Technical training.
Product information.

G12 LCI PHEV High-voltage Battery

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BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status: November 2018

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

The information contained in the training course materials is solely intended for participants in this training course conducted by BMW Group Technical Training Centers, or BMW Group Contract Training Facilities.

This training manual or any attached publication is not intended to be a complete and all inclusive source for repair and maintenance data. It is only part of a training information system designed to assure that uniform procedures and information are presented to all participants.

For changes/additions to the technical data, repair procedures, please refer to the current information issued by BMW of North America, LLC, Technical Service Department.

This information is available by accessing TIS at www.bmwcenternet.com.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application
- Aftersales Information Research (AIR)

G12 LCI PHEV High-voltage Battery

Contents

G12 LCI PHEV High-voltage Battery

1. Introduction

This product information describes the design of the high-voltage battery unit in the BMW 745e xDrive with the development code G12 LCI PHEV and the special features relating to its repair.
This document is not a replacement for the repair instructions, but should provide the reader with the necessary background knowledge and supplementary notes.

This product information only covers the new high-voltage battery (SP41) in comparison with its predecessor, the high-voltage battery (SP06) from the BMW 740e iPerformance and BMW 530e iPerformance. Knowledge of this predecessor and the high-voltage technology of hybrid generation 3.0 is a requirement.

Basic and further information can be found in the listed documents:

Further information
• G12 PHEV High-voltage Components Reference Manual • G12 PHEV High-voltage Battery Unit Reference Manual • G12 LCI PHEV High-voltage Components Reference Manual

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

2.1. Overview

2.1.1. High-voltage battery generation 3.0

Technical data	F15 PHEV	F30 PHEV	G12 PHEV G30 PHEV
Manufacturer	BMW	BMW	BMW
Technology	Lithium-ion	Lithium-ion	Lithium-ion
Number of battery cells	96	80	96
Cell voltage Capacity	3.7 V 26 Ah	3.66 V 26 Ah	3.66 V 26 Ah
Nominal voltage	355 V	293 V	351.4 V
Voltage range	269 - 399 V	225 to 328 V	269 to 398 V
Storable energy capacity	9.2 kWh	7.8 kWh	9.1 kWh
Energy available for consumption	6.8 kWh	5.8 kWh	7.3 kWh
Max. output	83 kW, briefly 43 kW, continuous	65 kW, briefly 45 kW continuous	83 kW, briefly 43 kW continuous
Weight	105 kg	88 kg	113 kg

The above list shows the high-voltage battery of battery generation 3.0. In case of potential defects, the generation 3.0 high-voltage battery unit can be repaired, in contrast to generation 1.0 to generation 2.0, which needed to be completely replaced.

2.1.2. High-voltage battery generation 4.0

With the G12 LCI PHEV, the high-voltage battery generation 4.0 is deployed for the first time. The basic layout of the lithium-ion battery is same as that for the high-voltage battery of the G12 PHEV and the G30 PHEV. It lays the foundation stone for a number of plug-in hybrid electric vehicles which above all have greater ranges than their predecessors. The most significant change compared to the predecessor is that the cell capacity has been increased from 26 Ah to **34 Ah**.

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

G12 LCI PHEV high-voltage battery (SP41)

A list of the changes and adopted features can be found in the separate subchapter " Overview of changes".

2.1.3. Technical data

The following table summarizes some key technical data of the high-voltage battery in the G12 LCI PHEV.

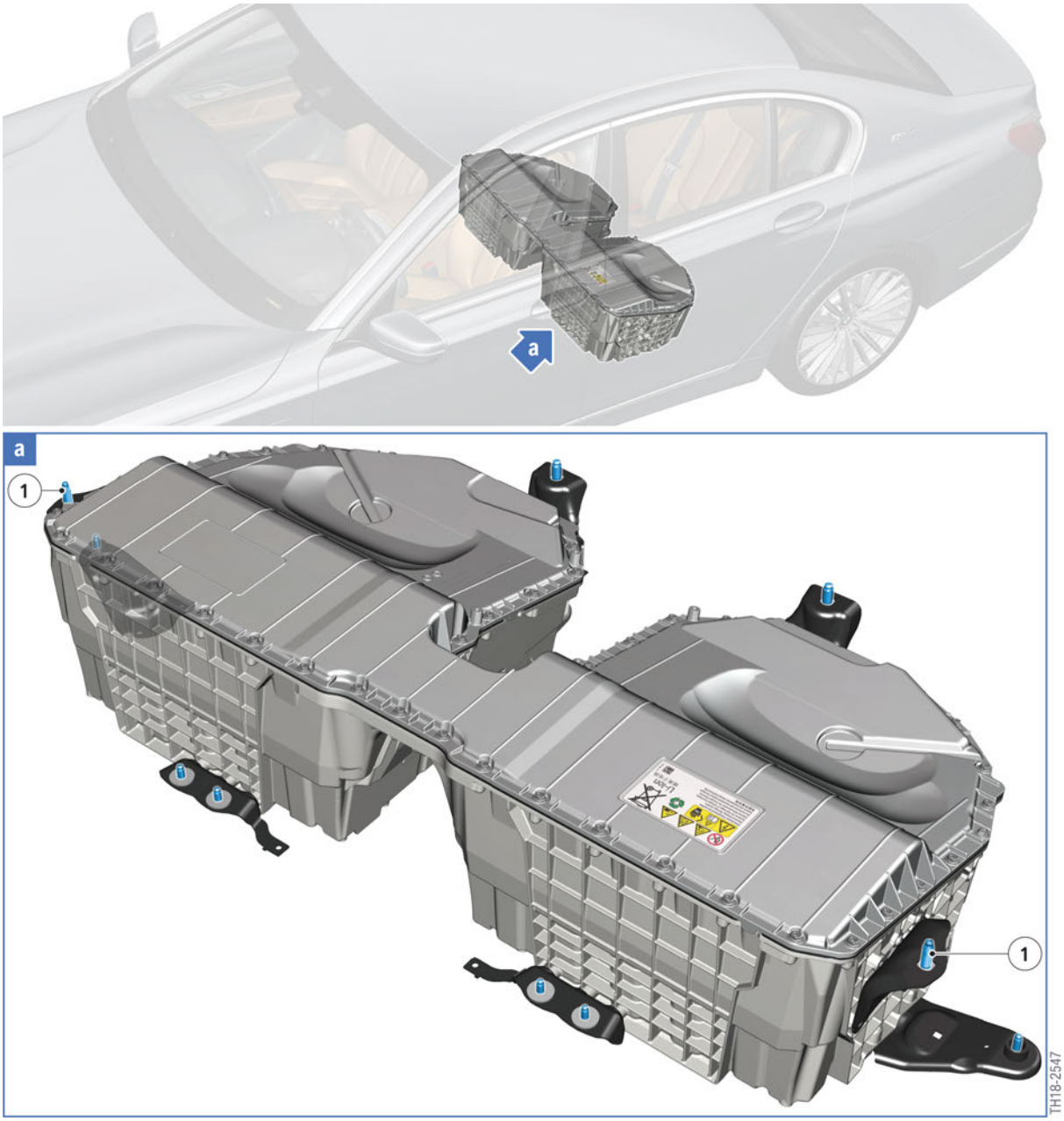
Technical data	G12 PHEV (SP06)	G12 LCI PHEV (SP41)
Voltage	351.4 V (nominal voltage) Min. 269 V – Max. 398 V (voltage range)	355 V (nominal voltage) Min. 269 V – Max. 403 V (voltage range)
Battery cells	Lithium-ion	Lithium-ion
Number of battery cells	96 in series	96 in series
Number of cell modules	6	6
Cell voltage	3.66 V	3.69 V
Capacity	26 Ah	34 Ah
Storable amount of energy	9.1 kWh	12 kWh
Usable energy	7.3 kWh	10.4 kWh
Max. power (discharge)	83 kW (short-term)	83 kW (short-term)
Maximum power (AC charging)	3.7 kW	3.7 kW
Weight	248 lbs (without retaining brackets)	261 lbs (without retaining brackets)
Dimensions	541 mm x 1134 mm x 271 mm	541 mm x 1134 mm x 271 mm
Cooling system	Refrigerant R1234yf	Refrigerant R1234yf

