

VOLUME 3
Technical specifications

Section 4
Testing, Operation, Maintenance and Training
Requirements

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1. INTRODUCTION

The present Tender requires the Tenderer to guarantee that the new electrical traction substation (ETS) Trebešica will supply overhead contact line (OCL) with electrical energy.

1.1 DEFINITIONS

1.1.1 *Technical Completion*

All civil, mechanical, electrical and control components and related functions are finished, tested, found in compliance with the contract conditions and accepted by the Engineer.

1.1.2 *Process Completion*

The technically completed plant has operated under normal conditions for a period of at least two months and the overhead contact line has been supplied with electrical energy.

At the end of the Commissioning Period, the Works are handed over to the Engineer (Taking-Over Certificate) and periodical monitoring of the operation of the substation shall be done by the Contractor during the following Defect Notification Period.

1.1.3 *Test on Completion*

Tests on Completion mean the tests which are specified in the Contract or agreed by both Parties or instructed as a Variation, and which are carried out under Clause 9 [Tests on Completion] before the Works or a Section (as the case may be) are taken over by the Engineer.

1.1.4 *Trial Operation*

Trial operation shall demonstrate that the Works or Section perform reliably and in accordance with the Contract.

1.1.5 *Defects Notification Period*

The period immediately following the date of taking over, during which the Contractor is required to remedy defects or faults as instructed by the Engineer. The Defects Notification Period is defined in the Contract. At the end of the Defects Notification Period and under the condition that all defects have been successfully remedied the Performance Certificate shall be issued.

1.1.6 *Preventive Maintenance*

The care and servicing by personnel for the purpose of maintaining equipment and facilities in a satisfactory operating condition by providing for systematic inspection, detection, and correction of incipient failures either before they occur or before they develop into major defects.

Maintenance includes tests, measurements, adjustments and parts replacement performed specifically to prevent faults from occurring.

Preventive Maintenance is carried out by Beneficiary.

1.1.7 *Corrective Maintenance*

Corrective maintenance is a maintenance task performed to identify, isolate and rectify a fault so that the failed equipment, machine, or system can be restored to an operational condition within the tolerances or limits established for in-service operations.

Corrective Maintenance is to be carried out by the Contractor during the Defect Notification Period and within the scope of warranty obligations exceeding the DNP.

2. TESTS - STRUCTURAL STEEL AND IRON WORK

2.1 GENERAL

All materials to be supplied and installed shall be in accordance with the relevant standards. Selection of samples for testing material will be made by the Engineer.

2.2 TESTS PRIOR TO SHIPMENT

Before and during manufacture, the Engineer shall have access to all workshops as and when required.

The tests and inspection shall be carried out by an authorized person assigned by the Engineer. The acceptance and test certificates shall be made available to the Engineer in an adequate number of copies. Castings and forgings shall be tested by suitable modern procedures. Tests are to be carried out on the premises of the manufacturer of castings and forgings on work pieces in the rough state in order to detect flaws in good time and therefore to avoid delays in delivery as far as possible. After partial machining in the works of the manufacturer, further tests may be carried out.

The Contractor shall allow the Engineer access to any and all test reports on request. If necessary, parts of the structure may be provisionally assembled in the assembly shops of the Contractor in order to check the correctness of dimensions and joints.

2.3 TESTING ON SITE

During erection, the Contractor shall carry out all necessary inspection checks and tests at suitable intervals in order to guarantee safety on the Site under the given conditions of erection and an orderly execution of the erection in accordance with the specifications, the drawings and the erection regulations. After final erection of the structure, inspections, checks and tests shall be carried out by the Contractor in the presence of the Engineer in order to demonstrate the completeness of the works, the correctness of the assembly and evidence of the guaranteed performance values.

To facilitate inspections and maintenance, the structures shall be provided with steps, ladders, handrails, screens, guards and other facilities in approved positions.

The following tests shall be performed at the Contractor's expense in approved laboratories:

- ▶ tensile tests, bending tests and chemical analysis for every 10 tons of structural steel delivered to the workshop,
- ▶ bolts shall be checked wherever required by the Engineer,
- ▶ 10% (ten per cent) of welded joints shall be examined by radio-graphical tests. In addition, all welded parts shall be tested by ultrasonic testing devices and visually investigated to ensure the quality of weld. Additional radio-graphical tests shall be performed in case the tested joints prove defective,
- ▶ samples simulating welded parts shall be tested radio-graphically and in tension to prove quality of weld.

2.4 INSPECTION

The Engineer will provide an Inspector for shop and field inspection of structural steel items.

