Base Load Power Hub (BLPH)

FACTORY ACCEPTANCE TEST PROCEDURE

HV Switchgear

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1 APPLICABILITY AND RESPONSIBILITY

These Job Instructions describe the testing procedures applicable to 6.6 kV Main Electric Switchboard manufactured by IMESA, in accordance with Regulations **IEC 62271-200**.

The Head of Quality Control (CQ) or his collaborators (see list of IMESA qualified testers) are responsible for ensuring the proper implementation of the following Job Instructions.

The tests described on this document will be executed at IMESA factory.

2 GENERAL INFORMATION

The switchboard will be placed in a separated area to which access is allowed only to authorised personnel; it should not be possible to isolate the switchboard, the area will be marked off by means of barriers, notices, visible and flashing barriers.

The tester will use the following standards, drawings (switchboard front, overall dimensions, schematic diagrams, etc.) and specifications, as reference:

Applicable standards:

- IEC 62271-200 HV Switchboard
- IEC 62271-100 Circuit breaker
- IEC 62271-102 Earthing switch
- IEC 61869-2 CTs
- IEC 61869-3 VTs
- IEC 60529 Degree of protection

Reference Contractor Documents:

- 123A90-DDL-EL-SP-20019 / Technical Specification, IDS and DDS for 6.6kV Switchgear
- 123A90-DDL-EL-DS-20020/ Technical Data Sheet (TDS) for 6.6kV Switchgear

Applicable IMESA Documents:

Document ID	Title
1723002197-EL-DA-00006	SG-100D1 GENERAL ARRANGEMENTS DWG AND FOUNDATION LOAD CALCULATION INCLUDING COG
1723002197-EL-DG-00010	SG-100D1 ELECTRICAL SINGLE LINE DIAGRAM
1723002197-EL-DG-00015	SG-100D1 MV SWG FUNCTIONAL DIAGRAM - INCOMING FEEDER (including Terminals and BOM)
1723002197-EL-DG-00016	SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BUS BAR METERING (including Terminals and BOM)
1723002197-EL-DG-00017	SG-100D1 MV SWG FUNCTIONAL DIAGRAM - BESS FEEDER (including Terminals and BOM)
1723002197-EL-DG-00018	SG-100D1 MV SWG FUNCTIONAL DIAGRAM - ELECTROLYSER FEEDER (including Terminals and BOM)
1723002197-EL-DG-00019	SG-100D1 MV SWG FUNCTIONAL DIAGRAM - FUEL CELL FEEDER (including Terminals and BOM)
1723002197-EL-DG-00020	SG-100D1 MV SWG FUNCTIONAL DIAGRAM - TRANSFORMER TR200ED1 (including Terminals and BOM)
1723002197-EL-DG-00021	SG-100D1 MV SWG FUNCTIONAL DIAGRAM – TRANSFORMER TR200DE1 (including Terminals and BOM)
1723002197-EL-DG-00022	SG-100D1 MV SWG INTERCONNECTING AND AUX DISTRIBUTION DIAGRAM (including BOM)
1723002197-EL-DG-00023	SG-100D1 MV SWG LOGIC DIAGRAM - INCOMING FEEDER
1723002197-EL-DG-00025	SG-100D1 MV SWG LOGIC DIAGRAM - BESS FEEDER
1723002197-EL-DG-00026	SG-100D1 MV SWG LOGIC DIAGRAM - ELECTROLYSER FEEDER
1723002197-EL-DG-00027	SG-100D1 MV SWG LOGIC DIAGRAM - FUEL CELL FEEDER
1723002197-EL-DG-00028	SG-100D1 MV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200ED1
1723002197-EL-DG-00029	SG-100D1 MV SWG LOGIC DIAGRAM - TRANSFORMER FEEDER TR200DE1
1723002197-COM-LIS-00052	SPARE PART INDEX REGISTER (COMMISSIONING AND OPERATION)
1723002197-EL-LIS-00053	SPECIAL TOOLS LIST
1723002197-QC-PRO-00055 1723002197-MAT-PRO-00004	PACKING, SHIPPING, HANDLING AND STORAGE PROCEDURES MV-LV SWG PAINTING PROCEDURE
1723002197-QC-ITP-00002	INSPECTION AND TEST PLAN - MV Switchgear

