Presentation for
Levine Lectronics & Lectric (L-3) Webinar

VFD & MCC Arc Resistant Equipment Solutions compliant with IEEE C37.20.7

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Arc Flash risk summary:

* Hotter than the sun (up to 30,000F)
* Deafening 160dB, and Blinding (~2M Lux)
* Explosive pressure 1400kg/m^2
* Average incident cost > $500K
* 5-10 incidents per day

ANSI/IEEE C37.20.7

IEEE 1584 defines the testing criteria for what may be considered “arc resistant” equipment

Previous L-3 Webinars have presented Arc Quenching solutions for IEEE C37.20.7 in switchgear and transformers.

SPS Medium Voltage Switchgear
with Arcteq MV Arc Quencher

Low Voltage UL1558 Square D
PZ-4 Switchgear
with Arcteq LV Arc Quencher

JST Cast Coil Transformer
with Arcteq LV Arc Quencher

Arc Resistant MCCs and VFDs

MCCs, VFDs, Panelboards, and Control Panels are the most common assets Qualified Persons perform diagnostic work on in an exposed-energized environment.

How do we protect the reliability of these assets and the safety of Qualified Persons during arc flash events?

Variable Frequency Drives
Photo courtesy Danfoss

Motor Control Centers (MCCs)
Photo courtesy Square D

Arc Resistant MCCs and VFDs
(both low-voltage and medium voltage)

When protected by an upstream Arc Quencher, all we need to do is add light sensors and annunciation panels

Rockwell Automation Centerline Arc Resistant MCC via Arc Quenching

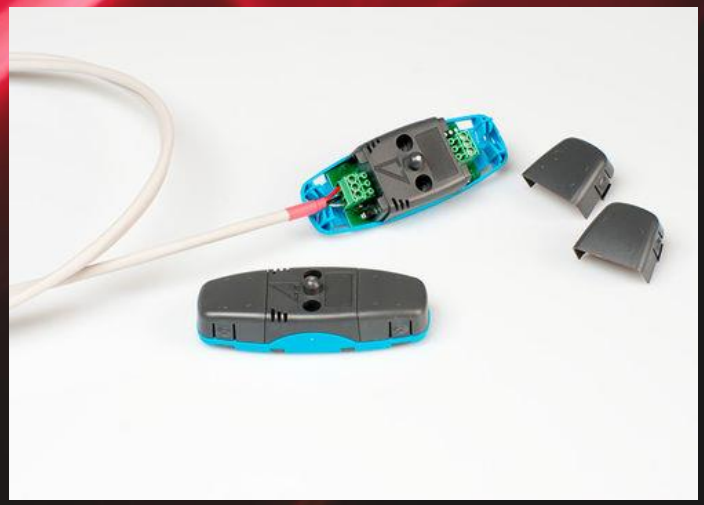
How do I make my existing VFDs and MCCs Arc Resistant?

