ARS-ALTMANN
PRODUCT RANGE

SIMMS 2.2 (New)
In-situ reading and Moisture- Dielectric Diagnostics of power transformers

Vacuum Separator VS-06
On-line Maintenance of power transformers

ADT (New)
On-line dehydration of power transformers

ADTmini (New)
On-line dehydration of power transformers

TRAFOSEAL
Hermetization of power transformers

Separator S-03
On-line Maintenance of tap-changers

SIMMS 2.2

Solid Insulation Moisture Measurement System

Solid Insulation

The accurate recording and managing of the water content in the transformer's solid insulation Qp (%), the tracking and limiting of the impact on the aging rate of the paper, and the maintaining the desired dielectrical strength of oil Ud (kV/2.5mm) at maximum process temperatures, have never been cost effective and easy to achieve. However, it is one of the most pro-active, life extending, and cost reducing preventative strategies available to a transformer manager.

One oil sample a year collected in a glass bottle or syringe, processed in a lab, with a high degree of variability due to the process and lack of controls, does not provide the degree of data and accuracy necessary for the competent failure risk management and for managing the appropriate insulation treatment program of the transformer.

With the release of the SIMMS portable online oil and solid insulation water diagnostic system, ARS Altmann Systems has produced and sent out this key transformer information.

SIMMS 2.2 is a portable oil sample and temperature diagnostic system, without the sampling contamination and variance risk. Simply connect SIMMS 2.2 to the oil sampling points of a transformer, connect the two temperature sensors, plug in, and start. From this moment on the sampled oil is by no means exposed to the atmosphere. Oil will flow from the transformer through SIMMS and return to the transformer.

SIMMS gives us then the all desired time-related profile - water content in oil $Qw = Qw(t)$ and both temperature $Tu = Tu(t)$, $Tb = Tb(t)$ – upper / bottom transformer temperatures and TTS   as main (averaged) transformer temperature. Both averaged Qw value and TTS value can be accurately used for calculating the water content in the cellulose $Qp = Qp(Qw, TTS)$.

Installation & Commissioning
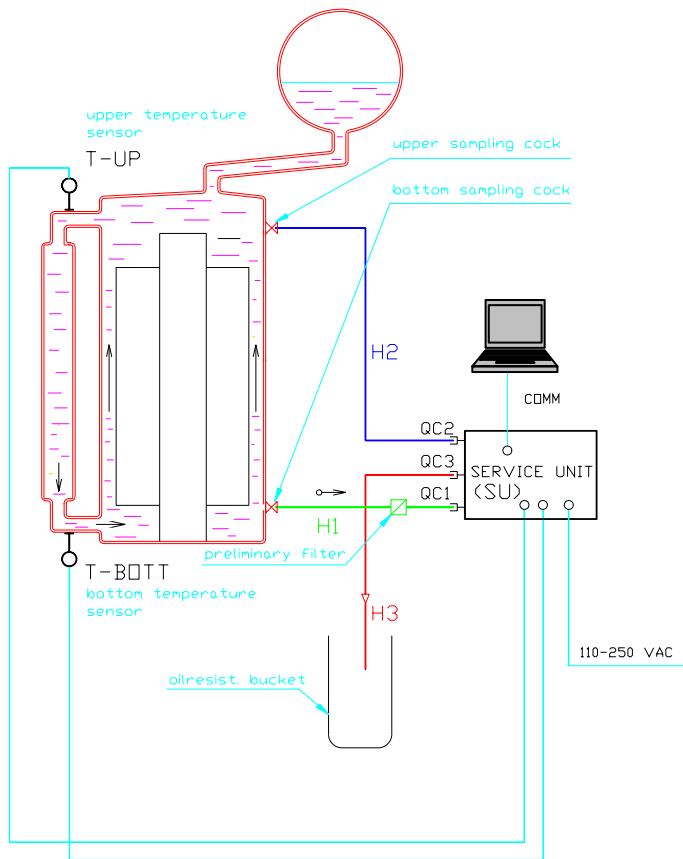
SIMMS is connected to two oil sample taps, one at the top one at the bottom. Then, both connecting hoses are evacuated to avoid contamination by air-moisture and a potential Buchholz trip. The oil is then drawn continuously through the SIMMS unit and passed back to the transformer. Independent temperature sensors are fitted to the designated top and bottom positions. Once SIMMS is installed, connected and started (ca 5 minutes), the transformer´s top (T-UP) and bottom temperatures (T-BOTT) and water content in the oil Qw (ppm) are recorded in a time based log.

Within 40 minutes an accurate snapshot decision info - if the adequate equilibrium is reached or not is obtained.
That allows precise accuracy in determining water content in the solid insulation, and the temperature related movement and time lag of the water movement between the paper and the oil. The dielectric strength and load risk at peak load can be determined more accurately. While online, the data can be accessed directly by lap-top, the graphs of trends produced, and saved as a file.
To meet plug & play features of SIMMS 2.2, the inherent part of the delivery is pre-programmed lap-top to avoid any communication and evaluation problems.

For the desired precision reading of the water content in the oil, the precise evaluation of the water content in oil (the Qw-value), the relevant evaluation of the water content in cellulose (the Qp-value) and the theoretical dielectric strength of oil (the Ud-value.

the average temperature of a transformer during a reading should always be over 30 C.

The evaluation of the water content in cellulose

This procedure is performed by the connected lap-top and uses measured values of water in the oil the Qw-value (ppm). the T-UP-value (upper transformer (Tx) temperature) and the T-BOTT-value (bottom temperature of Tx, for the evaluation of the percentage of water in its cellulose insulation the Qp-value (weight %).

Subsequently, the amount of water is calculated which has to be removed from the insulating system to obtain the desired, or norm-requested, water content in oil and the actual (theoretical) dielectric strength of oil (the Ud-value).

The Qp -value is used for the condition evaluation because we know that:

The calculated Q_p value represents here not only the average water content of cellulose insulants in the transformer

but

its temperature- invariant parameter

because

the Qp-value of any transformer doesn´t substantially change by the temperature-driven water migration between oil and cellulose : the amount of water which migrates between the celluse insulants and oil filling is very low compared to amount of water absorbed in the cellulose .

In practical terms, if we take an oil sample from the transformer under any temperature we must (under equlibrium conditions) get approximately the same Qp-value.

The Qp-value as an almost Tx-temperature constant, represents the key value of a moisture related problems of any transformer.
which
enables the prediction of the most important (Qw, Ud) values for the whole temperature range of the transformer
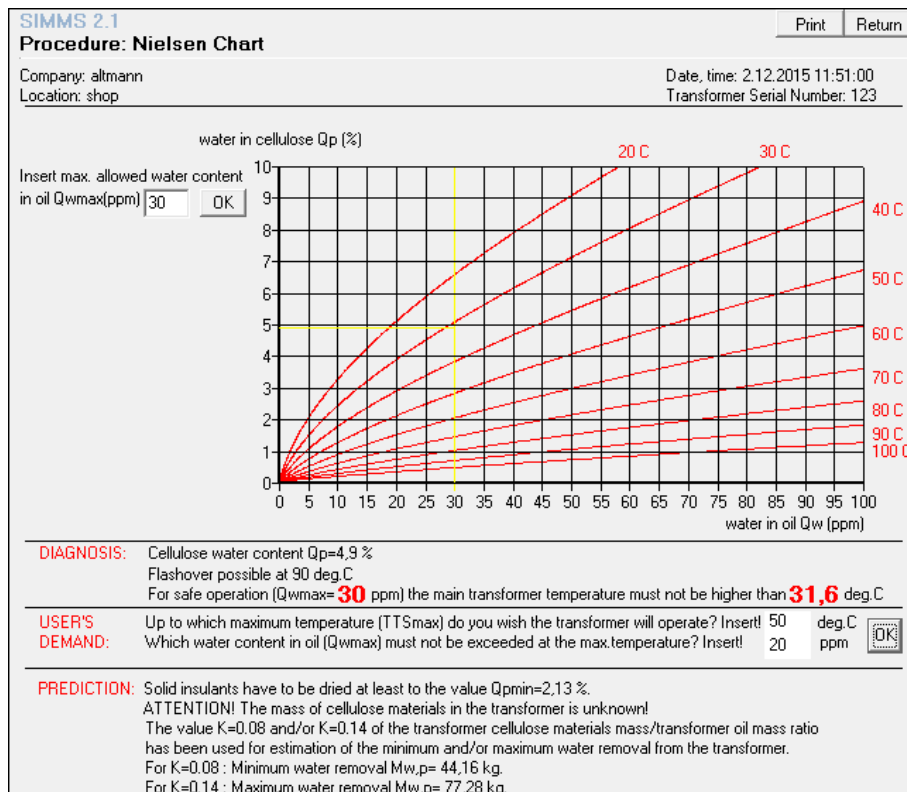
For the easy interpretation the improved and experimentally verified Nielsen equilibrium chart (relation) is used.

o Diagnosis section then interprets the reading and calculates the averaged water content in cellulose (here Qp= 4.9%). Based on the entry of target value of water content in oil Qwmax = 30ppm and given water content in cellulose Qp = 4.9% then calculates the maximum allowed operating temperatures of the transfomer, here **31.6C** (indicated as the point of intersection of both yelow lines)

o   User´s demands section is interactive and allows clients to enter pre-demanded values of:

- maximum operating temperature of transformer (50C)

- maximum allowed water content in oil (20ppm)
for further predictions.

o   Prediction section then calculates how much water has to be removed from this specific transformer to meet given demands (minimum ca 44 kg of water has to be removed in this case).

TLC-relation

This procedure uses the given Qp-value (%) for the calculation of the TLC-relation. The TLC(Temperature Loading Curve) then **predicts the dielectric strength of oil, the Ud-value**, **for the whole temperature range (here 20 – 100C) of** this specific transformer.
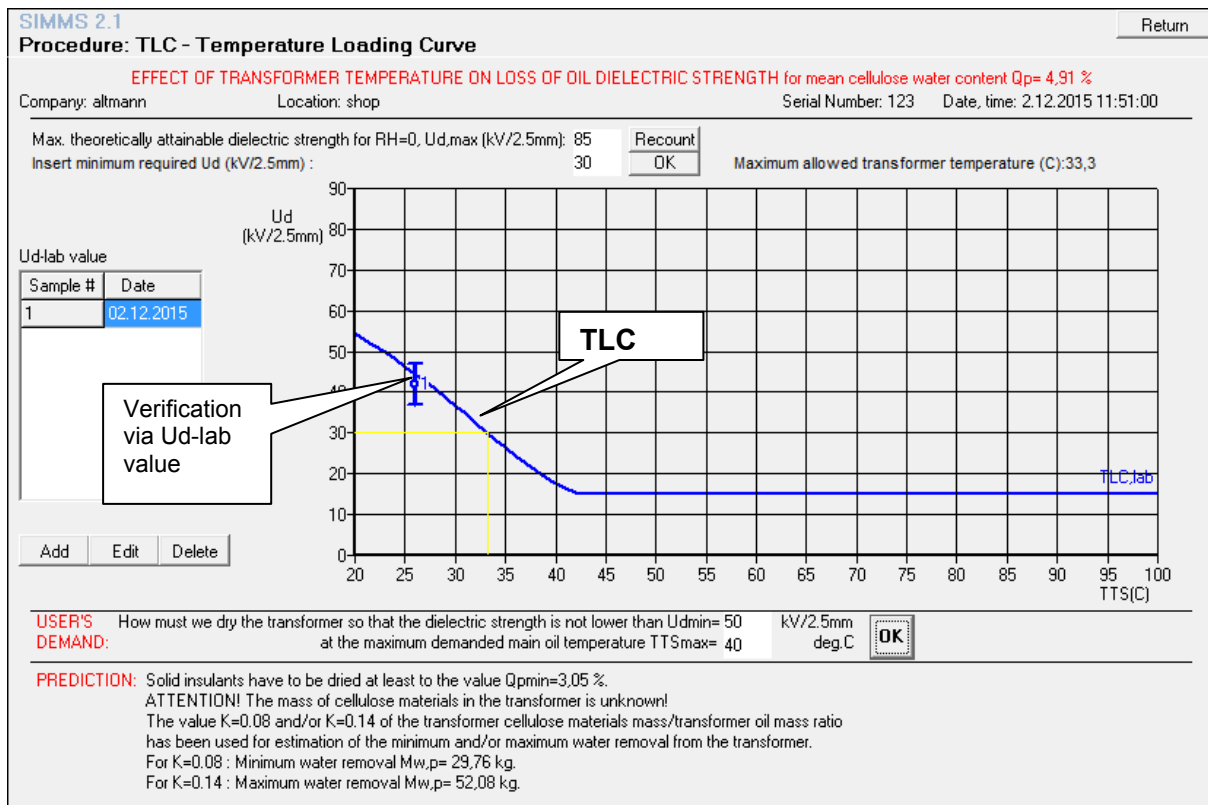
Simultaneously, based on the calculated TLC and allowed dielectric strength of oil (30 kV/2.5mm , horizontal yelow line), the maximum allowed temperature of the transformer (vertical yellow line : ca 33.3C) is determined.

The next calculation (Prediction) shows how much water must be removed from the insulating system (at the given temperature of the transformer) to meet the pre-determined miminum (e.g. norm-requested) dielectric strength of oil in its oil filling.

