TESCO METERING

EVSE Accuracy & Compliance in 2025 and Beyond

Tom Lawton – TESCO Metering
April 8, 2025 – 10:45 – 11:30 AM MT

Agenda

- Current Regulatory Landscape
- EVSE Testing & Test Equipment
- Implementation Gap
- Collaboration & Industry Innovation

Evolving Regulatory Landscape

Evolving Regulatory Landscape

US EVSE Testing Guidance

- HB 44 Section 3.40: EVSE accuracy testing
- NIST HB 130 EPO 30: National examination procedures
- CA EPO 52: State-level retail EVSE compliance

Challenges:

- Understanding evolving regulations
- Aligning state and federal standards

Evolving Regulatory Landscape

NIST Handbook 44 – Specifications, Tolerances and Other Technical Requirements for Weighing and Measuring Devices

- HB 44 Section 3.40: EVSE accuracy testing
- Provides outline for the tolerances, specs

NIST Handbook 130 – Uniform Laws and Regulations in the areas of legal metrology and engine fuel quality

- HB 130 – Examination Procedure Outline (EPO) 30
    - Retail Electric Vehicle Fueling Systems

NIST HANDBOOK 44: AC Testing Specifications

S.8. Minimum Measured Quantity (MMQ). The minimum measured quantity shall satisfy the conditions of use of the measuring system as follows:

(a) Measuring systems shall have a minimum measured quantity not exceeding:

(1) 0.5 kWh for AC EVSE

Note: To minimize the duration of required testing, manufacturers may want to consider limiting the declared MMQ to the level of 0.1 kWh for AC EVSE.
(Note Added 2023)
(Amended 2023)

N.3.1. Testing of an AC EVSE. Accuracy tests shall be performed at the following current levels:

(a) A point between 4 A and 10 A;
(b) A point between 40 % and 60 % of the [Maximum Deliverable Amperes] MDA; and
(c) A point between 70 % and 100 % of the MDA.

NIST HANDBOOK 44: DC Testing Specifications

S.8. **Minimum Measured Quantity (MMQ).** The minimum measured quantity shall satisfy the conditions of use of the measuring system as follows:

(a) Measuring systems shall have a minimum measured quantity not exceeding:

(2) 1.0 kWh for DC EVSE.

N.3.3. **Performance Verification in the Field of a DC EVSE**. Accuracy tests shall be performed at any voltage and the following current levels:

(a) A point between 10 % and 20 % of the MDA, but not less than 30 A; and

(b) A point between 25 % and 100 % of the MDA, with the recommendation to test at the maximum power level within that range that is possible using the test load and test standard available.

Note: The test points (a) and (b) above must not be at the same current level. It is recommended that the current levels should be separated to the extent that the test load and test standard will allow.

For DC systems it is anticipated that an electric vehicle may be used as the test load. Under that circumstance, testing at the load presented by the vehicle shall be sufficient for field verification provided that it is greater than 40 % of the MDA and no less than 30 A.

All DC EVSE placed into service prior to January 1, 2025 are exempt from this requirement until January 1, 2028.

(Amended 2022 and 2024).

Section 3.40. Electric Vehicle Fueling Systems

Section 3.40. Electric Vehicle-Fueling Systems was added as a “tentative code” in 2015. In July 2022, the status of the code was changed from “tentative” to “permanent” effective January 1, 2023.
(Amended 2022)

A. Application

A.1. General. – This code applies to devices, accessories, and systems used for the measurement of electricity dispensed in vehicle fuel applications wherein a quantity determination or statement of measure is used wholly or partially as a basis for sale or upon which a charge for service is based.

A.2. Exceptions. – This code does not apply to:

- The use of any measure or measuring device **owned, maintained, and used** by a public utility or municipality only in connection with measuring electricity subject to the authority having jurisdiction such as the Public Utilities Commission.
- Electric Vehicle Supply Equipment (EVSEs) used solely for dispensing electrical energy in connection with operations in which the amount dispensed does not affect customer charges or compensation.
- The wholesale delivery of electricity.