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

2.1.4. Installation location, connections and stickers

The high-voltage battery is fitted at the same location as its predecessor. Both the mounting of the high-voltage battery and its connections are also the same.



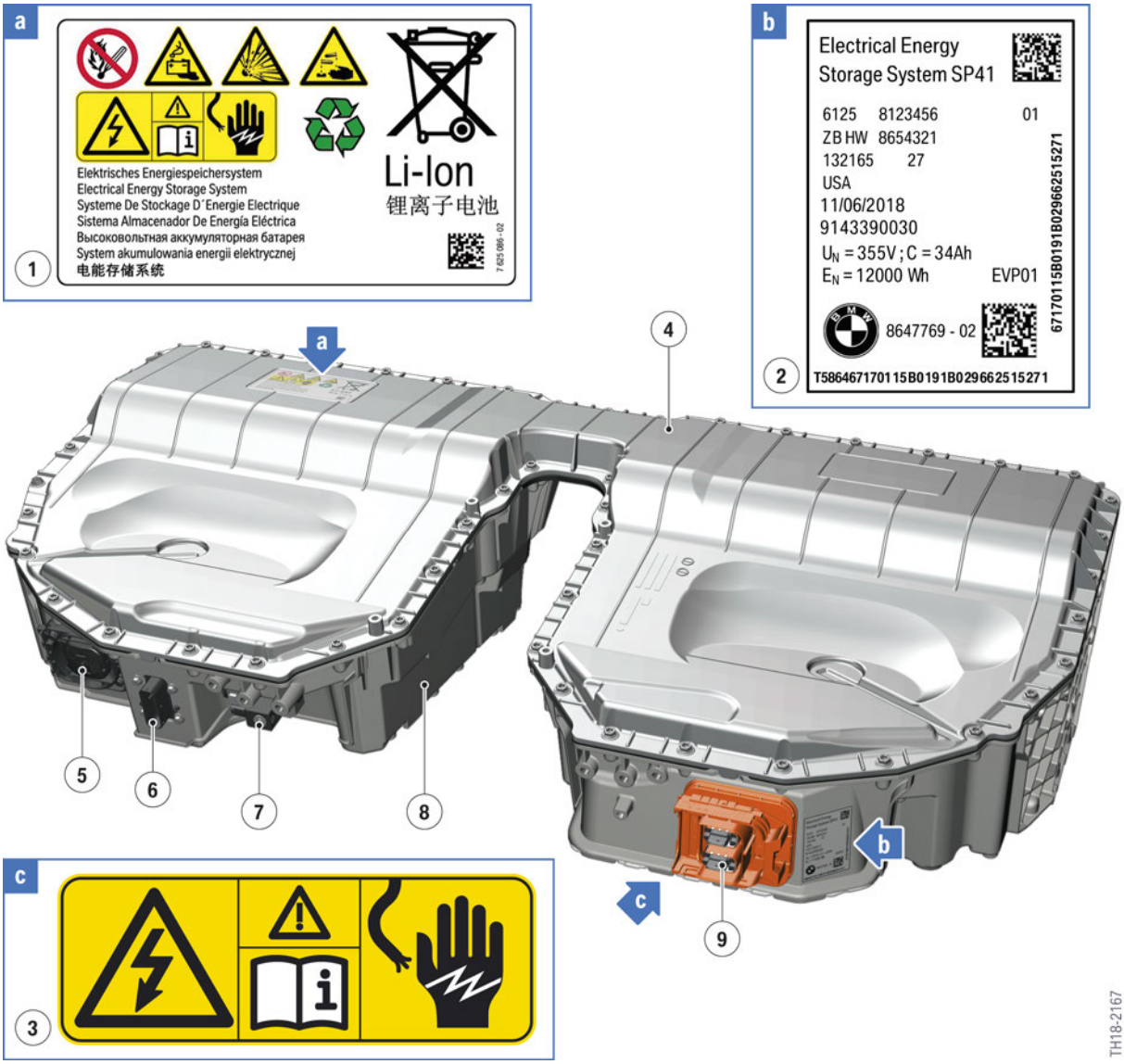
G12 LCI PHEV Mounting of the high-voltage battery

Index	Explanation
1	Mounting bolts that ensure the equipotential bonding between housing and body

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

The familiar procedure for installation is unchanged, in particular the tightening process for the mounting bolts that ensure equipotential bonding (four-eyes principle, documentation etc.).