User´s demands section is interactive again and allows the entry of values:

- **minimum-requested) dielectric strength of oil**

- **requested operating temperature of transformer**

Prediction **section then calculates how much water has to be removed from this specific transformer to meet these demands.**

Verification of diagnostic results by Ud-lab value(s) **based on the comparison of theoretical Ud-value (TLC-curve) with the Ud-lab value (See point** 1 **with error bars) at the same sampling time and the same temperature of the transformer.**

Technical data

Power supply voltage	80 – 250 VAC
Power supply frequency	50 - 60 Hz
Power consumption:	max 80W
Oil throughflow	max 100l per hour
Measuring range	
Water content in the oil	5 – 100 ppm (diluted water)
Temperature	0 – 100 C
Outlet /inlet filtering grade of preliminary filter	40 µm
Weight – inclusive lap-top, alu transport box and accessories	22 kg
Dry weight of the measuring unit only (without oil)	5 kg
Hydraulical connection	2 x flexible hose
Communication:	lap-top connector

Transportations
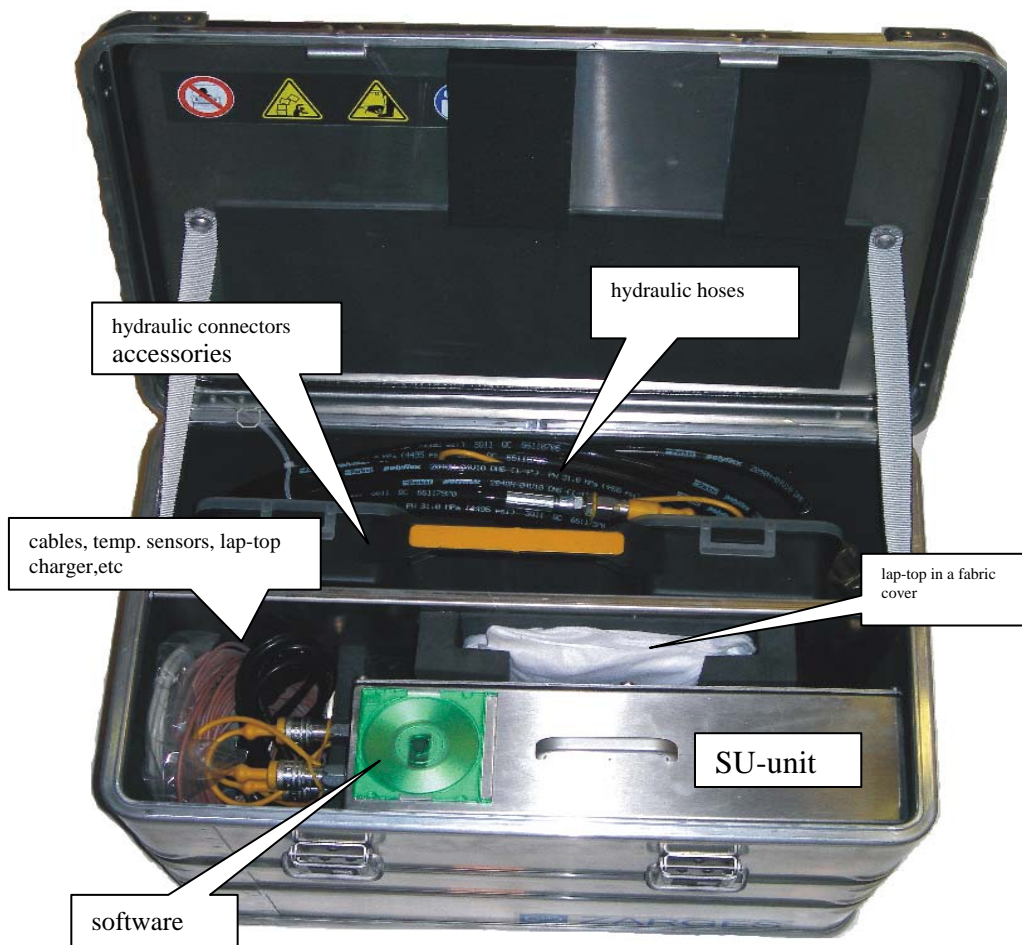
SIMMS 2.2 Service Unit is always transported, inclusively the lap-top and all accessories in high resistant alu box intended for all-day operations under very heavy conditions

VACUUM SEPARATOR VS-06 Climabox

PLUG & PLAY ON-LINE DEHYDRATION, DEGASSING AND FILTRATION OF TRANSFORMERS

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. 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
- ❑ effective removal of fault gases (H2, CH4, C2H2 etc.) via remote controlled stripping process

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 Q_w (ppm) and cellulose Q_p (weight %) at different operational temperatures.
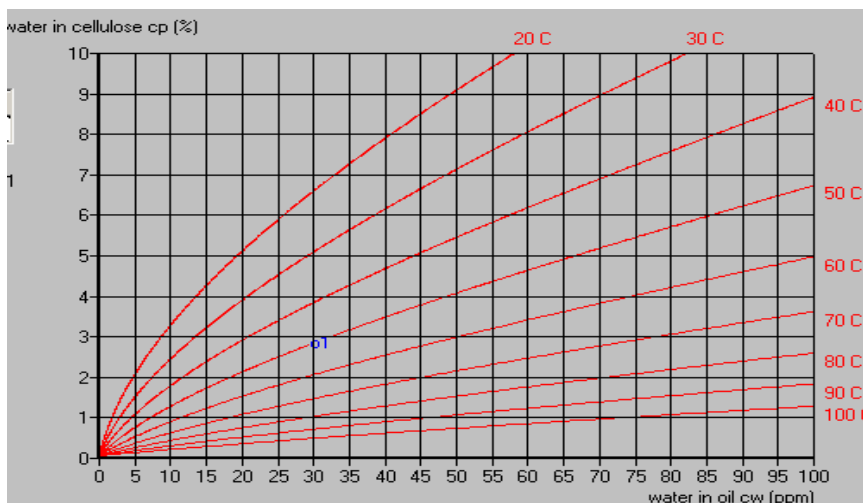

Fig.1 Moisture equilibrium chart (Nielsen diagram)

Example: **10MVA Transformer, 700 kg cellulose, 6000 kg oil**
Sampling temperature 50C, Q_w = 30 ppm of water in the oil → Q_p = **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.

Q_p (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 / News.

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Tel:+420-379 738 778, Fax:+420-379 738 775, Cell phone:+420-602 362 157 email:altmann@iol.cz, www.ars-altmann.com;
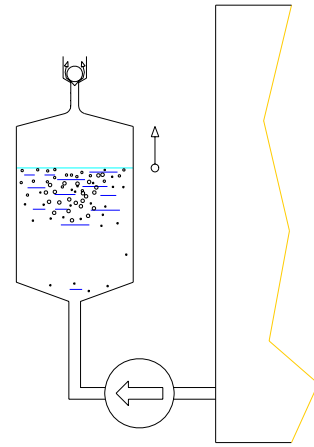
WHAT IS A LIQUID PISTON ?

The Liquid Piston is created by rising and falling oil level in a vessel which is caused by the cyclic operation of the robust gear pump.
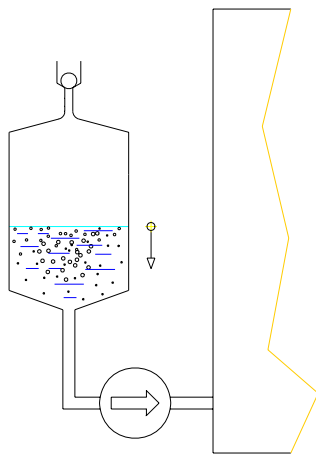
The first stage (*evacuation*) is schematically shown on the left. The oil is drawn from the apparatus by the gear pump. The sinking oil level acts as a piston and creates the basic vacuum necessary to separate gases and vapours from the oil

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 " – 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.
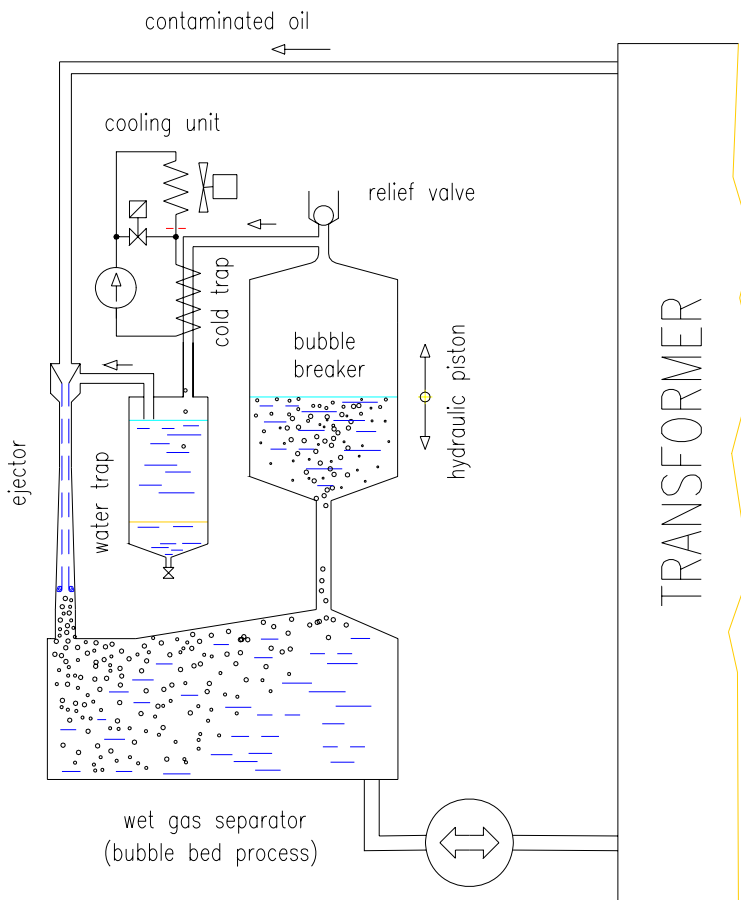
HOW ARE VAPOURS AND GASES SEPARATED FROM OIL ?

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.

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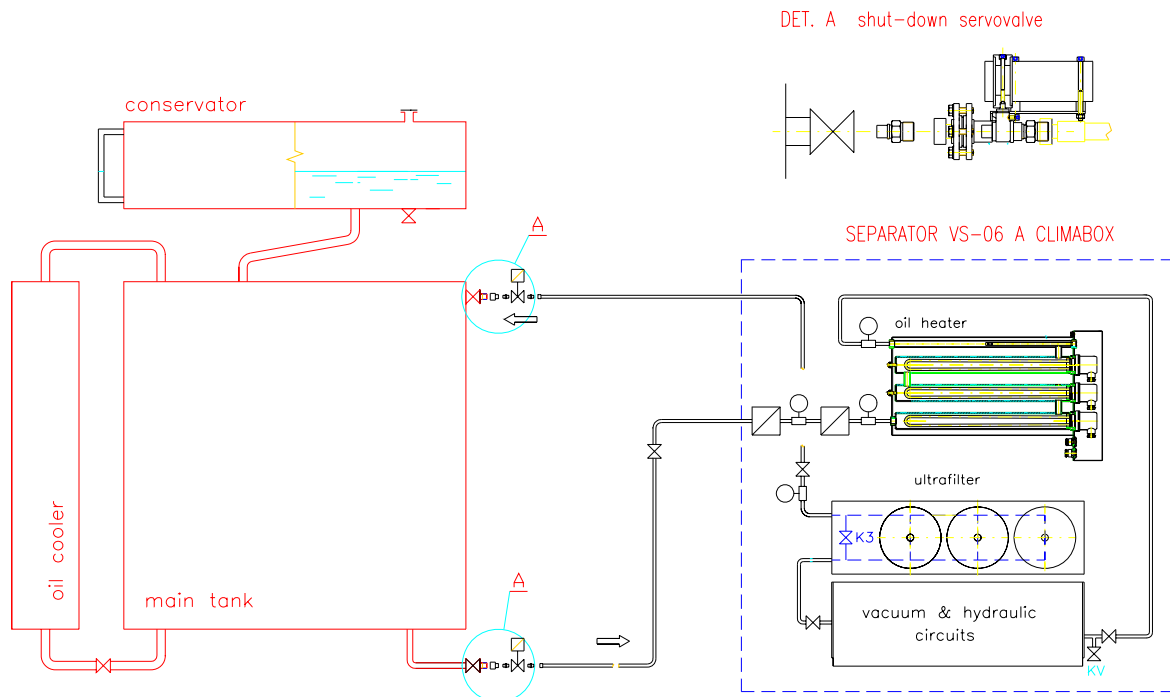
The separator can be connected to all types of transformers (i.e. open as well as sealed units). It should be located in close proximity of the transformer.

