S O U T H W E S T   R E S E A R C H   I N S T I T U T E®

6220 CULEBRA RD. 78238-5166 • P.O. DRAWER 28510 78228-0510 • SAN ANTONIO, TEXAS, USA • (210) 684-5111 • WWW.SWRI.ORG

CHEMISTRY AND CHEMICAL ENGINEERING DIVISION
FIRE TECHNOLOGY DEPARTMENT
WWW.FIRE.SWRI.ORG
FAX (210) 522-3377

NSF
Registered to ISO 9001:2008

# FIRE PERFORMANCE EVALUATION OF ALCOA ARCHITECTURAL PRODUCTS NORTH AMERICA'S *REYNOBOND ZINC COMPOSITE MATERIAL (ZCM) PANELS* TESTED IN ACCORDANCE WITH NFPA 285, 2006 EDITION, *STANDARD FIRE TEST METHOD FOR EVALUATION OF FIRE PROPAGATION CHARACTERISTICS OF EXTERIOR NONLOAD-BEARING WALL ASSEMBLIES CONTAINING COMBUSTIBLE COMPONENTS*

**SAMPLE ID:** ***4-MM ZINC SKIN FR PANELS***
**TRADE NAME:** ***REYNOBOND ZINC COMPOSITE MATERIAL (ZCM) PANELS***

**FINAL REPORT**
**Consisting of 32 Pages**

**SwRI® Project No. 01.16668.01.004**
**Test Date: November 30, 2011**
**Report Date: January 23, 2012**

**Prepared for:**

**Alcoa Architectural Products North America**
**50 Industrial Boulevard**
**Eastman, GA 31023**

Prepared by:

KCC

David Hintz

David Hintz
Research Engineer
Fire Resistance Section

Approved by:

Barry Badders

Barry L. Badders Jr., P.E.
Manager
Fire Resistance Section



HOUSTON, TEXAS (713) 977-1377 • WASHINGTON, DC (301) 881-0226

## ABSTRACT

Southwest Research Institute's (SwRI) Fire Technology Department, located in San Antonio, TX, conducted an Intermediate-Scale Multistory Test Apparatus fire performance evaluation test for Alcoa Architectural Products North America, located in Eastman, GA. Testing was conducted on November 30, 2011, on a wall assembly utilizing Alcoa Architectural Products North America's, *Reynobond Zinc Composite Material (ZCM) Panels* and other construction materials.

Testing was performed in accordance with the National Fire Protection Association 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Nonload-Bearing Wall Assemblies Containing Combustible Components,* 2006 Edition. The wall assembly **met** the acceptance criteria stated in the standard.

This report contains a description of the test procedure followed, assembly tested, and the results obtained. The results apply specifically to the specimens tested, in the manner tested, and not to similar materials, nor to the performance when used in combination with other materials.

## 1.0 INTRODUCTION

Southwest Research Institute's (SwRI) Fire Technology Department, located in San Antonio, TX, conducted an Intermediate-Scale Multistory Test Apparatus (ISMA) fire performance evaluation test for Alcoa Architectural Products North America, located in Eastman, GA, on November 30, 2011. Testing was performed in accordance with the National Fire Protection Association (NFPA) 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Nonload-Bearing Wall Assemblies Containing Combustible Components,* 2006 Edition. The wall assembly successfully **met** the acceptance criteria stated in the standard.

This report contains a description of the test procedure followed, assembly tested, and the results obtained. The results apply specifically to the specimens tested, in the manner tested, and not to similar materials, nor to the performance when used in combination with other materials.

## 2.0 SCOPE

NFPA 285 provides a method of determining the flammability characteristics of exterior, nonload-baring wall assemblies, which contain combustible components.

The test method is intended to simulate the "full-scale" fire performance of the wall assembly being evaluated. The primary performance characteristics evaluated in this test are the capability of the test wall assembly to resist the following:

1. Flame propagation over the exterior face of the system,
2. Vertical flame spread within the combustible core components from one story to the next,
3. Vertical flame spread over the interior (room side) surface of the panels from one story to the next, and
4. Lateral flame spread from the compartment of fire origin to adjacent spaces.

The above are assessed through visual observations and temperature data obtained during the test.

## 3.0 TEST ASSEMBLY

SwRI received the test materials from Alcoa Architectural Products North America, on November 28, 2011. Mr. Wallace Bielke was retained by SwRI Fire Technology Department's Listing, Labeling, and Follow-Up Inspections Services Section, as a third-party inspector, to witness the manufacture of the selected materials at the Alcoa Architectural Products North America facility located in Eastman, GA, on October 12, 2011. Upon receipt, the inspector's initials were verified to be present on the samples. A copy of the surveillance report is on file.

The *Reynobond Zinc Composite Material (ZCM) Panels* were a nominal 4-mm (0.16-in.) thick panel consisting of a polymeric compound FR core with zinc skins. The core was nominally 3-mm thick with a 0.5-mm thick skin on each side of the core. The core was bonded to the skins with polyethylene-based tie layer at a thickness of 0.003 in. The panels had a nominal weight of 2.3 lb/ft$^2$.

A base wall assembly was constructed by SwRI personnel, consisting of 18-ga, 6-in., C-channel steel studs framed vertically 16 in. on center. Additional studs were included at the window jambs for formation of the window opening, as well as 38½ in. on center off the vertical edges of the wall to accommodate the installation of the panels. The interior face of the wall was sheathed with ⅝-in., Type "X" gypsum wallboard. The interior face gypsum joints were finished with 2-in. tape and treated with joint compound compliant to ASTM C 475. The exterior face of the wall was sheathed with ⅝-in. Densglass® Gold sheathing. The interior surfaces of the window opening were also lined with ⅝-in. Densglass® Gold sheathing. The base wall assembly included 4-in. thick, 4-pcf, mineral wool insulation sheets placed within the stud cavity at each floor line and was held in place by "Z" clips. The mineral wool insulation was installed in multiple layers to cover the full thickness of the floor line, which was nominally 8 in. thick.

Prior to installation of the panels, a 24-ga window header flashing piece was installed which provided a horizontal drip edge that came flush with the exterior surface of the panel system.

The *Reynobond Zinc Composite Material (ZCM) Panels* were installed over an aluminum extrusion system provided by Kovach, Inc. The aluminum extrusion system is identified by Kovach, Inc., as the *KRS 225 System*, which consists of a grid of horizontal and vertical extrusions. The horizontal extrusions were installed continuously across the width of the wall, with the vertical extrusions then installed intermittently between the continuous horizontals. The extrusions were attached to the wall with 12 × 1½ hex head, self drilling, stainless steel fasteners spaced nominally 16 in. on center. The panels were fabricated such that the return lip of the panel clipped directly onto the aluminum extrusions without any fasteners. The panels clipped on such that the entire perimeter of the panel was continuously engaged with each extrusion. After the panels were attached to the extrusions by their perimeter return, insert extrusions were forced into the joints between panels, which ensured a tight fit of each panel onto the vertical and horizontal aluminum extrusions. Refer to Appendix A for client-provided construction drawings.

The window sill and jambs were finished with 24-ga thick steel flashing which capped the front and back edges of the window opening. The perimeter of the wall assembly was also finished with 24-ga thick steel flashing. The test wall assembly for the ISMA test was built into a movable frame system that was installed and secured to the test apparatus using fastening and construction details representative of actual field conditions. Figure A-1 (Appendix A) provides a sketch of the location of the test wall assembly when mounted on the test apparatus as well as client-provided drawings.

## 4.0 CALIBRATION

NFPA 285, Section 7-2, requires the apparatus to be calibrated (a) initially, prior to the first wall assembly test, (b) when significant changes to the gas flow system are made, (c) within 1 year prior to the test on an actual product wall assembly, or (d) whenever ceramic blanket covering more than 50% of the wall or ceiling surface in the burn room is replaced.

SwRI conducted an ISMA calibration test on November 10, 2011, with the burner regime shown in Table 1. This calibration confirmed the burner regime necessary to reach the required temperatures and heat flux levels.

**Table 1. Burner Regime.**

| Time Interval (min) | Room Burner SCFM | Room Burner kW (Btu/min) | Window Burner SCFM | Window Burner kW (Btu/min) |
|---|---|---|---|---|
| 00:00–05:00 | 43.8 | 770 (43,777) | – | – |
| 05:00–10:00 | 43.9 | 772 (43,907) | 9.7 | 170 (9,686) |
| 10:00–15:00 | 44.1 | 776 (44,141) | 15.4 | 270 (15,354) |
| 15:00–20:00 | 50.0 | 880 (50,046) | 20.7 | 364 (20,720) |
| 20:00–25:00 | 51.6 | 907 (51,585) | 24.2 | 425 (24,192) |
| 25:00–30:00 | 53.8 | 946 (53,802) | 32.3 | 567 (32,263) |

Table 2 compares the average heat flux data obtained during the calibration test with the allowable heat flux ranges specified in Table 7-1.8 of NFPA 285 for the indicated period.

