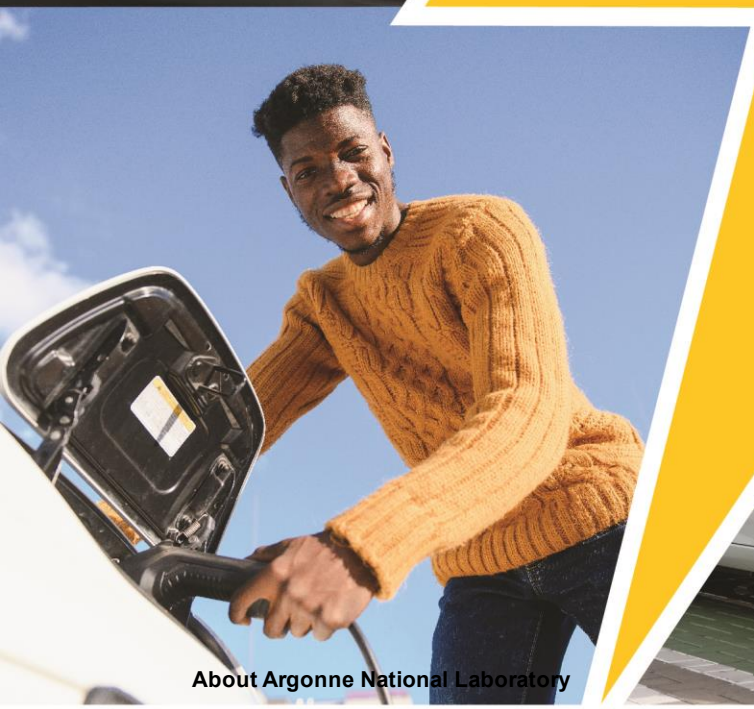
ChargeX Prescribed Testing Program at CharIN June 2024 Testival: Outcomes and Future Recommendations

CHARGEX consortium

Testing Task Force - Scaling Reliability

Sept 2024



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Contributors

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Revision Log

Version Date	Description	Author
08.06.2024	Initial version	Sam Thurston
09.04.2024	Draft version ready for review	Sam Thurston
09.16.2024	Executive summary added, minor edits of results and recommendations	Sam Thurston
09.30.2024	External comments and tracked changes reviewed/reflected	Sam Thurston

Executive Summary

In June 2024, the ChargeX Consortium developed an optional prescribed testing program for electric vehicle (EV) and electric vehicle supply equipment (EVSE) manufacturers that attended the CharIN Testival as testers. There were two driving purposes of this program; to introduce a new hybrid approach to testing events with both ad-hoc and prescribed testing offered, and to demonstrate the test cases and structure effectiveness of the EV-EVSE Interoperability Test Plan (EEITP) document developed within the ChargeX Testing Task Force. This program contained eight test scenarios to be performed during the final 30-minutes of a 90-minute testing slot with details like purpose, setup, pass criteria, etc. included within a written test plan document. A $2,000 rebate was offered to those who participated, and a ChargeX moderation force was present to collect EV and EVSE meta data, testing meta data, and testing results.

This document details the journey taken in developing the ChargeX prescribed testing program to give insight to those interested in implementing their own version of prescribed testing in the future. The ChargeX team used insights from the VOLTS 2023 prescribed testing program at CharIN, a similar event with a public report detailing outcomes, feedback, test scenarios, etc. to help lay the foundation of their program. Having bi-weekly Testing TF meetings allowed for constant communication with the correct industry audience in gathering feedback on program details leading up to the event. An important milestone for the development of this program was the in-person event held on April 29th, 2024, at Argonne National Laboratory that hosted industry, lab representatives, event hosts, and project sponsors. Here EEITP test cases were reviewed closely, the program was first announced publicly, and details were finalized for the structure of prescribed testing to be implemented in June 2024. On May 3rd, 2024, the test plan was released via the CharIN technical survey along with the sign-up option for testers to opt-in to the program.

10 EVs and 12 EVSEs opted-in to this program with 6/10 testing slots containing a 30-minute prescribed testing window. Opted-in testers matchmade with opted-out testers were given to option to participate in the prescribed testing program if desired, and two opted-in testers were expected to perform the tests. In total, 43 test pairings worked to attempt 163 test scenarios with 112 of those meeting all defined pass criteria. It was seen that some test scenarios had much higher attempt rates and/or success rates than others. Time to perform test scenarios was captured for future planning of test scenarios and given testing time.

Test scenarios 1 and 2 had a high attempt/success rate being basic plug-first or authenticate-first tests using DIN SPEC 70121 or J1772. Test scenarios 3 and 4 explored timeouts for the above two charge start methods, however it was realized early into testing that authenticate-first timeouts lacked true interoperability testing as the EV was not involved. Test scenario 5 was the same as TS1 but utilized ISO 15118-2 as the preferred high-level communication (HLC) protocol which yielded issues as some testers' present equipment was not prepared to switch between HLC protocols. Test scenario 6 introduced ISO 15118-2 Plug&charge testing with expired EV contract certificated designed to test fallback mechanisms, however compatibility issues between Hubject certificate pool and testers equipment led to low attempt and success rate. Test scenario 7 was ISO 15118-2 Plug&charge testing with valid certificates which had a similar compatibility issue to TS6, however some testers who brought their own local EV contract certificates were able to perform the test successfully. Test scenario 8 was a stretch goal of ISO 15118-20 basic plug-first charge start and yielded no attempts.

Feedback was received for the prescribed test program before, during, and after the CharIN June 2024 Testival which was combined and summarized in this report. Areas of discussion included communication improvements, preparation time, questionnaire rephrasing, results recording, including test systems, extending prescribed testing days, starting with prescribed testing, number of tests, gamification of testing, matchmaking involvement, pass/fail scheme, testing time, etc. CharIN survey data that pertained specifically to prescribed testing participation, incentives, and future interest was also included in this report.

For future implementations of prescribed testing there are many directions that can be taken. This document outlines the ChargeX Consortium's journey and decision-making process in creating this program, including what worked well and what could be improved upon. The hybrid structure of ad hoc and prescribed testing was quite effective, and testers gave positive feedback towards the moderation team present to support questions and record results. A "gamified" approach would be an interesting method of incentivizing testing of more advanced features and could make for a fun testing experience. Ensuring proper and timely communication/promotion of an upcoming prescribed test program is essential to success so testers can arrive prepared and ready to perform a prior reviewed test plan. The ChargeX Consortium team gathered a tremendous number of insights from this testing event and would be interested in performing another version of prescribed testing in the near future.

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1. Introduction

Electric vehicle (EV) charging infrastructure is a crucial component of the transition to sustainable transportation, aiming to support the growing adoption of EVs. However, interoperability issues often arise, as different manufacturers and technologies can lead to inconsistent performance and user experience. Interoperability in EV charging refers to the ability of different electric vehicle charging networks and equipment to work seamlessly together, allowing users to charge their vehicles across various charging stations without compatibility issues. Testing events play a pivotal role in addressing these challenges by allowing companies to evaluate and refine their products in real-world scenarios.

Charging Interface Initiative (CharIN) is a prominent organization that was established in 2015, with a mission to ensure a seamless, efficient, and standardized charging experience across various EV models and charging infrastructure worldwide. By fostering collaboration among automotive and energy stakeholders, CharIN supports rigorous testing and certification processes, while advancing standards to accommodate emerging technologies. CharIN is prominently known for their in-person testing events – known as Testivals - where they facilitate real-world testing of interoperability, performance, and compliance for EV and EVSE original equipment manufacturer (OEM) pre-production equipment as well as test systems, controllers (including SECC/EVCC), and other testing devices to support the testing activities. CharIN hosts 7-9 Testivals annually, with two located each year in North America. The Testivals are hosted by CharIN members and partners at locations with sufficient space and power. Logistics support is provided by CharIN Academy GmbH and technical support is contracted from Keysight Technologies for tester matchmaking and other logistical information.

In May 2023, CharIN hosted a first of its kind testing event that distinguished itself from others by its structure. The *Vehicle Interoperability Testing Symposium (VOLTS)* organized by CharIN marked a significant milestone by being the first event to require a prescribed test program for all participants in exchange for a significantly reduced registration fee. The prescribed test plan was designed to be conducted for 90 minutes of the 120-minute testing period. This structured approach ensured consistency and rigor across testing activities, requiring testers to adhere to a detailed and standardized testing program. The introduction of this prescribed test program aimed to enhance the accuracy of the evaluations, facilitate more comprehensive and comparable results, and streamline the process for identifying and addressing interoperability issues. This event was grant sponsored by the California Energy Commission (CEC), hosted at the Port of Long Beach, California at the WattEV Charging Depot, with a technical report prepared by DEKRA on behalf of CharIN North America.

The ChargeX Consortium's Testing Task Force (TF) has a targeted goal of improving upon and scaling interoperability for EVs and charging infrastructure. In 2024, the TF had two core tasks that work towards this scaling interoperability goal: the *EV-EVSE Interoperability Test Plan (EEITP)* and a *Prescribed Testing Program at CharIN June 2024 Testival.* Both tasks had similar timelines in terms of development and deliverable dates, relying heavily on the ChargeX Consortium industry participants for technical input. This document reports on the planning,

execution, and results of the prescribed testing program that was performed at the CharIN Spring 2024 Testival from June 11-14, 2024, at Lincoln Electric in Cleveland, Ohio.

2. Testing TF and Event Planning

This section works to create a roadmap of setup and planning for the prescribed testing program led by the ChargeX Consortium that took place at CharIN June 2024 Testival with respect to the core goals of the Testing Task Force.

2.1 Testing Task Force FY24 Tasks

In FY24, the ChargeX Consortium's Testing TF had three core tasks assigned to be completed as seen in Figure 1, and a GANTT chart depicting the timeline for the Testing TF for FY24 can be seen in Figure 2.

Task 1: Current Test Plans & Procedures
Subtask 1.1: 1-on-1 interviews
Subtask 1.2: Written report
Task 2: EV-EVSE Interoperability Test Plan (EEITP) Version 1
Subtask 2.1: Receive test plans from industry
Subtask 2.2: Create EEITP document structure
Subtask 2.3: Meet with SMEs, create EEITP test categories & cases, review with indsutry (In-Person event)
Subtask 2.4: Finalize EEITP version 1
Task 3: Prescribed Testing Program @ CharIN June 2024 Testival
Subtask 3.1: SOW & contract creation (Between ANL & CharIN)
Subtask 3.2: Create Prescribed Test Plan program structure & test cases, review with industry (In-Person event)
Subtask 3.3: Finalize Prescribed Test Plan for CharIN technical survey
Subtask 3.4: Create & coordinate moderation team, Execute program @ CharIN June 2024 Testival
Subtask 3.5: Report on Prescribed Test Plan program & future recommendations

Figure 1: Testing TF FY24 Task List

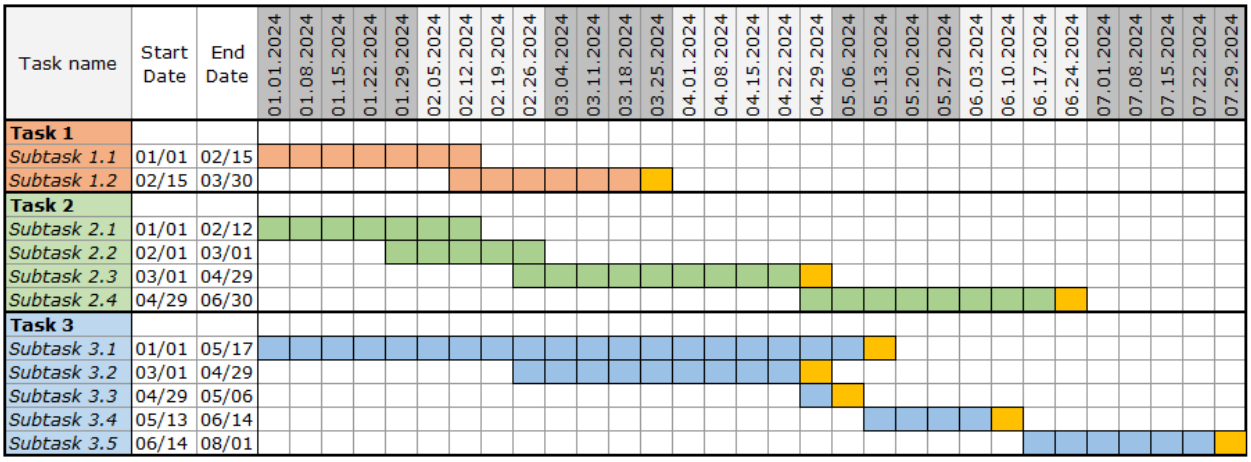
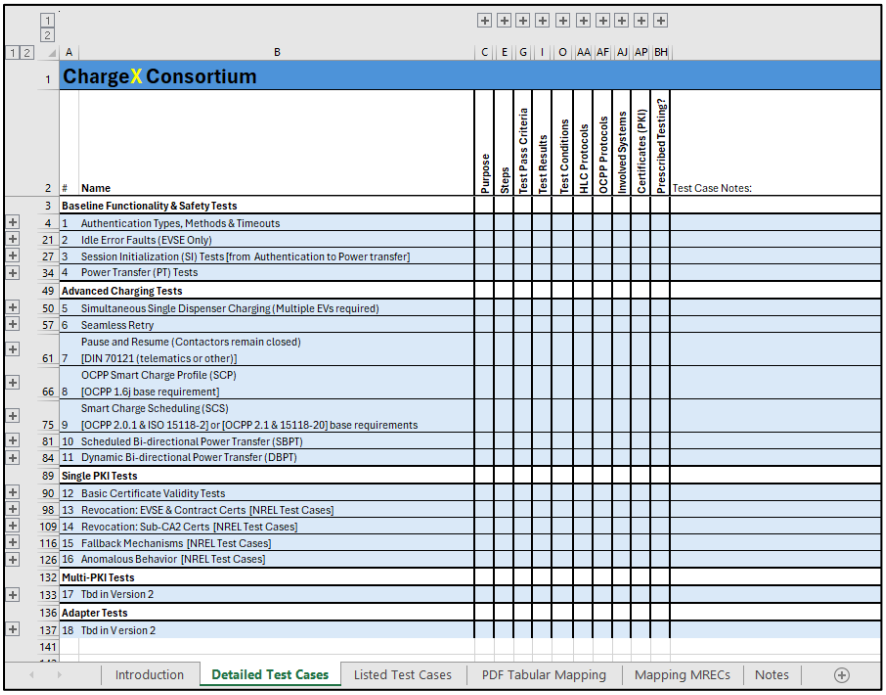


