



# EXPIOTECH SMART TRANSFORMER DRYING

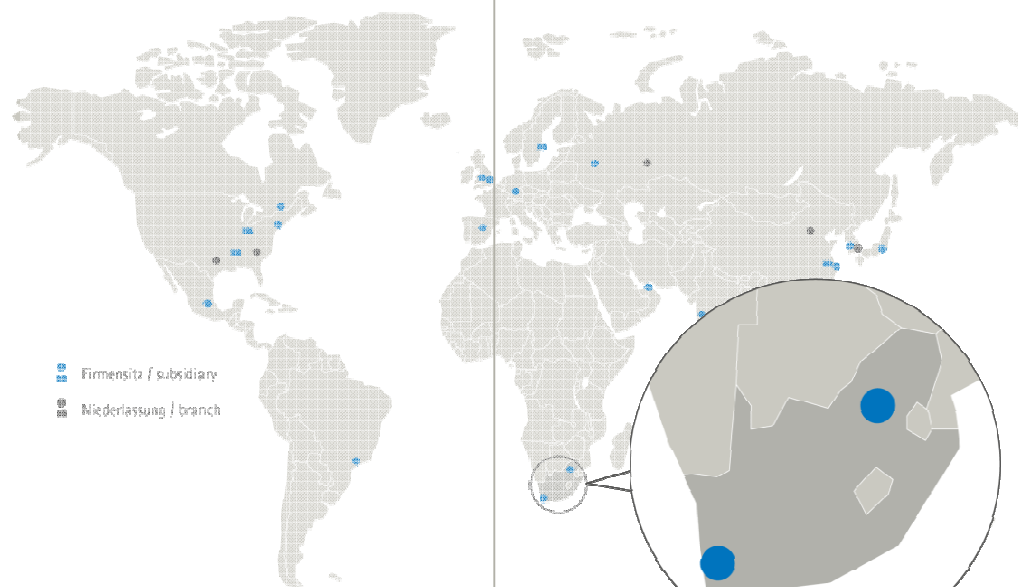
May 2018

MR

# MR GROUP AT A GLANCE

## Global leader in niches of power engineering

- | World market leader in transformer switching
- | 3,250 employees worldwide
- | 34 subsidiaries, 5 affiliated companies
- | € 700 million turnover
- | Founded in 1868



Reinhausen RZA South Africa  
Leading smart drying expertise  
through the acquisition of Expiotech



# THE PROBLEM OF WATER

## The problem of water



Water decreases transformer lifetime  
Water increases the risk of a flashover

## The challenges of drying



Paper moisture content is difficult to determine  
Oil is not very efficient in removing water from the paper



Risk of a loss of winding pressure

## The solution:



Expiotech's smart drying technology

## The equipment:



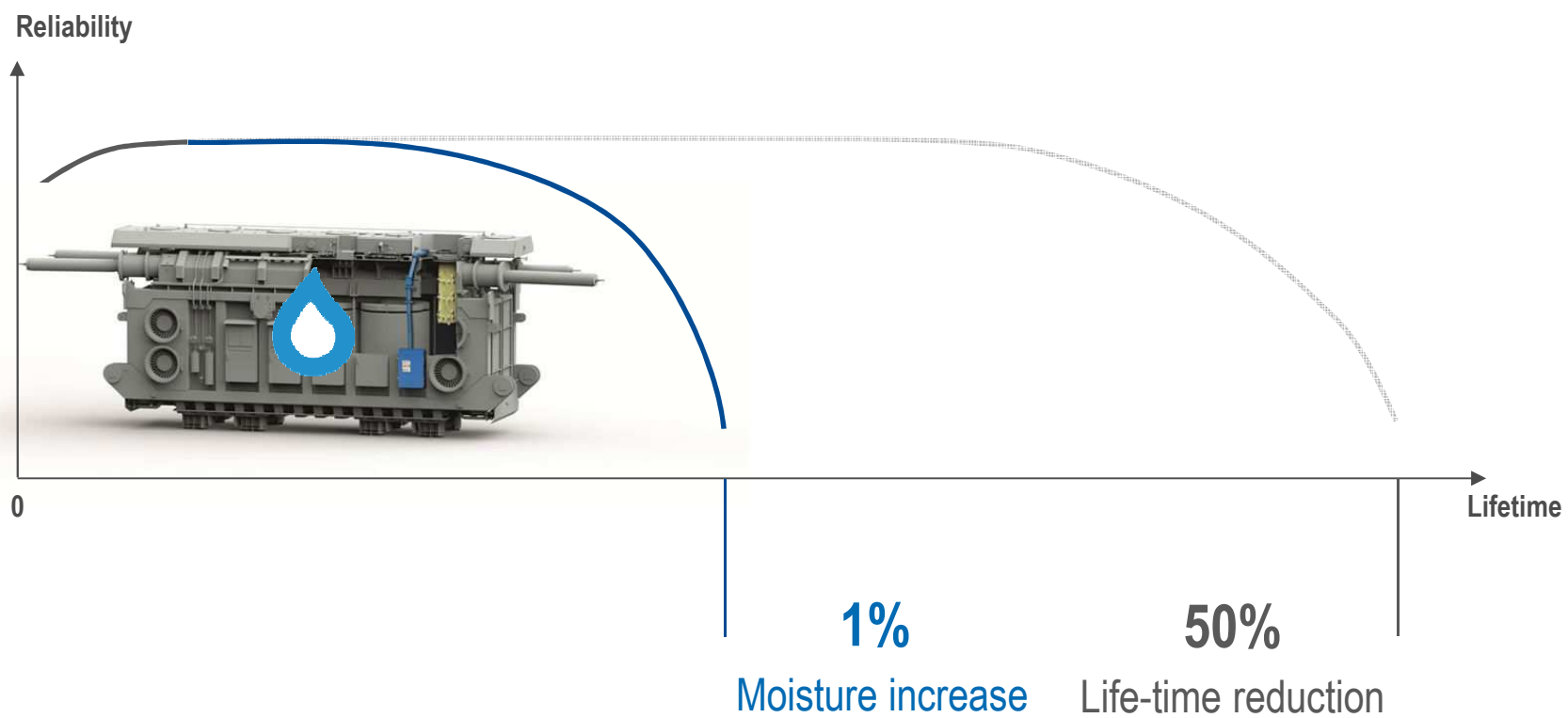
Applications  
Competitive advantages  
Features

# THE PROBLEM OF WATER



## Water decreases transformer lifetime

Transformer life-cycle curve



# THE PROBLEM OF WATER



## How water deteriorates the transformer: 3 key mechanisms

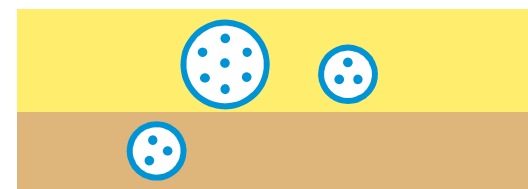
Reduces the mechanical strength of paper

Water breaks down the cellulose chains and makes the paper brittle.



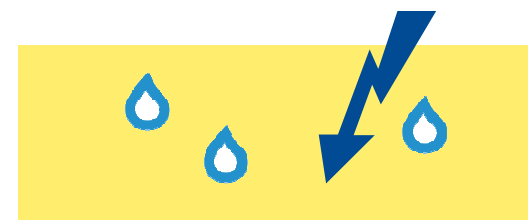
Reduces the dielectric strength

Moisture in paper evaporates and can form bubbles.



