DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof. Reference herein to any social initiative (including but not limited to Diversity, Equity, and Inclusion (DEI); Community Benefits Plans (CBP); Justice 40; etc.) is made by the Author independent of any current requirement by the United States Government and does not constitute or imply endorsement, recommendation, or support by the United States Government or any agency thereof.

RECOMMENDATIONS FOR MINIMUM REQUIRED DIAGNOSTICS INFORMATION

for Electric Vehicle Charging Infrastructure

CHARGEX consortium

JANUARY 2025

INL/RPT-25-82628

Argonne NATIONAL LABORATORY

Idaho National Laboratory

NREL Transforming ENERGY

DISCLAIMER

This report was prepared for the U.S. Department of Energy under DOE Idaho Operations Office Contract No: AC07-05ID14517, U.S. Department of Energy M&O Contract No: DE-AC36-08GO28308, and U.S. Department of Energy Office of Science Laboratory Contract No: DE-AC02-06CH11357. Funding was provided by the Joint Office of Energy and Transportation.

Revision Log

Version Date	Description	Author
09.23.2024	Preliminary version released to members of the ChargeX Diagnostics Task Force	All authors and contributors
01.08.2025	Public release version	All authors and contributors

Table of Contents

List of Figures

List of Tables

List of Acronyms

Acronym	Description
EV	Electric Vehicle
EVCC	Electric Vehicle Communication Controller
EVSE	Electric Vehicle Supply Equipment
ISO	International Standards Organization
MRDI	Minimum Required Diagnostic Information
MREC	Minimum Required Error Code
OCPP	Open Charge Point Protocol

Authors

Maria Eduarda Montezzo Coelho[1], Benny Varghese, Mayuresh Savargaonkar (Idaho National Laboratory).

Acknowledgements

The authors would like to acknowledge contributions and feedback from OEM representatives who participated in the Diagnostics Task Force meetings.

[1]MariaEduarda.MontezzoCoelho@inl.gov

1. Introduction

The rapid growth of electrified transportation, including light- and medium-duty electric vehicles (EVs) as a mobility solution requires a reliable EV-charging infrastructure. To advance charging reliability, the ChargeX Consortium reports "Recommendations for Minimum Required Error Codes for Electric Vehicle Charging Infrastructure"[2] and "Implementation Guide for Minimum Required Error Codes in Electric Vehicle Charging Infrastructure"[3] provided recommendations for a set of minimum required error codes (MRECs), their functional and responsibility classifications, and a guide for their implementation, using Open Charge Point Protocol (OCPP) versions 1.6J[4] and 2.0.1.[5] These reports outline a recommended practice for consistent error reporting and interpretation, which is essential for communicating issues uniformly across the complex and diverse EV-charging ecosystem. However, MRECs are just one part of diagnosing issues; another critical part is obtaining enough information about the current state and performance of the various charging components to identify root causes for each of the error codes. This additional diagnostics data can be used by technicians or automated systems to understand the context around an issue, allowing for timely resolution, decreased maintenance costs, and increased charging reliability. During everyday operations, data are regularly collected and analyzed across the ecosystem.[65] Although sharing of all that available data would be great for diagnostics, concerns on data ownership, privacy, and original equipment manufacturer (OEM) intellectual property pose a challenge. To overcome this obstacle, this report proposes a set of minimum required diagnostic information (MRDI) and recommends that the industry implement these uniformly across the North American EV charging ecosystem. MRDI provides a means to exchange only data deemed necessary for root cause determination.

1.1. Approach to Diagnostics Information Sharing

The ChargeX Consortium responsibility classification of MRECs suggests that multiple error codes require resolution measures to be initiated by EVs, EV supply equipment (EVSE), or both. Therefore, it is critical that the MRDI packet includes co-identification data to accurately identify a charging session for diagnostic purposes. Co-identification captures a comprehensive view of EV and EVSE interactions (e.g., connector type, communication protocol used, last firmware update) which enables a better understanding of the context surrounding a charging failure, facilitating fast and accurate troubleshooting. In addition, we recommend the MRDI packet includes general details related to the system state and specific error codes and would include additional information that relates to each error code appearing in the session. Error information (e.g., timestamp, system state during error, error count) provides an overview of the types of errors and their order of occurrence. The MRDI packet also includes additional information either from OCPP or International Standards Organization (ISO) 15118 protocols that can provide detailed insight into a specific error code being reported and help identify the root cause. Figure 1 shows the MRDI packet structure for EV and EVSE, with nested information fields for co-identification, error information, and additional information.

