
streamer
TRANSEC
TRANSEC
TRANSEC
TRANSEC
CL series
Online Moisture monitoring
& drying solutions
for oil insulated
transformers
2022


TRANSEU
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TRANSEU
#2

2004

TRANSEC UK Ltd created and the first TRANSEC unit launched

2007

First installation of 22 units with ABB in India

2009

Installation of TRANSEC units in the United Kingdom nuclear sites

2012

Standardisation of TRANSEC installation on all new transformers of PGCIL India

2012

Introduction of the first version of TRANSEC monitoring cabinet with VAISALA sensors

2016

Cooperation with Streamer Electric AG
Starting to promote and sell in new regions like South-East Asia, Latin America, Africa

2019

Streamer Electric AG taking over TRANSEC business. TRANSEC Electric Ltd is created. New investment round in the company and the design of the unit

2021

Launching of i version design

The issue: Moisture is threatening the transformer

Moisture is one of the primary causes of failures for power transformers and one of the main degradation factors for the insulation paper. It, therefore, increases the risks of operation failures and shortens the life expectancy of the asset.

Unfortunately, moisture can appear in a transformer from several sources, which are external or internal and it has a complex dynamic between the oil and paper within the transformer. The use of silica gel breathers, sealed tanks or nitrogen blankets can avoid all or at least the most of moisture from the atmosphere to affect the transformer. However, when the transformer is energised, the production of water inside the insulation is a natural and inevitable occurrence over time due to the depolymerisation of the cellulose paper.

Effect on safety:

As shown in figure 1, the higher the relative water saturation, the lower the oil's breakdown voltage (BDV). As water migrates between the solid and liquid insulation in a transformer with changes in load and, therefore, temperature so does the relative water saturation in oil. Peaks of relative saturation are usually observed during transformer state changes (high to low temperature or reverse). Moisture reduction is, therefore, a pivotal effort to be made to increase safety, especially for transformers with quick and frequent load changes.

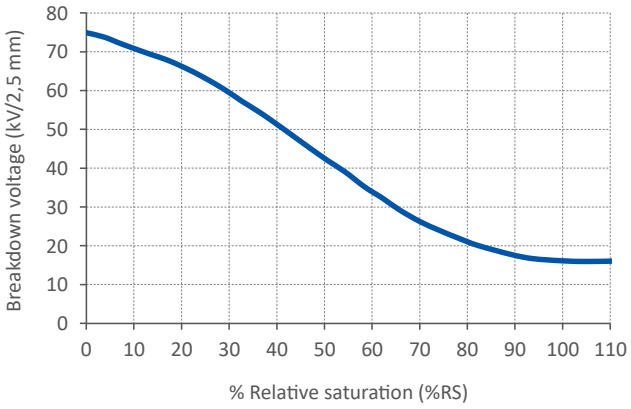


Figure 1. Dependency between breakdown voltage and water content in insulating liquid *

Effect on transformer life expectancy:

The insulation paper's mechanical strength is defined by the degree of polymerisation, also called DP, representing the average length of cellulose chains in the paper. A new transformer typically has a DP between 1200 and 1000 while the end of transformer life is considered when the DP falls to 200. This degradation cannot be stopped, but its speed will depend on the water content in the paper (see figure 2).

In CIGRE brochure D1.01.10 (2007), "Fallou showed that the rate of degradation of the paper at an initial value of 4% water content was 20 times greater than that at 0.5 % water content."

Moisture is having a significant effect on the speed of paper degradation and therefore on its life expectancy.

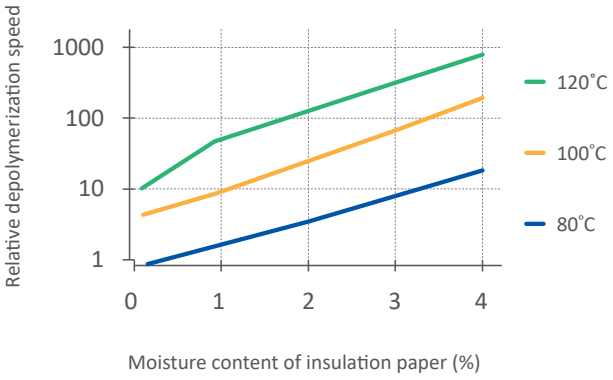


Figure 2. Cellulose depolymerisation speed dependence on moisture content in insulation paper for different temperatures **

* CIGRE Moisture measurement and assessment in transformer insulation - evaluation of chemical methods and capacitive moisture sensors, page 10
** CIGRE Moisture measurement and assessment in transformer insulation - evaluation of chemical processes and capacitive moisture sensors, page 14

The solution: Maintaining a dry transformer by continuous filtration

Maintaining a low level of moisture in a transformer provides significant benefits in terms of operations and risk as it carries a constant high insulation level. It is therefore possible to load the transformer at a higher level and to make this load vary without risk of damaging the transformer.

Also, it has consequent financial benefits since it elongates the asset's life by slowing down the paper degradation. This degradation creates particles or even sludges. Finally, moisture is also responsible for the creation of acids in the oil. Hence keeping a low level of moisture will lower the maintenance costs.

Only continuous filtration is efficient in removing moisture from a transformer

As moisture is created continuously and as it is one of the primary concern for the transformer safety and life expectancy, it seems counter-intuitive to apply a temporary solution for this ongoing problem.

Also it is essential to note that more than 98% of the water in a transformer is in the paper, while a meagre amount is dissolved in oil. The diffusion time of water from paper to oil is prolonged. This is why punctual filtrations are not solving the moisture issue.