Reduces the dielectric strength of oil

Can be determined by measuring the break-down voltage (BDV) in the lab.



risk of short circuit

# THE PROBLEM OF WATER



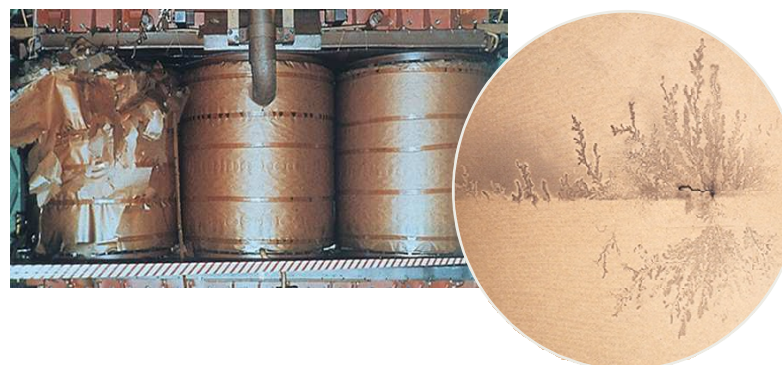
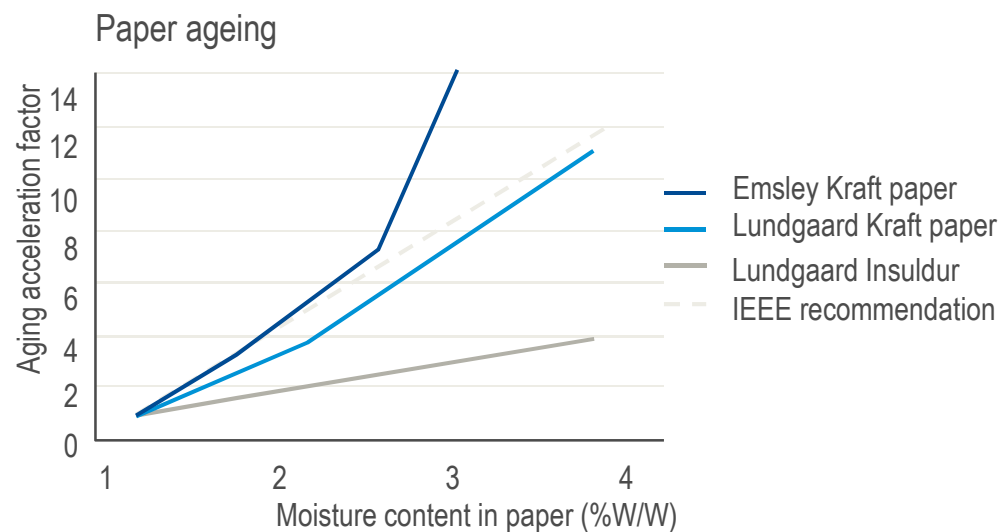
## Effects of moisture

### A. Reduced transformer life-time

- Due to accelerated
- | Paper degradation
- | Oil oxidation

### B. Increased risk of failure

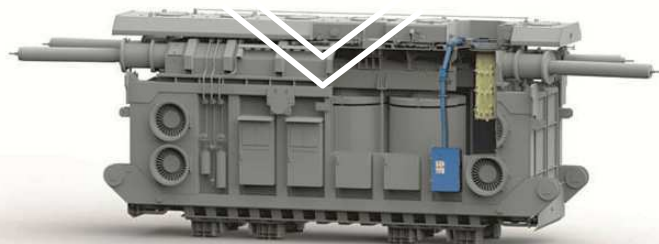
- Due to reduced
- | Dielectric strength of the transformer oil
- | Bubbling temperature



# THE PROBLEM OF WATER



## Where does the water come from?



### From the outside

- | Via seals imperfections
- | Via the conservator
- | Due to poor handling and repair

Can be reduced by transformer design & proper handling.



### From within

- | From the oxidation of paper and oil during operation
- | More water is created with increasing operating temperature

*Any transformer accumulates water.*

Largely out of control



# THE CHALLENGES OF DRYING

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Applications  
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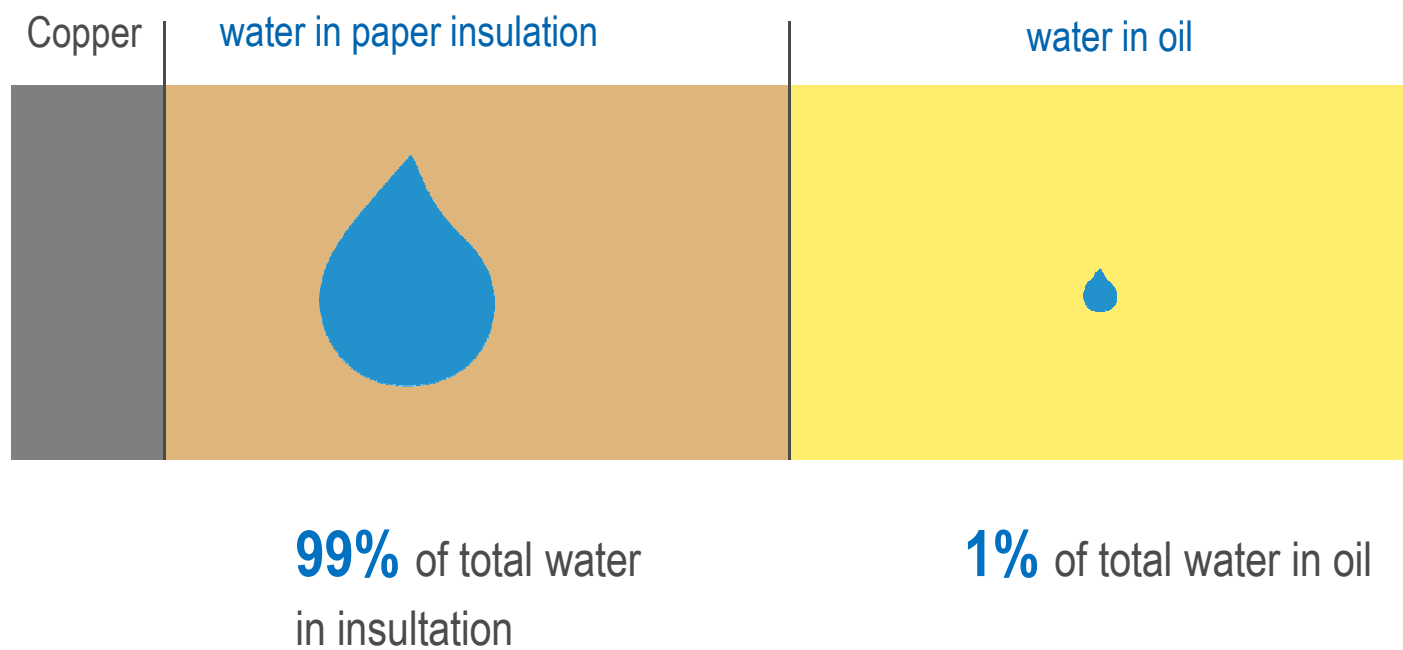


# THE CHALLENGES OF DRYING



## Dynamic equilibrium

- | Water content in insulation (oil and paper) distributes unevenly between paper and oil.
- | There is always a much higher portion of water in paper than in oil

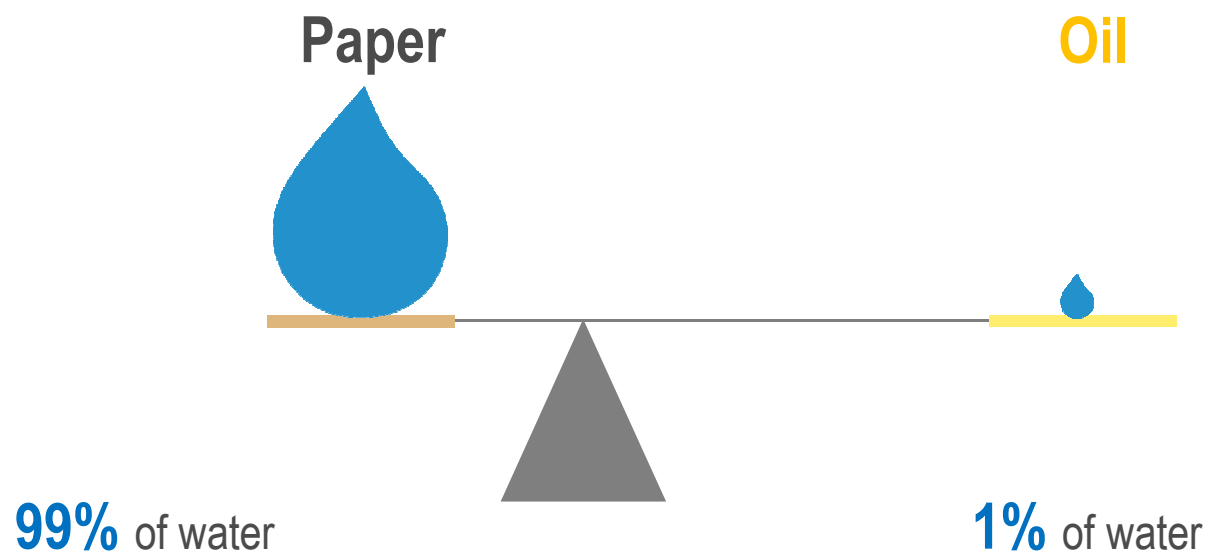


## THE CHALLENGES OF DRYING



### Dynamic equilibrium: Effects of drying

- | The distribution ratio remains constant as long as the temperature remains constant.
- | If water is removed from oil it will be replaced by water moving out of the paper.



