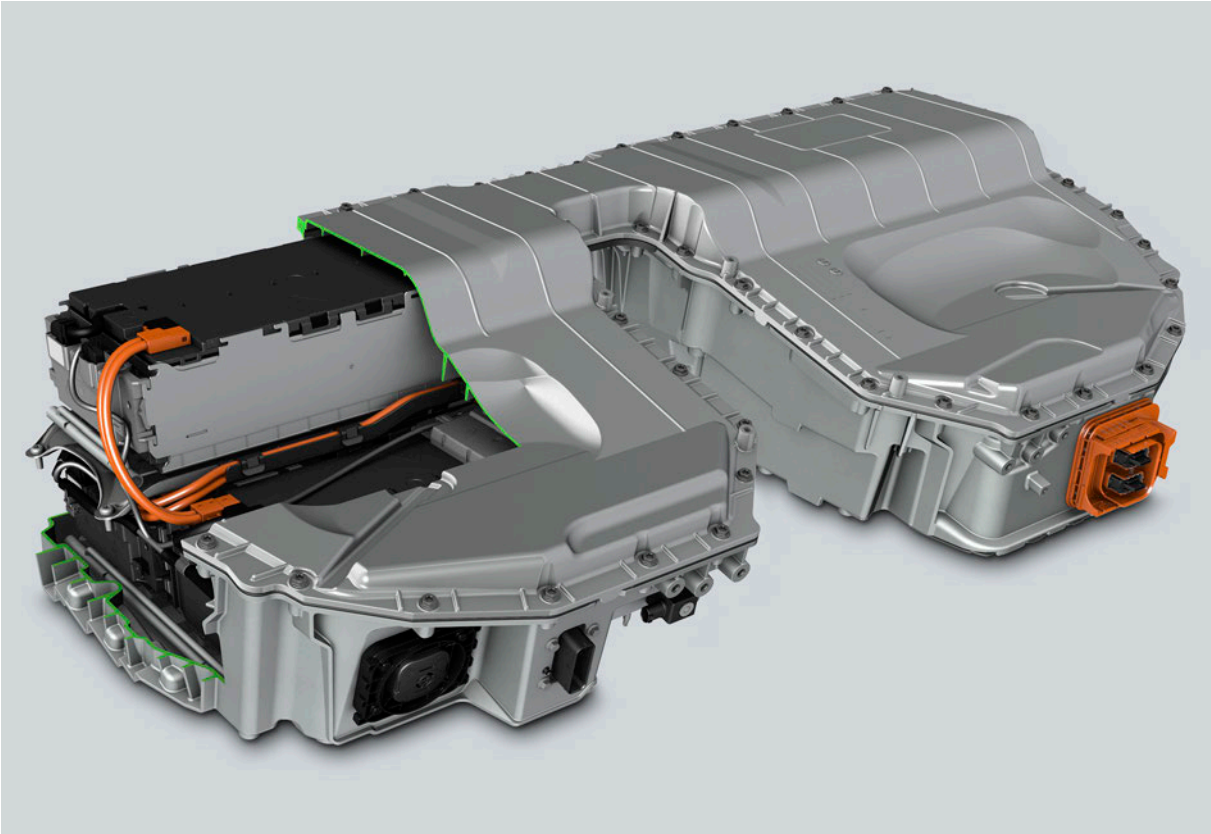
Reference Manual

SP41 HIGH-VOLTAGE BATTERY

Technical Training

Technical training.
Product information.

SP41 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: March 2019

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.dealerspeed.net.

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)

SP41 High-voltage Battery

Contents

SP41 High-voltage Battery

1. Introduction

This product information describes the design of the high-voltage battery with the development code SP41 and the special features of repair work on it. 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 deals only with the **alterations** to the new SP41 high-voltage battery in comparison with its predecessor, the SP06 high-voltage battery as used on the BMW 740e iPerformance (G12 PHEV) and BMW 530e iPerformance (G30 PHEV). Knowledge of this predecessor and the high-voltage technology of hybrid generation 3.0 is a requirement.

The new SP41 high-voltage battery is fitted in identical form in several generation 4.0 hybrid vehicles. For that reason, it is dealt with **independently of vehicle model** in this product information. This product information thus replaces the individual product information publications on the high-voltage batteries for the PHEV models appearing this year.

The SP41 high-voltage battery is fitted in the following vehicles:

- From March 2019
  - BMW 745e xDrive (G12 LCI PHEV)
- From July 2019
  - BMW 530e, BMW 530e xDrive (G30 PHEV)
  - BMW 330e, BMW 330e xDrive (G20 PHEV)

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

Further information on the SP06
• G12 PHEV High-voltage Components or G30 PHEV High-voltage Components reference manual • G12 PHEV High-voltage Battery Unit or G30 PHEV High-voltage Battery Unit reference manual

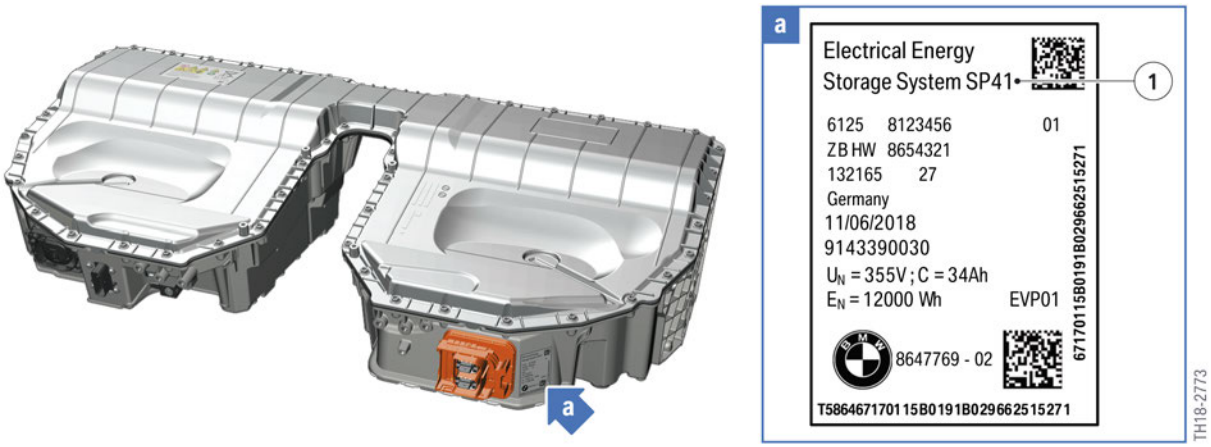
SP41 High-voltage Battery

2. High-voltage Battery

2.1. Overview

2.1.1. Development code

In order to be able to unambiguously identify the increasing number of high-voltage batteries, their development codes have been included in the technical documentation. That development code is indicated on the type plate and is thus visible on the outside of every high-voltage battery.



SP41 type plate showing development code

Index	Explanation
1	Development code

The development code is made up of 2 letters and a number.

