GP Consult SA

Projects Department

EC&I CONSTRUCTION PROCEDURES MANUAL

Quality | Planning | Safety | Installation | Testing & Commissioning

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00	2025	Draft Issue for Review	QC Officer	Site Manager	Manager – Projects
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SECTION 1 — QUALITY MANAGEMENT PLAN

Section	1
Document Ref	GPC-ECI-QMP-001
Applicable To	All EC&I Construction Works

1.1 Purpose

This Quality Management Plan (QMP) establishes the quality framework, inspection procedures, testing requirements, and documentation controls for all Electrical, Control and Instrumentation (EC&I) construction activities executed by GP Consult SA. It ensures that all installation works comply with project specifications, approved drawings, applicable engineering standards, and client requirements, and provides a single reference point for all quality activities from site establishment through to final handover.

1.2 Scope

This QMP applies to all EC&I construction activities including:

- Cable ladder, tray, and support structure installation
- Power, control, and instrument cable installation and routing
- Cable terminations at MCCs, panels, instruments, and junction boxes
- Instrument installation and Decabon / impulse tubing
- Earthing and bonding systems
- Electrical equipment installation (MCCs, switchgear, distribution boards)
- Electrical testing (insulation resistance, continuity, loop checks, phase rotation)
- Pre-commissioning and commissioning activities

1.3 Applicable Standards & References

Standard / Code	Title	Application
IEC 60364	Electrical Installations	All electrical installation works
IEC 60529	IP Protection Ratings	Equipment enclosure classification
IEC 60079	Hazardous Area Equipment	Hazardous area installations
SANS 10142	Wiring of Premises (SA)	All site wiring works
ISO 9001	Quality Management Systems	Overall quality framework
Client Eng. Standards	Project-specific standards	All project activities
Approved Drawings	Construction & routing drawings	All installations

1.4 Quality Roles & Responsibilities

Role	Quality Responsibilities
Project Manager	Overall accountability for project quality objectives; approves quality documentation; ensures adequate QC resources.
Site Manager	Ensures all construction complies with approved drawings, specs, and procedures; reviews and approves inspection records.
Quality Control Officer	Implements QC programme; conducts inspections; issues and closes NCRs; maintains quality dossier and all records.
QC Assistants	Support QC Officer with inspections, document control, inspection register maintenance, and test record filing.
Construction Foremen	Ensure workmanship quality; verify work before calling for inspection; do not call hold points until work is fully ready.

Client / EPCM QC	Witness Witness Points; approve Hold Points as defined in ITPs; sign off inspection and test records.
Safety Officer	Ensures all construction and testing activities comply with the Safety Plan and applicable legislation.

1.5 Material Receiving Procedure

All materials delivered to site shall be inspected prior to storage or installation. No materials shall be installed without a completed Material Receiving Inspection Report (MRIR).

Receiving Inspection Requirements:

1. Verify delivery against Purchase Order: quantities, descriptions, specifications.
2. Review material test certificates and manufacturer documentation.
3. Conduct physical damage inspection: cables, enclosures, instruments, panels.
4. Verify cable drum identification markings against the cable schedule.
5. Confirm instrument calibration certificates are valid and within calibration date.
6. Segregate and quarantine non-conforming materials pending disposition.

⚠ CRITICAL: All approved materials must be tagged 'APPROVED FOR INSTALLATION'. Non-conforming materials must be tagged 'HOLD – DO NOT USE' and reported immediately to the QC Officer for NCR issuance.

1.6 Non-Conformance Management

Any work or material not complying with project specifications, drawings, or approved procedures shall be subject to the NCR process.

NCR Process Steps:

7. Identify the non-conforming item — describe the non-conformance clearly and specifically.
8. Issue an NCR using the approved NCR form; assign a unique NCR number from the NCR Register.
9. Investigate the root cause of the non-conformance; identify contributing factors.
10. Determine the appropriate corrective action: repair, rework, replace, or concession (client approval required).
11. Implement the approved corrective action.
12. Re-inspect the corrected work and verify full compliance with specifications.
13. Obtain client or EPCM sign-off where required by the ITP or contract.
14. Close the NCR formally in the register and file all supporting documentation in the Quality Dossier.

NCRs shall be reviewed at weekly site quality meetings. Recurring NCRs shall trigger a formal corrective and preventive action review.