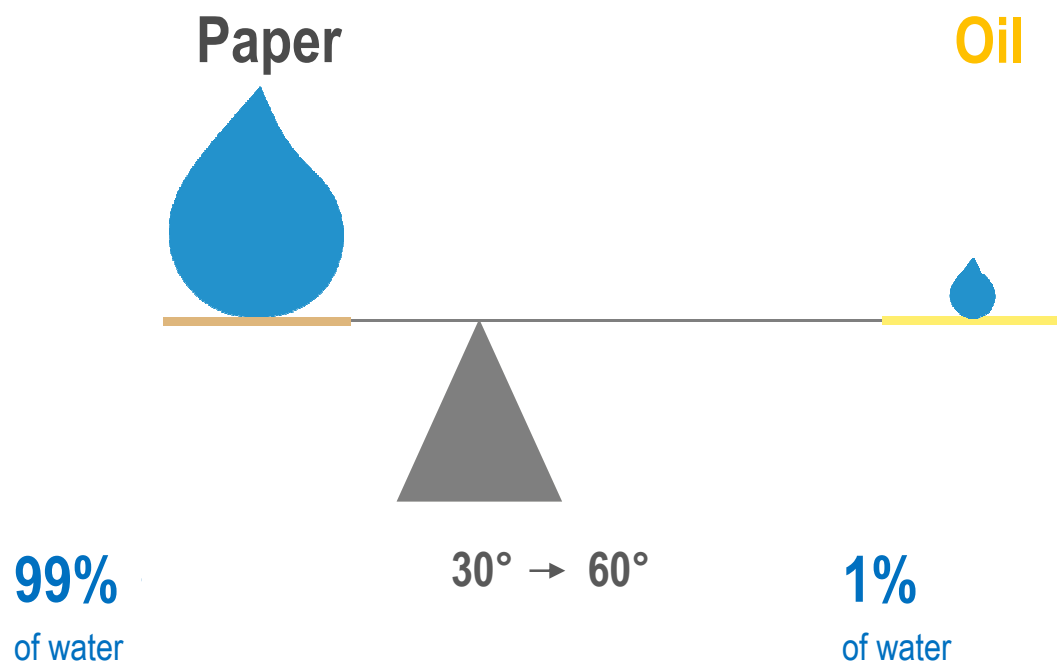
Single cycle  
drying of oil is  
ineffective

## THE CHALLENGES OF DRYING



### Dynamic equilibrium: Effects of temperature

- | The equilibrium shifts with temperature.
- | With increasing temperature, more water migrates from paper to oil.

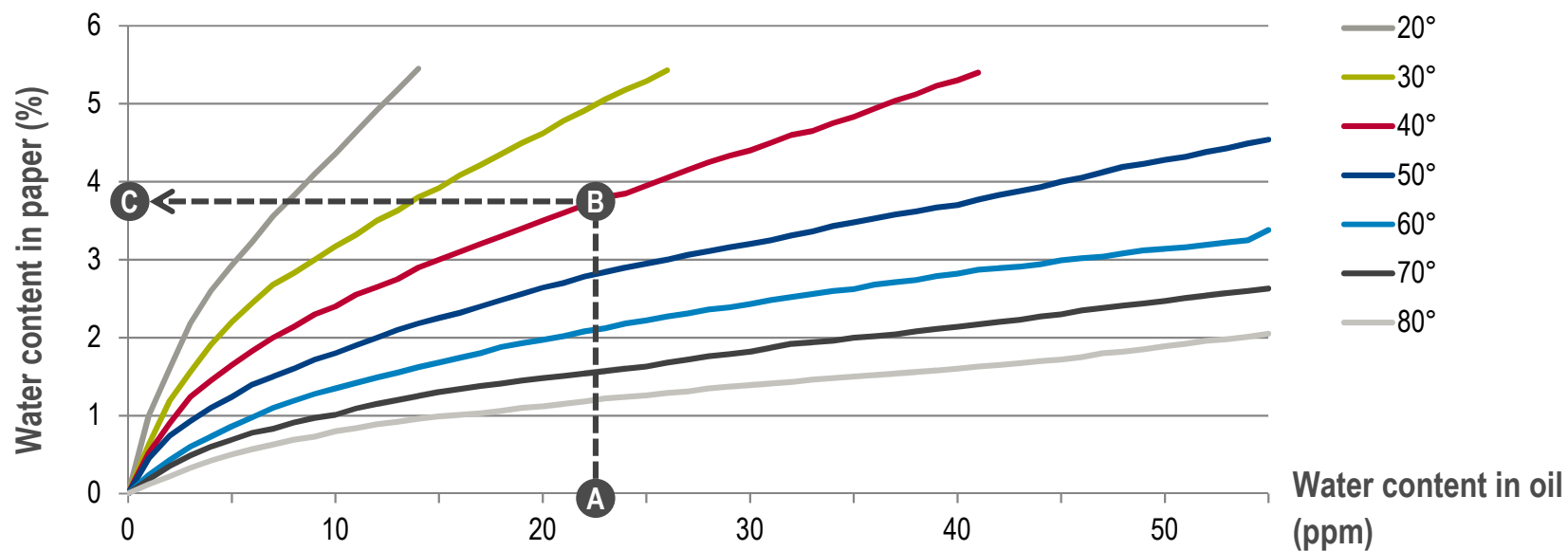


# THE CHALLENGES OF DRYING



## Theory: How to determine the water content of paper

Correlation diagram between oil and paper moisture at different temperatures



Water content of the paper insulation can be calculated:

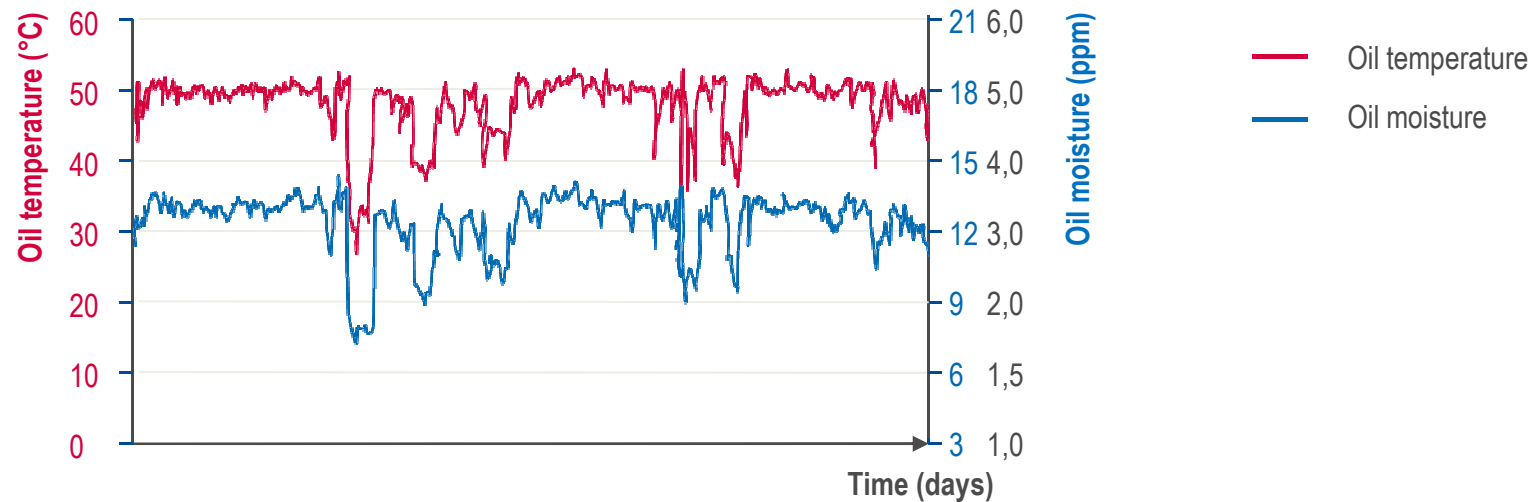
- A) Determine water content in oil
- B) Measure oil temperature
- C) Determine water content of paper by correlation chart