Inspection, shop or field, in no way relieves the Contractor from its responsibility to furnish satisfactory materials and workmanship, and the right is reserved to reject any material or work at any time before the final acceptance if, in the opinion of the Inspector, the material and/or workmanship do not conform to the requirements of the Contract.

The Engineer shall have full access at all times and at all points where work is being done or where materials are stored and shall have full authority to reject or have corrected any work or material that fails to conform to the Terms of the Contract.

The Engineer, in addition to the visual inspection, may order weld testing radiographic or any other standard non-destructive testing method at the places and locations as selected by him. The necessary shop assistance for satisfactory execution of testing shall be supplied by the Contractor.

If any one individual connection or any tested 5% length of total welding length in a continuous built-up member ready for shipping to field is found to contain cracks of 4% or more of defective welding length to such extent that welds are not acceptable in accordance with the specified standards, the Engineer can call at selected locations for additional testing until the extent of defects is determined or in one continuous built-up member ready for shipping to field falls below 4% of total welding length in the member. In such a case, all the non-destructive testing and retesting cost for the particular built-up member performed by the Engineer's selected testers shall be borne by the Contractor. All welding rejected by the Engineer due to defects discovered by testing or visual inspection shall be remedied at the expense of the Contractor.

2.4.1 Scope of Inspections

The following services can be requested:

- ▶ examination and finalization of welding procedure,
- ▶ inspection of welding material and electrodes to be used,
- ▶ check or qualifying tests and approval of welders,
- ▶ supervision and examination of welds,
- ▶ inspection of X-rays made by the Contractor,
- ▶ attendance at hydraulic tests and making good of welds,
- ▶ check of special tests in the event those performed by the Contractor are judged to be unsuitable,
- ▶ writing of reports, the number of copies to be supplied is stated in the respective article of the General Requirements.

2.5 X-RAY EXAMINATION OF WELDS

Ten per cent (10%) of welds shall be X-rayed. The areas to be X-rayed shall be those designated by the Engineer. X-rays of welds, any making good of welds declared unacceptable by the Engineer as well as any further X-rays which may be required after making good, shall be performed by the Contractor at its own expense.

If there are any unacceptable welds, the Engineer can require 100% X-ray at the Contractor's own expense.

The films shall be numbered using a code which should correspond to that established in the Special Conditions.

The X-rays shall be interpreted using all API 650 or other international applicable standards.

3. TESTS - TECHNOLOGICAL EQUIPMENT

3.1 GENERAL

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties.

Testing shall comply with Section 1 - General Technical Requirements. All tests of the materials and equipment shall be made in accordance with IEC standards if not otherwise agreed with the Engineer. If some test are not covered or a method of testing is not specified in the IEC standards or

if there are options in the relevant IEC standards, the Contractor shall submit the method by which he proposes to conduct the tests to the Engineer for the approval.

The following lists of tests do not preclude the Engineer's right to call for further tests if he considers these necessary at no extra cost to the Engineer.

High temperature operation tests shall be performed at the maximum ambient temperature of 40°C. Type tests shall be performed for each type and rating of the specified equipment with the purpose of proving its properties.

Routine test shall be performed for each piece of equipment to be supplied for the purpose of revealing faults in material or construction. They shall not impair the properties and reliability of a test object or reduce its lifetime.

3.1.1 Tests on Completion

After completion of the ETS technology units, the following tests and measurements shall be performed:

- ▶ test of power, protective and auxiliary circuits and test of protections and their settings according to specific rules,
- ▶ test of local and remote control and signalling for all switches, circuit breakers and disconnectors, and gas insulated switchgears,
- ▶ comprehensive testing of transformers,
- ▶ test of the Uninterruptible Power Supplies, batteries, including the charging device,
- ▶ control and test of protective and operating earthing,
- ▶ control of connections to junction boxes and control cable terminals,
- ▶ test of fire protection, control of protective equipment,
- ▶ dielectric test of insulation under the applicable technical standards.

3.2 CIRCUIT BREAKERS

3.2.1 Workshop Test

3.2.1.1 Type Test

The following type tests shall be performed:

- ▶ dielectric tests:
 - ▶ power frequency voltage tests (dry and wet conditions),
 - ▶ lightning impulse voltage tests,
- ▶ artificial pollution tests,
- ▶ partial discharge tests,
- ▶ test on auxiliary and control circuit,
- ▶ radio interference voltage (R.I.V.) test,
- ▶ measurement of resistance of the main circuits,
- ▶ temperature rise test,
- ▶ short time withstand current and peak withstand current test,
- ▶ verification of the degree of protection,
- ▶ tightness test,
- ▶ electromagnetic compatibility (EMC) tests,
- ▶ mechanical and environmental tests,
 - ▶ miscellaneous provisions for mechanical and environmental tests,
 - ▶ mechanical operation test at ambient air temperature,
 - ▶ low and high temperature tests,
 - ▶ humidity tests,
- ▶ static terminal load tests,

- ▶ short circuit current making and breaking tests, including short line fault tests terminal fault tests and out of phase making and breaking test,
- ▶ capacitive current switching tests,
- ▶ magnetizing and small inductive current switching tests.

