HANDS-ON RELAY SCHOOL

MARCH 26 - 31, 2023

EASTERN WASHINGTON UNIVERSITY
526 5TH ST. CHENEY, WA 99004

WesternEnergy INSTITUTE

OBJECTIVES OF THE HANDS-ON RELAY SCHOOL

The Hands-On Relay School is a professional development short course that trains protective relay technicians,electrical/power plant technicians, engineers, and protective relay test specialists.

Students are enrolled in one of eight tracks for the duration of the school.

- Basic
- Distribution
- Transmission
- Generation
- Electromechanical
- Computerized Relay Testing
- Automation & Integration
- Theory

Students participating in these tracks will:

- Become familiar with manual or computerized test methods for a variety of protective relays and test equipment.
- Gain valuable knowledge relating to relay applications and operating characteristics.
- Exchange ideas and resolve problems in an open forum.
- Learn preventative and corrective maintenance methods.

APPLICATION

School enrollment is limited, and priority is given to organizations providing Lab Facilitators, Lecturers, Steering Committee support, and Western Energy Institute member utilities. Refer to important application and enrollment procedures at the end of this brochure.

CALL FOR LAB FACILITATORS

If you are an experienced relay technician who is willing to share your knowledge with others, you can attend the Hands-On Relay School as a Lab Facilitator. Lab Facilitators work with groups of three students testing relays and may attend all classroom lectures and school activities. Lab Facilitators are not required to pay the application fee and their company receives priority points for students applying for the school. If you are interested, contact WEI at 503.231.1994 or sign up at westernenergy.org/programs/hands-on-relay-school-2

BASIC TRACK

The Basic Track focuses on the fundamentals of protection systems, safe work practices, relay settings, calibration, maintenance, testing, and application of microprocessor and electormechanical relays.

Students in this track will:

- Attend the Basic Overview lecture.
- Attend the Concurrent Open Lectures: “Phasors” and then “Stop Pumping My Breaker” on Monday. Choose four (4) Concurrent Open Lectures to attend on Tuesday.
- Attend the Friday Feature Lecture Presentations.
- Wire an overcurrent and a reclosing relay to a breaker simulator to test and troubleshoot an entire protection circuit.
- Perform hands-on testing in the lab on the following relays:
  - **ABB**: CO, IRD-9
  - **GE**: BDD
  - **SEL**: 311C, 751A

DISTRIBUTION TRACK

This track is for those students who wish to focus on the testing and understanding of multifunction microprocessor relays and recloser controllers used for distribution protection. The selection of relays may include overcurrent, transformer differential, reclosing, synch-check, and frequency protection. *18 Students Maximum.*

Students in this track will:

- Attend the Distribution Overview lecture.
- Choose six (6) Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab on the following relays:

  ABB: REF615
  Basler: BE1-11F
  Beckwith: M-7679-R
  Cooper: Form 6
  SEL: 751A, 787

DISTRIBUTION PROTECTION OVERVIEW LECTURE

John Gilrein, Avista Utilities

This lecture will review fundamental principles of distribution system protection, including IEEE device designations, fault current calculations, coordination of overcurrent protection, and reclosing schemes.

TRANSMISSION TRACK

This track features both electromechanical and microprocessor- based multifunction relays used for protection of transmission equipment, including distance and line current differential protection. *24 Students Maximum.*

Students in this track will:

- Attend the Transmission Overview lecture.
- Choose six (6) Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab on the following relays:

  ABB: KD10
  Beckwith: M-3311-A
  GE: L90
  Hitachi Energy: RET670
  SEL: 487V, 411L

TRANSMISSION PROTECTION OVERVIEW LECTURE

Abdur Rehman, AllumiaX Engineering

This lecture will review fundamental principles of transmission line protection. Concepts of distance protection, directional overcurrent, line differential, and pilot protection schemes will be discussed.

