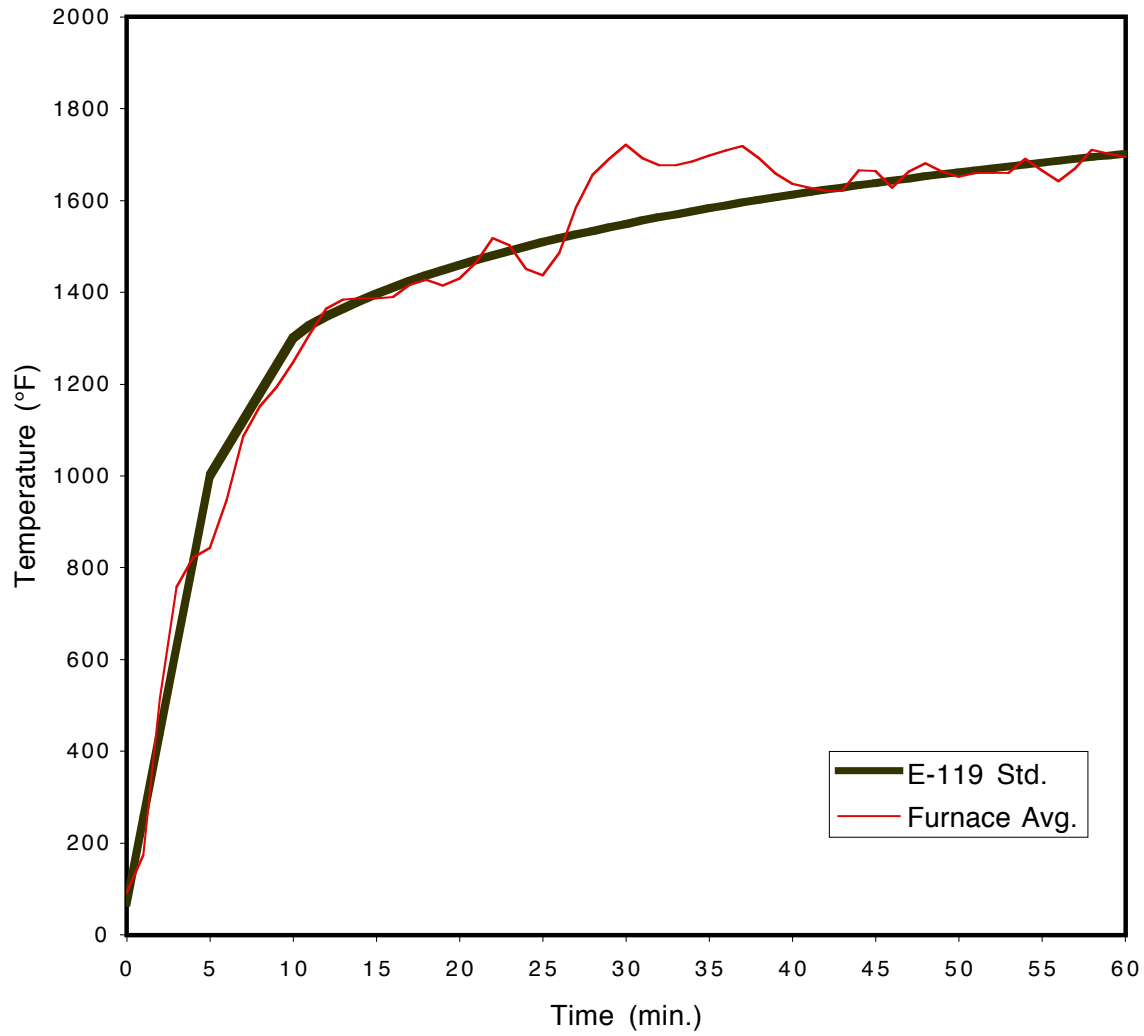
OMEGA POINT LABORATORIES Project No. 16094-111638
CIMA
Fig. 4 TC Locations

Scale: 1-1/2"=1'

