Tx-DEHYDRATOR

ADT

OPERATING INSTRUCTIONS 2018

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1. Technical data

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	2 ppm nominal , 1 ppm minimum
Outlet filtering grade	1 µm (or on demand)
Absorption capacity(maximum)	9 kg of water
Installation options	mobile unit / permanently installed
Weight	
Mobile unit	
Dry weight (without oil)	260 kg
Operating weight (oil filled)	272 kg
Dimensions	
Mobile version (cart)	1200 x 850 x 1490 (mm)
Permanent installation	1200 x 400 x 1260 (mm)
Hydraulical connection	2 x flexible 1/2“ hose
Communication:	On request: Faxmodem,GSM modem, Internet modem, LAN link, SMS

Operational condition:

Max. surroundings temperature: 50°C

For surroundings. temperature over 40°C is neccesary to ensure:

- cooling air with temperature lower as 40°C or
- special cooling unit

Min. temperature of dehydrated transformer 20°C

For successful dehydration of transformer and successfull oil drying it is neccesary to ensure:

hold the temperature of the transformer over 20°C

1. Installation

The dehydrator ADT is hydraulically connected to the transformer as shown in Fig.1, 2 and 3.

Installation procedure (all hydraulic and electric connectors are situated in the left bottom part of ADT housing See Fig.4):

- attach the oil-inlet set (coupling, insulation insert and servo valve **YV1** See Fig.1 to the lower access of the transformer (i.e. bottom filter press cock), then connect to the open end of the servovalve to the inlet hose **H1** (marked by brown belt), then connect the opposite end of the hose **H1** to the socket of quick-coupling **QC1** (marked by brown strip)
- attach the oil-outlet set (coupling, insulation insert and servo valve See Fig.1 to the upper access of the transformer (i.e. upper filter press cock at the end), then connect to the open end of the servovalve **YV2** the out-let hose **H2** (marked by yellow belt at the end), then connect the opposite end of the hose **H2** to the socket of quick-coupling **QC2** (marked by yellow strip)
- connect cable of servo valve **YV1** to the connector **XC1** situated over the hydraulic connector **QC1**
- connect cable of servo valve **YV2** to the connector **XC2** situated over the hydraulic connector **QC2**
- connect cable of power supply to the connector **XC3**
- check DC voltage of the data line (required 42-45V), then connect the data transmission cable to the connector **XC4** or for communication use the GSM modem and connect its antenna to the connector **XC5**
- connect the allarm line (two-level indications of ADT function to the control room) to the connector **XC6**
- connect the grounding screw by the proper cable to the existing grounding of the transformer

Flow diagram of ADT is shown on Fig. 2.

Detailed internal layout is shown in Fig. 3.

First start-up of the Altmann ADT should always be carried out by the manufacturer´s employe or through their designated service technicians.

ATTENTION !

Check the oil-level in the conservator tank always before first start up of the ADT .

- oil level should exceed the minimum mark by 1/3 of the scale in the conservator
- monitor this level continuously during the start-up procedure and during the operational stage: the oil level in the conservator tank should never fall below the minimum level indicator
- if the oil level falls below the minimum mark of the conservator tank, refill the oil immediately

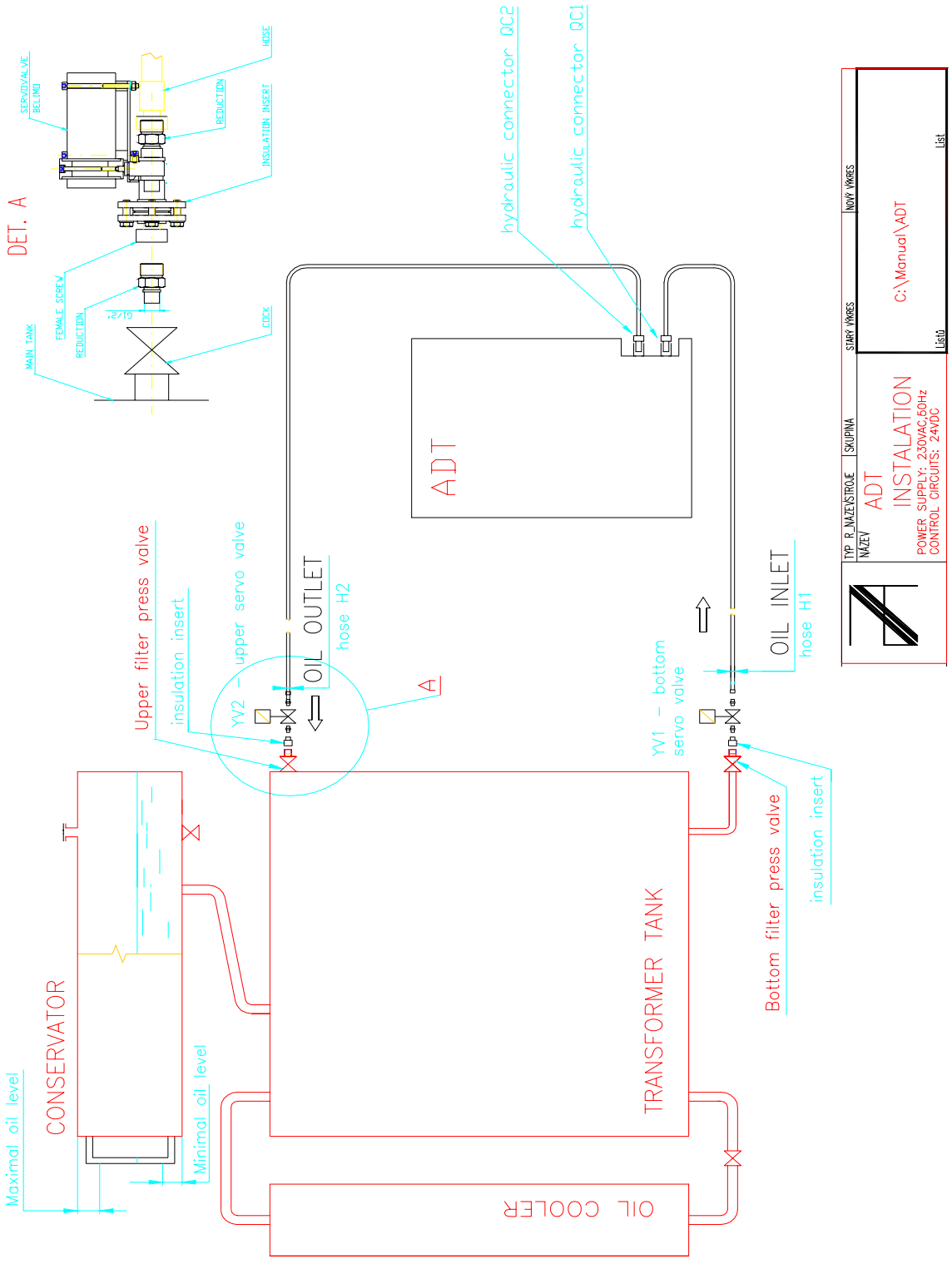
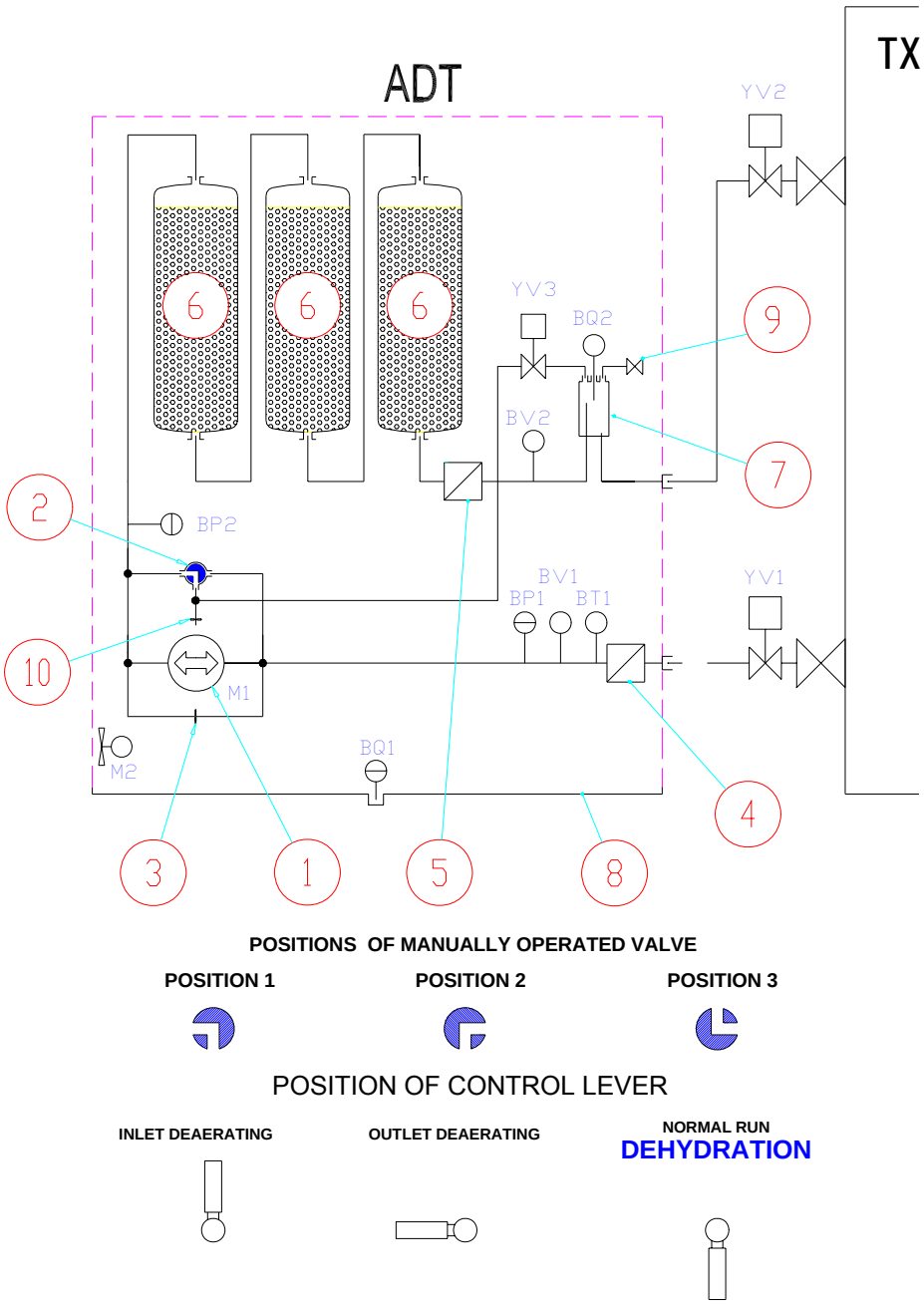


Fig.1 Installation



1	Gear pump	TX	Transformer
2	Control valve	M1	gear pump
3	Orifice	BP1	inlet pressure sensor
4	Inlet filter	BP2	outlet pressure sensor
5	Outlet filter	BV1	inlet humidity sensor
6	Absorption column	BV2	oulet humidity sensor
7	Sight glass	BQ1	leagake sensor
8	Oil sump	BQ2	oil level sensor
9	Manual deaeration valve	YV3	deaeration servovalve
10	Orifice in terminal of discharge hose	M2	fan
		BT1	oil inlet temperature (Tx bottom temp.)

Fig. 2 The ADT - flow diagram

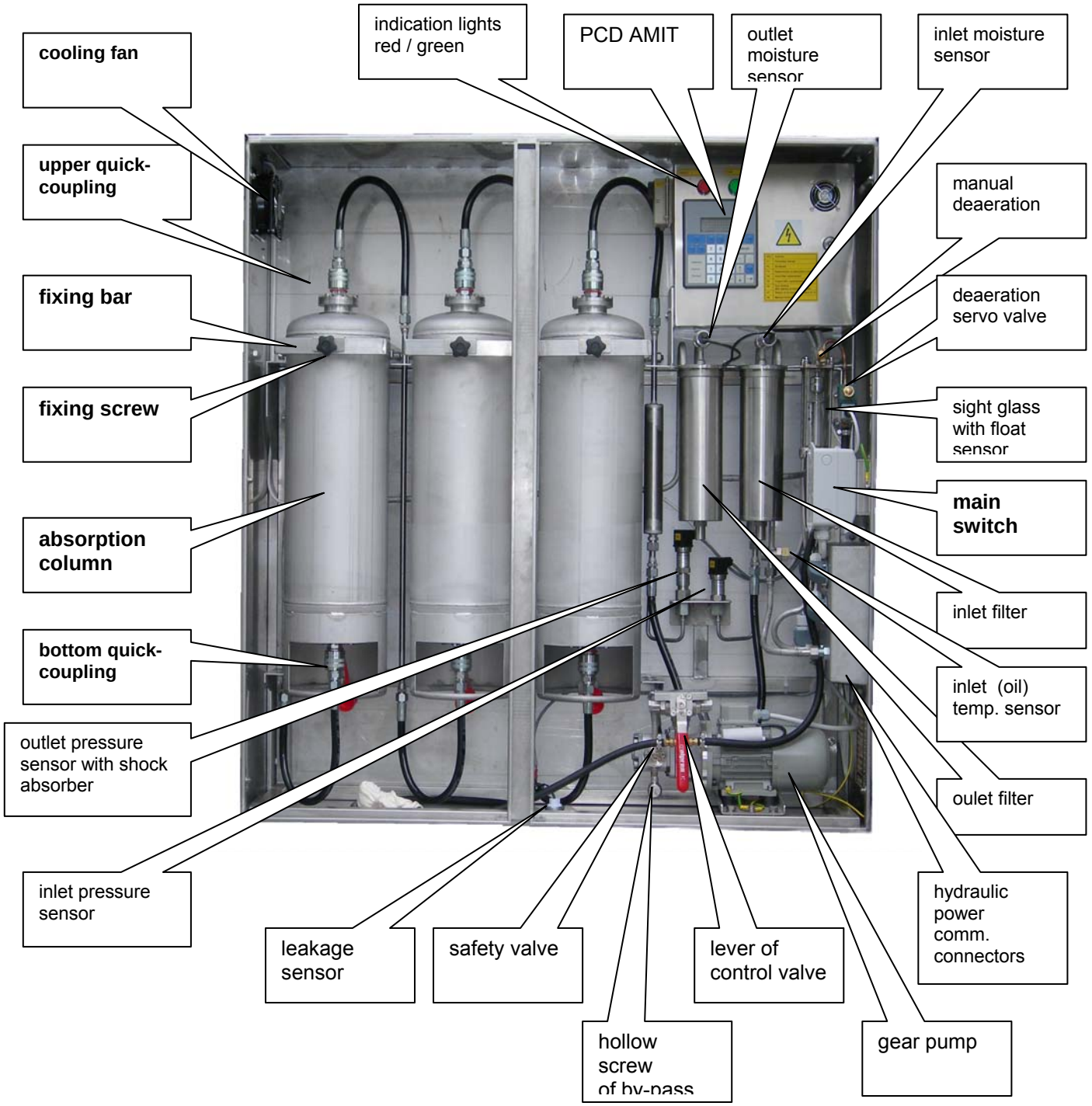


Fig. 3 The ADT - Internal layout of main components (open doors)

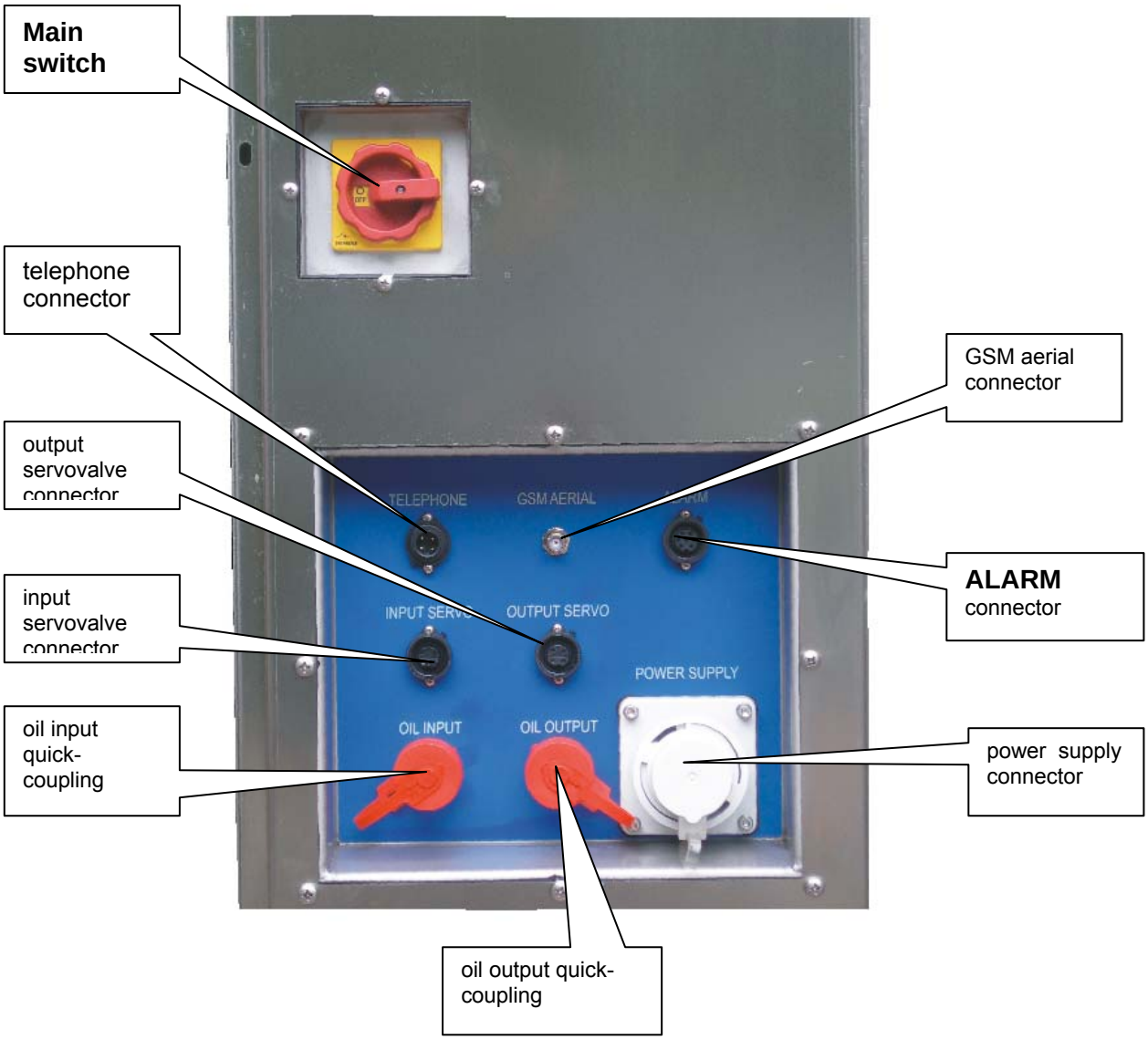


Fig. 4 The layout of connectors (ADT - right side)

3. Function

3.1 Computer control

The ADT is specifically for on-power dehydration of oil-immersed cellulose insulation systems of power transformers.