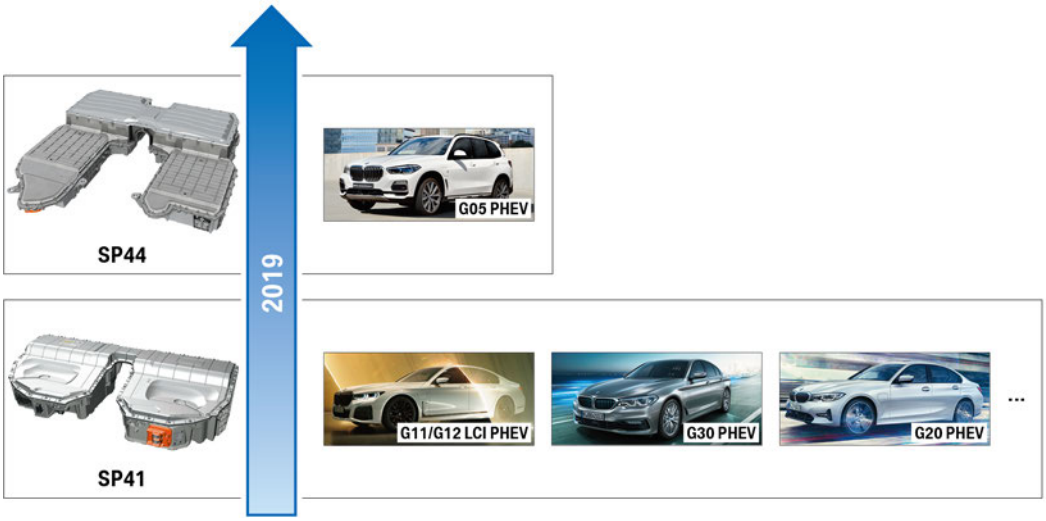
Position	Meaning	Index	Explanation
1	(High-voltage) storage device	S	In other words, storage device for electrical energy
2	Intended vehicle type	E H P	Electric vehicle Hybrid vehicle Plug-in Hybrid Electric Vehicle
3 + 4	High-voltage battery	06 41 44 etc.	Defined number for each high-voltage battery

2.1.2. High-voltage battery generation 4.0

The SP41 high-voltage battery marks the introduction of the first generation 4.0 battery. In so doing it lays the foundation for a series of high-voltage batteries that above all offer a higher energy capacity than their predecessors. In some cases the design of the high-voltage batteries is the same as the respective generation 3.0 predecessors – which is also true in the case of the SP41.

SP41 High-voltage Battery

2. High-voltage Battery



Overview of 4th-generation high-voltage batteries

The most significant change compared with the predecessor model, the SP06, is that the cell capacity has been increased from 26 Ah to **34 Ah**. A list of the changes and adopted features can be found in the separate subchapter "Overview of changes".

2.1.3. Technical data

The table below summarizes a selection of the important technical specifications of the SP41 high-voltage battery.

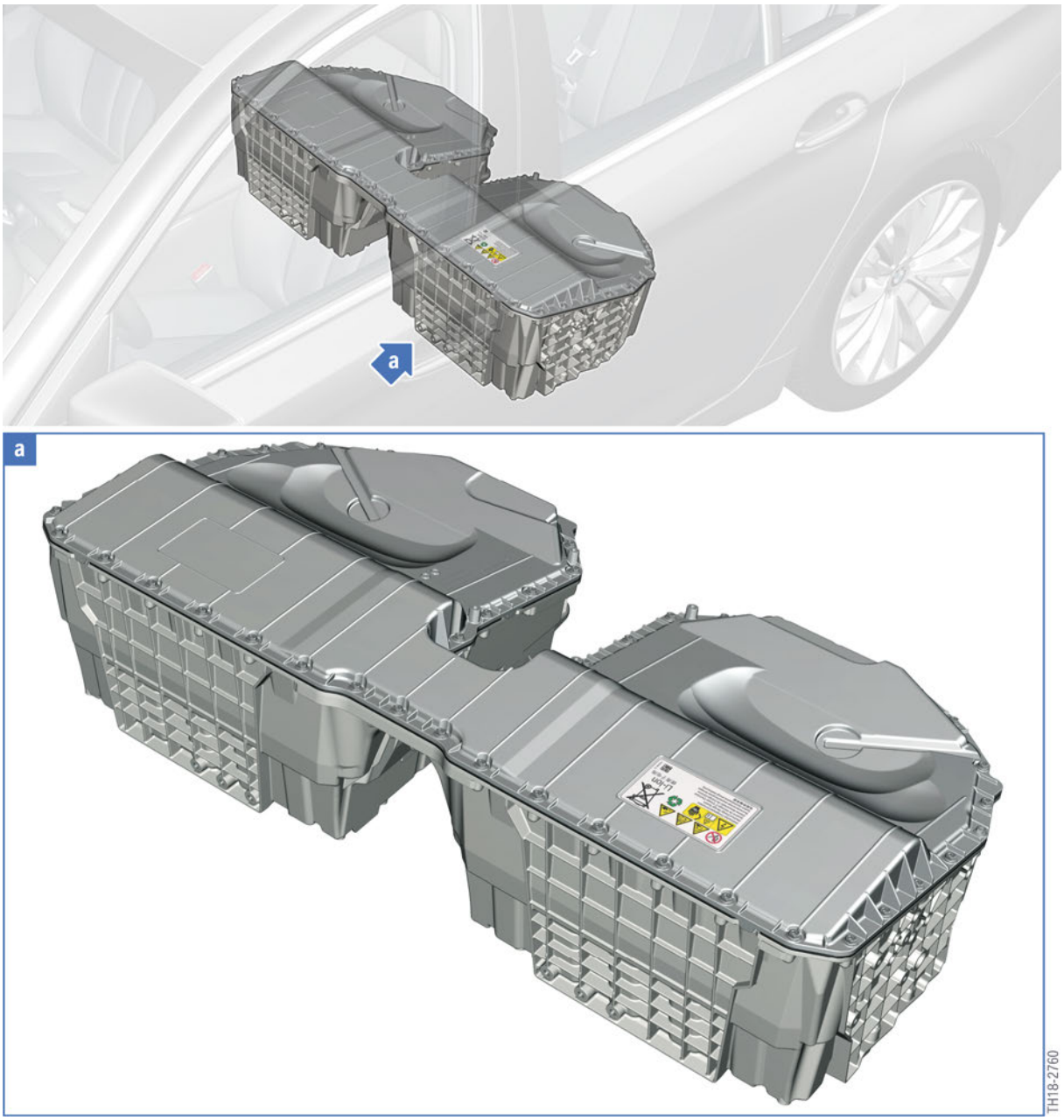
Technical data	SP06	SP41
Voltage	351.4 V (nominal voltage) Min. 269 V – Max. 398 V (voltage range)	355 V (nominal voltage) Min. 269 V – Max. 403 V (voltage range)
Battery cells	Lithium-ion	Lithium-ion
Number of battery cells	96 in series	96 in series
Number of cell modules	6	6
Cell voltage	3.66 V	3.70 V
Capacitance	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)	3.7kW	3.7kW
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

SP41 High-voltage Battery

2. High-voltage Battery

2.1.4. Installation location

The high-voltage battery is fitted in the same location as its predecessor. It is likewise attached by 10 bolts. The shape of the holder and the mounting points on the vehicle body differ slightly according to vehicle model.



