HANDS-ON RELAY SCHOOL

MARCH 27 - APRIL 1, 2022

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/37-hrs.

BASIC TRACK

This track is for those students who wish to focus on the calibration, maintenance, testing, and understanding of basic relays. The selection may include overcurrent, differential, distance, reclosing, voltage, or frequency relays. This track is an excellent choice for beginning technicians. *48 Students Maximum.*

Students in this track will:

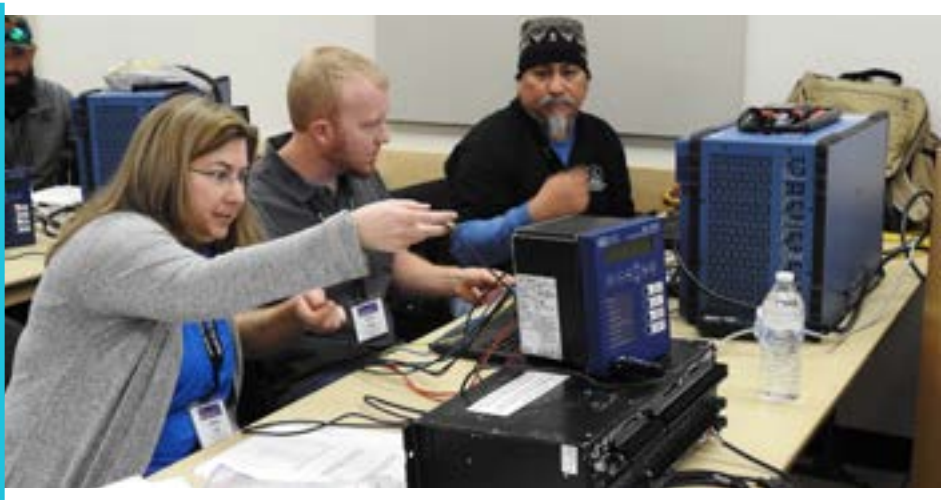
- Attend the Introduction to System Protection lecture series on Monday.
- Choose four (4) Concurrent Open Lectures to attend on Tuesday.
- Attend the Friday Feature Lecture Presentations.
- Wire an overcurrent and a reclosing relay to a breaker simulator to test and troubleshoot an entire protection circuit.
- Perform hands-on testing in the lab on the following relays:
  ABB: CO, HU
  GE: JBCG, CEY51a
  SEL: 751

INTRODUCTION TO SYSTEM PROTECTION LECTURE SERIES

This lecture series is for beginning relay technicians, newcomers to the relaying field, or anyone who needs the basics. We start with the very basics of relaying to provide a foundation of knowledge upon which to build. The closest thing to "Relaying for Dummies" that Hands-On Relay School has to offer! Taught by experienced system protection personnel, this lecture series will be presented on Monday only from 8:00 am – 12:00 pm.

Topics include:

- Introduction to Protection Basics and Terminology
  Bill Unbehaun, PacifiCorp
  Greg Sharpes, Avista Utilities
- Technician's Basic Math Review
  Bill Unbehaun, PacifiCorp
- Lessons Learned from the Field
  Paul Luther, Puget Sound Energy



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. Laptop Computer Required.*

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
  Beckwith: M7651A D-PAC
  Cooper: Form 6
  GE: F 60
  SEL: 751A, 787

DISTRIBUTION PROTECTION OVERVIEW LECTURE

Doug Taylor, 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. Laptop Computer Required.*

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: KD-10, REL670
  Beckwith: M-311A
  SEL: 411L, T400L, 587Z

TRANSMISSION PROTECTION OVERVIEW LECTURE

Matt Horvath, Power Engineers, Inc.

