HEC Note-064
December 1, 1998

Local quality control specifications for the assembly of HEC modules in a production line

Michael Aderholz, Horst Laskus and Hasko Stenzel

Max-Planck-Institut für Physik
Werner-Heisenberg-Institut
München, Germany

1 Introduction

The report gives a detailed description of all individual steps for the assembly of a module of the ATLAS Hadronic Endcap Calorimeter (HEC) and its quality control. In the context of the assembly of the overall calorimeter, production steps are given starting with a check of the delivered raw material, tests for stacking of absorber plates and electrodes till the final tests before shipping the modules to CERN. Special attention was given to the necessary quality control tests as a base for the accompanying technical test reports. All local quality control procedures are in agreement with the specifications given in the global QC document [1].

2 Setup and entrance test of delivered material

In general all materials which fails the entrance tests will be sent back to the producer; no attempt will be made to repair broken elements.

All details of test stands or assembly devices have to be taken from the technical drawings.

2.1 Preparing the assembly table

First the assembly table has to be aligned. Then all three alignment bars should be mounted together with a device to measure the alignment of the plates. Electrical grounding of the assembly table has to be installed for later HV tests.

2.2 Positioning of spacers

All aluminum spacers should be placed at the expected positions of the tie rods. The first copper plate will be put on these aluminum spacers.

2.3 Entrance inspection of copper plates

Copper plates are lifted out of the transport box with a crane outside the clean room and put in a special inspection position. Then the surface has to be checked for slivers, grooves and general quality. Holes and cutter traces must be checked for metal spans. Easiness of the threads for the connecting bars are checked using screws (report sheet A).

2.4 Cleaning of copper plates

Rests of dust on the plates are removed with a scotch roll. Possible chemical impurities have to be removed (report sheet A).

2.5 Ordering of layers

The successive order of plates has to be checked. If it turns out to be necessary the plates are reordered.

2.6 Random sample tests

The first, then each tenth and the last plate are used for "random sampling" measurements. Measured are the plate dimensions, their thickness in the vicinity of the holes and the maximum bending over the total length (report sheet B).

2.7 Tie rod inspection

The smoothness of the polished rod surface has to be checked. The easiness of the thread is confirmed by twisting the nut. The thread should be inspected for metal slivers. Dust must be removed with a fuzz-free textile and alcohol. (report sheet C).

2.8 Electrode inspection

EST- and pad boards are checked for possible damages during the transport. Special care should be taken to check the tabs (report sheet EST and PAD).

2.9 Measurement of the resistance

The surface resistance of EST-boards is measured between two HV-connectors or two ground-connectors respectively. Doing so the HV/ground-side is defined (on HV side resistance is factor 2 larger than on ground side) and EST1/EST2 are sorted and labeled (if they are not yet labeled before) (report sheet EST).

3 Module assembly

3.1 Inserting plates into the gap test stand

Using a lifting device the first copper plate is inserted into the gap test stand. The spacers are placed around the tie rod holes.

3.2 HEXCEL breakdown test

A Hexcel mat is inserted into the HV test stand. The lower electrode is connected to ground and the upper one to 3 kV. In case of a breakdown the mat will be discarded.
Important ! Discharge the electrodes after the test !
This test has to be done separately for all four mats required for a gap.

3.3 HEXCEL current measurement

Applying 2.5 kV to the upper electrode the leakage current through the HEXCEL mat is measured. If the measured current exceeds 100 nA at an air humidity of 40 %, the mat will be discarded.
Important ! Discharge the electrodes after the test !
This test has to be repeated separately for all four mats required for a gap. The tested mats are stored until insertion in a shelter.

3.4 Insertion of the HEXCEL mat into the gap test stand

A successfully tested mat will be put onto the copper plate in the gap test stand.

3.5 EST breakdown test

EST2 has to be inserted into the HV test stand. The lower electrode is connected to ground, the upper one to 3 kV. The board connections remain free (floating). Boards showing a breakdown have to be discarded.
Important ! After the test discharge the boards via the tabs! (report sheet EST).

3.6 Measurement of the EST leakage current

Apply 2.5 kV to the upper electrode and measure the leakage current through the EST2-board. Thus the impurities at the boundary of the electrodes are checked. If the leakage current exceeds 50 nA, the EST2-board has to be discarded.
Important ! After the test discharge the boards via the tabs! (report sheet EST).

3.7 EST corona test

Insert the EST2-board between two prepared HEXCEL mats. Both electrodes of the HV test device are connected to ground. A HV of 2.5 kV is applied to both sides of the EST2-boards. The measurement of the leakage current after 10 minutes has to be below 200 nA, otherwise the EST2-board has to be discarded.
Important ! After the test discharge the boards via the tabs! (report sheet EST).

