

The background image shows a large, grey industrial transformer in an outdoor power plant setting. The transformer is mounted on a metal frame and has several high-voltage insulators and cables connected to it. In the background, there are several wind turbines under a clear blue sky. The foreground shows a concrete base and some gravel. The overall scene is brightly lit, suggesting a sunny day.

# Transformer Controls & Schematics

Transformer Concepts & Applications Seminar

Goldsboro, NC

September 17-19, 2024

**waukesha**  
a prolec ge company

## Jeff Sills Sr. Engineering Technician, Controls Design

Jeff joined Prolec GE Waukesha in November of 2002 as a Controls design technician at the Goldsboro facility later to becoming a Sr. Engineering Technician, Controls Design in 2007. Throughout his career, Jeff has been part of the implementation and database management for controls software alongside the Wisconsin facility for the standardization and improvements of control designs. Jeff has also been part of continuous improvement teams, lean events, and special projects for quality and manufacturing improvements. Jeff attended Wayne Community College where he graduated with an associate in applied science degree focused on Mechanical Engineering, Drafting and Design.



# Agenda

1. Tour of Inside Control Enclosure
2. Control Schematic and Wiring Diagrams
3. Transformer Monitoring
4. Controls Specifications
5. What's New?

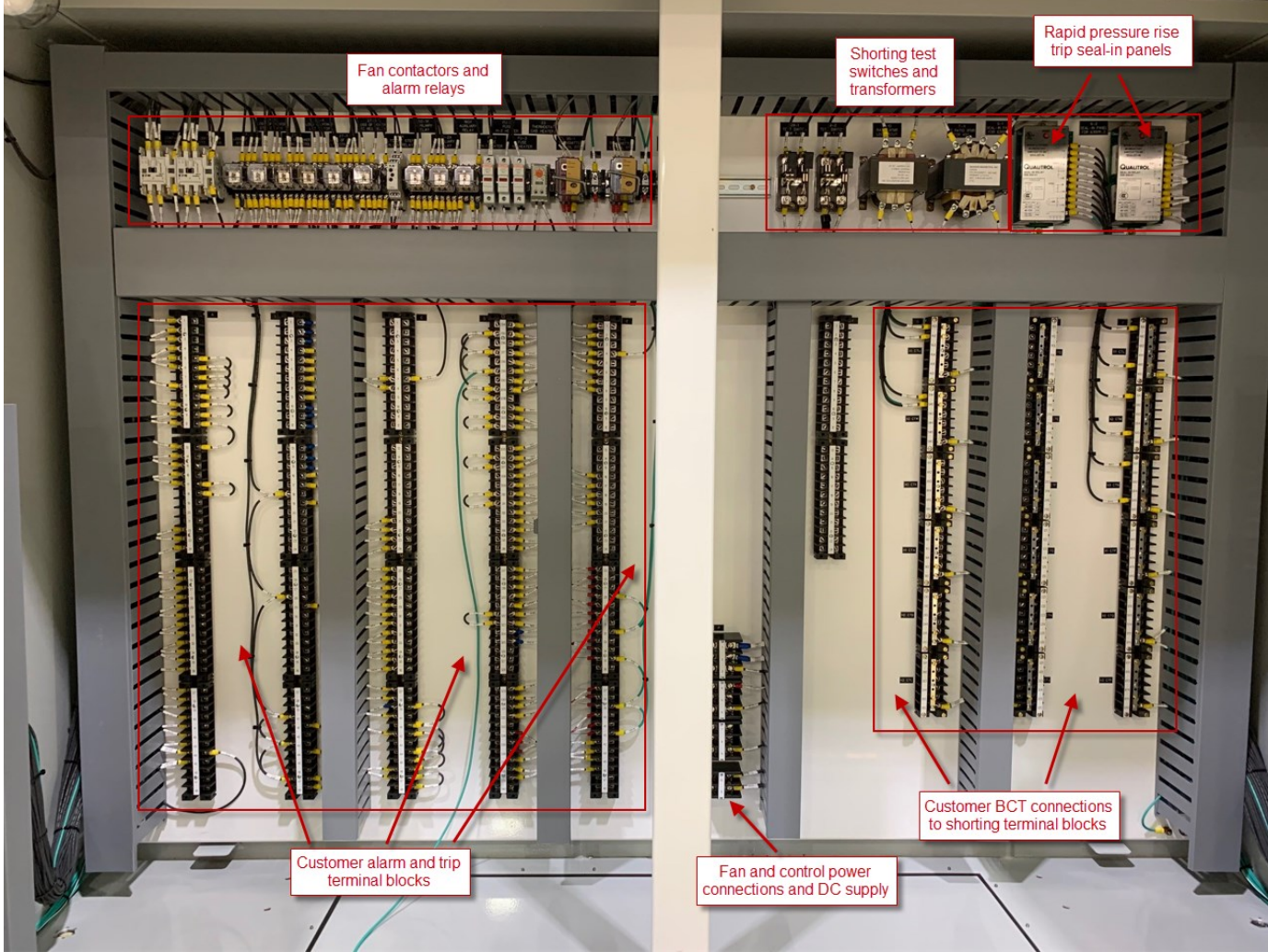
# Outside of the Control Enclosure



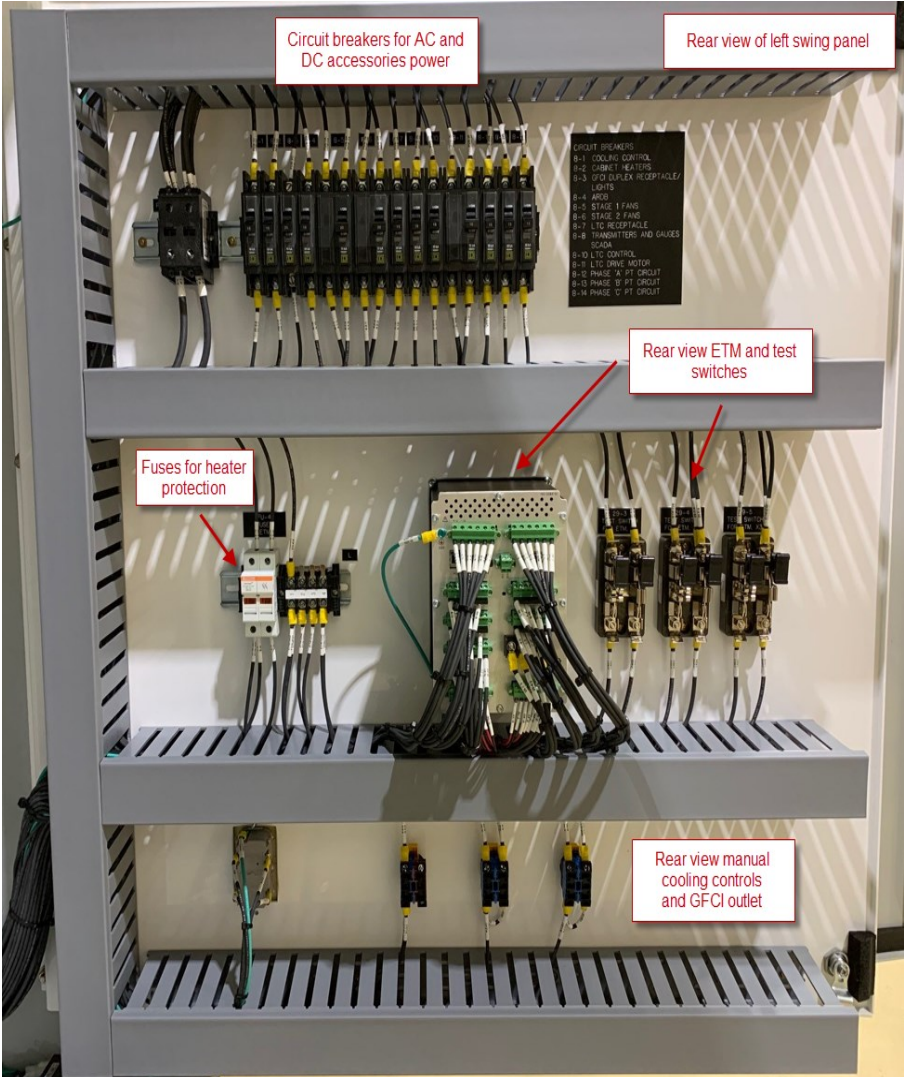
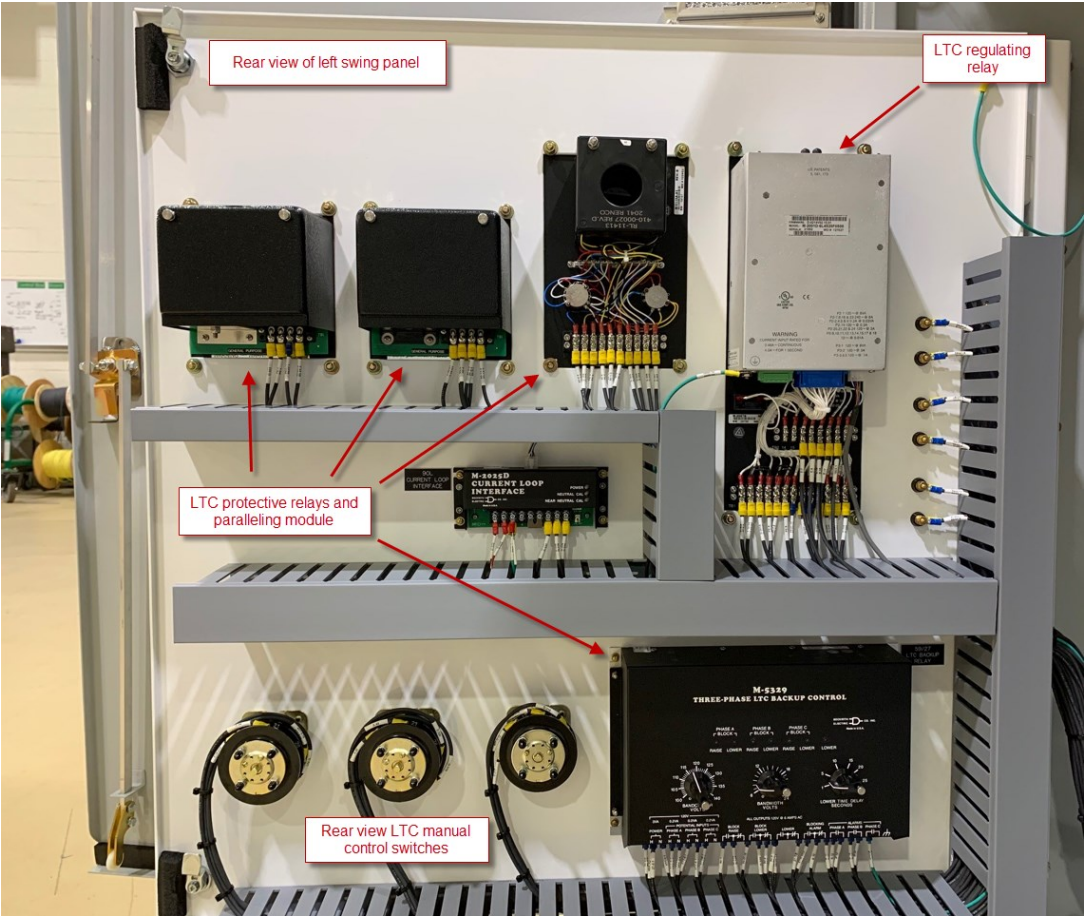
# Inside Control Enclosure



# Inside Control Enclosure



# Inside Control Enclosure



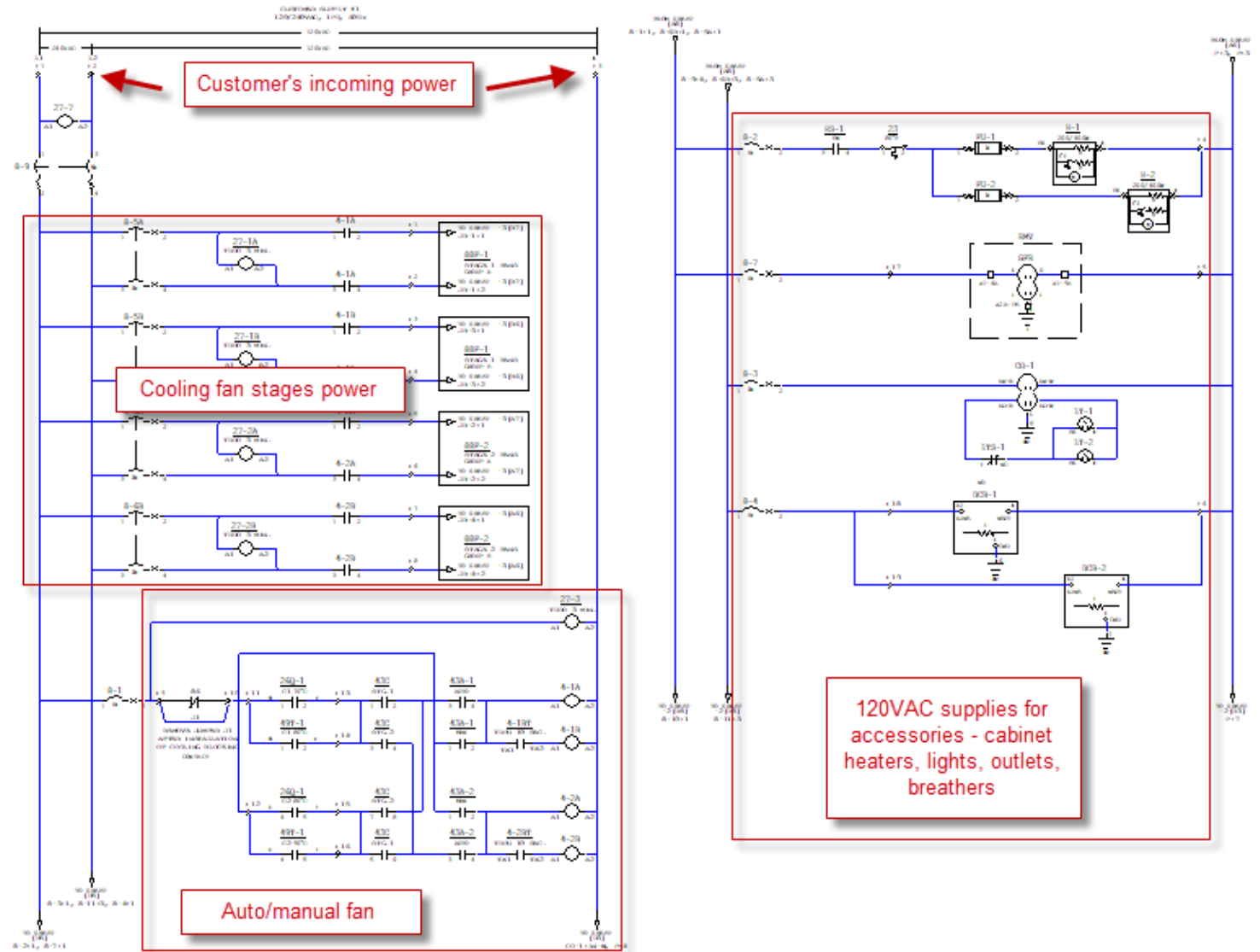
# Control Schematics

- Control cabinets are the customer interface to the transformer.
- Access to transformer alarm and trip devices, monitoring equipment and annunciator devices.
- Manual and automatic control of cooling device (fans or coolers)
- Tap changer control equipment, protective devices including manual and automatic control and LTC tap position equipment.
- Control drawing set includes schematics, panel layouts and point to point wiring diagrams.



