Integral Group

Deep Green Engineering

Presented by: W. Spencer Phillips, PE
March 18, 2019

Metal-enclosed vs. Metal-clad Switchgear

(...and other observations from an electrical engineer)
And that, Arnie, is why we wear hardhats on the job.
Objectives

Classifications

Types of Protection

Applications

Considerations
Objectives

• Explain what “metal-clad” means
• Identify what types of protection is used in different types of switchgear
• Understand why this engineer would select metal-clad over other forms of metal-enclosed switchgear
Objectives

Classifications

Types of Protection

Applications

Considerations
Classifications

- Open switchgear has no enclosure as a part of the support structure.
- Enclosed switchgear consists of a metal-enclosed supporting structure on the top and all sides (except vents and inspection windows) with access provided by doors or removable panels.
Classifications

Metal-clad Switchgear

Low-voltage Power Circuit Breaker Switchgear

Interrupter Switchgear
Classifications

All metal-clad switchgear is metal-enclosed

Not all metal-enclosed switchgear is metal-clad
What makes it Metal-Clad?

- Main device is draw-out
- Major parts are protected by grounded metal barriers
- Dead front construction
- Insulated primary bus
What makes it Metal-Clad?

- Mechanical interlocks
- Instrumentation is isolated from primary bus elements
- The door may contain instrumentation
Types of Protection

Objectives
Classifications
Applications
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Types of Protection

Fuses or Circuit Breakers?
Types of Protection

- Distribute and carry load
- Identify and clear faults quickly enough to minimize damage
- Provide sufficient segmentation of the medium-voltage system
Switches & Fuses

- Simplicity
- Economy
- Fast response characteristics
- Freedom from maintenance
Circuit Breakers & Relays

- Solid state tripping
- Excellent reliability
- Very narrow and predictable tolerances
- Easily selectively coordinated
Objectives
Classifications
Types of Protection
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Applications

- For this engineer, there is one primary use for fuses and that is short circuit protection.
Applications

• For all overload applications, I am selecting a circuit breaker

• For all other applications, circuit breakers seem to be the best choice as well (to me)
Objectives
Classifications
Types of Protection
Applications
Considerations
Considerations

• How many outages can be permitted for maintenance?
• How much load will be interrupted for fault protection or for maintenance?
• Is automatic reclosing necessary?
• Is sophisticated relaying required?
Considerations

- Is DC control power available?
- Is single-phasing a problem?
- Are skilled technicians available?
- Will cable size be based on ampacity?
- What are the economics?
Review
Personal Reflections of an Electrical Engineer
Voltage Drop in Conductors
Voltage Drop in Conductors

- NFPA 70 Table 9 (3-phase circuits)

<table>
<thead>
<tr>
<th>Size (AWG or kcmil)</th>
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### Voltage Drop in Conductors

**Table 9: Alternating-Current Resistance and Reactance for 600-Volt Cables, 3-Phase, 60 Hz, 75°C (167°F) — Three Single Conductors in Conduit**

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Note: Stranded... Solid...
Voltage Drop in Motors
Voltage Drop in Motors

- Starting Currents depend on efficiency of motor
- Premium Efficiency are Type ‘F’ or ‘G’.
- LRA = 3.0 to 6.0 times RLA
- Table 430.52 sets maximum at 800% (8X)
- Watch out for ‘low quality’ motors!
Voltage Drop in Motors

“Energy Efficient is 2 steps below “Premium Efficient”

Fire Pump Motors

For fire pump applications per NFPA® 20 where contaminants are minimal.

- Horsepower: 7.5 – 250 HP
- Phase: Three Phase
- RPM: 1800 and 3600 RPM
- Voltage:
  - 575
  - 208-230/460
  - 200/400
  - 230/460 Volts
- Efficiency: Energy Efficient
- Enclosure:
  - Open Dripproof (ODP)
- Mounting:
  - Footed and Footless
  - Vertical and Horizontal
- Vertical Shaft Type:
  - JP Close Coupled Pump Mounting
Prescriptive v. Performance

- Circuit breaker (and fuse) sizing calculations are prescriptive in NFPA 70
50 hp, $I_{fla}=65$ A @ 480v, 3 ph

\begin{align*}
V & := 480 & \text{ph} & := 3 & I_{fla} & := 65 \\
I_{cb} & := 1.75 \cdot I_{fla} & I_{cb} & = 113.75 & \text{CB} & = 125A/3P \\
I_f & := 1.25 \cdot I_{fla} & I_f & = 81.25 & \text{Fuse} & = 90A \\
I_w & := 1.25 \cdot I_{fla} & I_w & = 81.25 & \text{WIRE} & = 3 \#3, 1 \#6 \ G., 1 1/4" \ C. \ (Copper) \\
\text{WIRE} & = 3 \#1, 1 \#4 \ G., 1 1/2" \ C. \ (Aluminum) \\
kVA & := I_{fla} \cdot \frac{V \cdot \sqrt{\text{ph}}}{1000} & kVA & = 54.04 & kVA_{3ph} & := \frac{kVA}{3} & kVA_{3ph} & = 18.01
\end{align*}
Motor Starting

CURRENT IN AMPERES

TIME IN SECONDS

Motor 2.tcc  Ref. Voltage: 480V  Current in Amps x 1
Motor Starting
Motor Starting
Industry Consolidation
Industry Consolidation

SIEMENS
Landis Gyr

Schneider Electric

ASCO

Industry Consolidation

GE
ABB
EATON

Cutler-Hammer

COOPER

W
Industry Consolidation

- Products benefitting from consolidation:
  - Variable Frequency Drives
  - Metering
  - TVSS/SPDs
Short Circuit Current in VFD

- Most modern VFDs will not allow current to reverse power flow
- This means that a VFD can act as a gate valve preventing motor contribution in short circuit conditions...
  ... as long as the motor is not in bypass.
- Some newer VFDs do not act this way, however, so called Matrix Drives – AC-AC conversion drives
Regenerative Drives

- When ascending, elevators consume power, when descending, they are capable to regenerating power
- Some manufacturers will put this power back on to the ‘grid’
- May cause issues of reverse power flow when on emergency power or when the distribution system is small
Reverse Power Flow

- Reverse power flow is becoming more of a challenge as buildings become more energy efficient and on-site generation becomes larger and more prevalent.
No Such Thing as a Sucker’s Steak

- If you are good at it; stick to it
- If not; leave it to the other guys
I’m No Contractor...
No Contractor is an Engineer

- If you are good at it; stick to it
- If not; leave it to the other guys
International Building Code

- Are we better off?
- Local jurisdictions should not amend Codes. Except on the issue of selective coordination, of course!
- City of Atlanta ordinance on above ground fuel storage is a great (horrible) example
- The line item veto
Calling all Developers!

- Get your lease language updated
- Just because you are flipping a property does not mean that you can’t do something special
THANK YOU