LINE DESIGN & STAKING COURSE – LEVEL I

Date:
Monday – Thursday,
January 12 - 15, 2009

Time:
10:00 am–4:30 pm - Mon
8:00 am–4:30 pm - Tue-Thu

Location:
Colorado Rural Electric Assn.
5400 North Washington St.
Denver, Colorado

Instructor:
Hi-Line Engineering

Fee:
$1,200 per student

To Register:
Contact Liz Fiddes at
(303) 455-2700 ext. 103 or
liz@coloradorea.org

Registration Deadline:
December 26, 2009

Confirmation:
A minimum of eight people must be registered for the course to be held. A letter will be faxed to all participants confirming their registration in the course.

Cancellation Policy:
Cancellations received on or before the registration deadline will receive full refunds. Cancellations received after the deadline may be billed 25 percent of the registration fee.

COURSE DESCRIPTION

BASIC SURVEYING: This domain will teach the student the basic methods of line route surveying. He or she will learn how to make accurate distance measurements, turn and bisect line angles, and measure changes in elevation using the basic surveying instruments. A basic overview of total station and GPS surveying will be included as a reference and introduction to further study.

1. Fundamental principles
   a) How to achieve a level of accuracy relative to the job
   b) Understanding township, range, and section lines

2. Measurements
   a) Length — pacing, 100-ft tape, Rolatape (wheel),
   b) Turning and bisecting line angles — 100-ft tape, pull-finder, hand compass, transit
   c) Structure alignment — range rods, binoculars, transit

3. Elevation profile and object height
   a) Measuring changes in elevation using a hand level
   b) Measuring height and elevation using an Abney level or clinometer
   c) Using a transit and level rod for surveying a complete elevation profile

4. Special techniques
   a) Running offset lines around obstacles
   b) Busting-in between two points
   c) Extra long distance alignment

5. Total station (introduction and overview)
   a) Description of equipment and accessories
   b) Programming the job and conducting a survey
   c) Transfer of field data to AutoCAD

6. Geographical Positioning Systems (introduction and overview)
   a) Types of GPS systems and basic operation
   b) Using GPS to inventory existing line routes
   c) Overlay of GPS data to geo-referenced maps and aerial photographs

continued

OVERHEAD STRUCTURE DESIGN: The student will learn to design overhead electrical distribution structures. Tables and graphs will be provided for the student to lookup design values for immediate application in the field. He or she will also learn to make basic calculations to determine strength and maximum allowable spans for wind and ice loading, plus total guy load due to tension and wind.

1. Conductors
   a) Ruling span theory and calculation
   b) Sag and tension calculations and tables
   c) Galloping and Aeolian vibration
   d) Maximum span based on vertical and horizontal conductor separation
   e) Conductor stringing and sag measurement

2. Poles
   a) Ultimate resisting and bending moments of wood poles
   b) Transverse conductor wind load and calculations
   c) Calculation of maximum wind span for tangent poles
   d) Designing un-guyed small line angle poles and embedment
   e) Selection of pole class based on transformer weight and vertical loading

3. Pole-top assemblies
   a) Types of horizontal and vertical pole-top assemblies
   b) Crossarm loading and maximum weight spans
   c) Characteristics and selection of pin and post type insulator assemblies
   d) Pole-top assembly strength calculations

4. Guys and anchors
   a) Determination of horizontal pull based on transverse and longitudinal loads
   b) Calculation of total guy load as a resultant of guy lead to height ratio
   c) Soil classification and anchor selection
   d) Designing a deadend anchor/guy assembly
   e) Designing a line angle anchor/guy assembly

JOINT USE STAKING: This course will teach the student how to handle joint use attachments. He or she will learn how to perform make ready surveys, measure clearances, determine strength requirements, prepare construction estimates, make final inspections, and understand the requirements of joint use contracts.

