These are frames from the security camera in the Sinatra Station. Note how the first frame seems to be black and white, until the developing transformer fire starts to provide some more colorful lighting.

Transformer Fire Isolated

Tightly packed Las Vegas Strip substation experiences a dramatic transformer fire, but high-tech firewalls protect nearby equipment.

By **Gordon Smith**, *NV Energy*

The ever-increasing energy demands of the Las Vegas Strip needed a power boost in 2009. Enter the 230/138/12-kV Sinatra substation, which was designed and placed into a tiny pie-shaped site between the Interstate 15 freeway and Las Vegas' newest, mixed-use resort property known at the time as Project CityCenter.

This unique substation, which includes extensive gas-insulated switching (GIS) equipment, normally would have used approximately 5 acres (2 hectares) of land for a compact gas-insulated design. A more common open-air substation layout would have required 10 acres (4 hectares) or more of land. However, such space was just not available near the Strip. In

Aerial view of the entire Sinatra substation showing the location of the fire.

The 230/138-kV autotransformer tucked between the two ceramic panel firewalls before the fire.

Front and side views of the burned unit with the tertiary structure beside it, although all the equipment on this structure was destroyed, NV Energy was able to repaint and put the steel structure back in service.

fact, the entire substation sits on a mere 1.6 acres (0.6 hectare) that was available to tie into the transmission and distribution lines and serve such nearby casino operations as the Monte Carlo Resort, New York-New York Hotel & Casino and CityCenter Las Vegas.

For those curious about the load requirements of such properties, the original load forecast for CityCenter — which currently includes the Aria, Mandarin Oriental, Vdara Hotel & Spa and Crystals shopping, dining and entertainment center — was more than 100 MW.

The Challenge

Considering the size of the transformer needed to meet the related Las Vegas Strip loads, NV Energy's substation engineering team normally would have at least 30 ft (9 m) of separation between a transformer and other substation equipment. Because such space was not available, the team reviewed various options and scenarios to help mitigate the remote possibility of a transformer fire and to ensure, if a fire occurred, it would not damage expensive GIS equipment nearby.

The team initially looked at conventional static firewalls. However, the site was so compact the substation design team did not think there would be enough room for a crane to be deployed to remove or maintain the transformer unit with a conventional static firewall in place. This caused them to look for other options, including the use of removable firewalls.

The Preparation

The team looked at multiple alternatives and, through this process, discovered a composite, sectional and removable wall offered the necessary safety protections and competitive pricing with more traditional concrete firewalls. The substation designers specified two Intelli-Firewalls from Composite Support & Solutions Inc. These two walls — which measured 41 ft wide by 28 ft tall (12.5 m by 8.5 m) and 58 ft wide by 28 ft tall (17.7 m by 8.5 m) — were designed to withstand a hydrocarbon fire for up to four hours.

The modular panels were relatively lightweight at 320 lb (145 kg) each, and easy to maneuver and install. Each hollow panel used a heat-resistant surface similar to what has been used on NASA space shuttle tiles. In the case of the tight-spaced Sinatra substation, the panels also offered the flexibility of easy removal and reassembly, should NV Energy find it necessary to replace or maintain the large 230/138-kv autotransformer. In fact, a single wall can be assembled or disassembled in less

The undamaged 230-kV GIS equipment was protected by the firewalls.

The firewall is restored and none the worse for having lived up to its design function.

than a day, which can minimize power outages.

In the end, the substation team discovered the Intelli-Firewalls presented a smaller profile than a conventional barrier. To orchestrate all the equipment within a very narrow 1.6-acre site, the smaller profile was extremely helpful.

Once installed, no one knew exactly how they would serve in a dramatic prolonged fire, but designers and engineers were pleased to have the necessary precautionary measures in place, just in case. No one would have guessed the planning, selection and installation of new heat-resistant walls would be put to the test less than two years later.

The Fire

At 12:15 a.m. on Sunday, May 15, 2011, an explosion and fire occurred at the Sinatra substation. As a result of the fire, numerous pieces of the bushings flew off the large 230/138-kV autotransformer and became embedded in the firewalls. Fueled by the transformer's mineral oil, the fire quickly engulfed the entire transformer. Observers from nearby hotels and the interstate saw flames shoot into the dark sky, which some estimated to be as high as 80 ft (24 m). The incident made national news.

