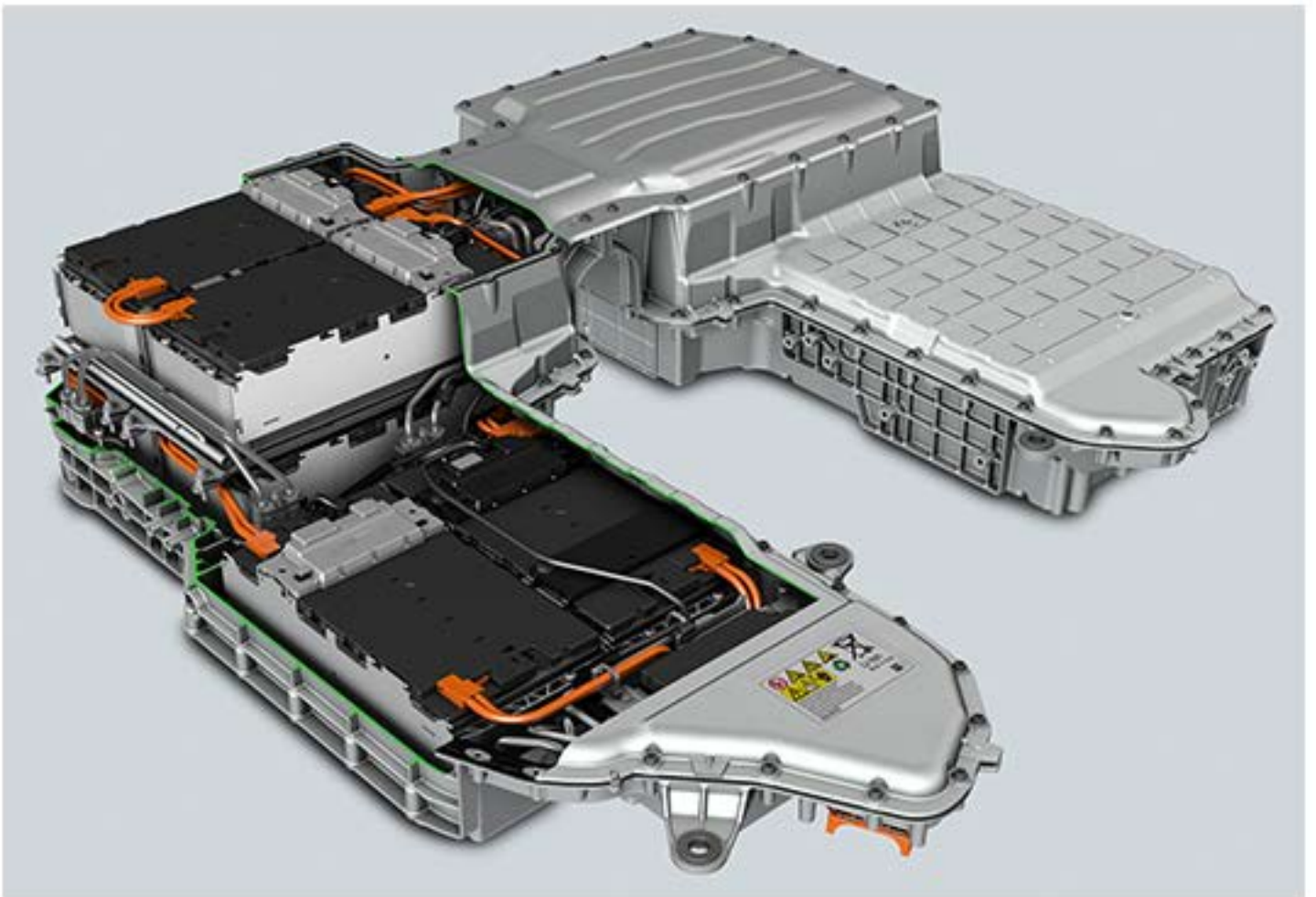


Reference Manual



SP44 HIGH-VOLTAGE BATTERY



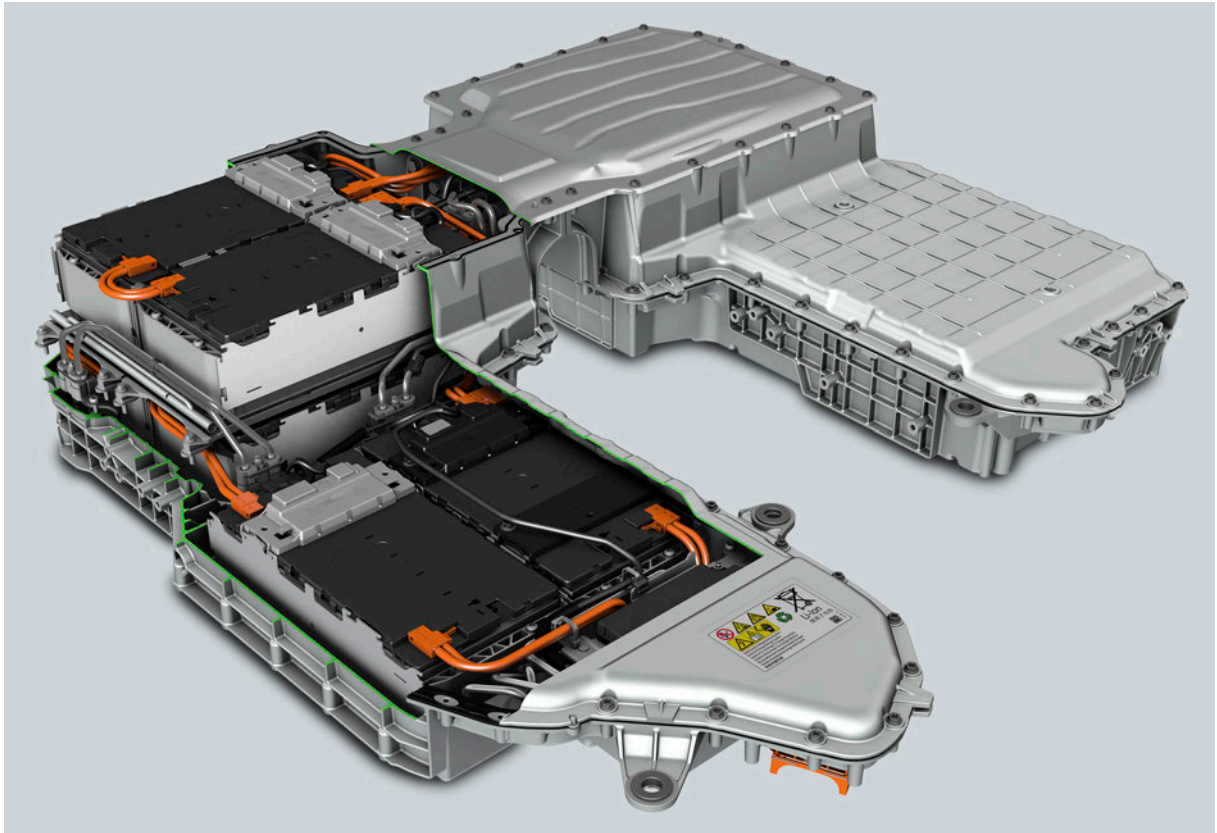
Technical Training

The information contained in this manual is not to be resold, bartered, copied or transferred without the express written consent of BMW of North America, LLC ("BMW NA").

Copyright © 2020 BMW of North America, LLC

Technical training.
Product information.

SP44 High-voltage Battery.



BMW Service

Edited for the U.S. market by:
BMW Group University
Technical Training

ST2006

6/1/2020

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.

Originally Published: May 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.bmwcenternet.com.

Additional sources of information

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

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

The information contained in this manual is not to be resold, bartered, copied, or transferred without the express written consent of BMW of North America, LLC ("BMW NA").

© 2020 BMW of North America, LLC

The BMW name and logo are registered trademarks. All rights reserved.

SP44 High-voltage Battery.

Contents.

1.	Introduction.....	1
2.	High-Voltage Battery Unit.....	2
2.1.	Overview.....	2
2.1.1.	Development code.....	2
2.1.2.	High-voltage battery generation 4.0.....	3
2.1.3.	Technical data.....	4
2.1.4.	Training.....	6
2.1.5.	Installation location.....	7
2.1.6.	Stickers.....	8
2.1.7.	Connections.....	10
2.1.8.	System wiring diagram.....	10
2.2.	Design.....	14
2.2.1.	Component overview.....	14
2.2.2.	Housing.....	16
2.2.3.	Cooling system.....	19
2.2.4.	Internal electrical connection.....	22
2.2.5.	Safety box.....	23
2.2.6.	Cell modules.....	25
2.2.7.	Cell supervision circuits.....	27
3.	Repair.....	31
3.1.	General information.....	31
3.2.	Upper housing section.....	32
3.3.	Safety rules.....	32
3.4.	Middle housing section.....	33
3.5.	Exchange of the cell supervision circuit.....	35
3.6.	Cell module exchange.....	36
3.6.1.	Reuse.....	37
3.6.2.	Tracking.....	37
3.6.3.	State of charge synchronization.....	40
3.7.	EoS tester.....	41

SP44 High-voltage Battery.

1. Introduction.

This product information describes the design of the high-voltage battery unit with the development code SP44 and the particularities and specifics pertaining 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.

Only the **differences** to the new SP44 high-voltage battery when compared with the current Generation 3.0 and 4.0 high-voltage battery units are addressed in this product information. The reader is required to be conversant with the technology of the Generation 3.0 high-voltage battery.

The SP44 high-voltage battery is currently only installed in the **BMW X5 xDrive45e** (G05 PHEV).

Further information can be found in the listed documents:

Further information

- “G05 PHEV Complete Vehicle” reference manual

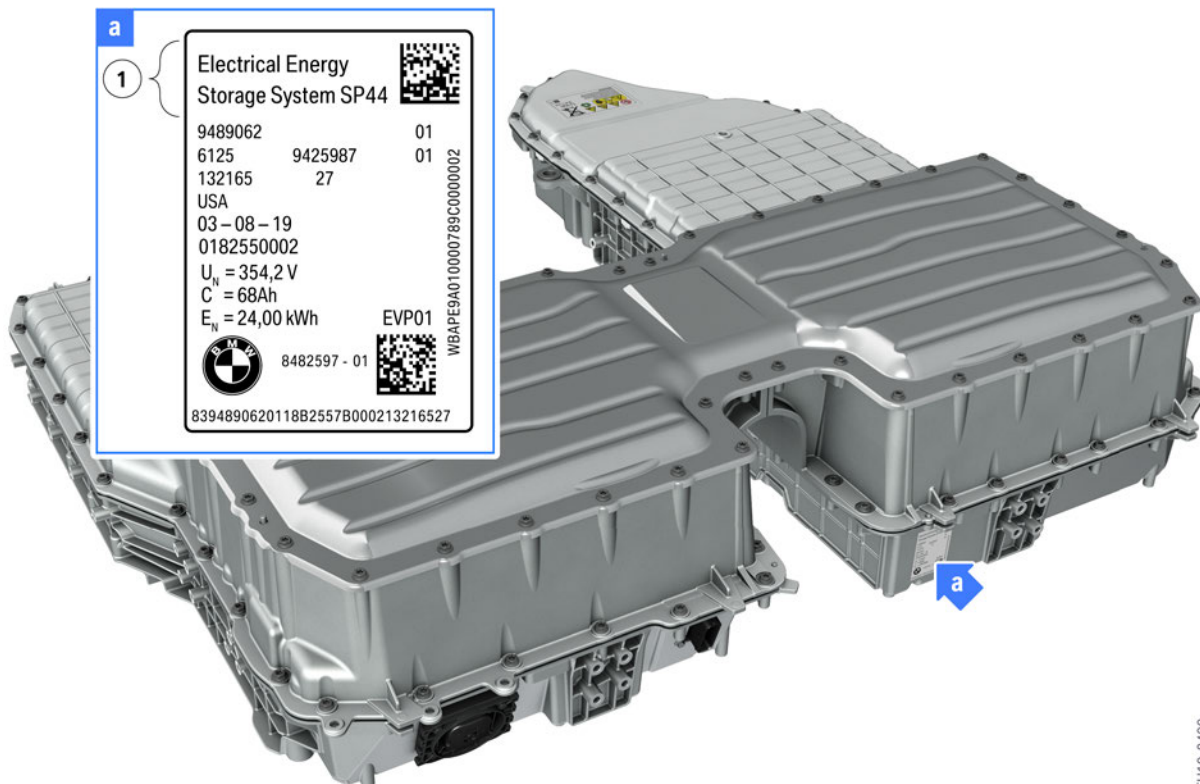
SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

2.1. Overview

2.1.1. Development code

With the ever-increasing number of high-voltage battery units, the development code of each unit has been included in the technical documentation so that each individual unit can be clearly identified. That development code is indicated on the type plate and is visible on the outside of every high-voltage battery unit.



TH19-0499

SP44 high-voltage battery - Type plate with development code

Index	Explanation
1	Development code

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

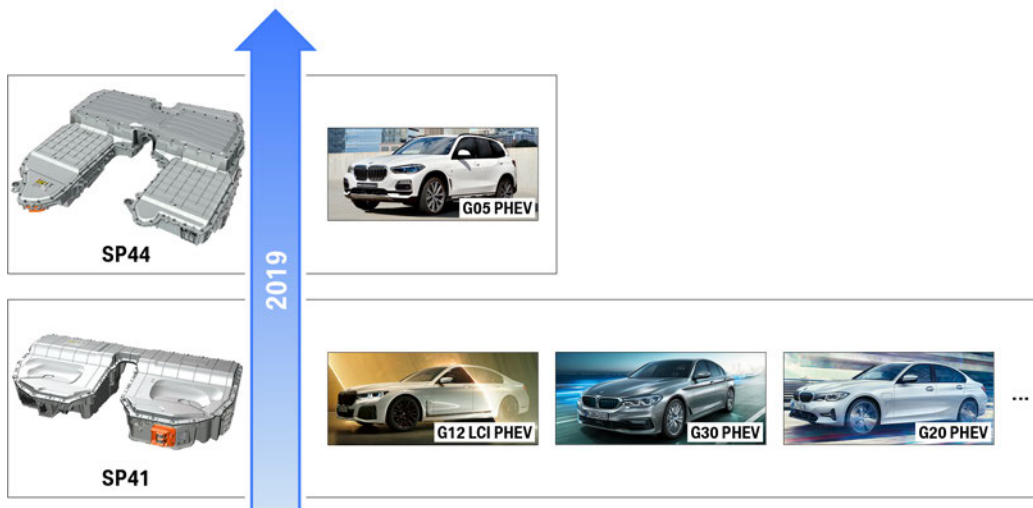
SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

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 unit	06 41 44 etc.	Defined number for each high-voltage battery unit

2.1.2. High-voltage battery generation 4.0

This Generation 4.0 high-voltage battery unit makes its debut at BMW in the form of the SP44 high-voltage battery. It completes a range of high-voltage battery units which above all offer a higher energy content than their predecessors. In part, the high-voltage battery units are identical in design to their Generation 3.0 predecessors.