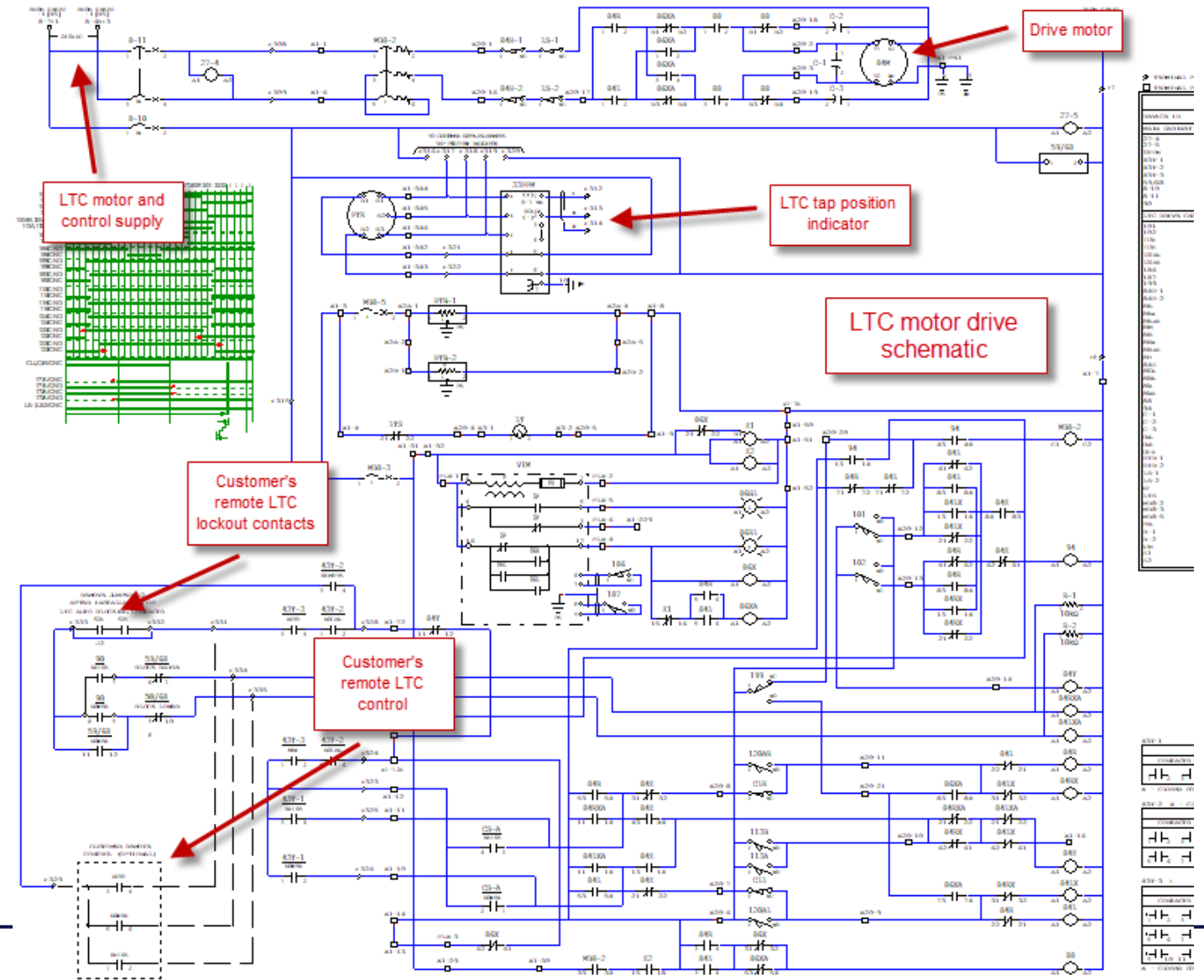
# Control Schematic

- Ladder diagram style schematic



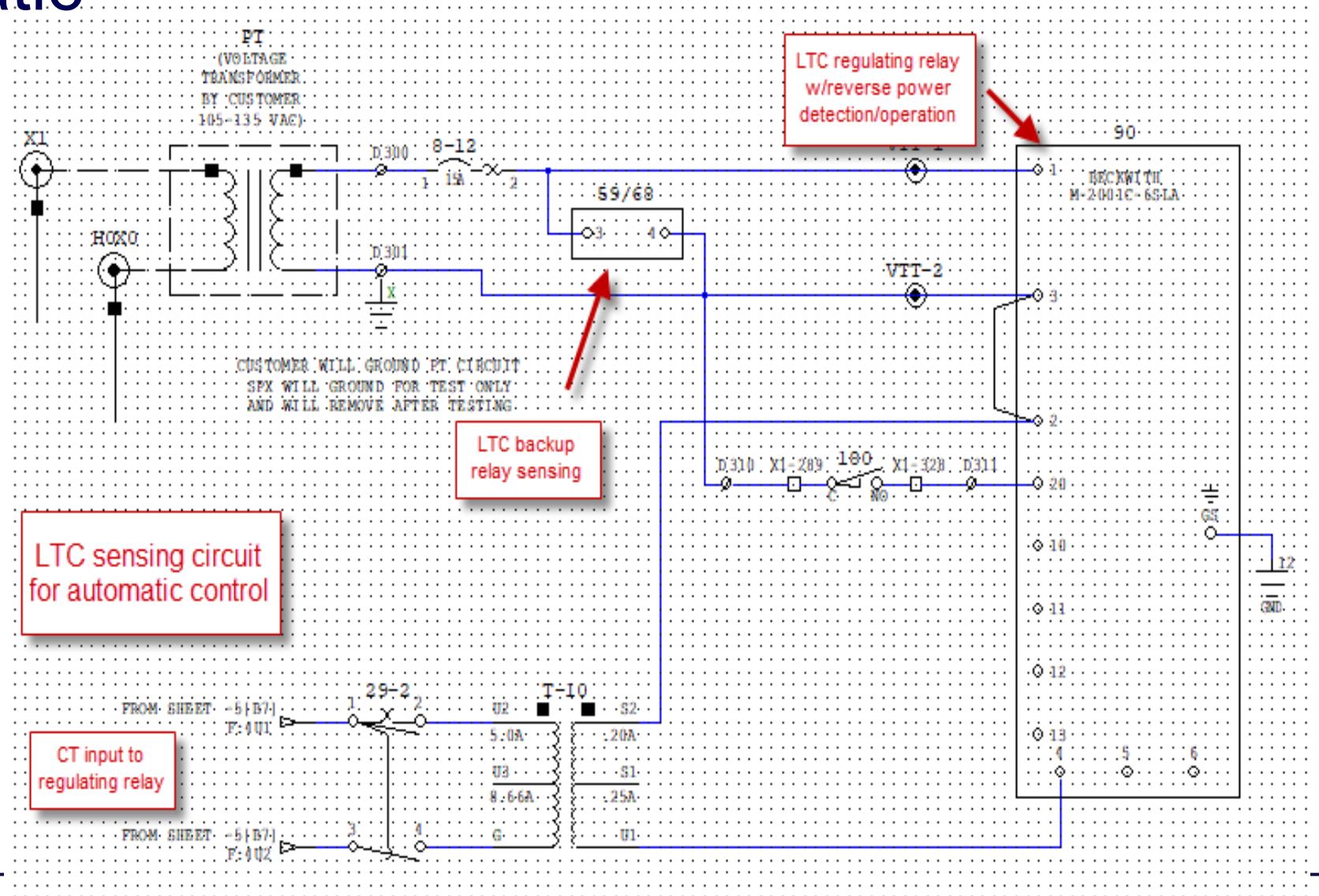
# Control Schematic

- LTC motor drive schematic
- Customer interface points noted in schematic
  - Remote LTC control
  - LTC lockout contacts
  - SCADA output for LTC control