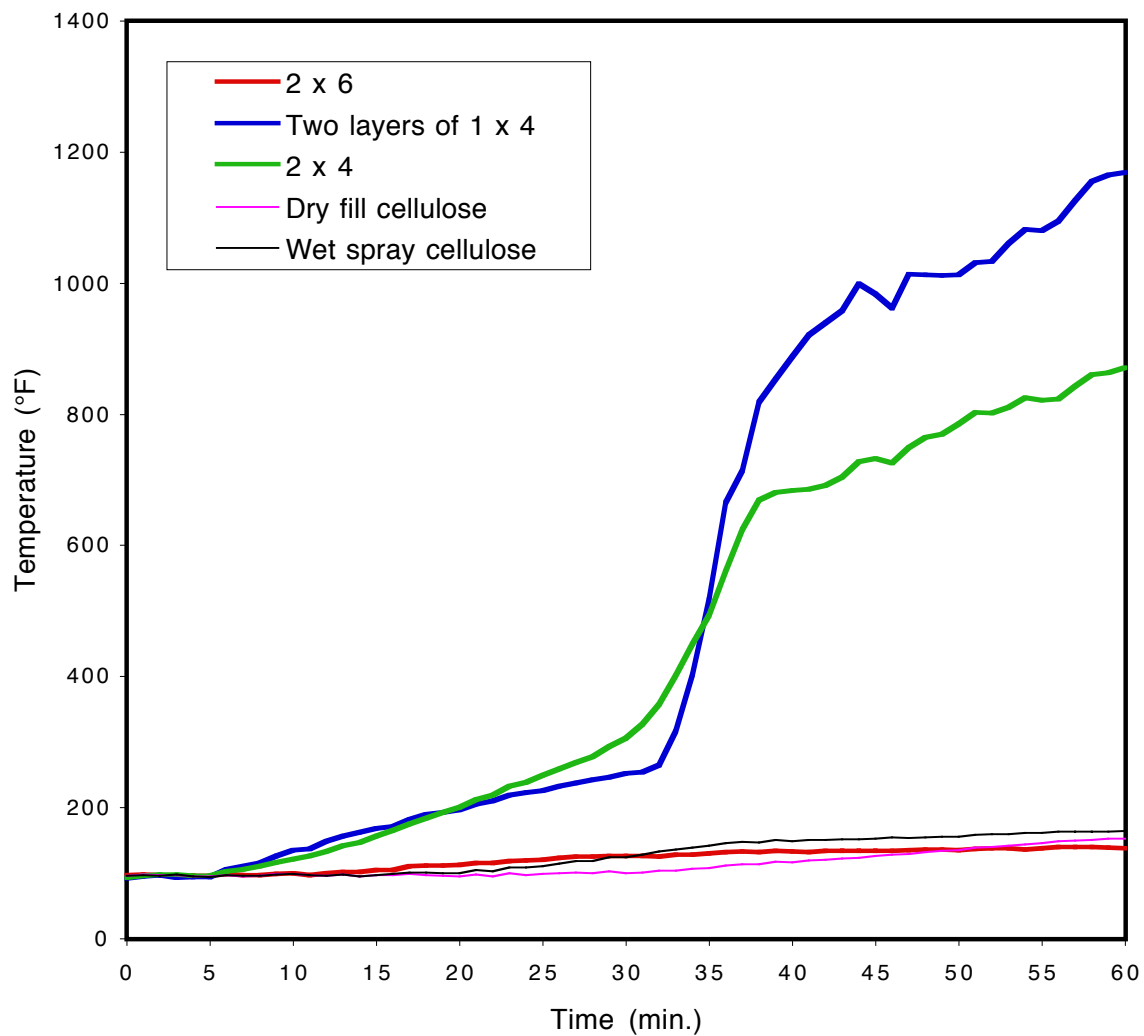
APPENDIX C
THERMOCOUPLE DATA



**Guardian Fiberglass
Project No. 15498-108320
Furnace Interior Temperatures**



CIMA
Project No. 16094-111638
Cellulose vs. Wood Fireblocking
Average Unexposed Temperatures



