

Technical Standard

Date January 18, 2022

Ref. No MEIA0016

Page 1 (29)

Mondi AG.
Mondi Standard Harmonization

IMPLEMENTATION PROCEDURE FOR ELECTRIFICATION, AUTOMATION AND INSTRUMENTATION CHECKOUTS AND COLD COMMISSIONING

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Distribution Mondi, AFRY

Orig.	18.01.2022 / SKO & KRa, AFRY	18.01.2022 / EP, AFRY	18.01.2022 / LCa, AFRY	18.01.2022 / LCa, AFRY	Original issue
Rev.	Date/Author	Date/Checked	Date/Approved	Date/Issued	Notes

ABBREVIATIONS

AC	Alternative Current
ARP	Address Resolution Protocol
DCP	Discovery and Basic Configuration Protocol
DCS	Distributed Control System
e.g.	exempli gratia, for example
E2E	end-to-end
EN	European Standard
EU	European Union
FAT	Factory Acceptance Test
HSA	Highest Station Address
IEC	International Electrotechnical Commission
IO	Input/Output
IP	Internet Protocol
LV	Low Voltage
MBP	Manchester Bus Powered
MCB	Miniature Circuit Breaker
MCC	Motor Control Center
MRP	Media Redundancy Protocol
NEXT, PS NEXT	Near End Crosstalk, Power Sum NEXT
OT	Operational Technology
PN	PROFINET
SAT	Site Acceptance Test
SM	Singlemode
TCL	Transverse Conversion Loss
UPS	Uninterruptible Power Supply
VAC	Voltage Alternating Current
VFD	Variable Frequency Drive

1 GENERAL

Activities performed on the construction site after the erection, but before the start-up, are called commissioning. The intention with the commissioning is to enable the start-up of the production units with a minimum of problems depending on mechanical, electrical or process control technical weaknesses as well as lacks in the delivery or in the installation. The commissioning is done as soon as possible after the erection inspection.

Electrification, automation and instrumentation check-out and commissioning consists of;

- complete loop tests including DCS functions
- taking loops into operation
- preliminary tuning of instrument loops
- MCC commissioning and check-out
- check-out of Motor Circuits and Feeders
- functional Check-out of electrical circuits
- rotating test of motors

Definitions:

Pre-check-out/erection check out is visual inspection which consists checking that all installation work is carried out according to the drawings, cables are correctly connected and all devices and cables have been marked. Pre-check-out/erection check out is part of instrumentation/electrical installation.

Field Instrument Testing means that the entire instrument loop is examined so that there is confidences that it functions properly and can be taken into operation.

Taking into operation involves completing the instrument loops into a faultless well-functioning system.

Tuning means rough adjustment of the instrument calibrations, controller parameters, alarm limits, interlocking limits and process time delays.

Commissioning is the activities after the installation phase and includes checking of signal connections, functional tests, rotation direction check for motors and water test runs.

Testing the control system is the responsibility of the control system supplier. The control system supplier shall ensure that it constitutes a well-functioning system in accordance with the configuration data. All preconditions for control system including corrections and changes pointed out during FAT-tests and also all control system internal set up issues etc. should be completed before field testing work can start.

1.1 Codes and Regulations

The equipment and installation shall comply with the following standards, regulations and instructions:

- Local authorities' regulations and recommendations
- Laws and regulations currently in force in the current country

- EU norms and directives
- Project instructions
- Mill instructions
- Mondi OT Security Policy
- IEC recommendations

1.2 References

EN 50346	Information technology - Cabling installation - Testing of installed cabling
IEC 61280-4-1	Fibre-optic communication subsystem test procedures - Part 4-1: Installed cabling plant - Multimode attenuation measurement

2 SAFETY

All work done during the check-out and commissioning must be carried out according to the applicable safety instructions and regulations. All personnel taking part in the works must attend the safety training and safety coordination meeting before starting the work.

The power connection to cubicles and systems will always be done after permission from the Purchaser. Switching on and off the power can be done only with permission by the responsible dedicated person.

During commissioning phase Purchaser lock out/tag out procedure must be used by all the parties.

3 ORGANISATION

The organisation for commissioning and start-up shall be named at an early stage. This team is led by the Purchaser's **Commissioning and Start-up Manager**, and manned with operating and maintenance personnel, and if required, with Suppliers, Contractors and Consultants.

The **Start-up Manager** and the **Commissioning Manager** decide the work order (based to the test system (water running) time schedule), manage the resources, co-ordinate the work of all parties and follow up the Commissioning Time Schedule.

The erection organisation, possibly with minimised personnel, shall co-operate with the commissioning organisation to correct any defects noticed and to carry out approved changes and completions, and assist the commissioning team with necessary installation services such as opening and closing of couplings and guards etc.

During testing period, DCS Operation stations are located e.g. in the electrical and rack rooms. Test group member who working on the operation station, keeping contact to site tester via walkie-talkie (preferably) or via other reasonable communication system. He/She will mark tested loops to loop or circuit diagrams by colour and date / signature. Also tested equipment will be marked to the test list.

Test documents (loop diagrams and wiring diagrams) are printed on yellow paper, which tells everyone that these documents are for testing purposes only.

The headquarter for the co-ordination and follow-up of the commissioning and later in the start-up will be established in the main administration building, where information is gathered daily and decisions of following work operations are made. Daily short meetings are held, chaired by the **Commissioning Manager**. An ideal meeting lasts about half an hour. As with all meetings, this is a forum of reports, while problems are solved in smaller groups of specialists case by case.

There are exceptions to these general rules. In many package or turn-key deliveries (like Quality System deliveries) the Supplier is responsible for the installation, commissioning and start-up until the hand-over. In these particular cases the Purchaser's duties are limited to the functioning of the service systems (electrical power, mill air, various waters etc.). It is, however, in the interests of the mill to have its own specialists as observers in the commissioning crews of these Suppliers.

The operators get a good training both in operating the plant and in finding the units in the department. The Functional Test Run (Water Run) should therefore be scheduled so that all shifts can participate.

4 REPORTING

4.1 Instrumentation, Automation and Electrical Follow-up

Daily check-out progress will be followed by web-based software or e.g. Excel forms, depends on agreement with Purchaser.

Installation and test order following the water run time schedule. Installation contractor will inform check-out team about equipment which are ready for test.