GENERATION TRACK

This track features electromechanical and multifunction microprocessor relays used for transformer and generator differential, over-excitation, stator ground, reverse power, synch-check, negative sequence, and loss of field protection of generators. *24 Students Maximum.*

Students in this track will:

- Attend the Generation Protection Overview lecture.
- Choose six (6) Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab on the following relays:

  ABB: REG615
  Basler: BE1-FLEX
  Beckwith: 3425A
  GE: CEH, INC77
  SEL: 700G/400G

GENERATION PROTECTION THEORY AND APPLICATION OVERVIEW LECTURE

Matt Horvath, POWER Engineers, Inc.

This lecture will review fundamental principles of generation protection theory and application with a focus on industry standards and best practices.

ELECTROMECHANICAL TRACK

This track focuses exclusively on electromechanical relays used for line, bus, transformer, or generator protection. More hands-on effort is spent on troubleshooting relay problems, calibrating relays, adjustment techniques, and verifying results. *15 Students Maximum.*

Prerequisite: Basic track or related experience.

Students in this track will:

- Attend their choice of Distribution, Transmission, or Generation Protection Overview Lectures.
- Choose six (6) Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab on the following relays:

  ABB: CO, CA, IRD9, HU, KD10
  GE: IAC, PVD, INC77

COMPUTERIZED RELAY TESTING TRACK

This track is intended for technicians who already understand relay operating principles, have experience in manual testing, and are ready to learn computerized testing methods. *Student Maximum Varies. Laptop Computer Required.*

Note: This track is NOT recommended for those relay technicians who are just starting out. The emphasis of this track is on the test equipment and software, not on the relays. The hands-on labs are taught by the test equipment and software manufacturers, not by the relay manufacturers.

Prerequisite: Experience in manual relay testing and computer use. A laptop computer will be used to communicate with the relays and/or the test set. All students must have administrative rights to their laptop, with the appropriate software pre-loaded.

Students in this track will:

- Attend their choice of Distribution, Transmission, or Generation Protection Overview Lectures.
- Choose six (6) Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Perform hands-on testing in the lab using one of the following testing software platforms:

Megger	Protection Suite (Beginning)
Omicron	RTS (Advanced)
Protection Suite (Advanced)	RTS (Beginning)

Some test software vendors will offer both a Beginning and an Advanced section, depending on enrollment and skill level of the students. Beginning computerized testing still requires a prerequisite understanding of manual testing.

Beginning Tracks will cover the following:

- Building of test plans
- Macros used for testing basic relay functions

Advanced Tracks will cover the following:

- Worksheets and advanced software features
- Quad Element Testing
- Breaker simulators
- Playback features
- End-to-end testing

AUTOMATION & INTEGRATION TRACK

This track is intended for technicians who have basic familiarity with microprocessor-based relays and would like to learn more about their integration into substation automation and communications systems. This includes metering and alarming (SCADA), time synchronization, networking, and substation communications protocols. *Student Maximum Varies.*

Students in this track will:

- Attend their choice of Distribution, Transmission, or Generation Protection Overview Lectures.
- Choose six (6) Concurrent Open Lectures to attend.
- Attend the Friday Feature Lecture Presentations.
- Participate in the following lab-based courses.

Time Synchronization

- IRIG & PTP Time Synchronization basics
- Time synchronization for line current differential relay applications
- Synchrophasor basics