**Table 2. Heat Flux Values for ISMA Calibration (Average Values for Time Period Indicated).**

| Time (min) | | 0–5 | 5–10 | 10–15 | 15–20 | 20–25 | 25–30 |
|---|---|---|---|---|---|---|---|
| Calorimeter 1 (2 ft above Window, W/cm²) | Range | 0.7–1.1 | 1.5–2.3 | 2.0–3.0 | 2.3–3.5 | 2.7–4.1 | 3.0–4.6 |
| | Actual | 0.9 | 2.2 | 2.5 | 2.9 | 3.2 | 3.7 |
| Calorimeter 2 (3 ft above Window, W/cm²) | Range | 0.8–1.2 | 1.6–2.4 | 2.1–3.1 | 2.6–3.8 | 3.0–4.4 | 3.2–4.8 |
| | Actual | 1.0 | 2.3 | 2.7 | 3.2 | 3.6 | 4.0 |
| Calorimeter 3 (4 ft above Window, W/cm²) | Range | 0.6–1.0 | 1.2–1.8 | 1.6–2.4 | 2.0–3.0 | 2.4–3.6 | 2.7–4.1 |
| | Actual | 0.8 | 1.7 | 2.1 | 2.5 | 2.8 | 3.2 |

**Notes**: Window Burner placed 1 in. away from face of wall assembly.

Table 3 compares the average temperature data obtained during the calibration test with the allowable temperature range specified in Table 7-1.8 of NFPA 285 for the indicated time period. The allowable temperature range is ± 10% of the temperature values specified in Table 7-1.8.

**Table 3. Average Temperature Values for ISMA Calibration (Average Values for Time Period Indicated).**

| Time (min) | | 0–5 | 5–10 | 10–15 | 15–20 | 20–25 | 25–30 |
|---|---|---|---|---|---|---|---|
| Burner Room Average of 5 TCs (ºF) | Range | 1036–1266 | 1211–1481 | 1334–1630 | 1440–1760 | 1437–1757 | 1483–1813 |
| | Actual | 1154.7 | 1374.8 | 1447.9 | 1550.4 | 1609.6 | 1667.0 |
| Interior Wall Surface Average of 3 TCs (ºF) | Range | 959–1172 | 1168–1428 | 1290–1576 | 1420–1736 | 1418–1734 | 1490–1821 |
| | Actual | 1169.7 | 1383.5 | 1448.9 | 1566.8 | 1636.9 | 1704.2 |
| 1 ft above Window (ºF) | Range | 542–662 | 782–957 | 857–1047 | 893–1091 | 941–1151 | 970–1186 |
| | Actual | 630.1 | **976.7** | 1016.0 | 1081.3 | 1117.8 | 1182.6 |

**Table 3. Average Temperature Values for ISMA Calibration (Average Values for Time Period Indicated) (Continued).**

| Time (min) | | 0–5 | 5–10 | 10–15 | 15–20 | 20–25 | 25–30 |
|---|---|---|---|---|---|---|---|
| 2 ft above Window (ºF) | Range | 611–747 | 914–1117 | 1009–1233 | 1065–1301 | 1121–1370 | 1166–1426 |
| | Actual | 676.9 | 1062.2 | 1119.7 | 1196.0 | 1237.7 | 1306.6 |
| 3 ft above Window (ºF) | Range | 581–711 | 874–1068 | 986–1206 | 1057–1291 | 1121–1370 | 1183–1445 |
| | Actual | 604.8 | 960.9 | 1050.3 | 1145.4 | 1197.0 | 1259.2 |
| 4 ft above Window (ºF) | Range | 519–635 | 772–944 | 884–1080 | 957–1169 | 1022–1249 | 1102–1346 |
| | Actual | 522.8 | 835.3 | 931.6 | 1035.3 | 1096.3 | 1161.7 |
| 5 ft above Window (ºF) | Range | 469–573 | 689–842 | 788–963 | 854–1044 | 906–1108 | 995–1217 |
| | Actual | 469.6 | 724.8 | 826.2 | 928.5 | 993.8 | 1056.8 |
| 6 ft above Window (ºF) | Range | 425–519 | 621–759 | 708–866 | 770–942 | 822–1004 | 909–1111 |
| | Actual | **422.7** | 628.7 | 721.6 | 816.9 | 878.0 | 932.8 |

**Notes**: Window Burner placed 1 in. away from face of wall assembly. Values in bold are outside the required range. Out of range values resulted from attempting to keep other thermocouples within range.

In summary, the calibration test provides documented evidence that SwRI's ISMA successfully demonstrated the ability to achieve the fire exposure conditions specified in NFPA 285, and that the facility can perform the fire evaluation described in NFPA 285.

## 5.0 INSTRUMENTATION

A Type "C" instrumentation layout was used as illustrated in Figure 6.1(c) of NFPA 285 with some modifications. Due to the presence of a thermal barrier behind the cavity air space, and the absence of cavity insulation, thermocouples (TC) 55-67 were excluded from the test assembly. TCs were installed 1 in. off the front face of the system, and in the midpoint of the air cavity between the interior surface of the panels and the exterior surface of the Densglass® sheathing. The TCs installed in the midpoint of the air cavity between the panel and the exterior Densglass® sheathing were offset 3 in. to the left to avoid the vertical aluminum stiffeners secured to the back face of the panels. The TC locations for this test are summarized by the following diagrams:

- Exterior face, assembly core, and interior face of test wall assembly as shown in Figures A-2 and A-3.
- Burn room ceiling area as shown in Figure A-4.
- Within the air cavity as shown in Figure A-5.

The temperature measurements were made using 18-ga, Type "K" TCs in the burn room and 20-ga, Type "K" TCs in all other locations. All data was recorded at intervals not exceeding 15 s. Flow rate of natural gas to each of the burners was monitored and recorded using turbine meters and frequency converters.

## 6.0 TEST PROCEDURE

Testing was conducted on November 30, 2011, in accordance with NFPA 285. Prior to testing, instrumentation connections were verified, and the window burner was positioned such that the vertical centerline of the window burner was offset 1 in. from the exterior face of the test wall assembly. The test conditions were recorded as an ambient temperature of 65 °F and a relative humidity of 38% on November 30, 2011. The airflow across the exterior face of the test assembly was less than 4 ft/s as determined by an anemometer placed at right angles to the exterior face.

Documentation for the test consisted of digital photographs taken of the test wall assembly during the test and during post-test to include dissection of the test assembly. Color video of the exterior face of the test wall assembly was taken prior to, during, and post-test. Color video of the test wall/floor intersection in the second-floor level was taken during the test period. Information from the second-floor video is used to assist in determination of flame penetration and/or smoke development.

## 7.0 TEST RESULTS

The ISMA performance evaluation test for Alcoa Architectural Products North America was performed on November 30, 2011. Present to witness the test were Messrs. Grant Nintzel and Thomas Rogers, representing Alcoa Architectural Products North America. Visual observations made during the test appear in Tables 4 and 5. Flame propagation observations are based on sustained flames on the surface of the wall. Intermittent flaming above the sustained flames is not considered for estimating the extent of flame propagation. The following sections outline the performance of the wall assembly with respect to the conditions of acceptance detailed in NFPA 285.

**Table 4. Test Observations of Front Wall.**

| TIME (min:s) | OBSERVATIONS OF FRONT WALL |
|---|---|
| 0:00 | Start of test. |
| 2:00 | Slight sagging of window header between fasteners. |
| 2:20 | Warping of exterior panel skin. |
| 5:00 | Window burner applied. |
| 6:30 | Heavier rippling of exterior panel skin. Exterior skin still intact. |
| 9:00 | Crack forming in surface of first panel above window on the right side of the flame plume. |
| 9:45 | Crack has opened up and a piece of the exterior skin has fallen away from the system. |
| 17:00 | Core is contributing to the burning. Flaming to approximately 3 ft above window header. |
| 18:20 | The center aluminum stiffener from the backside of the first panel above the window falls away. |
| 22:45 | Panel material is gone in the main area of the flame impingement. Burning around the perimeter of the flame plume. |
| 24:00 | Burning has begun at the bottom edge of the second panel above the window. Material is sagging and falling away. |

**Table 4. Test Observations of Front Wall (Continued).**

| TIME (min:s) | OBSERVATIONS OF FRONT WALL |
|---|---|
| 26:45 | Exterior skin has melted away to the 6-ft mark above the window. |
| 28:45 | Panel core is burning 5–6 ft above window. |
| 30:00 | Test terminated. No flaming observed at the 10-ft level. Observation period begins. |
| 34:00 | Residual burning continues at the perimeter of flame plume area on the first panel above the window. |
| 39:00 | Residual burning has extinguished. |

**Table 5. Test Observations of Second-Floor Room.**

| TIME (min:s) | OBSERVATIONS OF SECOND-FLOOR ROOM |
|---|---|
| 0:00 | Start of test. |
| 10:00 | No visible changes in second-floor room. 100% visibility. |
| 20:00 | No visible changes in second-floor room. 100% visibility. |
| 25:00 | Slight decrease to visibility in second-floor room. 90% visibility. |
| 30:00 | Test terminated. Visibility in second-floor room approximately 90% at end of test. |

### 7.1 Flame Propagation, Exterior Face of Wall Assembly:

1. TCs 11 and 14–17 did not exceed 1000 °F at any time during the test.
2. Flames emitting from the surface of the exterior face did not reach a vertical elevation of 10 ft above the top of the window opening at any time during the test.
3. Flames emitting from the surface of the exterior face did not reach a lateral distance of 5 ft from the vertical centerline of the window opening any time during the test.

### 7.2 Flame Propagation, Core Components:

1. The temperatures in the air cavity behind the panels, as measured by TCs 28 and 31–40, did not exceed 1000 °F at any time during the test.

### 7.3 Flame Propagation, Beyond First-Story Test Room:

1. Flames did not occur over the surface of the exterior face beyond the concrete block walls or beyond the intersection of the test wall assembly, and the concrete block fixture walls.
2. Temperatures of the air cavity, as measured by TCs 18 and 19, did not exceed 1000 °F at any time during the test.

### 7.4 Temperatures in Second-Story Test Room:

1. Temperatures 1 in. from the interior surface of the wall assembly within the second-floor test room, as measured by TCs 49–54, did not exceed 500 °F above the ambient temperature at any time during the test.