G12 LCI PHEV Stickers and connections of the high-voltage battery

Index	Explanation
1	Warning sticker for high-voltage battery
2	Type plate with technical data
3	High-voltage component warning sticker
4	Upper housing section of the high-voltage battery
5	Venting unit

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

Index	Explanation
6	Connection for signal connector
7	Connection for refrigerant lines
8	Lower housing section of the high-voltage battery
9	High-voltage connection

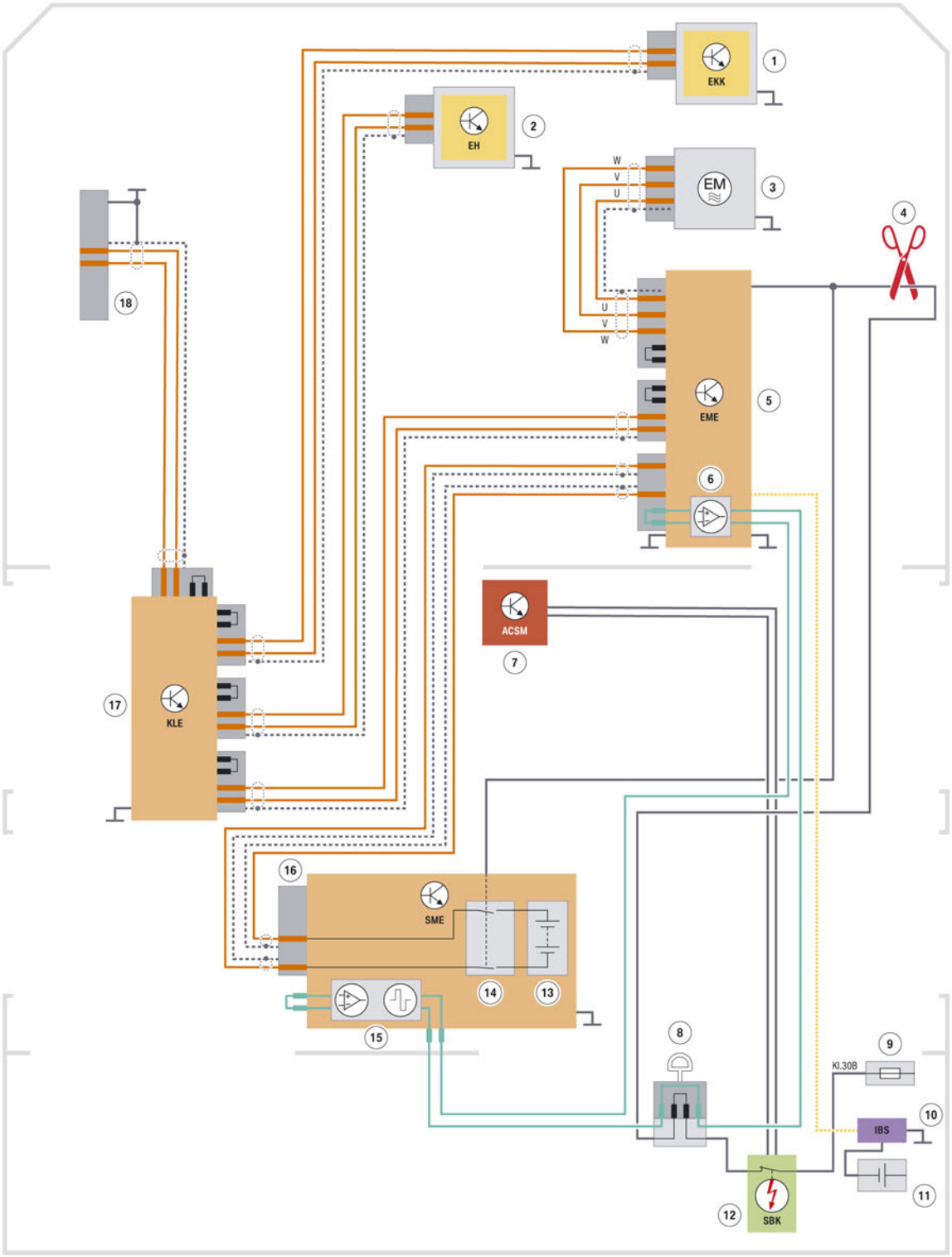
The type plate is now visible with the high-voltage battery installed. Previously, it was located on the upper housing section.

The majority of specifications on the type plate are individual for each high-voltage battery, for example serial number and production date. It is therefore necessary to specify these individual specifications when ordering a replacement type plate.

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

2.1.5. System wiring diagram



G12 LCI PHEV System wiring diagram in the high-voltage combination with high-voltage interlock loop and rescue disconnect

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

Index	Explanation
1	Electric A/C compressor (EKK)
2	Electrical heating (EH)
3	Electric motor
4	Rescue disconnect
5	Electric motor electronics (EME)
6	Evaluation circuit for test signal of the high-voltage interlock loop in the electrical machine electronics
7	Advanced Crash Safety Module (ACSM)
8	High-voltage service disconnect
9	Fuse for rear right power distribution box
10	Intelligent battery sensor (IBS)
11	Auxiliary battery
12	Safety battery terminal (SBK)
13	Cell modules
14	Electromagnetic switch contactor
15	Evaluation circuit for test signal of the high-voltage interlock loop in the battery management electronics
16	Battery management electronics (SME)
17	Convenience charging electronics (KLE)
18	Charging socket

2.1.6. Overview of changes

The following table provides an overview of the alterations to the new high-voltage battery. To ensure the overview is easy to understand, the technical data are compared in the subchapters of the same name.

