

# LEX OIL CONDITIONING SYSTEM



On-Line  
Oil Conditioning  
and Dry-Out for  
Power Transformers



**LEX ENGINEERING**  
D I V I S I O N

The LEX Oil Conditioning System (LEX-OCS) is a stationary, maintenance-free system that removes both free and dissolved moisture while reconditioning the oil on line. This economical and easy-to-use system extends the life of insulating oil and also the life of cellulose insulating materials over a period of time, by reducing moisture in paper via oil, paper, and temperature-moisture dynamics. It does this while the transformer remains in service, utilizing a molecular sieve filter media without the need for heating or vacuum.



#### Reduce moisture level to <10 PPM

- Automatically
- No transformer service outage is required
- Minimum man-hours, reduced labor cost
- More cost effective than any system available
- Signals when media baskets need changing or use SCADA network to monitor remotely
- Safe 24-hour unattended operation

# Effect of moisture-removing materials on transformer performance

The insulation system of most power transformers consists of organic materials: mineral oil, cellulose paper and pressboard. Moisture in the insulation system, together with operating temperature, constitutes the most important transformer insulation aging mechanism. Maintaining transformer insulation in a properly “dried out” state can be a difficult and expensive process; it requires considerable labor, capital-intensive equipment and at times, transformer outages.

Removing moisture from a “wet” transformer usually involves draining and drying the oil, drying the solid insulation using heat and/or vacuum, and vacuum refilling the unit. A more practical and less expensive method

is to use the oil as a transfer media to remove moisture from the solid insulation. As the oil is dried (most favorably when the transformer is hot), the moisture will be transferred from the solid insulation to the oil, based on the relative solubility at a given temperature. This process does not introduce air into the system, so degassing the oil will not be required. And the transformer may be dried while energized.

The time required to remove moisture from a transformer depends largely on the operating temperature. When lightly loaded (low operating temperature), the migration of water from the paper to oil is slow. At higher operating temperatures, the equilibrium between water in paper

and oil shifts to increase water content in oil and the LEX-OCS can remove dissolved water much more effectively. With freshly activated LEX media in each cartridge, the LEX-OCS has the capacity to remove approximately 12.8 kg. of moisture. Referring to Table 1, one can see that a transformer with oil @ 50 PPM and oil volume of 10,000 gallons would contain approximately 1.7 kg. of water in the oil.

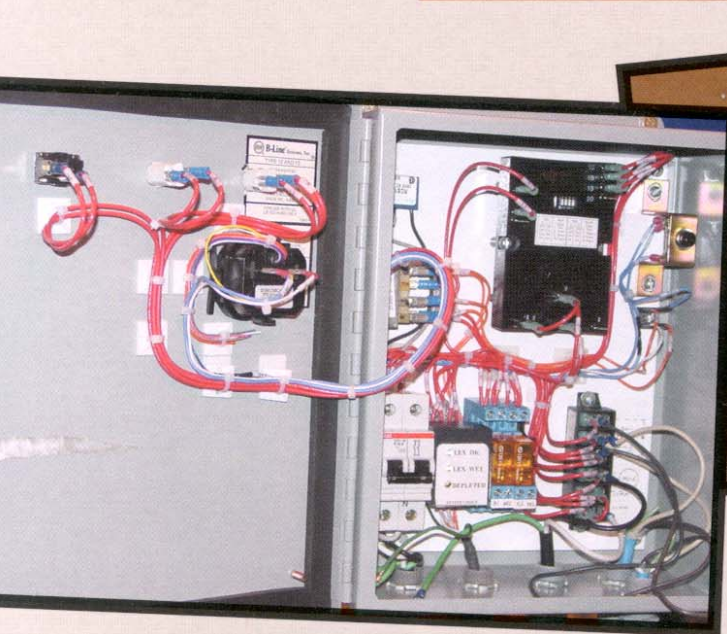
The total amount of moisture in the transformer in this example would depend on the operating temperature and weight of cellulose insulation present in the transformer. Moisture removal time may follow technical Chart 1 and Chart 2. Specific applications can be discussed with LEX ENGINEERING TECHNICIANS.

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**It works for Wisconsin Electric...** “I would like to express Wisconsin Electric’s appreciation to the Zenith Group for drying this transformer for us. Its life has almost certainly been extended. This means WE will have lower costs associated with serving customers and that should translate to smaller increases. Thank You.”

— Paul Ahrens

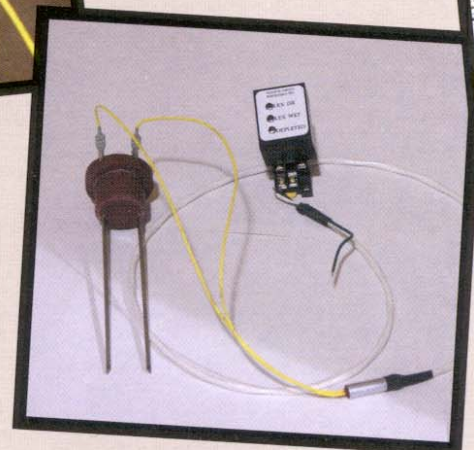
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The LEX-OCS’ versatile, automatic programmable controls permit setting the circulating/time cycle for optimal dry-out. The Hi/Lo pressure switches along with the check valves on the suction and discharge hoses provide protection against leaks or over-pressure and spillage of oil.