Installation location of SP41 high-voltage battery (as illustrated on G12 LCI PHEV)

The electrical connection between the housing of the high-voltage battery unit and the body is established by means of 2 equipotential bonding screws.

SP41 High-voltage Battery

2. High-voltage Battery

The low-resistance connection between the housing of the high-voltage battery and the body ground is an essential requirement for perfect operation of the automatic insulation monitoring function.
For that reason it is essential to pay attention to application of the correct tightening torque on all equipotential bonding screws.

It is also important to ensure that neither the housing of the high-voltage battery nor the body is painted, corroded or dirty around the screw holes concerned. It is also important to ensure the threads concerned are clean. Before fixing the equipotential bonding screws it may be necessary to expose the bare metal.

If the connection between the high-voltage battery and the body ground is not sufficiently conductive, a fault could remain undetected and thus pose a potential risk of personal injury.

When mounting the equipotential bonding screw, the exact procedure must be observed:

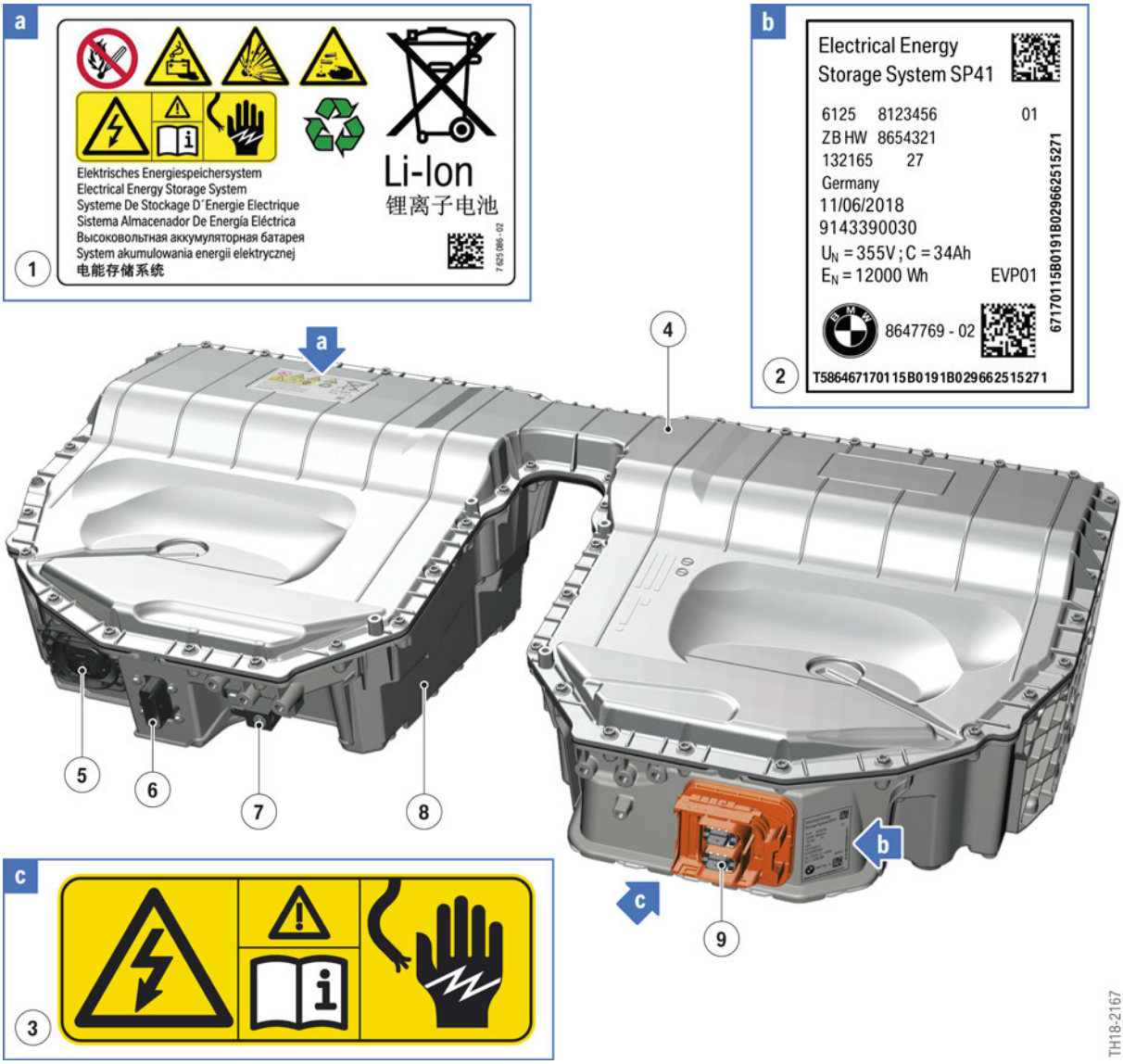
- Clean contact surfaces and screw hole threads and have them checked by a second person
- Tighten assembly screws to specified torque
- Have torque checked by second person
- Both persons must record this in the vehicle records for the correctness of the version. There is a **"form for equipotential bonding screw connections"** for the purpose in ISTA.