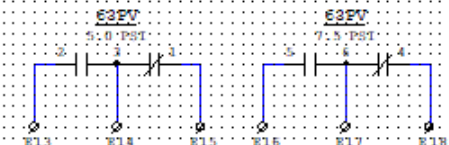
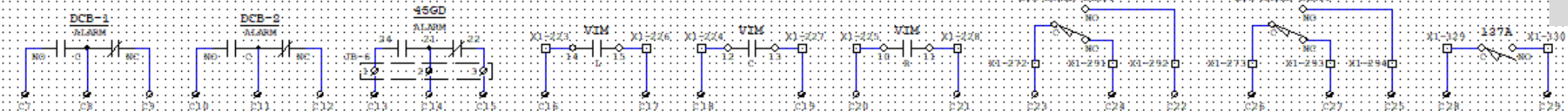
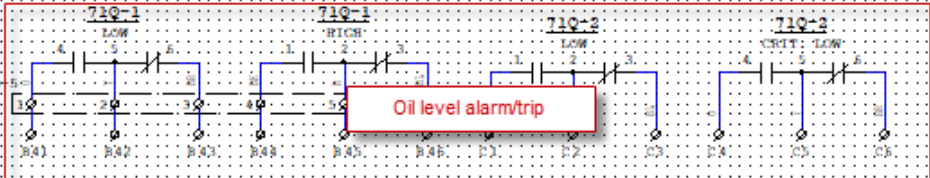
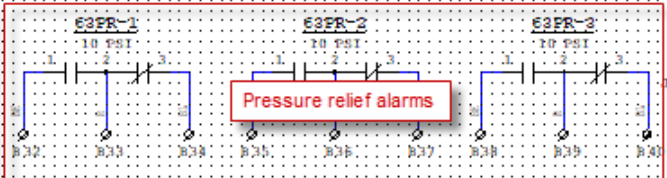
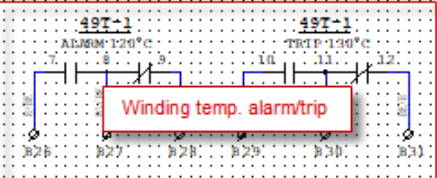
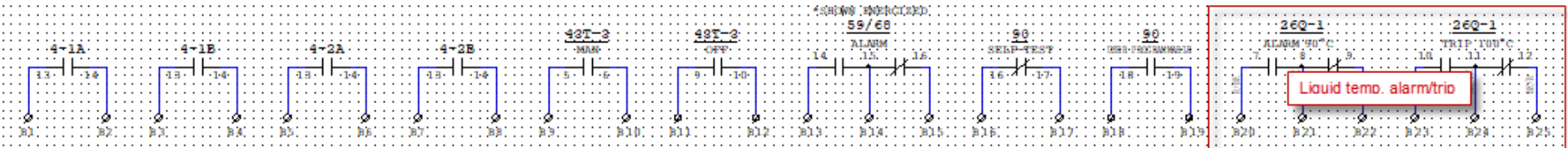
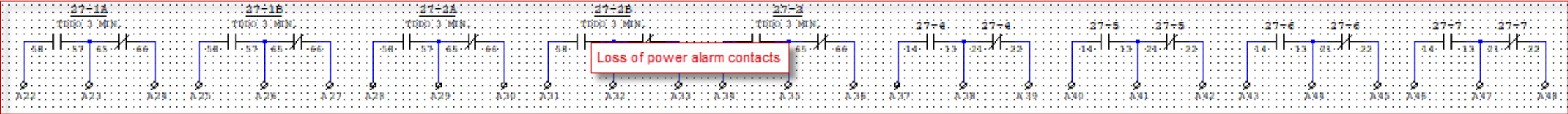


# Control Schematic

- LTC auto control sensing circuit



# Control Schematic

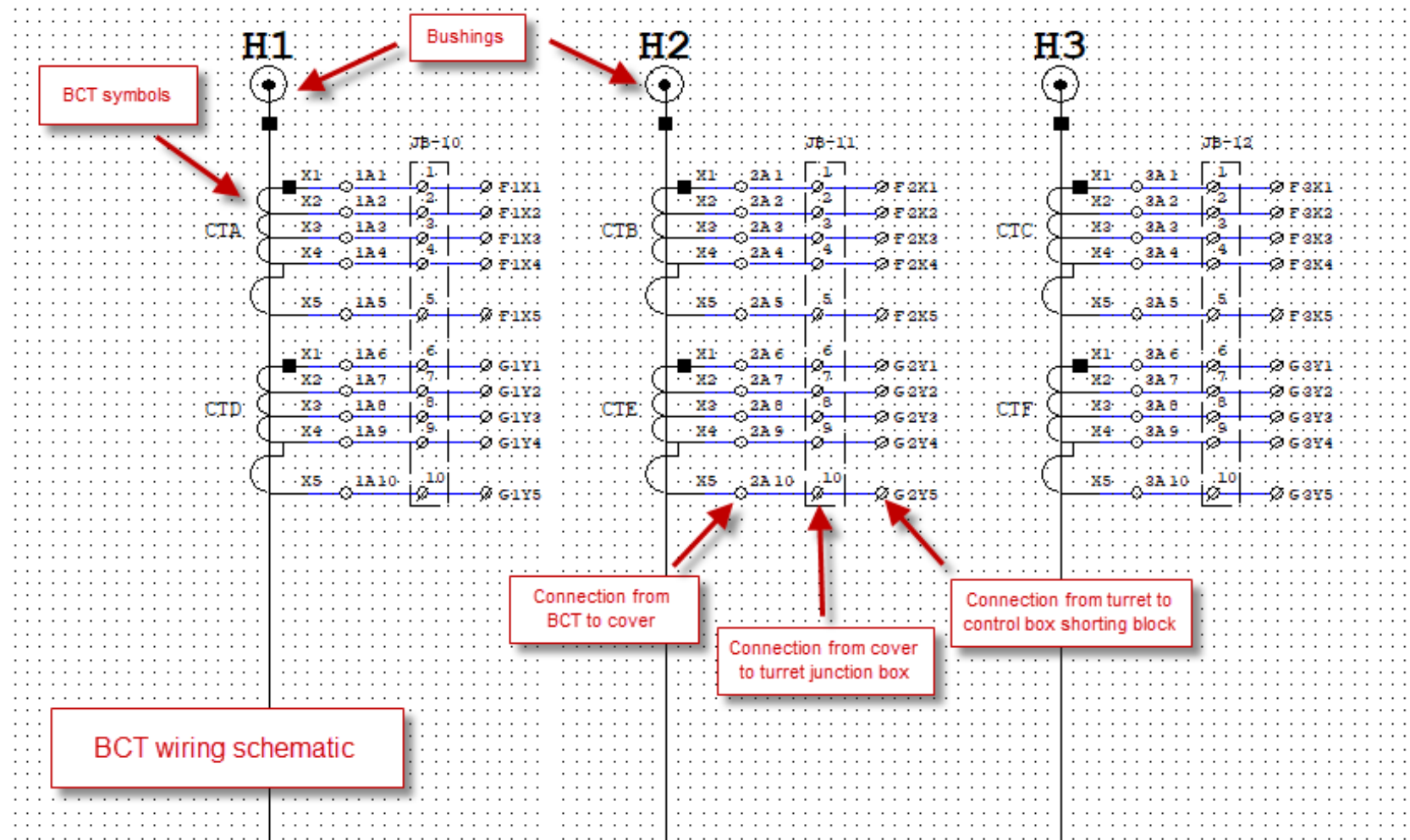


Other alarms include, fans running, LTC backup relay in operation, gas detection alarm, LTC raise/lower limits reached

