When Fire Containment Is Absolutely Imperative
Substation

Precast Products

Buildings/Shelters
Concrete Vaults
Fire Wall
Sound Wall
Fence Products

Trench Systems
Padmounts
Convault Above Ground Fuel Storage
Small Box Enclosures

Precast Foundations

Light Pole Bases
Control Bldg Foundations
Cell Block Foundations

Pipe Supports
Tower Foundations
Power Transformer Foundations
Substation Products & Services

Oldcastle Precast is the leading manufacturer of precast concrete, polymer concrete, and plastic products in the United States. In addition to the products listed above, we provide a wide range of products and services to the power transmission and distribution industry. Whether the project requires transformer pads, inverter buildings, or end transformer firewalls, from beginning to end and every point in between, we have the right product solutions to meet your application needs. We also welcome the opportunity to develop custom products to meet your specific project needs.
TRANSFORMER FIRE CONTAINMENT WALLS INSTALLED IN RECORD TIME

In less than twenty-four hours, a six-man crew at Imperial Irrigation District (IID) retrofitted three large transformer firewalls at a critical transmission substation. The firewalls are needed to contain transformer oil fires from spreading between three 230 kV transformers, a control house, and other equipment at the Coachella Valley Substation. This substation is a vital power hub for power transfers between Arizona, California and Mexico; hence, outage time must be minimized. The key to such a construction success lies in IID management’s selection of TruFireWalls.

Each firewall measures 40 by 24 feet. The walls were quickly assembled in the field from fire resistant precast columns and panels. First, the columns were bolted to the existing foundation and aligned. Next, the panels were slid down the grooved columns and assembly was then complete. Disassembly of these removable maintenance-free firewalls is equally simple and quick.

SUBSTATION FIRE HAZARD CONDITIONS AND POTENTIAL CONSEQUENCES

A power substation by its nature contains all the right ingredients to generate the perfect firestorm. A typical transmission transformer bank consists of three or more transformer tanks, each containing 10,000 to 45,000 gallons of mineral oil. The initial spark is likely to come from electrical arcing inside the tank, which also generates heat and pressure high enough to rupture the tank. Oxygen immediately rushes into the tank. The oil violently explodes accompanied by a blast of intense radiation, flying shrapnel, and flaming oil. The radiation’s effect is instantaneous and has been documented to ignite other transformers more than 60 feet from the initial fire.

The temperature of an oil fire is in the range of 960°C to 1,200°C. A power transformer’s fire duration ranges from 4 to 28 hours, which is, in most cases, the time it takes the fire to burn itself out. As larger substations are often located in outlying
areas, the fire department's response time is long. In addition, fire trucks are rarely equipped to suppress these supersized oil fires.

Firewalls are only a third of the total solution to effectively protect a substation against fire. The other two components needed are an early detection and alert system and the correct fire suppression system. Hence, the installation of effective firewalls is the bare minimum to protect a transformer bank and neighboring equipment.

In general, existing standards and codes do not realistically address the actual conditions of large hydrocarbon pool fires in open air. Therefore, performance-based criteria need to be applied to ensure effective fire protection in substations. To replicate real-world requirements, a transformer firewall must be exposed to a four-hour fire followed immediately by a high-pressure water jet blast on the same test sample.

The replacement cost of a large transformer is about $1.5 million to $2.5 million per phase. However, the higher cost by far is the replacement energy, which must be purchased from the spot market at premium prices. During peak hours, rates could spike up to $200,000 per hour.

Compounding the problem, the delivery time on a rush basis for these transformers is about 18 months. Insurance premium increases may be imposed (conversely, insurance companies have reduced rates when fire walls are installed), and long-lasting unfavorable public relations with the community, regulators, and investors can result.

**EFFECTIVE CONTAINMENT OF TRANSFORMER FIRES**

Effective transformer firewalls must be:

1. made from materials that can withstand the intense high temperature and long duration of these fires;
2. designed such that both thermal and mechanical requirements are met before, during, and after the fire.

