

Autotransformer Condition Monitoring Systems

The Bidders shall offer separately the following systems of par.1 “Integrated Condition Monitoring System” and par.2 “UHF PD Monitoring System”. Two systems following par.1 will be installed in two distinct autotransformers, one of 2017 construction in Koumoundourou Substation, CHINT made and one of 1997 construction in Arachtos Substation, BHEL made. One system following par.2 will be installed on the same autotransformer of 1997 construction in Arachtos Substation, BHEL made. In case the Contractors of the systems of par.1 and par.2 are different, IPTO will coordinate the installation and commissioning activities of both Contractors on the same autotransformer in Arachtos Substation.

1. Integrated Condition Monitoring System

1.1. General Requirements

The general description and requirements of the project are as follows:

- 1.1.1. An integrated condition monitoring system will be procured, installed and commissioned by the Contractor. The system will be installed on an operating 280MVA, 400/157.5/30kV three-phase autotransformer, on site.
- 1.1.2. The Contractor will provide all necessary consumables and spare parts for five (5) years of operation. A guarantee for at least two (2) years of operation will be also provided for all devices and systems starting from the date of the qualitative / quantitative acceptance of the installation. The expected lifetime/MTTF of the various consumables/spare parts shall be provided analytically.
- 1.1.3. Each Bidder will submit a detailed technical description of the offered integrated condition monitoring system. The description will refer also in detail to the capabilities of the offered software and to the communication requirements of the system. Technical datasheets and leaflets of all offered devices will be also included. Each Bidder will submit also the list of consumables and spare parts for five years of operation of the condition monitoring system.
- 1.1.4. The erection and commissioning crew for the integrated condition monitoring system shall be constituted by employees of the main Contractor or of a sub-contractor. The company providing the crew (Contractor or sub-contractor) shall be designated by each Bidder. A reference list shall be provided for the same company, which will include at least five similar installations of condition monitoring systems on HV power transformers during the last five years. The reference list will include transformer rated power and voltage, installed monitoring systems, owner of the transformer, location and date.
- 1.1.5. After Contract awarding, the Contractor shall submit also the name and CV of the foreman of the erection and commissioning crew for approval by IPTO. The foreman shall have experience of at least three similar installations of condition monitoring systems on HV power transformers.
- 1.1.6. IPTO will provide all available autotransformer drawings and a time schedule for the erection and commissioning works. Contractor will add the works regarding

the condition monitoring system to the time schedule and submit it to IPTO for approval.

1.1.7. The wiring drawings, layout drawings and detailed data sheets of the integrated condition monitoring system and of all its components will be submitted to IPTO for approval. After the commissioning, Contractor shall provide the as-built drawings of the system.

1.1.8. Operation and maintenance manuals shall be delivered for all systems and devices.

1.2. Condition Monitoring devices

The devices and sub-systems of the integrated condition monitoring system, their interconnections and communication capabilities will be as follows:

1.2.1. A dissolved gas and moisture monitor on the transformer tank, either of GE manufacture, Kelman Transfix DGA 500 type, or of Qualitrol manufacture, Serveron TM3 type, or of Siemens manufacture, Multisense 5 type, or of Doble manufacture, Morgan Schaffer Calisto 5 type. The device shall monitor three, four or five gases and moisture dissolved in transformer oil. It shall communicate remotely through Ethernet port and locally through a serial port (preferably USB). Its auxiliary power will preferably be 220 Vdc or else 230 Vac, fed from the control cabinet of the autotransformer.

The monitor shall be connected to the main tank through two pipes with ball valves for oil inlet and outlet. Alternatively it can be connected through one pipe with ball valve, if this is specifically specified by its manufacturer. The installation position will follow the guidelines of the manufacturer.

1.2.2. A stand-alone condition monitoring system, either of GE manufacture, MS3000 type, or of Qualitrol manufacture, QTMS type, or of Siemens manufacture, Sitram TDCM type, or of ABB manufacture, CoreTec type. The ABB CoreTec system shall include also a bushing monitoring sub-system of Doble manufacture, IDD type. The system will be housed on a separate cabinet, installed on the autotransformer tank. Its auxiliary power will preferably be 220 Vdc or else 230 Vac, fed from the control cabinet of the autotransformer.

The system will import the dissolved gas and moisture measurements through connection to the relevant monitor (par.1.2.1). It will use expert models to estimate the transformer condition from the measurements. The measurement of 3 - 5 gases will be used to perform key gas analysis and gas ratio analysis, correlating the gases with various disturbances, e.g. paper insulation overheating, partial discharges, electrical arcing.

The system will be connected to one bushing CT of the 400kV, 157.5kV and 30kV sides, preferably the one used for connection to the winding temperature thermometer (three CTs in total). Additionally it will be connected to at least one VT at 400kV side in the switchyard.