Public Utility Exemption Example

- Solely Owned, Maintained, & Used by GMP

Source: Vermont Department of Agriculture

- Owned, maintained by GMP, Used & Available to the Public

NEMA Update: ANSI Committee to be formed to provide guidance on EVSE Testing by utilities

Public Utility Exemption Implication: NEHC

- "The National Electric Highway Coalition (NEHC) is a collaboration among electric companies that are committed to providing electric vehicle (EV) fast charging stations that will allow the public to drive EVs with confidence along major U.S. travel corridors. The NEHC is the largest such alliance of electric companies that have organized around the common goal of deploying EV fast charging infrastructure to support the growing number of EVs and to help ensure that the transition to EVs is seamless for drivers."

Members of the National Electric Highway Coalition

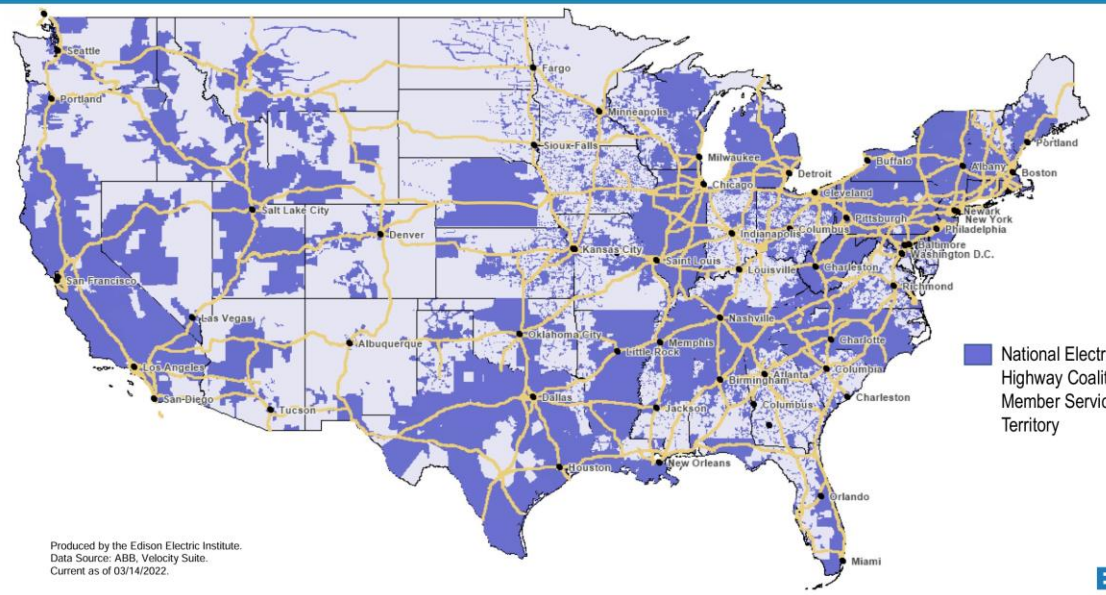
- AES Indiana
- AES Ohio
- Alliant Energy
- Ameren Illinois
- Ameren Missouri
- American Electric Power
- Arizona Public Service
- AVANGRID
- Avista Utilities
- CenterPoint Energy
- Central Hudson Gas & Electric
- Cleco
- Con Edison
- Consumers Energy
- Dominion Energy
- DTE Energy
- Duke Energy
- Duquesne Light Company
- Edison International
- El Paso Electric
- Entergy
- Evergy
- Eversource
- Exelon
- FirstEnergy
- Florida Power & Light Company
- Green Mountain Power
- Idaho Power
- ITC
- LG&E and KU Energy
- Liberty
- Madison Gas and Electric
- MidAmerican Energy
- Midwest Energy*
- National Grid
- Nebraska Public Power District*
- NIPSCO
- NorthWestern Energy
- NV Energy
- Oklahoma Gas & Electric
- Oncor
- Orange and Rockland Utilities
- Otter Tail Power Company
- Pacific Gas and Electric Company
- Pacific Power
- PNM Resources
- Portland General Electric
- PPL Electric Utilities
- PSE&G
- Puget Sound Energy
- Rocky Mountain Power
- San Diego Gas & Electric
- Southern Company
- Tennessee Valley Authority*
- Tucson Electric Power
- United Power*
- Unitil
- Upper Michigan Energy Resources
- We Energies
- Wisconsin Public Service
- Xcel Energy

*Non-Investor-Owned Electric Company Member
List current as of 03/14/2022.