1.7 Quality Documentation & Records

Record Type	Description	Responsible	Filing Location
MRIR	Material Receiving Inspection Reports	QC Officer	Quality Dossier
Inspection Reports	ITP inspection checklists for all activities	QC Officer	Quality Dossier
Test Reports	Insulation resistance, continuity, loop check results	QC Officer	Quality Dossier
Calibration Certs	Instrument and tool calibration records	QC Officer	Quality Dossier
NCR Register	Log of all non-conformance reports	QC Officer	Quality Dossier

Punch List	Outstanding items log and close-out status	Site Manager	Quality Dossier
As-Built Drawings	Marked-up construction drawings	Site Manager	Quality Dossier
Equipment Manuals	OEM documentation for installed equipment	Site Manager	Quality Dossier

1.8 Quality Dossier Structure

A Quality Dossier shall be compiled per system or work package. The dossier shall include the following in order:

15. Cover page and document index
16. Approved ITPs with sign-offs
17. All inspection reports and checklists
18. Test results (IR, continuity, loop, functional)
19. Calibration certificates for all instruments and test equipment
20. NCRs and closure records
21. As-built / redline drawings
22. Manufacturer data sheets and equipment manuals
23. Client acceptance certificates and handover sign-offs

SECTION 2 — PLANNING PROCEDURE

Section	2
Document Ref	GPC-ECI-PLN-001
Tools	Primavera P6 / MS Project

2.1 Purpose

This procedure defines the planning and scheduling methodology used to manage EC&I construction works for GP Consult SA projects. The planning system ensures that all activities are clearly defined and sequenced, resources are allocated effectively, progress is monitored against the approved baseline, and delays are identified and mitigated before they impact project delivery.

2.2 Planning Software

Project scheduling shall be performed using Primavera P6 (preferred) or Microsoft Project. All schedule files shall be version-controlled and stored in the project document management system.

2.3 Schedule Levels

Schedule Level	Description	Owner	Issue Frequency
Level 1	Project Milestones Schedule	Project Manager	Project Start / Key Changes
Level 2	Construction Execution Schedule (Baseline)	Site Planner	Baselined at Project Start
Level 3	Detailed Installation Schedule per Discipline	Site Planner	Weekly Updates
Level 4	Daily / Short-Interval Lookahead Plans	Planner + Supervisors	Daily

2.4 Planning Process — Step by Step

Step 1: Work Breakdown Structure (WBS)

The project shall be divided into the following major work packages:

24. Project Management & Site Establishment
25. Cable Ladder & Support Installation
26. Cable Installation & Routing
27. Instrument Installation & Tubing
28. Cable Terminations
29. Earthing & Bonding
30. Electrical Testing
31. Pre-Commissioning & Commissioning
32. Demobilisation & Close-Out

Step 2: Activity Definition

Each work package shall be broken into activities that are: clearly defined and measurable, aligned with the production quantities in the BoQ, sequenced logically, and suitable for earned value measurement.

Step 3: Duration Assignment

Durations shall be based on: installation quantities from the BoQ, site-specific productivity rates (norms), available manpower per gang, and agreed working hours (typically 10–12 hours per day, 6 days per week).

Step 4: Logic & Dependencies

Relationship Type	Description	Example
FS – Finish to Start	Activity B cannot start until Activity A is complete	Cable ladder complete before cable pulling begins
SS – Start to Start	Activities can start together with an offset	Cable pulling and terminations can overlap by system
FF – Finish to Finish	Activities finish together	Testing and QC sign-off complete simultaneously

Step 5: Resource Allocation

Resources shall be allocated to all activities including: Cable installation crews, Ladder and support installation crews, Instrument installation crews, Termination gangs, Supervisory staff, and QC/Testing personnel.

Step 6: Baseline Approval

Once approved by the client or PM, the schedule shall be formally baselined. The baseline is used for progress tracking, delay analysis, and formal reporting. No changes to the baseline shall be made without a formal change request.

Step 7: Weekly Progress Updates

Weekly progress updates shall capture: percentage complete per activity, actual start and finish dates, remaining durations, delay events with cause codes, and recovery actions for behind-schedule activities.

2.5 Earned Value Management (EVM)

EVM shall be calculated weekly to track project performance:

- Planned Value (PV) — Budgeted cost of work scheduled.
- Earned Value (EV) — Budgeted cost of work actually performed (rateable quantities x unit rate).
- Actual Cost (AC) — Actual cost incurred for work performed.
- Schedule Performance Index (SPI) = EV / PV — SPI < 1.0 indicates behind schedule.
- Cost Performance Index (CPI) = EV / AC — CPI < 1.0 indicates over budget.

⚠️ MANDATORY: EV calculations must be submitted to the QS and PM every Friday. EV below SPI 0.85 triggers a formal recovery plan submission within 48 hours.