3.2.1.2 Routine Tests

The following routine tests shall be performed:

- ▶ dielectric test of the main circuit including partial discharge measurement,
- ▶ dielectric test of auxiliary and control circuits,
- ▶ measurements of resistance of the main circuit,
- ▶ tightness test,
- ▶ design and visual checks,
- ▶ mechanical operating tests,
- ▶ Measurement of gas condition

3.2.2 Site Tests

3.2.2.1 General

Upon their arrival on Site and during and after the completion of erection, all items of equipment shall be inspected and tested so as to ensure that there is no delay in the commissioning due to a supply of incorrect or damaged equipment. The site tests are subdivided into stages:

- ▶ tests during and after completion of erection,
- ▶ tests on completion.

3.2.2.2 Tests During and After the Completion of Erection

In order to ensure correct installation of the equipment as well as to prove that the equipment has been correctly installed, the following tests shall be performed during and after the completion of erection of all equipment:

- ▶ verification of proper and complete erection,
- ▶ verification of a proper condition of porcelains, sealings and external surfaces,
- ▶ verification of proper connections to the earthing system,
- ▶ checking of circuit breaker bolted connections by a torque spanner,
- ▶ verification of the operation of operating mechanism,
- ▶ preliminary checking of control and protection circuits and wiring,
- ▶ preliminary measuring of the insulation resistance by a Megger,
- ▶ checking of the proper cabling and operation of all electrical low voltage equipment,
- ▶ voltage tests of all electrical low voltage circuits.

After a successful completion of all foregoing tests, the tests on completion specified below may follow.

3.2.2.3 Tests on Completion

The main objective of the tests on completion is to check proper and safe operation of the equipment and in particular to verify and confirm the performance guarantee.

The following tests on completion of the circuit breakers shall be performed:

- ▶ insulation resistance measuring by a 2500 V Megger,
- ▶ operation test of the “Open – Close” mechanism,
- ▶ checking of the complete wiring for individual and remote control and signalling,
- ▶ voltage test of all low voltage circuits,
- ▶ checking of contacts for protection against maloperation.

The tests shall be performed while observing the applicable approved standards, in particular the IEC standards.

After a successful completion of all tests on completion the equipment shall be subject to a Defects Notification Period.

3.3 DISCONNECTORS & EARTHING SWITCHES

3.3.1 Workshop Test

3.3.1.1 Type Test

The following type tests shall be performed:

- ▶ dielectric tests:
 - ▶ power frequency voltage tests (dry and wet conditions),
 - ▶ lightning impulse voltage tests,
- ▶ artificial pollution tests,
- ▶ partial discharge tests,
- ▶ test on auxiliary and control circuits,
- ▶ radio interference voltage (R.I.V.) test,
- ▶ measurement of the resistance of the main circuits,
- ▶ temperature rise test,
- ▶ short time withstand current and peak withstand current test,
- ▶ test to prove the short-circuit making and breaking performance of earthing switches (as applicable),
- ▶ operating and mechanical endurance tests,
- ▶ operation under severe ice conditions,
- ▶ operation at the temperature limits.

3.3.1.2 Routine Tests

The following routine tests shall be performed:

- ▶ dielectric test of the main circuit including partial discharge measurement,
- ▶ dielectric test of auxiliary and control circuits,
- ▶ measurements of the resistance of the main circuit,
- ▶ mechanical operating tests.

3.3.2 Site Tests

3.3.2.1 General

Upon their arrival on Site and during and after the completion of erection, all items of equipment shall be inspected and tested so as to ensure that there is no delay in commissioning due to a supply of incorrect or damaged equipment. The Site tests are subdivided into stages:

- ▶ tests during and after the completion of erection,
- ▶ tests on completion.

3.3.2.2 Test During and After Completion of Erection

In order to ensure correct installation of the equipment as well as to prove that the equipment has been installed correctly, the following tests shall be performed during and after the completion of erection on all equipment:

- ▶ verification of proper and complete erection,
- ▶ verification of a proper condition of porcelains, sealings and external surfaces,
- ▶ verification of proper connections to the earthing system,
- ▶ checking of disconnector & earthing switch bolted connections by a torque spanner,

- ▶ verification of the operation of operating mechanism,
- ▶ preliminary checking of control and protection circuits and wiring,
- ▶ preliminary measuring of the insulation resistance by a Megger,
- ▶ checking of the proper cabling and operation of all electrical low voltage equipment,
- ▶ voltage tests of all electrical low voltage circuits.