Traditionally, transformer "fire walls" have been built from reinforced concrete and/or concrete blocks. The initial cost of these walls is deceptively low, because these materials do not perform as needed under high temperature. At 650°C, concrete retains only about 35% of its room temperature strength, and steel has practically no strength left at that same temperature, which is about 350°C lower than the oil fire's 'working' temperature as shown below.

Hence, concrete walls fail under the actual conditions of a transformer fire. Furthermore, concrete walls are large and heavy, requiring deep reinforced foundations, and they must be torn down and rebuilt when major transformer maintenance is performed.

The firewall must also have sufficient impact resistance to survive shrapnel impingement because it is quite possible that the fire will initiate a transformer explosion. As there is yet no standard for firewall impact loading, ballistic and explosion experts have recommended applying UL Standard 752. This is equivalent to a firewall panel stopping a 44 Magnum projectile with no through-penetration, as the IID wall panels are capable of doing.

Refractories, as used in the IID firewalls, are water-based and totally inorganic with nothing to burn. The relatively lightweight thermal panels and
columns are cast from time-tested refractory concrete. Refractories emit no volatile organic compounds or hazardous material when manufactured, during the fire, or when disposed. The time-proven refractory cements that have been used for centuries to handle molten metal in foundries and smelters clearly meet the thermal and mechanical requirements over the service life of the substation.

Field-proven refractories and the well-established manufacturing process by Oldcastle Precast, with 80 plants throughout the United States, ensure that the required thermal and mechanical performance is achieved at a competitive cost. TruFireWalls by ThermalLimits are designed and certified to meet thermal, wind loading, seismic, and substation layout requirements. The modular design reduces manufacturing and installation costs.
Key Information on *TruFireWalls*

1) ThermaLimits Flyer

2) *TruFireWalls* Installation Case Study

3) Fire Wall Technologies Comparison Table

4) Loss of Strength with Temperature of Glass Reinforced Composite Walls

5) Loss of Strength with Temperature of Concrete Composite Walls

6) Life Cycle Costs - Concrete vs *TruFireWalls*

7) Installation Costs - Concrete vs *TruFireWalls*

8) Partial List of *TruFireWalls* in Service
Innovative Utility Installs Cost-Saving Transformer Fire Containment Walls in Record Time

Effective Fire Containment with Minimum Installation Time

In less than twenty-four hours, a six-man crew at Imperial Irrigation District (IID) retrofitted three large transformer fire walls at a critical transmission substation. The fire walls are needed to contain transformer oil fires from spreading between three 230 kV transformers, a control house, and other equipment at the Coachella Valley Substation. This substation is a vital power hub for power transfers between Arizona, California and Mexico; hence, outage time must be minimized. The key to such a construction success lies in IID management’s selection of TruFireWalls™.

Simple and Quick Installation: One Day - One Wall*

Each fire wall measures 40 by 24 feet. The walls were quickly assembled in the field from fire resistant precast columns and panels. First, the columns were bolted to the existing* foundation and aligned. Next, the panels were slid down the grooved columns and assembly was then complete. Disassembly of these removable maintenance-free fire walls is equally simple and quick.
Step One - Position, align, and secure the columns.

Step Two - Slide in the panels and …

The installation is COMPLETE!
Substation Fire Hazard Conditions and Potential Consequences

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In general, existing standards and codes do not realistically address the actual conditions of large hydrocarbon pool fires in open air. Therefore, performance-based criteria need to be applied to ensure effective fire protection in substations. To replicate real-world requirements, a transformer fire wall must be exposed to a four-hour fire followed immediately by a high-pressure water jet blast on the same test sample.

The replacement cost of a large transformer is about $1.5 million to $2.5 million per phase. However, the higher cost by far is the replacement energy, which must be purchased from the spot market at premium prices. During peak hours, rates could spike up to $200,000 per hour.

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Hence, concrete walls fail under the actual conditions of a transformer fire. Furthermore, concrete walls are large and heavy, requiring deep reinforced foundations, and they must be torn down and rebuilt when major transformer maintenance is performed.