The ADT-dehydrator is controlled by the „**P**rocess **C**ontrol **D**evice“ AMIT ART 4000 F.

Through remote data collection and transmission, **PCD** manages on-line the dehydration process in the dehydrator and of the whole transformer.

PCD enables the remote-monitoring of all important parameters of the dehydration process inside the transformer, and of the dehydrator‘s operation itself.

PCD allows to change by remote-control the important operative parameters of the dehydrator in order to guarantee optimum efficiency.

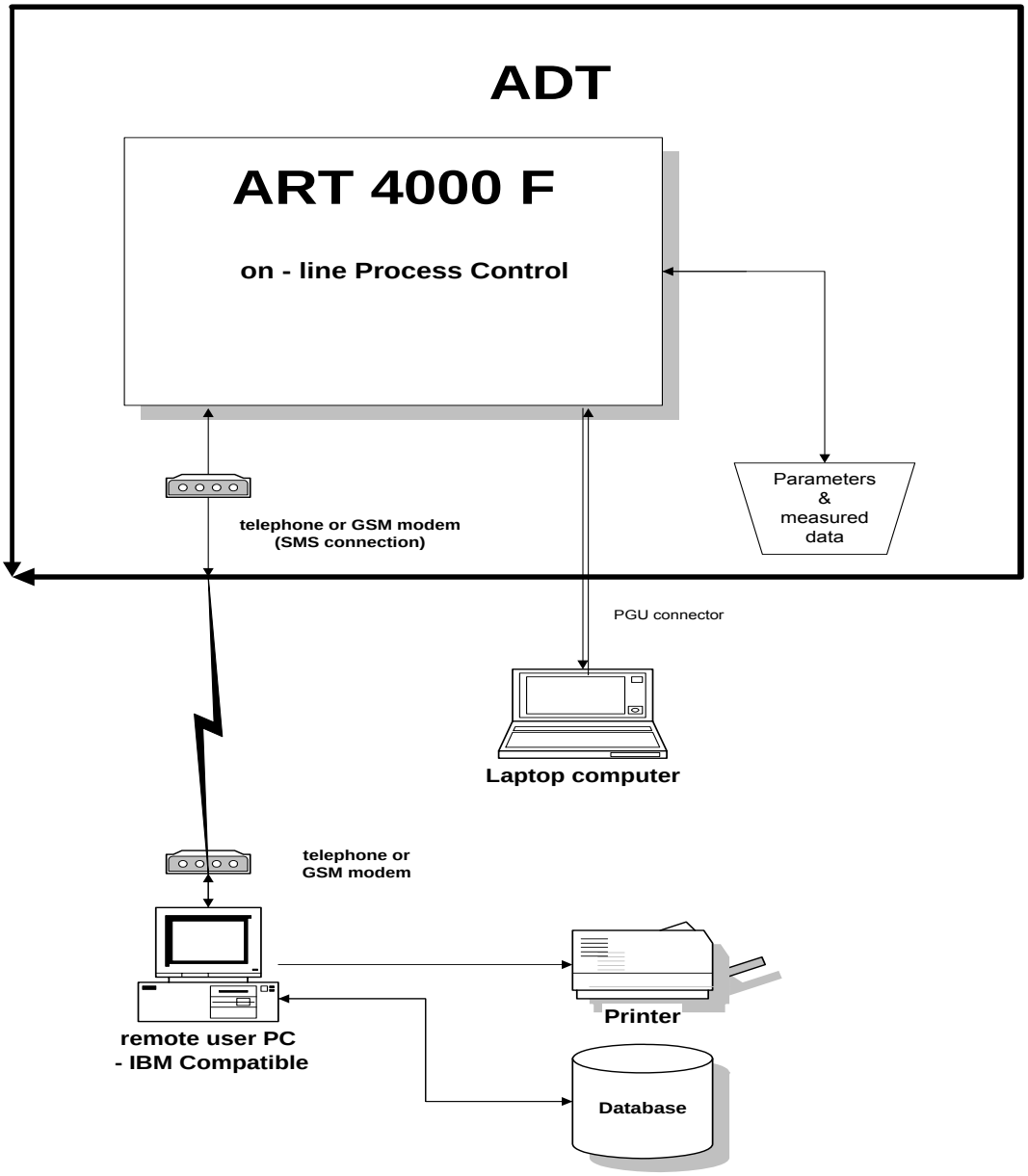


Fig. 5 Structure of control & communication of ADT
For more details about ADT Remote Control See Chapter 8.

The dehydrator is working without any local operator intervention or any necessary operating supervision. The **PCD** is increasing the self-governing autonomy of the dehydrator.

The operator‘s intervention is limited to:

⇒ connecting & disconnecting of the dehydrator to the transformer
(See **Installation**)

⇒ startup of the dehydrator by main-switch **QM1**
(See **Startup – Procedure**)

⇒ shutdown of the dehydrator (by main-switch **QM1** or pushing **F2** key on **AMIT** terminal
(See **Shutdown – Procedure**)

Any other in-situ activities of the operator are:

⇒ replacement of absorption columns - pushing **F3**
(See **Column Replacement – Procedure**)

⇒ changing the input filter insert - pushing **F4** key on **AMIT Terminal** (See **Inlet Filter Replacement - Procedure**)

⇒ changing the output filter insert - pushing **F5** key on **AMIT Terminal**
(See **Outlet Filter Replacement - Procedure**)

All these activities are computer controlled and supported. The computer requires operating activity on its terminal and then checks the results. The protection and any other functions of the dehydrator are solved in the same way.

Periodical monitoring, changes of parameters and all other functions can be realized by remote kontrol as well.

Table 1 shows list basic programs of ADT.

These programs are iniciated by pushing F1…F8 keys on **AMIT** terminal, or using the keyboard (for parameter changing).

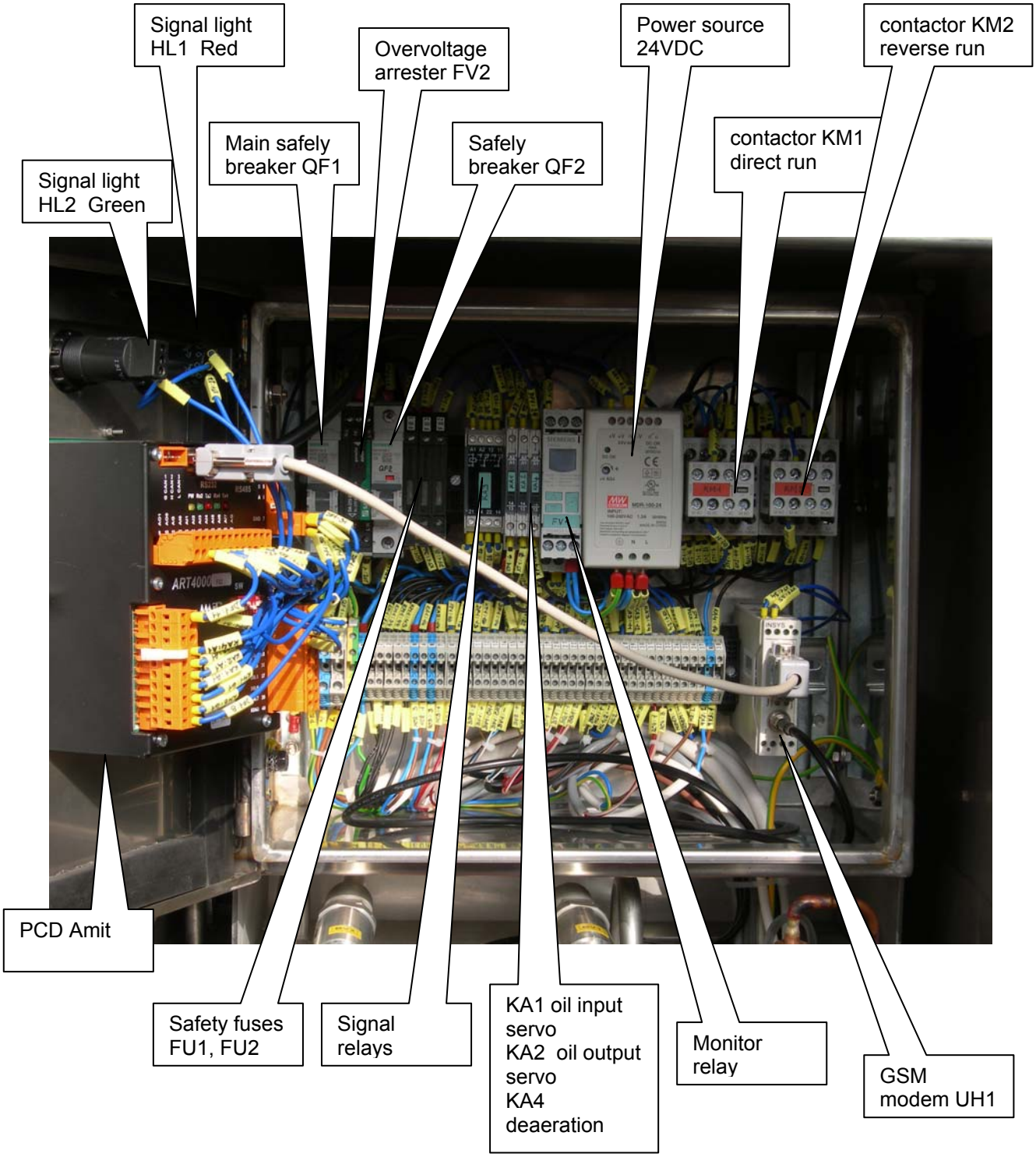
Push the selected key will start the choosen program.

Table 1 Key control

KEY	Activity
F1	Parameter change
F2	Computer controlled shutdown
F3	Computed controlled replacement of absorption column
F4	Computer controlled input filter replacement
F5	Computer controlled output filter replacement
F6	Zero Setting (after startup at new transformer: Mwc-value has to be set to zero) *
F7	Return of oil from bucket back into transformer (refilling of oil into Tx)
F8	Manual Control (all active elements of ADT can be switched ON/OFF)

;
* Mwc …. total amount of water removed from a given transformer during its dehydration
See: Data Table

The visual control of input / output relation of the PCD AMIT can be followed by means of LEDs See Relays K1-K5, Fig. 7



LED lighting = ON/OFF

KM1	Gear pump direct run	QF1	Main safely breaker
KM2	Gear pump reverse run	QF2	Power source safety breaker
KA1	Oil input Belimo servovalve	FU1	Safety fuse of servovalves
KA2	Oil output Brlimo servovalve	FU2	Safety fuse of indication lights
KA3	Indication relay Run / Outage	UH1	GSM modem
KA4	Deaeration relay		

Fig. 6 Layout of ADT switchboard

Parameter Table

The functions of Dehydrator ADT are controlled by basic pre-set parameters and parameters can be changed any time by:

- ⇒ pushing the key F1
- ⇒ rolling display down/ up till requested parameter is shown
- ⇒ pusching Enter to overwite the given parameter
- ⇒ pushing Enter to confirm new parameter
- ⇒ rolling display upward till the former display is reached

Parameter Table

Value	**Description**	
PMAX	maximum allowed absolute pressure	450 kPa
PMIN	minimum demanded absolute pressure	20 kPa
PAUTO	filling pressure	90 kPa
Mwmin	minimum demanded amout of removed water per day	10 ml/day
DQwmin	minimum allowed output-input difference of water content in oil	3ppm
DP	pressure difference for oil flushing	30 kPa
tprop	time-period for flushing	2 sec
Tsat	time-period between virtual Qp-readings during Tx-resaturation (gear pump is switched off)	48 hours
Tread	time-period of reading (gear pump is switched on)	1 hour
dQp	minimal demanded increment of virtual Qp-value	0.1%
Qpsoll	target water content in hard insulants	2 %
imax	number of requested reading cycles	2

For remote change of parameters See Section 10.

Attention
All parameters are optimally selected by the producer.
Don´t change them without previous consultation.

The Setting of internal clock of PCD AMIT

The change of Date and Time of the PCD AMIT according to local conditions can be performed anytime:

- o main switch QM1 OFF/ON and immediately click on key F2
- o AMIT displays two rows with date and time e.g.

10.06.16	(date)
06.23.06	(time)

- o click on ↑ to change the **date ,** enter required date via AMIT keyboard and confirm it by ENTER

- click on ↓ to change the **time** , enter required time via AMIT keyboard and confirm it by ENTER
- for return click on key F1

3.2 Startup Procedure

To start the dehydrator switch the main switch **QM1** situated on the right side of ADT to the position I (ON).

The first STARTUP after the first installation of the ADT by a new client *(or after the download of a new software)* always begins with the safeguard protocol :

PASSWORD ?
0

< ENTER >

Clicking on ENTER starts the subroutine for entering of the code numbers via PCD Amit keyboard.

PASSWORD ?
*** * * ***

< ENTER >

Four numbers have to be entered and confirmed by ENTER.

The safeguard protocol keeps the observance of contract and/or payment conditions.

ATTENTION :

Three attempts are allowed, then the PCD of the ADT is completely blocked and its recovery has to be performed either in situ by the producer staff or by remote control .

Two kind of PASSWORD are used here :

- **for time-limited operation** (ADT works only for limited time-period usually for 30 days). Then is ADT is automatically switched off.
- **for permanent operations** (the client obtains this specific password immediately after the fulfilment of contract conditions. When it is entered the ADT works permanently)

Under standard conditions e.g. by switching the main switch QM1 OFF / ON, the first display of the ADT dehydrator will show

COMMISSIONING

NEW START ?
PUSH < ENTER >

and enables to handle two accidental conditons which can happen during a standard ADT operation :

- **manual shut-down** of the dehydrator via main switch **QM1 (OFF)**. Then the new start of the dehydrator is performed by switching on the **QM1** (**ON)** and subsequently by pushing ENTER.

- **automatic ADT restart after power outage**. As soon as power supply is restored, the PCD waits 3 minutes. If ENTER button isn´t pushed during this time-period then the dehydrator will continue in the previous procedure (dehydration).

The next display requires the interconnection of hydraulic system of ADT via the hose with auxilliary container (oil-resistant bucket and hose are part of the delivery).

CONNECT HOSE TO
CONTROL VALVE AND
OPPOSITE END PLACE INTO
BUCKET PUSH <ENTER>

This interconnection enables requested decrease of absolute pressure in the ADT hydraulic system by means of gas and oil removal via direct and reverse run of gear pump.

This decrease of internal pressures (and subsequent flashing of dehydrator internal parts by the oil from transformer) is absolutely necessary to avoid an intrusion of air into transformer.

The whole start-up procesure begins with the evacuation of ADT inlet section . This specific procedure PCD requests at first the manul setting of control valve in the bottom part of ADT (See Fig.2) into requested position

TURN CONTROL VALVE
TO POSITION 1

PUSH <ENTER>

After confirmation by ENTER the direct run of gear pump will be started and gear pump removes the mixture of air and oil from inlet parts of ADT and expels it via control valve into oil resistant bucket.

The quasi-automatic start-up procedure gradually evacuates the whole inlet section of the dehydrator (up to servovalve YV1) and the display reports the process as:

VACUUM PROCESSING
IN INLET SECTION
WAIT PLEASE
P1 = P1 **P2=** P2 **(kPa)**

If the pressure **P1** in intlet section decreases below the preprogrammed absolute pressure **PMIN,** then the servovalve **YV1** will open automatically, **but the (bottom) sampling cock at main tank of the transformer is still closed** (See Fig.2).

If the desired vacuum level is met the PCD demands the opening of the bottom valve (cock) on the transformer main tank and evacuation of space between the YV1 and bottom sampling cock is performed.

If the pressure (P1) in the whole system decreases under PMIN-value this state is reported by display:

INLET ON VACUUM
OPEN BOTTOM VALVE
AT TX MAIN TANK
< ENTER >

Subsequently the oil from the main tank of transformer will flush the outlet section. The flushing continues automatically until the inlet section of dehydrator is filled.

The flushing process is reported by display

OIL FLUSHING ON
WAIT PLEASE
P1 = P1 **P2=** P2 **(kPa)**

When all residual air is removed and the gear pump expels from ADT only oil the ADT automatically goes ito the next step, the evacuation of ADT outlet section.

The PCD demands corresponding setting of the control valve again

TURN CONTROL VALVE
TO POSITION 2
PUSH <ENTER>

After confirmation by ENTER the direct run of gear pump will be started and gear pump removes the mixture of air and oil from outlet parts of ADT and expels it into oil resistant bucket the same way as before.