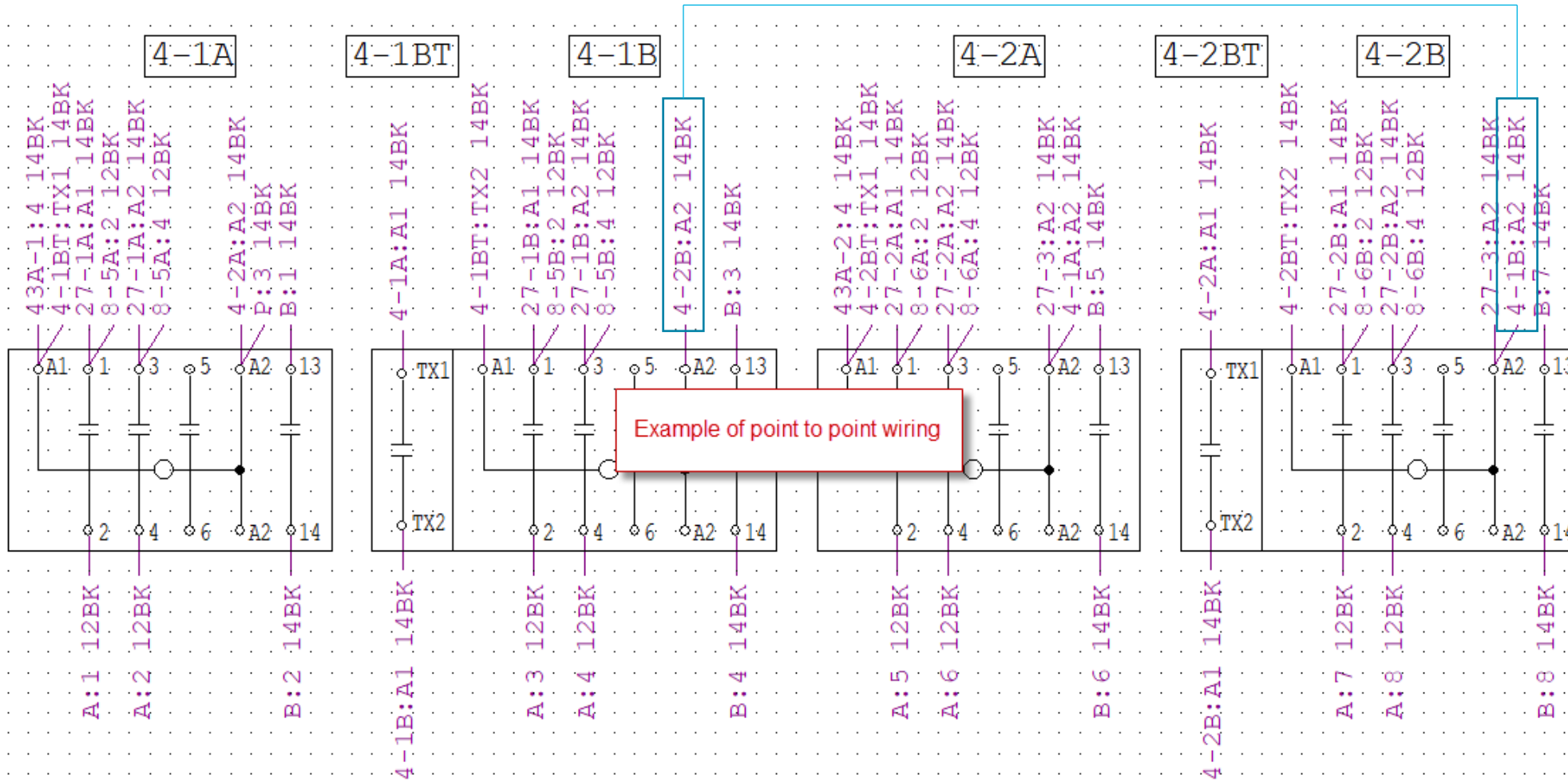
- Transformer alarm and trip contacts wired to terminal blocks for customer interface.

# Control Schematic

- BCT schematic showing path from internal BCT back to control box
- Shorting style terminals blocks for safety



