TRANSFORMER ON-LINE DEHYDRATION, DEGASSING AND ULTRAFILTRATION

FOR VERY HEAVY WORKING CONDITIONS

VACUUM SEPARATOR VS-06 A

version 2009 CLIMABOX

ON POWER RECOVERY OF OIL DIELECTRIC STRENGTH REMOTE PROCESS MONITORING AND CONTROL MINIMUM SUPERVISION OR MAINTENANCE

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Drying of transformers

The presence of moisture in the transformer, to whatever degree, does actual harm to insulation which is, in fact permanent damage. Drying methods only substantially reduce that deterioration.

Vacuum Separator VS-06 is intended for mobile and preferably preventative use on transformers with more than 2 - 2.5% water content in the cellulose, with particle contamination and excess gas. The quick restoration of safe dielectric conditions also forms part of the concept. The system can be installed regardless of the size of the transformer.

Main features of VS-06

- **Moisture, gas and particles content can be reduced to the level of a new transformer**
- **Quick restoration of dielectric strength of oil**
- **No impact on the insulating oil properties, no over-drying of the transformer**
- **No disconnection of the transformer under treatment, normally not even during the installation of a separator**
- **Installation and service with minimum manpower and energy**
- **Direct check of dehydration efficiency by volumetric measurement of the separated water**
- **Remote monitoring & control of the drying process**
- **Application of advanced and patented technologies like "hydraulic piston" for vacuum building and "bubble bed" for moisture separation**

HOW MUCH MOISTURE IS "TOO MUCH MOISTURE" ?

Moisture enters the transformer either through external contamination, or is generated internally by the oxidation (ageing) of insulants. In either case, practically all the water present in the transformer (over 98%) is contained in solid insulants because the cellulose has very strong affinity with the water.

Figure 1 shows the equilibrium relationship between the water content in the oil Cw (ppm) and cellulose Cp (weight %) at different operational temperatures.

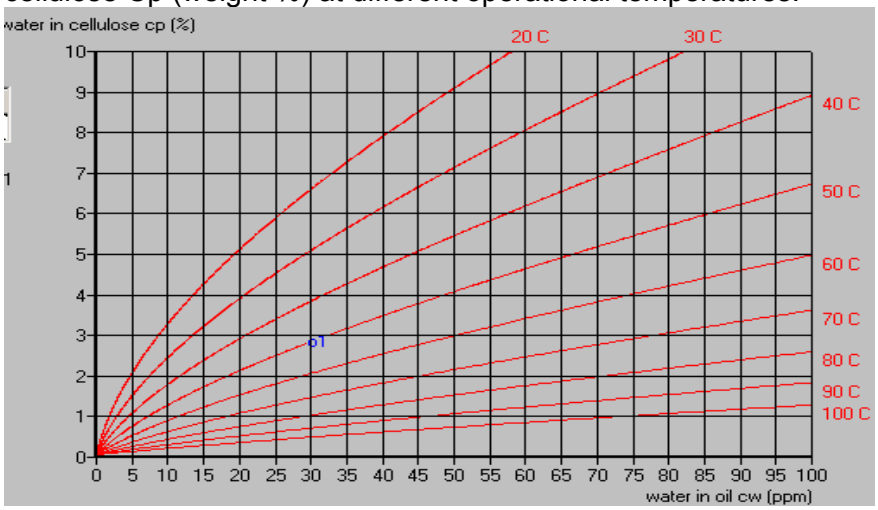

Fig.1 Moisture equilibrium chart (Nielsen diagram – TRACONAL 2005)

Example: **10MVA Transformer, 700 kg cellulose, 6000 kg oil**
Sampling temperature 50C, Cw = 30 ppm of water in the oil → Cp = **2.9%** weight percent of water in the cellulose.

Total amount of water in the cellulose: 700 x 0.029 = **20.3 kg**

Total amount of water in the oil : 6000 x 0.000030 = **0.18 kg**

If one wishes to reduce the moisture to acceptable 2% boundary then: 700 x (0.029 – 0.02) = **6.3 kg** water must be removed from the transformer.

The effect of moisture on the transformer is summarized in Table 1.

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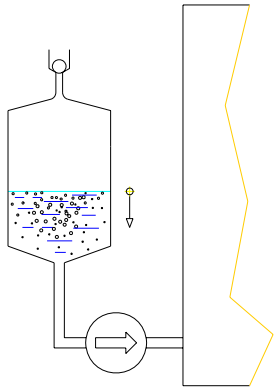
Cp (weight % in paper)	Transformer condition
0.5	new or highly dried
2.0	acceptable condition
3.3	paper starts to deteriorate
4.5	flashover possible at 90C
7.0	flashover possible at 50C
8.0	who knows ?