3 DESIGN, VISUAL AND MECHANICAL CHECK

3.1 Design, Visual and mechanical check

1. Check the structural dimensions with respect to those shown by the assembly drawings of the different units.
2. Check that there are no bends and that the sheet plate is perfectly flat
3. Check that assembly has been carried out correctly and that the doors are earthed.
4. Check that ducts have been provided for the auxiliary cables as shown by the foundation drawings.
5. Check the coating or plating If the bus-bars are plated (silver plating, resin coating etc).
6. Check that the Main Equipment has been positioned correctly as per the Mimic Diagrams and Switchboard Front View drawing.
7. Check that the equipment is securely fixed.
8. Check that the equipment is properly earthed, wherever appropriate.
9. Check the equipment for eventual damage caused during assembly.
10. Equipment characteristic and rated data checking
11. Check that the paint colour complies with that indicated on the assembly list and that is has not been damaged during assembly.
12. Check the thickness of the paint by an appropriate instrument insuring that the thickness corresponds to one in specification.
13. Check the required internal form of segregation
14. Equipment accessibility and removability checking
15. Check of nameplate and label legend
16. Bus bar creepage and clearance distances check (phase-earth min 60mm / phase-phase min 90mm)
17. Checking of steel thickness (20/10), steel structure work, welding (if any), sheet metal, lifting tool.

3.2 Mechanical structural tests

1. Check that the circuit-breakers can be plugged in and drawn out correctly and possible mechanical interlocking.
2. Check that mechanical locks to prevent the insertion into the unit of similar circuit breakers with rated current inferior to that of the compartment, have been fitted on the mobile section of the circuit breaker and on the fixed section of the unit.
3. Wherever appropriate, check the operating efficiency of the limit switches for racked-in and isolated circuit breaker. To carry out the check, electrically test the switching of the auxiliary contacts both with the circuit-breaker drawn out and the circuit breaker plugged in.
4. Check the operating efficiency of the signalling auxiliary contacts of the open – closed circuit breaker. The check consists of electrically testing the switching of the auxiliary contact both with the circuit breaker in open and closed position.

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5. Check the operating efficiency of the mechanical lock that prevents the manual or electrical closing of the circuit breaker when it is positioned between the plugged in and drawn out positions with the door open. To carry out the check, attempt to close the circuit breaker rack manually and electrically when the circuit breaker is more or less in the plugged in position (or in the case of a HV switchboard, with the door of the box is slightly open).
6. Check the operating efficiency of the key locks and ring the keys if necessary.
7. Check the operating efficiency of all the mechanical interlocks between the circuit-breakers, disconnecting switches and earthing switches.
8. Carry out a number of starting up and stopping sequences as indicated by the table referring to the cell.
9. Check the functional efficiency of the key locks and perform the key ringing when required
10. Check the operating efficiency of all mechanical interlocks between the circuit-breakers, disconnecting switches and earthing switches.
11. Carry out a number of starting up and stopping sequences as indicated by the table referring to the cell.
12. Connections resistor measurement by Voltage Drop Test

3.3 Checking the degree of protection

Check that the degree of protection of the Electrical Switchboards complies with the Order Specifications of the Customer and CEI EN 60529 regulation (Classifications of degrees of protection provided by enclosures for electrical equipment).

3.4 Checking the cabling

1. Check that the information shown on the switchgear nameplates complies with the project data.
2. Check that the cables and equipment have been correctly marked and tagged whit what is reported on the functional diagrams.
3. Check the section of the bars/cables, as provided by project for the power of switch/utilities.
4. Check that the connections on the main circuits are securely tightened (ensuring that the signs on the bolts are correctly marked, where applicable).

Bus bar tightness check

The table below shows the torque wrench settings to use for the nuts and screws for fixing and connecting the compartments and the busbar. (Tolerance 0 % + 20 %)

Screws	M6	M8	MI0	M12	M14	M16
Wrench setting (Nm) -Min	8	19	40	68	100	160
Wrench setting (Nm) -Nominmal	9	22	45	75	115	185
Wrench setting (Nm) -Max	10	25	50	83	130	200

Current Transformers tightness check:

Screw	Max. torque [Nm]	Min. torque [Nm]
M5	3.5	2.8
M6	4	3
M8	20	16
M10	20	16
M12	70	56

5. Check that the cables and wires comply with requirements (marine cable SH-W, etc.) and the nominal voltage U_0/U.
6. Check that all the wires are installed in suitable ducts or have been grouped in bunches placed so that they do not interfere with moving components or cut the insulating sheath.
7. Carry out sample checks on the cable terminations to ensure that they are properly crimped and marked as shown by the relevant diagram.
8. Check that the terminal boards have been correctly positioned and marked and that the terminal is suited to the required function.
9. Check the terminal board connection to the adjacent units ensuring that it has been marked as shown by the Functional Diagrams and that the terminals and jumpers comply with the schematics.
10. Carry out all the checks indicated by point 4 on terminal boards supplied by the Customer and check that all the contacts requested by the Customer have been cabled (e.g. auxiliary relay contacts, protection relay contacts etc.).