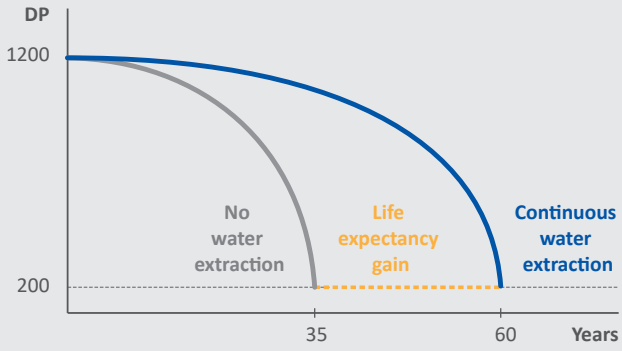


Figure 3. The benefit of continuous online drying system

	Oil filtration	LFH or similar method	Online drying system
Solution type	Temporary	Temporary	Continuous
Transformer live during process	Up to user risk assessment (oil flow >500l per hour)	NO	YES
Dries oil	YES	YES	YES
Dries paper	NO	YES	YES
Improves Breakdown voltage	Temporarily (months)	YES	YES
Extend life expectancy	NO	YES	YES
Dissolved Gasses level maintained	NO	NO	YES
Operator free process	NO	NO	YES
Cost	$	$ $ $	$

The issue: Assessing the amount of water in the transformer

1. More than 98% of the water present in the transformer is contained in the paper insulation while less than 2% is in the oil. Unfortunately, the insulation paper is not easily accessible for water assessment.

2. Water solubility in oil varies depending on oil temperature and therefore PPM differs also. Hence it is not possible to check the PPM value to define the amount of water in paper.

3. If PPM and oil temperature are known some curves exist (see Oomen curves figure 4) to link the water PPM in oil and the water content in the paper. But these curves are only really valid at equilibrium which is in general never reached on a running transformer.

4. As the water diffusion time is faster from the paper to the oil than the opposite it is possible to reach on the same transformer, several very different PPM values for the same oil temperature even at a few days difference (see figure 5).

5. As a result of the previous points, taking an oil sample once or twice per year to assess the moisture level in the transformer seems irrelevant.

6. Furthermore, oil samples can be contaminated at the sampling time or in the laboratory. As the moisture level is anyway very low in oil, any contamination (simple contact with the ambient air) will affect the sample PPM result. The chart (figure 6) shows PPM analysis results of 7 different laboratories on 3 different oils.

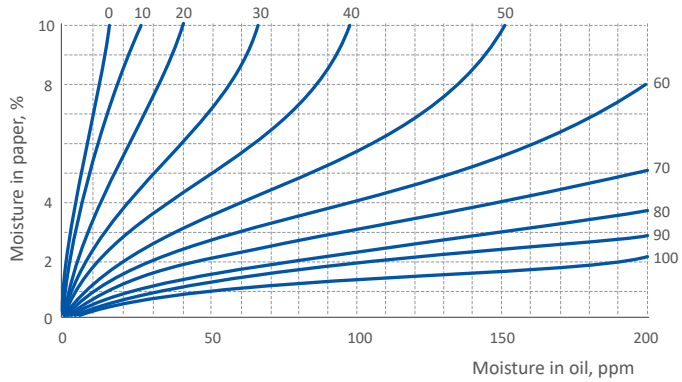


Figure 4. Moisture Equilibrium curves* (Oomen)

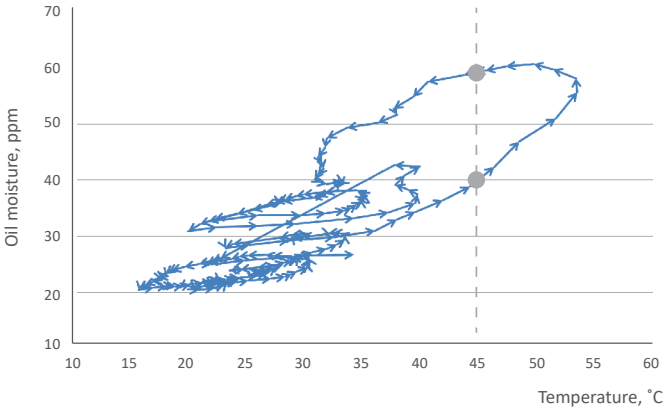


Figure 5. Moisture dynamics: hysteresis**

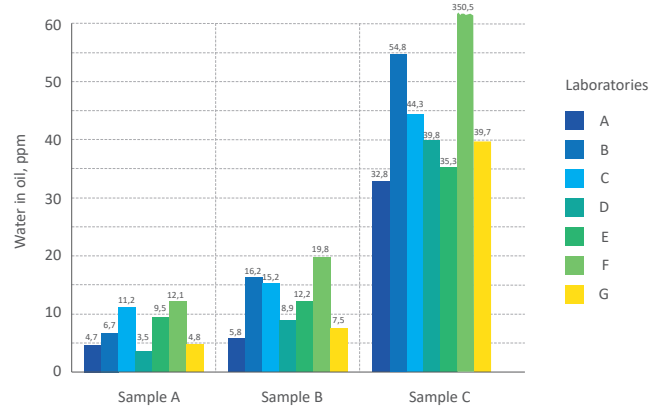


Figure 6. Reliability and Improvements of Water Titration*** by the Karl Fischer Technique

M. Koch1, S. Tenbohlen1, J. Blennow2, I. Hoehlein3*

* CIGRE Moisture measurement and assessment in transformer insulation - evaluation of chemical methods and capacitive moisture sensors, page 74
** Moisture in transformer Oil Behaviour, page 14
*** Reliability and Improvements of Water Titration by the Karl Fischer Technique, page 4

The Solution: Continuous moisture assessment

1. Moisture and temperature sensors within the oil

TRANSEC Online Moisture Monitoring system uses moisture and temperature sensors to monitor the relative saturation, the PPM, and the temperature of the oil flowing through the TRANSEC. This data is transferred to the TRANSEC monitoring cabinet for analysis. As the sensors are immersed in oil, there is no risk from external contamination, and as the sensors are not changing, repeatability is ensured.