Component / system	High-voltage battery G12 PHEV (SP06)	High-voltage battery G12 LCI PHEV (SP41)
High-voltage battery generation	3.0	4.0
Type plate	Located on the upper housing section	Located beside the high-voltage connection
Cell module	16 cells 26 Ah cell capacity 3 NCT temperature sensors	16 cells 34 Ah cell capacity 3 NCT temperature sensors

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

Component / system	High-voltage battery G12 PHEV (SP06)	High-voltage battery G12 LCI PHEV (SP41)
Safety box	Generation 3.0	Generation 4.0 Configuration for higher currents
Cell supervision circuits	6 control units with equal rights in a linear bus structure	1 primary control unit and 5 serially interconnected secondary control units (daisy chain)
CSC wiring harness	Black in color	Orange in color

Many components and systems have been adopted for the G12 LCI PHEV **unchanged** from high-voltage battery generation 3.0:

- Upper housing section, including seal
- Lower housing section
- 2 module intermediate flooring panels
- SME (battery management electronics, except changes to software)
- Cooling system with 4 evaporators, refrigerant temperature sensor and combined expansion and shutoff valve
- Venting unit
- Connections.

2.1.7. Training

Qualification to work on the high-voltage system of the G12 LCI PHEV can be acquired via the respective successfully concluded **web-based training** if the service employee meets the following **requirements**:

Performing work on high-voltage components

- Valid "High-voltage Components" certification for another vehicle of hybrid generation **3.0**

  OR
- Valid "High-voltage Components" certification for another vehicle of hybrid generation **4.0**

Working on the high-voltage battery

- Valid G12 LCI PHEV High-voltage Components certification

  AND
- Valid "High-voltage Battery" certification for another vehicle of the high-voltage battery generation **3.0** or **4.0**.

As the list indicates, a first-time qualification for the hybrid generation 4.0 can be acquired via web-based training if the relevant valid qualification for hybrid generation 3.0 has already been obtained. Face-to-face training specifically for qualification for hybrid generation 4.0 is then not required.

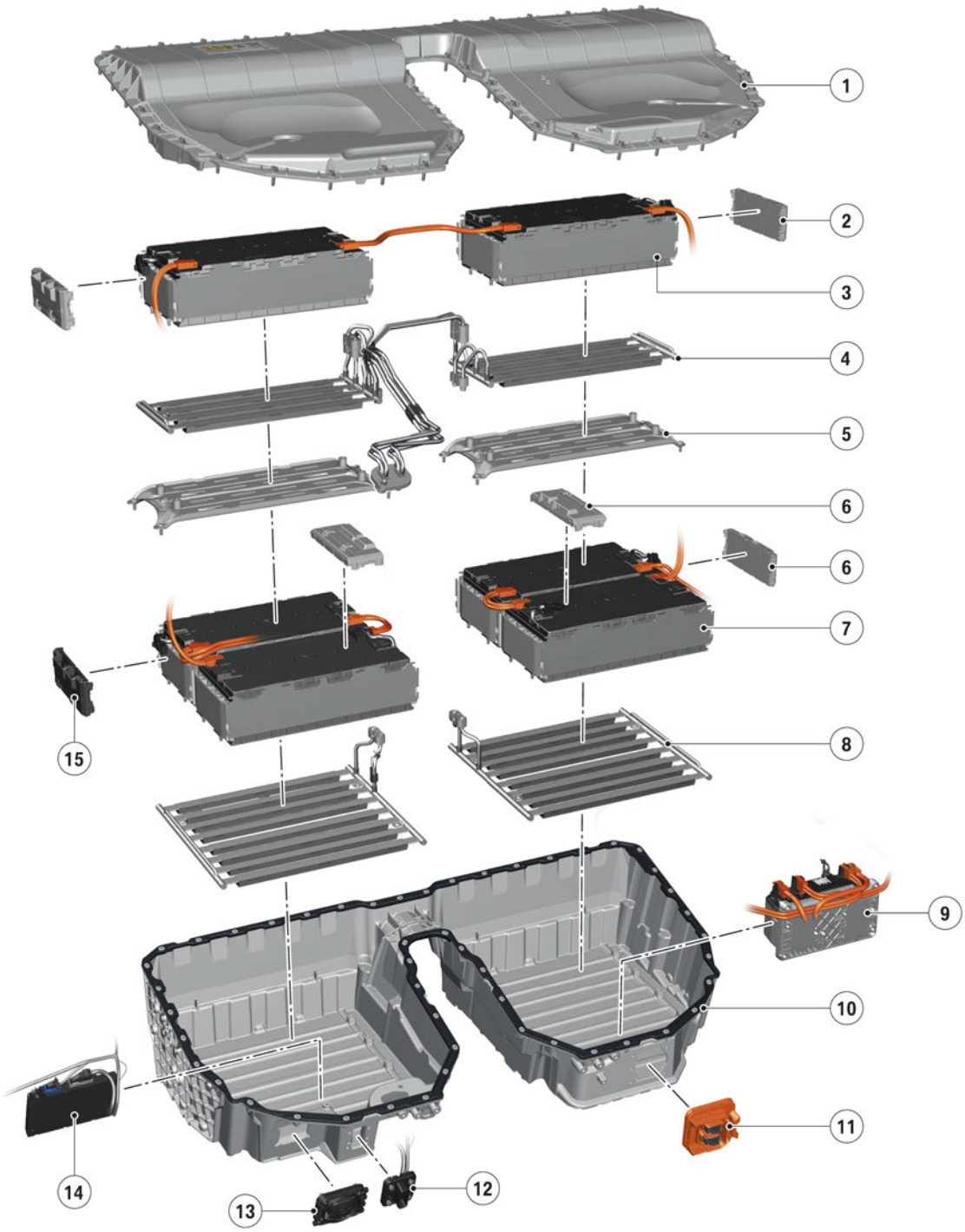
2.2. Inner structure

2.2.1. Component overview

The inner structure of the high-voltage battery and arrangement of the components are the same as on the predecessor.

