PRIEST & ASSOCIATES
CONSULTING, LLC

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FIRESIDE

Volume 3
Number 1
Spring 2015

FROM OUR VIEW

We are pleased to present the latest edition of our FIRESIDE Newsletter. We hope you find it useful and informative. As always, we stand ready to receive comments and suggestions of ways we might improve its content or specific subjects to cover.

All of us at PAC would like to take this opportunity to wish everyone a prosperous 2015

Industry Alerts!

Significant Changes to the 2015 IRC

Two significant changes to the 2015 International Residential Code (IRC) Edition regarding modifications of fire resistance requirements in R302.1 Exterior Walls - roof eave/roof overhang projections and R302.2 Townhouses - common walls separating townhouses. (See Code Corner, page 2).

California Chapter 7A Wildland Urban Interface Compliance

Questions regarding prescriptive compliance of components and assemblies with California Chapter 7A are addressed. (See Code Corner, page 2).

What Does a Building Type Mean (from a Building Code Standpoint)?

All is explained in our article on Building Construction Types – A Short Review, page 2.

Using Engineering Evaluations for Extending Data from NFPA 285 and other tests.

See Article on NFPA 285 Engineering Evaluations (EEV) and Data Share Program, page 3.

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THE CODE CORNER

By Howard Stacy how-ard.stacy@priestassociates.com
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IRC Code Changes[1]

Two significant modifications relating to unprotected roof overhangs and the fire resistance of townhouse party walls have been noted in the 2015 Edition of the IRC:

R302.1 Exterior Walls.

Unprotected roof overhangs are now permitted to project to within 2 feet of the property line when fire blocking is installed between the top of the wall and the roof sheathing. In most cases, projections are not permitted less than 2 feet from the property line. For dwellings with or without fire sprinkler protection, penetrations of exterior walls do not require fire-resistant protection unless they are located less than 3 feet from the property line.

R302.2 Townhouse Separation

The provisions for separating townhouses with structurally independent fire-resistant-rated walls in accordance with Section R302.1 have been removed in favor of the common wall provisions of Section R302.2. Common walls separating townhouses must now be rated for 2 hours when an automatic fire sprinkler system is not installed in the townhouse dwelling units.

The 2015 Code now reads as follows:

Common walls separating townhouses shall be assigned a fire resistance rating in accordance with Section R302.2 Item 1 or 2. The common wall shared by two townhouses shall be constructed without plumbing or mechanical equipment, ducts, or vents in the cavity of the common wall. The wall shall be rated for fire exposure from both sides and shall extend to and be tight against exterior walls and the underside of the roof sheathing. Electrical installations shall be in accordance with Chapters 34 through 43. Penetrations of the membrane of common walls for electrical outlet boxes shall be in accordance with Section R302.4.

For more complete information regarding these and other significant changes and the corresponding reasoning, please see the referenced document *"Significant Changes to the IRC 2015 Edition"*.

California Building Code, Chapter 7A (WUI) Compliance

From several questions asked recently regarding the compliance of building products and assemblies with Chapter 7A of the California Building Code (CBC), it seems there is a common misconception regarding the requirement for the need for publication of the listing with the State Fire Marshal's Building Materials Listing (BML) Program. The SFM listing service provides building authorities, architectural and engineering communities, contractors, and the fire service with a *reliable and readily available source of information*, but unless a local ordinance stipulates to listing with the BML, it is not mandatory. For covered products and assemblies, the code does require that the products be tested and labeled by an agency approved by the State Fire Marshal (Section 703.3 and 703.4). In addition, the code provides for prescriptive allowances which bypass the need for testing. For example, an exterior wall system incorporating either "ignition resistant" panels or ⅝ in. type X gypsum sheathing automatically complies with the requirements of Section 707A.

Please contact Howard Stacy at how-ard.stacy@priestassociates.com for more information on these and other code-related subjects.

Building Construction Types – A Short Review

Chapter 6 of the International Building Code (IBC) covers building Construction Types. Construction classifications range from noncombustible to combustible types of construction, with varying degrees of fire resistance requirements across this spectrum. The fire resistance rating requirements of the building elements allowed in these construction types are summarized in Table 601 of the IBC.

[1] Excerpted from "Significant Changes to the International Residential Code, 2015 Edition", Stephen Van Note & Sandra Hyde.