2.1.5. Connections and information signs

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

SP41 High-voltage Battery

2. High-voltage Battery



SP41 information signs and connections

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

SP41 High-voltage Battery

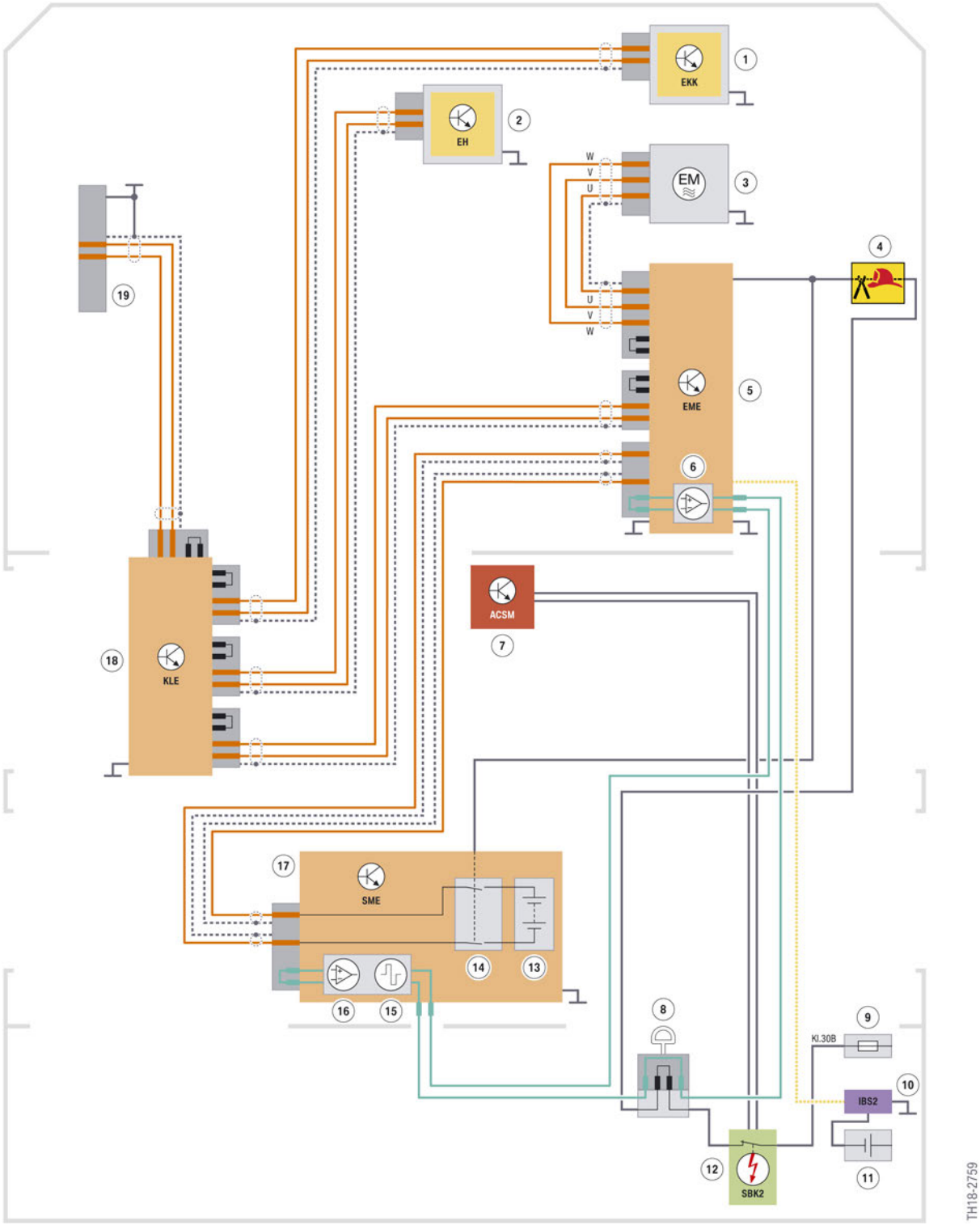
2. High-voltage Battery

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.

SP41 High-voltage Battery

2. High-voltage Battery

2.1.6. System wiring diagram



SP41 system wiring diagram in high-voltage system with high-voltage interlock loop and rescue disconnect (as illustrated on G12 LCI PHEV)

SP41 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 for auxiliary battery (IBS)
11	Auxiliary battery
12	Safety battery terminal for auxiliary battery (SBK)
13	Cell modules
14	Electromagnetic switch contactor
15	Generator for the test signal of the high-voltage contact monitor in the battery management module
16	Evaluation circuit for test signal of the high-voltage interlock loop in the battery management electronics
17	Battery management electronics (SME)
18	Convenience charging electronics (KLE)
19	Charging socket

SP41 High-voltage Battery

2. High-voltage Battery

2.1.7. 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	SP06	SP41
High-voltage battery generation	3.0	4.0
Type plate	Located on upper section of housing	Located beside the high-voltage connection
Cell module	16 cells 26 Ah cell capacity 3 NTC temperature sensors	16 cells 34 Ah cell capacity 3 NTC temperature sensors
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)

Many components and systems have been carried over **unchanged** from the SP06 high-voltage battery to the SP41:

- Upper section of housing and gasket
- 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 a combined expansion and shut-off valve
- Venting unit
- Connections

2.1.8. 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.

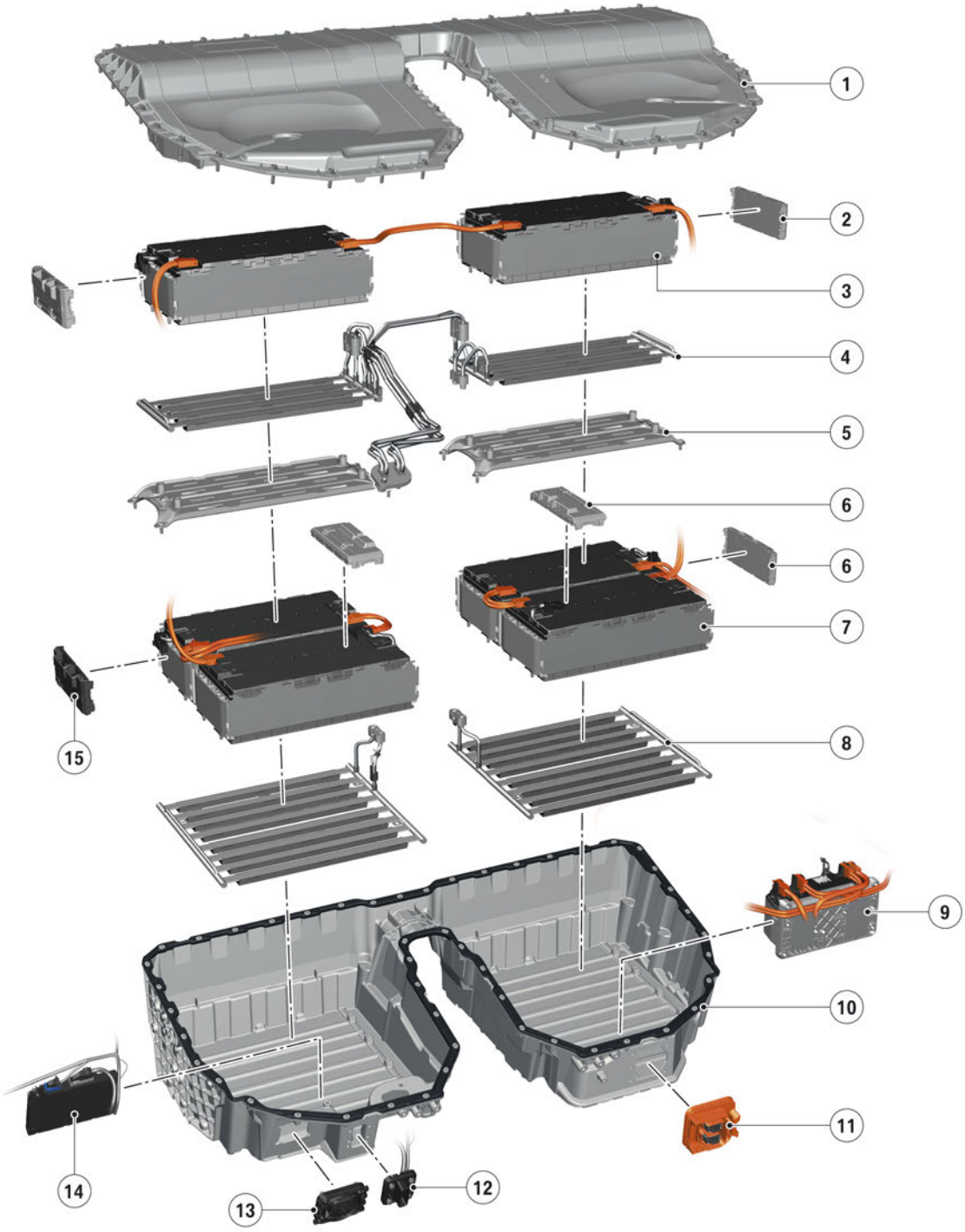
2.2. Inner structure

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.