Standard non-arc-resistant Rockwell LV MCC

Example: All equipment fed from the transformer is Arc Resistant

Transformer with integrated Arc Quencher System

Switchgear with Light Sensors installed

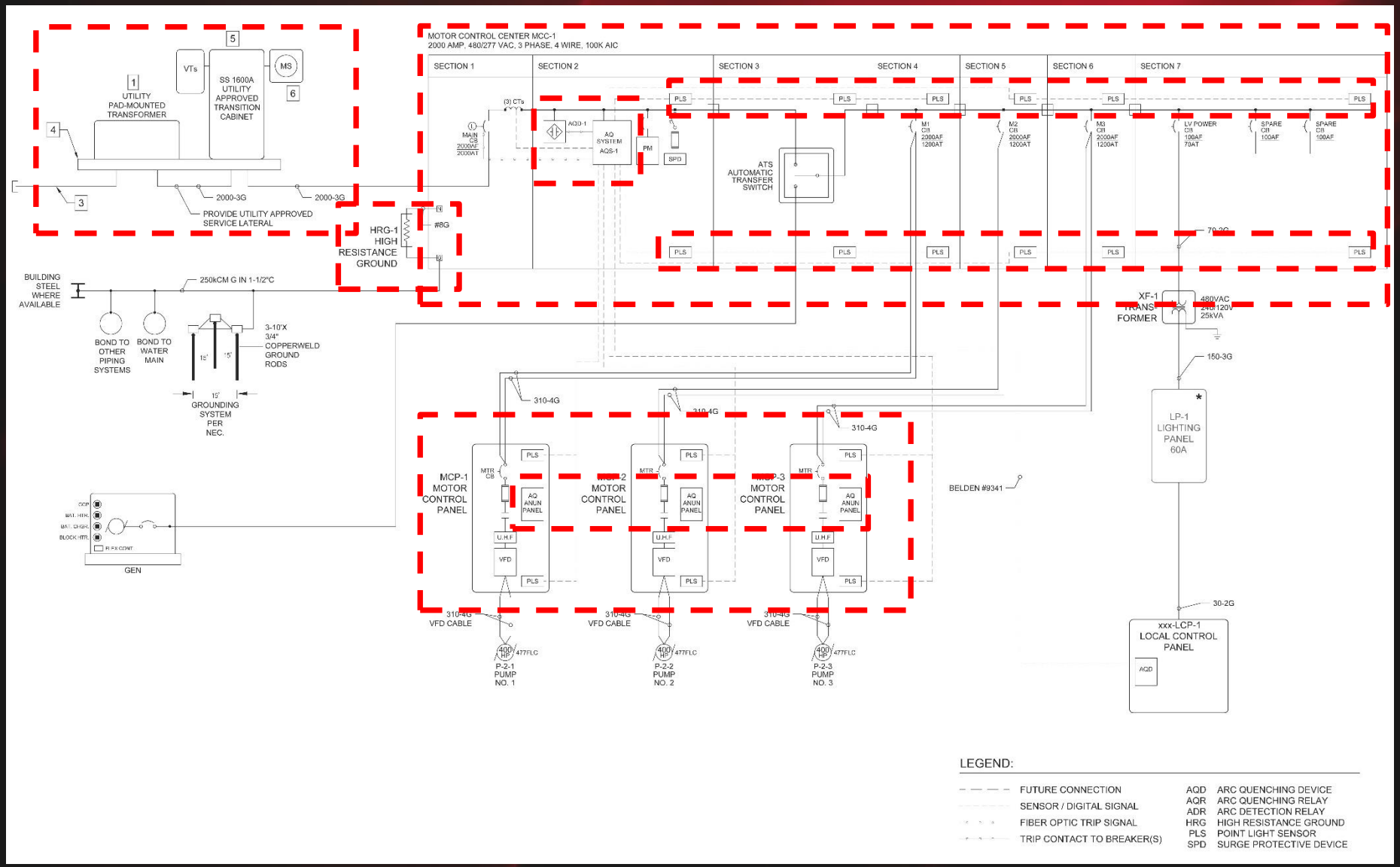


VFDs with Light Sensors Installed

MCCs with Light Sensors Installed

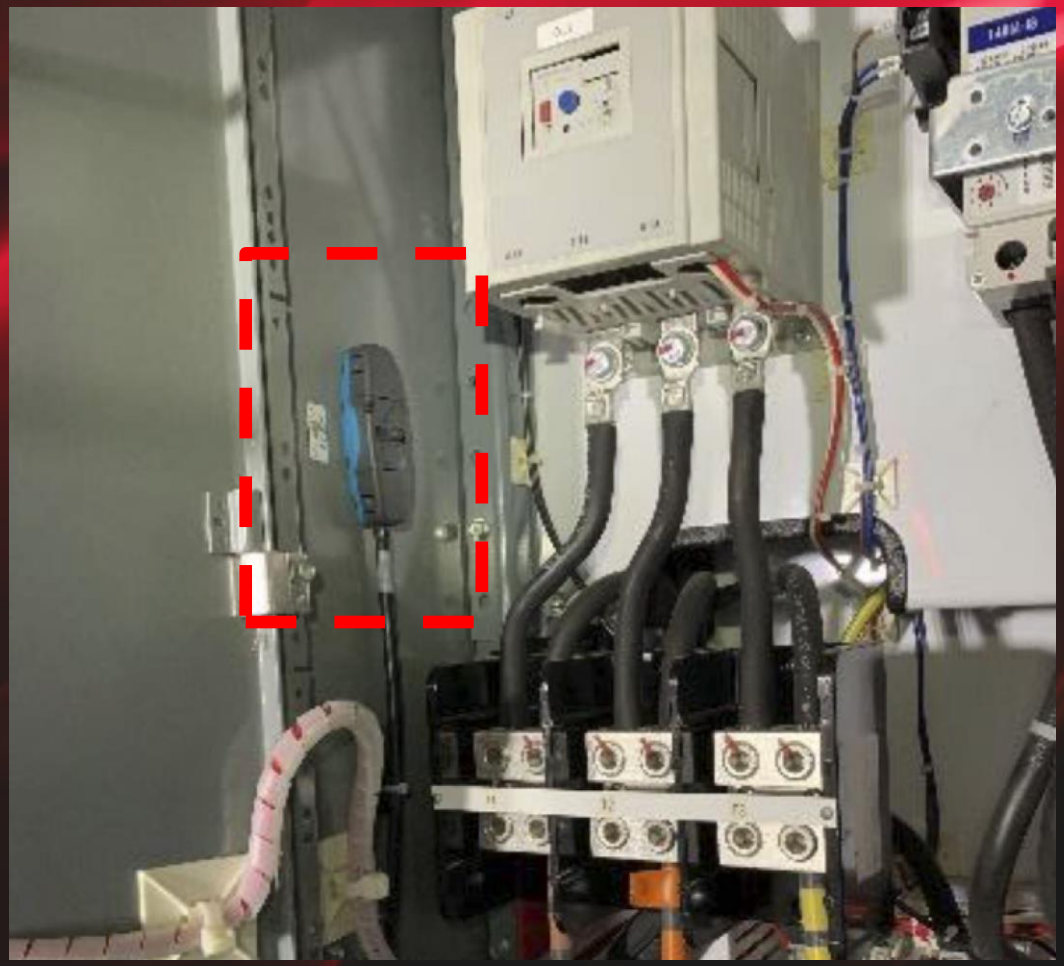
Panelboards with Light Sensors Installed