Moisture & temperature sensor

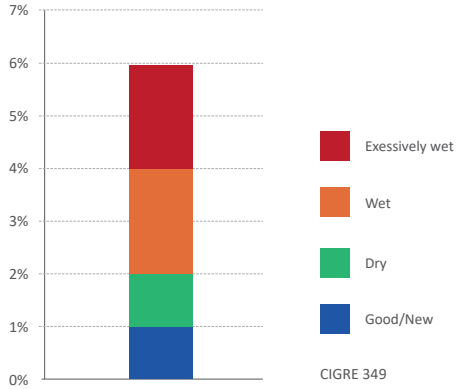


Figure 7. Water content in paper in %

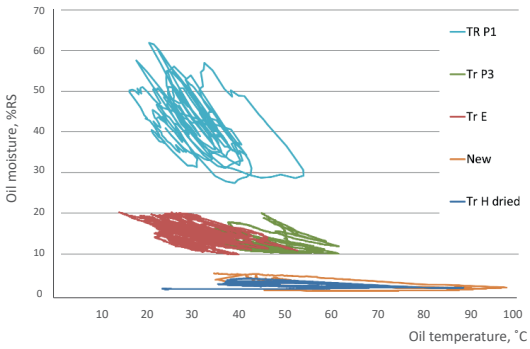


Figure 8. Hysteresis loops of %RS vs temperature in transformers with different moisture level*

* CIGRE Moisture measurement and assessment in transformer insulation - evaluation of chemical methods and capacitive moisture sensors, page 100

2. Continuous checking

Thanks to the constant sampling from the TRANSEC sensors, the relative saturation, the moisture PPM and temperature can be followed remotely on the webserver which allows assessment of the moisture level in the transformer and to observe the effect of the TRANSEC filtration.

- Based on the Oomen curve calculation, the trend of the water content in paper can be followed (see figure 7)

- Monitoring the relative saturation vs Temperature hysteresis enables observation of its shape. A narrow shape below 20% moisture shows a healthy transformer while a broad hysteresis exceeding 20% relative saturation (TR P1) on the picture below is a sign of a moist and unsafe transformer.

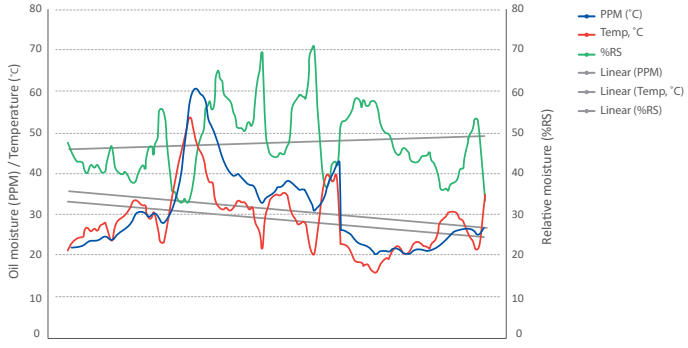
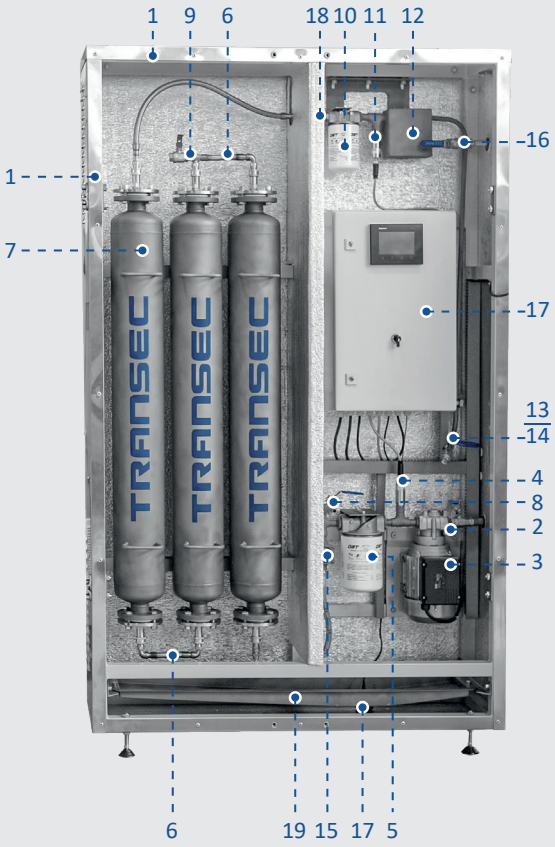


Figure 9. %RS, calculated water content and temperature with time in a 10 MVA moist aged transformer*