Figure 2: Testing TF FY24 GANTT Chart

The *Current Test Plans and Procedures* (Task 1) involved several 1-on-1 interviews with industry participants and subject matter experts (SMEs) to understand the needs of industry when it comes to conformance, interoperability, and the testing landscape. A detailed summary of these interviews was documented within the Testing TF and was a motivator in developing Tasks 2 and 3. These interviews alluded that an interoperability testing guide or reference was missing in the

current EV charging testing landscape, and thus the need for an *EV-EVSE Interoperability Test Plan* (Task 2) became within scope. This EEITP document was designed to take a wide variety of test scenarios from multiple sources and create alignment in terms of purpose, setup, procedure, and pass criteria across a series of categories containing both happy-path and edge-case testing. A general overview of test categories and test details can be seen in Figure 3 depicting version 1 of the EEITP.



	#	Name	Purpose	Steps	Test Pass Criteria	Test Results	Test Conditions	HLC Protocols	OCPP Protocols	Involved Systems	Certificates (PKI)	Prescribed Testing?	Test Case Notes:
1		ChargeX Consortium											
3		**Baseline Functionality & Safety Tests**											
4	1	Authentication Types, Methods & Timeouts											
21	2	Idle Error Faults (EVSE Only)											
27	3	Session Initialization (SI) Tests [from Authentication to Power transfer]											
34	4	Power Transfer (PT) Tests											
49		**Advanced Charging Tests**											
50	5	Simultaneous Single Dispenser Charging (Multiple EVs required)											
57	6	Seamless Retry											
61	7	Pause and Resume (Contactors remain closed) [DIN 70121 (telematics or other)]											
66	8	OCPP Smart Charge Profile (SCP) [OCPP 1.6j base requirement]											
75	9	Smart Charge Scheduling (SCS) [OCPP 2.0.1 & ISO 15118-2] or [OCPP 2.1 & 15118-20] base requirements											
81	10	Scheduled Bi-directional Power Transfer (SBPT)											
84	11	Dynamic Bi-directional Power Transfer (DBPT)											
89		**Single PKI Tests**											
90	12	Basic Certificate Validity Tests											
98	13	Revocation: EVSE & Contract Certs [NREL Test Cases]											
109	14	Revocation: Sub-CA2 Certs [NREL Test Cases]											
116	15	Fallback Mechanisms [NREL Test Cases]											
126	16	Anomalous Behavior [NREL Test Cases]											
132		**Multi-PKI Tests**											
133	17	Tbd in Version 2											
136		**Adapter Tests**											
137	18	Tbd in Version 2											
141													

Introduction | Detailed Test Cases | Listed Test Cases | PDF Tabular Mapping | Mapping MRECs | Notes

Figure 3: EEITP High Level Overview

Demonstrating the effectiveness of the EEITP was a logical next step for the Testing TF, one theorized way to do so was through a prescribed testing program during a testing event. Implementing a prescribed testing program at the CharIN June 2024 testing event (Task 3) was initially hinted at during CharIN Fall 2023 Testival in November and was confirmed in early 2024. By doing so, the ChargeX Consortium would help revive the idea of interoperability testing alignment that was once performed by CharIN in the past at VOLTS 2023, and it would be an opportunity to achieve the desired goal of demonstrating the EEITP's effectiveness to industry. After confirmation to move forward with the prescribed testing program, it was decided the Testing TF was most accurately suited from the ChargeX Consortium to perform this task and that efforts would begin early 2024 to start planning and gathering industry input towards event details.

2.2 Event Planning and Industry Input

This prescribed test program task commenced with an in-depth review of previous testing events, including VOLTS 2023. This event aided greatly in setting the foundation for ChargeX's prescribed testing program, as the VOLTS 2023 planning and results were well documented

within the technical report produced by DEKRA. Additionally, many of the industry members that regularly attend the ChargeX Testing TF meetings were testers/observers at the VOLTS 2023 event. This allowed for further input towards testers' experiences and feedback to be gathered by the Testing TF through surveys and 1-on-1 meetings.

From the VOLTS 2023 report, Testing TF surveys, and meetings with CharIN it was quickly realized that the following program structure details needed to be solidified for ChargeX's implementation of prescribed testing:

- Prescribed testing period duration
- Which test slots will include prescribed testing
- Order of testing (ad hoc-first vs prescribed-first)
- Number of prescribed tests per period
- Number of iterations per prescribed test
- Areas of interest for prescribed tests
- Difficulty of prescribed tests
- Method of reporting test results
- Necessity for moderators to be present
- Rebate incentives for participation
- Cut-off criteria for receiving rebate incentives
- Cut-off for who can/can't participate

Figure 4: Prescribed Testing Program Structure Considerations

To receive this direct feedback and spark discussion between industry participants and the ChargeX leadership team, an in-person one-day event was held by the Testing TF at Argonne National Laboratory (ANL) on April 29th, 2024. The goal of this event had two primary objectives:

1. Introduce the EEITP to industry and gather direct feedback on test case details.
2. "Soft launch" the optional prescribed testing program planned for CharIN June 2024 Testival and gather direct feedback on the above program structure details seen in Figure 4.

A majority (~75%) of the event was dedicated to the first objective of gathering EEITP feedback on test cases and document structure. Also, during that time industry was asked which test categories would be of specific interest to be included in a prescribed test program for a June 2024 Testival timeline. Of the test categories seen in Figure 3, industry feedback indicated the following five test categories would be the most desirable:

- 1. Authentication Types and Methods
- 3. Session Initialization (SI) Tests
- 6. Seamless Retry
- 8. Open Charge Point Protocol (OCPP) Smart Charge Profiles (SCP)
- 12. Basic Certificate Validity Tests (PnC)

The final segment of the one-day event was dedicated to the second objective of introducing ChargeX's plans for prescribed testing at the CharIN June 2024 Testing and gathering direct input. PollEV was used in support of a PowerPoint presentation that sparked discussion and gathered direct feedback towards the prescribed testing structure questions listed in Figure 4. The discussion topics, presented options, and feedback/decisions from the April 29th, 2024, in-person one-day event for the proposed prescribed test program structure are captured within Table 1.

Table 1: April 29th, 2024, In-Person Event Feedback - Prescribed Test Program Structure Details

Topic	Options or Discussion	Feedback
Prescribed testing period duration? (ad hoc:prescribed)	A. (45min:45min) B. (50min:40min) C. (55min:35min) D. (60min:30min) E. None of the above	100% (4 votes) for option D. Comment: The necessary amount of time for prescribed tests also depends on the number of tests included in the prescribed test program.
Which test slots will include prescribed testing?	Discussion	Dynamic testing is valuable, it allows for additional 1-on-1 time with pairings that may have been insufficient in previous pairing or were not paired in the first place. Prescribed testing should be kept to matchmade pairing test slots only.
Order of testing? (ad hoc-first vs prescribed-first)	Discussion	Allowing for ad hoc first allows for testers to iron out unexpected initial issues during that may arise when testing with a new pairing during free time, rather than during prescribed testing.
Feasible number of prescribed tests per **30-minutes**?	A. 1-5 tests B. 5-10 tests C. 10-15 tests D. 15-20 tests E. 20-25 tests	100% (3 votes) for Option A. Comment**:** 30-minute period used based on feedback in earlier topic question. Referenced VOLTS 2023 test scenario list (15 total). Feedback that feasible number also depends on complexity of tests.
Number of iterations per prescribed test?	Discussion	Some tests from VOLTS 2023 had a single iteration, others had many. Having the option to run a test again if something went awry would be desirable.
Areas of interest for prescribed tests?	Discussion	Five test categories from EEITP expressed to be of interest. As stated above, EEITP test categories 1, 3, 6, 8, and 12.
Difficulty of prescribed tests?	Discussion	Lead time for OEMs to prepare for upcoming prescribed tests is a very important factor. Given the shorter lead time (4-5 weeks) it was recommended the difficulty be kept low and to focus on event structure.
Method of reporting test results and concerns?	Discussion	Major concerns on how prescribed test results are reported on, who uses data and for what. Commented that these are pre-production vehicles in a testing environment and test results should not be used to influence policy. Data must be kept anonymous.
Necessity for moderators to be present?	Discussion	The idea of moderators accepted well. Would be nice to have a representative present to answer questions and record results.
Rebate incentives for participation?	Discussion	Two options: Monetary rebate, discounted admission. Discounted admission was clearly most desirable and streamlined, however having the option to choose from is best for most.

Cut-off criteria for receiving rebate incentives?	Discussion	75% submission rate of prescribed tests attempted when two opted-in testers are paired together. No "penalty" to one opted-in tester if the other declines prescribed testing.
Cut-off for who can/can't participate?	Discussion	EV and EVSE OEMs, prioritizing those that can perform DC fast charging (Testing TF's main focus). If an opt-in is paired with opt-out, they can still run prescribed testing with moderation if desired, however no rebate incentive for the opt-out tester.
Additional Questions		
What is Interoperability testing defined as?	- Testing that the implementation is done correct and interoperable with each other. - It is a functional test to ensure that any EV can connect and charge with any EVSE. - Testing different functionalities within the charging systems to ensure each of the components work together. - Ensuring that two conforming devices are fully operable in a system as intended. - Testing end to end equipment combinations. - Testing to ensure compatibility between EV and EVSE systems. - Functional system testing of the combined EV/EVSE charging system including power systems, communications and hand shaking, most often in a round robin style. - Testing if basic charging functionalities work between EV and EVSE, slowly introducing more complexity (i.e. different authentication methods, different start/stop methods, etc.) to ensure that both the EV and EVSE are compatible. - Testing that occurs because conformance testing is not broadly performed or incomplete.	
Main purpose or goal when attending Testival?	- Engaging with industry experts to identify loopholes and refine standards. - This time [June 2024] it is talk to the participants about the implementations. - Testing the interoperability of prototype hardware and software. - Help further refine relevant standards. - Validation of testing protocols and standards.	

This event was crucial in gathering direct feedback on ChargeX's prescribed test program plans. Soon after this event on May 3rd, 2024, a detailed document titled "*ChargeX-CharIN Prescribed Test Plan"* was completed and distributed to CharIN registrants through the CharIN technical survey. This document included all details for the prescribed test program structure, as well as the detailed test scenarios. This CharIN technical survey was the method in which testers opted-in to the prescribed test program which had the ChargeX test plan document attached. This *ChargeX-CharIN Prescribed Test Plan* can be found in the Appendix for reference.

3. Event Details and Program Structure

CharIN June 2024 was hosted by Lincoln Electric in Cleveland, Ohio, utilizing their facilities as the testing grounds and conference center. Figure 5 shows the layout and electrical connections present at Lincoln Electric for the two testing areas: one indoors and one outdoors. Figure 6 highlights those who participated in testing at the Testival, totaling 16 EV OEMs, 16 EVSE OEMs, and five Test systems. EVSEs remained stationary at their dedicated test slot location and EVs would rotate between at the end of each testing slots as depicted in Figure 7.