### 7.5 Flames in Second-Story Test Room:

1. Review of the pertinent TC data, second-floor videotape, and post-test inspection indicated that flame propagation did not occur in the second floor at any time during the test.

Appendix A contains descriptions of the wall assembly. See Appendix B for photographic documentation of the test and post-test inspection. Graphical temperature data can be located in Appendix C.

## 8.0 CONCLUSION

SwRI's Fire Technology Department, located in San Antonio, TX, conducted an ISMA fire performance evaluation test for Alcoa Architectural Products North America, located in Eastman, GA. The test performed on November 30, 2011, was conducted on a wall assembly utilizing Alcoa Architectural Products North America's, *Reynobond Zinc Composite Material (ZCM) Panels* and other construction materials. Using the methods described in this report on the wall constructed as described in this report, it was shown that the wall assembly **met** the acceptance criteria stated in the NFPA 285 standard.

# APPENDIX A

## TEST ASSEMBLY DRAWINGS AND INSTRUMENTATION LAYOUT

(CONSISTING OF 6 PAGES)

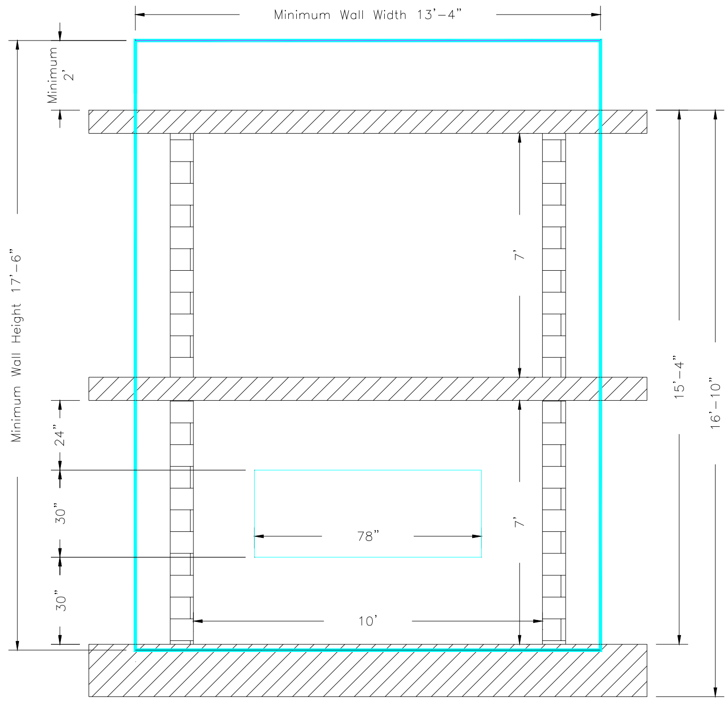


