Substation/Enclosed Switchgear/PCC Fundamentals

Niel Miele, PE, LEED AP

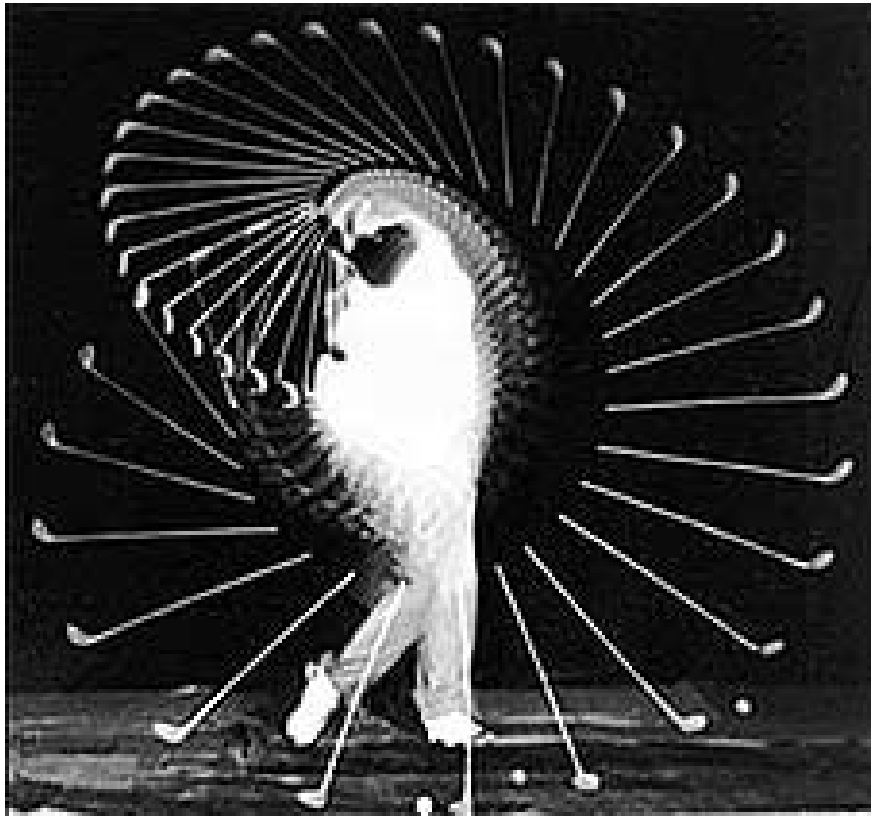
PACS Industries

PACS POWER AND CONTROL SYSTEMS

Let’s go Golfing

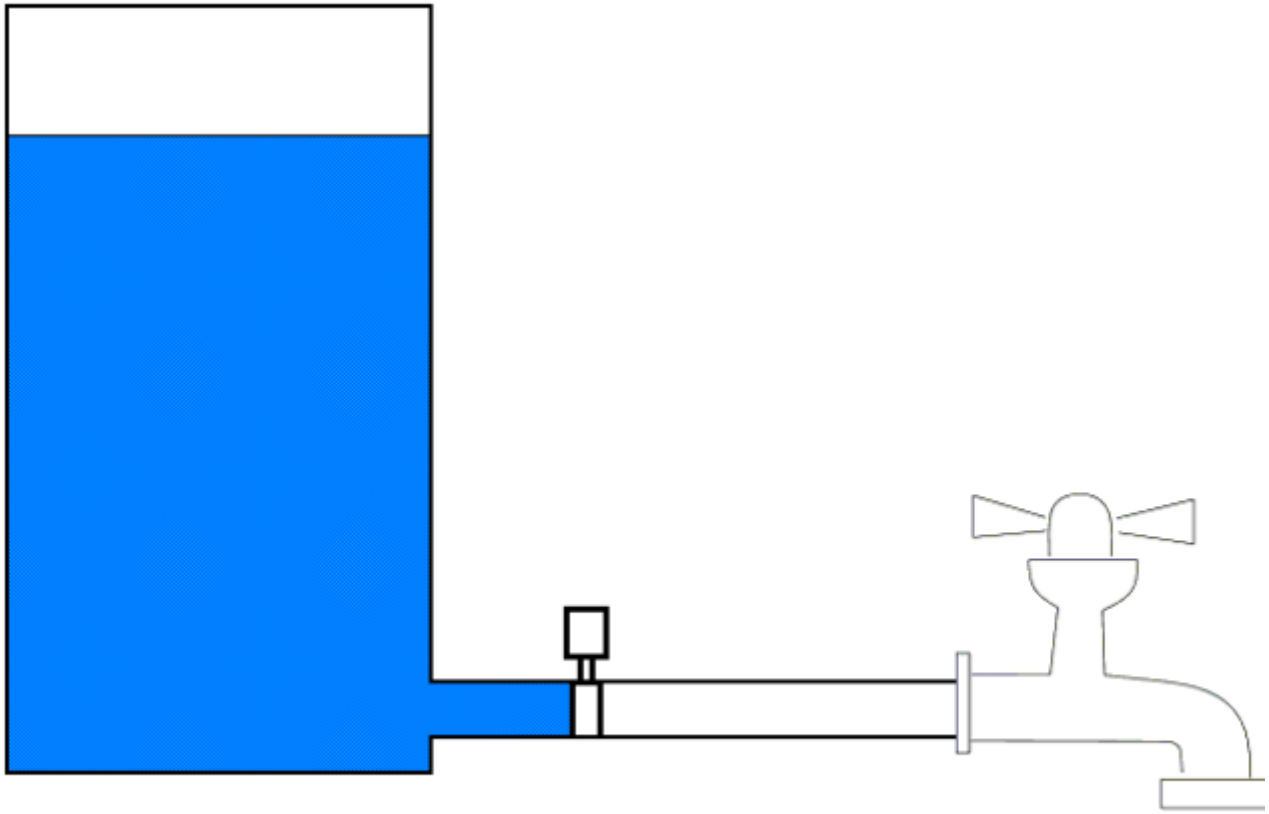
PACS POWER AND CONTROL SYSTEMS

Swing = Energy

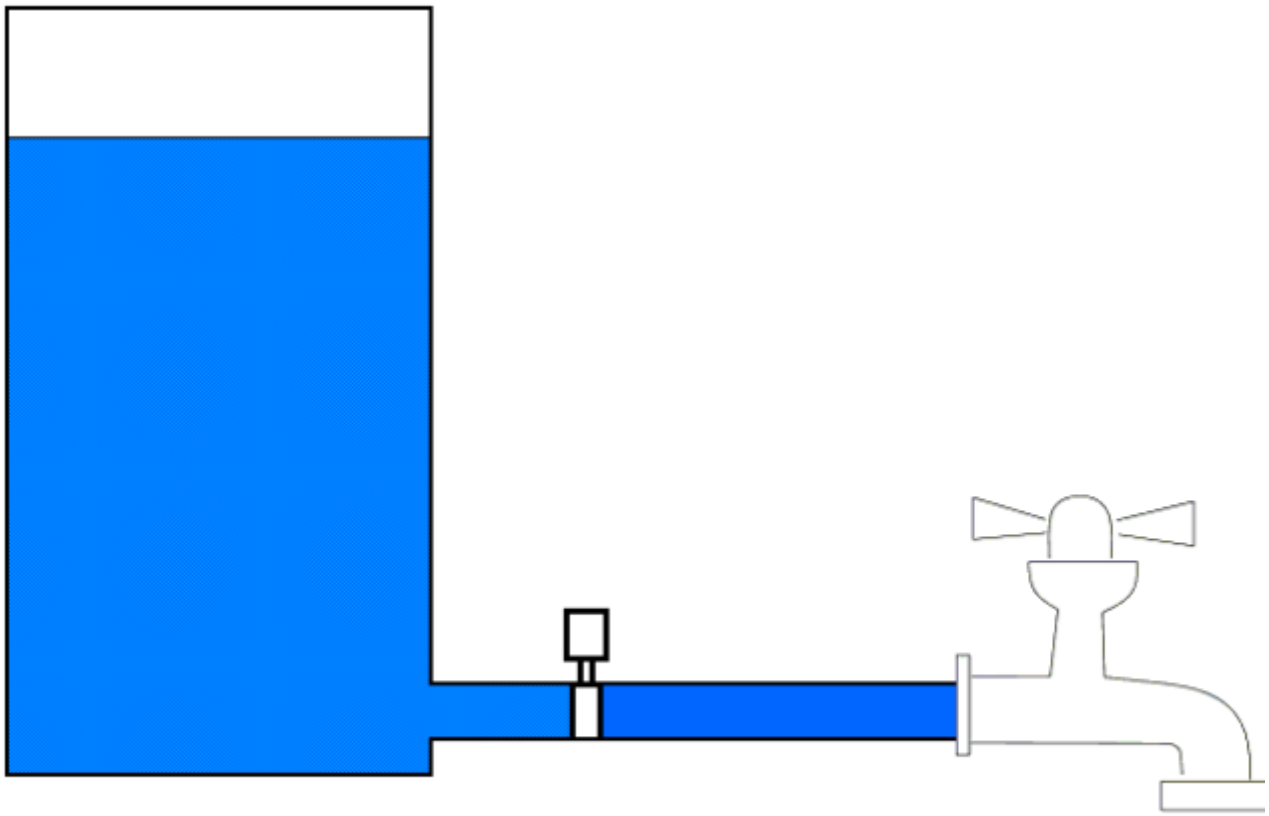


PACS POWER AND CONTROL SYSTEMS

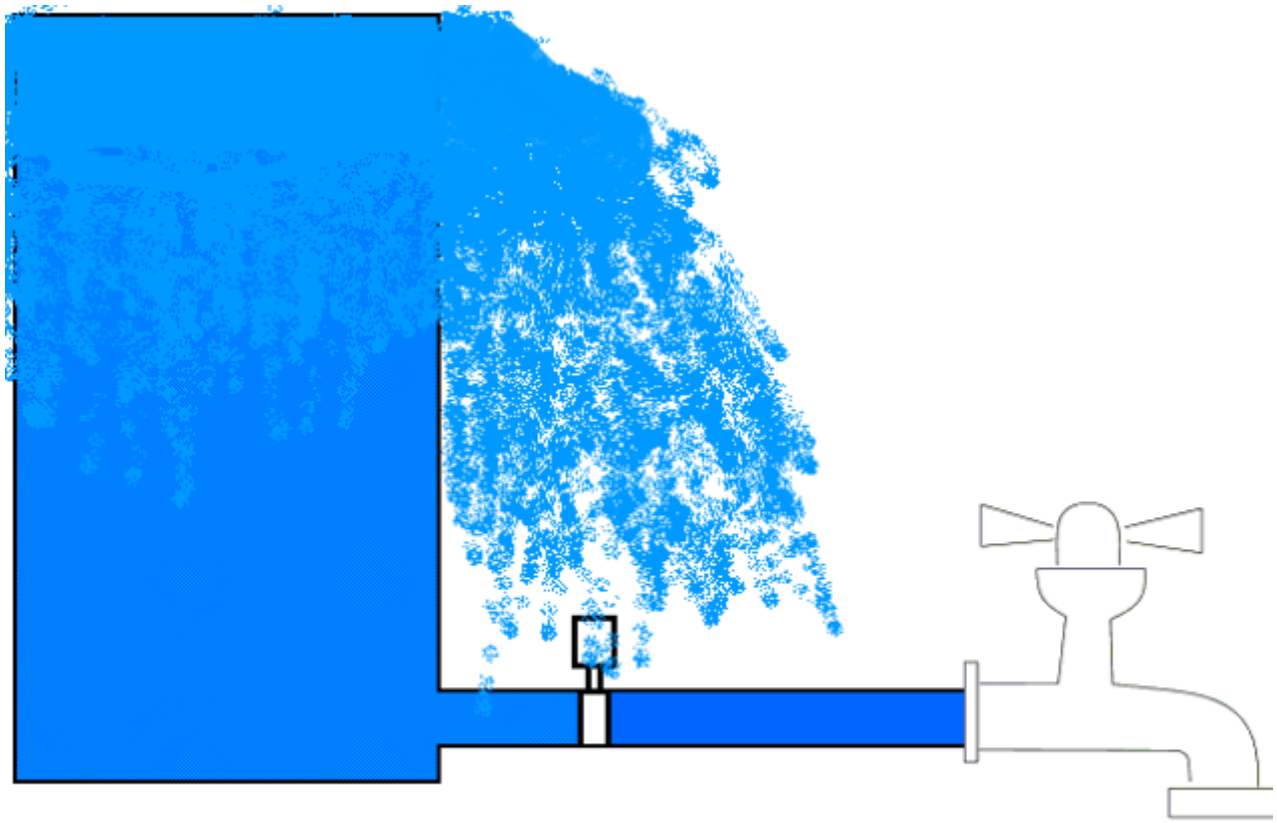
The Water Tank



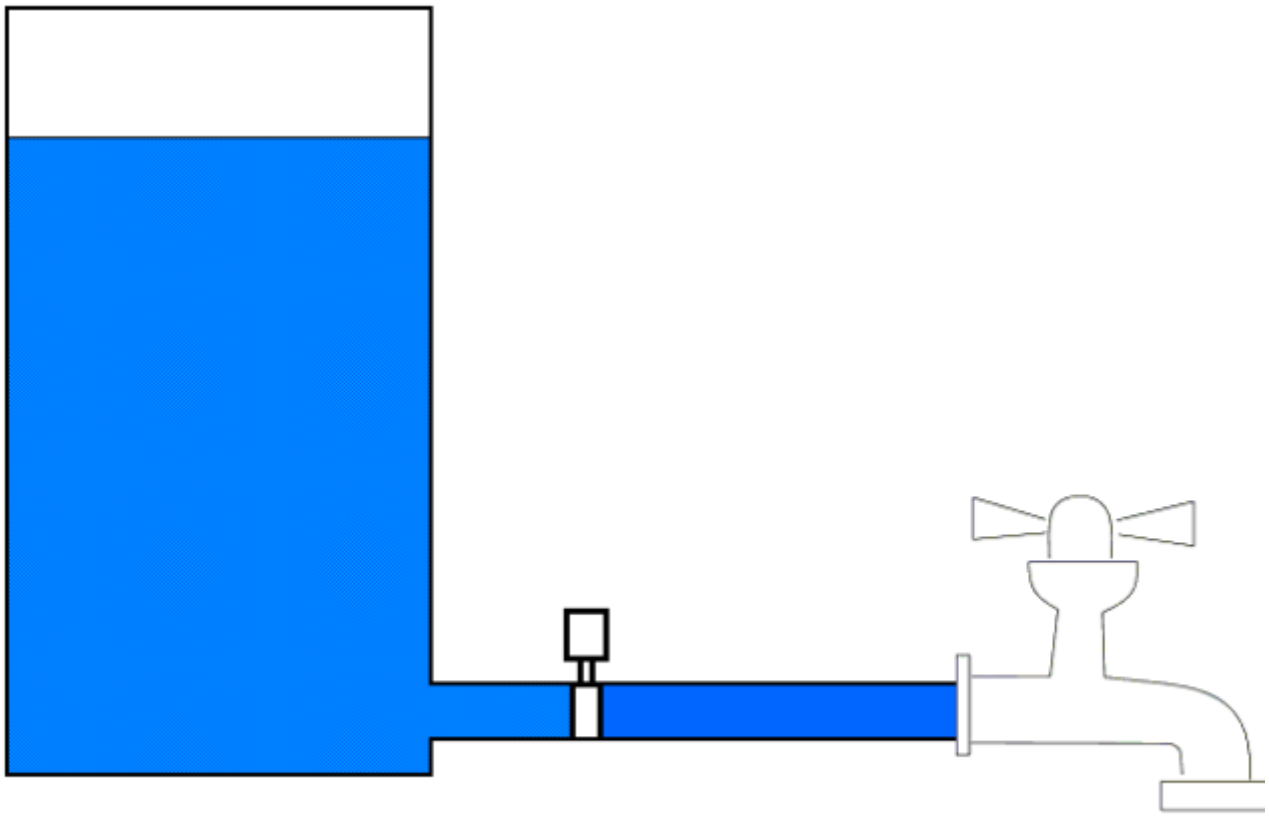
Voltage



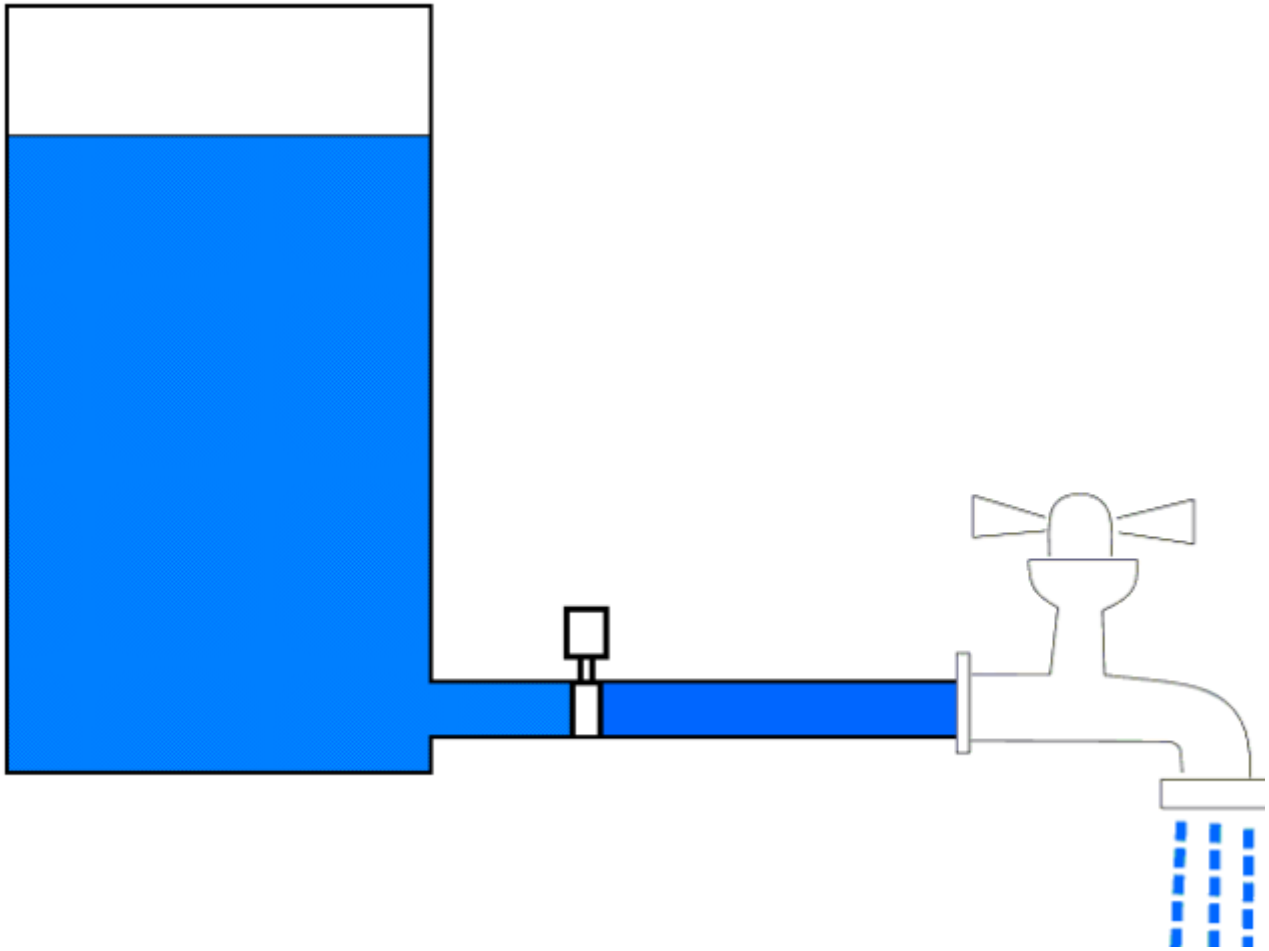
Impulse