4 Electrical and Functional Test

4.1 Functional Test

These tests consist of checking the operating efficiency of all the electric and electromechanical circuits, as shown by the diagrams, by simulating as far as possible different operating conditions. In the case of the **HV** switchboards, the cells must be placed in service position.

1. Check the supply and closing circuit of the spring charging geared motor as follows: set the supply voltage of the circuit to Vn and check the operating efficiency of the spring charging geared motor. With the supply voltage on Vn, place the unit on local operating mode and check compliance of the remote control and lock circuits with the Operating Diagram of the unit. The remote control function must also be simulated by activating on the output terminal boards.
2. Check the opening circuit as follows: set the supply voltage of the circuit on Vn and check the opening circuit of the circuit breaker in the following conditions:

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- **Local**: the circuit breaker must open when the relevant pushbutton or controller is pressed or activated.
- **Remote**: simulate remote operation by activating the relevant output terminal boards.

3. Check the closing circuit as follows: set the supply voltage of the circuit on Vn and check the opening circuit of the circuit breaker in the following conditions:
   - **Local**: the circuit breaker must close when the relevant pushbutton or controller is pressed or activated.
   - **Remote**: simulate remote operation by activating the relevant output terminal boards.
4. Check the signalling circuits as follows:
   - check the operating efficiency of the optical signals on the unit and ensure that they comply with the Operating Diagram;
   - check that the remote signalling circuits on the output terminal boards are suitable.
5. Check that all the logics shown by the diagrams have been complied with and are efficient both in local and remote by simulating electrical commands or locks from the exterior (it depends on the operating philosophy shown on functional and logic diagrams)
   - Check the closing and opening commands in local and remote.
   - Check the intertrip and interlock signals operating.
   - Check the HW remote alarm operating.
   - Check the operating of auxiliary devices.
   - Electrical functional tests on typical single unit including I/O.

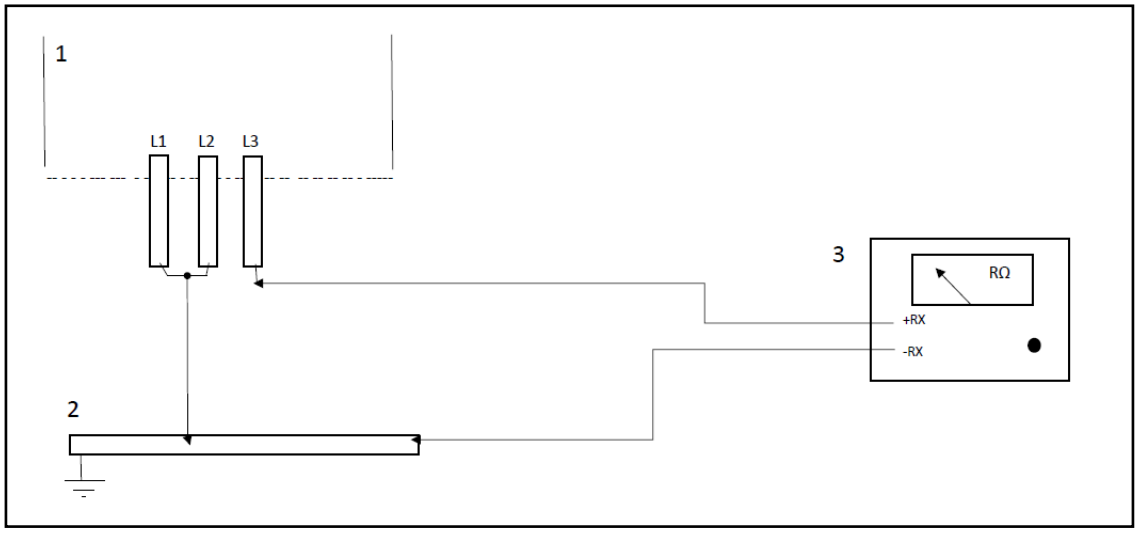
   For the above Tests, please take as reference the Functional and Logis schematic diagrams
6. Measurement of the resistance on the main circuits.
   (100% verification already done my IMESA before FAT. IMESA report can be provided.

