White Paper
of Charging Interface Initiative e.V.

Introduction of boost current for EV DC-Charging

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Contents

1. Introduction

In light of **global climate agreements**, including the Paris Agreement, as well as specific initiatives such as the European Green Deal, the Inflation Reduction Act in the United States, and China's carbon neutrality strategy, the transportation sector plays a central role in reducing CO_2 emissions. These regions have set ambitious goals to reduce greenhouse gases and promote clean technologies, with **electric vehicles being a key component of these strategies**.

A crucial aspect of enhancing the performance of current **electric vehicle charging technology** is the application of a "**rated boost current**," which involves short-term currents exceeding the rated continuous current.

This defined overload allows for further **reduction in charging times** without compromising safety or longevity. By significantly shortening charging times, a major weakness of electric mobility—namely, longer refueling times compared to internal combustion engine vehicles—is effectively eliminated.

The targeted use of rated boost current **increases the efficiency** of the charging process, which is particularly important for fast-charging stations. This contributes to **the broader adoption of electric vehicles** by improving **everyday usability** and further alleviating range anxiety.

Moreover, an improved charging infrastructure helps to **relieve the power grid** and **maximize energy efficiency**, offering both **economic and ecological benefits**. These developments are essential to successfully transitioning to **sustainable mobility**.

The white paper is structured as follows:

Chapter 2 Scope This chapter clearly defines the scope of the white paper. It outlines the specific topics and areas covered, ensuring that the reader has a clear understanding of the objectives and extent.

Chapter 3 Structure of the certification concept This chapter describes the fundamental certification concept. It provides a brief overview of the structure and key components for the certification of cable assemblies and EVSEs.

Chapter 4 Framework Conditions Here, the individual parameters of the framework are explained in detail.

Chapter 5 Enhanced temperature rise test for cable This chapter introduces an enhanced testing procedure for Boost Mode, based on the temperature rise test for cable assemblies. This procedure is also applicable to the system standard (61851-23).

Chapter 6 Implementation of the results into the International Standardization Finally, a proposed approach is presented to quickly integrate the requirements into international standards. This chapter offers practical steps and strategies to effectively incorporate the white paper's results into standardization.

New created values and changes for standardization is marked with grey background.

2. Scope

The purpose of this document is proposing a concept for boost current operation of DC charging accessories to better optimize the EV user's charging experience. This concept offers a framework for ensuring **interoperability** as well as **enhanced operational safety**.

Interoperability is ensured through defined operating conditions with corresponding performance characteristics and validation tests.

The **operational safety** enhancements relate to the minimum performance of the temperature detection means as well as the thermal behaviour during the boost operation, and in particular, in the event of foreseeable accessory faults. It is to be noted that the existing permissible limits for contact temperatures as well as the cable surface temperatures as defined in *IEC 61581* series and *IEC 62196* series remain valid with this proposal.

3. Structure of the certification concept

The fundamental certification concept for the application of Boost Mode in charging electric vehicles encompasses the certification of both *cable assemblies* and *charging systems*, based on specific international standards.

A ***cable assembly*** is certified regarding the defined framework conditions against the system parameters of the products data sheet. The requirements for the cable assembly are based on *IEC 62196-1* and *-3-1*.

A ***charging system*** is certified by testing the defined system behaviour with the ***certified cable assembly***. The requirements for the charging system are based on I*EC 61851-1* and *-23*.

4. Framework Conditions

The framework conditions of the ***boost mode*** are defined by the test conditions and the ***boost setup*** as a combination of the ***rated boost duration***, the ***rated boost current***, the ***rated cooling down duration*** and the ***thermal management parameters***. For safe operation, it is important to define the magnitude of the rated boost current from the state of thermal saturation.

Rated boost duration Δt_{RBC}
Maximum duration for applying the rated boost current at an ambient temperature of 40°C at a defined boost setup as specified in the manufacturer's datasheet and shall be minimum **5 minutes**.

Note: This duration is used solely for **testing** and **defining** the **rated boost current**. In real charging processes in field, the duration **may be shorter** than 5 minutes.

Rated boost current I_{RBC}

upper limit of the current specified by the manufacturer up to which the EV supply equipment has been designed to operate **in a defined *boost setup* at an ambient temperature of 40°C**

Rated cool down duration Δt_{RCD}

The minimum cool down duration required to recover from a previous full thermal saturation of the system to ensure the next boost period at an ambient temperature of 40°C as given by the manufacturer's datasheet.