2.6 Lookahead Planning

- 3-Week Lookahead: Issued every Monday; identifies upcoming activities, material requirements, and constraint resolution deadlines.
- 1-Week Lookahead: Issued every Friday for the following week; includes daily work front allocations per supervisor.
- Daily Plan: Distributed at the morning meeting; identifies the day's critical path activities and resource assignments.

2.7 Delay Management

All delays must be formally documented regardless of cause. The following process applies:

33. Identify the delay event and measure the time impact.
34. Record in the Delay Register with date, cause code, impact description, and time lost.
35. Capture photographic and documentary evidence.
36. Notify the client formally where required by contract (access delays, client-caused disruptions).

37. Update the schedule and issue a recovery plan to the PM within 48 hours.

SECTION 3 — HEALTH, SAFETY & ENVIRONMENT (HSE) PROCEDURE

Section	3
Document Ref	GPC-ECI-HSE-001
Legislation	OHSA (South Africa), IEC, SANS

3.1 Purpose

This procedure establishes the minimum health, safety, and environmental requirements for all EC&I construction activities executed by GP Consult SA. It is the responsibility of every person on site to understand and comply with these requirements. Zero harm is the non-negotiable standard.

3.2 Site Induction

All personnel — employees, subcontractors, visitors — must complete a site-specific induction before accessing any work area. Induction shall cover:

- Site rules, access control, and emergency procedures
- Permit to Work (PTW) system and its application
- PPE requirements and consequences of non-compliance
- Incident and near-miss reporting process
- Emergency evacuation routes and assembly points
- Site-specific hazards: electrical, working at height, mechanical, chemical

🔴 NON-NEGOTIABLE: No person shall commence work on site without a completed site induction record on file. Supervisors are responsible for enforcing this requirement.

3.3 PPE Requirements

Work Activity	Mandatory PPE
All site activities	Hard hat, safety boots (steel toe/midsole), hi-vis vest, safety glasses
Cable pulling & terminations	Leather gloves, cut-resistant gloves where required
Working at height (>1.8m)	Full body harness with double lanyard, hard hat with chin strap
Electrical testing (live work)	Insulated gloves (rated), arc flash PPE, face shield
Angle grinding / cutting	Face shield, cut-resistant gloves, hearing protection
Confined space entry	Full harness, retrieval line, gas monitor, standby person

3.4 Permit to Work (PTW) System

A Permit to Work is mandatory for all non-routine work activities. The following permit types apply to EC&I construction:

- General Work Permit — required for all daily construction activities.
- Electrical Isolation Permit — required for all work on or near energised electrical equipment.
- Hot Work Permit — required for welding, grinding, or any activity producing heat or sparks.
- Working at Height Permit — required for all work above 1.8 metres.
- Confined Space Entry Permit — required for work in tanks, pits, conduit vaults, or enclosed spaces.

PTW Process:

38. Work supervisor requests the permit from the site Safety Officer.
39. Risk assessment / JHA is completed and attached to the permit.
40. PTW is reviewed and issued by the authorised Safety Officer.
41. Work commences only after the permit is fully signed off.
42. At end of work or shift, permit is formally closed and filed by the Safety Officer.

🔴 MANDATORY: No work shall commence without a valid, signed PTW in place. Working without a permit is a serious offence and will result in immediate removal from site.

3.5 Lockout/Tagout (LOTO)

LOTO is mandatory for all electrical isolation activities. The procedure shall be:

43. Identify all energy sources to be isolated (electrical, mechanical, pneumatic, hydraulic).
44. Notify affected parties and obtain isolation approval.
45. Isolate all energy sources at source (breakers, isolators, valves, etc.).
46. Apply a personal safety lock AND red tag with worker name and date to each isolation point.
47. Attempt to re-energise to verify isolation is effective (test before touch).
48. Verify zero energy state using an approved voltage tester at the work point.
49. Only the person who applied the lock may remove it. If that person leaves site, the Emergency LOTO procedure applies.

🔴 CRITICAL: Never remove another person's lock. Never assume a circuit is de-energised without verifying with an approved voltage testing device. Failure to follow LOTO is a Category 1 offence.

3.6 Working at Height

- All work above 1.8 metres requires a Working at Height Permit.
- Full body harness with double lanyard must be worn and anchored at all times.
- Scaffold must be erected by a competent person and inspected before use.
- Scaffold inspection tags must be current and visible.
- All tools and materials must be secured against drop — use lanyards for tools, barricade below.
- Ladders must be secured at the top and base; three-point contact maintained.