SP41 High-voltage Battery

2. High-voltage Battery



SP41 design

SP41 High-voltage Battery

2. High-voltage Battery

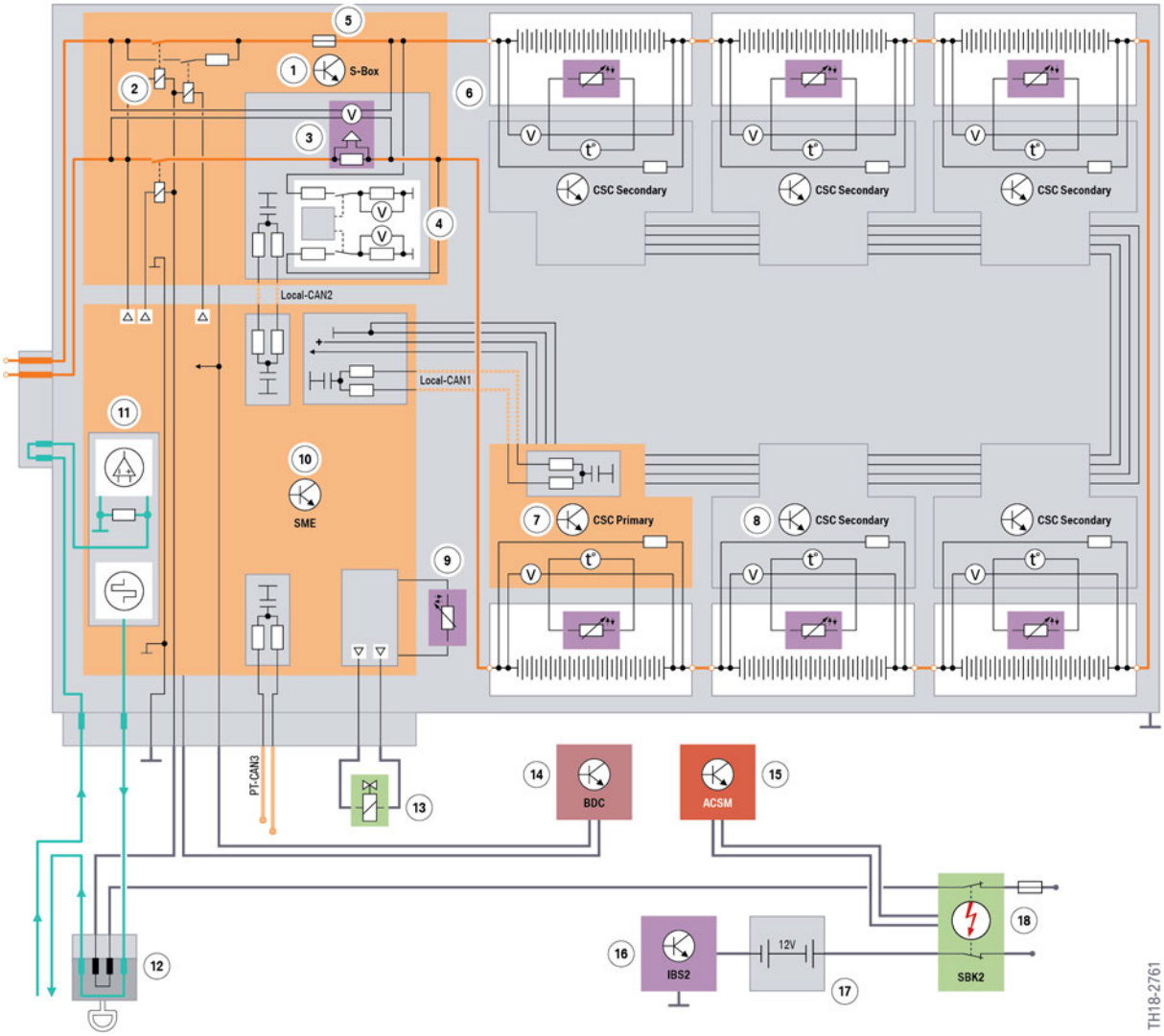
Index	Explanation
1	Upper housing section
2	Top cell supervision circuit (secondary, grey)
3	Upper cell modules
4	Top Evaporator
5	Module intermediate floor
6	Bottom cell supervision circuits (secondary, grey)
7	Lower cell modules
8	Bottom Evaporator
9	Safety box
10	Lower housing section
11	High-voltage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

SP41 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.



SP41 System wiring diagram

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 volt 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 (secondary) only communicate with one another and the primary cell supervision circuit.

The bus designation in the technical qualification course and the diagnostic system is not exactly the same. In the diagnostic system, some bus systems have different names due to permanently defined assignments.

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

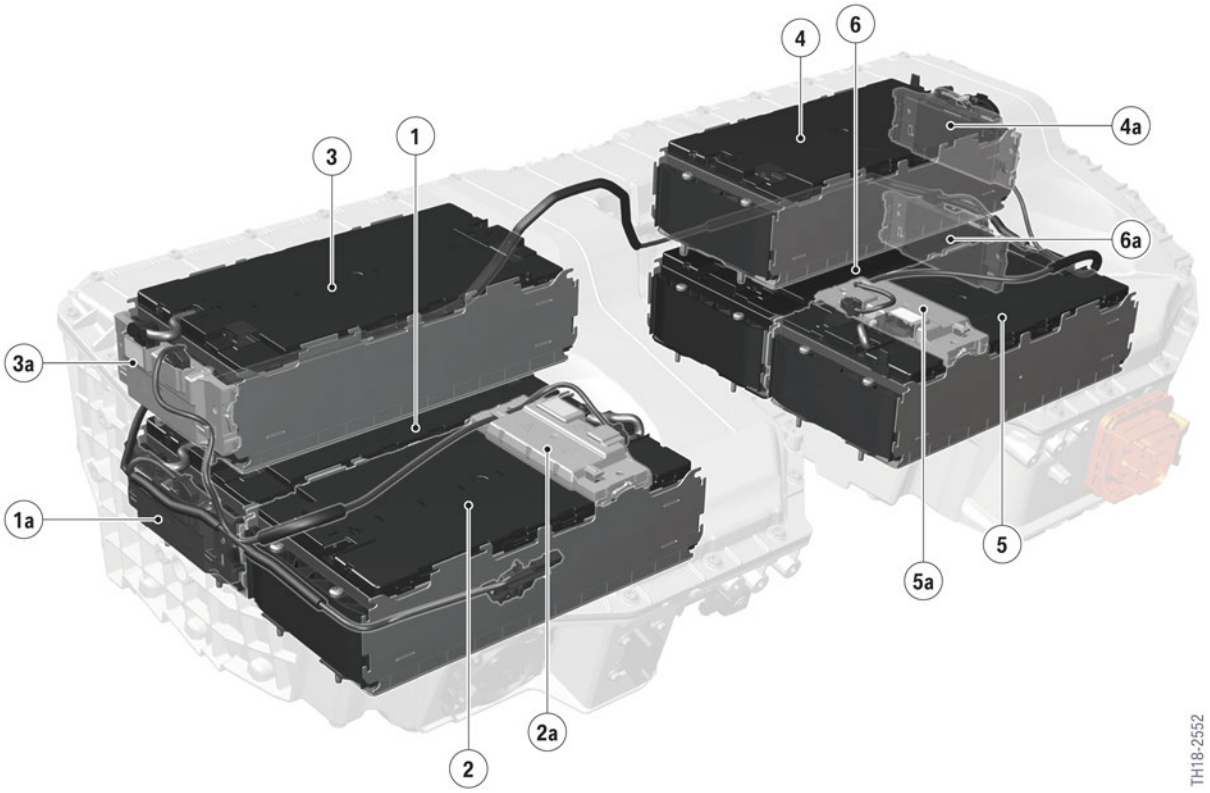
The safety boxes of generation 3.0 and 4.0 cannot be distinguished from the outside and must not be confused. The safety box of generation 3.0 must not be installed in a high-voltage battery of generation 4.0 (and vice versa). Make sure that the correct part is selected. An incorrectly installed safety 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).

