Understanding Manhole Events

Stuart Hanebuth
Vice President
Power Survey Company
Kearny, NJ
www.PowerSurveyCo.com
Manhole Events

• Smoking manholes
• Manhole fires
• Manhole Explosions
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

---

### Secondary System Events Associated with Low-Voltage Cable Failure

- **Event Type**
  - Service Interruption
  - Manhole Fire / Manhole Explosion
  - Smoking Manhole / Collateral Damage

- **Contact Voltage**
  - Fault Current
  - Mobile Contact Voltage Detection
  - Arcing Fault Detection
  - ~ 18 mA
  - ~ 25 A
  - ~ 5 kA
  - Limiters
Chemistry – Low Voltage Cable Events

- A variety of materials have been used for low voltage cable insulation:
  - Paper Insulated Lead (PILC)
  - Kerite
  - Styrene Butadiene Rubber (SBR)
  - Butyl Rubber
  - Neoprene
  - PVC
  - EPR
- Variety of duct materials have been used:
  - 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
- Building explosions from carbon monoxide accumulations
Event Prevention Strategies

• Post installation testing\textsuperscript{5}
• Duct sealing to minimize airflow\textsuperscript{6}
• Filling manholes with inert materials to minimize gas accumulation
• Contact voltage testing to find incipient faults\textsuperscript{7}
Visual Inspections

• Analysis of over 55,000 visual inspections found small reduction in secondary related events such as:
  – 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\textsuperscript{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

5. J. Côté, “Manhole Explosions Discussion Group Hydro-Québec Experience”,

Relevant but not cited references