Northwest Electric Meter School

Track D

Advanced Metering + Communications

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Northwest Electric Meter School

Track D

Section 1

Advanced Metering + Communications

Agenda

Track D Lead: Will Kahns, Puget Sound Energy

Monday, August 19

1:00 - 1:30	Keynote Presentation	Tracy Hoefft, PacifiCorp	Cafeteria
1:45 - 3:00	AC Efficiency	Will Elliott, Aclara	LB1131
3:15 - 4:30	Net Metering - Distributed Generation + Bi-Directional Metering	Leslie Moynihan, Puget Sound Energy	LB1131

Tuesday, August 20

8:00 - 9:15	Advanced Metering Infrastructure Overview + Systems	Mike Crumbaker, General Pacific	LB1131
9:30 -11:00	Meter Data Communications Techniques + Data Collection	Michael Vasquez, Sacramento Municipal Utility District	LB1131
11:00 - 11:45	Vendor Display		Gymnasium
11:45 - 12:45	Lunch		Cafeteria
12:45 - 2:15	Advanced Metering Data Management	Lewis McKillop, Idaho Power Company	LB1131
2:30 - 3:15	Totalization	Will Elliott, Aclara	LB1131
3:30 - 4:30	Circuit Imbalances	Malcolm Halliday, Radian Research	LB1131
4:45 - 6:00	Cookout		Patio/Cafeteria

Wednesday, August 21

8:00 - 9:00	Power Quality Essentials	Pat McCarthy, Schweitzer Electronic Lab	HS2634A
9:15 - 10:15	Power Quality Demonstration/Lab	Pat McCarthy, Schweitzer Electronic Lab	HS2634A
10:30 - 11:45	Advanced Metering- TLC, PT/CT Correction	Arlen Everist, Seattle City Light	LB1131
11:45 - 12:45	Lunch		Cafeteria
12:45 - 1:45	Basic Principles of Software Deployment Efficiency	Malcolm Halliday, Radian Research	LB1131
1:45 - 2:45	Roundtable: Introduction to AMI	Lewis McKillop, Idaho Power Company	LB1131
3:00 - 3:30	Analog Outputs (0-1 mA, 4-20 mA)	Eli Rooney, Sensus	LB1131
3:45 - 4:30	Advanced Metering SCADA Applications	Eli Rooney, Sensus	LB1131

Thursday, August 22

8:00 - 9:45	Communications Demonstration	Octavio Reza, Honeywell - Elster Solutions	LB1131
10:00 - 12:00	Harmonics Demonstration	Terry Gaiser, Sensus	ED1840A
12:00 - 1:00	Lunch		Cafeteria
1:00 - 2:00	Grounding + Bonding of Meters	Chuck Matsen, Seattle City Light	LB1131
2:15 - 3:15	Accuracy + Traceability of Reference Standards	Malcolm Halliday, Radian Research	LB1131
3:30 - 4:30	Safety Presentation	Robert Houser, Snohomish County PUD	Theater/LB1141

Friday, August 23

8:00 - 10:15	Track D Roundtable Discussion	Will Kahns, Puget Sound Energy	LB1131
10:30 - 11:00	Track D Evaluations	Will Kahns, Puget Sound Energy	LB1131

Northwest Electric Meter School

Track D

Section 2

Advanced Metering + Communications

Agenda

Track D Lead: Will Kahns, Puget Sound Energy

Monday, August 19

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1:45 - 3:00	AC Efficiency	Will Elliott, Aclara	LB1131
3:15 - 4:30	Net Metering - Distributed Generation + Bi-Directional Metering	Leslie Moynihan, Puget Sound Energy	LB1131