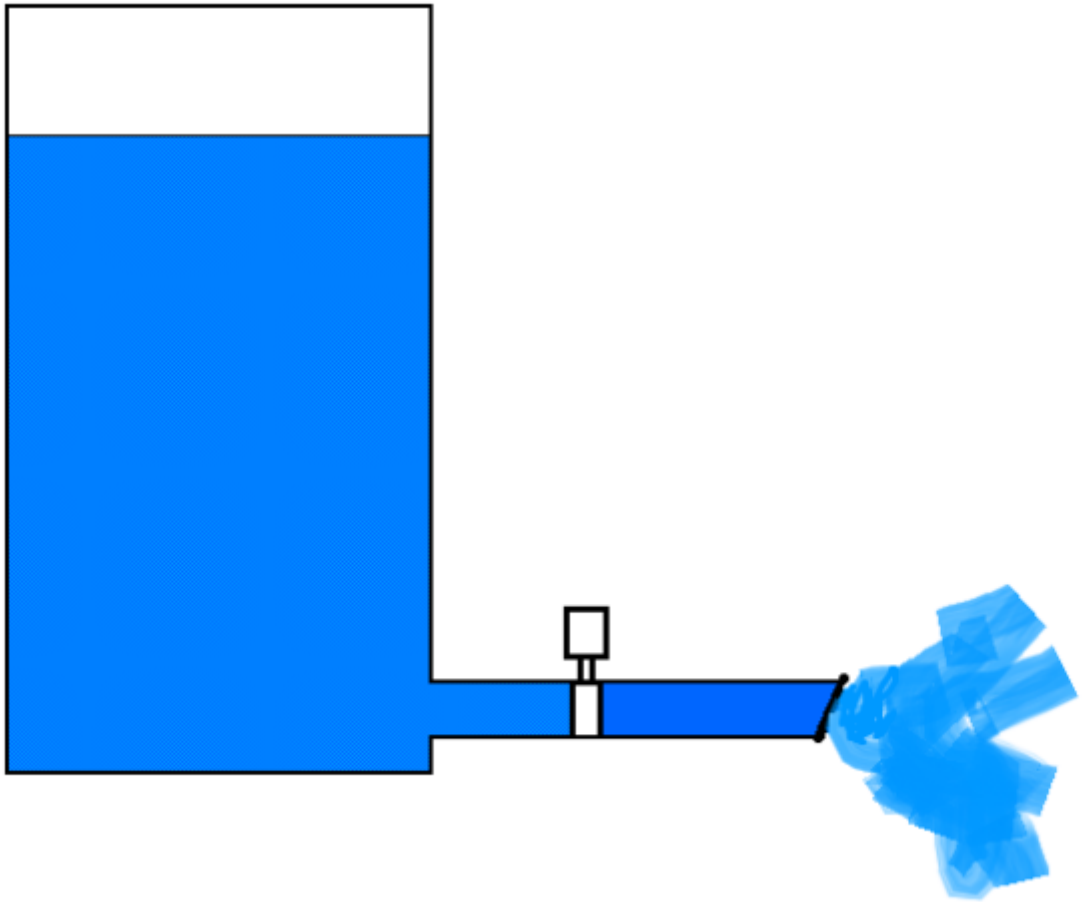
Voltage



Nominal Current



Short Circuit Current



PACS POWER AND CONTROL SYSTEMS

Electrical System

- Voltage
  - Steady State
  - Basic Impulse Level (BIL)
- Current
  - Nominal
  - Short Circuit

PACS POWER AND CONTROL SYSTEMS

Dangerous Territory

PACS POWER AND CONTROL SYSTEMS

Electrical Danger

- Electrical Current is Very Powerful
- Any Path to Ground Results in Electrical Current
- Less Than 100mA Can Kill
- Electrical Current Can Jump Between Conductors
- Arc Fault

