Understanding Manhole Events

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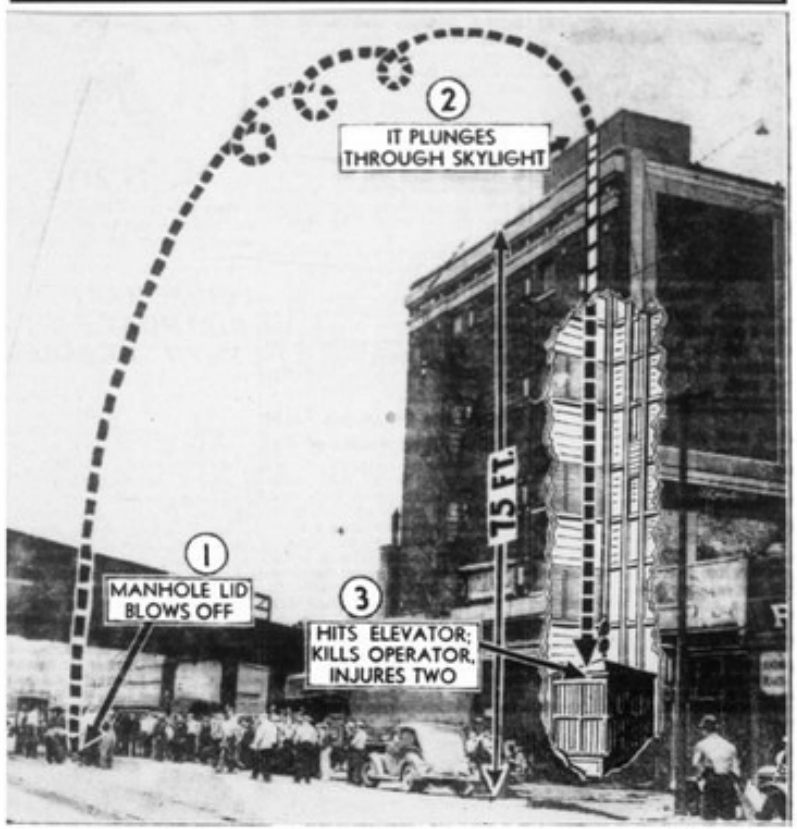
Manhole Events

- Smoking manholes
- Manhole fires
- Manhole Explosions

CHICAGO SUNDAY TRIBUNE: MAY 30, 1937

ONE KILLED WHEN BLAST FLIPS MANHOLE COVER



When a subterranean explosion tossed many manhole covers on Fullerton avenue into the air yesterday, one of the lids was blown high and crashed down the elevator shaft of the Hollander Storage and Moving company at 2418 Milwaukee avenue, killing the elevator operator, A. C. Day, 57 years old, of 5642 Melrose street. Two others on the freight elevator were slightly injured. Dotted line shows missil's path.