3.8 Insert the EST2 in the gap test stand

The successfully tested EST2-board should be put onto the HEXCEL mat inside the gap test stand. The HV/ground tabs are connected to the corresponding connectors of the gap test stand. Then the second successfully tested HEXCEL mat is put on top.

3.9 Pad breakdown test

The Pad-board is inserted into the HV test stand. The signal tabs are grounded, the HV tabs are floating and 3 kV is applied to both electrodes. Boards showing a breakdown are discarded.
Important ! After the test discharge the boards via the tabs!(report sheet PAD).

3.10 Pad corona test

Insert the Pad-board in between two prepared and tested HEXCEL mats. Both electrodes of the HV test stand are grounded, the signal tabs are grounded as well but 2.5 kV is applied to both HRC layers of the Pad board. After ten minutes the measured leakage current has to be below 200 nA, otherwise the Pad-board is discarded.
Important ! After the test discharge the boards via the tabs! (report sheet PAD).

3.11 Insert the Pad-board into the gap test stand

The successfully tested Pad-board is put onto the second HEXCEL mat in the gap test stand. The signal tabs are grounded but the HV tabs of the HRC layers are connected with the HV-connectors of the gap test stand. Then the third successfully tested HEXCEL mat is put on top.

3.12 HV tests of EST1

All tests described above (2.5, 2.6 and 2.7) are repeated for the EST1-board as well. (report sheet EST).

3.13 Insert the EST1 into the gap test stand

A successfully tested EST1-board is put on top of the HEXCEL mat in the gap test stand. The HV/ground tabs are connected with the corresponding connectors of the gap test stand. Then the fourth successfully tested HEXCEL mat is put on top.

3.14 Insert aluminum electrode

The aluminum electrode is put on top of the last HEXCEL mat. It is connected to the ground of the HV test stand.

3.15 Preparation for the gap test

The cover of the gap test stand is closed and pumping started until a pressure of 1 mbar is reached. Then the valve for the dry air (humidity 5%) inlet is opened until pressure balance is reached.

3.16 Gap test

A HV of 2.5 kV is applied to the four connected HV-lines (EST2, PAD2, PAD1 and EST1). After 10 minutes the leakage current is measured. It has to be below 50 nA per channel. (report sheet GAP).

3.17 Preparation for the capacity measurements

The cover of the gap test stand is opened. Thus normal air comes in, the gaps are discharged. The short circuit connector of the Pad connections is replaced by the capacity-measurement connector.

3.18 Capacity measurement

Each pad is measured individually while all other pads are floating. The HV/ground tabs are floating as well. A frequency scan from 75 kHz till 30 MHz is done. The result of this measurement is compared with a reference measurement and a protocol is written. The tolerances given by the reference measurement must not be exceeded. (report sheet GAP).

3.19 Lifting the preassembled unit

The boards and the aluminum electrode are disconnected. Then the copper plate with the gap structure is lifted. Plastics guide bolts are pushed into the holes foreseen for the rods. The aluminum electrode stays on the last HEXCEL mat. The preassembled unit is moved towards the stacking table.

3.20 Rod assembly[first gap only]

The tie rods with guide protection are inserted into the copper plate which is hanging from the crane. Doing so, the plastics guide bolts are removed. Then the rods are fixed by safety screws. Steps 3.20 to 3.22 are done while the preassembled unit is hanging on the crane.

3.21 Assembly of HV-distribution [first gap only]

The HV-distribution board is mounted onto the bottom side of the copper plate. The cables with strip lines are connected to the distribution board and are fixed.

3.22 Calibration board [first gap only]

The board for the distribution of calibration signals is mounted onto the bottom side of the copper plate.

3.23 Mounting the first preassembled unit on the assembly table

The copper plate together with its gap structure and aluminum electrode are aligned on the assembly table and then deposited onto the table. The positioning is checked at the alignment bars using a 0.1 mm capton strip (nominal value 0). The HV strip lines and cables are fixed to vertical support bars. The HV-connections at the distribution board are tested by measuring the resistance with a Ohm-meter. (report sheet MOD and cabling).

3.24 Preassembly of following units

The following gaps are preassembled and tested in steps as described from step 2.1 till 2.19.

3.25 Mounting of preassembled units

The aluminum electrode is taken away from the unit which is actually on the assembly table. Thus the aluminum electrode is ready to be used for the next gap test. The ensemble consisting of a copper plate, its gap structure and the aluminum electrode are aligned on the assembly table and then deposited onto the table. The positioning is checked at the alignment bars using a 0.1 mm Kapton strip (nominal value 0). To check the alignment of the copper plate a squared rail is pushed into the existing milled plate grooves (report sheet MOD).