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
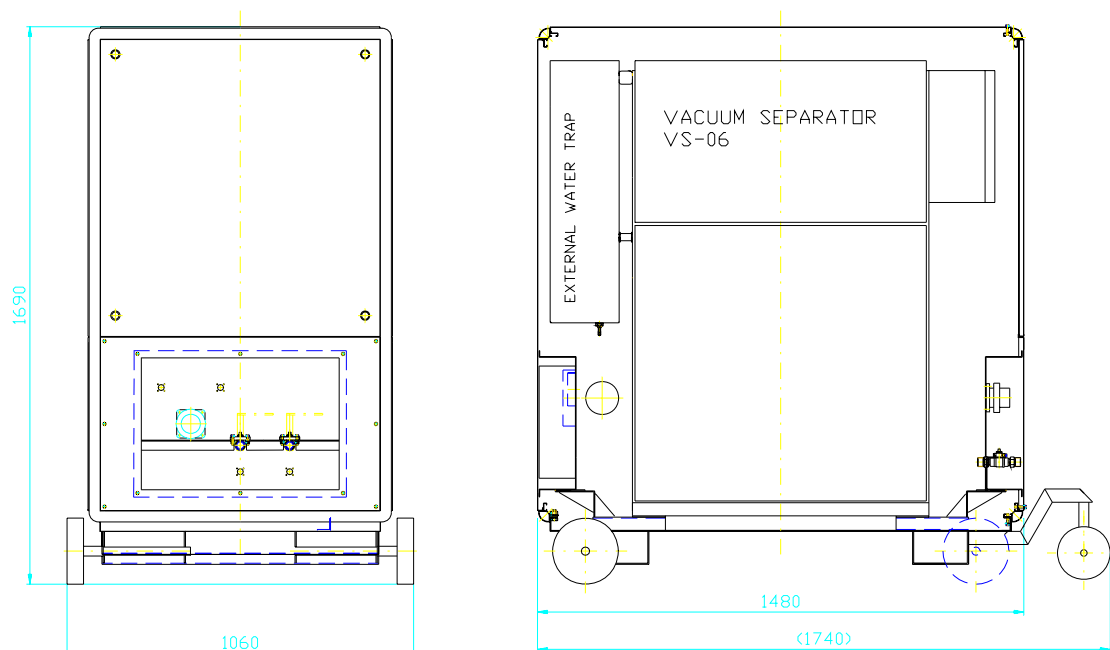
SPECIFICATION

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
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 (5µm)

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

Dry weight (without oil)	520 kg
Operating weight (oil filled)	580 kg
Hydraulical connection	2 x flexible 1/2" hose
Communication:	faxmodem, GSM modem, LAN link, SMS, Internet

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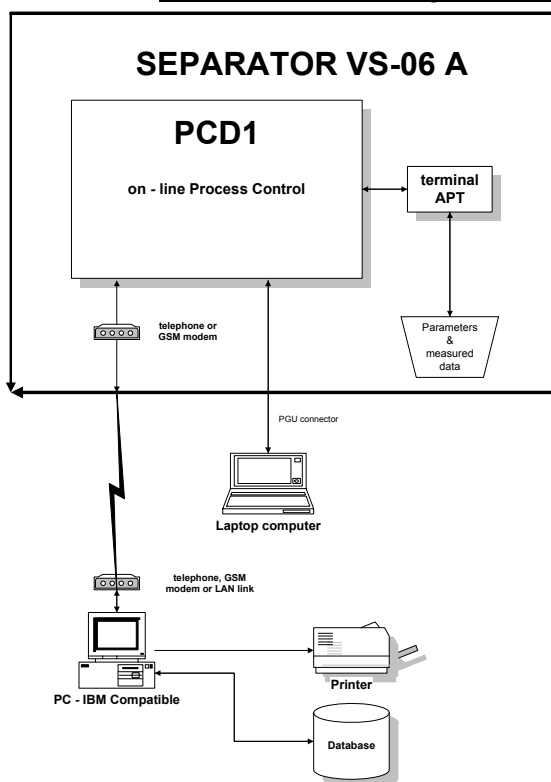
In order to avoid the lowering of the immediate reliability of the transformer, it is necessary to tune at least two antagonistic criteria in the whole process of dehydration

- 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 remotely 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 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.

**The advanced evaluation of the effectivity of transformer treatment**

For a better understanding of the long-term trends of dehydration effectivity of the VS-06 and a change of the dielectric behaviour of the transformer within the treatment two new procedures are used:

- o the **DDL** (**D**ehydration and **D**egassing **L**og)

- o the **DSL** (**D**ielectric **S**trength **L**og)

Both procedures can be started by clicking on the DDL or the DSL buttons in the Main window. By clicking on the DDL it shows :

The time-related change of basic variables (Mwc- total amount of removed water, Ttb - Tx temp. bottom, P2S -averaged process vacuum, Qw - water content in oil) are shown on the screen and
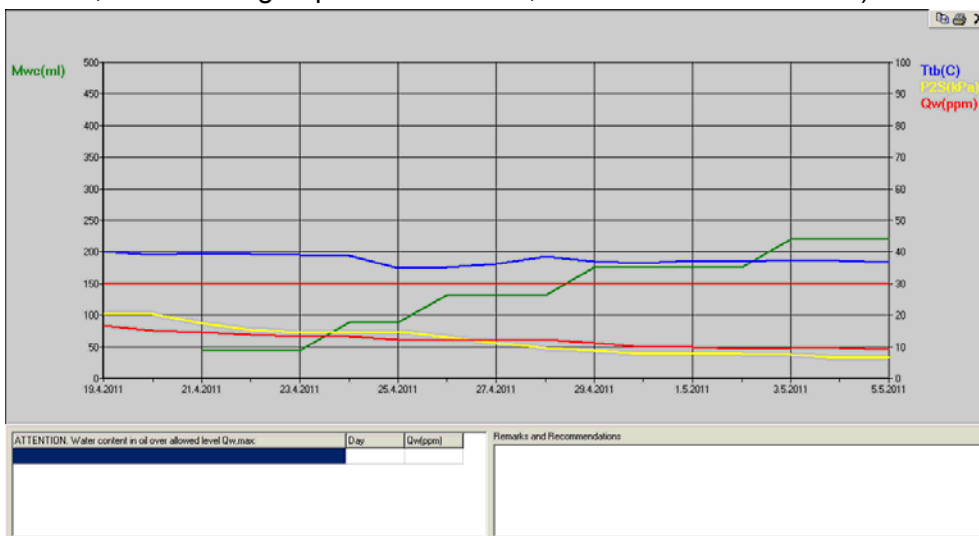

by clicking on the printer icone (in the upper part of the diagram), the diagram is converted into the user-friendly version. The end of the conversion and by clicking on the OK button , the final, printable output of the DDL procedure is shown

VACUUM SEPARATOR VS-06 - Main Data Log
OPTIM D3L (Dehydration **D**egasing **D**ielectric **L**og**)**
Procedure: DDL (Dehydration **D**egasing **L**og**)**
© Ing. Altmann, 2010

Transformer Location:	xxx
Transformer Serial Number:	xxx
VS-06 Serial Number:	xxxx

Time-period of evaluation :   19.04.2011 - 05.05.2011

Norm requested value Qw,max - red horizontal line
Qw,max = 30 ppm... maximum allowed water content in oil
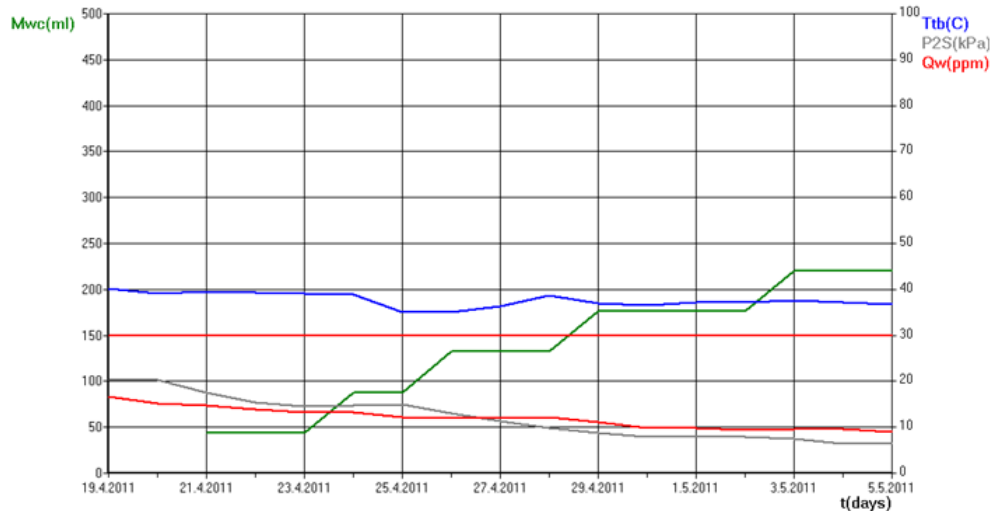
Mwc	Amount of removed water (ml)
Qw	Water Content in oil (ppm)
Ttb	Transformer temperature bottom (C)
P2s	Averaged vacuum in Separator (kPa)

ATTENTION.
Water content in oil Qw exceeded
allowed Qw,max-limit:

Day	Qw(ppm)

Remarks & Recommendations

Date of evaluation: 6.5.2011

where all directly measured values are clearly defined and shown in the form of a time-related diagram.

A new kind of assesment can be used now for the on-line diagnostic of dielectric behaviour of the transformer

DSL – Dielectric Strength Log

This absolutely new approach enables the DSL online to calculate the theoretical (maximum attainable) value of the dielectric strength of oil (the Ud,t –value) on the basis of the direct reading of the water content in the oil (the Qw-value).

This is the first time, that this specific online diagnosis can be validated by the offline data.

This mathematical model used for the calculation is based on the well documented near-linear relation between the decrease of dielectric strenght due to the increase of the relative humidity of oil (at lab temperature).

The DSL procedure enables a substantially more detailed insight into dielectric behaviour of a given transformer especially the „contardictory" change of the dielectric strength versus the temperature of the transformer.

After clicking on the Analyse button the resulting time-related Ud,t-relation is shown on the screen together with bottom temperature of the transformer.
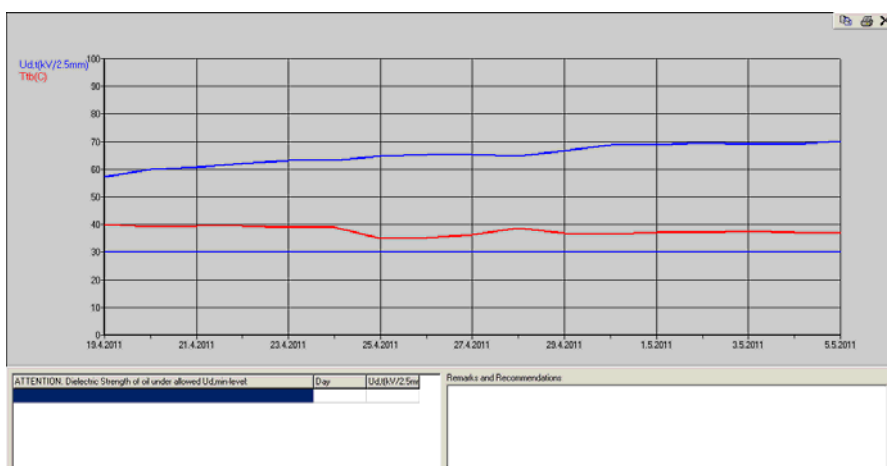
And shows the description of the dielectric behaviour of the transformer for the requested time period

VACUUM SEPARATOR VS-06 - Main Data Log
OPTIM D3L (Dehydration Degasing Dielectric Log)
Procedure: DSL (Dielectric Strength Log)
© Ing. Altmann, 2010

Transformer Location:	xxx
Transformer Serial Number:	xxxx
VS-06 Serial Number:	xxxx

Time-period of evaluation :   19.04.2011 - 05.05.2011

Norm requested value Ud,min - **blue** horizontal line
Ud,min = 30 kV/2.5mm... minimal allowed dielectric strength in oil
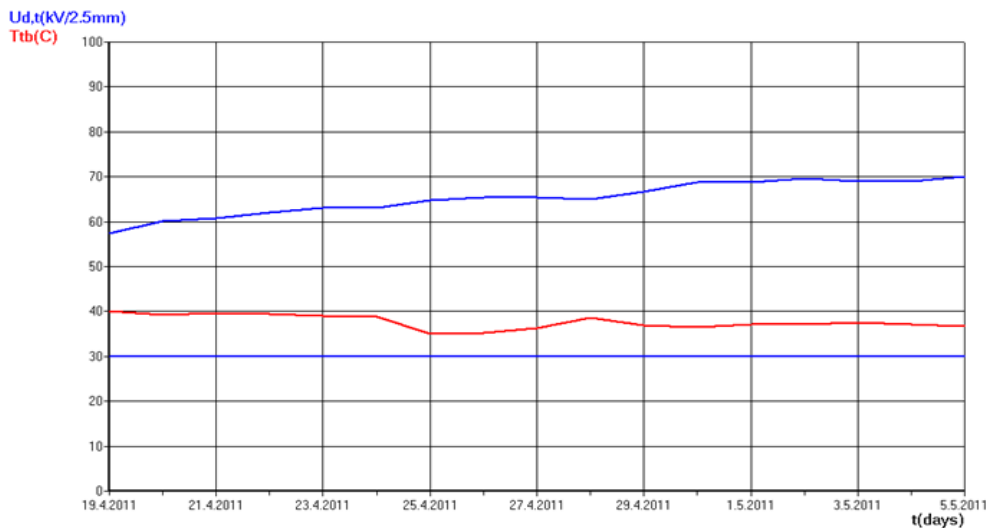
Ud,t	...	Theoretical Dielectric Strength of oil (kV/2.5mm)
Ttb	...	Transformer temperature bottom (C)

ATTENTION.   Number of lab verifications: 0
Dielectric Strength of oil Ud,t decreased
under allowed Ud,min-limit:

Day	Ud,t(kV/2.5mm)

