

**INSTALLATION AND OPERATION
INSTRUCTION FOR 110kV
TRANSFORMER**



Acquired ISO9001 Certificate

SHAANXI HANZHONG TRANSFORMER CO.,LTD

1. General

This instruction is applicable for 110kV oil-immersed power transformer.

This instruction includes requirements of transportation (by railway, road, ship), notice of site acceptance and storage, procedures of active-parts inspection and site installation, notes to acceptance tests, operation condition and daily maintenance, trouble-shooting explanation, etc.

Installation must be strictly according to this instruction, combine this with transformer's specific structure and refer to additional accessories' instruction. If there is any problem, please don't hesitate to contact the manufacturer to deal with the problem properly.

2. Transportation and lifting

2.1 Transportation requirements

2.1.1 If transformer is delivered with oil, the transformer must be filled with qualified transformer oil. Distance between oil level and tank cover is about 100mm, fill the space with dry nitrogen. Then check whether there is seepage or leakage. The pressure gauge installed on the top of tank should be remained positive reading.

2.1.2 If transformer is delivered with nitrogen, the transformer should be filled with dry pure nitrogen with purity more than 99.9% and dew point lower than -40°C. On the top of the tank there should be installed nitrogen-filling device and pressure gauge, initial pressure in the tank should be 0.02-0.03MPa. (On-load tap-changer is connected with main body by U-type pipe, filled with nitrogen simultaneously.) After transformer reaches site, a positive pressure in the tank should be remained.

2.1.3 If transformer is filled with nitrogen, records of nitrogen-filling during the transportation should be made.

2.1.4 Loading and fixing of transformer transportation should be according to relative regulations of transportation administration.

2.1.5 If necessary, transformer should be equipped with impact recorder.

2.1.6 If transformer is transported with on-load tap-changer, tap-changer's oil compartment should be connected to main body by U-type pipe.

2.2 Transportation of main body

2.2.1 Obliquity of transformer during transportation:

at major axis direction: $\leq 15^\circ$;

at minor axis direction: $\leq 10^\circ$.

2.2.2 Transformer is prohibited to move of its own accord on a slope, maximum acceleration limits are:

X-axis: $\leq 3g$;

Y-axis: $\leq 3g$;

Z-axis: $\leq 3g$.

2.2.3 Transportation speed:

On good-condition road: $\leq 40\text{km/h}$;

On ordinary-condition road: $\leq 15\text{km/h}$;

On bad-condition road: $\leq 10\text{km/h}$;

2.3 Lifting of main body

2.3.1 Lifting equipments, slings and ground base of the loading place should be capable of bearing transformer's lifting weight (transportation weight).

2.3.2 Lifting main body, lifting ropes should be placed at marked position.

2.3.3 Angle between lifting rope and vertical direction must be no more than 30° .

2.4 Traction of main body

2.4.1 Traction forcing point should be put at special pulling plate welded at lower part of tank. If no pulling plate, then traction forcing point should be placed at both sides' lifting lugs on main body. It is prohibited to force at connection pipe or accessories.

2.4.2 Traction speed on rail with wheel or rollers should not exceed 100m/h .

2.4.3 If load or unload the main body on slope, the obliquity mustn't be more than 10° and slope length should be more than 10m . Protection measures against skid must be taken.

2.4.4 Using hoisting jacks, all the jacks should be placed under jack pads, hoisting and lowering with simultaneous action and same speed. Protection measures against jack skid must also be taken.

3. Acceptance and storage

3.1 Goods examination after arriving to site

3.1.1 Examine nameplate, accessories and spare parts according to the contract.

3.1.2 Check the relative displacement of transformer body to truck during transportation. If the transformer is equipped with an impact recorder, impact recording should be checked. Then to have an appearance inspection to check whether there is collision damage. If yes, please contact with carrier and transportation administration immediately to find out the reason together so as to deal with the problem properly. And also please inform the manufacturer the information.

3.1.3 If the transformer is transported with nitrogen, nitrogen pressure in the tank should be check whether it is positive pressure. Make records.

3.1.4 Check whether the accessory cases are damaged or lost, and make records. If there is something damaged or lost, please contact the manufacturer.