The quasi-automatic start-up procedure gradually evacuates the whole outlet section of dehydrator (up to servovalve YV2) and the display reports the process as:

VACUUM PROCESSING
IN OUTLET SECTION
WAIT PLEASE
P1 = P1 **P2=** P2 **(kPa)**

If the pressure **P2** in outlet section decreases below the preprogrammed absolute pressure **PMIN,** then the servovalve **YV2** will open automatically, **but the (upper) sampling cock at main tank of the transformer is still closed (See Fig.2).**

If the desired vacuum is reached the PCD demands the opening of the upper valve (cock) on the transformer main tank and evacuation of space between the YV1 and bottom sampling cock is performed.

The decrease of pressure (P2) in the whole system decreases under PMIN-value is reported by display:

OUTLET ON VACUUM
OPEN UPPER VALVE
AT TX MAIN TANK
< ENTER >

The oil from the main tank now flows into ADT and will flush the outlet section. The procedure continues automatically until the inlet part of dehydrator is filled.

The flushing is reported by display

OIL FLUSHING ON
WAIT PLEASE
P1 = P1 **P2=** P2 **(kPa)**

The proccess is finished at the moment when all residual air is removed and the gear pump expels from ADT only the oil.

Subsequently the independent check of oil fulfilment of outlet section is performed via Sigh glass.

If the floating switch BQ2 (See Fig. 2) is in its bottom position (the well is partly fulfilled with air) the PCD stops the pump and demands venting of undesired air

OIL LEVEL IN SIGHT GLASS TOO LOW **WAIT PLEASE**

The PCD closes the outlet servovalve at first and starts the direct run of gear pump.

If the P2-pressure exceeds ca 150 kPa, the deaeration servovalve YV3 is opened (See and the gas cushion from upper part of sight glass is forced via connected hose into three-way connection under control valve and via discharge hose flows air into bucket and subsequently into surroundings.

Consequently the floater of switch goes up in its requested upper position, the start-up is finished and the dehydration procedure begins.

The manual deaeration of sight glass is possible as well.

The cap of cock in the upper part of sight glass has to be removed, the corresponding hose has to be connected to the cock and its opposite end has to be situated in the oil-resistant bucket and by opening of the cock the air and partly oil as well, is expelled into the bucket.

ATTENTION : the sight glas is pressurized, the cock should be opened very slowly to avoid any oil spill.

3.3 Dehydration of transformer

The dehydration procedure is semi- automatized and remote controled, local operator action is limited on setting of control valve to requested position only.

TURN CONTROL VALVE TO POSITION 3 **PUSH <ENTER>**

After confirmation by ENTER the direct run of gear pump is started and the oil from transformer is dehydrated by molecular sieve situated in the ADT columns and forced back into transformer.

The PCD display then shows in the main window all basic data describing dehydration process

TX DEHYDRATION **Date …… time : ……..** **Mw= …. Mwc= …. ml** **Qw1= …., Qw2= …. ppm**

any remaining data can be acccessed at any time by rolling the display down ↓

P1 = …. kPa **P2 = …. kPa** **T1 = …. C**

and to get back to the main window roll up the display by ↑

Data Table

Value	Description	dimension
Mw	amount of removed water per day	ml/day
Mwc	total amount of water removed from specific transformer	ml
Qw1	input value of water content in oil	ppm
Qw2	output value of water content in oil	ppm
P1	Pressure in inlet section	kPa
P2	Pressure in oulet section	kPa
T1	inlet temperature of the oil (which roughly corresponds bottom temperature of transformer)	C

All the above mentioned data can be monitored from remote, their time-related change can be diagrammatized by the software packet OPTIM D2L. The basic data transfer is possible by means of SMS as well.

If the water capacity of absorption colum is exhausted ng the replacement of absorption column is necessary.

The dehydration of transformer generally proceeds untill:

- required amount of the water from given transformer is removed
- required level of water content in oil is met
- absorption capacity of dehydration columns (ca 2.6 kg of water) is exhausted (difference between Qw2 and Qw1 is lower than parameter DQmin and Qw2 is higher than 5 ppm)
- occurrence of air in the sight glass

The ADT reports the depletion of water absorption capacity of the column as

COLUMN EXHAUSTED
REPLACEMENT ?

YES <ENTER>

The exhaustion of absorption columns is reported by the red indicator lamp situated on the roof of ADT housing and simultaneously reports to control room**.**

After confirmation by ENTER the ADT goes to the procedure REPLACEMENT OF ABSORPTION COLUMNS.

The occurrence of air in the sight glass and by corresponding reaction of floating switch BQ2 the gear pump is immediately switched-off and the problem is reported by the red indicator lamp and by display

GAS ALARM
DEAERATION OF
SIGHT GLASS
NECESSARY

The gas removal procedure:

1. remove the cap of cock in the upper part of sight glass
2. connect the hose to the cock and its opposite end situate into oil-resistant bucket

3. open of the cock (compressed air then freely escapes into the surrounding)

Consequently the floater of switch goes up in requested upper position, the start-up is finished and the dehydration procedure begins.

When GAS ALARM repeatedly occurs the problem is usually caused by :

⇒ oversaturation of oil filling of the transformer by gases

⇒ clogged inlet filter of ADT

and has to be analyzed in detail before next start of ADT is performed.

3.4 Replacement of Column

Attention : to avoid damage under rough transportation conditions the column is fixed to the frame via :

- ***fixing bundle in its upper part***
- ***screw situated in the hook in its botom part***

The bundle has to be cut off and the screw has to be removed (or correspondingly loosened) before the replacement of column.

The replacement of absorption column can be started :

- automatically as described above
- manually by pusching the key F3, the display is shown

COLUMN EXHAUSTED **REPLACEMENT ?** **YES <ENTER>**

During the replacement procedure is always necessary to discharge oil from the colum at first (transportation rules + dangerous pressure increase by an temperature increase) , the PCD therefore demands

CONNECT HOSE TO **CONTROL VALVE AND** **OPPOSITE END PLACE** **INTO BUCKET <ENTER>**

in the next step the PCD demands setting of control valve to requested position

TURN CONTROL VALVE **TO POSITION 2** **PUSH ENTER**

after the confirmation by ENTER the oil removal is then indicated by the display

REMOVAL OF OIL **FROM COLUMN** **WAIT PLEASE** **P1= …. P2= …. kPa**

The output servovalve **YV2** remains open and direct run of the gear pump forces air from the surroungings into upper part of the column and forces that way oil back into transformer.

As soon as the column is emptied the gear pump is switched off, the servovalve YV2 is closed and the PCD reports the end of this procedure as

COLUMN EMPTY
REPLACE COLUMN
FINISHED?
YES <ENTER>

The replacement of column is quite easy due to the quick-coupling in its upper- and bottom parts See Fig.6 :

- disconnect upper and bottom quick coupling of column (turn the sleeve of quick coupling counter-clockwise and remove the female connectors from the sockets)
- loosen the front screw of the crossbar and tilt the crossbar upwards
- lift the exhausted column from its bottom hook and remove it from the ADT
- install new column, fix it by the crossbar and by the front screw and connect it hydraulically to the ADT in the opposite sequence

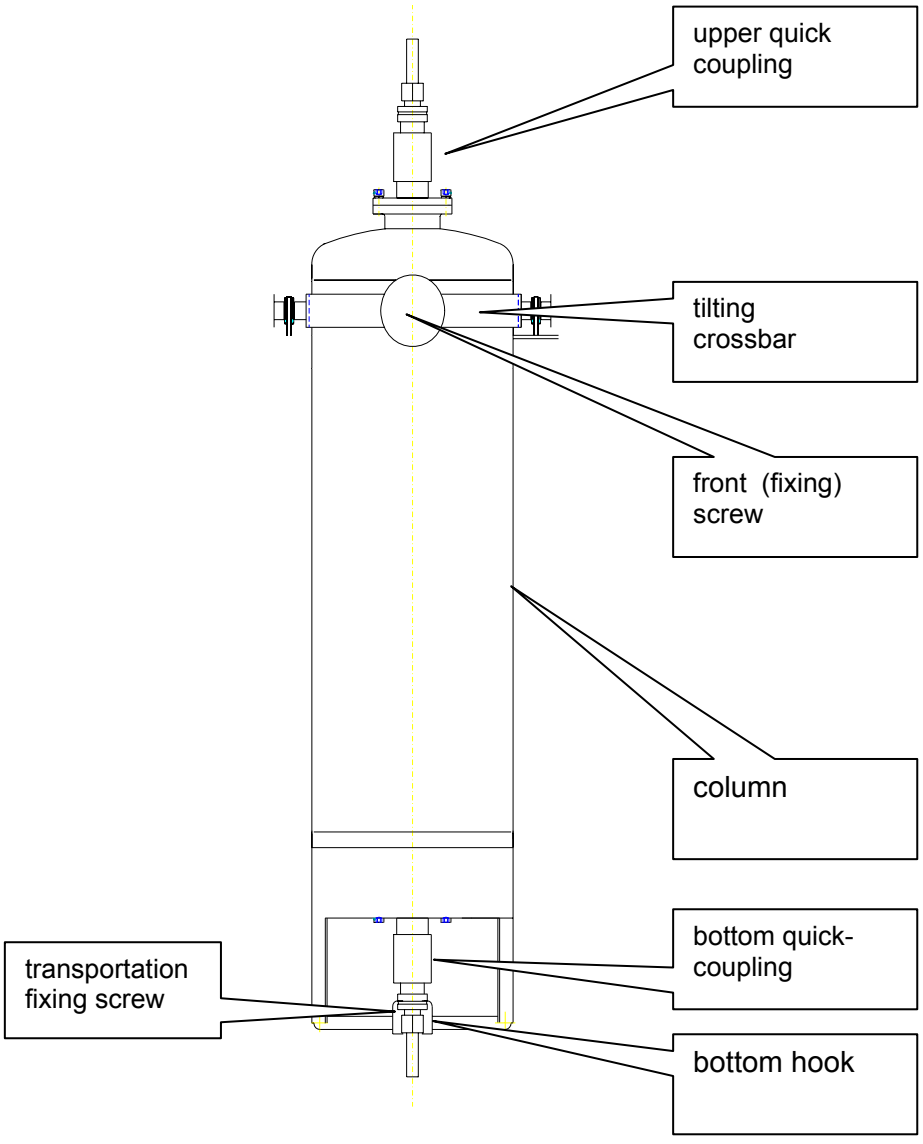


Fig.7 Hydraulic connections and fixing points of a column

After confirmation of replacement by ENTER the gear pump runs now in reverse, the pressure P2 decreases and this process is indicated as

VACUUM PROCESSING **IN OUTLET SECTION** **P1= …. P2= …. kPa**

If the pressure **P2** in outlet section decreases below the preprogrammed absolute pressure **PMIN,** then the servovalve **YV2** will open automatically.

The oil from the main tank now flows into ADT and will flush the outlet section. The procedure continues automatically until the outlet part of dehydrator is filled.

The flushing is reported by display

OIL FLUSHING ON **WAIT PLEASE** **P1 =** P1 **P2=** P2 **(kPa)**

The proccess is finished at the moment when all residual air is removed and the gear pump expels from ADT into the bucket only the oil.

Subsequently the independent check of oil fulfilment of outlet section is performed via Sigh glass.

If the floating switch BQ2 (See Fig. 2) is in its bottom position (the well is partly fulfilled with air) the PCD stops the pump and demands venting of undesired air

GAS ALARM **DEAERATIO OF** **SIGHT GLASS** **NECESSARY**

The cap of cock in the upper part of sight glass has to be removed and by opening of the cock the air is expelled into the surrounding

Attention: the proper degassing procedure is described in the Section 3.3 Dehydration.

Consequently the floater of switch goes up in its requested upper position, the start-up is finished and the dehydration procedure begins.

If properly prepared the replacement of colum takes ca 10 min, maximum.

3.5 Shutdown - procedure

Dehydrator ADT can be any time shut down by :

- main switch **QM1**
- key **F2**

3.5.1 Main switch

When main switch **QM1** is set **ON→OFF** in approx. 10 sec both servo valves **YV1** and **YV2** are closed. This way the dehydrator is quickly disconnected from the oil filling of transformer.

Not recommened procedure

ADT is full of oil and an increase of temperature can induce the dangerous increase of internal pressure(s).

When **QM1** is set **ON** and the button ENTER is pusched the dehydrator is automatically started again.

3.5.2 Computer controlled shutdown

this specific procedure is always strongly recommended :

⇒ if ADT is fulfilled by the oil : increasing surrouding temperature means here dangerous increase of internal pressure

⇒ before the ADT is installed on a next transformer to avoid an undesirable mixing of oils

The procedure is similar to replacement procedure :the aim is to remove major part of oil from outlet section.

Computer controlled shut-down procedure is inicialized by key **F2**

ADT SHUTDOWN **YES <ENTER**

During the shutdown procedure a discharge of a small amount of oil from ADT cannot be excluded, the PCD therefore demands

CONNECT HOSE TO **CONTROL VALVE AND** **OPPOSITE END PLACE** **INTO BUCKET <ENTER>**

in the next step the PCD demands setting of control valve to requested position

TURN CONTROL VALVE **TO POSITION 2** **PUSH ENTER**

The next step of procedure, after the confirmation by ENTER, is always to remove the oil from the column.

The oil removal is then indicated by the display

REMOVAL OF OIL **FROM COLUMN ON** **WAIT PLEASE** **P1= …. P2= …. kPa**

The output servovalve **YV2** remains open and direct run of the gear pump forces air from the surroungings into upper part of the column and forces that way oil back into transformer.

As soon as the column is completely emptied and the air begins to flow into sigh glass, the gear pump is immediately switched off, the servovalve YV2 is closed, the deaeration valve YV3 is opened (air freely flows in surroundings until the pressure decreases under predefined level and YV3 closes again).

The PCD reports the end of this procedure as

COLUMN EMPTY
TURN CONTROL VALVE
TO POSITION 3
YES <ENTER>

by turning of control valve into position 3 (and by closing of both servovalves YV1 and YV2) the ADT is hydraulically sealed against the surrounding and and the last step of shut-down procedure is reported as

SHUTDOWN FINISHED
CLOSE BOTH VALVES
AT TX MAIN TANK
MAIN SWITCH OFF

For the new Start-Up use the Main Switch OFF-ON .

6 Filter Replacement

Both filters, the inlet and outlet filter, are easy accesssible after opening the door of ADT See Fig. 5.To avoid any loss and/or spil of oil, the computer controlled replacement of both filters is recommended.

3.6.1 Input Filter Replacement

The computer controlled replacement of input filter is started by pusching key F4.

INPUT FILTER
REPLACEMENT ?

YES <ENTER>

After confirmation by ENTER the inlet servovalve **YV1** and outlet servovalve **YV2** is closed and PCD demands

CONNECT HOSE TO
CONTROL VALVE AND
OPPOSITE END PLACE
INTO BUCKET <ENTER>

in the next step the PCD demands setting of control valve to requested position

TURN CONTROL VALVE
TO POSITION 2

PUSH ENTER

The next step of procedure, after the confirmation by ENTER the gear pump runs in the normal direction. The discharge oil from inlet section induces a rapid decrease of pressure P1 reported by display

VACUUM PROCESSING
IN INLET SECTION
WAIT PLEASE
P1 = P1 **P2=** P2 **(kPa)**

If the pressure **P1** decreases under the **PMIN**-level, the gear pump is switched off and the replacement of input filter can begin.

REPLACE INLET FILTER

REPLACEMENT FINISHED?
YES <ENTER>

For detailed internal lay-out of both filters See Fig. 9.

Replacement Procedure:

- situate the oil-resistant bucket under the filter body See picture
- loosen the bottom nut and drain the oil off into the bucket
- lift down the cylindrical mantle of the filter
- loosen the cartridge fixing nut from central holder and remove the washer
- pull down clogged inlet filter and replace with new
- check upper and bottom O-ring and replace them if necessary
- pull new cartridge on and fix it by the washer and fixing nut (the cartridge of output filter has to be modestly axially compressed by fixing nut to avoid bypassing of oil)
- reassembly the filter in the opposite sequence
- push ENTER

If properly performed the whole procedure takes ca 5 minutes.

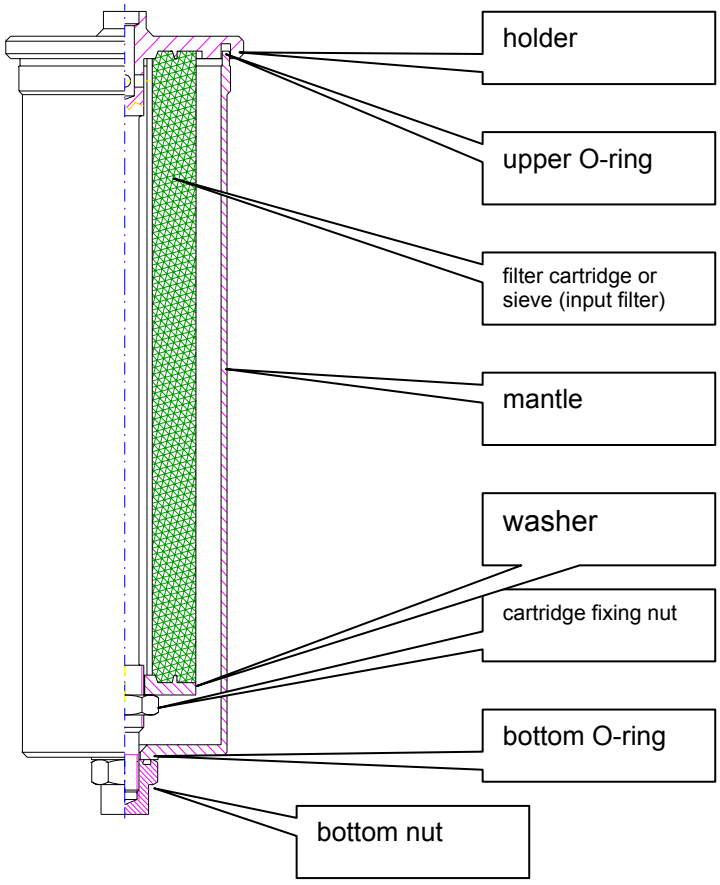


Fig. 8 Lay-out of the input and output filter

In the next step the gear pump will run in the normal run again the pressure P1 decreases and the whole process is shown on display

VACUUM PROCESSING **IN INLET SECTION** **WAIT PLEASE** **P1 =** P1 **P2=** P2 **(kPa)**

If the pressure **P1** in inlet section decreases below the preprogrammed absolute pressure **PMIN,** then the servovalve **YV1** will open automatically.