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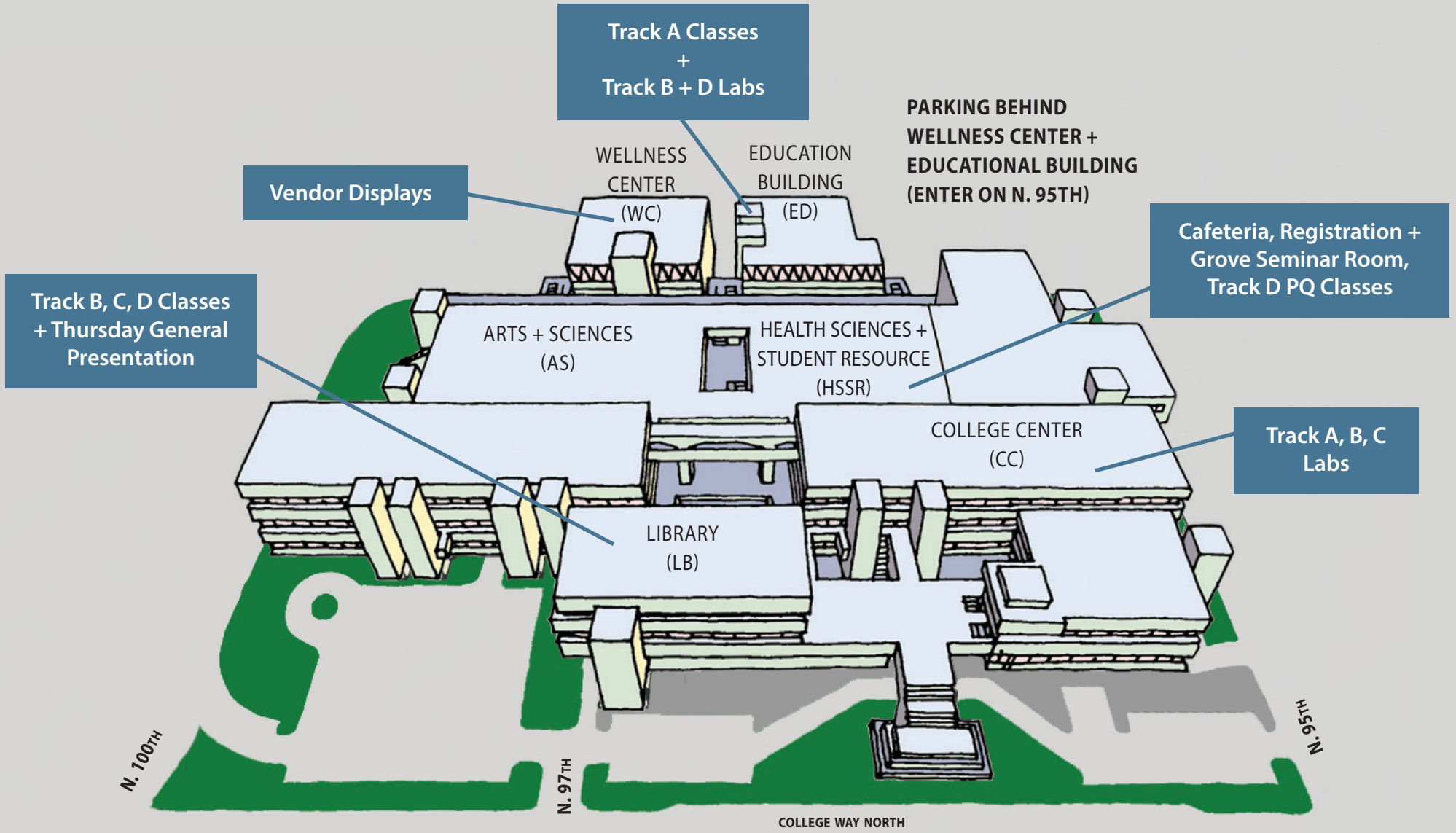
Northwest Electric Meter School