Automatic sensor system includes an electrode probe and a potted electronic circuit to monitor the probe signal strength, and alerts the user when the LEX media has been fully saturated with moisture and is ready for replacement. Three (3) LED lights continuously indicate the status of the LEX media. Sensor system can also be monitored remotely via SCADA (or other) data acquisition systems.



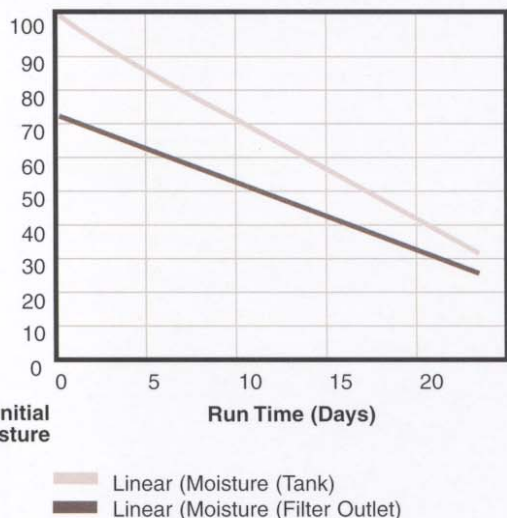
**TABLE 1**

Moisture (PPM by wt.)	10	20	30	40	50
Unit Oil Volume	Grams of Water Dissolved in Oil				
1000 gal	33	67	100	134	167
2000 gal	67	134	201	267	334
3000 gal	100	201	301	401	501
5000 gal	167	334	501	668	836
10000 gal	334	668	1003	1337	1671

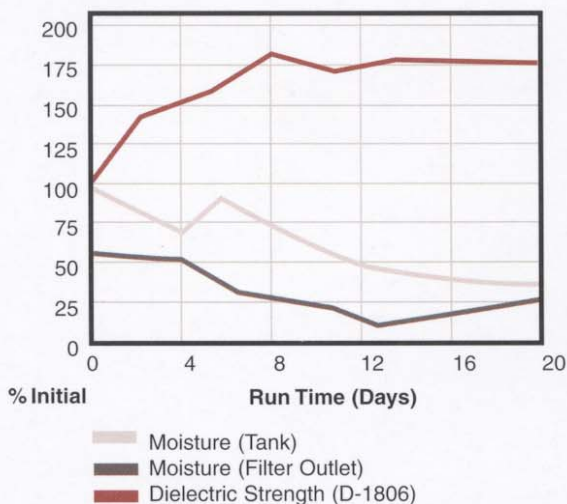
**TABLE 2**

Oil Property	Before Processing	After Processing
Moisture Content	38 PPM	5 PPM
Dielectric Strength	23kV	60kV
Power Factor @ 110°C	1.44	.054
IFT	35.0	38.3
Acid No.	0.014	0.007
DBPC Conc.	0.301	0.301

**CHART 1**



**CHART 2**



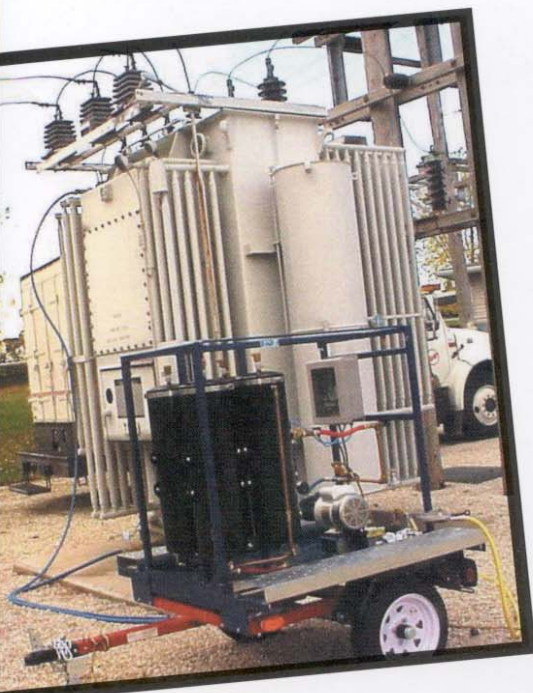
## COMPARE THE ADVANTAGES

- Molecular-sieve-filter media attracts and captures dissolved water molecules
- Safe, non-toxic molecular sieve is easy-to-handle
- LEX media is landfill disposable
- Versatile — programmable, automatic control allows setting circulating time/cycle for optimum drying
- LEX sensor module reduces need to sample and test oil to determine LEX media replacement
- Weather-resistant components assure long, maintenance-free life.
- Less than an hour to install by one operator
- Improves other critical oil attributes (*Table 2*)
- Removes particulate down to 3 micron (with BETA ratio of 75)