TRANSEC online drying system



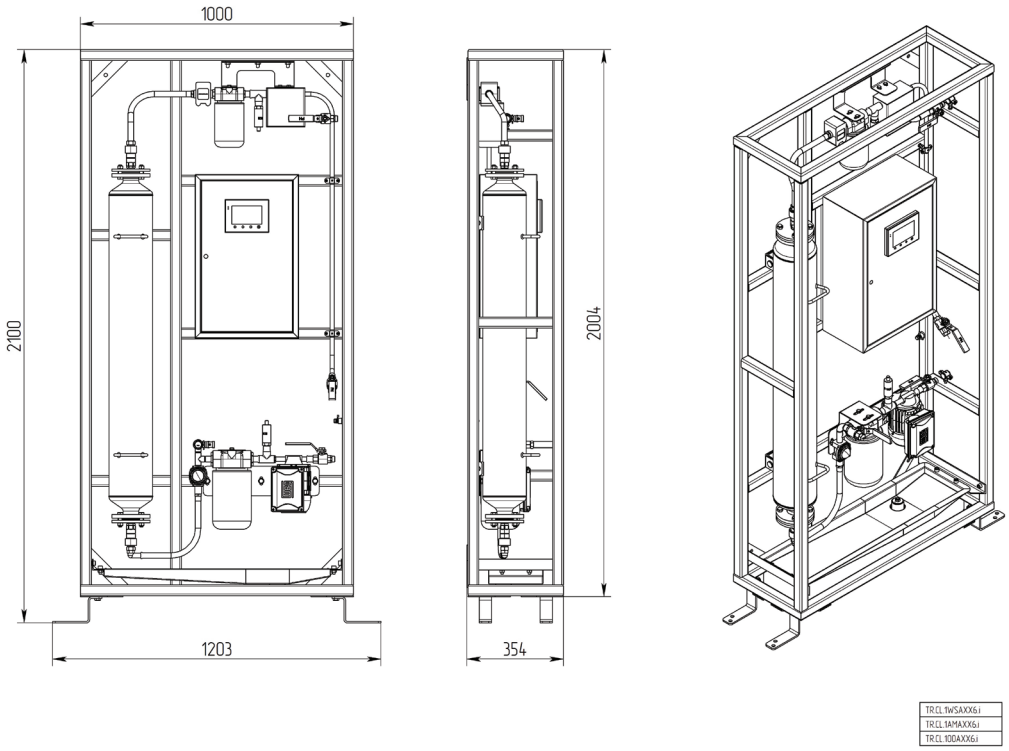
1. Frame
2. Inlet ball valve
3. Pump
4. Inlet moisture and temperature sensor
5. Oil pre-treatment filter (10 microns)
6. Connecting pipes
7. Adsorption tanks
8. Inlet sampling valve
9. Air bypass valve between cylinders 1 & 2
10. Fine filter (3 microns)
11. Outlet moisture and temperature sensor
12. Deaerator
13. Deaerator air bypass valve
14. Outlet sampling valve
15. Flow indicator
16. Outlet ball valve
17. Control and monitoring unit
18. Flow meter
19. Leak sensor & leak tray (optional)

TRANSEC Online Drying System uses molecular sieves to extract moisture from the oil. These granules (non-chemical) contain many pores of 3 Angstrom diameter which is the exact size to catch water molecules. That way other components like gases molecules with larger or smaller diameter are not filtered by these sieves.

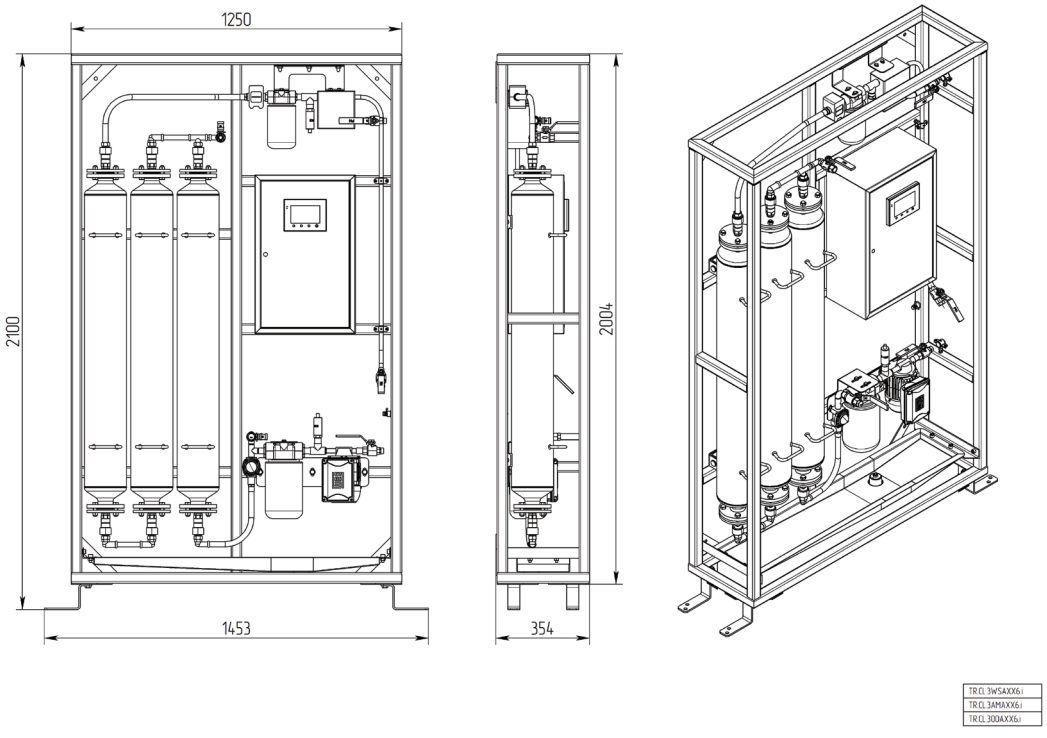
	CL1	CL3
Recommended transformer size	Below 10 MVA	10 MVA and above
Water extraction capacity before cylinder change	3 to 4 litres	10 to 12 litres
Flow rate	From 350 to 400 litres per hour	
Particle filter	10 microns on inlet & 3 microns on outlet. Other sizes possible on request	
Material	Powder coated and stainless steel	
Oil temperature range	0°C to 105°C	
Acceptable environment condition	-40°C to +60°C	
Protection class	IP65	
Power Supply	240V 50Hz or 110V 60Hz	
Pump	Nominal 10 l/min, 3.5 bar, 1.8A	
Monitoring	Available in option (see page 10-11)	
Size	2100 x 1000 x 354	2100 x 1250 x 354
Installation weight (including cylinders)	150 kg	250 kg
Installation time	5 to 6 hours with 2 people	
Manufacturing type test	3 bar pressure at 110°C for 1 hour	
Manufacturing routine test	2 bar pressure at 60°C for 30 minutes	
Enclosure	Optional. In aluminium or stainless steel (see page 12)	
Fixation	On the wall or the ground	