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery



G12 LCI PHEV Structure of the high-voltage battery

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

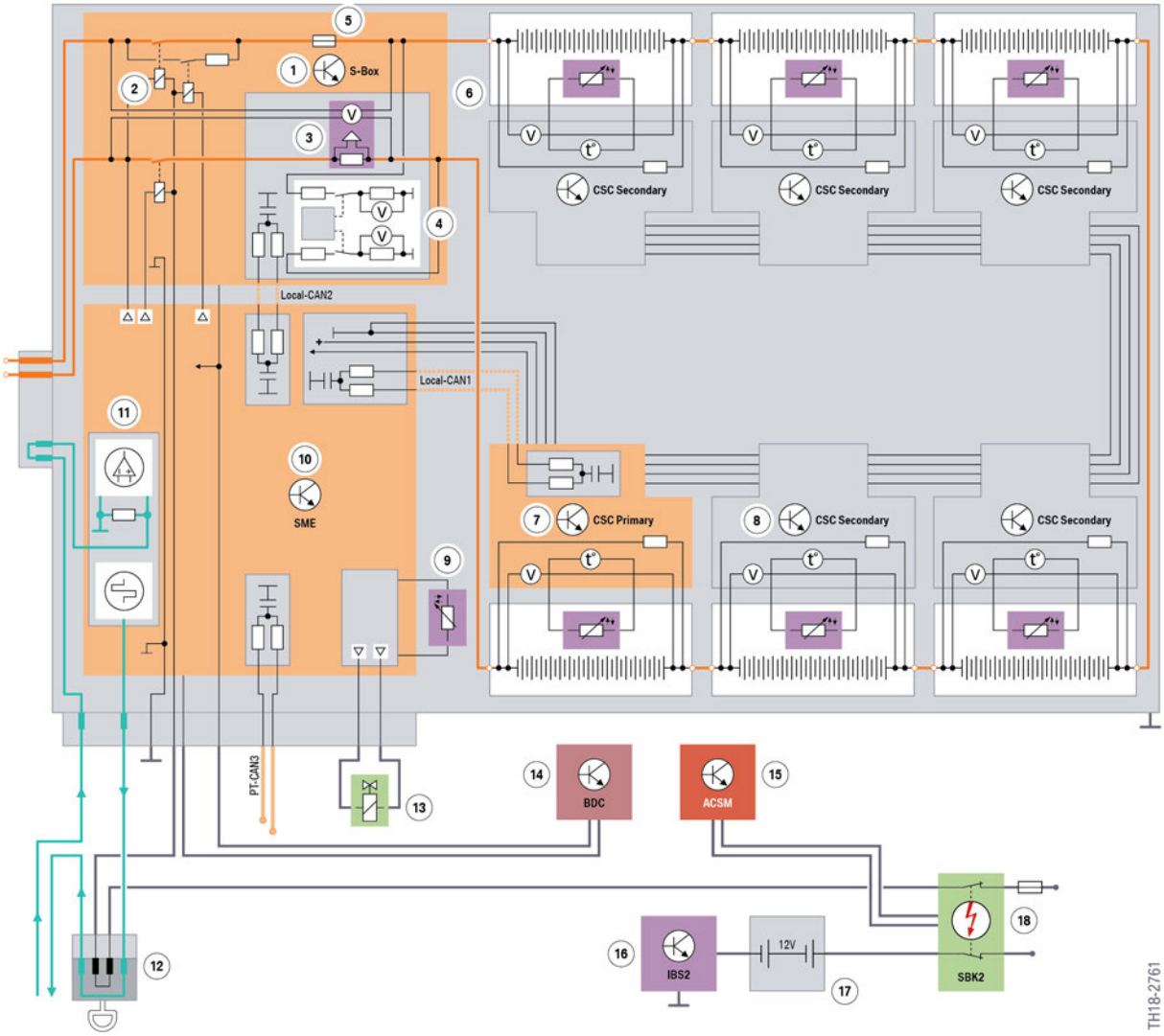
Index	Explanation
1	Upper housing section
2	Top cell supervision circuit (secondary, grey)
3	Upper cell modules
4	Top evaporator
5	Module intermediate floor
6	Bottom cell supervision circuits (secondary, grey)
7	Lower cell modules
8	Bottom evaporator
9	Safety box
10	Lower housing section
11	High-voltage connection
12	Signal connector
13	Venting unit
14	Battery management electronics (SME)
15	Bottom cell supervision circuit (primary, black)

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery

2.2.2. System wiring diagram

The majority of functions and inner electrical connections correspond to those in the predecessor battery.



G12 LCI PHEV System wiring diagram for high-voltage battery

Index	Explanation
1	Safety box
2	Switch contactors
3	Current and voltage sensor
4	Isolation monitoring
5	Main current fuse (350 A)
6	Cell module
7	Primary cell supervision circuit (CSC)

Index	Explanation
8	Secondary cell supervision circuit (CSC)
9	Temperature sensor for refrigerant line
10	Battery management electronics (SME)
11	Control of the circuit of the high-voltage interlock loop
12	High-voltage service disconnect
13	Combined expansion and shutoff valve of the refrigerant line
14	Body Domain Controller (BDC)
15	ACSM with control lines for activating the safety battery terminal
16	Intelligent battery sensor (IBS)
17	12 V battery
18	Safety battery terminal (SBK)

New is the bus structure of the local CAN1 and the division of the cell supervision circuits into primary and secondary control units. Communication between the battery management electronics (SME) and cell supervision circuits takes place exclusively through the primary cell supervision circuit. The remaining cell supervision circuits (secondaries) only communicate with one another and the primary cell supervision circuit.

