Pooya Pazhoohesh Arvid Pazh

Online Transformer Insulation Drying Techniques

a Study on T2 Transformer of Behshahr1 Electrical Power Station – Mazandaran Province


پیمانکار عمومی در صنایع (GC)
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شرکت دانش بنیان
پویا پژوهش آروید پاژ

Overview

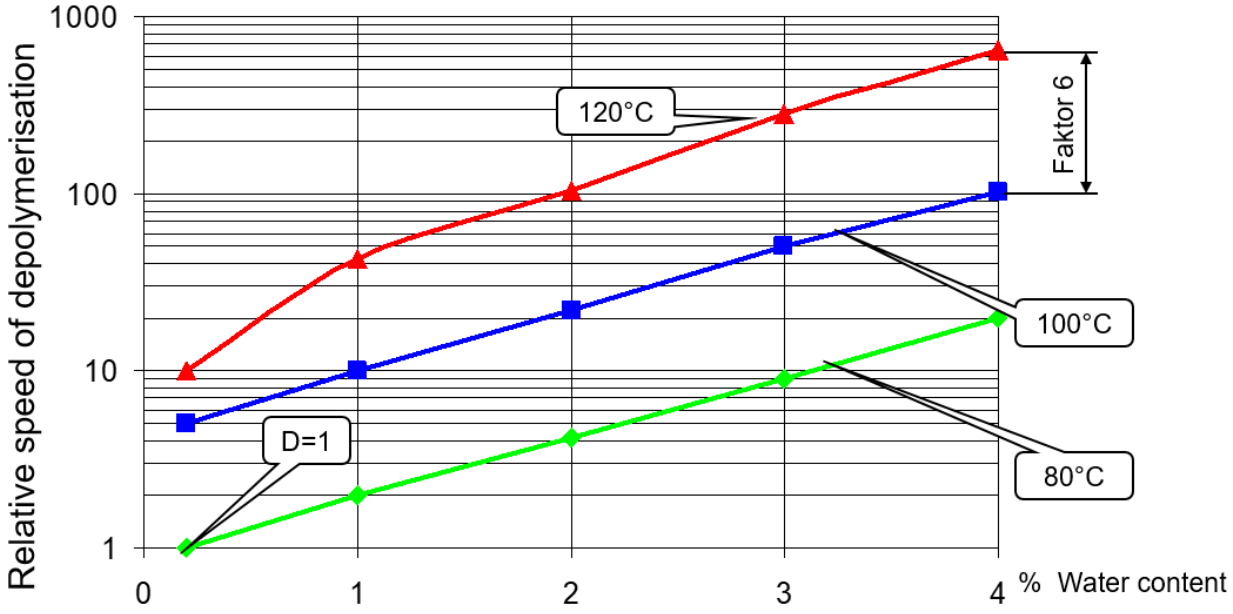
- Water in the transformer !?
- Physics of drying
- Onsite drying techniques
- Online Continuous Drying
- Online Transformer Dryer – DP100
- Practical Story of Online Drying

Introduction

- A moisture increase of 1% causes a doubling of the depolymerisation speed
- 4% moisture at 50°C leads to a moisture content in the oil of 50 ppm. Is the oil quickly cooled down (power failure during winter), is it possible to have free water already at 20 °C
- With a too high moisture content, there is the risk of bubble formation in the insulation at much lower hot spot temperatures as 140°C as with dry insulation

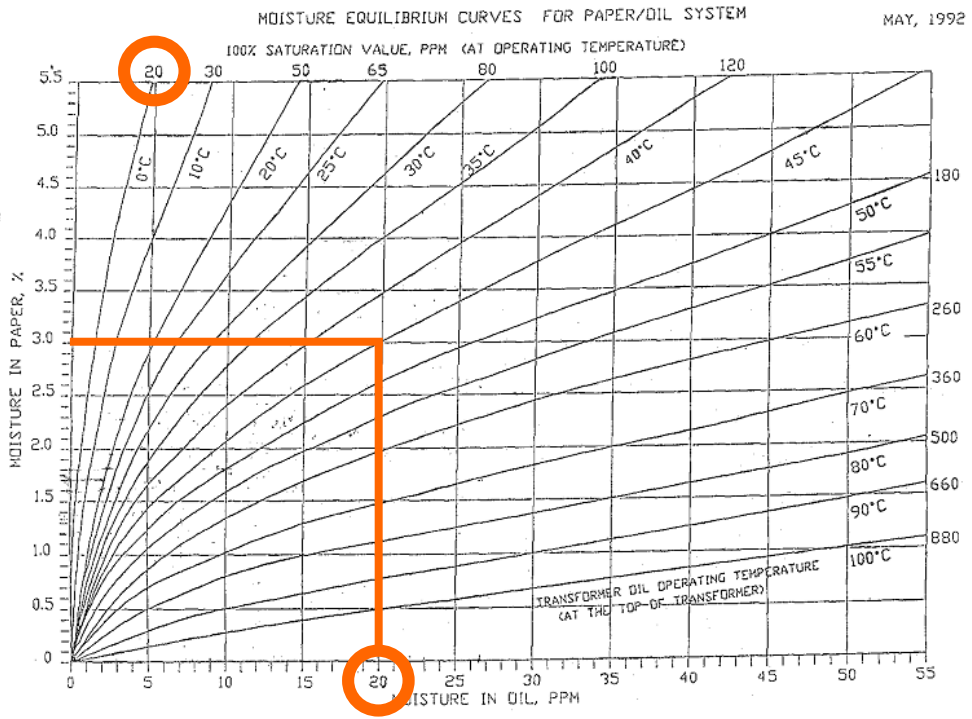
Paper Degradation

❖Speed of Depolymerization against Water Content
[D(80°C, 0.2% H20) = 1, according to Bouvier]

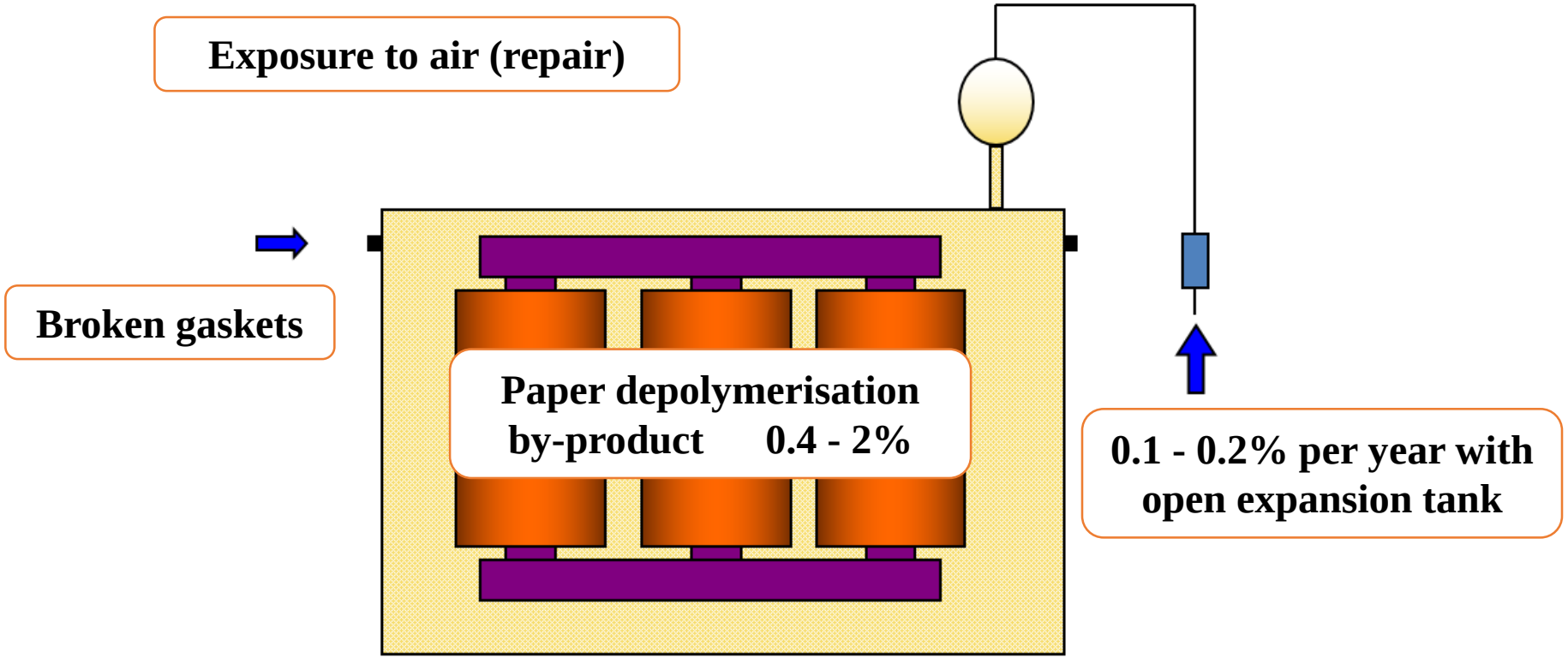


Moisture Equilibrium

❖Moisture Equilibrium Curve (Oommen Curve)

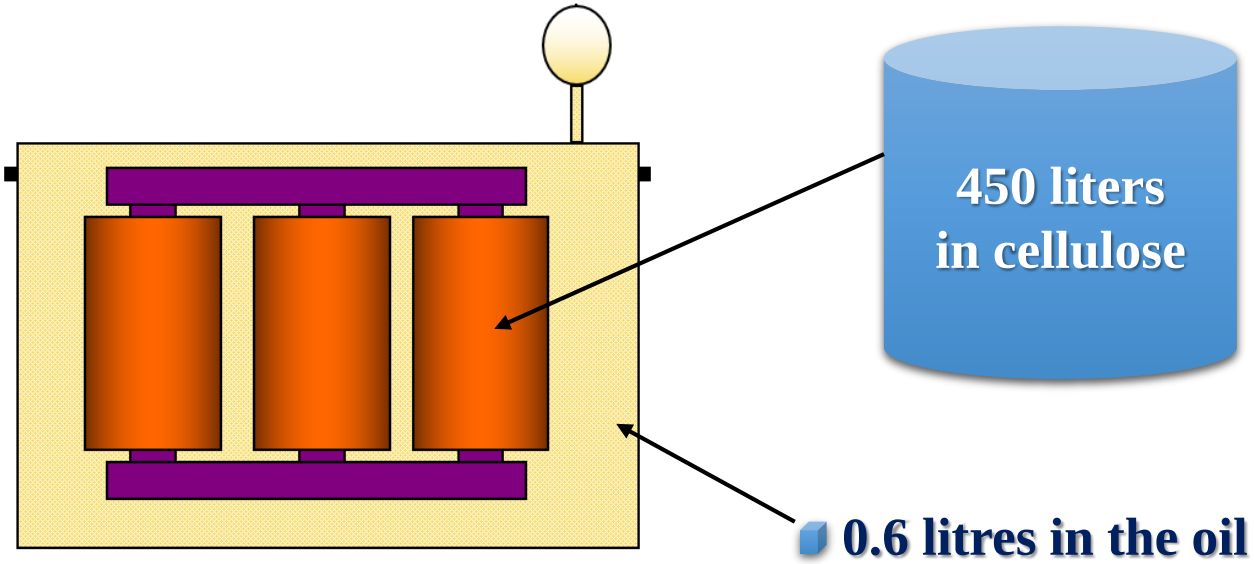


Sources of Water in Old Transformers



Moisture Distribution Paper-Oil

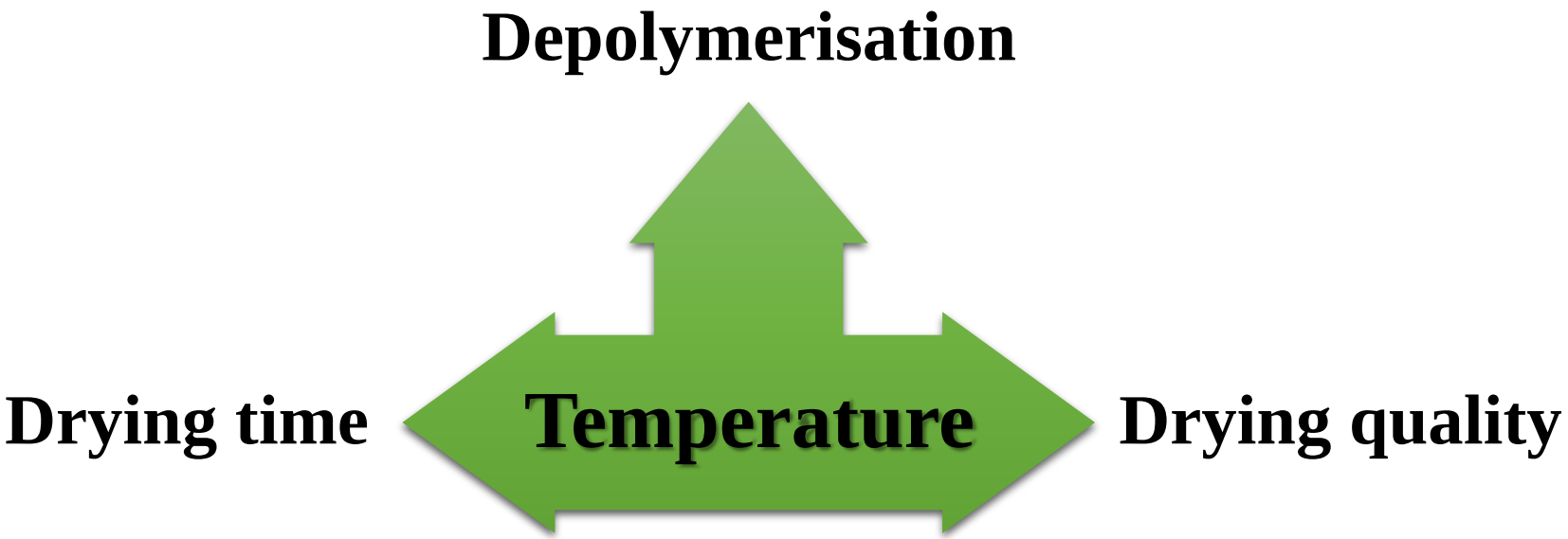
❖Example: 400 MVA Transformer with 15 Tones cellulose insulation and 60 Tones oil, 3% average moisture in cellulose, 30°C average oil temperature



Over 99 % of the moisture is collected in the cellulose!

