هيئة تنظيم الخدمات العامة
Authority for Public Services Regulation

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Charging of Electric Vehicles in Oman

Technical Requirements Guidelines

July 2023

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Table of contents

1. Introduction / Scope

This document provides technical requirement guidelines for charging stations for Electric Vehicles (EV), including (plug-in) electric passenger cars, motorcycles, minibuses and vans in Oman. The document's scope includes EV charging stations for residential, commercial and public environment[1], for both AC (typically 'slow') and DC (typically 'fast') conductive EV charging.

The aim of these technical requirement guidelines is to provide specific guidance and requirements for the equipment and installation of EV charging stations. These technical requirement guidelines are in addition to and shall not contradict with the Oman legislation, regulation and standards, regional (Gulf) standards and international standards, which is further clarified in chapter 2. Chapter 3 explains that this document applies the terminology defined Oman legislation, regulation and standards and in international standards.

International standards[2] define four charging modes (Mode 1 to Mode 4). Chapter 4 and chapter 5 specify that Mode 1 charging is not allowed in Oman and that Mode 2 EV charging shall only be applied for charging incidentally with limited power and for limited time. Mode 3 and Mode 4 are the preferred charging modes in Oman. Mode 3 and 4 charging stations are permanently connected to the electricity network, directly or via electrical installations in buildings. For 'slow' AC charging (Mode 3, typically applied in homes or offices), guidelines are described in chapter 6. For 'fast' DC charging (Mode 4), chapter 7 provides guidelines.

Notes:

- Not within the scope of the present document are bi-directional charging, wireless power transfer[3], charging of very large vehicles (trucks, buses, vessels) or small vehicles (bicycles, scooters or similar vehicles);
- Unless otherwise explicitly specified, the requirements in these technical requirement guidelines shall apply only to EV charging stations which will be installed after the date of publication of these technical guidelines.

2. Reference documents

These technical requirements guidelines are in addition to existing laws, regulation and standards. Accordingly, the technical requirements guidelines do not replace Oman laws, regulation, Oman Electrical Standards (OES) and international (Gulf/GSO, IEC) standards but intend to provide guidance to the application of the rules in these documents on EV charging in Oman and provide further detail on implementation and applicability of the international standards in Oman.

In case of any conflict of requirements, the order of precedence as described in section 1.2.1 of OES no. 4 (OES4) applies. The technical requirements guidelines in this document shall be considered preceded by the Oman sector law, the Oman distribution Code, OES 4 and other Oman Electrical

[1] E.g. residences, on-street, car parks (public and private, single level or multi-story), malls, offices, filling stations, dedicated (fast) charging locations.
[2] Standard IEC 61851-1 Electric vehicle conductive charging system.
[3] As referred to in IEC 61980 (series of standards).

standards (item a to d in section 1.2.1 of OES4), but precede international standards (item e to g in section 1.2.1 of OES4).

The most relevant regulation and standards for EV charging stations in Oman are:

[1] Omani Standard OES4 – Regulations for electrical installations, Third Edition 3.1, November 2021;

[2] Sultanate of Oman, The Distribution Code, Version 1.000, April 2020;

[3] Gulf standards, most notably GSO 2698:2022: Technical Requirements for Electric Vehicles, Edition 1 – 12 May 2022.

[4] IEC[4], BS and ISO standards, most notably:

- IEC 61851 Electric vehicle conductive charging system (series of standards);
- IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles (series of standards);
- IEC 61439-7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicle charging stations;

An overview of the most relevant applicable international standards is provided in

[4] available on www.iec.ch

Annex A: Applicable International Standards.

Note: Regulations, codes and standards are regularly updated and replaced by newer versions. If a fully approved later version of the referred regulation or standard is available, it shall be considered replacing the version that is referred to in this document.

3. Definitions

This document applies the electrotechnical vocabulary as defined in the Oman Distribution Code, Oman Electrical Standards (OES, most specifically OES4, section 1.6) and the International Electrotechnical Vocabulary (IEV) of the International Electrotechnical Commission (IEC)[5].

For more specific terminology on EVs in general and EV charging stations in particular, this document applies the terminology as defined in standards GSO 2698:2022 and IEC 61851-1. The most relevant definitions and applied acronyms are listed below.

Alternating Current	AC	Electricity as provided by the public electricity grid.
Direct Current	DC	Electricity as required by the EV's batteries for charging.
Distribution board		An assembly of parts, including main isolator, circuit-breaker, one or more fuses or circuit breaker, arranged for the distribution of electrical energy to final sub-Circuits or other distribution boards. (source: OES4)
Distribution Code Review Panel	DCRP	The Panel with the functions set out in GC.4 of the General Conditions of the Distribution Code. (source: Distribution Code)
Distribution Company		A company or body holding a distribution licence issued by the Authority pursuant to Royal Decree 78/2004 (as amended). (source: OES4)
Electric Vehicle	EV	In this document, plug-in electric passenger cars, motorcycles, minibuses and vans that can or must be charged from an external power supply.
EV charging profiles		Profile indicating the maximum charging limit for an EV charging station for typically each hour of the day.
EV charging station		The combination of all stationary equipment required to supply electricity from a supply network for the purpose of charging.
GCC Standardization Organization	GSO	Standards organization for the member states of the Gulf Cooperation Council and Yemen.
In-Cable Control and Protection Device	IC-CPD	Device integrated in a Mode 2 cable assembly that provides control of the charging power (pilot function) and protection against electric shock.
International Electrotechnical Commission	IEC	International standards organization that prepares and publishes international standards for all electrical, electronic and related technologies.

[5] available on https://www.electropedia.org

Low Voltage	LV	in Oman nominally 240 V (phase voltage) or 415 V (line voltage).
Medium Voltage	MV	in Oman typically 11 kV.
Oman Electrical Standard	OES	Electrical Standards for Oman, as approved and published by the Authority for Public Services Regulation.
Oman Electrical Standard no. 4	OES4	Oman Electrical Standard for Electrical Installations in Buildings
Residual Current Device	RCD	A protection device which operates when a residual earth leakage current occurs in excess of the specified value. Both RCCBs and RCBOs are classified as RCDs. RCDs provide the same functionality as the previous obsolete term Earth Leakage Circuit Breaker (ELCB) which previously related to both voltage and current operated devices. (source: OES4)
Vehicle connector		A plug that establishes an electrical connection to the electric vehicle for the purpose of power transfer and information exchange.
Vehicle inlet		The socket on the electric vehicle into which the electric vehicle connector is inserted for power transfer and information exchange.