3.1.5 Check the case quantity and accessories according to packing lists. If there is something damaged or lost, please contact the manufacturer.

3.2 Examination of accessories

3.2.1 Before installation, please inform manufacturer in advance about time to open cases, and examine and check again together with the manufacturer.

3.2.2 Check the accessories & parts according to packing list to see whether it is complete, and to see whether there is damage. Make records.

3.2.3 Check whether ex-works documents, technical specifications and certificates are complete or not.

3.3 Storage

3.3.1 Please make detailed records on checking and examination.

3.3.2 Different accessories and parts should be stored separately according to their specific characteristic. Measures against water, snow, corrosive gas should be taken.

3.3.3 Instruments, meters and electric parts should be put at dry and ventilating place, and damp-proof measures must also be taken.

3.3.4 If transformer is transported with oil, and after its arrival it will be put in storage for more than 2 months, the conservator should be installed in the first month after its arrival (including conservator of on-load tap-changer), and filled with qualified oil to the level corresponding to the site temperature, then install breathers. Or without the installation of conservator, the transformer should be evacuated and then filled with 0.01~0.03Mpa dry pure nitrogen with purity more than 99.9% and dew point lower than -40°C.

3.3.5 If transformer is transported with nitrogen, and after its arrival it will be put in storage for more than 1 month, then the transformer should be exhausted the nitrogen and filled with qualified insulation oil, installed with the conservator and dehumidifier. Exhausting nitrogen and filling transformer oil, operators must be far away from the transformer, avoid to be asphyxiated. If transformer is not filled with oil in time, it should be stored by filling the same gas with 0.01~0.03Mpa pressure and dew point lower than -40°C.

3.3.6 If the capacitor-type bushing will be stored for more than 6 months, the bushing end should be lifted up to an angle between bushing and level of more than 15°, or taken out from the case and put vertically.

3.3.7 Besides the above-mentioned, please check and examine regularly for rusting and oil leakage, etc. And sample oil for test every 5 months, or check the nitrogen pressure regularly and make records.

3.4 Management of insulation oil

- 3.4.1 Prevent impurity, damp, water and polluted air from entering into oil tank when filtering and filling insulation oil into the tank. It is prohibited to filter oil from one tank to another tank in a rainy day.
- 3.4.2 The oil container must be cleaned strictly and sealed completely. Or the container must be equipped with dehumidifier if the container is not sealed completely.
- 3.4.3 Transformer oil must meet the following technical specifications in Table 1.

Voltage level, kV	Breakdown voltage, kV	Dielectric loss factor at 90°C, %	Water content, 10 ⁻⁶
110	>35	<0.5	<15

- 3.4.4 Generally please use as far as possible the insulation oil provided by manufacturer. If it's necessary to complement other type of oil, it must comply with regulations of mixing oil, and the oil should be tested by specific department to make sure of their compatibility. If the two types of oil are not compatible, it's prohibited to use mixed oil.

4. Check of active part (This is canceled for wholly welded transformer)

- 4.1 Requirements for checking active part
- 4.1.1 After the transformer arrives at site, transformer active-part should be checked. Check of active part includes untanking check and check without untanking. Untanking check for bell-type transformer is untanking the upper part of tank to check, while for barrel-type transformer is lifting cover and active part out off tank to check. The non-untanking check needs only other type of check is for somebody entering into the tank through manhole to check the active part.
- 4.1.2 Generally for transformer transported by road is unnecessary to take untanking check, only to open manhole to check. But if there is some accident during transportation, then the transformer must be untanking for complete inspection.
- 4.1.3 For transformer transported by ship, it's necessary to take an untanking check. But if the reading of impact recorder is within the limits, then it's unnecessary to untanking.
- 4.1.4 Conditions for active part checking
- 4.1.4.1 For outdoor check, it is necessary to build a temporary protection tent or to take some dust-proof measures. It is forbidden to carry out the inspection in rainy, snowy and dusty day.
- 4.1.4.2 Ambient temperature should be higher than 5°C, if lower than 5°C, the circumstance should be heated by hot air blower or other measures. Temperature of active part should be higher than ambient temperature, if possible, it's better to be 10°C higher.
- 4.1.4.3 If entering into the tank to check in overcast sky, the transformer tank should be filled with hot and dry air continuously.
- 4.1.4.4 Exposure time of active part in air should conform to the following stipulation,

time is counted from the begin of the oil discharge or nitrogen exhausting.