Boost setup

The value of the specific *framework parameters* under which the amount of a certain ***rated boost current*** I_{RBC} is specified is referred to as the ***Boost setup***. These framework parameters include Δt_{RBC}, Δt_{RCD}, and additional parameters specified by the manufactures, e.g. thermal management parameters. See Table 1 Notional Boost Setups.

4.1. Rated boost duration Δt_{RBC}

4.1.1. Introduction

The *rated boost duration* specifies how long the *rated boost current* can be continuously applied without exceeding the permissible maximum temperatures according to the temperature rise test.

The *rated boost duration* is to be defined by the manufacturer of the cable assembly. For the certification of a cable assembly, a **minimum boost duration** of **five minutes** is introduced for the following reasons:

The safety considerations for the boost mode focus on preventing risks that could occur with very short boost times, which might theoretically allow for extremely high charging currents. However, in any implementation the point of maximum temperature rise, and the point of temperature sensing are at different locations – which can lead to a lag in detecting overheating.

To avoid these risks, a minimum test duration is set to give temperature monitoring systems enough time to accurately detect and respond to any potential thermal issues. Furthermore, implementing the minimum test duration allows consistent comparable testing conditions, thereby providing customers with a reliable basis for comparison and ensuring the overall interoperability.

Considering that shorter boost duration does not lead to significant charge performance improvements, five minutes are proposed.

4.1.2. Requirements

The ***minimum boost duration*** $\Delta t_{RBC\ min}$ for applying the boost test current is **5 minutes**.

Manufacturers of cable assemblies may specify a longer rated boost duration $\Delta t_{RBC} > \Delta t_{RBC\_min}$ with corresponding I_{RBC} in a *boost setup table* as well.

This duration is used for **type test** of the **cable assembly**. EVSE manufacturers can reduce the boost duration Δt_{BC} **to a shorter time** than Δt_{RBC}.

At temperatures below 40°C, the EVSE may apply a longer boost duration than specified in the selected *boost setup*. For the certification of the *EVSE*, it must be proven that the application of the extended boost duration does not result in exceeding the maximum permissible temperatures according to the temperature rise test.

4.2. Rated boost current I_{RBC}

4.2.1. Introduction

The *rated boost current* is defined in IEC 61851-23:2023 as follows:

3.7.129
rated boost current
<side B> upper limit of the current specified by the manufacturer up to which the EV supply equipment has been designed to operate for a limited period of time

Note 1 to entry: The rated boost current is more than or equal to the rated continuous current.

Note 2 to entry: The rated boost current of the side B cable assembly is under consideration in IEC 62196-1, IEC 62196-3 and IEC 62196-3-1. For more information, see 101.3.

Figure 1 Definition of rated boost current according to IEC 61851-23:2023

For comprehensive application and testing of the Rated Boost Current, it is important to establish additional requirements for the value.

4.2.2. Requirements

The amount of ***rated boost current*** I_{RBC} is specified after the state of **thermal saturation** at an ***ambient temperature*** of **40°C** and depends on the ***boost setup*** according to the manufacturers data sheet.

It is strictly prohibited to increase the amount of current beyond that defined in the boost setups, even if the *application time* Δt_{BC} is shorter than the related *rated boost duration* Δt_{RBC}.

4.3. Rated cooling down duration Δt_{RCD}

4.3.1. Introduction

The ***rated cooling down duration*** specifies the period a cable assembly must rest under defined conditions to safely withstand a subsequent boost.

4.3.2. Requirements

The ***rated cooling down duration*** is defined by the manufacturer of the cable assembly for each *boost setup* and ensures a subsequent boost of the system after a state of thermal saturation.

4.4. Boost setup

4.4.1. Introduction

The value of the specific *framework parameters* under which the amount of a certain ***rated boost current*** I_{RBC} is specified is referred to as the ***boost setup***. These framework parameters include Δt_{RBC}, Δt_{RCD}, and the *thermal management parameters*.

4.4.2. Requirements

The manufacturer of the cable assembly shall specify at least one ***boost setup*** with the ***intervention value*** used to prevent exceeding the permissible temperatures in the *data sheet*. Each ***boost setup*** shall correspond to only one ***rated boost current*** and shall be certified separately. The certification is carried out in accordance with the description in 5.2 Advanced temperature rise test for cable assembly with boost mode.