**Figure A-1. Front View of Wall System in Place on Test Structure.**

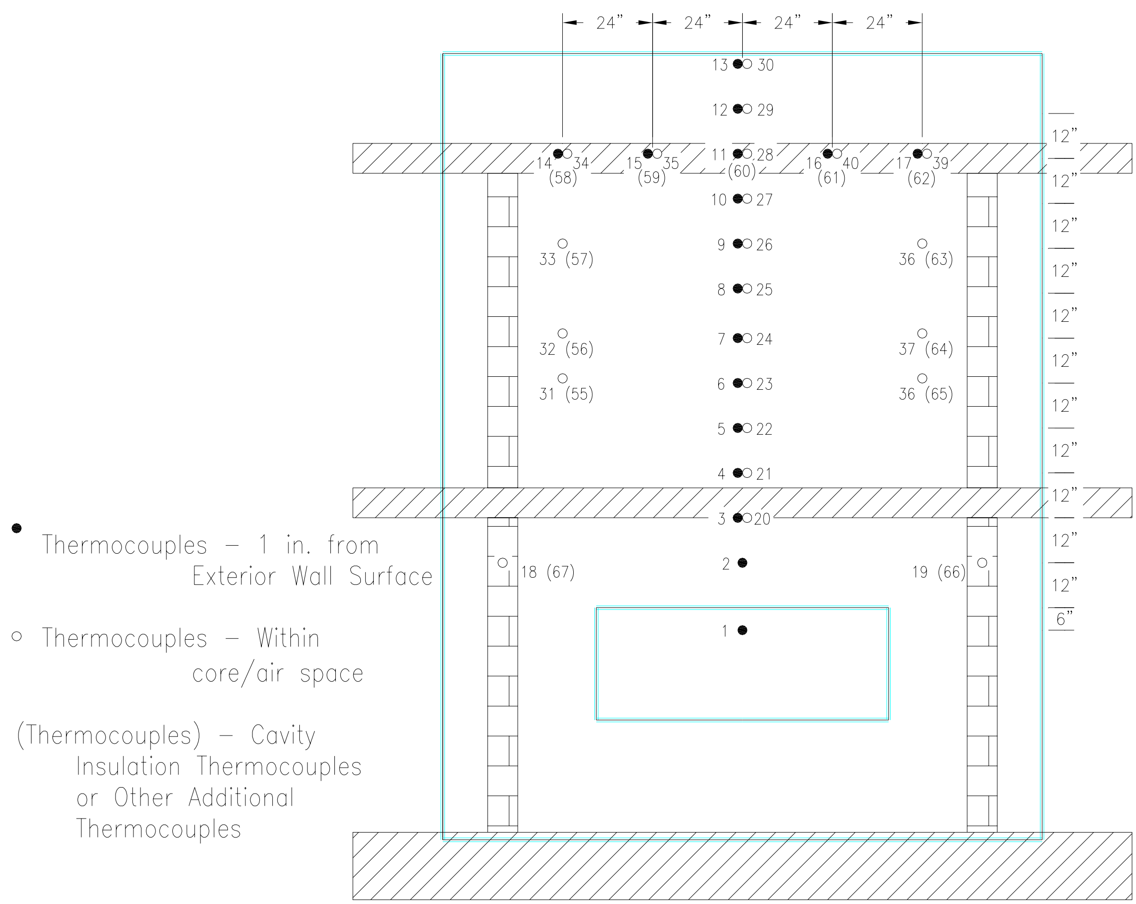


**Figure A-2. Instrumentation Arrangement (Exterior Face and Air Cavity).**

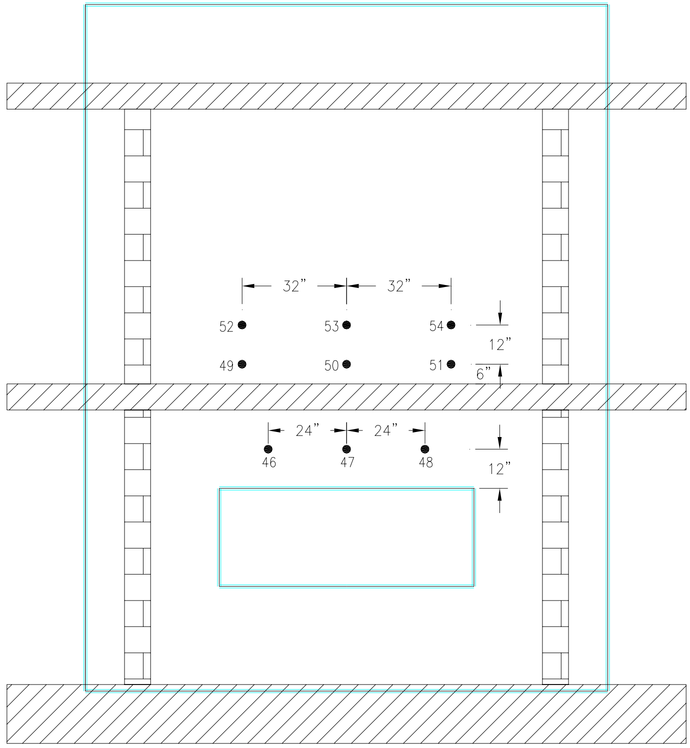


**Figure A-3. Instrumentation Arrangement**
**(Interior Face of Wall Assembly on Second-Floor Room and Burn Room).**

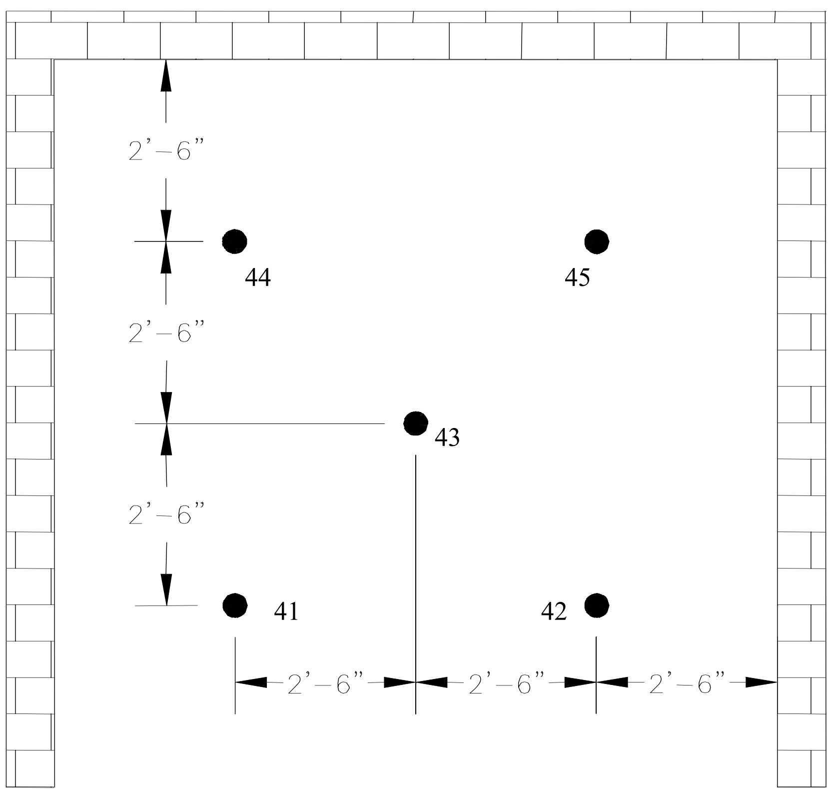


**Figure A-4. Instrumentation Arrangement (Burn Room Ceiling).**

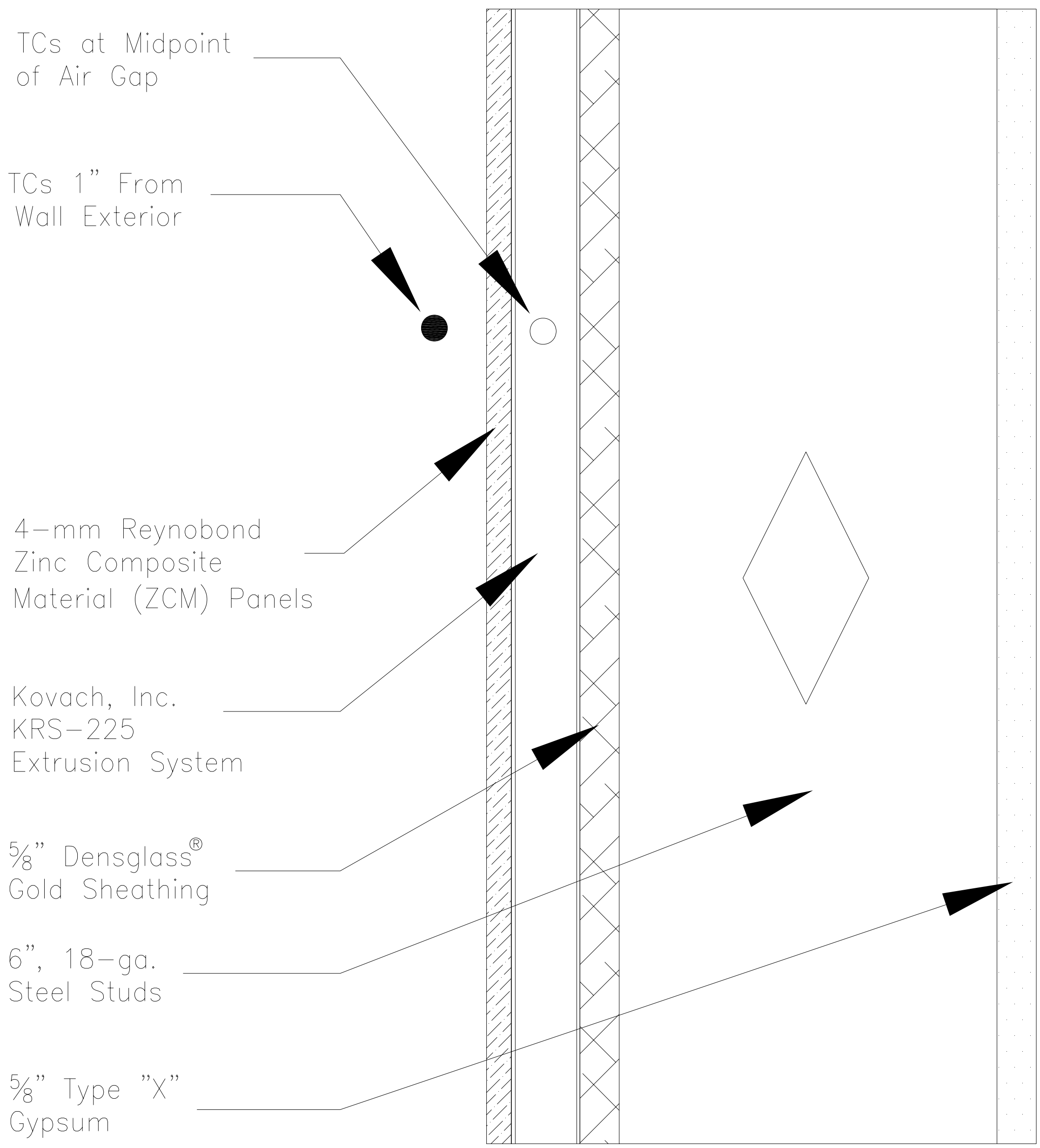


**Figure A-5. Instrumentation Arrangement – Profile View of System (Combustible Core, Air Cavity, and/or Insulation).**

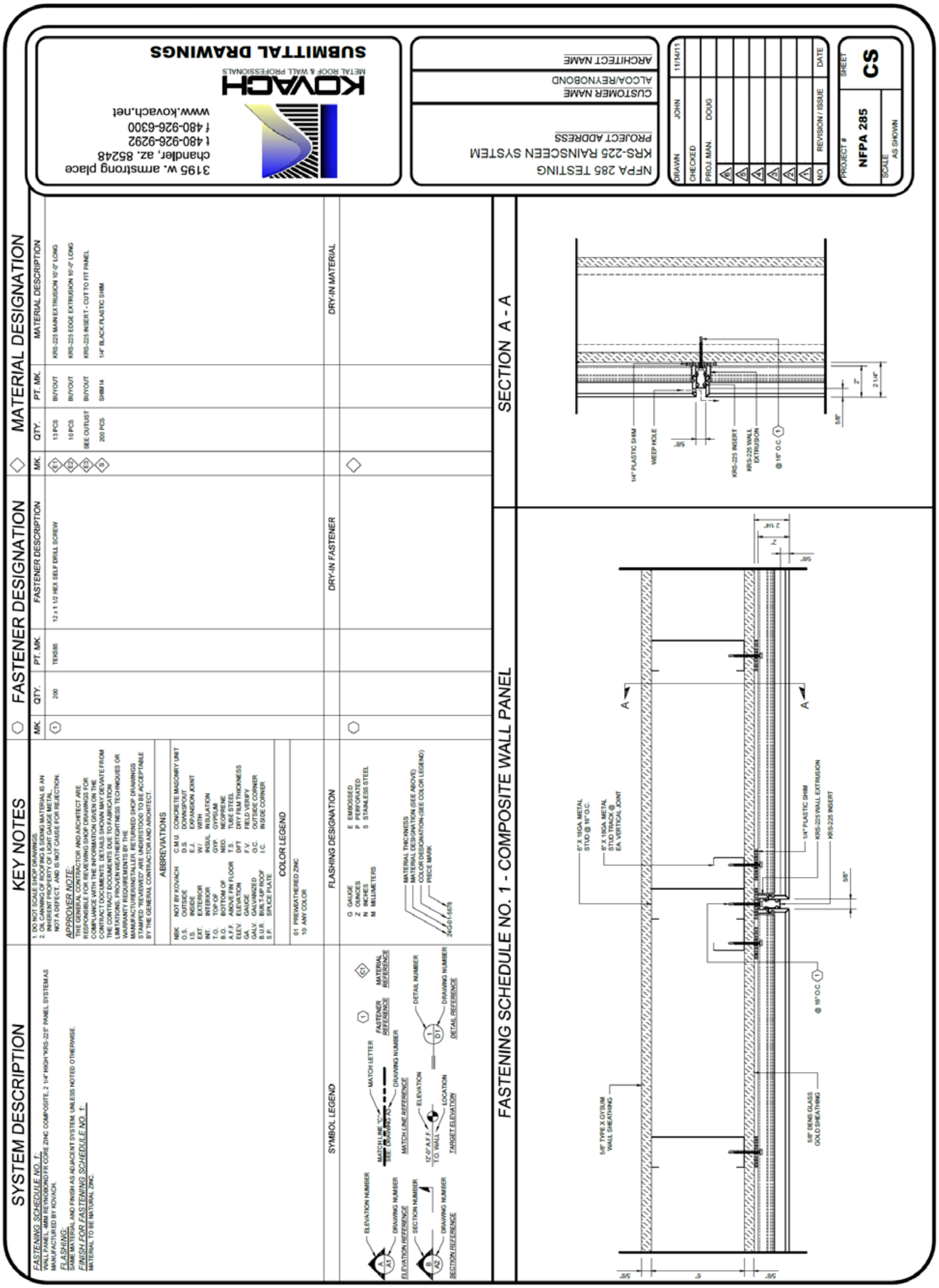


**Figure A-6. Client-Supplied Drawing (Panel Layout).**

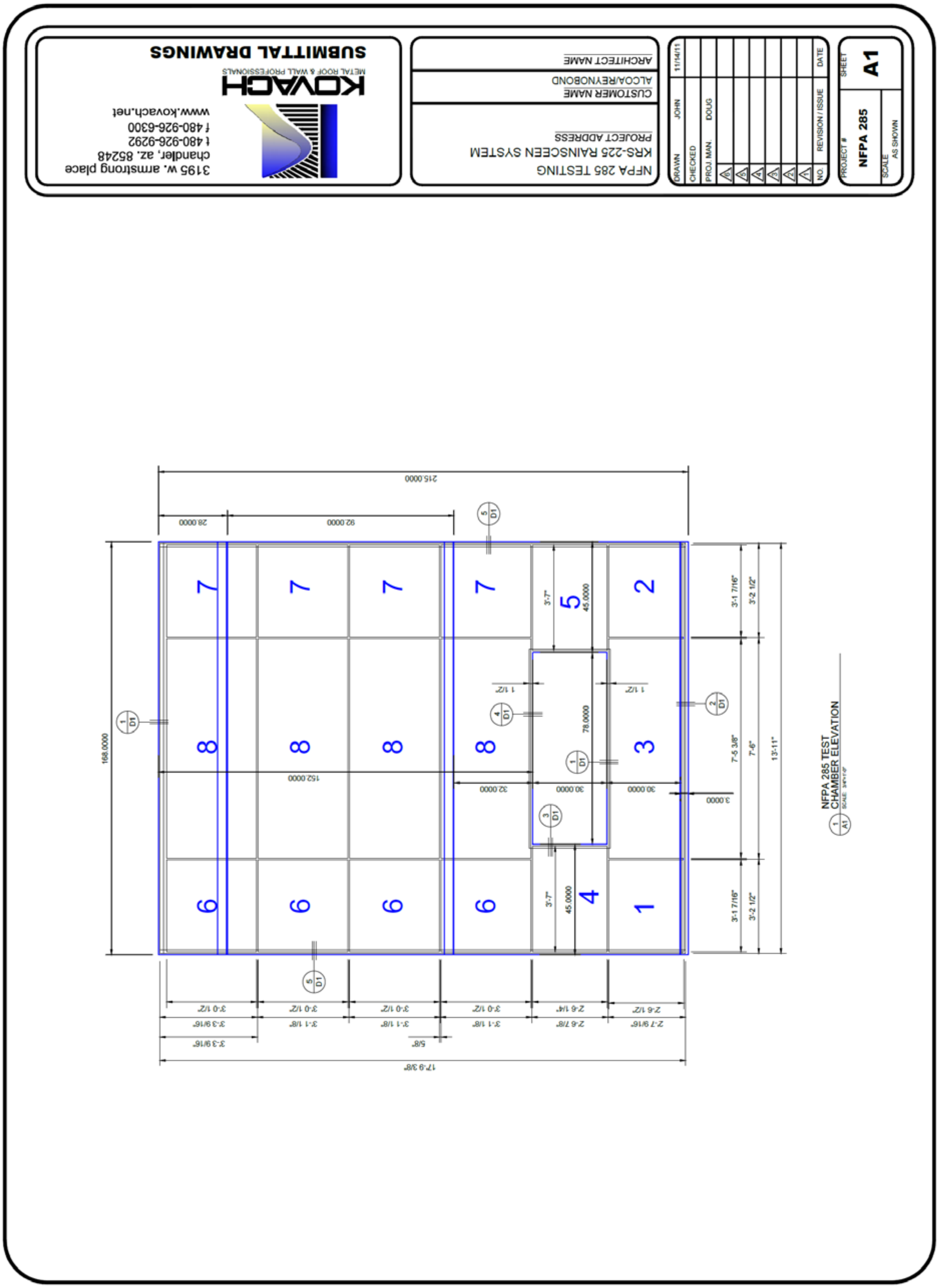


**Figure A-7. Client-Supplied Drawing (Typical Detail).**

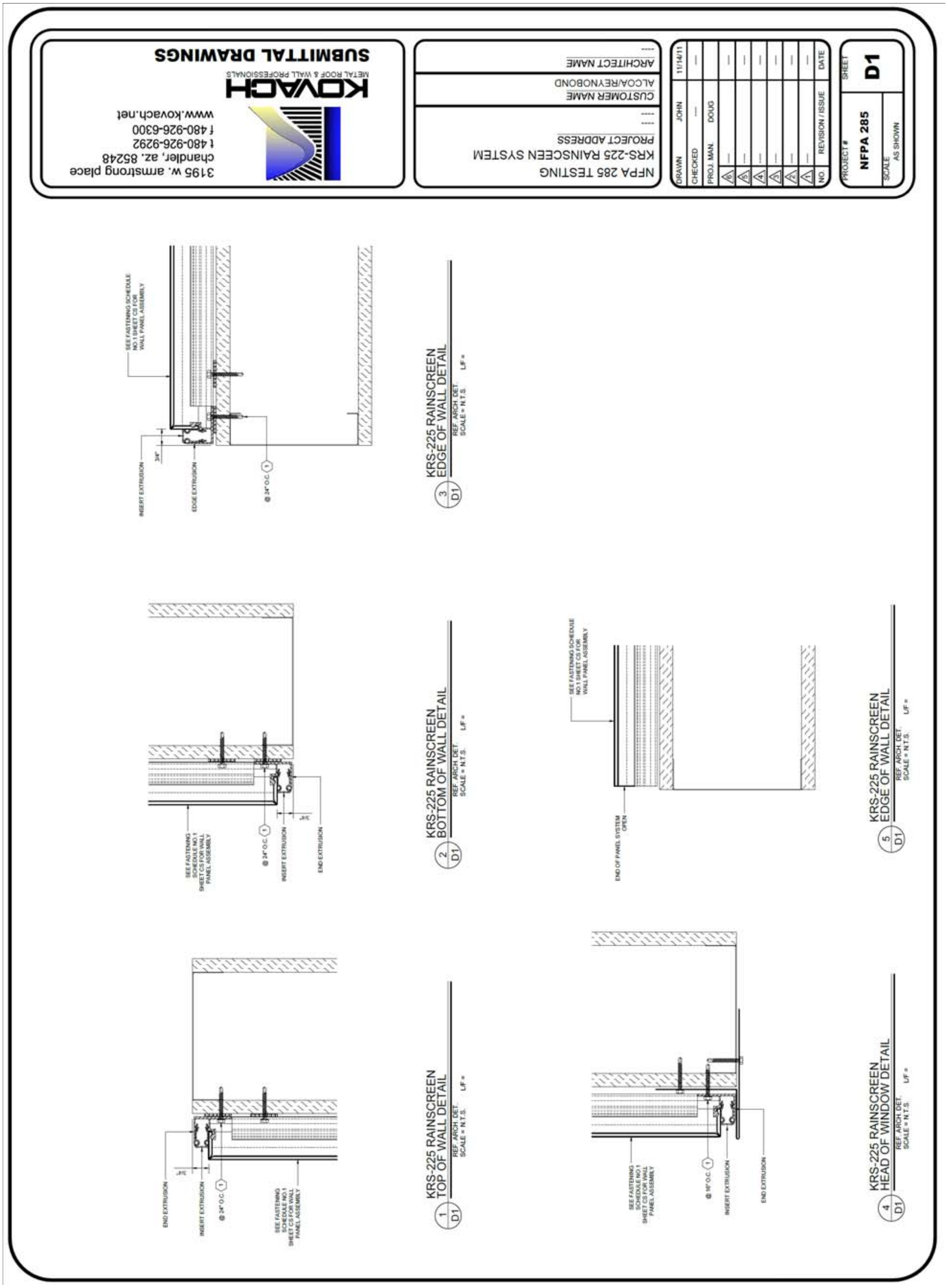


**Figure A-8. Client-Supplied Drawing (Typical Detail).**

## APPENDIX B

## PHOTOGRAPHIC DOCUMENTATION

## (CONSISTING OF 8 PAGES)

**Figure B-1. Installation of the *Reynobond Zinc Composite Material (ZCM) Panels*.**


**Figure B-2. Completed Wall Assembly prior to Test.**


**Figure B-3. Interior View of Second-Floor Room prior to Test.