2.2.3. Safety box

With the new high-voltage battery of generation 4.0, the safety box has been revised and adapted. The higher energy content of the high-voltage battery means that the inner components of the safety box (generation 4.0) have been configured for higher currents. These include:

- The electromagnetic switch contactor
- The pre-charging relay

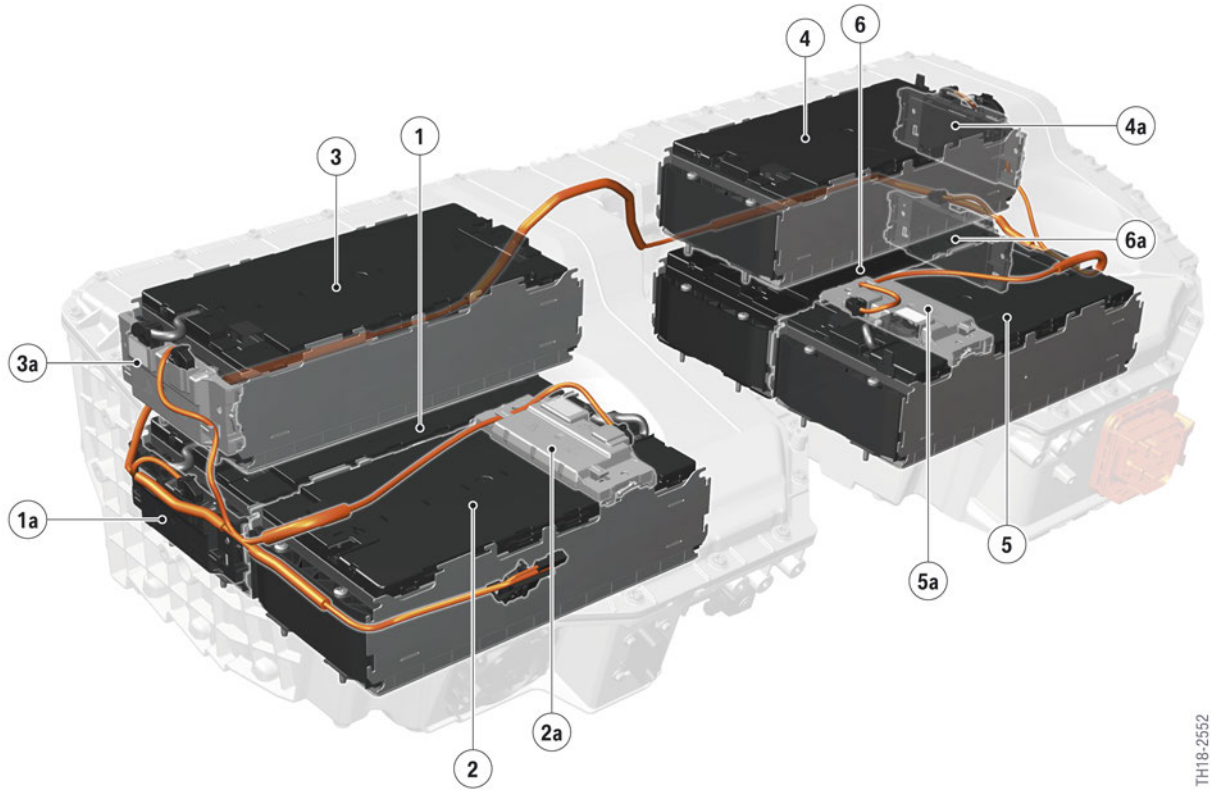
The safety boxes of generation 3.0 and 4.0 cannot be distinguished from the outside and must not be confused. The safety box of generation 3.0 must not be installed in a high-voltage battery of generation 4.0 (and vice versa). Make sure that the correct part is selected. An incorrectly installed safety box is only detected during the EoS test and therefore leads to high overhead for rework.

2.2.4. Cell supervision circuits

The structure of the local CAN1 has been changed. The 6 cell supervision circuits with equal rights are no longer deployed, rather 1 primary cell supervision circuit (black) and 5 secondary cell supervision circuits connected in series (grey).

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery



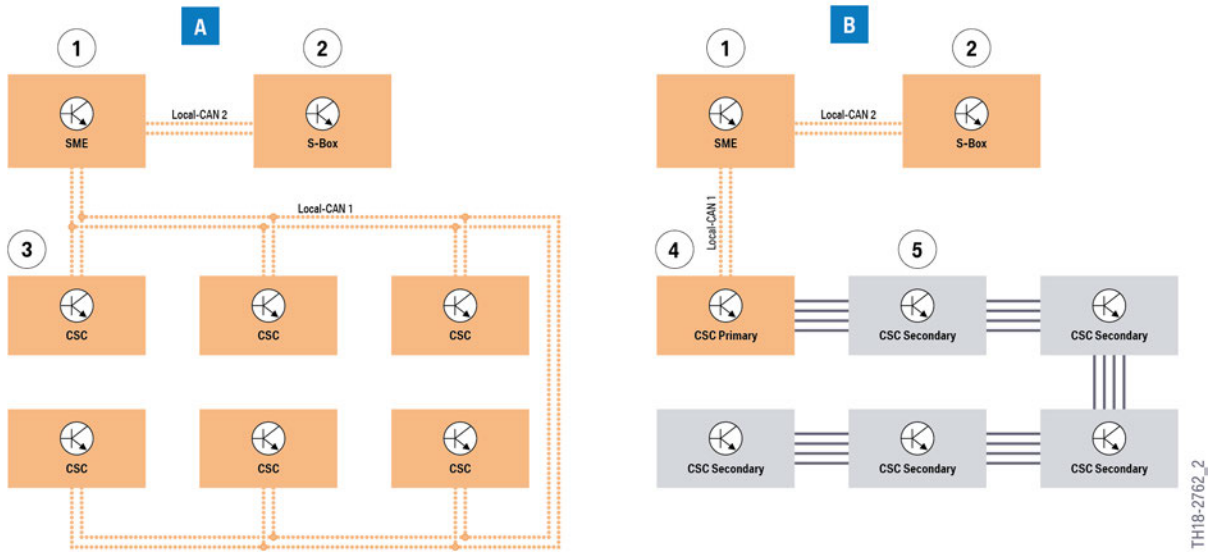
G12 LCI PHEV Cell supervision circuit

Index	Explanation
1	Cell module 1
1a	Cell supervision circuit 1 (primary)
2	Cell module 2
2a	Cell supervision circuit 2 (secondary)
3	Cell module 3
3a	Cell supervision circuit 3 (secondary)
4	Cell module 4
4a	Cell supervision circuit 4 (secondary)
5	Cell module 5
5a	Cell supervision circuit 5 (secondary)
6	Cell module 6
6a	Cell supervision circuit 6 (secondary)

