Intertek

ETL SEMKO

TEST REPORT

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ASTM E 119-05a

Fire Tests of Building Construction and Materials

2-HR FIRE RESISTANCE TEST OF A
NON-LOADBEARING WHEAT STRAW BALE WALL

Project No. 3098054A

July 31, 2006
Revised: July 9, 2007

Prepared for:

Ecological Building Network
11 Mark Drive
San Rafael, CA 94903

ABSTRACT

A 10 ft x 10 ft non-loadbearing wall constructed with 7.5 pcf rectangular wheat straw bales stacked in a running bond pattern, clad on each surface with 17 GA stucco netting and 1" of cement/stucco, produced, assembled, and tested as described herein, successfully met the conditions of acceptance as outlined in ASTM Method E 119-05a Fire Tests of Building Construction and Materials for a fire endurance rating of 2 hours.

Michael E. Dey
Manager, Fire Resistance Testing Services

7/10/07
Date

Reviewed and approved:

Deggary N. Priest
Director of Operations – Building Products

7/10/07
Date

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INTRODUCTION[1]

"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 E 119 test procedure is identical or very similar to the following standard test methods:

UL 263
UBC 7-1
NFPA 251
ANSI A2.1
ULC S101

The analogous test standard in the International Organization of Standardization (ISO), ISO 834 Fire-resistance Tests – Elements of Building Construction, is very similar to the above U.S. test methods. Its exposure curve, as well as the method used to measure temperatures within the furnace result in a slightly less severe temperature exposure

[1] **ASTM E 119-05a Standard Test Methods for Fire Tests of Building Construction and Materials ASTM** International, Volume 04.07 Building Seals and Sealants, etc.

than the E 119 test for the first two hours. The ISO 834 test requires a slightly greater positive pressure within the furnace. For those reasons, the E 119 test can be considered to be slightly more severe for tests of 2 h duration or less, only if the test article is not likely to be affected by a higher furnace pressure. (BS 476 Pt 20 Fire tests on building materials and structures is virtually identical to the ISO 834 test method, as is the new CEN standard, EN 1363-1.)

1. Scope

The test methods described in this fire-test-response standard 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 comparative performance to specific fire-test conditions during the period of exposure and shall not be construed as having determined suitability for use under other conditions or after fire exposure.

1.3 *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products or assemblies under actual fire conditions.*

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

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

4. Significance and Use

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

4.2 The test exposes a specimen to a standard fire controlled to achieve specified temperatures throughout a specified time period. When required, the fire exposure is followed by the application of a specified standard fire hose stream. The test provides a relative measure of the fire-test-response of comparable assemblies under these fire exposure conditions. The exposure is not representative of all fire conditions because conditions vary with changes in the amount, nature and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment. Variation from the test conditions or specimen construction, such as size, materials, method of assembly, also affects the fire-test-response. For these reasons, evaluation of the variation is required for application to construction in the field.

4.3 The test standard provides for the following:

4.3.1 For walls, partitions and floor or roof assemblies:

4.3.1.1 Measurement of the transmission of heat.

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

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

4.3.2 For individual load bearing assemblies such as beams and columns:

4.3.2.1 Measurement of the load carrying ability under the test exposure with some consideration for the end support conditions (that is, restrained or not restrained).

4.4 The test standard does not provide the following:

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

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

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

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

4.4.5 Measurement of flame spread over surface of tested element.

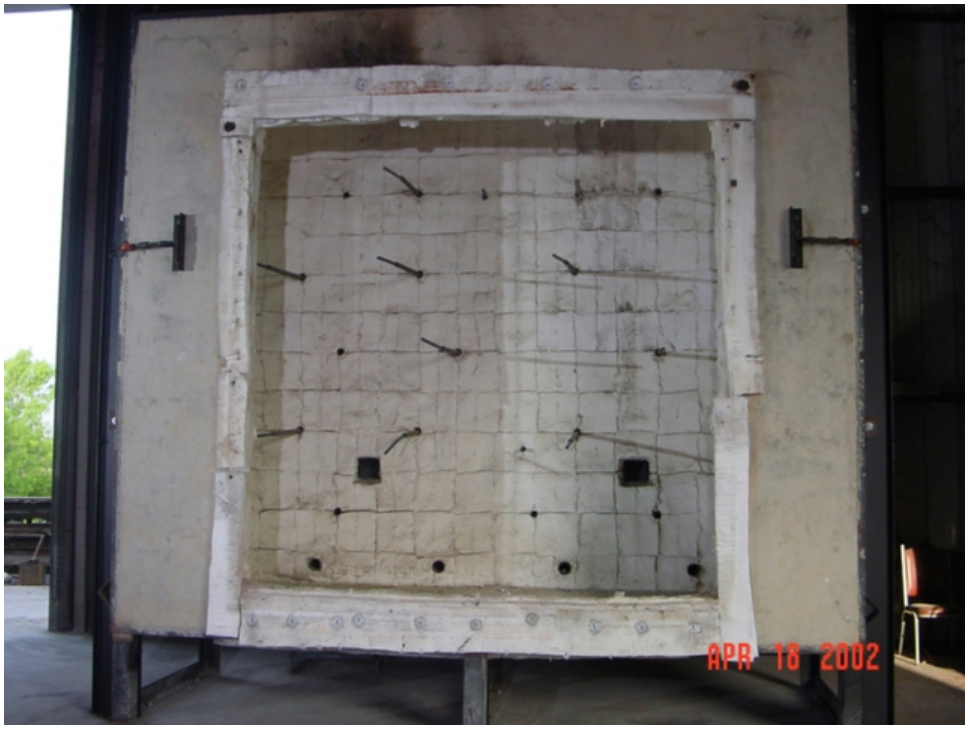
4.4.6 The effect of fire endurance of conventional openings in the assembly, that is electrical receptacle outlets, plumbing pipe, etc., unless specifically provided for in the construction tested."

TEST PROCEDURE

Test Furnace

The test furnace is designed to allow the specimen to be uniformly exposed to the specified time-temperature conditions. It is fitted with 6 propane/air burners positioned on the left and right side walls, designed to allow an even heat flux distribution across the face of a test specimen while allowing no direct flame impingement. The maximum energy input into the furnace is 15 MBtu/hr. The furnace operator has controls which allow the following items to be varied during the test: the overall energy input into the furnace; the air/gas ratio to the burners; and, the input of additional air beyond that passing through the burners. The furnace opening is 14 ft wide, 12 ft tall and 4 ft deep. It may be fitted with a collar that reduces the front opening to 10 ft x 10 ft, if desired. Furnace pressures may be maintained at any value from +0.15" W.C. to -0.15" W.C. Any full-size vertical fire test furnace will have a pressure difference between the bottom and top of approximately 0.01 in. W.C. per vertical foot after operating temperatures are reached. For this reason, the furnace is operated by controlling the pressure within the furnace (with respect to the laboratory ambient pressure) by regulating the pressure at a specific horizontal plane in the furnace. The furnace pressure will often be adjusted so that the "neutral pressure plane" (that where the pressure difference between the furnace interior and the laboratory ambient is zero) is at a desired location: for instance; at the top, at a point $^{1}/_{3}$ of the way down from the top, or at the bottom of the specimen.

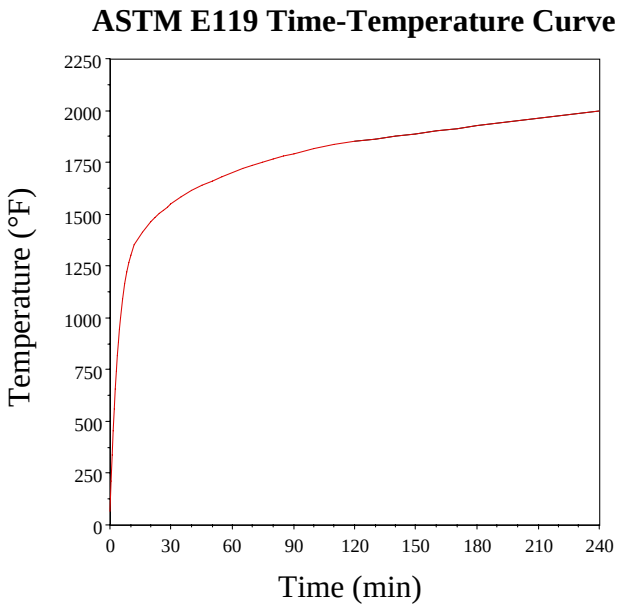
The temperature within the furnace is determined to be the mathematical average of thermocouples located symmetrically within the furnace and positioned six inches away from the vertical face of the test specimen. The materials used in the construction of these thermocouples are those suggested in the test standard. During the performance of a fire exposure test, the furnace temperatures are recorded every 15 seconds and displayed for the furnace operator to allow control along the specified temperature curve. For report presentation purposes, the data is saved once per minute.



This photograph of the vertical furnace shows it with a concrete adapter in place which reduces its opening to 120" x 120". Without the adapter the furnace will accept test specimens 144" tall x 168" wide. The furnace is 48" deep, with burners on the sides, so that no flame impingement on the specimen occurs.

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.

The fire exposure is controlled to conform with the standard time-temperature curve shown in Figure 1, as determined by the table below:



Time (min)	Temperature (°F)
0	68
5	1000
10	1300
20	1462
30	1550
60	1700
90	1792
120	1850
180	1925
240	2000

Figure 1

Fire Endurance Test

The fire exposure is continued on the specimen with its applied load if applicable, until failure occurs, or until the specimen has withstood the test conditions for the desired fire endurance rating.

Hose Stream Test

"11.1 Where required by the conditions of acceptance, the hose stream test shall be conducted to subject the specimen described in 11.2 or 11.3 to the impact, erosion, and cooling effects of a hose stream.
11.1.1 Exemption – The hose stream test shall not be required in the case of constructions having a resistance period, indicated in the fire endurance test, of less than 1 h.
11.2 The hose stream test shall be conducted on a duplicate test specimen.
11.2.1 The duplicate specimen shall be exposed to the effects of the hose stream

immediately after being subjected to a fire endurance test for a time period of one-half the fire endurance classification period determined from the fire endurance test on the initial specimen.

11.2.2 The length of time that the duplicate specimen is subjected to the fire endurance test shall not exceed 1 h.

11.3 Optional Program – As an alternative procedure, conduct the hose stream test on the initially tested specimen immediately following its fire endurance test.

11.4 In conducting the hose stream test, direct the hose stream first at the middle and then at all parts of the exposed face of the specimen. Any changes in direction shall be made slowly.