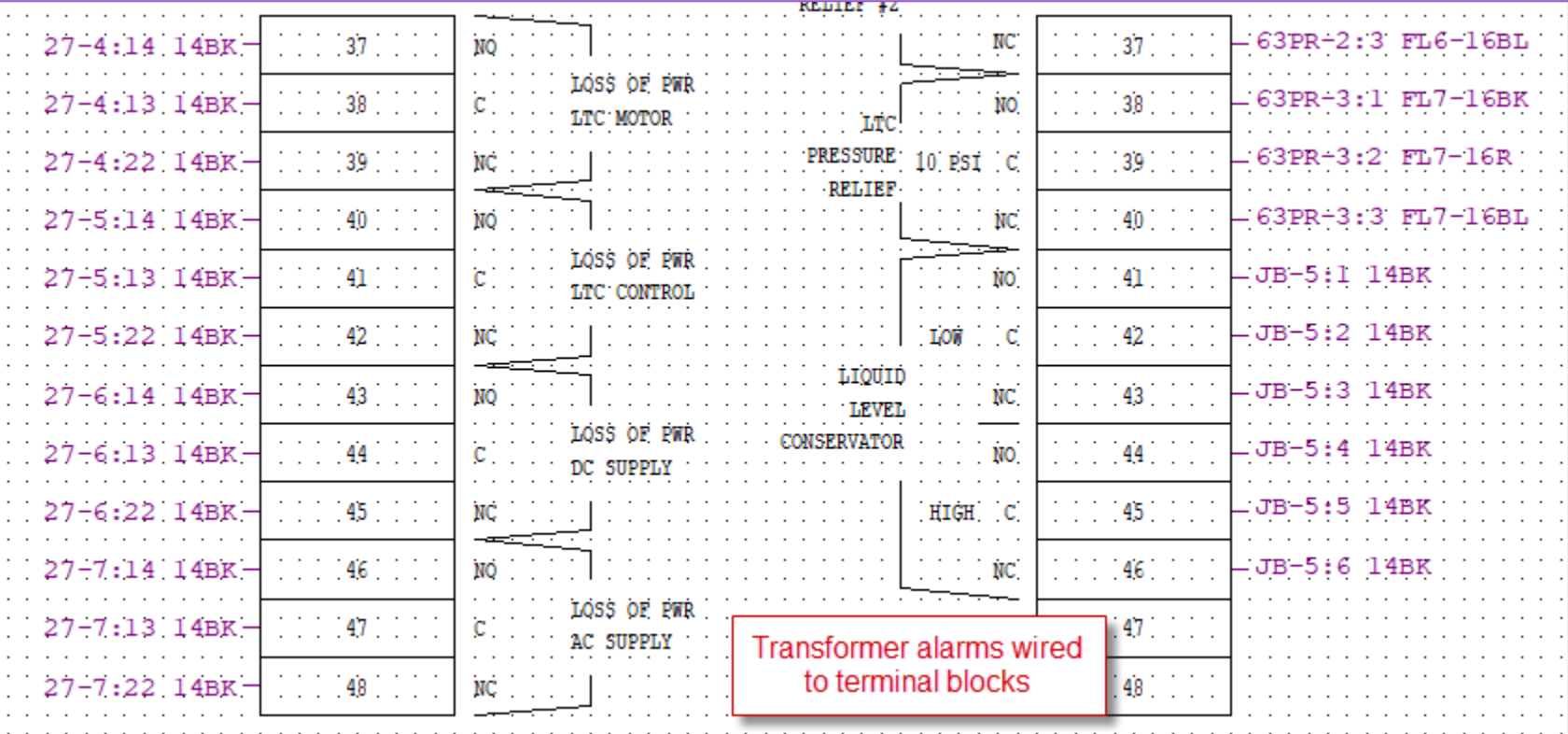
# Wiring Diagrams



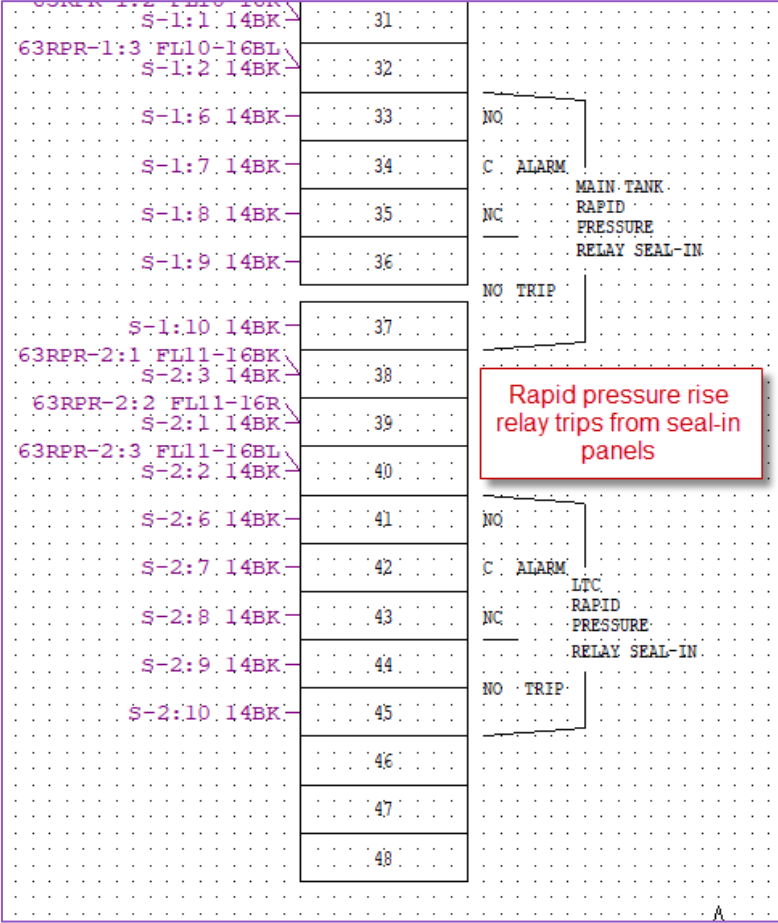
- Point to point wiring diagram used for manufacturing and field wiring
- Useful tool for troubleshooting
- Opposite end connections shown with wire gauge (awg) and color

# Wiring Diagrams

- Transformer alarms and trips wired to terminal blocks in control box



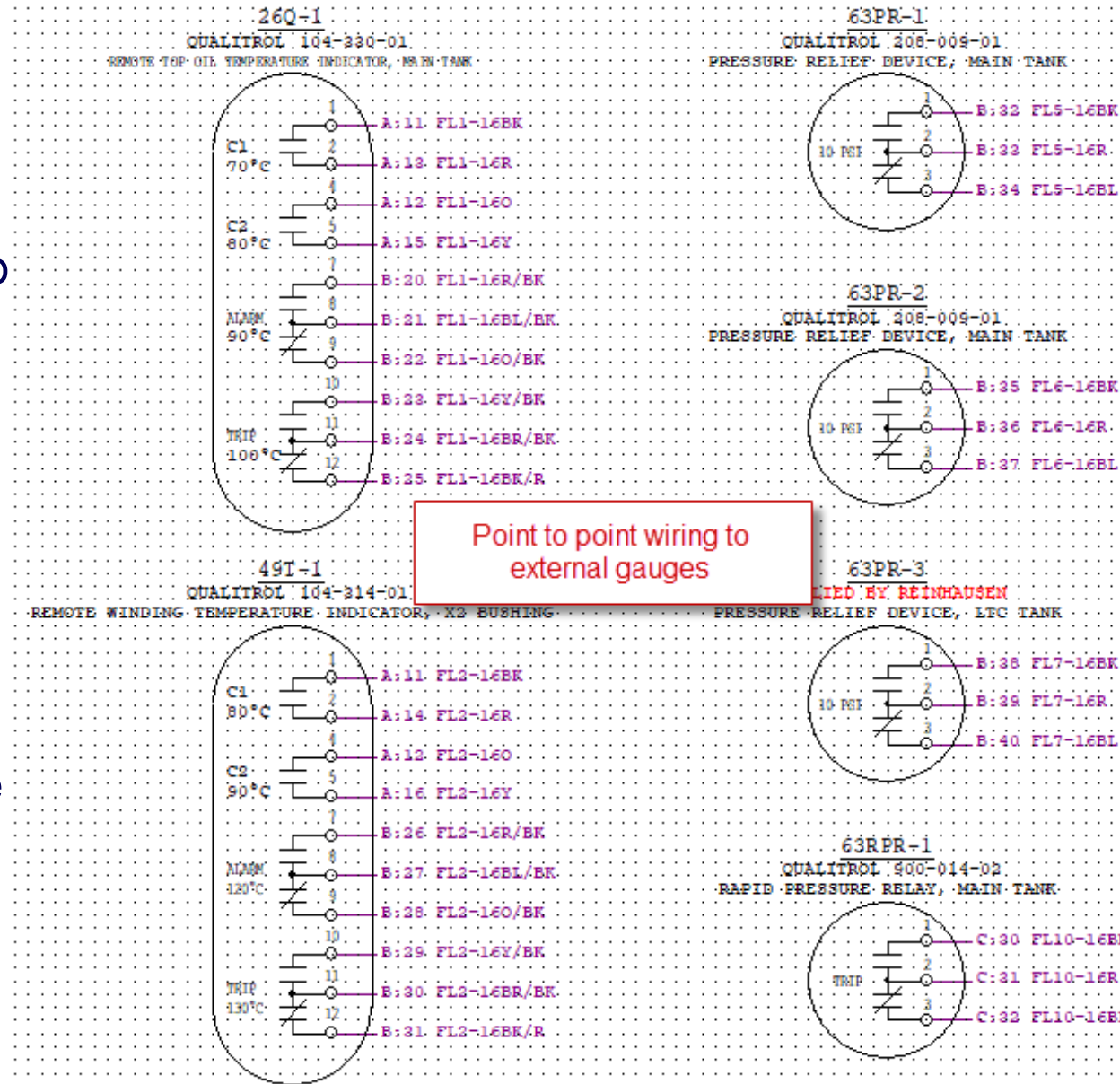
Transformer alarms wired to terminal blocks



