

**NERC Reliability Standards (33 CEH)**  
(Ideal for NERC Certification Test Preparation)

IIA #1 - Introduction to NERC Reliability Standards (2 CEH)  
State & describe function of NERC & describe roles within NERC's Functional Model.  
Describe process by which Reliability Standards developed & review content areas of typical Standard.  
Describe NERC System Operator Certification program.

IIA #2 – "BAL" Series of Reliability Standards (6.5 CEH)  
Describe & evaluate impact on system operations of current versions of BAL Standards.

IIA #3 – "CIP", "COM" & "EOP" Series of Reliability Standards (6 CEH)  
Briefly describe content of current versions of CIP Standards.  
Describe & evaluate impact on system operations of current versions of COM Standards.  
Describe & evaluate impact on system operations of current versions of EOP Standards.

IIA #4 – "FAC", "MOD" & "NUC" Series of Reliability Standards (3 CEH)  
Describe & evaluate impact on system operations of current versions of FAC Standards.  
Briefly describe content of current versions of MOD Standards.  
Briefly describe content of current versions of NUC Standards.

IIA #5 – "INT" Series of Reliability Standards (3.5 CEH)  
Describe & evaluate impact on system operations of current versions of INT Standards.

IIA #6 – "IRO", "PER", "TPL" & "PRC" Series of Reliability Standards (6.5 CEH)  
Describe & evaluate impact on system operations of current versions of IRO Standards.  
Describe & evaluate impact on system operations of current versions of PER Standards.  
Briefly describe content of current versions of TPL Standards.  
Describe & evaluate impact on system operations of current versions of PRC Standards.

IIA #7 – "TOP" & "VAR" Series of Reliability Standards (5.5 CEH)  
Describe & evaluate impact on system operations of current versions of TOP Standards.  
Describe & evaluate impact on system operations of current versions of VAR Standards.

Operations-Training-Solutions  
2983 Bellmeade Way  
Longmont, CO 80503

**Recipient**



Focus of O-T-S is Development & Delivery of  
Training Programs for Power System Operations  
Personnel

**Mike Terbrueggen**  
**CEO/Instructor**

Mike formed Operations-Training-Solutions in 1994 & is CEO & Principal Engineer. O-T-S designs, develops & delivers training seminars, develops training materials & provides consulting services for power operations.

Mike combines 10 years of power industry engineering experience with 25 years of power operations training & consulting experience. He applies his power background & training capabilities to offer real world solutions to companies' training & operating needs.

For your training needs & operations support contact Mike or Terri at:

Operations-Training Solutions  
2983 Bellmeade Way  
Longmont, CO 80503  
[mike@o-t-s.com](mailto:mike@o-t-s.com)  
[terri@o-t-s.com](mailto:terri@o-t-s.com)  
[www.o-t-s.com](http://www.o-t-s.com)



Operations-Training Solutions (O-T-S, 001) Recognized By  
North American Electric Reliability Council as Continuing  
Education Provider Who Adheres to NERC Continuing  
Education Program Criteria.

## Dynamics of Disturbances (33 CEH)

IIA #1 – Frequency Related Events (8 CEH)  
Using actual disturbance events describe & illustrate how frequency control accomplished. Events examined include 2/14/2008 in WECC @ Huntington, 5/10/2011 in Michigan's U.P. & 4/7/2015 in Washington, DC.

IIA #2 – Voltage Related Events (11 CEH)  
Using actual disturbance events describe & illustrate how voltage control accomplished. Events examined include 7/2/1996 in WECC, 8/14/2003 in Eastern & 3/13/1989 in Quebec.

IIA #3 – Angle Stability Related Events (6 CEH)  
Using actual disturbance events describe & illustrate concepts of angle stability & angle instability. Event examined 6/25/1998 in Twin Cities of Minnesota.

IIA #4 – Operator Error Related Events (8 CEH)  
Examine how field & system operator errors have resulted in or increased severity of power system disturbances. Events examined include 2/26/2008 in Florida, 9/8/2011 in Pacific Southwest & 7/14/2004 in Arizona.

## Power System Dynamics (33 CEH)

IIA #1 – Introduction to Dynamics (4 CEH)  
Describe & illustrate fundamental AC principles & concepts including concepts of generator operation, principles of generator control systems & describe purpose & function of NERC.

IIA #2 – MW & MVar Flow (4 CEH)  
Describe & illustrate concept & usage of voltage phase angle & develop equations for MW & MVar flow, describe construction & operation of phase shifting transformer & describe & illustrate concepts of power flow using graphical tools.