Example of reporting Excel forms:

- Profinet: Appendix 1
- Profibus DP: Appendix II
- Profibus PA: Appendix III
- Instrumentation: Appendix V
- Electrical: Appendix VI

Example of installation – check-out progress, figure 1.

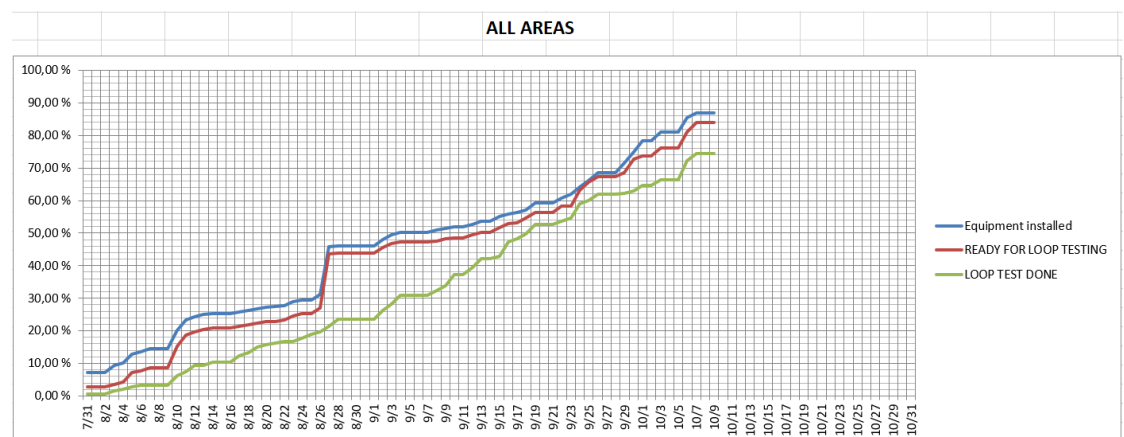


Figure 1

4.2 Master Commissioning Book

To follow the progress of the Commissioning there is Master Commissioning Book for Check-out and commissioning which shall show the actual status of the commissioning. The **Master Commissioning book** can be a web-based software, Excel forms or traditional folder with paper forms on the control room desk or other agreed place.

The process unit is ready for the Functional Test Run (Water Run) from the mechanical point of view, when mechanical check-out team is done and the Purchaser's Mechanical Check-Out Leader or his representative have signed in the Master Commissioning Book.

The Automation Check-out Leader and his team shall do the Loop check-out according to chapter 8. When the checks have been done he/she or his/her representative shall sign in the Master Commissioning Book.

The Electrical Check-out Leader and his team shall do the Loop check-out according to chapter 9. When the checks have been done he/she or his/her representative shall sign in the Master Commissioning Book.

5 DOCUMENT UP-DATING

Any found error or corrected faults in the documentation must be marked to the master loop and circuit diagrams and other necessary document (yellow copies) located in the electrical or rack rooms. The mark-ups must be done immediately when found and they must be clearly made, so that "as-built" drawings can be completed without any uncertainty. The tested field equipment will be marked with green highlight with date and tester signature.

All necessary notes or instructions which may help the future operation or maintenance of the Purchaser shall also be written in the master documents.

6 PROGRAM CHANGES

In a normal case there is no need to change the programming of the control system during the field check-out, because the programmes have been tested during FAT and found to be functioning correctly. Should there however be reason to change the programming; instructions in practice have to be agreed between the group members as straight forward and flexible as possible.

7 FIELDBUS TESTING

7.1 Warnings



The light beam, which is emitted by fibre optic repeaters (optical/electrical converters) could endanger your eyesight. Do never look directly into the aperture of the optical transmitter or optical fibre.

7.2 General

Fieldbus Site Acceptance Test (SAT) has the following steps:

1. Installation inspection
2. Testing of cabling

3. Fieldbus commissioning

They are slightly different for PROFINET, Profibus DP and Profibus PA. More detailed instructions are described in chapters 7.3, 7.4 and 7.5.

Test reports shall be made of all tests, see Appendices I, II and III.

Suppliers having parts of field buses in their delivery (i.e. copper segments), shall follow these instructions when applicable.

7.3 PROFINET

7.3.1 Installation Inspection

Installation inspection is part of the installation works and shall be made before the PROFINET commissioning can commence.

Visual inspection of the PROFINET cabling should always be carried out before other tests are started. Visual inspection will verify that the installation has been carried out according to cabling guidelines.

The following shall be inspected:

- Cable condition
- Cable bending radius
- Spacing between cables
- Cable ties
- Connectors, number of connectors per end-to-end (E2E) links
- Grounding of cable shield
- Cable lengths (copper E2E link length < 100 m)
- Markings
- Conformance to documentation

7.3.2 Testing of Cabling

In PROFINET the End-to-End (E2E) link defines a fixed transmission link between two network active devices (switches, IO controllers and IO devices). This link composes of cables and connectors. Patch cables and patch panels are not used in PROFINET Industrial Ethernet.

Design rule in this document follows PROFINET design guidelines issued by PI (PROFIBUS and PROFINET International). No more than 4 connectors are used in copper E2E links. In fibre optic links the number of connectors might be more and there the maximum attenuation in E2E link must not exceed 10.3 dB as specified in the design guideline for single mode fibre.