Only the primary cell supervision circuit communicates via the local CAN1 with the SME. The secondary cell supervision circuits communicate with the control unit via the CSC wiring harness.

G12 LCI PHEV High-voltage Battery

2. High-voltage Battery



G12 LCI PHEV Comparison of CSC bus structure of generations 3.0 and 4.0

Index	Explanation
A	Bus structure of the cell supervision circuits of the high-voltage battery generation **3.0** (SP06)
B	Bus structure of the cell supervision circuits of the high-voltage battery generation **4.0** (SP41)
1	Battery management electronics (SME)
2	Safety box
3	Cell supervision circuit with equal rights
4	Primary cell supervision circuit
5	Secondary cell supervision circuit

In this way, a series connection principle leads to advantages, but also disadvantages (in comparison with the CAN structure of the high-voltage battery generation 3.0):

Advantages

- Cost reduction of the secondary cell supervision circuits, as complex printed circuit boards are not required
- Greater reliability resulting from the reduction in number of components
- Separate recording and transmission of the serial number no longer necessary when exchanging a cell supervision circuit.

Disadvantage

- In the event of failure of a secondary cell supervision circuit, communication with the upstream secondary cell supervision circuits is no longer possible. All of the upstream secondary cell supervision circuits fail.
- This means that further failure of an upstream secondary cell supervision circuit can only be identified when the first fault has been remedied.

In the high-voltage batteries of generation **3.0**, exchanged cell supervision circuits arranged themselves in random order with their serial numbers at the SME during their first start-up. It was only possible to ensure unambiguous assignment of the exchanged cell supervision circuits in the SME with manual input of the position and serial number via ISTA.

In the new high-voltage battery generation **4.0**, this manual input of installation position and serial number is not required. The location determination of an exchanged secondary cell supervision circuit is performed automatically by the primary cell supervision circuit, which detects the position of the secondary cell supervision circuit on the basis of its position (order) in the CSC wiring harness.

An exchanged primary cell supervision circuit also detects its position automatically and reports this to the SME.

CSC wiring harness

In contrast to the predecessor battery, the CSC wiring harness is designed in the warning color orange. The reason for this is the fact that a defective cell supervision circuit can mean that the high voltage of the respective cell module is applied on the CSC wiring harness. During trouble-free operation, there is **no** high voltage on the CSC vehicle wiring harness.

G12 LCI PHEV High-voltage Battery

3. Repair

3.1. General information

The following description of the repair of the high-voltage battery unit is only a general list of the content and the procedure. **In general, only the specifications and instructions in the current valid edition of the repair instructions apply.**

Make sure that the correct part is selected within the framework of repairs. The inner components of the high-voltage battery generation 4.0 are not compatible with generation 3.0. Mixed installation is not permitted. The 34 Ah cell modules may only be used in high-voltage batteries of generation 4.0. Conversion of a high-voltage battery of generation 3.0 with 34 Ah cell modules is not permitted.

Before starting work on high-voltage vehicles that have been involved in an accident, the instructions and notices in the following documents in the repair instructions must be observed:

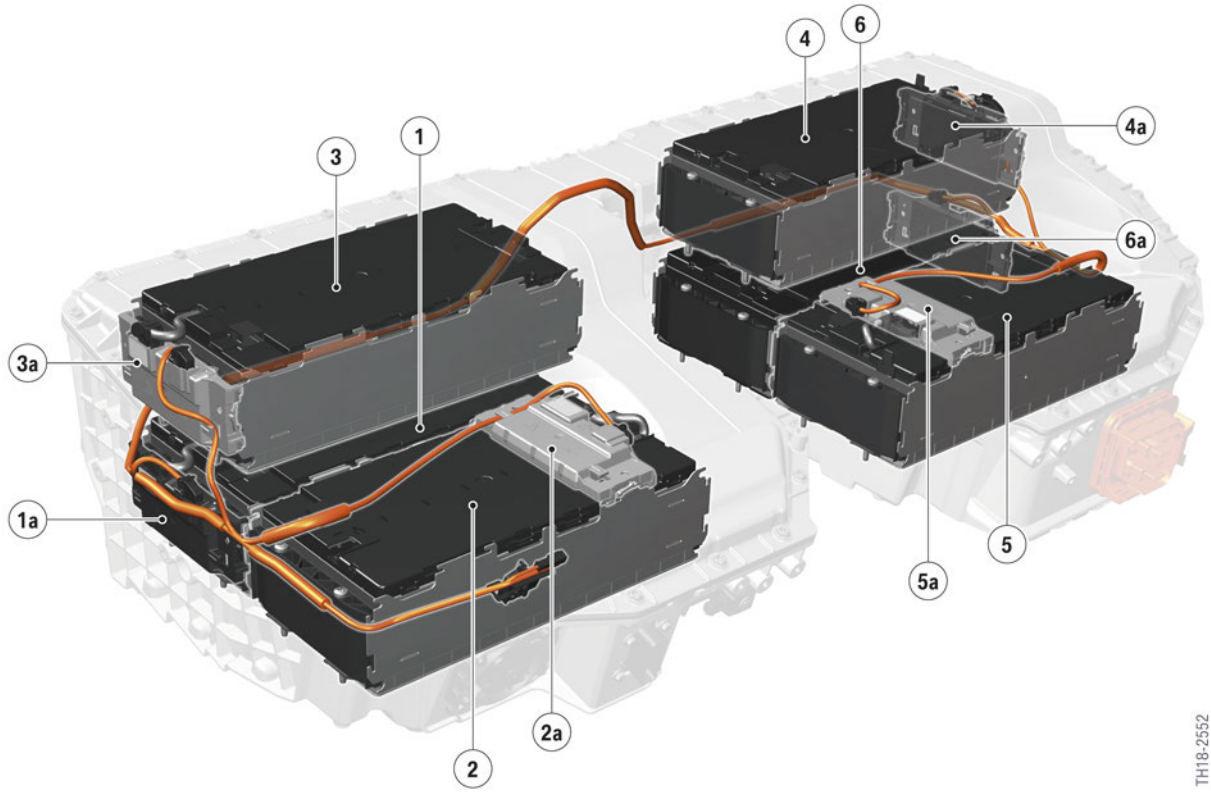
- Safety information for handling electric vehicles
- Assessment of vehicle that has been involved in an accident
- Visual inspection of high-voltage battery unit after an accident.