Remarks & Recommendations

Date of evaluation: 6.5.2011

To obtain relevant diagnostic results, the accuracy of the Ud,t-simulation for the given time-period **must always be correspondingly verified**:
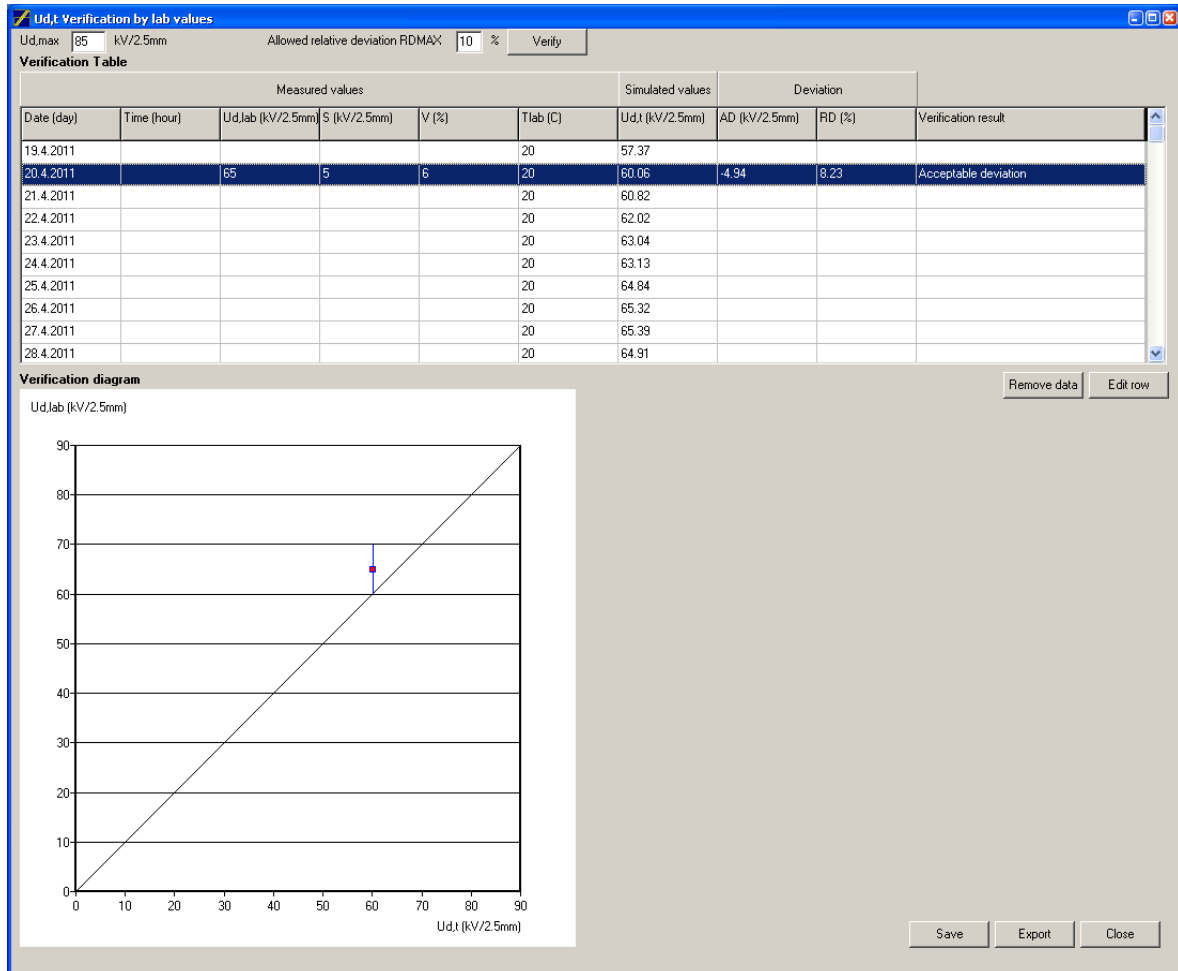
- o by the quantitative comparison of the Ud,t-value and the Ud,lab-value at the same time.

This means that the simulated Ud,t-value has to be compared with the Ud,lab- value at the same sampling time (the time when the oil for the lab Ud-reading has been sampled at the transformer).

Verification Diagram gives a direct and easy insight into the accuracy of on-line Ud,t-simulation and/or the Ud,lab-value :

- o if the Ud,lab≈Ud,t–point is situated in the 10kV/2.5mm band around the transverse 45° line, the consistency of the simulated Ud,t-value and the Ud,lab-value is very good and the subsequent diagnosis of the dielectric behaviour of the transformer for the given time-period is precise enough

- o if the Ud,lab≈Ud,t–point is situated in the 20kV/2.5mm band, the consistency of simulated Ud-value and measured Ud-value is sufficient (for field conditions) and the subsequent diagnosis is acceptable

- o if the Ud,lab≈Ud,t–point is situated outside of the 30kV/2.5 band, means that either the simulated Ud,t-value or the Ud,lab-reading is not precise enough. The relevant check of a dielectric behaviour of the transformer is not possible. Therefore the veracity of both values has to be checked.

The mutual comparison of simulated and directly measured Ud-values gives us an opportunity to check the plausibility of both values.

Typical applications of the VS-06 Climabox
Germany: 250 MVA Transformer
VS06 Climabox (and Online DGA) - controlled life-extention of the transformer

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

ADT

ON-POWER DEHYDRATION OF TRANSFORMERS

FOR VERY HEAVY WORKING CONDITIONS
ON POWER RECOVERY OF DIELECTRIC STRENGTH
LIFE EXTENSION OF TRANFORMER
REMOTE PROCESS CONTROL AND MONITORING
EASY CHECK OF FUNCTION VIA YOUR HANDY
ON-LINE DIELECTRIC SCREENING
EASY VERIFICATION BY LAB RESULTS
PLUG & PLAY INSTALLATION
AND MINIMUM SUPERVISION AND/OR MAINTENANCE

Main features

❑ **Easy and safe installation and commissioning: all procedures are computer controlled to avoid any human lapses and errors**

❑ **No disconnection of the transformer under treatment, normally not even during installation of dehydrator (Plug & Play design)**

❑ **No air venting after installation: hydraulical interconections to a transformer oil filling are set under vacuum and subsequently rinsed by oil**

❑ **Moisture 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 and DGA**

❑ **Direct check of dehydration efficiency based on amount of removed water: calculated as the product of difference input-otput water content in oil (2 x humidity sensors)   x precise volumetric reading of oil throughflow**

❑ **Easy control of function by SMS via your handy**

❑ **Remote monitoring & control of drying process: all relevant data are recorded and displayed (printed) as easy comprehensive diagrams**

❑ **Calculation of actual value of dielectic strength (Ud-value) of oil during the whole dehydration**

❑ **Easy verification of simulated Ud-values by lab reading(s) by means of Verification diagram**

❑ **Easy and safely replacement of adsorbent cartridges and filters without a potential oil spill: the oil is removed before replacement and forced back to the oil filling of transformer**

❑ **DOG (Dynamic Overdrying Guard) procedure inhibits the overdying of hard insulants**
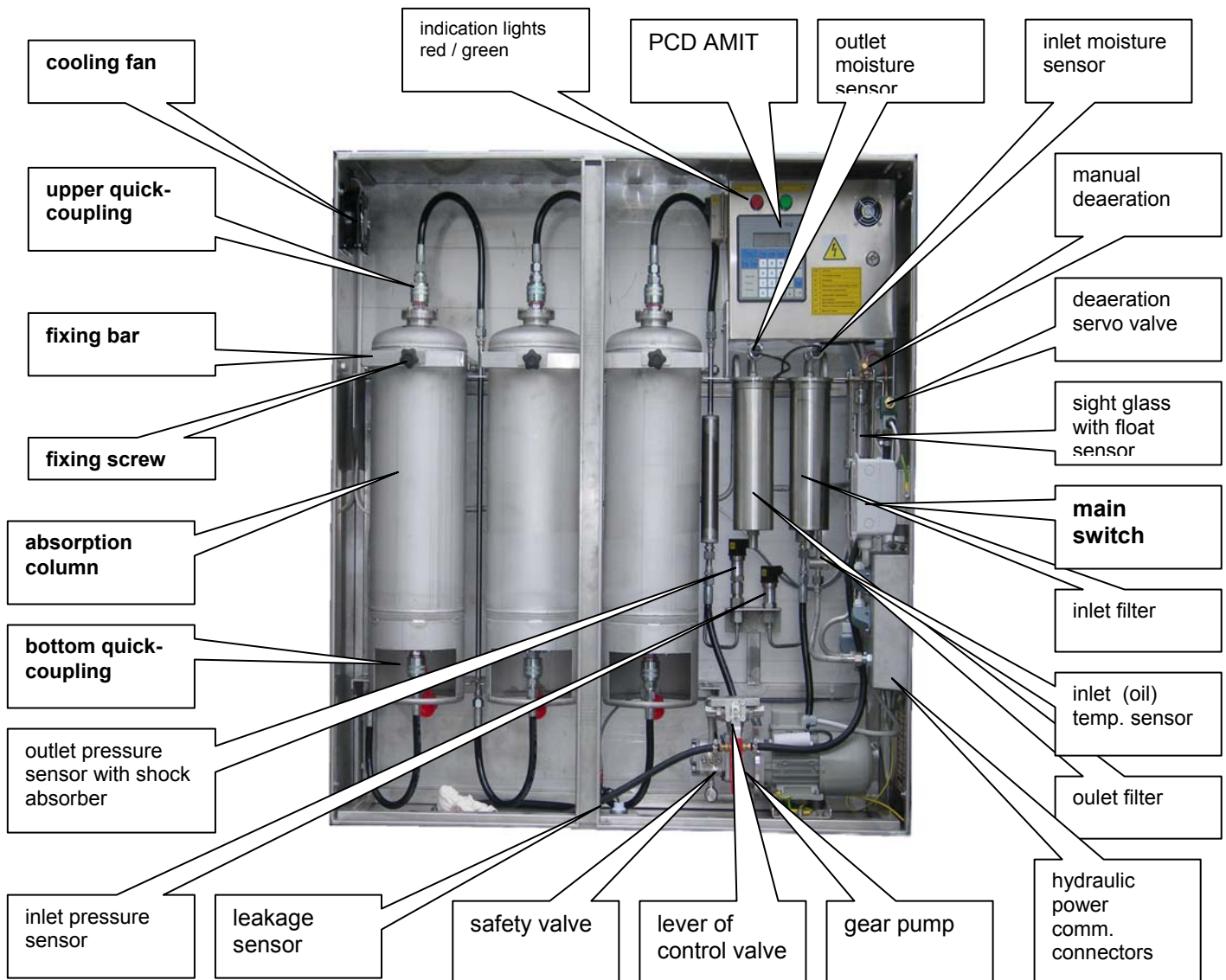
INSTALLATION
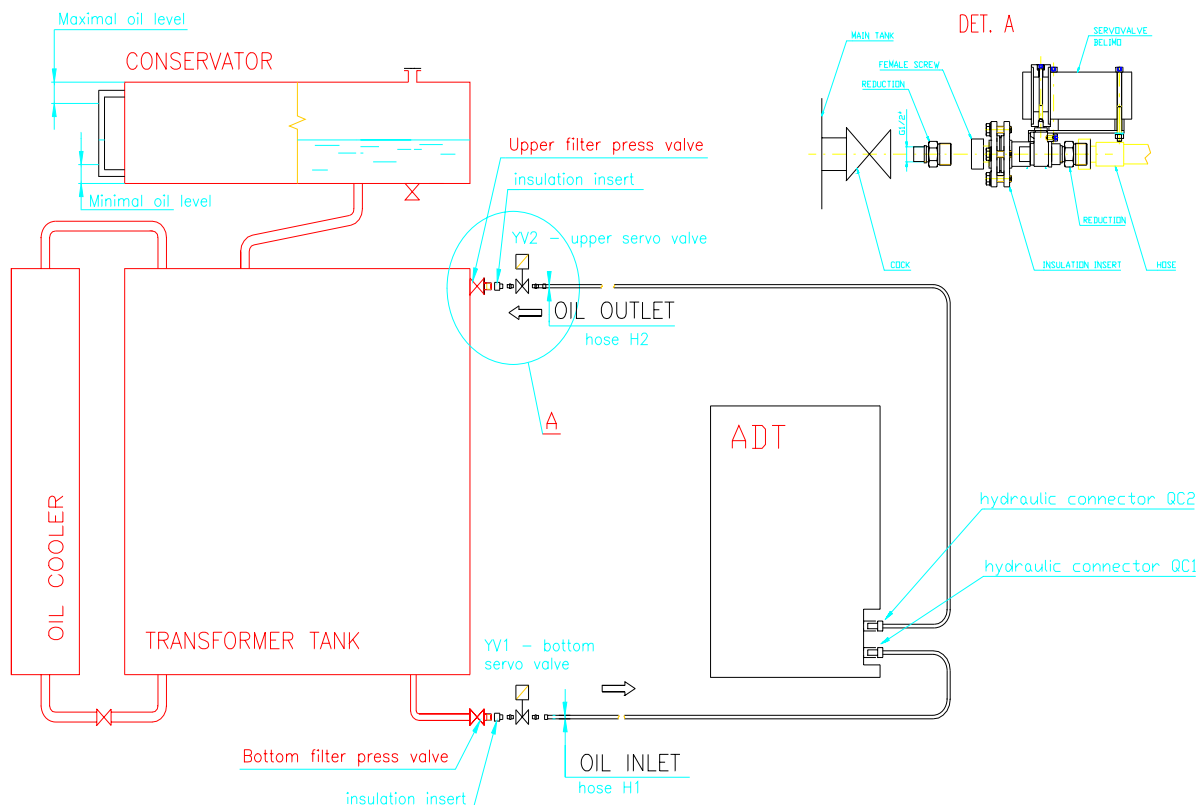
The ADT can be connected to all types of transformers (i.e. open as well as sealed units). It should be located in close proximity to the transformer.

All treatment utilities (hydraulic circuits, input/output filters, control circuits etc.) are installed in the moisture tight and internal air-conditioned box.
For detailed information See ADT Operational Manual 2018.