After a successful completion of all foregoing tests the tests on completion specified below may followed.

3.3.2.3 Tests on Completion

The main objective of the tests on completion is to check proper and safe operation of the equipment and in particular to verify and confirm the performance guarantees. The following tests on completion of the circuit breakers shall be performed:

- ▶ insulation resistance measuring by a 2500 V Megger,
- ▶ operation test of the “Open – Close” mechanism, manual and electro/mechanical,
- ▶ closing and opening tests at a reduced voltage,
- ▶ checking of operating time,
- ▶ checking of complete wiring for individual and remote control and signalling,
- ▶ voltage test of all low voltage circuits,
- ▶ checking of contacts for protection against maloperation (interlock checks).

The tests shall be performed while observing the applicable approved standards, in particular the IEC standards.

After a successful completion of all tests on completion the equipment shall be subject to a Defects Notification Period.

3.4 TRACTION TRANSFORMERS

3.4.1 Workshop Tests

3.4.1.1 Type Tests

These tests shall be carried out for the traction transformer. If evidence is available of a successful type test on an identical transformer or a transformer, which is similar for practical test purposes, by a recognized independent testing laboratory or independently witnessed, this may be accepted in lieu of these tests. The decision of the Engineer shall be final in that respect. The type test documents must be submitted and evaluated in the Tender Document. The type test certificate shall not be older than five (5) years for electronic equipment and ten (10) years for other equipment.

The following type tests shall be included:

- ▶ temperature rise test (this test shall be carried out with the transformer at the tap positions resulting in the highest losses and with the standby cooling unit out of service),
- ▶ measurement of power absorbed by cooling system.

3.4.1.2 Routine Tests

The following routine tests shall be performed:

- ▶ measurement of winding resistances,
- ▶ measurement of voltage ratio and check of voltage vector relationship,
- ▶ measurement of impedance voltage (principal, minimum and maximum tapping) short-circuit impedance and load loss,
- ▶ measurement of no-load losses and no-load current at rated frequency and nominal voltage,
- ▶ full-wave impulse test (LI),

- ▶ induced-voltage test with measurement of partial discharges,
- ▶ separate source voltage test (ACLD),
- ▶ tests on on-load tap-changers,
- ▶ oil test (see clause here-below),
- ▶ function tests of auxiliary equipment,
- ▶ measurement of insulation of core,
- ▶ measurement of dielectric factor of losses ($\tan \delta$ shall be $< 0,5$),
- ▶ measurement of insulation resistance by 5000 V d.c. 15 s and 60 s (by a Megger).

The following shall be the minimum values of insulation measurements:

- ▶ for 110 kV transformer side after 60 s at least the 4 000 MΩ,
- ▶ for 27,5 kV transformer side after 60 s at least the 1 500 MΩ.

Based of the measurement of insulation resistance values after 15 s and 60 s the factor of absorption shall be calculated (R_{60} / R_{15}) (which shall be at least 1,2).

3.4.1.3 Special Tests

The following special tests shall be performed:

- ▶ measurement of zero-sequence impedance,
- ▶ measurement of noise level, in accordance with NEMA No. TR 1,
- ▶ short-circuit test (IEC 60076-5).

Note: Transformer's ability to withstand without damage the thermal and dynamic effects of external short circuits shall be demonstrated by calculation and design considerations. Therefore, the transformers shall not be subjected to the short-circuit test, i.e. the short-circuit test shall not be carried out.

3.4.2 Site Tests

3.4.2.1 General

Upon their arrival on Site and during and after the completion of erection, all items of equipment shall be inspected and tested so as to ensure that there is no delay in the commissioning due to a supply of incorrect or damaged equipment. The site tests are subdivided into stages:

- ▶ tests during and after the completion of erection,
- ▶ tests on completion.