1. Types of joint use
   a) Communication on distribution
   b) Distribution on transmission
   c) Distribution on distribution

2. Determining strength requirements for joint use aerial attachments
   a) NESC grades of construction
   b) Transverse wind load on tangent structures

continued

3. NESC joint use requirements for separation of joint use utilities
   a) Overhead vertical and horizontal clearance at supports and mid-span
   b) Climbing and working space for operating personnel
   c) Separate lay and random lay of underground cables in a joint use trench
   d) Position of power and communication cables in an underground duct system

4. Joint use contracts
   a) The anatomy of a joint use contract
   b) Owner and renter responsibilities
   c) Permitting and application procedure
   d) Special requirements for joint use attachment
   e) Determining rental and construction costs

5. Inspection of joint use attachments
   a) System-wide inspections for NESC violations
   b) Post make-ready construction and attachment
   c) Attachment pole count frequency and procedure

6. Performing make-ready surveys
   a) Establishing attachment positions and measuring clearance
   b) Preparing construction specifications and cost estimates

UNIQUE STRUCTURES: The student will learn to design special structures that require additional strength due to extreme wind load, long spans, and multiple circuits. This section also includes designing steel pole and unguyed wood pole structures.

1. Extreme Wind Loading
   a) Evaluating pole strength for extreme wind applications
   b) Example problems

2. Double Circuit
   a) Configuration options
   b) Guying techniques
   c) Vertical spacing between circuits
   d) Maximum span lengths

3. Steel poles

4. Un-guyed line angle poles

continued

SUPPLIES NEEDED:
Workbooks and manuals will be supplied for the specialized instruction. Each student will be required to supply a personal copy of the *National Electrical Safety Code* and RUS Specifications. Each student should bring a scientific calculator and note taking materials to each seminar. The students will work class problems both in groups and individually. These problems will involve both the lookup tables and calculations based on the material contained in the manuals. The instructors will answer questions and go through the solutions to the problems. The instructors will also be available to discuss ideas and questions to a reasonable extent after normal class hours.

CERTIFICATION:
The course of study leads to certification as a qualified staking technician. The certification will be awarded after the student accomplishes well-defined tasks and demonstrates a working knowledge of the subject material though observation and completion of comprehensive written tests. The classroom and field training is divided into three phases of four domains each to be taught in three separate four-day seminars). To achieve certification, the student must attend all three seminars and pass a test for each of the twelve domains. Students may re-take any test if their first try is unsuccessful.

Colorado Electric Educational Institute
Colorado Rural Electric Association

LINE DESIGN & STAKING COURSE – LEVEL 2

Date:

January 2010

Location:
Colorado Rural Electric Assn.
5400 North Washington St.
Denver, Colorado

Instructor:
Hi-Line Engineering

COURSE DESCRIPTION

NATIONAL ELECTRICAL SAFETY CODE: This course will provide the staking technician with a working knowledge of the NESC and how to apply the applicable rules. The focus of this course will be on those rules that specifically apply to distribution line design such as grounding, overhead line clearances, overload factors, strength reduction factors, ice loadings, and underground line construction.

1. Purpose of the NESC
   a) Structure of the rules
   b) NESC versus NEC

2. Grounding requirements
   a) Definition of made electrodes (ground rods)
   b) Grounding intervals along a mile section of line
   c) Bonding of neutrals and messengers
   d) Grounding of guys and equipment
   e) Bonding of power and communications on the same pole

3. Substation clearances
   a) Fence clearance to substation equipment and height above grade
   b) Clearances to unguarded live parts inside the fence (vertical and horizontal)

4. Overhead lines strength of materials
   a) Grades of construction strength (B & C)
   b) Ice and wind loading on conductors including extreme wind
   c) Overload factors and strength reduction factors (Methods A & B)

5. Clearances
   a) Vertical clearance over roads, agricultural land, driveways, and water
   b) Horizontal and vertical clearance adjacent to poles, buildings, and signs
   c) Vertical clearance of conductors crossing over lines on different supporting structures
   d) Vertical and horizontal clearance of conductors on the same supporting structure
   e) Vertical and horizontal clearance of communication cables from power

continued

6. Underground rules
   a) Conduit systems — pulling tensions, bending radius, and manholes
   b) Direct buried cable identification, burial depths, and mapping
   c) Clearances of pad-mounted equipment from buildings
   d) Specified and random separation of electric cables from other utilities

EASEMENT ACQUISITION: In this domain the student will learn about easement law, land ownership rights, titles, easement descriptions, and recording easements. He or she will also learn valuable negotiating skills to aid in the procurement of an easement.