Typical SLD from a Water Project

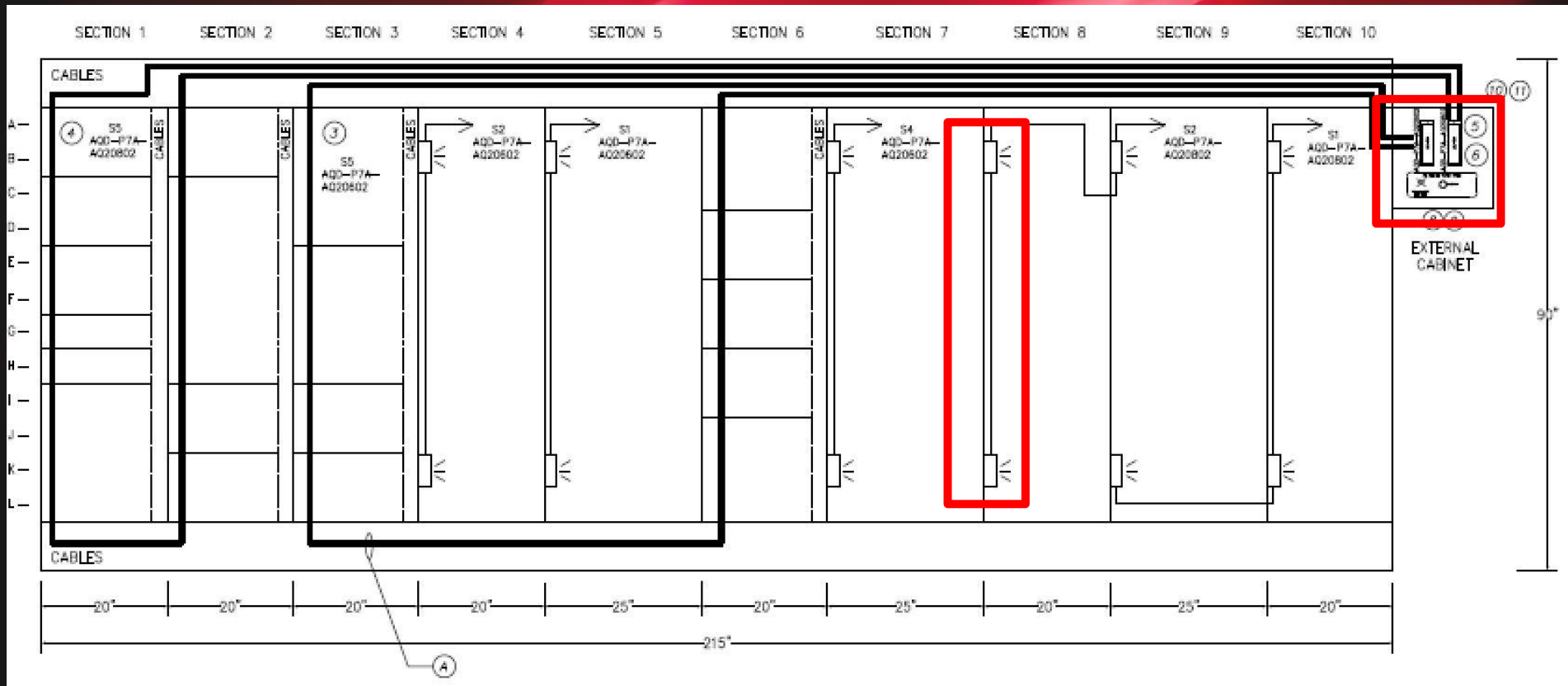


MCCs and VFDs are all Arc Resistant, compliant with IEEE C37.20.7

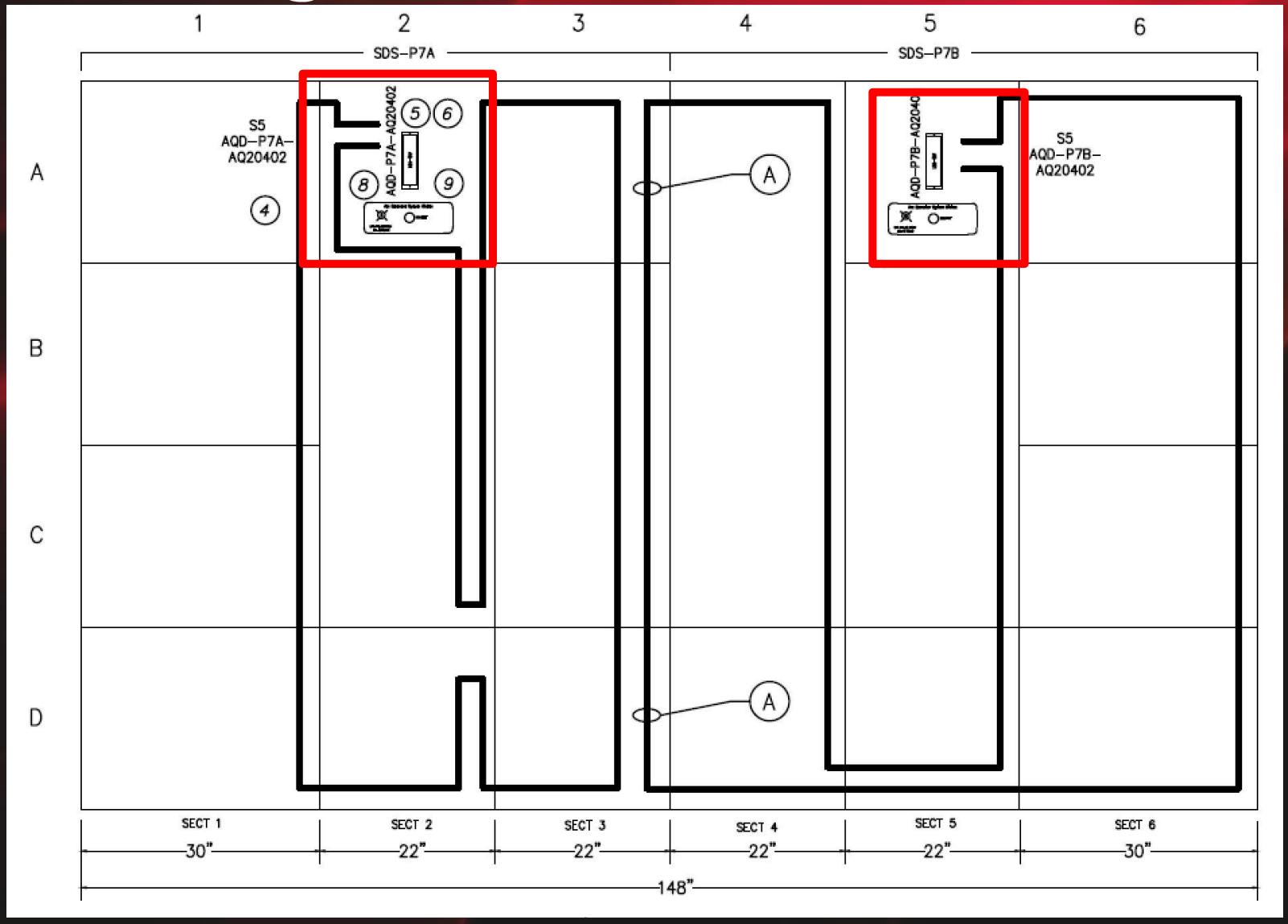
Light Sensor Installation



Light Sensor Installation



Light Sensor Installation



Type Testing Requirement

- Only equipment which is short-circuit type tested can be made “Arc Resistant”.

- If the VFD or MCC is not short-circuit type tested, it cannot be made “Arc Resistant” - - - by either mechanical venting *or* Arc Quenching.

DEFINITIONS
Short-Circuit Type Tested and Arc-Resistant

- "Type tested" is the colloquial term for equipment which has been short-circuit withstand or interrupting rating. Type-tested equipment equipment must maintain enclosure integrity when applied within its short-circuit rating.
  - No doors or panels may break open.
  - Internal components may be damaged by arcing faults.
  - Hot gas and plasma may be expelled from vents and seams in the enclosure.
  - Focused on safety, not equipment survivability after an arc flash event.
- "Arc Resistant" equipment compliant with IEEE C37.20.7 is *also* focused on safety, not the survivability of the equipment.
  - Type 1 – Protection from the front of the equipment.
  - Type 2 – Protection from the front, side, and rear of the equipment.
- All arc-resistant equipment is type-tested, *but not all type-tested equipment is arc-resistant.*

Type-Tested and Arc-Resistant

Example: UL891 Switchboard

Type-Tested, but *not* Arc-Resistant

Image courtesy Square D by Schneider Electric

Example: UL1558 Switchgear

Type-Tested *and* Arc-Resistant

Image courtesy Eaton Corporation

Not Type-Tested *or* Arc Resistant
Example: NEMA Motor Starter Control Panel

The individual motor starter branch circuits are series-rated up to 100kA at 480V (3-phase).