11.5 *Stream Equipment and Details* - The stream shall be delivered through a $2^1/_2$-in. (64-mm) hose discharging through a National Standard Playpipe of corresponding size equipped with a $1^1/_8$-in. (28.5-mm) discharge tip of the standard-taper smooth-bore pattern without shoulder at the orifice. The water pressure and duration of the application shall be as prescribed [in the table below]:

Conditions For Hose Stream Test		
Resistance Period	Water Pressure at Base of Nozzle,psi (kPa)	Duration of Application, min/100 ft^2 (9 m^2) exposed area
8 h and over	45 (310)	6
4 h and over if less than 8 h	45 (310)	5
2 h and over if less than 4 h	30 (207)	$2^1/_2$
1-1/2 h and over if less than 2 h	30 (207)	$1^1/_2$
1 h and over if less than 1-1/2 h	30 (207)	1
Less than 1 h, if desired	30 (207)	1

11.6 *Nozzle Distance* - The distance between the tip of the nozzle and the center of the exposed surface shall be determined by the deviation from normal between the center of the nozzle axis and the center of the exposed surface of the specimen. The distance shall be 20 ft (6 m) when the axis through the center of the nozzle is normal to the center of the exposed surface. This distance shall be decreased by an amount equal to 1 ft (305 mm) for each 10° of deviation from the normal."

Correction Factor

When the indicated resistance period is $^1/_2$ h or over, determined by the average or maximum temperature rise on the unexposed surface or within the test sample, or by failure under load,, a correction shall be applied for variation of the furnace exposure from that prescribed, where it will affect the classification, by multiplying the indicated period by two thirds of the difference in area between the curve of average furnace temperature and the standard curve for the first three fourths of the period and dividing the product by the area between the standard curve and a base line of 68°F (20°C) for the same part of the indicated period, the latter area increased by 3240°F•min to compensate for the thermal lag of the furnace thermocouples during the first part of the test. For a fire exposure in the test higher than standard, the indicated resistance period shall be increased by the amount of the correction. For a fire exposure in the test lower than standard, the indicated resistance period shall be similarly decreased for fire exposure below standard. The correction is accomplished by mathematically adding the correction factor, *C*, to the indicated resistance period.

The correction can be expressed by the following equation:

$$C = \frac{2\,I\,(A - A_S)}{3\,(A_S + L)}$$

where:

C = correction in the same units as *I*,
I = indicated fire-resistance period,
A = area under the curve of indicated average furnace temperature for the first three fourths of the indicated period,
A_S = area under the standard furnace curve for the same part of the indicated period, and
L = lag correction in the same units as *A* and A_S (54°F•h or 30°C•h (3240°F•min or 1800°C•min))

CONDITIONS OF ACCEPTANCE

18. Conditions of Acceptance – [Nonloadbearing Walls]

18.1 Regard the test as successful when the following conditions are met:
18.1.1 The wall or partition has withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which

classification is desired.

18.1.2 The wall or partition shall has [sic] withstood the fire and hose stream test as specified in Sections 10 and 11, without passage of flame, of gases hot enough to ignite cotton waste, or of passage of water from the hose stream. The assembly shall be considered to have failed the hose stream test if an opening develops that permits a projection of water from the stream beyond the unexposed surface during the time of the hose stream test.

18.1.3 Transmission of heat through the wall or partition during the fire endurance test shall not have been such as to raise the [average] temperature on its unexposed surface more than 250°F (139°C) above its initial temperature.

[The E 119 standard further states:]

7.4 Where the conditions of acceptance place a limitation on the rise of temperature of the unexposed surface, the temperature end point of the fire endurance period shall be determined by the average of the measurements taken at individual points; except that if a temperature rise of 30% [325°F above initial temperature] in excess of the specified limit occurs at any one of these points, the remainder shall be ignored and the fire endurance period judged as ended.

TEST SPECIMEN CONSTRUCTION

The observations and test results in this report are relevant only to the sample tested. This report by itself does not imply that the material, product, or service is or has ever been under an Intertek certification program.

The 10 ft x 10 ft wall assembly was constructed with rectangular wheat straw bales with the following nominal physical properties: 36-in long, 18-in tall (straw oriented vertically), 15-in wide, 42.3 lbs each (7.5 pcf). 2x4 lumber was fastened inside the perimeter of the test frame to act as top and bottom plates. The bales were stacked in a running bond pattern 6-1/2 courses high, completely filling the test frame. The wheat straw bales had two polypropylene ties per bale (PolyLine 430, GREENLEE®, 210 lb strength). The ties were placed in the wall in the “on-edge” orientation, meaning that the poly ties were exposed on the surface of the bales on both the heated and unheated sides. The gaps at the intersections of the stacked bales were stuffed with a mud and straw mixture that was prepared using locally available dirt plus a small amount of chopped straw mixed with enough water to hold its shape, then pushed as far into the cracks as possible. Each side of the wall was covered with 1-1/2 x 17 GA galvanized, self-furred stucco reinforcing mesh (KEYMESH®), placed underneath the bottom

course of bales and stretched vertically, with a minimum overlap of 4-in. The mesh was fastened to the 2x4s at the top of the wall using 1-1/2" long coarse thread square drive screws with 1" diameter washers, spaced nominally 6-in o.c. The stucco netting was also stapled to the 2x4s on the sides of the wall panel using 1-1/2" long galvanized fence staples spaced nominally 16" o.c. In the field, 9 GA "Robert pins" – "U" shaped wire roughly 16-in long simply bent into a "U" with 8-10" legs. The Robert pins were spaced nominally 18" o.c., and also used at overlaps and where necessary to hold the netting tighter to the bales. The bales had no interior or exterior vertical pinning. The cement / stucco was applied in two coats, each nominally ½" thick. The mix consisted of 1 part lime, 3 parts Portland cement, 10 parts sand, and water to a workable consistency. The stucco was applied using hand trowels.

The scratch coat was applied on June 1, 2006 by representatives of EBNet. Beginning the next morning, the stucco was wetted twice daily for four days, then covered with 6 mil thick polyethylene to hold the moisture in. The plastic was removed and the finish coat applied on June 13, 2006. The mix, application and wetting were the same for both coats of cement/stucco. Two small wooden boxes were filled with cement/stucco taken from the mix used on both days of application. These samples were sent to a local lab and compression tests were performed in accordance with ASTM C 42. Those results are located in Appendix E.

The wall was allowed to sit for 36 days prior to testing. On the morning of the test, the moisture content within the bales was measured, near each thermocouple and at three depths – exposed side, center of bale, and unexposed side. The readings were taken with a Protimeter Balemaster moisture meter. The average moisture content of 27 readings was 18.4%.

Construction drawings are located in Appendix A.

THERMOCOUPLES

All temperatures monitored on the unexposed surface of this wall assembly were measured using 24 GA., electrically-welded, Type K Chromel-Alumel, glass-glass insulated (Special Limits of Error: ±1.1°C) thermocouples, purchased with calibration certifications and lot traceability.

To meet the requirements of ASTM E 119, nine thermocouples were installed on the unexposed surface of the wall and covered with 6 in. x 6 in. x 0.40 in. thick dry, felted, mineral fiber pads, held in place with a small daub of silicone adhesive on each corner.

These thermocouples were distributed across the unexposed surface of the wall at various locations (see Appendix B).

TEST RESULTS AND OBSERVATIONS

The test wall, contained in a non-loadbearing frame assembly, was placed in front of the Laboratory's vertical wall furnace on July 19, 2006. The thermocouple leads were then connected to the data acquisition system and their outputs verified. The laboratory air temperature was 89°F, with a relative humidity of 74%. At 11:10 a.m., the furnace was fired and the standard E 119 time-temperature curve was followed for a period of 2 hours. The pressure difference between the inside of the furnace (measured by a pressure tap located approximately 1/3 of the way down from the top of the specimen, on the horizontal centerline of the furnace) and the laboratory ambient air was maintained at -0.03 in. of water column throughout the entire test, following the first five minutes of the test, which resulted in the neutral pressure plane being positioned at the top of the test assembly.

Observations made during the test are as follows:

Time (min:sec)	Observation
0:00	Start of test
15:00	Steam/smoke issuing from small cracks on the unexposed side
20:00	Popping noises coming from the exposed side, steam/smoke increasing
30:00	Small cracks have formed in the exposed stucco, with light flaming
60:00	Increase in amount of cracks and flames on the exposed side
60-120:00	No visible changes occurred
120:00	Furnace extinguished and assembly moved into position for the hose stream test

The wall withstood the fire and hose stream tests without passage of flame, of gases hot enough to ignite cotton waste, or of the passage of water from the hose stream. No openings developed that permitted a projection of water from the stream beyond the unexposed surface during the time of the hose stream test. Transmission of heat through the wall during the fire endurance test did not raise the average temperature on the unexposed surface more than 250°F, nor any individual temperature more than 325°F.

During the fire test, the wall was measured for deflection at three points along its vertical centerline: at 30" (position #1), 60" (position #2) and 90" (position #3) from the left side of the wall. Measurements were made from a taut string to the wall surface at each location.

Time (min)	Position #1 (in.)	Position #2 (in.)	Position #3 (in.)
0	1	2	7/8
20	1	2-1/4	1
30	1	2-1/4	1
55	1-1/8	2-3/8	1-1/8
73	1-1/4	2-1/2	1-1/4
100	1-1/4	2-1/2	1-1/4
120	1-1/4	2-1/2	1-1/4

In accordance with the E 119 test standard, a calculation for any correction to the indicated fire resistance period was done. The correction factor was then mathematically added to the indicated fire resistance period, yielding the fire resistance period achieved by this specimen:

ITEM	DESCRIPTION	TEST VALUE
C	correction factor	-0.38 minutes -23 seconds
I	indicated fire-resistance period	120 minutes
A	area under the curve of indicated average furnace temperature for the first three fourths of the indicated period	132 113 (°F•min)
As	area under the standard furnace curve for the same part of the indicated period	132 768 (°F•min)
L	lag correction	3240
	FIRE RESISTANCE PERIOD ACHIEVED BY THIS SPECIMEN ==>	120 minutes

Note: The standard specifies that the fire resistance be determined to the nearest integral minute. Consequently, if the correction factor is less than 30 seconds, and the test specimen met the criteria for the full indicated fire resistance period, no correction is deemed necessary. That was the case for this project.

A drawing showing the location of the thermocouples may be found in Appendix B. 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. Results of the stucco compression testing are located in Appendix E.

CONCLUSIONS

The observations and test results in this report are relevant only to the sample tested. This report by itself does not imply that the material, product, or service is or has ever been under an Intertek certification program.

A 10 ft x 10 ft non-loadbearing wall constructed with 7.5 pcf rectangular wheat straw bales stacked in a running bond pattern, clad on each surface with 17 GA stucco netting and 1" of cement/stucco, produced, assembled, and tested as described herein, successfully met the conditions of acceptance as outlined in ASTM Method E 119-05a Fire Tests of Building Construction and Materials for a fire endurance rating of 2 hours.