Overview of 4th generation high-voltage battery units

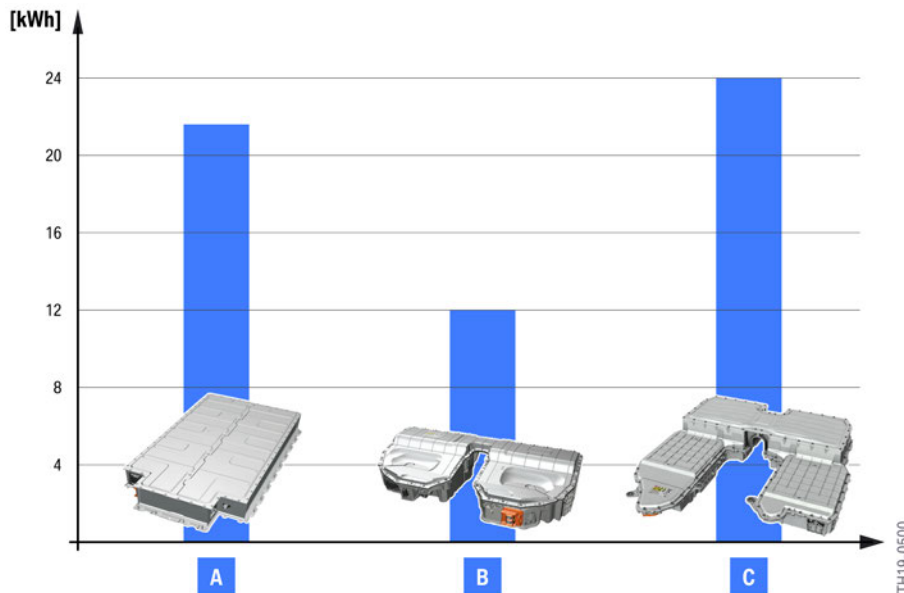
TH19-0446_2

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

2.1.3. Technical data

With its **12 cell modules** the SP44 high-voltage battery has a storable amount of energy of approx. **24 kWh** and is therefore the most powerful high-voltage battery unit to be used in a BMW plug-in hybrid electric vehicle to date. As a comparison: The high-voltage battery unit of the BMW i3 (60 Ah, SE03) boasted a storable amount of energy of approx. 21.6 kWh.



SP44 high-voltage battery - Comparison of usable energy content

Index	Explanation
A	SE03 high-voltage battery (I01, 60 Ah)
B	SP41 high-voltage battery (G20 PHEV, G12 LCI PHEV)
C	High-voltage battery SP44 (G05 PHEV)

As with all Generation 4.0 high-voltage battery units, the cell capacity of the cell modules has also been increased from 26 Ah to 34 Ah. A special feature of the SP44 high-voltage battery is the electrical connection inside the cell modules. The 16 cells of each cell module are not universally connected in series; instead, 2 cells are always connected in parallel and 8 of which are connected in series (see subchapter "Cell module"). This halves the nominal voltage of the cell module and doubles the capacity to **68 Ah**.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

The table below summarizes a selection of the key technical data of the high-voltage battery unit.

Technical data	SP44
Voltage	354.2 V (nominal voltage) Min. 269 V – Max. 403 V (voltage range)
Battery cells	Lithium-ion
Number of battery cells	192
Electrical connection of battery cells	Serial and parallel
Number of cell modules	12
Cells per cell module	16
Electrical connection inside the cell module	In each case 2 cells in parallel, 8 of which in series
Cell voltage	3.69 V
Cell-module voltage	approx. 29.5 V
Capacity	34 Ah 68 Ah (by parallel electrical connection)
Storable amount of energy	24 kWh
Usable energy	17 kWh*
Max. power (discharge)	83 kW (short-term)
Maximum power (AC charging)	3.7 kW
Weight	500 lbs (with retaining bracket)
Dimensions	1255 mm x 1246 mm x 276 mm
Cooling system	Refrigerant R1234yf 2 expansion valves

* The usable energy may vary, depending on the market and state of aging of the high-voltage battery unit.

The previous cell modules with plain series connection have a voltage of around 60 V. The fact that half the cells in the cell module of the SP44 high-voltage battery are connected in parallel halves the module voltage to approx. 29.5 V.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

2.1.4. Training

General information

Once the BMW Group High Voltage Technician has successfully obtained the certification for a high-voltage battery variant, this person has acquired the expertise to repair the high-voltage battery variant in all vehicles in which it is installed.

Working on the high-voltage battery unit is subject to the following certification requirements:

- **Installation and removal**
Removing and refitting the high-voltage battery requires the relevant vehicle-specific "... PHEV" certification (as with Hybrid Generation 3.0).
- **Repair** (without removing and refitting)
Only repairing a high-voltage battery unit that has already been removed from the vehicle requires valid certification for the SP44 high-voltage battery. Vehicle-specific certification is **not** required.

Via web-based training (WBT)

Qualification to perform repairs to the SP44 high-voltage battery can only be acquired through the respective **web-based training**. A face-to-face training course is not offered. Certification is provided through the WBT if the service employee fulfils the following **prerequisites**:

High-voltage battery unit still fitted in vehicle	High-voltage battery unit already removed from vehicle
Valid "High-voltage battery" certification for another Generation 3.0 and 4.0 high-voltage battery unit.	Valid "High-voltage battery" certification for another Generation 3.0 and 4.0 high-voltage battery unit.
+	
Valid certification for the vehicle from which the SP44 high-voltage battery is to be removed.	

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

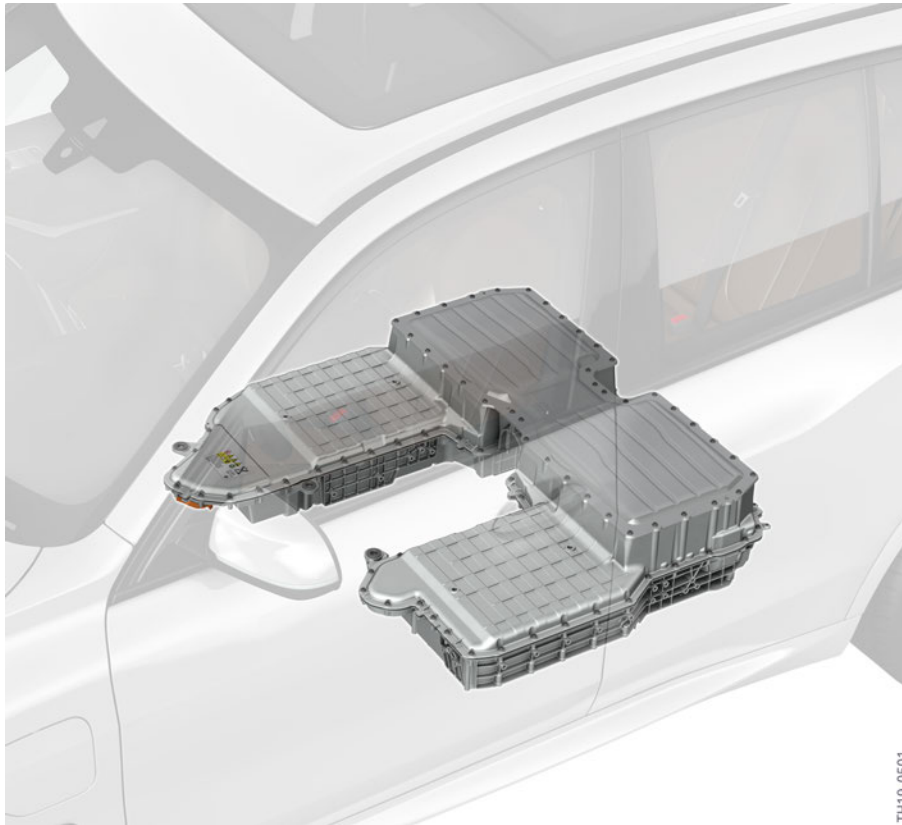
For more information, please refer to the "G12 LCI PHEV" reference manual.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

2.1.5. Installation location

The high-voltage battery unit is mounted centrally on the underbody in front of the rear axle.



SP44 high-voltage unit - Installation location (example: G05 PHEV)

The electrical connection between the housing of the high-voltage battery unit and the body is established by means of 3 equipotential bonding screws.



The low-resistance connection between the housing of the high-voltage battery unit and the body ground is an essential requirement for perfect operation of the automatic insulation monitoring function. For that reason it is essential 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 unit, nor the body are painted, corroded or contaminated around the corresponding bore holes. 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 unit and the body ground is not sufficiently conductive, a fault could remain undetected and thus pose a potential risk of personal injury.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.



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.

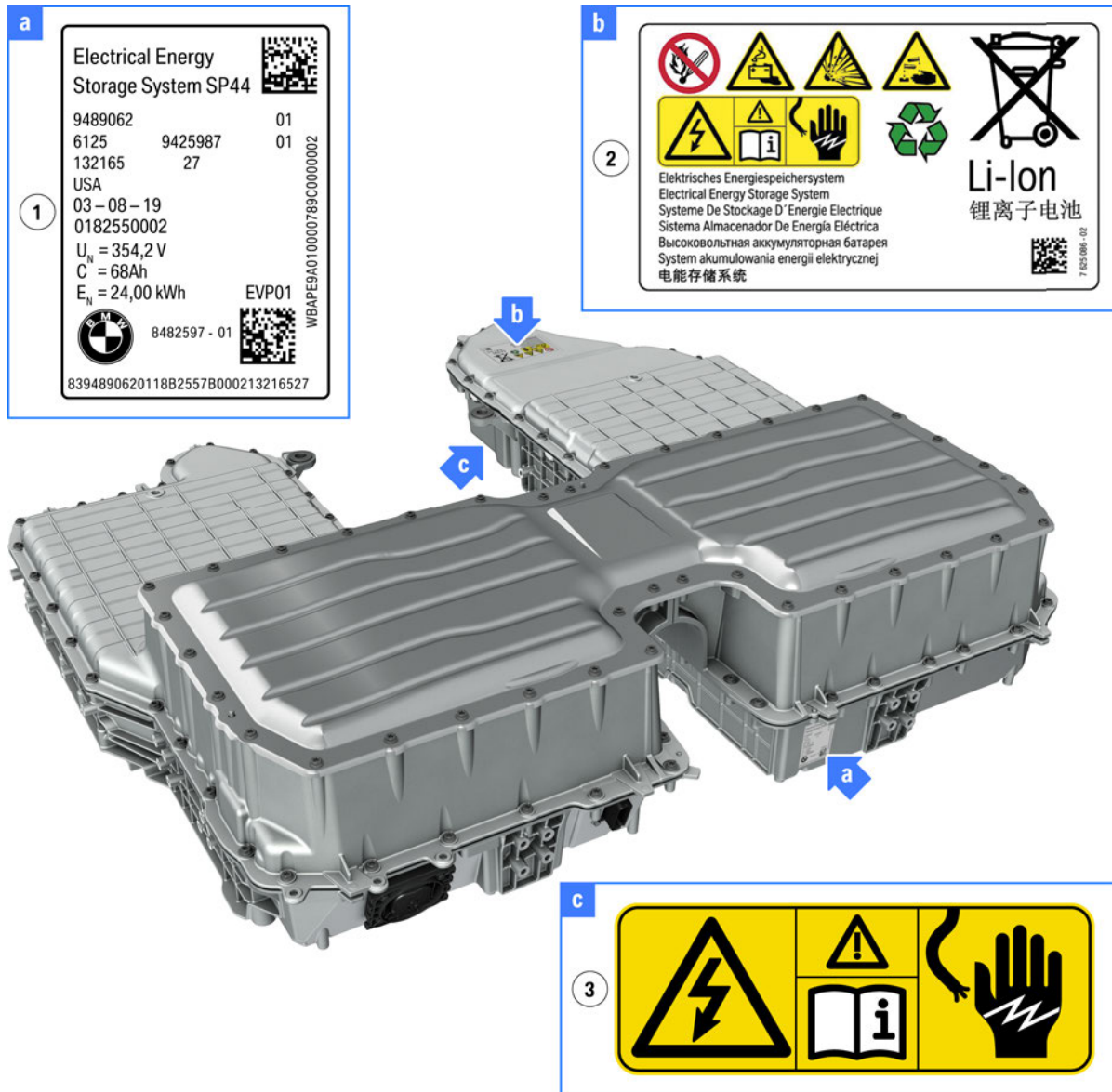
Refer to the product information pertaining to the vehicle for detailed information on the installation location and on mounting.

2.1.6. Stickers

The familiar stickers are also used on the SP44 high-voltage battery. The type plate is visible from below when the high-voltage battery unit is installed.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.