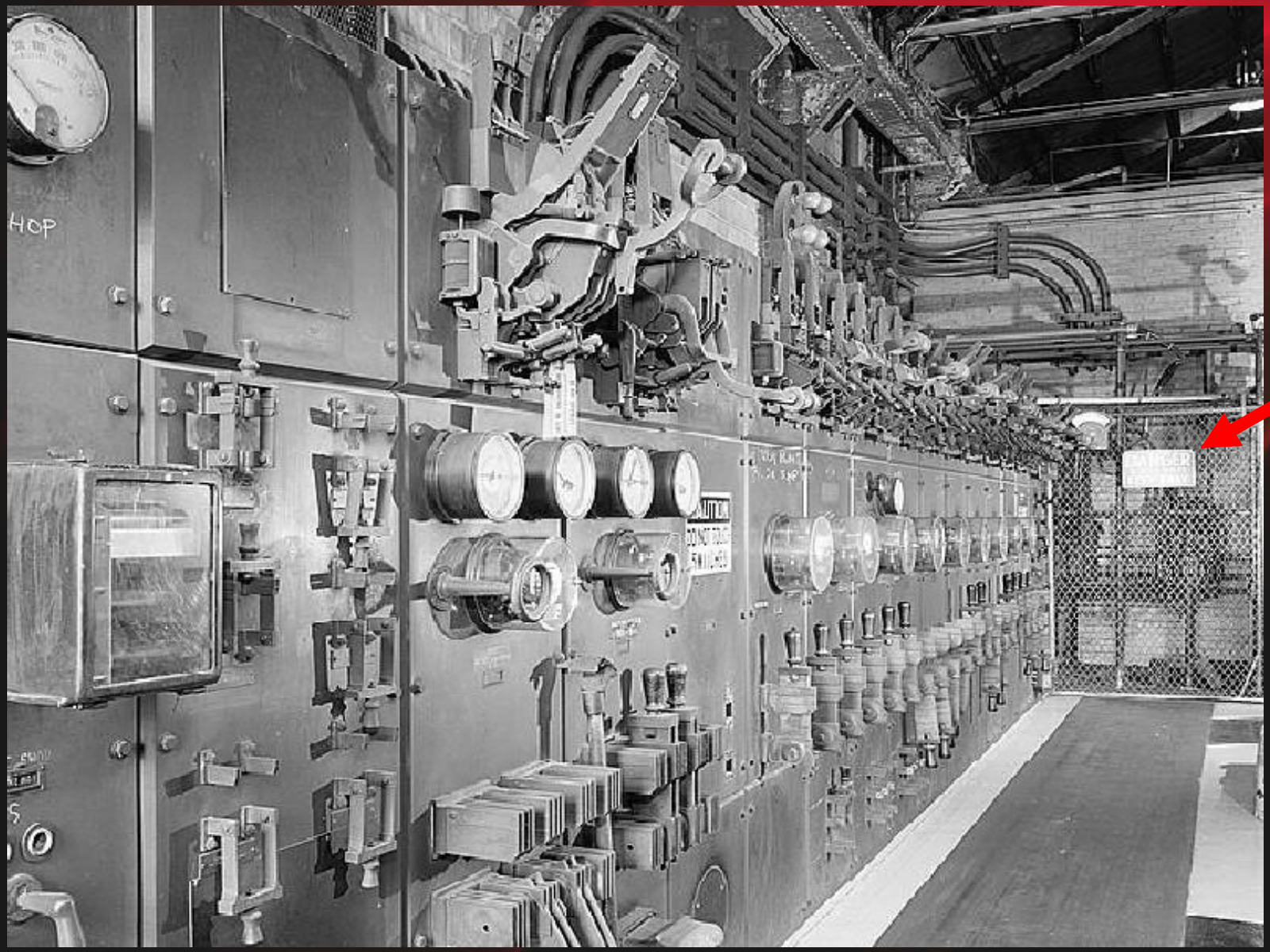
So why isn't this control panel considered type-tested for 100kA @ 480V?

What happens if an arc flash is initiated at either of these points?

Or here?? (Line-side of the branch motor circuit breaker)

Image courtesy Power Plus Controls (Atlanta, GA)

Type-Tested? Arc Resistant?



ANSI/IEEE C37.20.7

IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults

- Defines test procedures and criteria for electrical equipment to be classified as “arc resistant”.
- Available for both LV and MV equipment.
- The standard was written for “metal-enclosed switchgear”, but the test criteria has been applied to metalclad switchgear, switchboard, MCCs, VFD cabinets, panelboards and other type-tested electrical assets.
- C37.20.7-2007 criteria allow the use of equivalent volume dummy devices rather than the actual circuit breaker and other major components. *Therefore, the actual Arc Resistant enclosure being tested is independent of interior components.*

ANSI/IEEE C37.20.7

IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults

The introduction section of C37.20.7 states:

"Even when arc-resistant construction is specified, it is strongly recommended that supplemental power system protection be provided. This supplemental protection should limit the total energy that can be delivered in the event of internal arcing faults."

NFPA 70

What does the NEC say about Arc Resistant Equipment?