The Las Vegas fire department and NV Energy crews responded quickly, but it took approximately 90 minutes for the fire to burn itself out. Fortunately, no one was injured. Thanks to a carefully coordinated effort between NV Energy's transmission and distribution operations, as well as crews on site, the major distribution feeders were reenergized within a few hours. Later that Sunday morning, all customers were back in service.

In spite of the initial explosion and sustained oil-fed fire, both firewalls that bookended the autotransformer were remarkably intact. More importantly, the GIS equipment located behind the firewalls was protected from the heat and explosion. It was not damaged and remained available for service. The autotransformer was a total loss, naturally.

This event illustrates the modular firewall system worked well and literally acted as the last line of defense. It prevented a very expensive and lengthy substation rebuilding effort.

The Fix

The exploding porcelain bushings damaged several of the firewall panels. In fact, one side of the wall was penetrated and, in some cases, the shards became embedded in the firewall panels. Because the panels are fabricated with a hollow space inside, this posed no risk to the structural integrity and they performed as designed.

Fortunately, the majority of the panels were not penetrated, and they were tap-tested to determine their structural integrity. This testing is possible because the Intelli-Firewall is built with hollow "web-core" sandwich panels. A tap hammer — in the hand of an experienced operator — is an effective and simple way to determine the integrity of each panel. This test process, which does not require disassembly, can be done relatively quickly.

In spite of the fierce and prolonged fire on both sides of the autotransformer, only 12 panels had to be replaced. Additionally, several of the vertical beam covers were damaged in the fire and had to be replaced. Again, this was done relatively quickly and did not require any additional maintenance, restoration or replacement of the structural beams.

NV Energy maintenance crews completed the whole op-

Aerial view of the Sinatra substation looking toward the strip.

eration of removing and replacing the damaged panels and bringing the firewalls back into service in only a few days. In short, crews removed the damaged firewall sections and beam covers, replaced them and repainted the protective walls. They removed the burnt transformer. The intense heat from the transformer fire had resulted in the spalling and flaking of the concrete foundation, which had exposed the reinforcing bars in some places. Because of that severe damage, a new foundation was constructed and a replacement transformer was set into place. A spare 230/138-kV autotransformer was on hand, and NV Energy returned the substation to full service in just four months.

The Quantifiable Hazard

A risk of a transformer explosion and related fire is quantifiable. Specifically, IEEE Standard 979 survey notes a probability of a fire for a 500-kV transformer at 0.0009 fires per year. This is equivalent to one occurrence in every 1,111 unit-years. At first blush, this remarkably low probability can give a false sense of security. However, if one applies this probability to a utility fleet of 100 transformers, operating for an average of 35 years, it is extrapolated there will be 3.15 fire events (0.0009 x 100 x 35), or one transformer fire every 11 years. Put another way, this means a substation engineer or manger would likely experience an average of three transformer fires during a career. And, transformer fires do happen, as NV Energy discovered with this two-year-old substation.

The Lesson

The Las Vegas Strip revelers who witnessed the Sinatra substation fire last May likely gave no thought to the impact or potential impact of such a dramatic substation fire. It is a tribute to electricity-providing utilities that they are taken for granted and their reliability is so strong.

Unfortunately, other substations throughout the world have experienced similar dramatic fires with much more dramatic results and lengthy service interruptions. As Queen Elizabeth II once said, "With the benefit of historical hindsight, we can see all things which we would wish had been done differently or not at all."

Thanks to thoughtful engineering, planning and a product that lived up to its billing, NV Energy's Sinatra substation foresight was just as strong as its hindsight. TDW

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Editor's note: To see video footage of the May 15, 2011, Sinatra substation fire, see www.youtube.com/watch?v=GzCv_Pa-rLM.

Companies mentioned:
Composite Support & Solutions **www.Intellifirewall.com**
NV Energy **www.nvenergy.com**