- a) Less than 16h if relative humidity less than 65%;
- b) Less than 12h if relative humidity less than 75%;
- c) If relative humidity is more than 75%, active part should be dried correspondingly.

4.2 Preparation for active-part checking

4.2.1 To filter enough insulation oil according to total oil weight of the transformer (including adding oil);

4.2.2 For nitrogen-filled transformer, first to exhaust nitrogen, then to check the active part. When exhausting nitrogen, operators must keep away from the transformer, avoiding to be asphyxiated. Operator can exhaust the nitrogen by filling oil.

4.2.3 For oil-filled transformer, please discharge the oil into cleaned barrel or tank with vacuum oil filter. During discharging oil, please open the oil-filling butterfly valve on the tank cover. Operator is forbidden to enter into the tank if oil level higher than 200mm. Once operator enters into tank, someone must be arranged at the manhole to keep contact with the inspector. For barrel-type transformer, before untanking check, the oil lever should be 200~300mm lower than tank cover.

4.2.4 For bell-type transformer, before untanking, the operating lever of no-load tap-changer must be dismantled, and mark the position (phase position and tap position) for facilitating re-installation. Dismantlement of on-load tap-changer refers to the operation instruction of on-load tap-changer:

- a) Dismantle the connection of the head flange with main body of tap-changer on top of bell-type tank;
- b) Place the tap-changer body on support frame fixed on upper core-clamps;
- c) Mark the position;
- d) Take apart the connection between top of active-part and tank cover.

4.2.5 Prepare lifting equipment, vacuum device, oil filter, safety lamp, tools, standby material and testing equipment, etc. Making active part inspection, please make records for articles carried by the operators and check the articles according to the records frequently in order to assure that no foreign matters left in the tank. The operators must also clean the tools, clothes and shoes before entering into the tank.

4.2.6 Installation person and installation supervisor must be qualified person. Relative measuring device should be in valid period. Articles which are carried by the operators but is not relative to installation should be left outside the transformer.

4.3 Untanking

4.3.1 Untanking the transformer, please arrange somebody to look around the transformer, avoiding hoisting machine and upper part of tank to touch electric line or other obstruction. (It's better to choose suitable environment.)

4.3.2 For bell-type tank, please dismantle the bolts on tank flange and insert separately four locating sticks into four screw holes at four corners of tank flange. Adjusting hoisting machine or sling to correct position—upper tank flange is parallel with lower tank flange. Lifting height refers to drawing of power transformer.

Notice! (1) Avoid upper part of tank to contact leads or leads frame.

(2) Lifting capacity of crane must be 2 times of lifted object.

4.4 Check of active part

4.4.1 Notices for active-part checking

4.4.1.1 It is forbidden to hang or lean anything on leads, conductor clamps or insulation parts. Also it's forbidden to climb on leads or lead frame.

4.4.1.2 Don't put any article on active part.

4.4.1.3 Leads can't be folded, if any, please repair the folded leads and maintain it at original installation position.

4.4.1.4 Don't change lamp or check & repair tools in tank.

4.4.2 Items of active-part checking

4.4.2.1 Check whether the core and winding is displaced, deformed or not; whether tightening bolts of core and tie plate are loosened or not; check all the fixing parts; check whether press-on device of active part is pressed or not, and locking nut is locked or not.

4.4.2.2 Operate tap-changer with special spanner or handwheel to check whether contacts are clean and well contacted. For no-load tap-changer, three phases should be at principle position. Lead connection of tap-changer should be reliable. Oil compartment of on-load tap-changer should be well sealed, tighten the oil-draining plug at the bottom of oil compartment.

4.4.2.3 Check the earthing of core, clamp and shielding plate of side yoke by megohmmeter. Core should be grounded at one point and only one point. Insulation resistance should be good, no breakdown and flashover. Insulation resistance of core should be more than $200M\Omega$. If the core is not of tie-plate structure, please first dismantle the earthing sheet of the core, then to measure the insulation resistance between core and clamp (earth). If the yoke is tightened by low-magnetic steel tie-band, the operator should first take apart the connection between tie-band and clamps, to measure insulation resistance between tie-band and clamp, between tie plate and core.

