

Moisture is the enemy.

DryKeep[®] is the answer.



DryKeep[®] USA

**Power Transformer
Dry-out System
With SMART^{*}
Dehydration Control**

**Scada Monitoring Analysis and Reporting
Technology*

Fully complies with IEEE standard C57-140-2006, 7.2



Introduction

With immediate savings on maintenance costs and the ability to extend the life of any transformer, DryKeep® offers a positive return on investment.

The primary function of DryKeep® is to remove moisture from the oil and paper insulation to cost-effectively and efficiently improve the health, reliability, and performance of your most critical asset—the power transformer.

Several factors shape the life expectancy of a transformer. Excessive moisture in the solid and liquid insulations can significantly reduce the dielectric strength and partial discharge inception level. Moisture in the solid insulation also has a profound effect on the aging rate. For this reason, the reduction and prevention of moisture increase in power transformers has captured the attention of all involved in asset management. According to industry experts **“The life of a transformer**

is equal to the life of its insulation”.

Traditional transformer moisture maintenance by utilities is mostly reactive. **The use of portable units to dry out the oil, and hopefully the cellulose insulation, is a temporary solution at best.** After removal of a portable unit, moisture will once again build up in the transformer. It can be very difficult to explain to asset managers the considerable expenditure and **waste of maintenance dollars on a temporary, reactive solution.**

Repeated use of portable units requires the expensive allocation of time and personnel to address a problem that has already occurred rather than preempting it. **The damage to the insulation caused by the presence of this moisture is irreversible.** Insulation aging reduction must be a driving permanent consideration rather than a short term reactive solution. **DryKeep® performs this function on an ongoing, proactive basis, effectively slowing the aging process.**



Condition based maintenance with DryKeep® can extend the operational life of a power transformer by years.

Continuous on-line monitoring gives a reliable and real-time picture of the moisture levels in the oil under actual operating conditions. It also has a significant advantage over having to take individual moisture samples on a periodic basis. DryKeep® insures an immediate positive return on investment and allows utilities to track maintenance based on real-time conditions rather than relying on the results obtained from occasional routine testing.

DryKeep® offers a proactive solution that not only removes moisture that has previously accumulated, but also continuously keeps the cellulose insulation dry.

Application of the DryKeep® System

Installing DryKeep® on all of your power transformers will continuously reduce the moisture from the oil and cellulose insulation. The benefits of this proactive, cost-effective strategy include:

- 1) Slowing of the aging of the transformer.
- 2) Increasing the dielectric strength of the insulation system.
- 3) Increasing service reliability and safety.
- 4) Lowering maintenance costs and capital requirements.



New Transformers

After manufacture, the total moisture content in new transformers is typically stated by the manufacturer to be less than 0.5%. **Installing DryKeep® on all new transformers will ensure the moisture content remains at the factory-level and eliminate the irreversible, detrimental effects of allowing moisture to build up in the insulation system.**



Repaired Transformers

After a major overhaul in a workshop and undergoing a vapor-phase treatment, the moisture content of a repaired transformer is similar to that of a new transformer ($\geq 0.5\%$). Therefore, the application is the same as for new transformers.



Older In-Service Transformers

Transformers, regardless of age, should be fitted with DryKeep® to reduce the moisture in the transformer and eliminate future moisture buildup. Transformers that have been in service for many years typically have high moisture content greater than 2%. The objective is to reduce the moisture content of the paper insulation to an acceptable level and maintain that level. This will substantially increase the life of the transformer. A transformer should be assessed to determine the existing total moisture content. A moisture reduction plan can then be established. The SMART DryKeep® system implements and manages the moisture reduction plan.



Out of Service Transformers

Off-line transformers should be kept free from moisture formed through condensation during normal ambient temperature cycles. When the transformer is returned to service, the oil must be dry and capable of handling the electrical stresses of loading. DryKeep® is an obvious solution.



Storage Tanks Containing Transformer Oil

Installation of DryKeep® is recommended to reduce moisture content in tanks containing high levels of moisture ($>2\%$), eliminate buildup and maintain a low moisture content.