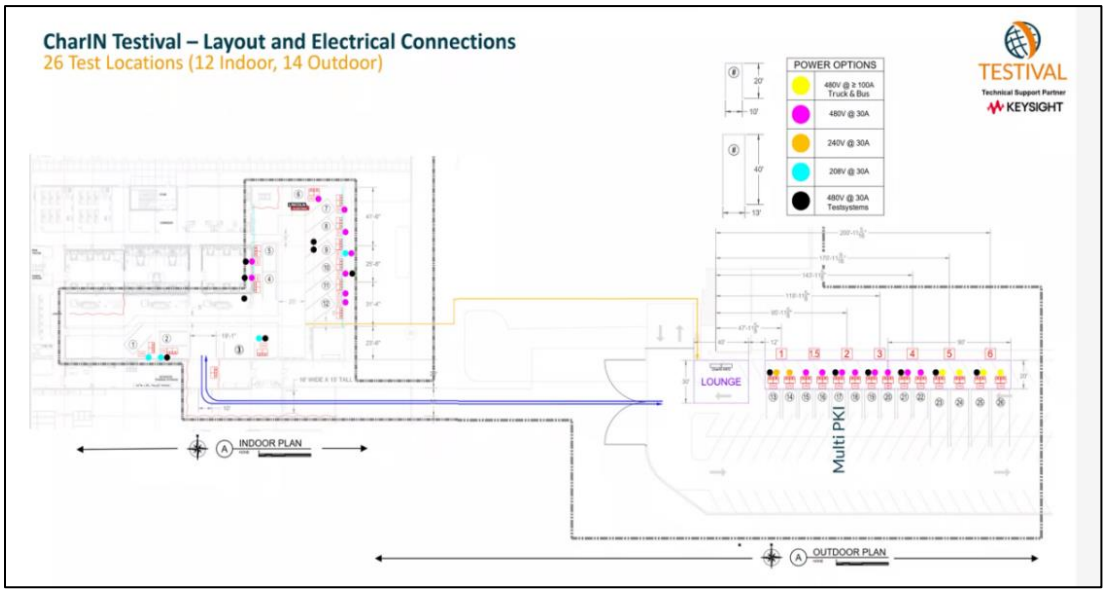


Figure 5: Lincoln Electric in Cleveland, Ohio Testing Grounds Map

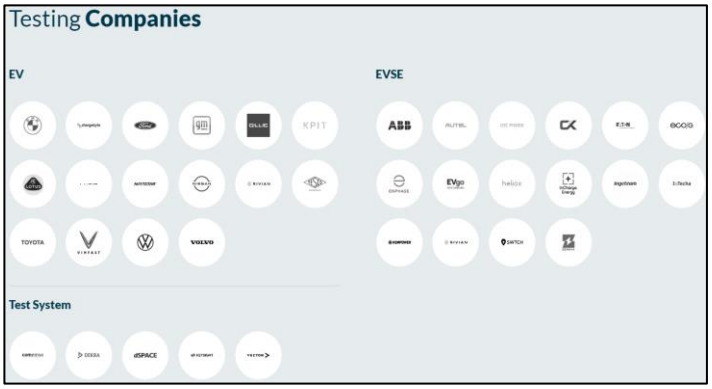


Figure 6: Testing Companies Participating at CharIn June 2024 Testival

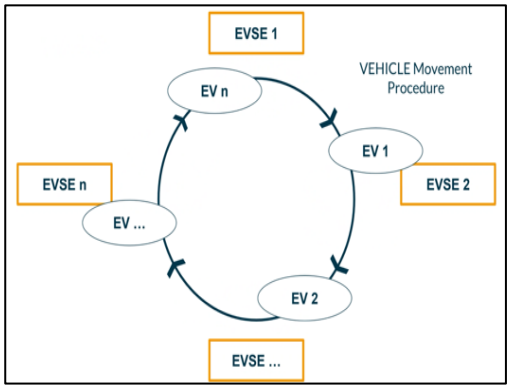


Figure 7: CharIN Test Pairing Rotation Structure

This Testival was a weeklong event following the schedule seen in Figure 8. Wednesday and Thursday were the days that the ChargeX Consortium would offer its optional prescribed testing program, with no testing on Monday/Tuesday, and Friday being dedicated to dynamic matchmaking testing with no ChargeX involvement. The following modified agenda seen in Figure 9 was created to reflect the prescribed testing and demonstrations schedule.

Figure 8: CharIN June 2024 Testival Schedule

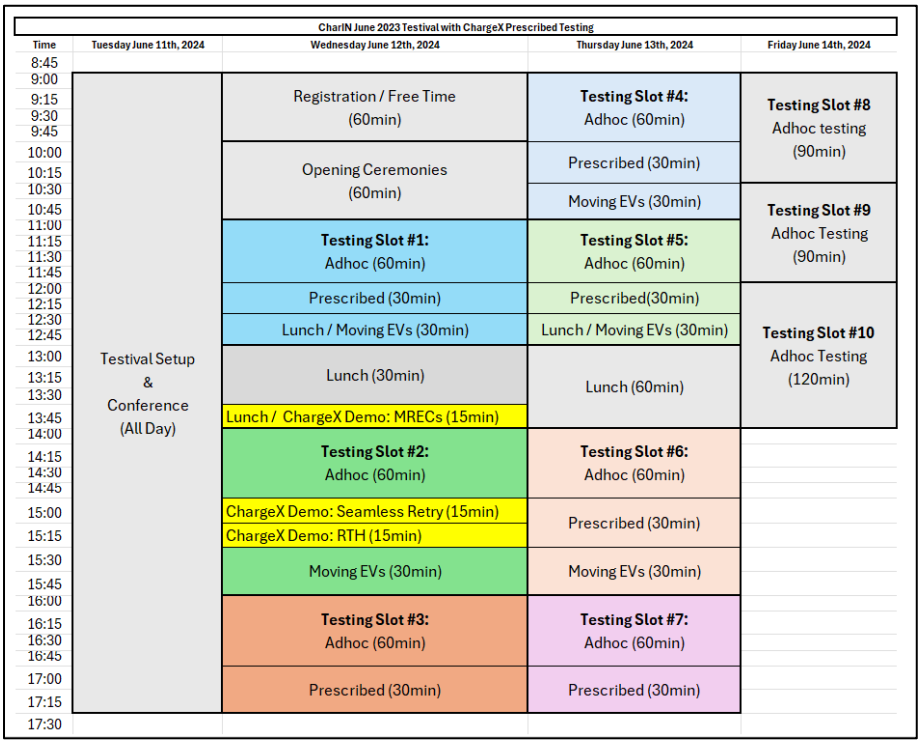
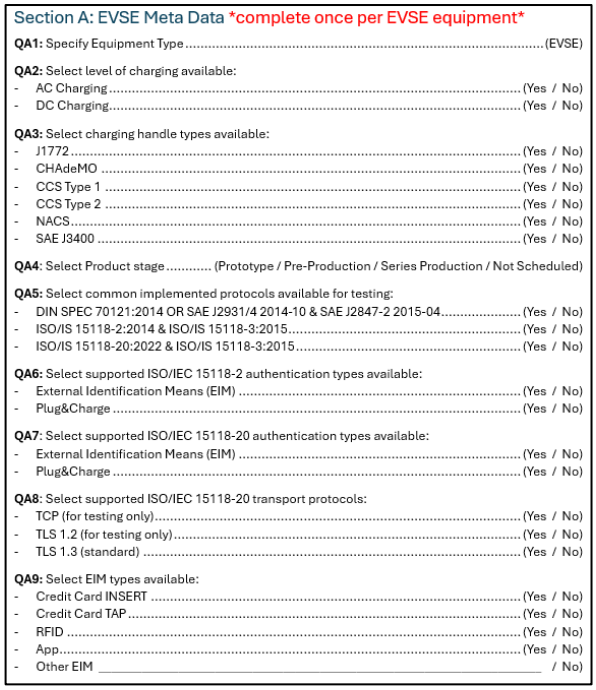


Figure 9: CharIN June 2024 Testival Schedule with Prescribed Testing and Demonstrations

Test Slots 1 and 3-7 each included a 30-minute prescribed testing period that was chosen to take place during the end of the 90-minute testing session. The intended benefit of choosing to have prescribed testing at the end of the test session was to allow testers to utilize the first 60-minutes of ad hoc testing to iron out any initial issues that may arise when setting up and running charge sessions with a new test pairing. Test slot 2 did not include prescribed testing and was rather utilized for ChargeX demonstrations so both observers and testers had the opportunity to attend.

During each test slot, if two opted-in testers were paired together, it was expected they would perform prescribed testing during the last 30-minutes if intended as per the schedule seen in Figure 9. If an opted-in tester was paired with an opted-out tester they were given the option to run prescribed testing with moderation if desired, however the opted-out tester would not receive any rebate incentive for doing so.

EV and EVSE anonymized meta-data were collected once per tester by moderators. This meta-data covered equipment type, available charging levels, inlet type, product stage, communication protocols implemented, authentication methods supported, etc. These EV and EVSE meta-data question sets can be seen below in Figure 10 and Figure 11.



Section A: EVSE Meta Data *complete once per EVSE equipment*

QA1: Specify Equipment Type ..... (EVSE)

QA2: Select level of charging available:
- AC Charging ..... (Yes / No)
- DC Charging ..... (Yes / No)

QA3: Select charging handle types available:
- J1772 ..... (Yes / No)
- CHAdeMO ..... (Yes / No)
- CCS Type 1 ..... (Yes / No)
- CCS Type 2 ..... (Yes / No)
- NACS ..... (Yes / No)
- SAE J3400 ..... (Yes / No)

QA4: Select Product stage ..... (Prototype / Pre-Production / Series Production / Not Scheduled)

QA5: Select common implemented protocols available for testing:
- DIN SPEC 70121:2014 OR SAE J2931/4 2014-10 & SAE J2847-2 2015-04 ..... (Yes / No)
- ISO/IS 15118-2:2014 & ISO/IS 15118-3:2015 ..... (Yes / No)
- ISO/IS 15118-20:2022 & ISO/IS 15118-3:2015 ..... (Yes / No)

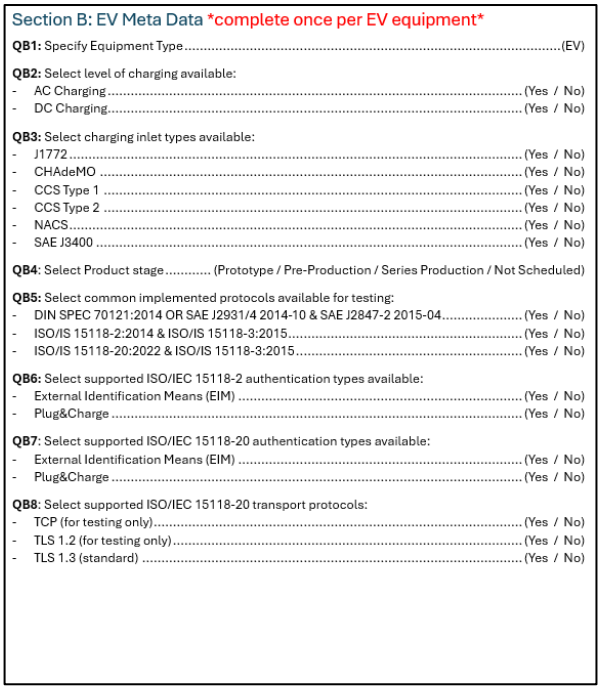
QA6: Select supported ISO/IEC 15118-2 authentication types available:
- External Identification Means (EIM) ..... (Yes / No)
- Plug&Charge ..... (Yes / No)

QA7: Select supported ISO/IEC 15118-20 authentication types available:
- External Identification Means (EIM) ..... (Yes / No)
- Plug&Charge ..... (Yes / No)

QA8: Select supported ISO/IEC 15118-20 transport protocols:
- TCP (for testing only) ..... (Yes / No)
- TLS 1.2 (for testing only) ..... (Yes / No)
- TLS 1.3 (standard) ..... (Yes / No)

QA9: Select EIM types available:
- Credit Card INSERT ..... (Yes / No)
- Credit Card TAP ..... (Yes / No)
- RFID ..... (Yes / No)
- App ..... (Yes / No)
- Other EIM _____ / No)

Figure 10: EVSE Meta-Data



Section B: EV Meta Data *complete once per EV equipment*

QB1: Specify Equipment Type ..... (EV)

QB2: Select level of charging available:
- AC Charging ..... (Yes / No)
- DC Charging ..... (Yes / No)

QB3: Select charging inlet types available:
- J1772 ..... (Yes / No)
- CHAdeMO ..... (Yes / No)
- CCS Type 1 ..... (Yes / No)
- CCS Type 2 ..... (Yes / No)
- NACS ..... (Yes / No)
- SAE J3400 ..... (Yes / No)

QB4: Select Product stage ..... (Prototype / Pre-Production / Series Production / Not Scheduled)

QB5: Select common implemented protocols available for testing:
- DIN SPEC 70121:2014 OR SAE J2931/4 2014-10 & SAE J2847-2 2015-04 ..... (Yes / No)
- ISO/IS 15118-2:2014 & ISO/IS 15118-3:2015 ..... (Yes / No)
- ISO/IS 15118-20:2022 & ISO/IS 15118-3:2015 ..... (Yes / No)