1. General
   a) Boundary and easement law
   b) Locating property according to the Public Land Survey
   c) Locating property according to a metes and bounds survey
   d) Types of land ownership and types of easements

2. Anatomy of an easement
   a) Legal elements and description
   b) Signatures, notarizing, and recording

3. Effective negotiating
   a) Understanding people and personalities
   b) Defining and responding to different behavior types
   c) Principles of negotiating, closing the deal, and breaking deadlock
   d) Effectively communicating with landowners
   e) Establishing good negotiating traits

4. Special situations
   a) Dealing with a hostile land owner
   b) Bartering for easements with old poles and services
   c) Establishing easement by prescription and adverse possession
   d) Obtaining an easement through condemnation

OBTAINING PERMITS: This domain teaches the student what information is required in a permit, how to setup an efficient permitting process, how to establish good personnel contacts to ease the process, and how to prepare permit documents and drawings.

1. General
   a) Establishing contact personnel
   b) Building files of permit documents
   c) Tracking progress in the permitting process
   d) Maintaining records and drawings (paper and electronic)

2. Departments of transportation (state, county, and municipal)
   a) Encroachment, crossing, and work permits
   b) Permit forms, vicinity maps, and traffic control diagrams

continued

3. US Corps of Engineers
   a) Wetlands permits
   b) Navigable water crossing permits

4. Transmission lines
   a) Crossing under an existing transmission line
   b) Locating a proposed structure in the transmission spans

5. Miscellaneous permits
   a) Environmental
   b) Archeological

LINE INSPECTION: The National Electrical Safety Code requires that a utility inspect its facilities periodically to ensure that they are safe and adequate to distribute electricity. In this domain, the student will learn the principles of making an inspection. The course will discuss the importance of a systematic method, the elements that should be checked, and different ways to perform the actual inspection.

1. NESC requirements
   a) Frequency of inspections
   b) Code violations and reporting

2. Records and maps
   a) Hand written inspection forms
   b) Electronic data entry (GPS) and management

3. Methods of inspection
   a) Helicopter and binoculars
   b) Vehicle ride through
   c) Foot patrol detailed inspection

4. Detailed visual inspection
   a) Clearances and other NESC requirements
   b) Condition of conductors, structures, and equipment
   c) Presence of required signage such as Two-Way-Feed, Caution, etc.
   d) Vegetation and environmental interference with the lines

5. Pole strength or integrity
   a) Visual inspection only of above ground pole surface
   b) Visual combined with sounding and screwdriver penetration
   c) Sonar and moisture/penetration
   d) Determination of strength or condition
   e) Marking and record keeping

continued

SUPPLIES NEEDED:
Workbooks and manuals will be supplied for the specialized instruction. Each student will be required to supply a personal copy of the *National Electrical Safety Code* and RUS Specifications. Each student should bring a scientific calculator and note taking materials to each seminar. The students will work class problems both in groups and individually. These problems will involve both the lookup tables and calculations based on the material contained in the manuals. The instructors will answer questions and go through the solutions to the problems. The instructors will also be available to discuss ideas and questions to a reasonable extent after normal class hours.

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Colorado Electric Educational Institute
Colorado Rural Electric Association

LINE DESIGN & STAKING COURSE – LEVEL 3

Date:

January 2011

Location:
Colorado Rural Electric Assn.
5400 North Washington St.
Denver, Colorado

Instructor:
Hi-Line Engineering

COURSE DESCRIPTION

UNDERGROUND LINE DESIGN AND SUBDIVISION LAYOUT: This domain will explain the components of underground distribution systems along with their application and limitations. The student will learn how to layout subdivisions, specify pad-mounted equipment, and design sectionalizing systems. This course will also cover conduit systems and the correct methods for calculating pulling tensions relative to conduit bends and cable runs.