SP44 high-voltage battery - Stickers

Index	Explanation
1	Type plate with technical data and development code
2	High-voltage battery unit warning sticker
3	High-voltage component warning sticker

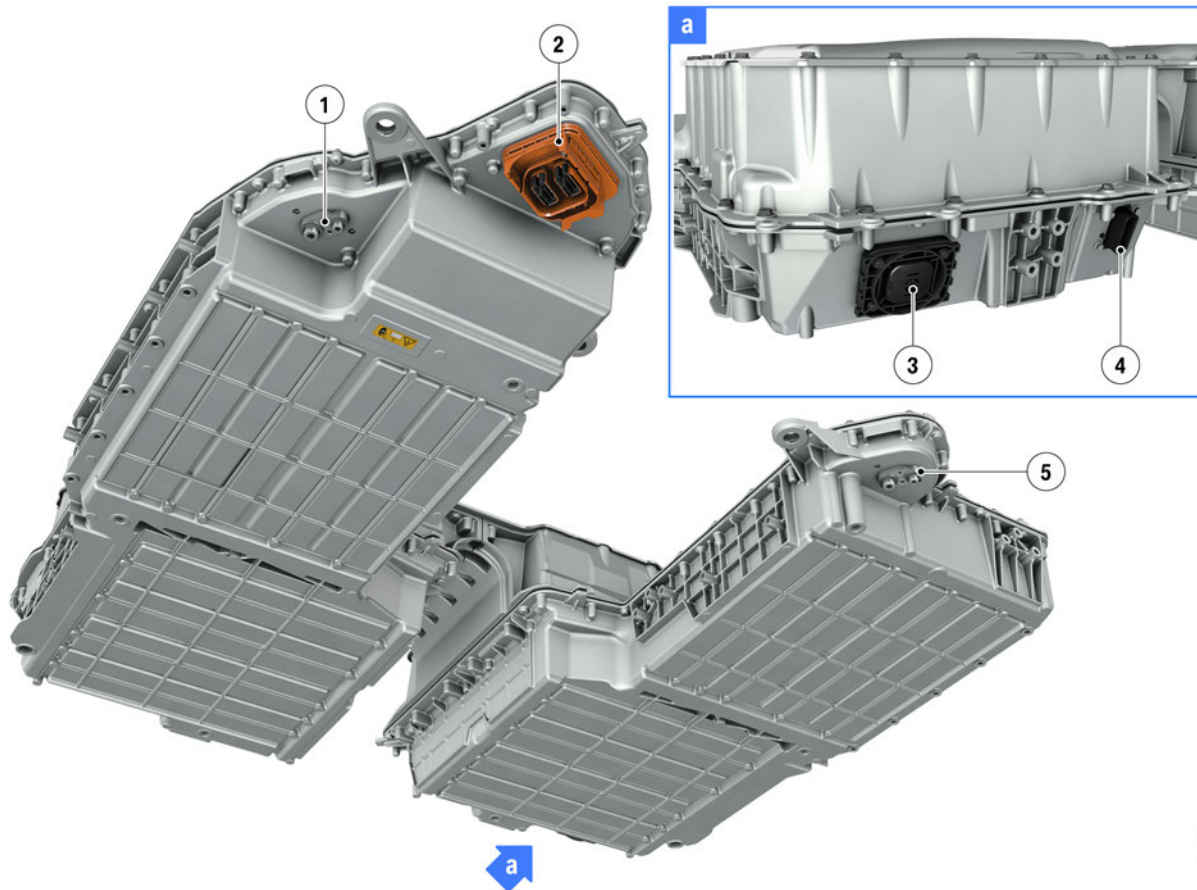
The majority of specifications on the type plate are individual for each high-voltage battery, e.g. development number, serial number and production date. It is therefore necessary to specify these individual specifications when ordering a replacement type plate.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

2.1.7. Connections

The connections of the high-voltage battery unit are adapted to its geometry and installation location. The high-voltage connection is located on the front underside of the right battery half. The signal connector connection and the venting unit are located on the back of the left battery half.



TH19-0504

SP44 high-voltage battery - Connections

Index	Explanation
1	Connection, expansion valve, right
2	High-voltage connection
3	venting unit
4	Connection for signal connector
5	Connection, expansion valve, left

Each battery half has a separate refrigerant connection on the front underside. An expansion valve is mounted on each of these refrigerant connections. Further information on the structure of the refrigerant systems can be found in the subchapter "Cooling System".

2.1.8. System wiring diagram


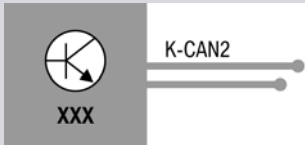
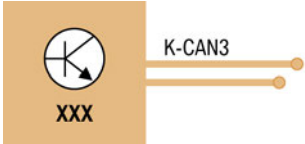
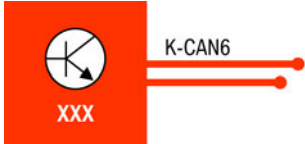

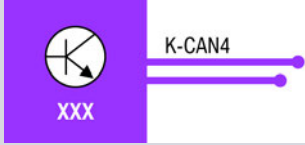


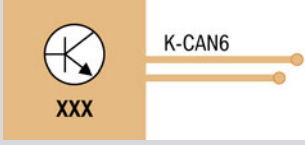

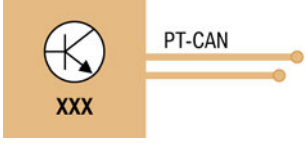

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

New representation

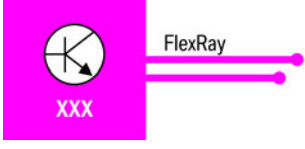
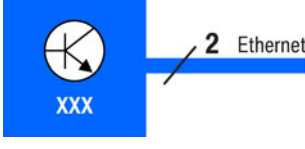
The representation of the individual bus systems and their designations have been adapted to the representation and the designation of the ISTA workshop information system.

The following table shows both the previous and the current representations and designations of the different bus systems:

Bus system previously	Bus system currently
K-CAN2 	K-CAN2 
K-CAN3 	K-CAN6 
K-CAN4 	K-CAN4 
K-CAN5 	Local-CAN 
K-CAN6 	K-CAN3 
PT-CAN 	PT-CAN 

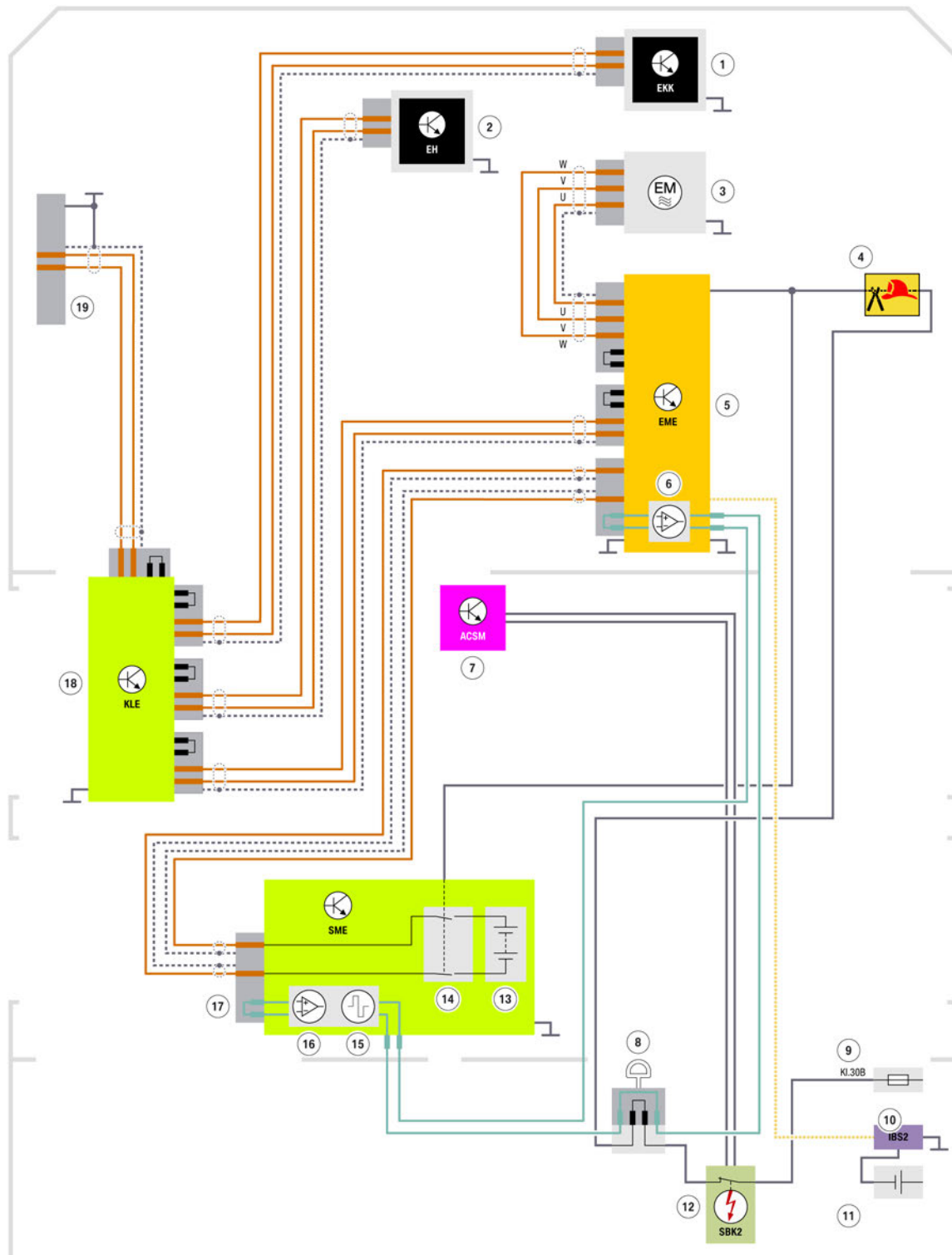
SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

Bus system previously	Bus system currently
PT-CAN2 	PT-CAN2 
PT-CAN3 	K-CAN5 
D-CAN 	D-CAN 
FlexRay 	FlexRay 
MOST 	MOST 
Ethernet 	Ethernet 
LIN bus 	LIN bus 

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.



SP44 high-voltage battery - System wiring diagram in high-voltage system with high-voltage contact monitor and rescue disconnect (example: G05 PHEV)

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

Index	Explanation
1	Electric A/C compressor (EKK)
2	Electrical heating (EH)
3	Electrical machine
4	Rescue disconnect
5	Electrical machine 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 contactors
15	Clock 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

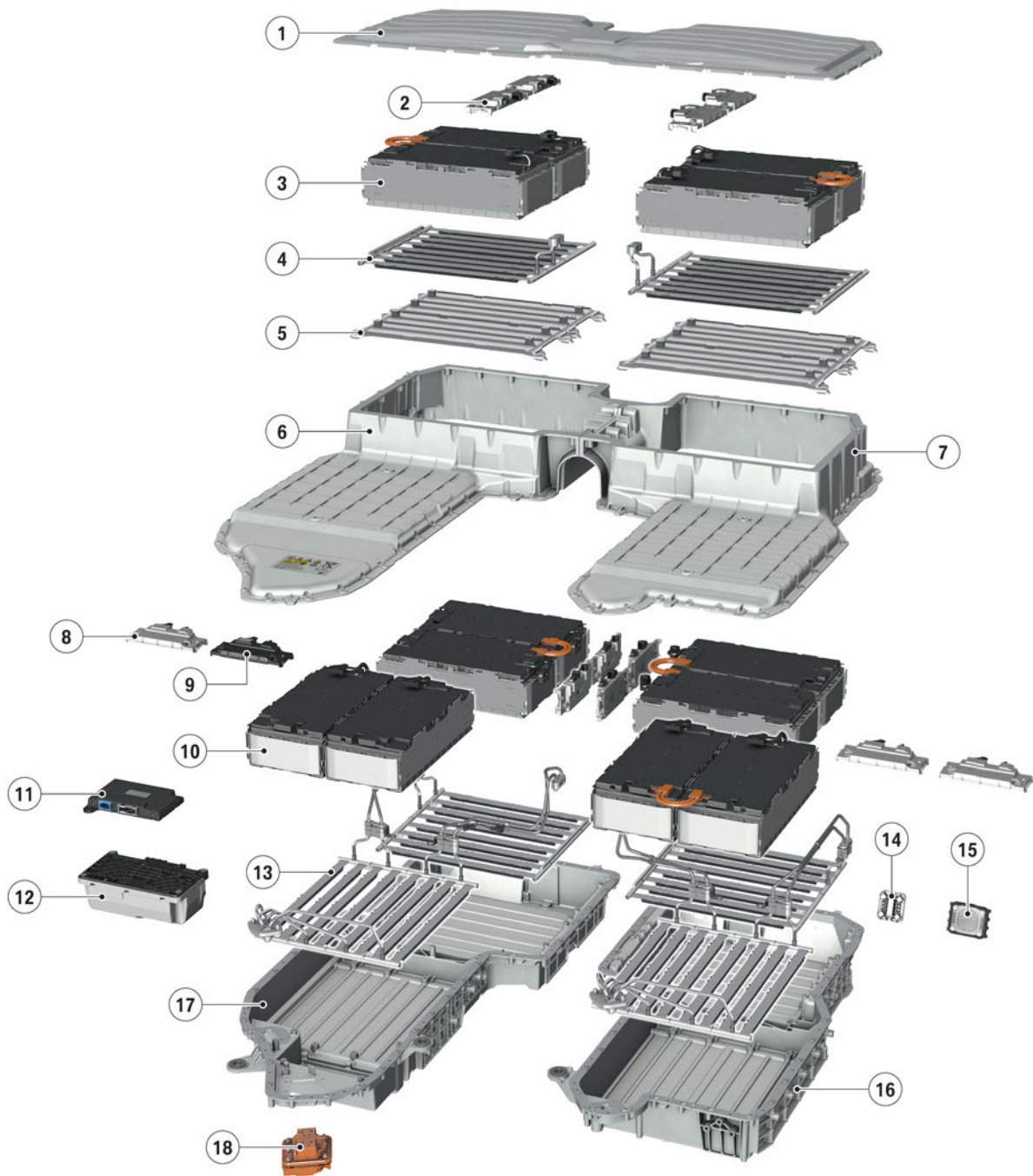
2.2. Design

2.2.1. Component overview

The structure of the high-voltage battery unit has been adapted to the use of 12 cell modules. Essentially, the established components from current Generation 3.0 and 4.0 high-voltage battery units are used.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.



