Substation Engineering

Batteries and DC Systems (Part 2 of 2)

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Batteries and DC Systems (Part 2 of 2)

- Course: Substation Engineering (DI04009011)
- Unit 5: Auxiliary Systems and Routine Operations
- Lecture 22: Batteries and DC Systems (Part 2 of 2)

Agenda

- Battery Charging Modes: Float vs. Boost
- Routine Battery Maintenance and Inspection
- Specific Gravity and Voltage Measurements
- Battery Capacity and Discharge Testing
- Safety Precautions and Ventilation
- DC System Ground Faults and Detection

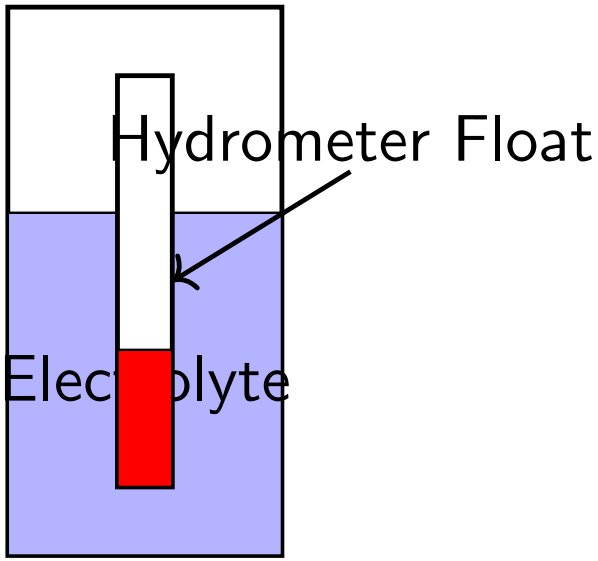
Battery Charging Modes

Parameter	Float Charge (Trickle)	Boost Charge (Equalize)
Purpose	Maintain full charge, supply continuous load	Recharge depleted battery, balance cell voltages
Voltage Level	Nominal (e.g., 2.15V - 2.25V per cell)	Elevated (e.g., 2.33V - 2.40V per cell)
Duration	Continuous	Temporary (8-24 hours)
Gassing	Minimal	Significant (requires ventilation)

Routine Battery Maintenance and Inspection

- Visual inspection for cracks, leaks, and corrosion on terminals
- Checking electrolyte levels (must be between min and max marks)
- Cleaning battery terminals and applying anti-corrosion petroleum jelly
- Verifying torque on inter-cell connections to prevent high resistance
- Ensuring the battery room environment is clean and climate-controlled

Measuring Specific Gravity



- Specific gravity (SG) indicates the state of charge in Lead-Acid cells
- Measured using a hydrometer or digital density meter
- Fully charged cell: SG typically 1.210 to 1.250 at 25°C
- Discharged cell: SG drops as sulfuric acid turns into water and lead sulfate
- Temperature correction must be applied to SG readings

Cell Voltage Measurements

- Individual cell voltages must be measured and recorded monthly
- Pilot cells: Selected cells monitored continuously for a representative snapshot
- Uneven cell voltages indicate the need for an equalize (boost) charge
- Internal resistance measurements (using specialized meters) help identify degraded cells
- A sudden drop in internal resistance or voltage indicates a failing cell

Capacity and Discharge Testing

- The ultimate test of a battery's health is a load test (capacity test)
- Performed using a dummy load bank to discharge the battery at a constant current
- Voltage is monitored until it reaches the End of Discharge Voltage (EODV)
- IEEE standards recommend a capacity test upon installation, then every 5 years
- If capacity drops below 80% of rated value, the battery must be replaced

Safety Precautions in Battery Rooms

- Acid Spills: Neutralize with baking soda (sodium bicarbonate) and wash with water
- PPE Required: Acid-resistant apron, face shield, rubber gloves
- Insulated tools must be used to prevent accidental short circuits
- Eye wash stations must be installed within or immediately adjacent to the room
- No smoking or open flames allowed due to explosive gas risks