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. Laptop Computer Required.*

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**: KLF-1, REG615
  - **Basler**: BE1-FLEX
  - **Beckwith**: 3425A
  - **SEL**: 700G

GENERATION PROTECTION THEORY AND APPLICATION OVERVIEW LECTURE

Wayne Hartmann, GE Grid Automation

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**: KLF-1, IRD-9, KD-11
  - **GE**: INC77, PVD, GCX51, BDD

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:

Manta	Protection Suite (Advanced)
Megger	Protection Suite (Beginning)
Omicron (Advanced)	RTS (Advanced)
Omicron (Beginning)	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 communications systems. This includes rudimentary metering and alarming (SCADA) up through complex process buss-style centralized protection. *Student Maximum Varies. Laptop Computer Required.*

Students in this track will:

- Attend their choice of Distribution, Transmission, or Generation Protection Overview Lectures.
- Integrate and troubleshoot relays using IEC 61850 protocol (Sample Measured Values and GOOSE messaging)
- Receive an overview of DNP theory and implementation
- Learn about high-precision timekeeping methods used in substations
- Learn the fundamentals of TCP/IP networking
- Learn about and experiment with communications standards and mediums including fiber

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. *30 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:

DISTRIBUTION FAULTS AND EVENTS ANALYSIS

Randy Spacek, Avista Utilities

A relay response to a fault is only as good as its application and settings. The capability to perform an analysis utilizing multiple sources of data and tools can provide insight into whether the relay response is correct. The lecture will use various recorded occurrences to demonstrate how to investigate, analyze, and evaluate an event. Mystery events will be presented for the technician to solve.

ESSENTIAL RELIABILITY SERVICES – SYSTEM VOLTAGE CONTROL AND FREQUENCY CONTROL

Rich Hydzik, Avista Utilities

Stable and reliable power system operation depends on effective voltage regulation and frequency regulation. The lecture will explain the difference between voltage and frequency steady state and contingency conditions to maintain equipment ratings to supply customer load and protect equipment, and voltage regulation needed to restore rated voltage and prevent voltage collapse during system events. It will review effective frequency control techniques to quickly restore load and generation balance, to prevent frequency decline resulting under frequency load shedding, equipment damage, and widespread outages.

GENERATION PROTECTION

Daniel Ransom, General Electric

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.

GENERATOR VOLTAGE REGULATOR AND GOVERNOR THEORY

Jeremy Winkle, Avista Utilities

Stable and reliable power system operation depends on effective voltage regulation and frequency regulation. This lecture will explain the function and control modes of voltage regulators and excitation systems. A review of frequency control systems, including droop, deadbands, and application to different types of generating resources.

REMEDIAL ACTION SCHEMES (RAS)

Chris Gallacher, Bonneville Power Administration

Topics include what is (and is not) a RAS, their purpose, types of RAS, and their hardware and logic. This will be a “RAS-101” type course, with time allotted for questions, so no advanced knowledge of RAS is required.

TRANSFORMER PROTECTION

Wayne Hartmann, GE Grid Automation

Why do transformers fail? A review of protection principles and modern technology differences and advantages including analysis tools to view relay operations. This lecture will include overcurrent,differential, through faults, and CT performance. We will also cover IEEE C37.91 “Guide for Power Transformer Protection.”

TRANSMISSION LINE PROTECTION

Michael Wright, Qualas Power Services

Transmission line protection is a fundamental form of protection critical to the effective transmission of electric power. This high level class removes some of the mystery about how line protection works and specifically does a deep dive into the end-to-end protection schemes where relays at each end of a line work together to detect faults and initiate isolation with as little time delay as possible. This class covers line protection topics such as physical characteristics of transmission lines, the MHO circle, theory of impedance protection, zones of protection, and end-to-end protection schemes.

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.

BREAKER FAILURE PROTECTION

This lecture will review different types of breaker failure protection systems, relays, and logic, including general considerations for determining relay pickup and timing settings.

CAPACITIVE TRIP DEVICES & AC CONTROL CIRCUITS

Brent Carper, 3AC Engineering

Although most utility substations traditionally have utilized DC for control circuits, AC control is becoming more common as utilities look to eliminate the maintenance costs and environmental risk associated with large batteries. Long used for industrial and 480V applications, capacitive trip devices (CTD) can be used to reduce or eliminate batteries, or as backup auto-trip protection for DC system failures. This lecture will discuss issues specific to AC control, how CTDs work, and the safety, operational, and engineering aspects that need to be considered.

TEST ISOLATION TOOLS AND TECHNIQUES FOR TECHNICIANS

Travis Rider, Pacific Gas & Electric

Performing maintenance, construction, and commissioning on complex protection and control systems is becoming increasingly more difficult. This can present greater risks and challenges to Engineers and Technicians that could lead to an undesired outage. Having a comprehensive test and isolation plan can greatly reduce and mitigate these risks. This presentation will highlight different processes, tools, and techniques that can be used when performing isolation for testing.