Rapid pressure rise relay trips from seal-in panels

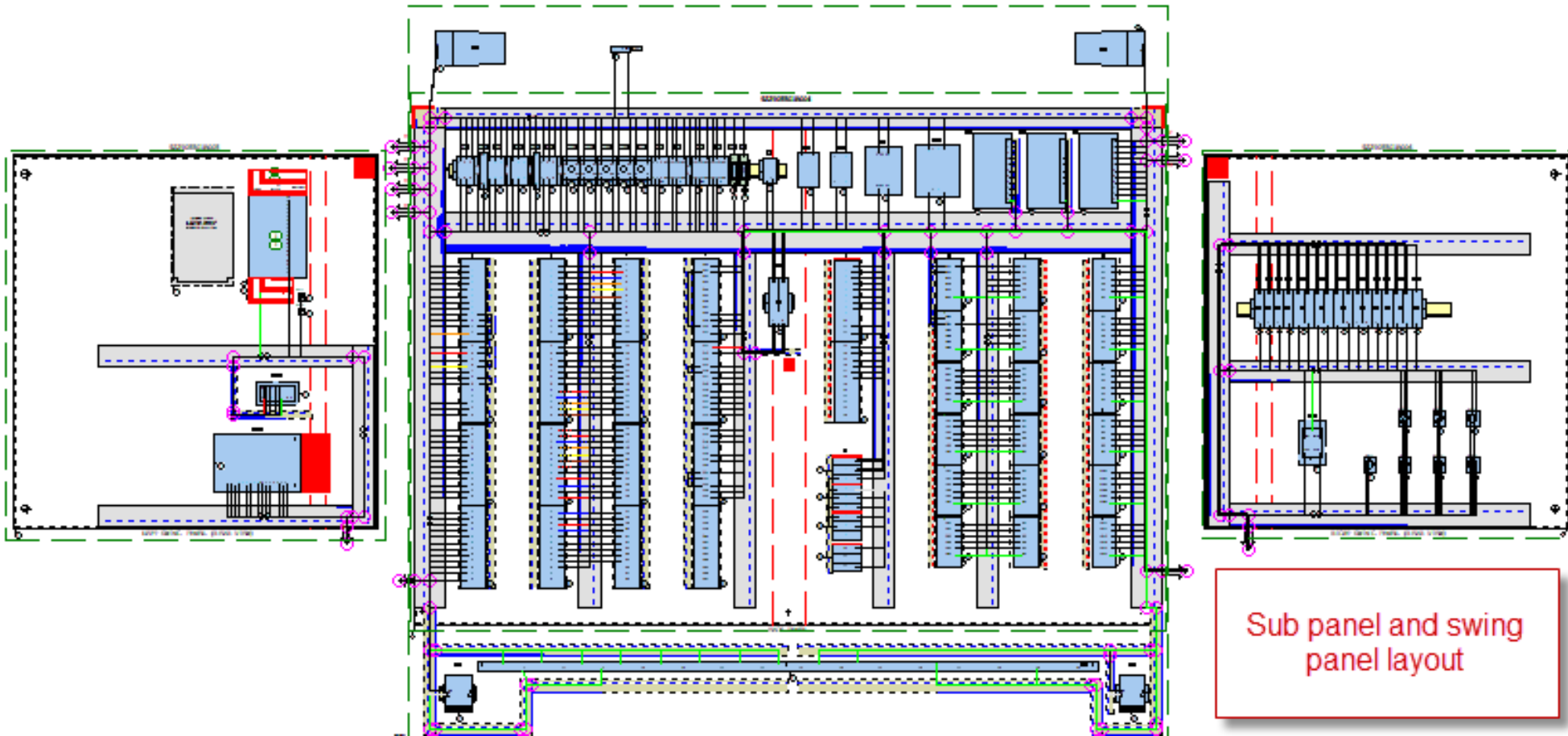
# Control Wiring

- External gauge point to point wiring
- Gauges include
  - Liquid level
  - Pressure relief
  - Rapid pressure rise
  - Winding temperature
  - Liquid temperature
  - Combustible gas detection
  - Tank pressure/vacuum





# Control Box Panel Layout



- Wire paths automatically routed by shortest distance with design program E3 by Zuken.

# Transformer Monitoring

- Transformer monitors are the fastest evolving component for controls design.
- Usually used for automatic fan control using temperature and transformer load input from bct.
- Seeing an increase in direct winding temp. measurement with fiber optic probes.
- Transformer health monitors are becoming more popular. Besides temp. monitoring these monitor
  - DGA Through fault current
  - Bushing health GIC
  - Partial discharge Direct winding temp. through fiber
  - Usually come in their own control enclosures to mount on tank

# Specifications and Controls

- Transformer specs for controls fall into 3 categories, highly detailed, some components specified and very few specifics provided.
- We make every effort to follow spec requirements but have standard components if items not specified.
- Ideally a spec has all configurable components like monitors and gauges have a complete part number specified or included in customer's purchase order.
- Custom circuitry provided as attachment.

# Specification Examples

## Temperature indicators

### All transformers except for autotransformers

11.7.1 Provide an Advance Power Technologies; model **TTC-1000-0K4900**, Electronic Temperature Monitor in place of an analog top oil temperature monitor. Monitor shall be equipped with a temperature probe main tank, a second liquid temperature probe for temperature, and one auxiliary CT input for

Exact configured part number for ETM

### Winding Temperature Indicator (WTI) and Control

1. Electronic Transformer Monitor (ETM). A SEL-2414 Transformer Monitor, model # MOT **241421ACA9X743A0130**, shall be used for cooling control and local annunciation. The SEL-2414 shall be mounted on control cabinet's swing panel at a height between 57 and 63 inches above **direct sunlight. Materialman will not provide drawings that expose the SEL-2414 to direct sunlight.**