SPECIFICATION

Power supply voltage	1 phase 230 VAC (or on demand)
Power supply frequency	50 (60) Hz
Power consumption:	200 W
Oil throughput	7.5 m^3 per day maximum
Outlet water content	5 ppm nominal , 1 ppm minimum
Outlet filtering grade	1 µm
Absorption capacity	8.2 kg of water
Installation options	mobile unit or permanently installed
Dry weight (without oil)	260 kg
Operating weight (oil filled)	272 kg
Dimensions	1200 x 850 x 1490 (mm)
Hydraulical connection	2 x flexible 1/2" hose
Communication:	Faxmodem,GSM modem, LAN link, SMS, Internet

cooling fan

upper quick-coupling

fixing bar

fixing screw

absorption column

bottom quick-coupling

outlet pressure sensor with shock absorber

inlet pressure sensor

leakage sensor

safety valve

lever of control valve

gear pump

hydraulic power comm. connectors

oulet filter

inlet (oil) temp. sensor

inlet filter

main switch

sight glass with float sensor

deaeration servo valve

manual deaeration

inlet moisture sensor

outlet moisture sensor

PCD AMIT

indication lights red / green

Internal layout of main components in ADT (open front doors)
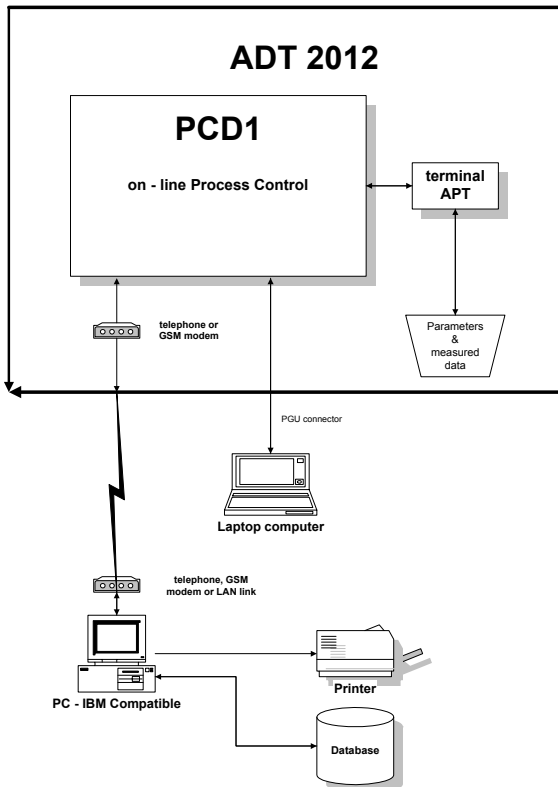
PARAMETRIC REMOTE CONTROL

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

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

Any **on-line** transformer dehydration is ultimately governed by the slow diffusion of moisture from the cellulose into the oil and this process can be accelerated only by a significant increase of its temperature. But, be carefull:

high transformer temperature → high water content in oil → high separation rate
which simultaneously means

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

ADT 2012

PCD1

on - line Process Control

terminal APT

telephone or GSM modem

Parameters & measured data

PGU connector

Laptop computer

telephone, GSM modem or LAN link

PC - IBM Compatible

Printer

Database

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 these targets the ADT can be programmed directly (manually) via the terminal of PCD or alternatively by the PC or lap-top.

This way offers remote monitoring and optimalization of dehydration by strictly controlling warming-up of the transformer.

The figure on the left shows the structure of dehydrator control systems and both connections between PCD1 and lap-top or remote PC.

The software for communication between the PCD1 and both computers - remote user PC and lap-top is provided by ARS.

The easy check of ADT-function can be performed by your handy anywhere and anytime: via SMS

The advanced evaluation of the effectivity of transformer dehydration

For a better understanding of the long-term trends of dehydration effectivity of the ADT and a change of the dielectric behaviour of the transformer within the treatment two new procedures are used:

- o the **DL** (**D**ehydration **L**og)
- o the **DSL** (**D**ielectric **S**trength **L**og)

Both procedures can be started by clicking on the DL or the DSL buttons in the Main window.
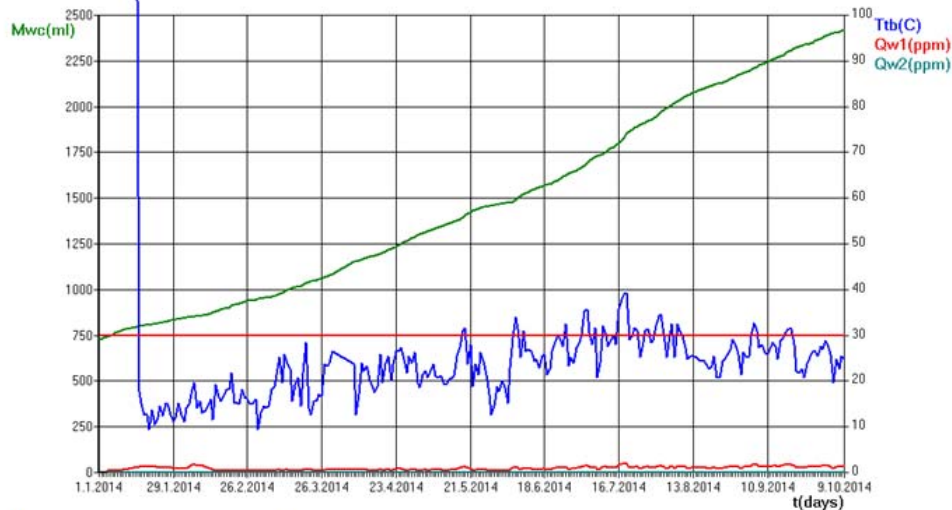
and by clicking on the OK button , the final, printable output of the DL procedure is shown

ADT 2012 Dehydrator - Main Data Log
OPTIM D2L (Dehydration Dielectric Log**)**
Procedure: DL (Dehydration Log**)**
© Ing. Altmann, 2013

Transformer Location:	xxxx
Transformer Serial Number:	
ADT 2012 Serial Number:	xxxx

Time-period of evaluation :   01.01.2014 - 09.10.2014

Norm requested value Qw,max - red horizontal line
Qw,max = 30 ppm... maximum allowed water content in oil

Mwc   amount of removed water (ml)
Qw1   input value of water content in oil (ppm)
Qw2   output value of water content in oil (ppm)
Ttb   transformer temp. bottom (C)

ATTENTION.
Water content in oil Qw exceeded
allowed Qw,max-limit:

Day	Qw(ppm)

Remarks & Recommendations

Date of evaluation: 10.10.2014
Replacement of temperature sensor at 11.1 2014

A new kind of assesment can be used now for the on-line diagnostic of dielectric behaviour of the transformer

DSL – Dielectric Strength Log

This absolutely new approach enables the DSL online to calculate the theoretical (maximum attainable) value of the dielectric strength of oil (the Ud,t –value) on the basis of the direct measuring of the water content in the oil (the Qw1-value).

And the following steps are similar as before :

o   requested time-range of data (Data File , Start , End)

o   Transformer Location, Transformer S/N and VS-06 S/N

o   Minimum allowable dielectric strength of the oil (Ud,min)

these can be directly and easily entered from the keyboard.

The DSL procedure enables a substantially more detailed insight into dielectric behaviour of a given transformer especially the „contardictory" change of the dielectric strength versus the temperature of the transformer.

ADT 2012 Dehydrator - Main Data Log
OPTIM D2L (Dehydration Dielectric Log)
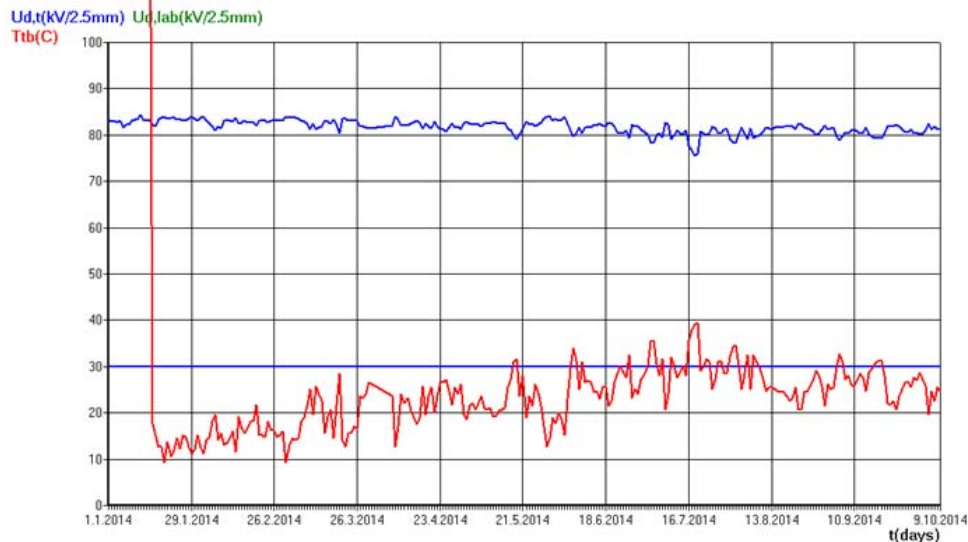Procedure: DSL (Dielectric Strength Log)
© Ing. Altmann, 2013

Transformer Location:	xxxx
Transformer Serial Number:	
ADT 2012 Serial Number:	xxxx

Time-period of evaluation :   01.01.2014 - 09.10.2014

Norm requested value Ud,min - blue horizontal line
Ud,min = 30 kV/2.5mm... minimal allowed dielectric strength in oil
T = 20 C ... Temperature of Simulation

Ud,t(kV/2.5mm) Ud,lab(kV/2.5mm)
Ttb(C)
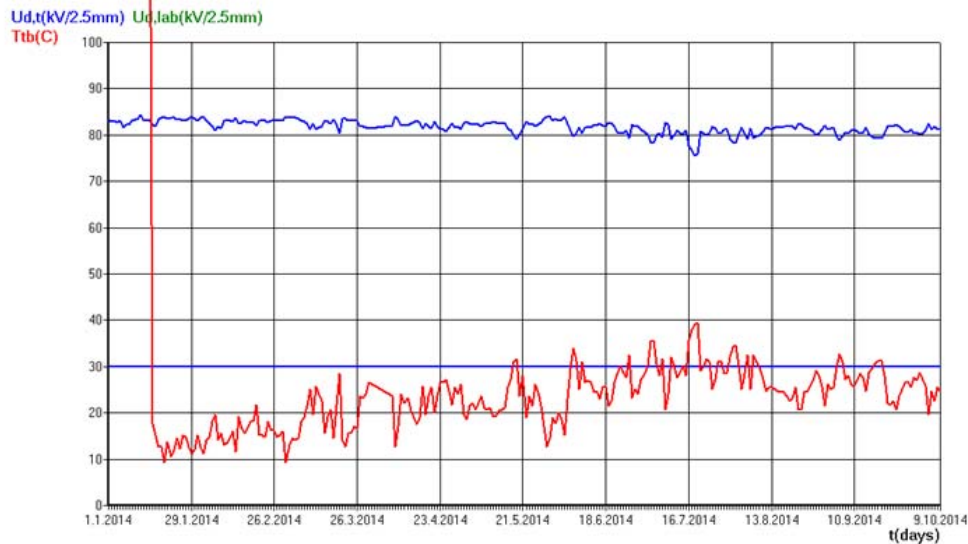
Ud,t	...	Theoretical Dielectric Strength of oil (kV/2.5mm)
Ttb	...	Transformer temperature bottom (C)
Ud,lab	...	lab reading(s) of dielectric strength of oil (kV/2.5mm)

ATTENTION.   Number of lab verifications: 0
Dielectric Strength of oil Ud,t decreased
under allowed Ud,min-limit:

| Day | Ud,t(kV/2.5mm) |
| | |

Remarks & Recommendations

| Date of evaluation: 10.10.2014 |
| Replacement of temperature sensor at 11.1 2014 |

To obtain relevant diagnostic results, the accuracy of the Ud,t-simulation for the given time-period must always be correspondingly verified:

   o   by the quantitative comparison of the Ud,t-value and the Ud,lab-value at the same time.

This means that the simulated Ud,t-value has to be compared with the Ud,lab- value at the same sampling time (the time when the oil for the lab Ud-reading has been sampled at the transformer).

The final result of the DSL-procedure is the quantitative verification by means of the Verification Table and the Verification Diagram.

DOG (Dynamic Overdrying Guard)

Any uncontrolled removal of water from a transformer always represents substantial decrease of its safety level.

The reason is simple: strong decrease of water content in its hard insulants inevitably induces their shrinkage and subsequent lost of clamping forces.

The danger of transformer failure then strongly increases especially under short-circuits events.

Main dehydration rule is then accordingly clear : the averaged water content in hard insulants (the Qp-value) may not be drastically and suddenly lowered during a dehydration campaign.

The reading of relevant Qp-value of the transformer during its dehydration campaign is therefore crucial.

But a relevant evaluation of Qp-value based on reading of Qw-value (water content in oil) and Ttb-value (transfomer temp. bottom) has to be performed under so-called equilibrium conditions (transformer is operated at approx. constant temperature for relatively long time-period → no water migration between hard insulants and oil inventory exists).

To satisfy these conditions during a dehydration campaign is impossible. To meet this target the dehydration process has to be interrupted and we have to wait till satisfactory equilibrium is met. It could take under optimal conditions (constant temp. of a Tx is hard to keep) more than 4 weeks.

If target Qp-value isn´t met, the dehydration has to be started again and the whole process is repeated till requested Qp-value is reached. A very time-consuming process.

This specific problem solves the new DOG procedure based on utilization of dynamic behaviour of oil-cellulose system and the introduction of new variable, the **virtual** Qp-value (Qpv):

⇒ continuous calculation of Qpv-value is based on direct reading of Qw- and Ttb-value and the algoritmus for evaluation of Qpv-value is based on Nielsen Chart

⇒ if Qpv-value decreases under a target Qpsoll -level (demanded averaged water content in hard insulants See Parameter Table) the dehydration process is temporarily terminated and ADT goes to measuring regime where **a dynamic change of Qpv-value during water resaturation of oil inventory is evaluated.**

⇒ if the dynamic increment of Qpv-value within given time-period (Tsat) is higher than predefined **dQp- level** (See dQp-value and Tread-value in Parameter Table), the **real Qp** value **has to be still higher than target Qpsoll-value** and ADT goes back to dehydration regime again.

⇒ if the dynamic increment of Qpv-value within given time-period (Tread) remains under dQp-value, the Qpv-value is already in the sufficient proximity of dehydration target (Qpsoll-level) and the dehydration of this specific transformer can be terminated

The advantage of this dynamic approach is obvious : the DOG procedure enables the basic evaluation (is target Qp-level met or not) in days and the whole dehydration campaing is adequately shortened.

