

ANNEX A rev 2: Autotransformer Condition Monitoring Systems

1. Integrated Condition Monitoring System for Autotransformers

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 during the manufacturing stages of the autotransformer. All necessary connections pipes, flanges, manholes, oil pockets, electrical wiring, junction and control boxes shall be incorporated in the design of the autotransformer. Only limited welding or threading operations are allowed on site.
- 1.1.2. The manufacturer/supplier 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 manufacturer must have installed the condition monitoring system on at least five (5) transformers in the last two (3) years with satisfactory operation. Reference letters from the end-users must be provided. The installed monitoring systems shall comprise at minimum the fiber optics temperature sensors and the Dissolved Gas Analysis and Moisture monitor. For the UHF monitoring system at the reference list should comprise if at least two (2) transformers in the last 2 (two) years with satisfactory operation. The correct operation shall be ascertained with end-users reference letters. In case that no previous or limited experience with the integrated monitoring system experience can be exhibited, the manufacturer shall provide a solemn declaration from the monitoring system vendor/manufacturer stating that he will support with know how transfer and supervision the correct installation, adjustment and functional testing of the integrated monitoring system in all stages of the manufacturing process as well as during commissioning (if necessary).
- 1.1.5. 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 along with mechanical and electrical drawings of the Autotransformer.

- 1.1.6 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 900 type, or of Qualitrol manufacture, Serveron TM8 type, or of Siemens manufacture, Multisense 9 type, or of Doble manufacture, Morgan Schaffer Calisto 9 type. The device shall monitor eight or nine 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 specified by its 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 Koncar manufacture, TMS 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 8 - 9 gases will be used to perform Duval triangle analysis, 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, adjacent phase reference methods 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 (if necessary) 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, Koncar or Siemens).

2. UHF PD Monitoring System

2.1. General Requirements

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

- 2.1.1. An integrated condition monitoring system will be procured, installed and commissioned by the manufacturer of the Autotransformer..
- 2.1.2. The manufacturer 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.
- 2.1.4. The system shall be installed in the premises of the manufacturer of the ATF, tested and verified during Partial Discharge measurement (IVPD testing during FATs). If necessary minor installation works shall be performed under the supervision of the monitoring system's manufacturer. .
- 2.1.5. 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. The system shall be installed during FATs. It's correct operation and sensitivity shall be verified during routine/type testing (IVPD testing and sensitivity check)

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 or GE manufacture will be provided. From Qualitrol, either the stand-alone 609 PDM type can be used, or the UHF PD function will be incorporated in the QTMS system of par.1.2.2. with the additional use of a dedicated optical input module in the system and of the converter unit OCU. From GE, the unit MS3000 PD UHF will be used, either as a stand-alone device, or incorporated in the MS3000 system of par.1.2.2. The system will include three UHF PD couplers and an external UHF antenna for noise filtering. The couplers will have bandwidth within the UHF range (200 – 3000 MHz). They will be installed on the autotransformer tank, as deemed adequate for achieving highest sensitivity. 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 system through coaxial cables of same length. For phase synchronization, the PD monitoring system will be connected to a VT at 400kV side in the switchyard. Alternatively, if the UHF PD function is incorporated in the condition monitoring system of par.1.2.2., the bushing tap measuring signals can be used for phase synchronization. The PD monitoring system will be installed in a separate box, installed on the transformer tank, or in the box of the condition monitoring system of par.1.2.2. 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) or a separate Ethernet port. The remote communication will be