3.7 Daily Toolbox Talk

A toolbox talk shall be conducted every day before work commences. It is the responsibility of the Site Manager or designated Safety Officer to chair the toolbox talk. The talk shall cover:

- The day's planned activities and associated hazards.
- Review of any incidents or near-misses from the previous day.
- Specific safety precautions for high-risk activities.
- Confirmation that all required permits are in place.

All attendees must sign the Toolbox Talk Register. The register must be filed daily.

3.8 Incident Reporting

Incident Type	Reporting Timeframe	Action Required
Near Miss	Immediately	Record in Near Miss Register; investigate within 24 hours
First Aid	Same day	Record in First Aid Register; Safety Officer notified
Medical Treatment Case	Within 4 hours	Safety Officer + PM notified; investigate within 24 hours
Lost Time Injury (LTI)	Immediately	PM + Client + Safety Manager notified; full

		investigation; mandatory report to DoL
Fatality / Serious injury	Immediately	All work stops; site secured; MD + Client + DoL notified; full investigation

SECTION 4 — CABLE LADDER & TRAY INSTALLATION PROCEDURE

Section	4
Document Ref	GPC-ECI-INS-001
ITP Reference	GPC-ITP-LADDER-001

4.1 Purpose & Scope

This procedure defines the correct installation method for all cable ladders, cable trays, and their supporting structures for EC&I works on GP Consult SA projects. It applies to all cable management systems including heavy-duty cable ladders, perforated cable trays, wire mesh trays, and associated brackets and fittings.

4.2 Pre-Installation Requirements

- Verify AFC drawings are the latest revision and confirm routing with QC before commencing.
- Confirm cable schedule is reviewed and ladder/tray sizing is correct for the cables to be installed.
- Inspect all materials against MRR: check for damage, confirm correct type, material grade, and coating (hot-dip galvanised or SS as specified).
- Confirm supporting structure (civil/steel work) is complete and structurally approved.
- Ensure all permits are in place (Working at Height, General Work Permit).
- Confirm measurement and levelling instruments are calibrated.

4.3 Installation Method

Support Installation:

50. Set out support positions from the AFC drawings; mark brackets at the correct spacing (max 1.5m horizontal / 1.2m vertical or per drawing).
51. Drill and anchor brackets to the structure using approved fixings; verify correct fixing type for the substrate.
52. Apply anti-corrosion compound to all cut or drilled surfaces on galvanised steelwork.
53. Verify brackets are level using a spirit level or laser level before installation of ladders.

Ladder / Tray Installation:

54. Lift and fit cable ladder sections onto the installed brackets; use appropriate mechanical aids for heavy runs.
55. Splice sections together using approved coupling connectors; ensure the coupling covers the full joint width.
56. Verify alignment, levelness, and straight runs throughout; correct any misalignments before proceeding.
57. Install all bends, risers, offsets, tees, and reducers per the AFC drawings.
58. Install fish plates at all joints; torque fasteners to the manufacturer's specified torque values.
59. Install conduit / raceway transitions where shown on drawings.

Earthing:

60. Bond each ladder section with an approved earth bonding conductor throughout the run.
61. Terminate earth bonds to the main earthing system per the earthing drawing.
62. Maximum earth continuity resistance across any single section: 0.1 ohm.

4.4 Quality Inspection Requirements

Inspection Item	Requirement	Hold Point?
Support spacing	Per drawing (max 1.5m)	No

Ladder level / alignment	Within 3mm per metre	No
Splice coupling installation	Correct type; torqued to spec	Yes – QC sign-off
Earth bond continuity	<0.1 ohm per section	Yes – QC test record
All cut surfaces treated	Anti-corrosion applied	No
Overall route vs AFC drawing	100% verification	Yes – QC + Client

SECTION 5 — CABLE INSTALLATION PROCEDURE

Section	5
Document Ref	GPC-ECI-INS-002
ITP Reference	GPC-ITP-CABLE-001

5.1 Purpose & Scope

This procedure covers the installation of all power, control, and instrument cables including pulling, routing, laying, segregation, identification, and making-off prior to termination.

5.2 Pre-Installation Requirements

- Verify cable schedule against AFC drawings; confirm cable type, size, and number of cores for each circuit.
- Inspect cable drums on receipt (MRIR): check for damage, verify drum markings against cable schedule, confirm cable is correct specification.
- Verify cable ladder / tray installation is complete and accepted before cable pulling commences.
- Ensure permits are in place for the work area.
- Confirm cable drum stands and pulling equipment are in good condition.

5.3 Cable Pulling Method

Preparation:

63. Set cable drum on drum stands; position at the pulling end of the run.
64. Unreel cable from the drum in the direction of rotation — never pull cable from a stationary drum.
65. Measure the required cable length from the drum using the cable schedule; allow minimum 500mm spare at each termination end for power cables and 300mm for control/instrument cables.
66. Attach a pulling sock to the cable end for longer runs; do not exceed the manufacturer's maximum pulling tension.