Table 602 addresses fire resistance requirements for exterior walls based on occupancy and fire separation distance. The Occupancy classification of these building types plays an important role in determining the level of fire resistance required, as well as fire separation distance. At the risk of oversimplification, a broad overview of the requirements for Construction Types is given as follows:

TYPE IA – Fire Resistive Noncombustible. Type IA buildings are typically high-rise and Group I occupancies. This classification includes 3 hour exterior walls, 3 hour structural frame, 2 hour floor/ceiling and 1½ hour roof construction.

TYPE IB – Fire Resistive Noncombustible. The Type IB classification is found in mid-rise office and Group R buildings. This classification is less restrictive than IA, and includes 2 hour exterior walls, 2 hour structural frame, 2 hour floor/ceiling separation and a 1 hour roof construction.

TYPE IIA – Protected Noncombustible. This classification can be found in warehouses, churches, arenas and school buildings. Type IIA buildings include 1 hour exterior walls, 1 hour structural frame, 1 hour floor and roof construction.

TYPE IIB – Unprotected Noncombustible. This type is commonly used in commercial buildings. No fire resistance ratings are specified.

TYPES I and II construction are those in which the building elements are noncombustible, except as specifically permitted by the code.

TYPE IIIA –This construction type allows fire-retardant-treated wood (FRTW) framing in place of noncombustible steel studs in exterior walls having a fire rating of 2 hours or less. Type IIIA buildings include 2 hour noncombustible loadbearing and nonbearing exterior walls, 1 hour bearing interior walls, 1 hour structural frame, and 1 hour floor and roof construction.

TYPE IIIB – Unprotected Combustible. Up to 2 hour noncombustible exterior walls (FRTW allowed). No requirements specified for interior walls, floor separation, roof construction or structural frame.

TYPE IV – Heavy Timber (HT). 2 hour noncombustible exterior bearing walls (including the allowance for FRTW), 1 hour structural frame or heavy timber, HT floor and roof construction. This classification also includes the use of cross-laminated timber construction.

TYPE VA – Protected Wood Frame (common in apartment construction). 1 hour exterior and interior bearing walls, 1 hour structural frame and 1 hour floor and roof construction.

TYPE VB – Unprotected Wood Frame (typically single family homes and garages). No fire ratings required (with the exception of regulated structures in Wildland Urban Interface zones).

Foam plastics are permitted in noncombustible exterior walls of Types I, II, III and IV construction classifications when in compliance with the NFPA 285 test requirements of IBC Chapter 26. Combustible water-resistive barriers (WRBs) and exterior claddings complying with the requirements of Chapter 14 are also allowed.

NFPA 285 Engineering Evaluations (EEV) and Data Share Program

One of our main services is writing Engineering Evaluations (EEV's). Others refer to these as Engineering Judgments or Judgment Letters. EEV's are engineering reports to allow alternate materials to be used in a tested assembly based on a test report that is submitted to us for evaluation. We analyze alternate constructions or materials used in the assembly to determine if the alternate construction or material used in a different assembly can still pass the test. We write these evaluations for many fire tests (E119, NFPA 286, etc.) but the focus today will be on NFPA 285 assemblies.

The Problem – Why EEV's?

A typical wall assembly can consist of (interior to exterior) interior gypsum wallboard, steel studs, cavity insulation, exterior sheathing, WRB, exterior insulation, WRB, air gap and cladding. For each of these components, many variables exist. For the cavity and exterior insulation, this can include insulation type, thickness, and density. For the WRB's (or AVB), this can include the huge array of manufacturers, types, and models available. The same can be said of the interior and exterior sheathing, stud gauge and depth, use of fire stops, and the huge array of claddings (with or without air gaps) available in the market. For some applications, the design of the window header can be very important.

Considering the number of choices for each component, the number of possible constructions can reach into the tens of thousands of assemblies. Without EEV's, each assembly needs to be tested to prove it can work (i.e., pass the test). The cost to comply with a fraction of the possible assemblies can reach into the millions of dollars since each NFPA 285 test costs approximately $18,000 – plus materials, shipping, installation and travel costs.

Typical Scenario

Most manufacturers test a handful of assemblies – hoping that they are similar enough to field designs that they will encounter when bidding for projects. The building official then must determine if the tested assembly is close enough to the building design to allow the construction to proceed. Many building officials do not want to take this risk and seek the advice of fire professionals to make the determination. This is the point at which the manufacturer seeks an EEV to determine if the exterior wall design can pass the test.