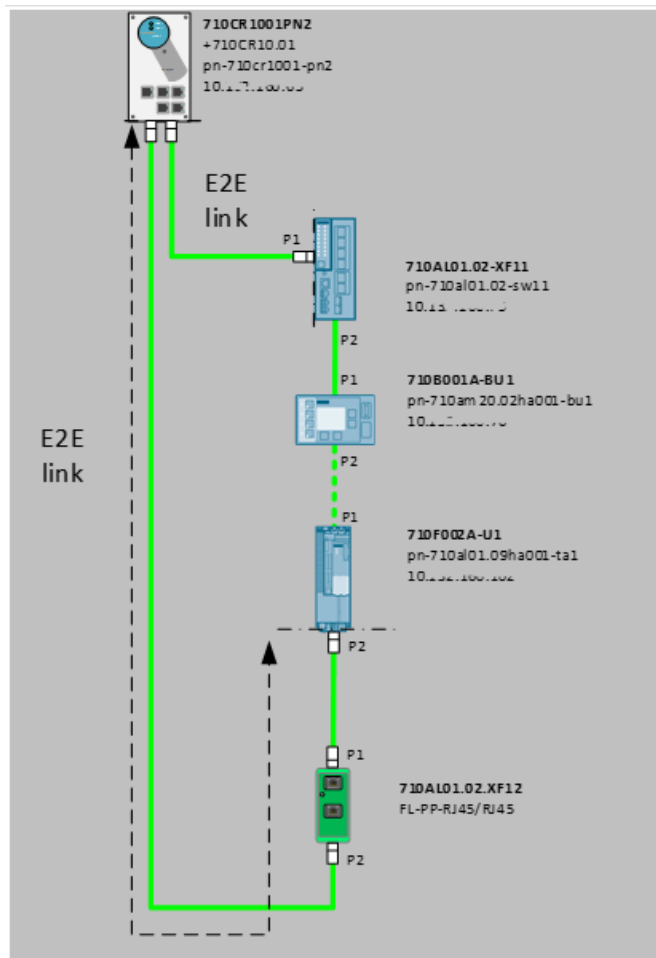


Figure 2 E2E links in MCCs

The acceptance procedure shall cover the verification of the electrical/optical E2E link. Measurement results shall be properly documented. Test reports shall be available before proceeding to PROFINET commissioning.

7.3.2.1 Copper cables

Testing of PROFINET copper cabling is installation contractor's responsibility.

Installation contractor measures only the installed cable with connectors. A separate test has to be arranged between E2E link end points if there is a doubt of link failure.

The cable tester shall have a special PROFINET test profile.

The following shall be reported:

- Wire map
- Cable length
- Resistance
- Insertion loss
- Return loss
- NEXT
- PS NEXT
- Transverse Conversion Loss (TCL)
- Shield continuity

7.3.2.2 Fibre Optic Cables

Testing of fibre optic cable segments is installation contractor's responsibility.

Installation contractor will measure the attenuation in fibres making the permanent link (between patch panels). A separate test has to be arranged between E2E link end points if there is a doubt of link failure. Total attenuation in the E2E link shall not exceed 10.3 dB for SM fibre.

Installation contractor shall also install and connect all the needed patch and connection cables according to installation documents.

7.3.3 PROFINET Commissioning

7.3.3.1 Prerequisites To PROFINET Commissioning

1. Installation finished and installation inspection done
2. Cabling measurement test reports available
3. PROFINET IO controller and device parametrization done (part of automation, instrumentation and electrification commissioning). Parametrized IO devices shall be marked with yellow sticker indicating Device PN name and IP address.

7.3.3.2 PROFINET IO Controller parameters and configuration

The PROFINET IO controller configuration tool shall be used to check standard parameters:

- send clock (default 1 ms)
- MRP settings for each device
- device update time (default 64 ms)
- device watchdog time (default 5 missed cycles = 320 ms)
- relevant device diagnostic selections

7.3.3.3 Power Supplies

Auxiliary power supplies for IO controller and IO devices in MCCs and drives shall be tested by the equipment supplier.

Additional power supplies feeding PROFINET switches, PN/PN couplers etc. in cabinets and field box shall be checked:

- Check installation and marking of power supply wires/cables
- Check fuses
- Check power supply redundancy
 - Switch off one redundant power supply and verify voltage after redundancy module/diode
 - Check alarm
 - Repeat for the other power supply unit
- After passed test apply yellow sticker to the units indicating approval and date

7.3.3.4 PROFINET Switches

PROFINET switches are configured by the control system supplier.

For each MRP ring or line

- Switch power supply on for switches
- Check ring redundancy for each switch in the ring (IO device MRP redundancy check is done in E/I commissioning)
 - Disconnect one PROFINET cable
 - Check fault LEDs
 - Check alarms
 - Verify that all nodes stay on the network
 - Reconnect and check that ring becomes healthy
 - Repeat for the other interface
- After passed test apply yellow sticker to the unit indicating Device PN name and IP address

7.3.3.5 Acceptance Test

The overall functionality of the bus system shall be verified.

- Switch auxiliary power supplies to IO devices
- Check that PROFINET stations indicate operation readiness (no comms fault present)
- Check with control system monitor or PROFINET online analyzer the availability of the devices (“live list”)
- Compare live list to the documentation
- Check device details
 - Device PN name
 - IP address, mask and default gateway
 - Similar devices shall have same firmware version

After acceptance test the bus system can be handed over to E/I commissioning.

7.3.3.6 Performance Test

The overall quality of the PROFINET shall be verified with online PROFINET tester (analyzer).

Performance test is arranged when all the subscribers are present on network.

For each PROFINET MRP ring

- Scan the network to create topology view
- Check topology against documentation
- Check statistics
 - Number of discarded packages
 - Network load on each device interface
 - Number of ARP broadcasts
 - Number of DCP multicasts
- Generate report

7.3.4 Plant Commissioning

When fibre optics and corresponding copper segments have been checked and the network system taken into operation normal E/I commissioning of the devices can be started, see separate commissioning instructions.

Note:

Checking of MRP and failsafe function (of control system and field equipment) is part of device commissioning

- MRP check
 - when device is active/running, disconnect one PROFINET cable from device and check MRP recovery (device remains in active/running)
 - reconnect cable and check MRP status
 - repeat for the other interface
 - Failsafe check
 - when device is active/running, disconnect (both) PROFINET cables from device and check failsafe function of device and in control system program.
- reconnect cables and check that device is staying in failsafe state.

7.4 Profibus DP

7.4.1 Installation Inspection

Installation inspection is part of the installation works and shall be made before the Profibus DP commissioning can commence.

Visual Checking

- Installation according to good Profibus DP installation method
 - Quality of connections by evaluating the usage of appropriate stripping tool
 - Safety distances to other cables
 - Grounding of shield
 - Length of copper segments
 - Bending radius etc.
- Markings
- Termination (In the beginning and in the end at the segment)
- Compare cabling to documents
- Setting of selection switches of connectors and field bus nodes
- Disconnect auxiliary power supplies for slaves (for cable test)

7.4.2 Testing of Cabling

Cabling test shall verify the electrical/optical function of the Profibus DP cables.

Testing of copper and fibre optic cabling is installation contractor's responsibility.

Measurement results shall be properly documented. Test reports shall be available before proceeding to Profibus DP commissioning.