EEI

National Electric Highway Coalition

Committed to a foundational EV fast charging network along major travel corridors



Source: EEI.org National Electric Highway Coalition

>36,000 chargers, December 2023 (theelectricgeneration.org)

Evolving Regulatory Landscape

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- **8.1.4. Light Load Test.**

(1) Connect the EVFS to the test set.

(2) Verify proper levels on the proximity pilot (PP) and CP lines.

(3) Based on the CP signal, determine the MDA from the EVFS.

(4) For AC EVFSs set the test set load to a value at a point between 4 A and 10 A.

For DC EVFSs set the test load to a point between 10 % and 20 % of the MDA, but not less than 30 A. All DC EVFSs placed into service prior to January 1, 2025 are exempt from the tests as specified in N.3.3. Performance Verification in the Field of a DC EVSE (3.40) until January 1, 2028. Requirements and provisions from the General Code and other device codes apply when equipment does not fall clearly in an established separate code.

(5) Start energy measurement on the test set.

(6) Start a charging transaction on the EVFS.

(7) Cycle the CP from state A to state B to state C.

(8) Continue the measurement for an accumulated energy of not less than the MMQ as declared by the manufacturer.

- **8.1.4. Light Load Test (cont.)**

(9) Cycle the CP from state C to state B to state A.

(10) Verify that the transaction on the EVFS has completed.

(11) Record the energy delivered as displayed on the EVFS.

(12) Record the price per kWh.

(13) Record the total price of the transaction.

(14) Record the energy delivered as displayed on the test set.

(15) *Verify Accuracy of Indications and Recorded Representations.* Verify the resulting energy indications and recorded representations are within applicable tolerances and meet requirements for agreement of indications.

Code Reference: 1.10: G-S.5.2.2., 3.40: S.2.4.4.

(16) Calculate the energy measurement error as follows:

(17) Based on the unit price(s) [fixed or variable] per kWh, calculate and record the itemized and total computed price for the transaction.

(18) Calculate the total sales price as follows:

$$\%\ \text{Energy Error} = \left(\frac{\text{Test Standard Indicated Energy} - \text{EVSE Indicated Energy}}{\text{Test Standard Indicated Energy}}\right) \times 100$$

$$(Quantity\ of\ Energy)(Energy\ Unit\ Price\ (\$kWh/)) = Sales\ Price \pm 12\ cent/$$

PRE-TEST DETERMINATIONS

1. **Applicability of Tolerances (Acceptance & Maintenance).**
   REF: § 4000. [1.10.] G-T.1., only (a) & (e), G-T.2.
2. **Application. REF: § 4000. [1.10] G-T.3.**
3. **Tolerance Values: REF: CCR § 4002.11 [3.40.] T.2., Table T.2.**

Table T.2. Accuracy Classes and Tolerances for EVSE

Accuracy Class	*Application or Commodity Being Measured*	*Acceptance Tolerance*	*Maintenance Tolerance*
2.0	**AC electricity as a vehicle fuel**	**1.0 %**	**2.0 %**
5.0[1]	**DC electricity as a vehicle fuel**	**2.5 %**	**5.0 %**
2.0[2]	**DC electricity as a vehicle fuel**	**1.0 %**	**2.0 %**

[1] The tolerance values for Accuracy Class 5.0 DC EVSE are applicable to devices installed prior to January 1, 2033.

[2] The tolerance values for Accuracy Class 2.0 DC EVSE are applicable to devices installed on or after January 1, 2033.

Figure 1 - Table 2. Accuracy Classes and Tolerances for EVSE.

5. **Light Load Accuracy Test.**
REF: § 4000. [3.40.] N.3., N.5., T.1, CCR § 4002.11 [3.40.] T.2.

(a) Connect the EVSE to the Field Test Standard.

(1) Based on the Control Pilot (CP) signal, determine the maximum current (e.g. 50 amps) available from the EVSE.