APPENDIX A

CONSTRUCTION DRAWINGS

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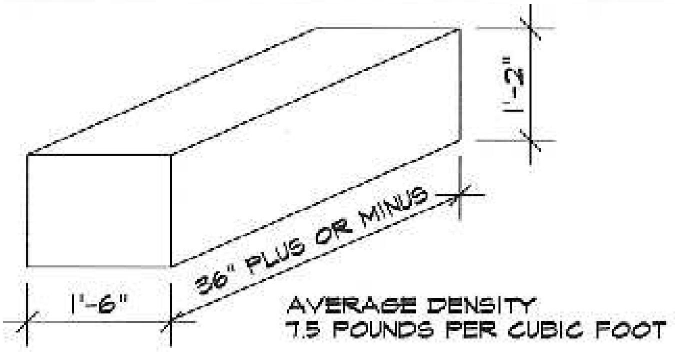
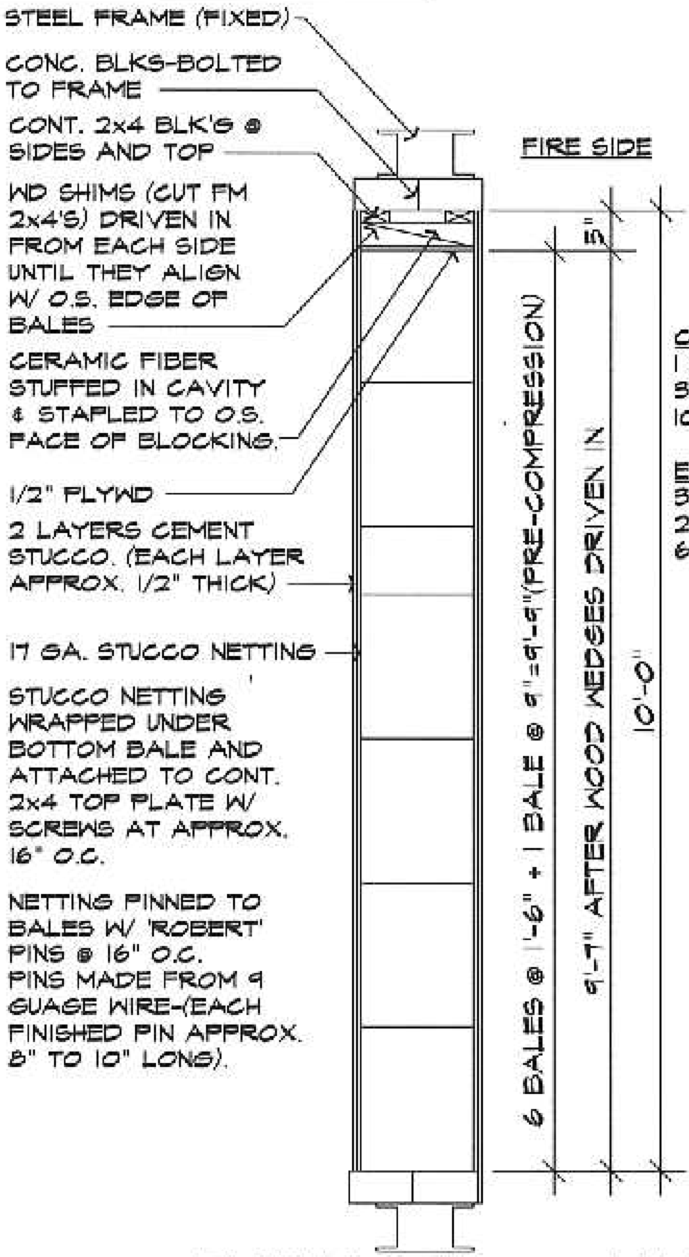


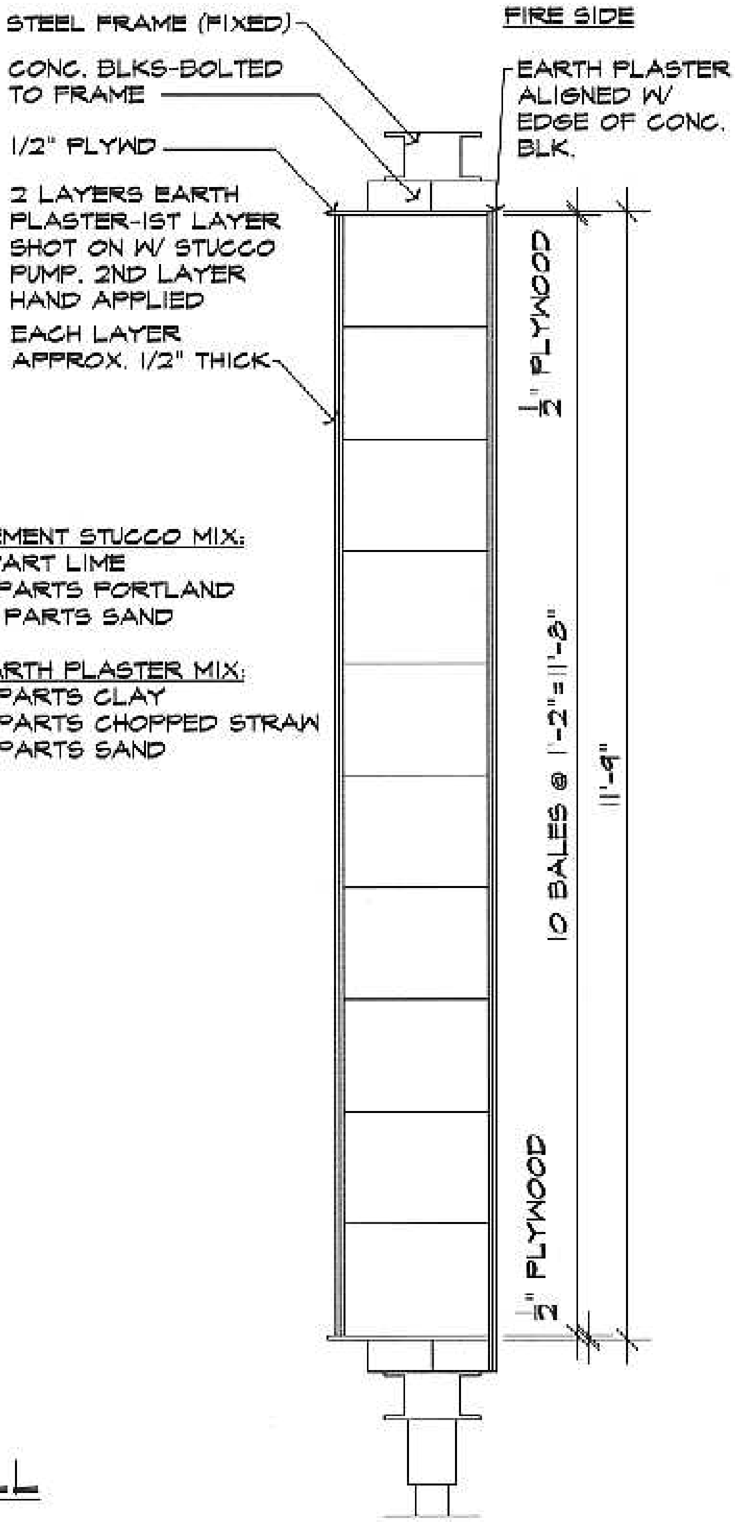
'AVERAGE' BALE



CEMENT STUCCO WALL

CEMENT STUCCO MIX:
1 PART LIME
3 PARTS PORTLAND
10 PARTS SAND

EARTH PLASTER MIX:
3 PARTS CLAY
2 PARTS CHOPPED STRAW
6 PARTS SAND



AFTER SCRATCH COAT WAS APPLIED, WALL WAS 'WETTED' DOWN ON BOTH SIDES. 6 MIL POLY WAS THEN WRAPPED OVER STRUCTURE AND TAPED TO THE FRAME TO HOLD MOISTURE IN.

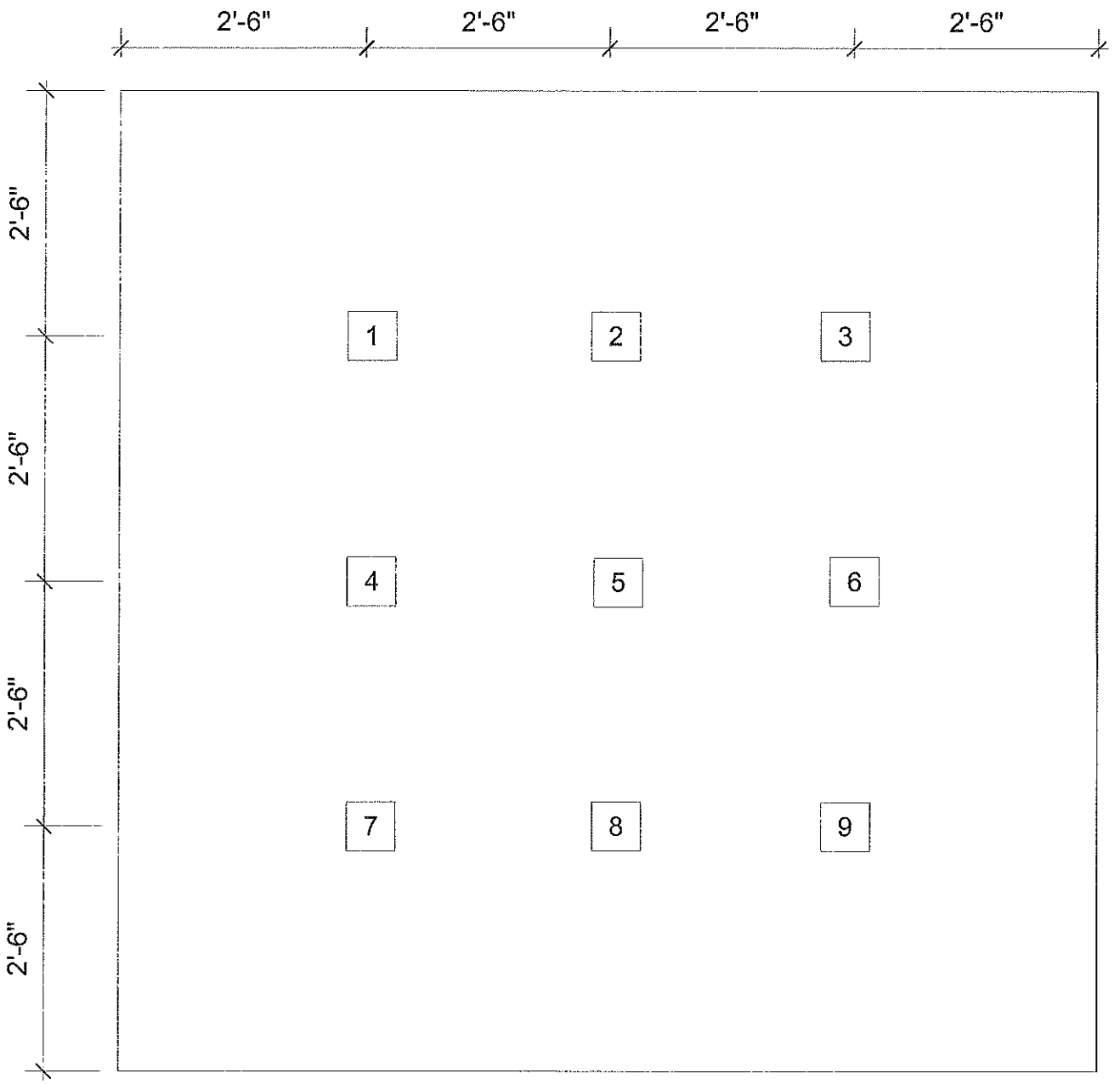
EARTH PLASTER WALL

0' 6" 1' 2' 3' 4' 5'

BENJAMIN OBREGON ARCHITECT 13423 OVERLAND PASS, AUSTIN TEXAS 78738
OFFICE: 512) 263-0177 FAX: 512) 263-5765 WEB: SustainableDesignCenter.com E-MAIL: bobregon@austin.rr.com

APPENDIX B

THERMOCOUPLE LAYOUT



ELEVATION VIEW

Note:

The unexposed surface was instrumented with 24 GA, fiberglass insulated Type K thermocouples as indicated in the standard, held under 6" x 6" x 0.4" thick mineral fiber pads. The TCs were located as near as possible to the locations indicated, but due to irregularities in the stucco surface, some pads were moved slightly to areas where the pad would be in full contact with the stucco surface.