Physics of Drying

- Diffusion / Drying speed is influenced by:
  - Temperature
  - Humidity
  - Material properties



Temperature is the key parameter in any drying process

Problems with Drying Transformers

Drying too short

→ Moisture content too high

→ Accelerated aging

→ Reduced lifetime

Drying too long

→ Energy costs, production speed

→ Paper too long at hot temperature

→ additional Loss of DP

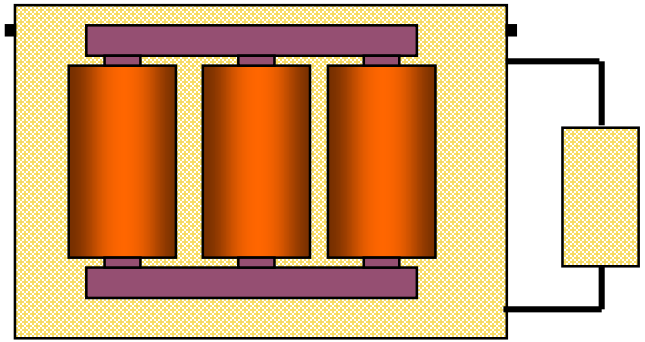
→ Reduced lifetime

➡ **Optimal drying time is essential**

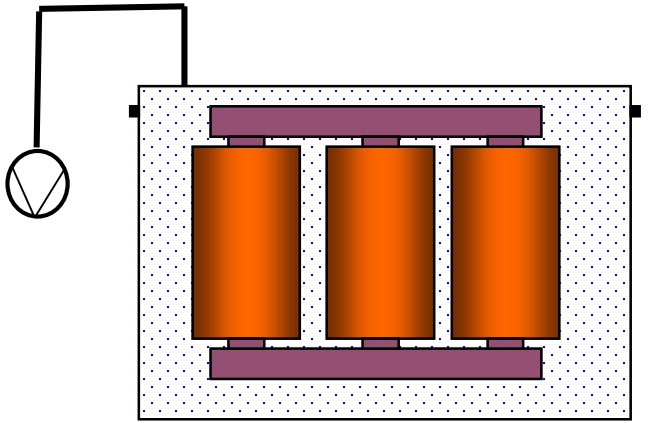
➡ **Monitoring of moisture content necessary**

On-Site Drying Methods

Oil drying



Vacuum drying



Oil Circulation

Advantages

- low costs
- simple technique
- low operative expenditure

Disadvantages

- long drying times
- poor drying quality
- shorter drying intervals required

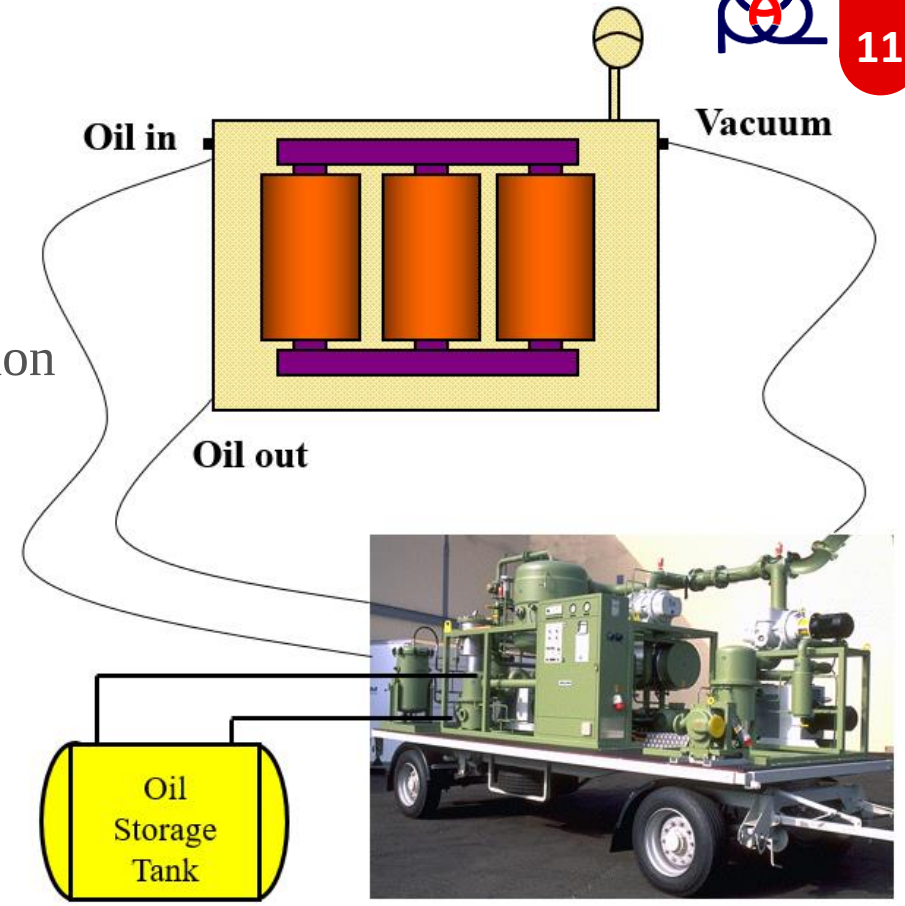
Oil Circulation & Vacuum

Advantages

- low costs
- simple technique
- drying improvement
  compared to solely oil circulation

Disadvantages

- long drying times
- various cycles required
- tank for oil storage



Hot Oil Spray

Advantages

- constant heat feeding under vacuum
- good drying results

Disadvantages

- difficult heating of the internal parts
- location of the spraying nozzle critical

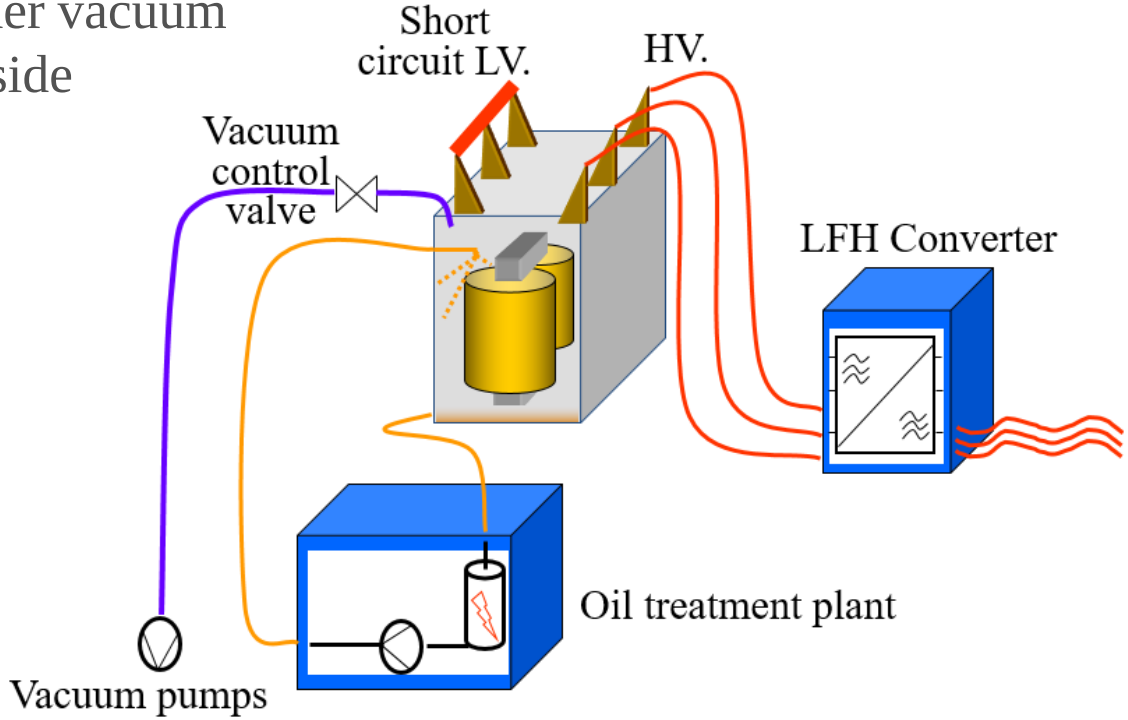
LFH and Hot Oil Spray

Advantages

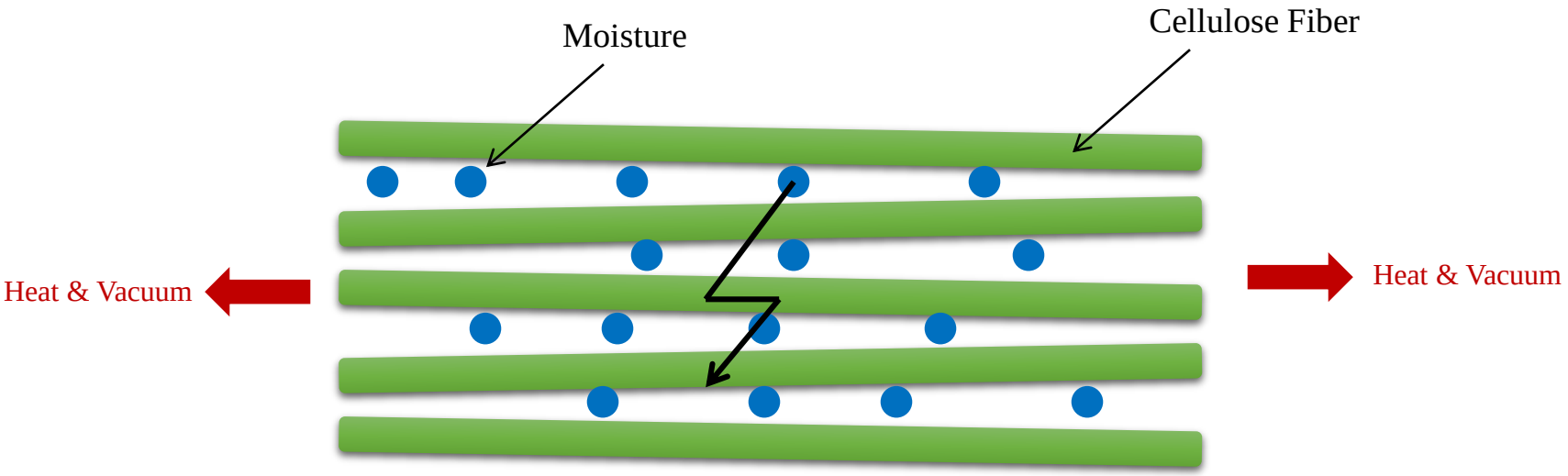
- ❖ constant heat feeding under vacuum
- ❖ Heat from inside and outside
- ❖Short drying time
- ❖Excellent drying results