SP41 High-voltage Battery

2. High-voltage Battery



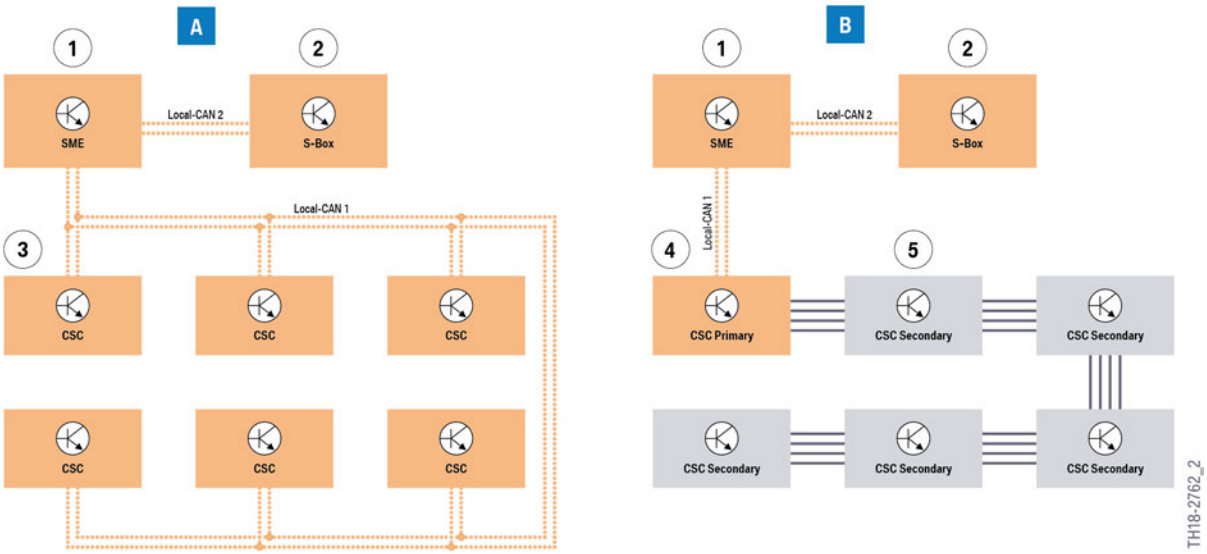
SP41 Cell supervision circuits

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)

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

SP41 High-voltage Battery

2. High-voltage Battery



SP41 Comparison of Gen 3.0 and 4.0 CSC bus structure

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.

SP41 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:

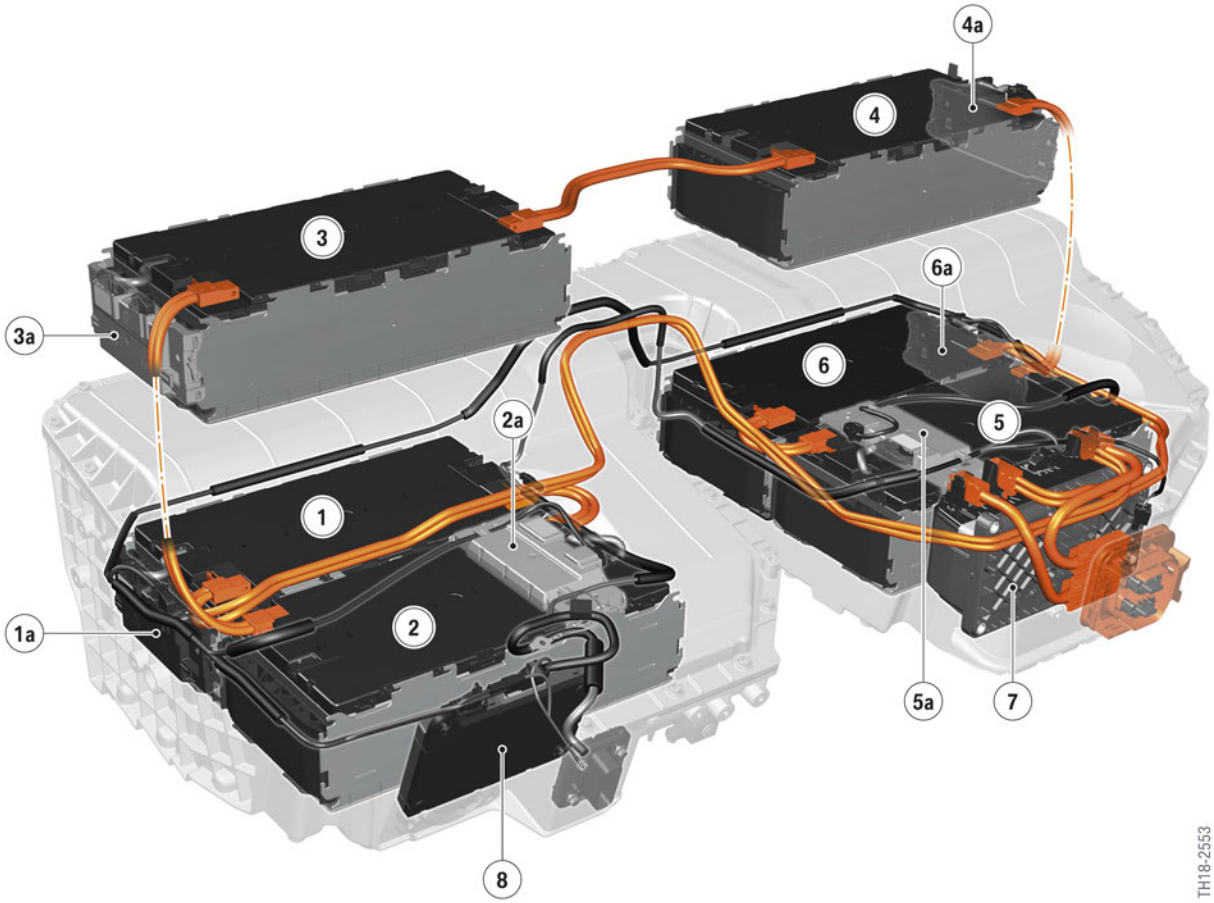
- Safety information for handling electric vehicles
- Assessment of vehicle that has been involved in an accident
- Visual inspection of high-voltage battery unit after an accident.