Smart Grid Application of the DryKeep® System

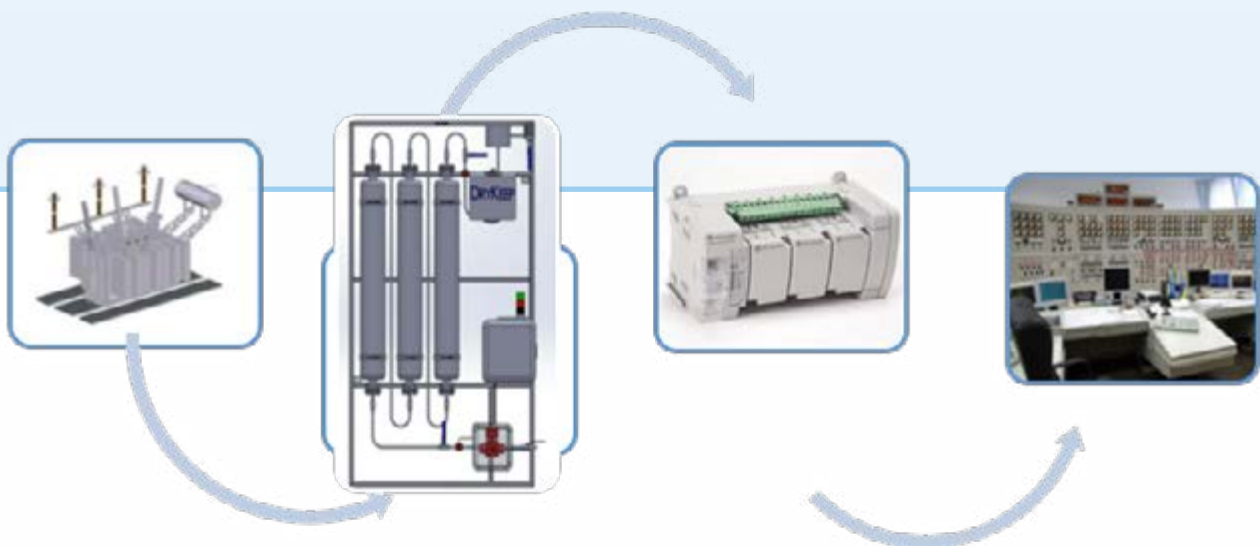
All DryKeep® SMART (**S**CADA **M**onitoring **A**nalysis and **R**eporting **T**echnology) systems include permanently installed moisture-in-oil sensors and a flow rate monitor that feed data to an intelligent controller. The intelligent controller monitors and controls the dehydration process while logging all moisture-in-oil, estimated moisture in the paper insulation and oil temperature data. A built-in RTU provides remote access to all real-time and logged data, alarms, and control of the system thru cellular, VPN, Ethernet, fiber, and/or SCADA with:

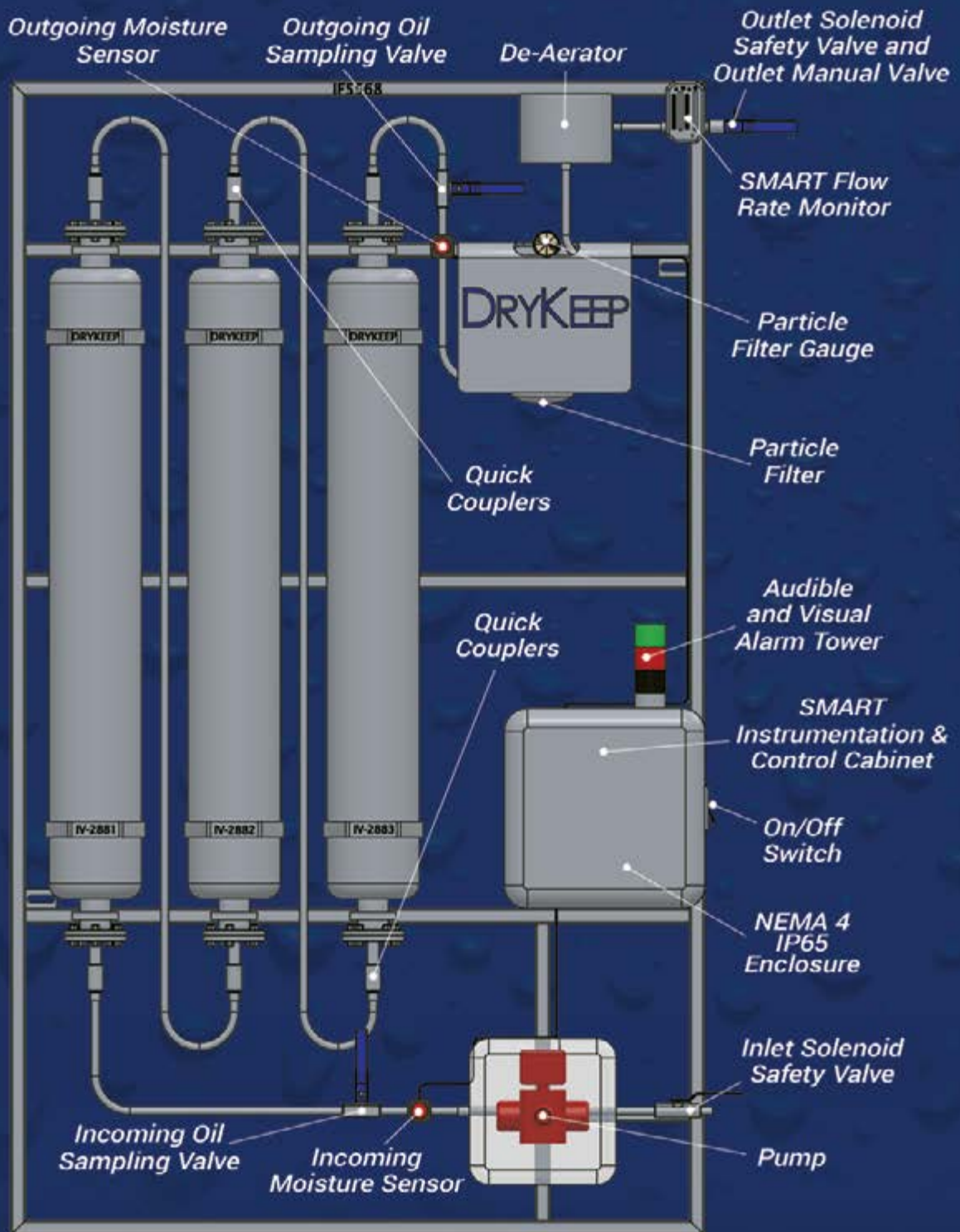
- DNP3 – Slave SCADA and MODBUS RTU/TCP/ASCII/RTU protocols.
- Cellular alarming with multi-carrier 4G LTE support with 3G/2G fallback.
- RJ45 Ethernet ports, 62.5/125 um (SC) Multimode Fiber Converter.
- Cellular VPN for remote system monitoring, control and reporting.