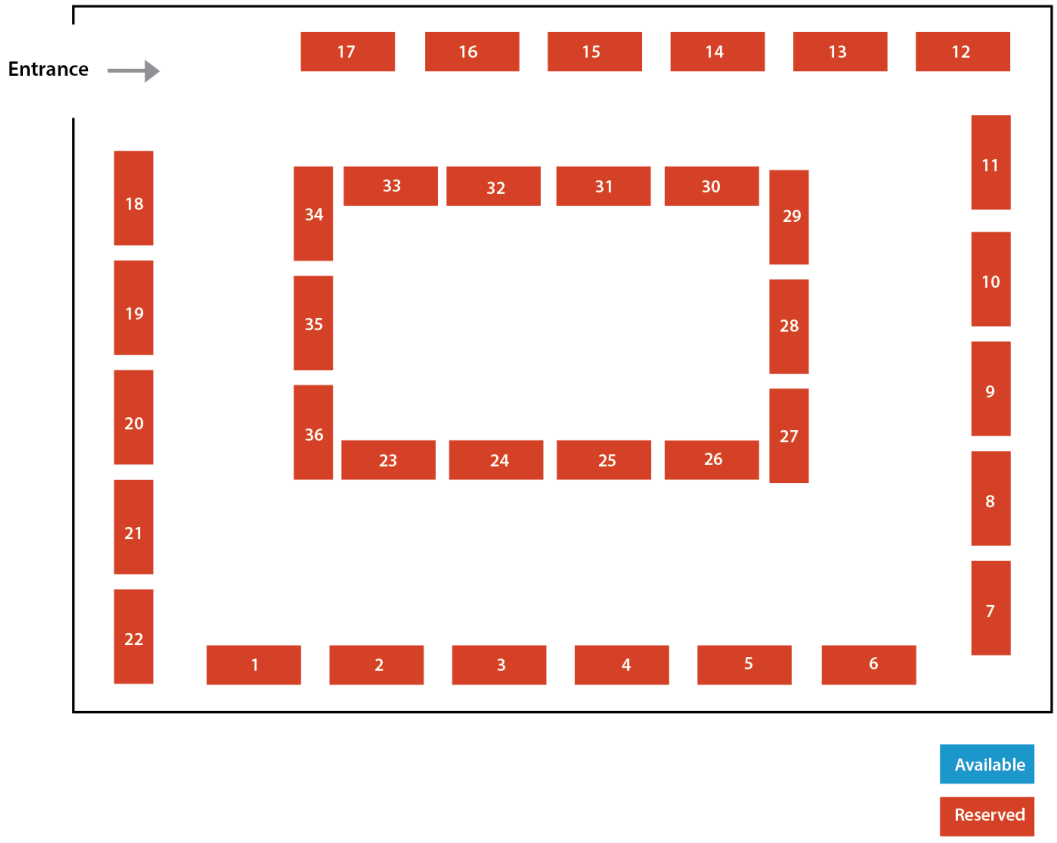
Campus Map



Vendor Displays
Building: PE Wellness Center

Vendor Listing

1. TESCO - The Eastern Specialty Company	10. Powermetrix	19. Honeywell	28. Schneider Electric
2. General Pacific, Inc.	11. National Metering/ NW Technical Training	20. Schweitzer Engineering Laboratories	29. Ritz Instrument Transformers
3. Nighthawk Total Control	12. Arteche USA	21. Peak Measure	30. McLaren Inc.
4. Cascadia Representatives	13. Aclara	22. SensorLink	31. Transdata, Inc.
5. Utilismart Corporation	14. The Durham Company	23. Electro Industries/GaugeTech	32. Itron, Inc.
6. Probewell Lab inc.	15. Landis+Gyr	24. Megger	33. OMICRON
7. DeWalch Technologies, Inc.	16. Inner-Tite Corp.	25. Eaton Corp.	34. Advanced Test Equipment Rentals
8. Sensus Metering Systems	17. Radian Research, Inc.	26. Primestone Technologies, Inc	35. AMETEK Power Instruments
9. Brooks Utility Products Group	18. Marwell Corp.	27. GE Grid Solutions	36. DragonWear



WEI ENERGY MEMBERS

WesternEnergy INSTITUTE

A

Alaska Electric Light & Power Company
Alaska Power & Telephone
AltaGas Canada Inc.
Anaheim Public Utilities
Arizona Public Service Company
ATCO Electric
ATCO Gas
ATCO Pipelines
Avista Corp.
Avista Utilities
Azusa Light & Water

B

BC Hydro
Bonneville Power Administration
Burbank Water and Power

C

Cascade Natural Gas Corp.
Central Lincoln PUD
Cerritos Electric Utility
Chelan County PUD
Chugach Electric Association
City of Banning Electric Utility
Clark Public Utilities
Colton Public Utilities
Consumers Power, Inc.

D

Dominion Energy
Dominion Energy Idaho
Dominion Energy Questar Pipeline, LLC
Dominion Energy Utah
Dominion Energy Wexpro
Dominion Energy Wyoming
Duquesne Light Company

E

El Paso Electric Company
Enbridge
ENMAX Corp.
ENSTAR Natural Gas Company
EPCOR Distribution and Transmission, Inc.
Eugene Water & Electric Board

F

FortisAlberta
FortisBC

G

Gill Ranch Storage, LLC
Grant County PUD
Great Plains Natural Gas Company

H

HAWAI'I GAS
Heritage Gas
Hydro One Inc.