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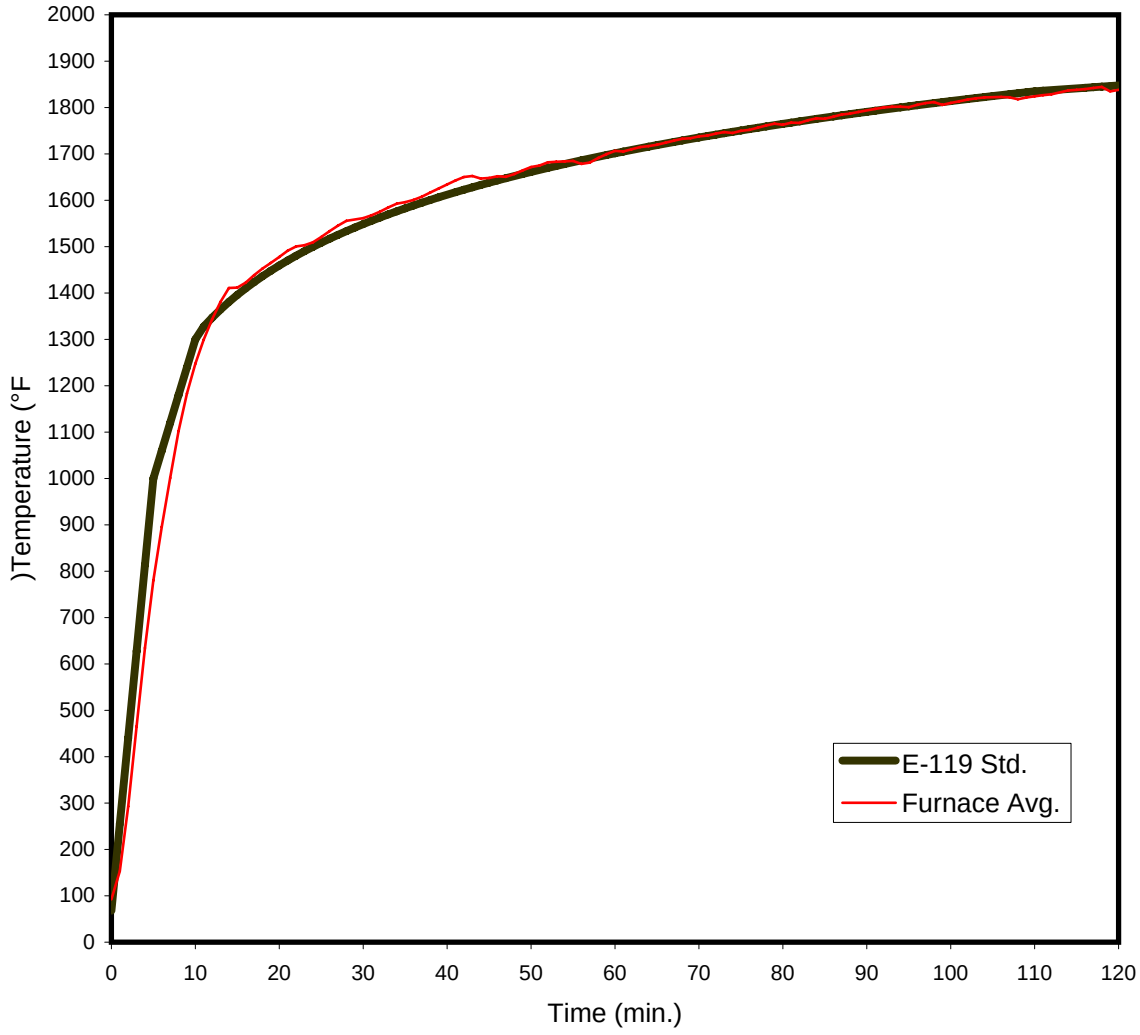
EBNet
Fig. 2 Thermocouple Layout

Scale = 1:20

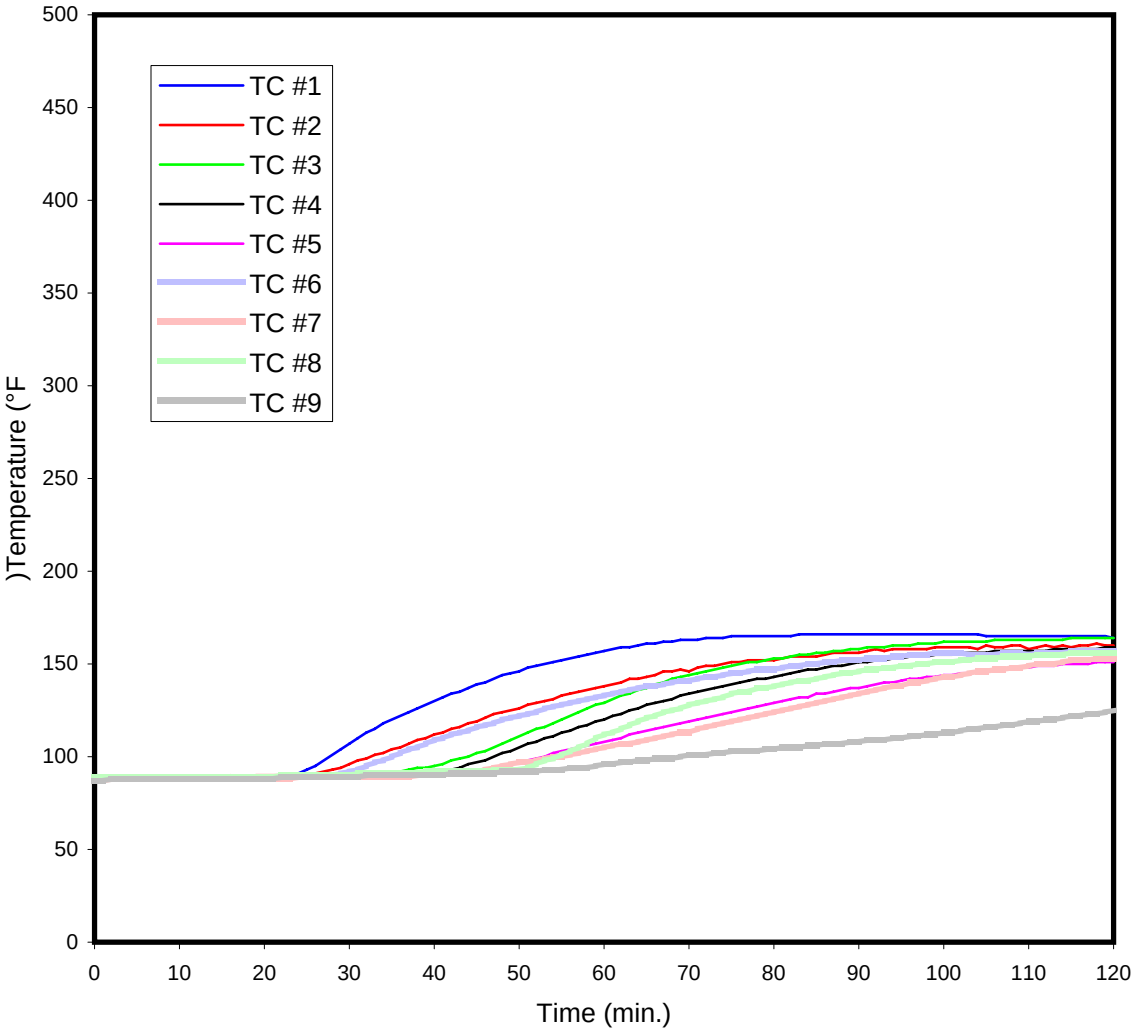
APPENDIX C

TEMPERATURE DATA

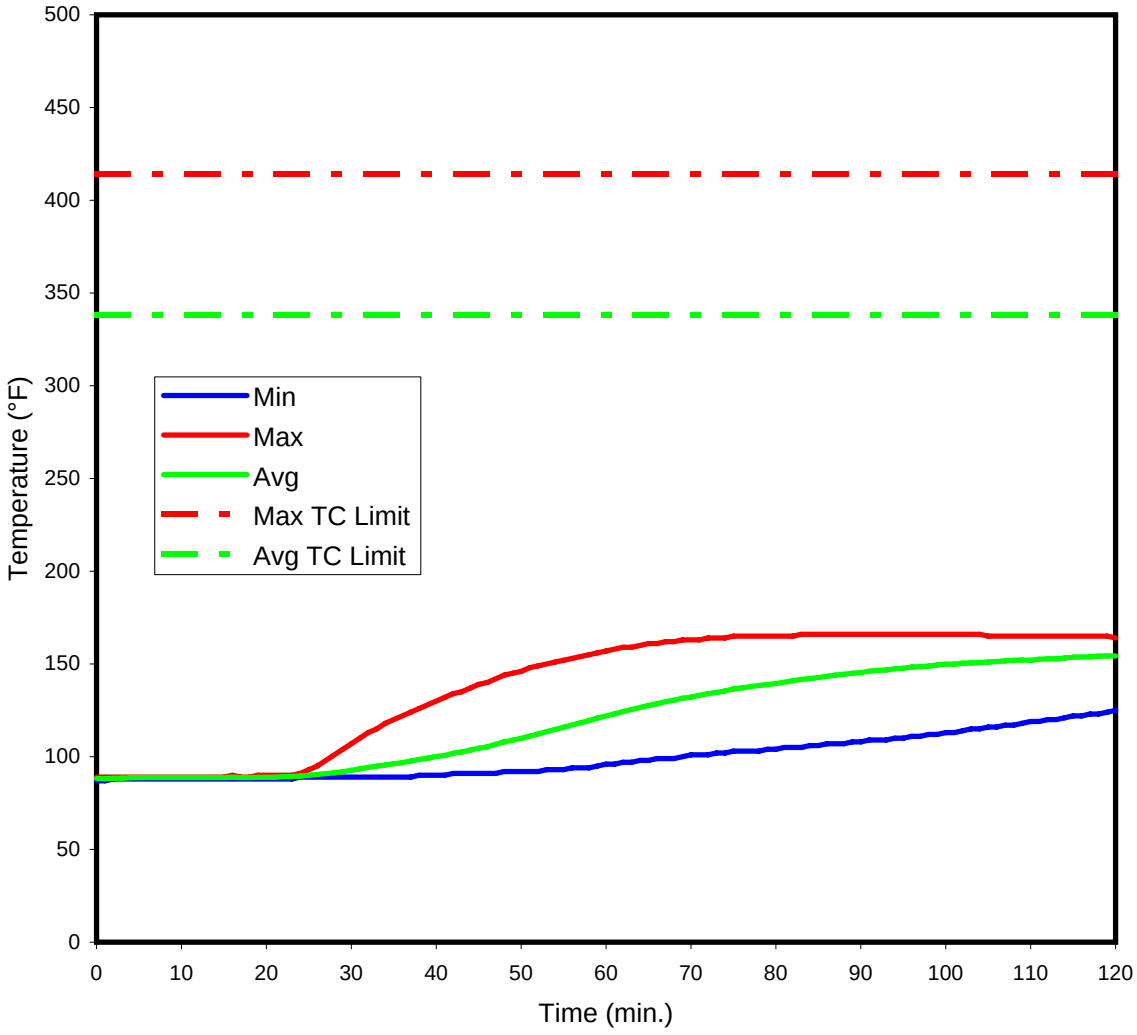
EBNet
Project No. 3098054A
Furnace Interior Temperatures



