
Osmose
Resilient Grids. Strong Networks. Safe Energy.
UNDERSTANDING AND PREVENTING
MANHOLE EXPLOSIONS

IT'S THE WAY A DISASTER MOVIE STARTS:

A normal, sunny day in a busy city. Lots of people walking on the sidewalk and cars in the streets. There might be a crackling sound, and some popping noises. Then, out of nowhere, a hundred-pound manhole cover is launched five stories in the air, only to come crashing down on an innocent bystander. But this isn't a disaster movie, it is a reality on too many city streets these days.

Manhole explosions and other events happen every day across the country, but often go unreported. Senior IEEE member Stuart Hanebuth, VP with Safety Management Group, estimates that there are between 3,000 and 5,000 manhole events in the U.S. annually, though not all of them are as spectacular or even happen when there is someone to witness the event. But a quick search on YouTube will show that they happen with some frequency, and sometimes even on camera during broadcast news. These explosions can produce the equivalent of up to 20 sticks of dynamite.

Understanding the chain of events that lead to these often dramatic and occasionally deadly incidents has not been simple. In fact, the first serious effort to codify what was happening underground to trigger manhole incidents occurred over 65 years ago. The IEEE PES-ICC's Arcing Fault Task Group was established in 1957 to develop prevention measures and met regularly for six years, but eventually dissolved without publishing guidance. Other attempts to address the issue have happened across several organizations in the decades since.

What is the Impact?

Explosions have propelled these massive cast iron disks, weighing between 70 and 300 pounds, anywhere from 1 foot to 50 feet into the air.

Impacts of Explosions:

- Risk of severe injury
- Loss of power in the aftermath
- Release of carbon monoxide and other toxic gases
- Evacuations of nearby buildings

3,000 to 5,000

estimated manhole events occur in the U.S. annually

A SCIENTIFIC LOOK AT WHAT'S GOING ON

Finally, in August 2022 the Institute of Electronics and Electrical Engineers (IEEE) published a definitive peer-reviewed work documenting the phenomenon: The IEEE Guide for Early Detection, Mitigation, Preventative Measures, and Response to Smoke, Fire, and Explosions in Underground Electrical Structures. Hanebuth is the chairman of the working group that prepared the guide.

Clocking in at over 60 pages, the publication documents causes and prevention, and at the heart of the guide is a flowchart titled "Root causes of manhole events."

> ***That chart and the guide itself should have public utilities rethinking aspects of their maintenance practices.***

The diagram details several pathways that lead to manhole fires, but the primary condition for all those paths is "aged or damaged cable and components."

Many of the most dangerous events are solely electrical in nature, where all the power of the explosion comes from a high-voltage electrical arc. More common, however, are explosions fueled by combustible gasses but sparked by a cable fault. And, not only are faulted cables commonly the source of the ignition but degrading cable insulation often produces the fuel. When the insulation degrades in a duct, methane, carbon monoxide, and other invisible, odorless gasses can accumulate until an arc from the faulty cable provides ignition.

About three in four of these events are based on combustion, usually when the cable and duct insulation smolders, and produces flammable gas in an anaerobic setting.

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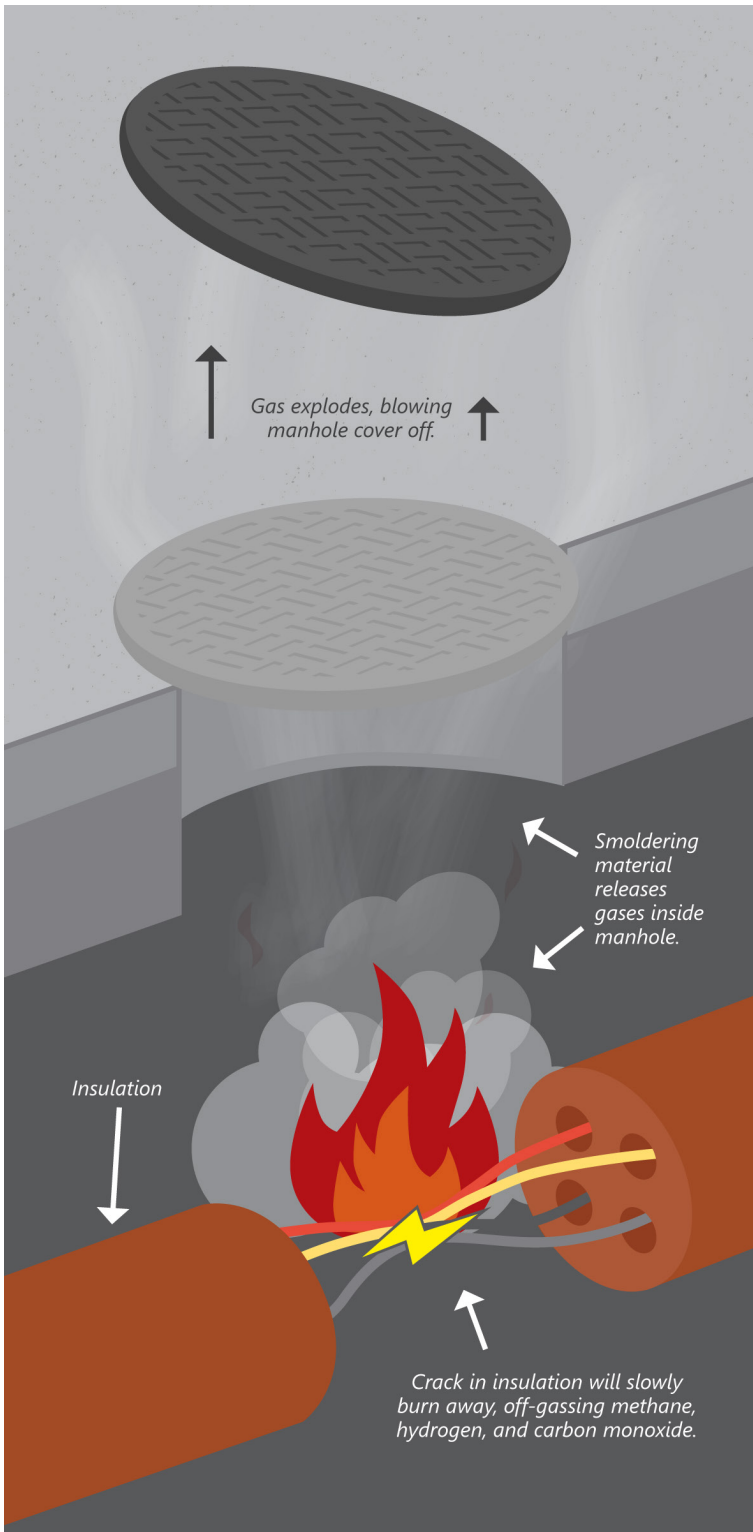
A common type of cable degradation happens when a cable with a minor crack in its insulation is installed in a duct. A small arc will occur across the small gap. Usually, the arc is just a few milliamps, too small to be detected in the distribution system by conventional monitoring. Still, it will slowly burn away at the insulation over time, off-gassing methane, hydrogen, and carbon monoxide. In most cases, the hydrogen will escape while the methane and carbon monoxide collect.