The very easy setting of dehydration target (and all main parameters of ADT mini as well) enables :

o in situ the Parameter Table: the values Qpsoll and dQpv can be changed via AMIT keyboard

o from remote the Parameter Table of OPTIM D2L software where all main parameters can easily be changed (by overwriting of existing value)

ADT MINI

ON-POWER DEHYDRATION OF TRANSFORMERS

FOR VERY HEAVY WORKING CONDITIONS
ON POWER RECOVERY OF DIELECTRIC STRENGTH

LIFE EXTENSION OF TRANFORMER

REMOTE PROCESS CONTROL AND MONITORING

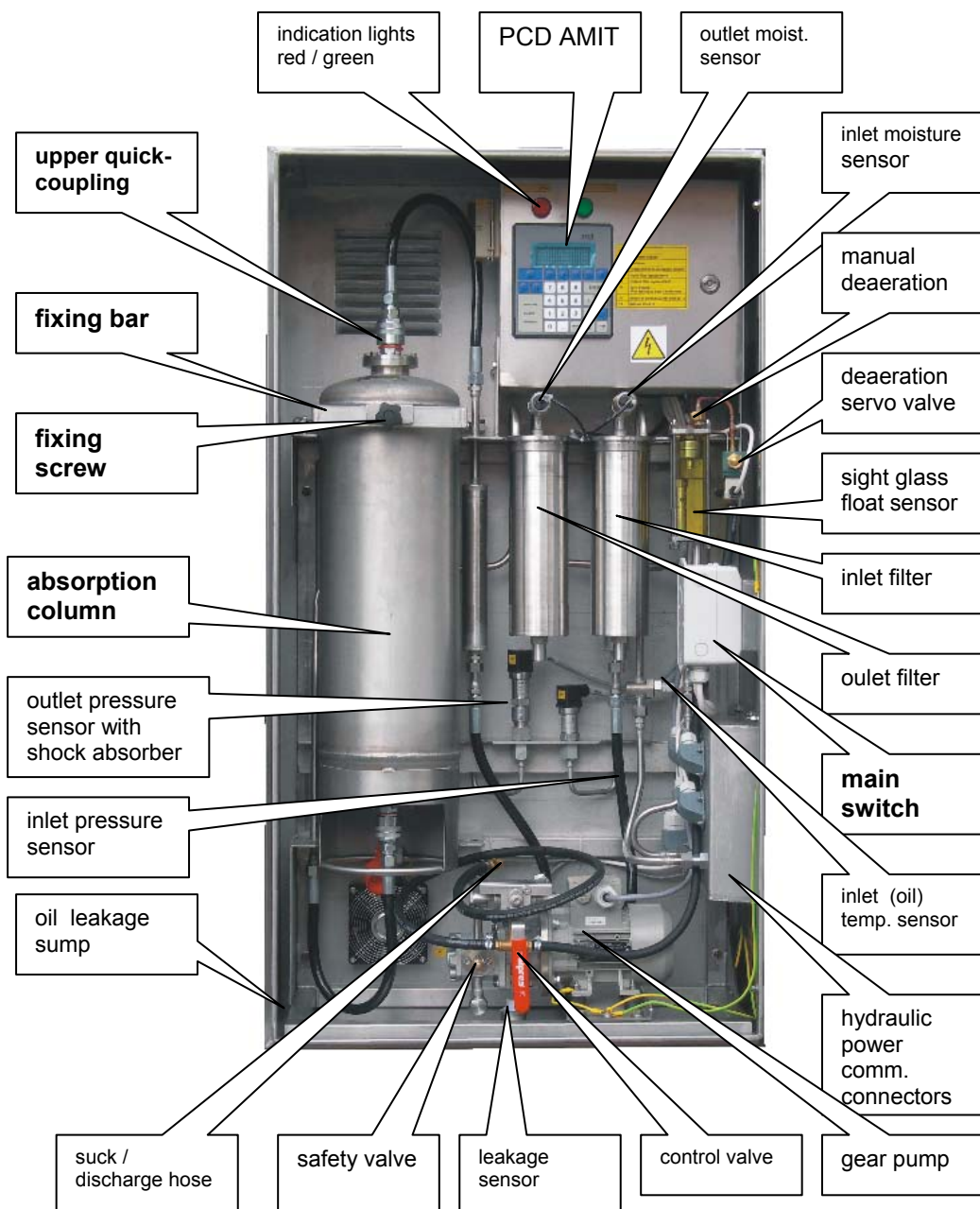**EASY CHECK OF FUNCTION VIA YOUR HANDY**

ON-LINE DIELECTRIC SCREENING

EASY VERIFICATION BY LAB RESULTS

PLUG & PLAY INSTALLATION
MINIMUM SUPERVISION AND/OR MAINTENANCE

Specification

Power supply voltage	1 phase 230 VAC (or on demand)
Power supply frequency	50 (60) Hz
Power consumption:	200 W
Oil throughput	7.5 m^3 per day maximum
Outlet water content	5 ppm nominal , 1 ppm minimum
Outlet filtering grade	1 µm
Absorption capacity	2.6 kg of water nominal, 3 kg maximum
Installation options	mobile unit / permanently installed
Dry weight (without oil)	128 kg
Operating weight (oil filled)	162 kg
Dimensions	700x600x1240 (mm)
Hydraulical connection	2 x flexible 1/2" hose
Communication:	Faxmodem,GSM modem, LAN link, SMS

indication lights red / green

PCD AMIT

outlet moist. sensor

inlet moisture sensor

upper quick-coupling

manual deaeration

deaeration servo valve

fixing bar

sight glass float sensor

fixing screw

inlet filter

absorption column

oulet filter

outlet pressure sensor with shock absorber

main switch

inlet pressure sensor

inlet (oil) temp. sensor

oil leakage sump

hydraulic power comm. connectors

suck / discharge hose

safety valve

leakage sensor

control valve

gear pump

Internal layout of main components in ADTmini (open door)

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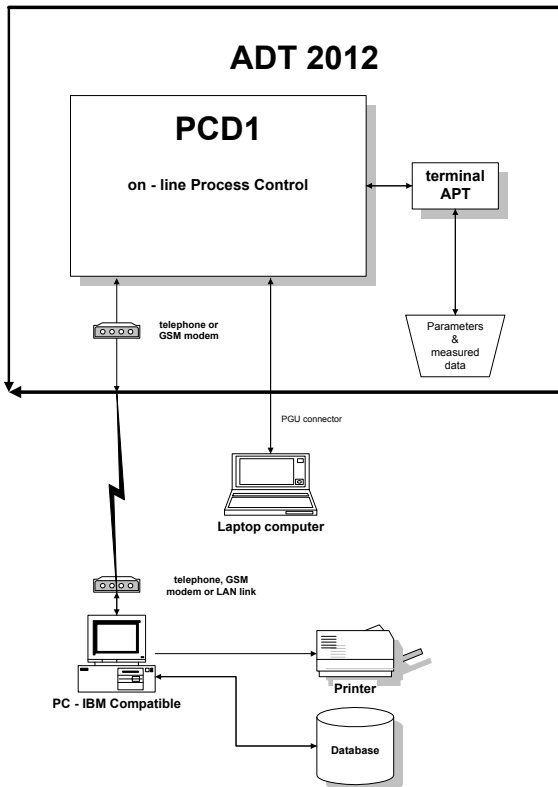
PARAMETRIC REMOTE CONTROL

Regardless of how efficient any method of __oil__ dehydration might be - the first law for the dehydration of __transformers__ is :

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

Any __on-line__ transformer dehydration is ultimately governed by the slow diffusion of moisture from the cellulose into the oil and this process can be accelerated only by a significant increase of its temperature. But, be carefull:

high transformer temperature → high water content in oil → high separation rate
which simultaneously means
→ **low dielectric strength of oil** → **low immediate reliability of transformer**

ADT 2012

PCD1

on - line Process Control

terminal APT

telephone or GSM modem

Parameters & measured data

PGU connector

Laptop computer

telephone, GSM modem or LAN link

PC - IBM Compatible

Printer

Database

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 these targets the ADT can be programmed directly (manually) via the terminal of PCD or alternatively by the PC or lap-top.

This way offers remote monitoring and optimalization of dehydration by strictly controlling warming-up of the transformer.

The figure on the left shows the structure of dehydrator control systems and both connections between PCD1 and lap-top or remote PC.

The software for communication between the PCD1 and both computers - remote user PC and lap-top is provided by ARS.

The easy check of ADT-function can be performed by your handy anywhere and anytime: via SMS.

. The advanced evaluation of the effectivity of transformer dehydration

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   o   the **DSL** (**D**ielectric **S**trength **L**og)

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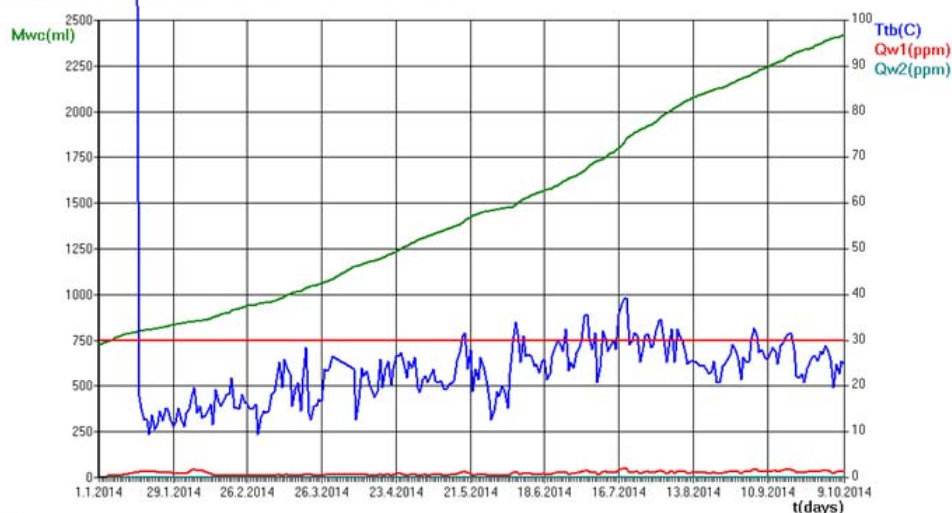
and by clicking on the OK button , the final, printable output of the DL procedure is shown

ADT 2012 Dehydrator - Main Data Log
OPTIM D2L (Dehydration **D**ielectric **L**og**)**
Procedure: DL (Dehydration **L**og**)**
© Ing. Altmann, 2013

| Transformer Location:	xxxx
Transformer Serial Number:	
ADT 2012 Serial Number:	xxxx

Time-period of evaluation :   01.01.2014 - 09.10.2014

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ATTENTION.
Water content in oil Qw exceeded
allowed Qw,max-limit:

Day	Qw(ppm)

Remarks & Recommendations

Date of evaluation: 10.10.2014
Replacement of temperature sensor at 11.1 2014

A new kind of assesment can be used now for the on-line diagnostic of dielectric behaviour of the transformer

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The final result of the DSL-procedure is the quantitative verification by means of the Verification Table and the Verification Diagram.

TRAFOSEAL

TRAFOSEAL **uses the transformer oil alone as a very effective sealing element.** The cold – gas & water contaminated oil in the conservator is separated from the hot (protected) oil in the main tank by a *thermal stratification layer, which is created naturally in the TRAFOSEAL by the temperature differential between hot and cold oil.*

This thermal stratification layer acts as a very thin horizontal, virtually undestructible natural „membrane" which seperates the **hot oil** in the upper half of the TRAFOSEAL tank, and the **cold oil** in bottom part (See Fig. 1). This natural „membrane" is extremely effective at stopping the mixing of (contaminated) oil from the conservator, with the hot (protected) oil from the main tank.
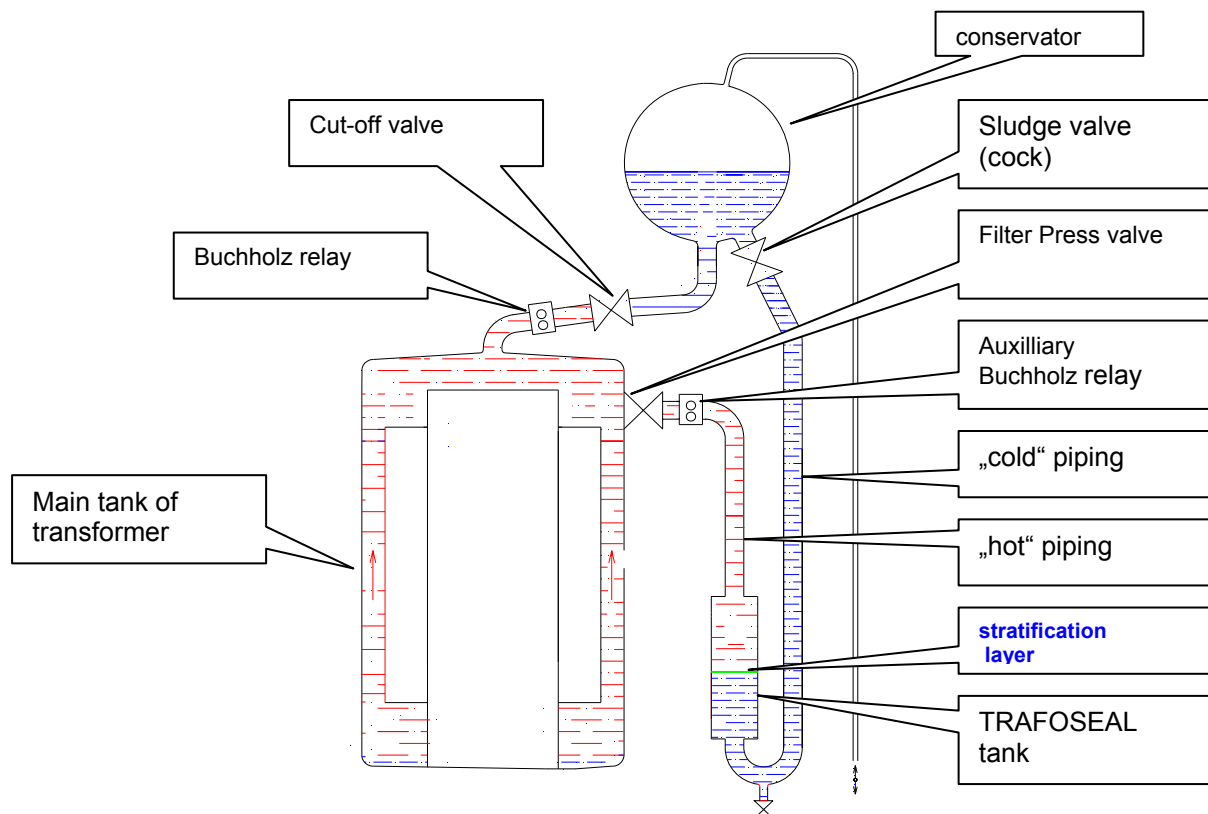
Fig.1   Schematic design of the TRAFOSEAL II sealing of the transformer.