[2] https://inl.gov/content/uploads/2023/07/ChargeX_MREC_Rev5_09.12.23.pdf
[3] https://inl.gov/content/uploads/2023/07/ChargeX_ImplementationGuide_09.29.23.pdf
[4] https://www.openchargealliance.org/protocols/ocpp-16/
[5] https://www.openchargealliance.org/protocols/ocpp-201/
[6] https://www.sae.org/standards/content/smsolutions0123/

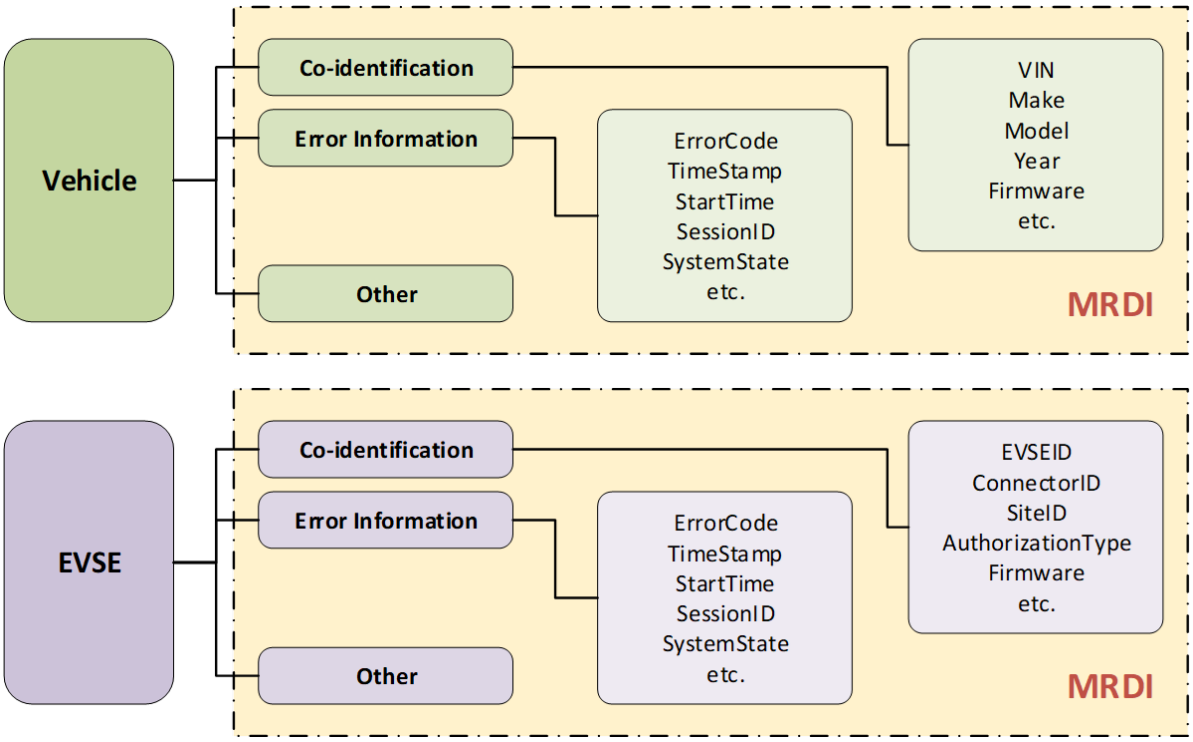

Figure 1. MRDI packet structure.

1.2. Scope

The scope of this report is limited to defining MRDI to be shared between EV and EVSE. Sharing of MRDI with other major stakeholders in the North American EV charging ecosystem (e.g., electric mobility service provider) will be addressed in future work. Recommendation of variables to be included in an EV MRDI packet is limited to ISO 15118[7] communication-protocol definitions. ISO 15118 is an international standard that defines how EVs communicate with EVSE. The standard covers a variety of charging methods, including alternating current, direct current (DC), wireless, and pantograph. This report is limited to DC charging. The recommended variables for an EVSE MRDI packet are based on available messages in OCPP, version 2.0.1, a communication protocol between charging stations and EVSE. Industry-wide consensus on OCPP and ISO communication protocols can potentially improve broader MRDI adoption within the charging ecosystem. Extensible Supply Equipment Communication Controller (SECC) Discovery Protocol (ESDP) and the Event Notification Protocol are possible avenues for information exchange between the Electric Vehicle Communication Controller (EVCC) and SECC.

[7] https://www.iso.org/standard/55365.html

2. Minimum Required Diagnostics Information

2.1. Co-Identification Data Fields

Table 1. presents the proposed minimum set of required diagnostic information relating to co-identification, along with the corresponding variables for EV and EVSE MRDI reporting. These variables were chosen to provide technicians or automated systems with the minimum data necessary to understand the context surrounding an issue.

Table 1. Co-identification MRDI data fields.