4. Mode 1: not allowed in Oman

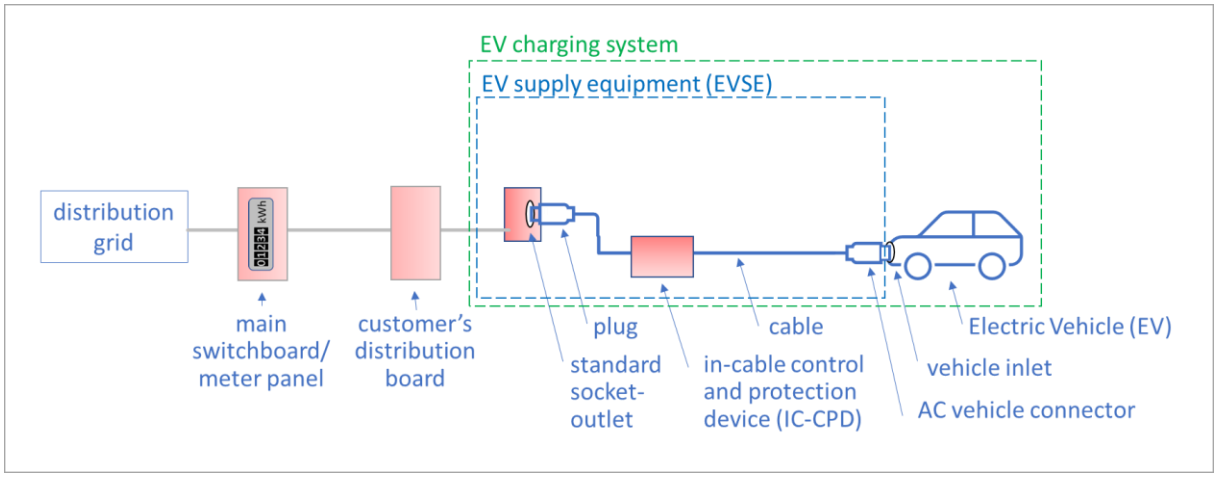
Mode 1 is defined as charging from a standard socket-outlet utilizing a cable and a plug. Different from Mode 2 charging (see section 5), Mode 1 charging does not provide current limitation and protection. For that reason, ***Mode 1 is not considered safe and shall not be used in Oman.***

5. Mode 2: only for incidental use, up to 13 A for 2 hours

5.1. What is Mode 2 charging?

Mode 2 charging applies a portable cable assembly that can be connected to a standard socket-outlet, typically a socket-outlet for domestic and similar general usage. The cable assembly incorporates an In-Cable Control and Protection Device (IC-CPD) between the standard plug and the AC vehicle connector (see Figure 1). This IC-CPD provides both control of the charging power (pilot function) and protection against electric shock.

Figure 1: Overview Mode 2 charging, including applied terminology in this section.



5.2. When shall Mode 2 be applied?

Considering that Mode 2 charging will use standard socket-outlets, the charging current shall be limited to the capabilities of the applied socket-outlet and the final circuit feeding this circuit.

Standard-outlets for domestic and similar general usage are typically designed for *non-continuous* use of up to 13 A. For this reason, ***Mode 2 charging shall only be applied for incidental use and up to 13 A, for not more than two consecutive hours and single phase use. The use of extension cords and conversion adapters is not allowed.***

For EV charging with larger power and longer charging periods, Mode 3 charging (see section 6) and Mode 4 charging (see section 7) shall be applied (see Textbox 1).

Textbox 1: Continuous use of Mode 2 charging

IEC 61851-1 allows Mode 2 charging for *continuous use (many hours, current up to 32 A and one or three phase charging*). However, standard socket-outlets for households are typically not designed for extended current draw or continuous use at maximum power. Hence, if Mode 2 charging will be continuously used for charging, socket-outlets shall apply specifically designed BS 1363-2 socket-outlets (marked with "EV" on the rear) or industrial socket-outlets in compliance with BS EN 60309-2 with appropriate interlocking. The socket-outlets shall be marked with "For use with electric vehicle supply equipment (or) electric vehicle charging system)" and the appropriate voltage and current data for use. Charging currents and times shall not exceed the specified limitations of the EV-socket and other relevant equipment.

5.3. Mode 2 charging station requirements

Mode 2 charging stations shall be compliant with IEC 61851 (series of standards), IEC 62752 (and other applicable standards, see

Annex A: Applicable International Standards) and consist of:

- A plug for connecting to standard domestic socket-outlets in Oman. This plug is referred to as the plug *'for domestic and similar general use'* in section 4.4 of OES4. The plug shall comply with BS 1363[6];
- A cord that is designed for outdoor use and dimensioned for continuous use at the rated current of the Mode 2 charger;
- A protective earthing conductor (integrated in the cable) from the plug to the AC vehicle connector;
- An in-cable control and protection device (IC-CPD) that incorporates over current protection and a Residual Current Device (RCD), has a control pilot function in accordance with Annex A of IEC 61851-1, checks supply conditions and prevents charging in case of supply faults under specified conditions;
- AC vehicle connector compliant with IEC 62196.

For use in Oman, the site conditions specified in section 3.1 of OES4 apply for purposes of design and selection of EV charging stations.

Mode 2 charging stations shall be tested and certified by testing laboratories that are approved by the Competent Authority for this purpose. Suppliers of equipment shall provide compliance certificates that confirm the compliance with the requirements in regulation in Oman, including – but not limited – to these technical requirements guidelines.

5.4. Installation requirements

Considering that Mode 2 charging is restricted to incidental use with current up to 13 A for not more than two consecutive hours, Mode 2 chargers can be connected to standard BS 1363 socket-outlets.

It shall be noted that:

- ***Socket outlets without earthing shall not be used;***
- ***The use of extension cords and conversion adapters is not allowed.***