   The test is carried out by applying a voltage of 5000 Vdc for 10" between the power circuits (in sequence L1, L2, L3) and ground.
   This Test is carried out to detect the Insulation resistance before and after the test described at item 4.3 (Hi-Pot Test)

   Acceptance Criteria:
   The insulation resistance (based on the cubicles tested) is greater than 10MΩ and the megger does not give an earth fault.

   Resistance Insulation Test on Power Circuit - HV Switchboard Lay-Out
   HV Switchboard Busbar
   Ground Reference
   Megger (-Rx shall be connected with the ground)

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Test lay-out for L1 phase Example

Carrying out the test
Reading of the insulation resistance with a “MEGGER” on the following points:
between phase L1 and the phases L2 and L3 connected to earth (-Rx of instrument);
between phase L2 and the phases L1 and L3 connected to earth (-Rx of instrument);
between phase L3 and the phases L1 and L2 connected to earth (-Rx of instrument).

7. Check the amperometric circuits as follows: apply a primary or secondary current and check the operating efficiency of the current transformers, ammeter, protection relays.
   (100% verification already done my IMESA before FAT. IMESA report can be provided.)
8. Check the voltmeter circuits as follows: applying primary power, check the operating efficiency of the voltmetrical transformers and the protection relays.
9. Check CT Polarity, physical marking of P1, P2 and S1, S2. Through the galvanometer, with the connection cables, connected to primary and secondary terminals of the current transformer, the instrument will indicate if the polarity is "according to" "or" discording "
   (100% verification already done my IMESA before FAT)
10. Check of anti-condensation resistance by means power supply. Check the operating efficiency of thermostat and anti-condensation resistance.
11. Check of the protection relay by means of secondary current/voltage injection to verify some trip functions

These tests consist of checking the operating efficiency of the electrical protective relays, by means of secondary current injection and secondary voltage supply, in terms of:

measurements delivered by the in-built instruments,

tripping of the relevant protection functions, in accordance with the settings defined in the Selectivity Analysis, proper activation of digital output contacts and optical signals (LED).

4.2 VOID

4.3 Power Frequency Test and measurement of Insulation resistance

The dielectric tests are carried out to check the insulation distances, the soundness of the insulating materials and that the connections have been made correctly.

Remember to disconnect all current absorbing equipment which would be damaged by the application of voltage (coils, metering instruments, differential circuit breakers etc). A voltage generator at industrial frequency is used to carry out this test.

On agreement between builder and user, operating frequency voltage test, it can be repeated after installation on site; in this case the test voltage shall be equal to 80% the value shown in the table below (CEI EN 62271-200):

Rated Voltage Efficacy Value (kV)	Test Voltage Efficacy Value (kV)
3,6	10
7,2	20
12	28
17,5	38
24	50
36	70

Voltage is applied for 60” for each configuration.

In the presence of CTs, they must be short-circuited and the switches closed.

During this time one operator check the activation of voltage indicator of relevant phase

Main busbars will be fully installed, and all MV circuit breakers will be closed and connected.

Carrying out the test

To run the test proceed as described:

- Connect to ground the control desk, the VT truck, the foil, the equipment under test;
- Limit the test patch with appropriate barriers;

- Connect the HV pole of VT to the object or to a phase of the electrical panel in test, with the other two phases grounded.
- Connect from table with special cables the lights flashing, the TV and the power plug of the same.
- The operator, before starting the test, must ensure that nobody is within the hurdles.
- Close the main switch of the instrument and work slowly on the rheostat knob until you reach the test voltage read on the voltmeter. (**N.B.** if the rheostat knob is in position zero, the circuit in not closed)

Acceptance Criteria:

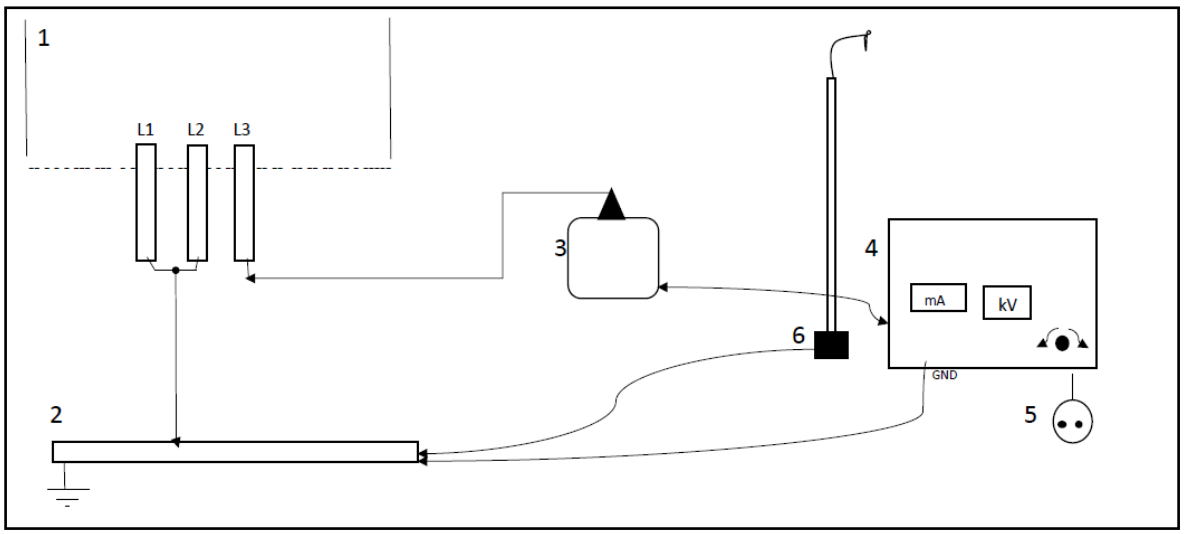
The test is passed if for a minute there is no shock.

Imesa consider valid the test if the control desk doesn't detect any fault, this shall consider valid also in case if some discharge can be hearded during the test

- After the test or if there has been a download, return to zero the rheostat, unload with the foil, the pole of VT. In these conditions you can approach the device under test.
- Apply to the other two phases the voltage required by repeating the steps described above for each phase.
- All voltage indicator lamps working properly

HI-Pot Test Lay-Out

1) HV Switchboard Busbar
2) Ground Reference
3) Step-up Transformer
4) Hi-Pot Tester
5) Power supply
6) Ground stick



Test lay-out for L1 phase Example

Carrying out the test

- between phase L1 and the phases L2 and L3 connected to earth;
- between phase L2 and the phases L1 and L3 connected to earth;
- between phase L3 and the phases L1 and L2 connected to earth.

During the Test a Tester has to check that the indication voltage presence of the main circuit is light on

Between to adjust the circuit for a new test it is necessary to discharge to system by Ground Stick

After the dielectric Test on each phase, item 6 has been repeated the value detected will be mentioned on the FAT Report.

4.4 Dielectric test on auxiliary circuit and Insulation resistance measurement

Testing of voltage applied between the auxiliary and control circuits and mass, 1.5kV for 1 min according to RINA rules.

Insulation resistance through Megger device to be checked before and after the here below dielectric Test.

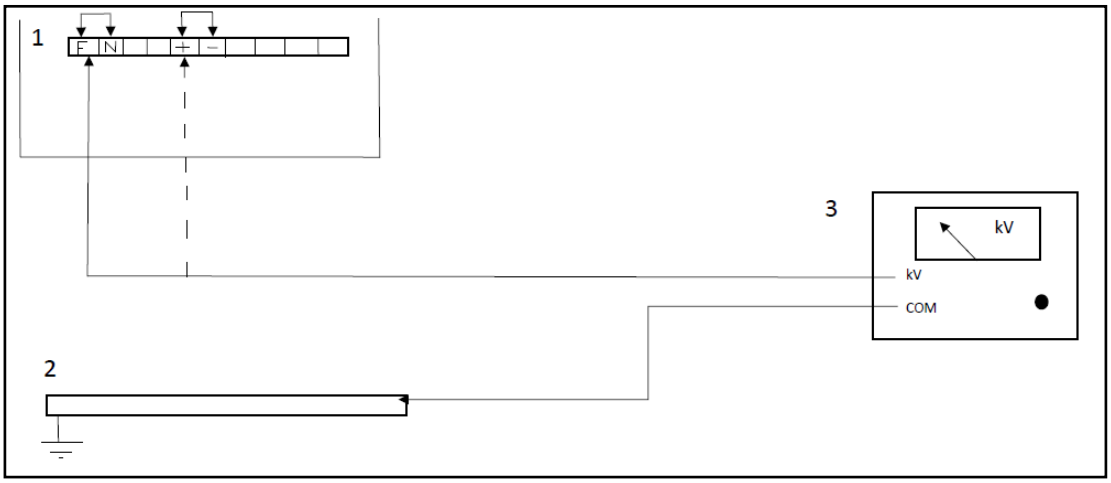
The values detected before and after will be reported in the Test Report.