IP Network Fundamentals

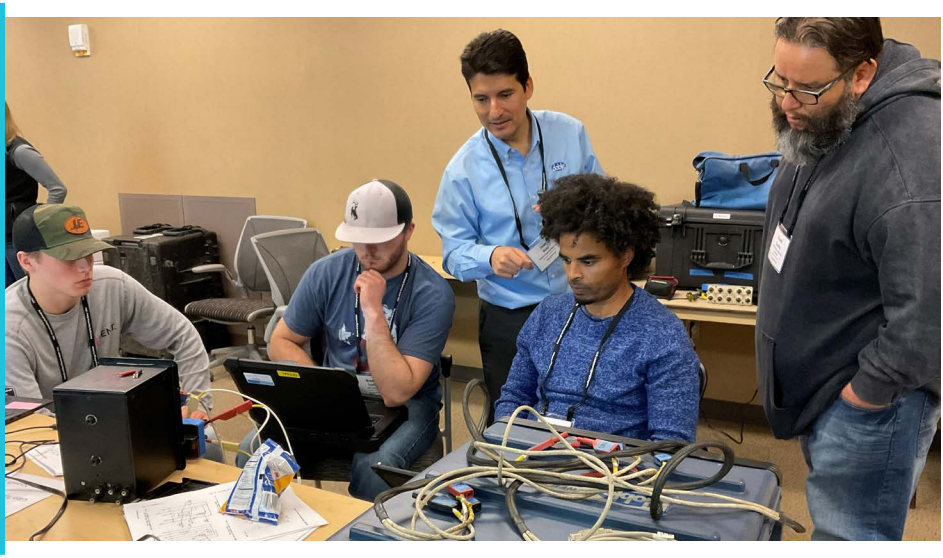
- OSI Model introduction, IPv4 Addressing, Subnetting, and MAC Addressing
- IPv4 Troubleshooting

SCADA Integration

- NovaTech Orion Automation Processor configuration and use
- Integration exercises with microprocessor relays

IEC 61850 Fundamentals

- Integration and troubleshooting of IEC 61850 protocol (GOOSE messaging and MMS) relay applications using the SEL RTAC platform
- Wireshark network protocol analyzer tool basics



THEORY TRACK

This track provides more in-depth training on the application and theory of operation of protection systems utilized in the power system. This track does not normally include any hands-on training with relays. *35 students maximum.*

Note: The theory track is for the journeyman relay technician and relay engineer. It is NOT recommended for those relay technicians who are just starting out. Instructors and lecturers for the theory track are considered to be experts in their field.

Students in this track will:

- Attend their choice of Distribution, Transmission, or Generation Protection Overview Lectures.
- Choose six (6) Concurrent Open Lectures to attend.
- Attend the Monday and Tuesday PM and all day Wednesday and Thursday Lectures.
- Attend the Friday Feature Lecture Presentations.
- Attend the advanced topic lectures throughout the week, as follows:

TRANSMISSION LINE PROTECTION IS GREAT

Ken Workman, Schweitzer Engineering Laboratories, Inc.

Transmission lines are the superhighways of the power system. With the enormous amounts of energy they move, it is essential that they be monitored with reliable and high-speed protection principles and devices. This class will examine traditional and modern protection practices for transmission lines, and why we use them. Topics of discussion will include: overcurrent protection, distance protection, communications assisted (pilot) protection, differential protection, travelling wave protection, and fault location principles.

BASICS OF COMMUNICATIONS AND TIME SYNCHRONIZATION FOR PROTECTION AND CONTROL APPLICATIONS

Galina Antonova, Hitachi Energy

Fundamentals of communications and time synchronization applicable to protection and control field will be covered. Various communication channel types, interfaces and technologies will be explained. Industry move towards packet-switched communications and integration of services will be highlighted. The basics and evolution of time synchronization methods will be presented. Latest time synchronization standard developments will be summarized.

WHY TRANSFORMERS FAIL

Drew Welton, Intellirent

In this session we will take a deep dive into transformer failure and bridge the gap between transformer protective relay systems and maintenance testing to form a more holistic approach to the subject. Often times there is a disconnect between those responsible for protective relaying and maintenance testing, and by looking at a more complete picture, we can possibly extend the transformer's life expectancy, and avoid catastrophic failure. We will define types of failures, location of failures within the transformer, and examine the difference between electrical, mechanical, and insulation failures. We will show examples and look at various case studies that include interactions between protective relays, and electrical test results. We will also examine diagnostic testing techniques for on-load tap changers and bushings, which make up a large portion of system failures.

PROTECTION OF POWER-SYSTEM GENERATORS

Dan Ransom, GE Grid Solutions, a part of GE Vernova

Power-system generators require adequate protection from faults and abnormal operating conditions. Protective relays safeguard these valuable assets. This session explores how protective relays guard generators against internal faults, system faults, and generator/power-system abnormal operation. References are the IEEE Guide for Generator Protection (C37.102) and other industry standards.