The National Electrical Code (NEC) does not require the use of any type of arc-resistant equipment. The only NEC reference to arc-resistant switchgear is in an informational note that follows the Article 100 definition of the term "switchgear." The last sentence of the informational note explains that switchgear is available in both "non-arc-resistant" and "arc-resistant" construction. *"This type of switchgear is used to enhance safety for equipment operators and maintenance personnel."*

Notice [again] the design criteria is SAFETY, **not** EQUIPMENT RELIABILTY or the ability to quickly return the electrical system to normal operation after an arc flash event.

Arc Resistant Electrical Equipment

There are two choices for IEEE C37.20.7 compliance

Mechanical Venting
(Arc Redirection)

Arc Quenching
(Arc Elimination)

How do these two competing technologies compare?

Mechanical Venting Definition

Mechanically-vented arc resistant equipment is designed to redirect arc energy upwards and out of the equipment through exhaust vents and plenums to a location away from equipment operators. This approach to arc resistant design typically uses vent flaps that will open under the pressure of an arcing fault and redirect the super heated gases and arc flash energy up and out of the equipment, away from personnel.

Mechanically-Vented Solutions for IEEE C37.20.7 compliance

Robust mechanical construction and extra attachment hardware

Typical mechanically-vented IEEE C37.20.7-compliant switchgear

Image courtesy Siemens Energy & Automation

Circuit breaker door weighs approximately ~400 pounds (181kg)

Typical mechanically-vented arc resistant switchgear exhaust plenums

Typical mechanically-vented arc resistant switchgear exhaust plenum area

Typical mechanically-vented arc resistant VFDs with exhaust plenums

Mechanical Arc Venting Disadvantages

1. Does not reduce arc flash incident energy, it merely redirects it.

2. Only redirects arc flash energy when properly enclosed and closed (enclosure closed and all doors/panels properly secured).

3. Cannot extend any arc-resistant (IEEE C37.20.7-compliance) benefits to downstream equipment.

4. Does not insure equipment reliability or rapid return to service (useability) after an arc flash event.

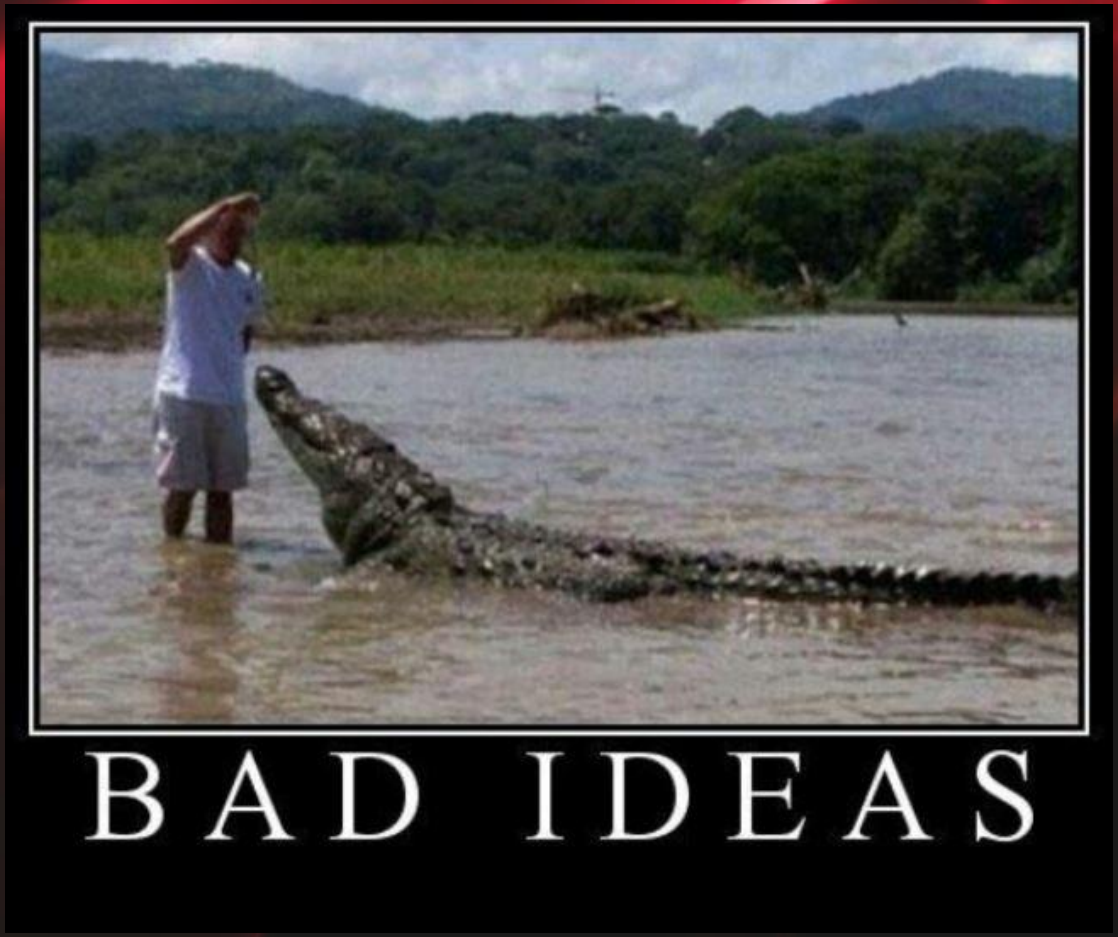
5. Poor maintainability in electrical mission-critical environments. Downstream MCCs, VFD's, and control panels have the same arc flash incident energy as standard non-arc-rated equipment.