7.4.2.1 Fibre Optics

The fibre optic cabling contractor is responsible of testing the fibre optic cable segments. The performance of the cabling and its compliance with relevant standards shall be tested in accordance with the instructions given in the standard EN 50346 (Information technology - Cabling installation - Testing of installed cabling).

The attenuation in fibres making the permanent link will be tested in both directions with two wavelengths of 850 and 1300 nm, respectively. The test equipment shall comprise optical power source and meter equipment in accordance with IEC 61280-4-1 (Fibre-optic communication subsystem test procedures - Part 4-1: Installed cabling plant - Multimode attenuation measurement).

Installation contractor shall deliver the test reports.

Checking of fibre optic components

- Check separation from power switching components
- Check settings of selection switches of fibre optic repeaters
- Set auxiliary power supplies “ON” for fibre optic repeaters
- Check that at least one bus subscriber is active on the bus (aux. power supply, bus cable connected and parameters (node address) for one slave)
- Check connection of fibre optic cabling by disconnecting one fibre (see fault LED’s in sending and receiving fibre optic repeaters)
- Checking of signal quality
 - receiving voltage level (mV) of each fibre optic channel is measured
 - measured value will be reported and compared to signal quality curve of manufacturer (NOTE: this measurement is not substituting the calibrated measurement in item **Chyba! Nenalezen zdroj odkazů.**)
- Check alarms of each fibre optic repeater

7.4.3 Copper Segments

7.4.3.1 Passive Tests (offline, no data communication)

Testing of segments

- Set auxiliary power supply for active termination ON (if this is used)
- Check settings of tester (like communication speed etc.) and select the correct mode of tester (see manufacturers manual)

Cabling test (no active devices)

Cabling shall be tested with Profibus DP cabling tester.

- Disconnect Profibus DP cable or switch off power supply of fibre optic repeater and connect tester to the segment (and test plug to the other end of segment if needed)
- Test measurements are:
 - Wire mix-up of A and B-wires
 - Short circuit between A and B
 - Ground faults (A or B to ground)
 - Line A and B or shield breaks
 - Terminations

”Live list”

- Connect auxiliary power supplies for slaves

- Check the availability of the slaves of the segment (with bus monitor or with tester or with analyzer)
- Compare available nodes to the documentation

Station test (only if station is thought to be faulty)

This kind of test can be done for any individual slave (to check the RS485 interface) by disconnecting the bus cable of the device.

7.4.3.2 Active Tests (Online, with Online Tester)

With online tester will evaluate the signal quality of Profibus DP cables by:

- Slave status analysis with event triggering and/ or
- RS485 driver output level measurement with deviations

With online tester oscilloscope AC voltage level of the segment shall be measured.

- When all masters are detached, AC voltage < 200 mV_{tt} (peak)
- When all masters are active, AC voltage min 2 V_{tt} and max 6 V_{tt} (all slaves have aux. voltage and parameters)

Profibus DP signal (amplitude, reflections, noise) shall be recorded from the active segment. All measurements shall be verified as passed and passed results shall be reported and stored. This test shall be repeated after the start up when the mill is running.

7.4.4 Profibus Commissioning

When fibre optic part and corresponding copper segment has been checked a normal commissioning of devices can be done.

NOTE:

Remember to check failsafe function (in control system and in field equipment)!

- when device is active/running, disconnect Profibus from device and check failsafe function of device and in DCS program.
- then connect Profibus cable and check that device is staying in failsafe state.

For example a motor starter:

- when contactor is ON, disconnect Profibus from starter and check failsafe function in starter and in DCS (in most cases motor has to stop, see separate instructions for special cases)
- then connect Profibus cable and check that motor is not starting (or not stopping if failsafe function was “retain status”)

Remember to check failsafe function for Profibus DP connected VFD's and I/O:s too.

7.4.4.1 Master parameters and configuration

Check master parameters and bus configuration if they are not verified in FAT of the control system. Check at least following:

Master Parameters:

- Data rate
- Watchdog time
- Slot time

- Cycle time
- HSA
- Max. retry limit

Field bus configuration:

- Node addresses
- Type of nodes (for ex. freq. converter or motor controller)

7.4.4.2 Power Supplies

Checking of power supplies for auxiliary power units (for field bus components like fibre optic repeaters etc.)

- Installation and marking of power supply wires/cables (routing, safety distance, twisted wires used etc.), fuses
- Check settings of selection switches of power units (if there are any)
- Check alarms of power supply units

7.5 Profibus PA

7.5.1 Installation Inspection

Installation inspection is part of the installation works and shall be made before the Profibus PA commissioning can commence.

Visual Checking:

- Installation according to good Profibus PA installation method
 - Safety distances to other cables
 - Grounding of shield
 - Bending radius etc.
- Markings
- Termination (In the beginning and in the end at the segment)
- Compare cabling to documents

7.5.2 Testing of Cabling

7.5.2.1 Passive Tests (offline, no data communication needed)

Tests shall be made with multimeter. Power supply of the DP/PA gateway shall be ON.

Total current of the segment:

- Measure total current of the segment from the terminals of the DP/PA gateway. Compare result to the calculated current. Max. current of the segment is 500 mA.

Voltage at the last device of the segment:

- Measure voltage from the last device of the segment. Compare result to the calculated voltage. Min. voltage is about 9 V but it depends on the device.

7.5.2.2 Active Tests (Online, with Online Tester)

With online tester (analyzer) will evaluate the signal quality of Profibus PA segments by:

- live list
- slave status analysis with event triggering
- message sampler (configuration faults, corrupted messages etc.)
- MBP driver output level measurement with deviations (if oscilloscope is connected/integrated)

With oscilloscope AC voltage level of the segment shall be measured.

- When master is active:
 - AC voltage min 0.75V_{tt} and max 1.00V_{tt}
 - Max. positive and negative amplitude difference (signalling bias) $\pm 50\text{mV}$

Profibus PA signal (amplitude, reflections, noise) shall be recorded from the active segment.

7.5.3 Profibus PA Commissioning

When corresponding copper segment has been checked a normal commissioning of devices can be done.

PA device test procedure:

- Check value of the status byte of the device input data from the application program.
 - Status ≥ 128 , good state
 - Status < 128 not good
- Check also that device addressing and cable connection are correct by short circuiting PA signal terminals of the device. (Short-circuit protection of the Drop box shall drop the device out from the segment and value of the status byte goes to zero.)

NOTE:

Remember to check failsafe function (in control system and in field equipment)!