DISTRIBUTION EVENT ANALYSIS

Cameron Chapman and Jill Ham, Avista Utilities

A look into distribution faults and the tools/concepts used to analyze them from an engineering and operations perspective by walking through various real-world examples highlighting the intricacies of distribution event analysis.

DISTRIBUTED GENERATION: INTERCONNECTION, OPERATION AND PROTECTION

Wayne Hartmann, GE Renewable Energy

This session provide solid background on distributed generation (DG) from multiple aspects: industry history, types, operational sequences, benefits to Utilities and Owners, control, example guidelines, IEEE 1547 and point-of-common coupling (PCC) interface to culminate and focus on protection aspects at the PCC as well as impact on distribution protection.

CONCURRENT OPEN LECTURES

The Hands-On Relay School offers twelve (12) lectures on a wide range of topics relevant to the trade. Each lecture is one (1) hour long and given a total of three (3) times. Students can attend up to six (6) lectures of their choosing.

SUBSTATION COMMISSIONING

Paul Luther, Puget Sound Energy

This presentation will cover commissioning practices and techniques required to insure proper operation of substation equipment, with an emphasis on CT's, PT's and auxiliary equipment. Common errors leading to unsuccessful short and long-term energization will be highlighted. Test equipment and some examples of documentation will also be covered.

STOP PUMPING BY BREAKER!

Brent Carper, 3AC Engineering

Circuit breaker internal wiring is not just a trip and close coil, but also includes auxiliary relays that perform critical functions such as close seal-in and anti-pumping. This class will do a step-by-step walkthrough of a typical substation breaker X/Y schematic while using a hardwired breaker simulator to demonstrate the functions. This is a good class for those wanting to better understand how to read control schematics.

SYMMETRICAL COMPONENTS 1

Stephen Marx, Bonneville Power Administration

Basic principles of symmetrical components with explanation of phasors, per unit system, and symmetrical component equations using sequence networks. Network connections for each power system fault type are analyzed. Suggest attending Symmetrical Components 2 lecture as a continuation of Symmetrical Component 2.

SYMMETRICAL COMPONENTS 2

Stephen Marx, Bonneville Power Administration

Continuation from Symmetrical Components 1. Samples of protective relay applications using symmetrical component method. Suggest attending Symmetrical Components 1 lecture as a prerequisite.

HISTORY OF PROTECTION

Scott Cooper, Omicron

A walk through a single substation often shows a varying array of relay types from old to new. This lecture will look at the similarities and differences of various vintages of protective relays including electromechanical, solid state, and microprocessor relays.

INSTRUMENT TRANSFORMERS

Thomas Morrell, Schweitzer Laboratory Inc.

Current and voltage inputs are fundamental to the successful operation of a relay. This session will provide a theoretical overview of current transformers (CTs), potential

transformers (PTs), and coupling capacitor voltage transformers (CCVTs) as well as their application in protective relays.

FAULT ANALYSIS FOR RELAY TECHS

Ken Workman, Schweitzer Engineering Laboratories, Inc.

Event reports continue to be an invaluable feature in microprocessor-based relays. Some events are relatively straightforward to analyze, and others require experience and considerable knowledge of the power system and protective relay system in order to find the root cause. This session provides an outline of the event analysis process, several \real-world event examples, time to evaluate them, and solutions.

HIGH IMPEDANCE FAULT PROTECTION

Ken Workman, Schweitzer Engineering Laboratories, Inc.

High-impedance fault (HIF) detection has existed for many years, but current events have been pushing it into the spotlight. Not all HIF events and downed conductors can be detected; therefore, it is important to understand detection methods and performance. This presentation covers topics related to HIF detection methods, their evolution, and limitations.

PHASORS

Ron Alexander, Grant County PUD

Phasors are the universal language of system protection technicians and engineers. This lecture emphasizes the need for a basic knowledge of phasor diagrams and their use in understanding the power system. Topics include load flow phasor analysis, fault phasor analysis, and using phasors to determine the phase angle across delta-wye transformers banks. It is recommended to take this lecture prior to the Symmetrical Components lecture.