The fire wall must also have sufficient impact resistance to survive shrapnel impingement because it is quite possible that the fire will initiate a transformer explosion. As there is yet no standard for fire wall impact loading, ballistic and explosion experts have recommended applying UL Standard 752. This is equivalent to a fire wall panel stopping a 44 Magnum projectile with no through-penetration, as the IID wall panels are capable of doing.
An IID fire wall panel stops a 44 Magnum bullet.

Refractories as used in the IID fire walls are water-based and totally inorganic with nothing to burn. The relatively lightweight thermal panels and columns are cast from time-tested refractory concrete. Refractories emit no volatile organic compounds or hazardous material when manufactured, during the fire, or when disposed. The time-proven refractory cements that have been used for centuries to handle molten metal in foundries and smelters clearly meet the thermal and mechanical requirements over the service life of the substation.

Field-proven refractories and the well-established manufacturing process by Oldcastle Precast, with 80 plants throughout the United States, ensure that the required thermal and mechanical performance is achieved at a competitive cost. TruFireWalls are designed and certified to meet thermal, wind loading, seismic, and substation layout requirements. The modular design reduces manufacturing and installation costs.
Transformer Fire Walls versus No Fire Walls

Physical Problem  =  EXTREME Fire Hazard  =  HIGH Risk

Substation Conditions (A HOT recipe):
- Fuel Type:
  - Highly combustible liquid hydrocarbon
  - Mineral oil has a higher energy content than gasoline

- Very LARGE Volume of fuel
  - Typical power transformers contain about 10,000 to 45,000 gallons per phase
  - The codes classify a flammable liquid as a hazard if the volume exceeds 5 gallons!

- Very high temperature spark provided by an electrical arc
  - The arc’s temperature exceeds that of the surface of the sun
  - Arcs, partial arcing or full-fledged arcs, inside a transformer are not unlikely events

- The oil is contained in a pressurized tank
  - Heat generated under fault conditions generates pressures high enough to rupture welded seams or shear off one-inch diameter bolts
  - The codes classify a flammable liquid as a hazard if the pressure exceeds 15 pounds!

Characteristics of a Transformer Oil Fire

- Violent explosions usually result as oxygen enters the tank, accompanied by a blast of intense radiation, flying shrapnel, and flaming oil
- The radiation’s effect is instantaneous. This type of heat flux ignited a second transformer 70 feet away from the fire origin.
- The flame core temperature of an oil fire is in the range of 960°C to 1,200°C
- A typical power transformer fire has a duration of 4 to 28 hours, which is in most cases the time it takes the fire to burn itself out.
- The larger power substations are often located in outlying rural areas, hence the fire department’s response time is usually too long.
- Fire departments, with few exceptions, are not trained nor equipped to suppress these type of oil fires (The standard fire truck carries only 5 gallons of chemicals to produce foam, which is by far a more effective suppression medium than water.)
- Water in excessive amounts is generally used to “fight” transformer fires, which produces large amounts of steam increasing the danger to personnel and creates an environmental clean-up problem of large proportions
When utilities do install a fire suppression system on their transformers, water sprinklers are used.

Fire walls are only a third of the total solution to effectively protect a substation against fire. The other two components are an early detection and alert system and the correct fire suppression system. Hence, the installation of the appropriate fire walls is the bare minimum to protect a transformer bank and its neighboring equipment or structures.

The seriousness of the fire hazard inherent to an electrical power substation was recognized circa 1910, as evidenced by transformer fire walls separating all transformer units in an early hydro generating plant, in addition to a special trap door at the bottom of the transformer tanks to dump the oil into the river as soon as the fire was detected.

A California utility experienced three 500 kV transformer bank fires within a period of five years. The transformers that originated the fires varied from newly installed to middle-age. The trend is for a higher frequency of catastrophic type of failures as transformer age and the system is cycled in ways it was not designed to operate.