4.4.2.4 Check whether the lead is damaged or deformed, insulation wrapping is damaged or loosened.

4.4.2.5 The inner tank wall and shielding device should be clean, no burr, mess and dirt, etc. If any, please clean it.

4.4.2.6 Dismantle the temporary fixing device used for transportation inside the tank.

4.4.2.7 After draining off oil, first assemble all the valves on lower part of tank which were dismantled during transportation, enclose all the valves which should be closed during vacuum oil-filling.

5. Re-assembly of transformer

5.1 Notices for transformer re-assembly

5.1.1 Put all the accessories and sealing gaskets in order, and clean them. Also clean the transformer oil in gasket channel on tank flange. The oil pipes which are equipped by customer himself also should be cleaned completely. The customer should not

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- install additionally metal mesh in the oil pipping to avoid being thrust into the tank, which is vital to transformer operation.
- 5.1.2 Check all flanges and sealing gaskets whether they are clean and in good condition.
 - 5.1.3 Tighten all the bolts evenly and symmetrically.
 - 5.1.4 Gasket should not be eccentric after pressed.
 - 5.1.5 Lifting cable must be bound solidly and should avoid collision when lifting.
 - 5.1.6 No step on tap-changer cover and bursting disc cover.
 - 5.1.7 Leads should not be strangled, or folded at will.
 - 5.1.8 Marks on steel structure should be matched correctly.
 - 5.1.9 Secondary side of current transformer should be shorted-circuit.
 - 5.1.10 During the assembly, things which has no relation to the assembly should be put away from the transformer. Place all the standard parts and tools in prepared container.
- 5.2 Preparations before re-assembly
- 5.2.1 Measure the performance of bushing according to the operation instruction of oil-impregnated-paper condenser type transformer bushing.
 - 5.2.2 Preset temperature limits according to operation instruction of temperature controller.
 - 5.2.3 Preset alarm signal and trip actuation value of gas relay according to the instruction.
 - 5.2.4 Check the actuation contact and restoration state of pressure relief valve according to the instruction.
 - 5.2.5 Check the actuation flexibility of oil level indicator according to its instruction.
 - 5.2.6 Assemble the conservator according to installation instruction of conservator.
- 5.3 Transformer re-assembly
- 5.3.1 Regarding to installation of conservator, please refer to the installation instruction of conservator, to install oil level indicator, connection pipes, capsule and dehumidifier. The connection of conservator to transformer tank refers to conservator assemble drawing which is collected in ex-works documents.
 - 5.3.2 Installation of pressure relief valve refers to its instruction. If the pressure relief valve is equipped with oil-guiding cover, then the oil-guide nozzle should toward outside of tank. When transformer is operating, the butterfly valve under the pressure relief valve should be open.
 - 5.3.3 Installation of gas relay and oil-guide box refers to their installation instruction. For transformer with no-load tap-changer, there is only one gas relay which should be inserted in connection pipe between conservator and tank. While for transformer with on-load tap-changer, there should be another gas relay (type QJ-25) installed between tap-changer's conservator and oil compartment of tap-changer. Installing the gas relay, the arrow should point to the conservator, and the operator should check if the copper pipe of gas-collecting box is unimpeded. Before putting the transformer into operation, please check whether the gas relay can actuate reliably,

and preset the actuation value upon customer's requirements.