PACS POWER AND CONTROL SYSTEMS

Arc Flash

PACS POWER AND CONTROL SYSTEMS

Arc Flash

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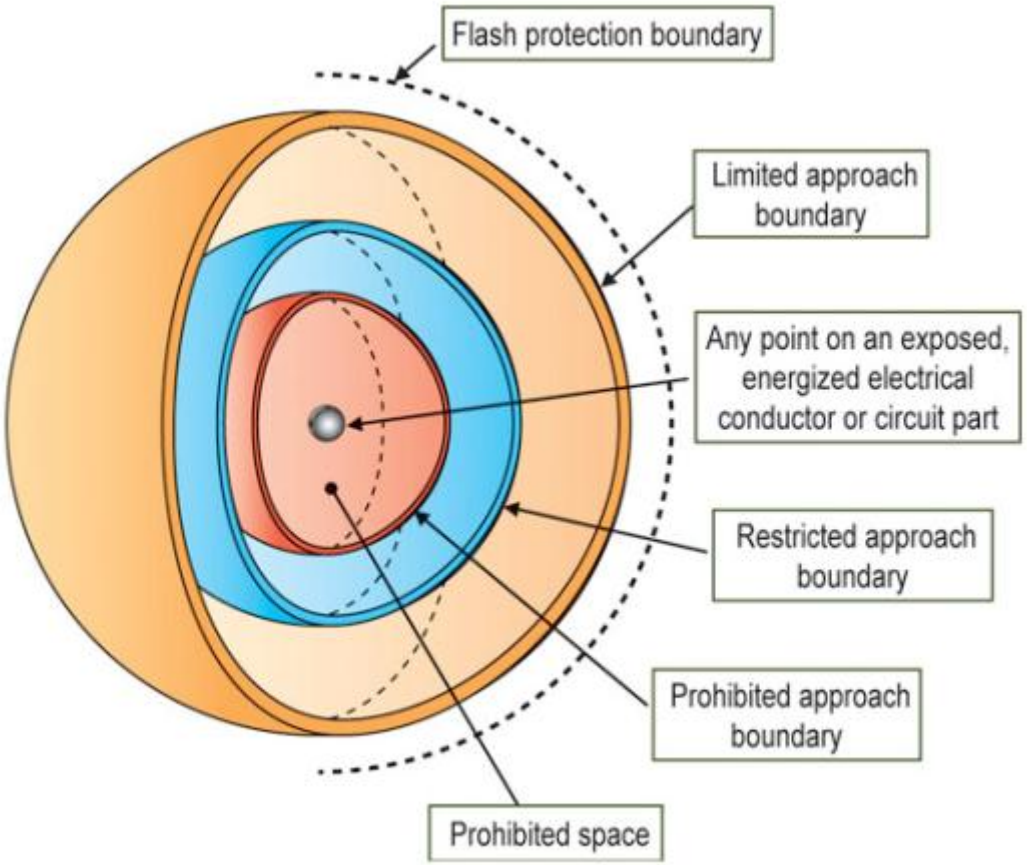
Arc Flash

- Plasma Arc Can be Greater than 35,000 Degrees
- Copper Expands and Vaporizes by a Factor of 67,000
- Arc Blast at 160dB
- Flame, Metal, Smoke and Debris Expel at 600MPH

PACS POWER AND CONTROL SYSTEMS

Arc Flash Boundaries



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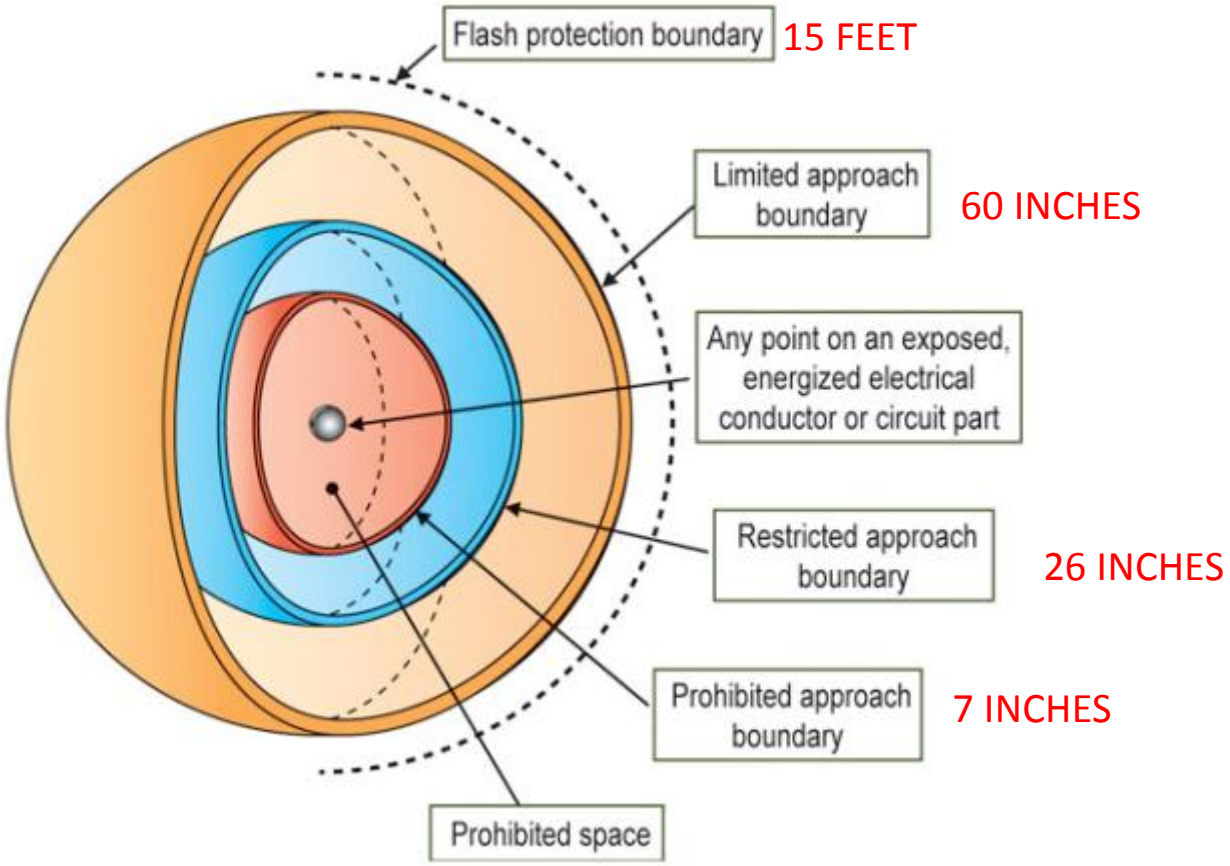
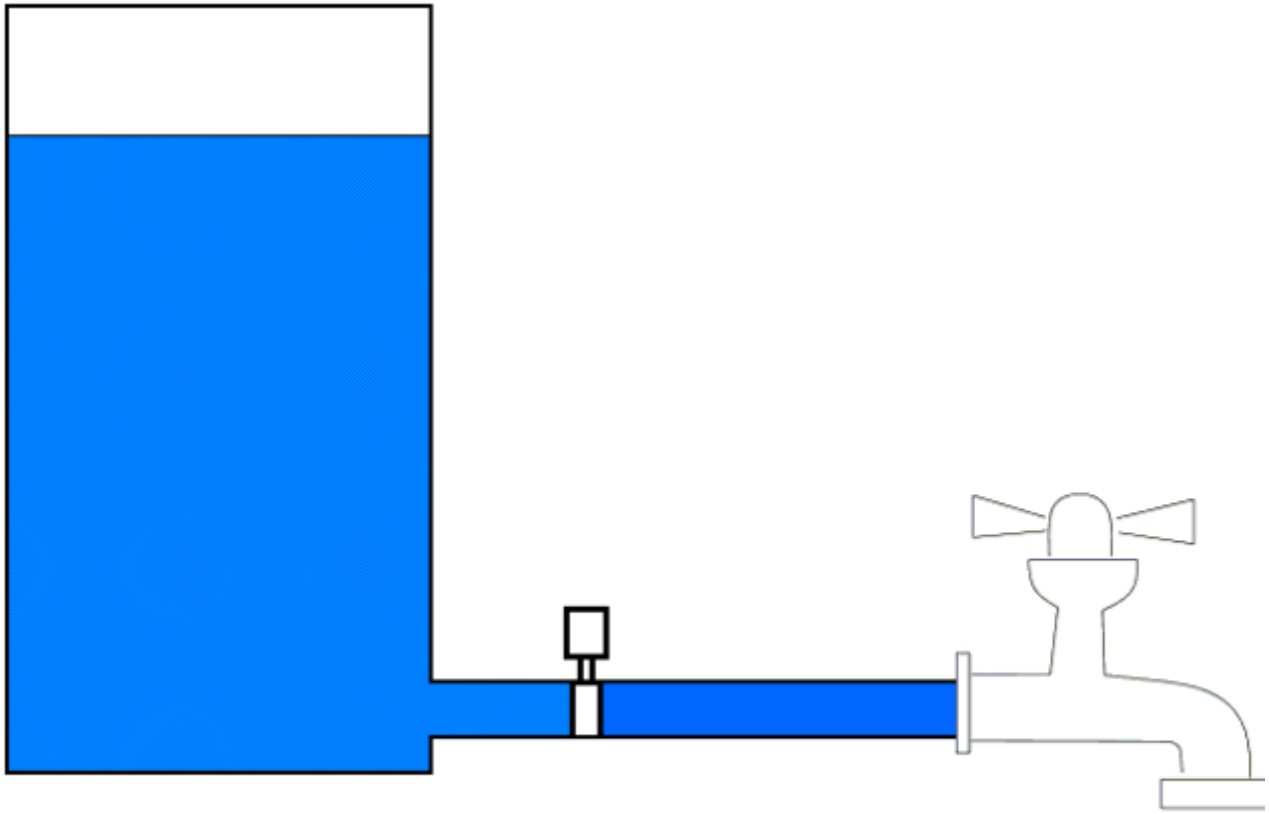
Arc Flash Boundaries @ 13.8kV