Dimension of the TRANSEC units

CL1



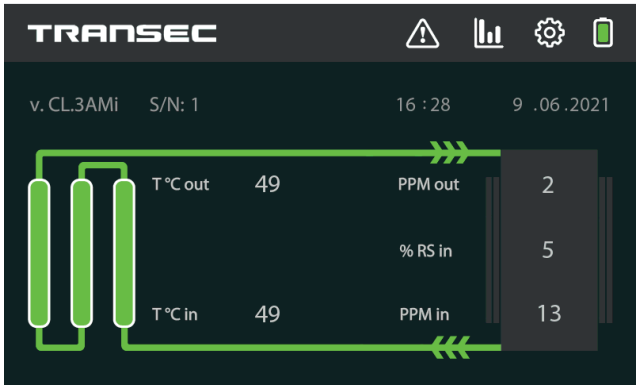
CL3



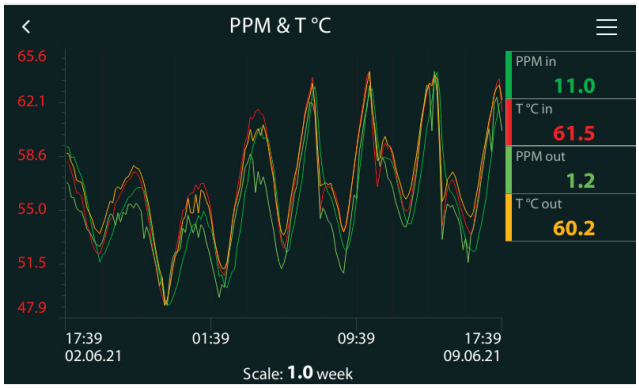
Continuous moisture assessment with the TRANSEC monitoring

MONITORING CABINET AMi

The AMi TRANSEC monitoring cabinet continuously monitors the temperature and moisture dissolved in the oil entering and exiting the TRANSEC. This allows monitoring the good water extraction for the TRANSEC but also the moisture level of the transformer. Alarms can be set, and reports of all data collected can be downloaded.



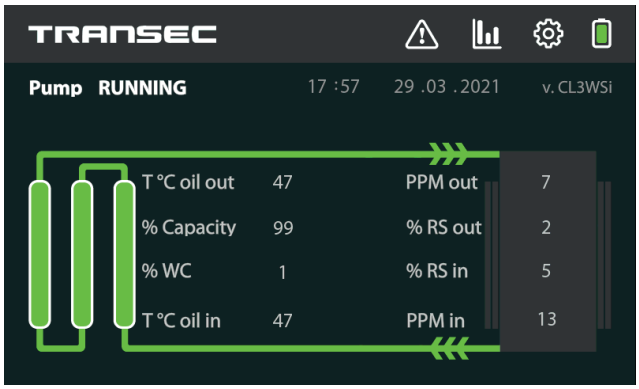
Picture of HMI



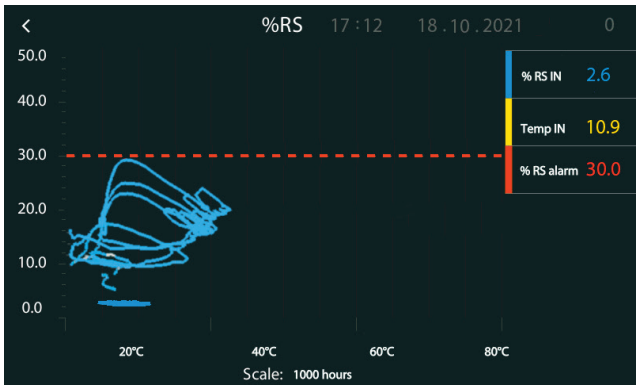
PPM and temperature trends on the AMi HMI

MONITORING CABINET WSi

The WSi TRANSEC monitoring cabinet provides continuous monitoring of the temperature and the moisture dissolved in the oil entering and exiting the TRANSEC and allows to take action on it. The pump can be stopped under certain conditions. Also, other analyses are provided which will help to better understand the current moisture situation of the transformer and to take action!