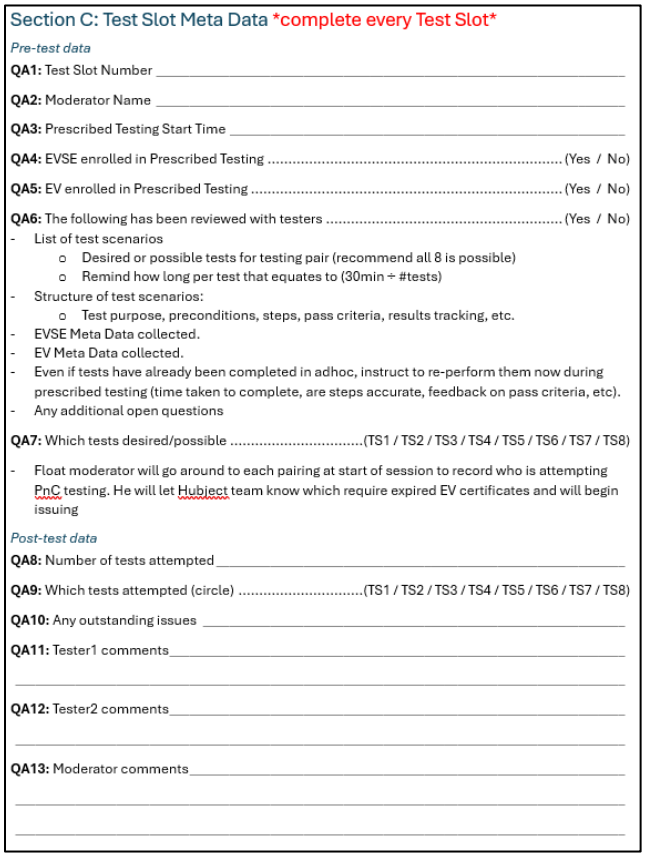
QB6: Select supported ISO/IEC 15118-2 authentication types available:
- External Identification Means (EIM) ..... (Yes / No)
- Plug&Charge ..... (Yes / No)

QB7: Select supported ISO/IEC 15118-20 authentication types available:
- External Identification Means (EIM) ..... (Yes / No)
- Plug&Charge ..... (Yes / No)

QB8: Select supported ISO/IEC 15118-20 transport protocols:
- TCP (for testing only) ..... (Yes / No)
- TLS 1.2 (for testing only) ..... (Yes / No)
- TLS 1.3 (standard) ..... (Yes / No)

Figure 11: EV Meta-Data

Test slot meta-data was completed at the start of each prescribed testing period for each test pairing to identify test slot number, start time, opt-ins/opt-outs and desired/possible test scenarios. Additionally, test slot meta-data was completed at the end of each prescribed testing period to capture the number of tests attempted, scenarios attempted, end time, outstanding issues, testers comments, and moderator comments. These test slot meta-data question sets can be seen below in Figure 12.



Section C: Test Slot Meta Data *complete every Test Slot*

Pre-test data

QA1: Test Slot Number _____

QA2: Moderator Name _____

QA3: Prescribed Testing Start Time _____

QA4: EVSE enrolled in Prescribed Testing ..... (Yes / No)

QA5: EV enrolled in Prescribed Testing ..... (Yes / No)

QA6: The following has been reviewed with testers ..... (Yes / No)

- List of test scenarios
  - Desired or possible tests for testing pair (recommend all 8 is possible)
  - Remind how long per test that equates to (30min ÷ #tests)
- Structure of test scenarios:
  - Test purpose, preconditions, steps, pass criteria, results tracking, etc.
- EVSE Meta Data collected.
- EV Meta Data collected.
- Even if tests have already been completed in adhoc, instruct to re-perform them now during prescribed testing (time taken to complete, are steps accurate, feedback on pass criteria, etc).
- Any additional open questions

QA7: Which tests desired/possible .....(TS1 / TS2 / TS3 / TS4 / TS5 / TS6 / TS7 / TS8)

- Float moderator will go around to each pairing at start of session to record who is attempting PnC testing. He will let Hubject team know which require expired EV certificates and will begin issuing

Post-test data

QA8: Number of tests attempted _____

QA9: Which tests attempted (circle) .....(TS1 / TS2 / TS3 / TS4 / TS5 / TS6 / TS7 / TS8)

QA10: Any outstanding issues _____

QA11: Tester1 comments_____

QA12: Tester2 comments_____

QA13: Moderator comments_____

Figure 12: Test Slot Meta-Data

A summary of the chosen test scenarios can be seen in Table 2, highlighted to indicate the intended communication protocol to be used for such test. It should be noted that two test scenarios were changed to "optional" to prioritize others if all were possible to be performed. This optionality was added in due to feedback on time constraints being able to perform eight test scenarios in 30-minutes. It should be noted that not all test categories detailed in Section 2 were included in this test plan (session initialization tests, seamless retry, and smart charge profiles), only *Authentication Types and Methods* and *Basic Certificate Validity Tests (PnC)* tests. This decision to limit the complexity of the test scenarios was made based on the feedback received from industry towards limited lead time for testers to prepare prior to the event.

Table 2: List of Prescribed Test Scenarios

ChargeX Prescribed Test Scenarios
TS1: EIM Authentication Types after Plug-in (DIN 70121)
TS2: EIM Authentication Types before Plug-In (DIN 70121)
TS3: Timeout after Plug-in (DIN 70121) *optional*
TS4: Timeout after Authentication (DIN 70121)
TS5: EIM Authentication types after Plug-in (ISO 15118-2) *optional*
TS6: PnC with EV Contract Certificates being Expired (ISO 15118-2)
TS7: PnC with Valid Certificates (ISO 15118-2)
TS8: EIM Authentication types after Plug-in (ISO 15118-20)

Each test scenario followed a tabular structure that was mapped directly from the EEITP document developed within the Testing TF. A test scenario example from this test plan can be seen in Table 3, covering all details in terms of test identifier, name, type, category, purpose, conditions, steps, pass criteria, observable metrics, error codes, and recorded results. This format was repeated eight times for all eight test scenarios included in this test plan.

Table 3: TS1 Test Setup and Procedure

Test Identifier:	TS1			
Test Name:	EIM Authentication Types after Plug-in (DIN 70121)			
Test Type:	Intentional Charging			
Test Category:	Authentication Types, Methods and Timeouts			
Purpose:	To ensure "Plug-first" option is available. To ensure alternative authentication methods are accepted.			
Pre-Test Conditions:	Authentication Type (choose):	• Credit Card INSERT • ~~Credit Card TAP~~ • ~~RFID~~ • ~~App~~ • ~~Other EIM~~		
	Plug-in or authenticate first:	Plug-in		
	Communication protocol:	DIN 70121		
	Involved Systems:	EV, EVSE		
Steps:	1	Set EVSE authentication option to '**Authentication Type'.**		
	2	Plug-in EV.		
	3	Within 30 seconds, provide '**Authentication Type'.**		
	4	Observe session initialization into power transfer.		
	5	Terminate charge session 30-60 seconds into power transfer.		
	6	Unplug EV.		
Pass Criteria:	1.Plug-first method is accepted.		Pass	Fail
	2.Authentication type is accepted.		Pass	Fail
	3.Session initialization begins and reaches power transfer stage.		Pass	Fail
Observed Metrics:	Session initialization stages			
Intended MRECs/Errors:	None			
Possible MRECs/Errors:	"Payment Failure", "AuthorizationTimeout", "Invalid Sequence"			
Recorded Test Results:	• Pass/Fails. • Point of failure (if applicable)			

The method of recording results was also included for moderator use in this document, an example of which can be seen in Table 4.

Table 4: TS1 Results Tracking

TS1Q1: Test attempt number	1	2	3
TS1Q2: Test start time			
TS1Q3: Test end time			
TS1Q4: All pass criteria met? (Y/N)			
TS1Q5: Which pass criteria not met			
TS1Q6: Point of failure			
TS1Q7: If test not attempted, why?			
TS1Q8: Comments			

A moderator schedule was created and used to keep track of which tester pairings would be assigned to each moderator throughout the event, as well as some initial tracking of results and comments throughout to be adaptable to changes that could arise. This moderator tracking sheet can be seen in Figure 13 where moderators, EVs, EVSEs, and test device names have been kept anonymous. This schedule was compiled based on the CharIN June 2024 Testival matchmaking schedule developed by Keysight Technologies for CharIN, where indicators for those who opted-in to the ChargeX prescribed testing program were present. This moderator schedule included pairings where both testers had opted-in, as well as those where only one tester had opted-in. Pairings where neither tester had opted-in to the prescribed testing program, and those paired with test devices were not considered in the making of this schedule. Those highlighted green indicated opted-in, yellow indicated opted-out, and red indicate not included in prescribed testing (i.e. test devices).

	TS1							TS2	TS3						
Moderators	TYPE	EV	EVSE	Location#	Tested?	EV Meta	EVSE Meta		TYPE	EV	EVSE	Location#	Tested?	EV Meta	EVSE Meta
MOD1								n/a							
MOD2	DC	EV1	EVSE1	7	Yes (3 done)	Yes	N/a	n/a	DC	EV14	EVSE15	24	Yes (5 done)	Yes	N/a
MOD3	DC	EV2	EVSE2	8	Yes (3 done)	Yes	N/a	n/a	DC	EV7	EVSE14	21	Yes (5 done)	N/a	N/a
MOD4	DC	EV3	EVSE3	9	Yes (4 done)	Yes	Yes	n/a	DC	EV12	EVSE3	9	No	--	--
MOD5	DC	EV4	EVSE4	10	No	N/a	Yes	n/a	DC	EV2	EVSE4	10	Yes (6 done)	--	--
MOD6	DC	EV5	EVSE5	17	No	No	No	n/a	DC	EV10	EVSE5	17	No	Yes	Yes
MOD7	DC	EV6	EVSE6	18	Yes (4 done)	Yes	Yes	n/a	DC	EV6	EVSE16	16	No	--	N/a
MOD8	DC	EV7	EVSE7	23	No	N/a	Yes	n/a	DC	EV8	EVSE7	23	No	N/a	--
MOD9	DC	EV8	EVSE8	25	No	N/a	Yes	n/a	DC	EV9	EVSE17	25	Yes (2 done)	--	Yes
MOD10	AC	EV9	EVSE9	2	Yes (3A 0done)	Yes	No	n/a	AC	EV13	EVSE9	2	No	Yes	Yes
MOD11	AC	EV10	EVSE10	4	Yes (1A TS5, 0 d	Yes	Yes	n/a	AC	EV3	EVSE10	4	Yes (4 done)	--	--
MOD12	AC	EV11	EVSE11	15	No	N/a	No	n/a	AC	EV1	EVSE11	15	No	--	--
MOD13	DC	EV12	EVSE12	20	No	Yes	N/a	n/a							
MOD14								n/a							
MOD15								n/a							
Not Testing 1	DC	EV13	TD1	5					DC	EV5	TD1				
Not Testing 2	DC	TD2	EVSE13	19					DC	TD3	EVSE13				
Not Testing 3	DC	TD3	EVSE14	21					DC	EV15	TD6				
Not Testing 4	AC	EV14	TD4	1											
Not Testing 5	AC	EV15	TD5	11											
Not Testing 6															
Not Testing 7															

Figure 13: Moderator Tracking Sheet

4. Results and Feedback

This section covers the prescribed testing results and feedback from meta-data and test scenarios data gathered at CharIN June 2024 Testival. In total, 22 sets of meta-data were collected for the EV and EVSE meta-data detailing equipment capabilities, 43 prescribed test pairings participated in the prescribed testing program each with their own test slot meta-data, and 163 tests attempted across the six test slots that contained prescribed tests. It should be noted that the test results from this event does not fully represent the industry's current charging capabilities, as many of the equipment units are pre-production models. **This testing environment serves as a platform for prototyping new software and identifying/resolving potential issues before the equipment is widely released.**

4.1 EV and EVSE Equipment Meta Data

Collecting EV and EVSE meta-data is essential for providing context, ensuring traceability in equipment history, and ensuring accurate comparisons between different units. Further, collecting meta-data is an effective method of benchmarking capabilities of equipment attending testing events over time. Having insight on the type of equipment present at testing events also provides context for testing results and may explain why certain tests were/weren't attempted. Figures 11-17 map results from meta-data questions outlined in Figure 10 and Figure 11. Figure 16 captures a very noteworthy datapoint: that most of the equipment present at this testing event were pre-production. Figure 17 also showcases that most equipment present were capable of DIN SPEC 70121 and ISO 15118-2, however few were capable of ISO 15118-20.