The oil from the main tank now flows into ADT and will flush the inlet section. The procedure continues automatically until the inlet part of dehydrator is filled.

The flushing is reported by display

OIL FLUSHING ON **WAIT PLEASE** **P1 =** P1 **P2=** P2 **(kPa)**

The proccess is finished at the moment when all residual air is removed and the gear pump expels from ADT into the bucket only the oil.

The ADT then automatically goes into Dehydration procedure again.

3.6.2 Output Filter Replacement

The computer controlled replacement of input filter is started by pusching key F5.

OUTPUT FILTER **REPLACEMENT** **YES <ENTER>**

After confirmation by ENTER the inlet servovalve **YV1** and outlet servovalve **YV2** is closed and PCD demands

CONNECT HOSE TO **CONTROL VALVE AND** **OPPOSITE END PLACE** **INTO BUCKET <ENTER>**

in the next step the PCD demands setting of control valve to requested position

TURN CONTROL VALVE **TO POSITION 1** **PUSH ENTER**

The next step of procedure, after the confirmation by ENTER the gear pump runs in the reverse direction. The discharge oil from outlet section induces a rapid decrease of pressure P1 and the whole process is reported by display

VACUUM PROCESSING **IN OUTLET SECTION** **WAIT PLEASE** **P1 =** P1 **P2=** P2 **(kPa)**

If the pressure **P2** decreases under the **PMIN**-level, the gear pump is switched off and the replacement of input filter can begin. The replacement procedure is the same as by inlet filter.

REPLACE OUTLET FILTER **REPLACEMENT FINISHED?** **YES <ENTER>**

In the next step the gear pump will run in the reverse run again the pressure P2 decreases and the whole process is shown on display

VACUUM PROCESSING **IN INLET SECTION** **WAIT PLEASE** **P1 =** P1 **P2=** P2 **(kPa)**

If the pressure **P2** in outlet section decreases below the preprogrammed absolute pressure **PMIN,** then the servovalve **YV2** will open automatically.

The oil from the main tank now flows into ADT and will flush the inlet section. The procedure continues automatically until the outlet part of dehydrator is filled.

The flushing is reported by display

OIL FLUSHING ON **WAIT PLEASE** **P1 =** P1 **P2=** P2 **(kPa)**

The proccess is finished at the moment when all residual air is removed and the gear pump expels from ADT into the bucket only the oil.

Subsequently the independent check of oil fulfilment of outlet section is performed via Sigh glass.

If the floating switch BQ2 (See Fig. 2) is in its bottom position (the well is partly fulfilled with air) the PCD stops the pump and demands venting of undesired air

OIL LEVEL IN SIGHT **GLASS TOO LOW** **WAIT PLEASE**

The AMIT at first closes the outlet servovalve Belimo and in the second step the direct run of gear pump is started.

Ïf the P2-pressure exceeds ca 150 kPa, the pump stops, deaerating servovalve opens and the gas cushion situated in the upper part of sight glass escapes (via hose connected to three-way valve into surroundings.

Consequently the floater of switch goes up in its requested upper position, the start-up is finished and the dehydration procedure begins.

3.6.3 Zero Setting

After startup at a new transformer, the new dehydration campaign begins and Mwc-value (the amount of water removed from former transformer) should be set to zero.

Corresponding procedure is started by click on F6

ZERO SETTING ?   **YES <ENTER>**

and after pushing ENTER the Mwc -value is set to zero and ADT goes back to dehydration.

3.6.4 Reentry of oil into transformer

The ADTcommissioning (building vacuum in its internal parts and their subsequent flushing by oil) requires the discharge of specific volume of oil from a transformer via ADT into oil-resistant bucket.
Its easy return into oil filling of this specific transformer (within the dehydration) is started by click on key F7

OIL RETURN TO TRANSFORMER ? **YES <ENTER>**

- if ENTER button isn´t pushed during next 3 minutes then the dehydrator will continue in the previous procedure (dehydration).
- after click on Enter the ADT continues to Reentry procedure and display shows

WAIT PLEASE

in the next step the PCD demands setting of control valve to requested position

TURN CONTROL VALVE TO POSITION 2 **PUSH ENTER**

after the confirmation by ENTER the PCD display demands that the opposite end of hose (connected to the control valve) has to be placed under the oil level in bucket.

PLACE HOSE UNDER OIL LEVEL IN BUCKET **<ENTER>**

after the confirmation by ENTER, the direct run of gear pump is started and removal of oil from bucket begins

OIL REMOVAL ON **WAIT PLEASE**

and this proces continues till total reentry of oil from the bucket via ADT into transformer is finished

REENTRY OF OIL FINISHED **PUSH ENTER**

by pushing ENTER the ADT goes back into Dehydration procedure.

3.7 Manual Control

The function of all computer controled parts of ADT (servovalves, direct and reverse run of gear pump) can be checked any time by Manual Control Procedure which is activated by pusching key F8.

ATTENTION

This kind of operation shoud be performed by authorized staff only.

The displays then show:

- in the first row the operation status of given part (ON or OFF)
- in the second row offers the change of given status by pushing **+** for ON , **-** for OFF
- in the third row shows the quantitative effect of this specific instruction on the main values P1 and P2.

The first display is used for a manual control of input servovalve

INPUT SERVOVALVE = ON **CHANGE : + ON / - OFF** **P1 = …. P2 = …. kPa** **ROLL FOR NEXT INSTR.**

All next displays are then achieved by rolling down by ↓

OUTPUT SERVOVALVE = ON **CHANGE : + ON / - OFF** **P1 = …. P2 = …. kPa** **ROLL FOR NEXT INSTR.**

PUMP DIRECT RUN = ON
CHANGE : + ON / - OFF
P1 = …. P2 = …. kPa
ROLL FOR NEXT INSTR.

PUMP REVERSE RUN = ON **CHANGE : + ON / - OFF** **P1 = …. P2 = …. kPa** **ROLL FOR NEXT INSTR.**

DEAERATION SERVO = ON **CHANGE : + ON / - OFF** **P1 = …. P2 = …. kPa** **ROLL FOR NEXT INSTR.**

and by rolling all displays up we will go back into the Dehydration procedure.

4. Protections

The ADT dehydrator is designed and build speciffically with remote control in order to operate for prolonged time periods without the necessity of any local supervision.

Therefore it is very important that any significant oil-loss will be ruled-out under any circumstances.

4.1 Oil loss

The dehydrator system consists of hermetically sealed hydraulic circuits (See Fig.1, 2 and 4). All these parts are hydraulically connected to the leakage tube (sump) in the bottom of dehydrator See Fig 8.

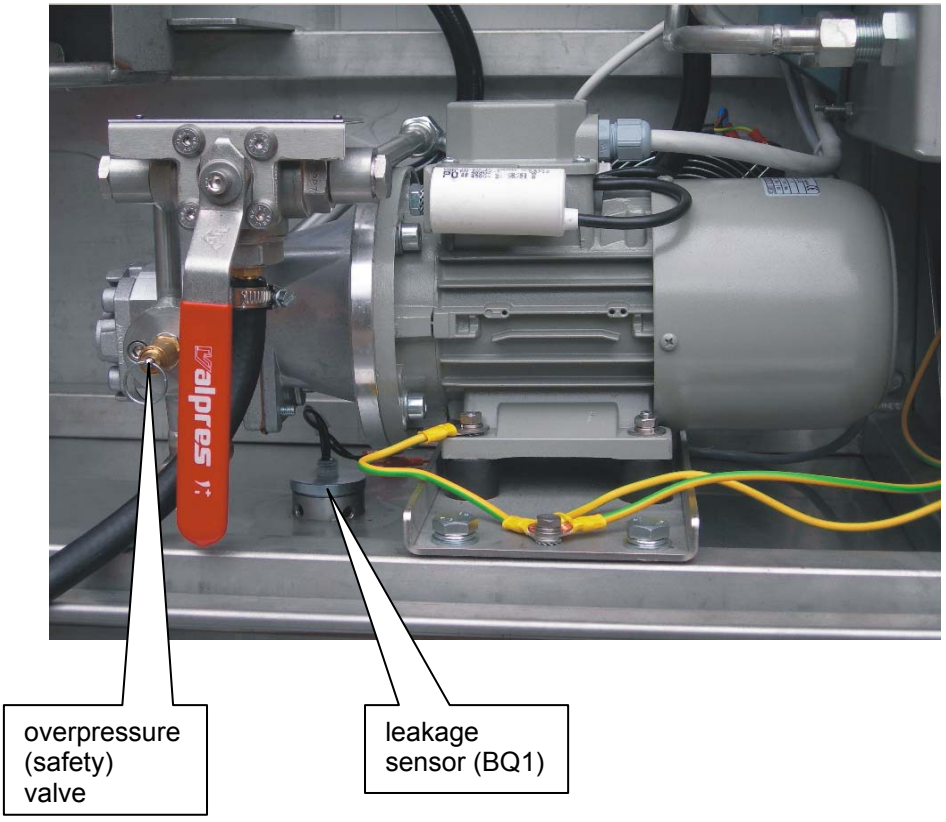


Fig. 9 Leakage sensor and overpressure safety valve

Any oil spil in the dehydrator system will be collected in this leakage tube. In the unlikely event of spill, leakage sensor **BQ1** mounted in the lowest part the tube will then generate oil loss Alarm. Immediatedly the dehydrator is stopped, and the servo valves shut-down.

Thus, in 10 seconds of detecting oil-spill, the transformer will be hydraulically disconnected from the dehydrator by closing down the two servo valves **YV1** and **YV2.**

The oil-leak Alarm is immediately indicated on the display of the **ADT** display

OIL LEAK **FIND & REPAIR LEAKAGE** **DRY OUT SENSOR BQ1**

by the red lamp and by the ALARM line to the control room (if requested).

After the detecting and sealing of leakage (and drying of container of leakage sensor **BQ1** – See photograph picture showing float sensor situated in container), reset the dehydrator by switching main switch **QM1** OFF and ON.

4.2 Overpressure

All hydraulic chambers of ADT are protected against overpressure in three levels:

- PCD controls the pressure **P1** and **P2**, and will recognize if these values will exceed the allowed limits **PMAX** (See **Parameter Table** . If this happens, the dehydrator is automatically shut off, and this state is indicated on the display, the the red lamp on its roof and corresponding signal is transmitted into control room.

If pressure P1 on the pump exceeds **PMAX** , alarm is generated (the red bulb on the roof is ON), and display on **ADT** terminal will indicate:

OVERPRESSURE P1
ÄLL VALVES IN
PROPER POSITION ?
RESET BY QM1 OFF/ON

If pressure P2 in the main chamber exceeds **PMAX** , alarm is generated (the red bulb on the roof is ON),, and display on **ADT** terminal will indicate:

OVERPRESSURE P2
ALL VALVES IN
PROPER POSITION ?
RESET - QM1 OFF/ON

.

In a very improbable case of the failure of above mentioned safely levels, the next, second safely, level represents overpressure(safety) valve gear pump.

If P2 exceeds ca 350 kPa (the safety valve is situated in the output only) the safety valve will open and the oil spill info oil sump activates the leakage sensor BQ1. The shut-down procedure is the same as in the section 4.1.

The check of proper function of safety valve can be performed manually via the ring situated on its central spindle..

The third safety level represents properly-dimensioned motor of the gear pump..

If the P2- or P1-level exceeds ca 500 kPa , the motor is overloaded, stops and corresponding overcurrent relay switch-off the motor.

5. Alarms

All vital functions of dehydrator are continuously observed, recognized and supervised by PCD.

ALARM is generated and indicated if PCD recognizes, that measured parameters P1, P2 will exceed preprogrammed , given criteria (oil loss) or the GAS ALARM condition occurs .

ALARM is indicated on ADT terminal, by the red bulb and corresponding two-level signal can be transmitted to control room as well (See Fig. 4: two-level connector) .

.

6. Maintenance

The ADT Dehydrator requires minimum maintenance.

Neverthelless, it is recommended that a regular maintenance schedule concerning potential clogging of both filters should be established:

6.1 Input filters - for Replacement See Chapter **3.6.1**

6.2 Ouput Filler - for Replacement See Chapter **3.6.2**

7. Electrical circuits

Power Circuit diagram is shown on Fig. 10 , Wiring diagram of Switch Board is shown on Fig.11

Name	Function	Designation	Qty.	Producer / Vendor
QM1	Main switch	3LD064-OTB53	1	Siemens
CONNECTORS				
XC1	Power supply connector	Mennekes, typ 826, 16A, 3p	1	Siemens
XC2	Input servovalve connector	C016 20G003 100 12	1	Amphenol
XC3	Output servovalve connector	C016 20G003 100 12	1	Amphenol
XC6	Alarm indication connector	C016 30G006 100 12	1	Amphenol
BREAKERS				
QF1	Main breaker	5SX21-B16	1	Siemens
QF2	Gear pump breaker	5SX21-C2		Siements
FV1	Monitoring relay	3UG46 33-1AL30	1	Siemens
FUSES				
FU1	Power supply	T/2,5A 5x20 35A	1	GES Electronics
FU2	Power supply 24DVC	T/5,0A 5x20 35A	1	GES Electronics
FU3	Fan (if installed)	T/2,0A 5x20 35A	1	GES Electronics
AC / DC POWER SUPPLY UNIT				
GU1	Power supply 24DVC	MW, DR-120-24	1	MEAN WELL
FV2	Overvoltage arrester	DA 275 DJ	1	Saltek
SERVOVALVES				
YV1	Oil Input	Belimo LF 24	1	MaR
YV2	Oil Output	Belimo LF 24	1	MaR
MOTOR				
M1	Gear pump	1LF7063-4AE17	1	Siemens
M2	Fan (if installed)	4114NH4, 24V DC	1	Pabst

SENSORS				
Process pressure 4-20 mA				
BP1	Pressure sensor	DMP331 0– 6 b	1	BD Sensors
BP2	Pressure sensor	DMP331 0 – 6b	1	BD Sensors
ON/OFF				
BQ1	Leakage sensor	RSF 54 Y 100 RC	1	LAC
BQ2	Gas Alarm (sight glas)	RSF 54 Y 100 RC	1	LAC
Temperature				
BT1	Input Oill temp.	PT30, Ni 1000	1	Rawet
Water content in oil				
UA1	Oil input	MMT 162	1	Vaisala
UA2	Oil output	MMT 162	1	Vaisala

PCD				
DF1	Proces Control Unit	ART 4000F	1	AMIT

COMMUNICATION				
UH1	Modem (landline)	56K Faxmodem		US Robotics
	or GSM Modem	INSYS GSM small 2.0	1	INSYS

Process Control Relays				
KA1	Input servovalve	3TX7 004 1MB00	1	Siemens
KA2	Output servovalve	3TX7 004 1MB00	1	Siemens
KA3	Process indication ON/OFF	3TX7 002 1FB02	1	Siemens
KA4	Deaeration	3TX7 004 1MB00	1	Siemens

Process Control Contactors				
KM1	Direct run of gear pump	3RH 1262-1BB40	1	Siemens
KM2	Reverse run of gear pump	3RH 1262-1BB40	1	Siemens