Seeking an EEV for each project can be cumbersome and expensive. So, manufacturers rely on fire professionals to lay out a table of allowed alternate materials so that architects and building officials can pick and choose from a menu of choices to create an assembly which has already been predetermined (via analysis) to pass the test.

What We Do

We typically start with a tested assembly and make a list of the materials used. We then make a list of conservative alternate materials which we know will improve results. This typically includes use of thicker stud gauges, shorter stud spacing, thicker sheathings, thinner insulations (and/or less dense), replacement of insulations with noncombustible products and alternate WRB/AVB materials based on relative flammability data using cone calorimeter tests. Exterior cladding choices can be evaluated via reduced air gaps and improved thermal performance.

<u>The only problem with this is the limited choices we have available based on publically available data, reports and approvals.</u> The range of extensions we can grant is limited by the amount of data available for alternate products or materials. The items most limited are alternate WRB/AVB products, insulation types, and claddings.

Data Share Program

Priest & Associates has worked with an extensive list of clients who are willing to share NFPA 285 or cone calorimeter reports to extend the range of choices we have for new clients. Some of our clients manufacture exterior insulations, cavity insulations, WRB/AVB products and claddings. It is in our clients' best interest to allow use of their reports for EEV's of new clients to extend the number of evaluations which reference their tested products.

The data share program starts with PAC asking an existing client for permission to use their data or reports for use in the analysis for a new client's EEV. The data or report is not shared with the new client, nor is the data revealed. The data is kept confidential in PAC files and is only used for reference and analysis for the new EEV.

Successful Examples

We have successfully been granted such permissions to analyze and add WRB/AVB products to several EEV's of manufacturers of exterior insulations who have conducted their own NFPA 285 test(s) with specific WRB(s). The reverse has also been successful in which we obtained permission to analyze and add exterior insulation products to EEV's for manufacturers of WRB/AVB products.

Also, our clients who manufacturer SPF cavity insulations have granted permission to use their NFPA 285 reports to allow use of SPF cavity insulations for a wide variety of wall configurations.

Call Us

If you hold a successful NFPA 285 report, and are seeking to expand the list of alternate products, call us to find out how we can help. We can also write job-specific Engineering Letters (short EEV's) for specific building projects if you do not need a full EEV. In all cases, we need an existing NFPA 285 report in order to successfully achieve your goals. If you do not hold an NFPA 285 report, we can help you design an NFPA 285 test which has a good chance of passing and has the most potential for granting engineering extensions to allow use of alternate products or materials.

THE STANDARDS BOX
By Deg Priest

Recent changes to ASTM E119 Fire Tests of Building Construction and Materials

The E119 standard (one of the oldest fire test standards we have) is undergoing some changes to bring it up to date. Some of these changes are:

Conditions of Acceptance for Loadbearing Beams

For many years, the requirement was to simply have maintained the applied load (which was certainly leaving a lot to interpretation). In 1999, the ISO 834-1 and EN 1363-1 standards on fire resistance adopted criteria for both amount of deflection and rate of deflection. This requirement was added to E119 as well, in 2012. The required conditions are:

A maximum total deflection of:

$$\frac{L_c^2}{400d}$$

And, after the maximum total deflection has been exceeded, a maximum deflection rate per minute as determined over 1 min intervals of:

$$\frac{L_c^2}{9000d}$$

Where:

L_c = the clear span of the beam, and
d = the distance between the extreme fiber of the beam in the compression zone and the extreme fiber of the beam in the tensile zone.

The units of L and d must be the same (e.g., inches or millimeters).

Construction of Furnace Temperature Probes

Until late 2012, the E119 furnace temperature probes were allowed to be constructed of No. 18 GA. Chromel-Alumel thermocouple wires, mounted in porcelain insulators and inserted into standard weight, nominal ½ inch iron, steel, or Inconel pipe. The thermal time constant of the completed device was required to be between 5.0 and 7.2 minutes.

ASTM E119-12a, however, modifies the requirements by requiring ½ in. Inconel 600 pipe, specifying the dimensions of the ceramic insulators, and allowing the use of Chromel-Alumel (i.e., Type K) thermocouple wires of 14, 16 or 18 GA. Since the construction is now so closely described, the time constant requirement was deleted.