Potential Costs Resulting from Uncontained Transformer Fires

- Replacement cost of transformer = $1.5 Million to $2.5 Million per phase
- Replacement energy cost, during peak hours = $100,000 to $200,000 per hour (Long term contracted economy energy would most likely not be accessible after the fire and purchases from the spot market must then be made at premium prices.)
- There are no domestic manufacturers of large power transformers. The delivery time on a rush basis for these transformers is about 18 months.
- Possible increase of insurance rates (conversely, insurance companies have given rate reductions when fire walls are installed)
- Unfavorable public relations

What Do the Standards Say?

- IEEE 979 specifies fire wall dimensions and their placement relative to the transformers being protected. This standard references ASTM E-119 on the testing methods to be used for fire walls, which is in accordance with the ICC’s codes (IBC, UBC, CBC, and local building codes). However, IEEE 979 does not require fire walls if there is a minimum separation between power transformers of only 30 feet, which is well known to be unrealistic and exceedingly risky.
- ASTM E-119’s test procedure is adequate if the four-hour rating is applied. But this standard specifies a maximum allowable temperature rise, which applies for fires in buildings and is irrelevant for a transformer fire. On the other hand, this standard provides two loop holes that can result in an ineffective transformer fire wall:
a) The hose stream test, which is supposed to be performed immediately after the four-hour fire exposure, appears to be optional (in the real world fire walls are blasted with cold water at 45 psi or more when the wall’s surface temperature is close to 2,000°F, and the wall must survive to continue to contain the fire);
b) The use of a fresh sample is allowed to perform the hose stream test, thus bypassing the thermal shock, erosion, and pressure withstand tests necessary to verify the fire wall’s survivability and integrity.

- NFPA standards reference ICC and ASTM fire wall standards. Standard NFPA 860 on fire protection at nuclear plant substations is scheduled for adoption in 2010. It might better reflect the actual conditions of an oil fire outdoors. The Nuclear Regulatory Agency has recently been more active enforcing fire protection in substations.
- ASTM 1529 on testing methods for fire rating of structures used in the oil industry’s installations was written to replicate more faithfully an oil fire.
- The US Navy has the most stringent and most realistic standards to protect against oil fires on board their ships, which ironically are surrounded by a sea of water. (Foam suppression was invented by the Navy.)

- In general the standards and codes do not realistically address the conditions of large hydrocarbon pool fires in open air (very high temperatures, extra long duration, extreme radiation and heat flux as compared to solid fuel fires with limited oxygen supply). Performance-based criteria need to be applied to assure effective fire protection in substations.

What Does the Law Say?

- What is the law?
  a) Adopted standards and codes are the law.
  b) Best practice in the industry.
  c) The general consensus by experienced litigation attorneys specializing in cases of fire origin is that if the owner of an installation is aware of an alternative method or technology to better protect against fire, and that alternative is economically competitive, a judgment will usually go against the owner if the owner chose not to apply the better technology.
Only *TruFireWalls'* refractory can take the heat.
Concrete and Block Walls Installation Costs versus Precast Refractory TruFireWall Savings

Practical construction factors result in significant cost and time when building a substation fire containment wall from concrete or block, as compared to precast refractory TruFireWalls.

Examples of Hidden Installation Costs of Concrete and Block So-called “fire walls”

- **Site preparation** - Foundations need to be increased to support the much greater weight of either concrete or block.
- **Much longer installation lead time** - Block and concrete both require a large footprint for installation and need to be installed well in advance of the transformers.
- **Wind loading** - Both concrete and block often require additional support to withstand wind loads. This is usually done by constructing wing walls, which adds to construction costs, interferes with access to the transformer, and reduces transformer ventilation cooling, hence de-rating of the transformer’s capacity.
- **Crane time** - In most substations projects, the large transformers will be on site long before the walls or barriers are installed and will need to be stored off the pads until such time as the walls can be erected. This could double the crane and crew time because the transformers must be relocated at a later date.
- **Schedule impact** - Block and concrete both require weeks or months to install and can also be delayed due to weather. Mobilizing and de-mobilizing crews will further impact costs.
- **Heating and shelter** - Both concrete and block require environmental protection in the northern zones before, during, and after installation to ensure a good finish.
- **Curing time** - Block may only be installed to a certain height per day to ensure proper curing time is allowed for strength. Concrete requires 28 days to cure and reach its rated strength. Construction concrete and block walls require scaffolding with its consequent high cost and cumbersome OSHA compliance requirements.
Precast Refractory *TruFireWalls* Installation Benefits

- **Site preparation** - Greatly reduced foundation requirements … in most cases pilasters and a shallow grade beam between columns are sufficient.
- **Schedule impact** - Installed (or removed) at the utility’s optimum time:
  
  ‘*One wall … One day’*. Minimum impact on construction and outages schedules.