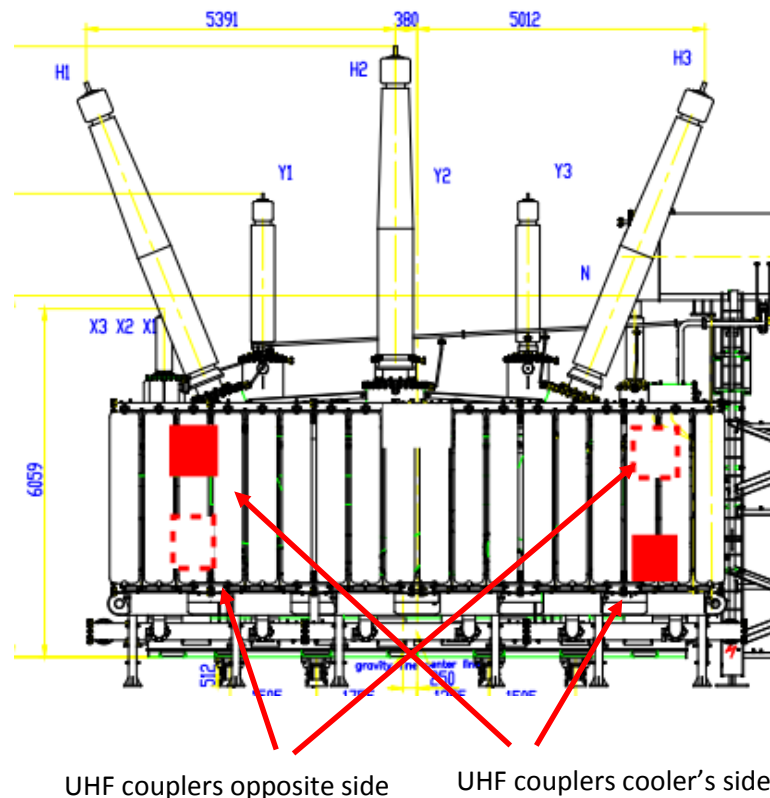
realized preferably through an embedded web server. Alternatively, to the web server, the manufacturer will provide one license for client desktop software. The functionality of the web server or client software will include PRPD (phase-resolved partial discharges), PRPS (phase-resolved pulse response) 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 of the system. 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.

3..SPECIAL TERMS:

3.1. The following deviations form technical specification SS-57_18 apply:

- §IX.12.9 On line monitoring moisture and fault gas monitoring system shall be according to Annex A, replacing the GE Hydran M2 device.
- Four UHF PD couplers shall be installed on the tank as depicted in the following drawing. The sensors shall be as per attached specification and may be used in the future for on-line measurement of PDs. Mounting details and coupler technical specifications shall be provided to the manufacturer at detailed design phase.



- The installation of monitoring systems shall be done by IPTO's personnel. The commissioning of the systems and any calibration/parametrization shall be undertaken by system's manufacturer competent personnel for all pieces.
- §IX.12.10 Additionally 2 sensors for each magnetic circuit limb shall be installed for direct temperature measurement of the magnetic core (one for surface temperature and one inside the core laminations). Furthermore the positioning of optical temperature sensors within the windings shall be clearly indicated in the submitted for approval documents and their positioning for the hot-spot measurement shall be supported with adequate multi-physics calculations/simulations.
- §IX.3 & § VIII.7 The breathers for main tank oil conservator and OLTC oil conservator shall be of self-regenerating desiccant type (maintenance-free dehydrating breather) suitably dimensioned. The breathers shall be MESSKO MTrab or Qualitrol STB 200D make.
- §8.2 For the MV (170kV), neutral and LV (52kV) bushings, the active part can have alternatively insulation of Resin Impregnated Paper

- §8.3 For the MV (170kV), neutral and LV (52kV) bushings, the insulation housing can be alternatively of silicon rubber
- §IX 1. Cooling system can be radiator or cooler type
- §XI The installation of SERGI system shall be performed by IPTO. The supplier shall arrange the commissioning supervision of the system by SERGI's competent personnel, which will also sign the acceptance in operation of the system.
- §XII The following list of spare parts shall be quoted and provide by the Bidders:

Description	No (pcs or sets)
HV bushing complete	2 pcs
MV bushing complete	2 pcs
LV bushing complete	2 pcs
Complete set of gaskets for bushings, covers, radiator/cooler flanges, manholes and hanholes	2 sets
Cooling fan and motor set	5 sets
Cooling pump and motors set	3 sets
Complete OLTC and motor drive unit with connecting rods, transmission gears and accessories	1pc
Contacts, resistors, screen caps etc for diverter switch	1 set
All components of Autotransformer (OTI,WTI, PRD, oil level indicator, Shudden Pressure relay, Buchholz relay, valves, breathers)	2 sets
Individual components of control cubicle (relays, timers, heating resistor, thermostat, contactors)	1 set per autotransformer

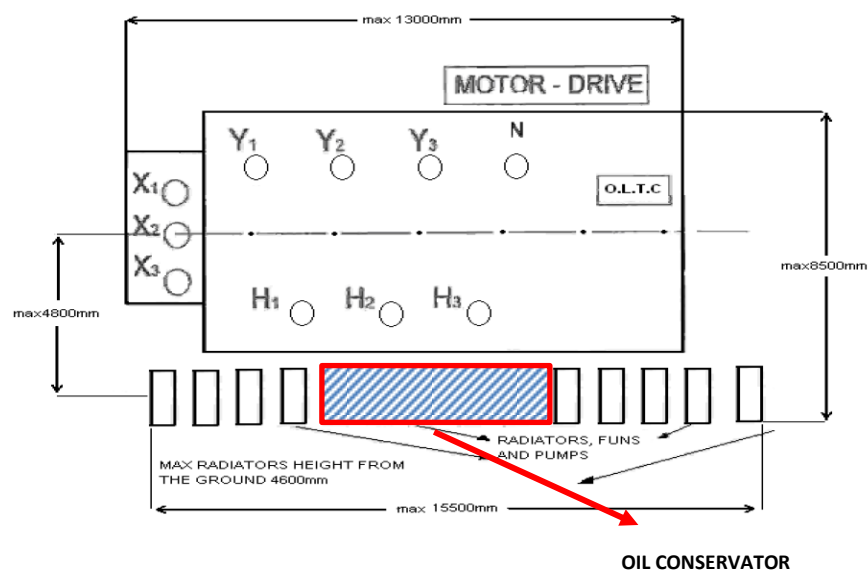
- Within the provisions of the framework regarding the acceptance of technical equivalent solutions, components and sensors other than the ones mentioned in the specification shall be accepted under the following provisions:
 - All technical characteristics are equivalent to those required in the technical specification and to the devices/sensors prescribed therein
 - The proposed equipment shall have been type tested (where applicable) and type tests along with any other technical documentation proving the equivalency shall be submitted for approval
 - The supplier shall provide a list of reference of previously manufactured and sold transformers where the proposed equipment has been installed and has been operating satisfactory for at least three (3) years. The list of references should comprise of at least

twenty (20) references for the following items, if any deviation from the specified ones is proposed by the supplier:

- Bushings
- OLTC
- Pressure Relief Devices
- Oil and Winding Temperature Indicators
- Oil flow control relay
- Buchholz relay
- Oil flow indicator
- Rapid pressure Rise relay
- Shock recorder
- Condition monitoring devices

The acceptance of proposed technically equivalent solutions lies with – IPTO, based on the above principles.

- A monitoring device for hydro type compensator (oil conservator air cell failure detection relay) shall be additionally installed with one (1) NO contact. The monitoring device shall be EMB make.
- The manufacturer shall provide a suitable number of manholes/handholes on the upper part of transformer tank that will allow the installation of pipes and sprinklers for the application of a Hot Oil Spray (HOS) insulation drying system during maintenance. The arrangement of manholes/handholes shall be suitable for supporting the use of commercial systems such as those provided by Micafluid (indicatively)
- The position of the conservator for six (6) of the seven (7) Autotransformers is indicated in the following outline sketch



3.2. The conservator for the remaining out one (1) of seven (7) Autotransformer shall be installed on top of an existing metallic structure. The positioning of the metallic structure relatively to Autotransformer's main tank and the details of metallic structure's foundation is given in the following outline sketches.