6. Not retrofittable; only available for new equipment installations.

7. Expensive to purchase, install, and maintain.

ELECTRICAL DESIGN CONCLUSION

From an electrical safety, reliability, and maintainability perspective, mechanically-vented solutions to IEEE C37.20.7 are . . .



If mechanically-vented solutions for IEEE C37.20.7 compliance are such a ‘bad idea’ (poor design practice), why is arc flash mechanical redirection switchgear so popular?

- It was invented first.
- It sounds good to risk management and safety managers, because ‘arc resistant’ sounds much better than non-arc-resistant.
- The USA is the most litigious society in the world, so avoiding costly litigation and negative publicity are high priorities.
- Even amongst electrical power engineers, Arc Quenching is often an unknown option or is viewed a nascent technology, or is misunderstood.

Arc Quenching Definition (per 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 Quencher Device Examples

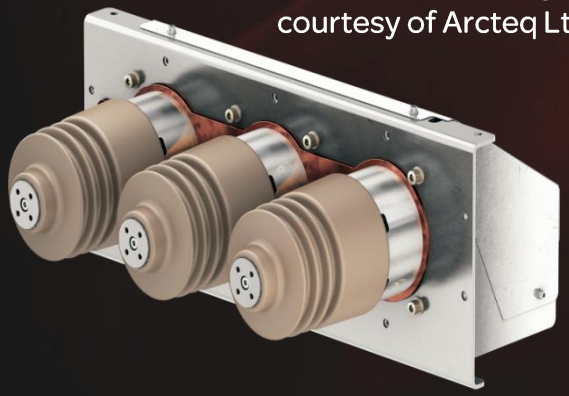
Resettable Devices

Non-Resettable Devices

Resettable AQ images courtesy of Arcteq Ltd.

Low Voltage Devices

LV Arc Quencher image courtesy Eaton Corporation



Medium Voltage Devices

MV Arc Quencher image courtesy ABB

How does an Arc Quencher work?

It detects a fault through current & light sensors and then bolts all three phases together with respect to ground, while simultaneously opening an upstream circuit breaker; this eliminates the arc flash before it becomes it becomes life-threatening or creates catastrophic equipment damage.

Arc Quencher Standards

- UL2748
- IEC 60947-9-1
- NEC 240.87
- NFPA 70E Annex 0.2.3(4)

Arc Quencher Standards

UL2748 Arc Quencher System

+

"Normal" non-arc-resistant equipment

=

C37.20.7-compliant equipment

Note: Type Tested!