3.4.2.2 Test During and After Completion of Erection

In order to ensure a correct installation of the equipment as well as to prove that the equipment has been installed correctly, the following tests shall be performed during and after completion of erection of all equipment:

- ▶ verification of proper and complete erection,
- ▶ verification of a proper condition of porcelains, sealings and external surfaces,
- ▶ verification of the proper connections to the earthing system,
- ▶ checking of transformer bolted connections by a torque spanner,
- ▶ voltage withstand test on transformer oil,
- ▶ verification of operation of the cooling system,
- ▶ verification of proper operation of off-circuit tap changer before connecting of the transformer to voltage,
- ▶ capacitance and angle of losses measurement,
- ▶ preliminary checking of control and protection circuits and wiring,

- ▶ preliminary measuring of insulation resistance by a Megger,
- ▶ checking of proper cabling and operation of all electrical LOW VOLTAGE equipment,
- ▶ voltage tests of all electrical low voltage circuits,
- ▶ measurement of physical, chemical, and electrical characteristics of the oil after filling,
- ▶ verification of turns ratio with measurement of charging current using low voltage supply,
- ▶ I.R. Measurements on winding with record of oil & ambient temperature,
- ▶ measurement of no-load (magnetising) current,
- ▶ verification of insulation of core,
- ▶ capacitance and angle of losses measurement for 110 kV bushings.

After a successful completion of all foregoing tests, the tests on completion specified below may follow.

3.4.2.3 Tests on Completion

Main objective of the tests on completion is to check proper and safe operation of the equipment and in particular to verify and confirm the performance guarantees.

The following tests on completion of the traction transformers shall be performed:

- ▶ insulation resistance measuring by a 5000 V d.c. Megger,
- ▶ operation test of Buchholz relay,
- ▶ operation tests of thermometers,
- ▶ operation tests of cooling system (valves, etc.),
- ▶ checking of complete wiring for individual and remote control and signalling,
- ▶ voltage test on all low voltage circuits,
- ▶ checking of excitation curve by raising the voltage through a variation of generator voltage,
- ▶ measurement of physical, chemical and electrical characteristic of the transformer oil after filling,
- ▶ checking of contacts for protection against maloperation of the tap changer.

The tests shall be performed while observing the applicable approved standards, in particular the IEC standards.

After a successful completion of all tests on completion the equipment shall be subject to a Defects Notification Period.

3.5 TESTS OF TRANSFORMER COMPONENTS

Tests of transformer components during and after manufacture shall be carried out in order to verify their compliance with the Specifications, good workmanship and their capability to perform the required duties when in service.

Unless otherwise specifically mentioned, these tests shall be made in accordance with the one of the applicable international standards, subject to the approval of the Engineer, or according to a method proposed by the Contractor and approved by the Engineer.

3.5.1 Transformer Tanks

3.5.1.1 Type Tests

Vacuum:

- a. A test at a vacuum equivalent to 0,3 kPa (3 mbar) absolute pressure for a period of 8 hours shall be performed for the purpose of checking the mechanical withstand capability of the tank; during this test, no damage or fractures shall occur. This test may be combined with other tests or performed during processing of the unit.

Pressure:

a. The transformer tank shall be subjected to a pressure corresponding to the normal pressure plus 35 kPa. After the releasing the excess pressure, there shall be no permanent deflection of the stiffeners nor shall the permanent deflection of panels between stiffeners exceed standard values. This test may be combined with a routine oil leakage test.

b. The tap-changer barrier shall be shown to withstand an over pressure test of normal pressure plus 35 kPa during 12 hours.

Pressure Relief Device:

When required by the Engineer, the pressure relief device shall be subject to increasing oil pressure and shall operate before reaching normal pressure plus 35 kPa.

The operating pressure shall be recorded on the test certificate.

3.5.1.2 Routine Tests

Oil leakage:

All tanks and oil filled compartments including all forms of radiators shall be tested for oil tightness by being completely filled with oil of a viscosity not greater than that of IEC 60296 insulating oil at a temperature of 15°C and subject to a pressure equal to normal pressure plus 35 kPa. This pressure shall be maintained for a period of not less than 24 hours, during which time no leakage shall occur.

The tap-changer barrier shall be subject to normal oil pressure head for 24 hours, during which time there shall be no leakage from the panel or bushings.

3.5.2 Fans, Motors, Pipework, Oil Sampling Devices and Valves

3.5.2.1 Type Tests

Motors:

Performance tests shall be in accordance with IEC 60034-1. However, certificates of type tests in accordance with IEC will be accepted.

Except for non-return valves, all valves and oil sampling devices which are subject to oil pressure in service or during maintenance shall withstand, when empty of oil, absolute pressure not exceeding 35 kPa. In case of valves this test is to be applied to their bodies only. This type test shall subsequently be followed by a repeated oil leakage test.

3.5.2.2 Routine Tests

Fans:

Static and dynamic balance shall be checked of all fan impellers.

Control gear:

All control gear shall be subject to the tests specified in the appropriate IEC.