1. Underground cable
   a) Solid, stranded, and strand-filled conductors
   b) The purpose and limitations of conductor shield
   c) Types and comparisons of conductor insulations
   d) Concentric neutrals, tape shields, and neutral ampacity

2. Components
   a) Separable connectors — 200 and 600 amp elbows, ANSI 386
   b) Cable terminators and potheads
   c) Joints — small and large cable splices
   d) Proper grounding of the cable and its components

3. Pad-mounted switchgear
   a) Purpose and types of switchgear in the complete underground system
   b) Insulating mediums — air, oil, gas, and vacuum
   c) Application of pad-mounted switchgear in vaults and open areas

4. Over-voltage protection
   a) Causes of cable failures due to treeing and lightning
   b) Controlling over-voltage and maintaining BIL with lightning arresters
   c) The phenomenon of ferroresonance and how to prevent its occurrence

5. Cable pulling in conduit systems
   a) Calculations for bending radius, clearance, jamming ratios, and pulling tensions
   b) The use of lubricants to reduce the coefficient of friction
   c) Designing a conduit pull for single and three-phase installations
   d) Using computer programs to calculate pulling tensions

continued

6. Designing underground systems
   a) Radial and looped primary cable layout
   b) Proper electrical loading of a looped single and three-phase system
   c) Correct fusing of underground cable systems
   d) The use of fault indicators and their application

CONSTRUCTION CONTRACTS: Accurate accounting of the materials, and close monitoring of the contractor's progress are essential to completing a project on time and on budget. In this domain, the student will learn how the construction contract affects every aspect of the project, how to prepare special conditions and units, and how to administer the contract terms and conditions for a successful outcome.

1. RUS construction contracts
   a) The anatomy of labor and materials contracts (RUS 830)
   b) The anatomy of labor only contracts (RUS 792)
   c) Holding pre-bid and pre-construction meetings

2. Plans and Specifications
   a) Specifying and using standard construction units
   b) Developing and identifying special construction units
   c) Preparing and adhering to special conditions and instructions
   d) Understanding and adhering to the specifications in the contract

3. Staking for a construction contract
   a) Need for accurate staking sheets and reliance on the units by the contractor
   b) Preparing well-defined drawings, notes, and marking the line route

4. Materials control
   a) The methodology of preparing material issue and return tickets
   b) Verifying and accounting for returned and salvaged materials

5. Contractor observation
   a) Submission of prices for construction units not included in the original contract
   b) Reviewing, accounting, and approving the contractor's invoices
   c) Establishing and tracking project milestones
   d) Making periodic inspections of the contract work
   e) Documenting changes, agreements, outages, and accidents

6. Contract closeout
   a) Performing the final inspection of the completed lines and facilities
   b) Preparing change orders including units, changes, and reasons
   c) Preparing the final inventory of the as-built remove and install construction units

continued

SIZING TRANSFORMERS AND CONDUCTORS: This domain will focus on basic electric theory and the methodology to correctly size transformers and service conductors for standard residential and small commercial loads. The student will learn how to perform basic calculations for current, voltage, power, and voltage drop.

1. Basic electric theory
   a) Voltage, current, and resistance
   b) Power and voltage drop equations

2. Transformers
   a) Theory of transformer operation
   b) Understanding ANSI C57.12 requirements
   c) Transformer connections and wiring
   d) Transformer construction and loading standards

3. Transformer sizing
   a) Sizing transformers based on panel size and/or load diversity
   b) Single phase and three-phase applications using lookup tables
   c) Using pad-mounted transformers for large industrial loads

4. Service voltage drop
   a) Voltage drop and flicker theory and calculations
   b) Sizing conductors based on amps and length

5. Computer programs
   a) Spreadsheet analysis
   b) Vendor programs

BASIC SECTIONALIZING AND LINE EQUIPMENT: This course will give the student a basic understanding of fault currents, sectionalizing devices, voltage regulators and capacitors. The focus of this section will be to teach the staking technician how to apply and locate these devices on the distribution system when the line is being staked.

1. Principles of over-current protection
   a) Isolation of faulted components
   b) Outage time benchmarking

2. Fault current calculations
   a) Basic equations and symmetrical components
   b) Maximum available fault currents (primary and secondary)

3. Over-current protection
   a) Breakers, reclosers, fuses, and sectionalizers
   b) Interrupting mediums (vacuum, gas, or oil)

continued

4. Transformer protection
   a) Peak loads and inrush currents
   b) Current limiting fuses

5. Line coordination
   a) Transformer/fuse, breaker/recloser, recloser/recloser, and recloser/fuse
   b) Duty cycles and minimum fault recognition

6. Regulators
   a) Basic theory of operation
   b) Placement in circuit

7. Capacitors
   a) Basic theory of operation
   b) Placement in circuit

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