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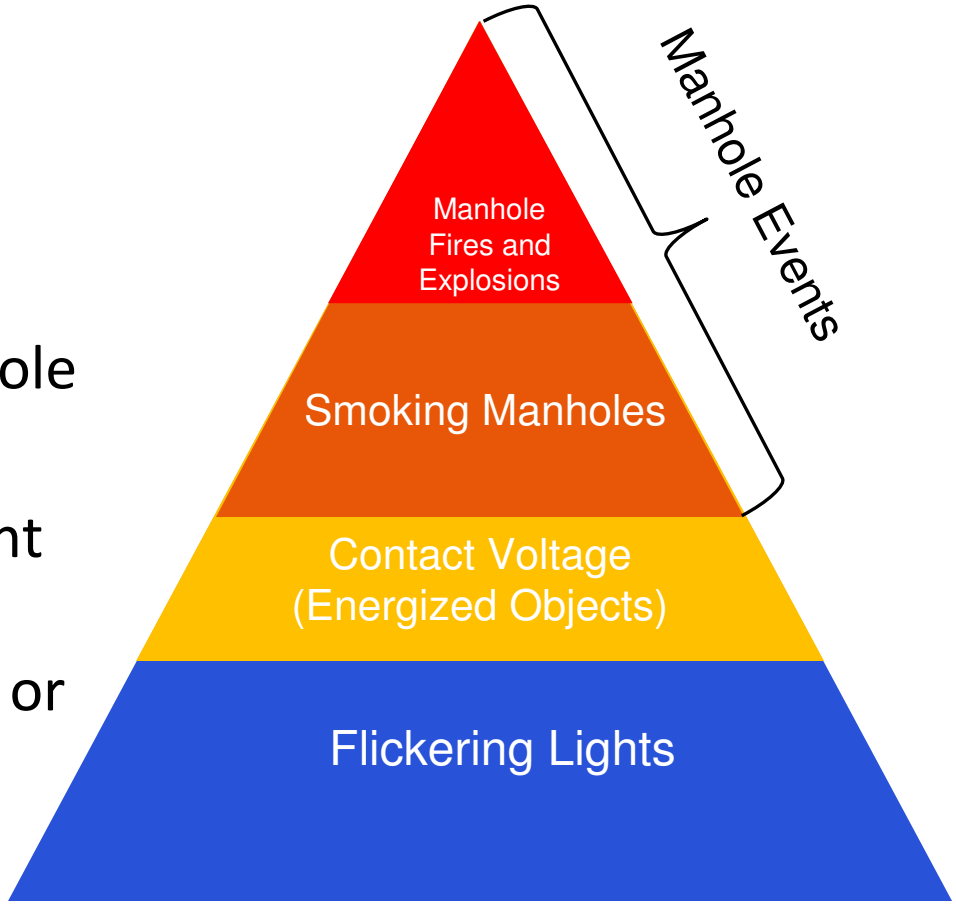
Manhole Event Sources

- Low voltage cable is the source of >95% of manhole events[1]
  - Generally initiated at point of damaged cable insulation
  - Most frequently are “Chemically Driven Events”
  - Large potential fuel source from cable insulation
  - Toxic and flammable gases produced during decomposition of insulation
- Transformer, Transmission and Primary Failures are the source of <5% of events

Low Voltage Cable Insulation Failure Outcomes

- Majority of failures result in power quality and contact voltage related issues
- Smoking manholes are the most frequent type of manhole event
- If an ignition source is present a smoking manhole can progress into a manhole fire or explosion