Time (min)	E119 Std Average (°F)	Furnace Average (°F)	Integration of Furnace Average (°F·min)	Integration of E119 Std Average (°F·min)	Error (%)	Furnace Probe # 1 (°F)	Furnace Probe # 2 (°F)	Furnace Probe # 3 (°F)
0	68	90	0	0	0.00%	89	90	90
1	254	173	64	93	-31.87%	133	131	224
2	441	514	339	373	-9.07%	410	379	683
3	627	757	907	839	8.07%	684	669	859
4	814	821	1628	1491	9.14%	776	773	880
5	1000	843	2392	2330	2.64%	809	807	892
6	1060	946	3218	3292	-2.25%	895	877	1025
7	1120	1085	4166	4314	-3.44%	1032	1009	1166
8	1180	1150	5215	5396	-3.35%	1115	1095	1210
9	1240	1192	6318	6538	-3.36%	1172	1149	1240
10	1300	1247	7470	7740	-3.49%	1236	1207	1292
11	1328	1308	8679	8986	-3.41%	1305	1268	1349
12	1347	1364	9947	10255	-3.00%	1365	1328	1405
13	1364	1384	11253	11543	-2.51%	1387	1358	1422
14	1381	1387	12571	12847	-2.15%	1394	1360	1416
15	1396	1386	13889	14167	-1.97%	1391	1365	1413
16	1410	1389	15209	15503	-1.90%	1400	1365	1410
17	1424	1415	16543	16851	-1.83%	1422	1387	1445
18	1436	1427	17896	18213	-1.74%	1437	1401	1450
19	1448	1414	19248	19587	-1.73%	1423	1389	1435
20	1459	1430	20602	20973	-1.77%	1434	1399	1462
21	1470	1465	21982	22370	-1.74%	1475	1435	1491
22	1480	1518	23405	23777	-1.56%	1522	1478	1557
23	1490	1502	24847	25194	-1.38%	1513	1485	1519
24	1499	1451	26256	26621	-1.37%	1466	1433	1461
25	1508	1437	27632	28057	-1.52%	1446	1416	1458
26	1517	1485	29025	29502	-1.62%	1493	1453	1514
27	1525	1584	30491	30955	-1.50%	1589	1530	1651
28	1533	1656	32043	32416	-1.15%	1674	1585	1733
29	1541	1690	33648	33886	-0.70%	1712	1628	1765
30	1549	1721	35286	35363	-0.22%	1756	1644	1801
31	1556	1692	36924	36847	0.21%	1717	1648	1730
32	1563	1676	38540	38338	0.53%	1698	1644	1699
33	1570	1676	40148	39837	0.78%	1694	1644	1699
34	1576	1685	41761	41342	1.01%	1696	1657	1711
35	1583	1697	43384	42853	1.24%	1713	1666	1717
36	1589	1709	45019	44371	1.46%	1724	1681	1727
37	1595	1718	46664	45895	1.68%	1735	1688	1737
38	1601	1692	48301	47424	1.85%	1711	1668	1702
39	1606	1658	49908	48960	1.94%	1677	1642	1666
40	1612	1636	51487	50501	1.95%	1649	1618	1649
41	1617	1627	53051	52048	1.93%	1639	1609	1642
42	1623	1620	54606	53600	1.88%	1632	1600	1638
43	1628	1621	56159	55158	1.81%	1637	1597	1634
44	1633	1665	57734	56720	1.79%	1678	1630	1689
45	1638	1664	59330	58288	1.79%	1675	1641	1686
46	1643	1628	60908	59860	1.75%	1645	1609	1634
47	1648	1662	62485	61437	1.71%	1673	1625	1691
48	1652	1681	64089	63019	1.70%	1696	1650	1704
49	1657	1662	65692	64606	1.68%	1674	1640	1681

Time (min)	E119 Std Average (°F)	Furnace Average (°F)	Integration of Furnace Average (°F·min)	Integration of E119 Std Average (°F·min)	Error (%)	Furnace Probe # 1 (°F)	Furnace Probe # 2 (°F)	Furnace Probe # 3 (°F)
50	1661	1651	67281	66197	1.64%	1666	1624	1665
51	1666	1660	68868	67792	1.59%	1672	1635	1680
52	1670	1660	70460	69392	1.54%	1678	1637	1671
53	1674	1660	72052	70996	1.49%	1676	1632	1676
54	1678	1690	73659	72604	1.45%	1706	1660	1708
55	1682	1665	75269	74216	1.42%	1679	1645	1678
56	1686	1641	76854	75832	1.35%	1657	1621	1651
57	1690	1670	78441	77452	1.28%	1683	1638	1692
58	1694	1710	80063	79076	1.25%	1721	1675	1737
59	1698	1702	81701	80704	1.24%	1714	1677	1725
60	1701	1694	83331	82336	1.21%	1709	1669	1710