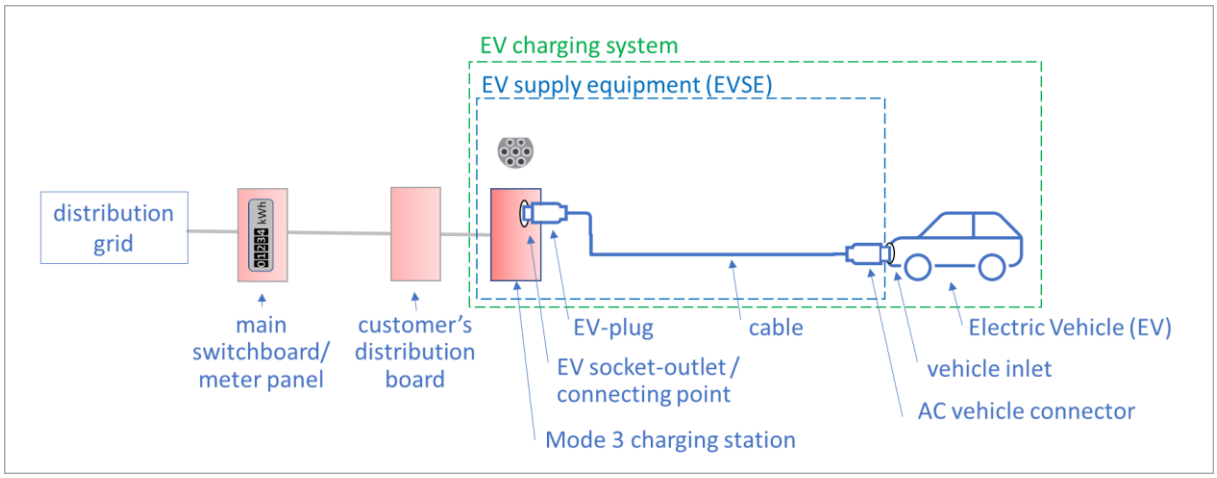
6. Mode 3: Default for AC charging

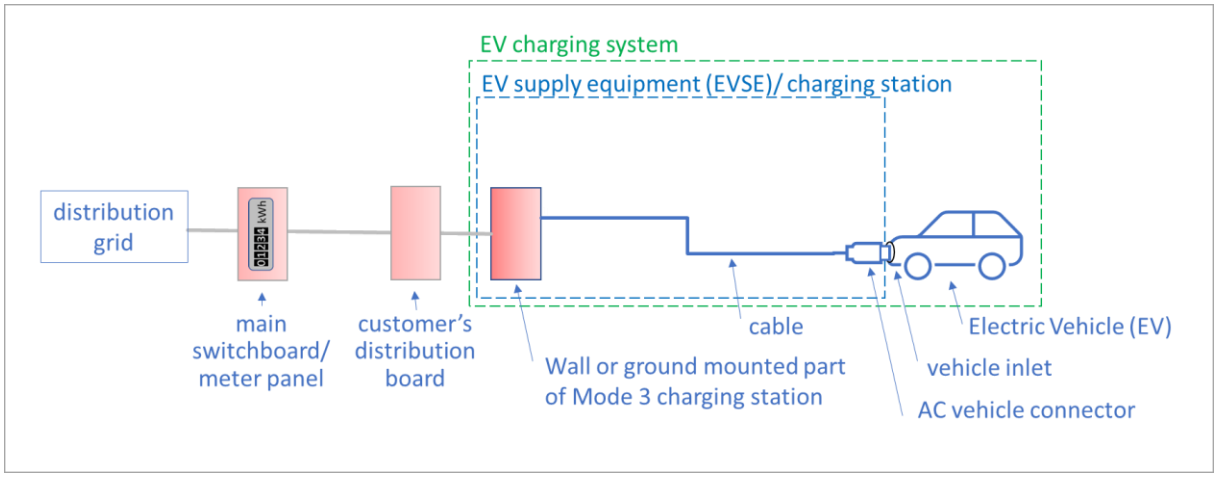
6.1. What is Mode 3 charging?

Mode 3 charging is typically applied for 'slow' AC charging (multiple hours), usually between 16 A and 32 A. Both single phase and three phase chargers may be applied. Mode 3 charging stations are typically designed as stand-alone 'charging posts' or wall-mounted charging units that are permanently connected to the electricity network or electrical installations in buildings (see Figure 2). Mode 3 charging provides the possibility to control the charging power to the vehicle (pilot function) and provides protection against electric shock. Furthermore, Mode 3 charging may be applied for smart charging applications.

[6] Referred to as Type G in IEC 60083.

Figure 2: Overview Mode 3 charging with detachable cable (upper figure) or permanent cable (lower figure), including applied terminology in this section.





Notes:

- A Mode 3 charging station may have more than one EV socket-outlets that share the rated capacity of the Mode 3 charging station. In the sections below, Mode 3 charging stations with more than one EV socket-outlets should be considered as a single Mode 3 charging station;
- Mode 3 charging station that provide standard BS 1363 socket-outlets in addition to the EV socket-outlets for Mode 3 charging shall not be applied.

Textbox 2: Current limitation of Mode 3 charging.

There is no limitation to the rated current of the Mode 3 charging station defined in this section. However, in practice for most EVs the current is limited to (less than) 32 A. If EVs accept more than 32 A and the Mode 3 charging stations can provide this, it shall be made sure that the cable has sufficient capacity. This should be part of the design if the cable is permanently attached to the Mode 3 charging station. In case of Mode 3 charging stations with detachable cords, EV owners are assumed to own and use their specific cables (> 32 A) with Type 2 connectors (as Type 1 does not support > 32 A). Hence, there is no generic limit to the charging current for Mode 3 charging. However, the distribution company may restrict the charging current in case of distribution network restrictions though (see section 6.5).

6.2. When shall Mode 3 be applied?

Mode 3 shall be used as the default charging method for AC charging in Oman (see section 7 for DC charging), both in domestic and at other locations, such as offices and public charging stations.

Note: In Oman, Mode 3 charging shall only be applied for unidirectional charging. This means that feeding electricity back into the network operated by the distribution company (Vehicle-to-grid or V2G) is not allowed.

6.3. Mode 3: charging stations requirements

This section includes the requirements for the Mode 3 charging station equipment. Section 6.3.1 lists generic requirements while sections 6.3.2 and 6.3.3 provide specific requirements for Mode 3 charging stations with detachable and permanent cables.

6.3.1. Generic requirements

Mode 3 charging stations shall be compliant with GSO 2698 (section 6), IEC 61851 (series of standards) and other applicable standards (see

Annex A: Applicable International Standards) and consist of:

- At least one EV socket-outlet (in case of a detachable cable, see section 6.3.2) or Vehicle Connector (in case of a permanent cable, see section 6.3.3). Each EV socket-outlet or Vehicle Connector shall be used to charge only one EV;
- A protective earthing conductor (integrated in the cable) from the Mode 3 charging station to the AC vehicle connector;
- A control pilot function in accordance with Annex A of IEC 61851-1;
- An interlock function that de-energizes the AC vehicle connector and its cable whenever the connector is uncoupled from the EV;
- An automatic means to de-energize the cable conductors and electric vehicle connector upon exposure to strain that could result in either cable rupture or separation of the cable from the electric connector and exposure of live parts;
- Protection against electric shock in accordance with section 8 of IEC 61851-1. If a Mode 3 charging station is equipped with more than one EV socket-outlets or AC vehicle connectors that can be used simultaneously, individual protection shall be incorporated in the Mode 3 charging station;
- The following marking by the manufacturer: *'For Use With Electric Vehicles'* and the appropriate voltage and current data for use. In addition, the Mode 3 charging stations shall be clearly marked with either *'Ventilation not required'* or *'Ventilation Required'*. All markings shall clearly visible after installation[7];

The Mode 3 charging station shall be capable of operating in compliance with the Distribution Code in general. More specifically, the Mode 3 charging stations shall operate within the voltage, frequency and voltage waveform quality ranges specified in the relevant sections of the Distribution Code of Oman.

The site conditions specified in section 3.1 of OES4 apply for purposes of design and selection of EV supply equipment. The minimum IP rating as defined in IEC 60529 shall be IP 54 for equipment mounted in enclosed locations (including locked cabinets) and IP 55 for equipment mounted externally.

Mode 3 charging stations shall be equipped with 'smart' functionality that applies exchanging information with the distribution company. The Mode 3 charging station and its communication protocol shall be able to:

- Communicate with the distribution company via internet by a standard communication protocol that is specified by the distribution company, e.g. OCPP vs 2.0.1 or higher. For a group of Mode 3 charging stations installed at one location, the communication may be aggregated for the group of Mode 3 charging stations;
- Measure energy consumption for each hour (or smaller time unit) of the charging station and share the measured values at least on a daily basis with the distribution company for the purpose of analysing specific EV load profiles;
- Be integrated in a platform (e.g. home automation/smart meter) that facilitates the optimization of local electricity use and generation (e.g. by solar PV);

[7] In accordance with GSO 2698.

- Receive EV charging profiles which define the maximum charging capacity limit for each hour (or smaller time unit) of the day. The Mode 3 charging station shall ensure that the maximum charging capacity limit is not exceeded. If communication is lost, charging stations shall continue taking into account the pre-loaded EV charging profiles. For a group of Mode 3 charging stations installed at one location, the maximum charging capacity limit may be applied to the aggregated charging of the group of Mode 3 charging stations;
- Receive instructions from the distribution company to stop charging.