EBNet
Project No. 3098054A
Individual Cold Side Temperatures



EBNet
Project No. 3098054A
Min, Avg, Max Cold Side 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	92	0.00	0.00	0.00	92	93	92
1	254	153	54.71	93.20	-41.30	227	115	160
2	441	293	209.62	372.80	-43.77	414	217	272
3	627	465	520.71	838.80	-37.92	595	375	436
4	814	635	1002.67	1491.20	-32.76	748	537	593
5	1000	780	1641.96	2330.00	-29.53	865	672	722
6	1060	896	2411.83	3292.00	-26.74	955	780	828
7	1120	1001	3292.17	4314.00	-23.69	1046	878	935
8	1180	1102	4275.79	5396.00	-20.76	1137	977	1047
9	1240	1183	5350.62	6538.00	-18.16	1211	1072	1130
10	1300	1248	6498.12	7740.00	-16.04	1270	1156	1196
11	1328	1300	7703.67	8985.80	-14.27	1317	1224	1251
12	1347	1343	8957.12	10254.99	-12.66	1355	1281	1300
13	1364	1381	10251.29	11542.58	-11.19	1388	1328	1340
14	1381	1411	11579.17	12847.15	-9.87	1417	1367	1372
15	1396	1412	12922.42	14167.49	-8.79	1418	1386	1377
16	1410	1422	14271.46	15502.53	-7.94	1426	1398	1392
17	1424	1439	15633.92	16851.37	-7.22	1441	1415	1412
18	1436	1453	17011.50	18213.18	-6.60	1455	1433	1425
19	1448	1465	18402.29	19587.25	-6.05	1466	1448	1439
20	1459	1478	19805.62	20972.92	-5.57	1478	1462	1452
21	1470	1491	21222.12	22369.62	-5.13	1489	1476	1467
22	1480	1500	22649.96	23776.82	-4.74	1498	1489	1476
23	1490	1503	24083.71	25194.05	-4.41	1502	1497	1482
24	1499	1509	25521.92	26620.85	-4.13	1508	1502	1490
25	1508	1521	26969.00	28056.85	-3.88	1518	1512	1500
26	1517	1533	28428.12	29501.66	-3.64	1530	1524	1513
27	1525	1545	29899.50	30954.95	-3.41	1540	1535	1525
28	1533	1556	31382.00	32416.40	-3.19	1549	1546	1535
29	1541	1559	32871.12	33885.73	-2.99	1553	1554	1539
30	1549	1562	34363.17	35362.66	-2.83	1556	1556	1540
31	1556	1568	35859.75	36846.93	-2.68	1560	1562	1547
32	1563	1575	37363.29	38338.32	-2.54	1566	1569	1553
33	1570	1585	38875.33	39836.59	-2.41	1574	1578	1563
34	1576	1593	40396.00	41341.54	-2.29	1582	1586	1571
35	1583	1596	41922.29	42852.98	-2.17	1585	1592	1574
36	1589	1601	43452.67	44370.71	-2.07	1589	1597	1578
37	1595	1608	44989.00	45894.56	-1.97	1595	1604	1584
38	1601	1617	46533.33	47424.37	-1.88	1602	1613	1593
39	1606	1626	48086.50	48959.98	-1.78	1610	1621	1603
40	1612	1634	49648.33	50501.24	-1.69	1618	1629	1611
41	1617	1643	51218.79	52048.01	-1.59	1626	1639	1620
42	1623	1650	52797.25	53600.15	-1.50	1631	1648	1628
43	1628	1652	54380.54	55157.54	-1.41	1632	1654	1631
44	1633	1647	55962.21	56720.06	-1.34	1628	1654	1627
45	1638	1648	57541.75	58287.59	-1.28	1627	1654	1629
46	1643	1652	59123.75	59860.01	-1.23	1630	1659	1633

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)
47	1648	1651	60707.00	61437.22	-1.19	1630	1662	1633
48	1652	1657	62292.67	63019.12	-1.15	1635	1665	1638
49	1657	1665	63885.25	64605.62	-1.12	1642	1673	1645
50	1661	1672	65485.37	66196.61	-1.07	1649	1680	1652
51	1666	1675	67090.71	67792.00	-1.03	1653	1683	1656
52	1670	1682	68701.08	69391.72	-1.00	1658	1690	1663
53	1674	1683	70315.54	70995.68	-0.96	1659	1693	1665
54	1678	1684	71931.00	72603.79	-0.93	1659	1694	1666
55	1682	1685	73547.37	74215.98	-0.90	1660	1695	1669
56	1686	1678	75161.04	75832.18	-0.89	1658	1693	1666
57	1690	1681	76772.96	77452.32	-0.88	1658	1690	1668
58	1694	1691	78391.33	79076.32	-0.87	1667	1698	1678
59	1698	1700	80018.79	80704.12	-0.85	1675	1704	1685
60	1701	1707	81653.83	82335.66	-0.83	1681	1711	1693
61	1705	1705	83291.71	83970.87	-0.81	1680	1712	1693
62	1709	1710	84931.42	85609.69	-0.79	1685	1714	1698
63	1712	1715	86575.92	87252.06	-0.77	1689	1719	1703
64	1716	1717	88223.79	88897.93	-0.76	1692	1722	1706
65	1719	1720	89874.12	90547.25	-0.74	1694	1724	1708
66	1722	1724	91528.08	92199.95	-0.73	1698	1727	1712
67	1726	1729	93186.46	93856.00	-0.71	1702	1732	1717
68	1729	1733	94849.04	95515.33	-0.70	1706	1735	1722
69	1732	1734	96514.25	97177.91	-0.68	1708	1737	1724
70	1735	1738	98182.08	98843.67	-0.67	1711	1742	1728
71	1738	1740	99852.75	100512.59	-0.66	1713	1744	1730
72	1742	1744	101526.42	102184.60	-0.64	1716	1747	1734
73	1745	1747	103203.87	103859.68	-0.63	1719	1750	1738
74	1748	1745	104881.96	105537.78	-0.62	1718	1749	1737
75	1751	1750	106561.42	107218.86	-0.61	1722	1753	1741
76	1753	1752	108244.25	108902.87	-0.60	1725	1756	1743
77	1756	1757	109930.42	110589.78	-0.60	1729	1759	1747
78	1759	1761	111621.33	112279.55	-0.59	1734	1765	1752
79	1762	1765	113316.58	113972.15	-0.58	1738	1767	1755
80	1765	1763	115012.62	115667.54	-0.57	1737	1767	1754
81	1768	1768	116709.83	117365.68	-0.56	1741	1771	1758
82	1770	1767	118409.04	119066.55	-0.55	1742	1774	1759
83	1773	1773	120110.83	120770.10	-0.55	1746	1779	1764
84	1776	1777	121817.50	122476.30	-0.54	1750	1783	1766
85	1778	1776	123525.79	124185.13	-0.53	1750	1783	1766
86	1781	1780	125235.87	125896.55	-0.52	1753	1788	1771
87	1783	1785	126950.46	127610.53	-0.52	1758	1792	1775
88	1786	1787	128668.42	129327.04	-0.51	1760	1794	1777
89	1788	1791	130389.17	131046.06	-0.50	1764	1798	1781
90	1791	1794	132113.33	132767.56	-0.49	1767	1801	1784
91	1793	1797	133840.79	134491.50	-0.48	1770	1805	1788
92	1796	1800	135571.33	136217.86	-0.47	1773	1809	1792
93	1798	1802	137304.17	137946.62	-0.47	1776	1811	1793

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)
94	1800	1802	139037.92	139677.75	-0.46	1777	1813	1794
95	1803	1801	140771.25	141370.00	-0.42	1776	1811	1794
96	1805	1806	142506.54	143105.00	-0.42	1780	1814	1799
97	1807	1810	144246.25	144842.50	-0.41	1784	1817	1803
98	1809	1812	145989.00	146582.50	-0.40	1787	1821	1806
99	1812	1806	147729.83	148324.50	-0.40	1782	1817	1801
100	1814	1810	149469.71	150068.50	-0.40	1785	1819	1805
101	1816	1813	151213.37	151815.00	-0.40	1789	1821	1809
102	1818	1817	152960.67	153564.00	-0.39	1792	1824	1813
103	1820	1820	154711.21	155315.00	-0.39	1795	1827	1816
104	1823	1822	156464.08	157068.00	-0.38	1797	1828	1817
105	1825	1822	158218.17	158823.00	-0.38	1798	1828	1818
106	1827	1823	159972.75	160580.00	-0.38	1799	1830	1819
107	1829	1822	161727.17	162339.00	-0.38	1798	1830	1818
108	1831	1818	163479.12	164100.00	-0.38	1795	1827	1815
109	1833	1822	165230.92	165863.00	-0.38	1798	1828	1818
110	1835	1824	166985.87	167628.00	-0.38	1801	1830	1822
111	1836	1827	168743.37	169395.00	-0.38	1803	1832	1825
112	1838	1829	170503.04	171163.50	-0.39	1805	1834	1826
113	1839	1833	172265.71	172933.00	-0.39	1810	1837	1831
114	1840	1837	174032.50	174704.00	-0.38	1814	1842	1835
115	1841	1838	175802.04	176476.50	-0.38	1815	1844	1836
116	1843	1840	177573.08	178250.00	-0.38	1817	1845	1837
117	1844	1842	179346.12	180024.50	-0.38	1820	1848	1840
118	1845	1845	181121.50	181800.50	-0.37	1822	1850	1843
119	1846	1835	182893.12	183578.00	-0.37	1815	1845	1834
120	1848	1838	184661.58	185356.50	-0.37	1817	1845	1837