Motors:

Each machine shall be subject to the following tests where applicable:

- ▶ measurement of winding resistance (cold),
- ▶ no load test at rated voltage for determination of fixed losses,
- ▶ an overvoltage test at 1.5 times rated voltage applied with the machine running at no load, for a period of 3 minutes, to test interturn insulation,
- ▶ high voltage in accordance with IEC 60034-1.

3.5.3 Oil

3.5.3.1 Sample Tests

Samples of oil from each consignment shall be tested in accordance with IEC 60296 before despatch.

As a minimum, the following tests shall be performed:

- ▶ electric strength of oil,

- ▶ physical and chemical analyses,
- ▶ chromatographic analyses.

Subject to an agreement of the Engineer a test certificate, confirming that the oil from which the consignment was drawn has been tested in accordance with IEC 60296, may be accepted. Before commissioning any transformer, the electric strength of its oil shall be check-tested and the results approved by the Engineer.

3.5.4 Gas and Oil Actuated Relays

3.5.4.1 Routine Tests

The following tests of relays shall be performed when completely assembled. Where oil is referred to, it shall have a viscosity not greater than that of IEC 60296 insulating oil at 15°C.

Oil leakage:

The relay, when filled with oil shall be subjected to an internal pressure of 140 kPa for 15 minutes. No leakage shall occur either from the casing or into normally oil free spaces, such as floats, within the casing.

Gas Collection:

- ▶ with the relay mounted as in service and at a rising angle of 5 degrees (tank to conservator) and full of oil, gas shall be introduced into the relay until the gas collection contacts close. The oil level contacts shall not close when gas is escaping freely from the relay on the conservator side. These contacts shall, however, close when the pipework is empty of oil,
- ▶ the empty relay shall be tilted, as if mounted in pipework rising from tank to conservator, at an increasing angle until the gas collection contacts open. The angle of tilt shall then be reduced and the gas collection contacts shall close before the angle is reduced to less than 13 degrees to the horizontal,
- ▶ with the relay mounted at a falling angle of 16 degrees to the horizontal and full of oil, the gas collection contacts shall be open.

Oil surge:

With the relay mounted as in service and full of oil at approximately 15°C, the surge contacts shall close within the steady oil flow limits specified in the Schedules. This operation shall not be adversely affected when the gas collection contacts have already closed and gas is escaping freely.

Voltage:

With the relay empty of oil, a voltage of 2 kV shall be applied in turn between each of the electrical circuits and the casing for one minute, the remaining circuits being connected to the casing.

3.5.4.2 Sample Test

At the discretion of the Engineer, the following tests shall be made:

- ▶ Variation of performance with mounting angle with the mounting conditions as in service, the mounting angle shall be varied within the rising angle limit 10° and 90° and tests repeated in the manner prescribed for routine tests.

3.5.5 Voltage Control Equipment

Type and routine tests shall be carried out in accordance with IEC 60214.

3.5.6 Tests of Bushings

It is not intended to test the bushings separately during the transformer factory tests. The Contractor shall submit for approval tests, records and data for all bushings for transformers including spare bushings. These tests shall at least give the following results:

- ▶ standard 1 min power frequency dry/wet withstand tests for all types of bushings,

- ▶ impulse tests (1.2/50 microseconds) for all types of bushings,
- ▶ the creepage distance shall be verified at the factory,
- ▶ capacitance and angle of losses measurement of 110 kV bushings.

3.5.7 Structures

A representative sample of support structure being provided shall be assembled prior to despatch to the site, and loads applied which simulate the specified design parameters.

3.5.8 Handling Devices and Lifting Tackle

3.5.8.1 Routine Tests

Mechanical Tests

All handling devices and lifting tackle supplied for maintenance purposes under this Contract shall, unless they are built into and form part of the equipment, be tested and marked and certificates of the test provided in the manner required by the appropriate regulations.

3.5.9 Dielectric Tests in Auxiliary and Control Circuit

All secondary wiring, including panel wiring and control circuits and all apparatus connected directly thereto shall withstand a high voltage test of 2.000 V to earth unless otherwise specified.

3.6 CURRENT TRANSFORMERS

3.6.1 Workshop Tests

3.6.1.1 Type Tests

The following type tests shall be performed:

- ▶ short-time current tests,
- ▶ temperature rise test,
- ▶ lightning impulse tests,
- ▶ switching impulse tests,
- ▶ wet test (power frequency voltage or switching impulse voltage),
- ▶ determination of errors,
- ▶ type test for Instrument security factor of measuring current transformers,
- ▶ type tests for current error and phase displacement of protective current transformers,
- ▶ type test for composite error of protective current transformers,
- ▶ radio interference voltage (R.I.V.) test,
- ▶ measurement of capacitance and dielectric dissipation factor.