Cable Pulling:

67. Pull cable through the routing in a single continuous pull where possible.
68. Minimum bend radius shall be maintained at all times: 8x cable OD for armoured cables (power), 6x cable OD for instrument cables, or per manufacturer specification if stricter.
69. Use cable guides at bends and changes of direction to prevent kinking.
70. Never allow cables to be dragged across sharp edges or through debris.

Cable Fixing & Segregation:

71. Fix cables to cable ladder using cable cleats at specified intervals (max 300mm on verticals, max 750mm on horizontals for power; max 500mm for control/instrument).
72. Segregate power, control, and instrument cables as per the project segregation philosophy (typically: separate trays or maintain minimum 300mm separation where tray sharing is unavoidable).
73. Install cable separation barriers where different voltage classes share a ladder.

5.4 Cable Identification

- Every cable must be identified with a permanent cable tag at both ends immediately after installation.
- Cable tags must include: cable number (per cable schedule), from/to circuit designation, cable size and type.
- Use UV-resistant, engraved, or stainless steel wire-on tags — not adhesive labels.
- Update the cable schedule to record the cable drum number, drum lengths used, and installed cable route.

5.5 Quality Inspection Requirements

Inspection Item	Requirement	Hold Point?
Cable type vs schedule	100% match	Yes – QC check
Minimum bend radius	Maintained throughout	No – QC observation
Cable segregation	Per segregation philosophy	Yes – QC sign-off
Cable identification tags	Both ends; permanent; correct info	Yes – QC sign-off
Cleating / fixing intervals	Per specification	No – QC observation
Cable slack at termination ends	Min 500mm power / 300mm I&C	No – QC observation

SECTION 6 — CABLE TERMINATION PROCEDURE

Section	6
Document Ref	GPC-ECI-INS-003
ITP Reference	GPC-ITP-TERM-001

6.1 Purpose & Scope

This procedure covers the preparation and termination of all power, control, and instrument cables at MCCs, panels, junction boxes, field instruments, and terminal blocks. It applies to all cable gland installation, screen/drain wire termination, and core identification requirements.

6.2 Tools & Equipment

- Approved cable stripping tools (non-nick type for individual cores)
- Calibrated torque screwdrivers / spanners for terminal tightening
- Approved ferrule crimping tools and correctly sized ferrules
- Cable gland box spanners and thread sealing compound
- Multimeter and continuity tester (calibrated)
- Phase rotation tester (for three-phase power cables)

6.3 Termination Method

Cable Entry & Gland Installation:

74. Select correct cable gland type, size, and IP rating for the enclosure and cable (refer to gland schedule or cable schedule).
75. Install gland plate and cable gland; ensure the gland is correctly tightened — inner seal grips armour, outer seal grips outer sheath.
76. Verify IP integrity: ensure the gland maintains the IP rating of the enclosure.
77. Earthing glands: connect armour earth tag to enclosure earth bar or MCC earth terminal.

Core Preparation:

78. Strip outer sheath to the minimum length required inside the enclosure; avoid excessive slack.
79. Carefully remove armour and inner sheath; do not damage individual cores.
80. Strip individual core insulation using the correct gauge of stripper — never nick the conductor.
81. Apply approved ferrules to all stranded conductors before termination; use the correct size for the conductor cross-section.

Core Identification & Termination:

82. Apply core ferrule labels matching the loop drawing or wiring diagram to every core at both ends before termination.
83. Terminate each core to the correct terminal number as per the wiring diagram; verify against the loop drawing.
84. Torque all terminal screws to the manufacturer's specified torque; use calibrated torque screwdriver.
85. Screen/drain wires: terminate per the loop/instrument drawing — typically earthed at the panel end only (except where specified otherwise).
86. Spare cores: loop out to terminal block; do not leave hanging free.
87. Complete the termination record / wiring checklist and sign off.

⚠ QUALITY HOLD POINT: QC must inspect all terminations before covers are closed. Core labels, ferrules, torque, and wiring diagram compliance must all be verified before the QC signs the termination checklist.

6.4 Post-Termination Testing

- Continuity test: verify ring continuity from panel to field device for every core.
- Insulation resistance (IR) test: measure IR of each cable core-to-core and core-to-earth after termination; minimum 100MΩ at 500VDC for control and instrument cables.
- Phase rotation test: for three-phase power cables, verify phase rotation is correct before energisation.
- Record all test results in the Cable Test Report; attach to the Quality Dossier.