- **Wind loading** - TruFireWalls are engineered to be free standing structures requiring no additional support.
- **Crane time** - All transformers can be installed in their final location upon delivery. The refractory fire walls can be installed later at the most convenient time using relatively light capacity cranes.
- **Heating and shelter** - None required.

**NOTE**: The above benefits are due to installation advantages of the refractory fire walls. Much greater cost advantage is obtained from *TruFireWalls’ effective transformer fire containment*, resulting in reduced outage time after a fire event.
Transformer Fire Wall
Lifecycle Cost Comparison Guide
(Normalized relative to concrete wall – No weighting factors used)

<table>
<thead>
<tr>
<th>Cost Items*</th>
<th>Concrete Fire Wall</th>
<th>Refractory Fire Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase of Fire Wall</td>
<td>1.0</td>
<td>1.15</td>
</tr>
<tr>
<td>Foundations</td>
<td>1.0</td>
<td>0.50</td>
</tr>
</tbody>
</table>
| Installation Labor  
(same ratio for installation time) | 1.0 | 0.12 |

**Major Cost Items**

**One Transformer-Fire Event**

- Replacement of Damaged Equipment  
  (Typical power transformer installed cost = $1.5 million per phase)  
  | Concrete Fire Wall | Refractory Fire Wall |
  | 1.0 | 0.0 |

- **Extended Outage Replacement Energy**  
  (Rush Delivery at least 18 months)  
  | Concrete Fire Wall | Refractory Fire Wall |
  | 1.0 | 0.0 |

- Replacement of Fire Wall  
  | Concrete Fire Wall | Refractory Fire Wall |
  | 1.0 | 0.0 |

**Two Major Transformer Maintenance Events**

- **Extended Outage Replacement Energy**  
  | Concrete Fire Wall | Refractory Fire Wall |
  | 1.0 | 0.0 |

- Replacement of Fire Wall  
  | Concrete Fire Wall | Refractory Fire Wall |
  | 1.0 | 0.0 |

- Negative Corporate Citizen Image  
  | Concrete Fire Wall | Refractory Fire Wall |
  | 1.0 | 0.0 |

**Service Life TOTAL COST**  
<table>
<thead>
<tr>
<th>Concrete Fire Wall</th>
<th>Refractory Fire Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0</td>
<td>1.77</td>
</tr>
</tbody>
</table>

* - Typical costs for a 4-hour rated wall. Assumed service life of 40 years

** - Replacement energy cost can be in the **hundreds of thousands of dollars per hour** during peak time.
Glass loses approximately 80% of its room temperature strength at half the temperature of a transformer oil fire.

An oil fire’s temperature is about $1960^\circ$F.

Source: High Strength Glass Fibers by David Hartman, Mark E. Greenwood, and David M. Miller from Owens Corning Corp., 1996, page 10, fig. 2.