A permanently installed SMART DryKeep® on-line monitoring system offers a timely cost-efficient maintenance procedure for power transformers.

A SMART DryKeep® system allows the user to remotely monitor moisture content and temperature of the insulating oil on a real-time basis without having to take individual oil samples. Moisture is always in a dynamic state, migrating between oil and cellulose insulation. A moisture reading from an oil sample taken at a single point in time may not be typical. These variable factors can provide a false sense of reliability and consistency when taking individual samples for Karl Fischer testing. In addition, oil samples can easily become contaminated if the sampling instructions are not strictly followed. **The SMART DryKeep® continuous on-line monitoring system eliminates these variables.**

Permanently installed sensors provide a repeatable engineering-based process that continuously measures the water content and temperature of the oil. The data is transmitted via two analog 4-20 mA channels, is shown in real-time on the controller display screen (HMI), is logged and graphed on the trending screens, and can be sent through the user's SCADA system.





The DryKeep® Dry-Out Process

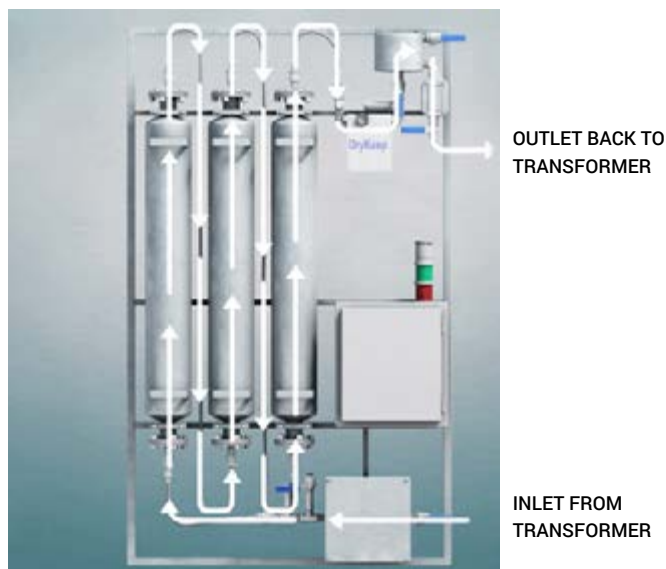
The system is unique in that unlike other drying techniques, the moisture removed cannot be released back into the oil under normal service temperature changes nor can it freeze under severe cold ambient conditions as the adsorbent material can only release the moisture when heated to 180° C.

(Class B).

DryKeep® is a safe solution to the problem of moisture in transformers. DryKeep® is simple to install, operate and maintain, and possess no risk to the transformer. Transformer oil is drawn from the bottom of the main transformer tank, circulated through the DryKeep® system, and returned dry back to the top of the main transformer tank by a 110/220/115/230 volt, 50/60Hz, TEFC external gear, positive displacement pump and remains at the same temperature and pressure conditions as the transformer. There are no pressure hazards as the pump is self-limiting and the system input and output are connected to the transformer which is exposed to ambient atmospheric pressure. DryKeep® is supplied pre-filled with Naphthenic transformer oil that fully complies with ASTM D-3487 Type II, Doble TOPS-884 Inhibited Type II, BS 148:1984 Class IIA (Inhibited), IEC 60296 Class IIA (Inhibited), and CAN/CSA-C50-08 Type II

The SMART flow indicator constantly monitors for leaks. If a leak were to occur, the SMART controller will immediately shut the pump motor down, the inlet and outlet solenoid safety valves will close to completely isolate DryKeep® from the transformer, and the red stack light will illuminate and flash to indicate a call to action. A "Low Oil Flow Detected" alarm will display on the HMI display screen. The Low Flow Detected alarm can also be received through the customer's SCADA system and via email or SMS directly to the appropriate personnel's mobile device.