I

Idaho Power Company
Imperial Irrigation District
Intermountain Gas Company

L

Liberty Utilities
Los Angeles Dept.artment of Water & Power

M

MDU Resources Group
Montana-Dakota Utilities

N

New Mexico Gas Company
Northern Wasco County PUD
NorthWestern Energy
NV Energy
NW Natural

P

Pacific Gas and Electric Company
Pacific Northern Gas Ltd.
Pasadena Water & Power
Pinnacle West Capital Corp.
Portland General Electric
Powerex Corp.
Puget Sound Energy

R

Riverside Public Utilities
Roseville Electric

S

Sacramento Municipal Utility District
Salt River Project
San Diego Gas & Electric Company
Seattle City Light
Snohomish County PUD
Southern California Edison
Southern California Gas Company
Southern California Public Power Authority
Southwest Gas Corp.

T

Tacoma Power
Tacoma Public Utilities
TC Energy
Tillamook PUD
Tucson Electric Power

U

UNS Electric
UNS Energy Corp.
UNS Gas

V

Vernon Public Utilities

W

Williams Northwest Pipeline

WEI SERVICE COMPANIES | PLATINUM MEMBERS

accenture
High performance. Delivered.

CHARGE

H&M HENKELS & McCOY

METSCO MAKING IT POSSIBLE

ROKSTAD

Altec

copperleaf

Honeywell

NAVIGANT CONSULTING

SAP

Booz | Allen | Hamilton

Itron
Knowledge to Shape Your Future

ORACLE Utilities

Sheffield Scientific
Independent, not Indifferent

CUPERTINO ELECTRIC INC.

BRIDGE ENERGY GROUP

KPMG

SIEMENS

Exponent
Engineering & Scientific Consulting

PAR ELECTRICAL CONTRACTORS, INC.
A Quanta Services Company

BURNS McDONNELL

FERREIRA POWER WEST LLC

KS ENERGY SERVICES
POWERED TO DELIVER

TATA CONSULTANCY SERVICES

CENTURI
CONSTRUCTION GROUP

HDR

Landis+Gyr

POTELCO INC
A Quanta Services Company

uplight

GOLD MEMBERS

ActiveTeleSource

E Source

JACOBS

PA

TDW
T.D. Williamson

arcos

ENERGYCARE

MICHELS

POWER ENGINEERS

ASPLUNDH
CONSTRUCTION CORP.

THE HDD COMPANY

Milwaukee

ProcureAbility
ADVISORY + TALENT YOUR WAY

vertexone

BARNARD
People building for People.

HUBBELL
Gas Connectors & Accessories

MOSAIC
Elevating Workforce Performance

SEL SCHWEITZER ENGINEERING LABORATORIES

westMONROE

BLACK & VEATCH

IBM

Nexant

SENSUS
a xylem brand

WILSON

CABLE

INTREN
OutPerforming. Everyday.

NEXTGEN TECHNOLOGIES LTD.

Snelson Companies, Inc.

wood.

Glossary of Meter Installation Terms

ANSI – American National Standards Institute. An independent administrator and coordinator of voluntary industry standards.

bypass – A device which shunts current around the socket, so the meter can be removed without interrupting service.

clearance – There are two, quite different meanings for "clearance." One meaning is: A specified minimum distance between two objects to assure adequate space for safety, security, or access. The other meaning is: An agreement between a foreman and the system operator, for permission. When describing new electric services, "clearance" has the first meaning – the distance between two objects.

common ground point – The point where the grounding electrode connects to the equipment-grounding conductor and/or the circuit-grounding conductor.

conduit – A pipe with a smooth interior surface for easy drawing-in of electrical conductors. Conduit may be metallic or nonmetallic.

corrosion inhibiter – An electrical joint compound used to retard oxidation at electrical connections.

current transformer – A transformer whose secondary current is a precise fraction of its primary current. Using current transformers, high-current circuits can be measured with conventional meters. Abbreviation: CT.

demand – The average rate at which energy (kilowatt hours) is consumed during a specified interval of time.

direct-burial cable – Cable which may be installed in the ground without the protection of a conduit.

direct-connect meter – A meter which carries full load current and connects across full line voltage. Also called a self-contained meter.

drip loop – A downward loop in the customer's conductors, near where the customer's conductors attach to the power company's overhead conductors, to prevent water from entering the service mast at the weatherhead.

fault – A partial or total failure of insulation which causes a short circuit between conductors, or between a conductor and ground, causing an abnormal current to flow. Also, a failure (break) in a conductor which causes an open circuit.