**


**Figure B-4. Exterior View of Wall Assembly at 3 min 25 s.**
**Warping of Exterior Panel Skin Visible.**

Figure B-5.  Application of Window Burner at 5 min.

Figure B-6.  Exterior View of Wall Assembly at 10 min 49 s into Test.


**Figure B-7. Second-Floor Room approximately 10 min into Test.**

**Figure B-8. Opening of Exterior Panel Skin at approximately 11 min into Test.**


**Figure B-9. Exterior View of Wall Assembly at 19 min 2 s into Test.**


**Figure B-10. Second-Floor Room approximately 20 min into Test.**

**Figure B-11. Exterior View of Wall Assembly at 25 min 25 s into Test.**

**Figure B-12. Exterior View of Wall Assembly at End of Test.**


**Figure B-13. Second-Floor Room at End of Test.**


**Figure B-14. Post-Test Assembly Dissection. Condition of Exterior Surface of Base Wall Underneath Panel System.**

**Figure B-15. Post-Test Assembly Dissection. Interior Surface of *Reynobond Zinc Composite Material (ZCM) Panels*.**

## APPENDIX C

## GRAPHICAL TEMPERATURE DATA

## (CONSISTING OF 6 PAGES)

Alcoa Architectural Products North America
SwRI Project No. 01.16668.01.004
Test Date: 30 November 2011
Test ID: 11-334Alcoa