3.26 HV-stacking test

The next-to-last gap is tested. Deposited onto it is already the last preassembled unit. The HV-connections of the aluminum electrode are connected with the tabs of EST1, PAD1, PAD2 and EST2. The ground tabs of EST1 and EST2 as well as all signal tabs are connected to the ground of the aluminum electrode. The ground connector of the aluminum electrode is connected to the assembly table. Then a HV of 2.5 kV is applied. After 10 minutes the current of all four channels is measured. The measured current has to be below 100 nA. After the measurement all gaps are discharged and the electrodes disconnected (report sheet MOD).

3.27 Stacking of further units

All further gaps are stacked in the same way as given from step 2.25 till 2.27.

3.28 Preparation for measurements of the stack height after the 8^{th} and the 16^{th} plate

After the 8^{th} plate and after the 16^{th} plate for the front module the aluminum electrode will be dismounted and spacer tubes put onto the tie rods. The spacer tubes are mounted on top of the spacers. On their upper end they are equipped with a plate to collect any rubbed off material. Shims are put in and the nuts are fastened with the prescribed torque (report sheet MOD).

3.29 Measuring the stack height

The stack height is measured at 7 reference points next to the tie rods. A protocol will be written. If there is a difference of more then ± 0.5 mm, then for the following 8 plates spacers with higher or lower thickness (8.45 mm / 8.55 mm) have to be used respectively (report sheet MOD).

3.30 Mounting the next-to-last plate

After the 15^{th} or 23^{th} plate respectively the next-to-last copper plate is put on top without any electrode structure.

3.31 Mounting of stainless steel parts

According to the drawing stainless steel parts are mounted at the tie rods and fastened with the torque required (report sheet MOD).

3.32 Mounting the last gap

The last gap is put on top of the last copper plate and has to be tested there in place (report sheet GAP). The electrode structure is put onto the next-to-last copper plate without the last copper plate.

3.33 Mounting of the last copper plate

The last copper plate is mounted according to the drawing and fastened with the stainless steel parts to the tie rods. The aluminum electrode is put directly onto the last plate.

3.34 HV test of the last gap

The last gap has to be tested according to 2.27 (report sheet MOD).

4 Final assembly and tests

4.1 Measurement of stack height and plate displacement

The actual stack height is measured at 7 reference points. It is compared with the nominal value and the result is logged. The plate displacement is measured at the alignment bars. The measurement is logged for later selection of shimming plates.

4.2 Removal of alignment bars

The alignment bars are being removed.

4.3 Preparation of thread rolling screws

The thread of the (gold plated) thread rolling screws is sprayed with Teflon spray in a suitable facility (only the thread!).

4.4 Assembly of HV-striplines

The HV-striplines are mounted and the connection to the Pad- and EST-boards is made (report sheet cabling).

4.5 Assembly of the PSB support plate

The PSB support plate is fixed to the module at the outer radius.

4.6 Signal cabling

Striplines with signal cables are attached to the module starting at the inner radius (report sheet cabling).

4.7 Calibration cabling

Calibration cables are mounted up to the PSB support plate. Cables with different length are then rolled up (report sheet cabling).

4.8 Capacity measurement of signal cables

The signal cables are connected via the signal input connectors with the capacity measurement device. Then the capacity of the cables is measured (report sheet cabling).

4.9 Contacting Pads

The signal tabs are connected to the stripline connector.

4.10 Test of signal cabling

For each channel the capacity of the pads including cabling is measured. The result is compared with individual measurements (pad/cabling). This is necessary to make sure that all pads are properly connected (report sheet cabling).

4.11 Assembly of PSB boards

The PSB-boards are mounted onto the support plate.

4.12 Mounting of short circuit connectors

In preparation of the HV long term test, short circuit connectors are mounted on the signal input connectors.

4.13 Assembly of the outer module connecting bar

The module connecting bar is screwed on the left hand side seen from the interaction point. The mounting is done with different shimming plates based on the information from plate displacement measurements. Threads of the screw bolts are sprayed with Teflon spray (report sheet MOD).

4.14 Mounting of dust protection

The module is covered by a plastic cover as protection against dust.

4.15 Assembly of the lifting bar

The lifting bar is mounted onto the last copper plate and fastened with bolts according to the drawing.

4.16 Displacement of the module into the long term test zone

The module is displaced together with the assembly table into a long time test zone.

4.17 HV long time test

For the HV-test 2 kV are applied to the 8 HV input connectors of the rear and 12 HV input connectors of the front module respectively. The leakage current is measured during two weeks, and the leakage currents logged (report sheet MOD).

4.18 Mounting of the signal input connector

The short circuit connectors are removed and the signal input connectors are screwed onto the PSB boards.