**provided that the temperature is stable over longer period of time**

# THE CHALLENGES OF DRYING



Practice: The equilibrium is never fully established

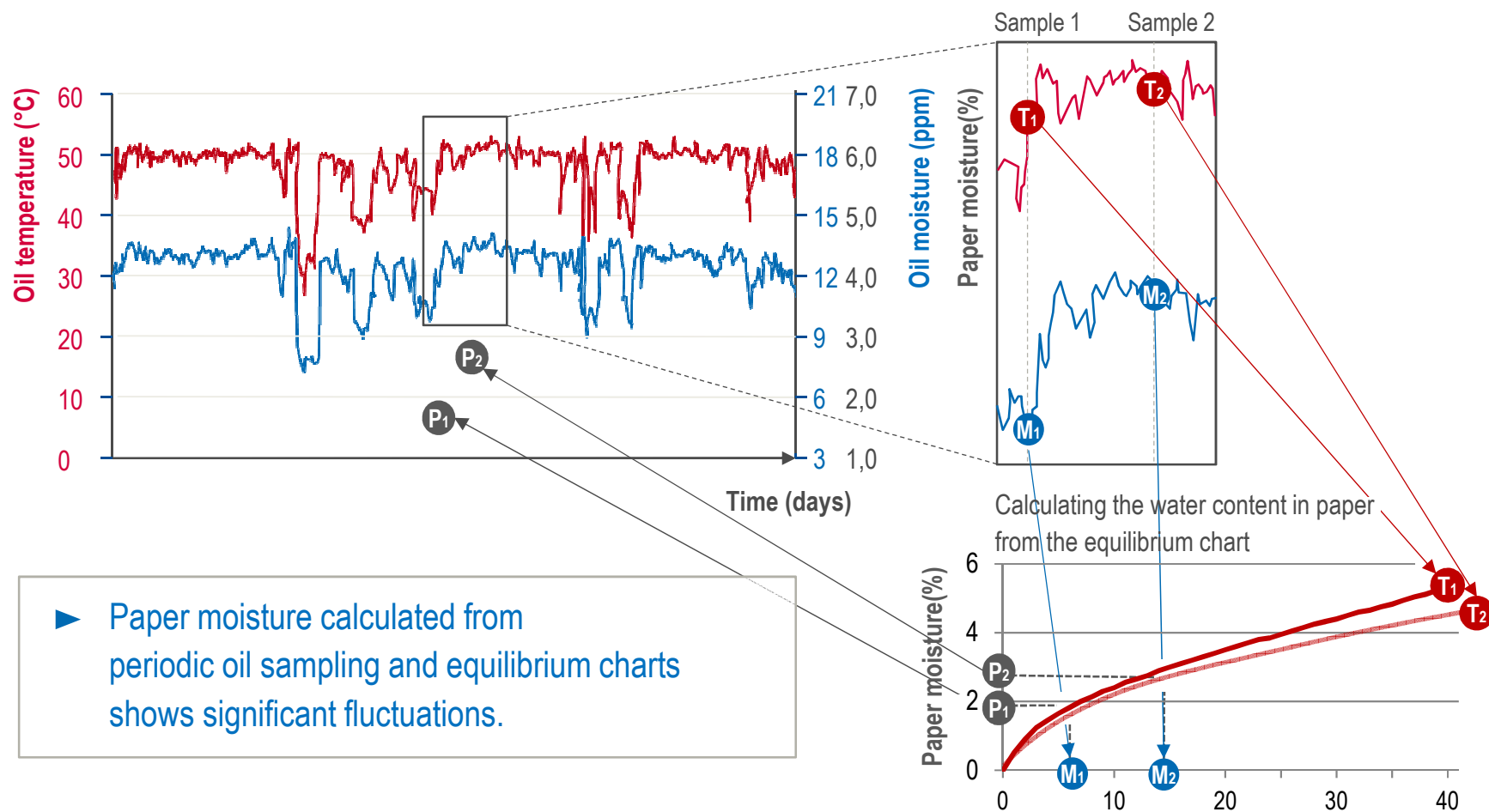


- | Oil temperature is constantly changing.
- | Water moves from paper to oil with temperature increases and vice-versa.
- | Paper releases water faster than it absorbs it back.

# THE CHALLENGES OF DRYING



Single measurements of oil temperature and moisture are insufficient to determine the water content of paper

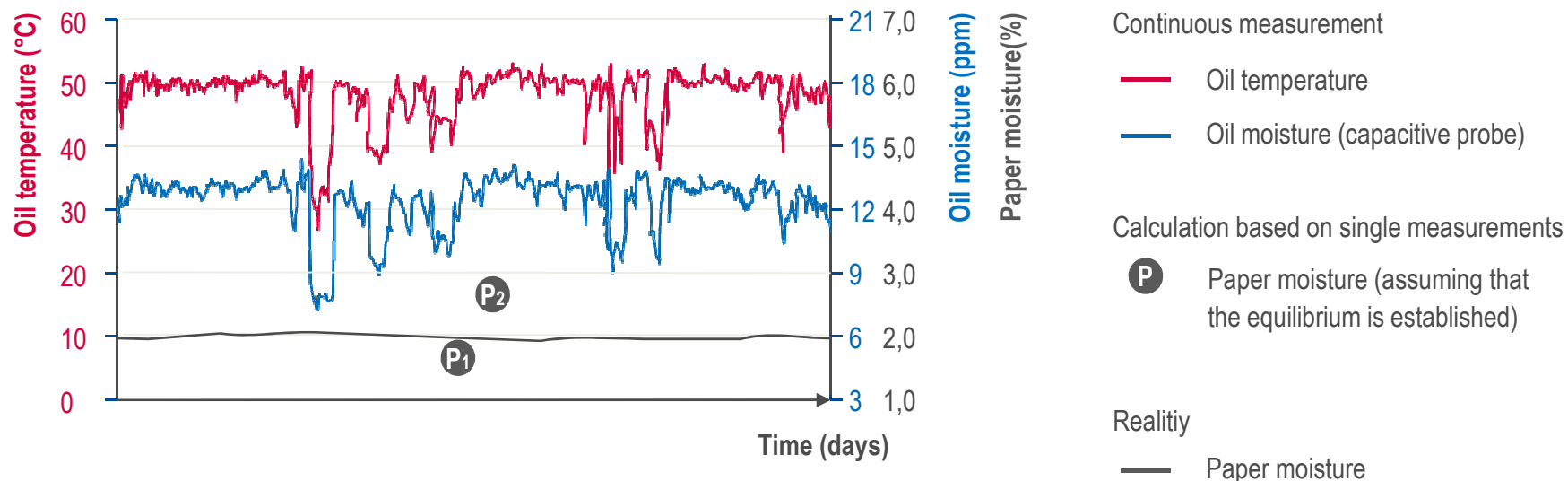


► Paper moisture calculated from periodic oil sampling and equilibrium charts shows significant fluctuations.

# THE CHALLENGES OF DRYING

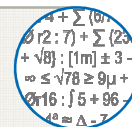


Single measurements of oil temperature and moisture are insufficient to determine the water content of paper



Actual paper moisture is practically constant due to the high relative water content of paper to oil (~100:1).

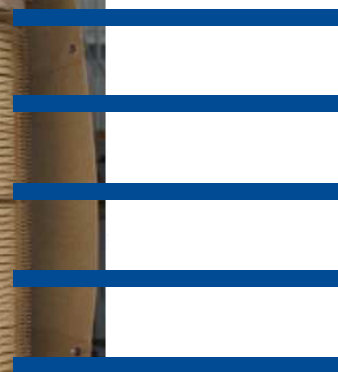
► Can be calculated accurately using Expiotech's algorithm.