→ Free Flowing Glass means glass reinforced composite walls cannot take the heat.
<table>
<thead>
<tr>
<th>Technologies</th>
<th>Meets Fire Wall Requirements per Industry Accepted Standards ?</th>
<th>Costs (Relative to concrete wall est. costs)</th>
<th>Ease of Assembly and Disassembly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temp. Resistance</td>
<td>Initial</td>
<td>Long Term</td>
</tr>
<tr>
<td></td>
<td>Maintains Integrity Before, During, and After a Fire ?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed Concrete Wall</td>
<td>Less than 500°C</td>
<td>NO.</td>
<td>100 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Absorbed moisture will generate steam pressure and break up the concrete, exposing the rebar to fire.</td>
<td>Low cost materials. Moderate cost process. Deep foundations</td>
</tr>
<tr>
<td>Steel Sheets and Concrete Sandwich Panels</td>
<td>Less than 650°C</td>
<td>NO.</td>
<td>170 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steel sheets and channel are exposed directly to flames. Steel loses half its working strength at ≤ 650°C.</td>
<td>High cost materials and manufacturing.</td>
</tr>
<tr>
<td>Phosphoric Acid Cement Screwed Panels</td>
<td>Less than 630°C</td>
<td>NO.</td>
<td>260 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thin panels reinforced with unprotected glass fiber. Glass softens at ≤ 630°C. Small screws exposed to direct flame.</td>
<td>Expensive materials and process. High cost shipping and storage.</td>
</tr>
<tr>
<td>Refractory Slide-in Panels</td>
<td>1,040°C</td>
<td>YES.</td>
<td>70 to 110 %</td>
</tr>
<tr>
<td>Technologies</td>
<td>Hazard Level</td>
<td>Corrosion Resistance</td>
<td>Coefficient of Expansion (COE) Compatibility</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------------------------</td>
<td>---------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Fixed Concrete Wall</td>
<td>Spalling during fire can be explosive.</td>
<td>Moisture ingress can produce rebar corrosion.</td>
<td>Concrete may crack due to differences in COE during curing stage or under fire.</td>
</tr>
<tr>
<td>Steel Sheets and Concrete Sandwich Panels</td>
<td>Zinc on galvanized steel sheets will melt off during fires. Induced voltages on exposed metal.</td>
<td>Exposed sheet metal, bolts and channels can corrode</td>
<td>Concrete between steel sheets may loosen due to differences in COE.</td>
</tr>
<tr>
<td>Phosphoric Acid Cement Bolted Panels</td>
<td>Phosphoric acid requires special handling.</td>
<td>Surface glass fibers will degrade with moisture and sunlight.</td>
<td>Screws exposed directly to flames may loosen.</td>
</tr>
<tr>
<td>Refractory Slide-in Panels</td>
<td>No potential hazards.</td>
<td>No organics, glass or unprotected metal.</td>
<td>No effects in panels. cosmetic cracking on cooling columns.</td>
</tr>
<tr>
<td>Technologies</td>
<td>Availability</td>
<td>Thermal Shock</td>
<td>Impact Resistance</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td></td>
<td><strong>Materials</strong></td>
<td><strong>Support</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Fixed Concrete Wall</strong></td>
<td>Widely available. Low cost.</td>
<td>Widely available.</td>
<td>May crack under temperature cycling extremes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Steel Sheets and Concrete Sandwich Panels</strong></td>
<td>Steel and concrete sandwich requires specialized manufacturing process.</td>
<td>Foreign with US representative.</td>
<td>Concrete pressed between sheets may break up. Bolts and nuts can loosen under temperature cycling.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phosphoric Acid Cement Bolted Panels</strong></td>
<td>Imported materials.</td>
<td>Foreign specialized technology and ownership.</td>
<td>Screws can loosen under temperature cycling.</td>
</tr>
<tr>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
# TruFireWalls In Service

(Partial List)

<table>
<thead>
<tr>
<th>SITE</th>
<th>Number of Fire Walls</th>
<th>Fire Wall Description (Width x Height in Feet &amp; Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperial Irrigation District,</td>
<td>3</td>
<td>41-2 x 24</td>
</tr>
<tr>
<td>Coachella Valley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bristol, IL</td>
<td>1</td>
<td>36-2 x 20</td>
</tr>
<tr>
<td>Shorewood, IL</td>
<td>1 2</td>
<td>47 x 22 29 x 22</td>
</tr>
<tr>
<td>Gilberts, IL</td>
<td>1 1</td>
<td>48 x 20 36 x 20</td>
</tr>
<tr>
<td>North Lake Data Center</td>
<td>2</td>
<td>32 x 18-6</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McHenry, IL</td>
<td>1</td>
<td>35-10 x 24</td>
</tr>
<tr>
<td>New Lenox, IN</td>
<td>1</td>
<td>36-2 x 21-6</td>
</tr>
<tr>
<td>Oakland J Substation</td>
<td>1</td>
<td>17 x 10</td>
</tr>
</tbody>
</table>
Wind Load Panel Resistance Test

Utility Vault
Pleasanton

A special test was performed to verify wind load panel resistance, which for this relatively light-weight wall is the governing design parameter, even in a Zone 4 Seismic Area.