3.2. Exchange of the cell supervision circuit

When cell supervision circuits are exchanged, it is no longer necessary to enter the serial number and installation position in the printed report and the SME (see subchapter "Cell supervision circuits").

G12 LCI PHEV High-voltage Battery

3. Repair



G12 LCI PHEV Cell supervision circuits

Index	Explanation
1	Cell module 1
1a	Cell supervision circuit 1 (primary)
2	Cell module 2
2a	Cell supervision circuit 2 (secondary)
3	Cell module 3
3a	Cell supervision circuit 3 (secondary)
4	Cell module 4
4a	Cell supervision circuit 4 (secondary)
5	Cell module 5
5a	Cell supervision circuit 5 (secondary)
6	Cell module 6
6a	Cell supervision circuit 6 (secondary)

The numbering of the cell modules remains unchanged. Cell module 1 is the cell module that forms the negative terminal of the high-voltage battery. The counting order of the other cell modules is numerical. This means that cell module 6 is the cell module that forms the positive terminal.

The numbering of the cell supervision circuits remains unchanged. The primary cell supervision circuit may only be connected at cell module 1.

G12 LCI PHEV High-voltage Battery

3. Repair

3.3. CSC wiring harness

The specified attachment points of the CSC wiring harness must be used. A deviation in the routing can diminish the electromagnetic compatibility.

3.4. Cell module exchange

The elements contained in the cells make the cell module a valuable component. In order to minimize the number of exchanged cell modules and improve the tracking of reuse, there are a number of new features.

3.4.1. Reuse

In some high-voltage vehicles with certain software versions, the entire high-voltage path must be replaced after the safety fuse (in the safety box) has triggered. To this end, the following components are output within the framework of diagnosis:

- All high-voltage cables
- The safety box
- All cell modules.

This applies to the following vehicles and integration levels:

- G12 PHEV and G30 PHEV (high-voltage battery SP06) and integration level **before** July 2018.

This leads to high costs. For this reason, the SME software has been extended and now has a counter that takes account of and counts the triggering of the safety fuse. Every time the safety fuse is triggered, a '1' is added to the counter reading. It is only when the counter reading reaches '2' that all cell modules have to be exchanged.

- First-time triggering of the fuse (counter reading 1)
  Exchange of all high-voltage cables and the safety box
- Renewed triggering of the fuse (counter reading 2)
  Exchange of all high-voltage cables, the safety box and all **cell modules**.

This applies to the following vehicles and integration levels:

- G12 PHEV and G30 PHEV (high-voltage battery SP06) and integration level **as of** July 2018
- G12 LCI PHEV (high-voltage battery SP41).

This means it can occur within the framework of diagnosis, depending on the vehicle and software version, that the cell modules are specified as components to be exchanged or not.

Within the framework of repair, the diagnosis outputs a list of which components must be replaced. This list must be complied with at all times.

The counter reading is not visible in ISTA and is automatically reset within the framework of the diagnostic function when the repair is completed. Manual resetting is not possible.

On exchange of the SME, the counter reading of the new SME is adopted. However, this only takes place in the case of a control unit exchange guided by means of ISTA.

3.4.2. Tracking

When a cell module is exchanged, the serial number of the new cell modules must be transferred into ISTA within the framework of the service function. What is new is that the serial numbers of the **exchanged** cell modules also have to be transferred into ISTA. In this way, the exchanged cell modules are also entered in ISTA.

In order to be able to adjust the input of the cell module serial numbers more flexibly to the workflow, there is a new service function that does not require any vehicle communication. This enables the service function "High-voltage battery unit: document serial number of cell module" to be executed when the high-voltage battery is still removed, open and the serial numbers are easily accessible. This is possible, for example, by reopening the last ISTA operation of the associated vehicle.

If the input of the serial numbers has taken place using this service function, this does not have to be done again within the framework of commissioning.

3.4.3. State of charge synchronization

Before the installation of a new cell module, its state of charge is brought to the level of the remaining cell modules, which was read out beforehand. The familiar module charger is used for this.

G12 LCI PHEV Cell module charging cable

In comparison with the predecessor cell modules, the module charging cable with special tool number 2 458 279 must be used.

The software of the module charger has been adapted for various climates. This means it is possible to adapt the cell module voltage over a greater temperature range.

Temperature range:
41 °F to 113 °F (previously 59 °F to 104 °F)

G12 LCI PHEV High-voltage Battery

3. Repair

3.5. EoS tester

Before installation into the vehicle, the high-voltage battery must be tested in the familiar manner using the EoS tester. The changes of the EoS tester are only related to the software. The connections, procedure and operation are unchanged for the G12 LCI PHEV. In the same way as all other plug-in hybrid electric vehicles, the blue clamping bell with the round seal is to be used for the venting unit.