SP44 high-voltage battery - Structure

TH19-0505

Index	Explanation
1	Upper housing section
2	Cell supervision circuit, top (secondary)
3	Upper cell modules
4	Upper heat exchanger

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

Index	Explanation
5	Module intermediate floor
6	Middle housing section, right
7	Middle housing section, left
8	Cell supervision circuits, bottom (secondary)
9	Cell supervision circuit, bottom (primary)
10	Lower cell modules
11	Battery management electronics (SME)
12	Safety box
13	Lower heat exchanger
14	Connection for signal connector
15	venting unit
16	Lower housing section, left
17	Lower housing section, right
18	High-voltage connection

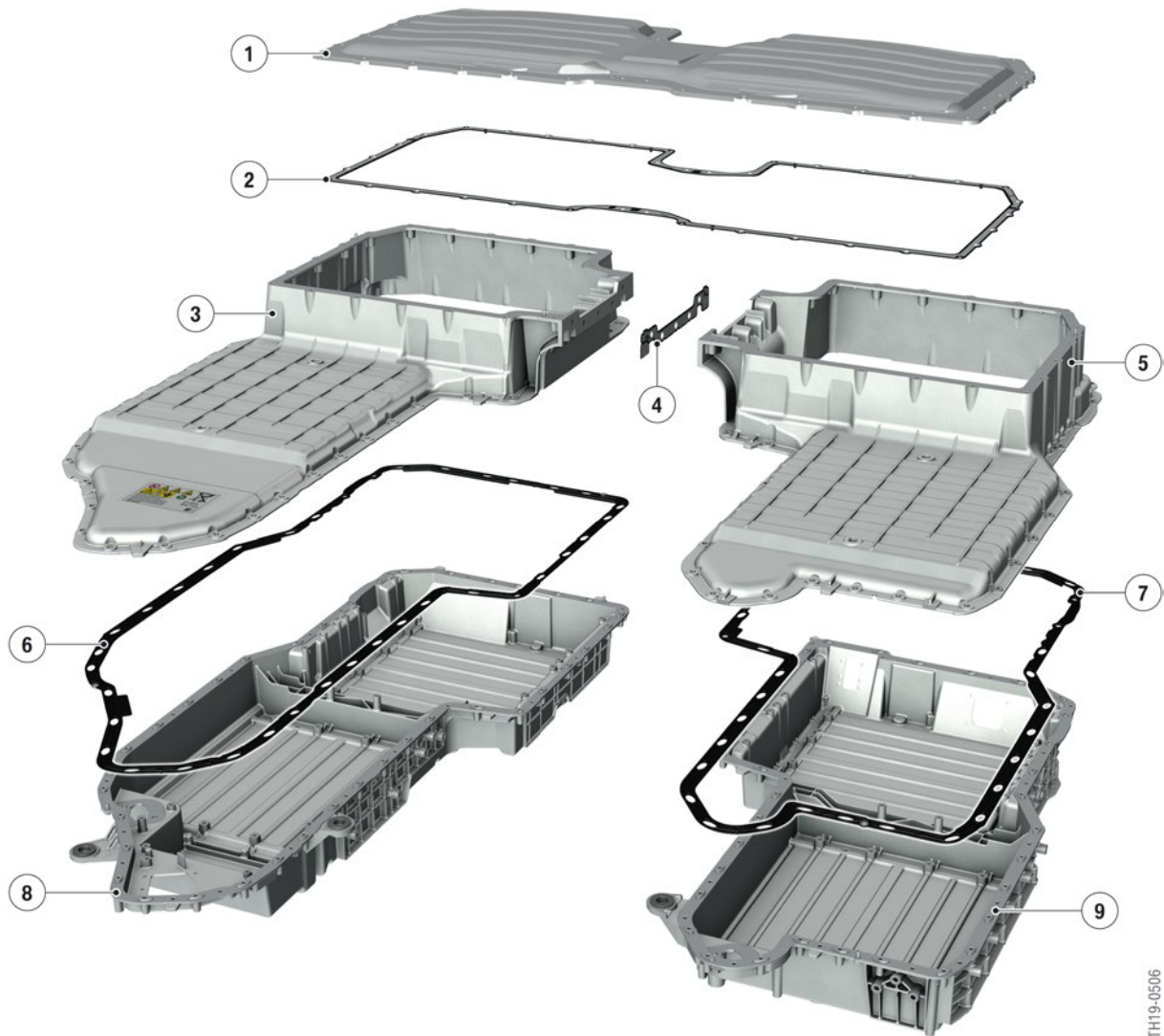
The high-voltage battery unit is divided into 2 halves – a right half and a left half. Each half accommodates 6 cell modules, 3 heat exchangers and the respective CSCs. The right half (looking in the direction of travel) also houses the safety box and battery management electronics (SME).

2.2.2. Housing

The aluminium housing consists of 5 parts. A total of 4 gaskets are fitted between the individual housing sections.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.



TH19-0506

SP44 High-voltage battery - Housing

Index	Explanation
1	Upper housing section
2	Gasket, upper housing section
3	Middle housing section, right
4	Gasket between the middle housing sections
5	Middle housing section, left
6	Gasket between the housing middle section and lower section, right
7	Gasket between the housing middle section and lower section, left
8	Lower housing section, right
9	Lower housing section, left

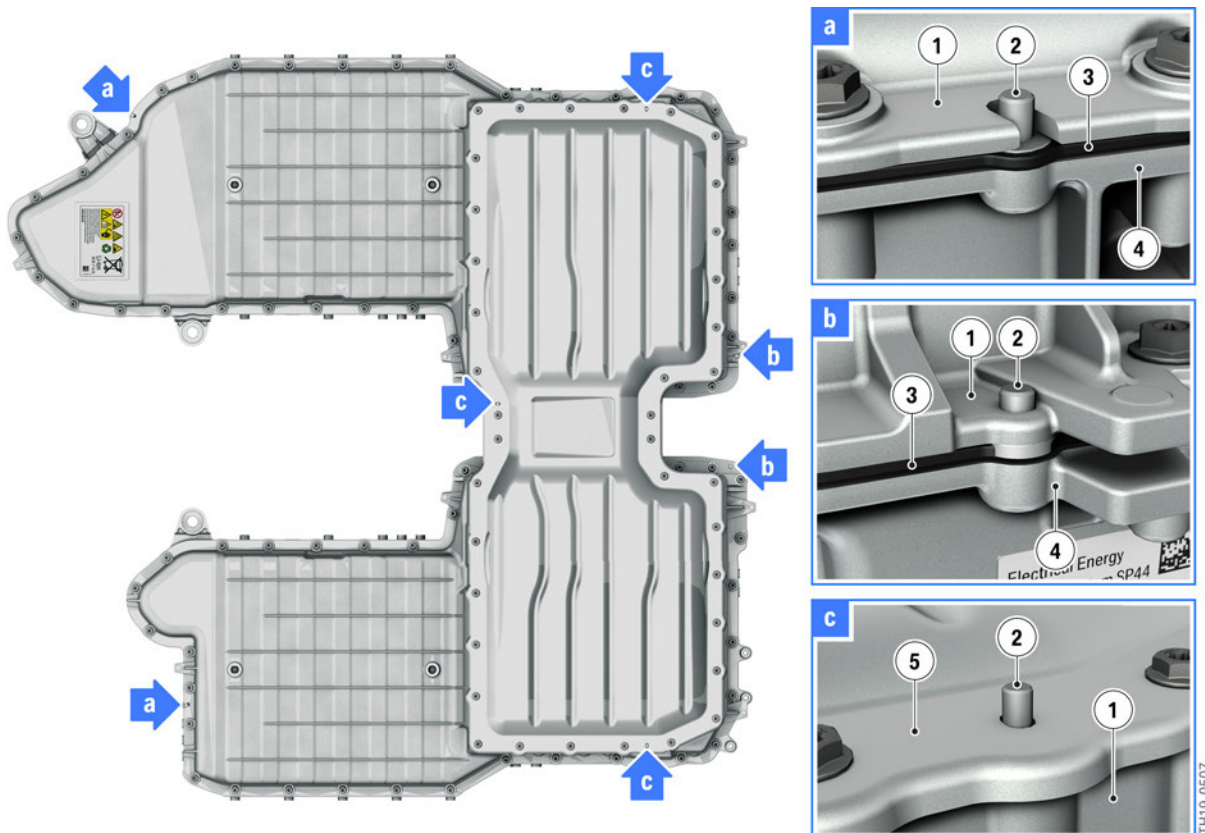
SP44 High-voltage Battery.

2. High-Voltage Battery Unit.



The two housing middle sections may only be disassembled together (as a single part) in service. Separating the left and right middle housing sections from each other may cause leaks at a later stage and hence lead to extensive reworking during the EoS test.

Retaining bolts are pressed into the lower housing sections to facilitate installing the middle housing section and the associated gaskets. Make sure when installing the middle housing section that it is correctly seated.



SP44 high-voltage battery - Retaining bolts for middle housing section

Index	Explanation
1	Middle housing section
2	Retaining bolt
3	Gasket between the middle and lower housing sections
4	Lower housing section
5	Upper housing section

The same principle applies to the upper housing section. 3 retaining bolts are pressed into the middle housing section to ensure it is fixed in position.

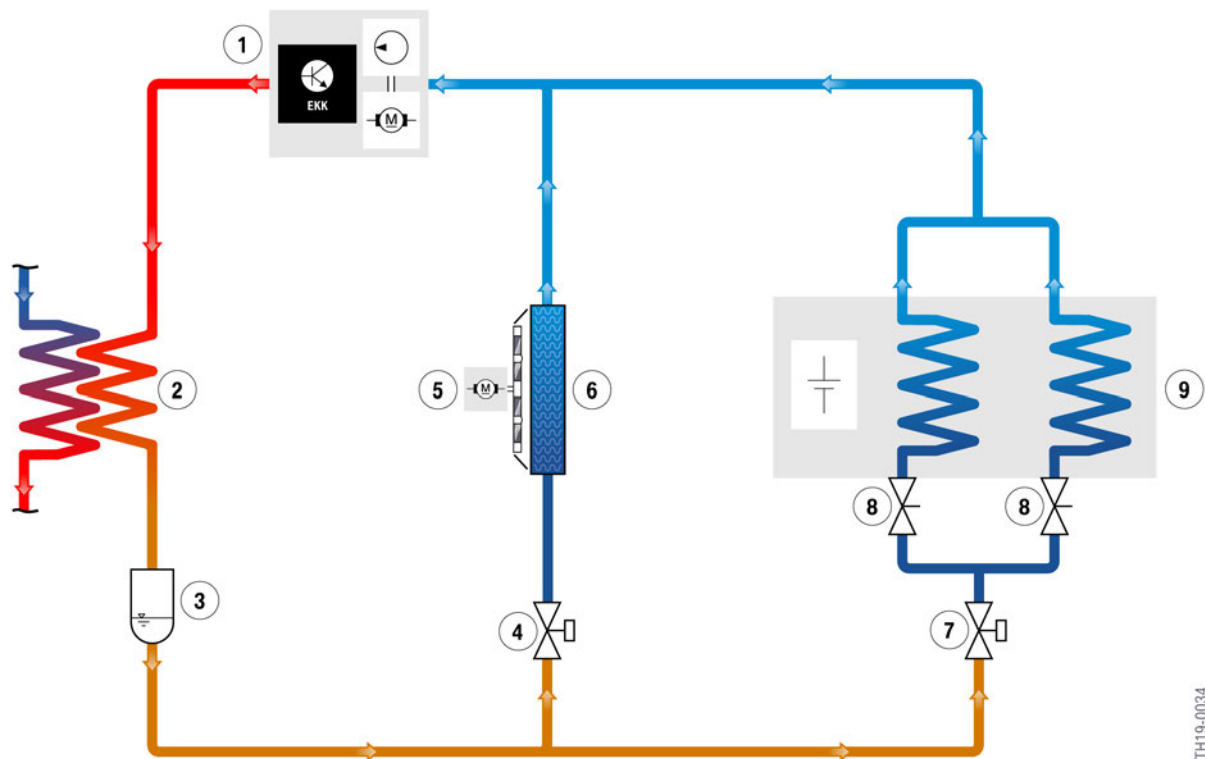
SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

2.2.3. Cooling system

System overview

As with all Generation 3.0 and 4.0 high-voltage battery units, the SP44 high-voltage battery is cooled with refrigerant by means of a separate circuit. Due to the parallel arrangement of the heat exchangers in the high-voltage battery unit, system cooling is controlled not by a combined expansion and shutoff valve but instead by 1 shutoff valve and 2 expansion valves.



SP44 high-voltage battery - Schematic cooling system overview (example: G05 PHEV)

Index	Explanation
1	Electric refrigerant condenser (EKK)
2	Coolant-based air conditioning condenser (coolant-refrigerant-heat exchanger)
3	Dryer flask
4	Combined expansion and shutoff valve (passenger compartment)
5	Blower for passenger compartment
6	Evaporator (vehicle interior)
7	Shutoff valve
8	Expansion valve
9	Heat exchanger in the high-voltage battery unit

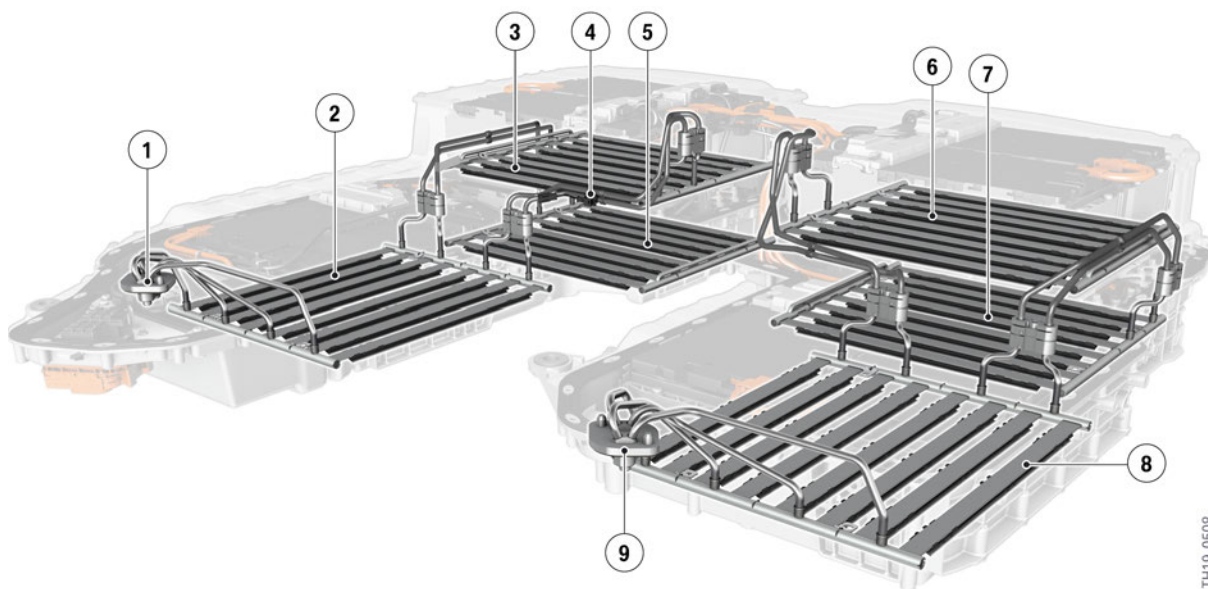
SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

The shutoff valve is activated in the established fashion by the battery management electronics (SME). It closes or opens both paths to the high-voltage battery unit on the pressure side (inlet). The expansion valves are seated on either half of the high-voltage battery unit (see graphic in the subchapter "Connections").