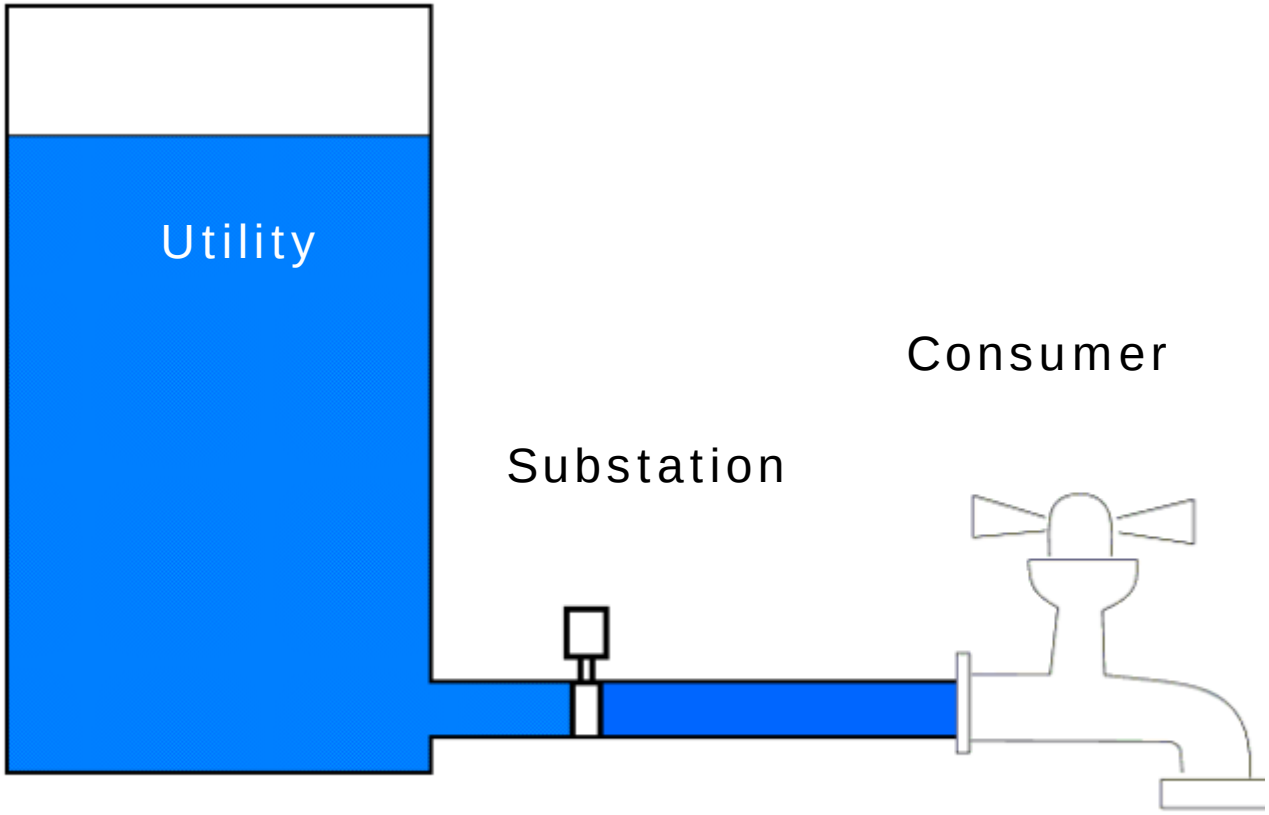


PACS POWER AND CONTROL SYSTEMS

System Model

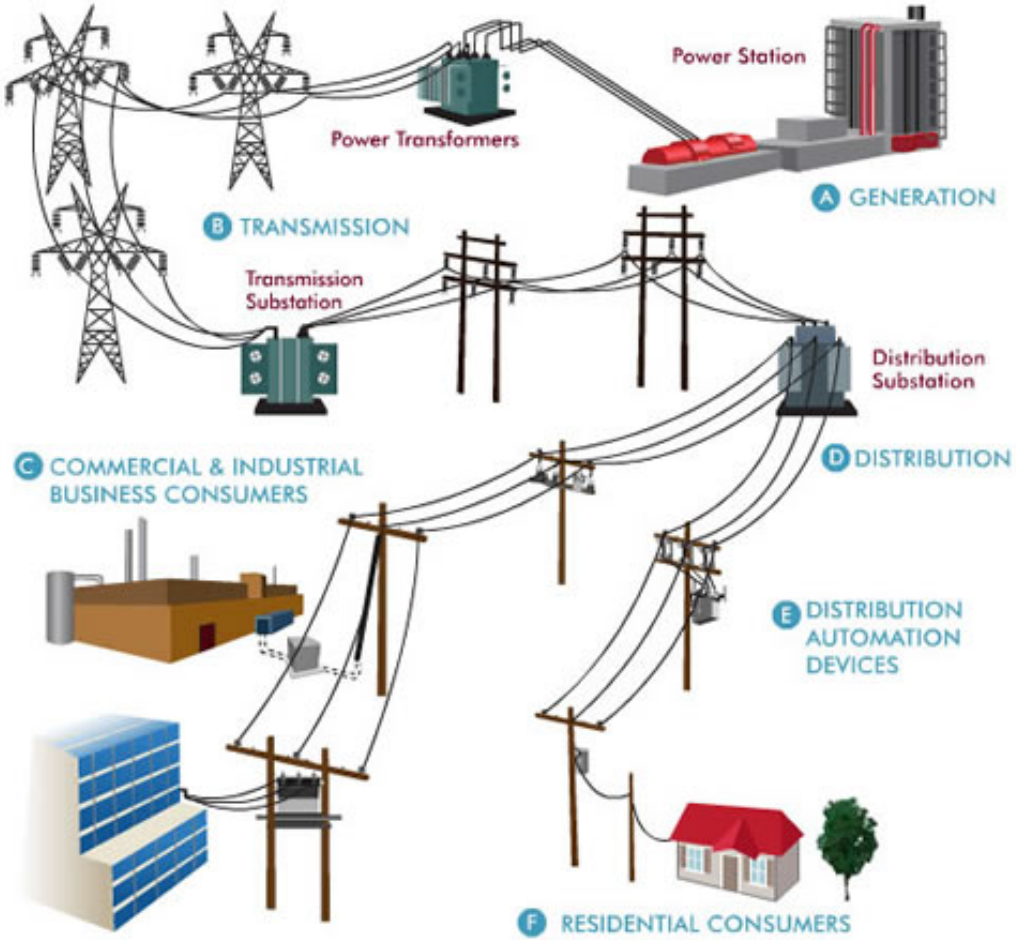


System Model



PACS POWER AND CONTROL SYSTEMS

Power Grid



PACS POWER AND CONTROL SYSTEMS

Electrical Substation

- Hub on the Power Grid
- Voltage Converter
- Distribution Point
- Link

PACS POWER AND CONTROL SYSTEMS

Substation Components

- Transformer
- Circuit Switches/Breakers
- Command and Control System
- Communication Network

PACS POWER AND CONTROL SYSTEMS

Circuit Breaker

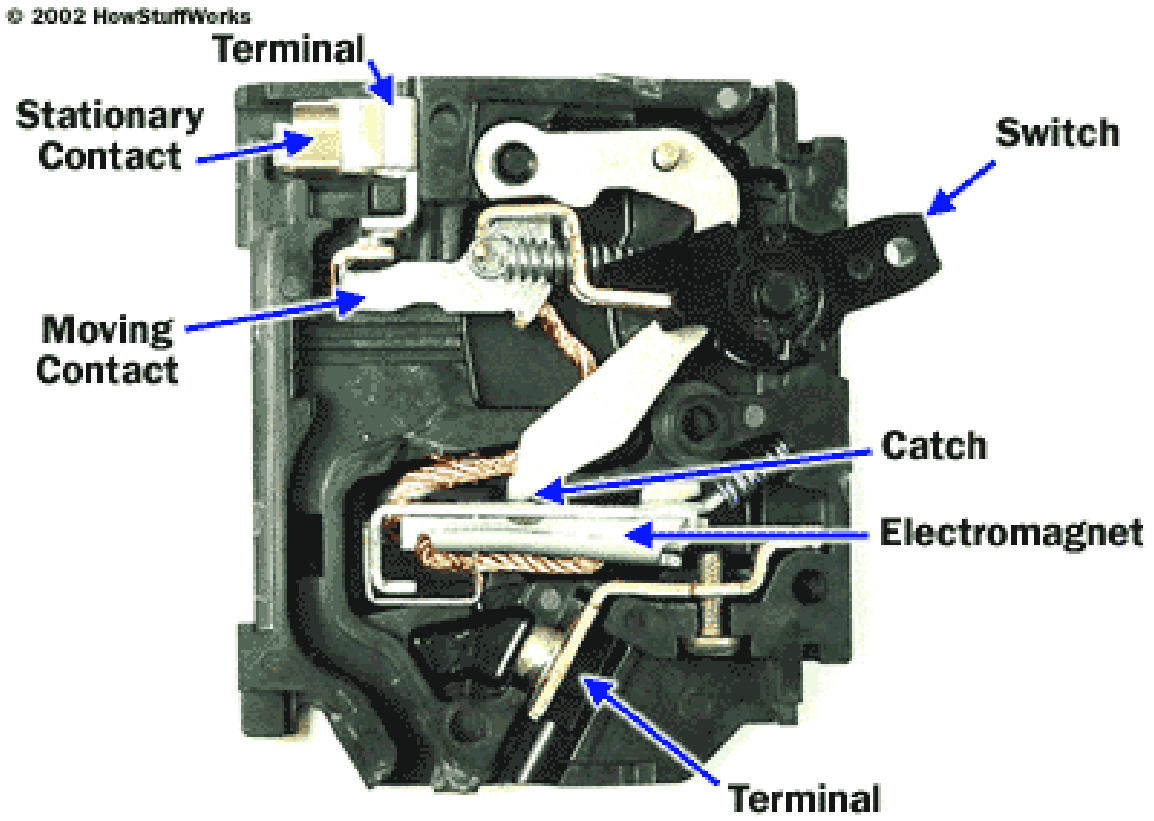
PACS POWER AND CONTROL SYSTEMS

Circuit Breaker

PACS POWER AND CONTROL SYSTEMS

Circuit Breaker-Low Voltage

Circuit Breaker-Low Voltage



Circuit Breaker-Medium Voltage

PACS POWER AND CONTROL SYSTEMS

Circuit Breaker-High Voltage

PACS POWER AND CONTROL SYSTEMS

Circuit Breaker-Extra High Voltage

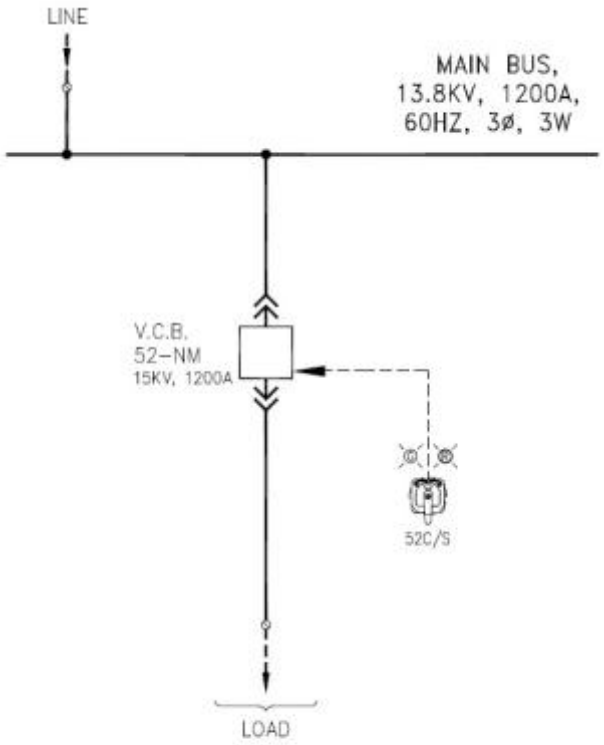
PACS POWER AND CONTROL SYSTEMS

Command/Control Systems

- Breaker Control
- System Monitoring
- Circuit Protection/Logic
- Feedback
- Metering

PACS POWER AND CONTROL SYSTEMS

Breaker Control



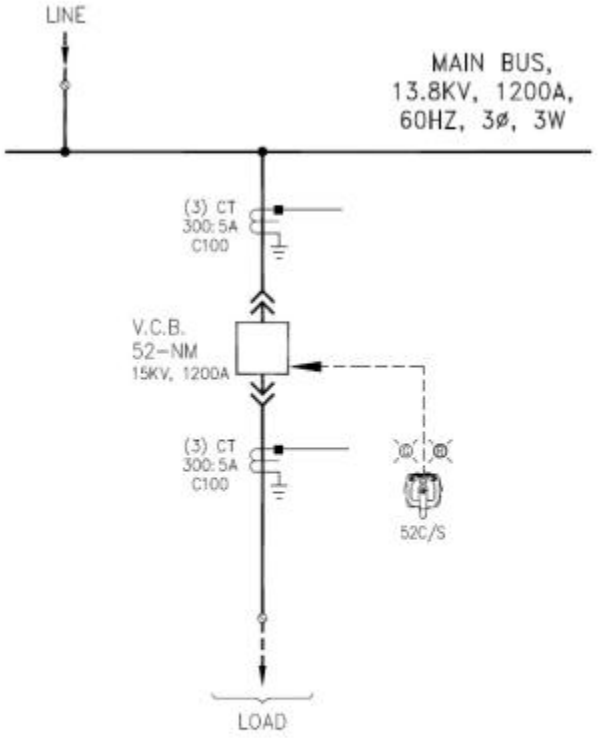
(1)

PACS POWER AND CONTROL SYSTEMS

Control Switches

PACS POWER AND CONTROL SYSTEMS

Current Monitoring



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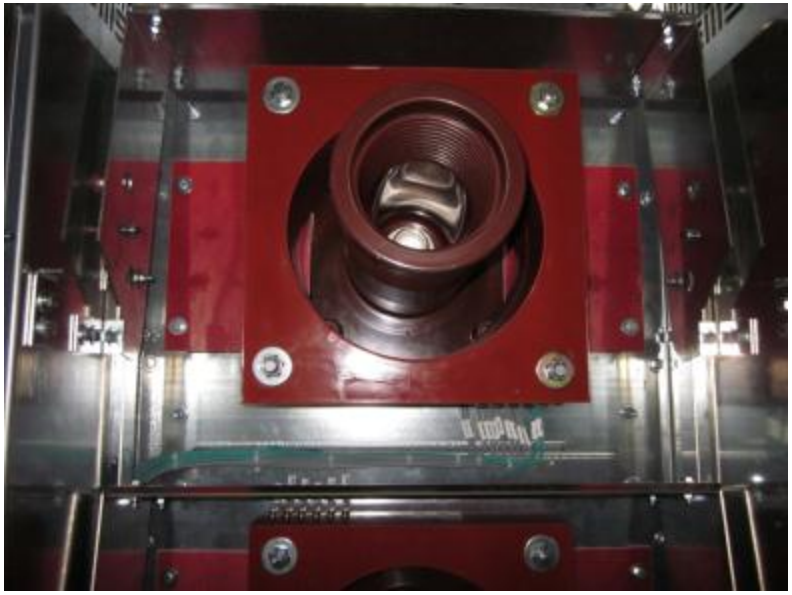
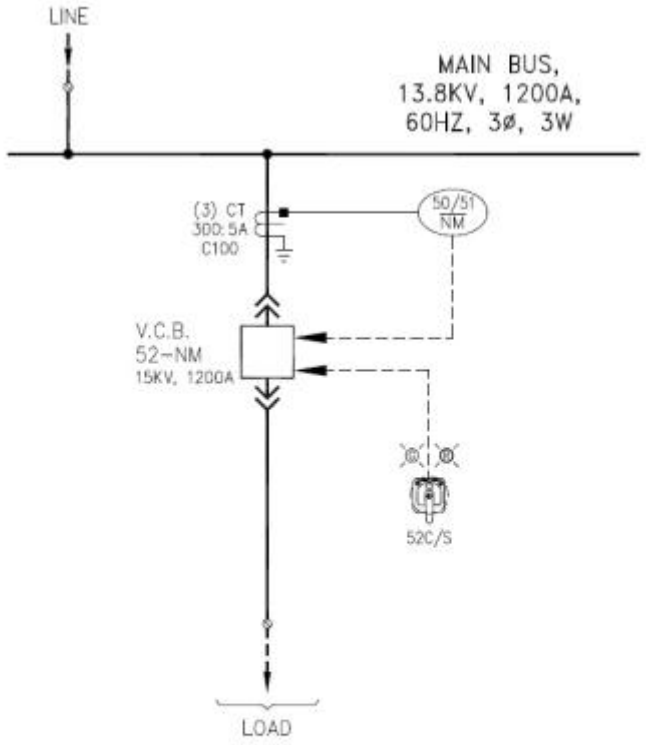
Current Transformer