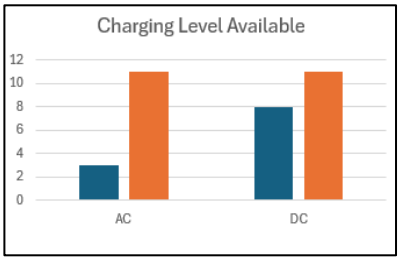


Figure 14: Charging Level Available

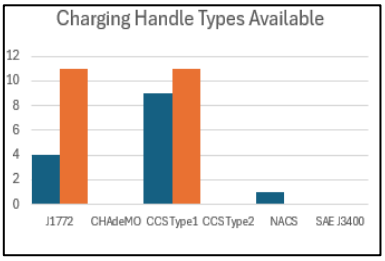


Figure 15: Charging Handles Available

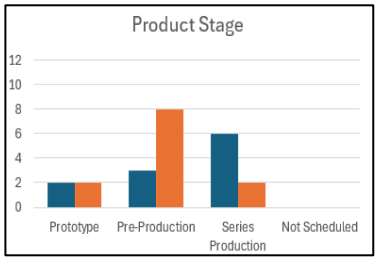


Figure 16: Product Stage

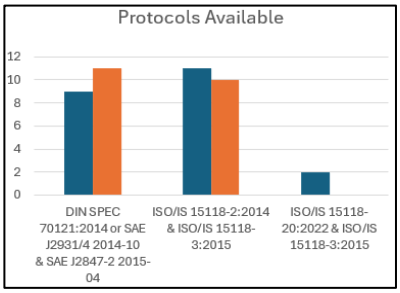


Figure 17: Protocols Available

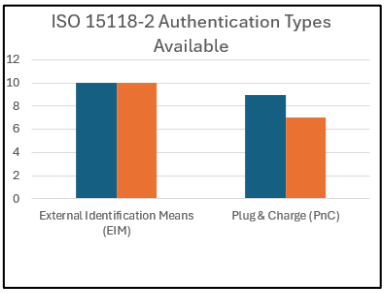


Figure 18: ISO 15118-2 Authentication Types Available

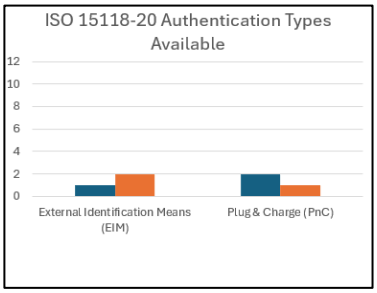


Figure 19: ISO 15118-20 Authentication Types Available

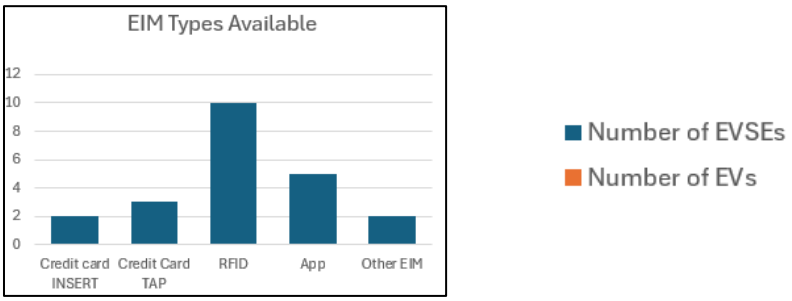


Figure 20: EIM Types Available

4.2 Testing Meta-Data

Collecting both pre-test and post-test metadata was crucial for ensuring accurate analysis and comparison, as it provided a comprehensive understanding of the testers' initial expectations and any changes or issues that occurred during testing. One example of this was tracking stated desired tests before and the actual tests attempted at the end of the testing period, which is captured in Figure 21 and Figure 22. This data highlights that several unforeseen barriers arose during testing that hindered progress such as time limits, equipment breakdown, unexpected interoperability issues between test pairings, etc.

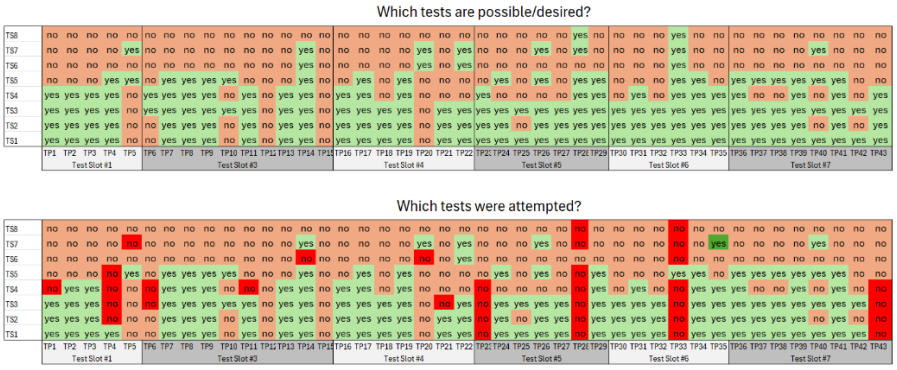


Figure 21: Tests Possible and Tests Attempted Tracking

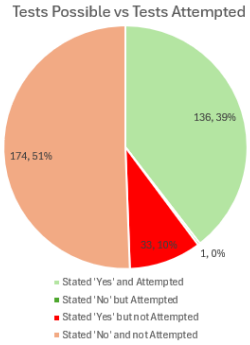


Figure 22: Tests possible vs Attempted % Breakdown

Another area of meta-data analysis examines the matchmaking process and how the decision to allow opted-in testers to perform prescribed testing with opted-out testers impacted results. Figure 23 highlights that of the 43 test pairings, nearly half (43%) were opt-ins paired with those who opted-out of the program. This willingness to participate was very impactful towards the amount of data collected on the moderation side, as well as providing the opportunity for testers to experience this prescribed testing program that did not initially sign up. Figure 24 reflects the total number of EVs and EVSEs that took part in prescribed testing who did not opt-in vs those who opted-out.

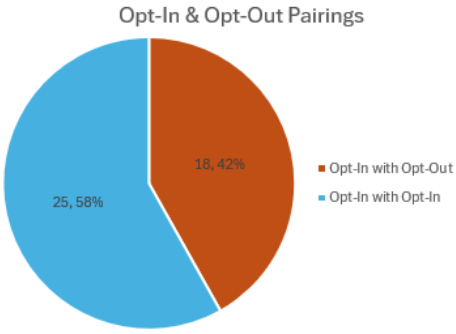


Figure 23: Opt-In and Opt-Out Test Pairings

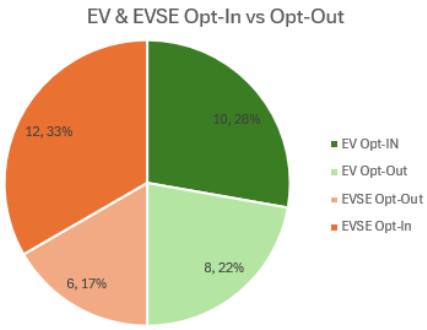


Figure 24: EV and EVSE Opt-In vs Opt-Out

4.3 Test Scenario Results

As stated, a total of 163 prescribed test program scenarios were attempted throughout the six test slots, with 112 attempts meeting all defined pass criteria. This dataset provided insights into the variety of outcomes that occurred during this testing events in terms of successes, failures, unexpected behavior, pass criteria results, general comments, etc. Figure 25 delivers a very high-level summary of the attempts vs success rate for each test scenario performed during Testival. Each of the test scenarios are detailed further within this section, covering attempt vs success rate causes and other noteworthy details/ comments.

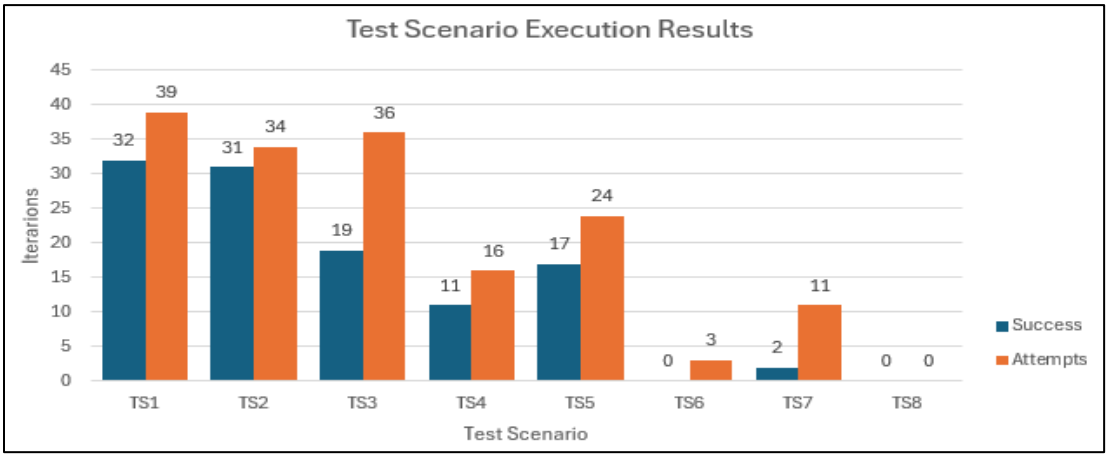


Figure 25: Test Scenario Execution High-Level Results

Test duration was another metric captured for each of the 163 test scenarios performed. TS6 and TS8 both had the lowest duration as they had little to no attempts or success. It was expected that TS3 and TS4 had the longest average and max test duration times as they are exploring timeouts. TS1 and TS2 were uniquely valuable as they represented the most common situation real-world EV drivers are expected to face (basic charge start) resulting in an average duration of 1.3 to 1.6-minutes, minimum of 0 to 60-seconds and a maximum of 4 to 5-minutes.

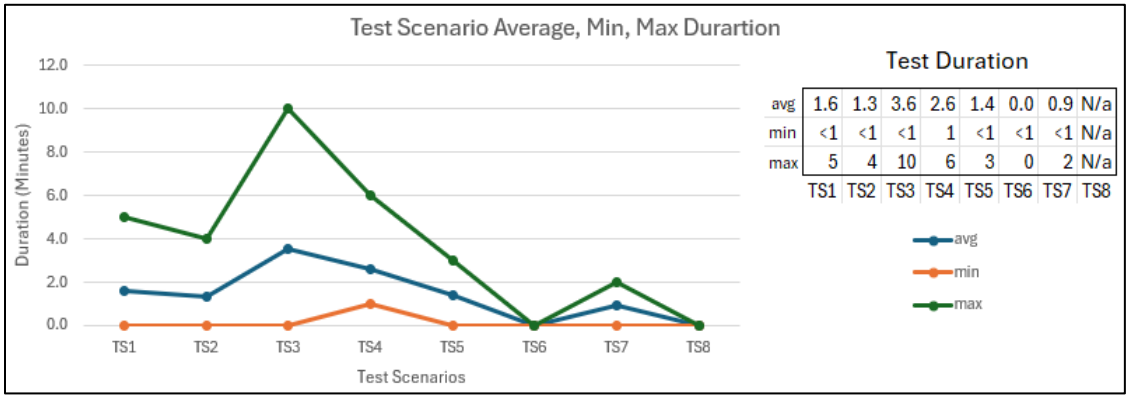


Figure 26: Test Scenario Durations - Avg, Min, Max

4.3.1 TS1 Results

Looking at *TS1: External identification means (EIM) Authentication Types after Plug-in (DIN 70121)*, a total of 39 attempts were made for plug-first charge start with 32 of those meeting all pass criteria requirements. The requirement for DIN SPEC 70121 was changed to also include J1772 for AC level 2 charging for test scenarios 1-4, which was not originally specified in their test scenario description. Even though this test specified to use "Credit Card INSERT", some testers equipment did not have this authentication method available (also reflected in Figure 20) and so other EIM types were used and noted. Of the unsuccessful attempts, some of the causes included payment error, unexpected early termination, and unexpected handle locking upon session end.

4.3.2 TS2 Results

Looking at *TS2: EIM Authentication Types before Plug-in (DIN 70121)*, a total of 34 attempts were made for authenticate-first charge start with 31 of those meeting all pass criteria requirements. TS2 had less attempts than TS1 as some of the equipment brought to Testival was not capable of authenticate-first charge start. Like TS1, this test scenario had a very high success rate and specified payment type as "Credit Card TAP" that some equipment came unequipped to handle, so other EIM methods were used instead. Of the unsuccessful attempts, the causes included payment error and control pilot signal fault.

4.3.3 TS3 Results

Looking at *TS3: Timeout after Plug-in (DIN 70121) *optional**, a total of 36 attempts were made for plug-first timeouts with 19 of those meeting all pass criteria requirements. This scenario's pass criteria specified that timeout should occur 120-seconds after plug-in if no payment was provided, however the actual results yielded a lot of variability. In some pairings the EV timed-out first, for others the EVSE timed-out first. Some of the timeout times met the expected 120-seconds, however there were others that were less than 120-seconds (60s, 70s, 90s), higher than 120-seconds (150s, 4min, 5min) or never timed-out at all. There was also quite a bit of variability in how a timeout was indicated through the EV user-interface (UI) and EVSE user-interface. Some EVSEs produced an error code indicating timeout on their UI, others threw no error and did not indicate timeout.