If the manufacturer of the cable assembly specifies multiple ***boost setups***, these shall be listed in a ***boost setup table***.

To certify an EVSE, the manufacturer of the EVSE shall select one of the boost setups defined by the manufacturer of the cable assembly in the boost setup table. The setting of the thermal management system shall be chosen at least as performant as defined in the selected boost setup.

Notional example of a *Boost Setup Table* for a liquid cooled cable assembles:

	Boost Parameters at T_{amb} = 40°C			Measurement	Thermal management	
Boost Setup	***Δt_{RBC}***	***I_{RBC}***	***Δt_{RCD}***	***Intervention value***	***T_{Supply}***	***Flow Rate***
A	*5 min.*	*1.000 A*	*3 min.*	1,3 kΩ	30°C	1 l/min.
B	*5 min.*	*1.200 A*	*1 min.*	1,1 kΩ	10°C	1 l/min.
C	*6 min.*	*900 A*	*4 min.*	1,4 kΩ	30°C	1 l/min.
D	*10 min.*	*1.000 A*	*1 min.*	1,2 kΩ	10°C	5 l/min.

Table 1 Notional Boost Setups

Each individual ***boost setup*** shall be verified through a separate test. In the example shown above, four verification tests would be required to certify the *cable assembly*.

4.5. Standardized test conditions

4.5.1. Introduction

Defined and comparable test requirements ensure consistency in testing. Unlike the current requirements according to IEC 61851-23:2023, Table 119, no differing requirements for the test specimens of *cable assemblies* in relation to the *rated boost current* shall apply.

4.5.2. Requirements

The tests are always carried out under identical conditions to **those used for testing the continuous rated current behaviour**. This applies in particularly to the **dimensioning of reference devices** and **setting the cooling parameters**.

5. Enhanced temperature rise test for cable assembly

5.1. Introduction

The enhanced temperature rise test of *IEC 62196-3-1, 24.102* is intended to ensure that the application of a complete rated boost current in intended operation does not lead to the *maximum permissible temperatures* being exceeded. See Figure 2, P.9

In this context, the intended operation is represented by the device-specific *rated cooling down duration* ***Δt_{RCD}*** required to perform a subsequent rated boost after a state of thermal saturation.

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Thermal saturation is brought about by the combination of a **rated boost** with the **existing temperature rise tests** at an ambient temperature of 40°C. This is caused by the following heating phases acting on the *cable assembly*:

- *Rated boost current* over the *rated boost duration* of at least 5 minutes Δt_{RBC} (t_0 – t_1)
- Continuous rated current for a system-specific / control-dependent transition duration Δt_{trans} (t_1 – t_2)
- Continuous rated current for at least 30 minutes in thermal equilibrium Δt_{Equ} (t_2 – t_3)

The resulting operating temperature rise is considered sufficient to represent a real charging process.

The proposed addition to the test procedure does not take into account the influence of local super-temperatures at the microscopic constrictions of the contact system. The device manufacturer must ensure that this effect does not damage the contact system and that the proportion of the *rated boost current* is significantly below the welding current limit of the respective contact pairing. This effect is significantly influenced by the design of the contact system.

For this reason, the test is followed by a visual inspection of the contact point of the inlet reference device's contact surface, during which no signs of heat welding or other thermal wear shall be visible.

The following clause presents an extended test procedure for the certification of cable assemblies with boost mode, based on the temperature rise test according to IEC 62196-3-1, Clause 24.102. New entries will be highlighted in **bold and grey background**.

5.2. Advanced temperature rise test for cable assembly with boost mode

For cable assemblies with boost mode, this test replaces the current 24.102 test.

Cable assemblies shall be so constructed that the temperature rise **including boost mode** in normal use is not excessive.

Compliance is checked by the following test for **each *boost setup***:

The DUT is a cable assembly with the cable attached to the vehicle connector having the longest length as specified by the manufacturer.

The reference device for this test complies with, Figure C.1, or Figure D.1, as appropriate **and is dimensioned for the rated continuous current according to the DUT manufacturer`s data sheet**. The reference device shall have **no visible signs of heat welding or other thermal wear at the contact surface**.

The corresponding test setup complies with Figure C.2, or Figure D.2, as appropriate.