Typical Arc Quenching System

Arc Flash Protective Relay

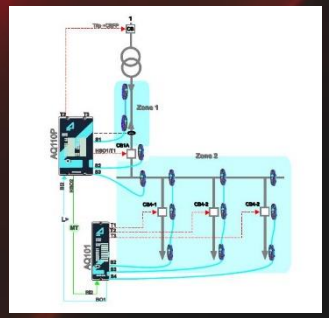
+

Arc Quenching Device

+

Annunciation System

=

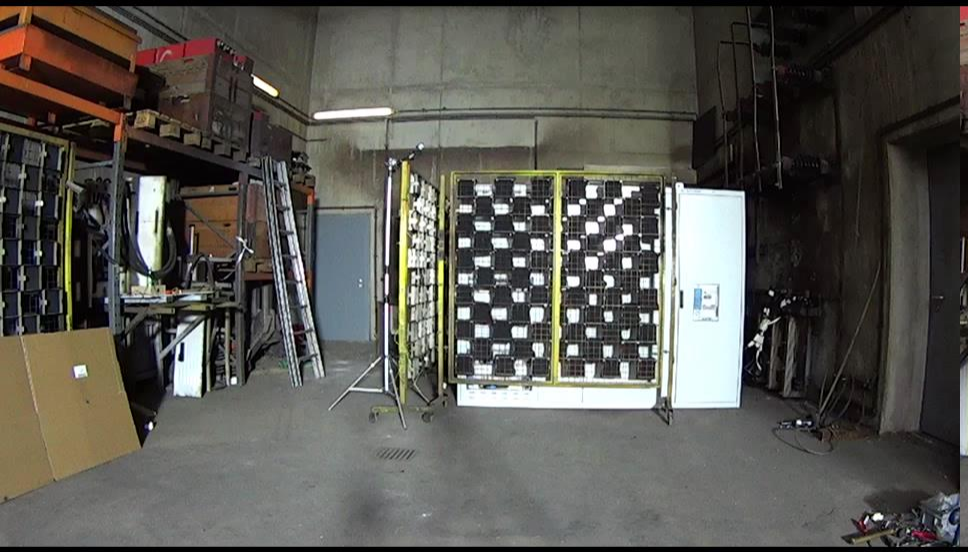


Arc Quenching System

Current Transformers & Light Sensors

65 kA / 480V arc test, peak transient 163kA

Quenching time 4ms

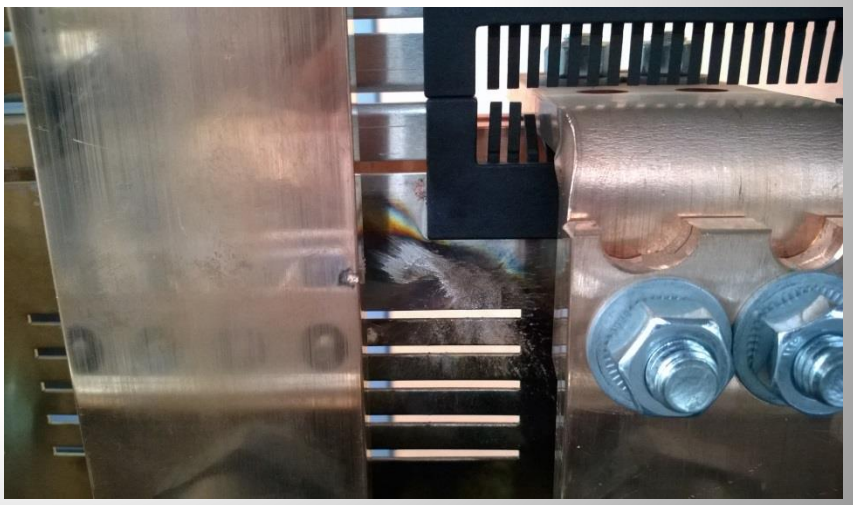


Tripping time 50ms

No electrical equipment damage

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

Quenching time 4ms



Mechanical Venting vs. Arc Quenching Comparison

SAFETY

Mechanical Venting (Arc Redirection)

Is ONLY arc-resistant when the equipment is properly closed and not exposed-energized

Image courtesy Eaton

Arc Quenching
(Arc Elimination)

Is arc-resistant whether equipment enclosure is open or closed.

Mechanical Venting vs. Arc Quenching Comparison

SAFETY

Mechanical Venting (Arc Redirection)

Personal Protective Equipment is not reduced.

Arc Quenching
(Arc Elimination)
No arc-rated PPE required by NFPA 70E

Mechanical Venting vs. Arc Quenching Comparison

RELIABILITY

Mechanical Venting (Arc Redirection)

Downstream assets are still non-arc-resistant, unless separately ordered as arc resistant.

Variable Frequency Drives (VFDs)
Image courtesy Danfoss

Motor Control Centers (MCCs)
Image courtesy Square D by Schneider Electric

Arc Quenching
(Arc Elimination)

Any asset with the light sensors installed also becomes arc-resistant and complaint with IEEE C37.20.7

Panelboards & Disconnects
Image courtesy Square D by Schneider Electric

Mechanical Venting vs. Arc Quenching Comparison Summary

Mechanical Venting	Arc Quenching
Only protects when equipment is closed	Protects when equipment is open or closed
Provides enhanced safety only	Improves both safety AND reliability
Equipment may be catastrophically damaged during arc flash event	Protects equipment from catastrophic during arc flash events
Does not provide an addition reduction of arc flash incident energy	Reduces arc flash incident energy to less than 1.2 calories per cm^2
Does not lower personal protective equipment (PPE) requirements	Always eliminates the NFPA 70E requirement for arc-rated PPE
Cannot extend arc-resistant protection to downstream assets	Any downstream asset which is equipped with light-sensors also becomes arc-resistant and compliant with C37.20.7.
Expensive to install and requires additional hardware (exhaust plenums)	Installs inside standard equipment, such as switchgear or transformers
New equipment only	New, retrofit, and retrofill applications

Arc Quenching Decision & Benefits

Three Practical Application Questions:

1. How important is facility reliability (uptime) and power system continuity?

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

3. Would the application benefit by eliminating the NFPA 70E requirement for arc-rated PPE clothing?

TECH 4
TECHNOLOGY FOR AUTOMATION

Arc Quenching™ Budgetary Costs

1. Arc Quencher systems vary by size and complexity.
2. The average cost of a low-voltage Arc Quencher system is $75,000. The average cost of a Medium Voltage Arc Quencher system is $85,000.
3. These budgetary costs include all design, drawings, electrical engineering services, hardware, software, assembly, project management, and factory acceptance testing (FAT). In other words, a complete tested system as it ships from the factory.
4. These budget numbers do not include jobsite installation by a local electrical contractor or site acceptance testing (SAT).

Q&A

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- Thank you for your time!