Disadvantages

- ❖ larger investment
- ❖ only reasonable for larger transformers



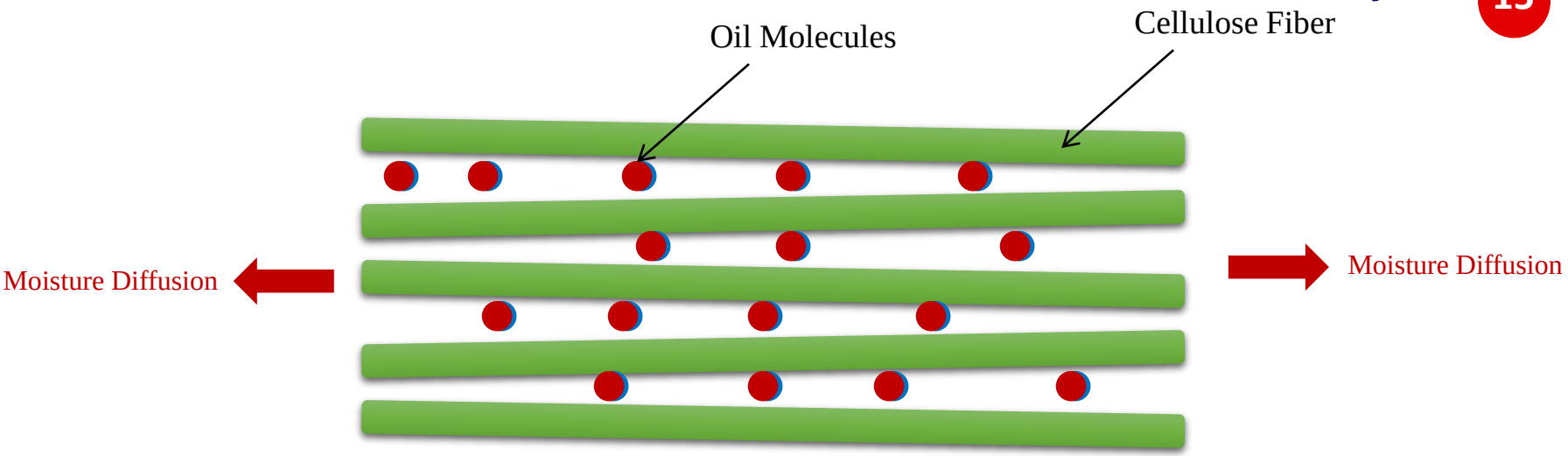
Rapid Drying Disadvantages



Drying potentially endangers the solid insulation as the winding coil usually is not re-fastened after drying

(>>> stability in case of short circuit)

Online Continuous Drying



Online Continuous Drying

❖**Drying as a continuous procedure:**

The liquid insulation is continuously dried during transformer operation.

Through the drying of the liquid insulation the solid components are dried as well.

Such systems are advantageous for already impregnated transformers with moderate water strain. The drying is performed during regular transformer operation, thus no outage is required.

Online Continuous Drying

❖Drying as a continuous procedure:

One of the most important advantages of continuous drying procedures in comparison to other on site drying procedures is the considerate treatment of the insulation

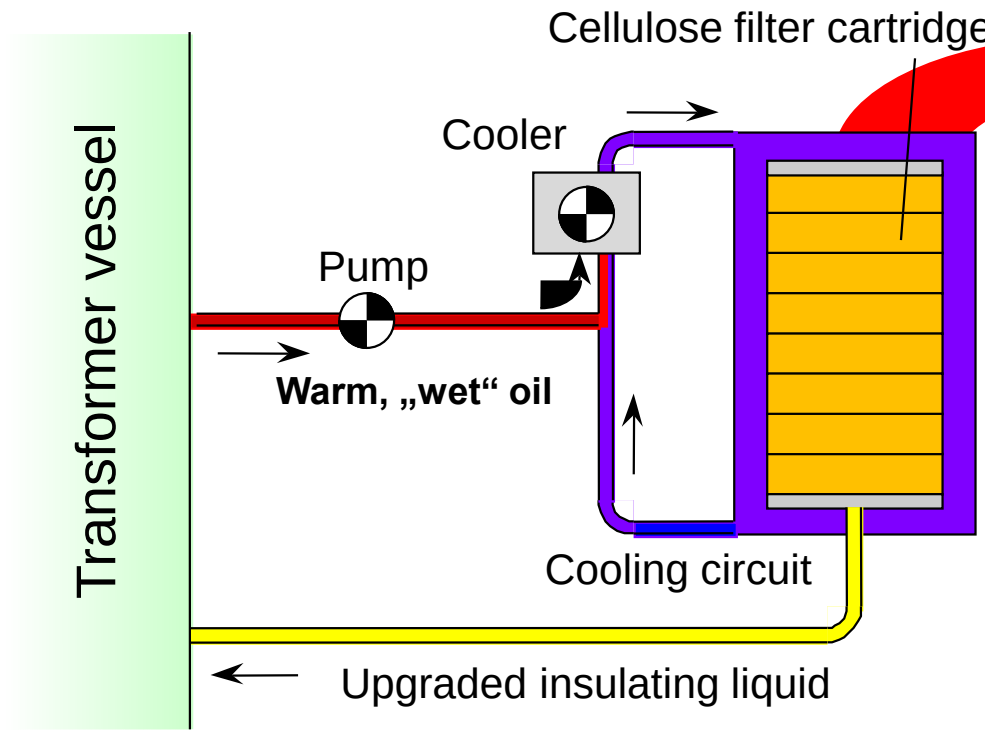
Caution: It should be looked out that the system does not influence the amount of failure gases as the failure gases are important for protection and diagnosis purposes in a transformer [Fofana & Borsi 2004]

Online Continuous Drying

❖Online Drying Methods:

- Cellulose Cartridge Filters
- Molecular Sieves

Cellulose Cartridge Filters

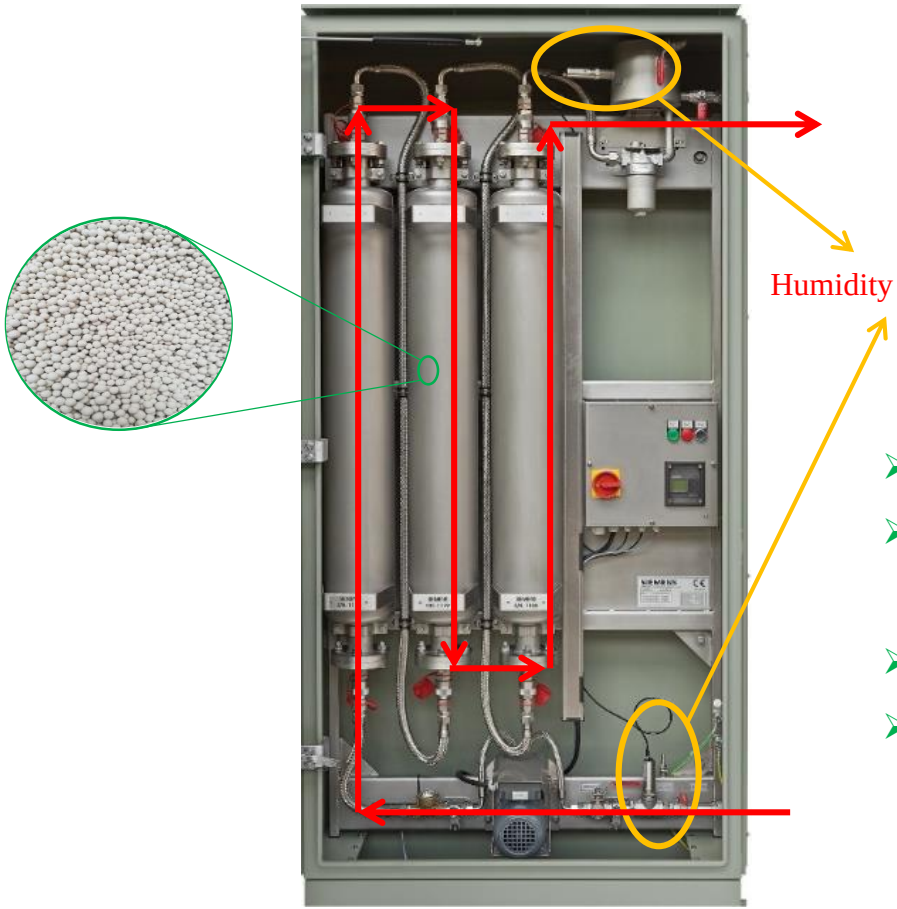


Features:

- Reduction in particle count
- Increase in breakdown voltage, but no change in acid number or interfacial tension.
- Removal of furans
- Reduction in dissolved gas concentration

Gentle, continuous desiccation

Molecular Sieves Dryer



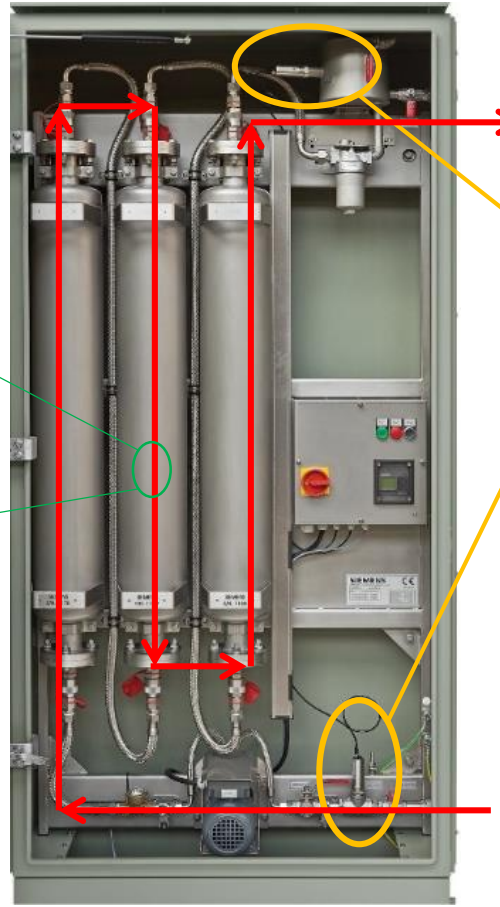
Features:

- Reduction in particle count
- Some increase in Breakdown Voltage and IFT, and a decrease in Acid Number
- Removal of furans
- No Reduction in dissolved gas concentration

Online Transformer Dryer
DP-100

Online Transformer Dryer – DP100

❖Simple Transformer Dryer Device



Humidity sensor

Online Transformer Dryer – DP100

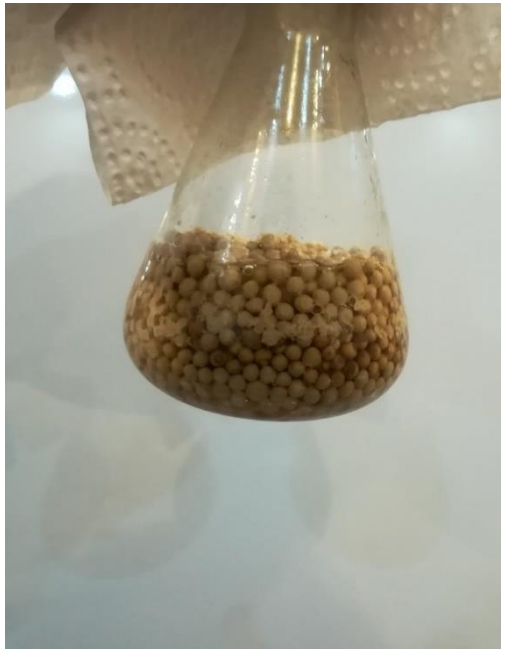
❖Adsorbents – Zeolite Molecular Sieve (**BASF CO. Germany**)