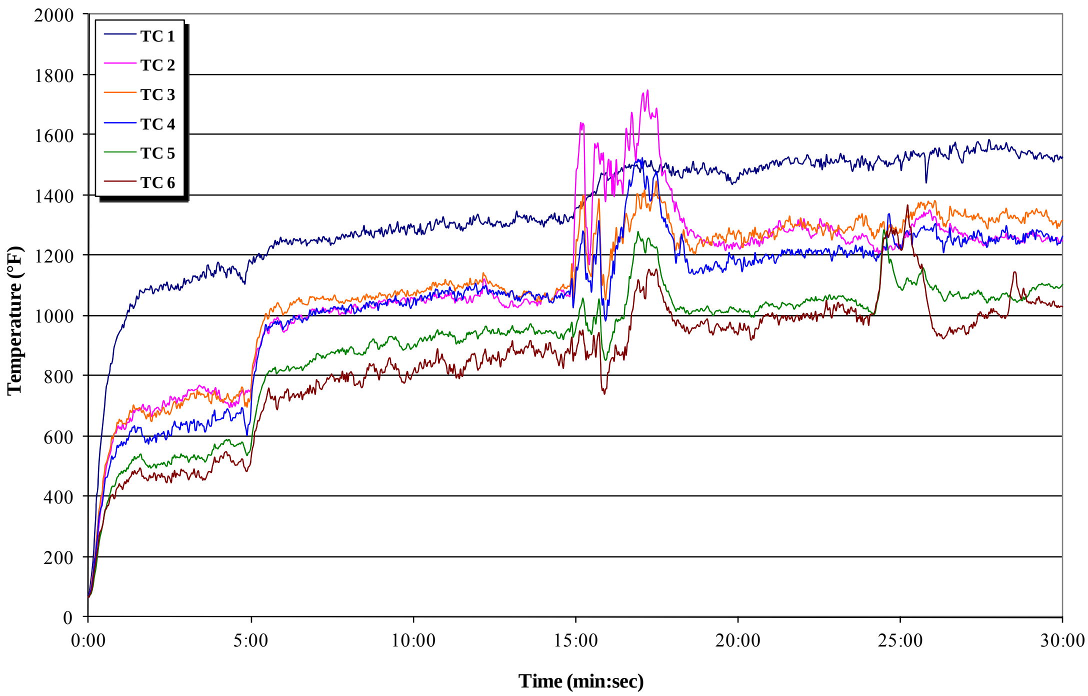


**Figure C-1. Exterior Wall Temperatures (TCs 1–6).**

Alcoa Architectural Products North America
SwRI Project No. 01.16668.01.004
Test Date: 30 November 2011
Test ID: 11-334Alcoa

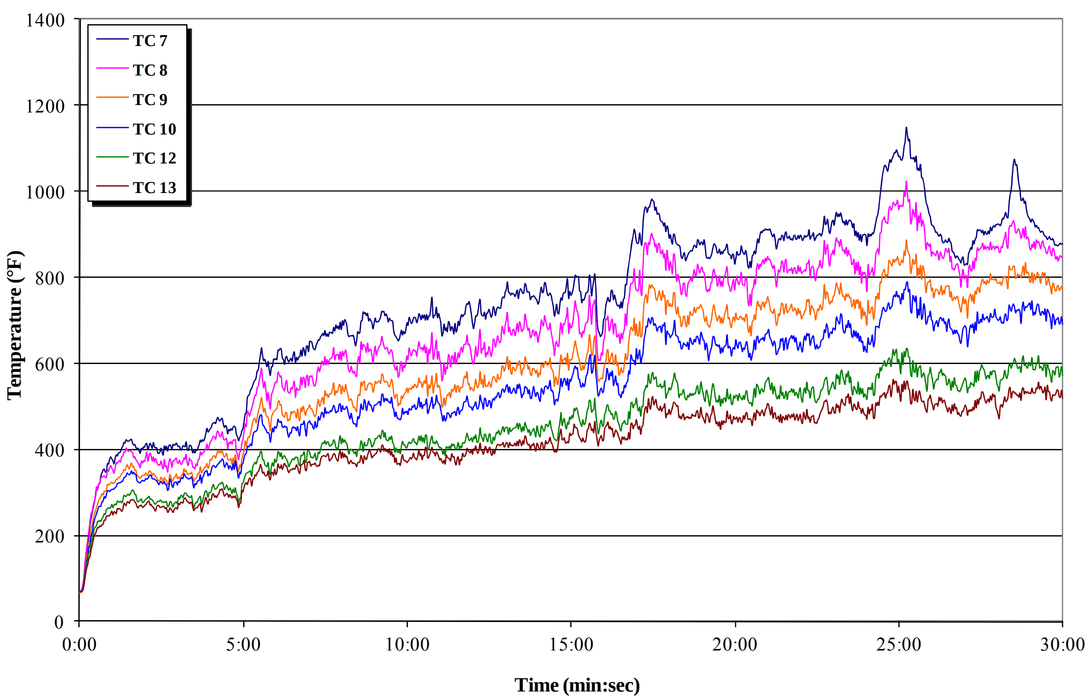


**Figure C-2. Exterior Wall Temperatures (TCs 7–10, 12, and 13).**

**Alcoa Architectural Products North America**
SwRI Project No. 01.16668.01.004
Test Date: 30 November 2011
Test ID: 11-334Alcoa

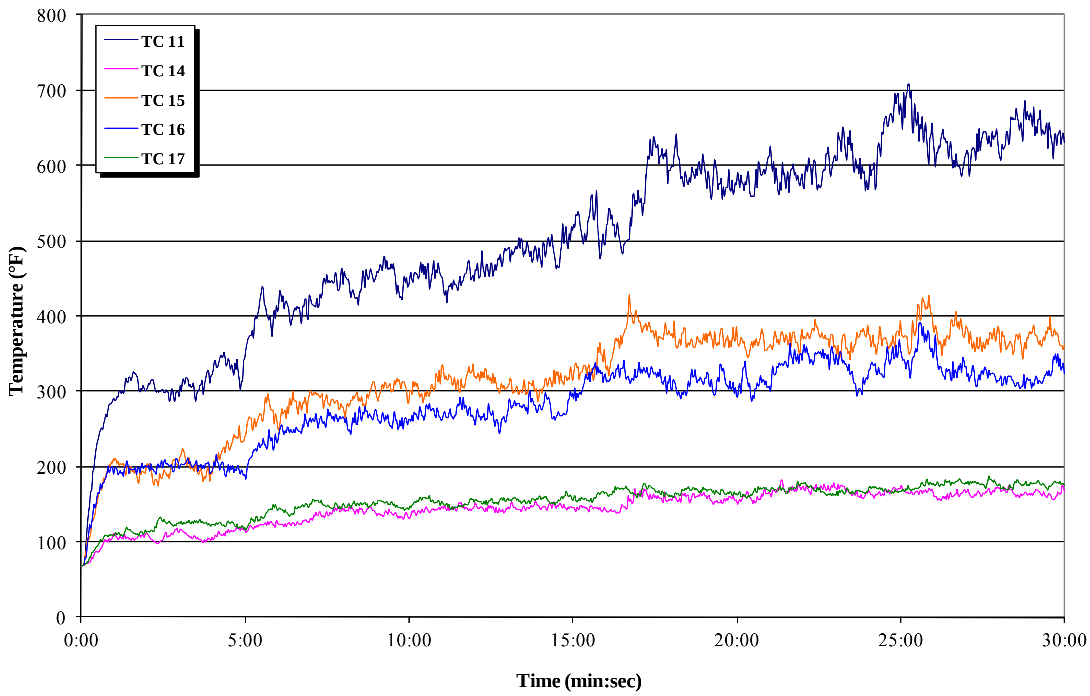


**Figure C-3. Exterior Wall Temperatures (TCs 11 and 14–17).**

**Alcoa Architectural Products North America**
SwRI Project No. 01.16668.01.004
Test Date: 30 November 2011
Test ID: 11-334Alcoa

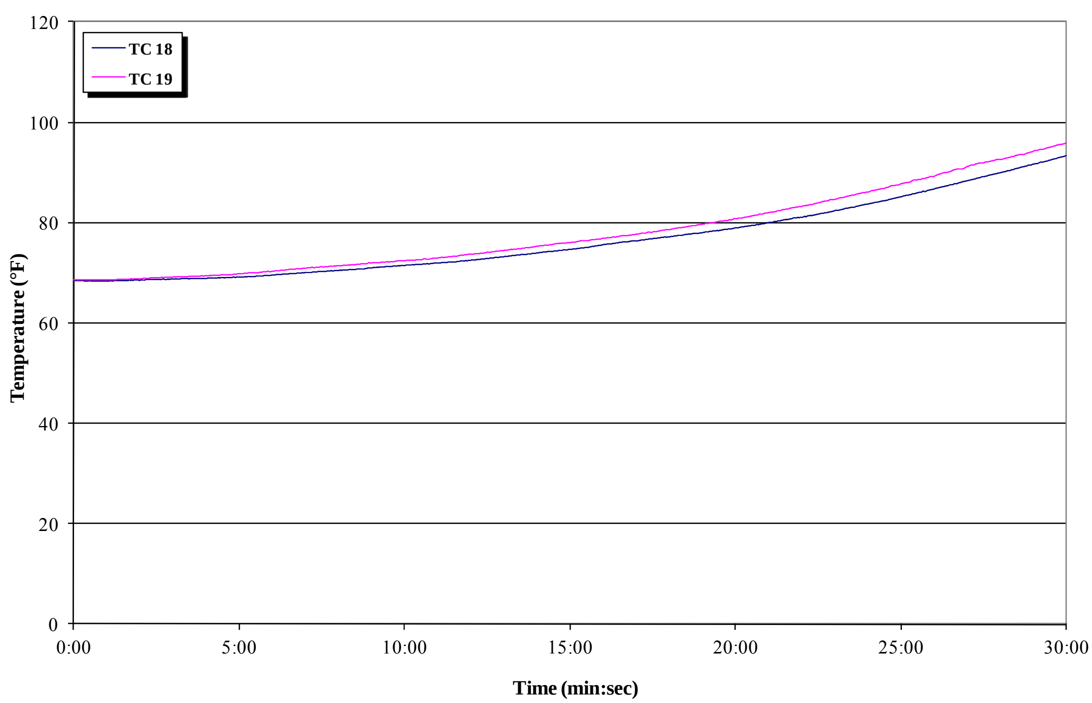


**Figure C-4. Exterior Wall Temperatures (TCs 18 and 19).**

**Alcoa Architectural Products North America**
SwRI Project No. 01.16668.01.004
Test Date: 30 November 2011
Test ID: 11-334Alcoa