The general test set-up complies with, Figure C.9, or Figure D.9, as appropriate.

If the cable assembly is equipped with thermal transport, then the thermal exchange parameters are used as specified by the DUT datasheet for 40°C.

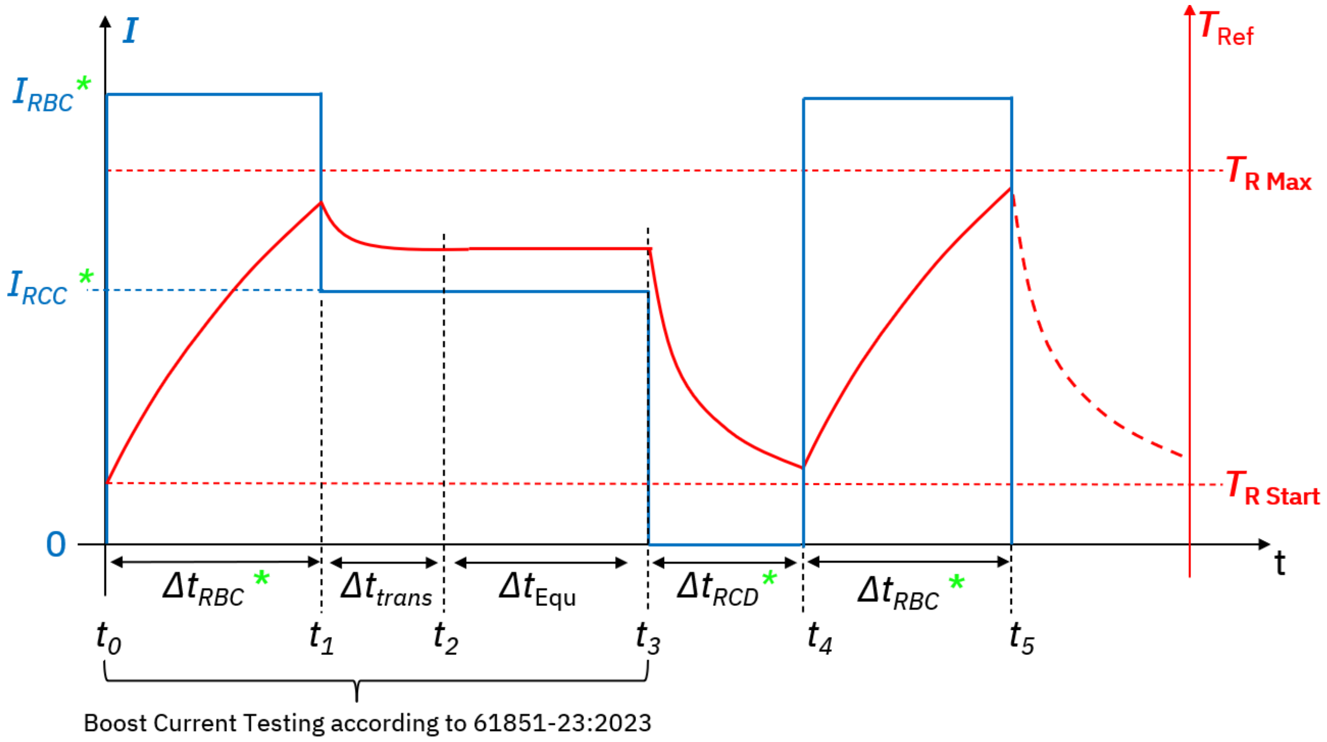
If the maximum permissible ambient temperature is higher than 40°C the test shall also be done at the maximum permissible ambient temperature. Different values for each combination of I_{RBC}, Δt_{RCD}, Δt_{RBC} , and thermal exchange parameters can be specified for this purpose.

For all cable assemblies with boost mode function the temperature rise test is performed at an ambient temperature of 40 ±5 °C. The results are corrected to an ambient temperature of 40°C.

The tests are conducted in a draft-free environment without forced convection.

The cable assembly is mated to the reference device.

The current flow sequence of the test run is described below. Figure 2 illustrates the current flow sequence with an exemplary temperature curve.