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").

SP41 High-voltage Battery

3. Repair



SP41 Cell supervision circuits

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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)
7	Safety box
8	Battery management electronics (SME)

SP41 High-voltage Battery

3. Repair

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.

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 (**SP06**) and I level **pre** 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 the fuse blows (counter reading 1):
  replacement of all high-voltage leads and the safety box
- Second time the fuse blows (counter reading 2):
  replacement of all high-voltage leads, the safety box and all **cell modules**.

This applies to the following vehicles and integration levels:

- G12 PHEV and G30 PHEV (**SP06**) and I level **from** July 2018 on
- G12 LCI PHEV (**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.

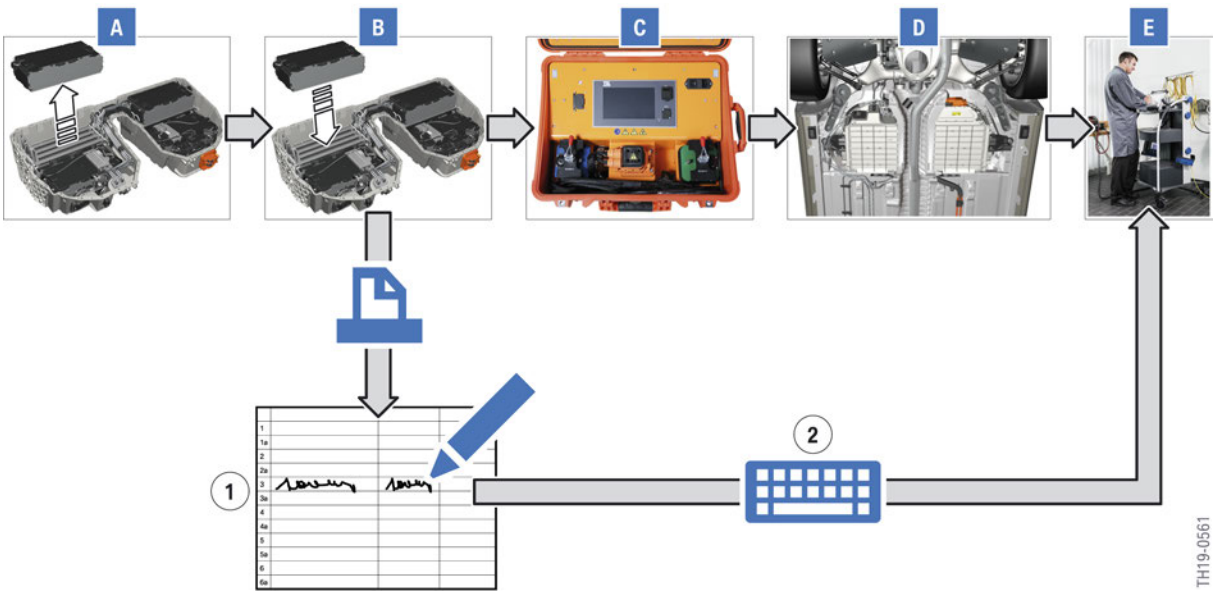
The counter reading is not visible in ISTA and is automatically reset within the framework of the diagnostic function when the repair is completed. Manual resetting is not possible.

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

Previous procedure

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. Previously, that required printing out the location plan and recording the new cell module serial number on it. Afterwards, the serial numbers noted down had to be entered in ISTA during commissioning of the high-voltage battery.



Entering serial numbers during cell module replacement – previous procedure

SP41 High-voltage Battery

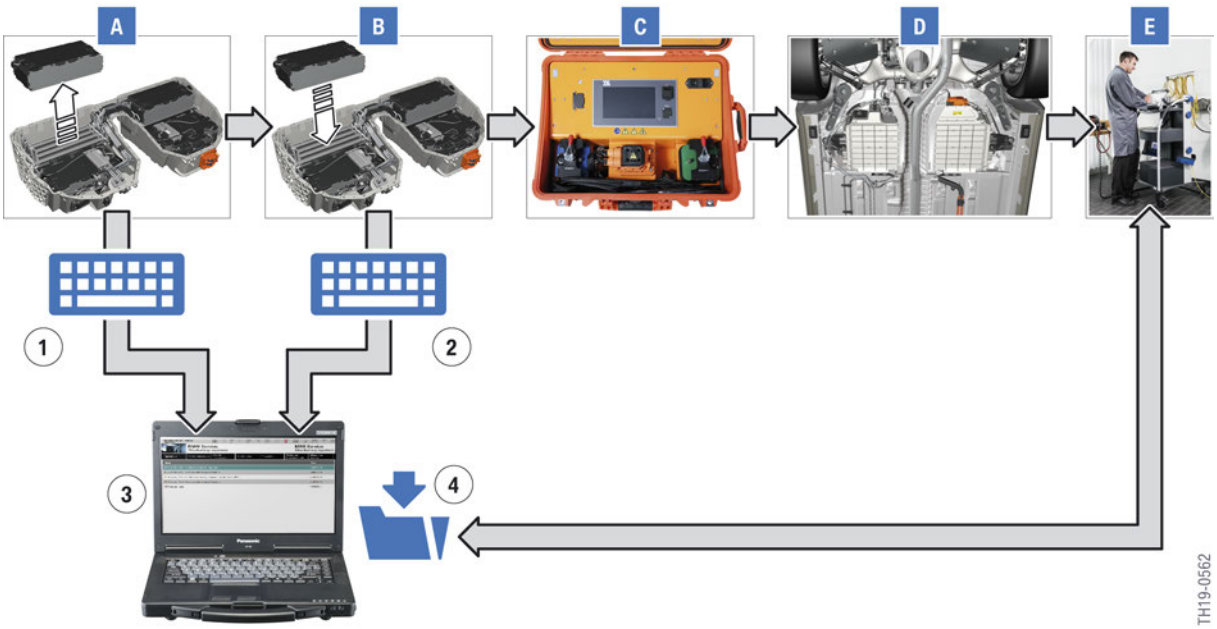
3. Repair

Index	Explanation
A	Removal of cell module
B	Installation of cell module
C	End-of-service test
D	Installation of high-voltage battery in the vehicle
E	Commissioning of the high-voltage battery
1	Noting down the serial number of the new cell module on the printed-out location plan
2	Entry of the new cell module serial number during commissioning

New procedure

The new feature is that the serial numbers of the **replaced** cell modules also have to transferred to ISTA beforehand. 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 by, for example, reopening the last ISTA operation for the vehicle concerned.