In order to avoid the deterioration of solid insulants, the moisture content should be kept under 2%. If the moisture level is suspected to exceed 2% , the transformer should be dehydrated as a matter of preventive maintenance.

For basic information about moisture impact at dielectric of the transformer See www.ars-altmann.com / TRACONAL or / News.

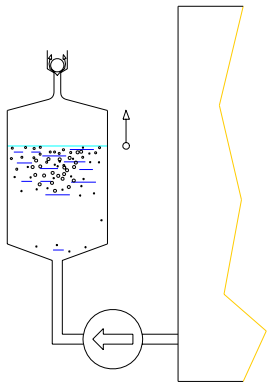
WHAT IS A LIQUID PISTON ?

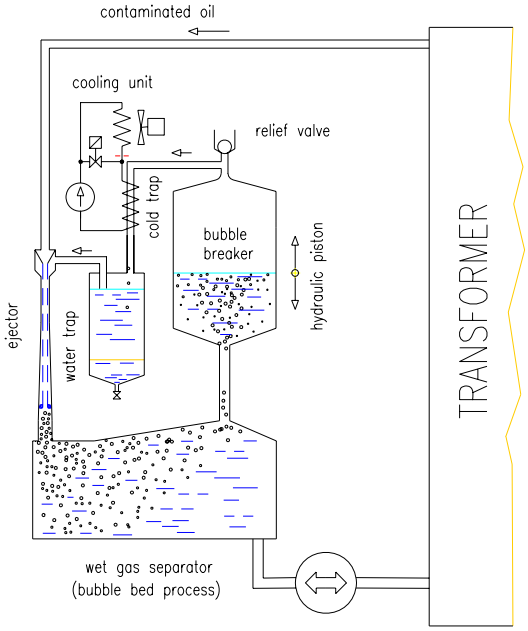
The Liquid Piston is created by rising and falling oil level which is caused by the cyclic operation of the robust gear pump.



The first stage (***evacuation***) is schematically shown on the left. The oil is drawn from the apparatus by the gear pump. The sinking oil level acts as a piston and creates the basic vacuum necessary to separate gases and vapours from the oil

The second stage (***compression***) is schematically shown on the right. The run of the gear pump is reversed and the liberated gas-vapour mixture is gradually compressed by the rising oil level (upward motion of the liquid piston). When the pressure rises, at first the condensation of oil vapours takes place **Only this way can be guaranteed "no-impact on oil properties under on-line long-term dehydration of a transformer " – condensed light fractions are automatically mixed back in the oil**. Subsequently, the gases are relieved via the non-return valve into atmosphere. This process continues until the whole apparatus is filled with oil, then the gear pump is switched on into direct run again and a new evacuation stage begins.





HOW ARE VAPOURS AND GASES SEPARATED FROM OIL ?

Vacuum, appropriate temperature and large interfacial area are essential for efficient separation.

Contaminated oil from the transformer is locally adjusted to an optimum temperature and the hot oil and the gas (previously separated from oil) get mixed in a vacuum via ejector in order to produce bubbles with a large interfacial area (bubble bed).

The intense diffusion of the moisture from the oil is enhanced by minimizing the partial pressure of the water vapour. This is achieved by undercooling the carrier gas to condense and freeze-out all traces of moisture prior to mixing with the contaminated oil.

Dissolved gases and vapours diffuse into bubbles which are then agglomerated, collected and broken.The water vapour is collected in the form of ice in the freezing trap, and periodically defrosted and collected as a liquid in the water trap.

Note that only a simplified scheme is shown here for clarity.