Picture of HMI



Relative Saturation versus temperature hysteresis graph

	AMi	WSi
Local display	Oil temperature IN&OUT, PPM Moisture IN&OUT, Relative Saturation in, Pump and sensor status or alarm, Settings, Reports, Trends	Oil temperature IN&OUT, PPM Moisture IN&OUT, Relative Saturation IN&OUT, Water content in paper, Pump and sensor status or alarm, Settings, Reports, trends, Cylinder saturation level, Total water volume extracted
Data logging	Temperature IN&OUT, PPM IN&OUT, Relative saturation IN, Alarms	Temperature IN&OUT, PPM IN&OUT, Relative saturation IN&OUT, Water content in paper, Cylinder Saturation, Alarms
Alarms	SensorInDown SensorOutDown Overheat %RS Alarm AlarmReset %CapacityAlarm T°C IN T°C OUT PPM IN PPM OUT	Pump status SensorInDown SensorOutDown OverheatCab LowFlow - Oil flow rate, l/h Leakage OverheatOil Paper overdry Alarm reset FreezeOil - Oil temperature below the setpoint %CapacityAlarm %RS Alarm T°C IN T°C OUT PPM IN PPM OUT Water Content - %WC alarm setpoint
Cylinders saturation	Saturation estimated based on the PPM IN&OUT difference	Calculated based on PPM and oil flow
Sensors	2x high accuracy moisture and temperature sensors	
Remote control	Alarm settings	Alarm settings, Pump stop & restart conditions
Communication	Via 3G/4G network or Ethernet: TCP/IP (VNC, HTTP, FTP/SFTP, MODBUS) USB stick	

Options available with TRANSEC

1. EXTERNAL ENCLOSURE

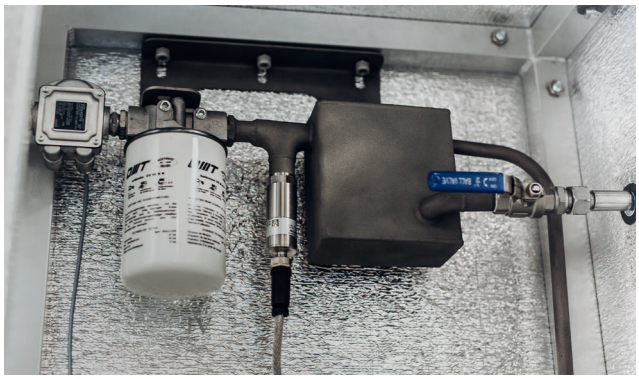
The optional enclosure for the TRANSEC unit will protect the HMI and the hardware from rain, dust, heat from direct sunlight and UV. The enclosure is either made of aluminium or stainless steel.

2. LEAK DETECTION TRAY

The accessory (only available on the WSi version) will detect any oil leak within the TRANSEC system and will provide the alarm accordingly. It is, of course, strongly advised to combine this option with an external enclosure (to protect from rain) and a solenoid inflow valve in order to block the oil circulation in case of leakage.

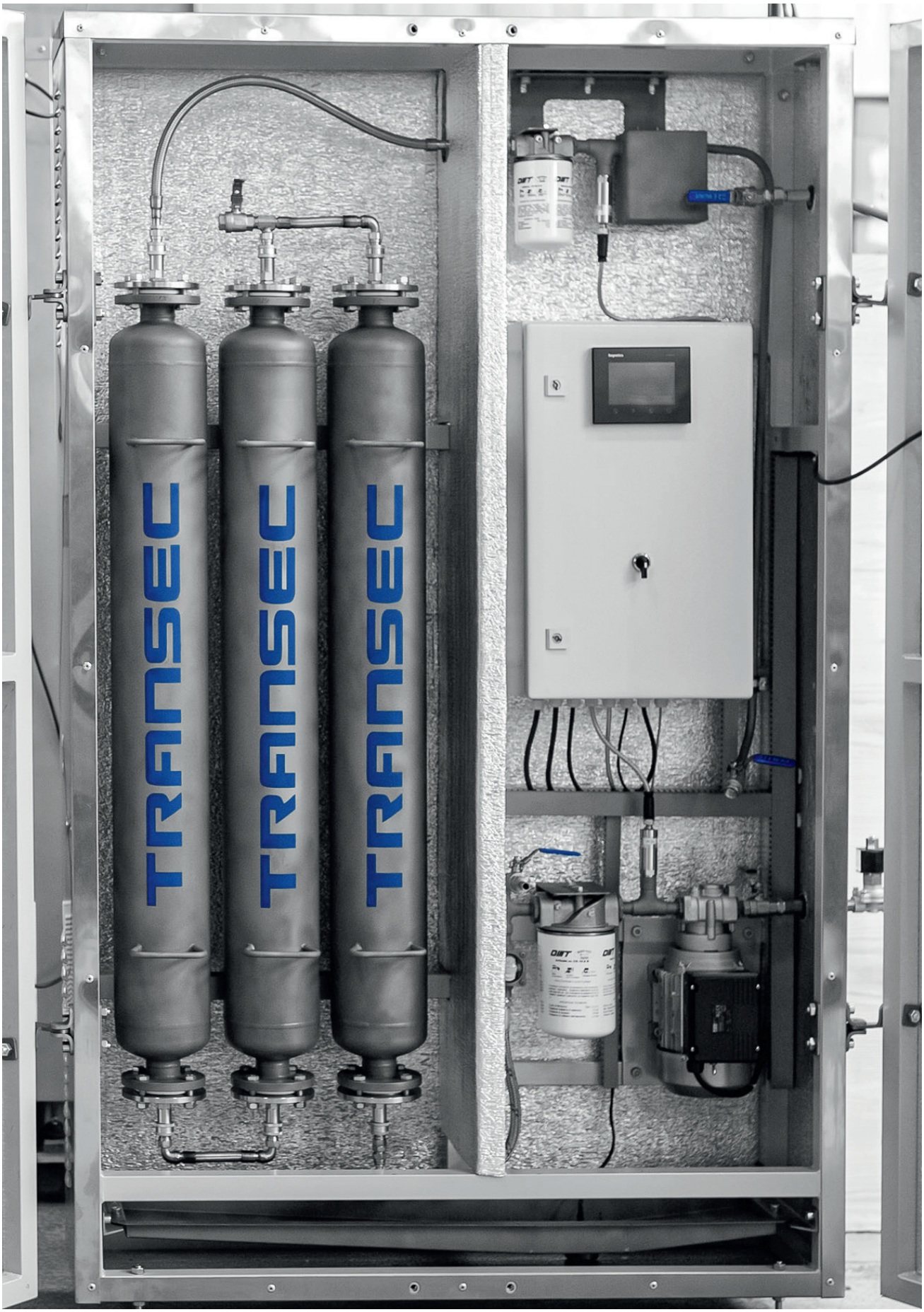
3. INFLOW CONTROLLABLE SOLENOID VALVE

This valve can be set remotely to operate and block the oil flow in case of leakage or rising temperature.