Indication light				
HL1	ON	HIS-95-R	1	ELECO
HL2	OFF	HIS-95-G	1	ELECO

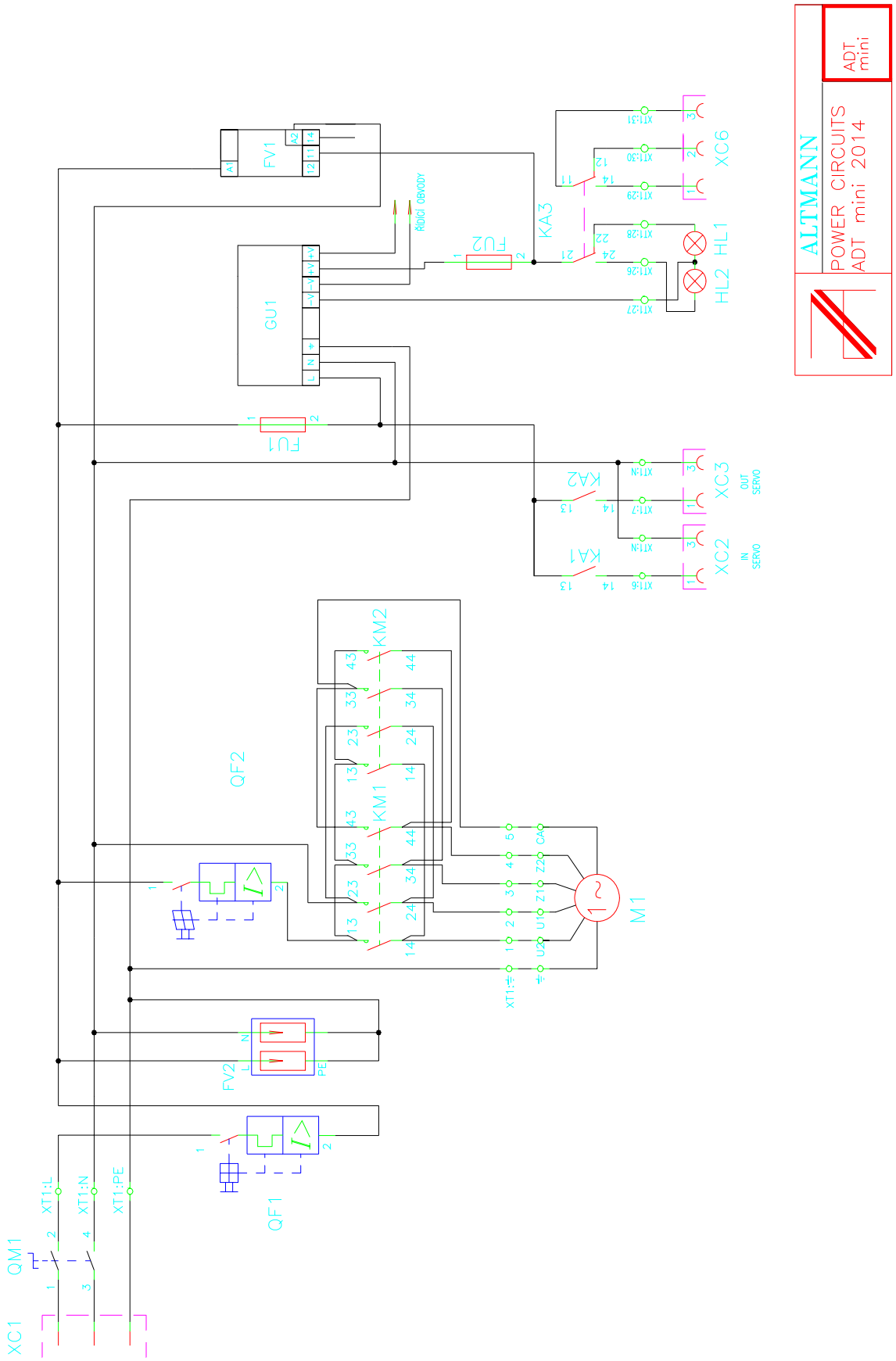


Fig. 10 Power circuit diagram

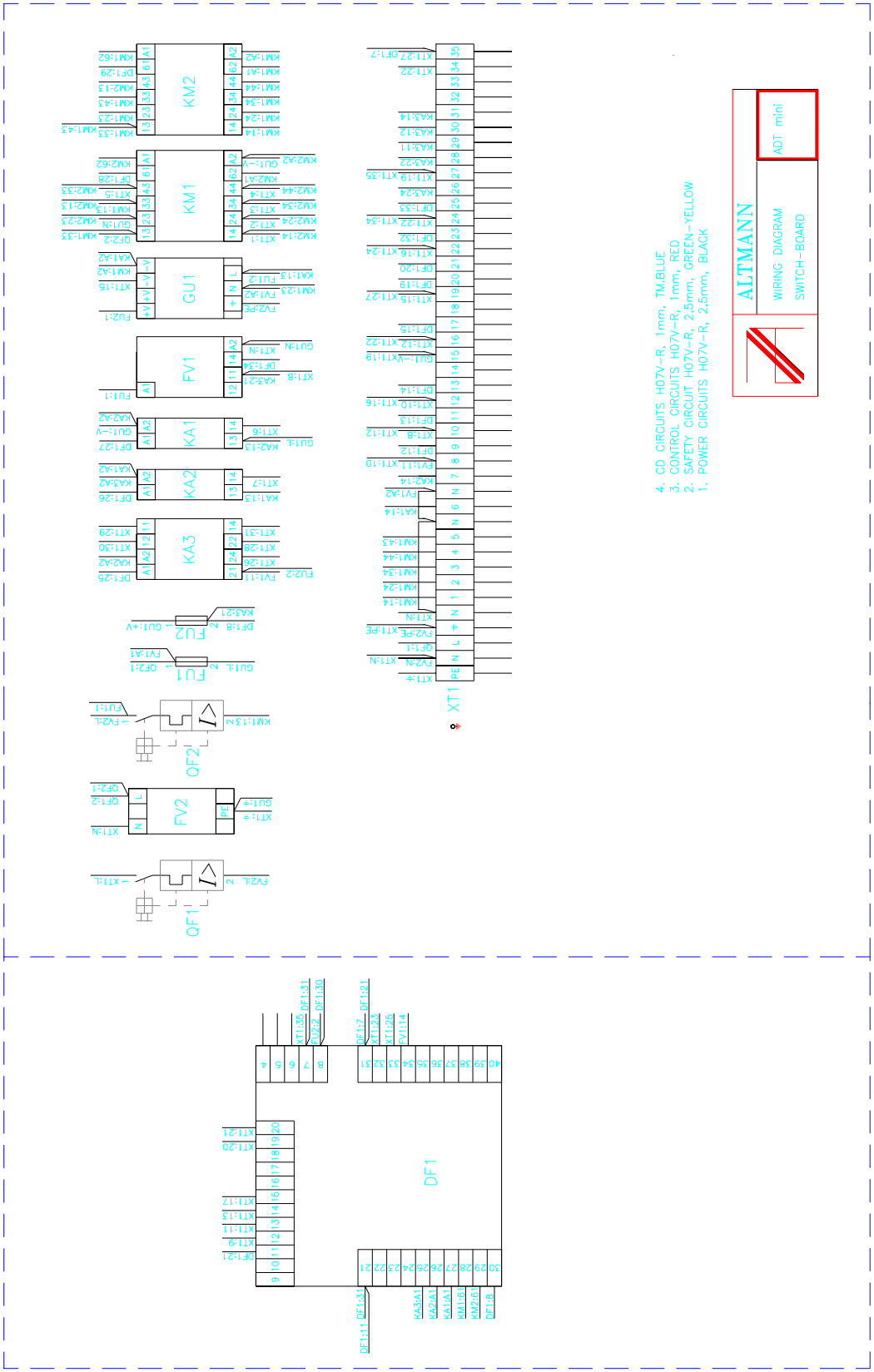


Fig. 11 Switch-board : wiring diagram

8. Remote Control

8.1 Program installation

Program OPTIM D2L - delivered USB - contains the main program for the remote (and in situ) control and the monitoring of ADT and additional sub-programs that enable an easy installation of the whole firmware into your computer.

Installation procedure:

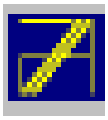
- insert ALTMANN USB into slot

  under a normal operational condition is USB installed automatically

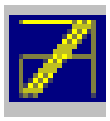
  if not

  - choose **START** and press **RUN**
  - type **D:\setup.exe**. into the command line
  - Press **OK (Enter)** to confirm the procedure.
  - After the **SETUP** panel has appeared, click on **TARGET** and choose the target directory into which you want to install the program. The program will offer you one of the possibilities (C:\ Altmann). Press OK to accept this offer
  - Click on **START** and program SETUP will install program ALTMANN into your computer
  - Press **OK (Enter)** to confirm the procedure

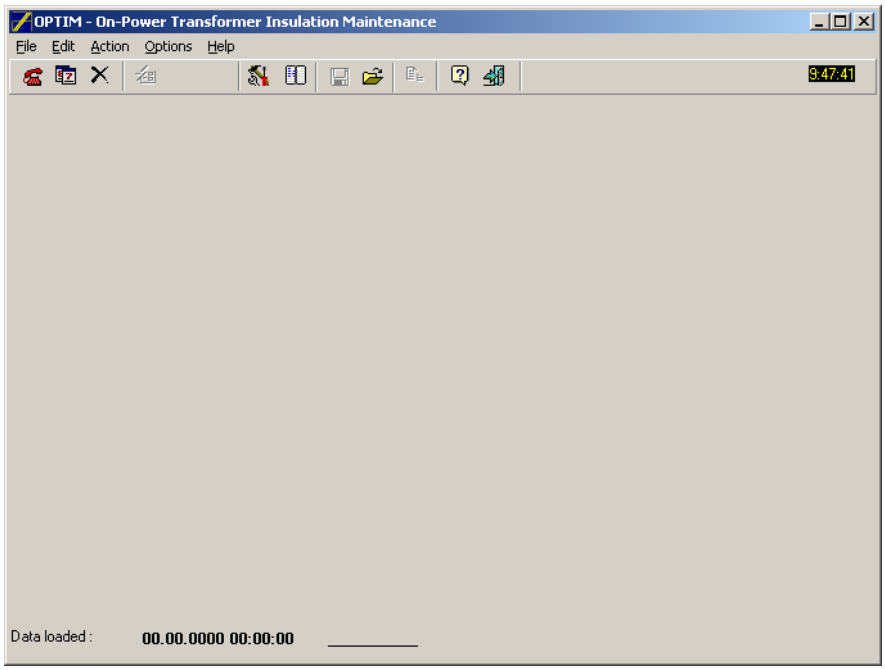
and your PC will offer you a window with the firm icon.



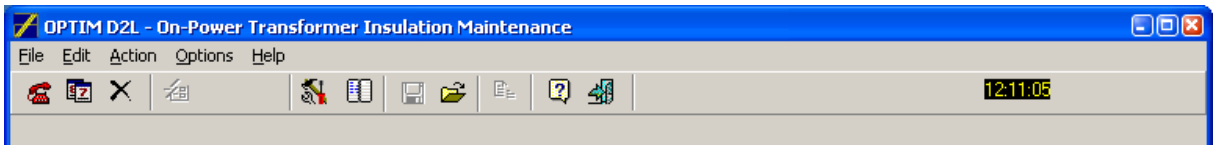
8.2 Starting the program

Click on the Altmann´s firm icon to  launch the program.

Having launched the program basic windows will appear.

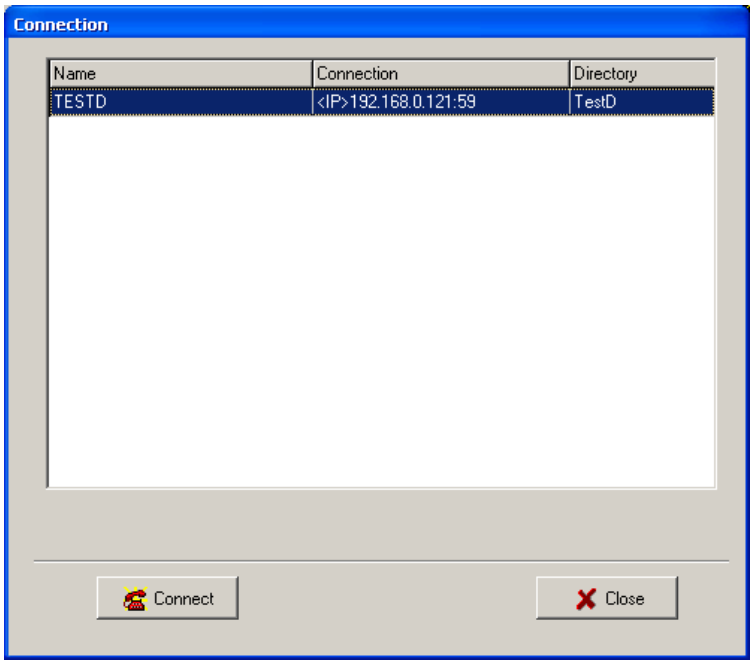


The toolbar contains the following buttons and tools -
click on particular buttons of the toolbar to enter various applications



8.3. Remote communication

Click on the icon opens the new window for the choice of the telephone number of the desired ADT.

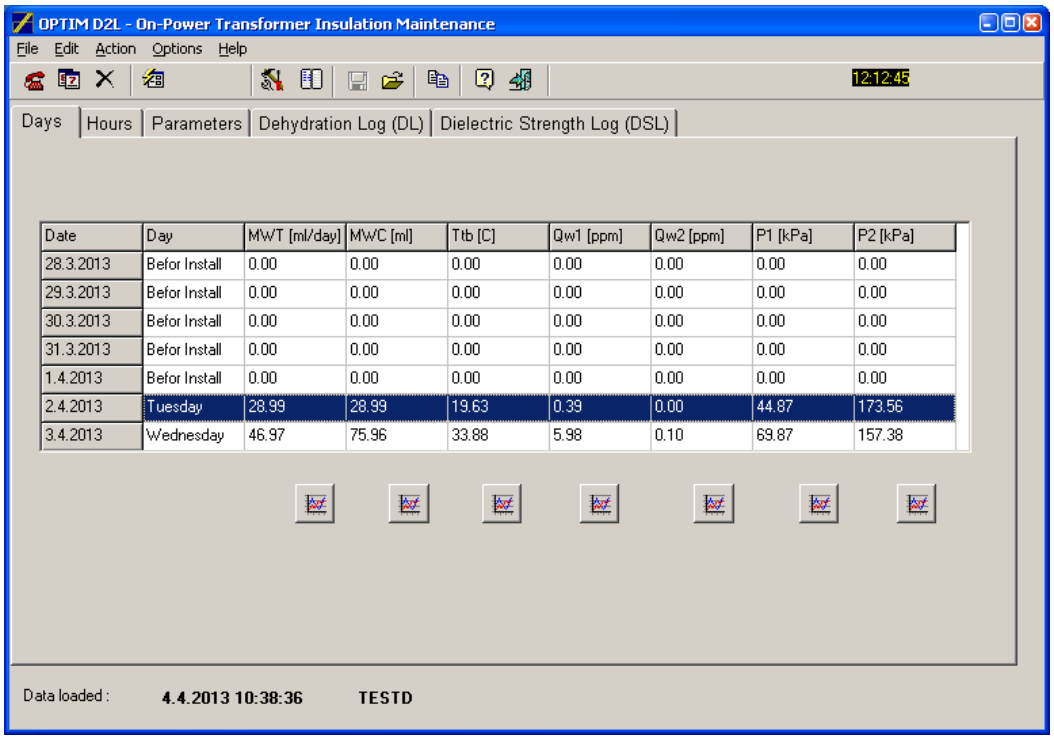


Attention : Before beginning a communication the programming of ***Communication Setup*** *and* ***Telephone directory*** *is neccessary.*

After click on the **Connect** the modem is started and the connection realized. The operational data separator are transfered at two time levels and summoned under auxiliary toolbar:

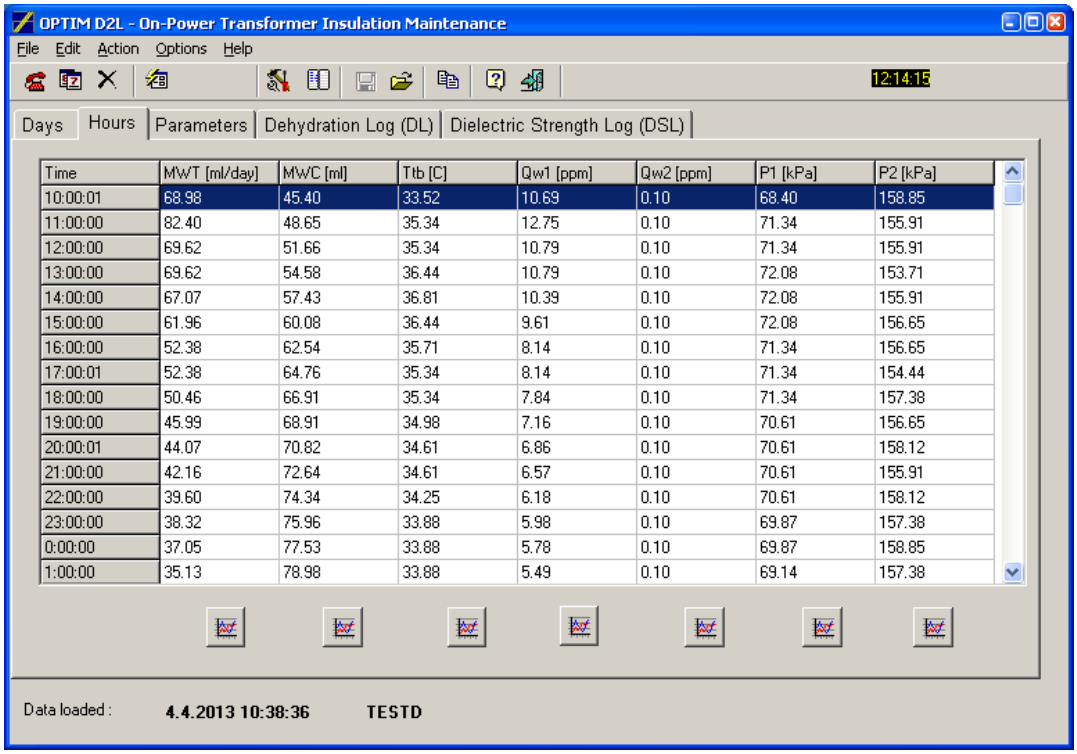
8.4 Data Transfer Button 

- last seven days (button **Days**)