Each cylinder contains a high-technology molecular sieve adsorbent material designed to remove the dissolved water from the oil. DryKeep® molecular sieve beads combine the highly selective adsorption properties of Zeolites with high mechanical integrity due to advanced manufacturing and de-dusting technologies. After synthesis, each Zeolite crystal is only a few microns across. To be of use in our fixed bed adsorption processes, it is necessary to form particles in a specific diameter. Expertise in molecular sieve beading has led to the optimized bead properties used in the DryKeep® system. Special binders are applied to the beads giving our molecular sieves a high stability against contaminants in the feed stream, thus allowing a long unit lifetime.



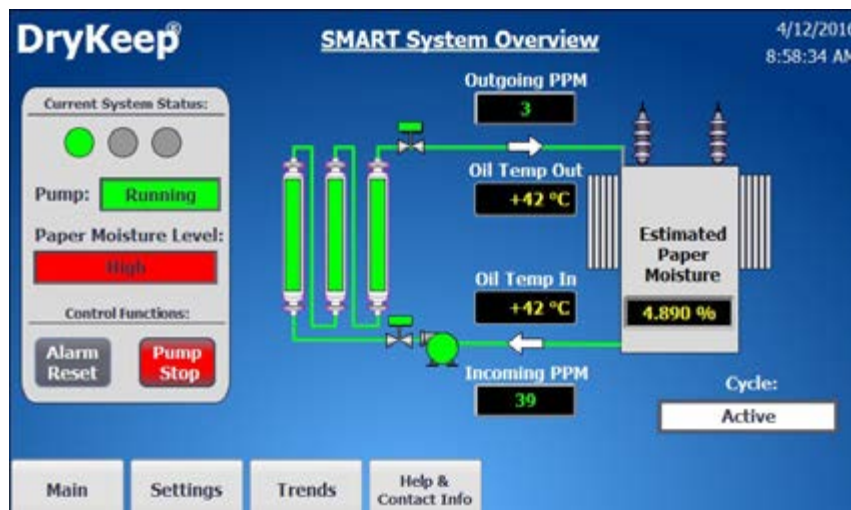
Dissolved Gas Analysis (DGA) is widely used as one of the tools to carry out condition monitoring on transformers and has become a useful early warning system to eliminate catastrophic failure.

To ensure the integrity of DGA trending, the molecular sieve beads in the DryKeep® cylinders are carefully selected for their preferential bonding with water molecules while excluding bonding with gas molecules.

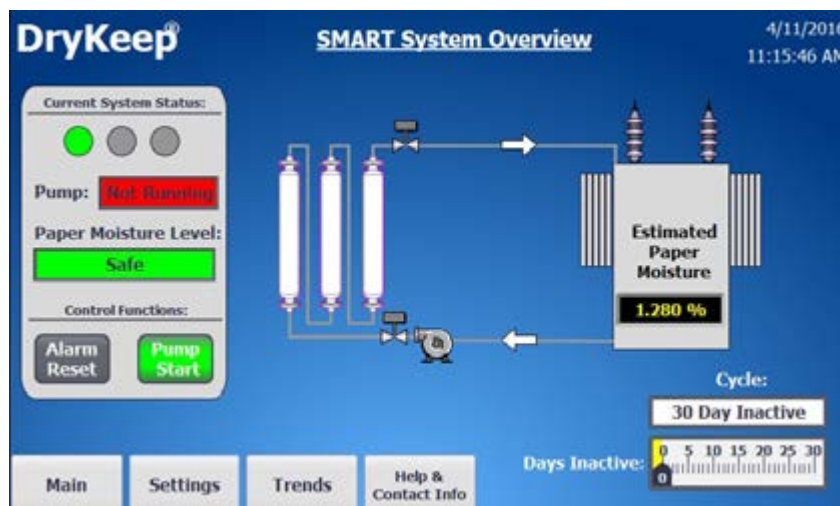
During the development of the DryKeep® system, Eskom Research Institution (TSI) carried out an investigation on transformers ranging in size from 40 MVA to 500 MVA to determine if DryKeep® had any appreciable effect on the interpretation of the DGA. Their conclusion stated that for a continuously gassing transformer, the action of the DryKeep® can never mask the generation of gas and will not significantly affect a trending analysis of gas production rates.

The SMART DryKeep® Monitoring System

To monitor and regulate the dry-out process, all SMART DryKeep® units include permanently installed moisture-in-oil sensors near the inlet and outlet of the system. The sensors monitor the oil temperature and the moisture in oil coming into and leaving the DryKeep® system. Sensor information is sent to the SMART DryKeep® controller and using proprietary algorithms, the controller calculates an estimated percentage of moisture in the paper. A 7-inch touch operated color LCD screen (HMI) is provided to view system status and real-time moisture and temperature values under actual transformer operating conditions since the transformer remains energized.