Outside the scope of these technical requirements guidelines are the means of communication (e.g. wired connection, such as Ethernet, or a wireless connection, such as wireless networking (Wi-Fi) or a mobile network) and related (cyber) security issues. The charging station shall comply with the Cyber Security Requirements based on international best practice such as ISO27001, ETSI EN 303 645, IEC 62443, …etc. The requirements of Cyber Security should fulfill the type of technology and communication applied. .

Mode 3 charging stations shall be tested and certified by testing laboratories that are approved by the Competent Authority for this purpose. Suppliers of equipment shall provide compliance certificates that confirm the compliance with the requirements in regulation in Oman, including – but not limited – to these technical requirements guidelines.

A Mode 3 charging station may be connected to the EV by either a detachable cable[8] or by a cable that is permanently attached to the Mode 3 charging station[9]. Sections 6.3.2 and 6.3.3 describe the specific requirements for each of the cable options.

6.3.2. Additional requirements for Mode 3 charging stations with detachable cable

A Mode 3 charging station that connects with detachable cables to the EV has a specific EV socket-outlet built-in. This EV socket-outlet shall be rated to support at least the rated power of the Mode 3 charging station. The EV socket-outlet may support single and/or three phase charging, depending on the number of phases offered by the Mode 3 charging station. The EV socket shall support AC charging and comply with IEC 62196-2 (preferably Type 2). An electrical or mechanical system shall prevent the plugging/unplugging of an EV plug from the EV socket-outlet unless the supply has been switched off.

The detachable cable assembly consists of an EV-plug, the cable and a vehicle connector, for which the following requirements apply:

- The cable assembly shall support all functions described in section 6.3.1;
- The cable assembly shall be dimensioned to support the maximum charging capacity of the EV or the Mode 3 charging station continuously;
- The assembly may support single and/or three phase charging;
- The assembly shall on both sides of the cable apply a connector type for AC charging in accordance with IEC 62196;
- The cable length shall not exceed 7.5 meter;
- The assembly shall comply with applicable standards, see

[8] Case B as defined in section 3.1.11 of IEC 61851-1.
[9] Case C as defined in section 3.1.12 of IEC 61851-1.

Annex A: Applicable International Standards.

6.3.3. Additional requirements for Mode 3 charging station with permanent cable

The permanent cable assembly of a Mode 3 charging station with a permanent cable consists of the cable and an AC vehicle connector, for which the following requirements apply:

- The assembly shall support all functions described in section 6.3.1;
- The permanent cable shall be dimensioned to support the number of phases and the maximum charging capacity of the Mode 3 charging station. The cable shall support three phase charging if the Mode 3 charging station supports three phase charging;
- The vehicle connector shall apply a connector type for AC charging in accordance with IEC 62196 (preferably Type 2);
- The cable length shall not exceed 7.5 meter;
- The assembly shall comply with applicable standards, see

Annex A: Applicable International Standards.

6.4. Installation requirements

This section includes the requirements for the installation of Mode 3 charging stations. Section 6.4.1 lists requirements to the site and physical installation and section 6.4.2 provides the specific electrical installation requirements, focused on domestic installations. Section 6.4.3 provides additional requirements that apply for non-domestic installations in addition to the requirements in sections 6.4.1 and 6.4.2.

6.4.1. Site and physical installation requirements

Mode 3 charging stations shall be permanently installed and the following requirements apply to the site:

- Mode 3 charging stations are positioned in such a way that it is possible to safely install, maintain and replace all equipment. It shall not be possible to access or touch live parts during installation, operation and maintenance. The positioning will take into account specific ventilation requirements of the equipment, where applicable and indicated by their manufacturer;
- The mounting heights of Mode 3 charging stations shall be such that the main operating controls and any socket-outlet are between 0.75m and 1.2m above fixed floor level. Display screens and status indicators shall be between 1.2 m and 1.4 m above fixed floor level;
- Mode 3 charging stations and their permanent or detachable cables shall be installed in a way that avoids obstruction to public or private footpaths, minimizes the distance between the vehicle inlet and the Mode 3 charging station and avoids unnecessary trip hazard;
- Mode 3 charging stations shall be installed in a way that minimizes the risk of vehicle impact caused by vehicles driving or reversing into the charging station. Any remaining risk may be mitigated by use of additional protection barriers;
- Mode 3 charging stations shall not be installed in locations where potentially explosive atmosphere exists;
- The design of the Mode 3 charging systems with one or more Mode 3 charging stations shall mitigate potential risks during the installation, commissioning, testing, operation and maintenance of the station. Safety guidance, requirements and instructions of the equipment's manufacturer shall be implemented;
- Adequate lighting shall be available to facilitate safe use of the Mode 3 charging station, which includes that it shall be possible to check AC vehicle connectors, EV plugs, cables, EV socket-outlets and vehicle inlets for evidence of damage prior to connect or disconnect the EV to the charging station. Adequate lighting shall also allow the identification of trip hazards.

6.4.2. Electrical installation requirements

Mode 3 charging stations are permanently connected to the local AC grid or an electrical installation in buildings.

The following requirements apply to the electrical installation of Mode 3 charging stations:

- Mode 3 charging stations shall not be connected to standard or industrial socket-outlets[10];
- Each final circuit shall be dimensioned to carry the rated current of the Mode 3 charging station continuously and take into account the maximum voltage drop as defined in section 3.3 of OES4;
- Each final circuit shall be individually protected by overcurrent, short-circuit and earth leakage protection in accordance with the requirements in OES4[11]. Section 8.8 in OES4 specifies that for earth leakage protection of charging stations, a Type B RCD shall be applied with a maximum operating current of 30 mA. In accordance with section 4.2.8 of OES4, the clearance times shall be a maximum of 40 ms at five times the tripping current. In addition, a label shall indicate that the RCD shall be tested at least every 12 months in accordance with section 13.11 of OET4;
- Public charging consumption shall be metered by a separate electricity meter. This separate meter must comply with the Technical Standard for Electricity Metering Systems (OS 1647/2022);
- The Mode 3 charging station, the final circuit and all associated equipment in the consumer's distribution board shall be labelled in accordance with section 3.4 or OES4;
- Mode 3 charging stations shall be provided with a means of safe isolation. An isolating device shall be installed for each Mode 3 charging station and shall be easily accessible and with appropriate labelling. The isolation device shall be provided with a method to prevent unintentional or inadvertent reinstating. At locations with more than one Mode 3 charging stations, separate isolation switches shall be installed.
- Earthing shall be provided from the Main Earth Bar (MEB). Each Mode 3 charging stations shall be earthed and bonded via its own earthing conductor that is not used for earthing or bonding any other equipment. Earthing systems for which Mode 3 charging stations are connected shall in principle comply with sections 5.2.9 ('Consumer's Earthing System')[12] and 8 ('Earthing and earth leakage protection') in OES4[13]. Compliance with these sections shall be confirmed at the time of installation of the Mode 3 charging station. In specific cases, earthing and bonding requires additional attention which is explained in Textbox 3;
- Where an emergency switch is provided it shall be located in a position that is readily accessible and shall be suitably identified by marking and/or labelling and shall disconnect all live conductors including the neutral;

[10] Single- or three-phase AC, as referred to in section 4.4 of OES4.

[11] Including, but not limited to OES4 sections 2.4, 4.2.8, 5.2, 8.8 and 9.9.