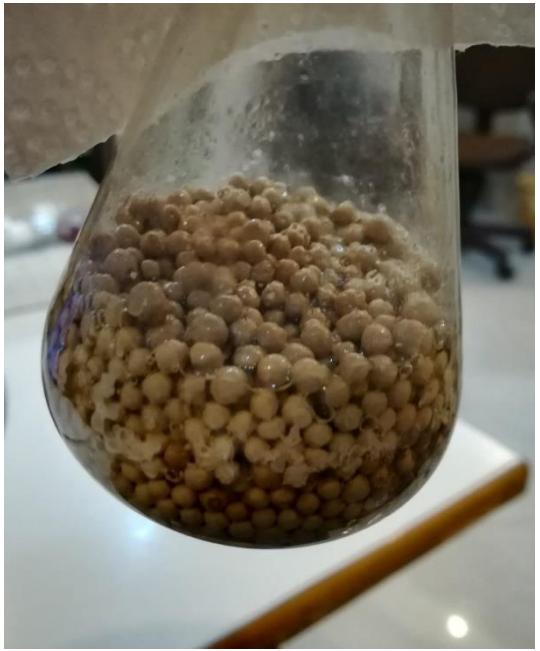
Online Transformer Dryer – DP100

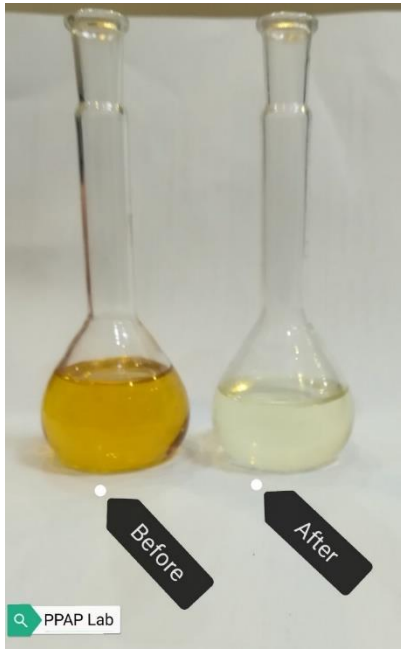
❖Initial Test – Oil Lab

Online Transformer Dryer – DP100

❖Initial Test (Oil Lab) – Qualitative Results

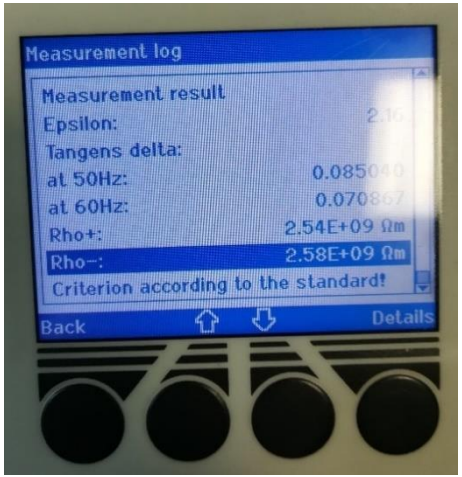






Online Transformer Dryer – DP100

❖Initial Test (Oil Lab) – Quantitative Results



Online Transformer Dryer – DP100

❖Certificate of Oil Antioxidant Adsorption Test

دانشگاه آزاد اسلامی
واحد قوچان

باسمه تعالی

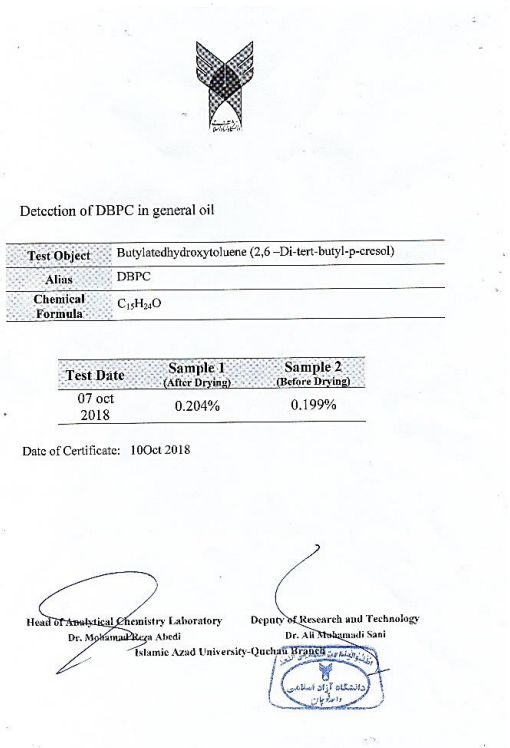
به: مدیریت شرکت پویا پژوهش آروید پاژ

موضوع: بررسی میزان آنتی اکسیدان (*DBPC*) در روغن

با سلام و احترام

عطف به درخواست آن شرکت جهت انجام آزمایش میزان آنتی اکسیدان (*DBPC*) برروی دو نمونه روغن دریافت شده (مربوط به قبل و بعد از عملیات خشک‌سازی با دستگاه خشک کن آنلاین ترانسفورماتور (*DP-100*)، به استحضار می‌رساند نتایج تست مذکور نشان می‌دهد که میزان آنتی اکسیدان در هر دو نمونه با تقریب قابل قبولی یکسان بوده که بیانگر تاثیر ناچیز عملیات خشک‌سازی توسط ژنولیت ۳ آنگستروم بر میزان این ماده شیمیایی در روغن می باشد. برگه نتیجه آزمایش به پیوست ارسال می‌گردد.

دکتر علی محدثی ثانی
معاون پژوهشی و آموزشی دانشگاه آزاد اسلامی واحد قوچان



Detection of DBPC in general oil

Test Object	Butylatedhydroxytoluene (2,6 –Di-tert-butyl-p-cresol)
Alias	DBPC
Chemical Formula	$C_{15}H_{24}O$

Test Date	Sample 1 (After Drying)	Sample 2 (Before Drying)
07 oct 2018	0.204%	0.199%

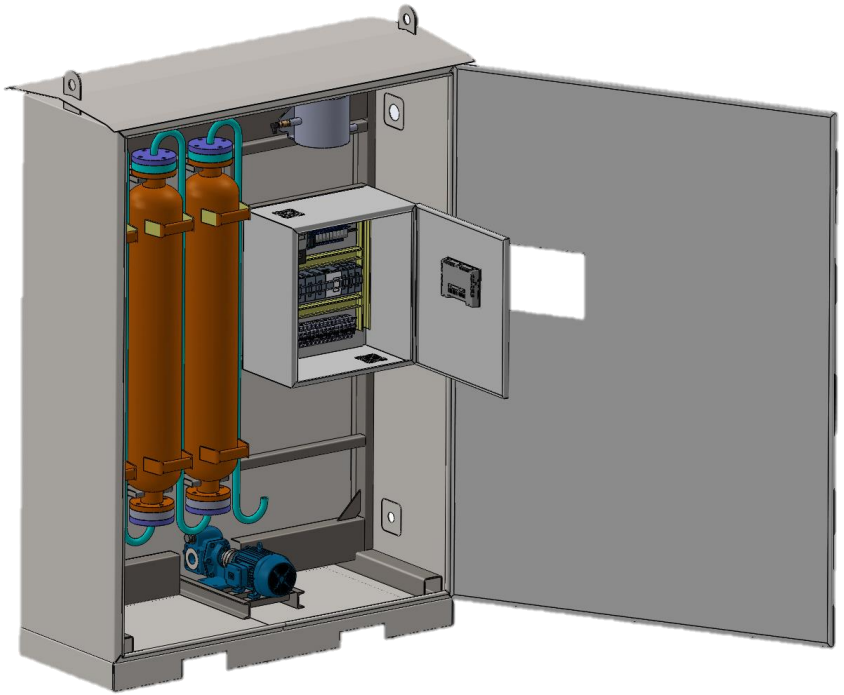
Date of Certificate: 10Oct 2018

Head of Analytical Chemistry Laboratory
Dr. Mohammad Reza Abedi
Islamic Azad University-Quchan Branch

