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| Megablock | | 10ft Container Electrical Safety Checklist | |
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| Test Specification | RKN | 09-01-2025 | 3.0.0 |

# 1. Introduction

The Megablock system contains many components utilizing potentially dangerous voltages and currents. It is a safety requirement that the electrical safety is tested before a product is shipped.

The testing is done according to the standard EN60204-1 Chapter 18, from which the tests in this document are described with room to note test results.

# 2. Revision Record

| Rev # | Author | Description | Revised By | Date |
|---|---|---|---|---|
| 1.0 | PBL | Initial Release | | 09/11-2023 |
| 2.0 | PBL | Adapted from 40ft Coolant Skid document | | 04/07-2024 |
| 3.0 | RKN | General review | | 09/01-2025 |

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# 5. Purpose and structure of this document

As Megablock is a large system, containing several parts assembled individually and brought together to fulfill the customer requirements, the components are tested individually.

With each component tested before final assembly, the interconnect must be tested, both before initial operation and after any disassembly, e.g. after shipping.

The purpose of this document is to compare the requirements outlined in EN60204-1 Chapter 18 against following testing performed Megablock components.

This is required for the CE approval of the Megablock Fuel Cell Power Plant.

This document is structured as follows:

1. The requirements from EN60204-1 are outlined:
    a. Section 7
2. Test Specifications to comply with the requirement outlined above.
    a. Sections 10 to 16
3. Summary table
    a. Section 17

# 6. References

| Document | Title | Author |
|---|---|---|
| DS/EN 60204-1:2018 | Safety of machinery – Electrical equipment of machines – Part 1: General Requirements | CENELEC |

*Table 1 – References*



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# 7. Requirements from EN60204-1 Ch 18

Figure 1 is reproduced from the EN60204-1 Ch18.1:

**18.1 General**

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c) and h) and may include one or more of the items d) to g):

a) verification that the electrical equipment complies with its technical documentation;
b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2);
c) in case of fault protection by automatic disconnection of supply, conditions for protection by automatic disconnection shall be verified according to 18.2;
d) insulation resistance test (see 18.3);
e) voltage test (see 18.4);
f) protection against residual voltage (see 18.5);
g) verification that the relevant requirements of 8.2.6 are met;
h) functional tests (see 18.6).

*Figure 1 – Excerpt from EN60204-1:2018, Chapter 18.1*

The mapping between the headlines from the standard and the requirement ID used in this document is listed in Table 2.

| Requirement headline | EN60204-1 Chapter 18.1 | EN60204-1 Chapter | Requirement ID |
|---|---|---|---|
| Verification that the electrical equipment complies with its technical documentation | A | n/a | A1 |
| Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2) | B | 18.2.2 – Test #1 | A2 |
| Verification of conditions for protection by automatic disconnection of supply | C | 18.2 | A3 |
| Insulation resistance tests | D | 18.3 | A4 |
| Voltage tests | E | 18.4 | A5 |
| Protection against residual voltages | F | 18.5 | A6 |
| Verification that the relevant requirements of 8.2.6 are met | G | 8.2.6 | A7 |

*Table 2 – Requirement headlines, chapter, and ID mapping*

Functional testing of the equipment is outside the scope of this document.



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| Test Specification | RKN | 09-01-2025 | 3.0.0 |

## 8. Test Equipment.

The test equipment is a CE MultiTester, manufactured by Metrel.

| Test Equipment | Ballard Equipment ID | Calibration valid until: |
|---|---|---|
| | | |
| | | |
| | | |

## 9. Device Under Test

The device to be tested is the 10ft container for the Megablock project.



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# 10. A1 – Verification that the electrical equipment complies with its technical documentation

## EN60204-1 requirements:

a) verification that the electrical equipment complies with its technical documentation;

*Figure 2 – EN60204-1:2018, Chapter 18.1*

## Megablock Component requirements:

Inspection of the electrical equipment and cabinets to ensure congruence between documentation and equipment/cabinet.

## Megablock Component validation:

| | |
|---|---|
| Component | 10ft Container |
| Result (pass/fail) | |
| Date and Initials | |



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# 11. A2 – Verification of continuity of the protective bonding circuit

## EN60204-1 requirements:

**18.2.2 Test 1 – Verification of the continuity of the protective bonding circuit**

The resistance between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see 414 of IEC 60364-4-41:2005) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross sectional area and the material of the related protective conductors and protective bonding conductor(s).