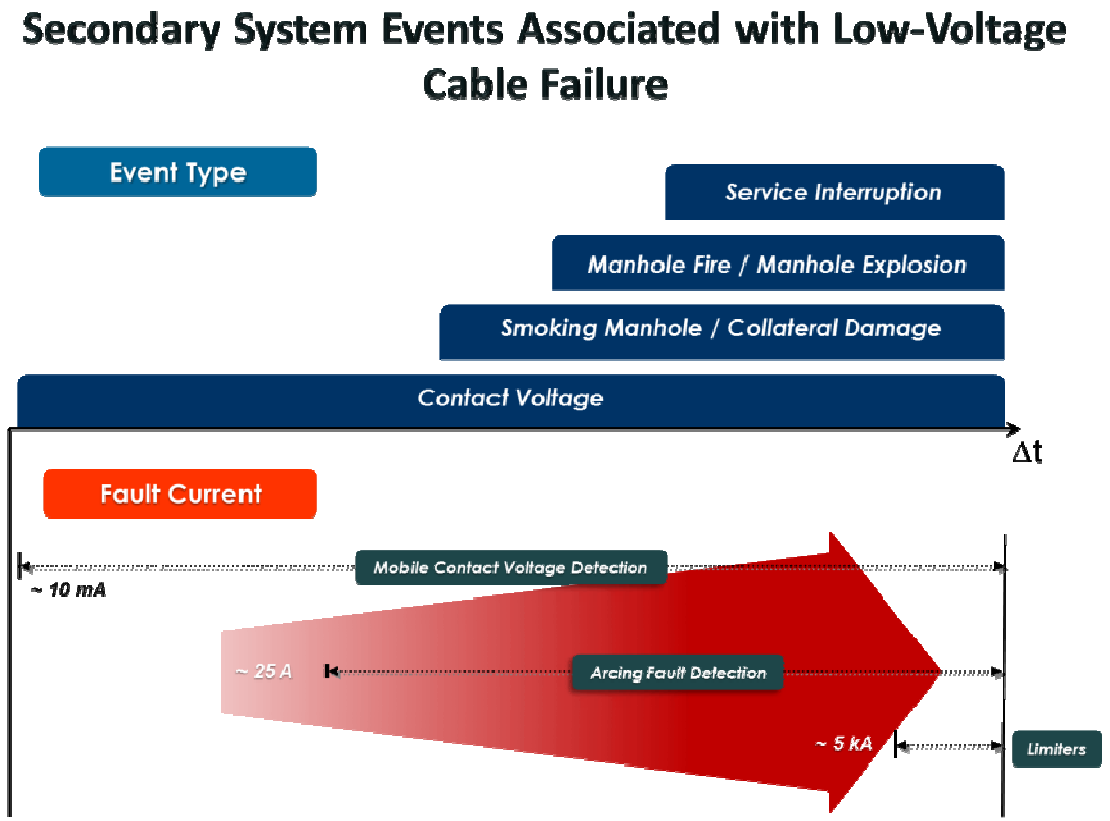


Two Types of Manhole Explosions

- Chemically Driven Events
  - Represent majority of manhole explosions
  - Low current electrical fault decomposes cable insulation
  - Energy released is from decomposition products of the insulation
- Electrically Driven Events
  - Energy released is from electrical fault

Protective Systems

- Limiters
  - Designed to protect adjacent sections from thermal overloads during three phase faults[8]
  - Typically limit in the 1,000-5,000 amp range
  - Not generally effective in preventing or mitigating gas producing faults
- Arc fault detection
  - Most sensitive systems in the 5 amp – 50 amp range[7]
  - May not be able to detect gas producing faults



Chemistry – Low Voltage Cable Events

- A variety of materials have been used for low voltage cable insulation[2]
  - Paper Insulated Lead (PILC)
  - Kerite
  - Styrene Butadiene Rubber (SBR)
  - Butyl Rubber
  - Neoprene
  - PVC
  - EPR
- Variety of duct materials have been used[3]
  - Wood
  - Cellulose-Tar
  - Concrete
  - PVC
- As these materials decompose they can produce flammable gases
  - Carbon Monoxide
  - Hydrogen
  - Methane

Collateral Damage Concerns

- Injury to public and employees
- Primary damage from low voltage faults
- Damage to nearby natural gas facilities[4]
- Building explosions from carbon monoxide accumulations

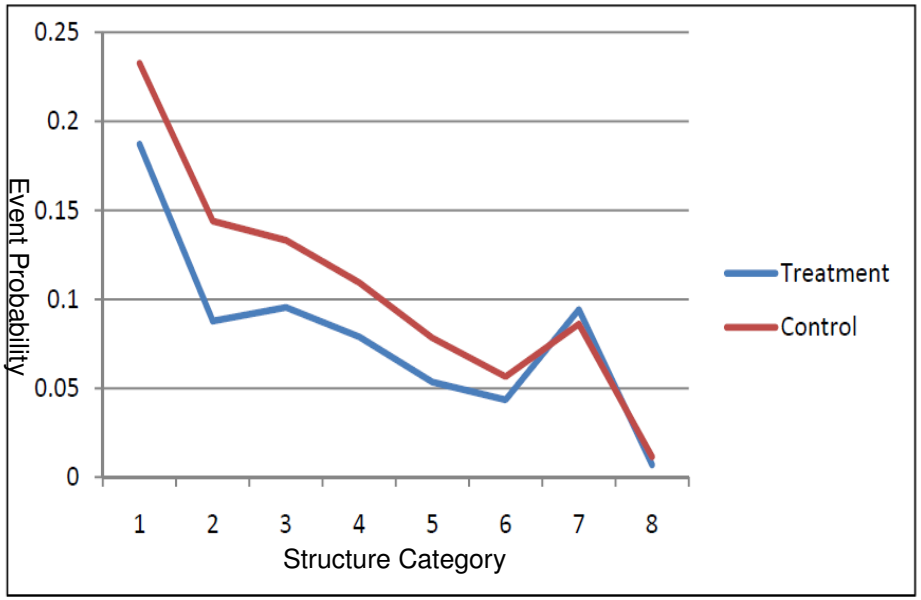
Danny Iudici/for New York Daily News

Event Prevention Strategies

- Post installation testing[5]
- Duct sealing to minimize airflow[6]
- Filling manholes with inert materials to minimize gas accumulation
- Contact voltage testing to find incipient faults[7]