- when device is active/running, disconnect Profibus from device and check failsafe function of device and in DCS program.
- then connect Profibus cable and check that device is staying in failsafe state.

7.5.3.1 Field bus configuration

Check at least following from the Profibus master:

- Node addresses
- Type of nodes (for ex. freq. converter or motor controller)

8 INSTRUMENTATION TESTING

The purpose of the automation commissioning is to verify the correctness of the DCS connections to field and the readiness of instrument installation before starting the commissioning (mechanical trial and water runs) of each department / subprocess.

The commissioning consists of loop testing and functional test run with equipment and piping.

8.1 Pre-check-out for Instrumentation commissioning

8.1.1 Pre-installation Checking (installation contractor)

The standard transmitters, indicators and control valves will arrive at the mill site calibrated and with tag numbers. The instrument installation contractor shall be responsible for checking calibration and tag numbers of instruments. Visual examination of instruments and valves shall be completed immediately upon receipt. The instrument installation contractor is obliged to inform the Purchaser of any errors or problems. After agreement with the Purchaser, the instrument installation contractor shall be change of calibration and give new tag numbers to instruments, if needed

8.1.2 After-installation “Cold Testing” (installation contractor)

The instrument installation contractor shall carry out initial “Cold tests” after the installation of instrumentation. The tests shall include the following main tasks and all tests shall be reported. See also standard MEAI0007 item 3.9.3.

Visual Examination of Field Instruments: Installation is in accordance with given information/drawings, instruments and cables are properly tagged and marked, fixing of the instrument is in accordance with the instructions, the instrument is correctly located, cables are fixed and protected correctly, entrances (cable glands) are watertight, fittings are tightened properly, necessary painting has been done.

Test for Signal and Supply Lines and Circuits: All tubes and wires are connected in accordance with the drawings, signals enter the correct instruments, air supplies are taken from indicated outlets and all lines are flushed prior to connection to instrument or valve, electric power is coming from the indicated breaker, there are no leaks in pneumatic signal or supply lines (bubble leak tests to be done if required), there are no loose electrical connections.

Check-out results will be filled in by the instrument Contractor in template (Appendix V).

8.1.3 Electrical power

Electrical power shall be available for automation. Both UPS and non-UPS power shall be available.

8.1.3.1 Powering Up Field Boxes (Electrical Commissioning Team)

The testing of voltage feed includes also verification of the cable protection and connection at both ends. Principally the Purchaser’s representative shall switch on the voltage feed (e.g. substations), because he knows the status of the acceptance inspections.

The auxiliary voltage to the cabinets and boxes will be connected only after the supplier has given the permission to do so.

Powered field boxes will be marked with a label “230 VAC CONNECTED” with the initial of the Purchaser’s representative and the date.

8.1.3.2 Powering Up Instrument Equipment (Instrumentation Commissioning Team)

In general, the system can be powered up with equipment switched off on the secondary side. However, it shall be noted that there may be individual units or devices with non-protected power outlets, which may have to be unloaded to prevent damage.

The following check list may serve as a model for powering up most equipment or devices. The manufacturer or supplier's instructions shall always be taken into account.

Visual inspection prior to powering-up

- correctly connected
- no foreign objects
- no moisture or dirt
- no damage to insulation or other similar issues
- equipment earthing is correctly done
- screened cables are correctly earthed
- wire cross section areas are correct
- the voltage to be connected is correct
- cables and equipment correctly marked
- secondary side (all connection points) are switched off
- secondary side loaded, if this is necessary
- no exceptional voltages detected

Checking and powering-up

- Measure that correct voltages are connected. If the device/equipment/unit has its own switch, the voltage shall be measured (on the field) before switching on the power to the device/equipment itself.
- Measurements show that all secondary internal power supplies are correct.
- Connect and measure internal secondary voltage.
- Pay attention to any smell or noise.
- Measure on the signal side that there is a correct output signal

Connect the outer loop and check that signals and power supplies are correct.

8.1.4 Control system readiness

The control system must be operational which means that the system is installed, powered and programs loaded.

8.1.5 Field buses

The field buses have been commissioned and in operation.

8.1.6 Compressed air

Instrument air is required for the check-out. It is recommended to have the instrument air network available from the final source of compressed air and to avoid temporary solutions for pressurizing the network. The main instrument air network has to be clean blown before the field boxes and instrument air headers can be pressurised.

8.1.7 Tools

Sufficient test equipment shall be available (simulators, walkie-talkies, hand held tools etc.).

8.2 Instrument Loops testing

After the instrument installation work is completed and the instrument installation contractor has reported the instruments are “cold tested”, the actual testing can be started.

Testing is divided into:

- Field Tests of Instrument Loops
- Functional Tests (Water run)

Reports will be issued so that the progress and status is available at any time. Test results of checking will be reported according chapter 4.

The detailed automation activities from field instrument point of are shown in Appendix IV “Commissioning Instructions for Field Instruments”.

The commissioning will end when the Functional Test Run is completed. The start-up and test run with final process medium will commence.

8.2.1 Field Tests of Instrument Loops

The purpose of the loop check-out is to verify the correctness of the DCS connections to field and the readiness of instrument installation before starting the functional test Run.

Commissioning team carries out the field tests (mechanical, electrical and pneumatic) of instrument loops.

The check is done from the control system operator station or engineering stations by simulation. The check involves connecting a testing device to the transmitter and observing that the DCS and/or panel readout follows the input signal. Also if the loop has an actuating element, e.g. a valve, it shall be observed that the actuating element follows the output changes.

All parts of a loop shall be tested to ensure that they work correctly. All indicating units like panel mounted instruments, displays and local instruments of the loop shall be also checked.

The DCS supplier shall make all needed changes in application programs.

Testing shall be documented in a separate set of loop diagrams by highlighting the tested parts in green and with the tester's signature on the diagram.

Checked-out field devices will be marked with a green sticker.

In case of fault, the field device will be marked with a red sticker to prevent double testing and time losing. This procedure will be taken on place if fault is not possible to fix immediately.

Any related loops should be tested so that at least one unit overlaps the next loop.

To prevent any impurities from entering the pneumatic devices, pneumatic systems shall be purged with compressed air before testing.

The impulse pipe connections and installation principles should be checked and the pipes shall be flushed with steam or air. Impulse pipes with barometric legs shall be filled. Impulse line purging and flushing equipment shall be pre adjusted to meet the requirements of the process.