These, and other changes to this often used standard are all being done to remove inter-laboratory variables in the test equipment and improve harmonization across the building materials industry.

Recent change to ASTM C1396 Standard Specification for Gypsum Board

In reaction to corrosion issues caused by gypsum board installed in buildings in warm, humid locations, ASTM has recently added Section 4.7 Volatile Sulfur Compounds to the standard for gypsum board. This requirement limits the amount of a specific type of sulfur (orthorhombic cyclo-octasulfur, S_8) present in gypsum board to no more than 10 ppm. This sulfur compound, as stated in the standard, "…when exposed to heat, humidity, or both, emits volatile sulfur compounds in quantities that cause abnormal corrosion on electrical wiring, plumbing pipes, fuel gas lines, HVAC equipment, or any components of the foregoing."

ISO Fire Standards Update
By Deg Priest

The ISO TC92/Subcommittee 2 (on Fire Containment) working groups are developing new fire tests continuously.

Discussion and test programs are underway examining the question of whether or not solid steel tension rods (coated with fire protective materials) need to be fire tested. BAM in Germany and Akzo-Nobel in the UK have done some testing, the results of which are being examined by the committee.

Work continues on another part to ISO 834: a standard for evaluating protected beams with web openings.

Development of standards to evaluate Lift Landing (Elevator) Doors, Horizontal Door Assemblies, Fire Curtains and others continues.

GRP Gratings (update)

A growing concern about the performance of Glass-Reinforced (GRP) Gratings when exposed to hydrocarbon pool fires has been brought to ISO TC92/Subcommittee 2, to see if there is enough interest to begin a new work item developing a standardized test method for evaluating these products. The worry is that GRP Gratings successfully tested using the cellulosic fire curve (such as ISO 834 or ASTM E119) may not perform adequately when exposed to a high temperature, short duration hydrocarbon fires which may be experienced on off-shore facilities. Much interest in this subject has arisen, and we will keep reporting on the committee's progress in the future.

ACROSS THE PONDS
By Deg Priest

EUROPE/MIDDLE EAST/ASIA (EMEA)

The United Arab Emirates (UAE) and other Middle East countries continue their move towards using North American standards, and adopting many sections of the International Building Code. Commercial and industrial construction in the Middle East remains very strong. New construction in the Middle East is expected to remain strong for years to come.

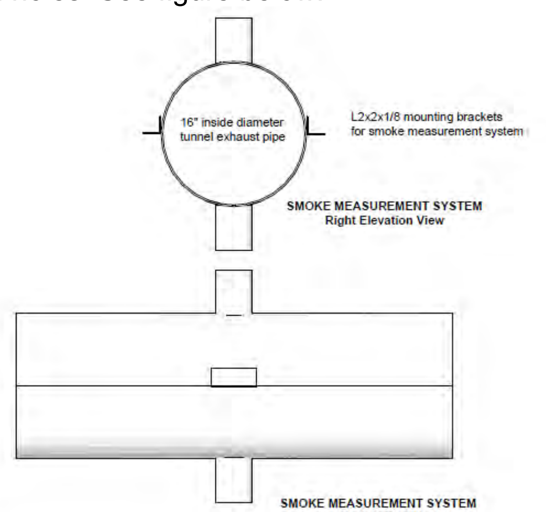
An example of the scale of construction occurring is the Kingdom Tower, a kilometer-high building under construction in Jeddah, Saudi Arabia, at an estimated cost of $1.23 Billion. This tower is to be the centerpiece of a planned $20B development, to be called the Kingdom City. The Tower is being designed by American architect Adrian Smith, who also designed the Burj Khalifa in Dubai.

HOW IT WORKS
By Javier Trevino

Possible Source for Non-Reproducibility Between Labs of Steiner Tunnel Smoke Measurements

One unique aspect of our Fire Test Equipment consulting services is that we get to see how different labs interpret the standards. In ASTM E84 section 5.19, the photometer system is described. The description indicates that the beam of light shall pass through 3 inch diameter openings in the exhaust duct, and that the distance between the light source and photocell shall be 36 inches.