It should be noted that these testing results do not indicate an "equipment failure" because the resulting timeout time was higher or lower that 120-seconds, it indicates that it did not meet the pass criteria for the structure of this test scenario specifically. The purpose of this test was to quantitatively examine the difference in implementations in a rudimentary test scenario such as plug-first payment timeout.

4.3.4 TS4 Results

Looking at *TS4: Timeout after Authentication (DIN 70121),* a total of 16 attempts were made for authenticate-first timeouts with 11 of those meeting all pass criteria requirements. TS4 had a steep drop off from TS3 in terms of attempt rate, which was due to an oversight in test scenario

creation. It was realized during the execution of TS4 that this test did not involve the EV and was therefore deemed as not an interoperability test scenario. TS4 remained as an optional test for EVSEs to be performed once (as repeated tests would yield the same result). Like TS3, the attempts performed yielded a variety of results such as the expected 120-second timeouts, and some less than (55s, 60s, 90s) and more than (4min, 6min) the 120-second pass criteria. In addition, upon timeout some equipment did not indicate or throw any error codes and just returned to the "ready to charge" home screen.

4.3.5 TS5 Results

Looking at *TS5: EIM Authentication types after Plug-in (ISO 15118-2) *optional**, a total of 24 attempts were made for ISO 15118-2 using EIM with 17 of those meeting all pass criteria requirements. There was a noticeable drop-off between TS1 and TS5 when all that had changed was the communication protocol. This drop-off was due to a common issue of not being able to switch between protocols at Testival. This issue may have been impacted by inadequate prior knowledge of the prescribed test program prior to the event, which is discussed further in Section 4.4. With more equipment capable of changing protocols at testival this test may have yielded a higher attempt and success rate. Of the unsuccessful attempts for TS5, some of the causes included payment error, timeout issues, SLAC issues, and unexpected early session termination.

4.3.6 TS6 Results

Looking at *TS6: PnC with EV Contract Certificates being Expired (ISO 15118-2)*, only three attempts were made with zero of those meeting all pass criteria requirements. One factor towards this attempt and success rate outcome involved compatibility between testers equipment and Hubject's certificate platform offered to testers as a resource during CharIN June 2024 Testival. Some testers' equipment was not interoperable with Hubject's certificate structure and instead testers brought their own valid local certificates to perform Plug&charge testing. Improving the compatibility between testers and Hubject, and/or encouraging testers to bring local invalid certificates may have improved the attempt and success rate of TS6. Some testers commented that TS6 was not attempted because the team had prior knowledge that their equipment did not handle invalid certificates, and this test execution would not be an effective use of their time.

4.3.7 TS7 Results

Looking at *TS7: PnC with Valid Certificates (ISO 15118-2)*, a total of 11 attempts were made for ISO 15118-2 using Plug&charge with two of those meeting all pass criteria requirements. TS7 had a relatively low attempt and success rate. Like TS5, some testers attended Testival without the ability to change protocols or authentication methods on the fly. Like TS6, some testers' equipment was not compatible with Hubject's certificate structure and instead brought their own valid local certificates to perform Plug&charge testing. Both issues impacted the attempt rate of TS7. Of the unsuccessful attempts, some of the causes included unexpected early session

termination, HLC structure/field length compatibility issues, certificate exchange issues, missing product certificates, and HLC mismatch.

4.3.8 TS8 Results

Expectedly, *TS8: EIM Authentication types after Plug-in (ISO 15118-20)* had zero attempts, significantly less than the other test scenarios. This result was expected seeing ISO 15118-20 is a more advanced charging protocol. TS8 was included in the test plan as a "stretch-goal" test case, and as seen in Figure 17 only two participants equipment came equipped with such HLC protocol capabilities.

4.4 General Comments, Feedback and Recommendations

Overall, the prescribed testing program ran during the CharIN June 2024 Testival was a success. Achieving a sign-up rate of 22/36 opted-in testers, collecting the results of 43 unique test pairings, and receiving over 163 test scenarios results was more than was expected from ChargeX's first attempt at a prescribed testing program. The testers were very optimistic in performing prescribed testing and were willing to provide feedback wherever possible. Executing this program gave the ChargeX Consortium valuable insight into the EV charging testing space and allowed for a new hybrid ad hoc/prescribed interoperability testing event to be demonstrated. The feedback gathered from testers, observers, moderators, etc. were combined and summarized within this section.

1. **Communication Improvements**. Lack of thorough communication and promotion was a barrier during this event. Some testers in attendance had been opted-in to the prescribed testing program were not familiar with the program, test cases, structure, or ChargeX involvement whatsoever. A main cause of this was contract delays between the ChargeX Consortium and CharIN, which ultimately delayed the promotion and communication of the prescribed testing program. Improvement of communication is also encouraged at the industry level internally between management who registers equipment for events and testers who attend. Improvements could also be made between the prescribed testing program facilitators, the ChargeX Consortium, and all others involved (CharIN, Hubject, Keysight, management, and testers) to ensure expectations are set and questions clarified. This may have led to less confusion, more preparedness, and overall, a more thorough Testival experience yielding more attempts and success at test scenario execution.
2. **Preparation time.** Providing and promoting the prescribed test program details for testers more prior to the event would have given more time to ensure equipment and resources could perform tests during the event (i.e. switching between HLCs, bringing suitable Plug&charge certificates, striving for other outlined tests in the program, etc.).
3. **Rephrasing meta-data questionnaire.** Rather than gathering meta-data phrased to ask, "what this equipment is capable of" it could have been more effective to ask, "which of the following test scenarios can be completed with the current version of equipment present at Testival". Adding in more meta-data questions about capabilities and compatibilities could have also proven useful as well.

4. **Digital recording of results.** Feedback from testers was received that having physical paper versions of the test plan details (setup, steps, pass criteria, etc.) directly in front of them was desirable rather than having an electronic version. However, it was recommended that inputting test results, whether it be moderator or testers, could have been done electronically to save resources and time transferring results electronically in post. If done electronically, it was recommended to be a platform that allows for modularity, where switching between tests and attempts is seamless rather than a sequenced approach.
5. **Including test equipment/devices.** This prescribed testing program at CharIN June 2024 Testival did not allow for test equipment or devices to take part, however there were discussions around the inclusion of test equipment in future revisions. Further feedback on the subject noted that the main goal of this prescribed testing is alignment on interoperability testing between EVs and EVSEs, and with test equipment's inclusion it can begin to steer more towards conformance testing.
6. **Day 3 Dynamic Testing.** Feedback received was to consider including prescribed testing during day three of Testival which is typically dedicated to ad hoc dynamic testing. This structure would likely have followed a similar structure of an ad hoc/prescribed testing split; however, it may have introduced unknown issues without a hardened matchmaking schedule ahead of time like what was available for testing days one and two.
7. **Start with prescribed testing.** The recommendation was that the test slot could have started with prescribed testing and then used the remaining time to perform ad hoc testing, which can be advantageous. Common feedback received was that test scenarios during the prescribed testing period had already been performed earlier during ad hoc testing period, and that it was less valuable spending time repeating tests. Counter feedback discussed drawbacks to starting with prescribed testing, and that trackable testing could be derailed if an unexpected issue arises when matched with a new partner causing prescribed testing time to slip away.
8. **List of Test Scenarios to choose from.** A recommendation was that rather than a set list of tests expected to be completed in the granted prescribed testing period, a wider range of tests could have been offered to allow testers to choose which were of interest. Counter feedback discussed that there is less alignment on results tracking as fewer of the same prescribed tests would have been ran by all test pairings.
9. **Gamify prescribed testing.** Building off the previous point of having a list of test scenarios to choose from, it was discussed that gamification might be an interesting concept to create a point system for attempting more tests. Further, awarding points for more difficult tests may have incentivized testers to have their equipment perform more advanced charging features. Counter arguments discussed there could have been drawback with the idea of "competing" against other testers. Adding gamification may have incentivized testers to bring more production ready equipment and focus less on equipment/software development at Testival. This gamification approach would have required a lot of thought and tactfulness in its structure and planning if it were to be successful and stay true to the objective of CharIN Testivals.
10. **Involvement in matchmaking.** Feedback that the prescribed test program could have also involved themselves in the matchmaking process that is typically performed by the event host. This could have helped the opted-in matchmade pairings match with more opted-in testers for prescribed testing could have resulted in more prescribed tests attempted.

11. **"Pass/Fail" scheme.** Some testers were hesitant on the idea of tests results indicating a "Fail" if test pass criteria were not met. This could be reworded more carefully to specify that it did not pass this specific test scenario pass criteria but does not imply an improper implementation.
12. **Increase prescribed testing time.** Some testers commented they would have liked to have been given more prescribed testing time, while others commented they would have preferred spending less time doing prescribed testing. The ratio of ad hoc to prescribed testing is a delicate balance with industry's preferences always being considered. Additionally, some participants requested that the initial test scenario on the first day be an additional 30 mins to allow for any potential set up issues.

As usual, CharIN conducted a post-Testival survey that collected feedback from testers on their experience. This survey also contained questions pertaining to the prescribed test program led by the ChargeX Consortium around overall experience, motivations for registering, and interest towards future implementations. These results can be seen in Figure 27, where most responses indicate a favorable prescribed testing experience. It can also be seen that the rebate incentive and supporting both ChargeX and beneficial data collection were key drivers influencing participation, and that most are open to the idea of future prescribed testing programs.

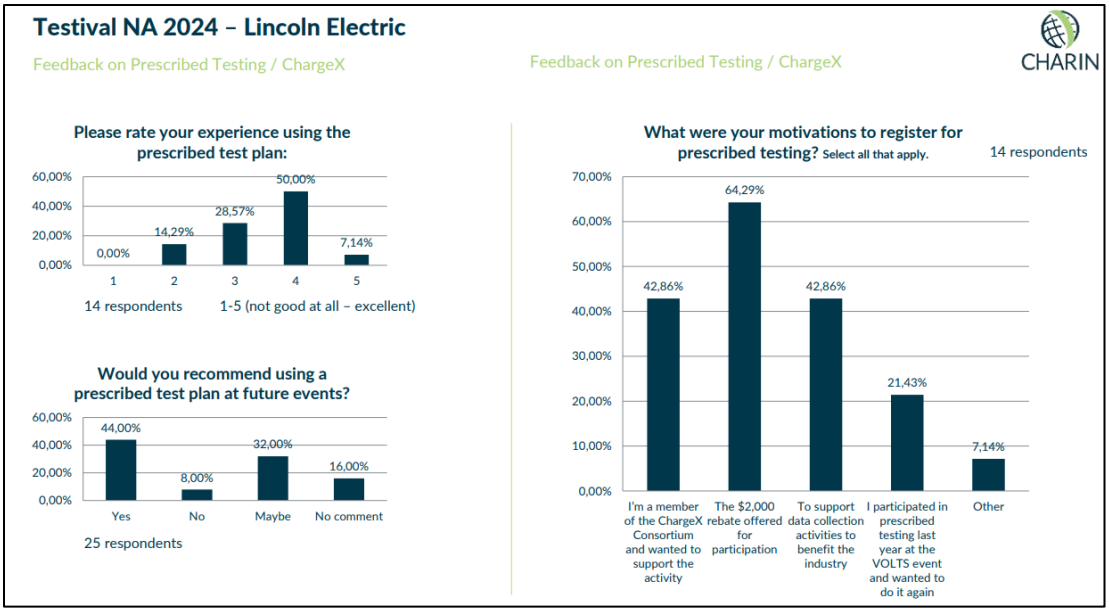


Figure 27: CharIN Survey Results for Prescribed Test Program

If future implementations of prescribed testing programs are of interest to CharIN and/or other test event hosts, it would be recommended to gather as much industry input and feedback throughout the programs' development to ensure their experience is as seamless as possible. A moderation team was very effective for ChargeX's prescribed testing program, however that may not always be feasible due to limited staffing, technical background of moderators, number of testers opted-in to the program, etc. Performing prescribed testing without a moderation force is possible but requires much communication with testers when it comes to relaying expectations for structure, test setup, cut-off criteria, and the like. Overall, prescribed testing is

a very effective means of alignment and encouragement of testing, and a hybrid approach of ad hoc and prescribed would be the most recommended approach. It is recommended that those developing their own program use this report and other test event reports as a valuable resource when it comes to understanding industry's interest and feedback towards prescribed testing.

Appendix A: ChargeX-CharIN Prescribed Test Plan

ChargeX-CharIN Prescribed Test Plan v2

Prepared By: Sam Thurston – Argonne National Laboratory

Role: ChargeX, Working Group 3, Testing TF Lead

Intended Use: During the CharIN June 2024 Testival in Cleveland, OH

Date: 06/06/2024

1. Scope of Document

This document details the conditions for the prescribed test plan scenarios to be used for the upcoming CharIN June 2024 Testival in Cleveland, OH.