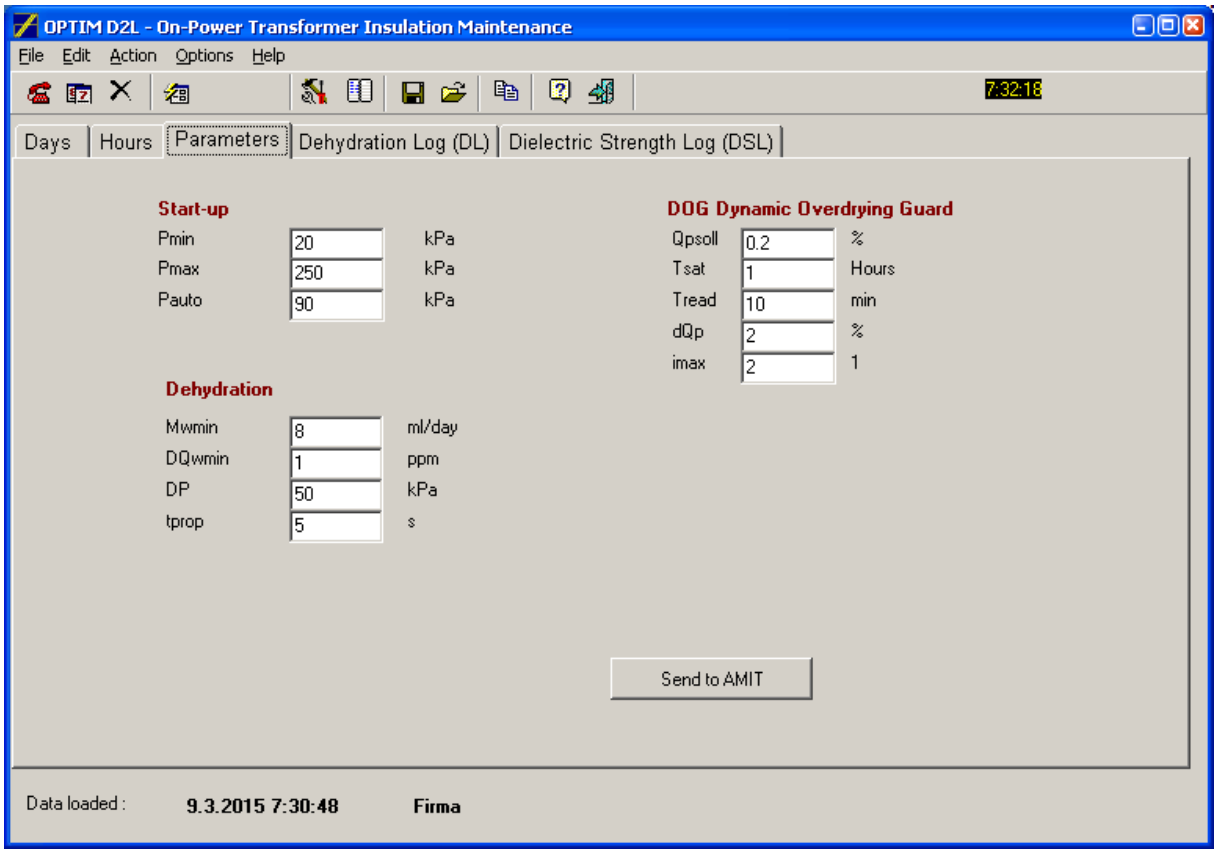
Date	Day	MWT [ml/day]	MWC [ml]	Ttb [C]	Qw1 [ppm]	Qw2 [ppm]	P1 [kPa]	P2 [kPa]
28.3.2013	Befor Install	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29.3.2013	Befor Install	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30.3.2013	Befor Install	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.3.2013	Befor Install	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.4.2013	Befor Install	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.4.2013	Tuesday	28.99	28.99	19.63	0.39	0.00	44.87	173.56
3.4.2013	Wednesday	46.97	75.96	33.88	5.98	0.10	69.87	157.38

- last 24 hours (button **Hours**)



Time	MWT [ml/day]	MWC [ml]	Ttb [C]	Qw1 [ppm]	Qw2 [ppm]	P1 [kPa]	P2 [kPa]
10:00:01	68.98	45.40	33.52	10.69	0.10	68.40	158.85
11:00:00	82.40	48.65	35.34	12.75	0.10	71.34	155.91
12:00:00	69.62	51.66	35.34	10.79	0.10	71.34	155.91
13:00:00	69.62	54.58	36.44	10.79	0.10	72.08	153.71
14:00:00	67.07	57.43	36.81	10.39	0.10	72.08	155.91
15:00:00	61.96	60.08	36.44	9.61	0.10	72.08	156.65
16:00:00	52.38	62.54	35.71	8.14	0.10	71.34	156.65
17:00:01	52.38	64.76	35.34	8.14	0.10	71.34	154.44
18:00:00	50.46	66.91	35.34	7.84	0.10	71.34	157.38
19:00:00	45.99	68.91	34.98	7.16	0.10	70.61	156.65
20:00:01	44.07	70.82	34.61	6.86	0.10	70.61	158.12
21:00:00	42.16	72.64	34.61	6.57	0.10	70.61	155.91
22:00:00	39.60	74.34	34.25	6.18	0.10	70.61	158.12
23:00:00	38.32	75.96	33.88	5.98	0.10	69.87	157.38
0:00:00	37.05	77.53	33.88	5.78	0.10	69.87	158.85
1:00:00	35.13	78.98	33.88	5.49	0.10	69.14	157.38

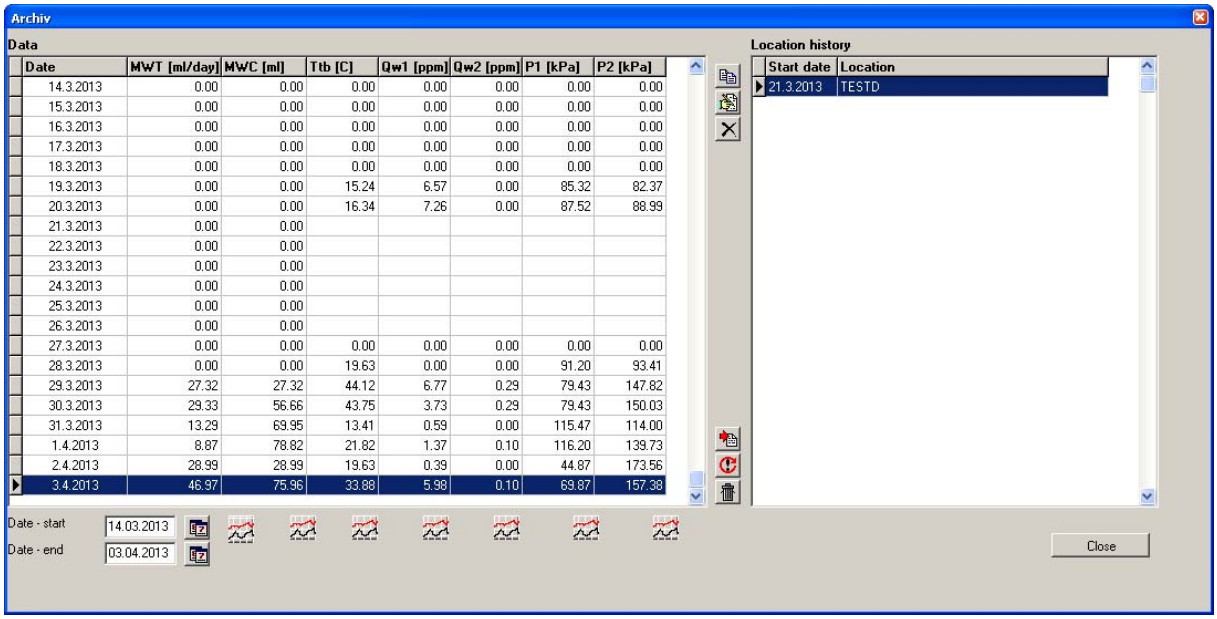
and the same toolbar contains a table **Parameters** which enables the remote re-programing of the ADT (See Parametrical Programming)



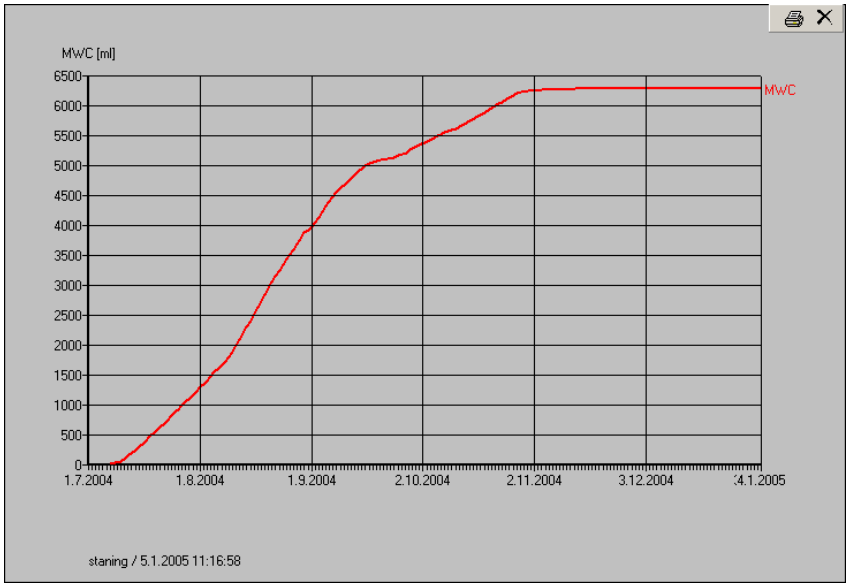
8.5 . Return button – enables return into a main window

8.6 Archive

Click on button **Archive** opens a data table which contains all **Days** data from the beginning a drying procedure at the given transformer. This database is automatically actualized by click on **Connect**. The database Archive contains data all maintained transformers by the given separator and is saved at a remote PC level .

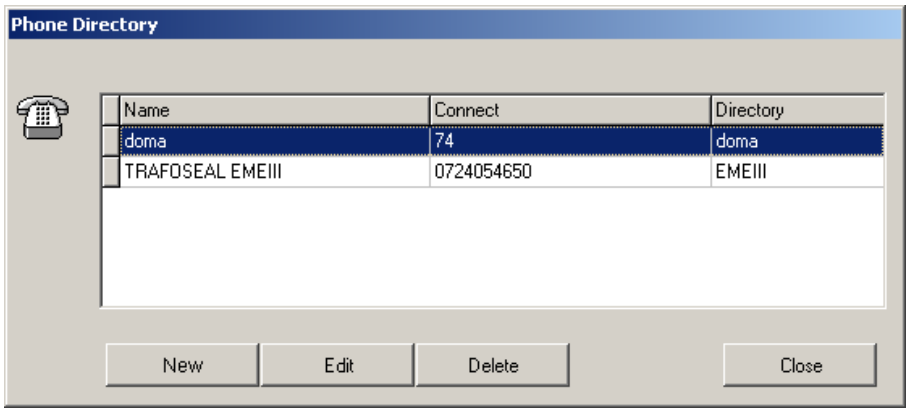


and click on the graph button under the data column opens time-related data visualisation



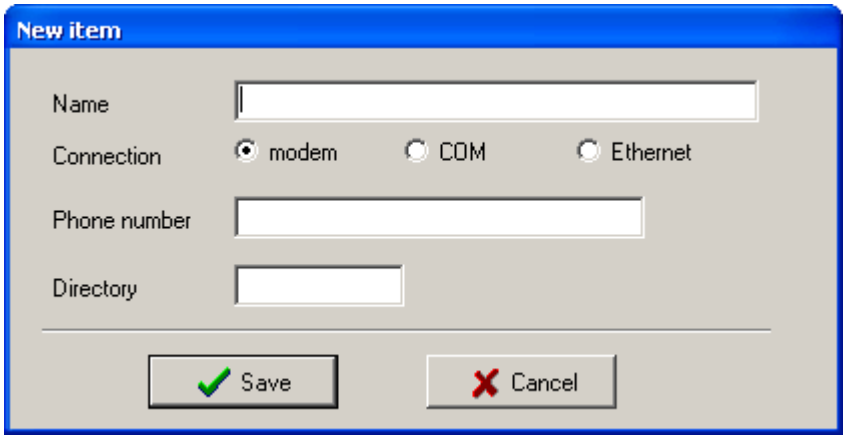
8.8 Telephone directory

The „telephone directory“ database is used to avoid mistakes and for fast choice of the communication with the separator.



For actualizing choose button on the toolbar

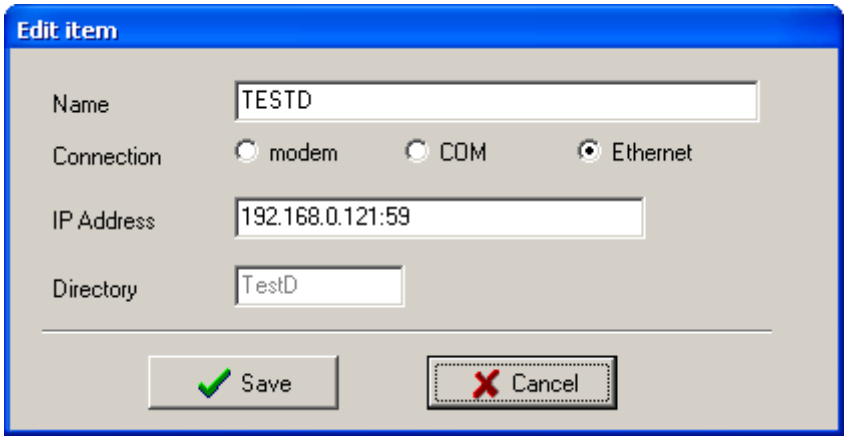
Click **New** - a new „card“ of the telephone directory will appear.



Write down in the **new record** all desired data concerning given transformer very carefully to avoid a very unpleasant mutual exchange of maintained transformers.

- (identification) name - **customer name, location, Serial Number** (S/N) of a given transformer
- connection
  - having chosen the **modem** connection write down into the **Phone** window:
    - the number of the telephone line assigned to the separator
    - or the number of the separator GSM modem
  - the COM connection is destined for a direct cable connection of PC or lap-top with an internal computer (for detailed in-situ data transfer procedure See ….)
  - identification of Ethernet connection via IP address
  - put down the name of the directory where you will archive the monitored data
  - Click on **Save** to put down required connection in memory

Button **Edit** serves to actualize records in the telephone directory. Click on **Edit** to open the following window



where you can change any items and confirm it by the button **Save** or you can the change cancel by click on button **Cancel.**

If you need to cancel any record from the **Telephone directory** you can do it very easy by click on **Delete** and the following window will be opened

and confirm clicking on (Yes) or you can go back to **Telephone Directory** by click on(No).

8.9 Save

click on Save will store data Days, Hours, and Parameters of a given unit into a time-specified file.

8.10 Open

This command opens time-specified files and shows them under Optim D2L enviroment (See Data Transfer).

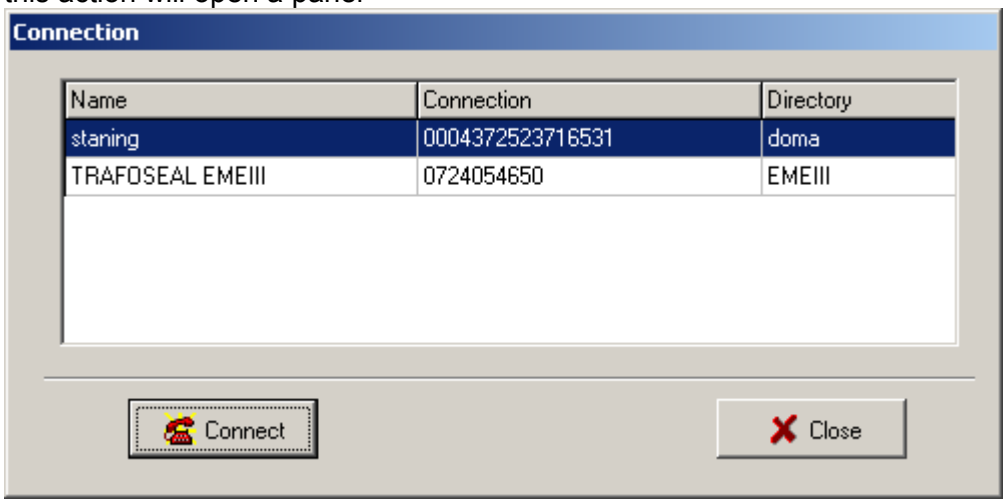
8.11 Copy to Clipboard

Command **Copy to Clipboard** saves the data from the actual screen into a clipboard file and this packet can be freely used e.g. by Excel.

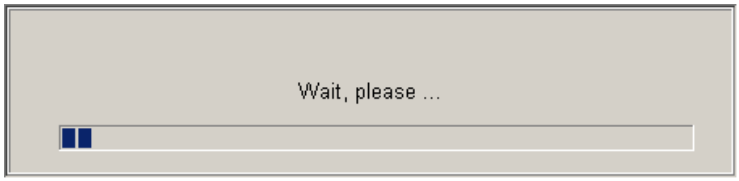
8.12 Standard communication with the ADT dehydrator

After setup you can start proper communication between your PC and the dehydrator pushing button 

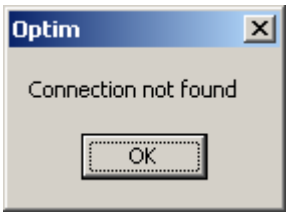
this action will open a panel



after you have finished the choice of a particular number, click on **Connect** – it will start the communication (RUNDMODEM procedure) and will show the following panel

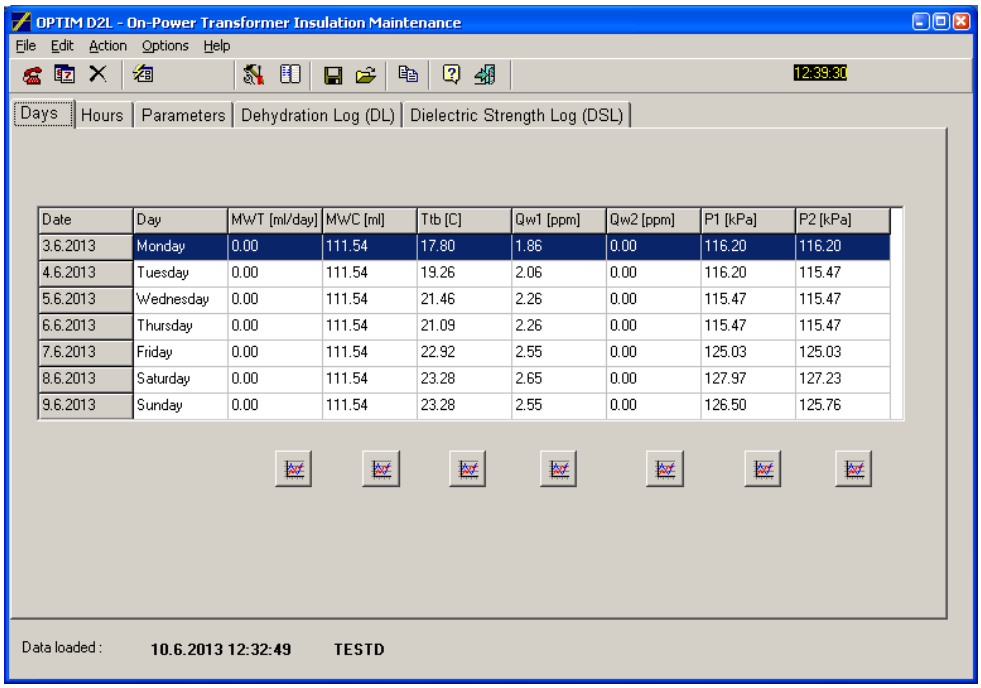


if the connection fails, the program opens the following window



This may happen when the phone or GSM network is busy – simply repeat the process to get the connection.