**Max Temp
Max Allowed**

Time (min)	Furnace Probe										Info TC #10 (°F)
	# 4 (°F)	TC #1 (°F)	TC #2 (°F)	TC #3 (°F)	TC #4 (°F)	TC #5 (°F)	TC #6 (°F)	TC #7 (°F)	TC #8 (°F)	TC #9 (°F)	
0	90	93	93	93	96	96	96	96	96	96	89
1	203	95	98	95	96	99	97	94	98	99	100
2	586	96	101	97	94	98	98	93	96	99	170
3	815	101	96	97	100	97	94	98	99	95	181
4	855	95	94	98	96	92	96	97	93	94	191
5	864	93	95	98	94	92	97	95	91	95	204
6	987	105	101	101	100	97	94	98	99	94	245
7	1134	105	104	108	97	93	95	99	94	93	330
8	1179	107	113	111	93	97	98	93	95	99	440
9	1207	117	118	114	98	101	97	96	100	98	551
10	1254	123	122	119	99	100	96	97	101	97	671
11	1311	128	124	127	100	97	94	98	99	94	791
12	1356	133	129	136	99	94	95	99	96	93	894
13	1371	139	144	143	96	100	98	94	98	100	945
14	1379	141	144	155	95	92	97	97	92	95	982
15	1374	150	158	162	94	98	98	93	96	101	999
16	1381	163	161	170	100	97	94	99	100	97	1020
17	1406	171	173	179	100	100	95	98	103	100	1063
18	1419	178	179	193	100	97	94	99	102	100	1090
19	1409	183	186	207	98	93	96	100	97	101	1104
20	1425	188	197	216	93	94	98	94	98	107	1133
21	1459	207	206	224	101	97	94	101	105	106	1173
22	1514	206	214	236	94	93	97	98	99	110	1246
23	1489	223	230	244	99	102	97	99	110	116	1218
24	1444	227	233	256	101	95	95	104	108	112	1191
25	1428	234	247	267	97	100	98	99	111	122	1216
26	1479	247	249	279	102	101	95	105	117	121	1274
27	1567	257	257	291	103	102	96	107	121	125	1364
28	1631	265	262	306	104	98	96	111	121	123	1412
29	1656	276	279	325	104	104	99	112	127	132	1447
30	1683	285	283	349	104	97	99	119	124	130	1480
31	1674	299	298	383	104	98	101	123	126	134	1482
32	1664	322	322	429	110	102	99	128	136	135	1498
33	1669	356	367	481	108	100	102	133	135	138	1522
34	1675	399	432	517	106	107	107	130	140	146	1539
35	1691	449	475	556	113	104	106	140	143	141	1550
36	1703	505	571	605	115	111	109	139	149	148	1561
37	1713	570	653	648	117	111	112	143	151	147	1578
38	1688	650	697	659	118	107	114	146	147	145	1530
39	1649	705	695	642	120	114	117	147	153	150	1526
40	1627	705	691	653	114	112	123	143	148	154	1512
41	1618	714	692	650	117	115	126	145	150	155	1517
42	1611	726	696	653	117	115	128	145	151	156	1522
43	1616	757	695	660	125	112	128	154	150	150	1526
44	1663	789	730	662	125	113	132	154	149	151	1575
45	1656	779	747	670	122	120	136	148	153	156	1532
46	1622	777	735	663	131	118	136	157	154	151	1505
47	1657	797	754	696	130	117	140	158	151	152	1579
48	1673	803	773	716	132	119	143	159	152	153	1569
49	1655	802	784	723	128	125	148	153	154	159	1548