2. Testing Conditions

The following outlines all details surrounding testing purposes, setup, structure, rebates, etc.

2.1 Goals

- To demonstrate the effectiveness of the *EV-EVSE Interoperability Test Plan (EEITP)* ChargeX deliverable through a subset of tests to be included in a prescribed test plan.
- To reflect industry-desirable test cases based on industry feedback throughout Testing TF meetings and the EEITP workshop hosted at Argonne National Laboratory on April 29th.
- To encourage the testing of advanced charging features such as ISO 15118-2 and ISO 15118-20 implementations, Plug&charge capabilities, authentication methods, and fallback mechanisms.
- To provide a well-structured prescribed testing approach with technical details decisions based on industry input and previous prescribed testing experiences.
- To collect comparable results through the outcomes of prescribed testing, and to benchmark the technological advancements and common issues of pre-production equipment /software from those participating in this program.

2.2 Test Participants

- This event targets manufacturers and CPOs of EVs and EVSEs capable of DC fast charging attending the CharIN Testival who have opted to participate in the prescribed testing program.
- Every participating company shall provide staff who can set up, configure, and execute the test scenarios according to the test plan and categorize potentially found interoperability issues according to the test reporting template.

2.3 Test Process

- Tests will be conducted in test couples based on a test schedule that is derived through a technical matchmaking system. This matchmaking is based on registration information and prescribed testing program signup that will be provided by each participating company before the event.
- During each test slot the registered participants will be testing in parallel to one another. Test pairings will change in Round Robin procedure between test slots according to the provided test schedule.
- A ChargeX moderator will be assigned to each test pairing during the prescribed testing period to relieve the testers from additional duties such as recording results, relaying test case steps and setup details, providing clarification, etc.
- The time breakdown between ad hoc and prescribed testing is as follows:
    - 60-minutes ad hoc, 30-minutes prescribed

- If the number of EV and EVSE pairings exceeds 15, a two-group structure will be followed. All pairings will be designated as either “Group 1” or “Group 2” for each specific timeslot. This is done to minimize the necessary ChargeX moderator work force staff. The time breakdown between ad hoc testing and prescribed testing for the two groups is as follows:
    - Group 1: 30-minutes ad hoc, 30-minutes prescribed, 30-minutes ad hoc
    - Group 2: 30-minutes ad hoc, 30-minutes ad hoc, 30-minutes prescribed
- Testers should aim to complete all included test scenarios during the prescribed testing period if they have the technical capabilities to do so. If tests scenarios were not able to be performed or completed by the end of the testing period, it should be noted in the results of that test scenario.
- Testers are not limited to the number of attempts at completing a test scenario to achieve success if desired, however it should be noted in the results section if a test was performed multiple times, as well as the issues that arose during the prior unsuccessful test attempts.

2.4 Test Report Submission

- Each test couple is required to work with their assigned moderator to submit a test report until the end of each prescribed testing period according to the method provided by ChargeX.

3. Test Scenarios

The test scenarios are designed to be completed in sequential order, with tabular details surrounding the test case description. Further details around testing setup and conditions may be provided if necessary closer to the event date. The prescribed test plan includes the following 8 test scenarios:

- TS1: EIM Authentication types after Plug-in (DIN 70121)
- TS2: EIM Authentication types before Plug-In (DIN 70121)
- TS3: Timeout after Plug-in (DIN 70121) *optional*
- TS4: Timeout after Authentication (DIN 70121)
- TS5: EIM Authentication types after Plug-in (ISO 15118-2) *optional*
- TS6: PnC with EV Contract Certificates being Expired (ISO 15118-2)
- TS7: PnC with Valid Certificates (ISO 15118-2)
- TS8: EIM Authentication types after Plug-in (ISO 15118-20)

4. Test Setup, Procedures and Results Tracking

4.1 Section A: EVSE Meta Data *complete once per EVSE equipment*

QA1: Specify Equipment Type ..... (EVSE)

QA2: Select level of charging available:
- AC Charging..... (Yes / No)
- DC Charging ..... (Yes / No)

QA3: Select charging handle types available:
- J1772 ..... (Yes / No)
- CHAdeMO..... (Yes / No)
- CCS Type 1 ..... (Yes / No)
- CCS Type 2 ..... (Yes / No)
- NACS..... (Yes / No)
- SAE J3400..... (Yes / No)

QA4: Select Product stage .....(Prototype / Pre-Production / Series Production / Not Scheduled)

QA5: Select common implemented protocols available for testing:
- DIN SPEC 70121:2014 OR SAE J2931/4 2014-10 and SAE J2847-2 2015-04..... (Yes / No)
- ISO/IS 15118-2:2014 and ISO/IS 15118-3:2015 ..... (Yes / No)
- ISO/IS 15118-20:2022 and ISO/IS 15118-3:2015 ..... (Yes / No)

QA6: Select supported ISO/IEC 15118-2 authentication types available:
- External Identification Means (EIM) ..... (Yes / No)
- Plug&charge..... (Yes / No)

QA7: Select supported ISO/IEC 15118-20 authentication types available:
- External Identification Means (EIM) ..... (Yes / No)
- Plug&charge..... (Yes / No)

QA8: Select supported ISO/IEC 15118-20 transport protocols:
- TCP (for testing only)..... (Yes / No)
- TLS 1.2 (for testing only)..... (Yes / No)
- TLS 1.3 (standard)..... (Yes / No)

QA9: Select EIM types available:
- Credit Card INSERT..... (Yes / No)
- Credit Card TAP..... (Yes / No)
- RFID..... (Yes / No)
- App..... (Yes / No)
- Other EIM _____ / No)

4.2 Section B: EV Meta Data *complete once per EV equipment*

QB1: Specify Equipment Type .....(EV)

QB2: Select level of charging available:
- AC Charging.....(Yes / No)
- DC Charging .....(Yes / No)

QB3: Select charging inlet types available:
- J1772 .....(Yes / No)
- CHAdeMO.....(Yes / No)
- CCS Type 1 .....(Yes / No)
- CCS Type 2 .....(Yes / No)
- NACS.....(Yes / No)
- SAE J3400.....(Yes / No)

QB4: Select Product stage.....(Prototype / Pre-Production / Series Production / Not Scheduled)

QB5: Select common implemented protocols available for testing:
- DIN SPEC 70121:2014 OR SAE J2931/4 2014-10 and SAE J2847-2 2015-04.....(Yes / No)
- ISO/IS 15118-2:2014 and ISO/IS 15118-3:2015 .....(Yes / No)
- ISO/IS 15118-20:2022 and ISO/IS 15118-3:2015 .....(Yes / No)

QB6: Select supported ISO/IEC 15118-2 authentication types available:
- External Identification Means (EIM) .....(Yes / No)
- Plug&charge.....(Yes / No)

QB7: Select supported ISO/IEC 15118-20 authentication types available:
- External Identification Means (EIM) .....(Yes / No)
- Plug&charge.....(Yes / No)

QB8: Select supported ISO/IEC 15118-20 transport protocols:
- TCP (for testing only).....(Yes / No)
- TLS 1.2 (for testing only).....(Yes / No)
- TLS 1.3 (standard).....(Yes / No)

4.3 Section C: Test Slot Meta Data *complete every Test Slot*

4.3.1.1 Pre-test data

QA1: Test Slot Number _____

QA2: Moderator Name _____

QA3: Prescribed Testing Start Time _____

QA4: EVSE enrolled in Prescribed Testing .....(Yes / No)

QA5: EV enrolled in Prescribed Testing.....(Yes / No)

QA6: The following has been reviewed with testers .....(Yes / No)

- List of test scenarios
    - Desired or possible tests for testing pair (recommend all 8 is possible)
    - Remind how long per test that equates to (30min ÷ #tests)
- Structure of test scenarios:
    - Test purpose, preconditions, steps, pass criteria, results tracking, etc.
- EVSE Meta Data collected.
- EV Meta Data collected.
- Even if tests have already been completed in ad hoc, instruct to re-perform them now during prescribed testing (time taken to complete, are steps accurate, feedback on pass criteria, etc).
- Any additional open questions

QA7: Which tests desired/possible.....(TS1 / TS2 / TS3 / TS4 / TS5 / TS6 / TS7 / TS8)

- Float moderator will go around to each pairing at start of session to record who is attempting PnC testing. He will let Hubject team know which require expired EV certificates and will begin issuing

4.3.1.2 Post-test data

QA8: Number of tests attempted _____

QA9: Which tests attempted (circle) .....(TS1 / TS2 / TS3 / TS4 / TS5 / TS6 / TS7 / TS8)

QA10: Any outstanding issues _____

QA11: Tester1 comments _____

_____

QA12: Tester2 comments _____

_____

QA13: Moderator comments _____

_____

_____

4.4 Section D: Test Scenarios

4.4.1 TS1: EIM Authentication Types after Plug-in (DIN 70121)

Table 5: TS1 Test Setup and Procedure

Test Identifier:	TS1			
Test Name:	EIM Authentication Types after Plug-in (DIN 70121)			
Test Type:	Intentional Charging			
Test Category:	Authentication Types, Methods and Timeouts			
Purpose:	To ensure "Plug-first" option is available. To ensure alternative authentication methods are accepted.			
Pre-Test Conditions:	Authentication Type (choose):	• Credit Card INSERT • ~~Credit Card TAP~~ • ~~RFID~~ • ~~App~~ • ~~Other EIM~~		
	Plug-in or authenticate first:	Plug-in		
	Communication protocol:	DIN 70121		
	Involved Systems:	EV, EVSE		
Steps:	1	Set EVSE authentication option to '**Authentication Type'.**		
	2	Plug-in EV.		
	3	Within 30 seconds, provide '**Authentication Type'.**		
	4	Observe session initialization into power transfer.		
	5	Terminate charge session 30-60 seconds into power transfer.		
	6	Unplug EV.		
Pass Criteria:	1.Plug-first method is accepted.		Pass	Fail
	2.Authentication type is accepted.		Pass	Fail
	3.Session initialization begins and reaches power transfer stage.		Pass	Fail
Observed Metrics:	Session initialization stages			
Intended MRECs/Errors:	None			
Possible MRECs/Errors:	"Payment Failure", "AuthorizationTimeout", "Invalid Sequence"			
Recorded Test Results:	• Pass/Fails. • Point of failure (if applicable)			

Table 6: TS1 Results Tracking

TS1Q1: Test attempt number	1	2	3
TS1Q2: Test start time			
TS1Q3: Test end time			
TS1Q4: All pass criteria met? (Y/N)			
TS1Q5: Which pass criteria not met			
TS1Q6: Point of failure			
TS1Q7: If test not attempted, why?			
TS1Q8: Comments			

4.4.2 TS2: EIM Authentication Types before Plug-In (DIN 70121)

Table 7: TS2 Test Setup and Procedure

Test Identifier:	TS2			
Test Name:	EIM Authentication Types before Plug-in (DIN 70121)			
Test Type:	Intentional Charging			
Test Category:	Authentication Types, Methods and Timeouts			
Purpose:	To ensure "Authenticate-first" option is available. To ensure alternative authentication methods are accepted.			
Pre-Test Conditions:	Authentication Type (choose):	• ~~Credit Card INSERT~~ • Credit Card TAP • ~~RFID~~ • ~~App~~ • ~~Other EIM~~		
	Plug-in or authenticate first:	Authenticate		
	Communication protocol:	DIN 70121		
	Involved Systems:	EV, EVSE		
Steps:	1	Set EVSE authentication option to '**Authentication Type'.**		
	2	Provide '**Authentication Type'.**		
	3	Within 30 seconds, Plug-in EV.		
	4	Observe session initialization into power transfer.		
	5	Terminate charge session 30-60 seconds into power transfer.		
	6	Unplug EV.		
Pass Criteria:	Authentication-first method is accepted.		Pass	Fail
	Authentication method is accepted.		Pass	Fail
	Session initialization begins and reaches power transfer stage.		Pass	Fail
Observed Metrics:	Session initialization stages			
Intended MRECs/Errors:	None			
Possible MRECs/Errors:	"Payment Failure", "AuthorizationTimeout", "Invalid Sequence"			
Recorded Test Results:	• Pass/Fails. • Point of failure (if applicable)			

Table 8: TS2 Results Tracking

TS2Q1: Test attempt number	1	2	3
TS2Q2: Test start time			
TS2Q3: Test end time			
TS2Q4: All pass criteria met? (Y/N)			
TS2Q5: Which pass criteria not met			
TS2Q6: Point of failure			
TS2Q7: If test not attempted, why?			
TS2Q8: Comments			