Heat exchangers

In all 6 heat exchangers on 2 levels are used to ensure that all 12 cell modules are adequately cooled. There is no connection of the refrigerant circuit between the respective halves of the high-voltage battery unit. Thus, 3 heat exchangers assume the task of cooling 6 cell modules in each half of the high-voltage battery unit.



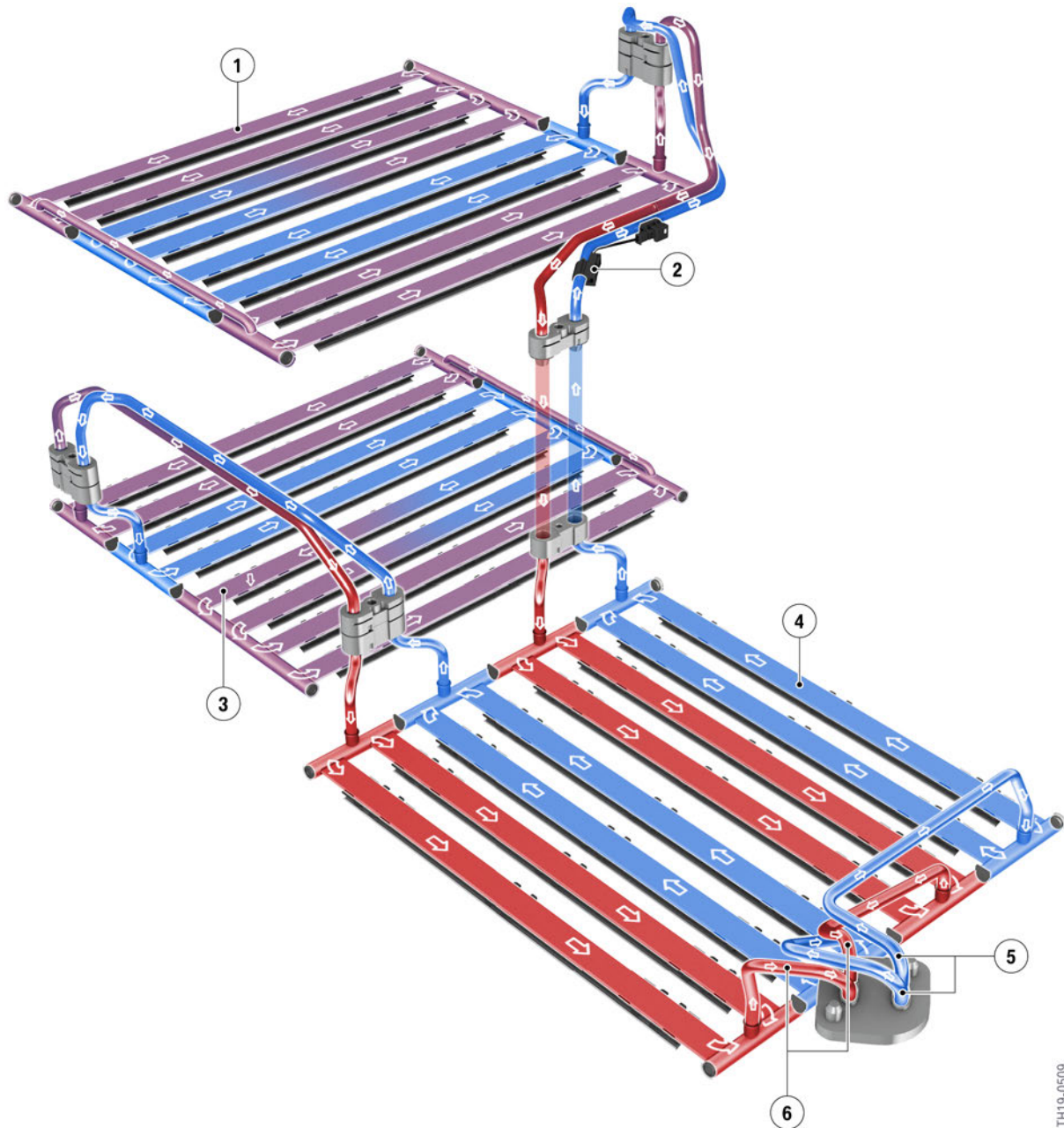
SP44 high-voltage battery - Components for cooling

Index	Explanation
1	Connecting flange for expansion valve, right
2	Heat exchanger, right front
3	Heat exchanger, top right rear
4	Temperature sensor for refrigerant line
5	Heat exchanger, bottom right rear
6	Heat exchanger, top left rear
7	Heat exchanger, bottom left rear
8	Heat exchanger, left front
9	Connecting flange for expansion valve, left

The refrigerant flowing in through the supply line is divided in the front heat exchanger and at the end directed into the top and bottom heat exchangers. The refrigerant flowing absorbs the heat from the cell modules as it passes through the heat exchangers. At the end of the top and bottom heat exchangers the refrigerant is again routed through the front heat exchangers to the return line.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.



SP44 high-voltage battery - Heat exchangers (example: right battery half, referred to the direction of travel)

Index	Explanation
1	Heat exchanger, top right rear
2	Temperature sensor for refrigerant line
3	Heat exchanger, bottom right rear
4	Heat exchanger, right front
5	Supply line, pressure stage
6	Return line, suction stage

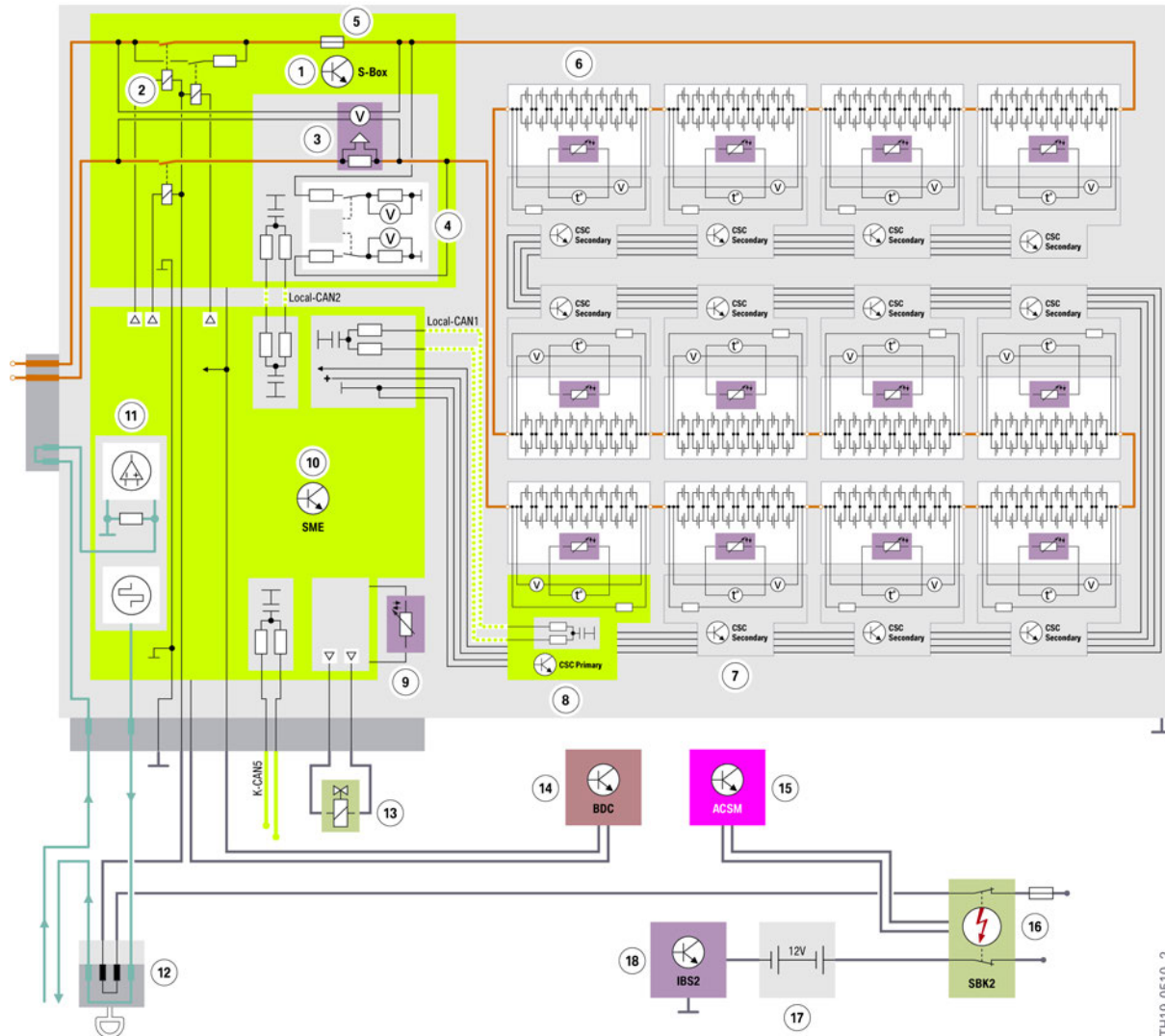
TH19-0509

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

2.2.4. Internal electrical connection

Many of the functions are the same as those of the Generation 3.0 high-voltage battery. The geometry and number of cell modules mean that the internal electrical connection is complex.



SP44 high-voltage battery - 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)

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

Index	Explanation
6	Cell module
7	Secondary cell supervision circuit (CSC)
8	Primary cell supervision circuit (CSC)
9	Temperature sensor for refrigerant line
10	Battery management electronics (SME)
11	Control and analysis of the high-voltage contact monitor circuit
12	High-voltage Service Disconnect
13	Shutoff valve of refrigerant lines
14	Body Domain Controller (BDC)
15	ACSM with control lines for activating the safety battery terminal
16	Safety battery terminal for auxiliary battery (SBK)
17	Auxiliary battery
18	Intelligent battery sensor for auxiliary battery (IBS)

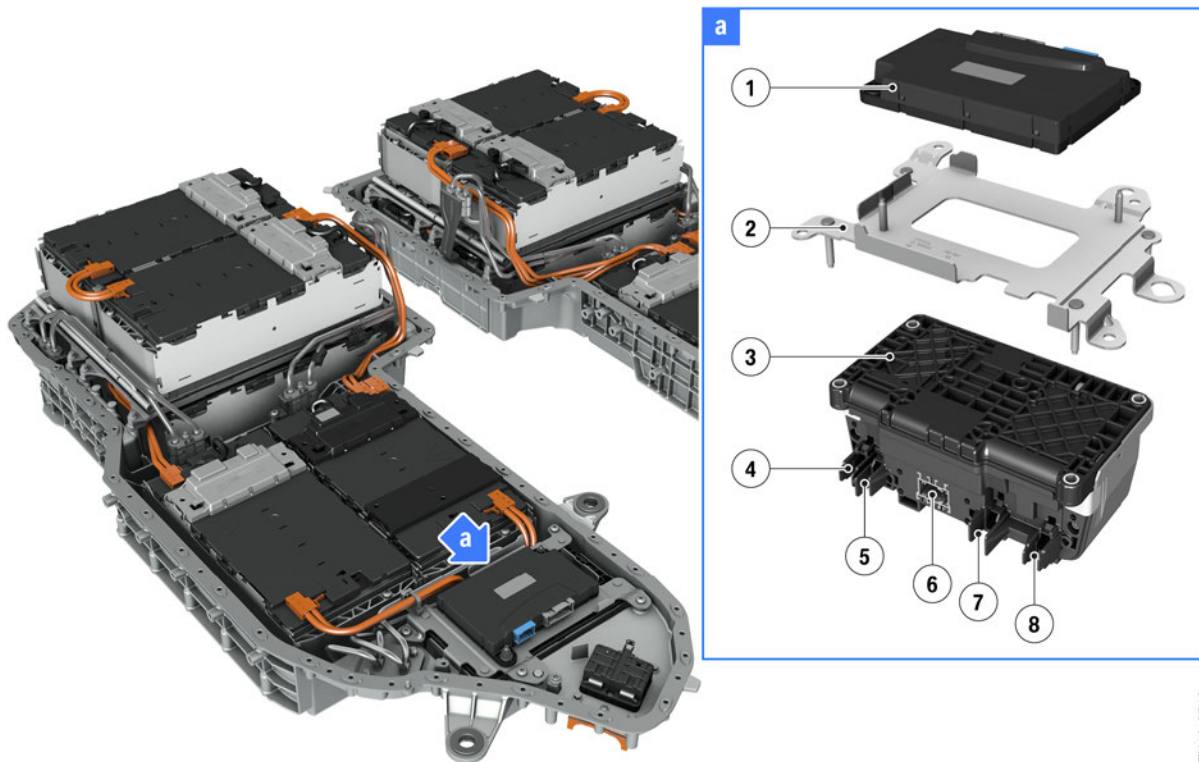
As in all Generation 4.0 high-voltage battery units the bus structure of the local CAN1 has changed and the cell supervision circuits are divided into primary and secondary control units. Communication between the battery management electronics (SME) and cell supervision circuits takes place exclusively through the primary cell supervision circuit. The remaining cell supervision circuits (secondary) only communicate with one another and with the primary cell supervision circuit.

2.2.5. Safety box

The safety box is located in front of the right battery half. It is secured together with the SME by means of a bracket on the lower housing section.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.