Exact configured part number for ETM

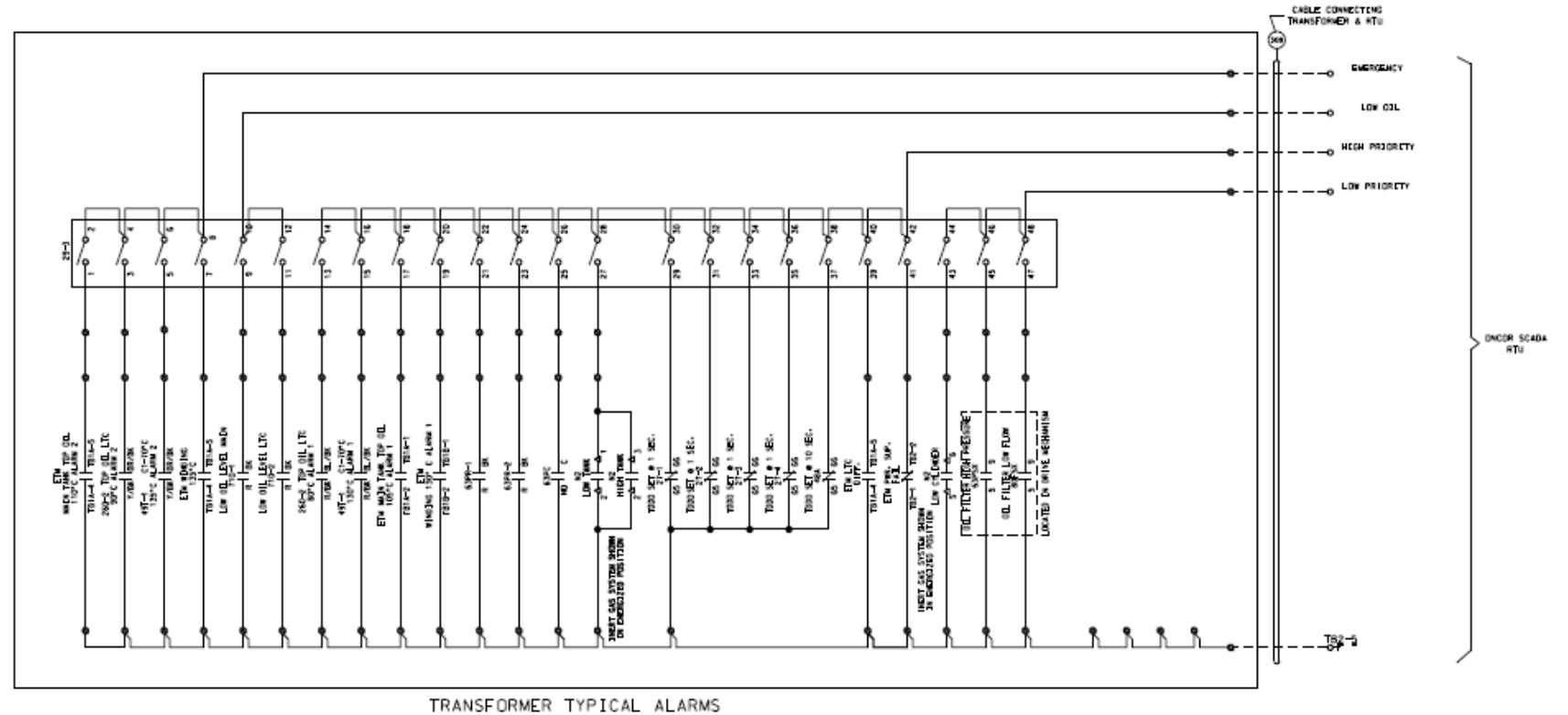
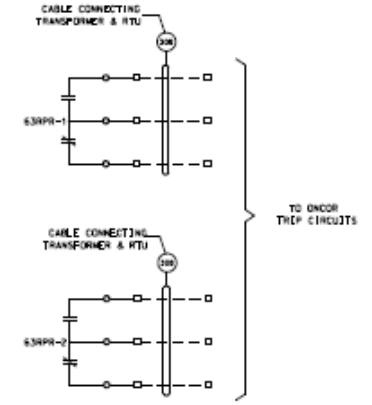
2414 is not designed for

\* Transformer health monitors are difficult to get exact control drawing information up front on approval drawings!

# Specification Examples

NOTES:  
1. NOT REQUIRED FOR VACUUM TAP CHANGERS

Special circuitry included with spec.



# Specifications Do's and Don'ts

## Do's

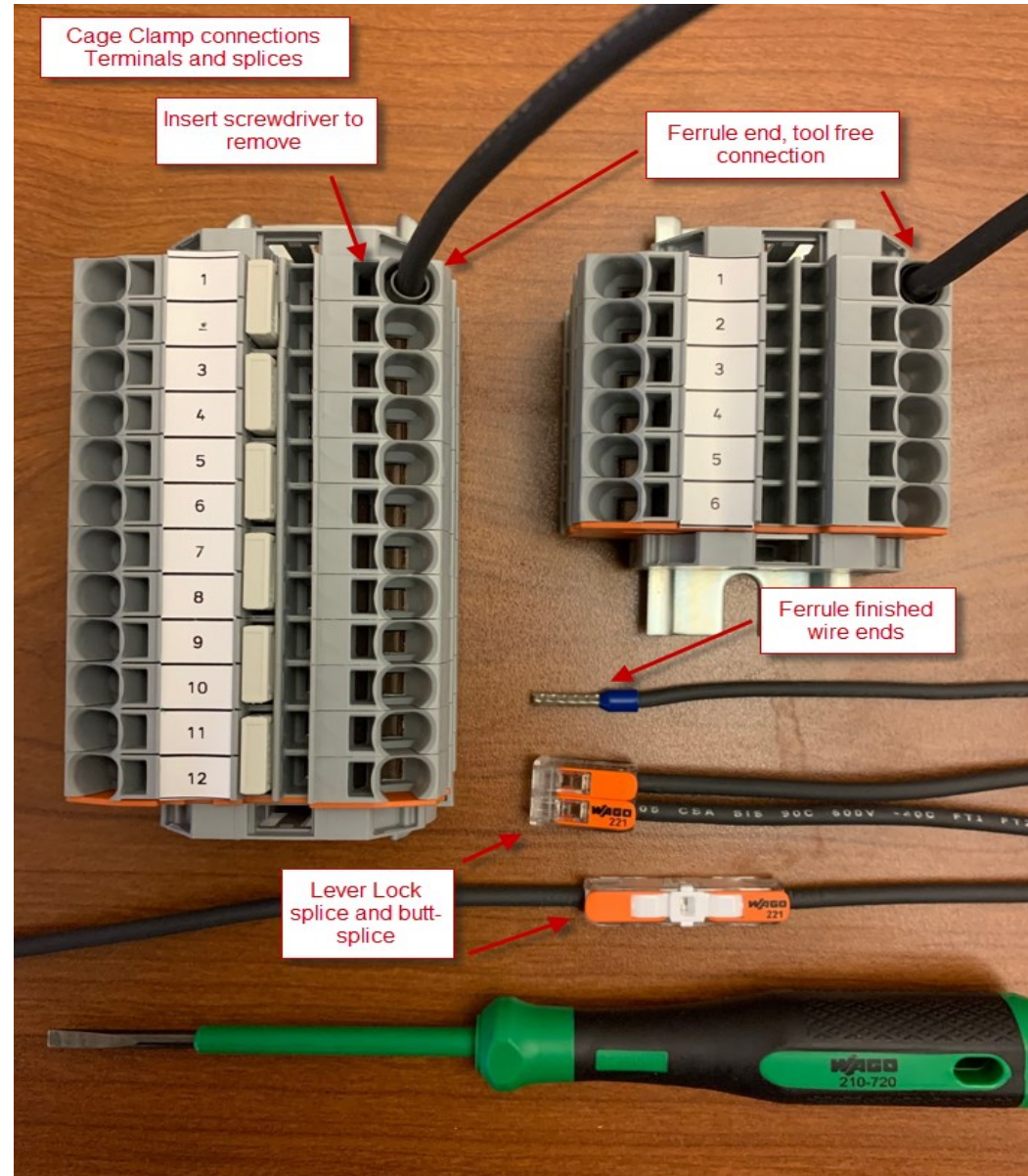
- Provide complete vendor part numbers for configurable components – etms, annunciators, regulating relays, gauges whenever possible
- Detailed specifications for etm and annunciator inputs and outputs
- Schematic diagrams of special circuitry with part numbers defined for components
- All requested component part numbers are current and available to purchase & not obsolete
- Provide special drawing formats, nomenclature or notes on schematics and wiring diagrams
- Provide standard configurations for transformer health monitors – DGA, bushing health, fiber optics with specification if possible

## Don'ts

- Provide multiple specs with conflicting information.
- Technical information in specifications detailing component details, such as input and output cards on an SEL monitors is not required.
- Have multiple engineers reviewing drawings that may contradict previous drawing changes from resubmittals for approval.
- If returned comments on control drawings contradict specification, specification should be updated for future units.

# What's New?

- More requirements for ferrules and no bare wire connections
- New wire connection technologies being used on devices (terminal connections) and accepted by customers.
- Push-In Cage Clamp Connection
- Tools free connections
- Screwdriver required for removal



waukesha  
a proleco company

Questions?





## **Contact**

### **Jeff Sills**

Sr. Engineering Technician, Controls Design

jeff.sills@prolec.energy

Prolec-GE Waukesha, Inc.

2701 US Highway 117 South

**[www.waukeshatransformers.com](http://www.waukeshatransformers.com)**