PACS POWER AND CONTROL SYSTEMS

Overcurrent Trip



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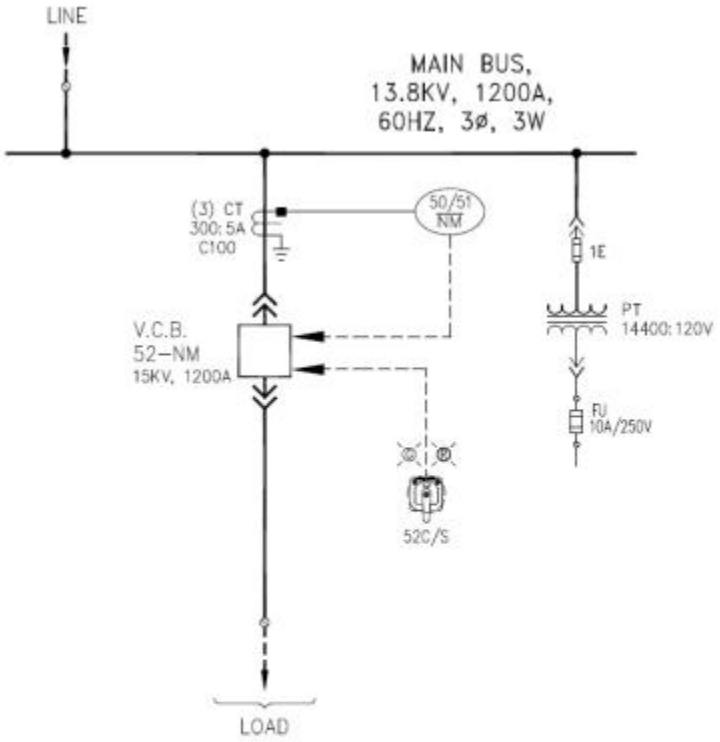
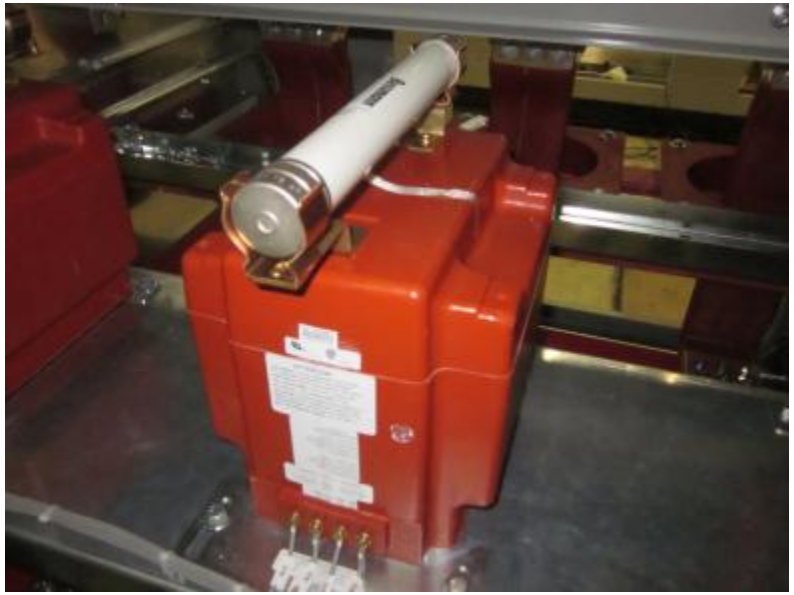
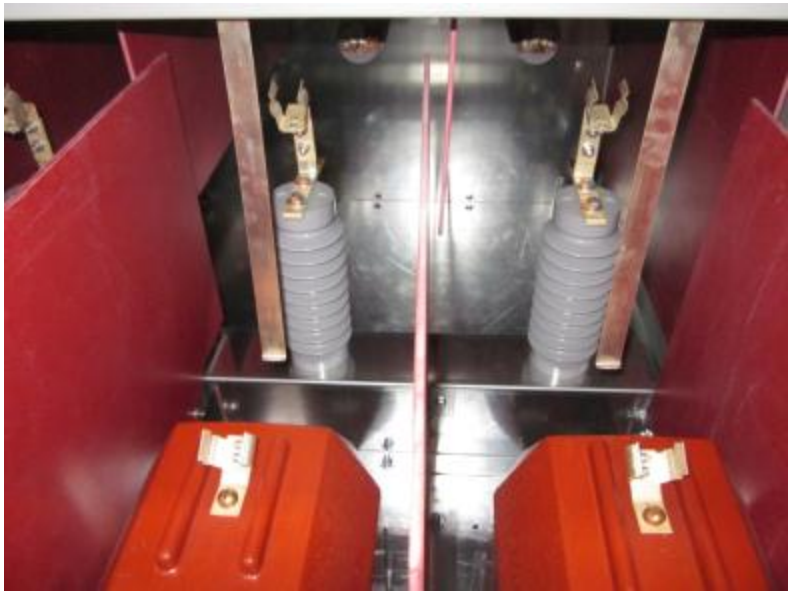
PACS POWER AND CONTROL SYSTEMS