HIGH LEVEL OVERVIEW OF DISTRIBUTED ENERGY RESOURCES/IBR (INVERTER BASED RESOURCE)

Laurence Abcede & Jose Cardenas, San Diego Gas & Electric

We continue to see more and more Inverter Based Resources (IBR) connected to the grid. This session aims to provide a high-level introduction to IBR's and their impact to the electrical system. Highlights to include IBR applications, the challenges and opportunities IBR's create, and address some of the fundamental differences between IBRs and traditional energy sources.

TRANSFORMER PROTECTION

Tyler Smith, Idaho Power Company

Fundamental overview of transformer protection techniques and philosophies including overcurrent-based, operate/restraint, and percent-restraint differential protection. Transformer connections as well as CT sizing and considerations will also be covered.

NERC COMPLIANCE (PRC-005)

Scott Dixon, Idaho Power Company

This presentation will look at the basics of the PRC-005 standard, the importance of the standard to the Relay Technician, and how the standard has driven the developement of the tools we use today to ensure our companies remains compliant with the standard.

TRANSFORMATIONS OF THE NORTHWEST ELECTRIC GRID (1880 – PRESENT)

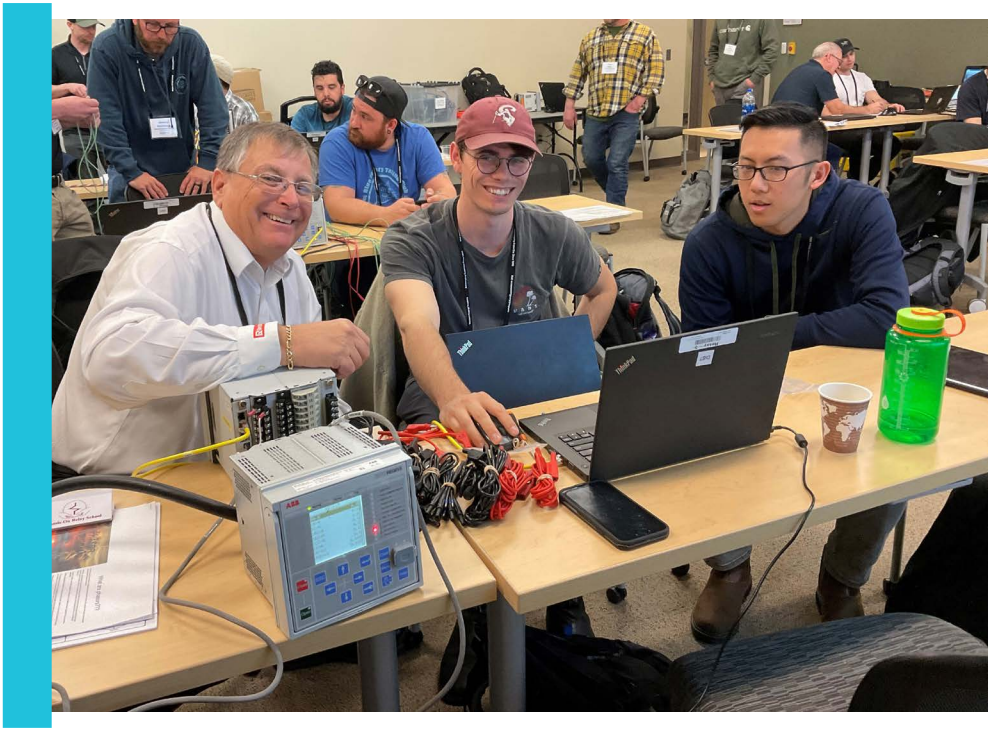
Joshua Binus, Bonneville Power Administration

Transformations of the Northwest Electric Grid examines the historical development of the electric grid in the Pacific Northwest by focusing on seven key periods of transformation since its origins in the 1880s. The review of each period of transformation will highlight important and relevant drivers, stakeholders, technological innovations, evolving or emerging systems and operations, new institutions, and key outcomes. This presentation is especially designed for folks that are new to the Northwest or new to the electric utility industry in general (although industry veterans have enjoyed it too).