IIA #3 – Frequency Control (10 CEH)  
Describe fundamental theory of frequency control, describe importance of load-frequency relationship & inertia, describe & illustrate usage & operation of governor control systems, describe & illustrate usage & operation of AGC systems, describe need for operating reserves, describe & illustrate NERC control performance standards, describe purpose & operation of UFLS & illustrate impact of generator trip using time-based 4 stage approach.

IIA #4 – Voltage Control (6 CEH)  
Describe & illustrate concept of reactive power, describe & illustrate causes & effects of power system high & low voltage & describe & illustrate how voltage control equipment used to control voltage.

IIA #5 – Voltage Stability (4 CEH)  
Define key terms used in study of voltage stability, describe 3 types of voltage collapse, describe concepts & illustrate usage of P-V & V-Q curves & use fictional & actual events to illustrate voltage instability & collapse process.

IIA #6 – Angle Stability (5 CEH)  
Define key terms used in study of angle stability, describe 3 types of angle stability, describe & illustrate processes of angle stability & angle instability, describe & illustrate usage of equipment to prevent angle instability, describe different modes of power system oscillations, describe theory & usage of PSS & describe purpose & usage of North American Synchrophasor Initiative (NASPI).

## Power System Protection (33 CEH)

IIA #1 – Introduction to Protection (4 CEH)  
State purpose of protective relaying, list & define key relaying terms, describe types of relays, describe quantities & events monitored by relays, list & illustrate usage of IEEE device numbers, state goals of protective relaying & explain concept of zones of protection.

IIA #2 – Protection Related Mathematics (4 CEH)  
Describe purpose & illustrate usage of per-unit system, vectors & phasors, transformer polarity, symmetrical components & polarizing quantity.

IIA #3 – Protection Equipment (4 CEH)  
Describe purpose & illustrate usage of instrument transformers, differential relays, over-current & distance relays, types of backup protection, electromechanical relay designs versus microprocessor relay designs & power system grounding.

IIA #4 – Transmission Line Protection (5 CEH)  
Describe differences in protecting radial vs. looped transmission lines, describe & illustrate how distance relays applied for transmission line protection, describe & illustrate transmission line backup protection & describe & illustrate operation of common types of pilot protection.

IIA #5 – Generator Protection (4 CEH)  
Describe different types of generators including different methods of connecting generation to system & describe & illustrate protection typically applied to generators.

IIA #6 – Transformer Protection (4 CEH)  
Describe & describe issues associated with power transformer protection, describe how protective relays used to provide protection for transformers & describe how protective relays used to provide protection for shunt capacitors & reactors.

IIA #7 – Additional Protection Topics (4 CEH)  
Describe & illustrate out-of-step protection, state advantages & disadvantages of automatic reclosing, describe usage of UFLS & UFLS & describe purpose & application of RAS.

IIA #8 – Bus Protection & NERC Standards (4 CEH)  
Describe & illustrate application, design & operations of low & high impedance bus differentials, describe purpose & illustrate design of commonly applied substation bus configurations & describe & illustrate content of NERC PRC series of Standards.

## Power System Fundamentals (33 CEH)

IIA #1 – Mathematics Review (2.5 CEH)  
Describe & illustrate math concepts including use & application of fractions, use & application of exponents, use of square roots, use & application of sine & cosine functions & introduction to per-unit system.

IIA #2 – DC Theory Concepts (3.5 CEH)  
Describe & illustrate DC theory concepts including difference between conductor & insulator, concept of voltage, concept of electro-magnetic induction, creation of an AC voltage & conversion to DC, concept of current, operation of DC electrical circuit & usage of HVDC transmission.

IIA #3 – AC Theory Concepts (4 CEH)  
Describe & illustrate AC theory concepts including development of AC voltage using electro-magnetic induction, details of AC sine wave, concepts of inductance & inductive reactance, concepts of capacitance & capacitive reactance, usage of impedance & power triangles, reactive power concept, concept of power factor & advantages of 3-phase systems.

IIA #4 – Power System Components (8 CEH)  
Using diagram of key components of power system step through & describe typical power system arrangement. Include description of how load varies, describe & illustrate NERC's 4 Interconnections, describe roles of organizations (FERC, NERC, Regions) which administer power system & describe & illustrate components & purpose of generation & transmission systems.

IIA #5 – NERC's Functional Model (4 CEH)  
List, describe & illustrate job function of each of 18 entities listed in NERC's Functional Model.

IIA #6 – Power System Operations (7 CEH)  
Describe & illustrate how generation, transmission & emergency operations accomplished.

IIA #7 – Introduction to NERC Reliability Standards (5 CEH)  
List & briefly describe content of current NERC Reliability Standards.