A uniformly applied wind load was simulated by the uniform pressure exerted by a rectangular pool of water resting on the test panel. The pool’s frame dimensions are just slightly larger than the test panel, such that the pool’s liner and water can slide freely onto the panel, thus loading it.
The height of the water was measured and recorded as the pool was being filled. One pound per square foot of pressure equals 0.1922 inches of water. A 35 psf pressure is equivalent to a water height of 6.73”. This water level was reached with absolutely no cracks. A max. sag of 1/16” was measured at the midpoint of the 91” x 36” x 2” panel.
The test was repeated with a second panel. The water height was increased to 8-1/4”, which is equivalent to 43 psf. Again there were no cracks of any kind and the same amount of sag was observed.

**Conclusion**

The 35 psf specification by Southern California Edison was met by the standard 2” thick *ThermaLimits* panel. The panel has a safety margin of at least 20%.

Alonso R.
Ballistics Benchmarking Tests of TruFireWalls Refractory Panels Hand Guns and Rifle Shots

Figure 1 - Bullets used in these tests, left to right: 9 mm -124 g -Full Metal Jacket; 357 Magnum - 158 g - Jacketed Soft Point; 44 Magnum - 240 g - Truncated cone soft point; 223 Remington - 5.56 NATO; 308 Winchester - 7.6 NATO; 30-06 M2 Armor Piercing tungsten carbide tip

Figure 2 - Target at 50 feet; bullet velocity measured every shot at 10 ft from muzzle, per UL 752. All target panels were 16 " x 16" x 2 " thick samples made with standard TruFireWalls refractory concrete.
Results Summary

1. All hand gun bullets, including the 44 Magnum, were stopped by the standard 2-inch thick TruFireWalls refractory panels, with no through penetrations.

![Image of bullet holes in panels]

2. Even though the rifle shots resulted in clear penetrations, the witness panels placed behind the target panels clearly showed that only harmless dust exited out the penetration hole. The bullets essentially disintegrated as they traveled through the target panel.

![Image of bullet holes with labels]
The single exception was the 30-06 A2 armor piercing bullet that could have resulted in possible damage. The witness panel was penetrated, but only when there was no air gap between it and the target panel. With a 1.375 inch air gap between the two panels, a depression 0.8 inches in depth and spalling on the back side of the witness panel were observed, but no penetration of the witness panel. This type of projectile “catching” is desired, as the projectile’s energy is dissipated without ricocheting, which can generate more shrapnel.
CERTIFIED 4-HOUR FIRE WALL RATING
• Certified by Southwest Research Institute per ASTM E-119 and compliant with IEEE Std 979, IBC, CBC, and UBC construction codes.
• Surpassed both the required 4-hour fire exposure test and the 45 psi water jet blast at 1,960°F.

SIMPLE, QUICK ASSEMBLY AND REASSEMBLY
• Results in significant cost savings due to grooved columns and slide-in panels that allow construction of one wall in one day or less.
• Built from prefabricated components, with standard tools. No special training is necessary.
• Constructed with low-capacity boom trucks due to light-weight panels and columns.

VERSATILE AND EASILY ADAPTED TO OUTDOOR AND INDOOR USE
• Economically meet all mechanical specifications throughout the expected temperature range due to unique refractory design.
• Applicable to substations with different wall arrangements and dimensions.
• Easy and safe to adjust in the field with ordinary tools.
• Field-proven refractory and reinforcement materials - highly superior to concrete and other cements.