4. DEAERATOR GLASS GAUGE AND SWITCH

To be sure that no air is entering the transformer, a deaerator is placed at the end of the TRANSEC. For additional protection, it is possible to see the level of air in the deaerator with an optional glass gauge and to have a switch that will signal an alarm if the level of air reaches a dangerous level.


TRANSEC
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Product Selection guide

TRANSEC UNIT	TR.CL.	X	X	X	X	X	X	X	.	i
Number of Cylinders	1 cylinder (4 litres of water extraction)	1								
	3 cylinders (12 litres of water extraction)	3								
Monitoring	No Monitoring		0	0						
	Monitoring with local display; PPM, Temp & %RS; Alarms		A	M						
	Monitoring with local display; PPM, Temp & %RS; Alarms; Analytics; Cylinder Saturation; Automation		W	S						
Mounting	Standard frame with lifting eyes for stand alone or wall/transformer mounting				A					
Pump/Power Supply	50Hz 240VAC					5				
	60Hz 120VAC					6				
Oil inside cylinders	Un-inhibited napthynic oil IEC 60296						U			
	Inhibited napthynic oil IEC 60296						I			
	Other (please specify)						O			
Filters	2x standard filters: inlet 10 microns & outlet 3 microns							6		
Version										i

MONITORING UNIT

TR.MT.00AM.00.iW	Monitoring with local display; PPM, Temp & %RS; Alarms
TR.MT.00WS.00.iW	Monitoring with local display; PPM, Temp & %RS; Alarms; Analytics; Cylinder Saturation; Automation
TR.SR.MONI.UP.WW	Service for Monitoring box installation

COMMUNICATION OPTION

TR.MT.RTFO.00.WW	Fiber optic Router
TR.MT.RTGS.00.WW	GSM Router (2G,3G and 4G(LTE))

ACCESSORIES

TR.AC.NCYL.01.iW	1 new cylinder
TR.AC.NCYL.03.iW	3 new cylinders
TR.AC.IKIT.00.WW	Installation kit: 2x Male Stud Couplings, 1x Reducing tee, 1x Brass stud coupling, 3m copper tube, 1x Non return valve, 2x2m tube SS 15mm cold annealed
TR.AC.FLAN.15.WW	Flanges for installation DN15
TR.AC.FLAN.25.WW	Flanges for installation DN25
TR.AC.FLAN.50.WW	Flanges for installation DN50
TR.AC.FLAN.00.WW	Flanges for installation (size to be specified)
TR.AC.LEAK.00.WW	Leak tray & sensor*
TR.AC.GGAU.00.WW	Glass Gauge on dearator
TR.AC.RLVL.00.WW	Dearator level alarm switch*
TR.AC.SLSV.02.WW	1x inflow controllable solenoid valves *
TR.AC.HTCA.00.WW	Heater for monitoring cabinet
TR.AC.EFAN.02.WW	Fan for enclosure
TR.AC.ENCL.P1.iW	Enclosure with insulation for CL1
TR.AC.ENCL.P3.iW	Enclosure with insulation for CL3
TR.AC.ENCL.S1.iW	Stainless Steel Enclosure with insulation for CL1
TR.AC.ENCL.S3.iW	Stainless Steel Enclosure with insulation for CL3

SERVICES

TR.SR.REGE.03.WW	Regeneration of 3 cylinders
TR.SR.SINS.00.WW	Installation Supervision
TR.SR.INSP.00.WW	Transformer inspection
TR.SR.MONI.UP.WW	Service for Monitoring box installation
TR.SR.MODI.00.WW	Product modification service

*only available for WSi version

Financial benefit example of using TRANSEC

It is easy to understand that delaying a significant investment represents financial savings for a company. The amount of money not invested can generate interests interest. Purchasing a power transformer is one of these significant investments, and the more it can be delayed, the better it is.

By extending the life expectancy of the transformer, TRANSEC contribute to generating financial benefits to its user. Installing a TRANSEC unit on an old and wet transformer can still extend the unit's life expectancy by several years. Installed on a new transformer, TRANSEC can push the transformer to its total life expectancy.

The table below shows concrete examples of what these savings can represent. Where n is the number of years of transformer life extension. We considered an Interest Rate (IR) of 5% and a price of new transformer (C) constant of the years.

Cost of a new transformer - 40 MVA	400'000 US$
Saving calculation formula	C * [(1 + IR)n – 1]
TRANSEC life extension on old transformer	5 years
Savings	110'512 US$
TRANSEC life extension on new transformer	15 years
Savings	431'571 US$

We can see that the amount saved can be even more than the actual cost of a new transformer and, of course, cover several times the price of a TRANSEC unit and its installation. The benefit mentioned above is just one among a batch of gains provided by applying TRANSEC on power transformers. Furthermore, as TRANSEC always maintains a high oil breakdown voltage, it makes the transformer much safer to use and drastically reduces the risk of failure and explosion. Therefore, it would be possible also to lower the user's insurance premium, which will represent significant savings.