The system will include Pt100 oil temperature sensors, installed in pockets designed according EN 50216-5. Two oil temperature sensors shall be installed on the autotransformer tank. One will be located on the tank cover, at the hottest oil point, near the temperature sensor of the oil temperature indicator. The other will be located at the bottom of the tank, at the coldest oil point. Two

oil temperature sensors shall be installed on the cooling system. One will be located at the oil inlet pipe from the autotransformer tank and the other at the oil outlet pipe to the autotransformer tank. The sensors will have three wires at least and they will be of QUALITROL or MR manufacture. The system will include also two sensors for ambient temperature measurement, one placed in shade and one under direct sunlight.

The system will use the above data and expert algorithms to calculate the following additional data:

- calculated hot-spot temperature
- cooling system efficiency
- moisture in insulation paper
- bubbling temperature
- ageing rate
- lifetime consumption
- long-time overloading level
- short-time overloading levels / times

The system will include sensors connected to the test tap of the 400kV and 157.5kV bushings. Through these sensors the system will measure the capacitance (C1) and dissipation factor ($\tan\delta$) for each bushing, using sum of three-phase method, adjacent phase reference method or reference signal method.

The system will import the position of OLTC, using a suitable transducer, supplied by Contractor. Additionally it will include measurement of the OLTC motor current, using a CT, and of the OLTC motor voltage. In this way it will monitor the operation of the OLTC drive. The system will calculate also the cumulative switched current. It will use an expert algorithm to assess the used and remaining contact life in the OLTC and estimate the remaining operations until next service or contact replacement. To configure the mentioned expert algorithm, IPTO will provide the OLTC data regarding contact wear versus current, as requested by the Contractor.

The system will have adequate storage capability for archiving of the measured data. It will communicate remotely through an Ethernet port and locally through a serial port (preferably USB). The remote communication will be realized preferably through an embedded web server. Alternatively to the web server, the Contractor will provide one license for client desktop software. The functionality of the web server or client software will include data visualization, measurement trends, condition estimations, downloading of data archives, report generation, remote setting. Additionally, the system will include communication capability through IEC 61850 protocol to the substation automation system for alarms transmitting.

The system will be commissioned on site, in presence of a technician from the manufacturer (GE, Qualitrol, ABB or Siemens).

1.3. Services

The required services of the project are as follows:

- 1.3.1. The needed additional wiring on the transformer will be installed by the Contractor on outdoor type conduits.
- 1.3.2. The installation and commissioning of the system will be coordinated with the commissioning of the autotransformer by IPTO personnel. Taking the transformer out of operation and emptying it from oil before the installation will be performed by IPTO's personnel. All necessary works for the installation of the system will be performed by the Contractor. Filling the transformer with oil and putting it in operation again will be performed by IPTO's personnel. After the electrification of the autotransformer and the connection of the system to the substation communications, the commissioning of the system will be performed by the Contractor. The installation and the commissioning activities of the system will be performed possibly on remote dates due to restrictions imposed by the System Operator, which shall be taken into account by each Bidder. For all delays induced by System Operation restrictions neither the contractor nor IPTO shall be held responsible. The work schedule shall be adjusted to the restrictions as these will be notified to the contractor by IPTO.
- 1.3.3. He will provide also a four-days training for the system. Two days will be devoted to maintenance of devices on site, troubleshooting and basic failures rectification at least as those described in the operation and maintenance manual. Two days will be devoted to software operation in IPTO's offices in Athens. The training for the system will be performed by technical personnel of the manufacturer of every subsystem of par. 1.2.1 and 1.2.2. Alternatively, personnel having at least two years' experience of every subsystem of par. 1.2.1 and 1.2.2, after submission of relevant CVs and IPTO's approval, can perform training. If according to contractor's experience or established training practice additional training is recommended, this should be clearly mentioned in the offer.
- 1.3.4. Contractor will install new oil temperature pockets on the autotransformer tank (as in par.1.2.2) and two pipes (or one pipe) with ball valves for the connection of the dissolved gas monitor (as in par.1.2.1). Any new devices or boxes fed with AC auxiliary voltage, as the PD monitoring system (par.2.3), shall be connected to the tank through isolating joints, in order not to interfere with the autotransformer's earth-fault tank protection. Contractor will restore any corrosion protection (painting, galvanizing, etc.) damaged during the installation works.

2. UHF PD Monitoring System

2.1. General Requirements

The general description and requirements of the project are as follows:

- 2.1.1. An integrated condition monitoring system will be procured, installed and commissioned by the Contractor. The system will be installed on an operating 280MVA, 400/157.5/30kV three-phase autotransformer, on site.
- 2.1.2. The Contractor will provide all necessary consumables and spare parts for five years of operation. A guarantee for at least two (2) years of operation will be also provided for all devices and systems starting from the date of the qualitative / quantitative acceptance of the installation.