Visual Inspections

- Analysis of over 55,000 visual inspections found small reduction in secondary related events such as[9]
  - Smoking manholes
  - Contact voltage
  - Power Quality Events
- No reduction in manhole fires or explosions



Mitigation Strategies

- Several cover designs and restraining approaches have been implemented[10]
  - Tethering
  - Self restraining
  - Venting
- Deployment strategies not well established
  - Is 100% installation the optimal approach?
  - High density areas
  - Dense structures
  - Duct or Cable driven installation
- Analysis needed on impacts of deployment
  - Water
    - Primary Joints
    - Customer basements
  - Debris accumulation
  - Access
  - Civil design
  - Increased duct airflow

Conclusion

- Low voltage cable failures are at root of most of these events
- Need wider focus than simply mitigating manhole events, also need to consider:
  - Prevention
  - Early detection
  - Maintenance
  - Response
- Field open for quantitative analysis of early detection and mitigation methods
- General need to define common terms to discuss the issue

Bibliography

Cited References

1.L. Zhang, "Mitigation of Manhole Events Caused by Secondary Cable Failure," Ph.D. dissertation, Dept. of Elect. and Electronic Eng., Univ. of Conn., Storrs-Mansfield, CT, 2011

2.C. Zuidema et al., "A Short History of Rubber Cables," IEEE Electr. Insul. Mag, vol. 27, no. 4, pp 45-50, Jul/Aug 2011

3.L. Zhang et al., "The Electro-Chemical Basis of Manhole Events," IEEE Electr. Insul. Mag, vol. 25, no. 5, pp. 25-30, Sep/Oct 2009

4.T.J. Parker and D. J. Ward, "Insuring Adequate Spacing Between Underground Distribution Conductors in Conduit and Gas Lines," IEEE Trans. Power Del., vol. 18, no. 1, pp. 291-294, Jan 2003

5.J.Côté*, "Manhole Explosions Discussion Group Hydro-Québec Experience",* http://www.pesicc.org/iccwebsite/subcommittees/subcom_c/C34/Presentations/2011Spring/C17.pdf

6.L. Zhang, S.A. Boggs and S. Livanos, "Manhole Events Caused by Secondary Cable Insulation Breakdown," in Annual Report Conference on Electrical Insulation Dielectric Phenomena, Quebec City, Canada, 2008, pp. 107-110

7.N. Weisenfeld, Y. When, "Arcing Fault Detection Projects", 2010 Jodie S. Lane Public Safety Conference, New York, NY

8.F. Heller, and I. Matthysse, "Limiters, Their Design Characteristics and Application" IEEE Trans. Power App. Syst., vol. 74, pp. 924-950, Oct 1955

9.Consolidated Edison Co. of NY, Inc. Stray Voltage Test and Inspection 2010 Annual Report 04-M-0159, Consolidated Edison Co. of NY, Inc., New York, NY, 2011

10.W. Black, J.Côté, "Mitigating Manhole Explosions" http://www.pesicc.org/iccwebsite/subcommittees/subcom_c/C34/Presentations/2012Spring/C-21.pdf

Relevant but not cited references

1.D.G. Ece, F.M. Wells and H.G. Senel, "Analysis and Detection of Arcing Faults in Low-Voltage Electrical Power Systems," in 7th Mediterranean Electrotechnical Conference., Antalya, Turkey, 1994, pp. 929-935

2.W. Charytoniuk et al., "Arcing fault detection in underground distribution networks feasibility study," in Industrial and Commercial Power Systems Technical Conference, Clearwater Beach, Fla, 2000, pp.15-20

3.B. Koch and Y. Carpentier, "Manhole Explosions Due to Arcing Faults on Underground Secondary Distribution Cables in Ducts," IEEE Trans. Power Del., vol. 7, no. 3, pp. 1425-1433, Jul 1992

4.Hamel, A. Gaudreau, and M. Cote, "Intermittent Arcing Fault on Underground Low-Voltage Cables" IEEE Trans. Power Del., vol. 19, no. 4, pp. 1862-1868, Oct 2004

5.Office of the Telecommunications Authority Hong Kong. (2010, June, 30). Implementation Guidelines on Mitigating the Risk of Gas Explosion in Telecommunications Manholes [Online]. Available: http://tel_archives.ofca.gov.hk/en/report-paper-guide/guidance-notes/gn_201003.pdf