(2) Set the Field Test Standard load to a value not greater than 10 % of the available current.

(b) Start energy measurement on the Field Test Standard.

(c) Start a charging transaction on the EVSE.

(d) Continue the measurement for an accumulated energy of not less than the minimum measured quantity (MMQ) declared by the manufacturer.

NOTE: The regulatory official may conduct a screening test for accuracy at less than the manufacturer's MMQ (minimum time 5 minutes). If screening test fails, the official shall conduct the full accuracy test to determine compliance with applicable tolerances.

(e) Verify that the transaction on the EVSE has completed.

(f) Record the energy delivered as displayed on the EVSE.

(g) Record the price per kWh.

(h) Record the total price of the transaction.

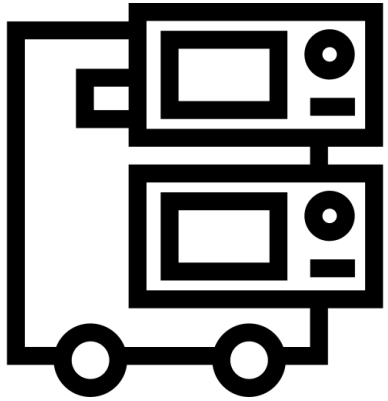
(i) Record the energy delivered as displayed on the Field Test Standard.

(j) Based on the unit price(s) [fixed or variable] per kWh, calculate and record the itemized and total computed price for the transaction.

(k) Determine the energy measurement as follows. The EVSE indication of energy, minus the Test Standard Indicated Energy divided by the Test Standard Energy, then multiply the result by 100 equals the percent Energy Error.

$$\% \text{ Energy Error} = \left(\frac{\text{EVSE Indicated Energy} - \text{Test Standard Indicated Energy}}{\text{Test Standard Indicated Energy}} \right) \text{X } 100$$

Figure 2 - Energy Measurement Calculation



Role of EVSE Test Equipment

The Role of EVSE Test Equipment

Why Compliance Matters:

- Prevents overbilling, ensures fair transactions
- Reduces post-installation compliance corrections

TESCO's NIST-Approved Equipment:

- T4350 & PL4150: AC/DC charger testing solutions
- Precision, ease of use, broad compatibility

TESCO's NIST-Approved Equipment

TESCO EVSE History

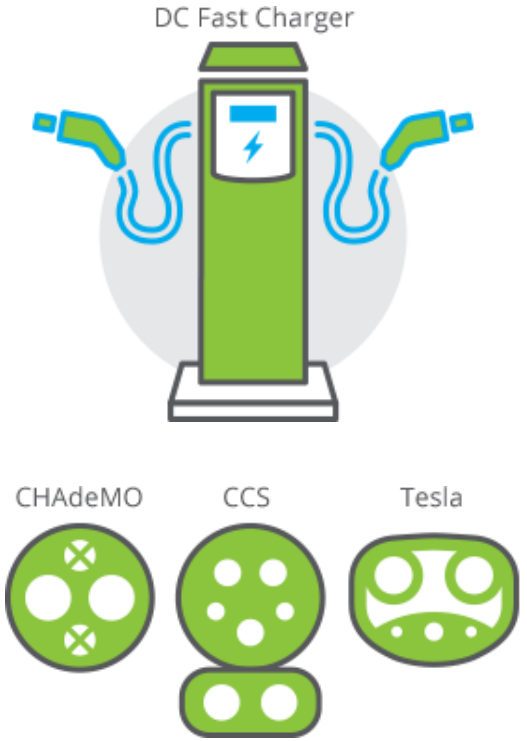
- TESCO: Metering since 1904; energy measurement is what we do and AC electrical metrology is a well practiced and researched field
- ~10 years ago we saw that Electric Vehicle (EV) chargers, since they would be selling energy, would need to be calibrated and tested similar to revenue grade utility meters
- 2015: TESCO's first patents for AC/DC calibration of Electric Vehicle Service Equipment (EVSE)
- This field is still nascent and developing! Compared to Utility Metering, this is new and has new rules…