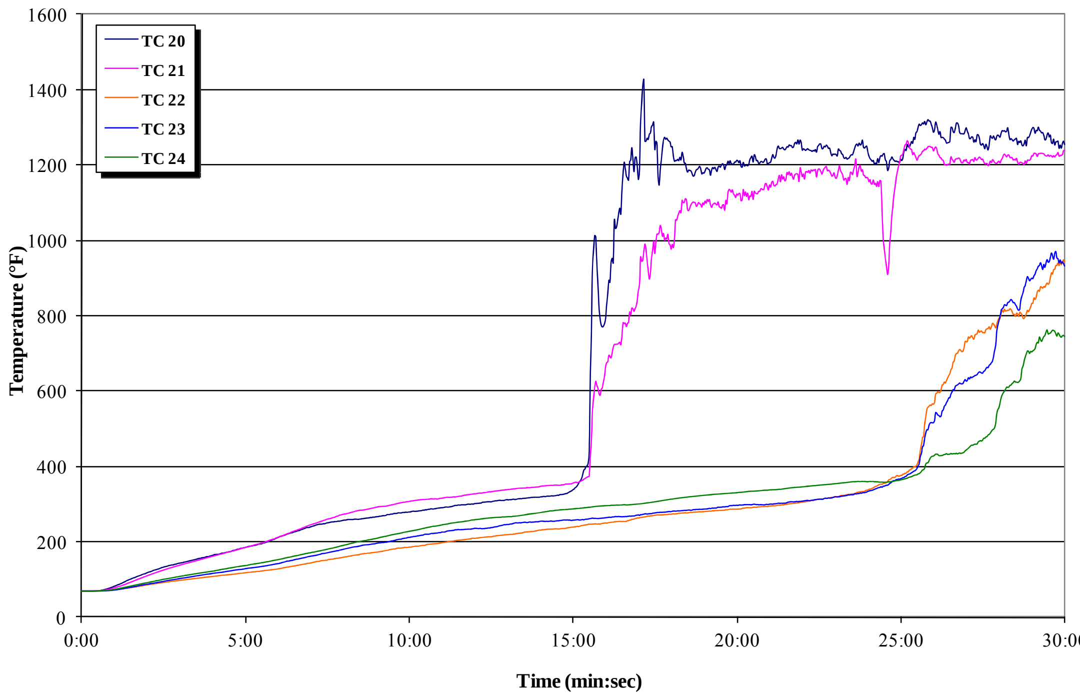


**Figure C-5. Core Temperatures (TCs 20–24).**

**Alcoa Architectural Products North America**
SwRI Project No. 01.16668.01.004
Test Date: 30 November 2011
Test ID: 11-334Alcoa

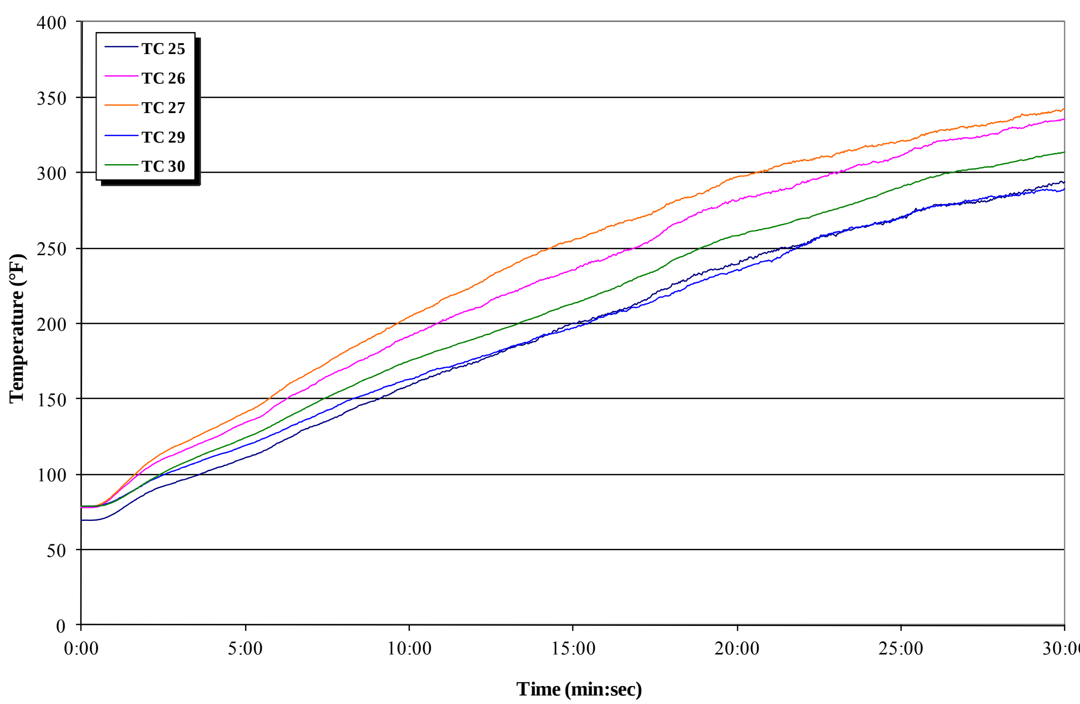


**Figure C-6. Core Temperatures (TCs 25–27, 29, and 30).**

**Alcoa Architectural Products North America**
SwRI Project No. 01.16668.01.004
Test Date: 30 November 2011
Test ID: 11-334Alcoa

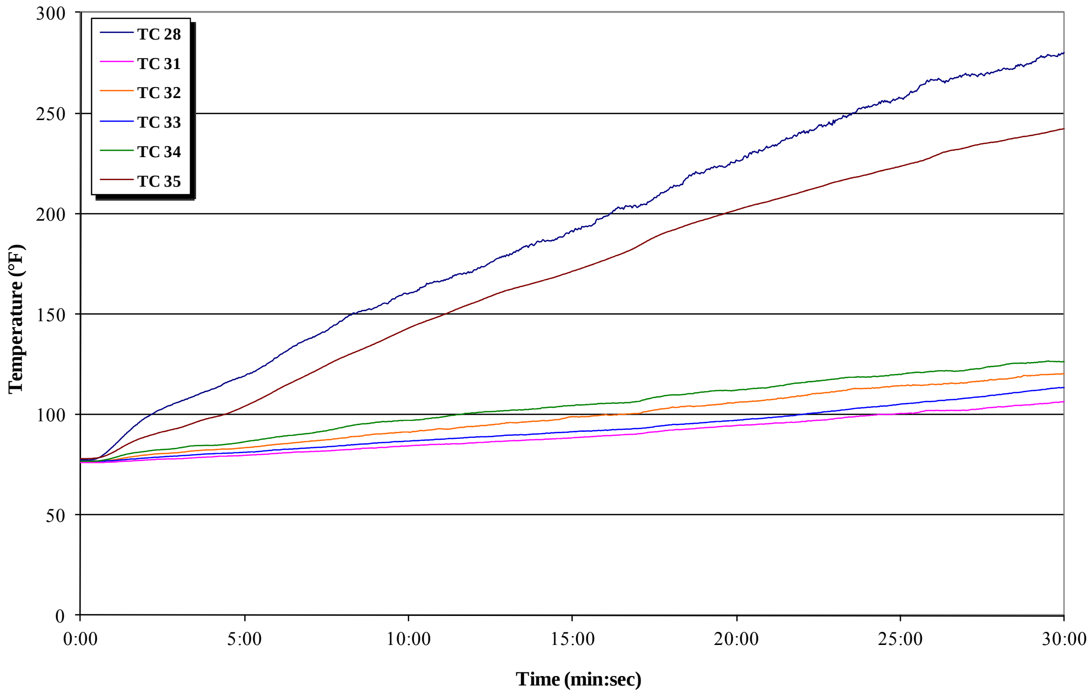


**Figure C-7. Core Temperatures (TCs 28 and 31–35).**

**Alcoa Architectural Products North America**
SwRI Project No. 01.16668.01.004
Test Date: 30 November 2011
Test ID: 11-334Alcoa