Voltage Monitoring



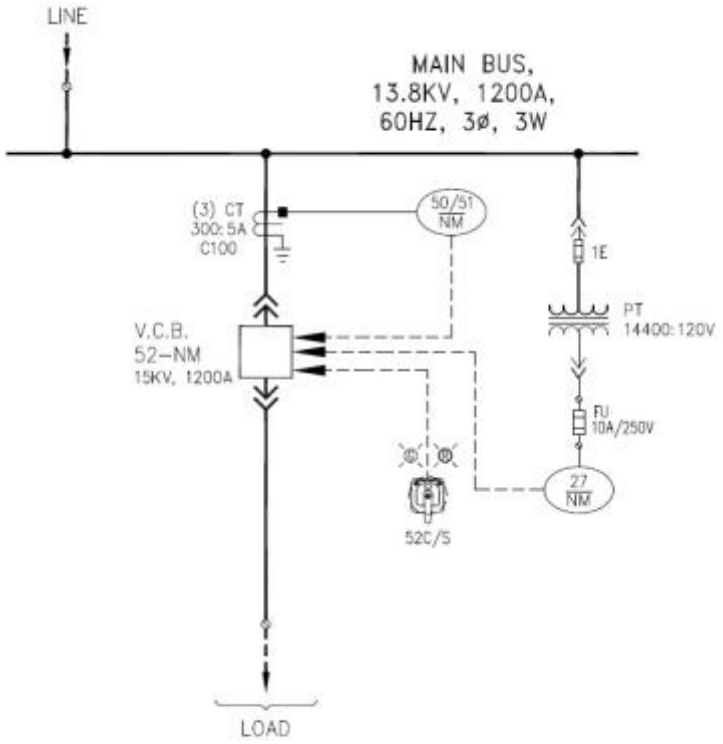
Potential Transformer





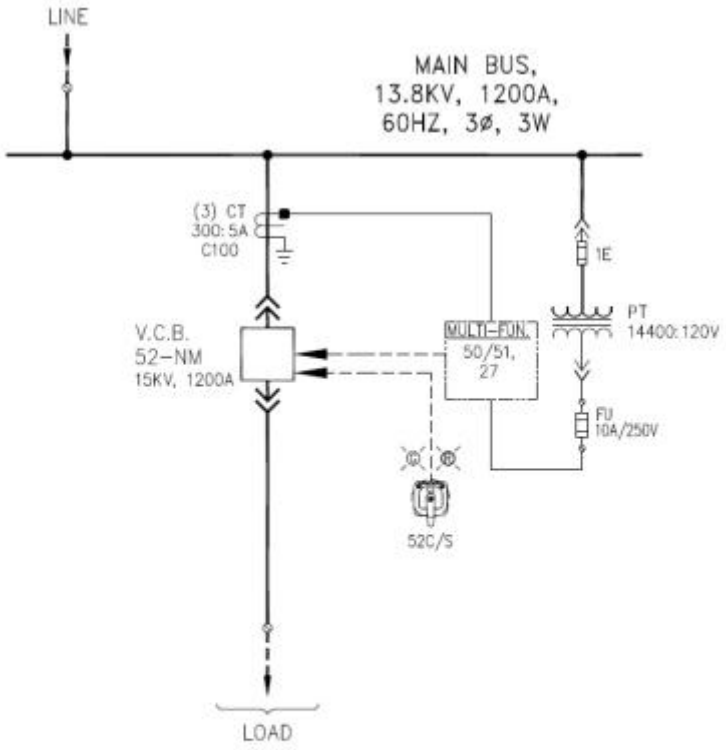
PACS POWER AND CONTROL SYSTEMS

Undervoltage Trip



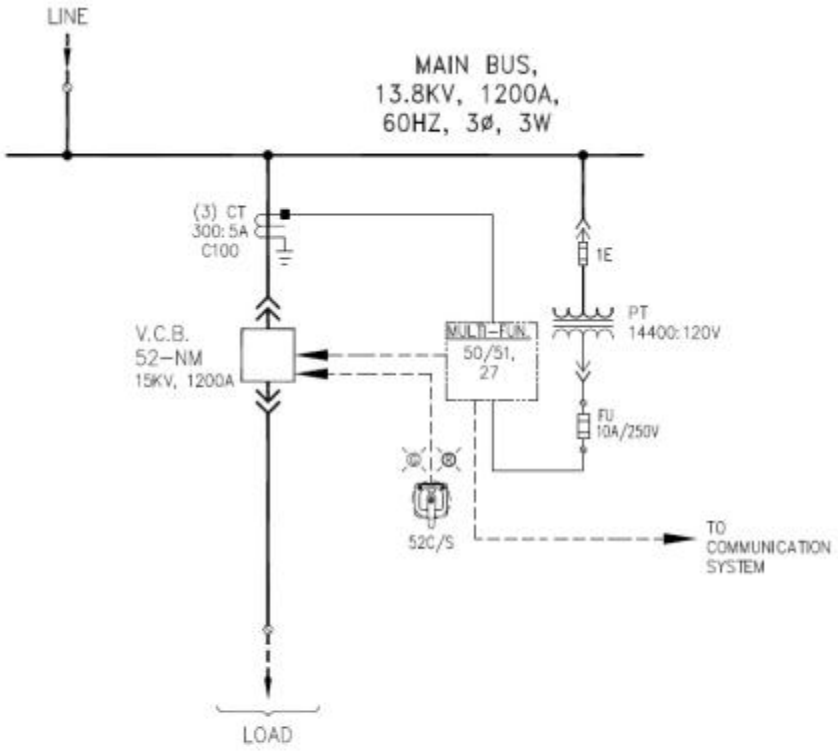
Electromechanical Relays

Multi-Function Relay



Multi-Function Relay

Communication

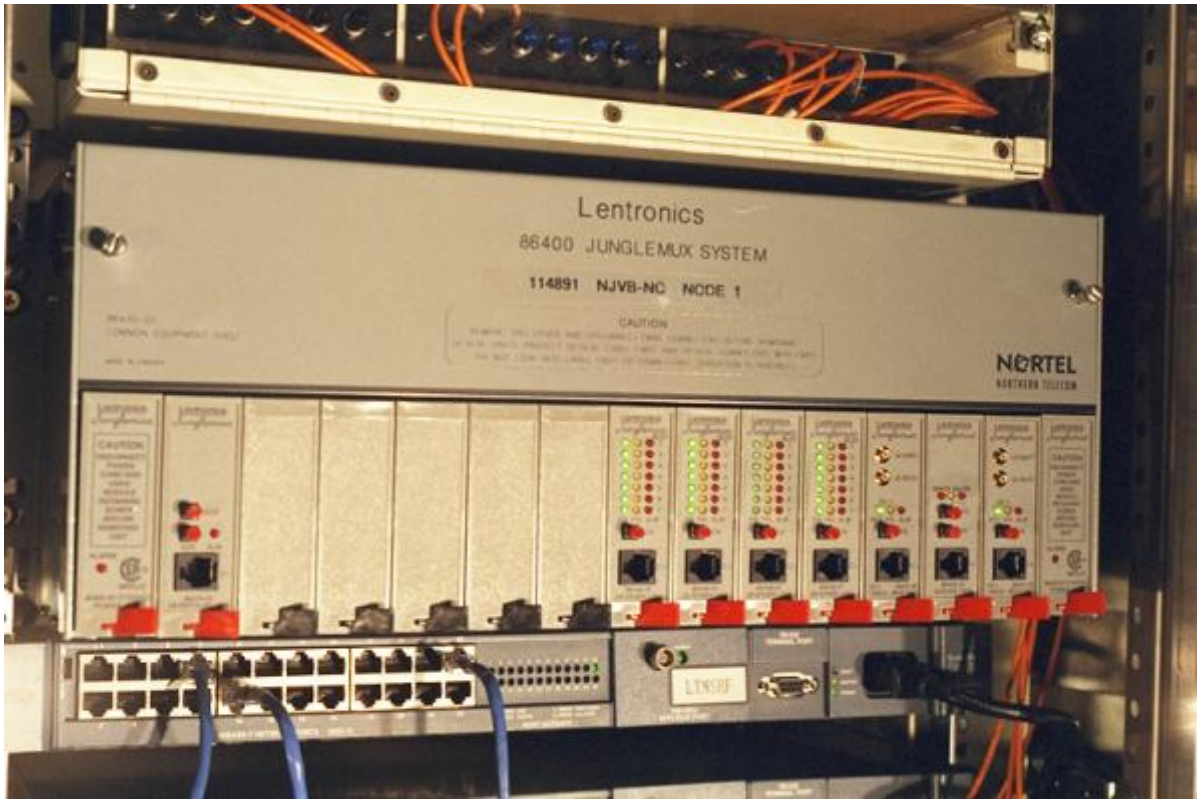


Communication Network

- Multiple Communication Loops
- Internal/External
  - Status
  - Health
  - Data Collection
- Copper and Fiber Optic Connection

PACS POWER AND CONTROL SYSTEMS

Communication Network

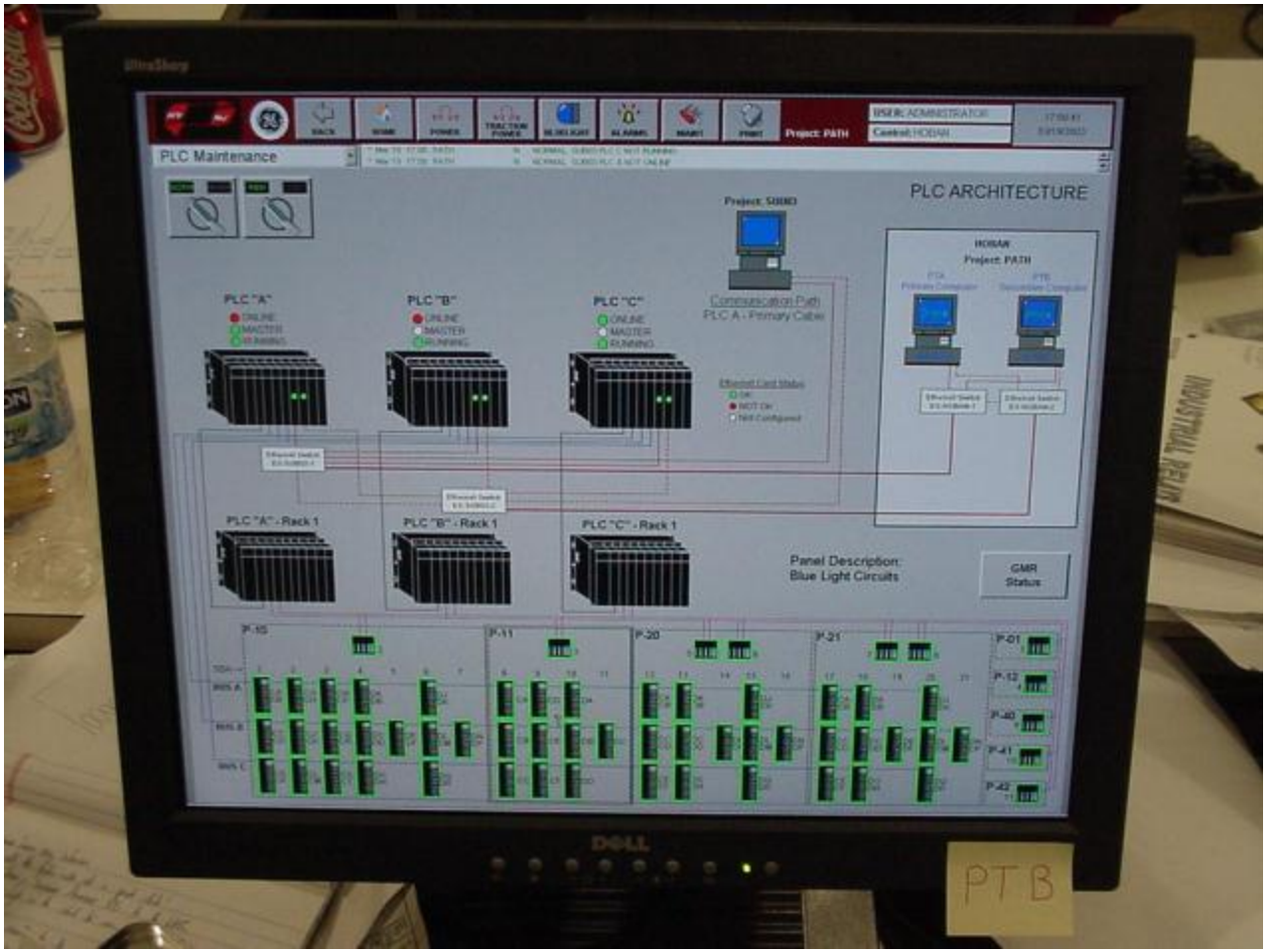


SCADA

- Supervisory Control And Data Acquisition
- Series of Inputs and Outputs
- Digital
- Analog
- Master CPU or PLC
- Communicates To/From Master Processor

PACS POWER AND CONTROL SYSTEMS

SCADA


PLC Maintenance
PLC ARCHITECTURE
PLC "A"
PLC "B"
PLC "C"
Communication Path
PLC A - Primary Cable
PLC "A" - Rack 1
PLC "B" - Rack 1
PLC "C" - Rack 1
Panel Description:
Blue Light Circuits
GMR Status
PT B

Substation Design Criteria

- IEEE/ANSI Standards/Guidelines
  - Equipment and Conductor Clearances
- Transmission 69kV – 765kV
- Distribution 5kV – 35kV
- Overhead Bus and Lines
- Large Sites with Civil Issues
  - Drainage
  - Grounding
  - Steel Foundations

PACS POWER AND CONTROL SYSTEMS

Transmission Substation

PACS POWER AND CONTROL SYSTEMS

Distribution Substation

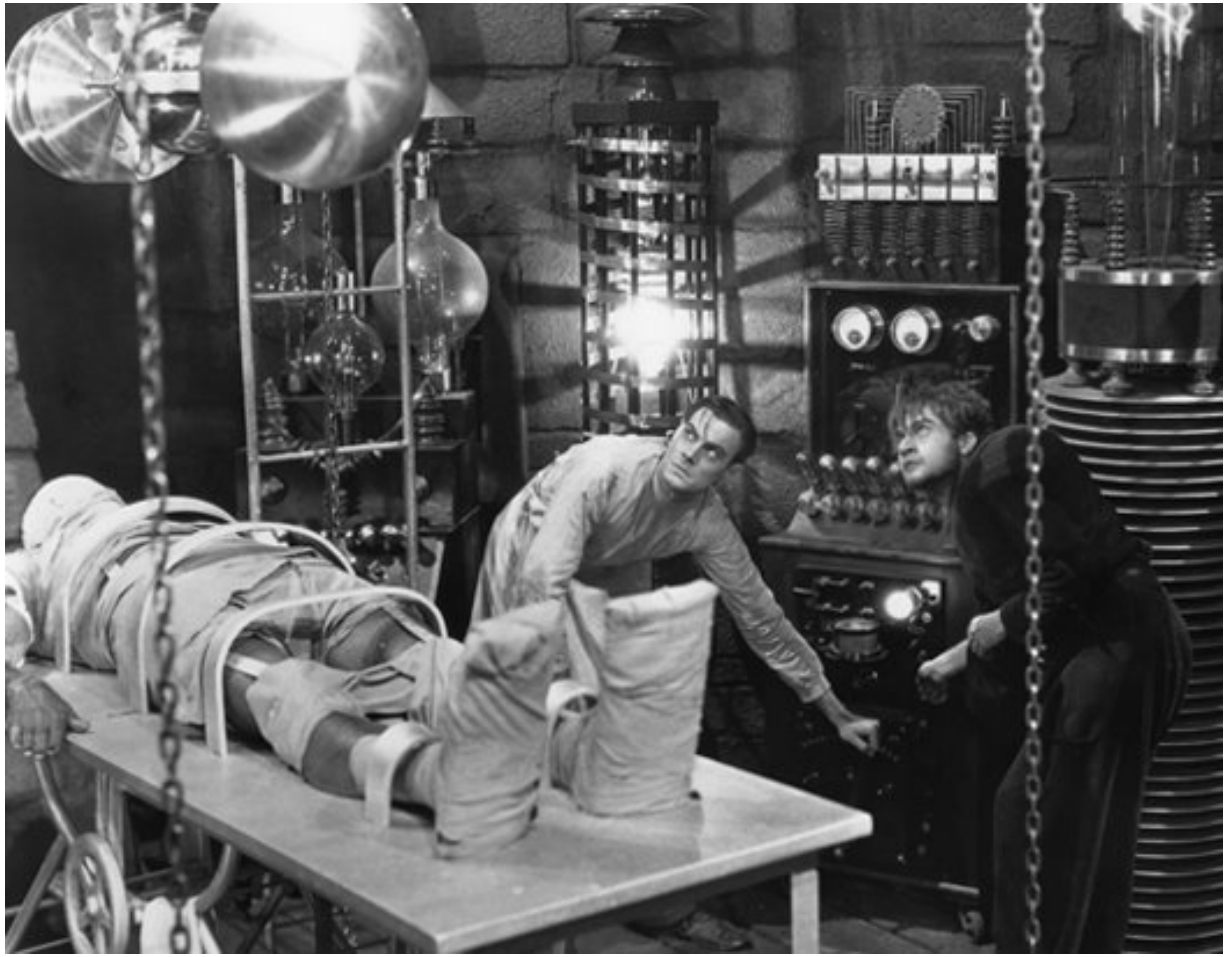
PACS POWER AND CONTROL SYSTEMS

Switchgear Design Criteria

- IEEE/ANSI Standards/Guidelines
  - Internal Bus Needs Phase to Phase/Ground Clearance
- Medium Voltage 5kV – 38kV
- High Current 1000A – 5000A
- Self Contained in One or More Lines of Cubicles
- Indoor or Outdoor
- Confined Space for Operation
- Metalclad
- Arc Resistant