Process shut-off valves shall be closed. Any relief valves shall be opened.

Testing procedure:

- Analog measurement signals are simulated from the field instrument with a simulator at 0 %, 50 %, 100 %, 50 % and 0 %. Reading shall be checked from the DCS operator station. Calibration ranges, scales, proper actions and set points for alarm etc. for all instruments, including those mounted on the control panels, auxiliary racks or boxes are checked. Zero points shall be also checked of all instruments e.g. transmitters and gauges (adjustments if required).
- The pre-calibration routines for some instruments like weight transmitters, ultrasonic level transmitters, consistency transmitters, some analysis transmitters, etc. need/shall be carried out before taking into operation.
- Switching sensors which cannot be simulated by simulating the device itself are simulated by means of short-circuiting signal terminals of the sensor.
- Some switching sensor like sealing water flow switches and rotation switches shall be pre-adjusted during testing to meet the process requirements.
- All DCS alarm signals shall be tested to compare the function with theoretical data.
- If the tested loop has interlock signals to other loops, these signals shall be tested to compare the present values and functions.
- Control valves shall be tested together with the respective instrument loop.
- Control valve signals are operated at 0 %, 10 %, 50 %, 100 %, 50 %, 10 % and 0 % from the operator station and the valve movement is checked in the field. The correct valve position in signal or air supply failure is also verified.
- To zero check a control valve: Set 0% position with mA source e.g. 4mA, then mark valve stem, followed by a ≤ 3 mA setting, while monitoring if the valve stem moves (no movement will indicate fully closed at 4mA). This method will make sure that the valve is really closing.
- On-off valves are operated from the operator station and the valve movement is checked in the field. The correct valve position in signal or air supply failure is also verified. The opening and closing speeds are pre-adjusted to meet the requirements of the process.
- The control and on-off valve testing should pay special attention in case of air supply failure. Depends on the valve specification it could be:
 - Valve remains in the last position
 - Valve close (spring to close actuator)
 - Valve open (spring to open actuator)
- Limit switches shall also be tested. On-off valve open and close limit switches are adjusted according to the real valve opening and closing speeds (supervision time in control system to be adjusted to match correct opening speed).
- Other binary control signals are operated from DCS and the operation of the controlled element is verified.
- The effect of the external interlocks to the loop shall be also checked. The correct valve position and function during and after the interlock shall be checked. Valve opening and closing speed in interlock case need to be also verified (different ramp speed is specified for interlock functions)

- The operation of the instrument loop in I/O or bus failure shall be checked. The correct valve position and function during and after the I/O failure shall be checked.
- The above-mentioned points are examples of how the tests of instrument loops should be carried out. The examples do not cover all existing loop types, but are intended to serve as a reference to show the extent and objectives of the test.

After completion of tests, a loop can in most cases be considered commissioned as far as the signal side is concerned (electric and pneumatic). The power and air supplies shall be left on.

8.2.2 Functional Tests (Water run)

The commissioning team shall perform the functional tests.

The testing shall be performed so that at least one unit in the test overlaps the next loop.

Tests shall be made from safe initiation to safe actuating device, i.e. an auxiliary relay is not enough to verify correct operation.

For emergency functions one complete loop shall always be tested at the same time. For example, pressure release shall be done with a compressed air cylinder linked to the pressure switch. Correct function is verified if a pump stops, a valve opens, etc.

Required final adjustments for field instruments will be made during functional test runs of the process and, if required, later on during the start-up period of the mill, including:

- Control loop tests with running process (final adjustment)
- Any damping of the signals
- Checking of 0-points
- Checking of tank levels
- Opening closing speeds of control/on-off valves
- Any recalibration, for example of alarm point settings
- Leak tests for control valves when required
- All other tests and/or modifications required by the commissioning team.

8.3 Taking into Operation

Taking into operation of instrument equipment consists of examining that mechanical, electrical and pneumatic systems are ready for operation. In addition, it is important to make sure that any process tests, such as pressure tests and other measures that might damage the sensing element (e.g. consistency sensor), have been carried out.

The next tasks in the plant are to close any relief valves and to open the system towards the process. Then correct signals shall be verified. Necessary zero point corrections shall be carried out.

Taking into operation may also consist of final connection of the signal (electric or pneumatic), which cannot or must not be connected before start-up of the plant, for example disconnected alarms, jumping connections, cancelling of force-locked valves, etc.

The purpose is to adapt the procedure of taking into operation so that the plant can be started up as quickly, safely and simply as possible.

8.4 Tuning

Tuning of the instrument system can be divided into three periods depending on the stage of the commissioning progress:

- Rough Tuning (preliminary)
- Fine Tuning, Optimisation
- Optimisation Control

8.4.1 Rough Tuning (Preliminary)

Before functional test runs (water runs) the system is tuned roughly to meet theoretical values in the situation where all processes are completely ready for operation. Before the water runs tuning parameters are set to values based on experience. Preset tuning parameters are adjusted during rough tuning period. The rough tuning period allows simulation of process disturbances to study the behaviour of the process. Loops can be extensively influenced to create realistic process conditions.

8.4.2 Fine Tuning (During Water Runs and after Start-up)

When testing the systems with process media, all the equipment can be fine-tuned and optimised to ensure the best possible performance. The possibilities for simulating process disturbances are best at the beginning of the period, but decrease over time, as saleable production naturally must be reached. It is important to note that any measures that need to be taken must be planned in cooperation with the operating planning staff.

8.4.3 Optimization Control

Optimisation control is needed during the first months of operation to analyse processes in more detail. The possibilities for simulation of disturbances are virtually non-existent during this period.

Process studies with the aid of special instrumentation must be applied to allow the best possible use of advanced process technology for stable and high production of a good quality saleable product.

9 ELECTRIFICATION TESTING

9.1 General

During the electrical check-out, the correctness of the connections from the field equipment to the control system, the cabling between different systems as well as the types and technical data will be tested/ checked (e.g. motors).

The commissioning of electrical equipment can only be started after the electrical installation contractor has checked its own work and made the required measurements and determined that the electrical equipment is safe to use with regard.

Checked equipment will be tagged with safety signs, indicating that the functionality test may begin, and the machine will run without warning. The notation is agreed on a case-by-case basis for each project and must be approved by the Purchaser.