3.6.1.2 Routine Tests

The following routine tests shall be performed:

- ▶ tests for verification of terminal markings,
- ▶ power frequency withstand tests of primary windings,
- ▶ partial discharge measurement,
- ▶ power frequency withstand tests of secondary windings,
- ▶ power frequency withstand between sections,
- ▶ inter-turn overvoltage test,
- ▶ determination of errors,
- ▶ test for Instrument security factor of measuring current transformers,
- ▶ tests for current error and phase displacement of protective current transformers,
- ▶ test for composite error of protective current transformers,
- ▶ measurement of capacitance and dielectric dissipation factor.

3.6.2 Site Tests

3.6.2.1 General

Upon their arrival on Site and during and after the completion of erection, all items of equipment shall be inspected and tested so as to ensure that there is no delay in the commissioning due to a supply of incorrect or damaged equipment. The site tests are subdivided into stages:

- ▶ tests during and after completion of erection,
- ▶ tests on completion.

3.6.2.2 Test During and After Completion of Erection

In order to ensure correct installation of the equipment as well as to prove that the equipment has been installed correctly, the following tests shall be performed during and after completion of erection for all equipment:

- ▶ verification of proper and complete erection,
- ▶ verification of a proper condition of porcelains, sealings and external surfaces,
- ▶ verification of proper connections to the earthing system,
- ▶ checking of current transformer bolted connections by a torque spanner,
- ▶ secondary winding resistance and burden measurement,
- ▶ ratio test and checks by primary and secondary injection.

After a successful completion of all foregoing tests, tests on completion specified below may follow.

3.6.2.3 Tests on Completion

The main objective of the tests on completion is to check proper and safe operation of the equipment and in particular to verify and confirm the performance guarantee.

After a successful completion of all tests on completion the equipment shall be subject to a Defects Notification Period.

3.7 VOLTAGE TRANSFORMERS

3.7.1 Workshop Tests

3.7.1.1 Type Tests

The following type tests shall be performed:

- ▶ temperature rise test,
- ▶ short-circuit withstand capability test,
- ▶ lightning impulse tests,
- ▶ switching impulse test,
- ▶ wet test (power frequency voltage or switching impulse voltage),
- ▶ determination of errors,
- ▶ type test for accuracy of measuring voltage transformers,
- ▶ type test for accuracy of protective voltage transformers,
- ▶ radio interference voltage (R.I.V.) test,
- ▶ temperature rise test.

3.7.1.2 Routine Tests

The following routine tests shall be performed:

- ▶ verification of terminal markings,
- ▶ power frequency withstand tests of primary windings,
- ▶ partial discharge measurement,

- ▶ power frequency withstand tests of secondary windings,
- ▶ power frequency withstand between sections,
- ▶ determination of errors,
- ▶ routine test for accuracy of measuring voltage transformers,
- ▶ routine test for accuracy of protective voltage transformers,
- ▶ measurement of capacitance and dielectric dissipation factor.

3.7.2 Site Tests

3.7.2.1 General

Upon their arrival on Site and during and after the completion of erection, all items of equipment shall be inspected and tested so as to ensure that there is no delay in the commissioning due to a supply of incorrect or damaged equipment. The Site tests are subdivided into stages:

- ▶ tests during and after the completion of erection,
- ▶ tests on completion.

3.7.2.2 Test During and After Completion of Erection

In order to ensure correct installation of the equipment as well as to prove that the equipment has been installed correctly, the following tests shall be performed during and after the completion of erection on all equipment:

- ▶ verification of proper and complete erection,
- ▶ verification of a proper condition of porcelains, sealings and external surfaces,
- ▶ verification of proper connections to the earthing system,
- ▶ checking of voltage transformer bolted connections by a torque spanner,
- ▶ no-load test with normal applied voltage on secondary terminals for a minimum 30 minutes,
- ▶ burden measurement,
- ▶ ratio test and checks by primary and secondary injection.

After a successful completion of all foregoing tests, tests on completion specified below may follow.

3.7.2.3 Tests on Completion

The main objective of the tests on completion is to check proper and safe operation of the equipment and in particular to verify and confirm the performance guarantee.

After a successful completion of all tests on completion the equipment shall be subject to a Defects Notification Period.

3.8 OTHER TECHNOLOGICAL EQUIPMENT

Upon their arrival on Site and during and after the completion of erection, all items of equipment shall be inspected and tested so as to ensure that there is no delay in the commissioning due to a supply of incorrect or damaged equipment. The Site tests are subdivided into stages:

- ▶ tests during and after the completion of erection,
- ▶ tests on completion.