Earthed PELV supplies can produce misleading results in this test and therefore shall not be used.

*Figure 3 – EN60204-1:2018, Chapter 18.2.2*

## Megablock Component requirements:

The EN60204-1 Chapter 18.2.2, Test #1 specifies a current of 10A.

Megablock Component bonding resistance test is performed with a current of 10A and a test period of 10 seconds.

## Megablock Component validation:

The primary earthing point for the Power Converter Container is the main ground bar located at the rear of the main output breaker (=BA30-FC30).

Each component is verified and compared to expected values for the following locations.

| ID | Test Point | Expected Value | Recorded Value |
|---|---|---|---|
| 1 | Busbar to busbar | <100mΩ | |
| 2 | Main DC/Acpoint 1 | | |
| 3 | Main DC/Acpoint 2 | | |
| 4 | Main DC/Acpoint 3 | | |
| 5 | DC/AC conduncter point 1 | | |
| 6 | DC/AC conduncter point 2 | | |
| 7 | DC/AC conduncter point 3 | | |
| 8 | LT coolant pipe | | |
| 9 | Cable tray | | |



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| Test Specification | RKN | 09-01-2025 | 3.0.0 |

| | | | |
|---|---|---|---|
| 10 | Main transforer grounding bolt | | |
| 11 | Main transformer chassis | | |
| 12 | Cable tray | | |

*Table 3 – Bonding Resistance Test point and expected resistance values.*

When performing the test, ensure the connection between the test leads and the equipment is not contributing to inaccurate measurements.

# 12. A3 - Verification of conditions for protection by automatic disconnection of supply

## EN60204-1 requirements:

**18.2 Verification of conditions for protection by automatic disconnection of supply**

**18.2.1 General**

The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.

Test 1 verifies the continuity of the protective bonding circuit.

*Figure 4 – EN60204-1:2018, Chapter 18.2*

## Megablock Component requirements:

As specified in chapter 18.2.1, Test #1 is performed (see section 11). Chapter 18.2.1 further specifies testing of Residual Current Devices (RCD) according to manufacturer specifications.

Megablock Component module does not contain any RCD devices.

# 13. A4 - Insulation resistance tests

## EN60204-1 requirements:

**18.3 Insulation resistance tests**

When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

*Figure 5 – EN60204-1:2018, Chapter 18.3*



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| Test Specification | RKN | 09-01-2025 | 3.0.0 |

### Megablock Component requirements:

**Before performing this test, isolate all fuel cell DCDC converters from the DC bus (Cabinets UC01 to UC06)**

Use a set of test leads and alligator clips to create a single AC node (3 phases shorted together)

The Megablock Component insulation requirements are higher than as specified chapter 18.3. The test is specified in Table 4):

| Test point | Pass criteria | Test Voltage [VDC] |
|---|---|---|
| =LA01+UC31-QB01 | >1MΩ | 500 |

*Table 4 – Megablock Component Power Circuit Insulation Resistance Requirements*

### Megablock Component validation:

Each component is verified and compared to pass criteria in Table 4.

| Component | Power Converter Container |
|---|---|
| Result – AC Node (value and pass/fail) | |
| Date and Initials | |

# 14. A5 – Voltage tests

### EN60204-1 requirements:

**18.4 Voltage tests**

When voltage tests are performed, test equipment in accordance with IEC 61180-2 should be used.

The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

Components and devices that are not rated to withstand the test voltage and surge protection devices which are likely to operate during the test shall be disconnected during testing.

Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing.

*Figure 6 – EN60204-1:2018, Chapter 18.4*



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### Megablock Component requirements:

The requirements from EN 60204-1:2018, Chapter 18.4 is compared in Table 5.
AC Voltage for Megablock Components is at most 480V, so twice the supply voltage is 960Vac.

| Parameter | EN 60204-1:2018, Chapter 18.4 | Megablock Component Testing |
|---|---|---|
| Voltage [VAC] | 960 | 2500 |
| Frequency [Hz] | 50 or 60 | 50 |
| Duration [sec] | 1 | 10 |
| Maximum Current [mA] | No arcing | 5 |

*Table 5 – Voltage Test Requirements*

### Megablock Component validation:

Connection point is internal side of main output breaker.

| Component | Power Converter Container |
|---|---|
| Voltage Test – L1 (value and pass/fail) | |
| Voltage Test – L2 (value and pass/fail) | |
| Voltage Test – L3 (value and pass/fail) | |
| Date and Initials | |

## 15. A6 – Protection against residual voltages

### EN60204-1 requirements:

**18.5 Protection against residual voltages**

Where appropriate, tests shall be performed to ensure compliance with 6.2.4.