After achieved the satisfactory connection the program loads the data from PCD in your PC and shows them in the main window.



In order to cut communication fees, the program always works off-line – takes the pre-worked data from PCD, checks them and switches off the connection.

The program offers implicitly so called Days data first – this means the PCD measured 7 quantities are averaged over 24 hours and stored in PCD for 7 days.

Together with the day values the program also loads so called Hours data – PCD measured 5 quantities are averaged over 1 hour and stored in PCD for 24 hours.

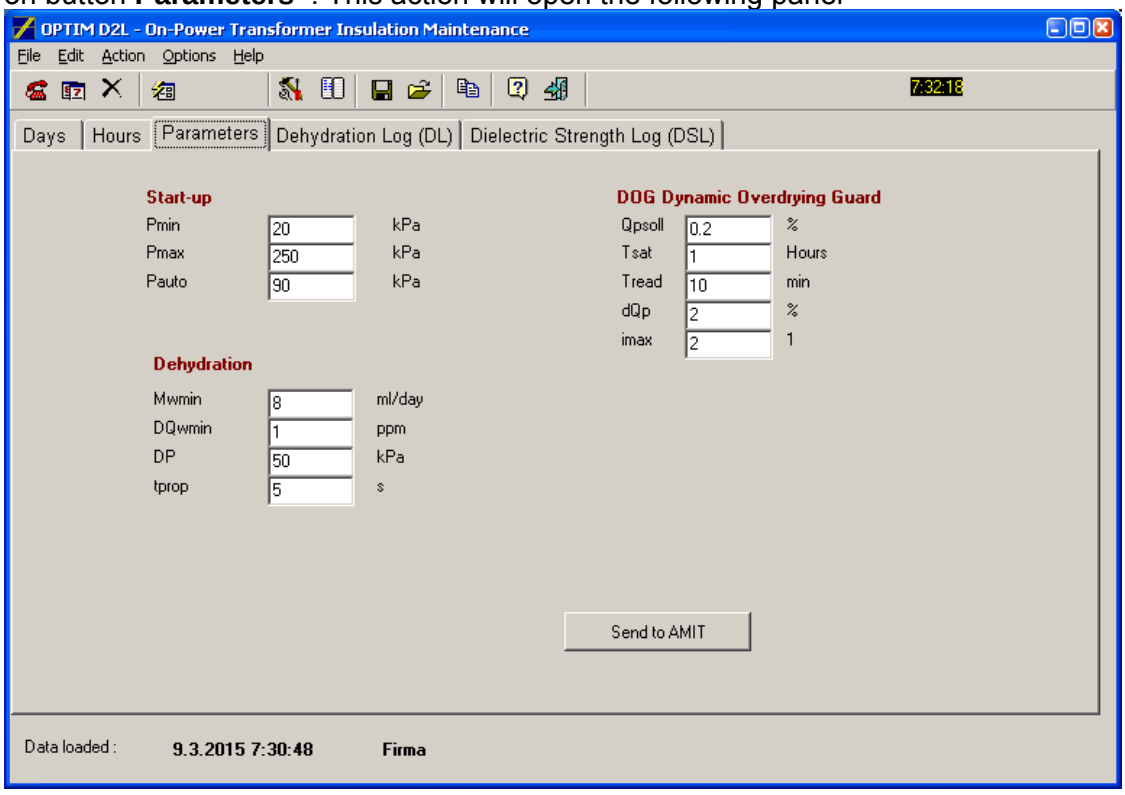
Day and hour averages can be also showed in the form of diagrams pushing the graph button below each column of the values.

The PCD can (only on demand of PC !) implicitly scan , average and store the following basic values send at any time to the remote user PC:

MWT ….	water removal rate (ml/24 day)
MWC…..	total amount of water removed from a particular transformer (ml)
T1 ….	temperature of the transformer derived from oil temperature inflowing into the dehydrator (^{o}C)
Qw1	water content in inflow oil (ppm)
Qw2	water content in outflow oil (ppm)
P1	pressure in the intlet section (kPa)
P2	pressure in outlet section (kPa)
Qpv	virtual water content in hard insulants (%)

8.13 Parametric process control

To optimize of the dehydrator function and the dehydration process of the transformer, click on button **Parameters** . This action will open the following panel



Every basic function of the dehydrator (from start up to shut down) can be parametrically programmed, but:

ATTENTION !!

Parameters are already optimally pre-set.

If you want to change any parameter consult it with your dealer or producer of the separator first.

Adjusting parameters

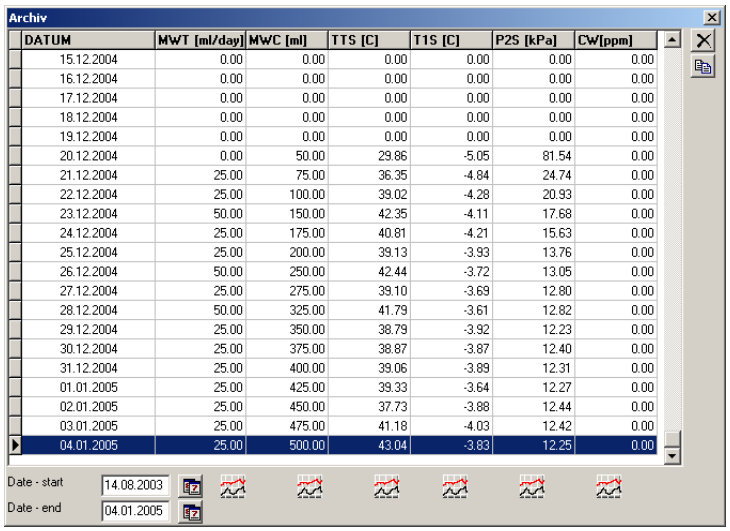
- Re-write the given parameter to change it
- Click on button **Send to AMIT** to send the changed value back to the separator PCD

8.14 Transformer dehydration record

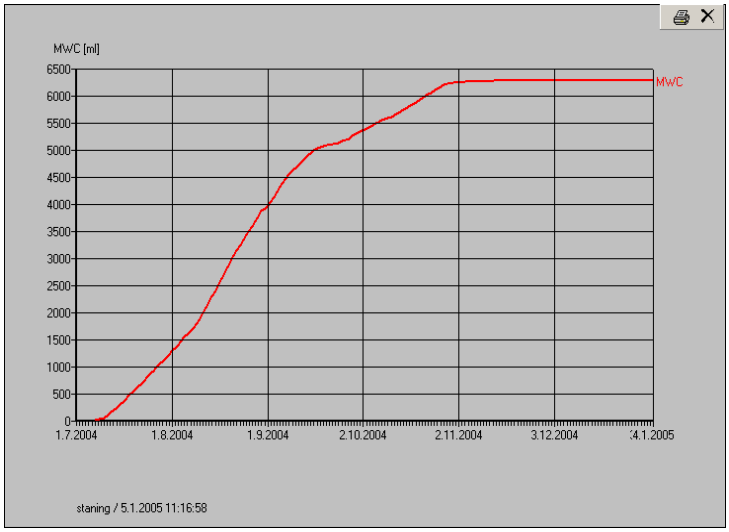
For the dehydration record and an evaluation of achieved results the procedure **Archive** is obviously used.

Click on 

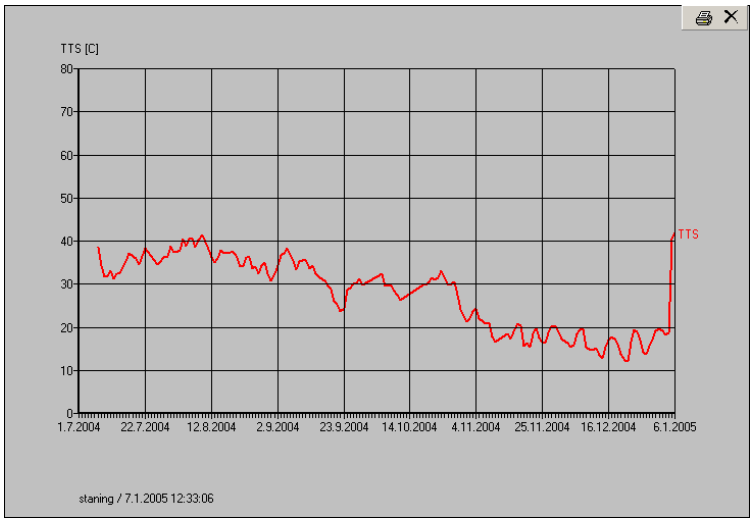
and this step will be confirmed showing the panel



For a better understanding of a on-line drying process of a transformer is most often used time-related graphical output which is inicialized by click on the graph button under chosen columns e.g. MWC (total amount of water removed from the given transformer)



and Ttb (Transformer temperature bottom)



The comparison of both time-related graphs gives us very often plausible answer at a basic questions about the drying process.

In this case is quite obvious that the reduction of the amount of removed water was induced by the strong decline of the transformer temperature.

8.15 Optimization of the on-power dehydration of transformers .

The relevant moisture and dielectric diagnostics is always absolutely necessary before the beginning of any dehydration procedure e.g. to avoid a dehydration of „dry“ Tx .

The SIMMS 2.0 or Tx-Multiscan should be used to evaluate the water content in the cellulose materials of the transformer.

To avoid a overdrying of transformer and subsequent very dangerous loss of clamping forces the dehydration target has to be defined .

Generally : water content in cellulose insulants, the Qp-value should be not reduced under ½ of original value.

Do not forget, regardless of how efficient any method of **oil** dehydration might be, the water removal from the transformer under normal operational conditions - the **transformer dehydration** - is ultimately governed by slow diffusion of moisture from cellulose and this process can be accelerated only by high Tx-temperature.

That is why you always have to describe any dehydration process of **transformer** with at least two values – **MWT** (average water removal rate and) **or MWC** (total amount of removed water) and **TTS** (temperature of the transformer).

In order to avoid lowering the immediate reliability of the transformer we have to tune at least two antagonistic criteria:

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

The first criterion is fully understandable – we want to dehydrate the transformer as soon as possible. Thus we need to release maximum of water from the cellulose into the oil filling by raising the temperature of the transformer.

This fundamentally collides with the second criterion – if the temperature of the wet transformer will be too high, water contents in oil may easy exceed 30 ppm limit and the dielectric strenght of oil drops relatively quickly under 40 – 50 kV/2.5mm.

If the moisture sensor is installed, follow always its on-line reading. The Qw1-value should never exceed 30 ppm.

To solve the dilemma between both criterions the method of gradual heating of the transformer is recommended especially if an on-line Qw1-reading isn´t available:

- check at first both actual values of water content in the oil (Qw1-value) and dielectric strength of the oil (Ud-value).

  - If the Qw1-value is substantially under 30 ppm, increase the temperature TTS of the transformer, about 10 C, wait 5 days and check the result, if necessary, repeat the procedure until the Qw1-value is about 20 – 25 ppm is reached

  - If the Qw1-value is about 30 ppm, decrease the temp. ca 5 C, check the result

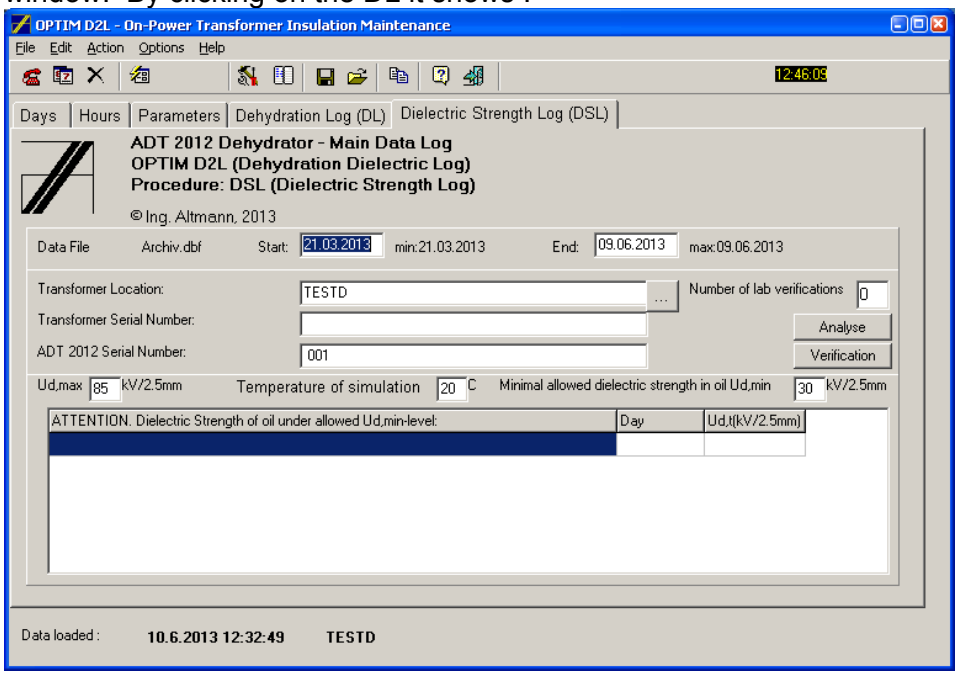
  - If the Qw1-value is substantially over 30 ppm, the temp. has to be immediately decreased until the allowed Qw1-level is reached and simultaneously the Ud-level will be over 30 kV/2.5mm.

9. 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:

- the **DL** (**D**ehydration **L**og)
- 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. By clicking on the DL it shows :

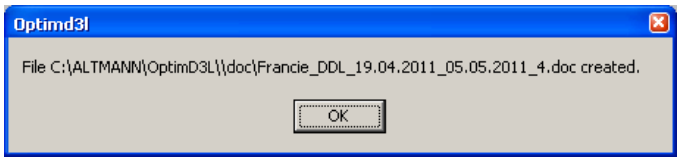


all the necessary basic data concerning :

- requested time-range of data (Data File , Start , End)
- Transformer Location, Transformer S/N and VS-06 S/N
- Maximal allowed water content in oil (Qw,max)

can be directly and easily entered from the keyboard.

By clicking on the Analyse button the time-related change of basic variables (Mwc, Ttb, Qw1, Qw2,) 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 is indicated as



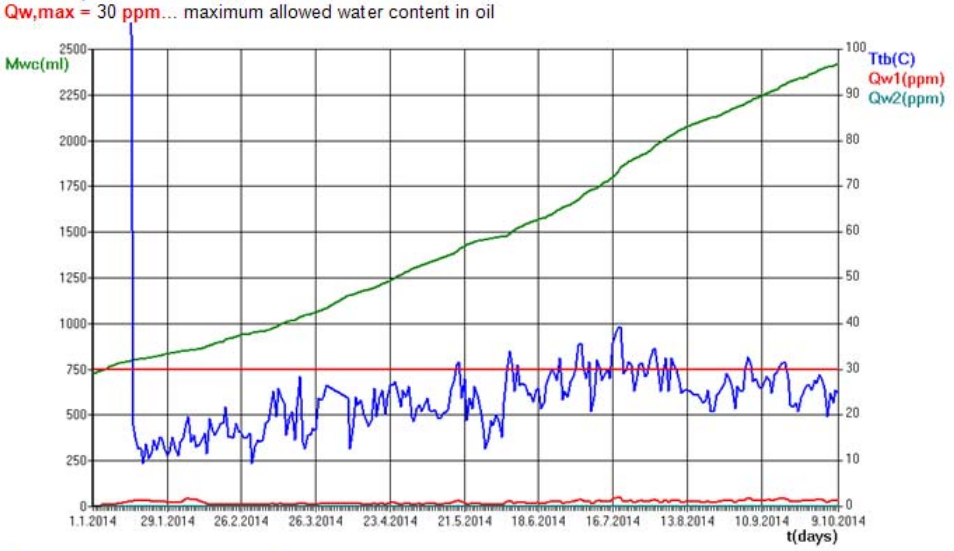
and by clicking on the OK button , the final, printable output of the DL procedure is shown

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

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

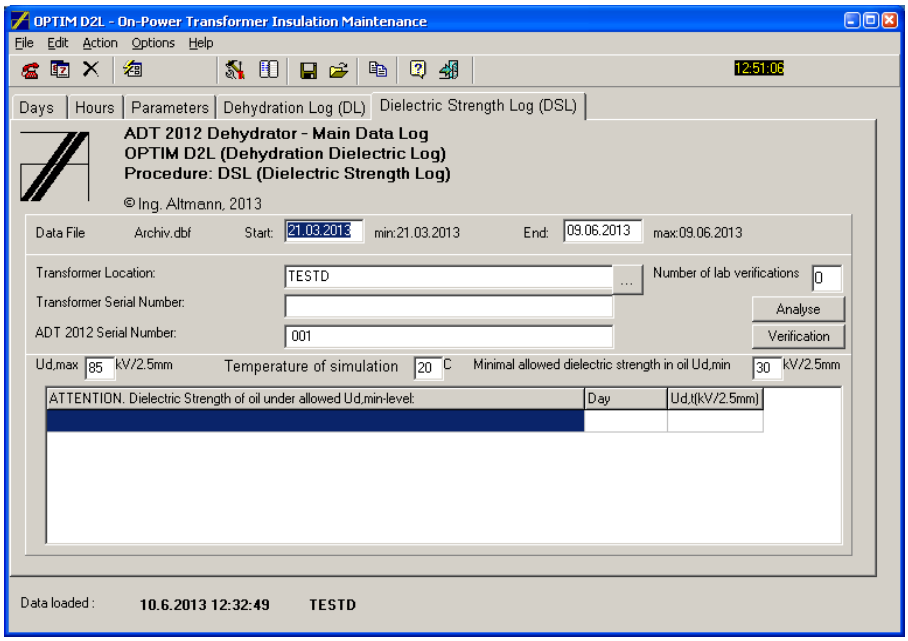
This absolutely new approach enables the DSL online to calculate the theoretical (maximum attainable) value of the dielectric strength of oil (the Ud,t –value) on the basis of the direct measuring of the water content in the oil (the Qw1-value).