SECTION 7 — INSTRUMENT INSTALLATION PROCEDURE

Section	7
Document Ref	GPC-ECI-INS-004
ITP Reference	GPC-ITP-INST-001

7.1 Purpose & Scope

This procedure defines the installation requirements for all field instruments including transmitters, level instruments, pressure gauges, control valves, flow meters, and associated Decabon impulse tubing. Installation shall be carried out in strict accordance with the project instrument installation details (IID), loop drawings, and instrument data sheets.

7.2 Pre-Installation Checks

- Verify instrument tag number against the instrument index and data sheet before installation.
- Confirm calibration certificate is valid and within date for all instruments requiring calibration.
- Check instrument specification (pressure rating, temperature range, process connection, material) against data sheet.
- Do not install instruments that are not included in the MRIR as approved.

7.3 Mechanical Installation

88. Install instrument stands, brackets, or supports as shown on the installation detail drawing.
89. Mount instruments at the correct orientation (level, vertical, horizontal as specified) and at the correct elevation.
90. Process connections: use approved thread sealant (PTFE tape or approved compound); do not over-torque — use calibrated torque wrench.
91. Verify installed orientation against manufacturer requirements (e.g. flow transmitters are direction-sensitive).
92. Install impulse tubing / Decabon tubing from the process tap to the instrument; support at 500mm centres; slope correctly to allow draining or venting.
93. All instrument process connections must be tested for leak-tightness before commissioning.

7.4 Electrical Connection

94. Follow Section 6 for cable gland and termination requirements.
95. Verify terminal designations against the instrument loop drawing.
96. Observe correct polarity for 4-20mA signals: + to +, – to –.
97. Apply intrinsic safety (IS) requirements where instruments are installed in Zone 1 or Zone 2 hazardous areas.
98. Install cable glanding: correct IP rating; correct Ex entry fitting in hazardous areas.

7.5 Instrument Tagging

- Every instrument must be tagged with its tag number immediately after installation.
- Use engraved stainless steel or approved plastic tags — never adhesive labels in exposed or wet locations.

SECTION 8 — EARTHING & BONDING PROCEDURE

Section	8
Document Ref	GPC-ECI-INS-005
ITP Reference	GPC-ITP-EARTH-001

8.1 Purpose

This procedure covers the installation of all earthing and bonding systems for EC&I works. Effective earthing is critical for personnel safety, equipment protection, and system EMC performance.

8.2 Earthing System Requirements

- All metallic enclosures, equipment frames, and cable management systems shall be earthed.
- Earthing conductor sizes shall be as specified on the earthing drawings; minimum conductor sizes per IEC 60364 / SANS 10142.
- Use approved compression lugs for all earth conductor terminations.
- Cable ladder earth bonding: bond each section with a continuous earth conductor; maximum measured resistance across any section is 0.1 ohm.

8.3 Earthing Installation Method

99. Install earth electrodes (earth rods) at the locations shown on drawings; measure and record Earth Electrode Resistance (EER) before backfill.
100. Install earth conductors (bare copper, PVC-insulated green/yellow, or as specified) along the routes shown.
101. Make all connections using approved compression connectors or cable lugs; no twist-and-tape connections permitted.
102. Inspect all connections for tightness and correct lug size.
103. Apply anti-oxidant compound to all connections before making up.
104. Install earth bars and earth distribution boards as shown.
105. Bond all cable ladders, tray sections, and equipment frames to the nearest earth conductor.

8.4 Testing Requirements

- Earth electrode resistance: measured and recorded for each earth rod using a calibrated earth tester. Maximum resistance per specification (typically ≤ 1 ohm for main electrodes).
- Earth continuity: tested from each piece of equipment back to the main earth point. Maximum resistance: typically 1 ohm total loop resistance.
- All test results to be recorded in the Earthing Test Report and filed in the Quality Dossier.

SECTION 9 — ELECTRICAL TESTING PROCEDURE

Section	9
Document Ref	GPC-ECI-TST-001
ITP Reference	GPC-ITP-TEST-001

9.1 Purpose & Scope

This procedure defines the testing requirements for all installed EC&I works prior to commissioning. All testing shall be performed by a competent person using calibrated test equipment, with results formally recorded. No installation shall be commissioned without successful completion of all pre-commissioning tests.

9.2 Test Equipment Requirements

- All test equipment must be calibrated and within calibration date.
- Calibration certificates must be available on site and attached to the Quality Dossier.
- Test equipment includes: insulation resistance tester (Megger), continuity tester, multimeter (CAT III minimum), clamp meter, phase rotation tester, loop calibrator (4-20mA), loop tester.