[12] As noted in section 5.2.9 of OES4, *'the Oman earthing system differs from those defined in IEC 60364 and also used by BS 7671. The Oman system includes the following characteristics: Consumer installation earth electrodes; Separate neutral and protective conductors throughout the system; The distribution system is directly connected to earth at the neutral point of the supply transformer. This earth reference is provided to the consumer from the distribution company via the incoming cable earth sheath or armour which is connected to the consumer's main earthing terminal. 2. The use of any other system of earthing shall not be used unless approved by the Distribution Company.'.*

[13] As explained in section 12.5.3 of OES4, '*In the case of making additions or alterations to existing older installations with legacy earthing systems that do not comply with Sections 8 and 5.2.9 (particularly those without an earth electrode or if the neutral and earth conductors are combined), additional protection may be required to automatically disconnect the supply if the voltage between the circuit protective conductor and earth is greater than 70 V. This additional protection may be provided by internal capabilities of the charging equipment.'*

- Where a building has a lightning protection system or in cases that surge protection is provided as part of the overall lightning protection system, the need for additional surge protections for the Mode 3 charging stations shall be investigated and implemented if considered required (see section 9.18 in OES4 and IEC 62305 (series of standards));
- Owners of Mode 3 charging stations may prevent for unauthorized use of the Mode 3 charging station by installing appropriate measures such as physical or electronic keys;

Textbox 3: Additional attention required for earthing and bonding issues,

The following situations require additional attention with respect to earthing and bonding:

- *Simultaneously accessible exposed conductive-parts should be connected to the same earthing system.* For example, if the Mode 3 charging station is installed in a domestic garage, it shall be ensured that protective bonding is supplied for conductive-parts accessible from the EV in accordance with section 8.6 of OES4;
- Especially in case of many charging stations or other equipment that applies DC (such as solar PV), the impact of DC leakage currents shall be taken into account in the design of the earthing and bonding system. The design shall limit or mitigate DC leakage currents through conducting materials that may be affected by corrosion;
- Protective conductive paths between installations fed by separate earthing arrangements shall be considered to avoid problems and suitable protective steps shall be taken.
- It may be the case that sufficient earth fault protection cannot be guaranteed by earthing from the MEB, for example if the earthing system is different from the earthing system in section 5.2.9 in OES4 or if the distance to the MEB is too large. In this case additional measures need to be installed, which may include earthing rods.

6.4.3. Non-domestic installation

This section applies to non-domestic charging sites, which include single or groups of Mode 3 charging stations that are connected to an existing connection or to a new connection. These include Mode 3 charging stations in the open air or in buildings and accessible to the public or to specific groups of people.

In addition to the requirements in sections 6.4.1 and 6.4.2, for non-domestic installation the following requirements apply:

- Mode 3 charging stations shall not be connected to existing lighting circuits or other existing street equipment that may have surplus capacity;
- Single Mode 3 charging stations may have their own metered connection to the Low Voltage grid (in compliance with OES4);
- Public charging consumption shall be metered by separate electricity meters. This separate meter must comply with the Technical Standard for Electricity Metering Systems (OS 1647/2022);
- Groups of Mode 3 charging stations may be connected to a single low voltage or medium voltage connection via one or more feeder pillar that connects the charging stations. As a guideline, EV charging stations with a connection capacity of 400 kVA will be connected to the low voltage network (see Textbox 4).

Textbox 4: Typical grid connections of EV charging systems that require a separate connection to the network operated by the distribution company.

EV charging systems with a connection capacity of up to 400 kVA will typically connect to the Low Voltage (LV, 240/415 V) network. If the installation of the EV charging station exceeds the feeder technically acceptable limits, a new substation might be envisaged by the distribution company. Based on the initial enquiry and the preference of the EV charging station owner, the distribution company must propose the means of connection.

For EV charging systems with connection capacity between 400 kVA and 1000 kVA a dedicated secondary substation may be required. This substation includes a transformer that transforms Medium Voltage (MV, 11 kV) to LV. This substation may be either a new substation owned by the distribution company or a new private substation that is connected to the distribution network. In case of a private substation, the distribution company will inform the charging system owner on the specific requirements, including (but not limited to) protection coordination, the type and size of the incoming cables and the required terminations.

For EV charging systems with a capacity larger than 1000 kVA, the distribution company will provide a connection to 11 kV networks or – if very large – to 33 kV networks. The connection of these charging stations requires a dialogue with the distribution companies.

6.5. Connection process and communication with the distribution company

The connection process for Mode 3 charging stations depends on the number and size of Mode 3 charging stations applied. Section 6.5.1 describes the connection process applicable for stand-alone charging stations up to 32 A (23 kW for 415 V, three phase). This may typically apply to Mode 3 charging stations for domestic use. Section 6.5.2 describes the connection process for locations with larger or multiple Mode 3 charging station.

6.5.1. Connection process for domestic stand-alone Mode 3 charging stations up to 32 A.

On behalf of the charging station owner, electrical contractors with DCRP registrations for grades A, B, C, D or E [14] are allowed to design, implement and energize charging systems with a single Mode 3 charging station up to 32 A. Licensed electrical contractors shall fulfil the following requirements:

- Confirm that the connection capacity of the consumer is sufficient for adding the load of the Mode 3 charging station. If the connection capacity of the consumer is insufficient or if a single-phase connection needs to be upgraded to a three phase connection, the licensed electrical contractor may – on behalf of the consumer – apply for the required change of the connection at the relevant distribution company, in line with the distribution company's connection statement;
- Fully comply with the requirements in this document and other applicable regulations and standards;
- Make sure that the Mode 3 charging station's communication with the distribution company's systems is established in accordance with the requirements in 6.3.1;
- Make sure that the additional metering of the Mode 3 charging station is connected to the distribution company's metering system in accordance with the requirements in 6.4.2;

[14] Contractors that are approved by the Distribution Code Review Panel (DCRP) and listed at DCRP's website.

- On behalf of the consumer, inform the distribution company about the new Mode 3 charging station, its capacity and its date of starting operation. The distribution company is entitled to visit and review the installation. However, an official approval by the distribution company is not required before energisation;
- On completion, the licensed electrical contractors shall provide the charging station owner with an electrical installation certificate, and inspection and test schedules (see section 6.6).

Distribution companies will further detail this process and provide the necessary forms.

6.5.2. Connection process for public charging stations, charging stations of more than 32 A and charging systems with multiple Mode 3 charging stations at one location

On behalf of the charging station owner, electrical contractors with DCRP registrations[15] for grades A, B, C or D are allowed to design, implement and energize public charging stations, charging stations of more than 32 A and charging systems with multiple Mode 3 charging stations at one location. If work on 11kV overhead lines, underground cables or 11/0.415 kV substations is required, the electrical contractor shall have a DCRP registration for grade A, B or C. Licensed electrical contractors shall fulfil the following requirements:

- The (future) EV charging stations' owner or his licensed electrical contractor must ask for an initial enquiry by the distribution company which at least specifies the planned charging capacity and the starting date of EV charging[16]. If the EV charging stations require a new connection or if the existing connection capacity of the consumer is insufficient or if a single-phase connection needs to be upgraded to a three phase connection, this requirement shall be part of the initial enquiry;
- The Distribution company provides the (future) EV charging station owner with his connection budgetary cost estimate and time estimation for realizing the connection or reinforcing the grid if necessary. If the requested capacity cannot be provided by the requested energisation date, the distribution company may offer the available capacity at the requested energisation date as a temporary solution.
- *Before the construction starts,* the (future) EV charging station owner shall submit the design of charging station to the relevant distribution company in accordance with section 1.3 of OES4, for review and approval. If applicable, at the same time the new connection or the connection upgrade process will be started in accordance with the distribution company's connection statement. The distribution company shall provide approval or feedback to the (future) EV charging station owner;
- *Before energization:* After the charging station has been completed, and before energisation, the licensed electrical contractor shall inspect and test the charging stations and confirm that the charging stations comply with the requirements in the present document and other applicable regulations and standards and in accordance with sections 2.10 and 13 of OES4.