Max Temp
Max Allowed

Time (min)	Furnace Probe #4 (°F)	Furnace Probe #5 (°F)	Furnace Probe #6 (°F)	Furnace Probe #7 (°F)	Furnace Probe #8 (°F)	Furnace Probe #9 (°F)	Furnace Probe #10 (°F)	Furnace Probe #11 (°F)	Furnace Probe #12 (°F)
0	92	92	93	92	92	93	93	92	92
1	149	195	137	133	137	143	157	165	119
2	269	391	265	247	259	271	319	373	216
3	410	587	430	399	433	446	516	589	369
4	559	755	596	567	632	621	702	767	537
5	716	876	728	746	802	768	860	912	694
6	842	968	831	898	943	880	982	1017	824
7	950	1069	935	1028	1062	971	1064	1125	949
8	1055	1166	1037	1141	1169	1062	1141	1224	1071
9	1140	1242	1127	1225	1249	1138	1200	1293	1174
10	1206	1302	1198	1286	1311	1200	1245	1345	1256
11	1260	1352	1255	1333	1359	1250	1286	1389	1318
12	1307	1396	1306	1370	1399	1293	1318	1427	1369
13	1346	1434	1350	1404	1438	1329	1343	1458	1413
14	1376	1463	1385	1434	1468	1358	1362	1480	1448
15	1381	1459	1391	1434	1465	1356	1359	1464	1450
16	1392	1467	1403	1444	1473	1368	1370	1474	1462
17	1411	1481	1420	1459	1488	1383	1384	1490	1478
18	1427	1494	1436	1471	1500	1399	1398	1502	1492
19	1441	1505	1450	1482	1511	1410	1411	1512	1504
20	1454	1518	1464	1491	1524	1424	1425	1524	1517
21	1469	1531	1478	1505	1537	1439	1438	1536	1530
22	1479	1539	1489	1511	1546	1446	1451	1542	1539
23	1484	1541	1492	1514	1547	1446	1453	1540	1539
24	1492	1546	1497	1520	1552	1453	1462	1548	1542
25	1503	1557	1508	1530	1563	1465	1476	1562	1556
26	1516	1569	1522	1541	1576	1478	1491	1573	1568
27	1529	1580	1533	1554	1587	1490	1507	1585	1579
28	1540	1590	1543	1562	1598	1500	1522	1594	1589
29	1545	1592	1546	1566	1601	1498	1523	1595	1591
30	1548	1593	1547	1569	1602	1502	1535	1598	1592
31	1553	1599	1553	1573	1608	1510	1542	1605	1600
32	1561	1606	1561	1580	1615	1518	1557	1612	1607
33	1571	1614	1569	1590	1624	1529	1569	1620	1615
34	1580	1621	1576	1597	1631	1536	1582	1627	1623
35	1584	1624	1579	1600	1633	1539	1589	1628	1624
36	1589	1628	1582	1605	1637	1544	1600	1634	1627
37	1595	1634	1589	1611	1644	1552	1610	1641	1635
38	1605	1642	1598	1620	1653	1561	1622	1650	1643
39	1614	1651	1606	1628	1662	1571	1630	1659	1651
40	1623	1660	1614	1637	1670	1580	1643	1667	1658
41	1632	1668	1623	1645	1679	1590	1652	1673	1666
42	1640	1674	1629	1651	1685	1604	1663	1678	1671
43	1643	1676	1631	1653	1686	1609	1666	1677	1671
44	1638	1670	1626	1647	1680	1602	1657	1669	1665
45	1640	1670	1627	1648	1681	1607	1661	1669	1665
46	1645	1674	1629	1651	1683	1611	1666	1672	1669

Time (min)	Furnace Probe #4 (°F)	Furnace Probe #5 (°F)	Furnace Probe #6 (°F)	Furnace Probe #7 (°F)	Furnace Probe #8 (°F)	Furnace Probe #9 (°F)	Furnace Probe #10 (°F)	Furnace Probe #11 (°F)	Furnace Probe #12 (°F)
47	1644	1673	1628	1651	1682	1608	1662	1669	1666
48	1650	1678	1634	1655	1688	1617	1672	1677	1671
49	1658	1686	1641	1662	1695	1626	1683	1684	1679
50	1665	1693	1647	1668	1703	1634	1693	1692	1685
51	1669	1696	1651	1672	1706	1637	1694	1694	1688
52	1677	1702	1658	1679	1712	1645	1704	1700	1694
53	1678	1702	1658	1680	1713	1650	1704	1700	1695
54	1680	1702	1659	1681	1713	1650	1707	1700	1695
55	1681	1703	1659	1682	1714	1652	1708	1701	1695
56	1677	1698	1654	1677	1707	1641	1694	1689	1687
57	1679	1700	1656	1678	1709	1651	1702	1697	1689
58	1690	1709	1664	1688	1719	1661	1716	1707	1699
59	1698	1717	1672	1696	1727	1671	1727	1716	1707
60	1705	1723	1678	1703	1735	1677	1735	1722	1715
61	1704	1722	1677	1702	1734	1676	1731	1719	1713
62	1709	1726	1682	1706	1738	1683	1739	1725	1717
63	1714	1731	1686	1710	1743	1686	1746	1729	1722
64	1716	1732	1688	1712	1745	1690	1746	1730	1724
65	1718	1735	1691	1714	1748	1695	1751	1733	1726
66	1721	1739	1696	1717	1754	1701	1755	1740	1730
67	1726	1744	1700	1722	1758	1703	1760	1744	1735
68	1730	1746	1704	1727	1762	1707	1765	1748	1739
69	1732	1747	1705	1728	1763	1711	1764	1747	1740
70	1736	1752	1709	1731	1768	1712	1770	1751	1744
71	1737	1754	1711	1733	1770	1713	1770	1753	1746
72	1742	1758	1715	1737	1775	1719	1775	1758	1750
73	1746	1761	1718	1741	1779	1721	1778	1760	1754
74	1743	1760	1717	1738	1778	1719	1773	1757	1752
75	1747	1765	1722	1743	1783	1723	1779	1763	1757
76	1749	1766	1724	1745	1785	1726	1780	1765	1758
77	1754	1770	1729	1749	1791	1731	1786	1770	1763
78	1757	1775	1734	1753	1796	1736	1790	1775	1769
79	1760	1779	1738	1756	1802	1741	1793	1780	1773
80	1758	1778	1736	1754	1799	1737	1787	1777	1771
81	1764	1782	1741	1759	1804	1740	1792	1782	1776
82	1763	1783	1741	1758	1804	1735	1788	1781	1775
83	1768	1788	1746	1764	1810	1743	1796	1786	1782
84	1772	1792	1750	1767	1815	1748	1800	1791	1786
85	1771	1791	1750	1766	1815	1747	1799	1789	1784
86	1775	1795	1754	1770	1820	1749	1805	1794	1789
87	1780	1799	1758	1775	1825	1756	1809	1798	1794
88	1781	1801	1761	1777	1827	1758	1810	1801	1797
89	1785	1804	1765	1780	1831	1759	1814	1804	1801
90	1788	1808	1768	1783	1836	1762	1817	1807	1805
91	1791	1812	1772	1786	1840	1763	1820	1810	1808
92	1794	1815	1775	1789	1844	1764	1822	1812	1811
93	1796	1817	1777	1790	1846	1765	1823	1813	1813

Time (min)	Furnace Probe #4 (°F)	Furnace Probe #5 (°F)	Furnace Probe #6 (°F)	Furnace Probe #7 (°F)	Furnace Probe #8 (°F)	Furnace Probe #9 (°F)	Furnace Probe #10 (°F)	Furnace Probe #11 (°F)	Furnace Probe #12 (°F)
94	1797	1817	1778	1791	1846	1763	1820	1814	1812
95	1796	1816	1776	1790	1844	1764	1819	1813	1811
96	1801	1821	1780	1795	1850	1768	1826	1819	1816
97	1804	1825	1784	1798	1854	1774	1831	1822	1820
98	1807	1826	1787	1801	1856	1774	1833	1823	1821
99	1802	1819	1782	1794	1850	1767	1823	1817	1816
100	1807	1824	1785	1798	1854	1771	1830	1822	1819
101	1810	1827	1788	1802	1858	1775	1834	1825	1823
102	1814	1832	1792	1806	1863	1778	1838	1828	1826
103	1817	1834	1793	1809	1866	1782	1841	1831	1828
104	1819	1836	1795	1810	1869	1782	1843	1835	1831
105	1819	1836	1797	1810	1870	1783	1842	1835	1832
106	1819	1838	1797	1810	1870	1783	1841	1835	1833
107	1818	1838	1796	1810	1869	1783	1840	1833	1831
108	1815	1833	1793	1806	1865	1778	1833	1828	1827
109	1818	1836	1797	1809	1869	1784	1839	1833	1831
110	1821	1837	1799	1811	1872	1787	1842	1836	1833
111	1823	1839	1802	1814	1875	1788	1845	1839	1836
112	1826	1842	1803	1816	1876	1791	1846	1841	1837
113	1830	1848	1806	1821	1879	1795	1851	1844	1841
114	1834	1855	1809	1825	1881	1798	1856	1848	1845
115	1835	1854	1811	1826	1884	1800	1857	1850	1847
116	1837	1854	1812	1827	1886	1803	1860	1851	1849
117	1840	1858	1814	1830	1888	1805	1862	1852	1850
118	1841	1858	1817	1832	1891	1807	1865	1855	1853
119	1832	1849	1809	1823	1881	1794	1849	1844	1842
120	1835	1852	1811	1825	1883	1802	1856	1849	1846