STATE OF THE INDUSTRY

Rich Bauer, NERC

The electrical grid is in a period of unprecedented change. Changing to a low carbon resource mix requires a new look at how we have performed our jobs for over a century. From system protection to resource adequacy to rate structure, everything needs to be viewed through a different lens. Join us as we talk about how the Industry is managing these unprecedented times.



2023 SCHEDULE AT A GLANCE

The Hands-On Relay School is held on the Eastern Washington University campus in Cheney, Washington. Evening events and Sunday check-in registration are held at Eastern Washington University in Cheney, Washington, or as noted.

SUNDAY, MARCH 26

3:00 - 6:00 PM	**Facilitator Lab Set Up**
5:30 - 7:30 PM	**Registration & Reception**
7:00 - 8:00 PM	**Lab Facilitator Meeting**

MONDAY, MARCH 27

6:45 - 7:30 AM	**Registration**
7:30 AM - Noon	**Opening Announcements**
	Safety Presentation
	Overview Lectures
	Concurrent Open Lectures
1:00 - 5:00 PM	**Hands-on Lab Instruction**
5:00 PM	**Optional Social Get-Together**

TUESDAY, MARCH 28

7:30 AM - Noon	**Concurrent Open Lectures**
1:00 - 5:00 PM	**Hands-on Lab Instruction**
5:00 - 7:30 PM	**Suppliers' Showcase**

WEDNESDAY, MARCH 29

7:30 AM - Noon	**Hands-on Lab Instruction**
1:00 - 5:00 PM	**Hands-on Lab Instruction**
6:30 - 9:00 PM	**Dinner and Social Networking**

THURSDAY, MARCH 30

7:30 AM - Noon	**Hands-on Lab Instruction**
1:00 - 5:00 PM	**Hands-on Lab Instruction**

FRIDAY, MARCH 31

7:30 - 8:00 AM	**Closing Remarks**
8:00 - 11:30 AM	**Friday Feature Presentations**

STEERING COMMITTEE

Chris Gallacher	*Chair, Bonneville Power Administration*
Ron Alexander	*Grant County PUD*
Karl Cabrera	*Salt River Project*
Ben Crum	*Seattle City Light*
Scott Dixon	*Idaho Power Company*
Bryan Focht	*Portland General Electric*
Peter Jereb	*Pacific Gas and Elextric*
Tyge Legier	*San Diego Gas & Electric*
Paul Luther	*Puget Sound Energy*
Stephen Marx	*Bonneville Power Administration*
Andy Parks	*Chelan PUD*
Travis Rider	*Pacific Gas and Electric Company*
Greg Sharpes	*Avista Utilities*
Tanyl Tinhof	*PacifiCorp*
Bill Unbehaun	*PacifiCorp*
Beverly Woolf	*Western Energy Institute*
Vlad Yerokhin	*Tacoma Power*
Diana Zoren	*Western Energy Institute*

CONTRIBUTING ORGANIZATIONS

The Hands-On Relay School Steering Committee gratefully acknowledges the following organizations for their generous contributions of equipment and support personnel.

3AC Engineering
ABB, Inc.
Agile Power Professionals, Inc.
Ametek
Arizona Public Service
Avista Utilities
Basler Electric Company
Bonneville Power Administration
CES/Panduit/Rockwell
Camlin Power
Central Electric
Chelan County PUD
Clark Public Utilities
Doble Engineering Company
Doble RVS
Douglas County PUD
Eaton
Grant County PUD
GE Grid Solutions, Part of GE Vernova
Hitachi Energy
Hubbell Beckwith
Idaho Power Company
Manta Test Systems
Megger
NERC
NV Energy
NorthWestern Energy
Omicron Electronics Corp. USA
PacifiCorp
Pacific Gas & Electric Company
Pacific Power
Peak Measure
Pend Oreille PUD #1
Portland General Electric
Power Engineers
Puget Sound Energy
Qualas Power Services
RFL Electronics Inc.
Relay Application Innovation, Inc.
Salt River Project
San Diego Gas & Electric
Schweitzer Engineering Laboratories, Inc.
Seattle City Light
SecuControl, Inc.
Siemens
Snohomish County PUD
Tacoma Power
Tri-State Generation & Transmission
U.S. Army Corp of Engineers
U.S. Bureau of Reclamation
Valence Electrical Training Services
Western Area Power Administration
Western Energy Institute