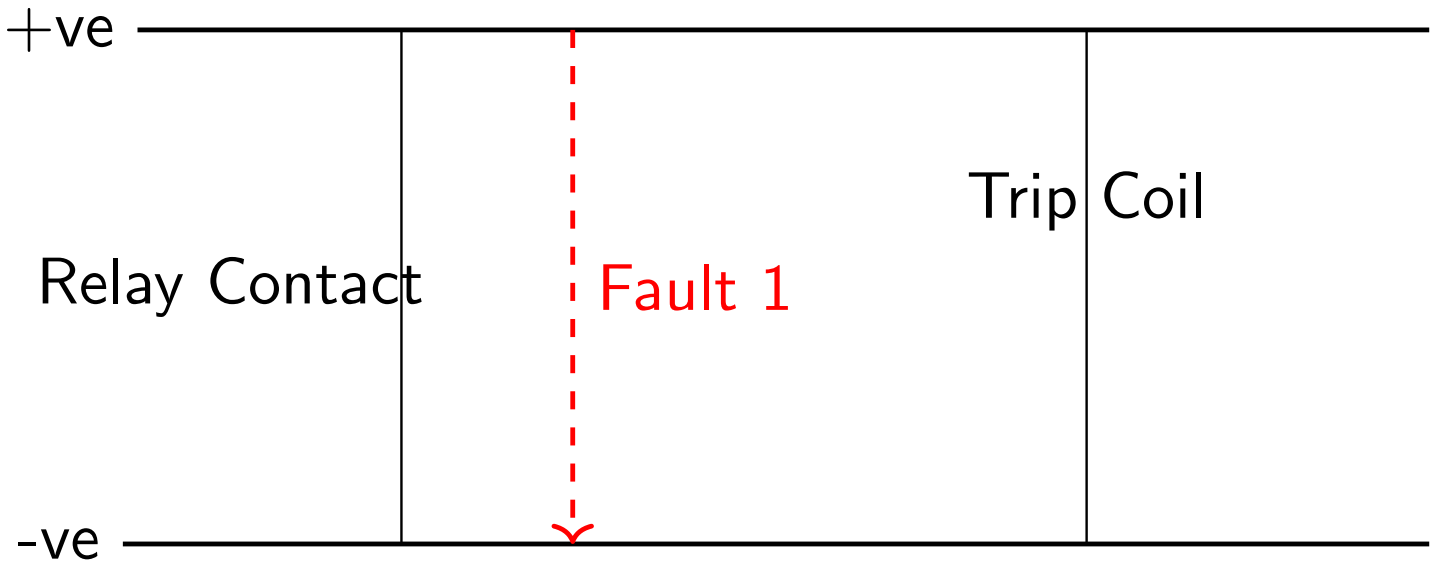
Hydrogen Gas Evolution and Ventilation

- During boost charging, lead-acid batteries undergo electrolysis, releasing Hydrogen gas
- Hydrogen is explosive at concentrations between 4% and 75% in air
- Battery rooms require forced ventilation (exhaust fans) to keep H2 levels below 1%
- Explosion-proof light fittings and switches are recommended
- Hydrogen detectors provide alarms to SCADA if ventilation fails

DC System Ground Faults

- Substation DC systems are typically ungrounded (floating)
- A single ground fault (e.g., positive to ground) does not cause a short circuit or blow a fuse
- However, a second ground fault on the opposite pole will cause a short circuit
- Can lead to blown fuses, loss of DC power, or false tripping of circuit breakers
- Immediate location and repair of the first ground fault is critical

Impacts of DC Ground Faults on Relays



Ground Fault Detection Methods

- Simple Method: Two series lamps connected across the DC bus, with the center point grounded. A fault dims one lamp and brightens the other
- Modern Relays: Injection of a low-frequency AC signal to measure insulation resistance to ground
- Portable Fault Locators: Inject a traced signal and use a clamp-on ammeter to trace the fault down to the specific circuit
- Sequential Isolation: Turning off DC MCBs one by one until the ground alarm clears (highly disruptive)

Redundancy in DC Systems

- Extra High Voltage (EHV) substations employ dual redundant DC systems (DC System 1 and DC System 2)
- Physically separated battery rooms and duplicated chargers
- Main 1 and Main 2 protection relays are fed from independent DC systems
- Circuit breakers are equipped with dual trip coils (TC1 and TC2)
- Ensures that a complete failure of one DC system does not leave the substation unprotected

Summary

- Float charging maintains the battery, while boost charging restores it
- Maintenance involves checking specific gravity, voltages, and terminal tightness
- Hydrogen outgassing requires strict ventilation and safety protocols
- DC systems are ungrounded; a single ground fault must be addressed immediately to prevent false tripping
- Redundant DC systems provide maximum reliability for EHV substations

Preview of Next Lecture

- Introduction to Routine Substation Operations
- Safe Switching Principles
- Operation of Isolators vs. Circuit Breakers
- Isolation and Tagging (LOTO) Procedures
- Substation Interlocking Schemes