[15] Contractors that are approved by the Distribution Code Review Panel (DCRP) and listed at DCRP's website.
[16] In case of clusters of EV charging connected to the same distribution feeder, the potential EV charging load (in kW) may significantly impact the loading and voltage in local distribution networks. Accordingly, voltage and network capacity limits in distribution networks may be exceeded, even if the contacted capacities at individual connections are not exceeded.

After compliance has been confirmed, the distribution company shall be requested to inspect, test and energise the connection in accordance with sections 1.5, 2.10 and 13 of OES4.

6.6. Periodic inspection and testing

For all EV charging stations, periodic inspections and tests shall be performed in accordance with section 13.11 of OES4. As part of his work, the licensed electrical contractor shall provide an 'inspection, testing and maintenance' schedule that is based on manufacturer recommendations and compliance with requirements in regulation. For example, section 13.11 of OES4 includes the requirement that RCDs shall be tested at least every 12 months.

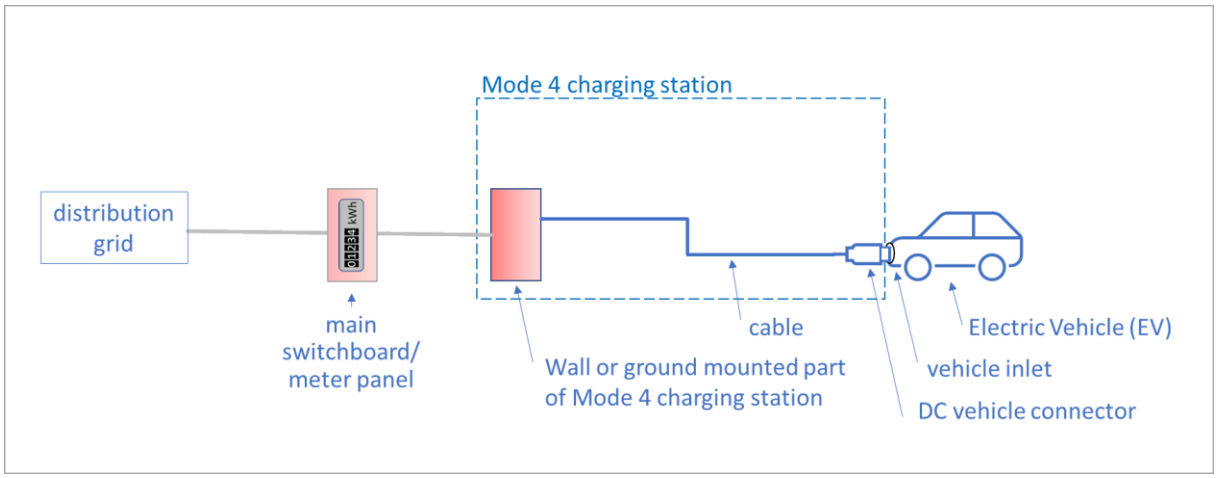
7. Mode 4: DC charging

7.1. What is Mode 4 charging?

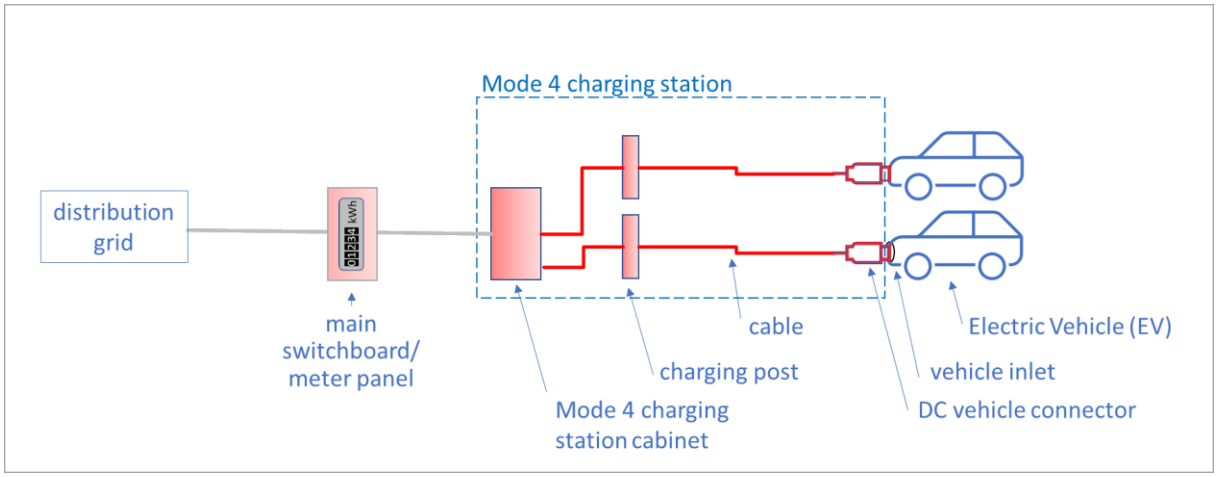
Mode 4 charging stations apply Direct Current (DC) which allows for fast charging with typically 50 kW and above . Mode 4 charging stations are typically installed at locations where fast charging is required. For example, at high-way rest stops Mode 4 charging stations provide EVs with a recharge while their passengers take a short break.

Mode 4 charging makes use of stationary EV supply equipment that is permanently connected to the local AC grid (see Figure 3). Mode 4 charging stations convert the AC power into DC power. The DC power is typically provided to the EV by *a cable that is permanently attached* to the Mode 4 charging station[17]. One Mode 4 charging station can charge more than one EV simultaneously via separate cables, which may be connected to several charging posts. Mode 4 charging provides the possibility to limit the power to the vehicle and provides protection.

Figure 3: Overview of two implementations of Mode 4 charging, including applied terminology in this section.



[17] Case C as defined in section 3.1.12 of IEC 61851-1.



7.2. When shall Mode 4 be applied?

Mode 4 shall be used as the *default* charging method for *DC fast charging* (see section 6 for AC charging). In Oman, Mode 4 charging shall not be applied for feeding electricity back into the network operated by the distribution company (Vehicle-to-grid or V2G).