Deputy of Research and Technology
Dr. Ali Mohamadi Sani

Online Transformer Dryer – DP100

❖Primary Design



Online Transformer Dryer – DP100

❖Device Manufacturing

Online Transformer Dryer – DP100

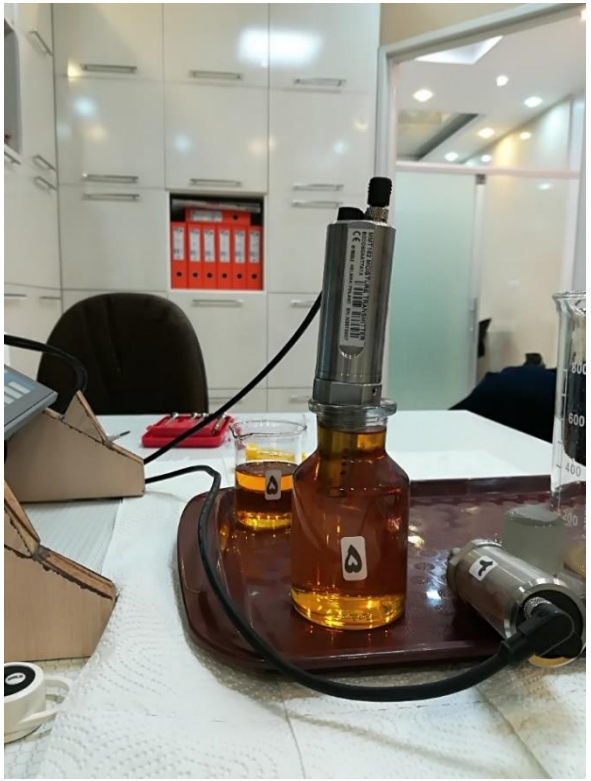
❖Device Manufacturing

Online Transformer Dryer – DP100

❖Device Manufacturing – Electrical Test

Online Transformer Dryer – DP100

❖Sensor Calibration on Lab



Online Transformer Dryer – DP100

❖DP100 on Exhibition

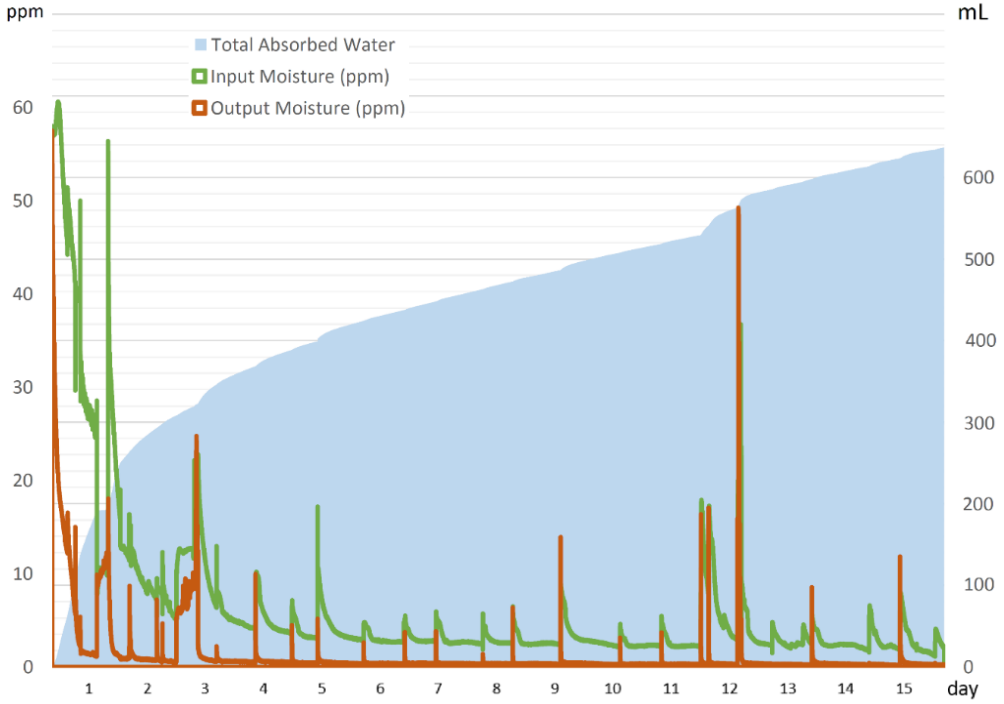
Online Transformer Dryer – DP100

❖Primary Drying Test

Online Transformer Dryer – DP100

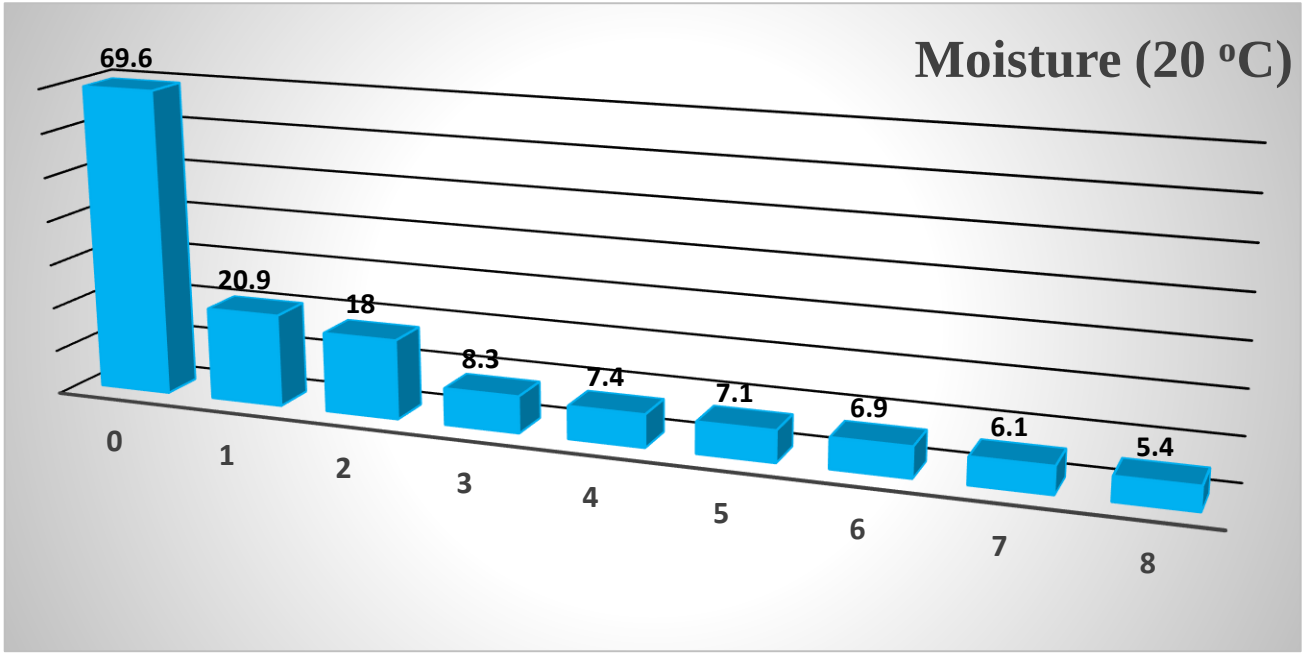
❖Test Results

Before After



Online Transformer Dryer – DP100

❖Test Results



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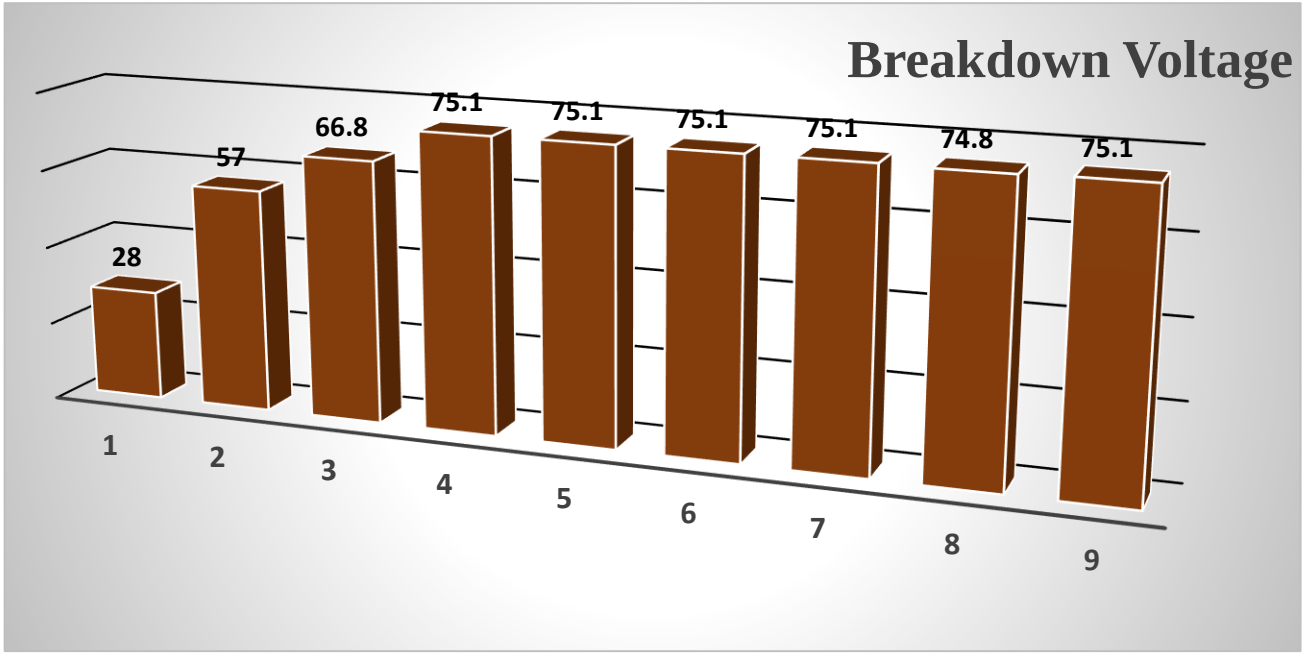
❖Test Results



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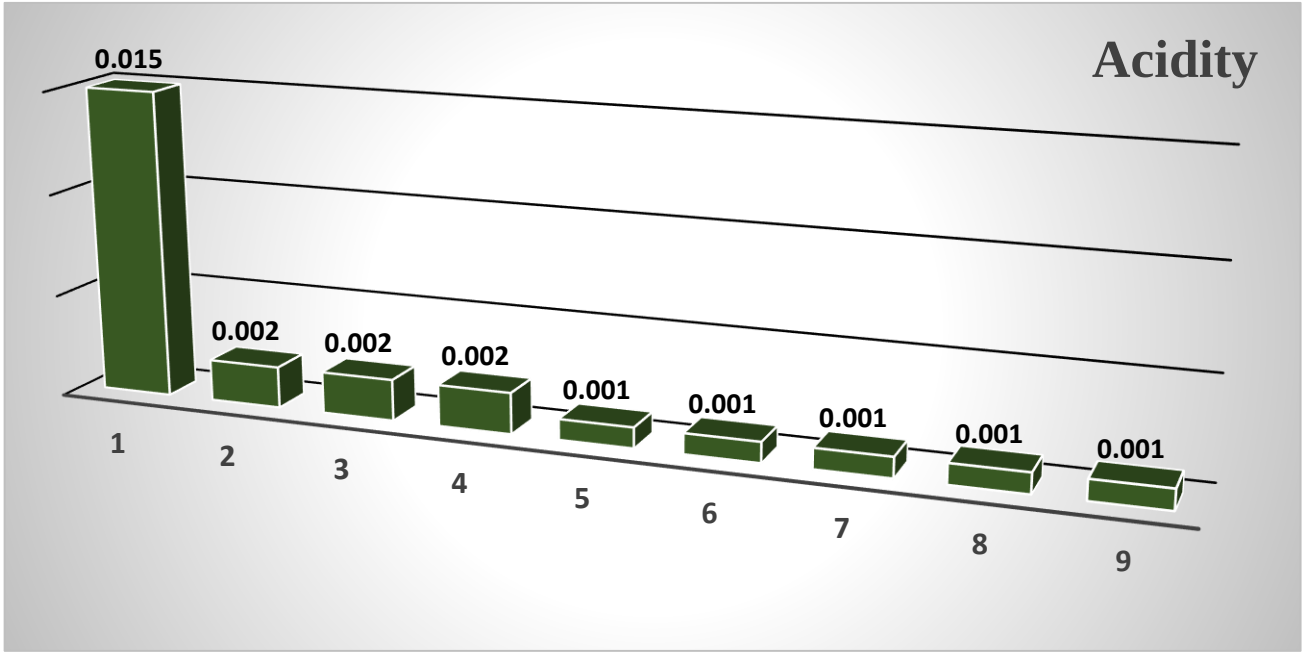

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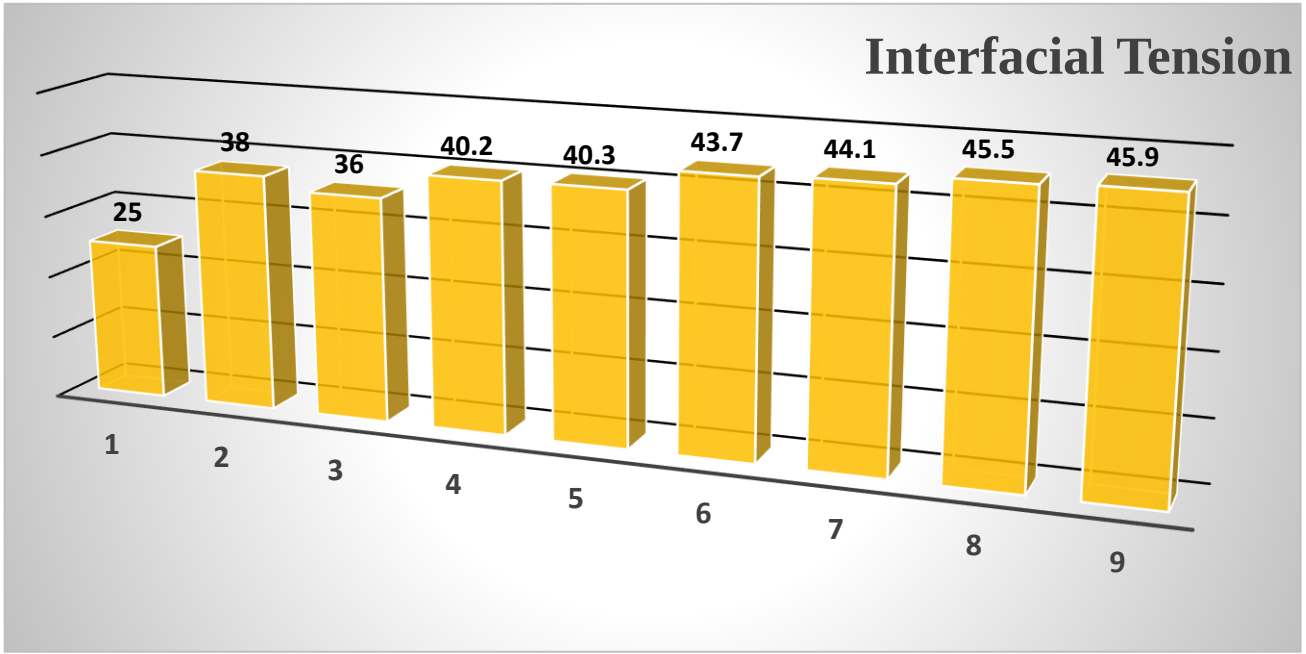
❖Test Results



Online Transformer Dryer – DP100

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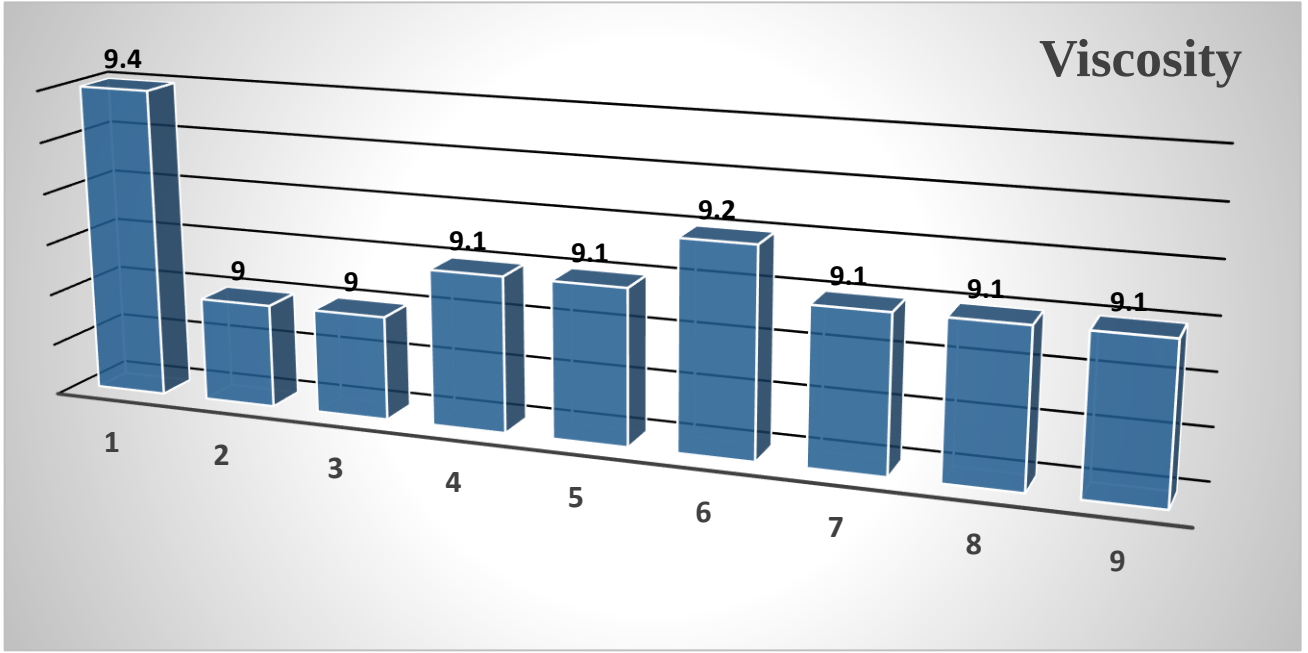