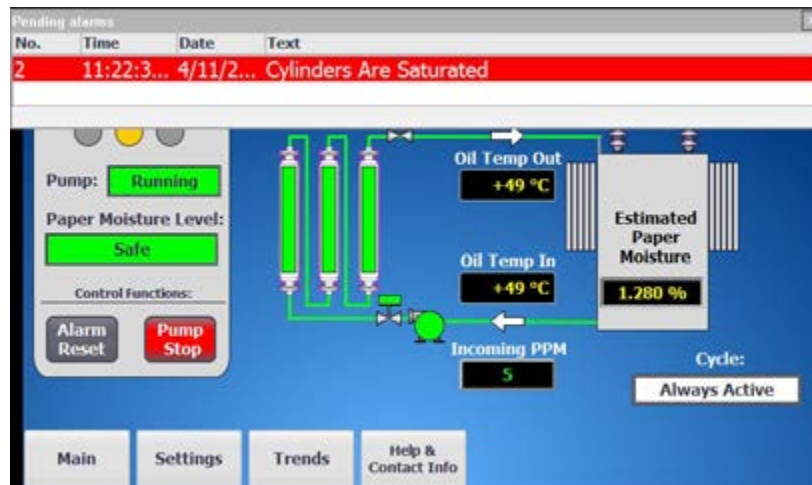
The HMI displays the estimated percent moisture in paper, incoming and outgoing moisture-in-oil in parts per million, oil temperature (F or C), system status, current process cycle, alarms, pump status, and flow integrity. For transformers that were already in-service before DryKeep® was installed, the controller will determine whether the pump motor should be on or off based on the calculated estimated percent moisture in paper to prevent over-drying. Once the safe estimated percent moisture in paper level is reached, the controller will cycle the pump motor off for 30 days.



The SMART DryKeep® Monitoring System

After the 30 day inactive cycle, the controller will restart the pump motor and evaluate whether the system should stay active or go back to inactive based on the estimated percent moisture in paper. Regardless of the pump motor status, the green light will remain solidly lit to show the system is operating correctly.

The controller constantly compares the incoming PPMs at the inlet to the outgoing PPMs from the outlet. When the outgoing PPMs converges with the incoming PPMs, the HMI will show an alarm signaling that the cylinders are saturated and the amber stack light will illuminate. The saturated cylinder alarm can also be received through the customer's SCADA system and via email or SMS directly to the appropriate personnel's mobile device.

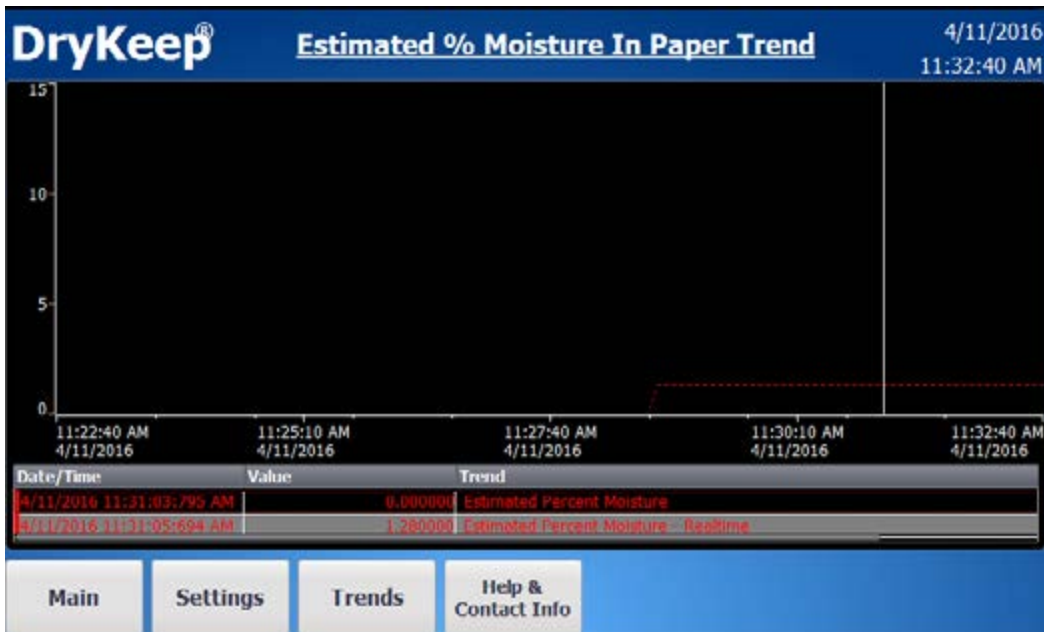
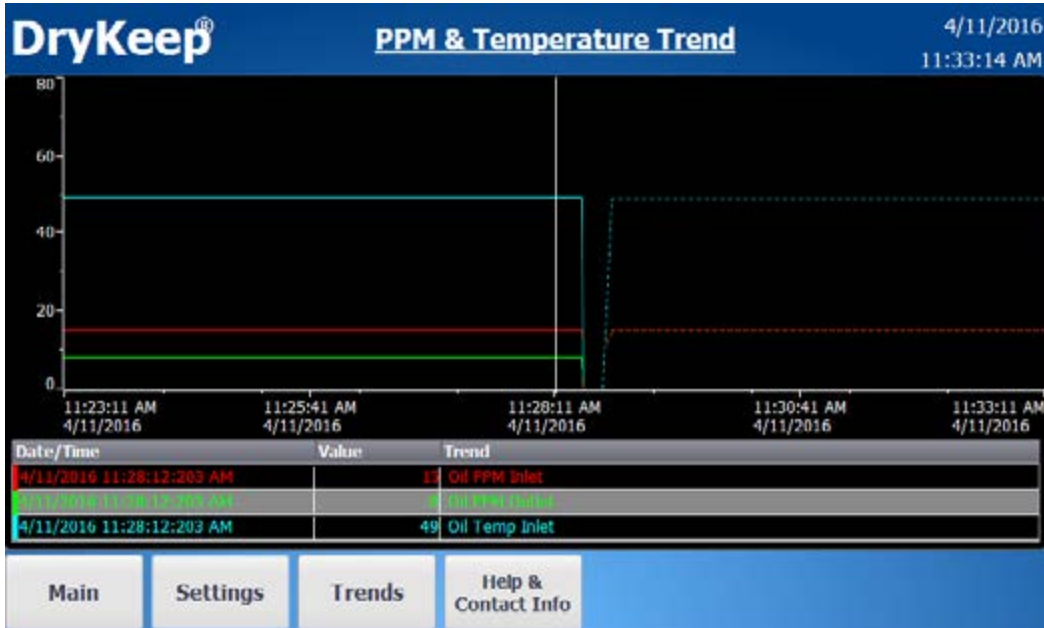