Acceptance Criteria:

The test is passed if for a minute there is no shock detected by the Test Banch.

Resistance Insulation Test on Aux Circuit HV Switchboard Lay-Out

1) HV Switchboard Busbar
2) Ground Reference
3) Megger (-Rx shall be connected with the ground)



4.4 Applied voltage test on the auxiliary and control circuits

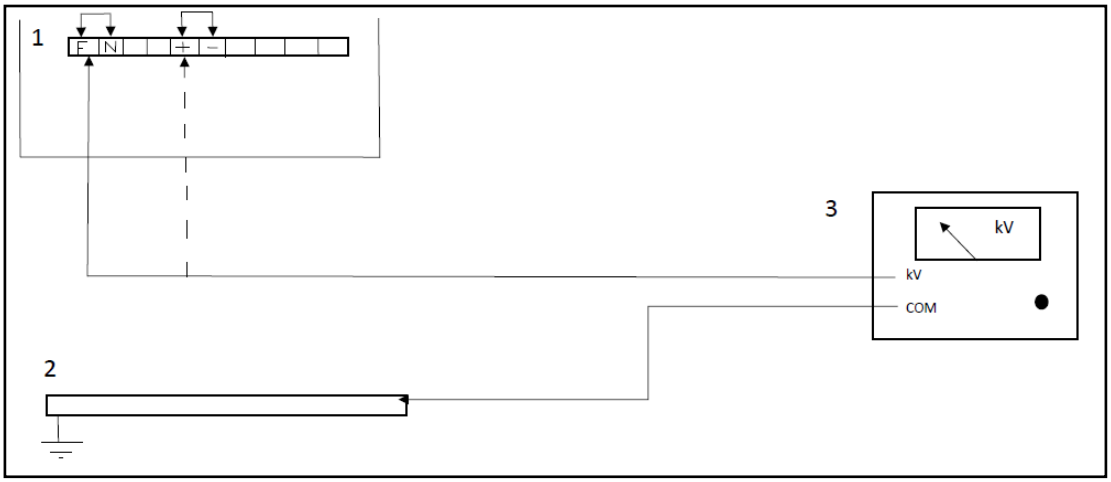
Testing of voltage applied between the auxiliary and control circuits and mass, applying a voltage of 2 kV for 60 seconds (CEI EN 62271-1)

Acceptance Criteria:

The test is passed if for a minute there is no shock detected by the Test Banch.

Resistance Insulation Test on Aux Circuit HV Switchboard Lay-Out

1) HV Switchboard Busbar
2) Ground Reference
3) Megger (-Rx shall be connected with the ground)



Test lay-out for L1 phase Example

After the dielectric Test on each phase, item 4.4 has been repeated the value detected will be mentioned on the FAT Report.

4.5 Checking the continuity of the protection circuit

The purpose of this check is to ensure that the protection circuit has been installed correctly and is carried out with both a visual examination (check that rough contact washers have been fitted) and an electrical test (resistor less than 0,1Ω).
With the multitest instrument we use a measure system with no.4 wires. Switchboard is split into no.2 parts and the measure of the continuity of the protection circuit is carried out as follows:
RPE connectors red and reference black are connected to the earth main busbar in the rear section of the switchboard. To close the circuit others RPE red and reference black connectors are connected to the earthing strap on the auxiliary front door on the opposite side of the first red connector on main earth busbar.
An injection of 25A ac is carried out for 3 sec, and the resistance of the circuit is measured.
Test is considered accepted if the resistance is less than 0,1Ω.

4.6 Drop voltage on main busbar

The drop voltage is performed to check the busbar connections, and is carried out with nr. 2 tests.