Not all manhole events are as spectacular as an explosion sending a steel disk into the sky.

> ***Generally, there are three categories of events: smoking manholes, burning manholes, and exploding manholes.***

According to Hanebuth, manhole events are one possibility in a spectrum of negative outcomes rooted in a broken piece of cable.

With documented causes, consequences, detection methods, and prevention tools issued from the IEEE, it becomes the responsibility of the utilities and cities to take reasonable steps to ensure that the public is safe from these events.



AN OUNCE OF PREVENTION

Perhaps the most straightforward prevention method is to ensure the integrity of cables as they are installed. After a recent spate of secondary cable failures, a Canadian utility inspected its underground cables and found about 5 percent had been damaged during installation. The problems occurred from dragging the cables across joints and obstructions and from debris that was allowed into the ducts.

Reducing that damage during installation will prevent future incidents.

Of course, the real challenge is addressing the thousands of miles of manhole cables already in place. Vented manhole covers have already been installed by some utilities under the theory that the combustible gasses will clear through the vents. Unfortunately, there is evidence that the enhanced airflow may worsen the problem by helping propagate flames.

In contrast, latching manhole covers down can mitigate some of the more dangerous aspects of manhole explosions. Some utilities have even tried filling the manholes with sand, preventing any meaningful gas buildup. Accessing the cables for maintenance becomes much more costly, requiring equipment to pump the sand out of the manhole.

In fact, restricting airflow in underground ducts, or sealing them, may be the most effective method to prevent manhole events, but sealing millions of duct ends can be an overwhelming prospect for many utilities and municipalities.

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DETECTION IS THE EASIEST PATH

After a high-profile manhole event, utility companies will often inspect their structures with an eye toward other faults. Although those inspections can be useful, more than 95 percent of the cable is hidden in the duct and not accessible by visual inspection, leaving most of a system's underground cables vulnerable.

One option is to monitor for combustible gases. Con Edison, for instance, has been working to install thousands of gas-detecting sensors in that utility's territory. These systems look for early signs of events like smoke or arcing in the underground ducts. However, those signals often coincide with linked customer calls for outages in the nearby service area, making it hard for the maintenance crews to respond before the gases catch fire or explode.

A second, perhaps more preventative option is to find the contact voltages created by the cable degradation. These contact voltages occur after a conductive pathway is established across damaged insulation. The voltage is persistent and can be detected with survey equipment tuned to its signatures. Osmose's Power Survey™ is amongst the earliest and most reliable detection methods to survey for contact voltage. Manholes are among the street-level, urban objects scanned by the Power Survey mobile electric field detection system. Several cities, such as New York City and Toronto have recently engaged Osmose to perform a whole-city assessment of the city's underground cables using the proprietary tool.

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Mobile electric field detection is the most sensitive, comprehensive, and accurate non-invasive testing method for locating faults in underground electric distribution systems. The heart of Power Survey is Osmose's SVD, a mobile detector specifically designed to find the low-level electric fields that emanate from the surfaces of structures that have become energized due to an underground distribution system fault. It simultaneously detects voltage on all surfaces in an area, including streetlights, manholes, fences, hand-hole covers, roadways, sidewalks, and trees.

"It's a pretty affordable way to take a good solid look at your system. A scan allows you to answer critical questions like: How many of these events did we find? Where did we find those events? What do they all have in common?" Hanebuth said. Understanding the current state of the underground grid is key to mitigating unexpected manhole events in the short term and developing a long-term strategy for true prevention, and Osmose's Power Survey is best suited for that work.

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