Max Temp
Max Allowed

Time (min)	Cold Side Min (°F)	Cold Side Avg (°F)	Cold Side Max (°F)	Cold Side TC #1 (°F)	Cold Side TC #2 (°F)	Cold Side TC #3 (°F)	Cold Side TC #4 (°F)	Cold Side TC #5 (°F)	Cold Side TC #6 (°F)	Cold Side TC #7 (°F)	Cold Side TC #8 (°F)	Cold Side TC #9 (°F)	Lab Ambient (°F)
0	87	88	89	88	89	89	88	88	88	88	89	87	88
1	87	88	89	88	89	89	88	88	88	87	89	87	88
2	88	88	89	88	89	89	88	88	88	88	89	88	88
3	88	88	89	88	89	89	88	88	89	88	89	88	89
4	88	89	89	88	89	89	89	89	89	88	89	88	89
5	88	89	89	89	89	89	89	89	89	88	89	88	89
6	88	89	89	89	89	89	89	89	89	88	89	88	90
7	88	89	89	89	89	89	89	89	89	88	89	88	90
8	88	89	89	89	89	89	89	89	89	88	89	88	89
9	88	89	89	89	89	89	89	89	89	88	89	88	89
10	88	89	89	89	89	89	89	89	89	88	89	88	91
11	88	89	89	89	89	89	89	89	89	88	89	88	91
12	88	89	89	89	89	89	89	89	89	88	89	88	91
13	88	89	89	89	89	89	89	89	89	88	89	88	91
14	88	89	89	89	89	89	89	89	89	88	89	88	91
15	88	89	89	89	89	89	89	89	89	88	89	88	90
16	88	89	90	89	90	89	89	89	89	88	89	88	89
17	88	89	89	89	89	89	89	89	89	88	89	88	90
18	88	89	89	89	89	89	89	89	89	88	89	88	89
19	88	89	90	89	90	89	89	89	89	88	89	88	90
20	88	89	90	89	90	89	89	89	89	88	89	88	90
21	88	89	90	89	90	89	89	89	89	88	89	88	90
22	88	89	90	89	90	90	89	89	89	88	90	89	90
23	88	89	90	90	90	90	89	89	89	88	90	89	90
24	89	90	91	91	90	90	89	89	89	89	90	89	90
25	89	90	93	93	91	90	89	89	90	89	90	89	91
26	89	90	95	95	91	90	90	90	90	89	90	89	89
27	89	91	98	98	92	90	90	90	90	89	90	89	91
28	89	91	101	101	93	90	90	90	90	89	90	89	91
29	89	92	104	104	94	90	90	90	91	89	90	89	90
30	89	93	107	107	96	91	90	90	92	89	90	89	91
31	89	93	110	110	98	91	90	90	93	89	91	89	91
32	89	94	113	113	99	91	90	90	95	89	91	90	91
33	89	95	115	115	101	91	90	90	97	89	91	90	91
34	89	96	118	118	102	92	90	90	98	89	91	90	91
35	89	96	120	120	104	92	90	90	100	89	91	90	92
36	89	97	122	122	105	92	90	90	102	89	91	90	91
37	89	98	124	124	107	93	91	90	104	89	91	90	92
38	90	99	126	126	109	94	91	91	105	90	91	90	92
39	90	99	128	128	110	94	91	91	107	90	92	90	93
40	90	100	130	130	112	95	92	91	109	90	92	90	94
41	90	101	132	132	113	96	92	91	110	90	92	90	93
42	91	102	134	134	115	98	93	91	112	91	92	91	93
43	91	103	135	135	116	99	94	92	113	91	92	91	93
44	91	104	137	137	118	100	96	92	114	92	92	91	93
45	91	105	139	139	119	102	97	93	116	92	92	91	94
46	91	105	140	140	121	103	98	93	117	93	92	91	94

Time (min)	Cold Side Min (°F)	Cold Side Avg (°F)	Cold Side Max (°F)	Cold Side TC #1 (°F)	Cold Side TC #2 (°F)	Cold Side TC #3 (°F)	Cold Side TC #4 (°F)	Cold Side TC #5 (°F)	Cold Side TC #6 (°F)	Cold Side TC #7 (°F)	Cold Side TC #8 (°F)	Cold Side TC #9 (°F)	Lab Ambient (°F)
47	91	107	142	142	123	105	100	94	118	94	93	91	95
48	92	108	144	144	124	107	102	95	120	95	93	92	94
49	92	109	145	145	125	109	103	96	121	96	93	92	95
50	92	110	146	146	126	111	105	97	122	97	93	92	92
51	92	111	148	148	128	113	107	98	123	97	94	92	93
52	92	112	149	149	129	115	108	99	124	98	96	92	93
53	93	114	150	150	130	116	110	100	126	99	98	93	93
54	93	115	151	151	131	118	111	102	127	100	99	93	93
55	93	116	152	152	133	120	113	103	128	100	101	93	93
56	94	117	153	153	134	122	114	104	129	101	103	94	92
57	94	118	154	154	135	124	116	105	130	102	105	94	93
58	94	119	155	155	136	126	117	106	131	103	107	94	93
59	95	121	156	156	137	128	119	107	132	104	110	95	91
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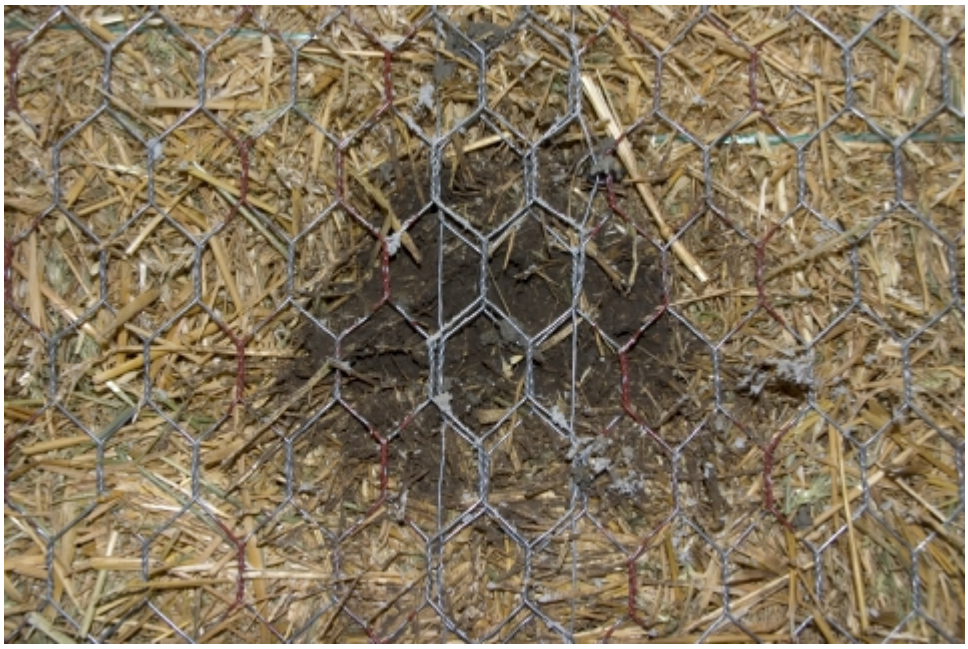
61	96	123	158	158	139	131	122	109	134	106	113	96	93
62	97	124	159	159	140	133	123	110	135	107	115	97	94
63	97	125	159	159	142	134	125	112	136	107	117	97	93
64	98	127	160	160	142	136	126	113	137	108	119	98	93
65	98	128	161	161	143	137	128	114	138	109	121	98	94
66	99	129	161	161	144	139	129	115	138	110	122	99	93
67	99	130	162	162	146	140	130	116	139	111	124	99	93
68	99	130	162	162	146	142	131	117	140	112	125	99	94
69	100	132	163	163	147	143	133	118	141	113	126	100	94
70	101	132	163	163	146	144	134	119	141	113	128	101	94
71	101	133	163	163	148	145	135	120	142	115	129	101	94
72	101	134	164	164	149	146	136	121	143	116	130	101	95
73	102	135	164	164	149	147	137	122	143	117	131	102	94
74	102	135	164	164	150	148	138	123	144	118	132	102	93
75	103	137	165	165	151	149	139	124	145	119	134	103	93
76	103	137	165	165	151	150	140	125	145	120	135	103	93
77	103	138	165	165	152	151	141	126	146	121	135	103	92
78	103	138	165	165	152	151	142	127	147	122	137	103	92
79	104	139	165	165	152	152	142	128	147	123	137	104	91
80	104	139	165	165	152	153	143	129	147	124	138	104	93
81	105	140	165	165	153	153	144	130	148	125	139	105	93
82	105	141	165	165	154	154	145	131	149	126	140	105	92
83	105	142	166	166	154	155	146	132	149	127	141	105	93
84	106	142	166	166	154	155	147	132	150	128	141	106	94
85	106	143	166	166	154	156	147	134	150	129	142	106	94
86	107	143	166	166	155	156	148	134	151	130	143	107	94
87	107	144	166	166	156	157	149	135	151	131	144	107	94
88	107	144	166	166	156	157	149	136	152	132	145	107	95
89	108	145	166	166	156	158	150	137	152	133	145	108	95
90	108	145	166	166	156	158	151	137	152	134	146	108	94
91	109	146	166	166	157	159	151	138	153	135	147	109	95
92	109	147	166	166	158	159	152	139	153	136	147	109	95
93	109	147	166	166	157	159	152	140	153	137	148	109	95

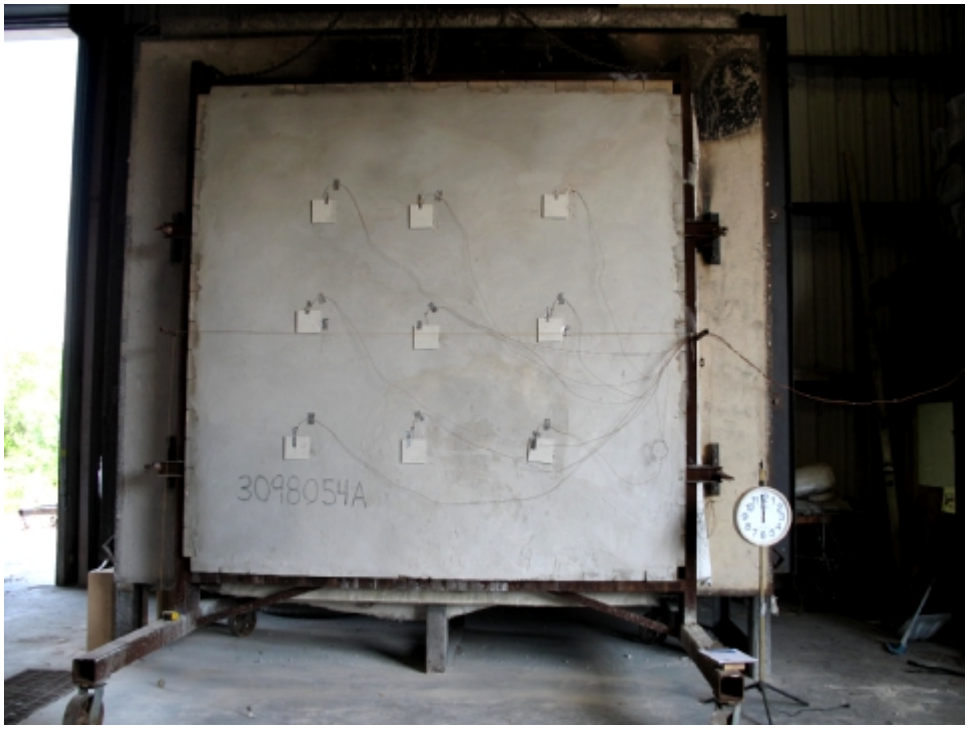
Time (min)	Cold Side Min (°F)	Cold Side Avg (°F)	Cold Side Max (°F)	Cold Side TC #1 (°F)	Cold Side TC #2 (°F)	Cold Side TC #3 (°F)	Cold Side TC #4 (°F)	Cold Side TC #5 (°F)	Cold Side TC #6 (°F)	Cold Side TC #7 (°F)	Cold Side TC #8 (°F)	Cold Side TC #9 (°F)	Lab Ambient (°F)
94	110	147	166	166	158	160	153	140	154	138	148	110	95
95	110	148	166	166	158	160	153	141	154	138	149	110	95
96	111	148	166	166	158	160	154	142	155	140	149	111	95
97	111	149	166	166	158	161	154	142	155	140	150	111	96
98	112	149	166	166	158	161	154	143	155	141	150	112	94
99	112	149	166	166	159	161	155	143	156	142	151	112	96
100	113	150	166	166	159	162	155	144	156	143	151	113	96
101	113	150	166	166	159	162	155	144	156	143	151	113	94
102	114	150	166	166	159	162	156	145	156	144	152	114	95
103	115	151	166	166	159	162	156	145	155	145	152	115	96
104	115	151	166	166	158	162	156	146	155	146	153	115	97
105	116	151	165	165	160	162	156	146	155	146	153	116	97
106	116	151	165	165	159	163	157	147	155	147	153	116	96
107	117	152	165	165	159	163	157	147	156	147	154	117	97
108	117	152	165	165	160	163	157	148	156	148	154	117	96
109	118	152	165	165	160	163	157	148	156	148	154	118	95
110	119	152	165	165	158	163	157	148	155	149	154	119	96
111	119	153	165	165	159	163	157	149	156	150	155	119	96
112	120	153	165	165	160	163	157	149	156	150	155	120	95
113	120	153	165	165	159	163	158	149	156	150	155	120	94
114	121	153	165	165	160	163	158	150	156	151	155	121	96
115	122	154	165	165	159	164	158	150	157	152	156	122	96
116	122	154	165	165	160	164	158	150	157	152	156	122	97
117	123	154	165	165	160	164	158	150	157	152	156	123	96
118	123	154	165	165	161	164	158	151	157	153	156	123	96
119	124	154	165	165	160	164	159	151	157	153	156	124	97
120	125	154	164	164	160	164	159	151	157	153	156	125	97
Max Temp	125	154	166	166	161	164	159	151	157	153	156	125	
Max Allowed	412	338	414	413	414	414	413	413	413	413	414	412	