- 5.3.4 Installation of bushing refers to its instruction. Root of leads and connection pole should not be strangled, folded and pulled toughly. For leads of 66~110kV and above, their root has cone type insulation, which should enter into equalizing sphere of bushing. Operator can observe through inspection window and then adjust. A length of 150mm of leads under the bushing-equalizing-sphere must be straight. Equalizing sphere must be tightened and cleaned inside. Bushings and ascending flanges must be correctly installed according to the marks.
- 5.3.5 Radiator installation refers to its installation instruction. For transformer with ONAF cooling mode, wide-plate type or flat-pipe type are both applicable to it. Lifting and installing radiator, operator should pay attention to that radiators should not collide some thing or collide each other to avoid damage resulting in oil-leakage.
- 5.3.6 Fan installation refers to its installation instruction. Notice: name plate of fan should be faced outside.
- 5.3.7 Control-circuit installation refers to wiring drawing of control circuit in ex-works documents. Please wire and install wiring box on tank beforehand, because it is difficult to wire after radiators' installation. If transformer is equipped with bushing type current transformer, the measuring and controlling controlled circuit should also be connected. During transformer's operation, secondary circuit of bushing type current transformer should be closed. If it is not connected with meter, it should be shorted-circuit.
- 5.3.8 Installation of on-load tap-changer refers to its installation instruction, including: connect main body of tap-changer, install horizontal and vertical transmission shafts, install electric drive mechanism, correct tap position and clockwise & anti-clockwise revolutions. Please make sure of tap position coincidence of electric drive mechanism, tap-changer main and remote indication. If it's no-load tap-changer, installation of operation lever and transmission drive should ensure coincidence of tap position of three phases. If locating device of active part is needed to re-assemble, operator should pay attention to ensuring the insulation of the connection between the device and tank.
- 5.3.9 Installation of temperature controller refers to its instruction. Fixing the temperature sensors, fill the temperature indicator socket with transformer oil to a level of 50mm lower than the top. The setting value should be preset according to customer's requirements beforehand, also local and remote temperature indication should be adjusted to be same.
- 5.3.10 Install all the connection pipes and their parts.
- 5.3.11 The connection pipes are designed with a slope when design the transformer. It is unnecessary to set a slope for complete transformer.

6. Vacuum oil-filling

6.1 Vacuum oil-filling

- 6.1.1 If active-part checking and re-assembly can be finished within one day, then after re-assembly, transformer should be evacuate and filled with oil immediately.

6.1.2 If it takes more than one day, after some working then please fill the transformer with qualified oil in time, and continue to check or re-assembly the next day after draining the oil. And to evacuate transformer and fill the oil as soon as the check and re-assembly are finished completely.

6.1.3 For transformer with OLTC (On-load tap-changer), the oil in the oil compartment of tap-changer also must be drained at the same time. Use a “U” type pipe to connect the tap-changer’s oil compartment with transformer tank so that the oil compartment can be evacuated at the same time. Oil-filling pipe of tap-changer also should be connected, so tap-changer can be filled with oil together. If the tap-changer isn’t filled with oil together with transformer tank, then it must be filled with oil before filling the tank.

Notice: please install a vacuum meter to supervise the vacuum in the tank during oil-filling.

6.1.4 Evacuating pipe and vacuum meter are fixed at $\phi 80$ butterfly valve on the top of tank or at connection flange of gas relay.

6.1.5 Oil-filling pipe is fixed at $\phi 80$ gate valve at the lower part of tank to fill oil with oil filter.

6.1.6 Start vacuum pump to evacuate gradually, maintain the vacuum according to the following table:

Table 2

Voltage level, kV	Vacuum, Pa	Duration, h	Max. positive pressure, MPa
110	133	8	0.098

6.1.7 Open gate valve under vacuum condition, fill qualified insulation oil with temperature of 50~70°C and filling speed of 2~3t/h. The vacuum refers to the above table.

6.1.8 At the same time fill the oil compartment of on-load tap-changer with qualified oil. Stop filling as soon as oil level is 100mm under tank cover. Maintain the vacuum for at least 8h, then aerate and dismantle the vacuum pipe and vacuum device.

6.2 Supplementary oil-filling and placing still

6.2.1 Equip the oil-filling pipe at filling valve of conservator. (Because supplementary oil should be filled from the tank top to avoid air bubble into the tank.)

6.2.2 After installing gas relay, please open butterfly valves and gate valve of conservator and oil-filter or other valves which should be open during transformer operation. And lock them after ensuring their open condition of valves.

6.2.3 Remove the “U” type pipe between on-load tap-changer and transformer tank, and seal the flange, install the conservator of tap-changer.

6.2.4 Open oil-filling valve to fill supplementary oil, and open the air-release plug of ascending flange, air conduit, oil-collecting box of cooler or radiator according to the rising of oil level, screw the plug immediately when oil overflows.

6.2.5 Fill oil to the oil level in conservator, corresponding to the circumstance temperature (the air releasing of conservator refers to its instruction). The

conservator of on-load tap-changer should be also filled with oil to the level corresponding to the temperature.