Almost every lab I have visited uses 4 inch pipe welded to the exhaust duct which contains the 3 inch holes. See figure below:



The 4 inch pipe is left open at the bottom pipe, but most labs use a slab of glass mounted on the top of the upper pipe. The standard does not specify guidance on this but it is what most labs do. The upper pipe can hold smoke if it is not allowed to draw in purging air. Additionally, the glass will develop a soot layer as smoke accumulates on the glass surface. This causes two problems. First, the smoke trapped in the upper pipe increases the measured smoke density depending on the length of the pipe. With this arrangement, we have witnessed smoke densities (opacity) as large as 40% during red oak calibrations, while the smoke curve for red oak (Fig. 9 in ASTM E84) peaks around 12%. Second, as smoke accumulates on the glass, the zero-baseline becomes non-zero and increases over time while more and more smoke accumulates on the glass. At the end of a test, we have seen the "zero" reading be as high as 5 or 10% opacity. There are solutions to this but first some history on this issue.

Short History of Purge Air (by Deg Priest)

Round robin testing in the late 1970's revealed the fact that most of the smoke in the exhaust tube is traveling along the upper third of the cross-section of the tube. For that reason, doubling of the amount of smoke volume does not result in a doubling of the amount of smoke in the light path, hence a compression of the smoke readings. One solution was to thoroughly mix the exhaust at the tunnel exit end (by use of an orifice plate) and change the smoke measurement calculation to optical density (which is linear with respect to the number of smoke particles). With such a huge database of existing tests, it was decided that the only practical thing to do was to maintain the calculation methods and not mix the exhaust, since many previously-approved materials and products might have their status changed. However, all labs agreed at the E5 meetings to run open on bottom and closed on top, with a small, controlled leakage or forced air addition to keep smoke out: an important improvement. It has been known and discussed at ASTM E5 meetings over many years that if the top opening is left wide open, incoming, clean air dilutes the smoke stream penetrating into the smoke layer about 4" before being bent by the exhaust flow, resulting in as much as 6" of clean air with no smoke in it, thus dramatically reducing the measured smoke opacity. This has been confirmed recently during a lab visit. As discussed above, it is emphasized that he exhaust flow is extremely laminar with hot gases flowing on top of the exhaust pipe and cooler gases along the bottom of the exhaust pipe. Consequently, inrushing clean air has a large effect when it enters from the top of the smoke metering system, but almost no effect when it enters from the bottom. Based on the discussion above we recommended at the E5 meetings years ago that the top be sealed (with a small air leakage hole, to avoid pooling of smoke in the top tube), and the bottom be left open. This verbiage never ended up in the standard.

A Simple Solution (by Priest and Trevino)

Since the exhaust duct is under negative pressure due to the location of the blower, allowing fresh air to purge the top smoke tube eliminates the problem of soot deposits on the glass and smoke lingering in the upper tube. By simply drilling purge holes in the top pipe section, both problems disappear, and a red oak calibration curve similar to Figure 9 in the standard is achieved. The location of the holes should be within an inch or two from the top of the pipe (close to the glass). The size and number of holes needed varies. We have seen as few as one ¼ inch hole (with forced air purge) work, and a series of 4 symmetrical ⅜ inch holes (natural inflow) work. In some cases, raising the glass off of the pipe with thin spacers (approx. ⅛ inch) produces the same effect. The goal is to experiment with the inflow of clean air until a read oak curve similar to the one depicted in the standard is achieved.

HOW IS SMOKE MEASURED?

Two different methods of measuring smoke are currently used in various fire test standards: percent transmission and optical density.

Steiner Tunnel

Percent transmission is an intuitive unit of smoke as used in the E84 Steiner tunnel. This is simply the ratio of the light intensity versus the starting light intensity. $\%T = V/V_0 \times 100$ where V_0 is the voltage of the photocell at the start of the test, and V is the voltage during the test at any given time. As the test progresses, V changes creating a smoke curve. But, in the E84 tunnel, %A is displayed in test reports as the percent absorbed curve (or % obscuration). This is simply a relationship such that %A + %T = 100. One can then calculate %A based on %T. The %A curve is then integrated to obtain the area under the curve (%A-min). This is then compared to the red oak %A-min to obtain the Smoke Density Index. SDI = %A-min for the tested product divided by %A-min for red oak x 100 then rounded. (The %A is used, since it displays a signal proportional to the amount of smoke present, as opposed to %T, which represents the amount of transmitted light.)