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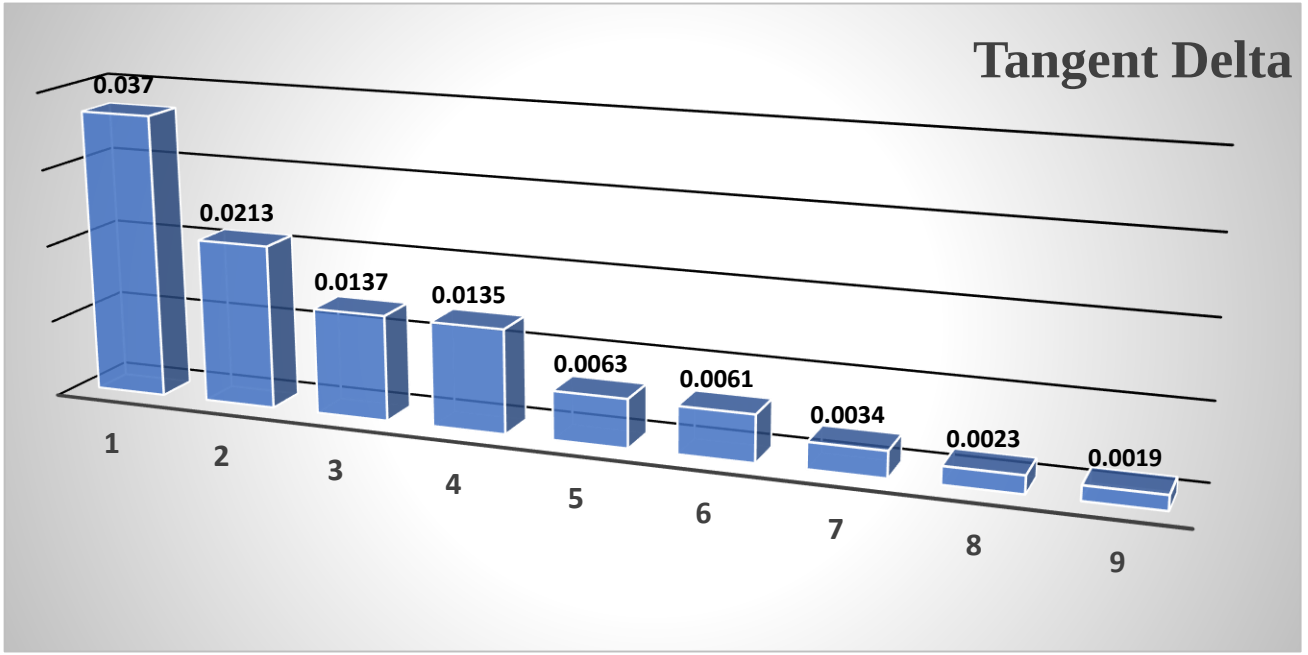

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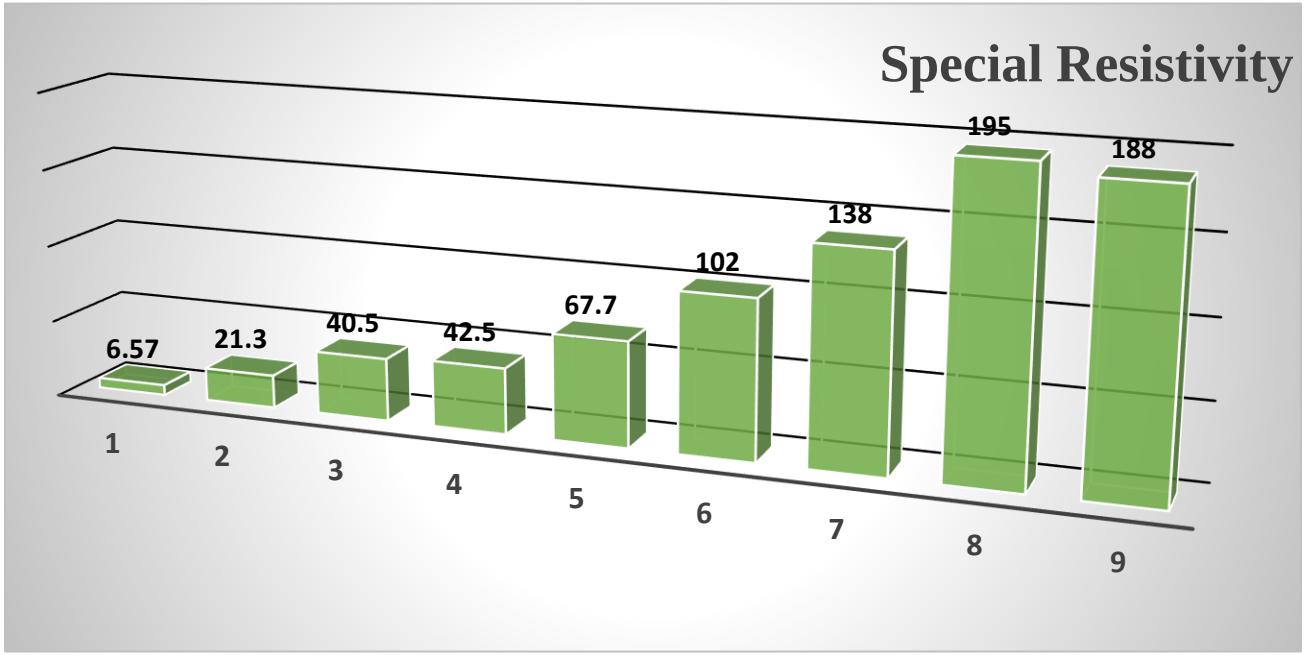


Online Transformer Dryer – DP100

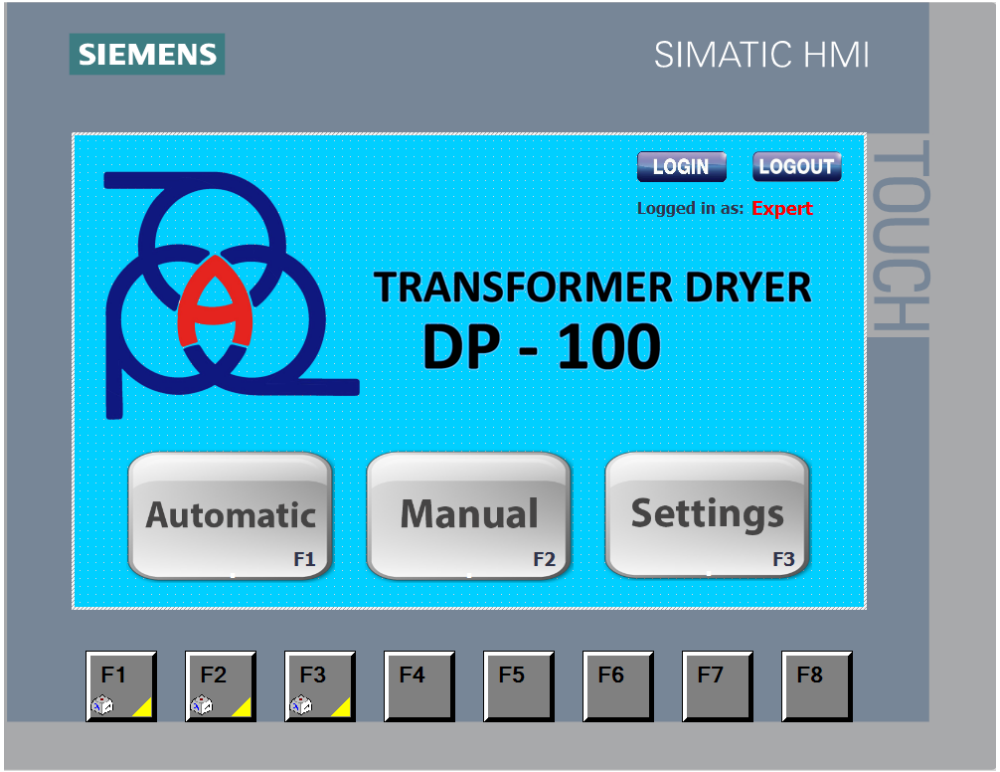
Advantages

- ✓ Online dehydration of transformer oil
- ✓ Raising breakdown Voltage
- ✓ Paper insulation dehumidifying
- ✓ Removing oil particles
- ✓ Reduction of oil insulation loss factor
- ✓ Reduction oil acidity
- ✓ Increasing transformer load capacity
- ✓ Increasing transformer age
- ✓ Improve most of chemical parameters and no effect on oil gases