7.3. Mode 4: charging stations requirements

Mode 4 charging stations shall be compliant with GSO 2698 (section 6), IEC 61851 (series of standards) and most specifically with IEC 61851-23 and IEC 61851-24 and other applicable standards (see

Annex A: Applicable International Standards) and consist of:

- At least one cable with a DC Vehicle Connector that complies with IEC 62196-3 (preferably CCS Combo 2);
- A protective earthing conductor (integrated in the cable) from the Mode 4 charging station to the DC vehicle connector;
- A control pilot/communication function in accordance with IEC 61851-24;
- An interlock function that de-energizes the DC vehicle connector and its cable whenever the connector is uncoupled from the EV;
- An automatic means to de-energize the cable conductors and electric vehicle connector upon exposure to strain that could result in either cable rupture or separation of the cable from the electric connector and exposure of live parts;
- Protection against electric shock in accordance with section 8 of IEC 61851-1. If a Mode 4 charging station is equipped with more than one cable that can be used simultaneously, individual protection shall be incorporated in the Mode 4 charging station;
- The following marking by the manufacturer: *'For Use With Electric Vehicles'* and the appropriate voltage and current data for use. In addition, the Mode 4 charging stations shall be clearly marked with either *'Ventilation not required'* or *'Ventilation Required'*. All markings shall be clearly visible after installation[18];

The mode 4 charging station shall be capable of operating in compliance with the Distribution Code in general. More specifically, the Mode 4 charging stations shall operate within the voltage, frequency and voltage waveform quality ranges specified in the relevant sections of the Distribution Code of Oman.

The power factor of the Mode 4 charging station shall be higher than 0.9 and shall comply with the Electromagnetic compatibility (EMC) standards in IEC 61000 (series of standards).

The site conditions specified in section 3.1 of OES4 apply for purposes of design and selection of EV supply equipment. The minimum IP rating as defined in IEC 60529 shall be IP 54 for equipment mounted in enclosed locations (including locked cabinets) and IP 55 for equipment mounted externally.

Mode 4 charging stations shall be equipped with 'smart' functionality that applies exchanging information with the distribution company. The Mode 4 charging station and its communication protocol shall be able to:

- Communicate with the distribution company via internet by a standard communication protocol that is specified by the distribution company, e.g. OCPP vs 2.0.1 or higher. For a group of Mode 4 charging stations installed at one location, the communication may be aggregated for the group of Mode 4 charging stations;
- Measure energy consumption for each hour (or smaller time unit) of the charging station and share the measured values at least on a daily basis with the distribution company;
- Receive EV charging profiles which define the maximum charging capacity limit for each hour (or smaller time unit) of the day. The Mode 4 charging station shall ensure that the maximum

[18] In accordance with GSO 2698.

charging capacity limit is not exceeded. If communication is lost, charging stations shall continue taking into account the pre-loaded EV charging profiles. For a group of Mode 4 charging stations installed at one location, the maximum charging capacity limit may be applied to the aggregated charging of the group of Mode 4 charging stations;
- Receive instructions from the distribution company to stop charging.

Outside the scope of these technical requirements guidelines are the means of communication (e.g. wired connection, such as Ethernet, or a wireless connection, such as wireless networking (Wi-Fi) or a mobile network) and related (cyber) security issues. The charging station shall comply with the Cyber Security Requirements based on international best practice such as ISO27001, ETSI EN 303 645, IEC 62443, …etc. The requirements of Cyber Security should fulfill the type of technology and communication applied.

Mode 4 charging stations shall be tested and certified by testing laboratories that are approved by the Competent Authority for this purpose. Suppliers of equipment shall provide compliance certificates that confirm the compliance with the requirements in regulation in Oman, including – but not limited – to these technical requirements guidelines.

A Mode 4 charging station shall be equipped with a permanent cable assembly that consists of the cable and an DC vehicle connector, for which the following requirements apply:

- The assembly shall support all functions described in this section 7.3;
- The permanent cable shall be dimensioned to support the maximum charging capacity of the Mode 4 charging station;
- The vehicle connector shall apply a connector type for DC charging in accordance with IEC 62196 (preferably CCS Combo 2);
- The cable length shall not exceed 7.5 meter;
- The assembly shall comply with applicable standards, see

Annex A: Applicable International Standards.

7.4. Installation requirements

This section includes the requirements for the installation of Mode 4 charging stations. Section 7.4.1 lists requirements to the site and physical installation and section 7.4.2 includes the specific electrical installation requirements.

Note: The installation of Mode 4 charging stations differs from location to another depending on the specific condition of that location (e.g. outdoor/indoor, at highway location). This section defines the minimum requirements.

7.4.1. Site and physical installation requirements

Mode 4 charging stations shall be permanently installed and the following requirements apply to the site:

- Mode 4 charging stations and their charging posts are positioned in such a way that it is possible to safely install, maintain and replace all equipment. It shall not be possible to access or touch live parts during installation, operation and maintenance;
- The positioning of a Mode 4 charging station will take into account the manufacturer's installation and operational instructions and recommendations with respect to required ventilation and cooling taking into account the weather conditions in Oman. It is noted that this is even more important for Mode 4 than for Mode 3 charging stations considering that Mode 4 charging stations include equipment (such as power electronics for AC to DC conversion) that may cause heat;
- The mounting heights of Mode 4 charging stations shall be such that the main operating controls are between 0.75m and 1.2m above fixed floor level. Display screens and status indicators shall be between 1.2 m and 1.4 m above fixed floor level;
- Mode 4 charging stations, their charging posts and their permanent cables shall be installed in a way that avoids obstruction to public or private footpaths, minimizes the distance between the vehicle inlet and the Mode 4 charging station and avoids unnecessary trip hazard;
- Mode 4 charging stations and their charging posts shall be installed in a way that minimizes the risk of vehicle impact. Any remaining risk may be mitigated by use of additional protection barriers;
- Mode 4 charging stations and their charging posts shall not be installed in locations where potentially explosive atmosphere exists;
- The installation of the charging equipment and its commissioning shall be performed in accordance with the manufacturer's instructions and requirements by specifically trained engineers of electrical contractors with DCRP registrations for grades A, B, C or D[19]. If work on 11kV overhead lines, underground cables or 11/0.415 kV substations is required, the electrical contractor shall have a DCRP registration for grade A, B or C;
- The design of the Mode 4 charging systems with one or more Mode 4 charging stations shall mitigate potential risks during the installation, commissioning, testing, operation and

[19] Contractors that are approved by the Distribution Code Review Panel (DCRP) and listed at DCRP's website.

maintenance of the station. Safety guidance, requirements and instructions of the equipment's manufacturer shall be implemented;
- Adequate lighting shall be available to facilitate safe use of the Mode 4 charging station, which includes that it shall be possible to check DC vehicle connectors, cables and vehicle inlets for evidence of damage prior to connect or disconnect the EV to the charging station. Adequate lighting also allows the identification of trip hazards.

7.4.2. Electrical installation requirements

Mode 4 charging stations are permanently connected to the local AC grid or an electrical building installation. Considering that Mode 4 charging stations are typically not applied in domestic situations, this section's focus is on non-domestic charging sites. These include single or groups of Mode 4 charging stations, in the open air or in buildings and accessible to the public or to specific groups of people.