TH19-0743

SP44 high-voltage battery - Safety box and SME

Index	Explanation
1	Battery management electronics (SME)
2	Holder
3	Safety box
4	Positive to high-voltage connection
5	Negative terminal of cell module 1
6	Connection, communication wiring harness
7	Positive terminal of cell module 12
8	Positive to high-voltage connection

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

- The electromagnetic switch contactors
- The pre-charging relay

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

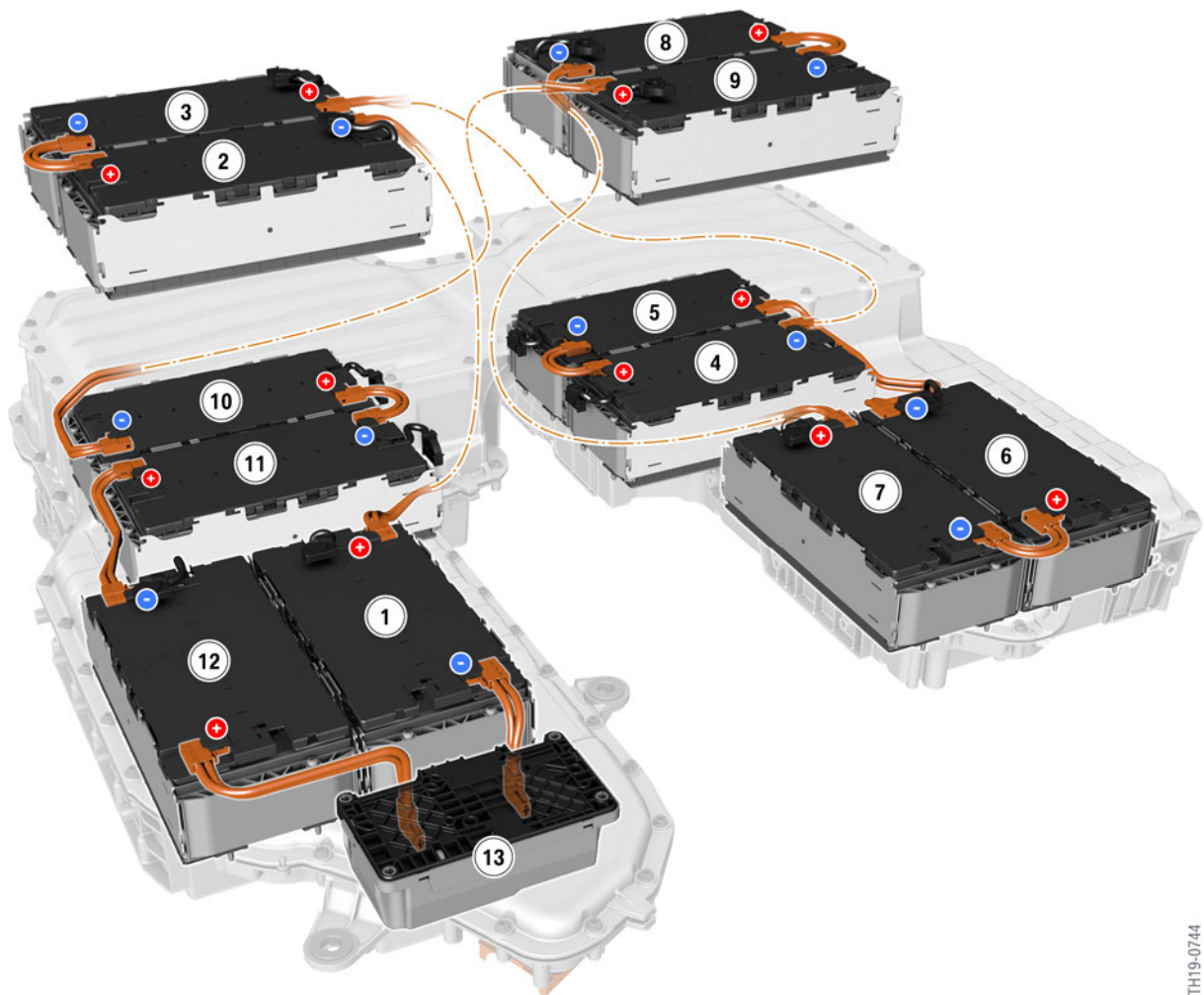


The safety boxes of generation 3.0 and 4.0 cannot be distinguished from the outside and must not be confused. The Generation 3.0 safety box must not be installed in a Generation 4.0 high-voltage battery unit (and vice versa). Make sure that the correct part is selected. An incorrectly installed safety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

2.2.6. Cell modules

The high-voltage battery unit is made up of 12 cell modules wired in series. Cell module 1 is the cell module that forms the negative terminal of the high-voltage battery unit. The counting order of the other cell modules is numerical. Thus, cell module 12 is the cell module that forms the positive terminal of the high-voltage battery unit.

The 68 Ah cell modules have the same form, mounting arrangement and connections as the established cell modules of Hybrid Generations 3.0 and 4.0.



SP44 high-voltage battery - Arrangement, polarity and electrical connection of cell modules

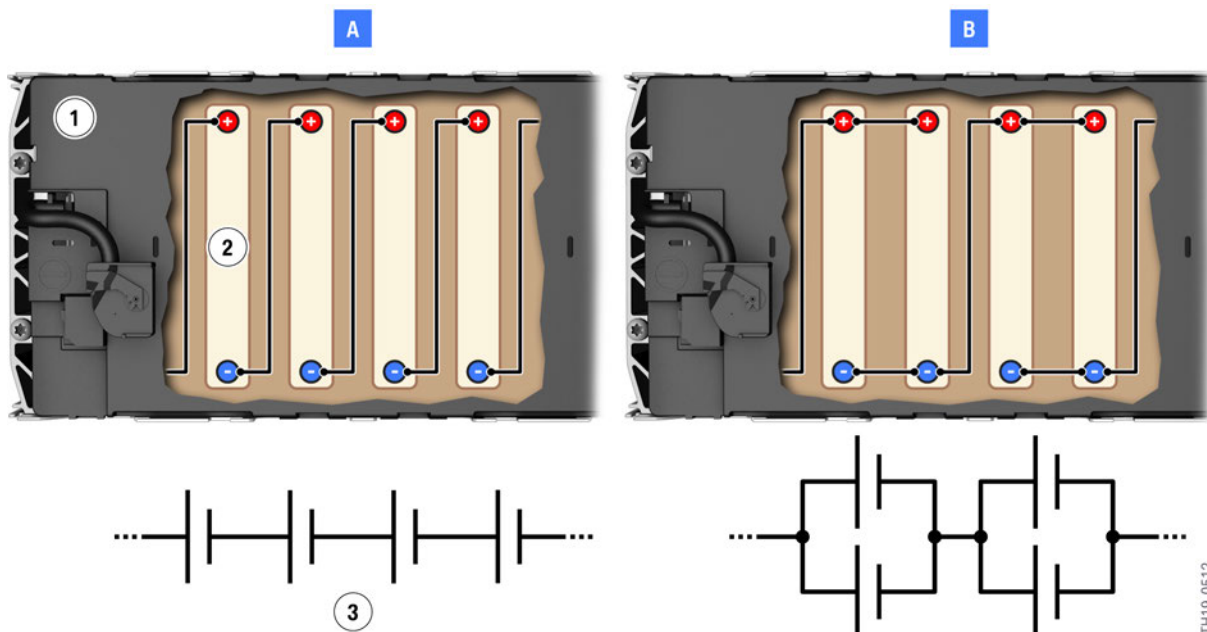
TH19-0744

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

Index	Explanation
1	Cell module 1
2	Cell module 2
3	Cell module 3
4	Cell module 4
5	Cell module 5
6	Cell module 6
7	Cell module 7
8	Cell module 8
9	Cell module 9
10	Cell module 10
11	Cell module 11
12	Cell module 12
13	Safety box

Each cell module has 16 cells and a capacity of 34 Ah. As a result of the modified electrical connection by mean of the internal cell contacting system the capacity is doubled to 68 Ah and the module voltage halved to approx. 28.8 V (nominal).



SP44 high-voltage battery - Cell module comparison (simplified, schematic diagram)

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

Index	Explanation
A	Electrical connection of a 34 Ah cell module (example: SP41 high-voltage battery)
B	Electrical connection of a 68 Ah cell module (example: SP44 high-voltage battery)
1	Cell module
2	Cell
3	Equivalent circuit diagram

The 16 cells of each 68 Ah cell module are not universally connected in series; instead, 2 cells are always connected in parallel and 8 of which are connected in series.

The 68 Ah cell modules can be distinguished externally from a 34 Ah cell module by the following features:

- Different part number
- Connector which connects the cell module to the cell supervision circuit. This is violet in color and mechanically encoded so that the cell module can only be connected to the associated cell supervision circuit.

Each cell module has 3 NTCs for determining the cell temperature.

At series launch it is planned to fit the top of the cell modules with a non-combustible insulating mat. This is made of mica and is mounted on the black cell module cover. Mica denotes minerals from the group of layered silicates which are highly resistant to heat.

In the event of a thermal reaction by the cell module, the insulating mat is designed to reduce the propagation of heat in the upward direction (to the cell module above or into the vehicle interior).

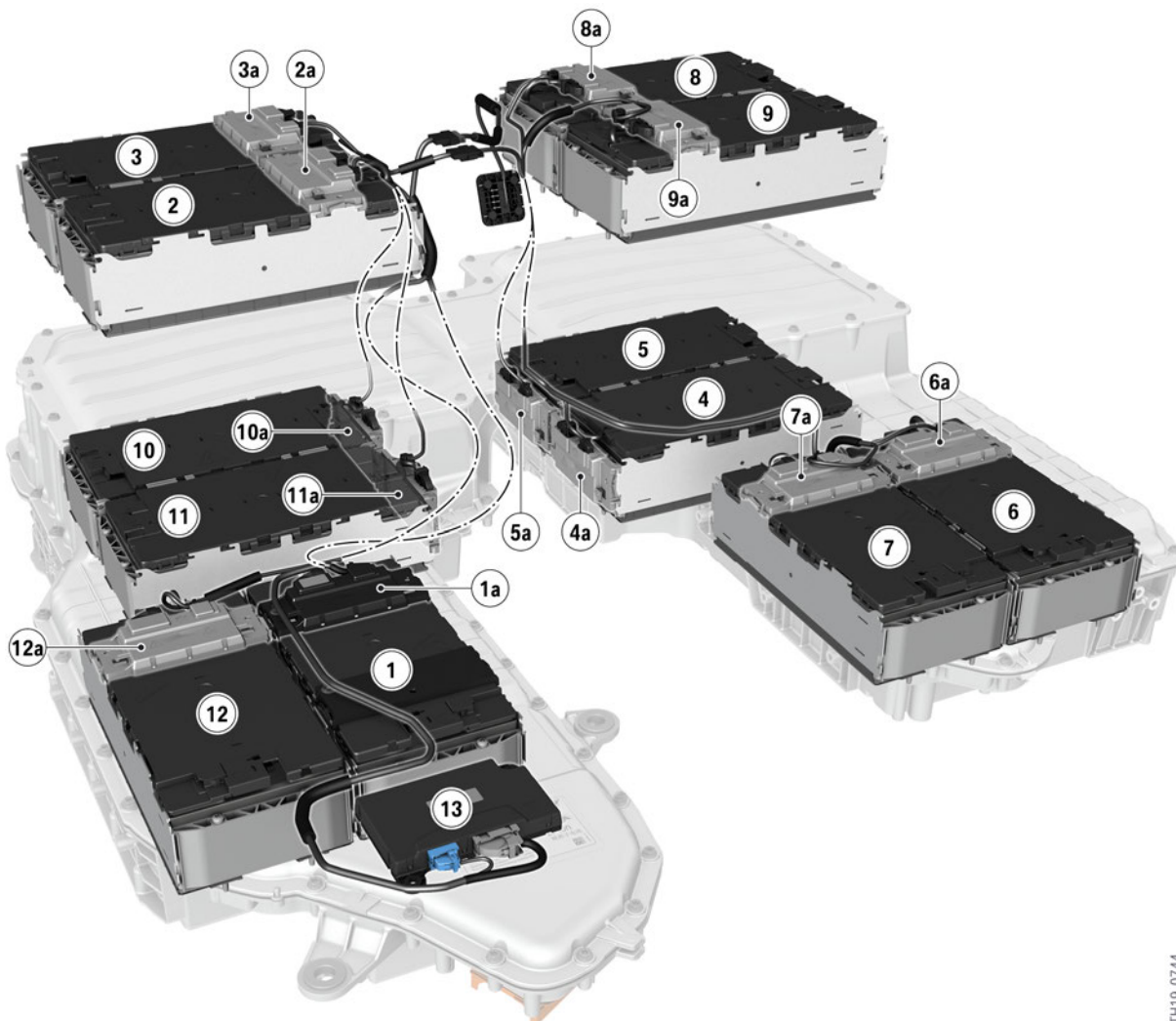
The insulating mat is silver in color and is permanently connected to the cell module's plastic cover.

2.2.7. Cell supervision circuits

As in all Generation 4.0 high-voltage battery units, the structure of the local CAN1 has been changed. It no longer features cell supervision circuits with equal rights, but instead 1 primary cell supervision circuit and 12 secondary cell supervision circuits connected in series.

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.