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).

And this theoretical relationship can be verified by lab data.

By clicking on the DSL button the first Windows shows



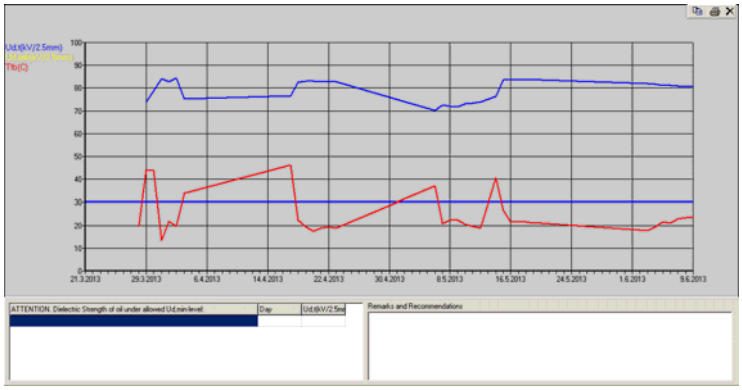
And the following steps are similar as before :

- 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)

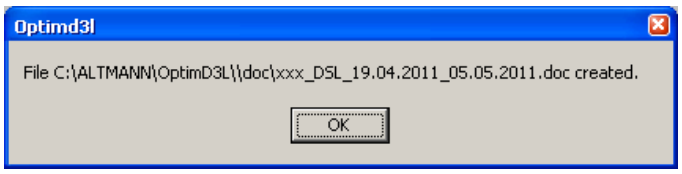
these can be directly and easily entered from the keyboard.

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.

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.



clicking on the printer icone shows



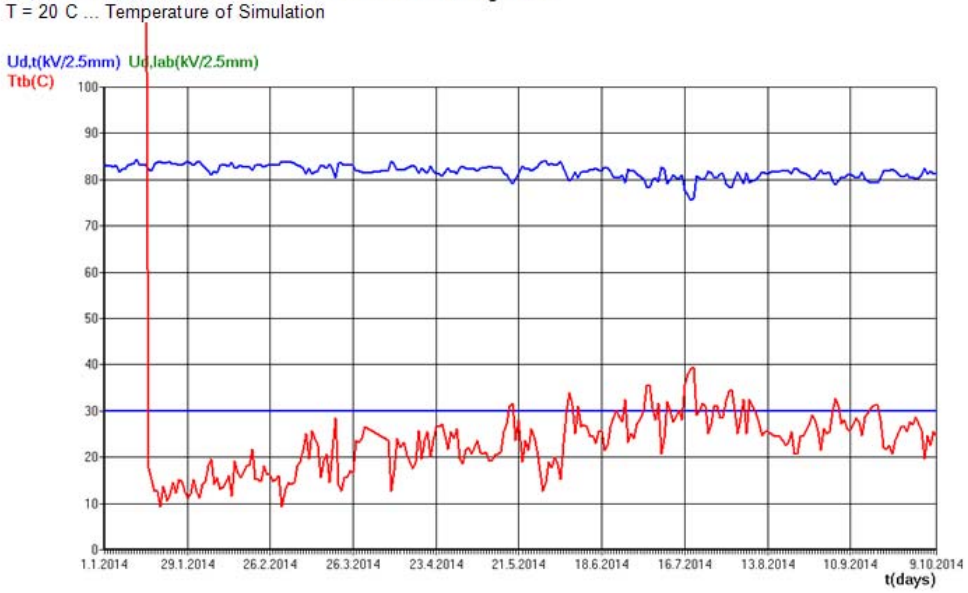
And clicking on the OK shows the description of the dielectric behaviour of the transformer for the requested time period

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 ... 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.
Dielectric Strength of oil Ud,t decreased under allowed Ud,min-limit:

Day	Ud,t(kV/2.5mm)

Number of lab verifications: 0

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:

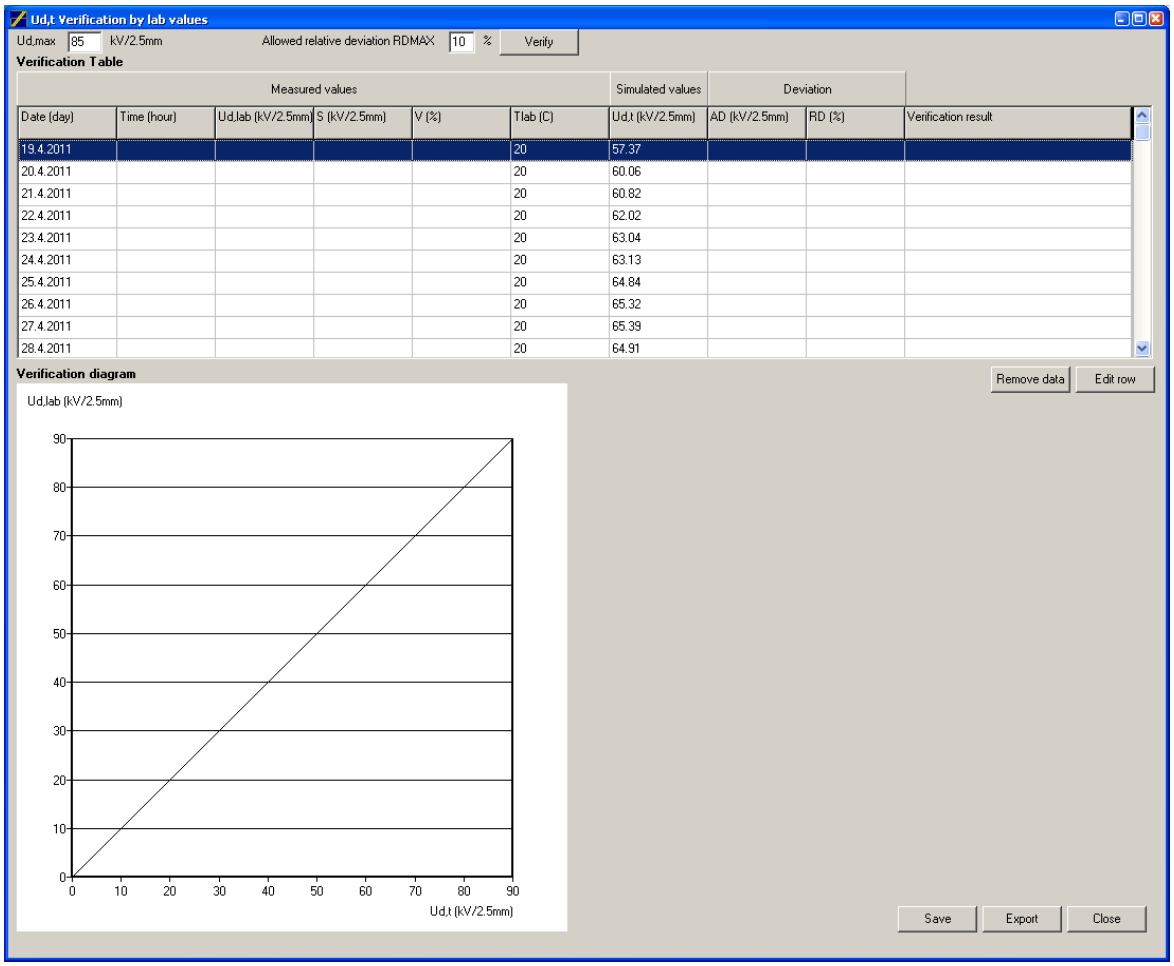
- by the quantitative comparison of the Ud,t-value and the Ud,lab-value at the same time.

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).

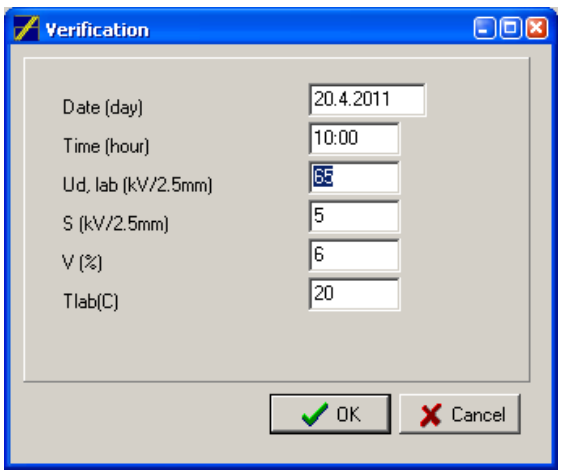
The final result of the DSL-procedure is the quantitative verification by means of the Verification Table and the Verification Diagram.

By clicking on the Verification button in the DSL window, the Verification Table and the Verification Diagram is shown.

At first the time(s) of sampling and the corresponding Ud-lab value(s) and other lab values have to be entered into the Verification Table:

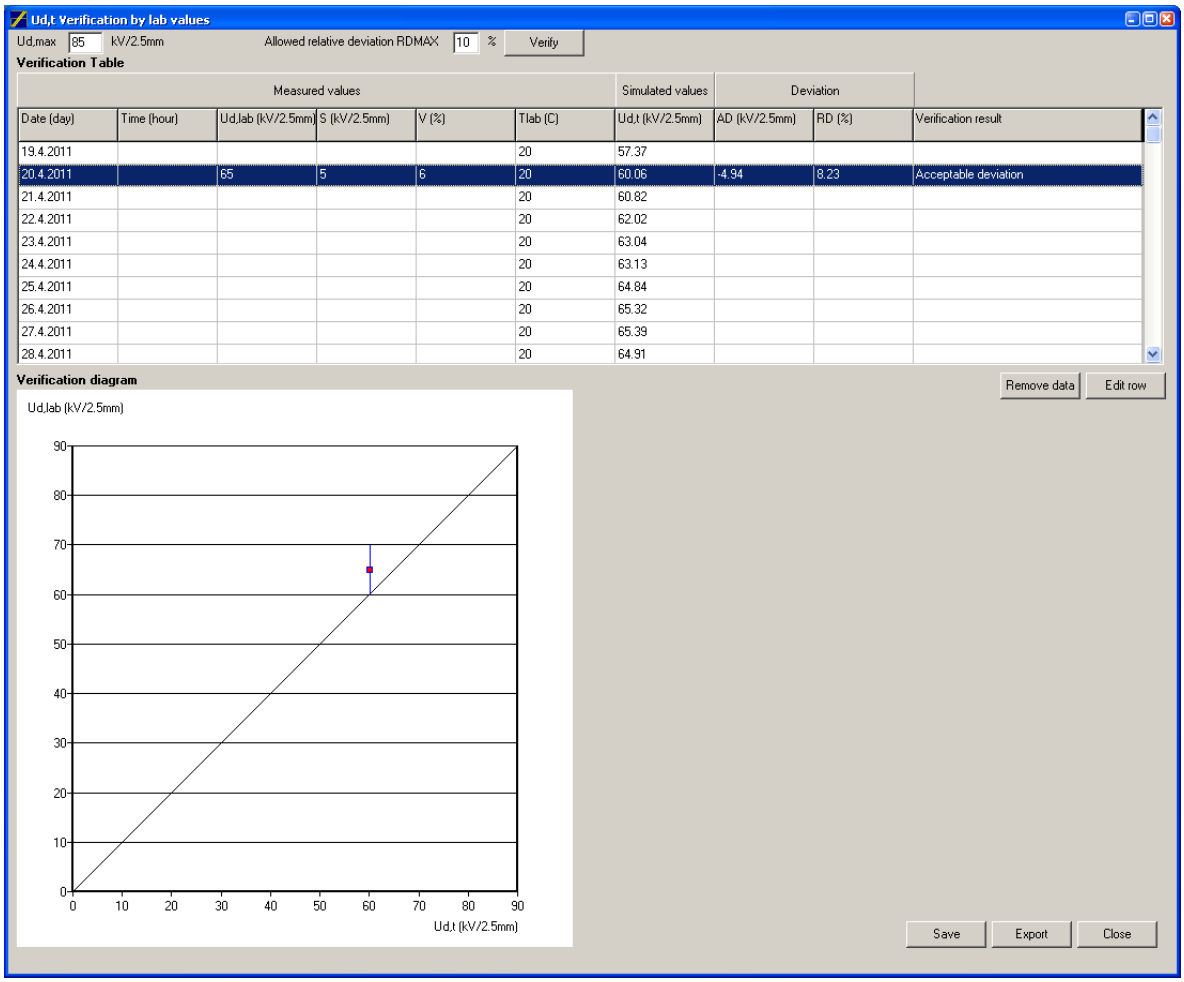


For example: the sampling of oil was performed 20.4 2011 at 10.00 lab reading was performed at 20C and Ud,lab = 65 kV/2.5mm, S = 5 kV/2.5mm , V = 6%



By clicking on the pre-defined date, here 20.4 2011, the day is marked (by the blue colouring of the row). To enter the lab data the Edit row button is used.

Clicking on the OK button then gives the requested result(s), which is shown in the Verification Diagram in the bottom part of the window .



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

- 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
- 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
- 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.

10. The Dynamic Overdrying Guard (DOG)

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.**

PCD display then shows this step as

DYNAMIC OVERDRYING
GUARD
OIL RESATURATION
WAIT PLEASE

and after pre-determined time period Tsat (See Parameter Table) the reading of Qw1-value, Ttb-value and subsequently the evaluation of Qpv-value begins

DYNAMIC OVERDRYING
GUARD
READING
Qw1= … ppm, Ttb = … C

⇒ 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.

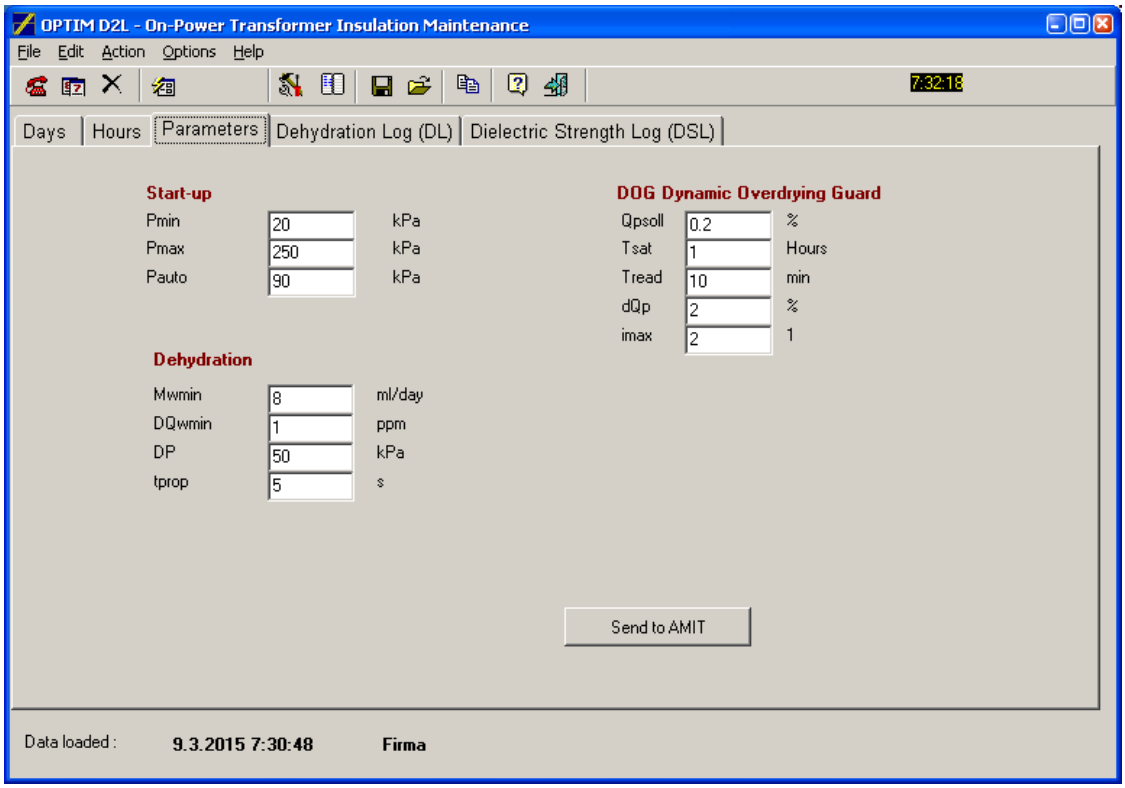
This final step is shown as

DEHYDRATION FINISHED
Qpv = … %

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 remote setting of dehydration target (and all main parameters of ADT as well) enables OPTIM D2L again.

By clicking on the Parameters button in the main Window the Parameter Table is shown



where all main parameter can easily be changed (by overwriting of existing value) and by clicking on Send to Amit, the change is downloaded to the PCD.