Active Arc Quenching Standards

Improving Critical Electrical System Reliability and Eliminating the requirement for arc-rated PPE

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Introduction

• My Background
• The Arc Terminator Project (1997-2000)
• August 2001 & The Funeral
• Arc flash mitigation between 2001-2010
• NEC beginning in 2014 Edition
• NFPA 70E beginning in 2018 Edition
• Arc Quenching Standards
• IEEE C37.20.7 Compliance
• Arc Quenching Application Examples
This is not a presentation on why arc flash events are catastrophic.

“5 to 10 arc flash explosions occur in electrical equipment every day in the United States.”

Hotter than the sun! Vaporizing metal. Deafening 160dB, and Blinding Explosive pressure 1400kg/m².
## The Arc Flash Mitigation Toolbox

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<th>Arc Flash Protection</th>
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<th>Protection through Superior Design</th>
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### Progress of Pressure and Temperature under Arcing

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<th>Pressure</th>
<th>Temperature</th>
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<tr>
<td>2.5 kPa</td>
<td>100°C</td>
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### Core Selection:

- **Core Selection:**
  - **Type:** Short circuit
  - **Material:** Steel
  - **Size:** 50 mm x 50 mm
  - **Rating:** 100 A

### Protection Level:

- **Level:** Class A
- **Rating:** 100 A
- **Selectivity:** Delayed
- **Coordination:** Time overcurrent relay

**Note:**

- Always consult local codes and standards for specific requirements.
- Ensure proper training and certification of personnel.
- Regular maintenance and testing of protective devices are essential.
- Always follow safe work practices when working with electrical systems.
Arc Quenching is the appropriate arc flash mitigation solution for critical processes

➢ How would an arc flash effect the process?
➢ Impact on safety, profitability & corporate image?
➢ Manufacturing lead-time for replacement equipment?
➢ Is downtime an option, or is it unacceptable?
➢ Does ELIMINATION of the NFPA 70E requirement for arc-rated PPE improve safety and maintainability?

**Note:** A generator provides emergency power but

*What if downstream electrical assets are damaged?*
Arc Quenching Definition

“A fast-acting low-impedance arc flash mitigation system which has a total clearing time from arc flash initiation to complete extinguishing of the arc flash event in less than .006 seconds (6ms).” - Draft Standard EN 50110.
Arc Quenching System

Arc Flash Protective Relay
+ Arc Quenching Device
+ Annunciation System
= Arc Quenching System

Current Transformers & Light Sensors
Transformer-Integrated Arc Quencher Example

Transformer with Arc Quencher integrated into the secondary air termination (ATC) compartment

Arc Quencher Control Panel

Arc Quencher Device (AQD)
Arc Quenching Standards

- UL2748 Listed
  - The recognized North American Standard
  - Applicable to both resettable and one-time-use arc quenching devices
- IEC 60947-9-1
  - The global standard
- NFPA 70E Annex 0.2.3(4)
- NEC 240.87
- IEEE C37.20.7
**UL 2748** - Maximum (peak) fault current and short-time fault-current withstand. The Arcteq AQ-1000 has a peak current rating of 162.5kA and a short-time fault-current withstand of 100kA for 200ms.

**IEC 60947-9-1** – The IEC standard defines the maximum voltage drop across the Arc Quenching Device (AQD) as 34 volts peak; this essentially precludes the addition of significant impedance between the AQD and ground.
Arc Quenching Definition – NFPA 70E

NFPA 70E – Annex O.2.3:

(4) Energy-reducing active arc flash mitigation system.

This system can reduce the arcing duration by creating a low impedance current path, located within a controlled compartment, to cause the arcing fault to transfer to the new current path, while the upstream breaker clears the circuit.

The system works without compromising existing selective coordination in the electrical distribution system.
Arc Quenching Suppliers Today

- Arcteq AQ-1000 & AQ-2000 Arc Quenchers – Only UL-listed resettable arc quenchers.
- ABB UFES – Only arc quencher rated for 27kV & 34.5kV applications. Uses ABB REA protective relays.
- GE Arc Vault – One-time-use low-voltage Arc Quencher.
- Schneider Electric Arc Terminator - The first arc quencher in the world, now obsolete; 5kV & 15kV Masterclad switchgear only.
- Siemens SIQuench – Resettable MV quencher; IEC-only, resettable five times at maximum fault current. Uses Arcteq AQ-110P protective relays.
Arc Resistant Switchgear

There are two choices for IEEE C37.20.7 compliance:

- Mechanical Venting (Arc Redirection)
- Arc Quenching (Arc Elimination)
Typical mechanically-vented IEEE C37.20.7-compliant switchgear
Typical mechanically-vented arc resistant switchgear exhaust plenums
Typical mechanically-vented arc resistant switchgear exhaust plenums
Typical mechanically-vented arc resistant switchgear exhaust plenum area
Traditional “Arc Resistant” Equipment