First test is carried out as follows:
A current generator 100A dc is connected between the vertical busbar near the upper pole of the circuit breaker and cable connection with main circuit breaker closed and connected. The test is carried out for each phase.
With a digital multimeter the value of the drop voltage is measured in mV.
Consequently it is calculated the value of the contact resistance in microΩ.
Acceptance criteria:
The test is considered accepted if the value of the contact resistance does not deviate each other more than 30%.

Second test is carried out as follows:
A current generator 100A dc is connected between the begin and the end of horizontal main busbar. The test is carried out for each phase.
With a digital multimeter the value of the drop voltage is measured in mV.
Consequently it is calculated the value of the contact resistance in microΩ.
Acceptance criteria:
The test is considered accepted if the value of the contact resistance does not deviate each other more than 30%.

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4.7 External Auxiliary Power Supply

Redundancy Test of Incoming supply Lines (110Vdc)

Since there are n.2 incoming line for 110Vdc, the test consists of disconnecting one line at a time verifying that all units continue to be supplied without any unexpected switchgear malfunction.

4.8 Check electric arc

Electric arc on busbar compartment, switch compartment and cable compartment

Trial set:

- Connect the test bench with amperometric terminal blocks for secondary current injection.
- Check flash setting (maximum output)

Test procedure:

- Turn on and close the switches of the users involved.
- Carry out the flash test in the absence of power, in the compartment concerned, checking the correct opening of the "light only" trip switches according to the project specifications.
- Close the switches of the users involved.
- Inject the current onto an amperometric input of the protection relay, with a value higher than the threshold limits and check that the relays acquire this value.
- Carry out the flash test in the compartment concerned, checking the correct opening of the "light and power" trip switches according to the project specifications.
- Repeat the tests alternating the amperometric inputs of the three-phase protection relay.

Acceptance Criteria:

• The incoming and bus-tie circuit breakers must open and the blocking relay must be activated, depending on the design specifications.

4.9 Integrate Test with EMS

(This test will not be held with HV switchgear FAT since it is not in charge of IMESA)

5 Final checks

Once all the tests have been carried out on the different units, before sending the switchboard to the packaging department, the following checks must be carried out:

1. Check that all the jumpers used for the electrical tests of the different circuits have been removed from the terminal boards and the equipment.
2. Clean all the equipment in the unit.
3. Touch up the paintwork if necessary.
4. Check that the foundation bars comply precisely with the drawings.
5. Compile the "Mod. CAR/CAB 04 bill of material for shipment" with an indication of the material to be shipped loose, including material required for installation of the units.
6. Make out the list of missing materials (this list should include materials which are missing because found to be faulty during testing and the equipment to be installed by the Customer).
7. Check that the Manufacturer's data plate showing the characteristics of the switchboard has been fitted.
8. Insert the maintenance manual of the framework
9. CQ deals with the issue the test report and sees to its storage.
10. Check the commissioning spare parts, if any.

N.B In case of acceptance by the customer, it's up to present PM inform RP which involves the planning of production and make it aware of CAB and CQ; PM also defines the exact date that he agreed with the customer and informs the affected functions.

At the end of the test, customer must sign the test report.

6 TEST EQUIPMENT

The following test equipment will be used to carry out the above tests:

- Universal power supply for the auxiliary circuits,

- Amperometric power supply for the primary and secondary currents,

- Instrument for the applied voltage test at industrial frequency of the main circuit,

- Instrument for the applied voltage test of the auxiliary and control circuits,

- Digital thickness gauge

7 CARRYING OUT THE TESTING ACTIVITIES

The testing activities must be carried out in compliance with the safety requirements of the current regulation by restricting the test area with the special hurdles.

The testing activities must be carried out exclusively by personnel who have received training under the CEI 11-27 anyway the operators must always be at least two.

If testing is manned by customer (or by those third parties designated by it), this is absolutely not permitted to carry out maneuvers on the switch and are not allowed to stay alone at the IMESA plant.

All electrical parts must be banned from all contact and the area should be well lit and free from hindrances and obstacles.

Operators must be equipment with suitable DPI and certified equipment under current regulations.

During testing must always be at least one first aid worker who has received its education.

When testing the dielectric properties (applied voltage test), remember to wear insulated gloves and shoes with retractable toe caps as well as suitable protection clothing covering body and arms. If the test is suspended even temporarily, the test instrument must be disconnected from the mains.

8 ANNEX

- See Annex 1 (Fac-simile Test Report)
- See Annex 2 (Checklist)