Under normal operational conditions, the temperature of the oil in the transformer main tank varies causing the oil to expand and contract accordingly. As the **temperature rises**, oil moves gradually from the main tank into upper part of the TRAFOSEAL tank, the **thermal stratification layer moves downward** and the cold oil from the bottom part of the TRAFOSEAL tank is displaced into the conservator. Then, as the **transformer temperature decreases**, the cold oil from the conservator flows into bottom part of the TRAFOSEAL tank causing the **upward movement of strafication layer**.

The advantages of the new kind of oil / oil hermetization of a transformer are quite obvious especially if compared with present transformer hermetization methods:

- no mechanically moving parts and no „consumables" items (as supply of N2)

- no potential leaking / replacement of a „hermetization" element (as with Bag-In-Tank)

- no strong pressure changes due temperature variations (as with „flexible walls" hermetization) and subsequently Buchholz Relay alarms induced by the release of gases from oversaturated oil

- monitoring of proper function is not necessary

Applications

The TRAFOSEAL conservator – main tank sealing/hermetization System is applicable to any type and size of oil immersed transformers.

Heavy loaded generation, furnace and transmission transformers that are currently free breathing are the good candidates for this simple, elegant and cost effective sealing method, with considerable life extension.

The elimination of oxygen and water vapour entering the main tank from the conservator using TRAFOSEAL, immediately decreases the oxidation related ageing intensity of the cellulose (and oil) and significantly prolongs the life of the transformer.

The conversion of a free breathing transformer to a sealed one with TRAFOSEAL is very easy. No substantial modification of the main tank or the conservator is necessary. because two required connecting points are usually standard equipment of the main tank and conservator (Filter-Press Valve + sludge valve).

Fig. 2 shows the pipe work, the installation usually takes less than one to two days with two engineers, depending on the size of the transformer.
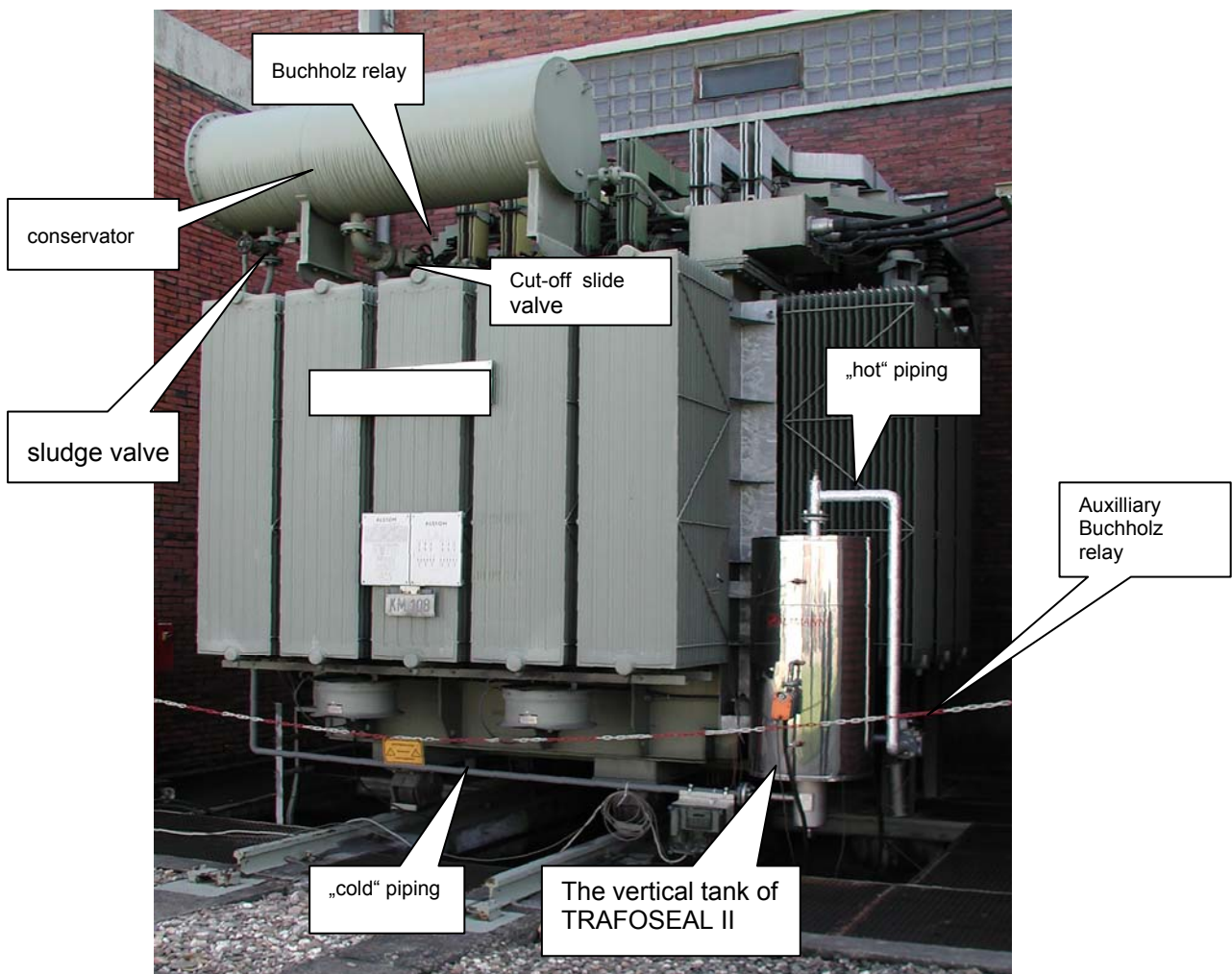

Fig. 2   The retrofit of 17MVA furnace transformer by the TRAFOSEAL II technology.

For the dynamic animation of the function of the TRAFOSEAL II See: www.ars-altmann.com / Product Range / Trafoseal / Technical Specification – Dynamic Animation

Deaerating cock

Horizontal tank of TRAFOSEAL II

new desludging cock

„hot" piping

„cold" piping connecting the bottom part of TRAFOSEAL with bottom part of conservator

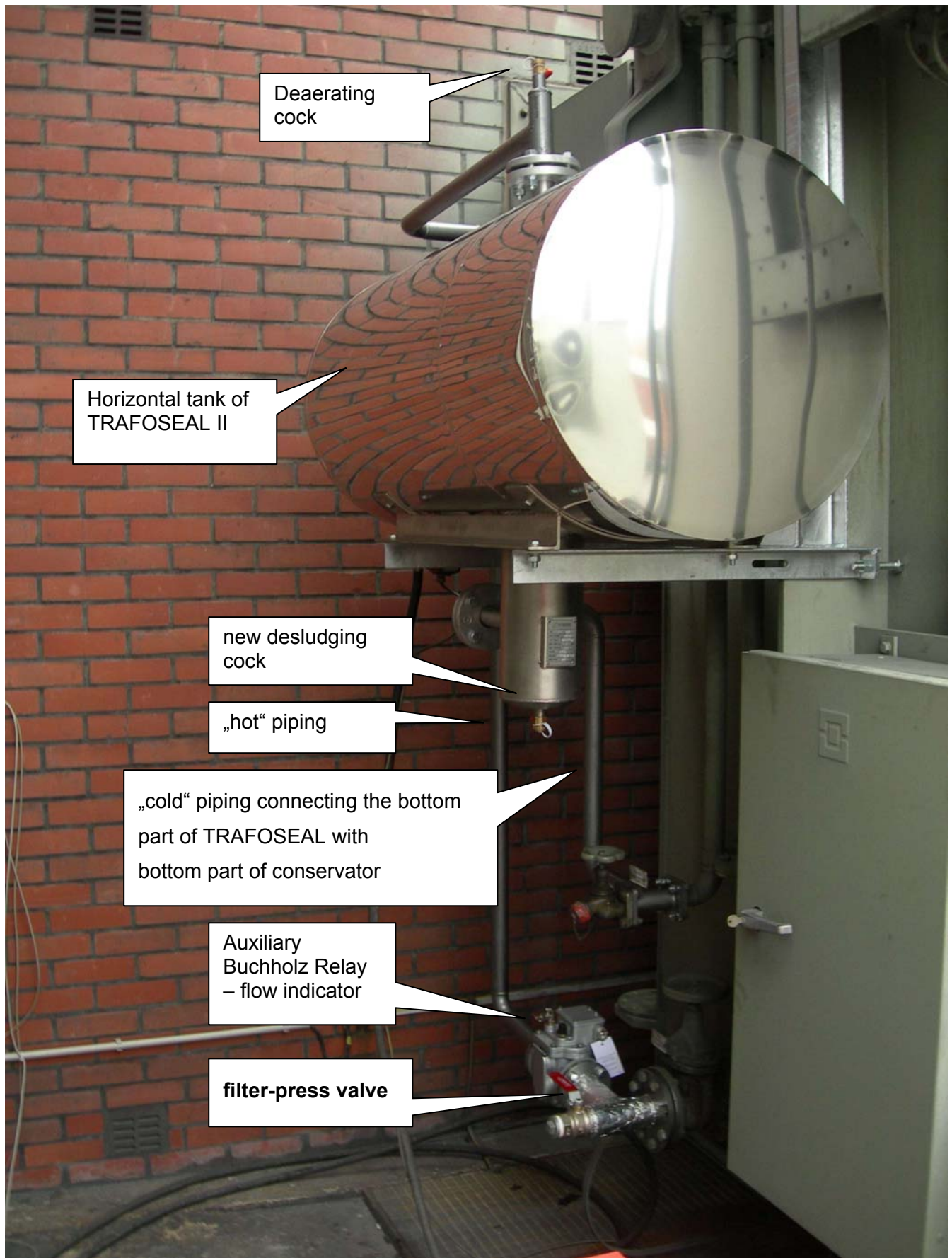Auxiliary Buchholz Relay – flow indicator

filter-press valve

Fig.3 The horizontal version of the TRAFOSEAL II - the retrofit of the 63MVA furnace transformer

The verification of the TRAFOSEAL function

Verification of the function by the TRAFOSEAL was performed on a 17 MVA furnace transformer with a constant load.

Automatic on-line chromatography (DGA) equipment TGM (Gatron) analyzed the transformer oil in the main tank oil twice per day.
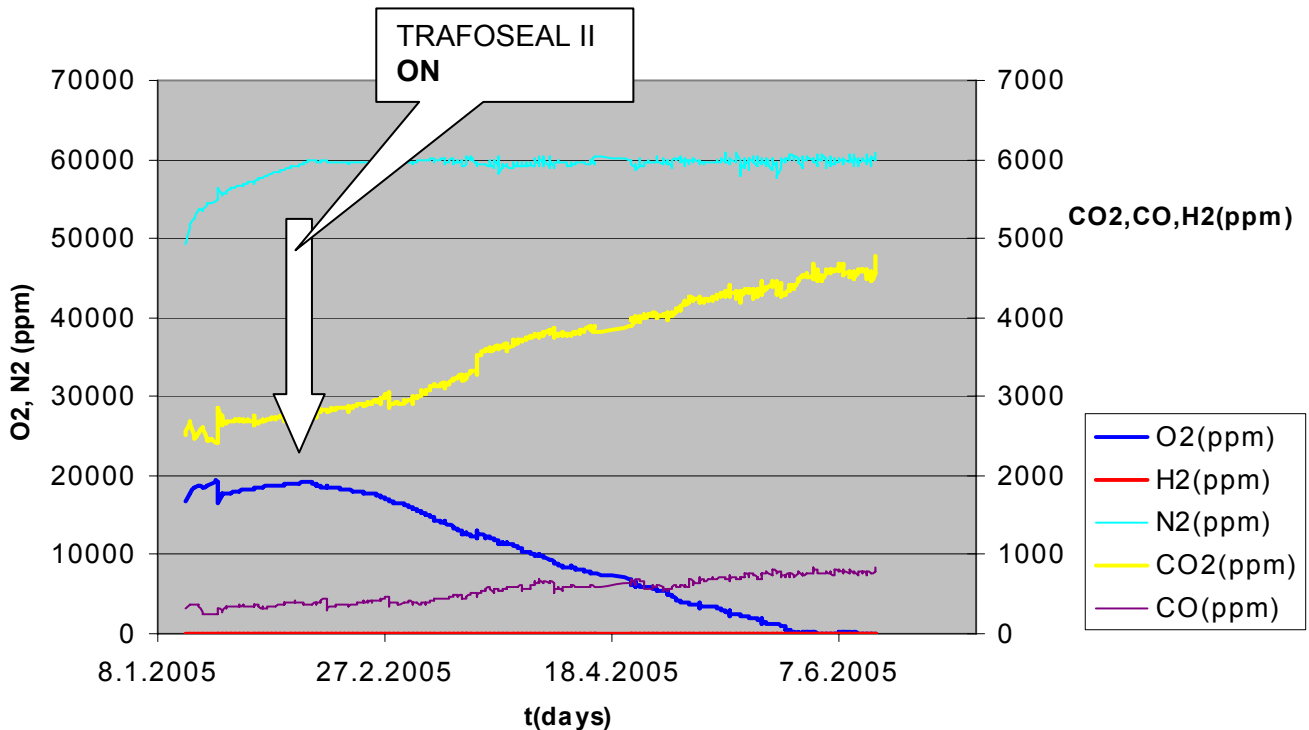

Fig.4.   Dynamic of dissolved gases in oil after switching the TRAFOSEAL **ON.**

The picture shows that after switching the TRAFOSEAL ON, the inlflow of air gases (O2,N2) into the main tank and simultaneously, the outflow of ageing products (CO, CO2, H2) from the main tank, is effectively stopped and consequently:

❑   the N2-level which previously slightly increased, is now approx. constant. The N2 is an inert gas and therefore an ideal marker of the intensity of the transportation process between the main tank and the conservator. The conclusion is clear, the free oil throughflow between the main tank and conservator is now very low or non-existent.