fault current – A current which flows between conductors, or between a conductor and ground, due to an abnormal connection between the two. A fault current flowing to ground may be called a ground fault current.

guy – A cable or brace that supports a mast or pole.

high leg – In a four-wire delta service, the phase with a voltage higher than the other two phases. Also called wild leg, delta leg.

instrument transformer – A transformer which delivers as its output, a precise fraction of the input line current or line voltage. Instrument transformers allow standard meters to measure high currents and voltages.

instrument-rated meter – A meter used in conjunction with instrument transformers, to measure high-voltage or high-current services. Also called a transformer-rated meter.

line conductor – A service conductor installed by the electric utility, to the meter.

load conductor – A service conductor to the customer's load, after the meter.

manual link bypass – Provision for manually installing conductive links between the line and load terminals in the meter socket. These links maintain electrical service to the customer when the meter is removed. Also called manual circuit-closing block.

meter jaw – A spring-loaded receptacle inside a meter socket which captures the terminals (blades) of a meter, and connects the meter terminals to the service conductors.

meter pedestal – A factory-built assembly containing a meter socket and disconnect switches.

meter ring – A metal ring which secures the meter to the meter socket, which can be sealed by the electric utility to prevent tampering with the meter.

meter socket – The mounting device consisting of meter jaws, connectors, and enclosure for receiving a socket-type meter.

NEC – National Electrical Code. National regulations for the installation of electrical equipment inside buildings. Published by the National Fire Protection Association. NEC rules apply to equipment on the customer's side of the point of delivery.

NEMA – National Electrical Manufacturers Association. A trade association which publishes standards for manufacturers of electrical equipment, including enclosures and racks.

NESC – National Electrical Safety Code. National regulations for the installation, operation, and maintenance of electric supply and communication lines. Published by Institute of Electrical and Electronics Engineers. NESC rules apply to equipment on the electric utility's side of the point of delivery.

neutral – The grounded conductor in a single-phase three-wire, or three-phase four-wire system.

point of attachment – The point at which the utility's service conductors are mechanically attached to the customer's premises. For overhead services, the point of attachment is usually an insulated clevis.

point of delivery – The point where the utility's service line makes the electrical connection to the customer's wires. For overhead services, the point of delivery is the splice between the utility's and the customer's conductors. For underground services, the point of delivery is the secondary lugs of the distribution transformer, or the service stubout, or the secondary hand hole – if the utility's existing service is on the customer's property. If the utility's existing service is not on the customer's property, the point of delivery is the customer's property line. The utility determines the point of delivery based, in part, on convenient access to existing service.

power factor – Technically, the cosine of the phase angle between the circuit voltage and current waveforms. Since phase angles are difficult to measure, power factor is usually derived by measuring power or impedance. Power factor is the ratio of active power to apparent power (watts divided by volt-amperes). Power factor has no units, but is commonly expressed as a percentage. For example, if active power is 96 kW and apparent power is 100 kW, the power factor is 96%.

primary voltage – The voltage at which electricity is delivered from substations to distribution transformers. Primary voltage is greater than 600 volts.

raceway – An enclosed channel for holding wires or cables. If designated for line conductors, the raceway must be sealable. The intermixing of line and load conductors in the same raceway is not permitted.

seal – A locking device to secure a meter or other service equipment.

secondary voltage – The voltage at which electricity is delivered from distribution transformers to customers. Secondary voltage is less than 600 volts.

select backfill – Soil or sand free from sharp objects, rocks, scrap building material, and corrosive material.

self-contained meter – A meter which carries full load current and connects directly across full line voltage. Also called a direct-connect meter.

service drop – For overhead service, the power company's service line between the distribution transformer and the point of delivery.

service line – Conductors from the distribution transformer to the customer's point of delivery. See service drop, service lateral.

service entrance equipment – The service equipment which is supplied by the customer: conduit, conductors, mast, weatherhead, meter base, enclosures, disconnects, and panels.

service lateral – For underground service, the service line between the distribution transformer and the point of delivery.

service mast – For overhead service, the conduit rising above the meter to provide mechanical protection to the customer's conductors and to support the service drop from the power company.

socket – The mounting device for socket meters. Includes spring-loaded meter jaws, connectors for line and load conductors, and an enclosure.

temporary service – Electric service during the construction phase of a project.

test switch – A device used to isolate connections to a meter.

transformer-rated meter – A meter used in conjunction with instrument transformers, to measure high-voltage or high-current services. Also called an instrument-rated meter.