- 6.2.6 Oil leakage test is usually by oil static-pressure method with pressure not more than 0.03MPa. Still the oil-filled transformer for 24h to check whether there is oil leakage or not. If any, it should be treated soon till no leakage.
- 6.2.7 The total duration of still placing should be more than 72h from complement of supplementary oil-filling. During this period, operator should release air from time to time.
- 6.2.8 Even the transformer is not untanked, should also be filled with oil according to this regulation.
- 6.3 Oil-filling of full-vacuum-type conservator
 - 6.3.1 For a full-vacuum type conservator, if situation on installing site is permissible, the transformer entirety (including conservator, radiator and other accessories) have to be vacuum-pumped fully (the capsule in the conservator should be protected from damage), and fill oil in one time to the level corresponding to the temperature, the detailed operation and the requirement of oil-tight test of transformer entirety is stated above.

7. Acceptance test and Commission

- 7.1 Check before acceptance test
 - 7.1.1 Check if the tap position of three phases of off-load tap changer is the same. If transformer is with on-load tap changer, check whether the tap indication in motor drive mechanism and remote tap position indication is the same.
 - 7.1.2 External insulation clearance of the transformer should be no less than the regulations in table 3 and table 4.

Table 3

Rated voltage (kV)	Maximum operating voltage (kV)	Rated lightning impulse withstanding voltage (kV)	Minimum Air Clearance (mm)
10	12	75	125
35	40.5	200	340
66	72.5	325	630
110	126	480	880

Table 4

Rated Voltage class (kV)	Maximum system voltage (Um/kV)	Rated Switching Impulse Withstanding Voltage (peak) (kV)		Rated Lightning Impulse Withstanding Voltage (peak) (kV)	Minimum Clearance (mm)		
		Phase-earth	Phase-phase		Phase-earth	Phase-phase	To other winding terminal
110	126	480	480	530	900	900	900

Note: The data in the table is based on the condition that the altitude is no more than 1000m. The data will increase 1% per hoisting 100m as altitude is over 1000m but below 2500m.

- 7.1.3 Check if the oil level height of oil conservator is a false level and if the oil level of conservator conform to ambient temperature. If the oil level is below normal level, fill oil from the oil-filling pipe under conservator. First of all, open the air-relief plug on oil-filling valve until the oil-relief plug has oil flowing out , and then fill oil.
- 7.1.4 Check if the earthing system is solid and right.
- 7.1.5 Check the core earthing to ensure that there is only one point to be earthed and no closed circuit is formed.
- 7.1.6 Check if the tank is earthed reliably.
- 7.1.7 Check if the valves of components to be put in operation (except emergency oil-draining valve, vacuum oil-filling valve) is in open position. Gas relay, ascending holder and so on should be air-released again.
- 7.1.8 Inspection of temperature controller should be carry out according to the operation instruction and set the temperature limit to the required value of customer.
- 7.1.9 During checking the secondary wiring, if the high or low oil temperature limit contacts, or the overload contacts of current relay are shorted the blower fans should operate or stop normally.
- 7.1.10 Check if the alarm and trip circuit of oil level indicator, pressure-relief valve, gas relay, temperature controller and so on are expedite.
- 7.2 The inspection before commission
 - 7.2.1 Change the tap position of off-load tap changer continuously on non-excited condition in order to eliminate the effect of oil film to contact resistance between contacts. Then align tap position, the D.C. resistance between the movable and fixed contact should be less than 500uohm. Every tap-changer should be put in a same tap position in accordance with line voltage.
 - 7.2.2 When transformer is in operating the test tap of condenser-type bushing (60kV, 110kV) should be earthed reliably.
 - 7.2.3 Check if the neutral terminal of electrified side of transformer is earthed reliably (the neutral terminal should be earthed directly while transformer is been switching.)
 - 7.2.4 Check if pre-set value and action sensitivity of each protecting device and breaker are perfect.
 - 7.2.5 Check relay protection, for example, check if the metering circuit, protecting circuit and controlling circuit wiring of relay, pressure release valve and bushing type current transformer are right. Make a short-circuit linkage test if necessary.
 - 7.2.6 Check if the unloaded secondary terminals of bushing type current transformer is shorted, not allowed open in operation.
 - 7.2.7 Check if the dehydrator of conservator is expedite.
 - 7.2.8 Recheck if the earthing system is earthed reliably.