❑   O2 is steadily consumed by oxydation processess in the transformer then due present very low entry of the O2 from the conservator, the O2-level in the oil of the main tank continuously decreases until non-measurable level is reached (O2→0).

❑   CO2- and CO-levels continue to increase untill the oxygen is completely depleted, then due no or very low production both levels remain relatively constant.

The interpretation of the data is clear and simple:

TRAFOSEAL stopped oxidation ageing of the transformer

Moreover, the TRAFOSEAL is constructed of permanent materials and requires no maintenance, no supervisions, has no moving parts and will outlive the transformer.

The intelectual property corresponding a TRAFOSEAL sealing method of power transformers is already covered by patents e.g. US 7,122,075, CZ 292 922 or CZ 289 115.

SEPARATOR S-03

continuous on-load dehydration & filtration of tap-changers

The continuous filtration of tap-changers of power (main) transformers is generally focussed on the reduction of the internal contamination of its oil inventory caused by :

- ❑ particles
- ❑ moisture

When an on-load tap-changer works under load the dirt is always internally generated causing an increase in mechanical wear and a reduction of the dielectric strength of the oil as a consequence.

The another very unpleasant decrease of the dielectric strength of a switching oil is simultaneously caused by the moisture, because two potential sources of the water in the tap-changer always exist :

- ➢ internal - as a by-product of the arc-induced decomposition of the oil.
- ➢ external – due leaking of the air filter or conservator

The S-03 fitration unit was developed to handle a very new problem of recent versions of tap-changers built from non-hydroscopic (hydrofobic) insulants.

Hydrofobic insulants, on the contrary to the previously used hydroscopic materials (as e.g. boards) of „old" tap-changers, do not have any „buffer capacity" to the water - they are not able to bind the water from the oil.

Therefore any little amount of the water which enters into the oil inventory of a modern „hydrofobic" tap-changer immediately increases the relative humidity and decreases the dielectric strength of the oil.

Users of „hydrofobic" tap-changers are therefore exposed to a new and very uncomfortable operational reality.

While old „hydroscopic" tap-changers were able to withstands the slight water contamination for relatively long time without the critical loss of the dielectric strength, the dielectric behaviour of modern tap-changers is very sensitive to any water input and the user is therefore forced to continuously remove the water and/or a dirt from his tap-changer to prevent the decrease of the dielectric strength of the oil.

The S-03 filtration unit, working continuously, satisfies both requirements by means of the external collection of the undesired substances.

The large-volume of the pre-dried cellulose insert simultaneously **binds the water and dirt particles** for relatively long time without negative impacts on the reliability of a tap-changer.

Basic advantages of the S-03 filter unit: :

- the long-term preservation of the required dielectric strength of the oil

- the reduction of the wear of mechanical parts

- the reduction of costs due to prolonging of maintenance time-intervals

- the strong reduction of the number of oil replacements = cost reduction

- easy change of the filter insert under normal operational conditions.

Technical specification

Motor:	Type :3-phase, squirrel-cage (or on demand)
	Power: 0.18 kW
	Voltage: 3x400V, 50Hz (60Hz) (or on demand)
	Speed: 1350 1/min.
	Protection class : IP65 (fully hermetized)
Oil pump:	Gear pump (Monobloc version)
	Hydraulic power : 250 l/hour
Safety valve	Adjustable: 3b
Filter insert	Type : B-005-OK-250BP (dia 150) Materiál: Cellulose (pre-dried at 0.2 % mass weight)
	Filtering grade: 3 µm
	Typical pressure drop at 20C:
	New insert : < 2 bar (3 bar)
	Max. storage time : 12 months, with undamaged package
Pressure / flow reading	Gauge (-100, 300 kPa)
Noise	< 65 dB(A)
Connection	Hose 3/8" , hard tubing 3/8"
Surface protection	stainless steel

Installation

The schematical lay-out of the installation of the S-03 filter unit on a tap-changer is shown at Fig.1
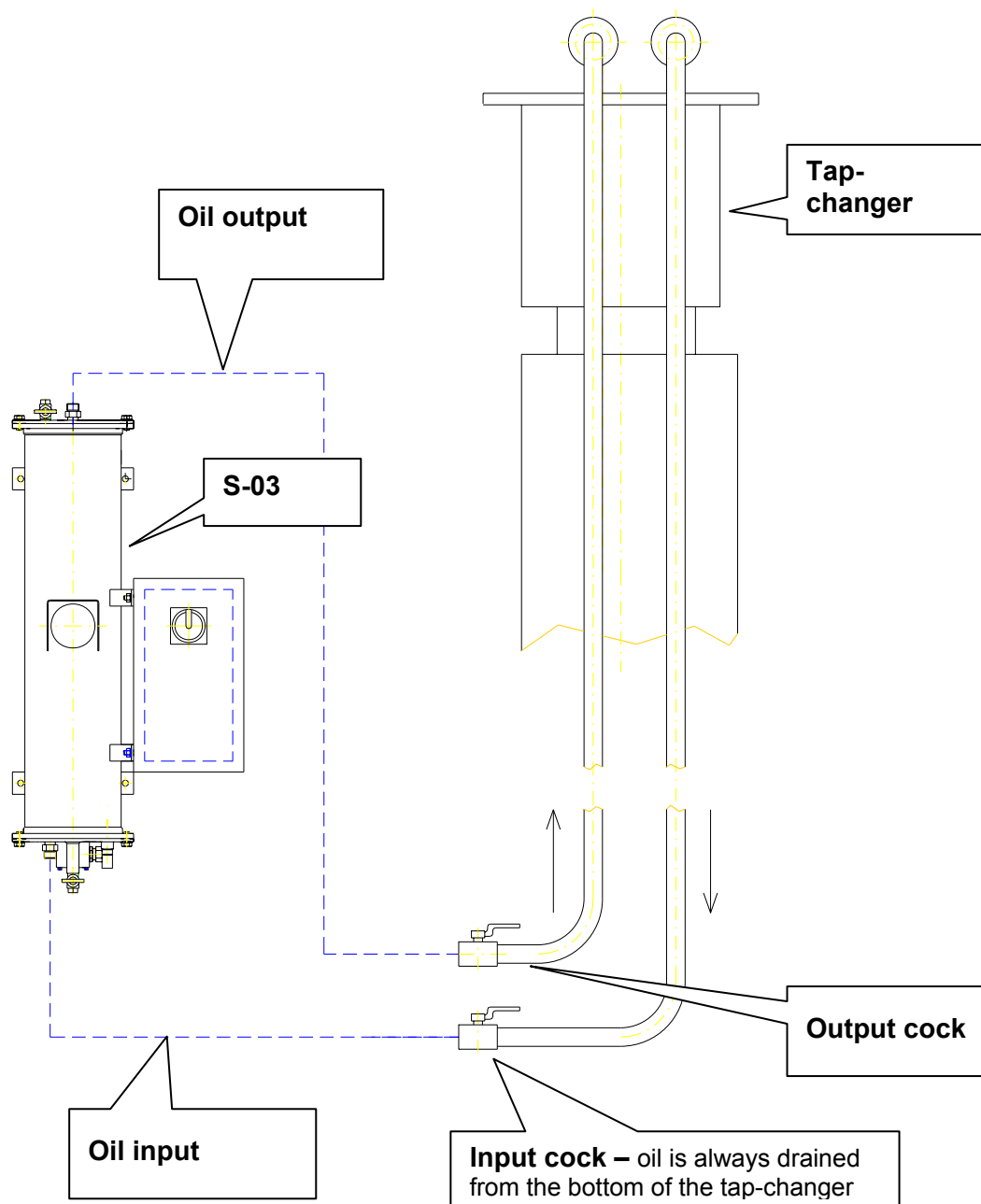

Fig. 1.   The schematical lay-out of the installation

The S-03 filter unit is usually fixed directly onto the main tank of a transformer.
The hydraulical interconnection between the tap-changer and the S-03 unit is performed by 3/8" hoses or 3/8" seamless tubes.For the detailed description of the installation , power supply and the replacement of the filtration insert See: www.ars-altmann.com /News/Manuals.

bleeding cock

Output screw
coupling

Filter insert

Control box

Main switch

Monobloc
gear pump

inlet screw
coupling

Gauge (-100, 300)kPa
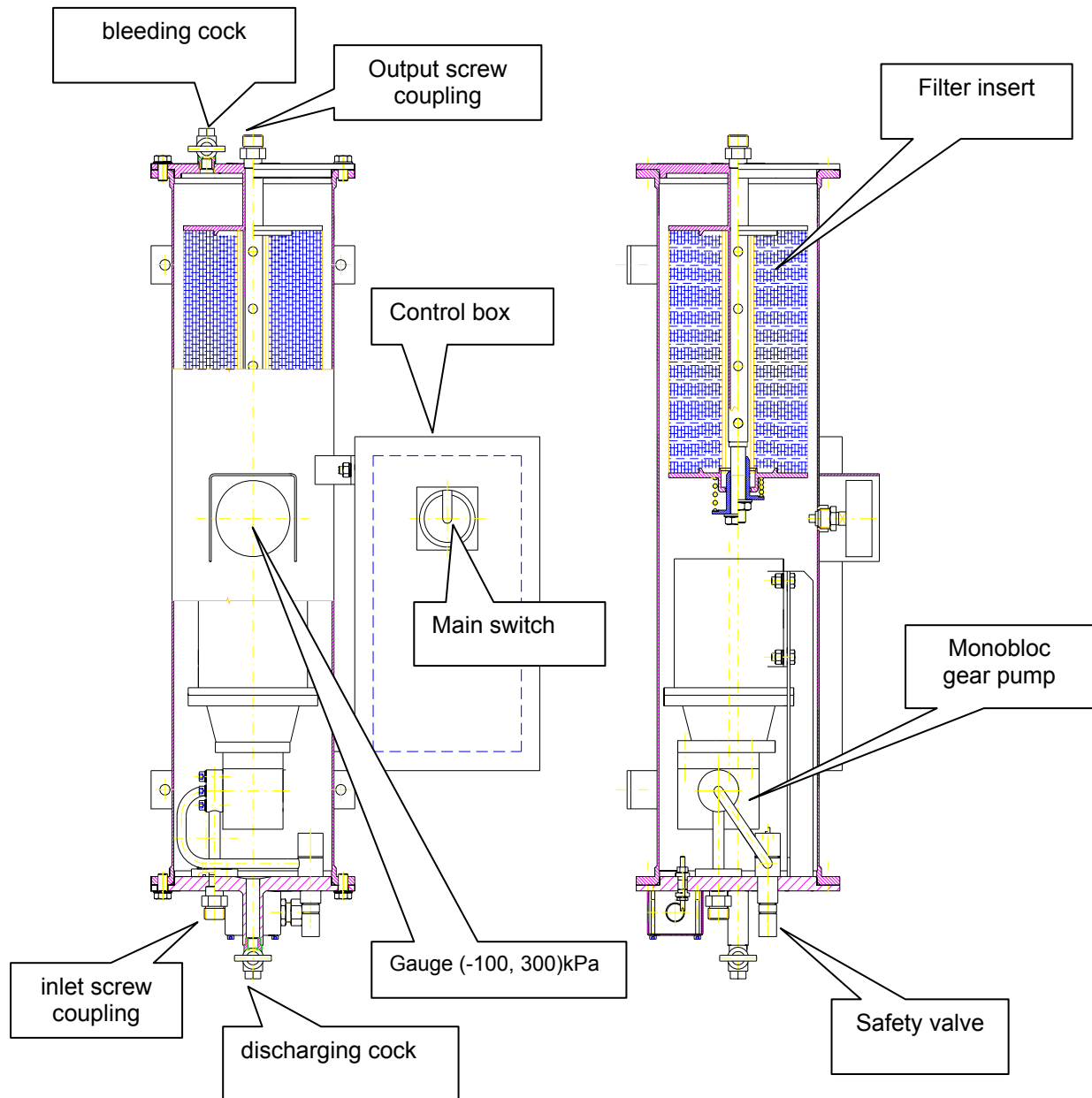
Safety valve

discharging cock

Fig. 2 Internal structure of the S-03 unit

The contaminated oil from the bottom of the tap-changer is fed into the S-03 unit by the inlet screw coupling and forced by the monobloc gear pump into the vessel where the special large-volume cellulose filter insert is situated.

The water and particles are removed from the oil due the radial flow of the through the filter insert, and captured in/on cellulose fibres. The clean oil leaves the S-03 via outlet screw connection and flows back into the upper part of the tap-changer.

The replacement of the saturated filter insert is very simple and can be performed under normal operational condition of a transformer.

For a detailed description of the filter insert See S-03 Manual.

An example of the standard application – the tripple S-03 system - the three S-03 filter units on the common frame for the simultaneous filtration of three tap-changers of the 60 MVA main transformer.

The hydraulical circuits are performed by pressure hoses with a minimal intervention into the existing oil system of tap-changers. Every tap-changer has here its own S-03 filtration unit.

Contacts

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