Time (min)	Info TC #11 (°F)	Info TC #12 (°F)	Info TC #13 (°F)	Info TC #14 (°F)	Info TC #15 (°F)	TC #16 (°F)	TC #17 (°F)	TC #18 (°F)	TC #19 (°F)	TC #20 (°F)
0	90	90	90	91	91	92	92	92	96	96
1	317	93	148	122	161	96	91	96	98	94
2	841	109	185	177	192	99	93	97	98	94
3	881	134	173	179	186	94	92	92	96	97
4	899	140	176	175	180	94	95	93	95	99
5	989	148	183	178	196	95	94	93	95	99
6	1207	192	274	234	408	102	105	110	97	100
7	1245	196	426	344	605	108	111	113	96	104
8	1249	204	540	445	724	118	110	118	103	107
9	1304	208	641	547	814	124	121	132	109	115
10	1355	213	740	666	888	130	132	142	113	124
11	1406	225	827	782	964	134	134	142	120	132
12	1421	269	896	857	1015	142	149	155	124	138
13	1414	359	944	911	1054	155	149	164	136	139
14	1410	449	977	954	1069	158	160	169	134	146
15	1401	546	998	977	1090	166	159	179	144	145
16	1428	630	1020	1010	1112	164	166	182	143	149
17	1479	734	1061	1047	1145	171	176	199	147	149
18	1430	822	1088	1080	1161	175	185	207	147	152
19	1454	896	1098	1086	1159	181	189	207	147	155
20	1486	975	1130	1109	1188	188	190	211	149	156
21	1498	1051	1164	1148	1219	187	201	227	149	155
22	1545	1157	1220	1184	1255	195	205	231	150	158
23	1445	1168	1205	1195	1252	200	213	244	155	154
24	1423	1160	1174	1178	1222	202	225	242	153	160
25	1497	1200	1187	1178	1237	214	220	243	159	156
26	1555	1258	1235	1220	1279	212	229	255	157	159
27	1615	1336	1290	1267	1321	216	234	263	157	158
28	1613	1381	1319	1301	1338	215	240	271	155	159
29	1626	1422	1338	1322	1358	222	240	277	159	156
30	1629	1444	1362	1345	1367	222	250	283	154	160
31	1615	1474	1386	1369	1394	228	247	287	160	156
32	1631	1493	1396	1389	1412	230	267	297	157	160
33	1646	1518	1417	1403	1423	255	362	331	156	162
34	1654	1542	1433	1417	1442	331	499	376	161	158
35	1656	1547	1446	1438	1455	447	648	457	157	162
36	1661	1571	1460	1450	1471	617	820	557	161	159
37	1671	1584	1472	1463	1480	675	848	617	159	161
38	1604	1544	1449	1452	1461	913	850	690	157	162
39	1607	1547	1441	1442	1456	952	842	766	160	160
40	1584	1545	1436	1432	1448	963	859	839	157	163
41	1590	1549	1440	1433	1450	984	855	922	162	159
42	1592	1549	1442	1434	1452	943	859	1017	162	159
43	1592	1541	1448	1443	1451	949	872	1053	162	159
44	1638	1578	1484	1467	1476	979	913	1104	162	158
45	1590	1569	1461	1461	1475	936	927	1085	156	163
46	1560	1541	1442	1451	1456	888	912	1084	160	160
47	1634	1567	1477	1465	1469	902	955	1182	162	159
48	1622	1586	1481	1473	1478	882	978	1177	156	162
49	1599	1578	1475	1467	1480	870	980	1184	156	163

Time (min)	Info	Info	Info	Info	Info	TC #16 (°F)	TC #17 (°F)	TC #18 (°F)	TC #19 (°F)	TC #20 (°F)
	TC #11 (°F)	TC #12 (°F)	TC #13 (°F)	TC #14 (°F)	TC #15 (°F)					
50	1592	1569	1474	1469	1476	862	988	1188	157	163
51	1620	1594	1489	1478	1493	875	1010	1207	162	158
52	1582	1571	1467	1478	1487	869	1026	1203	158	161
53	1629	1593	1491	1487	1496	889	1055	1237	157	162
54	1645	1618	1510	1507	1520	919	1077	1249	158	162
55	1583	1586	1478	1485	1499	921	1073	1245	162	158
56	1590	1586	1476	1485	1499	930	1092	1261	161	159
57	1640	1614	1510	1506	1522	965	1125	1287	162	159
58	1656	1631	1532	1526	1543	992	1162	1311	162	159
59	1631	1618	1522	1523	1538	1003	1183	1309	162	158
60	1621	1607	1514	1525	1534	1014	1202	1291	158	162
Max Temp	1671	1631	1532	1526	1543	1014	1202	1311	162	163
Max Allowed						417	417	417	421	421