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- 7.2.9 Check the pre-set value of protecting device, when the system voltage is not stable, adjust the pre-set value of protecting system suitably in order to protect the transformer effectively.
 - 7.2.10 Only after above check and test conform with requirements, can the transformer switched on and commissioned without loading.
 - 7.3 Put into trial operation
 - 7.3.1 Making no-load commissioning, the transformer primary should be switched on power supply, if site situation is permissible the voltage may increase from zero to rated value slowly, also may be switched on with voltage surge.
 - 7.3.2 For no-load switching-on of transformer, pay attention to the following :
 - 7.3.2.1 Before no-load switching-on transformer should be placed in still for more than 24 hours, the ascending flange and bushing should be air released regularly with air relief plug.
 - 7.3.2.2 Before no-load switching-on, actuating time limit of over current protection should be preset to zero; signal contacts of gas relay should be connected into trip circuit temporarily
 - 7.3.2.3 The out-off-step time difference of three-phase breaker connected at power supply side should be less than 10ms, when the transformer is switched on it must be protected by lightning arrester, the neutral of transformer should be earthed reliably (earthed directly)
 - 7.3.2.4 The voltage of no-load switching-on should not exceed 5% of the voltage corresponding to the tap position. The most times of no-load switching-on should be 5, the continuous time should be not less than 10 min after the first excitation, the interval between any two switching-ons should be not less than 5 min.
 - 7.3.2.5 After finishing test, connect the signal contacts of gas relay into the alarm circuit, trip contacts into the trip circuit, and adjust the limit of overcurrent protection
 - 7.3.3 Loaded commissioning
 - 7.3.3.1 After no-load commissioning of 24 hours without abnormality, transformer can be shifted in loaded commission and its load will be increased from 25% to 50%, 75%, up to 100% step by step.
 - 7.3.3.2 After commissioning with certain load continuously for 24 hours, the main body and accessories of transformer are all normal, then the transformer will be shifted into normal operation.

8. Maintenance in (service) operation

- 8.1 Normal operation
 - 8.1.1 If the transformer doesn't appear the abnormal phenomenon in commissioning, it is thought that the transformer has been put into normal operation.
 - 8.1.2 During the normal running phase, check often the top oil temperature, the changing of oil level and if the oil in conservator overflows or the oil level descends. If it is found that there is the flammable gas in the gas relay, should find out its reason.
 - 8.1.3 Check, watch and listen if the sound of transformer is normal and has the noise of

implosion and so on, and if the cooling system is normal. Check if the radiators or coolers and auxiliary and spare cooler can run and stop automatically according to the regulated preset value. For forced-air-cooled transformer, when the transformer reaches 2/3 rated current or top oil temperature reaches 65°C, blast devices should be started when load current is less than 1/2 rated current or top oil temperature is less than 50 °C , fans should be stopped. For forced-oil & forced-air-cooled transformer, a corresponding number of cooler should be automatically put into running or stopped according to loading situation.