COMMUNICATION-AIDED TRIPPING

Tyler Smith, Idaho Power Company

The fundamental objective of power system protection schemes is to quickly provide isolation of a system problem while leaving the remainder of the system intact. Communication assisted protection schemes are applied to provide high speed tripping for faults over 100% of the transmission line length and are designed to provide either increased dependability or increased security.

CT TESTING & THEORY

Moritz Pikisch, Omicron Electronics Corp. USA

Opening an energized current transformer (CT) secondary can result in very hazardous voltages and possible damage to the CT. This is a discussion of how a CT can generate high voltages, some video demonstrations of an open CT secondary, and suggested work practices to safely work on current transformer secondaries.

DC GROUND DETECTION

Eric Haut, Portland General Electric

Unmitigated ground paths on ungrounded DC systems pose a threat to reliability and safety. The technology for monitoring and troubleshooting DC grounds has evolved over the decades. This lecture will cover the simple dual-lightbulb monitoring of the past up to today's digital monitoring systems. Watch hands-on demonstrations of troubleshooting methods, from the simple-but effective resistive jumper to computerized DC ground locators.

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.

PRECISION TIMING (IRIG)

Steve Laslo, Bonneville Power Administration

Learn about precise timing theory and application in the electric power industry. The presentation will include topics such as time distribution over IRIG and PTP, satellite-synchronized clocks, power system applications of precise timing, installation best practices, and troubleshooting common issues with relay time synchronization.

PT CONNECTIONS WITH PHASOR–Y DELTA, OPEN DELTA

Jason Hall and Andrew Wick, Puget Sound Energy

Discussing standard and non-standard PT configurations and their effect on relay protection systems and relevant applications.

SYMMETRICAL COMPONENTS

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. Samples of protective relay applications using symmetrical component method.

BLACKOUT – DEEP DIVE

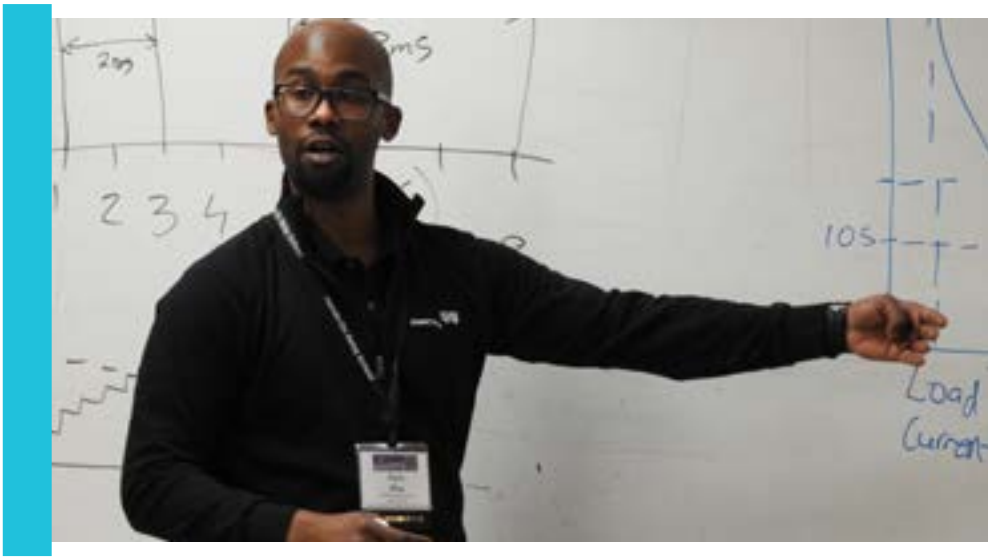
Michael Wright, Qualas Power Services

On April 29, 2002 a large municipal power company experienced a city-wide blackout. While the event was triggered by the failure of a 138kV surge arrestor, the blackout was the result of many years of small issues combining on a fateful day in a series of incidents that cascaded into an unrecoverable system collapse. The purpose of this presentation is to share this story so that others might have a better appreciation of how all of the systems supporting a power company work together. This is a story of politics, vegetation management, meter calibration, mis-applied devices, engineering errors, lack of redundancy, situational awareness, and reactive culture.