UL – Underwriters Laboratories. An independent product-testing and certification organization.

voltage transformer – A transformer whose secondary voltage is a precise fraction of its primary voltage. Using voltage transformers, high-voltage circuits can be measured with conventional meters. Abbreviation: VT, or PT (potential transformer).

Metering Formulas

$$\frac{E_p}{E_s} = \frac{N_p}{N_s}$$ E_p and E_s are primary and secondary voltages, N_p and N_s are number of primary and secondary winding turns in a transformer

$$\frac{I_p}{I_s} = \frac{N_s}{N_p}$$ I_p and I_s are primary and secondary currents, N_p and N_s are number of primary and secondary winding turns in a transformer

$$I = \frac{E}{R}$$ I = current in amperes, E = potential in volts, R = resistance in ohms

$$K = \frac{K_h \times TR \times SF}{p \times K_r}$$ K = program watthour constant, SF = scaling factor (used in program), p = number of pulses per nameplate K_h (usually 12 or 24)

$$K_h = \frac{10{,}000 \times K_r}{R_r \times R_s}$$ = watthour constant

$$K_r = \frac{K_h \times R_r \times R_s \times TF}{10{,}000}$$ = register constant

$PK_h = K_h \times TR = K_h \times CTR \times VTR$ = primary watthour constant

$$\frac{R}{r} = \frac{k_h}{K_h}$$ R and K_h are revolutions and watthour constant of a standard, r and k_h are revolutions and watthour constant of a meter under test

$$R_r = \frac{10{,}000 \times K_r}{TF \times K_h \times R_s}$$ = register ratio

$R_g = R_r \times R_s$ = gear ratio

TR = TF = (CTR x VTR) "transformer ratio, also known as transformer factor"

$$\text{VA} = E \times I$$

$$\text{Vars} = E \times I \times \sin\theta$$

$$\text{VA} = W + j \times \text{Vars}$$ (for lagging power factor)

$$\text{VA} = W - j \times \text{Vars}$$ (for leading power factor)

$$W = \frac{3600 \times r \times PK_h}{t}$$ W = watts, r = number of revolutions, t = time in seconds, 3600 = watt seconds. (also known as "timed load check" formula)

$$W = E \times I$$ (single phase, unity power factor)

$$W = E \times I \times \cos\theta$$ (single phase, any power factor)

$$W = E \times I \times \cos\theta \times \sqrt{3}$$ (three phase, balanced circuit, E measured phase to phase)

$$W = E \times I \times 3 \times \cos\theta$$ (three phase, balanced circuit, E measured phase to neutral)

$$W = I^2 \times R$$ commonly used for losses

$$W_p = W_s$$ transformer wattage in equals wattage out (except for losses)

pico = 0.000,000,000,001 (one trillionth) 1×10^{-12}

nano = 0.000,000,001 (one billionth) 1×10^{-9}

micro = 0.000,001 (one millionth) 1×10^{-6}

milli = 0.001 (one thousandth) 1×10^{-3}

none = 1 (one) 1×10^{0}

kilo = 1,000 (one thousand) 1×10^{3}

Metering Formulas

mega = 1,000,000 (one million) 1×10^6

giga = 1,000,000,000 (one billion) 1×10^9

tera = 1,000,000,000,000 (one trillion) 1×10^{12}

BIL is the abbreviation for Basic Lightning Impulse Insulation Level

Blondel's Theorem states that in a system of "N" conductors, "N-1" meter elements properly connected will measure the power or energy taken

CTR = current transformer ratio

K_e is the pulse constant for the KYZ outputs of a solid state meter, programmable in unit-hours per pulse.

K_m is the value, in unit quantities, of one increment (pulse period) of stored serial data

One horse-power = 746 watts

One watthour = 3.413 BTUs (British Thermal Units)

One circular mil = $\frac{\pi}{4}$ square mil

R_s = gear reduction between worm or spur on disk shaft and meshing gear wheel of register

VTR = voltage transformer ratio

$$\text{Percent meter registration} = \frac{k_h \times r \times A}{K_h \times R}$$

A = percent registration of standard, K_h and R are from standard, k_h and r are from Meter

$$\text{Power factor} = \cos \text{ of phase angle } \theta = \frac{\text{watts}}{\text{volt} - \text{amperes}}$$

$$\text{Tan } \theta = \frac{\text{vars}}{\text{watts}} = \frac{\text{varhours}}{\text{watthours}}$$