9.3 Insulation Resistance (IR) Test — Megger Test

Cable Type	Test Voltage (VDC)	Minimum Acceptable IR
LV Power Cables (up to 1kV)	500 VDC	≥ 1 MΩ per core (minimum; manufacturer's data may be higher)
MV Power Cables (1kV – 11kV)	1000–5000 VDC (per standard)	Per cable manufacturer data sheet
Control Cables	500 VDC	≥ 100 MΩ
Instrument Cables	250–500 VDC	≥ 100 MΩ
Motor Windings	500 VDC	≥ 1 MΩ (PI test recommended for large motors)

IR Test Procedure:

106. Verify cable is disconnected at both ends before testing.
107. Short and earth all cores not under test.
108. Apply test voltage for 1 minute; record the final IR value.
109. Discharge the cable after testing (short all cores to earth for at least as long as the test duration).
110. Record results in the IR Test Record; include cable number, circuit, test voltage, result, and date.

> ⚠ SAFETY: Never megger a cable or equipment while it is connected to other equipment without first verifying that the connected equipment can withstand the test voltage. Ensure LOTO is in place before any IR testing on installed systems.

9.4 Continuity Testing

Continuity testing verifies the integrity of conductors from end to end after termination.

111. Using a calibrated continuity tester or multimeter, verify continuity of each conductor core from terminal to terminal.
112. Verify correct wiring by cross-referencing loop drawings and wiring diagrams.
113. Test earth continuity from equipment frame to earth bar.
114. Record all results on the Continuity Test Record.

9.5 Loop Checking

Loop checking verifies that the complete signal loop from field instrument to the control system (DCS/PLC) is correctly wired, calibrated, and functional.

115. Confirm all cables are terminated correctly per loop drawing at field instrument, junction box, and panel/DCS end.
116. Apply a calibrated 4-20mA signal source at the field instrument terminal (or use instrument simulation).
117. Verify correct signal display at the DCS/PLC tag — 4mA = 0% process variable; 20mA = 100% process variable.
118. Test alarm setpoints: verify LO, HI, LOLO, HIHI alarms annunciate correctly in the DCS.
119. Record calibration data, signal source values, DCS readings, and results in the Loop Test Record.
120. QC Officer and client engineer (where required) to co-sign the loop test record.

9.6 Phase Rotation Test

121. Before energisation of any three-phase motor or equipment, verify phase rotation using a calibrated phase rotation tester.
122. Confirm rotation direction matches motor nameplate and process requirements.
123. Record phase rotation test results on the Phase Rotation Test Record.

SECTION 10 — PRE-COMMISSIONING & COMMISSIONING PROCEDURE

Section	10
Document Ref	GPC-ECI-COM-001
ITP Reference	GPC-ITP-COM-001

10.1 Purpose

This procedure defines the systematic approach for transitioning all EC&I installation from construction completion to a commissioned, client-accepted state. It covers pre-commissioning verification, energisation, functional testing, and final handover.

10.2 Pre-Commissioning Prerequisites

> ⚠ MANDATORY: ALL items below must be completed and signed off by QC before any pre-commissioning activity commences. Partial completion is not acceptable.

- All cable installation complete and accepted (IR tests passed; continuity tests passed).
- All terminations complete and signed off by QC.
- All instruments installed, calibrated, and tagged.
- All earthing and bonding complete and tested.
- All relevant ITPs completed and signed off.
- All NCRs closed or formally accepted with concession.
- Punch list reviewed and outstanding items categorised (A = must close before commission; B = close before handover).
- All Category A punch list items closed.
- Loop folders prepared and pre-filled with test records.
- Client QC notified of pre-commissioning readiness.

10.3 System Energisation Procedure

124. Obtain formal Energisation Permit signed by the client and GP Consult SA Site Manager.
125. Verify all LOTO devices are removed and isolation permits are cancelled.
126. Confirm all personnel are clear of the equipment being energised.
127. Energise at source (MCC, distribution board, or sub-board) in sequence from the supply end.
128. Verify correct supply voltage and phase rotation at the load end before connecting loads.
129. Record energisation sequence, date, time, and approval signatures on the Energisation Record.

10.4 Functional Testing

Motor Functional Test:

130. Verify control circuit: start, stop, E-stop functions operate correctly from local and remote.
131. Verify interlocks and permissives are functioning as designed.
132. Jog test: brief energisation to verify correct motor rotation direction.
133. Run test: confirm motor runs without abnormal noise, vibration, or heat; record run current.