➢ Popular because of the words “arc resistant”
  ➢ Should more properly be called “arc venting” or “arc redirection” equipment

➢ Does not reduce arc flash incident energy vs. standard equipment; therefore, it delivers no additional “exposed energized” protection from arc flash hazards

➢ Traditional Arc Resistant switchgear does not protect downstream assets (such as MCCs, VFDs, and control cabinets) any more than standard equipment. **It is old out of date technology!**

➢ Expensive to purchase and expensive to install
A popular *ad hominem* argument:

“I am concerned about Arc Quenching because it creates a high stress low-impedance current path.”
baloney

definitions

noun

1. Nonsense; pretentious talk; bold and deceitful absurdities; applesauce, bullshit, hooey: No matter how you slice it, it's still baloney

2. A stupid person: You dumb baloney

verb

: And don't try to baloney me, either

[late 1920s+, perhaps fr Irish balonie, "nonsense"; about 1920 the word meant "an unskilled boxer; palooka" ]
Why is system stress an ad hominen argument against arc quenching?

1. Must be “Properly applied and installed” for the maximum available fault current.

2. All upstream and downstream transformers must be protected within their damage curves.
“Trust is good, but verification is better”

Independent tests run at various LV and MV voltages, comparing arcing faults using both arc quenchers and circuit breakers under identical fault conditions.

In both case studies, there was less stress with the Arc Quencher™ than with a circuit breaker by itself.
15kV Arc Fault Currents At The Fault Location With & Without an Arc Quenching Device Ground Fault. **Single Phase**
15kV Arc Fault Currents At The Fault Location With & Without an Arc Quenching Device
Three-Phase Fault
Arc Quenching Decision

Three Practical Application Questions:

1. How important is **uptime** and power system continuity?

2. How important is reducing arc flash hazards? 
   (Lowering the arc flash thermal incident energy to 
   $< 1.2$ calories per cm$^2$ at the Working Distance)

3. Are there benefits associated with eliminating the NFPA 70E 
   requirement for **arc-rated PPE clothing**?

The Four Primary Arc Quenching Benefits

- Minimize arc flash incident energy
- Maximize personnel / Qualified Person safety
- Minimize downtime and equipment damage
- Eliminate the requirement for arc-rated PPE clothing

40kA @ 12.47kV
480V Arc Flash Energy Comparison

Comparison of incident energy

- Conventional overcurrent protection (400ms+50ms)
- Zone selective interlocking (100ms+50ms)
- Light & current based detection (7ms+50ms)
- Arc Quencher (<4ms)
65 kA / 480V arc test, peak transient 163kA

Quenching time 4ms

Tripping time 50ms
65 kA / 480V arc flash test
Low Voltage Square D QED-2 Switchboard
(peak transient current 163kA)

Quenching time  4ms
Arc Quencher Device Example

- Thompson coil-based system (a resettable electromagnet)
- Must include full diagnostics and intelligent controls
- UL 2748-listed to withstand 100kA for 500ms
Installation / Application Examples
“Before” @ Kimberly-Clark
“After” @ Kimberly-Clark: 0.4 Calories per cm$^2$
Green Bay Waste Water Treatment Plant (NEW Water) – Arc Quencher™ Front Panel
Land O’Lakes Fertilizer Plant
Caledonia, New York
Just like a circuit breaker, the Arc Quencher™ system is an electromechanical life-safety device. As such, it must be periodically tested to assure a compliant clearing-time.

- Factory testing
- Jobsite testing
- Recommended testing frequency
Arc Quenchers – IEEE C37.20.7 Compliance

➢ With “representative testing”, complies with all ANSI/IEEE C37.20.7-2007 arc resistant equipment requirements
➢ An Arc Quencher solution does not “redirect” or “vent” the electrical arc: it eliminates the arc.
➢ The Arc Quencher solution is superior to traditional “arc resistant” switchgear in all respects:
   ➢ Only Arc Quenchers protects both people and the physical equipment assets from the damaging effects of arc flash events, even when exposed-energized
   ➢ Only Arc Quencher systems may be configured and expanded to protect downstream assets
   ➢ Only the Arc Quencher eliminates the NFPA 70E requirement for AR-rated PPE
Arc Quenching System
Design Considerations

1. Does it need to be resettable?
2. Does it need to protect the primary switchgear equipment?
3. Does it need to protect downstream assets?
4. Are there safety and maintainability benefits associated with eliminating the NFPA 70E requirement for arc-rated PPE?
5. New application or retrofit application?
Thank you for your time!