TH19-0744

SP44 high-voltage battery - Cell supervision circuits

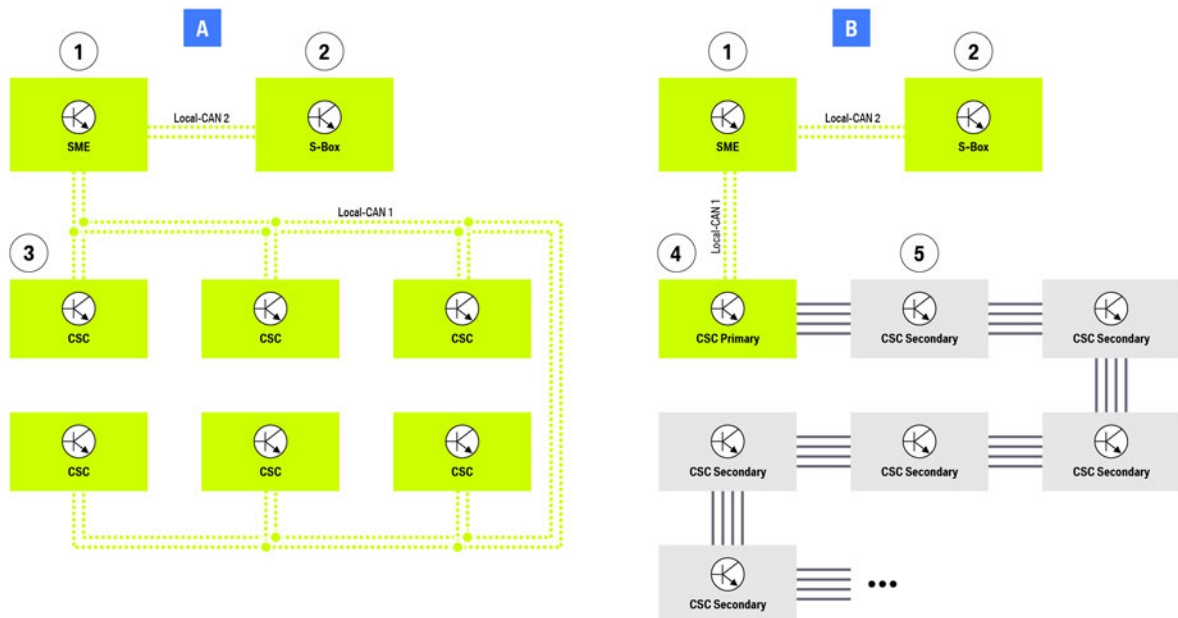
Index	Explanation
1	Cell module 1
1a	Cell supervision circuit 1 (primary)
2	Cell module 2
2a	Cell supervision circuit 2 (secondary)
3	Cell module 3
3a	Cell supervision circuit 3 (secondary)
4	Cell module 4
4a	Cell supervision circuit 4 (secondary)
5	Cell module 5
5a	Cell supervision circuit 5 (secondary)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

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

Index	Explanation
6a	Cell supervision circuit 6 (secondary)
7	Cell module 7
7a	Cell supervision circuit 7 (secondary)
8	Cell module 8
8a	Cell supervision circuit 8 (secondary)
9	Cell module 9
9a	Cell supervision circuit 9 (secondary)
10	Cell module 10
10a	Cell supervision circuit 10 (secondary)
11	Cell module 11
11a	Cell supervision circuit 11 (secondary)
12	Cell module 12
12a	Cell supervision circuit 12 (secondary)
13	Battery management electronics (SME)

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.



SP44 high-voltage battery - Comparison of Gen 3.0 and 4.0 CSC bus structure

TH19-0746_2

SP44 High-voltage Battery.

2. High-Voltage Battery Unit.

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 capability
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 Generation **3.0** high-voltage battery units, 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.

SP44 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 68 Ah cell modules may only be used in the SP44 high-voltage battery. Converting a different high-voltage battery unit with 68 Ah cell modules is not permitted.



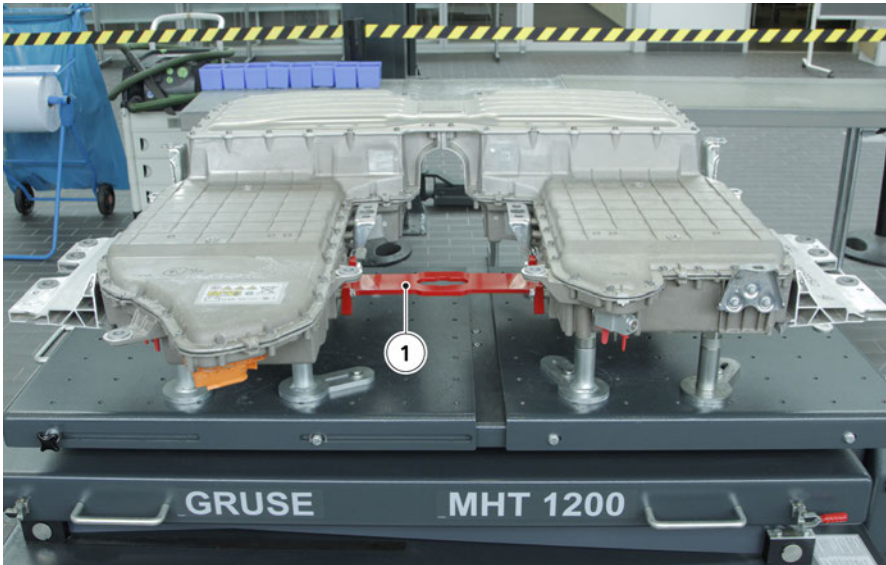
Before starting work on high-voltage vehicles that have been involved in an accident, the instructions and notices in the following documents in the repair instructions must be observed:

- 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.
-

To remove the high-voltage battery unit from the vehicle, it is necessary to mount the pictured special tool first. This mounting bridge must be mounted and remain between the battery halves while the high-voltage battery unit is being repaired.

SP44 High-voltage Battery.

3. Repair.



SP44 high-voltage battery - Mounting bridge between the lower housing sections

Index	Explanation
1	Mounting bridge from set of special tools 2 467 913

The special tool may be removed again only when the high-voltage battery unit is secured in the vehicle. Only exception: The mounting bridge must be detached when one of the two lower housing sections is being exchanged.

3.2. Upper housing section

Before opening the high-voltage battery unit, remove any dirt or moisture on the upper housing section to prevent any fouling of the high-voltage battery unit.

The upper housing section is secured with 38 screws on the middle housing section. Due to the high number of screw connections an electric screwdriver may be used to release the upper housing section.

The gasket and the screws must be replaced each time the upper housing section is disassembled. The screw connection must be tightened mechanically to the specified torque.

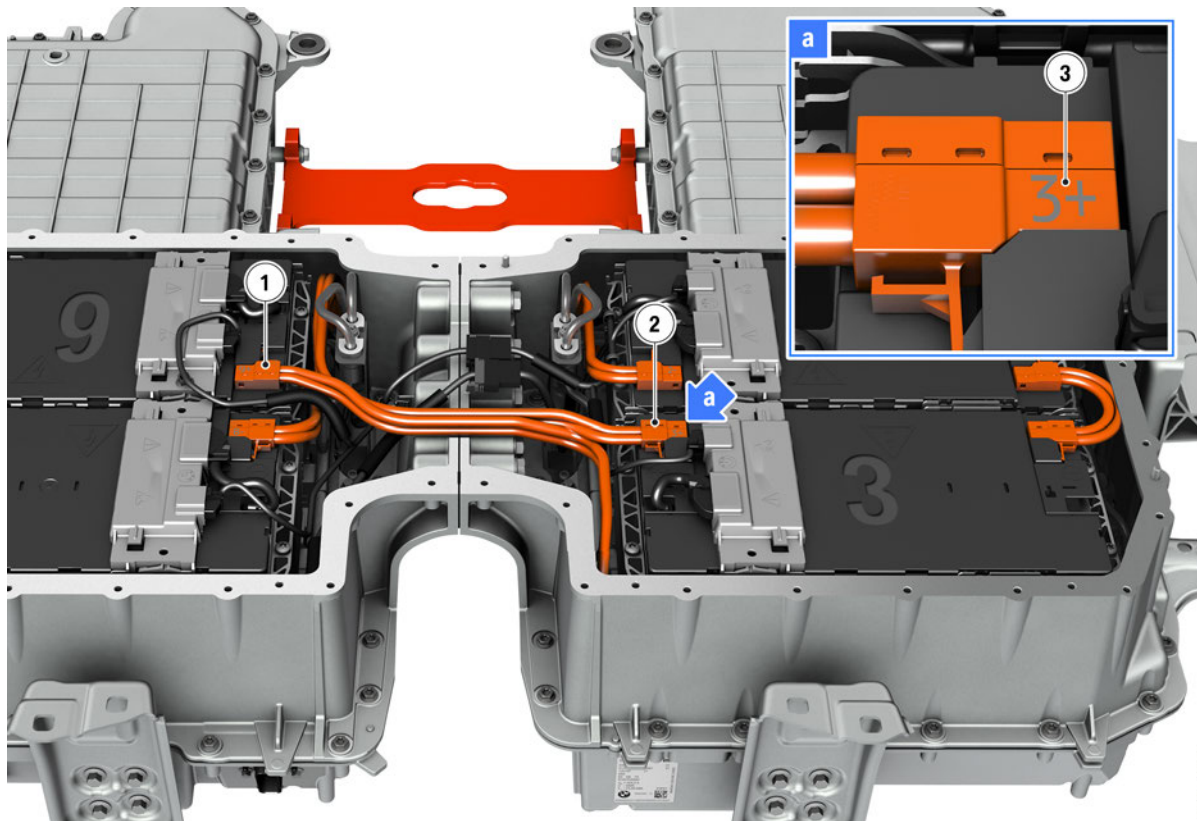
3.3. Safety rules

After disassembling the upper housing section and **before** performing any work in the opened high-voltage battery unit, always disconnect the following high-voltage cables to interrupt the series connection:

- High-voltage cable at the positive terminal of cell module **9**
- High-voltage cable at the positive terminal of cell module **3**.

SP44 High-voltage Battery.

3. Repair.



SP44 high-voltage battery - Interrupting the series connection after opening

Index	Explanation
1	High-voltage cable at the positive terminal of cell module 9
2	High-voltage cable at the positive terminal of cell module 3
3	Location data on the high-voltage cable connector

After completing repairs and before mounting the upper housing section, reconnect the high-voltage cables to the correct cell modules.



Danger

If the positive cable of cell module 3 is mistakenly connected to the positive terminal of cell module 9, a number of cell modules will create a **short circuit**. This creates the risk of damage and physical injury.

In general the following applies: Before connecting high-voltage cables, always cross-check the location data on the high-voltage cable connector with the cell module to be connected.

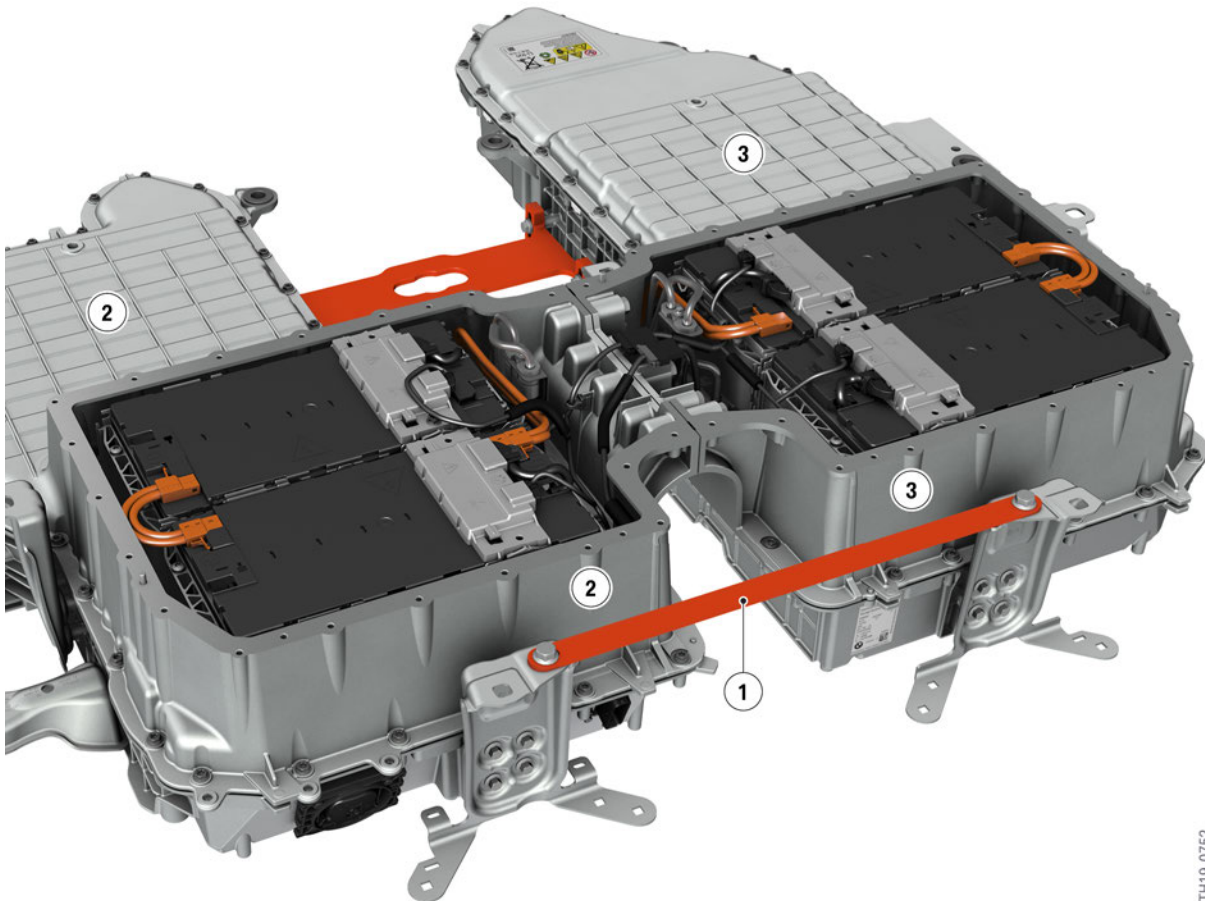
3.4. Middle housing section

The upper cell modules 2, 3, 8 and 9 are accessible from above and can be removed without having to disassemble the middle housing section.

SP44 High-voltage Battery.

3. Repair.

Before releasing the screws on the middle housing section, it is essential to install a strut (from set of special tools 2 467 913) between the two rear brackets and tighten it to the specified torque. In this way, the two lower housing sections are fixed in position if the middle housing section has been disassembled.



SP44 high-voltage battery - Strut for removing the middle housing section

Index	Explanation
1	Strut from set of special tools 2 467 913
2	Middle housing section, left
3	Middle housing section, right

An electric screwdriver may also be used to release the screw connections of the middle housing section. The screw connection must be tightened mechanically to the specified torque.



The two housing middle sections may only be disassembled together (as a single part) in service. Separating the left and right middle housing sections from each other may cause leaks at a later stage and hence lead to extensive reworking during the EoS test.

SP44 High-voltage Battery.