The energising of transformers, switchgear, MCCs and other distribution boards will be co-ordinated by the person designated for the task. Electrical equipment must not be switched on without permission.

9.2 Erection check-out

9.2.1 MCC commissioning and check-out (MCC supplier)

The commissioning and check-out of MCCs will be performed by the MCC supplier.

The MCC supplier will also take care of settings and check-outs of the protection relays and intelligent motor controller parametrization.

9.2.2 Fieldbus check-out

The fieldbus check-out will be performed according to chapter 7.

9.2.3 Check-out of Motor Circuits and Feeders (Electrical installation contractor)

The following will be done:

- Installation made according to documentation
- Visual inspection of connections

Cabling test:

- Checking of control cable connection and markings.
- Checking of power cable connection (star/delta, rotation) and markings.
- All cabling and wiring shall be tested for continuity, short circuits and earth faults.
- Insulation tests (megger test) shall be made on each and every power circuit when installation is complete and before power is applied. Motor winding shall be meagered (to earth) and power cables meagered (phase/phase and phase/earth) prior to connection of the cables to the motor. No electronic circuits shall be meagered.

Mechanical tests:

- Free rotation (by hand)

Marking of checked-out devices:

- The MCC door will be marked with a label “INSTALLATION TEST DONE” with the initial of the test group member and the date.

Check-out results will be filled in by the electrical Contractor in templates (Appendix VI). A representative of the electrical contractor or the electrical supervisor will sign the Test Report.

All test reports will go to the commissioning team through the electrical supervisor. The electrical supervisor locks (padlock) the check-outed MCC modules.

9.3 Functional Check-out (Project Commissioning team)

9.3.1 General

The functional check-out (commissioning) will be done in check-out groups, consisting of Purchaser's, electrical installation company's and Purchaser's/control system Supplier's representatives (preferably 3 persons / check-out group). Several check-out groups will be necessary depending on the size of the department and the check-out schedule.

The check-out group member in the field (an experienced check-out person from the Electrical installation contractor), will fix the detected defects immediately.

The second check-out group member will be in the electrical room (e.g. Purchaser's electrical fitter) and the third member (e.g. designer's / Purchaser's representative) working on the operation station. The group member working on the operation station will be the group leader and keep log on the tested loops.

The representative of the control system supplier can work simultaneously with several check-out groups in one department.

In addition to this, a representative of the equipment supplier shall be present in certain special cases or replace one of the regular members of the group (e.g. frequency converter).

The check-out group members will communicate with each other with the help of walkie-talkies.

Circuit types to be checked:

- Intelligent motor controller controlled standard and reversible motors
- Frequency controlled drives
- Alarm and signal circuits
- Power supply circuits (auxiliary voltage supplies)

Before testing the motor circuits, the control power of the MCC will be switched on.

9.3.2 Intelligent motor controller controlled standard motors

MCC starter will be checked: *)

- Name plates
- Fuse sizes
- Intelligent motor controller current scale /range
- The name plate texts and motor values in the name plate will be checked. *)
- The existence of the thermistor and the type will be checked. *)
- The parameterization of the intelligent motor controller, current parameters acc. to the motor values in the name plate as well as the existence of the thermistor and parameterization acc. to the thermistor type will be checked. In case the thermistor is missing, although the motor frame size would call for it, a marking "not in use" will be made in the circuit diagram and the parameterization will be changed accordingly. *)

Testing Procedure (for example see appendix VII wiring and circuit diagram):

NOTE: Always check during the test also by measuring the no-voltage or voltage of the motor starter or feeder starter.

- Ensure that the main switch (-Q1) in MCC starter module is in Off-position and safety switch (-Q2) is Off.
- **Switch starter in test position. (If the test position is not available then remove the main fuses and close Q1 auxiliary contacts 13 and 14. In this example auxiliary contacts are 13 and 14)**
- The ready to run signal at the display should be "0" and DCS indicate MCC fault.
- Close MCB -voltage supply to intelligent motor controller in the MCC module.
- Ensure that device led indicate green light and DCS side intelligent motor controller is ready for use.
- Close MCB – control voltage supply to starter in the MCC module.
- Ensure that MCC fault should be "0". Field fault should be on.
- Close safety switch (-Q2).
- Ensure correct input and indication in DCS.
- Activated input (ready to run) shall be in the display.
- MCC & Field faults fault should be "0".
- Turn the safety switch at field off position and ensure on the display field fault.
- Turn the safety switch back on position.
- Start the motor from the control room DCS.
- The motor will not actually start/run as the module is in test-position (or main fuses are removed).
- Please ensure that any interlocking preventing the motor to start/run are temporarily by-passed in the DCS.
- Ensure that the starter contactor in the MCC module will pull in. the display from DCS indicate run mode.
- Stop the motor from the control room DCS.
- Ensure that the starter contactor in the MCC module drops out.
- Ensure correct input and indication in DCS.
- The display indicate stop mode.
- Should the motor have any local or parallel controls the function shall be tested as described above.
- Motor thermistor will be tested by short circuit from the motor. Thermistor function shall give an alarm in the diagnostic display. Thermistor function will stop the motor. So called failsafe-test will be made, “fail safe function: stop”

- Profibus or Profinet connector will be disconnected from starter. Motor should stop in ~300ms.
- Some special motors will be left running without control in case of a bus failure. When the bus failure is cleared, the motor can continue controlled running. Such motors have been specified separately and will be marked in the check-out form “failsafe function: running”.

Completion of Functional Testing:

- Turn main switch (-Q1) in OFF position. (Reinstall the main fuses if they were removed and release Q1 auxiliary contacts 13 and 14).
- Lock starter in Disconnect position and open starter of MCBs
- Compile relevant check-out and functional testing documentation
 - Relevant wiring diagram.
 - Erection defect list.
 - Relevant circuit diagram.

*) = preparatory checks which can be made for each water run group or for each MCC before the actual circuit check-out.

9.4 Rotating test

Testing Procedure:

- Check once more from the erection check-out test the motor and cable insulation has been done.
- Ensure that the coupling with the driven equipment/machinery is disconnected or the relevant Vendor/supplier has allowed the rotation.
- Ensure that the Safety Switch (-Q2) at the field is closed.
- Close control MCB - voltage supply to intelligent motor controller in the MCC module.
- Close control MCB - control voltage supply to starter in the MCC module.
- Close main switch (-Q1) in the MCC module.
- Check direction of motor rotation by starting from DCS. (Or with operator panel instead).
- Measure and record motor current.
- Completion of Rotation Test.