4.4.3 TS3: Timeout after Plug-in (DIN 70121) *optional*

Table 9: TS3 Test Setup and Procedures

Test Identifier:	TS3				
Test Name:	Timeout after Plug-in (DIN 70121)				
Test Type:	Timeouts				
Test Category:	Authentication Types, Methods and Timeouts				
Purpose:	To test for "provide authentication" timeout time. To ensure clear instructions are delivered to EV driver upon timeout. To ensure "AuthorizationTimeout" MREC is produced from timeout (Optional).				
Pre-Test Conditions:	Authentication Type (choose):		• ~~Credit Card INSERT~~ • ~~Credit Card TAP~~ • ~~RFID~~ • ~~App~~ • ~~Other EIM~~		
	Plug-in or authenticate first:		Plug-in		
	Communication protocol:		DIN 70121		
	Involved Systems:		EV, EVSE		
Steps:	1	Set EVSE authentication option to '**Authentication Type'.**			
	2	Plug-in EV.			
	3	Do not provide **'Authentication Type'**, wait 2.5-minutes or until timeout.			
	4	Upon timeout, log timeout time, log EV and EVSE instructions for user after timeout			
	5	Unplug EV.			
Pass Criteria:	Timeout occurs.			Pass	Fail
	User is prompted with instructions through EV and/or EVSE after timeout.			Pass	Fail
Observed Metrics:	EVSE user interface, EV user interface, Time after plug-in				
Intended MRECs/Errors:	"AuthorizationTimeout"				
Possible MRECs/Errors:	"Payment Failure"				
Recorded Test Results:	• Pass/Fails. • Session timeout time. • Instructions after timeout, where they were provided. • Point of failure (if applicable)				

Table 10: TS3 Results Tracking

TS3Q1: Test attempt number	1	2	3
TS3Q2: Test start time			
TS3Q3: Test end time			
TS3Q4: All pass criteria met? (Y/N)			
TS3Q5: Which pass criteria not met			
TS3Q6: Point of failure			
TS3Q7: If test not attempted, why?			
TS3Q8: Comments			

4.4.4 TS4: Timeout after Authentication (DIN 70121)

Table 11: TS4 Test Setup and Procedures

Test Identifier:	TS4			
Test Name:	Timeout after Authentication (DIN 70121)			
Test Type:	Timeouts			
Test Category:	Authentication Types, Methods and Timeouts			
Purpose:	To test for "provide plug-in" timeout time. To ensure clear instructions are delivered to EV driver upon timeout. To ensure "AuthorizationTimeout" MREC is produced from timeout (Optional).			
Pre-Test Conditions:	Authentication Type (choose):	• ~~Credit Card INSERT~~ • ~~Credit Card TAP~~ • ~~RFID~~ • App • ~~Other EIM~~		
	Plug-in or authenticate first:	Authenticate		
	Communication protocol:	DIN 70121		
	Involved Systems:	EV, EVSE		
Steps:	1	Set EVSE authentication option to '**Authentication Type'.**		
	2	Provide **'Authentication Type'**.		
	3	Do not plug-in, wait 2.5-minutes or until timeout.		
	4	Upon timeout, log timeout time, log EV and EVSE instructions for user after timeout		
	5	Unplug EV.		
Pass Criteria:	Timeout occurs.		Pass	Fail
	User is prompted with instructions through EV and/or EVSE after timeout.		Pass	Fail
Observed Metrics:	EVSE user interface, EV user interface, Time after authentication			
Intended MRECs/Errors:	""AuthorizationTimeout"			
Possible MRECs/Errors:	"Plug-in Failure"			
Recorded Test Results:	• Pass/Fails. • Session timeout time. • Instructions after timeout, where they were provided. • Point of failure (if applicable)			

Table 12: TS4 Results Tracking

TS4Q1: Test attempt number	1	2	3
TS4Q2: Test start time			
TS4Q3: Test end time			
TS4Q4: All pass criteria met? (Y/N)			
TS4Q5: Which pass criteria not met			
TS4Q6: Point of failure			
TS4Q7: If test not attempted, why?			
TS4Q8: Comments			

4.4.5 TS5: EIM Authentication types after Plug-in (ISO 15118-2) *optional*

Table 13: TS5 Test Setup and Procedure

Test Identifier:	TS5			
Test Name:	EIM Authentication Types after Plug-in (ISO 15118-2)			
Test Type:	Intentional Charging			
Test Category:	Authentication Types, Methods and Timeouts			
Purpose:	To ensure "Plug-first" option is available. To ensure alternative authentication methods are accepted. To ensure ISO 15118-2 session initialization is functional.			
Pre-Test Conditions:	Authentication Type (choose):	• Credit Card INSERT • Credit Card TAP • RFID • App • Other EIM		
	Plug-in or authenticate first:	Plug-in		
	Communication protocol:	ISO 15118-2 (TLS or No-TLS)		
	Involved Systems:	EV, EVSE		
Steps:	1	Set EVSE authentication option to '**Authentication Type'.**		
	2	Plug-in EV.		
	3	Within 30 seconds, provide '**Authentication Type'.**		
	4	Observe session initialization into power transfer.		
	5	Terminate charge session 30-60 seconds into power transfer.		
	6	Unplug EV.		
Pass Criteria:	Plug-first method is accepted.		Pass	Fail
	Authentication method is accepted.		Pass	Fail
	Session initialization begins and reaches power transfer stage.		Pass	Fail
Observed Metrics:	Session initialization stages			
Intended MRECs/Errors:	None			
Possible MRECs/Errors:	"Payment Failure", "AuthorizationTimeout", "Invalid Sequence"			
Recorded Test Results:	• Pass/Fails. • Authentication type used. • TLS or No-TLS used. • Point of failure (if applicable)			

Table 14: TS5 Results Tracking

TS5Q1: Test attempt number	1	2	3
TS5Q2: Test start time			
TS5Q3: Test end time			
TS5Q4: All pass criteria met? (Y/N)			
TS5Q5: Which pass criteria not met			
TS5Q6: Point of failure			
TS5Q7: If test not attempted, why?			
TS5Q8: Comments			

4.4.6 TS6: PnC with EV Contract Certificates being Expired (ISO 15118-2)

Table 15: TS6 Test Setup and Procedure

Test Identifier:	TS6			
Test Name:	PnC with EV Contract Certificates having Incorrect Fields (ISO 15118-2)			
Test Type:	Fallback methods			
Test Category:	Single PKI: Basic Certificate Validity Testing			
Purpose:	To ensure Plug&charge functionality fails with invalid certificates (expired). To ensure fallback method to EIM functions properly.			
Pre-Test Conditions:	Authentication Type (choose):	1. Plug and Charge (PnC) 2. Other EIM		
	Communication protocol:	ISO 15118-2 (TLS or No-TLS)		
	Involved Systems:	EV, EVSE, ProvServ		
	EV Provisioning certificate	Valid	n/a	
	EV Contract certificate	Invalid	Expired 'After' date	
	EVSE Contract certificate	Valid	n/a	
	ProvServ Contract certificate	Valid	n/a	
	Fallback method	EIM (ISO 15118-2 or DIN 70121)		
Steps:	1	Ensure EV Provisioning certificate is valid.		
	2	Ensure EV Contract certificate is expired (Bring EV PCID to Hubject team and request expired EV cert).		
	3	Ensure EVSE Contract certificate is valid (Bring EVSE PCID to Hubject team and request valid EVSE cert).		
	4	Ensure Provisioning Service Contract certificate is valid.		
	5	Set EVSE authentication option to '**Authentication Type'**.		
	6	Plug-in EV.		
	7	Observe fallback to EIM after PnC failure.		
	8	Provide '**Authentication Type**'.		
	9	Observe session initialization into power transfer.		
	10	Terminate charge session 30-60 seconds into power transfer.		
	11	Unplug EV.		
Pass Criteria:	Plug&charge method is not accepted due to invalid certificate.		Pass	Fail
	Session initialization fallback method to EIM functions correctly.		Pass	Fail
Observed Metrics:	Session initialization stages, HLC Messages			
Intended MRECs/Errors:	None			
Possible MRECs/Errors:	"Invalid Certificate", "Payment Failure"			
Recorded Test Results:	• Pass/Fails. • HLC protocol for Fallback method • TLS or No-TLS used. • Point of failure (if applicable)			

Table 16: TS6 Results Tracking

TS6Q1: Test attempt number	1	2	3
TS6Q2: Test start time			
TS6Q3: Test end time			
TS6Q4: All pass criteria met? (Y/N)			
TS6Q5: Which pass criteria not met			
TS6Q6: Point of failure			
TS6Q7: If test not attempted, why?			
TS6Q8: Comments			

4.4.7 TS7: PnC with Valid Certificates (ISO 15118-2)

Table 17: TS7 Test Setup and Procedure

Test Identifier:	TS7			
Test Name:	PnC with Valid Certificates (ISO 15118-2)			
Test Type:	Intentional Charging			
Test Category:	Single PKI: Basic Certificate Validity Testing			
Purpose:	To ensure Plug&charge functionality works with valid certificates.			
Pre-Test Conditions:	Authentication Type (choose):	• Plug and Charge (PnC)		
	Communication protocol:	ISO 15118-2 (TLS or No-TLS)		
	Involved Systems:	EV, EVSE, ProvServ		
	EV Provisioning certificate	Valid	n/a	
	EV Contract certificate	Valid	n/a	
	EVSE Contract certificate	Valid	n/a	
	ProvServ Contract certificate	Valid	n/a	
	Fallback method	n/a		
Steps:	1	Ensure EV Provisioning certificate is valid.		
	2	Ensure EV Contract certificate is valid. (Bring EV PCID to Hubject team and request valid EV cert).		
	3	Ensure EVSE Contract certificate is valid. (Bring EVSE PCID to Hubject team and request valid EVSE cert).		
	4	Ensure Provisioning Service Contract certificate is valid.		
	5	Set EVSE authentication option to '**Authentication Type'**.		
	6	Plug-in EV		
	7	Observe session initialization into power transfer.		
	8	Terminate charge session 30-60 seconds into power transfer.		
	9	Unplug EV.		
Pass Criteria:	Plug&charge method is accepted.		Pass	Fail
	Session initialization begins and reaches power transfer stage.		Pass	Fail
Observed Metrics:	Session initialization stages, HLC Messages			
Intended MRECs/Errors:	None			
Possible MRECs/Errors:	"Invalid Certificate", "Payment Failure"			
Recorded Test Results:	• Pass/Fails. • TLS or No-TLS used. • Point of failure (if applicable)			

Table 18: TS7 Results Tracking

TS7Q1: Test attempt number	1	2	3
TS7Q2: Test start time			
TS7Q3: Test end time			
TS7Q4: All pass criteria met? (Y/N)			
TS7Q5: Which pass criteria not met			
TS7Q6: Point of failure			
TS7Q7: If test not attempted, why?			
TS7Q8: Comments			

4.4.8 TS8: EIM Authentication types after Plug-in (ISO 15118-20)

Table 19: TS8 Test Setup and Procedure

Test Identifier:	TS9			
Test Name:	EIM Authentication Types after Plug-in (ISO 15118-20)			
Test Type:	Intentional Charging			
Test Category:	Authentication Types, Methods and Timeouts			
Purpose:	To ensure "Plug-first" option is available. To ensure alternative authentication methods are accepted. To ensure ISO 15118-20 session initialization is functional.			
Pre-Test Conditions:	Authentication Type (choose):	• Credit Card INSERT • Credit Card TAP • RFID • App • Other EIM		
	Plug-in or authenticate first:	Plug-in		
	Communication protocol:	ISO 15118-20 (TLS or No-TLS)		
	Involved Systems:	EV, EVSE		
Steps:	1	Set EVSE authentication option to '**Authentication Type'.**		
	2	Plug-in EV.		
	3	Within 30 seconds, provide '**Authentication Type'.**		
	4	Observe session initialization into power transfer.		
	5	Terminate charge session 30-60 seconds into power transfer.		
	6	Unplug EV.		
Pass Criteria:	Plug-first method is accepted.		Pass	Fail
	Authentication method is accepted.		Pass	Fail
	Session initialization begins and reaches power transfer stage.		Pass	Fail
Observed Metrics:	Session initialization stages			
Intended MRECs/Errors:	None			
Possible MRECs/Errors:	"Payment Failure", "AuthorizationTimeout", "Invalid Sequence"			
Recorded Test Results:	• Pass/Fails. • Authentication type used. • TLS or No-TLS used. • Point of failure (if applicable)			

Table 20: TS8 Results Tracking

TS8Q1: Test attempt number	1	2	3
TS8Q2: Test start time			
TS8Q3: Test end time			
TS8Q4: All pass criteria met? (Y/N)			
TS8Q5: Which pass criteria not met			
TS8Q6: Point of failure			
TS8Q7: If test not attempted, why?			
TS8Q8: Comments			

CHARGEX
consortium

About the ChargeX Consortium

The National Charging Experience Consortium (ChargeX Consortium) is a collaborative effort between Argonne National Laboratory, Idaho National Laboratory, National Renewable Energy Laboratory, electric vehicle charging industry experts, consumer advocates, and other stakeholders. Funded by the Joint Office of Energy and Transportation, the ChargeX Consortium's mission is to work together to measure and significantly improve public charging reliability and usability by June 2025. For more information, visit chargex.inl.gov.

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