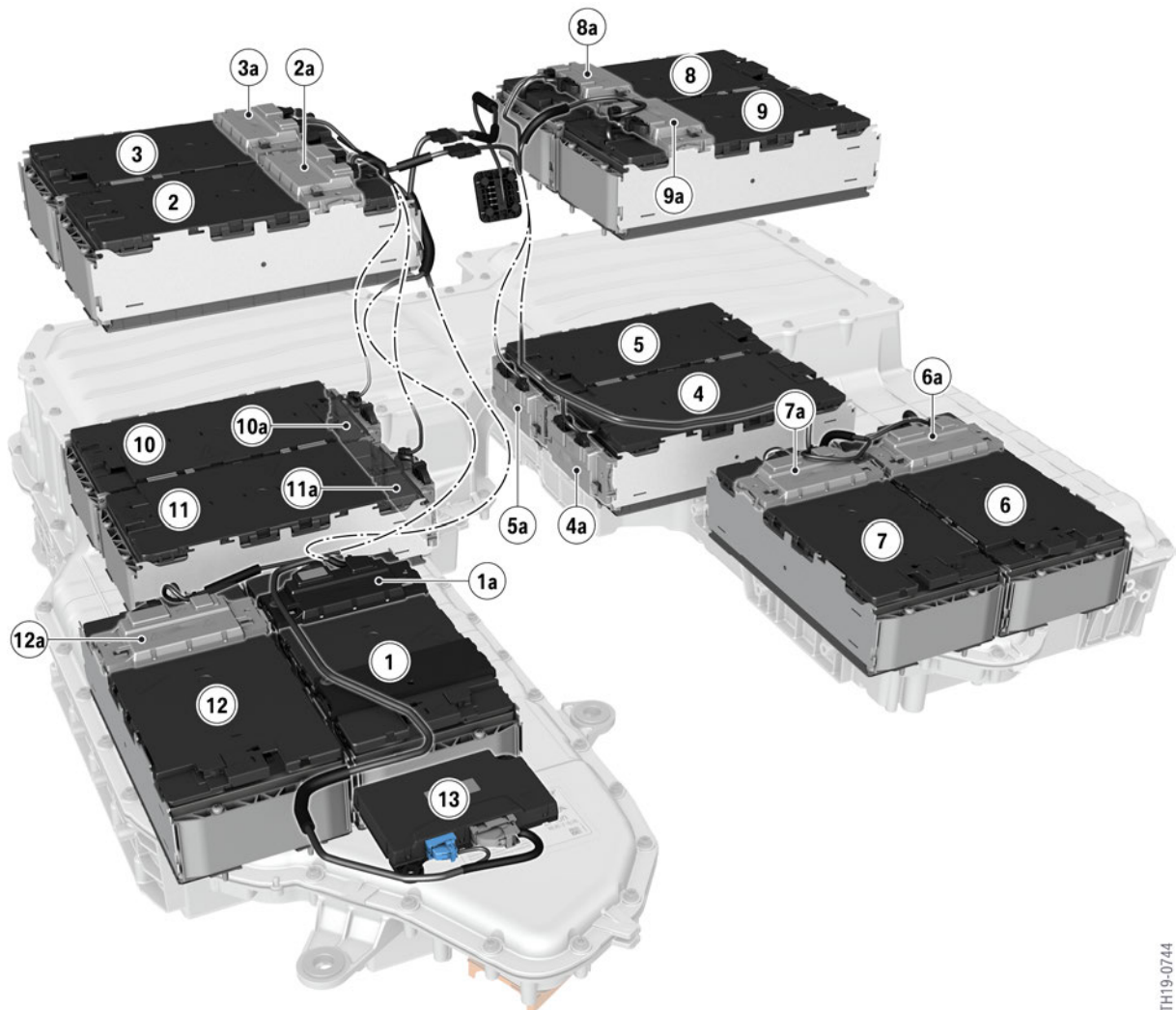
3. Repair.

Owing to its size, 2 service technicians are required to remove and install the middle housing section. The gaskets and the screws must be replaced after each disassembly.

The strut between the rear brackets can be removed again if the middle housing section has been mounted to the specified tightening torque.

3.5. 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").



SP44 high-voltage battery - Cell supervision circuits

TH19-0744

SP44 High-voltage Battery.

3. Repair.

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)
7	Cell module 7
7a	Cell supervision circuit 7 (secondary)
8	Cell module 8
8a	Cell supervision circuit 8 (secondary)
9	Cell module 9
9a	Cell supervision circuit 9 (secondary)
10	Cell module 10
10a	Cell supervision circuit 10 (secondary)
11	Cell module 11
11a	Cell supervision circuit 11 (secondary)
12	Cell module 12
12a	Cell supervision circuit 12 (secondary)
13	Battery management electronics (SME)

The primary cell supervision circuit may only be connected at cell module 1.

3.6. Cell module exchange

Due to the number of cell modules and cell supervision circuits, it is still necessary before exchanging a cell module to provide an easily visible marking of the installation positions on the respective components.

The established special tool 2 360 072 is used to lift out the cell modules.

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.

SP44 High-voltage Battery.

3. Repair.

3.6.1. Reuse

The SME software has been enhanced and now has a counter which takes account of and counts the triggering of the main fuse (in the safety box). A '1' is added to the counter reading each time this safety fuse is triggered. 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 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.

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

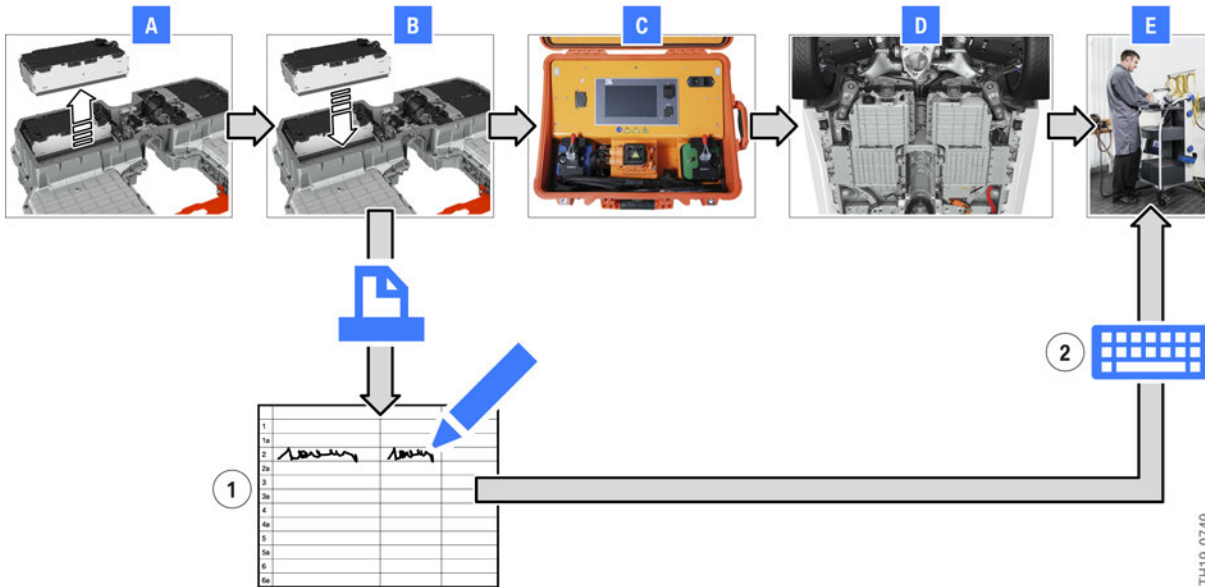
3.6.2. Tracking

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. Then the serial numbers noted down had to be entered in ISTA at a later stage during commissioning of the high-voltage battery unit.

SP44 High-voltage Battery.

3. Repair.



Write down serial numbers during cell module exchange – Previous procedure

Index	Explanation
A	Removal of cell module
B	Installation of cell module
C	End-of-service test
D	Installation of the high-voltage battery unit in the vehicle
E	Start-up of the high-voltage battery unit
1	Write 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

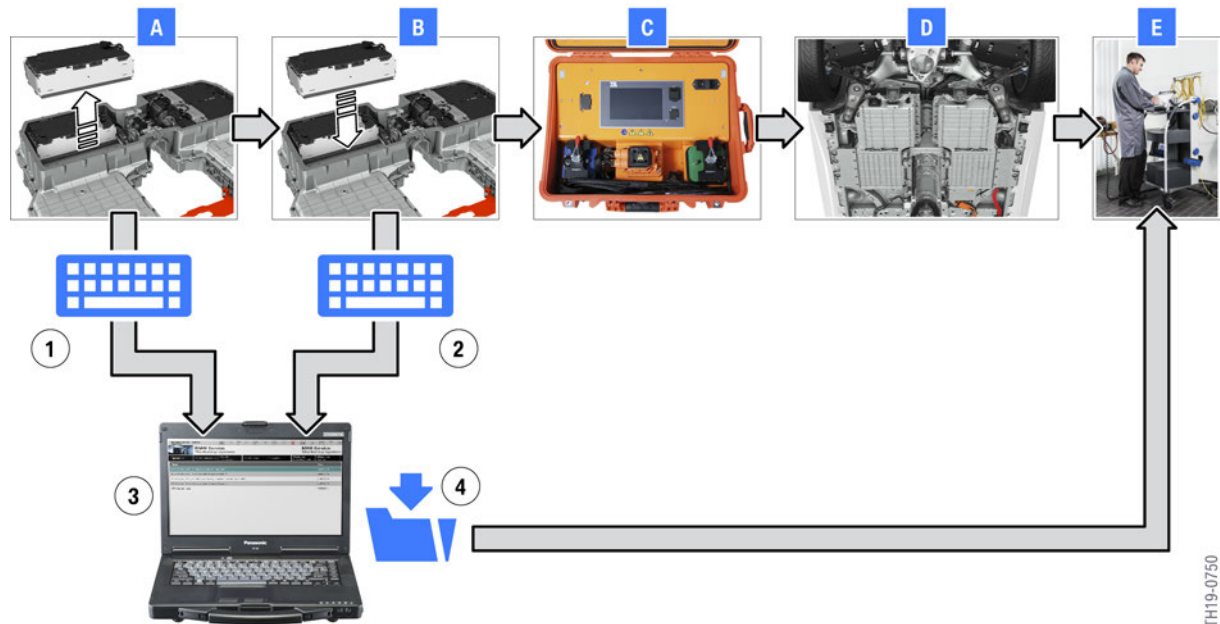
New procedure

The new feature is that the serial numbers of the **replaced** cell modules also have to be transferred to ISTA beforehand. In this way, the exchanged cell modules are also entered in ISTA. To facilitate assignment to the high-voltage battery unit, the serial number must also be entered beforehand.

In order to be able to adjust the input of the 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. Opening a new procedure and identifying the vehicle via the vehicle identification number (VIN) make this possible.

SP44 High-voltage Battery.

3. Repair.



Write down serial numbers during cell module replacement – new procedure

Index	Explanation
A	Removal of cell module
B	Installation of cell module
C	End-of-service test
D	Installation of the high-voltage battery unit in the vehicle
E	Start-up of the high-voltage battery unit
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

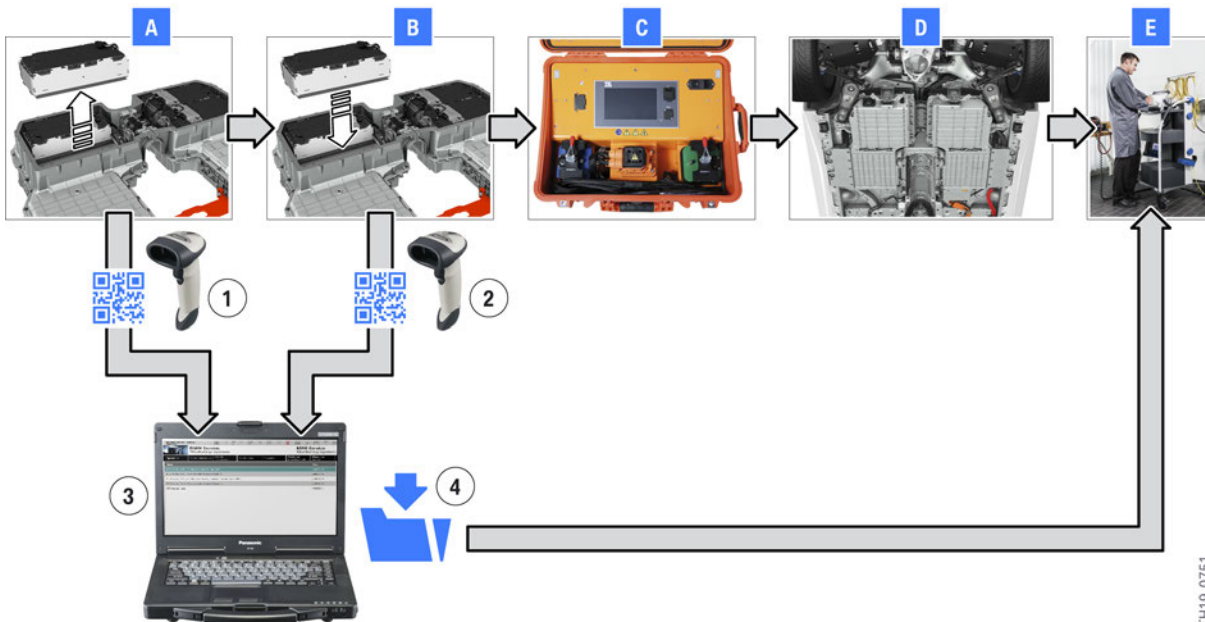
If the serial numbers have been entered using the keyboard, they are saved locally and automatically transferred to ISTA when the high-voltage battery unit is commissioned. The serial numbers then do not need to be entered again in the course of commissioning.

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.

SP44 High-voltage Battery.

3. Repair.



Write down 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 the high-voltage battery unit in the vehicle
E	Start-up of the high-voltage battery unit
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.

3.6.3. 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.

As for all cell modules of the Generation 4.0 high-voltage battery, the module charging cable with special tool number 2 458 279 must be used.

SP44 High-voltage Battery.

3. Repair.



SP44 high-voltage battery - Cell module charging cable

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)

The instructions for updating the software can be found in ISTA or AIR under the service information special tool "New software for the module charger DBL1200HV-60".

3.7. EoS tester

Before being installed in the vehicle, the high-voltage battery unit must be tested in the established manner using the EoS tester. The connections, procedure and operation are unchanged for the SP44 high-voltage battery. 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.

The changes of the EoS tester are only related to the software. The instructions for updating the software can be found in ISTA or AIR under the service information special tool "Software update to software version v ... for the End-of-Service tester".