Time (min)						Info	Info	Info			
	TC #21 (°F)	TC #22 (°F)	TC #23 (°F)	TC #24 (°F)	TC #25 (°F)	TC #26 (°F)	TC #27 (°F)	TC #28 (°F)	TC #29 (°F)	TC #30 (°F)	
0	97	93	93	93	91	90	90	93	94	94	
1	95	94	93	90	92	96	89	93	96	93	
2	94	94	93	90	127	174	148	93	96	92	
3	93	91	94	90	155	176	170	89	93	95	
4	95	90	94	93	158	175	173	91	92	96	
5	95	90	94	93	160	179	174	91	92	96	
6	103	96	93	97	191	198	197	99	95	95	
7	102	94	95	98	197	201	209	96	93	97	
8	103	99	97	93	201	211	211	95	98	96	
9	115	104	98	98	210	265	227	100	102	99	
10	125	105	101	103	227	363	253	105	102	102	
11	125	104	105	100	245	486	286	99	103	105	
12	138	107	107	108	289	637	369	108	104	110	
13	140	115	110	107	353	750	497	111	112	111	
14	145	112	113	113	434	807	656	114	110	117	
15	145	121	116	111	530	855	753	117	119	120	
16	144	121	120	114	610	892	825	117	119	125	
17	154	130	123	121	700	930	882	128	126	128	
18	156	133	126	127	778	963	932	133	126	134	
19	153	132	131	129	826	978	968	132	127	139	
20	151	136	135	128	871	1002	991	134	133	143	
21	159	143	138	137	922	1030	1023	145	139	148	
22	153	144	143	138	963	1065	1057	143	143	153	
23	157	155	145	141	1002	1084	1078	154	151	153	
24	160	154	153	149	996	1072	1077	158	152	158	
25	156	162	155	146	999	1069	1073	161	159	158	
26	162	166	154	156	1029	1088	1104	171	162	163	
27	162	170	155	159	1081	1129	1151	176	167	168	
28	162	171	158	164	1137	1174	1202	180	169	174	
29	157	176	159	164	1177	1208	1235	183	173	180	
30	159	172	164	171	1207	1235	1270	185	173	188	
31	155	180	166	168	1222	1249	1277	188	181	187	
32	153	179	170	171	1226	1253	1284	187	181	197	
33	161	182	175	180	1242	1260	1299	195	187	201	
34	156	189	180	177	1259	1273	1307	195	194	202	
35	163	189	182	188	1274	1283	1327	199	193	207	
36	161	197	184	187	1291	1297	1336	203	204	208	
37	164	201	188	193	1306	1308	1350	208	207	212	
38	162	198	192	198	1298	1310	1350	210	208	217	
39	163	205	197	197	1294	1304	1336	216	217	217	
40	162	200	201	203	1284	1298	1333	217	217	223	
41	156	207	203	197	1284	1298	1325	219	224	221	
42	158	210	206	201	1285	1299	1326	223	227	226	
43	157	215	210	204	1287	1301	1327	229	229	228	
44	157	218	211	206	1311	1317	1349	235	231	231	
45	161	218	214	217	1309	1325	1357	242	228	241	
46	154	223	213	210	1293	1318	1339	246	237	242	
47	156	232	218	213	1320	1326	1352	260	245	247	
48	161	230	217	225	1327	1341	1370	275	249	260	
49	161	234	223	227	1323	1341	1368	289	262	271	

Time (min)	TC #21 (°F)	TC #22 (°F)	TC #23 (°F)	TC #24 (°F)	Info	Info	Info	TC #28 (°F)	TC #29 (°F)	TC #30 (°F)
					TC #25 (°F)	TC #26 (°F)	TC #27 (°F)			
50	157	236	224	228	1319	1343	1363	298	274	284
51	159	249	225	231	1333	1347	1365	318	292	297
52	163	249	227	235	1331	1351	1371	337	303	317
53	163	251	233	240	1338	1351	1374	349	317	334
54	155	253	235	237	1353	1370	1389	352	327	349
55	157	262	231	239	1346	1372	1384	372	347	362
56	162	271	239	246	1343	1366	1380	387	356	378
57	160	280	245	246	1364	1377	1393	399	371	392
58	160	292	252	250	1390	1397	1416	407	378	402
59	158	296	257	251	1385	1402	1414	413	400	420
60	155	303	263	256	1377	1401	1413	419	416	438
Max Temp	164	303	263	256	1390	1402	1416	419	416	438
Max Allowed	422	418	418	418				418	419	419

Time (min)	TC #31 (°F)	TC #32 (°F)	TC #33 (°F)	Info TC #34 (°F)	Info TC #35 (°F)	Info TC #36 (°F)
0	97	97	97	92	92	92
1	96	98	98	90	92	98
2	95	99	96	95	121	160
3	93	95	98	97	143	162
4	96	94	97	100	150	163
5	95	94	98	100	157	169
6	100	100	96	102	186	196
7	99	95	96	104	192	218
8	94	98	97	97	194	257
9	98	101	98	100	200	304
10	101	101	97	102	211	364
11	94	96	99	99	229	444
12	104	96	98	108	284	528
13	103	101	100	102	343	594
14	109	97	100	110	395	637
15	108	102	104	106	447	683
16	110	99	105	108	491	717
17	118	106	107	113	547	763
18	122	105	108	117	604	806
19	121	101	111	119	645	825
20	119	103	114	117	683	855
21	127	107	113	122	737	890
22	121	106	118	119	785	937
23	124	112	119	121	835	957
24	129	110	119	127	841	941
25	125	114	120	122	840	942
26	131	117	122	127	860	968
27	133	118	123	128	900	1015
28	135	118	123	132	950	1055
29	132	120	126	128	999	1097
30	137	116	124	137	1034	1115
31	134	120	124	131	1060	1133
32	131	117	127	133	1069	1142
33	140	119	126	140	1088	1150
34	136	122	127	136	1105	1167
35	143	122	126	145	1125	1179
36	140	126	128	142	1144	1196
37	144	127	127	151	1163	1209
38	144	124	127	156	1169	1208
39	144	130	127	158	1170	1204
40	144	126	127	164	1165	1198
41	140	131	125	164	1169	1198
42	139	133	128	166	1172	1202
43	140	134	126	170	1178	1204
44	141	135	125	177	1198	1225
45	144	132	126	192	1210	1233
46	138	135	127	185	1205	1225
47	142	137	124	191	1219	1235
48	146	135	126	200	1237	1252
49	146	135	126	207	1241	1254