### Transformer Dry-Out — Comparison of Processes

(Comparison Scale: 1 to 10 with one being lowest cost and 10 highest cost)

	Heat/Vac Off line	LEX-OCS On line	Other Process On line	Paper Media On line	Heat/Vac On line
Investment \$	10	1	1	1	9
Energy \$	10	1	4	4	10
Outage \$	10	N/A	N/A	N/A	N/A
Oil Sampling Testing \$	9	1	6	6	9
Moisture Removal \$	10	1	9	9	10
Labor \$	10	1	4	4	10



The system suction line is attached to the transformer bottom drain valve and oil is returned from the LEX-OCS to the top fill valve. Four (4) molecular sieve cartridges are connected in series. Activated molecular media (LEX) reconditions the oil and reduces moisture to <10 PPM in a typical medium-power transformer depending on moisture level at the start. The LEX media can remove 3.2 kg. of water per cartridge or 12.8 kilograms total before the LEX media needs changing.

# LEX-OCS Specifications

- 120 V AC 10 Amps
- Programmable Controls — mounted NEMA 4 Enclosure  
4 "ON" times: 1 day, 2 day, 5 day, 10 day  
4 "CYCLE" times: 2 day, 4 day, 10 day, 20 day
- Hi-Low pressure switches with check valves on suction and discharge hoses for protection against leaks and over-pressures
- Pump is heavy-duty rotary gear rated at 2.0 GPM with 1/3 HP, 1140 RPM TEFC outdoor electric motor.
- Automatic air bleeders on each housing for air removal on start up
- Visual oil flow indicator
- Operates at very low noise level (<60 DbA)
- Conveniently located oil sample valves (inlet and outlet).
- Conveniently mounted on 40" X 48" utility trailer for ease of highway transport and positioning at the substation transformer
- Non-slip, safety-tread platforms for operator safety and ease of basket replacement
- Dimensions - LEX-OCS without trailer W28" x L48" x H45"
- Weight approximately 500 lb. (227 Kg.)
- Self-contained residual oil storage reservoir for ease of media basket change-out. No oil loss or spillage; no additional oil handling required, as piping and pump are designed to return oil to transformer after change-out.
- System base designed with 2" lip to contain any minor leaks or oil spillage during media basket change-out.
- Heavy Duty Environmental Cover
- LEX media sensor continuously monitors media condition and indicate/signal when to change media with no need for oil sampling and testing.

## Optional Spare Parts

- 3/4" Heavy Duty hose, 15'
- 1/2" Heavy Duty discharge hose, 25'
- Standard unit ships with 40" x 48" utility trailer (may omit)
- Transformer drain and fill valve adapter fittings kit
- 3/4" and 1/2" Quick Disconnects
- Positive Displacement Pump, 2.0 GPM w/ internal pressure relief
- Spin on final particle filter 3 micron with BETA ratio of 75
- LEX Media Oil Conditioning Baskets — activated, sold in sets of four (4)

## Determine optimum run/cycle with easy-to-use software program

Computer Dry-Out Calculation Program (on floppy disk) provides all the necessary calculations for the set up and operation of the LEX-OCS transformer dry-out process.

Step-by-step program determines how much moisture to remove, to meet desired final conditions and how many LEX media cartridges are required to complete the transformer dry out.

### Sample Transformer Dry-Out Calculations

Unit Information	LEX-OCS-1 Transformer Dryout Calculations					
	BoxElder	Average Oil Temp	Moisture in Paper (%)	Equilibrium Moisture in Paper (kg)	Equilibrium Moisture in Oil (kg)	Moisture to be Removed (kg)
MVA	15/20/25	60	3.91	87.91	0.73	65.95
C & C Weight						
BIL	550					
<b>INPUT: Oil Volume (gal)</b>	<b>5460</b>					
<b>INPUT: Insulation Weight (kg)</b>	<b>2250</b>					
<b>INPUT: Top Oil Temp</b>	<b>65</b>					
<b>INPUT: Bottom Oil Temp</b>	<b>55</b>					
<b>INPUT: Moisture (Oil) (PPM)</b>	<b>40</b>					
<b>INPUT: Nominal Final Conditions</b>						
Oil in PPM	10.00					
Paper in Percent	1.00					
Time for 1 Turn (Hours)	51					
Run Time (days)	6					
Cycle Time (days)	13					
Moisture to be Removed (kg)	66					
Number of Cartridges	22					
Number of Set Changes	5					
Remaining Water (kg) (in oil)	0.18					
Remaining Water (kg) (in paper)	22.50					

**Information needed to determine dry-out calculations**

- Input Oil Volume in Gallons (Required)
- Input Insulation Weight in kgs (If Known\*)
- Input Top Oil Temperature (°C) (Required)
- Input Bottom Oil Temperature (°C) (If Known\*)
- Input Moisture in Oil (PPM) Required
- Input Final Conditions Desired

\* If unknown, program uses 3300 designs to determine insulation weight.



# LEX ENGINEERING D I V I S I O N

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