DP-100
Screen Panel

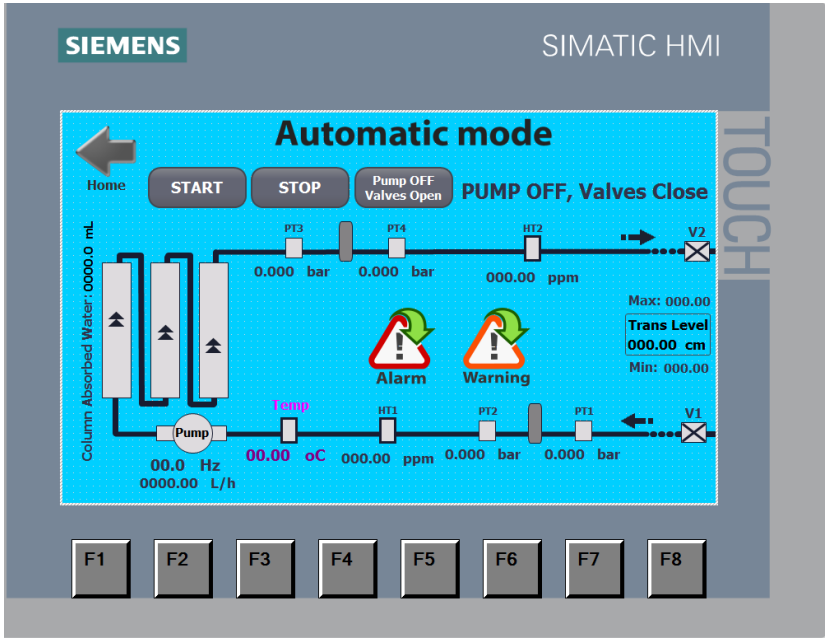
DP-100 Screen Panel

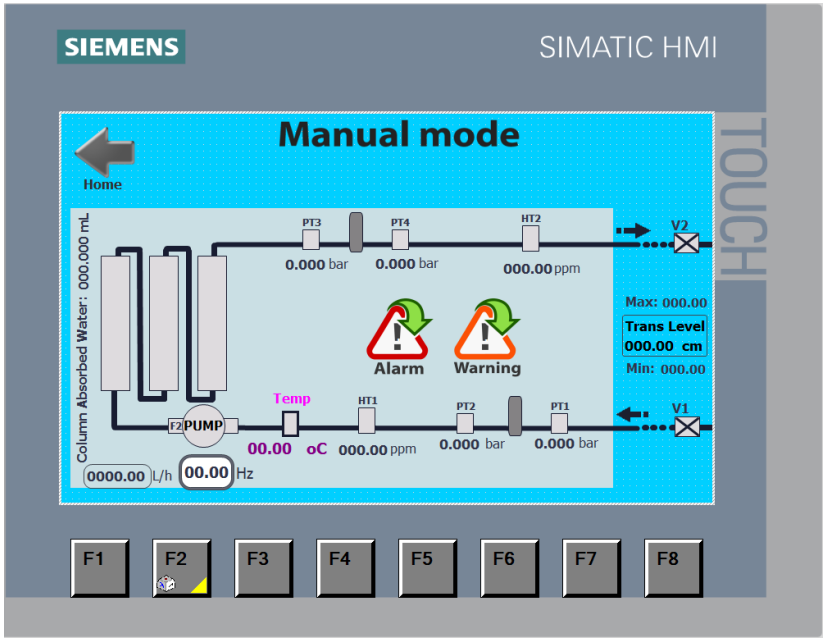
❖ Home Screen Page



DP-100 Screen Panel

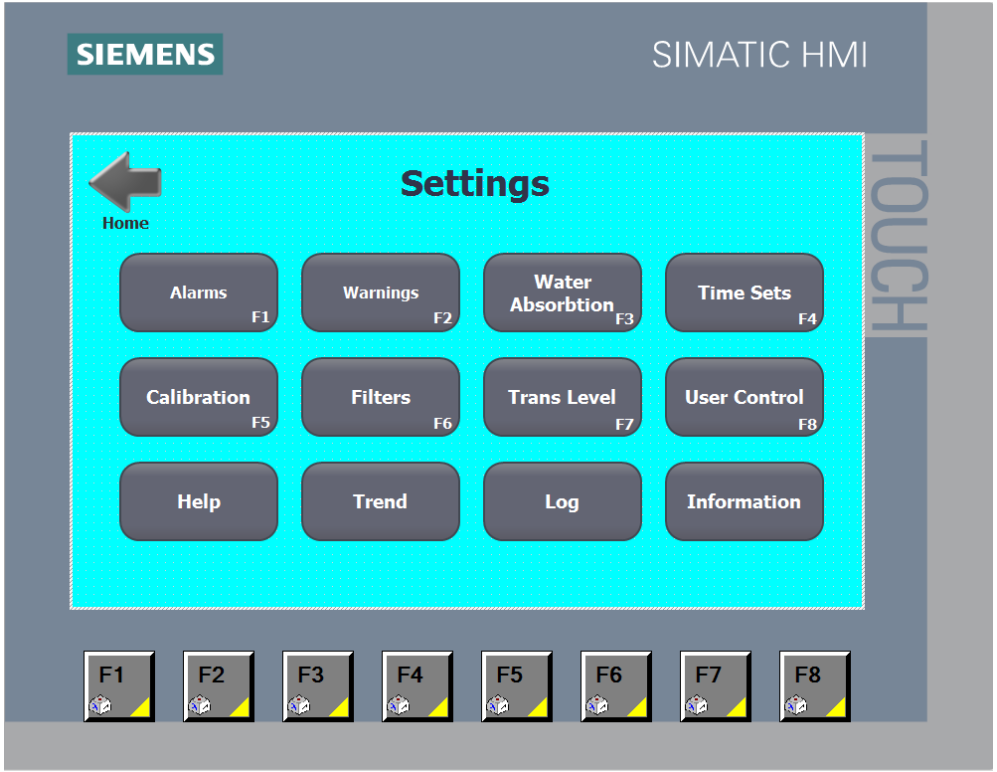
❖ Auto and Manual Operation Pages





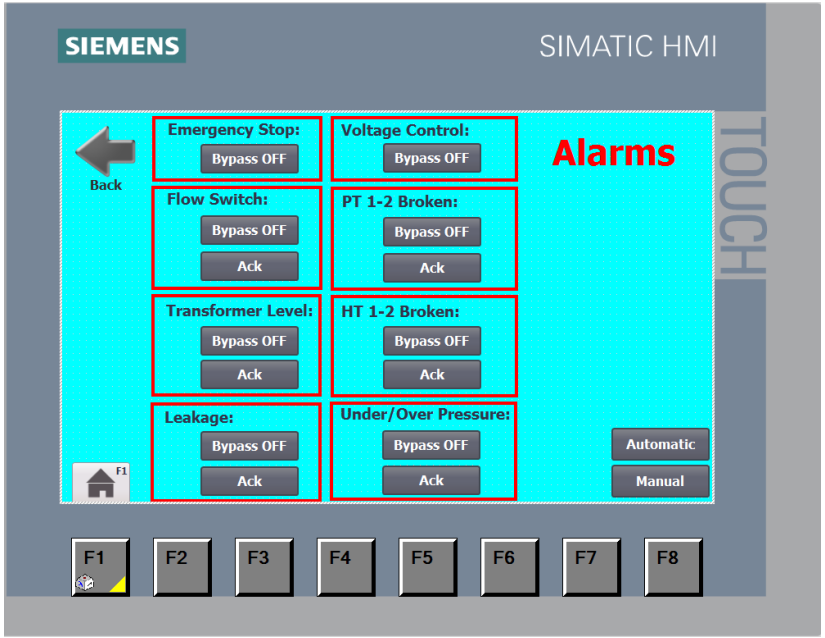
DP-100 Screen Panel

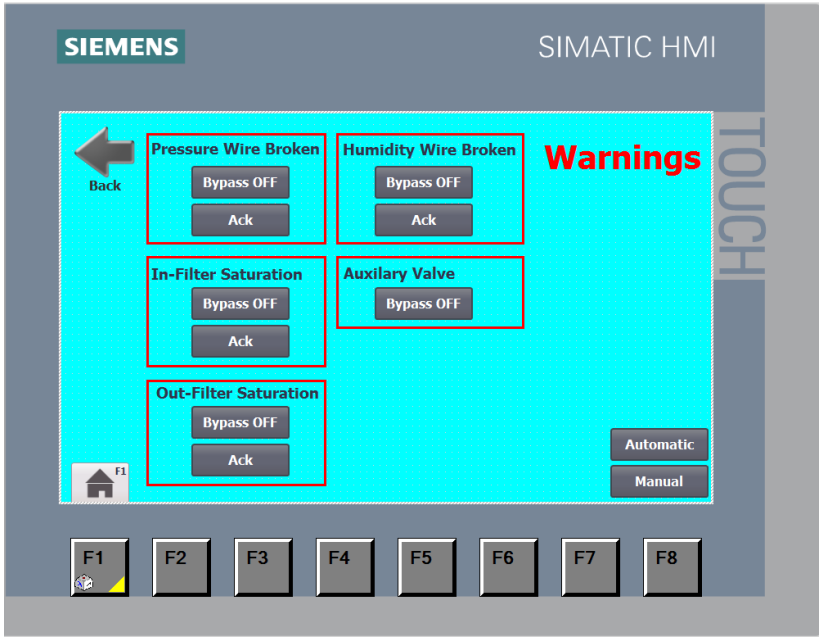
❖ Setting Page



DP-100 Screen Panel

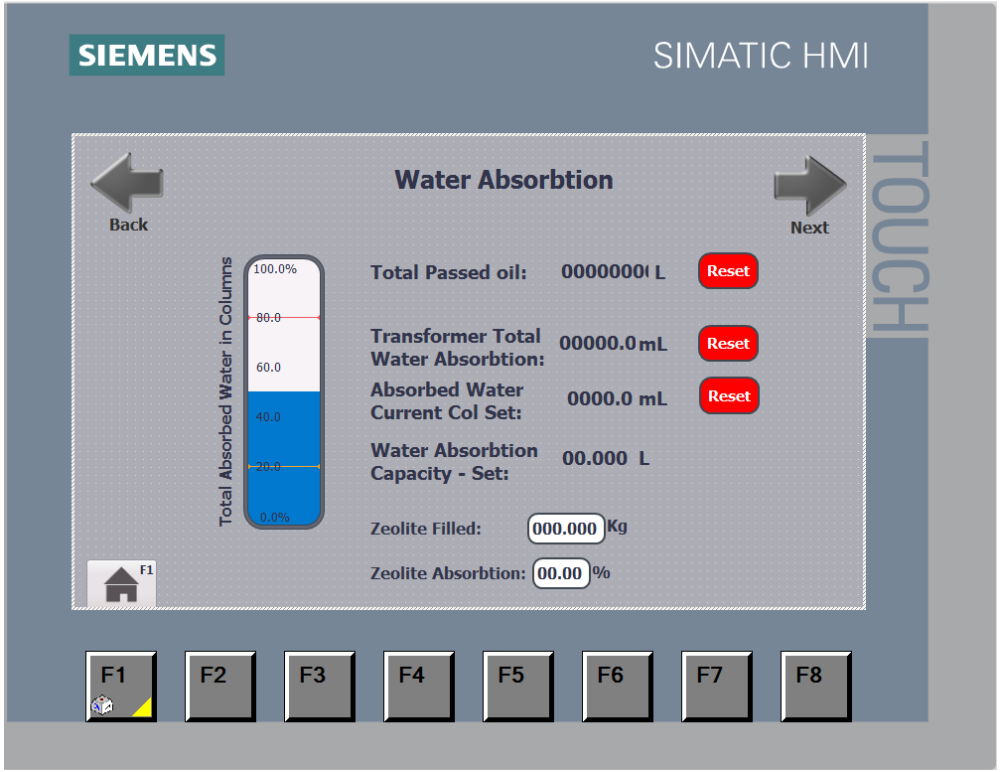
❖ Alarms and Warnings Page (Safety Interlock)