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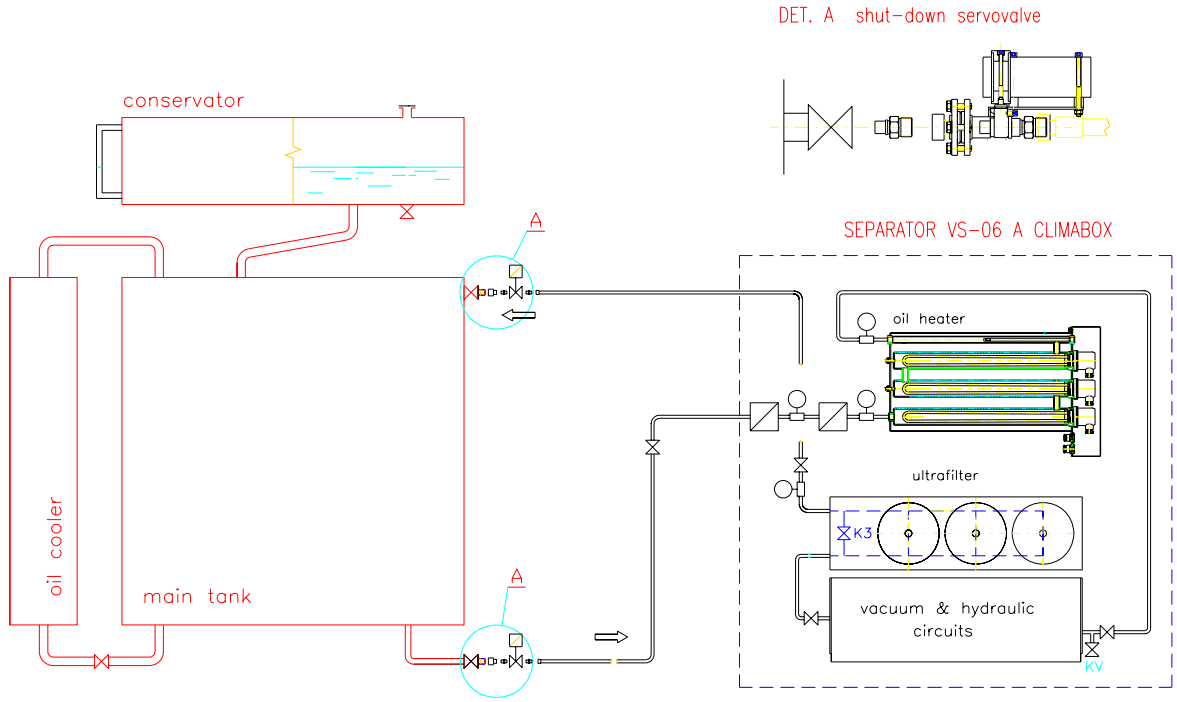
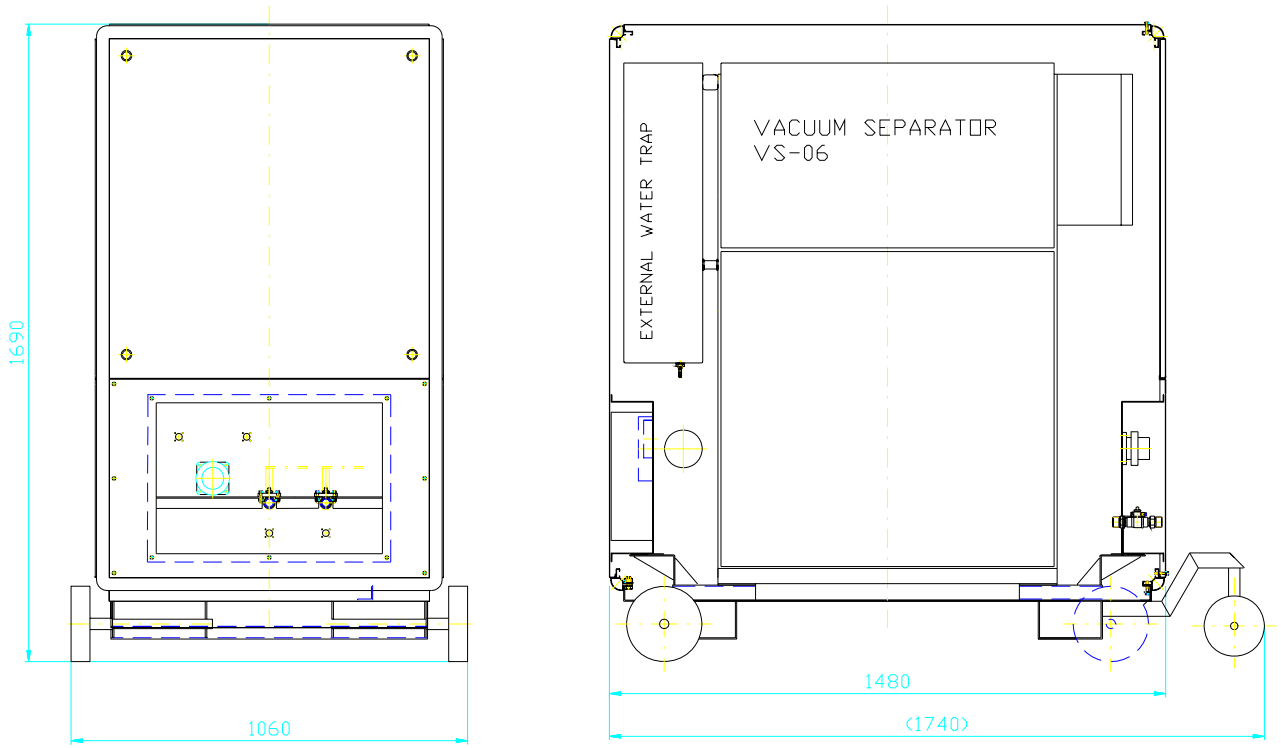
INSTALLATION



The separator can be connected to all types of transformers (i.e. open as well as sealed units). It should be located in close proximity of the transformer.