*Figure 7 – EN60204-1:2018, Chapter 18.5*



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| *Document type* | *Author* | *Revision date* | *Revision* |
| Test Specification | RKN | 09-01-2025 | 3.0.0 |

**6.2.4 Protection against residual voltages**

Live parts having a residual voltage greater than 60 V when the supply is disconnected shall be discharged to 60 V or less within a time period of 5 s provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 µC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure that contains the live parts.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time to 60 V shall not exceed 1 s, otherwise such conductors shall be protected to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided. When the equipment is located in places open to all persons, which can include children, warnings are not sufficient and therefore a minimum degree of protection against contact with live parts to IP4X or IPXXD is required.

*Figure 8 – EN60204-1:2018, Chapter 6.2.4*

## Megablock Component requirements:

Identical to EN60204-1 requirements.

## Megablock Component validation:

No live parts of the Megablock Component system are accessible without disassembling barriers or accessing electrical cabinets. All connectors are IP2X or higher in unmated state in applications higher than 60V (power system)

Frequency converters and motor drives are marked with applicable durations before internal capacitors are discharged.

Maintenance procedures for the Megablock Component module include a manual verification before any work on exposed components is permitted.



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# 16. A7 – Verification that the relevant requirements of 8.2.6 are met

## EN60204-1 requirements:

**8.2.6 Additional requirements for electrical equipment having earth leakage currents higher than 10 mA**

Where electrical equipment has an earth leakage current that is greater than 10 mA AC or DC in any protective conductor, one or more of the following conditions for the integrity of each section of the associated protective bonding circuit that carries the earth leakage current shall be satisfied:

a) the protective conductor is completely enclosed within electrical equipment enclosures or otherwise protected throughout its length against mechanical damage;

b) the protective conductor has a cross-sectional area of at least 10 $mm^2$ Cu or 16 $mm^2$ Al;

c) where the protective conductor has a cross-sectional area of less than 10 $mm^2$ Cu or 16 $mm^2$ Al, a second protective conductor of at least the same cross-sectional area is provided up to a point where the protective conductor has a cross-sectional area not less than 10 $mm^2$ Cu or 16 $mm^2$ Al. This can require that the electrical equipment has a separate terminal for a second protective conductor.

d) the supply is automatically disconnected in case of loss of continuity of the protective conductor;

e) where a plug-socket combination is used, an industrial connector in accordance with IEC 60309 series, with adequate strain relief and a minimum protective earthing conductor cross-section of 2,5 $mm^2$ as part of a multi-conductor power cable is provided.

A statement shall be given in the instructions for installation that the equipment shall be installed as described in this 8.2.6.

*Figure 9 – EN60204-1:2018, Chapter 8.2.6*

## Megablock Component requirements:

The Megablock Component does not have a leakage current higher than 10mA.

## Megablock Component validation:

The protection against excessive leakage current is twofold:

- Ground fault detection is installed with a proven component (Bender Isometer). Detection of ground fault causes system shutdown and service technician is dispatched.
- Conductivity measurement of internal coolant is a part of the regular maintenance procedures (see N01-003 Service and Maintenance Manual)



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# 17. Summary Table

The requirements from sections 10 to 16, together with results are summarized below in Table 6:

| Requirement headline | EN60204-1 Chapter | Req ID | Pass/Fail? |
|---|---|---|---|
| Verification that the electrical equipment complies with its technical documentation | n/a | A1 | |
| Verification of continuity of the protective bonding circuit (Test 1 of 18.2.2) | 18.2.2 – Test #1 | A2 | |
| Verification of conditions for protection by automatic disconnection of supply | 18.2 | A3 | |
| Insulation resistance tests | 18.3 | A4 | |
| Voltage tests | 18.4 | A5 | |
| Protection against residual voltages | 18.5 | A6 | |
| Verification that the relevant requirements of 8.2.6 are met | 8.2.6 | A7 | |

*Table 6 – Summary Table*



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