A stainless steel variable flow rate indicator constantly measures the oil flow for leaks and any drop in flow rate. If the flow indicator senses a potential leak, the controller will immediately shut the pump motor down, and the inlet and outlet solenoid safety valves will close to completely isolate DryKeep® from the transformer. The red stack light will illuminate and flash to indicate a call to action. A "Low Oil Flow Detected" alarm will display on the HMI. The Low Flow Detected alarm can be received through the customer's SCADA system and via email and or SMS directly to the appropriate personnel's mobile device. DryKeep® normally shares the same safety envelope as the transformer as it is usually installed onto or adjacent to the transformer.



The SMART DryKeep® Monitoring System

Real-time and historical trend analysis is provided with a “PPM and Temperature” and “Estimated Percent Moisture in Paper” graphs.



PPM and temperature values are logged every fifteen (15) minutes. Estimated percent moisture in the paper is logged once a day. All logged data can easily be downloaded to a laptop in .CSV format through the RJ45 Ethernet Panel Interface Connector mounted on the outside of the enclosure.

DryKeep® System Description

DryKeep® is suitable for any size transformer and has been successfully installed on transformers up to 1000mVA. All DryKeep® systems fully comply with IEEE Standard C57-140-2006, section 7.2 and are manufactured in the USA under ISO 9001 quality management. Two sizes are available depending on the MVA rating of the transformer. Recommended selection criteria is as follows:

SYSTEMS:	# OF CYLINDERS	TRANSFORMER SIZE	MINIMUM H2O REMOVAL
RT-3	1	LESS THAN 10 MVA	3 LITERS
RT-9	3	10 MVA AND LARGER	9 LITERS

The RT-3 and RT-9 models are assembled on similar frames and the installation instructions are similar.

All SMART DryKeep® systems feature:

- a) Two (2) permanent moisture-in-oil and oil temperature sensors.
- b) Flow switch for automatic leak detection and shutdown.
- c) Solenoid safety isolation valves at the system inlet and outlet to isolate DryKeep® from the transformer in the unlikely event of a leak.
- d) Deaerator tank with oil bleed valve and hose to remove any oxygen in the system.
- e) One (1) or three (3) regeneratable adsorption cylinders each capable of adsorbing a minimum 3 liters, maximum 4.2 liters of moisture before saturation with TD 1049 cork compounded with Nitrile (NBR) rubber cylinder gaskets suited for mineral and silicone oil according to ASTM D3455 "Test Methods for Compatibility of Construction Materials with Electrical Insulating Oil of Petroleum Origin" and ASTM D5282 "Test Methods for Compatibility of Construction Materials with Silicone Fluid used for Electrical Insulation".
- f) Static dissipative core tube, 304 stainless steel braided, PTFE hoses between cylinders to SAE 100R14B standard.
- g) 7" color touchscreen HMI with 12MB on-board data, 4GB Micro SD card for data logging, and 2 USB ports.
- h) SMART Server license for remote viewing and operation via VPN connection.
- i) Built-in RTU for remote access thru cellular, VPN, Ethernet, fiber, and/or SCADA with:
 - DNP3 – Slave SCADA and MODBUS RTU/TCP/ASCII/RTU protocols.
 - Cellular alarming with multi-carrier 4G LTE support with 3G/2G fallback.
 - RJ45 Ethernet ports, 62.5/125 um (SC) Multimode Fiber Converter.
 - Cellular VPN for remote system monitoring, control and reporting.
- j) Visual, SCADA, and cellular alarm/signaling for leak detection, cylinder saturation, and AC power restoration.
- k) 0.33HP, 110/220/115/230 V, 50/60Hz, TEFC external gear, Frame 56C, positive displacement pump with Viton lip seal, Viton O-Ring gaskets, and 150PSI relief valve pressure setting for a maximum pumping height of 100 feet at nominal capacity rating of 0.6/0.7 GPM (2.27/2.65 LPM).
- l) Stainless steel frame, cylinders, valves, and hardware. Unit is of substation quality durability.
- m) Hydraulic quick couplers with thread-actuated chrome alloy ball valves for easy saturated cylinder removal and change-out while transformer remains energized.
- n) 24VDC power supply for sensors and control cabinet components.
- o) RJ45 Ethernet Panel Interface Connector on deadfront panel of controller enclosure to permit downloading of logged data.
- p) 1-micron particle filter with visual status indicator.
- q) Two (2) oil sampling ports.
- r) Ultra wide-band 2G/3G/4G LTE/Cellular/CDMA and Wi-Fi antenna for 2G/3G/4G applications.