$\boldsymbol{I_{RBC}}$ = Rated boost current (*)

$\boldsymbol{I_{RCC}}$ = Rated continuous current (*)

Δt_{RBC} = rated boost duration (*)

Δt_{RCD} = rated cool down duration (*)

Δt_{trans} = transition duration (for information only)

Δt_{Equ} = stable thermal equilibrium duration

$\boldsymbol{T_{Ref}}$ = Temperature measured by the reference device

$\boldsymbol{T_{R\ Start}}$ = Temperature for starting the test procedure

$\boldsymbol{T_{R\ Max}}$ = maximum permissible temperature (currently: 90°C / current CDV of IEC 62196-3: 100°C)

(*) = Defined by manufacturer

Figure 2 Example of a boost current curve with temperature rise on accessory level

The cycle for the test is defined as follows:

Phase 1 Δt_{RBC}

(period t_0 – t_1 in Figure 2): The *test current* is the *rated boost current* I_{RBC} according to the DUT manufacturer`s data sheet. The test current is applied to the cable assembly at the DC+ and DC– contact for minimum boost duration according to the DUT manufacturer`s data sheet.

Phase 2 Δt_{trans}

(period t_1 – t_2 in Figure 2**) When t_1 is reached, the *test current* shall be reduced to the *rated continuous current* I_{RCC} according to the DUT manufacturer`s data sheet.**

The duration required to reach the start of the thermal stabilization phase at the reference device is defined as transformation time Δt_{trans} (for information only).

Phase 3 Δt_{Equ}

(period t_2 – t_3 in Figure 2**) The *rated continuous current* is applied to the cable assembly at the DC+ and DC- contact. When thermal stabilisation is reached after Δt_{Equ} (for information only), the applied current shall be reduced to 0 A after 10 minutes.**

Phase 4 Δt_{RCD}

(period t_3 – t_4 in Figure 2**) The applied current remains at 0 A for the duration of the *minimum cool down duration* Δt_{RCD} according to the DUT manufacturer`s data sheet.**

Phase 5 Δt_{RBC}

(period t_4 – t_5 in Figure 2**): The test current is the *rated boost current* I_{RBC} according to the DUT manufacturer`s data sheet. The test current is applied to the cable assembly at the DC+ and DC– contact for *rated boost duration* $\Delta t_{RBC}$ according to the DUT manufacturer`s data sheet. *After minimum boost duration* the applied current shall be reduced to 0 A.**

The temperatures at the DC contacts measured by the temperature sensors (T_1+ and T_1−) and the provided values from the thermal sensing devices of the cable assembly (T_S+ and T_S−) are recorded with one or more sample per second throughout the test.

The values provided by the thermal sensing devices of the cable assembly are converted into temperature values according to the manufacturer's data sheet.

This test is passed if:

- the temperature rise measured by the temperature sensors (T_1+ and T_1−) has not exceeded $T_{R\ max}$; and
- the surface temperature of the cable assembly does not exceed the limits according to 16.5; and
- the measured values of the thermal sensing devices (T_S+ and T_S−) have not exceeded the intervention value provided by the manufacturer according to 16.101
- **No signs of heat welding or other thermal wear shall be visible at the contact surface of the *reference device*.**

6. Implementation of the results into the International Standardization

6.1. Background

It is proposed to implement the additional requirements mentioned above, into the appropriate standards, e.g.: 62196 and / or 61851-Series.

The additions cannot be included to IEC 61851 -23 ED2 and 62196-3 ED3.

Full implementation of the boost mode in the above-mentioned standards will probably be possible until 2030 into the next Editions.

6.2. Objective

In the meantime, a supplementary temporary IEC document (e.g. PAS or TR) is to be created, based on the CharIN-Whitepaper for Boost Current.

This document

- covers the requirements and tests for the charging cable, as well as for the system.
- shall be published via SC 23 H / MT8

On the system side, coordination with the TC 69 / MT5 is to take place at an early stage in order to ensure efficient synchronization.

6.3. Proposed procedure

The proposal of CharIN will be presented to the German national standardization body.

A possible NWIP for the temporary IEC document can be suggested via DKE AK 542.4.3;

The synchronisation with MT5 shall be introduced via DKE AK 353.0.2.

7. Reference

This whitepaper is the outcome of the working group "HPC Performance Increase" of the Focus Group Charging Connection of the CharIN association led by Markus Kroner (Phoenix Contact) and supported by Semih Tetik (CharIN). More working group members were involved in the creation of the whitepaper such as:

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