Completion of Rotation Testing:

- Lock the MCC starter module in disconnect position. Turn main switch (-Q1) in the MCC module OFF.

- Turn Safety switch (–Q2) OFF and lock.
- Compile relevant check-out and functional testing documentation.
- Record completed functional test in Test Sheet.

9.5 LV Frequency controlled drives

When testing the frequency converters a representative of VFD supplier shall be present and be responsible for the start-up of the frequency converters. The frequency converters supplier will also take care of parametrization.

Testing Procedure:

- MCC part will be checked *)
- Name plates
- Fuse sizes
- The frequency converter name plate texts outside the MCC will be checked. *)
- The name plate texts in the field and motor values in the name plate will be checked *)
- The necessary motor name plate values and the rotation speed control range will be given to the frequency converter supplier
- The existence of thermistor will be checked in the field
- Frequency converter main voltage will be switched on
- Frequency converter auxiliary voltages will be switched on
- The frequency converter parameters will be checked and tested by the converter supplier acc. their own instructions
- Further testing will be made as in item Intelligent motor controller controlled standard motors.
 - field failure
 - MCC failure
 - thermistor will be checked
 - failsafe test

Frequency converters with a separate power feeding (stand alone drives): the power feeding part shall be tested as well (MCC failure).

Because during the frequency control tests the main circuit shall be connected up to the motor, a representative of the equipment supplier shall be present in all such tests, where the motor power transmission (coupling) is connected on. The motor rotation direction can also be checked at the same time.

*) = preparatory checks which can be made for each water run group or for each MCC before the actual circuit check-out.

9.6 6kV and 10kV motors (I/O controlled motors)

Testing Procedure:

- **The circuit breaker will be in the TEST position**
- MCC starter (switchgear cubicle) will be checked *)

- Name plates
- Settings of protection relay are done and they are correct
- Power transducer scale is correct
- The name plate texts and motor values in the name plate will be checked *)
- The existence of the PT-100 and the connections will be checked *)
- Control voltage will be switched on
- A test position indication will be checked by taking out the circuit breaker and putting it to the test position
- A field failure will be noticed by closing the circuit breaker and pushing the emergency push button open
- A MCC failure will be noticed by closing the circuit breaker and switching the control voltage off
- A motor running status will be checked by closing the circuit breaker
- The function of the guards of the motor circuit will be tested (rotation guard, plugging watch, limit switches etc.) and the device types will be checked
- The motor PT-100 temperature measurements shall be tested as far as possible. Overheating of motor windings/ bearings will stop the motor with protection relay.
- The function of the motor space heater will be checked (space heater will be on when circuit breaker is off position)
- The function of power measurement will be checked by comparing the DCS display value with the power value of protection relay display (when motor is running)
- The check-out group leader will control the circuit breakers on from the operation display. He will notify the correctness of the control display and keep the check-out log.

Completion of Functional Testing:

- Turn the circuit breaker in OFF position.
- Lock starter in Disconnect position and open starter of MCBs
- Compile relevant check-out and functional testing documentation
 - Relevant wiring diagram
 - Erection defect list
 - Relevant circuit diagram

*) = preparatory checks which can be made for each water run group or for each MCC before the actual circuit check-out.

9.6.1

Rotating test

- Check once more from the erection check-out test the motor and cable insulation has been done.
- Ensure that the coupling with the driven equipment/machinery is disconnected or the relevant Purchaser/Supplier has allowed the rotation.
- Close control MCB - control voltage supply to starter in the MCC module
- Close the circuit breaker in the MCC module.
- Check direction of motor rotation by starting from DCS. (or with operator panel instead)
- Measure and record motor current.

Completion of rotation testing:

- Turn the circuit breaker in OFF position.
- Lock the MCC starter module in disconnect position.
- Compile relevant check-out and functional testing documentation.
- Record completed functional test in test sheet.

9.7 Emergency stop circuits

The emergency stop circuits can be tested when corresponding motors are “running” in the TEST position. All motors under the emergency stop circuits shall be tested and made sure that the function of the emergency stop really stops the motors.

Motors can be started and tested one by one.

All emergency stop pushbuttons shall be tested one by one to make sure that all pushbuttons will work the same way.

Also, the alarms of emergency pushbuttons will be checked from the DCS display/alarm printer.

The reset push-button shall be tested. If the feedback from the motor contactor is cut (e.g. one motor starter has been taken out), the reset push-button does not activate the emergency stop relay.

End of testing; a few motors shall be started in reality. The emergency push-button will be pushed once more and checked that motors will stop.

A detailed test report will be made. In it is shown that all push-buttons are tested and emergency stop circuit is working properly. The initials with date are required.

The test report will be filed for later use. (Report could be required by authorities and Purchaser’s safety department.)

9.8 Alarm and signal circuits

Alarm circuits will be tested by causing an alarm or when this is not possible taking a corresponding alarming action in the terminal block of the alarming MCC or device and checking the alarm in the alarm list and DCS display.

Testing of signal circuits (e.g. testing of start-up alarms/ warnings) has to be agreed with the Purchaser and a suitable time has to be chosen in order to avoid unnecessary disturbances.

9.9 Power supply circuits (auxiliary power supplies)

The testing of voltage feed includes also verification of the cable protection and connection at both ends. Principally the Purchaser’s representative shall switch on the voltage feed (e.g. substations), because he knows the status of the acceptance inspections.

The auxiliary voltage to the cabinets and boxes will be connected only after the supplier has given the permission to do so.

Control voltage can be switched on by the check-out group.

9.10 Logging of the tested circuits

Test results of checking will be reported according chapter 4.

Cabling and circuit diagram documentation (yellow files) are placed in the electrical room. Test results will be marked in circuits diagrams and circuits will be signed tested with the initial of the test group member and the date.

Circuits will be signed tested in a separate follow-up list, example form is shown in Appendix VI.

Marking of checked-out devices:

- The direction of the motor rotation will be marked with a tape in the motor itself with the text "DIRECTION OF ROTATION OK" with the initial of the test group member and the date.
- The safety switch will be marked with a label "FUNCTIONAL TEST DONE" with the initial of the test group member and the date.
- The MCC door will be marked with a label "FUNCTIONAL TEST DONE" with the initial of the test group member and the date.