Among all solutions, the TRANSEC Online drying system offers the best extraction price per litre of water. The Low-Frequency Heating (LFH) method can quickly extract a large amount of water, but the operation requires a transformer shut down and is relatively expensive. On the other hand, the oil circulation method is easy to implement and affordable. Still, it extracts only a minimal amount of water (basically only the water dissolved in oil, representing less than 2% of the total volume).

In the table below, we considered a transformer 40 MVA, 25'000 litres of oil with 20 PPM of moisture. It would require the extraction of 40 litres of water. LFH can do such extraction within one week of the shutdown. TRANSEC will need several years to extract the same amount, but it will be done online, and the transformer will be in operation. For the oil circulation, we considered that it could remove 100% of the water from the oil in a few days, which means half a litre.

Method	Approximate price per litre of water extracted
LFH	1750 US$
Common Oil Circulation	5000 US$
TRANSEC	1000 US$

What to do when the moisture extraction cylinders are saturated?

The first thing to do is to contact your local representative of Streamer Electric AG. Streamer make an effort to find companies close to you to support you efficiently. Local representatives have a stock of ready cylinders which they can provide to you.

TRANSEC units can typically extract between 3 to 4 litres of water per cylinder before saturation. The rate of extraction is directly linked to the amount of water available in the transformer. The higher the moisture content and the warmer the oil is, the faster the extraction will be. You can find the typical saturation time below.

The cylinder saturation can be determined either by the TRANSEC monitoring system or by comparing water PMM in 2 oil samples (inlet & outlet).

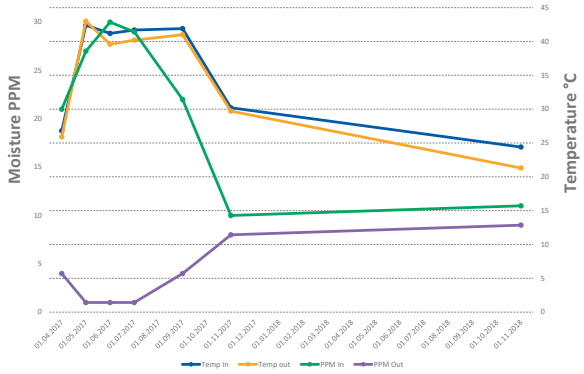
A set of saturated cylinders can be removed and replaced while the transformer is online by new cylinders within 30 minutes.

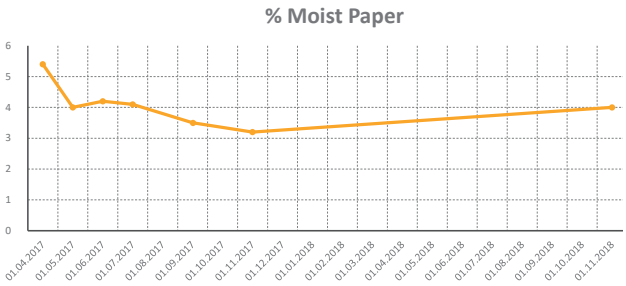
Characteristics	Typical time for extraction of 10 litres of water
New transformer water content <1%	5 years
Old/Wet transformer water content >3%	6-12 months
Moderately wet transformer water content = 2%	2 years

More than 15 years of successful experience

A TRANSEC unit was installed in November 2017 on 40 MVA General Electric 3 phases transformers in the Dammam region, Saudi Arabia. This 115kV/13.2kV transformer from the 1970s had reached a very high water content in the paper (above 5%) and needed urgent drying. Once installed, the TRANSEC started removing moisture from the oil immediately. It provided a positive effect on the breakdown voltage value. In a second step, water extracted from the paper as the oil dried out after a few weeks.

Over the 1st year, you can see on the 2 graphs that the PPM inflow and the water content are dropping. Within that year, the water content in the paper went from 5% to about 3% (a much more acceptable level). We can also see that the PPM values of inflow and outflow during the second year of operation were almost matching, which is a sign of water saturation in the Transec unit. This is confirmed by the water content increasing again to 4% at the end of the second year. New ones then replace the saturated TRANSEC extraction cylinders to restart the filtering process. They had extracted about 12 litres of water from that transformer within 1 year.





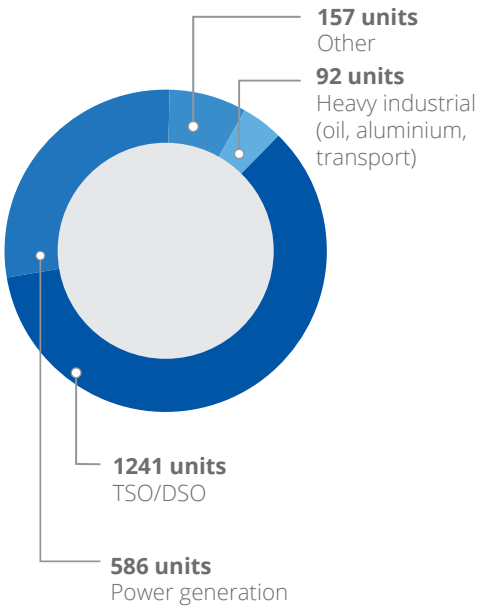
More than 2500 units installed by the end of 2019

Major Clients:

ALSTOM e·on ABB

BRUSH eDF पावरग्रिड POWERGRID

भेल BHEL UK Power Networks Delivering your electricity dubai Dubai Aluminium Gaz de France



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