All treatment utilities (vacuum and hydraulic circuits, preheater, ultrafilter control circuits etc.) are installed in the moisture tight and internal air-conditioned CLIMABOX .
For detailed information See VS-06A CLIMABOX Operational Manual 2006

CLIMABOX DIMENSIONS



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SPECIFICATION

Power supply voltage	400 V (or on request)
Power supply frequency	50 Hz (or on request)
Power consumption:	
without oil heater	850 W
with oil heater PO-01	6200 W maximum
air condition unit	300 W
Oil throughput	10 m^3 per day maximum
Outlet water content	10 ppm nominal , 4 ppm minimum
Outlet gas content	1% nominal, 0.3 % minimum
Outlet filtering grade	1 µm

Weight – CLIMABOX version (separator, heater ultrafilter, external water trap etc.)

Dry weight (without oil)	520 kg (+ autotransformer + aircondition, if requested)
Operating weight (oil filled)	580 kg
Hydraulical connection	2 x flexible 1/2“ hose
Communication:	faxmodem, GSM modem, LAN link, ARSCOM Internet utility
Moisture reading :	Vaisala humidity sensor on request

PARAMETRIC REMOTE CONTROL

Regardless of how efficient any method of **oil** dehydration might be - the first law of the dehydration of **transformers** always is :

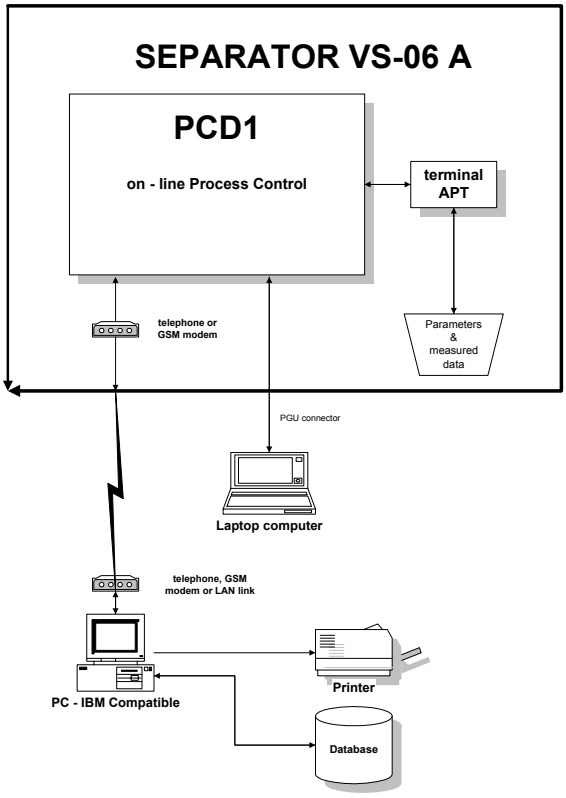
water removal from cellulose materials of the transformer has to be safe and effective

Any **on-line** transformer dehydration is ultimately governed by slow diffusion of the moisture from cellulose in the oil and this process can be accelerated only by a significant increase in temperature. But the second basic law of any on-line dehydration limits the effort because **:**

high transformer temperature → high water content in oil → high separation rate

means

→ low dielectric strength of oil → low immediate reliability of transformer



In order to avoid the lowering of the immediate reliability of the transformer, it is necessary to tune at least two antagonistic criteria in the whole process of dehydration

- max. separating efficiency of dehydrator (max. water removal rate)
- dielectric strength of oil - has to be maintained or improved

To achieve this target the VS-06 can be programmed directly (manually) via terminal of PCD 1 or better with the use of suitable PC or lap-top on the basis of actual and previously measured values.

This way is possible not only to remotely monitor and optimize the dehydrator function but to optimize the whole dehydration process as well, by strictly controlled warming-up of the transformer.

The figure on the left shows the structure of separator control systems and both connections between PCD1 and lap-top or remote PC. Communication between the PCD1 and both computers - remote user PC and lap-top is provided by the firmware of the ARS.

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Typical applications of the VS-06 Climabox

Indonesia:

Installation of VS-06 Climabox at block transformer
Improvement of Tx dielectric

Germany: 250 MVA Transformer

VS06 Climabox (and Online DGA)
controlled life-extention of aged transformer

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