PACS POWER AND CONTROL SYSTEMS

Switchgear

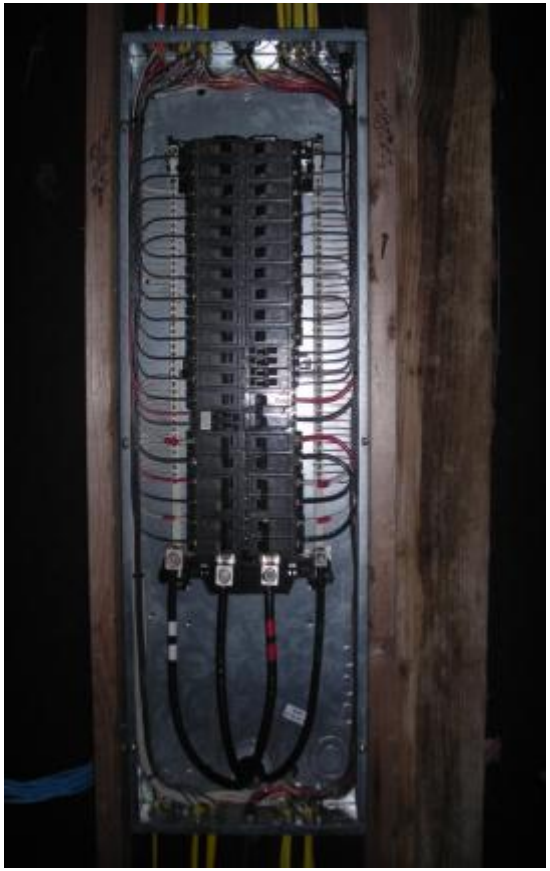


PACS POWER AND CONTROL SYSTEMS

Switchgear

PACS POWER AND CONTROL SYSTEMS

Switchgear

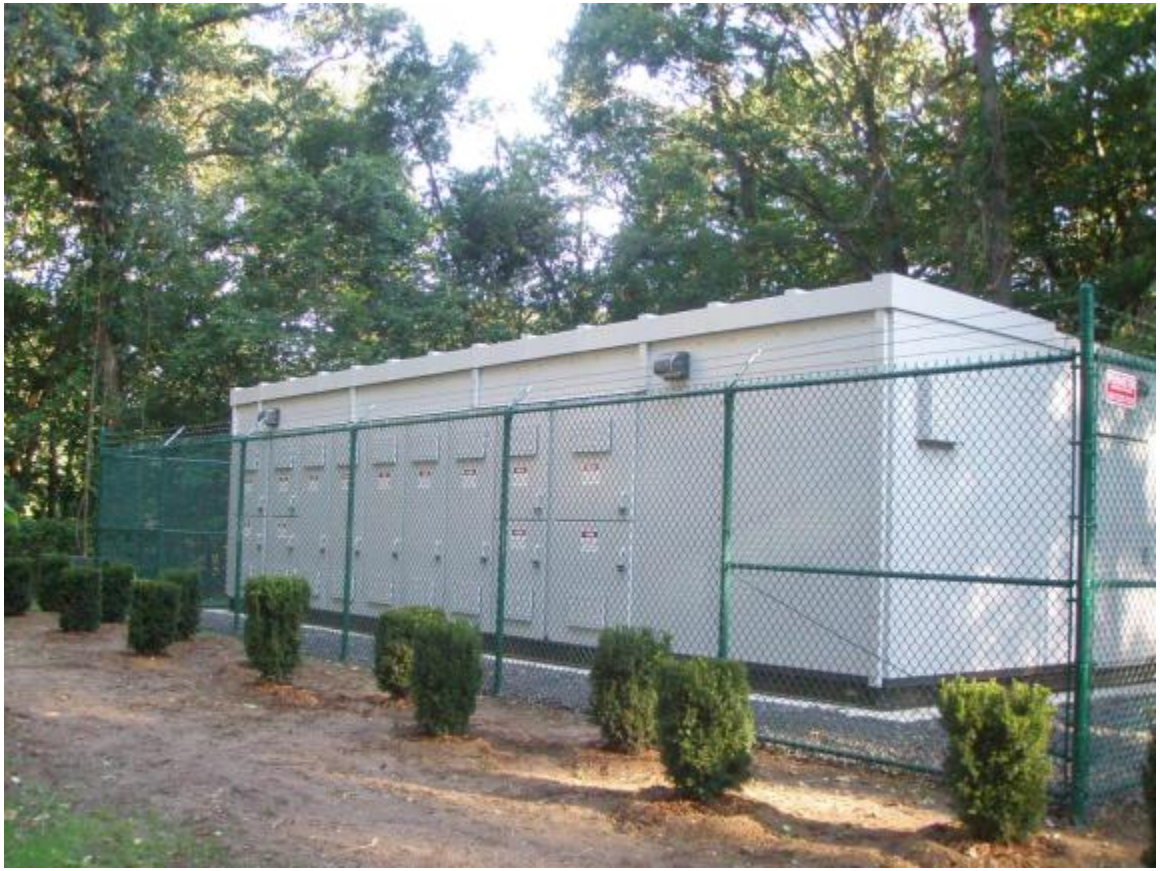


PACS POWER AND CONTROL SYSTEMS

Switchgear

PACS POWER AND CONTROL SYSTEMS

Switchgear



PACS POWER AND CONTROL SYSTEMS

Switchgear

PACS POWER AND CONTROL SYSTEMS

Design Considerations

- Space Allocation
  - Sufficient Arc Flash Boundary
  - Work Clearance per NEC
- Controllability
- Accessibility
- Maintainability
- Personnel/Arc Flash Protection

PACS POWER AND CONTROL SYSTEMS

Warning Signs

PACS POWER AND CONTROL SYSTEMS

Personnel Protective Equipment (PPE)

PACS POWER AND CONTROL SYSTEMS

Special Tools

PACS POWER AND CONTROL SYSTEMS

Special Tools

PACS POWER AND CONTROL SYSTEMS

Arc Resistant Switchgear

POWER AND CONTROL SYSTEMS

Power Control Centers

PACS POWER AND CONTROL SYSTEMS

Power Control Centers

PACS POWER AND CONTROL SYSTEMS

Power Control Centers

PACS POWER AND CONTROL SYSTEMS

Switchgear Construction

PACS POWER AND CONTROL SYSTEMS

Switchgear Construction

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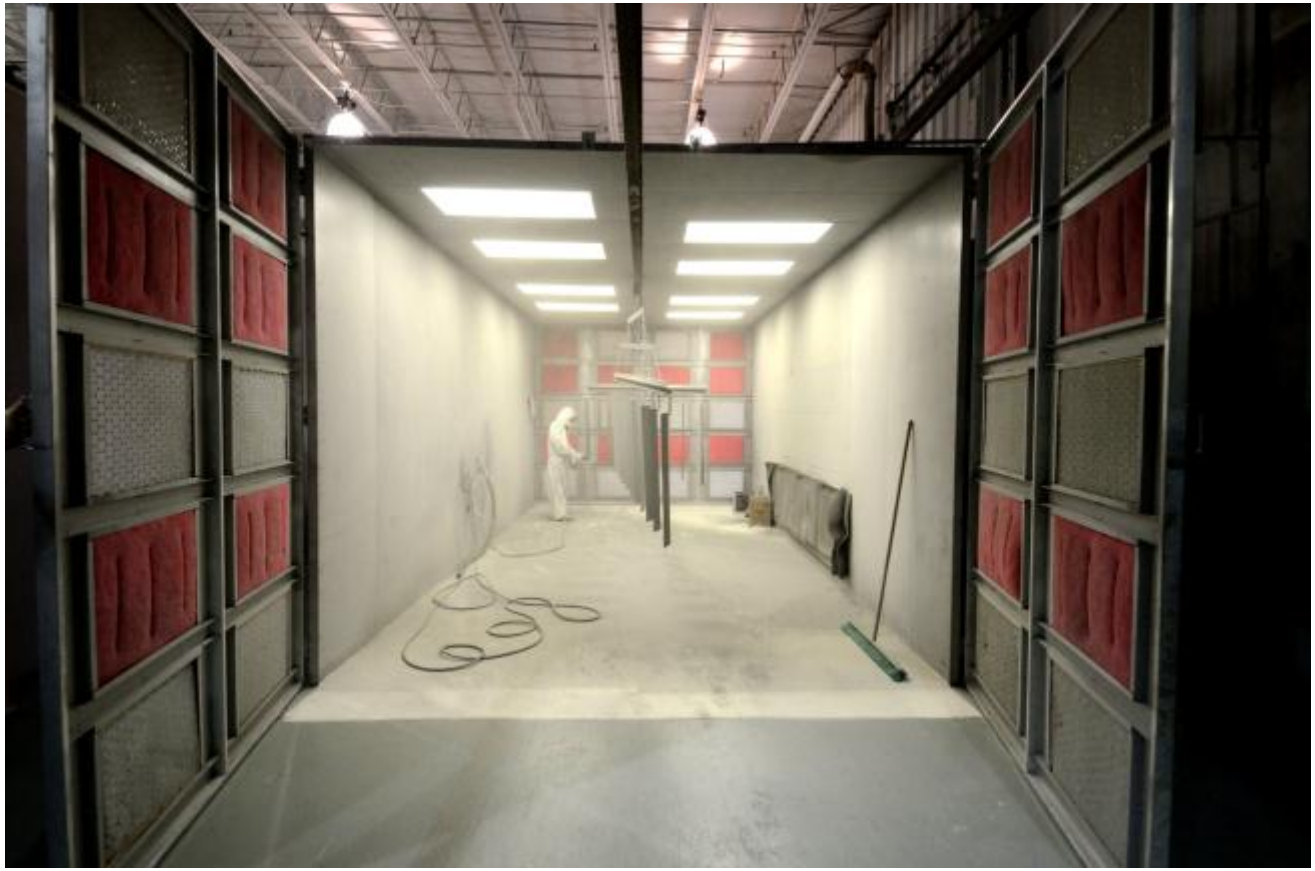
Switchgear Construction

PACS POWER AND CONTROL SYSTEMS

Switchgear Construction



PACS POWER AND CONTROL SYSTEMS

Switchgear Construction

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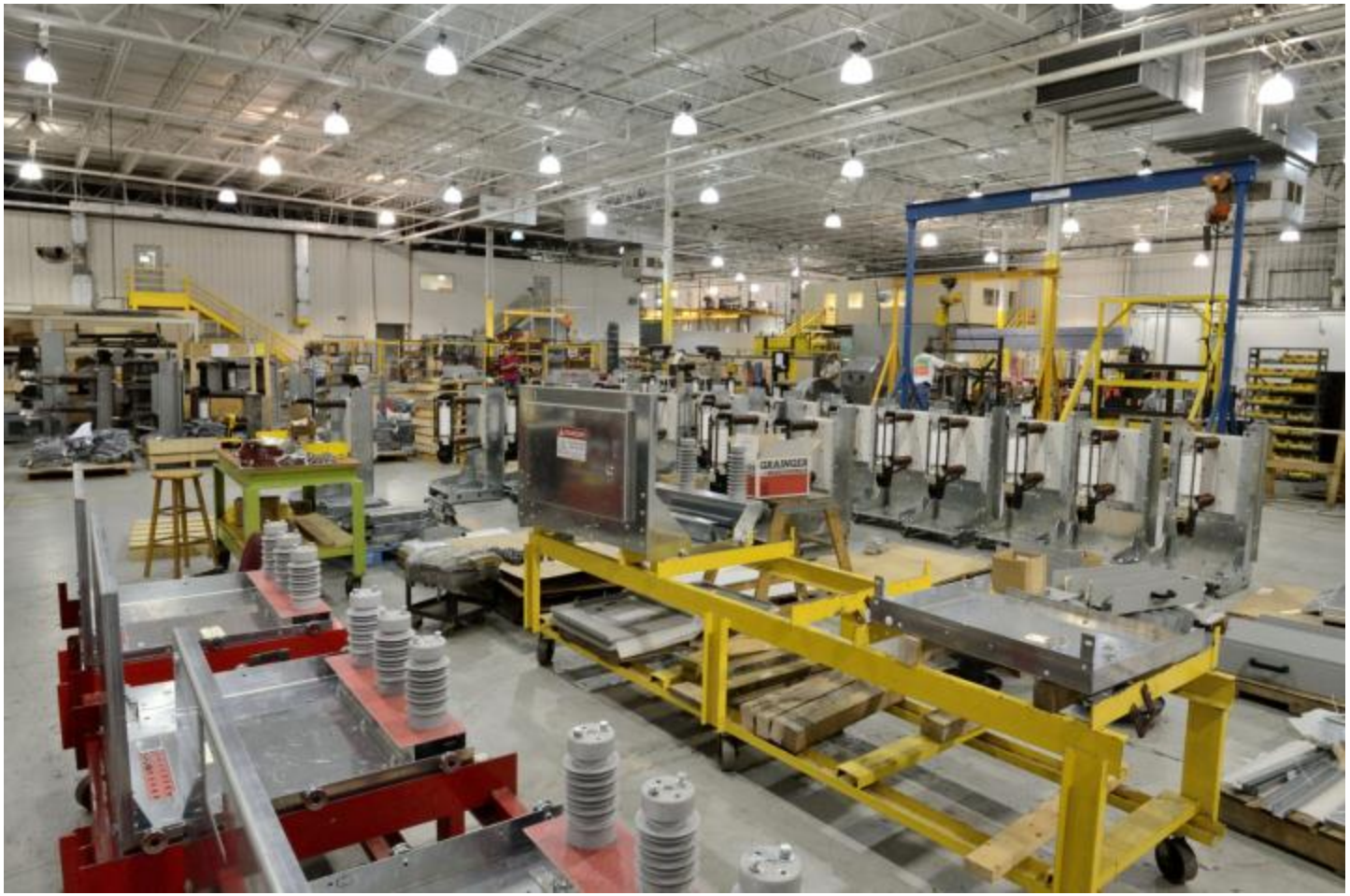
Switchgear Construction