4. TRAINING

4.1 GENERAL

The Contractor shall be required to provide on-site training of the final Beneficiary's assigned local staff in managing, operating and maintaining the Works during the last three (3) months before Taking Over.

The total allowance to cover the Contractor's expenses in connection with the training shall be included in the Volume 4, Section 2 - A. General Items, item A.11 of this Tender. This shall include travelling (airplanes, taxis, buses, etc.), accommodation and per diem allowance.

The Contractor shall carry out the training on the basis of a "Structured Programme", which shall be submitted not less than two (2) months before the start of the training period for review and approval to the Engineer and to the appointed Beneficiary's Representative.

The training shall in general consist of familiarisation with operational aspects of the system as a whole, followed by familiarisation with the specific items of equipment.

The training shall be based on the actual Plant and the implementation of operation and maintenance schedules outlined in the operation and maintenance manuals provided by the Contractor.

The training for each piece of equipment shall have a duration of not less than one week, to the satisfaction of the Engineer representing the Beneficiary.

The Contractor shall be required to provide practical instructions to the final Beneficiary's assigned local staff to ensure that by the end of this period the staff will be considered by the final Beneficiary to be capable of managing, operating and maintaining the Works to the highest internationally accepted standards without additional supervision.

The training to be provided in advance of commissioning is aimed at enabling the Beneficiary's staff to participate in the full process commissioning of the system.

The Contractor shall allow for training of the following personnel:

- ▶ substation operative and maintenance personnel,
- ▶ engineers and technicians,
- ▶ substation manager.

The trainees shall be allowed the unhindered access at any time to any part of the Works/Substation.

The liability for the entire Works the during training remains with the Contractor, irrespective of who may be responsible for any fault or damage.

4.2 TRAINING PROGRAMME

As a minimum, the training programme shall include, without any limitations, to the following:

- ▶ general training covering the principle of the ETS regarding its functional, electrical and mechanical processes,
- ▶ operational training: practice in the operation of all electrical and mechanical equipment and its effect on the substation operation. Normal operation of all processes and "Troubleshooting",
- ▶ automation training: covers programming, application design, and debugging principles and practise,
- ▶ the training procedure shall include an introduction of the software used to the staff,
- ▶ preventive maintenance, covering all electrical and mechanical equipment,
- ▶ health and safety procedures and training.

4.3 TRAINING TO BE PROVIDED IN ADVANCE OF COMMISSIONING

This course shall be designed to familiarize the assigned Beneficiary's staff with overall running of the standard operation system including but not limited to:

- ▶ connection and disconnection of the ETS,
- ▶ system operator interface (local, remote),
- ▶ operator control of programme/task execution,
- ▶ PLC system interrogation facilities – alarm lists, log printouts select mimic and trend display etc.,
- ▶ all functions associated with each access level of the PLC system.

4.4 EXECUTION OF TRAINING

To ensure that adequate training is provided, the training personnel of the Contractor shall carry out each and every operation and maintenance activity identified in the Operation, Maintenance and Safety Manuals and shall train the final Beneficiary's personnel to carry out these activities even if these are not required during the actual operation of the Works.

The Contractor shall pay particular attention to safety training for all assigned personnel. The safety training shall not be limited to personal safety, but shall include detailed actions to be taken by all staff in emergency situations and the use of all safety equipment. The Contractor shall be responsible for establishing procedural links with the appropriate emergency services.

The Contractor shall make available during the training period, all the facilities necessary for training including didactic equipment, simulation video, slides and overhead projection equipment.

Training shall be carried out in the English or Montenegrin languages. The Contractor shall provide a sufficient number of interpreters to overcome any difficulties arising from the assigned personnel not being completely fluent in the English language.

4.5 TOOLS

The project shall include a training programme. Generally the training shall be equipped with all kinds of tools, instruments and special equipment that are needed to perform regular maintenance work. A complete set of tools including spanners and special tools, necessary for the servicing, maintenance and dismantling of most critical parts of the ETS shall be handed over by the Contractor immediately before Taking-Over. The Contractor shall, based on the manufacture's recommendation, determine the required tools for all equipment and prepare a list of tools. The list shall be included in the Tender.

4.6 CONTRACTOR'S PERSONNEL

The Contractor shall provide training personnel for each of the positions required for management, operation and maintenance as identified in the training programme. The duties of each of the training personnel shall be to manage, operate and maintain that element or those elements of the Works which are relevant to his position, and to train the final Beneficiary's assigned staff members for that particular position. The emphasis shall be on "hands-on" training.

In addition to his usual training personnel, the Contractor shall also provide specialist trainers who shall be responsible for formal classroom or workshop training.