# THE CHALLENGES OF DRYING



Drying reduces winding pressure



Winding pressure

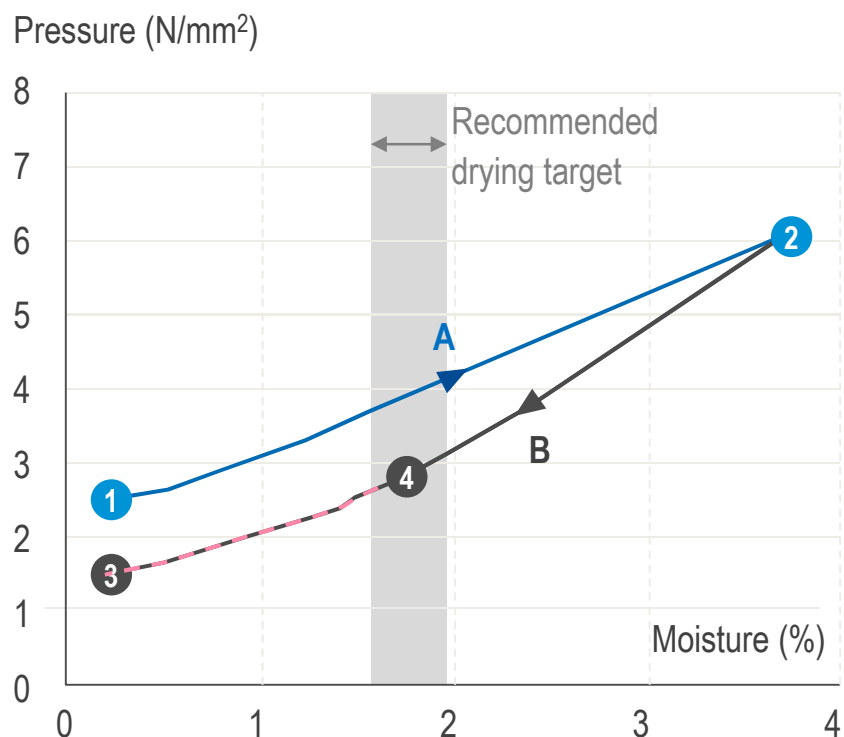


# THE CHALLENGES OF DRYING



## Drying reduces winding pressure

Effects of drying on winding pressure



- 1 Initial moisture and winding pressure (new transformer)
- A Moisture accumulates over time, winding pressure increases accordingly
- 2 Critical moisture is reached, drying initiated
- B Transformer is dried, winding pressure declines disproportionately
- 3 If drying is continued to the initial moisture level, winding pressure becomes critically low, impairing the transformer's mechanical stability
- 4 Smart drying targets a moisture range, that perfectly balances the benefits of moisture reduction and the risks of loss of winding pressure



# SMART TRANSFORMER DRYING

## The problem of water



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Risk of a loss of winding pressure

## The solution:



Expotech's smart drying technology

## The equipment:

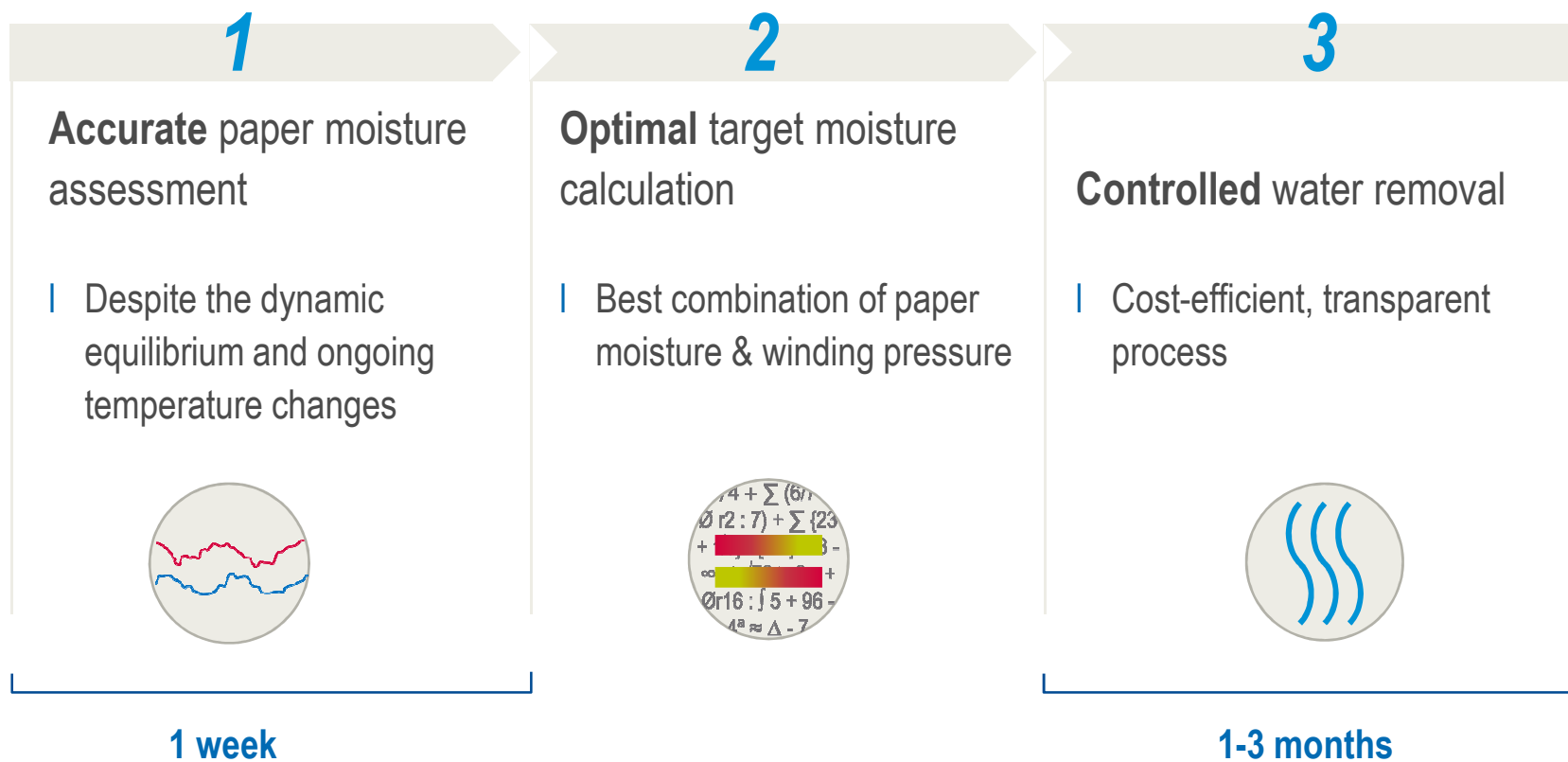


Applications  
Competitive advantages  
Features

# SMART TRANSFORMER DRYING



## Smart drying: overcoming all the challenges



# SMART TRANSFORMER DRYING

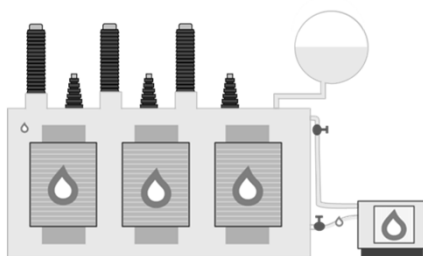


## Step 1 & 2: Moisture assessment & target moisture calculation

### Moisture determination

Measurement:

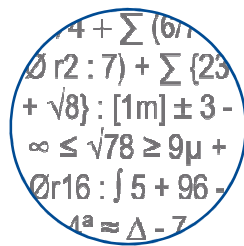
- | one-week monitoring
- | 4 oil temperature sensors,
- 2 oil moisture sensors



+ Key transformer data:

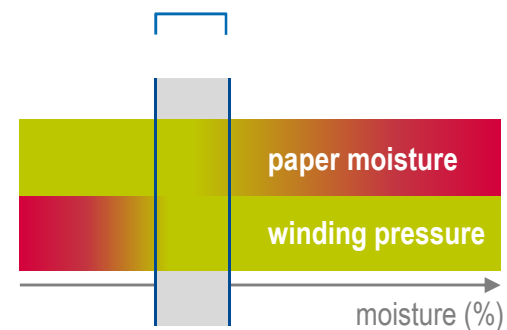
- | MVA rating, oil volume, oil density

### Algorithm



### Target moisture

**Sustainable paper moisture and winding pressure**

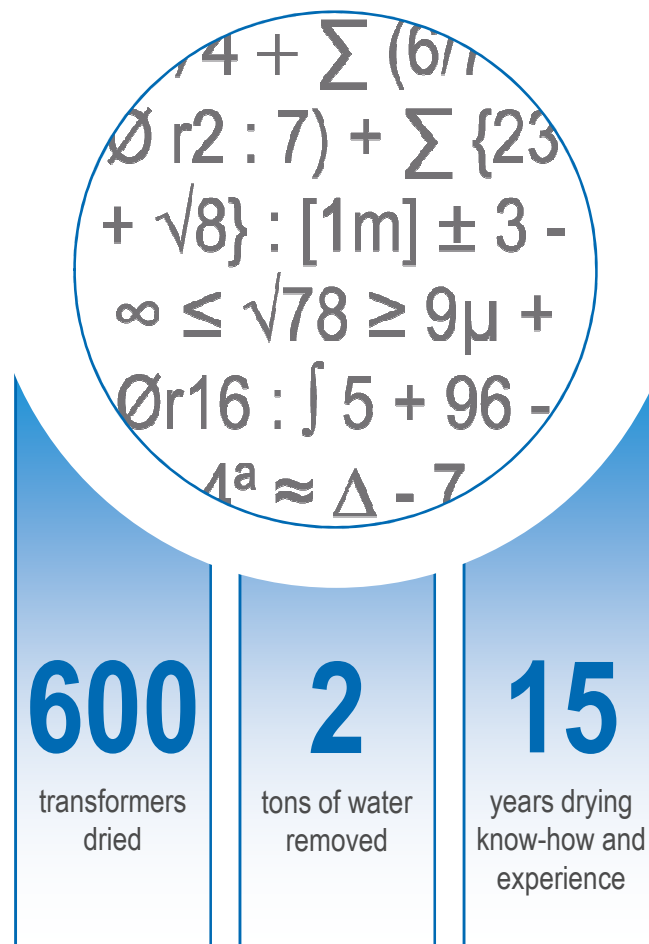




# SMART TRANSFORMER DRYING



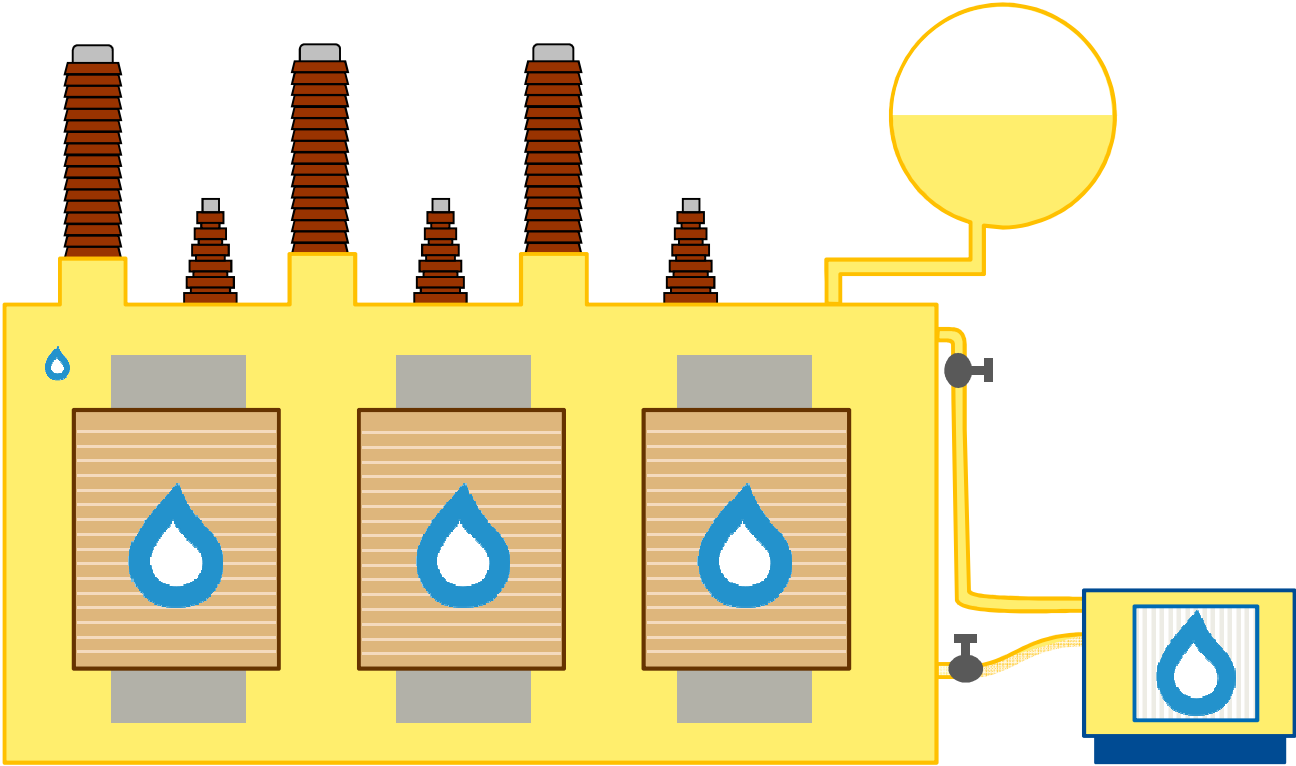
Expiotech's algorithm is extensively validated by practical experience



# SMART TRANSFORMER DRYING



## Step 3: Drying using filter technology





## THE EQUIPMENT

### The problem of water



Water decreases transformer lifetime  
Water increases the risk of a flashover

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Risk of a loss of winding pressure