The following requirements apply to the electrical connection:

- Single Mode 4 charging stations may have their own metered connection to the Low Voltage grid;
- Groups of Mode 4 charging stations may be connected to a single low voltage or medium voltage connection via one or more feeder pillar that connects the charging stations. As a guideline, EV charging stations with a connection capacity of 400 kVA will be connected to the low voltage network (see Textbox 4);
- Each Mode 4 charging station shall connect to a dedicated final circuit;
- Mode 4 charging stations shall **not** be connected to standard or industrial socket-outlets[20], or to existing lighting circuits or other existing street equipment that may have surplus capacity to connect to the power supply;
- Each final circuit shall be dimensioned to carry the rated current of the Mode 4 charging station continuously and take into account the maximum voltage drop as defined in section 3.3 of OES4;
- Each final circuit shall be individually protected by overcurrent, short-circuit and earth leakage protection in accordance with the requirements in OES4[21]. Section 8.8 in OES4 specifies that for earth leakage protection of charging stations, a Type B RCD shall be applied with a maximum operating current of 30 mA. In accordance with section 4.2.8 of OES4, the clearance times shall be a maximum of 40 ms at five times the tripping current. In addition, a label shall indicate that the RCD shall be tested at least every 12 months in accordance with section 13.11 of OET4;
- Public charging consumption shall be metered by separate electricity meters. This separate meter must comply with the Technical Standard for Electricity Metering Systems (OS 1647/2022);
- The Mode 4 charging station, the final circuit and all associated equipment in the consumer's distribution board shall be labelled in accordance with section 3.4 or OES4.
- Mode 4 charging stations shall be provided with a means of safe isolation. An isolating device shall be installed for each Mode 4 charging station and shall be easily accessible and with

[20] Single- or three-phase AC, as referred to in section 4.4 of OES4.
[21] Including, but not limited to OES4 sections 2.4, 4.2.8, 5.2, 8.8 and 9.9.

appropriate labelling. The isolation device shall be provided with a method to prevent unintentional or inadvertent reinstating. At locations with more than one Mode 4 charging stations, separate isolation switches shall be installed.

- Earthing shall be provided from the Main Earth Bar (MEB). Mode 4 charging stations shall be earthed and bonded via their own earthing conductor that is not used for earthing or bonding any other equipment. Earthing systems for which Mode 4 charging stations are connected shall in principle comply with sections 5.2.9 ('Consumer's Earthing System')[22] and section 8 ('Earthing and earth leakage protection') in OES4[23]. Compliance with these sections shall be confirmed at the time of installation of the Mode 4 charging station. In specific cases, earthing and bonding requires additional attention which is explained in Textbox 3;
- Where an emergency switch is provided it shall be located in a position that is readily accessible and shall be suitably identified by marking and/or labelling and shall disconnect all live conductors including the neutral;
- Where a building has a lightning protection system or in cases that surge protection is provided as part of the overall lightning protection system, the need for additional surge protections for the Mode 4 charging stations shall be investigated and implemented if considered required (see section 9.18 in OES4 and IEC 62305 (series of standards));
- Owners of Mode 4 charging stations may prevent for unauthorized use of the Mode 4 charging station by installing appropriate measures such as physical or electronic keys.

7.5. Connection process

The connection process for Mode 4 charging stations is the same as described in section 6.5 for Mode 3 charging stations

7.6. Periodic inspection and testing

For all EV charging stations, periodic inspections and tests shall be performed in accordance with section 13.11 of OES4. As part of his work, the licensed electrical contractor shall provide an 'inspection, testing and maintenance' schedule that is based on manufacturer recommendations and compliance with requirements in regulation. For example, section 13.11 of OES4 includes the requirement that RCDs shall be tested at least every 12 months.

[22] As noted in section 5.2.9 of OES4, *'the Oman earthing system differs from those defined in IEC 60364 and also used by BS 7671. The Oman system includes the following characteristics: Consumer installation earth electrodes; Separate neutral and protective conductors throughout the system; The distribution system is directly connected to earth at the neutral point of the supply transformer. This earth reference is provided to the consumer from the distribution company via the incoming cable earth sheath or armour which is connected to the consumer's main earthing terminal.'*

2. The use of any other system of earthing shall not be used unless approved by the Distribution Company.

[23] As explained in section 12.5.3 of OES4, '*In the case of making additions or alterations to existing older installations with legacy earthing systems that do not comply with Sections 8 and 5.2.9 (particularly those without an earth electrode or if the neutral and earth conductors are combined), additional protection may be required to automatically disconnect the supply if the voltage between the circuit protective conductor and earth is greater than 70 V. This additional protection may be provided by internal capabilities of the charging equipment.'*

Annex A: Applicable International Standards

This appendix includes a (non-exclusive) overview of applicable international standards applicable to Charging of Electric Vehicles. The documents below refer to the latest versions of the standards.

IEC 60309-1	Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements
IEC 60309-2	Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories
IEC 60309-4	Plugs, socket-outlets and couplers for industrial purposes – Part 4: Switched socket-outlets and connectors with or without interlock
GSO IEC 60479-2	Effects of current on human beings and livestock - Part 2: Special aspects
GSO IEC 60755	General requirements for residual current operated protective devices
IEC 60755	General requirements for residual current operated protective devices
IEC 60884	Plugs and socket-outlets for household and similar purposes
IEC 60947-1	Low-voltage switchgear and control gear – Part 1: General rules
IEC 60947-2	Low-voltage switchgear and control gear – Part 2 : Circuit-breakers
IEC 60947-3	Low-voltage switchgear and control gear - Part 3: Switches, disconnections, switch-disconnections and fuse-combination units
IEC-61000-2-4	Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in industrial plants for low-frequency conducted disturbances.
IEC-61000-3-2	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)
IEC-61000-3-12	Electromagnetic compatibility (EMC) - Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase.
IEC 61140	Protection against electrical shock – Common aspects for installation and equipment
IEC 61439 series	Low-voltage switchgear and control gear assemblies
IEC TS 61439-7	Low-voltage switchgear and controlgear assemblies - Part 7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicles charging stations.
GSO IEC 61851-1	Electric vehicle conductive charging system - Part 1: General requirements
GSO IEC 61851-21	Electric vehicle conductive charging system - Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. supply
IEC 61851-21-1	Electric vehicle conductive charging system - Part 21-1 Electric vehicle on-board charger EMC requirements for conductive connection to AC/DC supply
IEC 61851-21-2	Electric vehicle conductive charging system - Part 21-2: Electric vehicle requirements for conductive connection to an AC/DC supply - EMC requirements for off-board electric vehicle charging systems
GSO IEC 61851-22	Electric vehicle conductive charging system - Part 22: AC electric vehicle charging station
IEC 61851-23	Electric vehicle conductive charging system - Part 23: DC electric vehicle charging station
IEC 61851-24	Electric vehicle conductive charging system - Part 24: Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging
IEC 61980	*Not within the scope of this document:* Electric vehicle wireless power transfer (WPT) systems

GSO IEC 62196-1	Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 1: General requirements
OS 1647/2022	Technical Standard for Electricity Metering Systems
GSO IEC 62196-2	Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tub accessories
IEC 62196-3	Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 3: Dimensional compatibility and interchangeability requirements for d.c. and a.c./d.c. pin and contact-tube vehicle couplers
IEC 62335	Circuit breakers - Switched protective earth portable residual current devices for class I and battery powered vehicle applications
IEC 62335	Circuit breakers – Switched protective earth portable residual current devices for class I and battery powered vehicle applications
IEC 62752:2016	In-Cable Control and Protection Device for mode 2 charging of electric road vehicles (IC-CPD)
IEC/TS 60479 series	Effects of current on human beings and livestock
GSO IEC/TS 60479-1	Effects of current on human beings and livestock - Part 1: General aspects
BS 1363	13 A plugs, socket-outlets, adaptors and connection units Specification for rewirable and non-rewirable 13 A fused plugs