TESCO EVSE History: AC vs DC

- Developed AC calibration capability first
  - Familiarity with AC measurement in shop and field test units for utility space was helpful here
- DC was not so easy….
  - First electric meter standards developed in 1910… a few years *after* DC meters were obsolete
  - There was never a recognized standard in NA for DC metering
  - TESCO worked to develop the methodology and process for DC metrology
  - Created equipment, took data, reviewed data, adjusted equipment, more data…
    - Fast-forward several years.. TESCO's lab received expansion of scope for ISO 17025:2017 accreditation to include DC Energy Measurement

DC EVSE STANDARDS

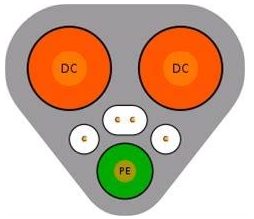
- **Standards evolving rapidly**
  - Combined Charging System
    - CCS1 SAE J1772 North America
    - CCS2 Europe
  - CHadeMO (Only Nissan and Mitsubishi)
  - Tesla V1
  - Tesla V2/V3 (Introduced in 2019)
  - Chaoji (China, Japan, India
    - Successor to CHadeMO and GB/T
  - >100kW is considered “high end” (400V Systems)
  - First US **350kW** units installed Dec 10, 2018 (800V)



Source: calevip.org; forbes.com

DC EVSE STANDARDS

- **Market Direction**
  - DC Generation 1 (less than 150kW)
    - Nominal 400-500 VDC
    - Up to 300 A max
    - All current EV's except one
  - DC Generation 2 (up to 400 kW)
    - Nominal 800 VDC (1000VDC max)
    - Up to 350A typ, 500 A max
  - Today: 600kW, even Megawatt Charging (MCS)



MCS

EVSE Accuracy Testing

TESCO METERING

AC Calibration

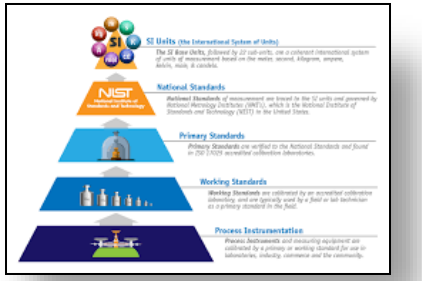
DC Calibration

EVSE Accuracy Testing

Level 1, 2, 3 EVSE Charger

TESCO Catalog #T4350

TESCO DCT



TESCO ISO 17025:2017 Accreditation

How are we doing it?

Test Methods

- Simulation
  - Use of a load emulator, “Phantom Load”, but *resistive*
  - *Full Load Test, Light Load Test*
- Man-in-the-middle (MITM)
  - Use of an electric vehicle, “Customer Load”, *via EV charge*

SIMULATION

MAN-IN-THE-MIDDLE

TS400 Overview: Hardware

TS400 TEST LIMITS

Simulation

- Tesla
- CHAdeMO
- CCS1
- Additional standards available upon request.
- Easy to use – select a site and press “test”
- Extremely fast, full accuracy is achieved in less than five seconds at any power level
- Field ready, and easily transportable
- Performs all accuracy and safety tests auto-matically without need for operator intervention.
- All information for sites, equipment, test procedures and test results are stored in internal database.
- Compatible with all current EV charging protocols.
- Software for exporting data and creating reports.

TS400 Test System includes the T4000 EVSE Tester and PL4000 Load Emulator to test all AC/DC charging standards.

CAT. TS400

ELECTRIC VEHICLE SERVICE EQUIPMENT (EVSE) TEST SYSTEM

TS400 Overview: Hardware

T4000 SPECIFICATIONS

AC:
240V * 80A -> ~19.2kW
208V * 80A -> ~16.6kW

DC :
1000V * 200A -> ~200kW

Note: The charger is the limit. The T4000 can go to 650V AC, but CCS1_AC is limited to 240V maximum

OPERATING TEMPERATURE: -20°C to 50°C (-4°F to 122°F)
STORAGE TEMPERATURE: -22°C to 60°C (-22°F to 140°F)
DIMENSIONS: 21.2" x 16" x 10.6" (53.8 x 40.6 x 26.9 cm)