Entering serial numbers during cell module replacement – new procedure

SP41 High-voltage Battery

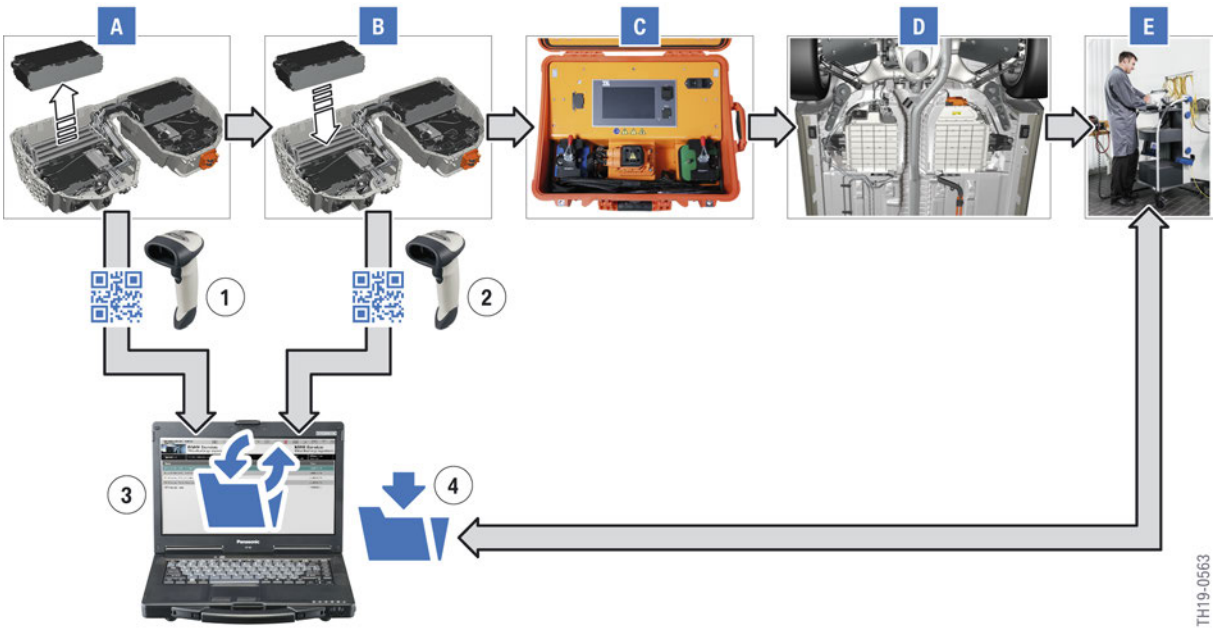
3. Repair

Index	Explanation
A	Removal of cell module
B	Installation of cell module
C	End-of-service test
D	Installation of high-voltage battery in the vehicle
E	Commissioning of the high-voltage battery
1	Entry of serial number of the replaced cell module
2	Entry of serial number of the new cell module
3	Service function "High-voltage battery unit: Documenting cell module serial numbers"
4	Saving and automatic retrieval of the serial numbers entered

If the serial numbers have been entered using the keyboard, they are saved locally and automatically transferred to ISTA when the high-voltage battery is commissioned. The serial numbers then do not need to be entered again in the course of commissioning.

New procedure with QR code scanner

Entry of the serial numbers of the replaced and the new cell module can be performed even more easily with the aid of a standard QR code scanner. This requires that the QR code scanner is connected to the ISID via the USB port and selected as the input method at the start of the service function.



Entering serial numbers during cell module replacement – new procedure with QR code scanner

Index	Explanation
A	Removal of cell module
B	Installation of cell module
C	End-of-service test
D	Installation of high-voltage battery in the vehicle
E	Commissioning of the high-voltage battery
1	Scanning serial number of the replaced cell module
2	Scanning serial number of the new cell module
3	Service function "High-voltage battery unit: Documenting cell module serial numbers"
4	Saving and automatic retrieval of the serial numbers scanned

Afterwards the QR code on the side of the cell module can also be scanned (in addition to the serial number) if the service function prompts you to do so. In that way, entry of the long serial number on the keyboard is dispensed with.

3.4.3. State of charge synchronisation

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.

SP41 cell module 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)

SP41 High-voltage Battery

3. Repair

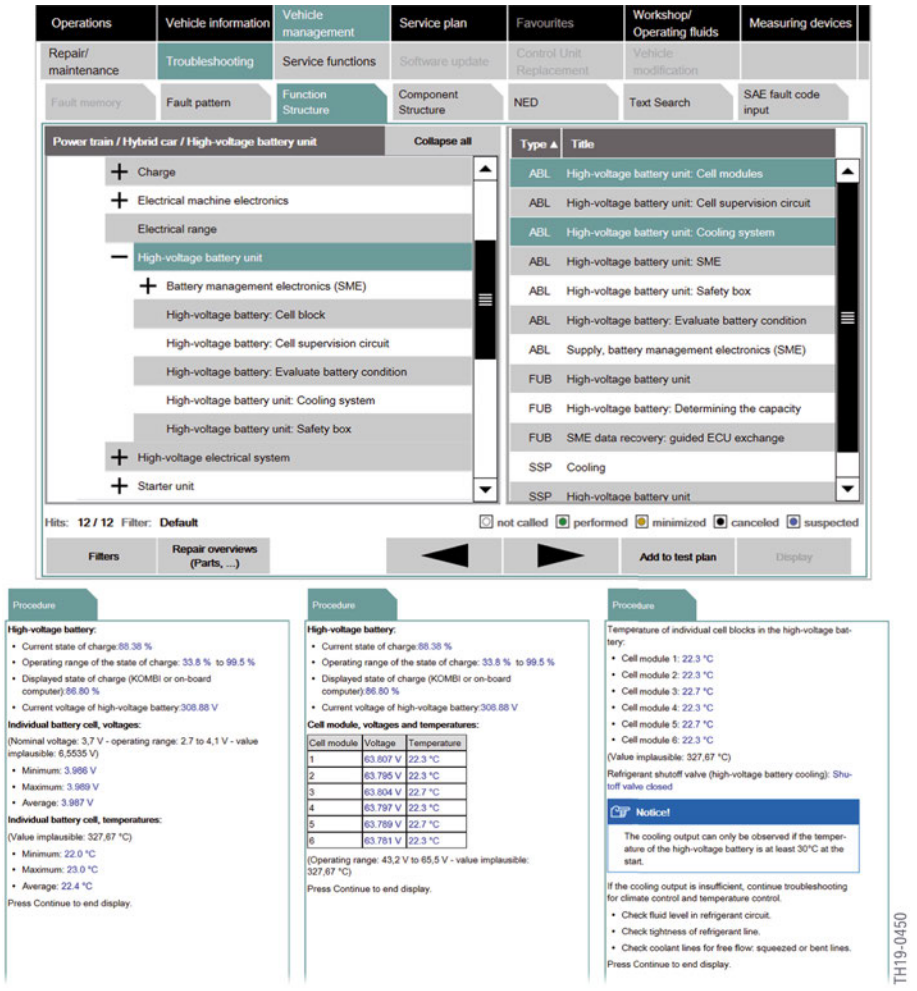
3.5. EoS tester

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 SP41. 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.

3.6. Procedures

In the test modules for the (SME) battery management module and the (KLE) easy charging module, measured data can be read. The requirement for doing so is that the control unit concerned has **not** registered any faults.

In the test module for the (SME) battery management module, measured data such as voltages and temperatures relating to the individual cell modules can be read.



SP41 procedure for battery management module cell modules and cooling system