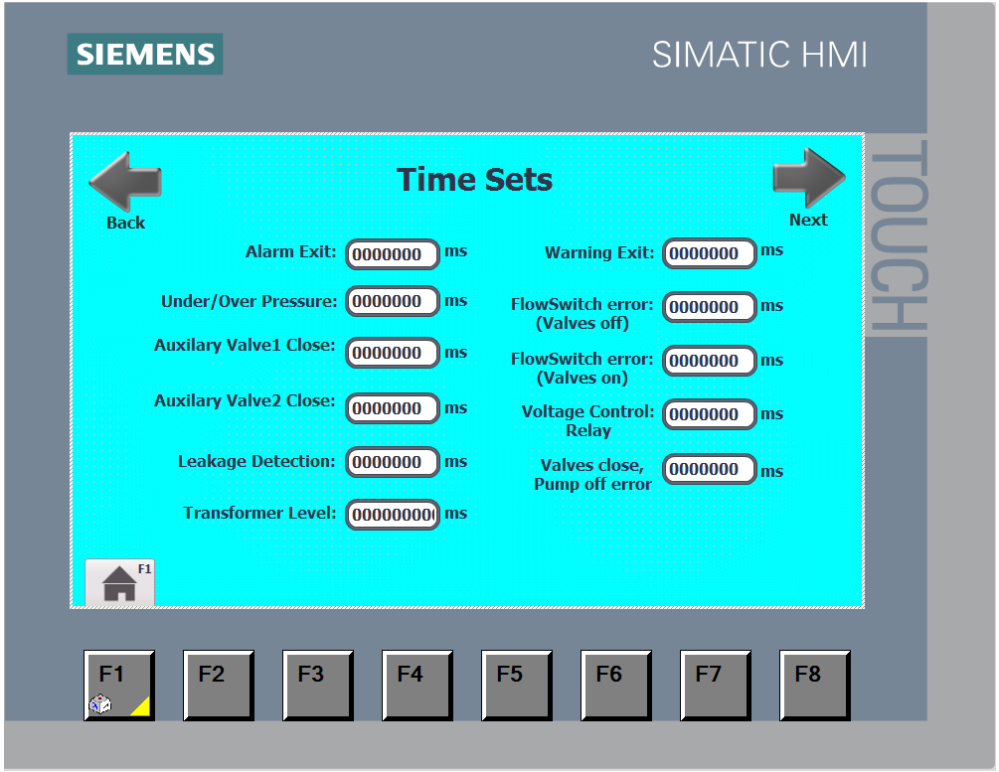
DP-100 Screen Panel

❖ Water Absorption Page



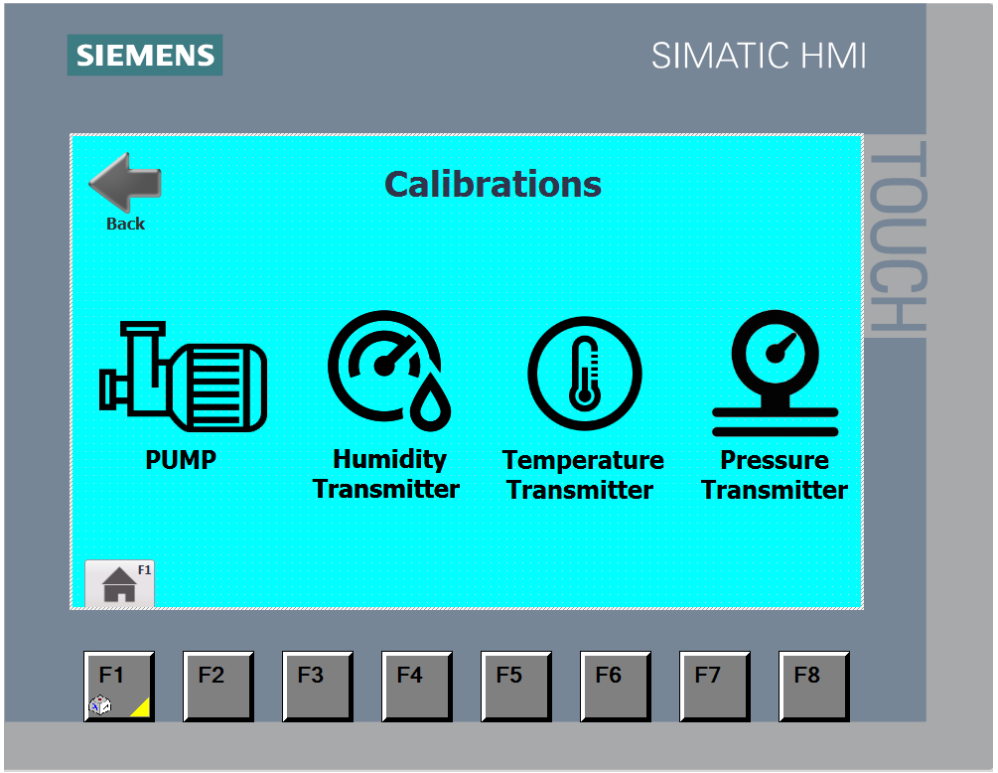
DP-100 Screen Panel

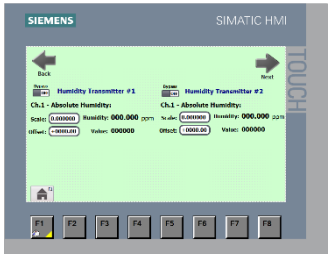
❖ Time Sets Page

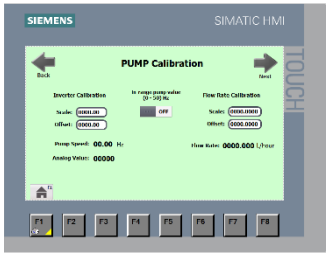


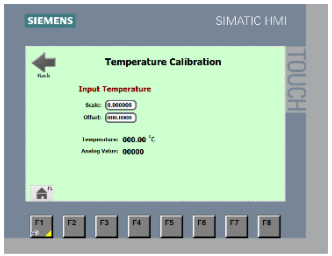
DP-100 Screen Panel

❖ Calibration Pages



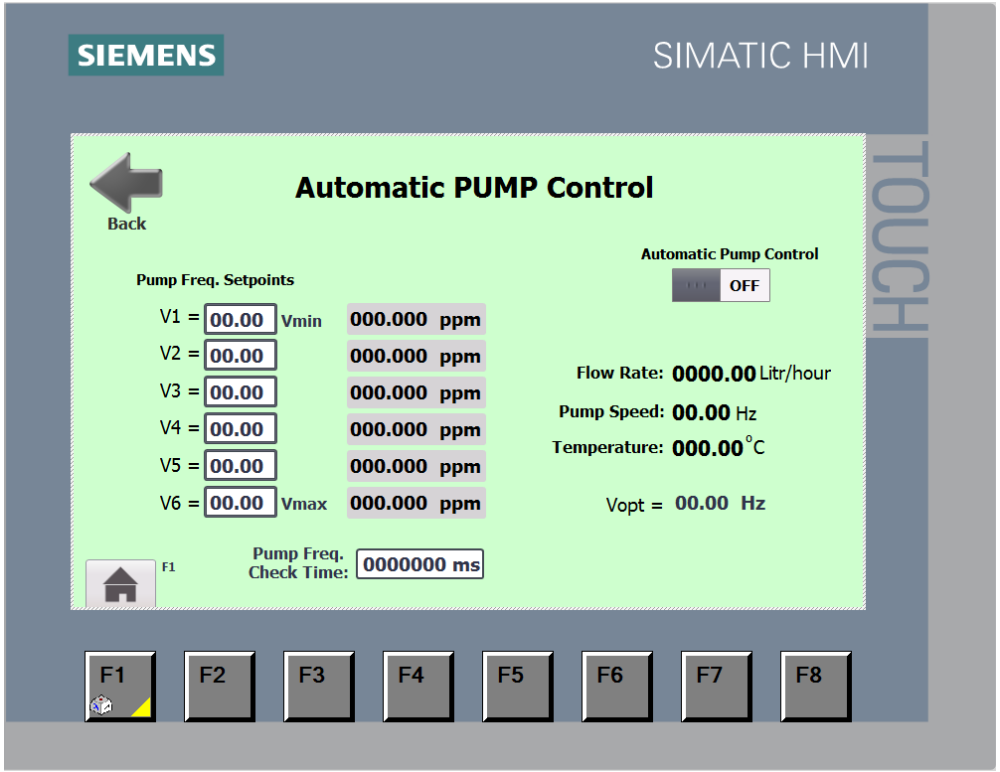






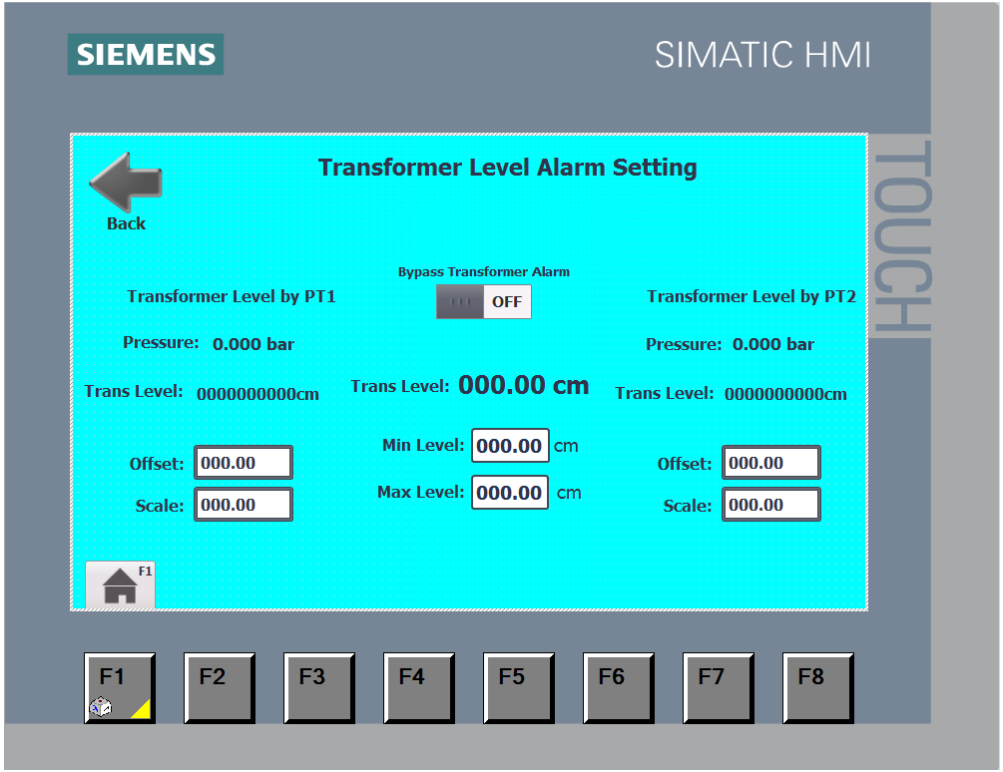
DP-100 Screen Panel

❖ Automatic Pump control Page



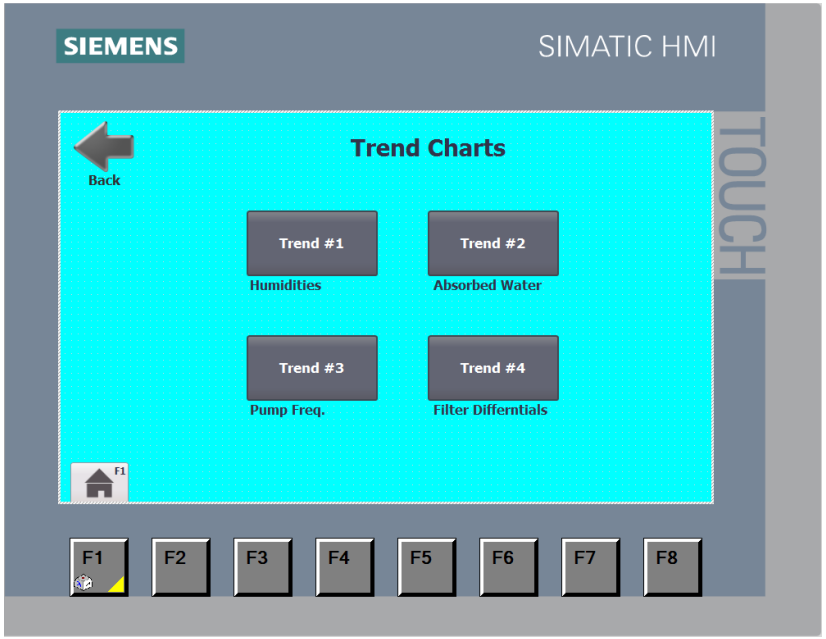
DP-100 Screen Panel

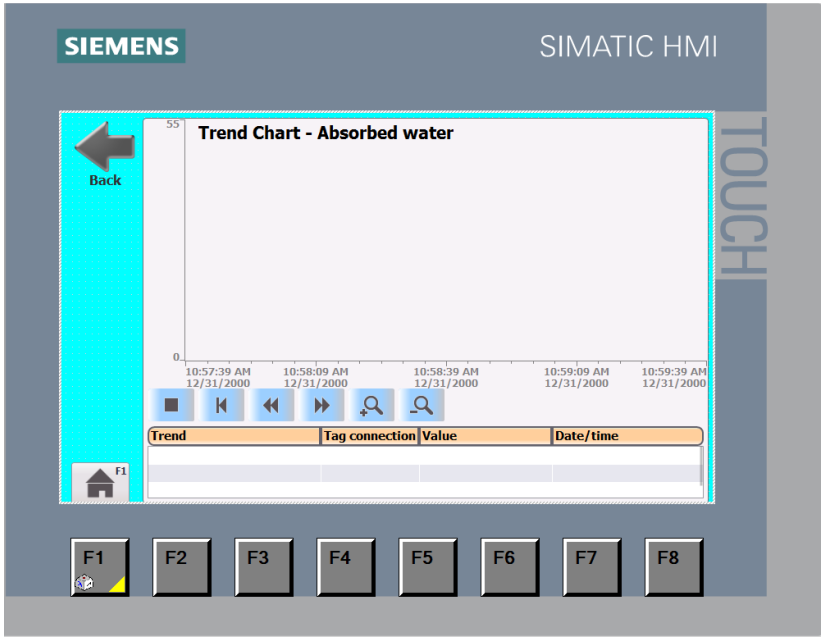
❖ Transformer Level Page



DP-100 Screen Panel

❖ Trend Pages



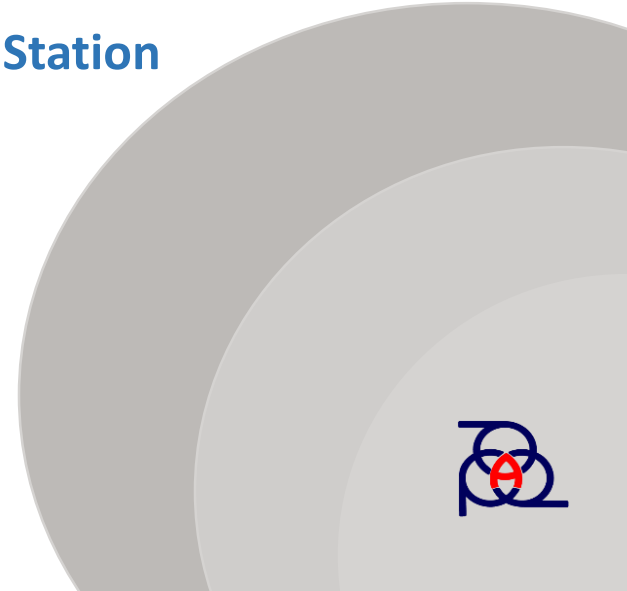


DP-100 Screen Panel

❖ Log table Page

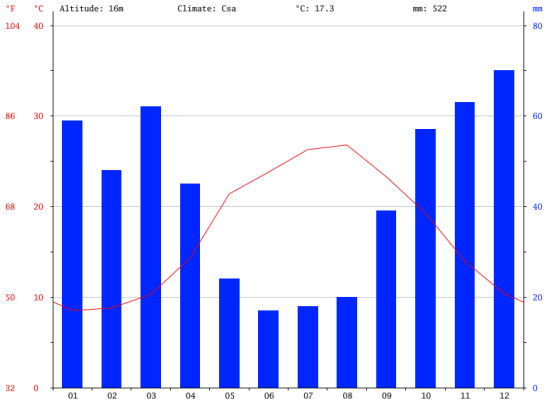
A True Story of DP-100 on

T2 Transformer of Behshahr1 Electrical Power Station



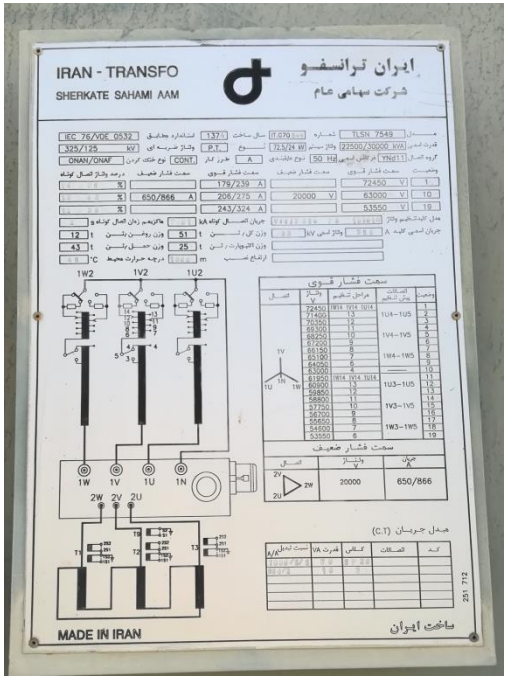
DP-100 Test on T2-Behshahr1

❖Transformer Location: Behshahr city – Mazandaran Province



DP-100 Test on T2-Behshahr1

❖T2 Transformer of Behshahr1 Station



DP-100 Test on T2-Behshahr1

❖Device Commissioning

DP-100 Test on T2-Behshahr1

❖FDS test before drying

DP-100 Test on T2-Behshahr1

❖Connections

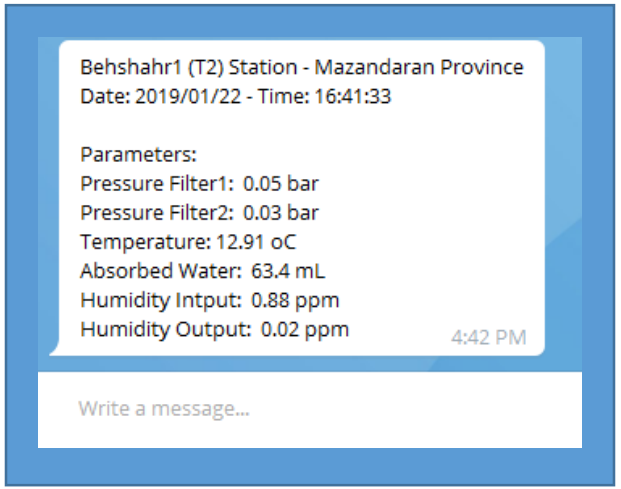
DP-100 Test on T2-Behshahr1

❖Air Trapping

DP-100 Test on T2-Behshahr1

❖Operation and Parameters

SMS Text message



DP-100 Test on T2-Behshahr1

❖Results