- 2.1.3. Each Bidder will submit a detailed technical description of the offered integrated condition monitoring system. The description will refer also in detail to the capabilities of the offered software and to the communication requirements of the system. Technical datasheets and leaflets of all offered devices will be also included. Each Bidder will submit also the list of consumables and spare parts for five years of operation of the condition monitoring system.
- 2.1.4. The erection and commissioning crew for the integrated condition monitoring system shall be constituted by employees of the main Contractor or of a sub-contractor. The company providing the crew (Contractor or sub-contractor) shall be designated by each Bidder. A reference list shall be provided for the same company, which will include at least two similar installations of condition monitoring systems on HV power transformers during the last five years. The reference list will include transformer rated power and voltage, installed monitoring systems, owner of the transformer, location and date.
- 2.1.5. After Contract awarding, the Contractor shall submit also the name and CV of the foreman of the erection and commissioning crew for approval by IPTO. The foreman shall have experience of at least one similar installations of condition monitoring systems on HV power transformers.
- 2.1.6. IPTO will provide all available autotransformer drawings and a time schedule for the erection and commissioning works. Contractor will add the works regarding the condition monitoring system to the time schedule and submit it to IPTO for approval.
- 2.1.7. The wiring drawings, layout drawings and detailed data sheets of the integrated condition monitoring system and of all its components will be submitted to IPTO for approval. After the commissioning, Contractor shall provide the as-built drawings of the system.

2.2. UHF PD devices

The devices of the UHF PD monitoring system, their interconnections and communication capabilities will be as follows:

A UHF partial discharge (PD) monitoring system of QUALITROL manufacture will be provided. The system will include three UHF PD couplers, an external UHF antenna for noise filtering, a converter and filtering unit of OCU type and a stand-alone PD monitoring system of QTMS type. The couplers will have 200 – 1500 MHz bandwidth. They will be installed on existing manhole or hand hole covers on the autotransformer tank, by replacing or modifying them. The location of the couplers will follow the guidelines of the manufacturer, so that all the transformer windings are covered. The external antenna will be installed in a suitable location. The couplers and the antenna will be connected to the converter and filtering unit through coaxial cables of same length. The converter and filtering unit will be connected to the PD monitoring system through a suitable Ethernet cable. Additionally, the PD monitoring system will be connected to a VT at 400kV side in the switchyard. The PD monitoring system will be installed in a separate box, installed on the transformer tank. The auxiliary power of both converter unit and PD system will preferably be 220 Vdc or else 230 Vac, fed from the control cabinet of the autotransformer.

The system will have adequate storage capability for archiving of the measured data. It will communicate remotely through an Ethernet port and locally through a serial port

(preferably USB). The remote communication will be realized preferably through an embedded web server. Alternatively to the web server, the Contractor will provide one license for client desktop software. The functionality of the web server or client software will include PRPD (phase-resolved partial discharges), PRPS (phase-resolved pulse response) and trend analysis, downloading of data archives, report generation. Additionally, the system will include communication capability through IEC 61850 protocol to the substation automation system for alarm transmitting.

The system will be commissioned on site, in presence of a technician from the manufacturer (Qualitrol). During the commissioning of the system, a sensitivity check will be performed. The sensitivity check of the system will follow the guidelines of the manufacturer. The injection device for the sensitivity check shall be also part of the supply. The methodology for the sensitivity check shall be also part of the training session towards IPTO's personnel.

2.3. Services

The required services of the project are as follows:

- 2.3.1. The needed additional wiring on the transformer will be installed by the Contractor on outdoor type conduits.
- 2.3.2. The installation and commissioning of the system will be coordinated with the commissioning of the autotransformer by IPTO personnel. Taking the transformer out of operation and emptying it from oil before the installation will be performed by IPTO's personnel. All necessary works for the installation of the system will be performed by the Contractor. Filling the transformer with oil and putting it in operation again will be performed by IPTO's personnel. After the electrification of the autotransformer and the connection of the system to the substation communications, the commissioning of the system will be performed by the Contractor. The installation and the commissioning activities of the system will be performed possibly on remote dates, which shall be taken into account by each Bidder. For all delays induced by System Operation restrictions neither the contractor nor IPTO shall be held responsible. The work schedule shall be adjusted to the restrictions as these will be notified to the contractor by IPTO .
- 2.3.3. He will provide also a two-days training for the system. One day will be devoted to maintenance of devices on site troubleshooting and basic failures rectification at least as those described in the operation and maintenance manual and one day will be devoted to software operation in IPTO's offices in Athens. The training for the system will be performed by technical personnel of the manufacturer.
- 2.3.4. The installation of the system requires the installation of a new manhole covers or modification of the existing ones for installation of the PD couplers (as in par.2.2). Any new devices or boxes fed with AC auxiliary voltage shall be connected to the tank through isolating joints, in order not to interfere with the autotransformer's earth-fault tank protection. The Contractor will restore any corrosion protection (painting, galvanizing, etc.) and any sealing of manholes damaged during the installation works.