SCHOOL INFORMATION

APPLICATION PROCESS AND FEES

- Application is online at: https://www.westernenergy.org/hands-on-relay-school-student-application/
- Priority is given to utilities providing Lab Facilitators, Lecturers, Steering Committee Support, and Western Energy Institute member utilities, if the Application is received by January 15, 2023. The remaining slots will be filled on a first-come, first-served basis.
- Applicants select which track they wish to attend in order of preference. Every effort will be made to place students into their preferred track, but track placement is by availability and subject to the priorities as described above. Many tracks will fill up and students may not be able to get their preferred track.
- Students will be notified in writing no later than **February 10, 2023**, of their acceptance into the school and track placement. You are not accepted to attend until unless you receive the confirmation of acceptance from WEI which you will have two weeks to complete your registration and make payment to keep your spot in the school.
- School fee of $700 includes electronic copies of lecture notes, Sunday night reception, Tuesday night Suppliers' Showcase, Wednesday night social meal, break refreshments, and EWU offers free parking in designated areas.
- Payment is due at the time of registration. Once invoiced you will have two weeks to secure a spot in the school. If payment is not received the school reserves the right to fill your spot with other applicants.

ACCOMMODATIONS AND TRAVEL

Please make your own travel and hotel reservations once you have received registration confirmation. Spokane International Airport is 15 miles north of Cheney. Holiday Inn Express (509.235.1100) in Cheney, and the Double Tree Spokane (509.455.9600) in Spokane, have rooms blocked for this event.

CANCELLATION POLICY

Your full registration fee will be refunded if WEI receives your written cancellation notice by March 3, 2023. Cancellations made after March 3 are subject to a processing fee of $350. Students who do not attend and have not canceled by March 17 are responsible for the full registration fee. Substitutions may be made at any time.

PROGRAM CHANGES AND CANCELLATIONS

The Hands-On Relay School reserves the right to make changes in programs or speakers or to cancel programs if enrollment criteria are not met. In the unlikely event that this School is canceled, the School's liability is limited to refund of registration fees. If we are unable to place you in a track you have selected or an acceptable substitute track, your full registration will be refunded.

AMERICANS WITH DISABILITIES ACT

Accommodations for individuals who qualify under the Americans with Disabilities Act are available upon request. Please contact us at least ten (10) days before the school at 503.231.1994, or email info@westernenergy.org.

CONTINUING EDUCATION UNITS (CEU)

CEUs are available to participants who complete a CEU enrollment form prior to the start of the school and satisfactorily complete the requirements for the class. CEUs are nationally recognized units of achievement that may be used as evidence of professional development and for job advancement. One CEU is awarded for every 10 hours of instruction, totaling 3.6 for this school. A fee of $90 must accompany the registration fee to receive the CEU credits.

REGISTER TODAY

https://www.westernenergy.org/hands-on-relay-school-student-application/

REVIEWS OF HANDS-ON RELAY SCHOOL

"[I was most impressed with] the amount of thought put into the classes. Instructors are either relay techs or work directly with them which creates a more real world basis on the curriculum."

"As a true beginner I appreciated the thoroughness of lectures and instructors."

"It's an amazing chance to experience the variety of systems and techniques used across the industry and to build relationships with others in the field."

"This school provides the opportunity to network, learn from other craftsman, and experience in testing different relays."

"I paid for this myself and it was 100% worth it. Great connections with other utilities, learned a lot, was able to spend more time exploring the relays and test different ways."

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