Available Products

The standard RT-3 and RT-9 are supplied with the SMART instrumentation and control package.

Catalog Number DryKeep SMART RT-9



Catalog Number DryKeep SMART RT-3

The SMART RT-3 is identical in features to the SMART RT-9. The only difference being it is a single cylinder model for use on transformers below 10mVA.



- ✓ Three (3) cylinder continuous transformer dehydration and moisture monitoring system with SCADA-ready SMART controller monitoring, control, alarming, and reporting system for transformers rated 10MVA or above. System will dry the main tank oil while the transformer is in-service. Each cylinder can capture a minimum of 3, maximum of 4.2 liters of moisture before saturation and regeneration is required.
- ✓ Built-in cellular RTU with DNP3 – Slave SCADA and MODBUS RTU/TCP/ASCII/RTU protocols, RJ45 Ethernet ports and 62.5/125 um (SC) Multimode Fiber Converter for SCADA connections. Cellular alarming via SMS or email with multi-carrier 4G LTE support with 3G/2G fallback. Cellular VPN for remote system monitoring, control and reporting.
- ✓ Two (2) permanent moisture-in oil and oil temperature sensors provide real-time oil analysis.
- ✓ 7" color touchscreen HMI with 12MB on-board data, 4GB Micro SD card for data logging, and 2 USB ports.
- ✓ Trending screens for real-time and historical data analysis.
- ✓ Visual, SCADA, and cellular alarm/signaling for leak detection, cylinder saturation, AC power loss (requires optional UPS backup system), AC power restoration, and low battery (requires optional UPS backup system).
- ✓ Inlet & outlet solenoid safety shutoff valves automatically isolate DryKeep® from the transformer in the event of a leak, drop in oil flow, or power loss.
- ✓ 0.33HP, 110/220/115/230 V, 50/60Hz, TEFC external gear, Frame 56C, positive displacement pump with Viton lip seal, Viton O-Ring gaskets, and 150PSI relief valve pressure setting for a maximum pumping height of 100 feet at nominal capacity rating of 0.6/0.7 GPM (2.27/2.65 LPM).
- ✓ All metal parts are of stainless steel construction and unit is of substation quality durability.
- ✓ Hydraulic quick couplers allow for fast and simple saturated cylinder change-outs while transformer remains energized.
- ✓ Integral DC power supply for controller, RTU, sensors, and HMI display screen. All controller, communication, and protection devices are enclosed in a padlockable NEMA 4– IP65 enclosure.
- ✓ RJ45 Ethernet Panel Interface Connector on deadfront panel of controller enclosure to permit downloading of logged data..
- ✓ 1-micron particle filter with visual status indicator.
- ✓ Two oil sampling ports.

Available Products

Catalog Number DryKeep RT-9



Catalog Number DryKeep RT-3

The RT-3 is identical in features to the RT-9. The only difference being it is a single cylinder model for use on transformers below 10mVA.



- ✓ Three (3) cylinder continuous transformer dehydration and moisture management system for transformers rated 10mVA and larger. System will dry the main tank oil while the transformer is in-service. Each cylinder can capture a minimum of 3 liters of moisture before saturation and regeneration is required.
- ✓ 0.33HP, 110/220/115/230 V, 50/60Hz, TEFC external gear, Frame 56C, positive displacement pump with Viton lip seal, Viton O-Ring gaskets, and 150PSI relief valve pressure setting for a maximum pumping height of 100 feet at nominal capacity rating of 0.6/0.7 GPM (2.27/2.65 LPM).
- ✓ All metal parts are of stainless steel construction and unit is of substation quality durability.
- ✓ Hydraulic quick couplers allow for fast and simple saturated cylinder change-outs while transformer remains energized.
- ✓ 1-micron particle filter with visual status indicator.
- ✓ Bypass valves/oil sampling ports provided at both the inlet and outlet so system is capable of incorporating on-line monitoring of temperature and moisture in oil and allows for oil sampling.
- ✓ Visual oil flow indicator.
- ✓ De-aerator with air bleed valve. ISO-9001.
- ✓ Complies with IEEE standard C57-140-2006, 7.2.
- ✓ Made in USA

Optional Products



Installation Kit Two (2) stainless steel transformer valve flange adapters to customer's provided dimensions. Two (2) 0.44" O.D. static dissipative core tube, 304 stainless steel braided, PTFE hoses to SAE 100R14B standard with all necessary unions, bushings, and hardware for hose connections to connect DryKeep® inlet and outlet valves to the transformer.