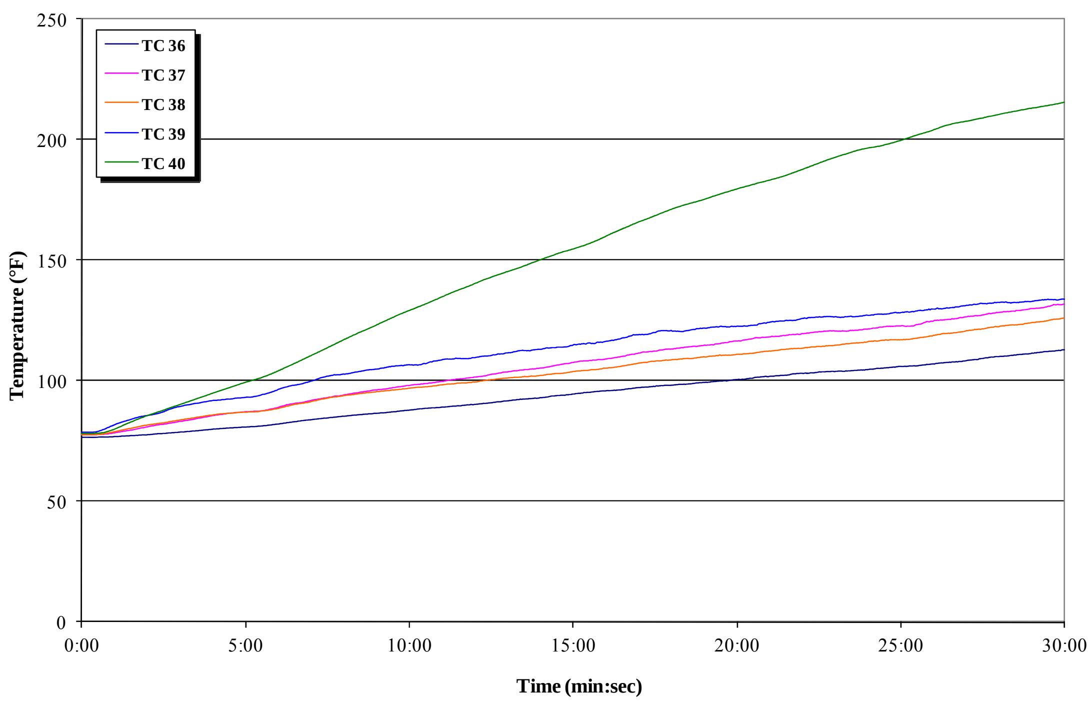


**Figure C-8. Core Temperatures (TCs 36–40).**

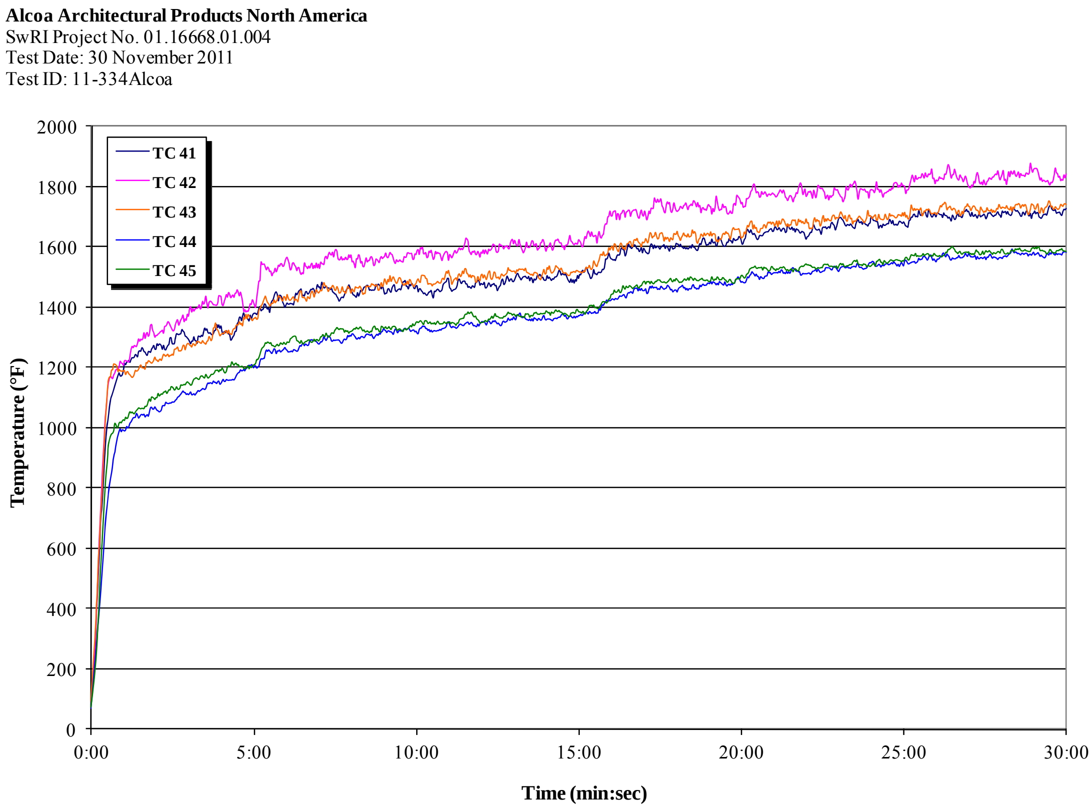


**Figure C-9. Room Temperatures (TCs 41–45).**

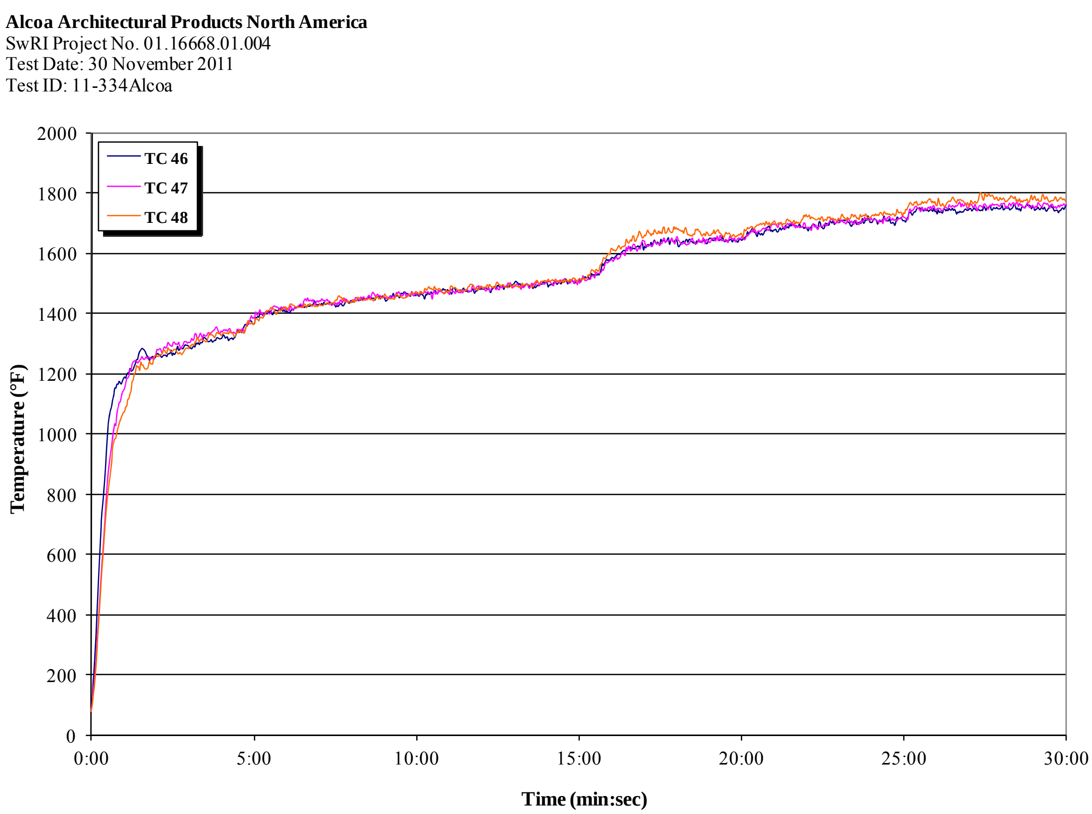


**Figure C-10. Room Temperatures (TCs 46–48).**

**Alcoa Architectural Products North America**
SwRI Project No. 01.16668.01.004
Test Date: 30 November 2011
Test ID: 11-334Alcoa

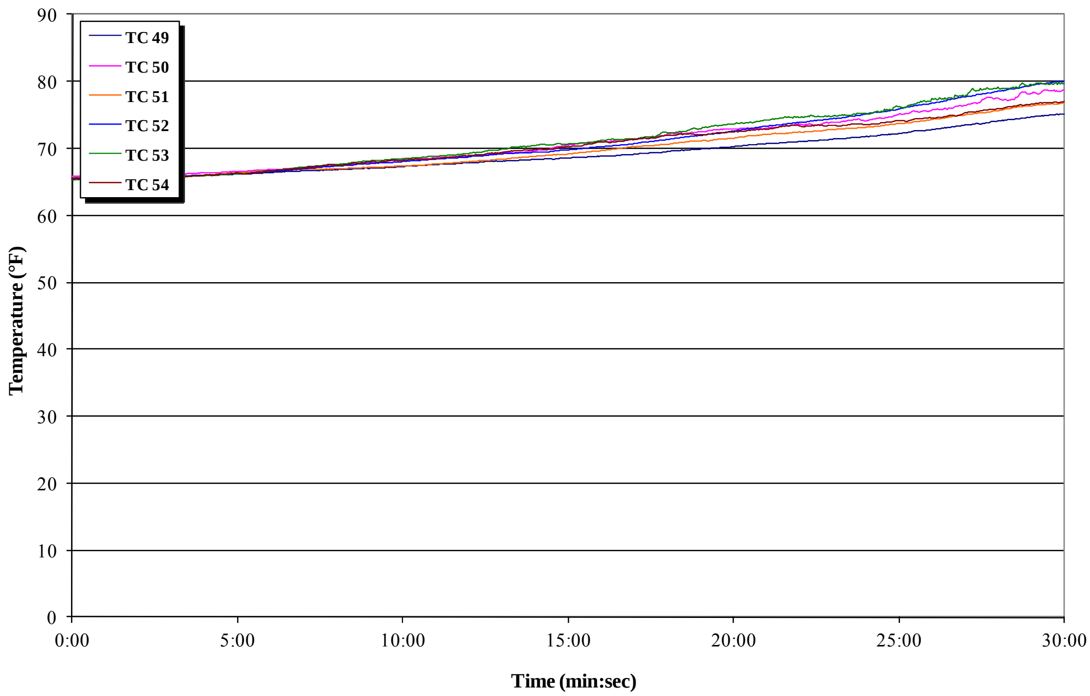


**Figure C-11. Second Story Temperatures (TCs 49–54).**