### The solution:



Expitech 's smart drying technology

### The equipment:



Applications  
Competitive advantages  
Features

# THE EQUIPMENT: HARDWARE



## Expiotech's Smart Moisture Management System





# THE EQUIPMENT: HARDWARE



High-quality components, easy to handle

Remote GSM connection –  
process and alarms

Filter changes do not  
require special tools

PLC to control  
processes  
and protection  
devices

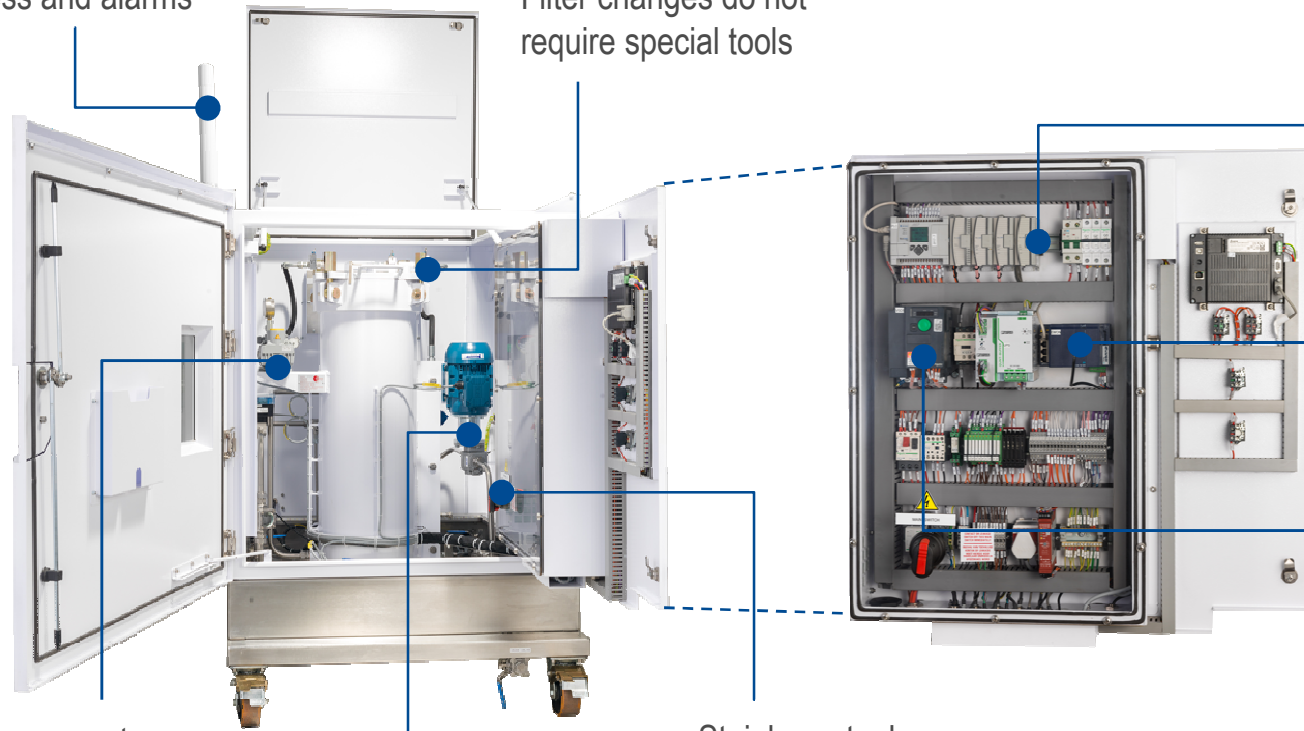
GSM  
communication  
module

VSD for speed  
control  
of oil pump

Vacuum pump to  
evacuate air when  
commissioning

Positive displacement  
gearpump with  
variable speed

Stainless steel  
tubing



# THE EQUIPMENT: SAFETY



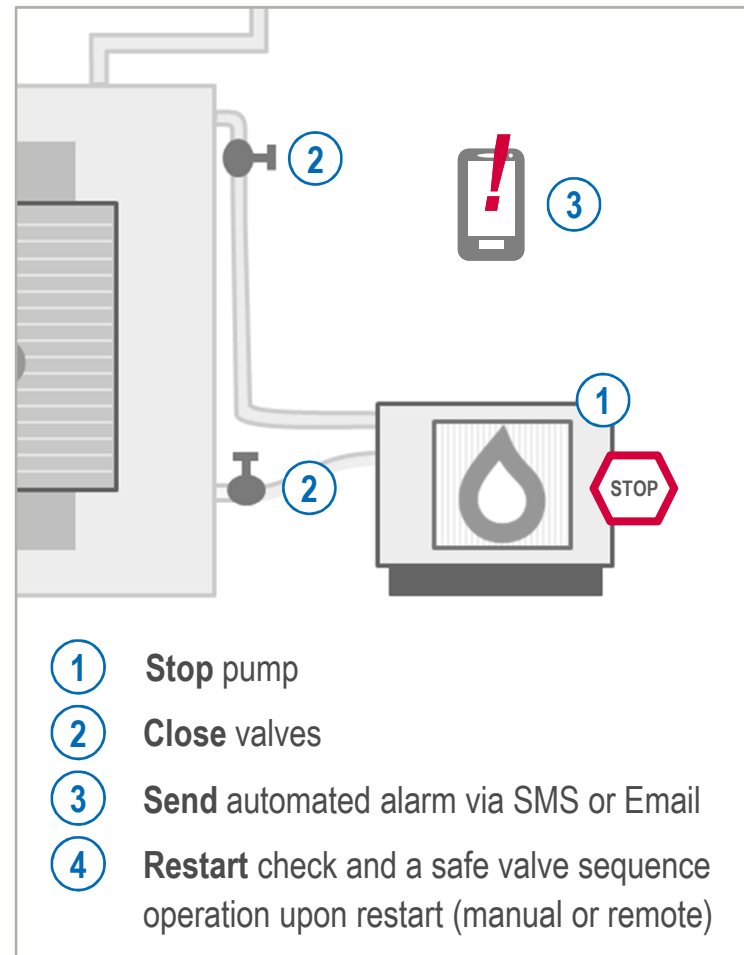
## Fail safe mode for ultimate safety

### In the event of any malfunction:

- | Detection of a leak
- | Component failure

### Or in the case of excessive conditions:

- | Filter clogged (pressure)
- | High or low temperature
- | Low flow



# THE EQUIPMENT: SAFETY



## Additional safety features

### Reliable pipe systems

- | High quality components and stainless steel piping inside the cabinet. A strainer at the inlet prevents solid particles from entering the system and possibly damaging the pump
- | Mobile unit equipped with double pipe system with solenoid valves on inlet and outlet lines.
- | Any pipe leak or burst will result in oil flowing back to the machine and fill up the bottom tray until a float will trip and isolate the machine from the transformer and send alarm.



### Additional safety features

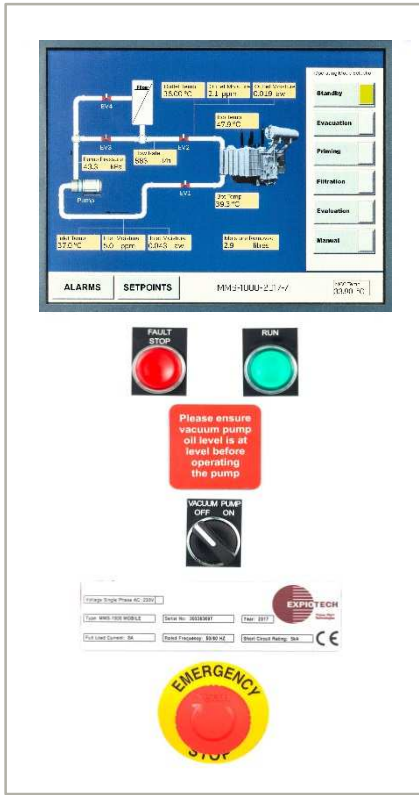
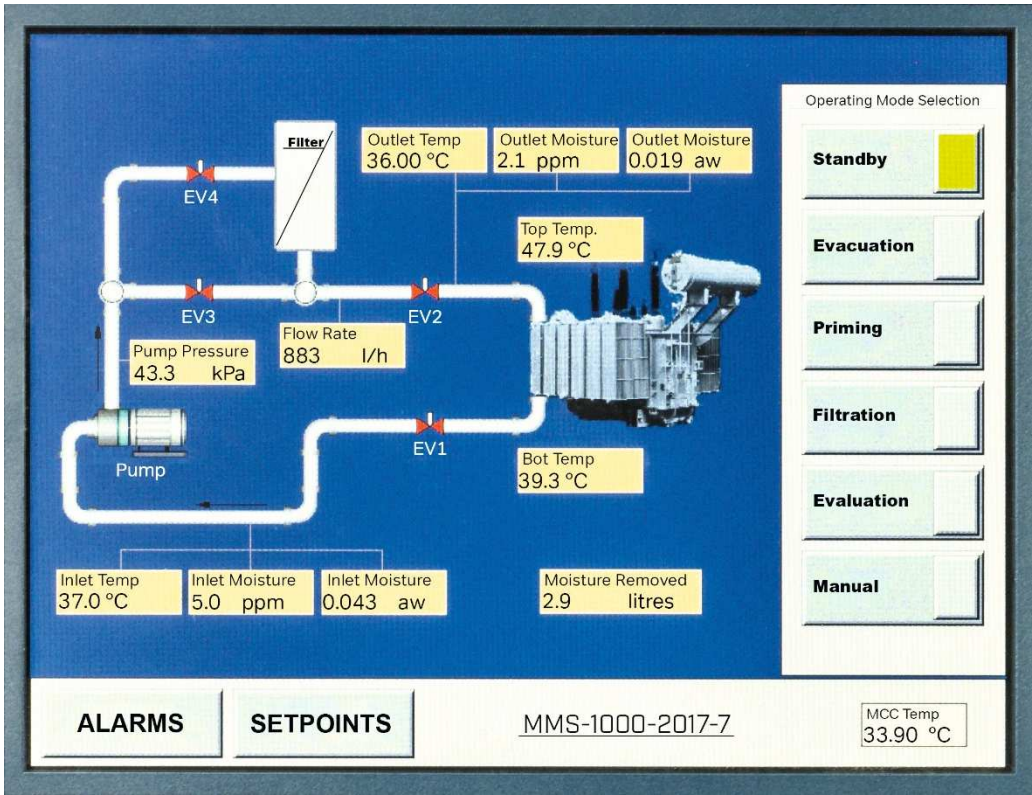
- | Three pressure protection (low and high) devices
- | Temperature control of the cubicle.
- | Surge protection on control panel.



# THE EQUIPMENT: USER INTERFACE AND COMMUNICATION



User-friendly touch-screen  
for local control and display of parameters



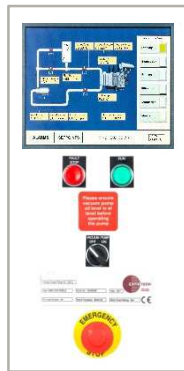


# THE EQUIPMENT: USER INTERFACE AND COMMUNICATION

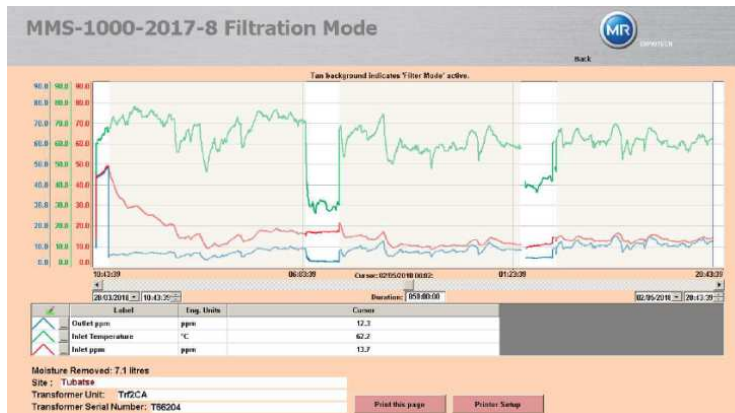
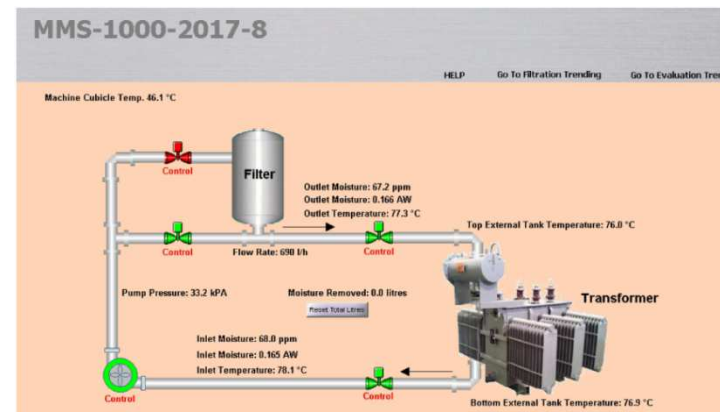