PL4000 SPECIFICATIONS

AC:
240V * 58A -> ~14kW
208V * 50A -> ~10.4kW

DC:
240V * 58A -> ~14kW
500V * 28A -> ~14kW

Note: The PL4000 is the limit. CCS1_AC can go to 80A, but the PL is limited to 58A

OPERATING TEMPERATURE: -20°C to 50°C (-4°F to 122°F)
STORAGE TEMPERATURE: -22°C to 60°C (-22°F to 140°F)
DIMENSIONS: 16.9" x 16.3" x 26" (42.9 x 41.4 x 66 cm)
WEIGHT: Approx. 46 lbs.

Ask about **TESCO's Cat. 1060 UtiliCart®** to easily transport and hold your equipment in the field.

Charging Station not included.

T4000 FEATURES

DISPLAY	7", 1024 x 600, high brightness, daylight readable LCD
ETHERNET	100 BaseT with support for: *Web Services*, Remote Control, Database Access
USB	2X USB Type A with support for: Device, External Memory Storage, WiFi, Keyboard, Mouse; 1X USB Type B connection to computer
GPS	Integrated GPS system provides location information for automatic determination of test site and data base access
GFCI	Provision is provided to test the GFCI functionality of the EVSE (0-200ma)
BATTERY	99.6WHr Li-ion removable battery
PL INTERFACE	Provides communications and power to any Programmable Load (PL Series)
PC SIGNAL	Frequency +/- 1Hz, Duty Cycle +/-0.5%, Wave form amplitude +/- 0.3%
CASE	Watertight, crushproof, and dustproof Pelican™ Storm Case™

CAT. TS400

ELECTRIC VEHICLE SERVICE EQUIPMENT (EVSE) TEST SYSTEM

T4350 vs T4000

- T4350 – what's in a name?
  - "T": Tester
  - "4": 4th generation
  - "350": rated for 350A continuous load

- What's changed?
  - The T4350 is capable of higher power testing and supports the full spectrum of charger types across AC/DC

Load Characteristics	T4000	T4350
Continuous Load	200A	350A
Max Load	400A	650A

PL4150 vs. PL4000

- PL4150 – what's in a name?
  - "PL": Phantom Load
  - "4": 4th generation
  - 150: 150 kW Capable

- PL4150 is an AC/DC, 150kW capable dissipative load-box
- What's Changed?
  - The PL4000 was only capable of ~14kW and thus was only relevant for AC Load dissipation in a regulatory capacity; the PL4150 can handle up 150 kW @ 100% FL

		Test Currents (Amps) at Various Charging Levels at 400VDC									
	Max Current (A)	75	125	187.5	250	375	500	625	750	875	1000
Test Percentage	Max Power (kW)	30	50	75	100	150	200	250	300	350	400
Low Point											
10%		7.5	12.5	18.75	25	37.5	50	62.5	75	87.5	100
20%		15	25	37.5	50	75	100	125	150	175	200
Middle Point											
40%		30	50	75	100	150	200	250	300	350	400
60%		45	75	112.5	150	225	300	375	450	525	600
High Point											
70%		52.5	87.5	131.3	175	262.5	350	437.5	525	612.5	700
100%		75	125	187.5	250	375	500	625	750	875	1000

< 30A | Testable with a 150kW load. | requires 300 kW load

TESCO EVSE Testing

EV Charging Station Test Report

DEVICE MANAGER

EVSE TESTER DEVICE INFO:

System Name: **T4000**
Software Version: **1.3.4r**

Serial Number: **00046**
Calibration Date: **Nov-22-2022 7:23 AM**

EVSE Charger Info:

Establishment Name: **l'Esplanade**
Customer: **Hydro Quebec**

Address:
8181 Av de l'Esplanade, Montreal
ON, HGP 2R5

EVSE INFO:

Manufacturer: **Circuit Electrique**
Serial Number: **CEA-10028**

Model: **smartTwo**
GFCI rating: **0.02**

PORTS INFO:

Port #1:
Name: **Port1**

Connector Type: **CCS1 AC**

DEVICE MANAGER

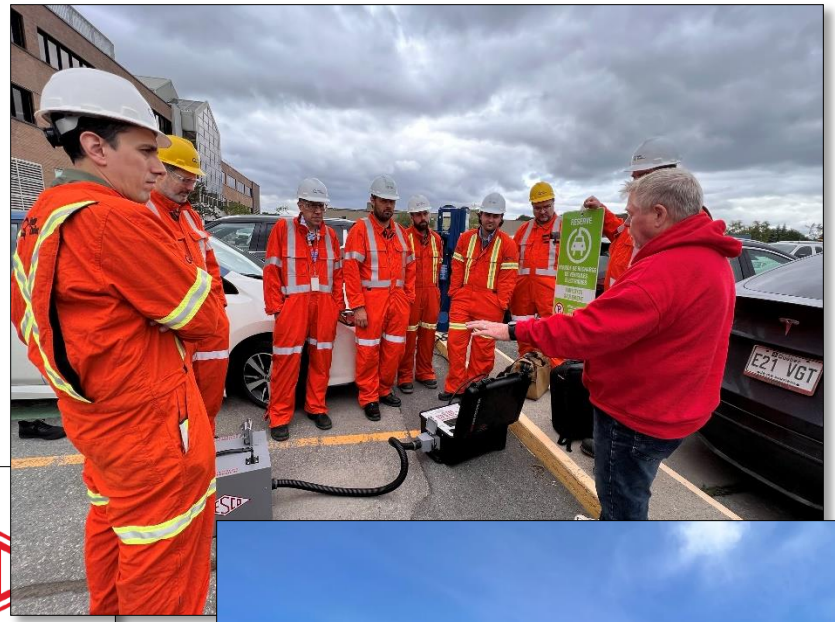
EvseSimulation TEST

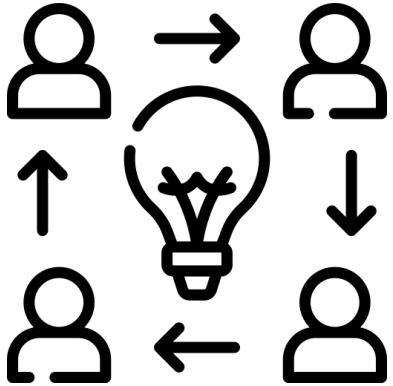
AC-FAST : CCS1 AC
PORT: Port1

Conducted by: **HYDRO QC**
Conducted on: **Jun-07-2023 12:03 PM**

TEST INDEX	TEST NAME	DURATION	RESULT	ENERGY DELIVERED	ENERGY READING	% ERROR	COMPUTED SALES AMT	EVSE SALES AMT	TOLERANCE TYPE	TOLERANCE
1-1	FL	00:00:52	PASS	0.1003	0.1000	-0.30	0.100	0.000	Maintenance	2.00%
1-2	FL	00:00:52	PASS	0.1003	0.1000	-0.30	0.100	0.000	Maintenance	2.00%

Test Types: **NL** = No Load, **SL** = Startup Load, **LL** = Light Load, **FL** = Full Load, **GFCI** = Ground Fault Test, **DIODE** = CP Diode Test
% Error = ((X-S)/S) * 100





Collaboration And Industry Innovation

Collaboration & Industry Innovation

Customer-Driven Enhancements:

- Improved user experience with EV charging stations
- Advanced calibration techniques for accuracy

Key Takeaways from Industry Events:

- Standardization efforts (CharIN Testival, NCWM)
- Training opportunities (NCWM EVSE Technical Training Conference)

Closing Remarks

Summary:

- EVSE compliance is crucial for transparency and consumer trust
- Proactive testing ensures long-term industry success
- Test specifications and tolerances are defined by HB 44 Section 3.40; procedure is defined by HB 130 EPO 30
- ANSI has developed a working group to provide guidance to electric utilities to test chargers they own and operate for use by the general public
- Test equipment continues to evolve alongside the regulatory landscape; looks and behaves similarly to existing Electrical Metrology Equipment

Open Discussion Q&A

Discussion Points:

- Challenges in EVSE compliance
- Collaboration between regulators and manufacturers
- Future advancements in EVSE metrology

Questions and Discussion

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