4.19 Packing cover for transportation

For protection during the transport the module is covered by an additional plastic cover.

4.20 Removing of the module

The module will be removed from the clean room and lifted from the assembly table using a crane.

4.21 Further cabling work at the bottom side of the module

Cable fixations are mounted at the bottom side of the first plate. Then the calibration cables are connected with the distribution board.

4.22 Assembly of the transportation frame

The module is put onto the transportation frame and bolted to the frame.

4.23 Packing of the module

The module is put into the transportation box. Now it is ready for shipping to CERN.

References

[1] M. Rosvick, ATLAS Hadronic Endcap Calorimeter Quality Control Specifications, HEC-Note-060

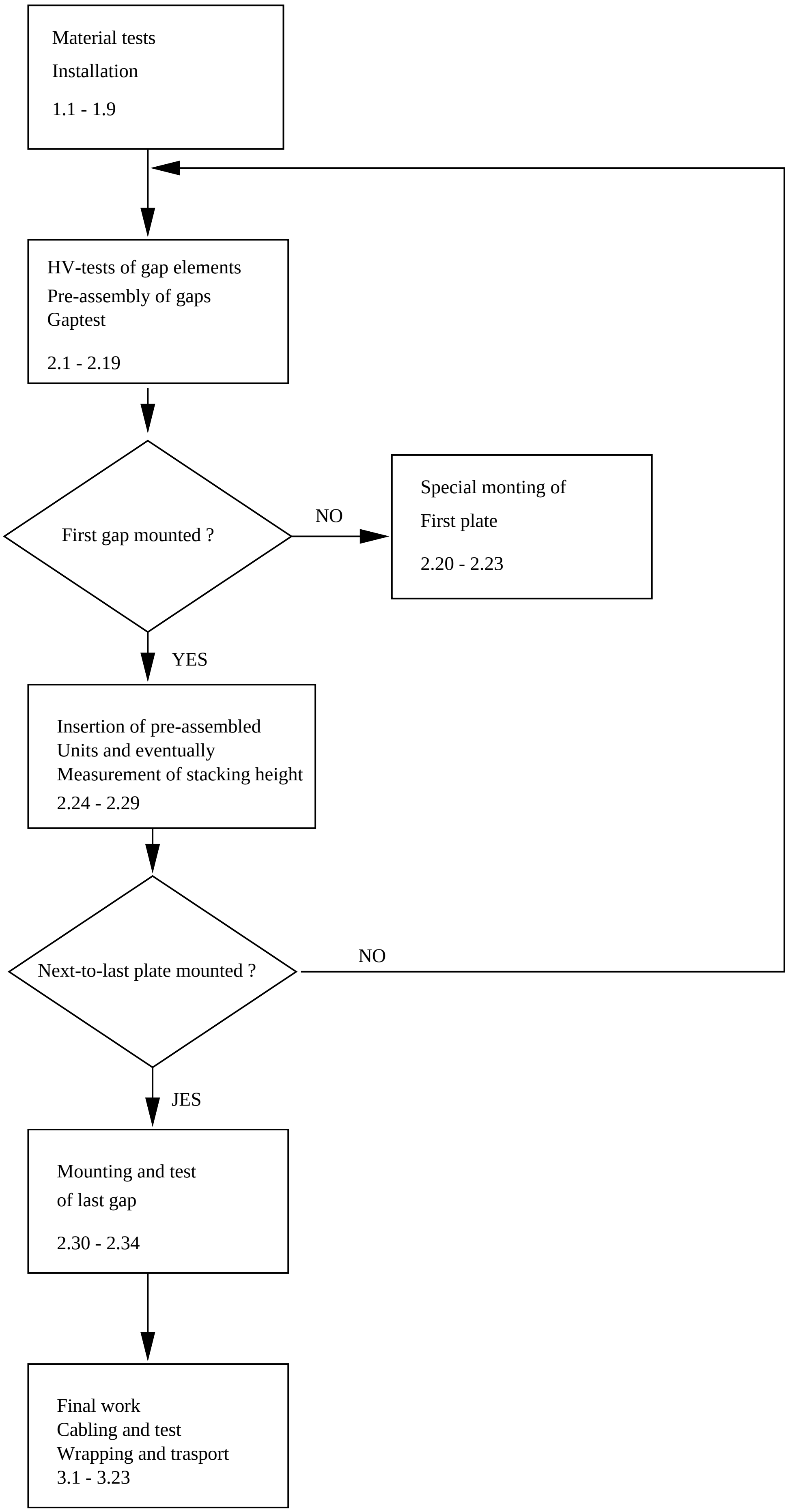

Figure 1: Schematic work flow diagram.