				Info	Info	Info
Time	TC #31	TC #32	TC #33	TC #34	TC #35	TC #36
(min)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)
50	140	136	128	208	1244	1260
51	144	141	126	214	1257	1267
52	148	140	125	224	1266	1270
53	148	139	125	230	1269	1273
54	140	137	129	233	1282	1290
55	143	141	128	233	1287	1289
56	147	144	128	241	1284	1281
57	145	144	129	243	1300	1297
58	145	144	129	249	1324	1319
59	144	143	129	251	1329	1323
60	142	139	131	254	1328	1326
Max Temp	148	144	131	254	1329	1326
Max Allowed	422	422	422			

APPENDIX D
PHOTOGRAPHS





Test frame



One of the wall sections prior to insulating the center cavity



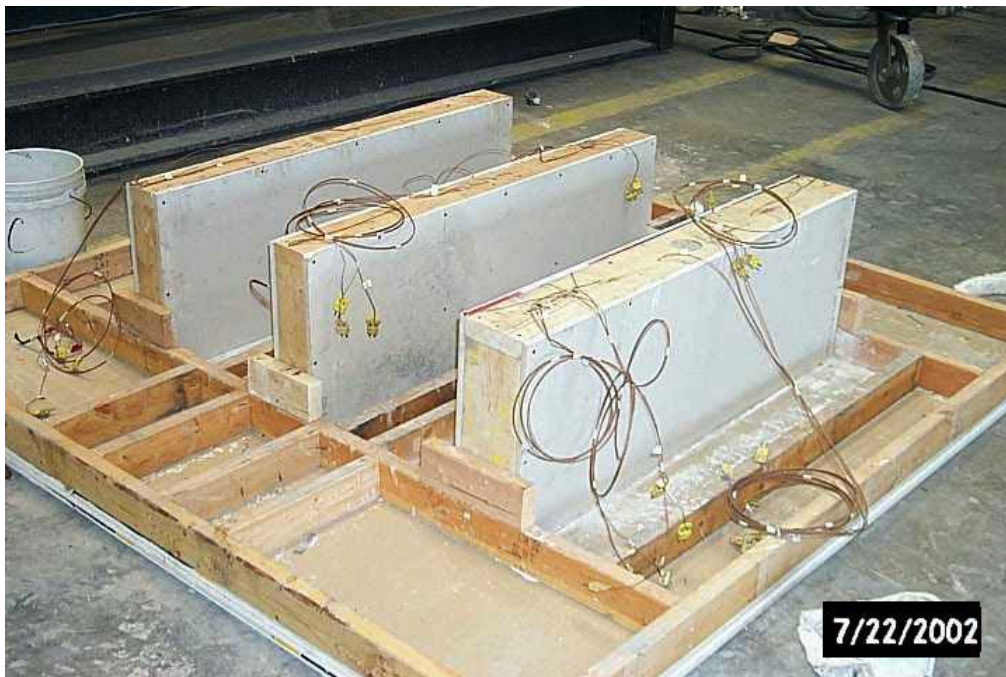
Preparing the test sample



One cavity was dry-filled through a hole in the top plate



(L-R) single 2 x 4, dry-fill insulation, wet spray insulation (the block in the center cavity was removed prior to testing)