Fire Calorimeters

Optical density is a logarithmic function that better represents the number of smoke particles in an air stream, being directly related. Optical Density uses the formula OD = $\log_{10}(V_0/V)$ (or $\ln(V_0/V)$ depending on the standard), which is more scientifically useful than percent obscuration and is used for calculations of smoke measurements in calorimetry tests.

When performing smoke density calculations, fire calorimeter software calculates the logarithm of the ratio (V_0/V), where V_0 is the initial photocell reading without smoke and V is the current photocell reading during a test. A reference signal (via a beam splitter and 2nd photocell) adjusts the calculation if the laser beam is drifting or noisy. This logarithm is a measure of how many particles blocked the beam of light but is a non-dimensional value (i.e., has no units).

Since $\log_{10}(X)$ or $\ln(X)$ are proportional to the number of particles, then dividing by the length of the beam provides a measure of particles per meter. That is why one sees smoke units in terms of (1/m or m^{-1}) in some test reports. This is sometimes called the smoke extinction coefficient, k, but uses the natural logarithm ln(X) in the calculation.

The smoke density depends on the volume flow rate of the blower system so we normalize this by multiplying the optical density value by the volume flow rate which results in smoke numbers having units of m^2/s. This is called Smoke Release Rate and is relatively independent of the flow rate (i.e., the SRR is constant over a wide range of duct flow rates). This is typically used in full scale calorimeter tests. Integrating SRR over time yields the Total Smoke Release (TSR) used in full scale room fire tests.

SRR is a "self-correcting" formula for various blower volume flow rates. For a given fixed smoke density release, as you increase the blower speed, more fresh air enters the hood, cools the airstream, increases the orifice plate pressure, decreases the smoke density and results in a constant smoke release rate. If you decrease the blower speed, less fresh air enters the hood, causes the airstream temperature to rise, decreases the orifice plate pressure and increases the smoke density, resulting in a fixed constant smoke release rate.

You can test this with a cone calorimeter during a constant burn. However, during a short transition, you will see a spike or dip in smoke release rate as the time lagged variables catch up with the change until equilibrium is re-established. So, never change the blower speed during a test and spikes in SRR data will be avoided.

In fire calorimeter applications, multiplying the natural log optical density by the volumetric flow rate, then dividing by the mass loss, we obtain the specific extinction area as seen in some test reports. This has units of m^2/kg. This is essentially dividing the SRR by the mass loss and integrating with respect to time. This is also the same as TSR divided by mass loss.

Smoke units are confusing and have "weird" units. In NFPA 286, the total smoke release (TSR) is the integrated SRR curve and has units of m^2. This has nothing to do with square meters of area. The units just happen to have units of geometric area. In ASTM E84, a Smoke Developed Index of 450 is considered the cutoff for life safety. It is rumored that the 1000 m^2 TSR value listed in the building codes for NFPA 286 was calculated based on the SRR of a product which produced a 450 SDI in a tunnel test. This needs confirmation but I have heard it from more than one reliable source.

I hope this information helps in understanding smoke density units. - Javier

DID YOU KNOW?
By Javier Trevino

PAC's Equipment Design and Construction Activities

Since we began offering this service, we have designed and built/rebuilt the following types of test equipment:

Intermediate Calorimeter (ICAL)
PenLight/IRMS (a specialty high intensity furnace)
Many ASTM E84 units have been built or upgraded.
Penetration Seal Air Leak Apparatus
ASTM E119 Furnaces – Various sizes
NFPA 285 Apparatus – Several
ASTM E1354 Apparatus - Several

We have also written software packages to control and/or monitor all of the above test methods.

WHO WE ARE

Deg Priest
President

Deg Priest has been involved with fire testing of building materials since 1977. His career spans a wide range of product development, fire test equipment design and construction, attendance on consensus standards setting organizations and P&L management of fire testing laboratories.

Javier Trevino
Principal

Javier Trevino has been in the fire testing industry for 22 years. His expertise lies in flammability issues (E84, NFPA 286, NFPA 285, cones, etc.). He is our expert in fire modeling, computer programming, and field work involving refurbishing and commissioning of fire test equipment such as tunnels, cones, furnaces, HRR hoods.

Howard Stacy
Principal

Howard Stacy has more than thirty five years of experience encompassing a broad range of fire testing, product development, construction litigation support and 3rd party certification for the building products and construction industries. Howard is the Chairman of SC E05.14 "External Fire Exposures" under ASTM E5 committee on Fire Standards.