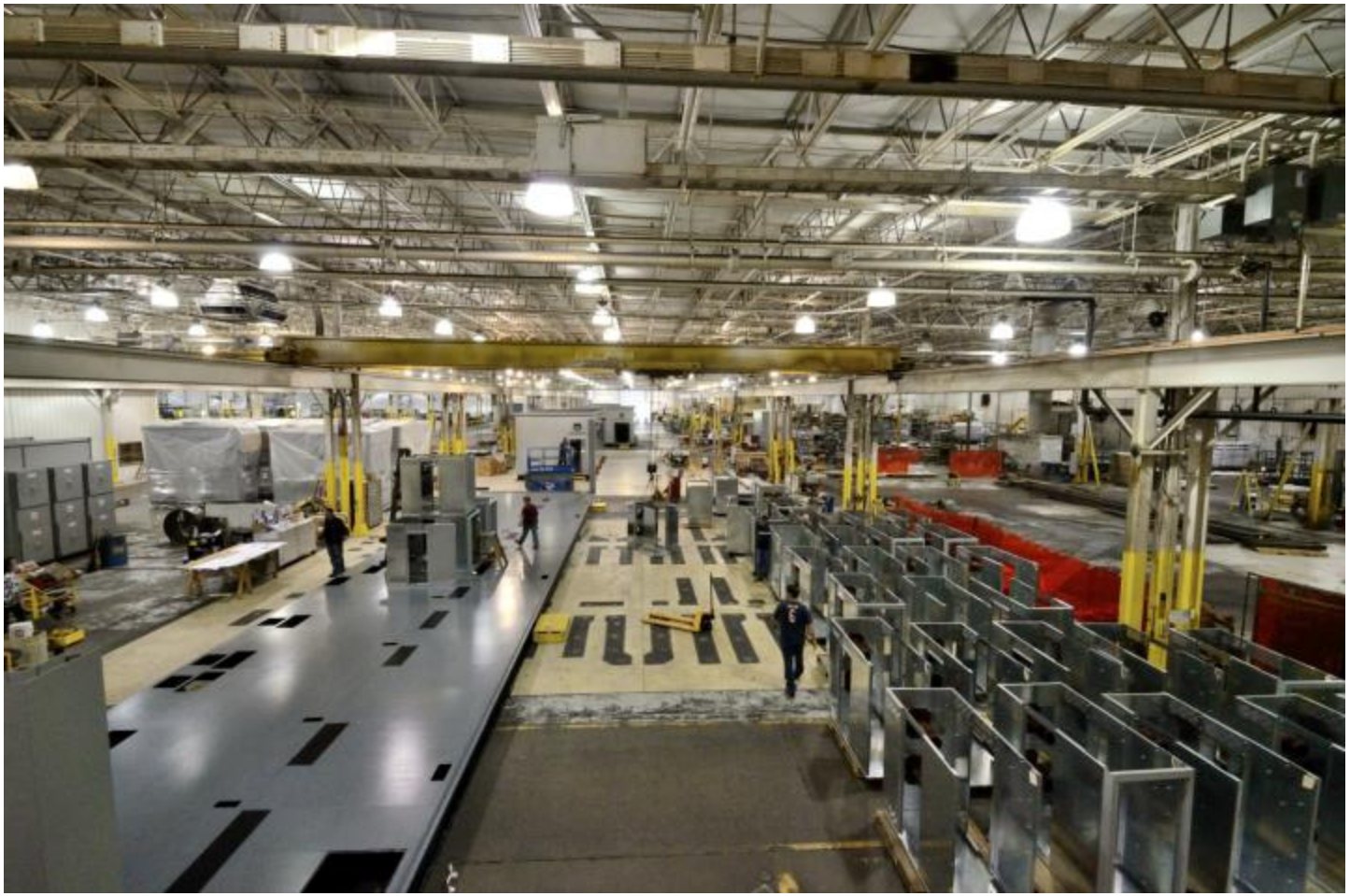
PACS POWER AND CONTROL SYSTEMS

Manufacturing



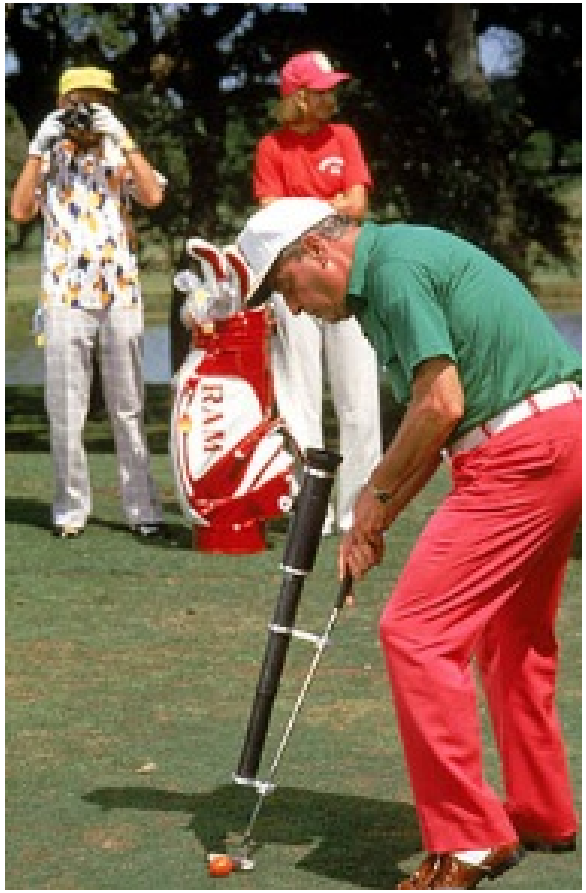
PACS POWER AND CONTROL SYSTEMS

Manufacturing



PACS POWER AND CONTROL SYSTEMS

Special Tools



PPE

PACS POWER AND CONTROL SYSTEMS

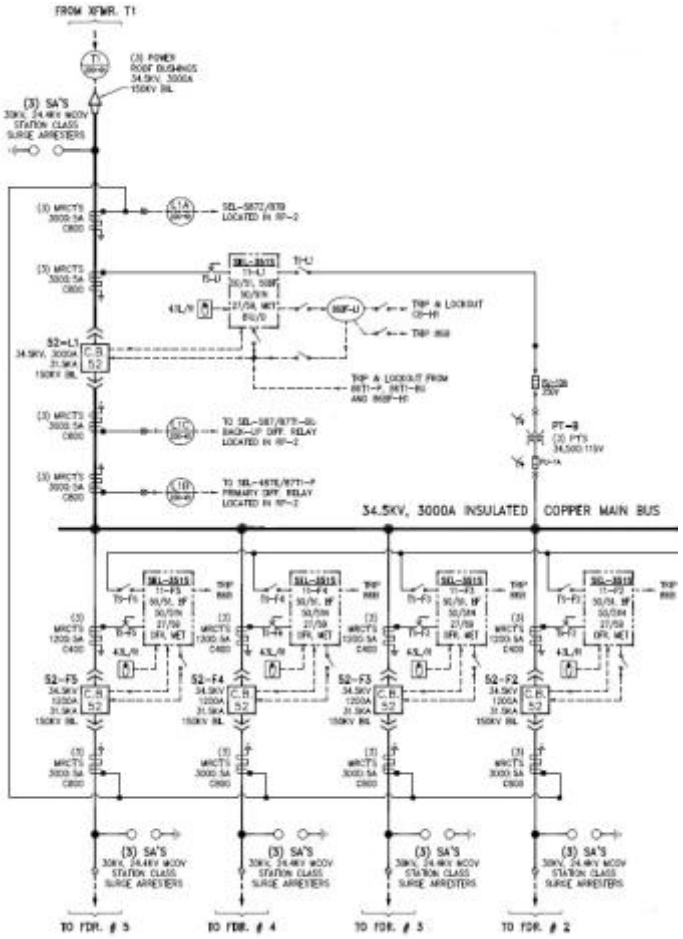
Switchgear

PACS POWER AND CONTROL SYSTEMS

Substations

PACS POWER AND CONTROL SYSTEMS

Protection/Controls

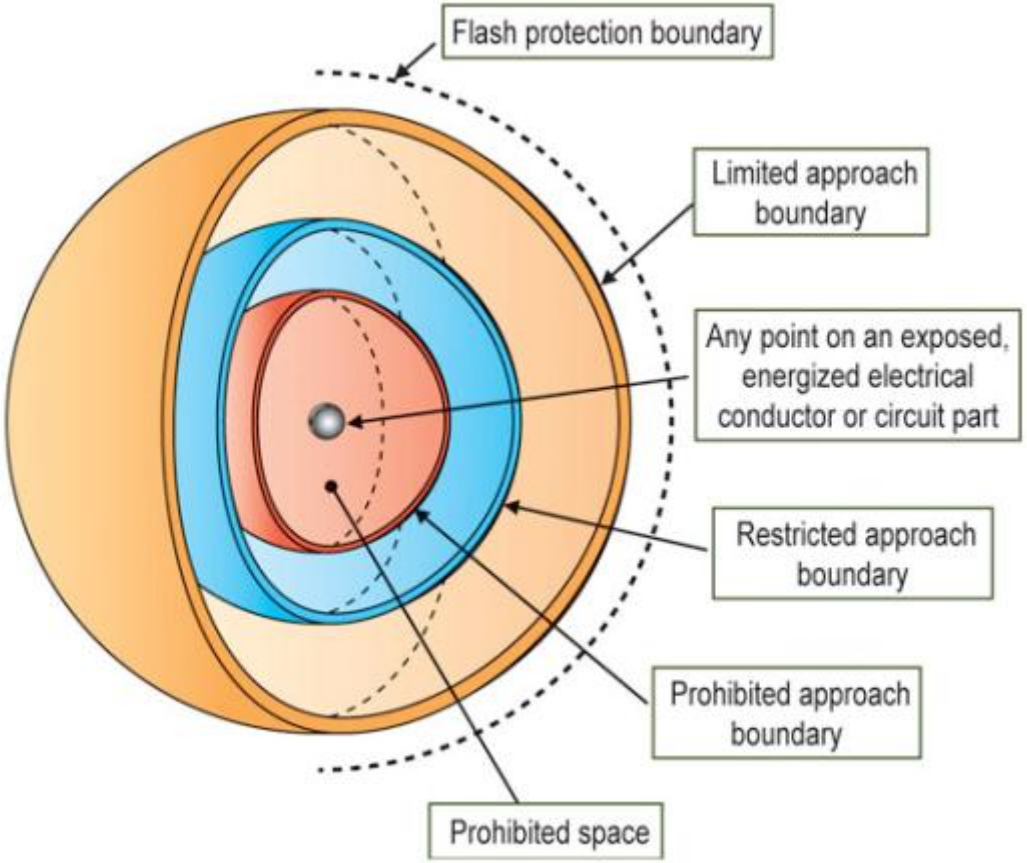


PACS POWER AND CONTROL SYSTEMS

Components

PACS POWER AND CONTROL SYSTEMS

Arc Flash



PACS POWER AND CONTROL SYSTEMS

Voltage/Current

- System Voltage
- BIL
- Nominal Current
- Short Circuit Current

PACS POWER AND CONTROL SYSTEMS

Golf Time