Backup Power Supply 24VDC UPS System with two (2) 6-cell, 12VDC, 12.0 AH, rechargeable, sealed, lead acid batteries connecting in series, 24VDC, 10 A uninterruptible power supply, battery below < 85% alarm.



Spare Cylinders New and unused, for all DryKeep® SMART and Basic systems. Factory-filled with the precise amount of proprietary sized and coated synthetic zeolite (sodium aluminosilicate) adsorbent capable of adsorbing a minimum of 3 liters and maximum of 4.2 liters of moisture before saturation. TD 1049 cork compounded with Nitrile (NBR) rubber cylinder gaskets suited for mineral and silicone oil according to ASTM D3455 "Test Methods for Compatibility of Construction Materials with Electrical Insulating Oil of Petroleum Origin" and ASTM D5282 "Test Methods for Compatibility of Construction Materials with Silicone Fluid used for Electrical Insulation". Hydraulic quick couplers with thread-actuated chrome alloy ball valves for easy saturated cylinder removal and sealing. Factory-filled with severely hydrotreated naphthenic transformer oil that fully complies with ANSI / ASTM D-3487 Type II, Doble TOPS-884 Inhibited Type II, BS 148:1984 Class IIA (Inhibited), CAN/CSA-C50-08 Type II (Class B), NEMA TR-P8-1975.

Free-standing climate controlled enclosure for extreme temperature environments

Where environmental operating temperatures may fall below 0°C, an optional 90" x 60" x 20" NEMA 4 double-door free-standing enclosure made of 12 gauge steel is available. Enclosure includes a 17" x 11" Lexan viewing window on the right door. Enclosure is UL Listed Type Rating 4, CSA Certified Type Rating 4. The DryKeep® frame is mounted to horizontal Unistruts welded on the rear of the enclosure. A climate control package is mounted on the left side to control the temperature inside the enclosure. The SMART unit stack light system is mounted on top of enclosure.



Onsite Installations



Installation Information

The DryKeep® RT-3 and RT-9 systems are shipped filled with oil and fully assembled on the framework along with all components. The installation is fairly easy. An optional installation kit containing flexible hoses, flange adapters and fittings to connect to the transformer at the inlet and outlet is available. Contact DryKeep® USA for details. **For detailed installation instructions, please refer to our website DryKeep.com**

SAFETY NOTE: It is recommended that the transformer be de-energized when installing the DryKeep® system. Once installed, DryKeep® operates while the transformer remains energized. The replacement of the saturated cylinders can also be performed while the transformer is energized.

Operation and Maintenance

The DryKeep® frame, cylinders, de-aerator and pipe-work are 300 series stainless steel to insure minimal maintenance. Static dissipative PTFE stainless steel braided hoses prevent electrostatic potential. Once the system is in operation, only periodic inspection is required to check normal operation of the system. Oil flow rate (leak protection) and cylinder saturation status are all monitored by the SMART DryKeep® and all data is available through the user's SCADA to ensure ultimate reliability. **For detailed operations and maintenance, refer to our website DryKeep.com**

Saturation of Cylinders and Replacement

Oil sampling for moisture content is not required with the SMART DryKeep® as the built-in moisture sensors continuously monitor the parts per million moisture in the oil and display the PPM values on the HMI screen. PPM and incoming oil temperature are plotted on the PPM and Temperature Trend graph screen and are logged for historical data retrieval and analysis. When the input and output PPM readings show roughly the same value, the cylinders have reached the saturation point and need to be regenerated. The HMI will show an alarm signaling that the cylinders are saturated and the amber stack light will illuminate. The saturated cylinder alarm can be received through the customer's SCADA system and via email or SMS directly to the appropriate personnel's mobile device. The pump will remain on even if the cylinders are saturated as the unique adsorbent material used in DryKeep® cannot return any moisture that has been captured. **For detailed instructions on cylinder replacement, please refer to our website DryKeep.com**

Other methods of measuring the moisture content in the oil utilizing our supplied sample ports include:

- Karl Fischer titration testing comparing oil samples taken from the DryKeep® inlet and outlet oil sampling valves, or
- Portable moisture sensors such as the Doble Domino USS or Vaisala MM70 at the inlet and outlet oil sampling valves.

Warranty

The warranty is valid for a period of twelve months from the date of installation or eighteen months from the date of shipment, whichever is the earlier.

DryKeep[®] USA

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For more info, visit us at **DryKeep.com**