Data Field	EVSE MRDI	EV MRDI
Timestamp	TxCtrlr component—TxStartPoint variable AND TxCtrlr component—TxStopPoint variable AND MRDI creation date-time in ISO 8601 format	SessionSetupRes message—EVSETimeStamp field AND SessionStopReq message timestamp AND MRDI creation date-time in ISO 8601 format
Geolocation	Lat/long—reference + offset + level following conventions specified in OCPI[7][8]	GPS—only available when authorized by EV user
Entity Tag	EVSE component—ISO15118EvseId variable (SECCID) AND EVSE make, model, and year	Partial VIN, SessionSetupReq message—EVCCID field (MAC)
Firmware	Controller component—FirmwareVersion variable	EVCCSoftwareVersion (in upcoming ISO 15118-200)
Connector Id	TransactionEvent	NA
Session Identifier	StartTransactionRequest message—Transaction Id field	SessionSetupReq message—Header field—SessionID field
Protocol Used in Session	Connector component—ChargeProtocol variable	supportedAppProtocolReq message—AppProtocol field
Token Type	(PnC/EIM) AuthCtrlr and ISO15118Ctrlr	AuthorizationReq message—SelectedAuthorizationService field, AuthorizationMethod in ESDP Extensions HLC

[8]https://evroaming.org/ocpi/

2.2. Error Data Fields

Table 2 presents the proposed minimum set of required diagnostic information relating to a charging failure, along with the corresponding variables for EV and EVSE MRDI reporting. These variables were chosen to provide technicians or automated systems with the minimum data necessary to understand the issue, its timing, and overall system state.

Table 2. Error MRDI data fields.

Data Field	EVSE MRDI	EV MRDI
System State During Error	TransactionEventRequest message—ChargingStateEnumType at MREC timestamp	ChargeParameterDiscoveryReq message—DC_EVChargeParameter field—DC_EVStatus field
Error Count	Not currently supported in standards, but recommended to obtain information on how many recurring errors and how many unique errors	Not currently supported in standards, but recommended to obtain information on how many recurring errors and how many unique errors
Error Codes	NotifyEventRequest message—techCode field	DC_EVStatus—DC_EVErrorCode

2.3. Additional Error Information

Table 3 presents the proposed minimum set of required diagnostic information relating to a specific error code, along with the corresponding variables for EV and EVSE MRDI reporting. These variables were chosen to provide technicians or automated systems with the minimum data necessary to understand the current state and performance of the various charging components relating to the error code.

Table 3. Additional error-information MRDI data fields.

Error Code	EVSE MRDI	EV MRDI
ConnectorLockFailure	EVRetentionLock status	DC_CableCheckReq/Res
GroundFailure	RCD	EVSEIsolationStatus
HighTemperature	TemperatureSensor	NA
OverCurrentFailure	OverCurrentProtection AND stoppedReason from TransactionEventRequest	CurrentDemandReq/Res
OverVoltage	ControlMetering AND MeterValuesRequest, Voltage at location = Outlet and evseId > 0	MeteringReceiptReq/Res, PreChargeReq/Res
UnderVoltage	ControlMetering AND MeterValuesRequest, Voltage at location = Outlet and evseId > 0	MeteringReceiptReq/Res, PreChargeReq/Res
WeakSignal	DataLink	NA
EmergencyStop	EmergencyStopSensor	NA

Error Code	EVSE MRDI	EV MRDI
AuthorizationTimeout	AuthCtrlr Timeout, TokenReader	AuthorizationReq/Res
InvalidVehicleMode	ConnectedEV, ISO15118Ctrlr	EVErrorCodeType, FAILED_EVShiftPosition
CableCheckFailure	RCD	DC_CableCheckReq/Res
PreChargeFailure	ControlMetering AND MeterValuesRequest, Voltage at location = Outlet and evseId > 0	DC_PreChargeReq/Res
NoInternet	DataLink	NA
PilotFault	CPPWMController	DC_CableCheckReq/Res
PowerLoss	ControlMetering AND MeterValuesRequest, Voltage at location = Inlet and evseId = 0	NA
EVContactorFault	NA	PowerDeliveryReq/Res
EVSEContactorFault	PowerContactor	NA
CableOverTempDerate	TemperatureSensor, AirCoolingSystem, LiquidCoolingSystem, ControlMetering	NA
CableOverTempStop	TemperatureSensor, AirCoolingSystem, LiquidCoolingSystem	DC_EVStatusType, EVErrorCode
PartialInsertion	ConnectorPlugRetentionLock, LockFailure	DC_CableCheckReq/Res
CapacitanceFault	RCD, StatusNotification, Capacitance measurement	EVSEIsolationStatus, EVSEStatusCodeType, EVSE_IsolationMonitoringActive
ResistanceFault	RCD, StatusNotification, Resistance measurement	EVSEIsolationStatus, EVSEStatusCodeType, EVSE_IsolationMonitoringActive
ProximityFault	StatusNotification, Proximity voltage measurement	DC_CableCheckReq/Res
ConnectorVoltageHigh	BayOccupancySensor, ControlMetering, MeterValuesRequest, Voltage at location = Outlet and evseId > 0	NA
BrokenLatch	ConnectorPlugRetentionLock, LockFailure, Proximity voltage measurement	NA
CutCable	CableBreakawaySensor, cable TemperatureSensor	NA

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**.

JANUARY 2025

INL/RPT-25-82628

Argonne NATIONAL LABORATORY

INL Idaho National Laboratory

NREL Transforming ENERGY