Wall sections mounted in the test frame





Bottom view prior to placing the assembly on the furnace



Bottom view prior to placing the assembly on the furnace



Bottom view prior to placing the assembly on the furnace



Bottom view prior to placing the assembly on the furnace



Samples 1-3

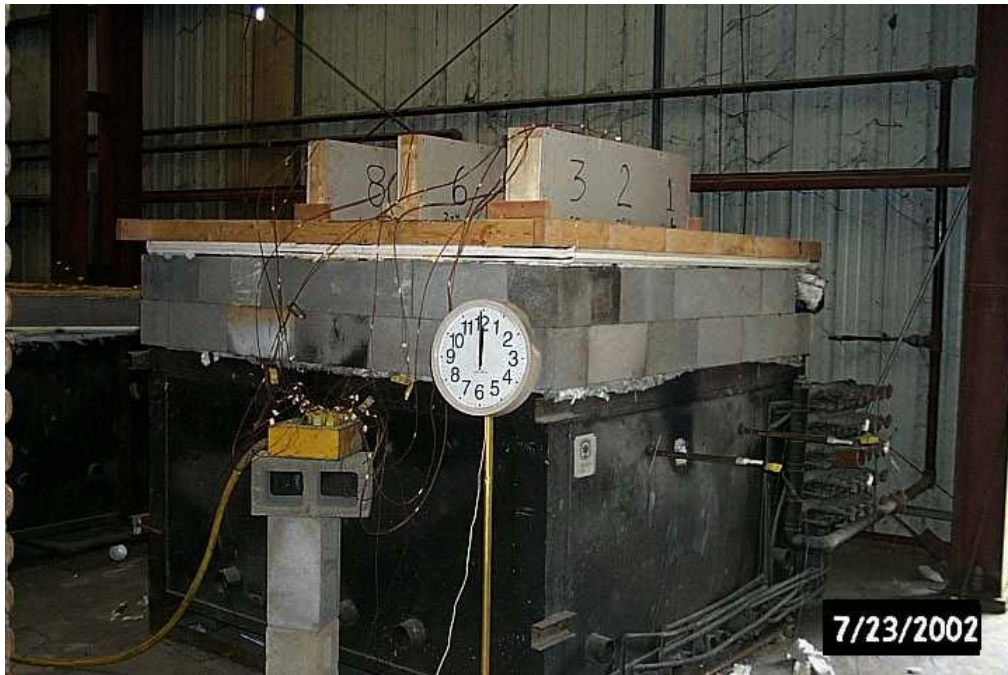


Samples 4-6





Samples 7-8



Start of test





The furnace was extinguished after 60 minutes



Samples 1-3 immediately after the test



Samples 4-6 immediately after the test

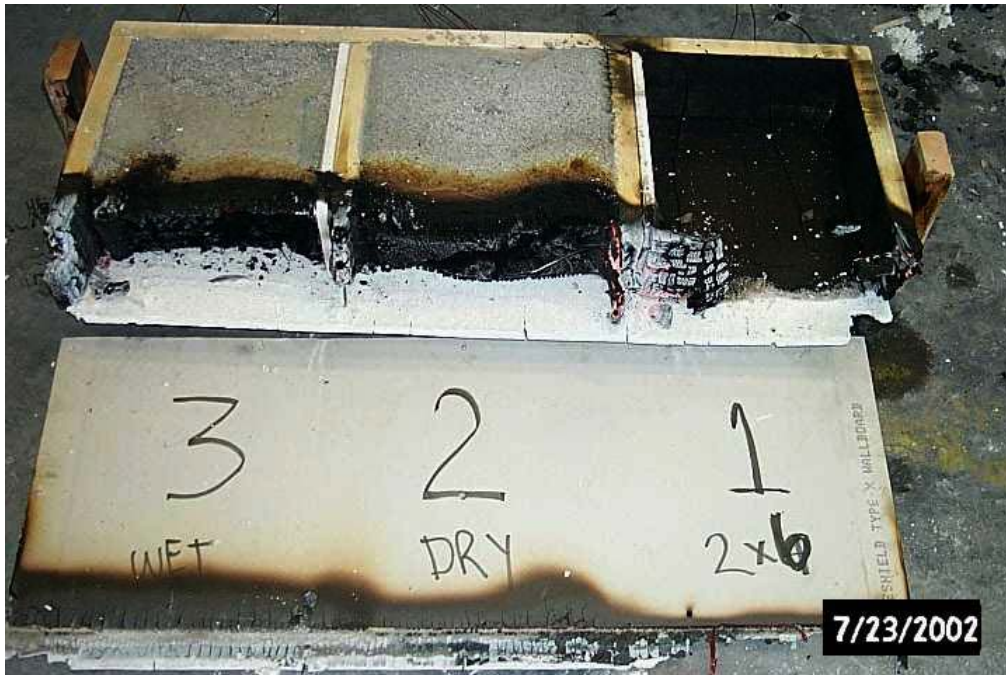


Samples 7-8 immediately after the test





Removing the assembly from the furnace



Approximately 10" of virgin material remained in the insulated cavities, and the 2 x 6 was completely burnt





Approximately 10" of virgin material remained in the insulated cavity, the 2 x 4 was charred, and the two 1 x 4 were completely burnt



Approximately 10" of virgin material remained in the insulated cavity, the 2 x 6 was charred