## Remote monitoring and control

Onsite



Anywhere, client or MR



**MMS-1000-2017-8 Evaluation**

**ASSESSMENT OF MOISTURE IN TRANSFORMER INSULATION - INPUT SHEET : ###**

Client: Samancor  
Site Location: Tubatze  
Unit: TrDCA Serial Number: T86204  
Test Number (generated by system): 22  
Works Order Number: TBA

**1. TECHNICAL DATA:**

Equipment Make: Tarrini  
Rating (MVA): 12.0  
Voltage Ratio (kV): 33  
Year of Manufacture: TBA  
Oil Content (litres): 12000 Oil SG: 0.870  
Oil Weight (kg): 10600 Calculate from Oil litres  
Estimated Mass of Insulation (kg): 954 Calculate from Oil kg 0%

**2. TEST INFORMATION:**

Machine Serial Number: MMS-1000-2017-8  
Sampling Period: 2018-03-28 06:00 to 2018-03-28 08:00

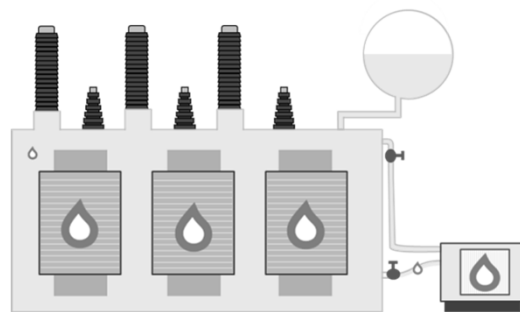


## THE EQUIPMENT: USER INTERFACE AND COMMUNICATION



Full control: any time – anywhere

Automated alarm via email or SMS



Service Team  
and / or  
Customer



### Process parameters:

- | Current moisture content of the transformer insulation
- | Temperature
- | Flow rate
- | Progress of the dry-out process
- | Filter saturation

Real-time monitoring & control from anywhere

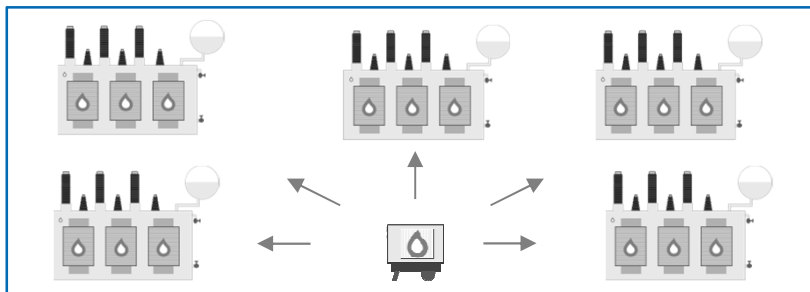
# THE EQUIPMENT: APPLICATIONS



## Two applications available

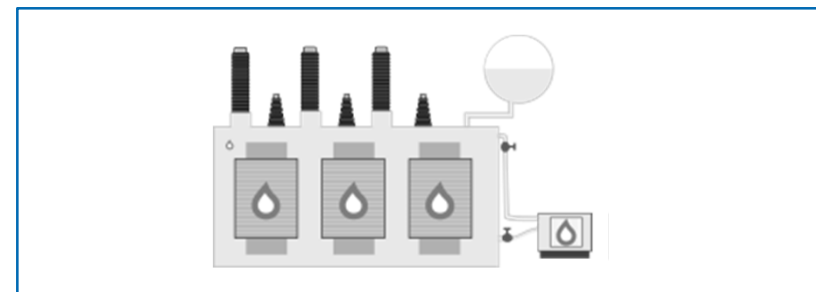
### MMS 1000 (Mobile)

- | Comes with 2 hoses for connecting inlet and outlet and a toolbox
- | Recommended flow rate 1000 lph
- | Vacuum pump integrated for priming the system during the connection to the transformer
- | Periodic drying of transformers, temporary installation (typically 2-3 months)
- | Investment can be optimized over a fleet of transformers



### MMS POL (Permanent On-Line)

- | Connection is made via stainless steel piping
- | Recommended flow rate 300 lph
- | Permanent connection – No vacuum pump required, only air trap with tripping of the MMS
- | When installed on a new transformer, maintains the moisture constant at initial factory level, thus optimizing its lifetime.



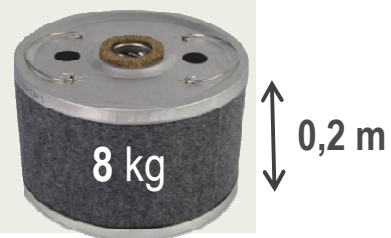
# THE EQUIPMENT: COMPETITIVE ADVANTAGES



## Comparison of drying approaches

### A. Expiotech smart drying

- | Velcon Superdri® technology specifically for transformer oil
- | Special cartridge model adapted to MR requirements
- | Patented cartridge design allowing the use of the finest pore size adsorbent hence selectively removes water
- | Will not affect all key interpretation gases
- | Has built-in particle filters (1micron) at cartridge inlet and outlet
- | Cartridges are disposable with normal oil residues

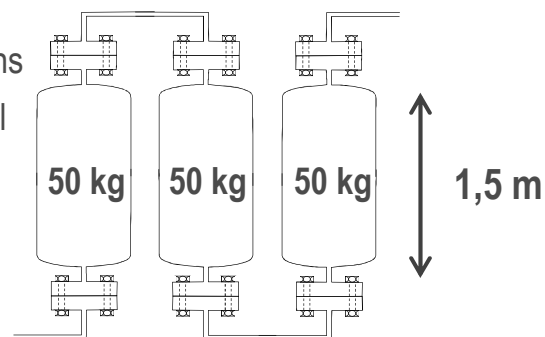


### C. Active drying using vacuum

- | Removes water through a vacuum degassing chamber
- | Removes almost completely all faults gases
- | Uses a separate particle filter

### B. Other molecular sieve systems

- | Adsorbent material is contained in metallic columns
- | Low grade (higher pore size) molecular sieve will remove significant levels of key fault gases
- | Columns need to be exchanged and sent for regeneration
- | Uses a separate particle filter





# THE EQUIPMENT: COMPETITIVE ADVANTAGES



## Expiotech Smart Drying removes H<sub>2</sub>O specifically

### Expiotech

Molecular sieve with very small pores



### Standard

Molecular sieve with larger pores



Relative size of molecules of key dissolved gases

- Water (H<sub>2</sub>O)**
- Carbon Monoxide (CO<sub>2</sub>)
- Hydrogen (H<sub>2</sub>)
- Acetylene (C<sub>2</sub>H<sub>2</sub>)
- Carbon Monoxide (CO)
- Methane (CH<sub>4</sub>)
- Ethylene (C<sub>2</sub>H<sub>4</sub>)
- Ethane (C<sub>2</sub>H<sub>6</sub>)



# THE EQUIPMENT: COMPETITIVE ADVANTAGES



## Feature comparison: Drying Performance

	Expiotech Smart Drying	Molecular Sieve Systems	Vacuum
Intelligent PLC based control of the drying process. Elimination of the risk of the Risk of <b>Overdrying</b> (critical loss of winding pressure)	Yes	No	No
<b>Accuracy of the Paper Moisture</b> assessment over the whole drying process. <b>Field proven</b> algorithm	High	Low	Low
<b>Key diagnostics gases affected</b>	No	Partly	Completely
Capacity of the particle filters	High	Low	High
<b>Restitution</b> of moisture at elevated oil temp. (> 100C)	No	Possible	No



## CONTACT / FURTHER INFORMATION

Dedicated support around the world, on-site and remote, 24/7



| About **200 Technicians**

| and more than **30 subsidiaries** worldwide



THE POWER BEHIND POWER.

[www.reinhausen.com](http://www.reinhausen.com)