8.2 Maintenance

- 8.2.1 Monitor oil sample of the transformer in operation, if find that the gas dissolved in the oil is over regulation or other performance index is over limit value, make the oil chromatogram tracing, when the value is over two times standard, stop operating and find out the reason.
- 8.2.2 For oil immersed ONAF cooling transformer when fans stop working and if the top oil temperature is no more than 65°C, the transformer is allowed to operate with rated load. For OFAF or ODAF cooling transformer, if power supply of the cooling system is failure and all coolers are cut off, the transformer should be allowed to run for 20minutes with rated load; if the top oil temperature doesn't reach 75°C, then allow it to rise to 75°C, but the longest operation time should be no more than 1 hour.
- 8.2.3 Earthing bushing of transformer core should be earthed effectively when transformer is in operation. The earthing current measured of core should be no more than 0.1A. Pay attention to preventing the core from being earthed at multiple point and being instant open-circuit.
- 8.2.4 Maintenance of OLTC refers to instruction of OLTC, the oil sample test shall be carried out every three months and should purify the oil or replaced the oil if necessary. Make a record the on-load tap-changer's operation. If the on-load tap-changer operates frequently in a certain period, please take oil sampling and conduct oil test immediately
- 8.2.5 Check silicagel in oil purifier and breather, change them if the ratio of damping reaches 60%
- 8.2.6 Check regularly whether the fan-motor operates normally, if the fan-motor appears the phenomenon hitting housing, quit operation and check or change it.
- 8.2.7 Measure regularly the dielectric strength of insulation oil, dielectric loss factor(tan), moisture content, acid value, and compare them with the original record.
- 8.2.8 Measuring the dielectric loss factor should notice that arc-suppression coil in network system has a heavy effect to the measured result. When the dielectric loss factor is being measured, stop using the arc-suppression coil. When the system is effected by a so heavy interference that there is no way to measure the dielectric loss factor, take measures to eliminate the interference and try again
- 8.2.9 Check the circuits of protection relays (gas relay, pressure relief valve and so on) and differential protection whether the wiring connections are firm and whether their connecting cables are of heating or aging

8.2.10 Check regularly if any assembling bolt is loose and sealing gasket is aged and results in seepage or leakage. If the above problems come about in daily maintenance, repair it immediately or inform the manufacturer to help to repair and record it in detail.

8.3 Analysis and elimination of transformer faults

8.3.1 If gas relay alarms, find out the reason as soon as possible, collect the gas to analyze

8.3.2 If insulation oil is unqualified, take measures to process oil immediately.

8.3.3 If transformer is in operation, any of the following situations appears must stop transformer operation immediately and check the active part.

- a) When oil temperature rise exceeds allowable value;
- b) When oil level descends too rapidly to deal with because of leakage
- c) When oil level rises abnormally under normal cooling and loading;
- d) When the sound in transformer isn't normal or uneven, well-proportioned and has bursting noise;
- e) When oil sprays from on-load tap-changer because of breakage of bursting disc;
- f) When pressure relief valve is actuated and oil sprays from it;
- g) When oil color changes severely and carbonization occurs;
- h) When bushing is broken seriously and discharges;
- i) When there are flammable gases appears in oil and total hydrocarbon grows fast.

8.4 The operation and maintenance of the forced-oil-cooling system

8.4.1 Forced oil circulating system should have two separate power suppliers, when one doesn't work, the other one continue to supply electricity. When both of the two suppliers don't work, the cooling system will be under self-cooling condition, if the transformer is with rated load, the operation time duration is 20 min. Anyway the time duration does not exceed 1h if the transformer is not fully loaded and the top oil temperature does not exceed 75°C.

8.4.2 If the fans do not work while the oil pump operates normally, the transformer should be controlled according to oil temperature.

8.4.3 Control of starting or stopping of cooling system, user should set up the top oil temperature limitation according to the local environment temperature.

8.4.4 When loading of the transformer is low, certain number of coolers will be started according to loading condition, the physical calculation is as following:

$$S_n = \sqrt{P_k' / P_k} \times S_H \quad (\text{kVA})$$

Where S_n – Permissible loading of transformer under operation of n coolers;

S_H -- Rated power of the transformer, kVA;

P_k --Load losses at 75°C, kW;

P_k' – Allowable load los under operation of n coolers;

$$P_k' = nP - P_0$$

Where n – number of operated coolers;

P₀ – no-load loss at rated frequency;

P – Dissipation power of every cooler when transformer is loaded fully;

$$P = (P_0 + P_k) / (N - 1)$$

N – Number of coolers installed

8.5 The extra (Max.) moment on bolts should follow the values in table 5.

Table-5

Bolts	M10	M12	M16	M20	M24	M30	M36	M42
Moments(Nm)	35	45	75	120	200	260	300	480

Attachment A

The preset value of transformer oil temperature indicator and winding temperature indicator: (for reference)

a) Transformer oil temperature indicator

Fan starting temperature: 65°C

Fan stop temperature: 50°C

Alarming temperature: 85°C

b) Transformer winding temperature indicator

Fan starting temperature: 80°C

Fan stop temperature: 70°C

Alarming temperature: 105°C

Tripping temperature: 120°C

Note: Average winding temperature is about 20~25°C higher than oil temperature.

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