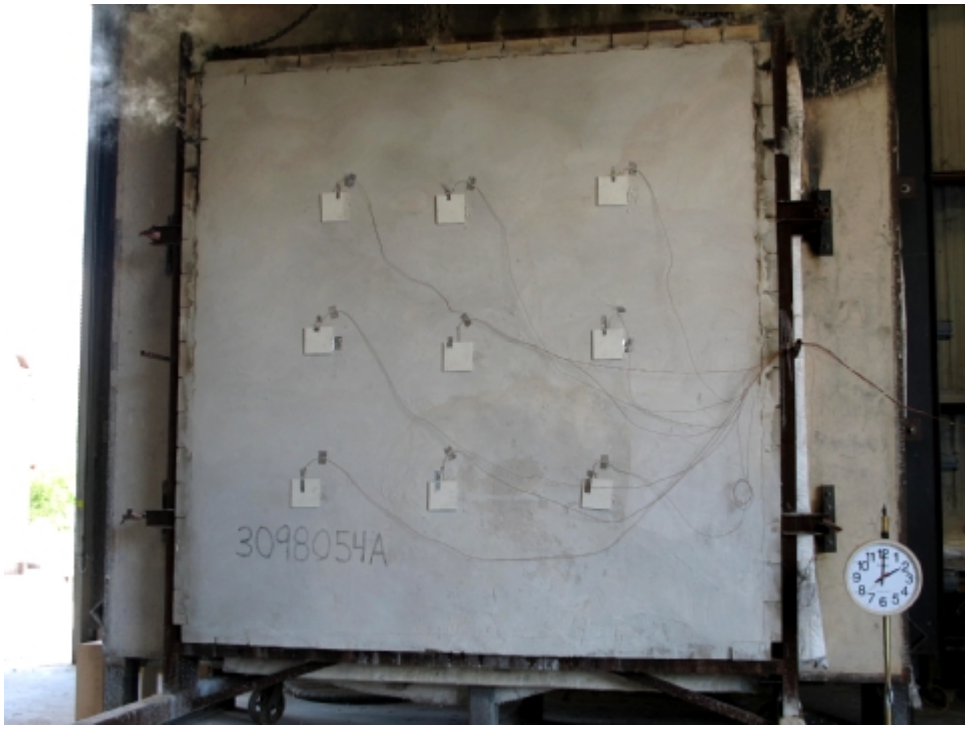
APPENDIX D

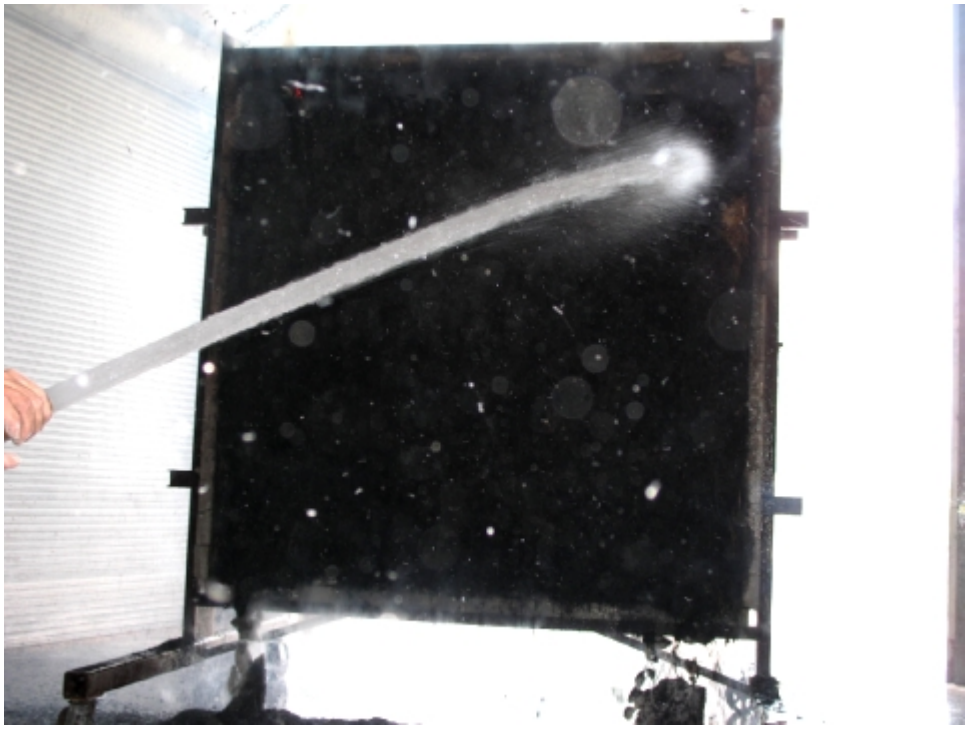
PHOTOGRAPHS


GAFFEY




3098054A


3098054A

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APPENDIX E

ASTM C 42 COMPRESSION RESULTS

Intertek
ETL SEMKO

LABORATORY TESTING REPORT

Engineering • Testing • Environmental • Facilities • Infrastructure

Raba Kistner

Raba Kistner Consultants, Inc.
12821 W. Golden Lane
P.O. Box 690287, San Antonio, TX 78269-0287
(210) 699-9090 • FAX (210) 699-6426
www.rkci.com

CLIENT: Intertek Testing
16015 Shady Falls Road
Elmendorf, Texas 78112-9784
Attn: Mr. Mike Dey

PROJECT: Testing Services (Intertek)

PROJECT NO.: ASD05-173-00
DATE RECEIVED: 06-30-06
SAMPLED BY: Client
DATE TESTED: 07-20-06
TESTED BY: C. Berger (R-K)
DATE REPORTED: 07-24-06

RE: Compressive Strength – Earthen Plaster & Straw Bale Clay

Earthen Plaster (Cast 06-22-06):			
Specimen No.	Area (sq.in.)	Load (lbs.)	Compressive Strength (psi)
1	36.04	10,940	300
2	36.12	10,260	280
		Average (28 days):	290

Straw Bale Clay (Cast 06-05-06):			
Specimen No.	Area (sq.in.)	Load (lbs.)	Compressive Strength (psi)
1	36.07	7,780	220
2	36.22	8,290	230
		Average (45 days):	225

COPIES TO: Above (1)

KENNETH W. MARQUARDT 23371 LICENSED PROFESSIONAL ENGINEER

RABA-KISTNER CONSULTANTS, INC.

BY: K.W. Marquardt 7/28/06

ASSIGNMENT NO.: S06-038017
/dgp 07-25-06

Raba Kistner

Raba Kistner Consultants, Inc.
12821 W. Golden Lane
P.O. Box 690287, San Antonio, TX 78269-0287
(210) 699-9090 • FAX (210) 699-6426
www.rkci.com

CLIENT: Intertek Testing
16015 Shady Falls Road
Elmendorf, Texas 78112-9784
Attn: Mr. Mike Dey

REPORT OF TESTS ON STUCCO CORES

Project Name: Testing Services (Intertek)	Project No.: ASD05-173-00	Assignment No.: S06-038017
Date Placed: Not Provided	Date Cored: 07-19-06	Date Tested: 07-20-06
Age of Concrete: Not Provided	Average Area: 6.50 sq.in.	Nominal Diameter, D: 2.877 inches

Core No.	Core Location	Unit Weight (pcf)	Length, L (inch)			Length Diameter L/D	Load (lbs.)	Compressive Strength (psi)	Correction Factor	Corrected Compressive Strength (psi)
			Cored	Sawed	Capped					
1	Straw Stucco Scratch Coat	125.2	5.597	5.554	5.779	2.01	27,940	4,300	1.0	4,300
2	Straw Stucco Scratch Coat	133.7	5.652	5.512	5.766	2.00	29,930	4,600	1.0	4,600
1	Cement Stucco	112.6	4.381	4.246	4.479	1.56	10,040	1,540	.9648	1,490
2	Cement Stucco	112.1	4.341	4.232	4.474	1.56	10,810	1,660	.9648	1,600
							Straw Stucco Scratch Coat Average:			4,450
							Cement Stucco:			1,550

Remarks:
(1) The compressive strength testing of these cores were conducted in accordance with ASTM C 42 procedures and per client's instructions.
(2) The test cores were loaded perpendicular to the horizontal plane of concrete placement.
(3) The test cores were dry at the time of testing.
(4) The nominal maximum aggregate size: Not Applicable
(5) The test samples were free of reinforcing steel.
(6) The test cores were capped with a sulfur compound.
(7) Cored by C. Berger at R-K on 07-19-06.

Prepared By: CB

Tested By: TW/CB

Copies To: Above (1)

RABA-KISTNER CONSULTANTS, INC.

By: K.W. Marquardt 7/27/06

KENNETH W. MARQUARDT
22371
LICENSED
PROFESSIONAL ENGINEER

/dgp 07-25-06