Instrument & Loop Functional Test:

134. With process connected (or simulated), verify correct transmitter output against known process variable.
135. Confirm DCS/PLC displays correct engineering units.
136. Test all configured alarm setpoints and verify annunciation.

137. Test all control loops: manual/auto mode, setpoint changes, and output responses.

Protection & Interlock Testing:

138. Test all protection devices: overloads, temperature switches, pressure switches, proximity switches.
139. Verify all safety interlocks operate correctly and in the correct sequence.
140. Record all test results on the Functional Test Certificates.

10.5 Handover to Client

141. Compile the complete Quality Dossier per system boundary.
142. Review and close all Category A punch list items.
143. Obtain client sign-off on all loop test records and functional test certificates.
144. Issue Mechanical Completion Certificate (MCC) for each system.
145. Transfer all as-built drawings, equipment manuals, and calibration records to client.
146. Conduct formal handover meeting; issue Handover Certificate signed by PM and client representative.

SECTION 11 — INSPECTION & TEST PLAN (ITP) TEMPLATES

Section	11
Document Ref	GPC-ECI-ITP-001

11.1 ITP — Cable Ladder & Tray Installation

Activity	Inspection Point	Type	Acceptance Criteria	GP QC	Client	Record
Material receiving	Check against PO, spec, MRIR	H	Correct type, no damage	✓	W	MRIR
Support installation	Spacing, level, fixing	W	Per drawing; ±3mm level	✓		IR-001
Ladder installation	Alignment, splices, bends	W	Per drawing; correct fittings	✓	W	IR-001
Earth bond installation	Continuity test	H	<0.1 Ω per section	✓	W	Test Report
Final route inspection	Route vs AFC drawing	H	100% as-per-drawing	✓	H	IR-001

ITP Legend: H = Hold Point (work must stop; sign-off required before proceeding) | W = Witness Point (notification required; work may proceed if client does not attend within agreed notice period) | R = Review (review documents only)

11.2 ITP — Cable Installation

Activity	Inspection Point	Type	Acceptance Criteria	GP QC	Client	Record
Material receiving (cables)	Check drums vs cable schedule	H	Correct spec; no damage	✓		MRIR
Cable pulling	Bend radius; segregation	W	Per spec; no damage	✓		IR-002
Cable identification	Tags at both ends	W	Correct tag no.; permanent	✓		IR-002
Cable fixing / cleating	Interval and cleat type	W	Per spec	✓		IR-002
IR test (pre-term)	Core-to-core; core-to-earth	H	Per Section 9 criteria	✓	W	Test Report

11.3 ITP — Cable Terminations

Activity	Inspection Point	Type	Acceptance Criteria	GP QC	Client	Record
Gland installation	Type, size, IP, armour termination	W	Per schedule; IP maintained	✓		IR-003
Core preparation	Ferrules; correct strip length	W	No nicks; correct size	✓		IR-003

Core labelling	Label on every core, both ends	H	Matches loop drawing	✓	W	IR-003
Wiring to terminals	Correct terminals per diagram	H	100% correct	✓	H	IR-003
Torque verification	Terminal torque	W	Per manufacturer torque spec	✓		IR-003
Continuity test	Core end-to-end	H	Correct continuity; per diagram	✓	W	Test Report
IR test (post-term)	Core-to-core; core-to-earth	H	Per Section 9 criteria	✓	W	Test Report

SECTION 12 — NON-CONFORMANCE MANAGEMENT

Section	12
Document Ref	GPC-ECI-NCR-001

12.1 NCR Register

All NCRs shall be entered into the NCR Register and tracked to closure. The register shall be reviewed weekly at the site quality meeting.

NCR No.	Date Raised	Description	Root Cause	Corrective Action	Responsibility	Target Date	Status	Close Date

12.2 NCR Classification

Classification	Description	Response Required
Major NCR	Non-conformance that affects safety, structural integrity, or system functionality	Immediate stop-work; client notification required; formal corrective action plan within 24 hours
Minor NCR	Non-conformance that does not immediately affect safety or functionality but does not meet specification	Corrective action within agreed timeframe; QC sign-off on closure
Observation	Potential non-conformance or substandard workmanship that does not yet require formal NCR	Documented and addressed proactively; reviewed at weekly QC meeting

12.3 Corrective Action Verification

All corrective actions must be verified by the QC Officer before an NCR is closed. Where the NCR was raised against a client hold point, the client must co-sign the closure record. Closed NCRs shall be filed in the Quality Dossier.

Document Sign-Off:

_____ _____

Dave Opperman Date

Manager – Projects | GP Consult SA

_____ _____

Site Manager / PM (Site) Date

— End of EC&I Construction Procedures Manual —