LITTLE FALLS DESTRUCTIVE TESTING OF HYDRO GENERATOR

Doug Taylor, Avista Utilities

In the fall of 2018, Avista and SEL performed destructive testing on an 8.8MVA, 4.16kV hydro generator scheduled for upgrade. The purpose of the testing was to provide comprehensive measurements of the generator operating quantities during stator and rotor faults in order to look for methods of detecting these faults with greater sensitivity. This presentation will describe the planning and execution components of the testing, including the fault survey that was performed to identify the appropriate fault locations, the process used to estimate the fault currents, and the test setup, fixtures, and safety precautions that were implemented. Lastly, the presentation will provide an overview of the test results and some of the insights gained from the data.



2022 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 27

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 28

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

TUESDAY, MARCH 29

7:30 AM - Noon	**Concurrent Open Lectures**
1:00 - 5:00 PM	**Hands-on Lab Instruction**
6:30 - 9:00 PM	**Suppliers' Showcase**

WEDNESDAY, MARCH 30

7:30 AM - Noon	**Hands-on Lab Instruction**
1:00 - 5:00 PM	**Hands-on Lab Instruction**
6:30 - 9:00 PM	**Banquet & Entertainment**

THURSDAY, MARCH 31

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

FRIDAY, APRIL 1

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

STEERING COMMITTEE

Chris Gallacher	*Chair, Bonneville Power Administration*
Beth Andrews	*Avista Utilities*
Karl Cabrera	*Salt River Project*
Scott Dixon	*Idaho Power Company*
Bryan Focht	*Portland General Electric*
Keane Johnson	*San Diego Gas & Electric*
Tyge Legier	*San Diego Gas & Electric*
Paul Luther	*Puget Sound Energy*
Stephen Marx	*Bonneville Power Administration*
Andy Parks	*Chelan PUD*
Pat Phillips	*Seattle City Light*
Travis Rider	*Pacific Gas and Electric Company*
Greg Sharpes	*Avista Utilities*
Tanyl Tinhof	*PacifiCorp*
Randy Turnley	*Puget Sound Energy*
Bill Unbehaun	*PacifiCorp*
Beverly Woolf	*Western Energy Institute*
Louis Wright	*Retired, Bonneville Power Administration*
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
Beckwith Electric Co, Inc.
Bonneville Power Administration
CES/Panduit/Rockwell
Camlin Power
Central Electric
Chelan County PUD
Clark Public Utilities
Doble Engineering Company
Douglas County PUD
ENOSERV
Eaton's Cooper Power System Business
General Electric Automation
Grant County PUD
Hubbell Power Systems
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. Bureau of Reclamation
Valence Electrical Training Services
Western Area Power Administration
Western Energy Institute

SCHOOL INFORMATION

APPLICATION PROCESS AND FEES

- Application is online at: westernenergy.org/programs/37-hrs
- School fee of $700 includes electronic copies of lecture notes, Sunday night reception, Tuesday night Suppliers' Showcase, Wednesday night banquet meal, break refreshments, and campus parking fees.
- Payment is due by the start of the school. There will be a $50 late fee assessed to any registrant who has not paid by 30 days after the school.
- 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, 2022**. 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 4, 2022,** of their acceptance into the school and track placement. You are not accepted to attend unless you receive the confirmation of acceptance from WEI.
- Questions? Call 503.231.1994 or email us at info@westernenergy.org. Visit our website at westernenergy.org/programs/37-hrs.

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 4, 2022. Cancellations made after March 4 are subject to a processing fee of $350. Students who do not attend and have not canceled by March 18 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 (CEUS)

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

westernenergy.org/programs/37-hrs/

REVIEWS OF HANDS-ON RELAY SCHOOL

"The school provides excellent hands-on training with equipment that I am directly exposed to daily, along with the necessary theory to provide a strong understanding of protection."

"The structure of taking senior and experienced technicians and letting them teach, walk through relays, and pass that experience on to upcoming technicians. What an outstanding concept."

"Fantastic learning opportunity...knowledgeable, experienced facilitators are priceless."

"This program is an incredible resource. All the instructors display great passion for the industry and the desire to pass on knowledge."

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