SDMyers ACTS 4:12

Ten Years of Transformer Life Extension

A Field Validation of InsulMax®





SDMyers
180 South Avenue
Tallmadge, OH 44278
(330) 630-7000

sdmyers.com

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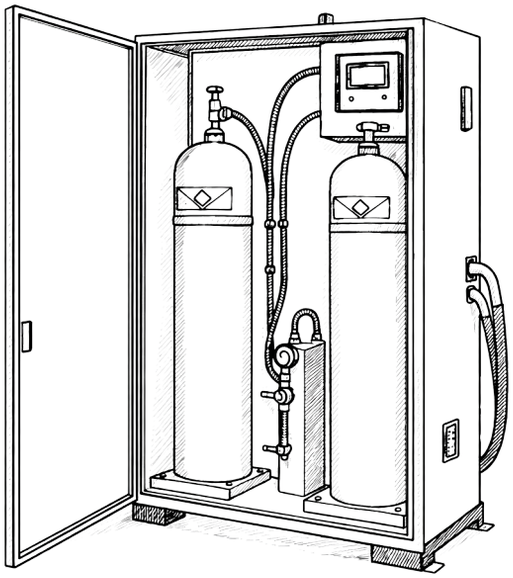
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Executive Summary

CASE STUDY

InsulMax®

Substation-Grade
Oil Purification System



Four critical power transformers—two generator step-up units (GSUs) and two auxiliary transformers, each 30–50 years old—were selected for a long-term InsulMax® life-extension program. Over 10 years of annual monitoring, every aging-related oil quality metric either held steady or improved, validating InsulMax as a proven strategy to maximize transformer reliability and extend asset life.

10
Years of Continuous Field Data

4
Critical Power Transformers Monitored

3x
Potential Life Extension vs. Unprotected Units

2.5
Average Years Per Filter Column Exchange for Each Transformer

This case study documents the results (the data, the economics, and the engineering rationale) for engineers, asset managers, and owners who prioritize the long-term resiliency and reliability of their critical infrastructure.

Background

The Problem: Moisture and Oxygen Are the Primary Drivers of Transformer Aging

Industry experts and published technical guides (IEEE and IEC, for example) agree that aging and reliability in liquid-filled transformers are affected by factors such as heat, moisture, and oxidation byproducts. By the nature of power transformers, heat is always present, but aging from oxidation and moisture is controllable. Transformers don't simply wear out. They reach end of life when their cellulose (paper) insulation can no longer withstand the mechanical and electrical stresses of operation.

InsulMax® uses a patented process to do four (4) important things to control the primary drivers of transformer aging:

01 Moisture Reduction

InsulMax reduces moisture and keeps it at the lowest measurable levels—well under IEEE limits in both ppm and % relative saturation, which relates to an ideal 0.5% moisture by dry weight.

02 Acidic Byproduct Removal

Large power transformers use oil preservation systems to reduce atmospheric gas ingress, but heat, oxygen, and moisture can still cause oxidation. InsulMax filters out acidic byproducts from the mineral oil, helping to protect insulation and extend its lifespan.

03 Particle Filtration

InsulMax filters particles to the 2–5-micron level and, in the absence of moisture, maintains very high dielectric strength.

04 Hydrogen Monitoring

InsulMax monitors hydrogen, a key combustible gas, which may signal the presence of other combustible gases, particularly in fast-acting faults. Its patented inline hydrogen gas monitor reports levels directly to your Transformer Dashboard.

Why Moisture Is the #1 Enemy

Industry standards confirm that when the moisture content doubles, insulation life is cut in half. Every year of delayed moisture control costs approximately two years of reliable service. Oil can be reclaimed—but the paper insulation cannot be restored without an expensive rewind.

InsulMax was born from the experience of nearly 1,000 transformers that had the SDMyers DryMax® installed to reduce moisture. DryMax is an online passive dryer, as supported by IEEE C57.140, Section 7, and IEEE C57.162, Section 8. During the drying process, data on oil qualities other than moisture also showed improvement. The concept, including a basic gas sensor, was prototyped into a unit for smaller transformers and received a U.S. patent. These include:

- Acid — ASTM D974
- Interfacial Tension — ASTM D971
- Liquid Power Factor — ASTM D924
- Dielectric Strength — ASTM D1816

In concept and application, InsulMax can be implemented to offset ongoing industry problems associated with electric capacity and reliability in existing assets, as well as limited replacement availability. Most manufacturers' delivery times for larger power units are one to two years. In data mining the results of 950+ service renderings, the difference in oil quality before and after the moisture-reduction service was noteworthy. The units below were typical of all our DryMax installations, in which oil qualities other than moisture noticeably improved. (Note: D1816 data was limited.)

5/5 **INDICATORS** showed improvement

950+ transformers in aggregate data

2,750 gal average oil capacity represented

18,000 kVA average transformer rating

Moisture

% Saturation

56% ▲

BEFORE 25.3 → AFTER 10.9

*IEEE VALUE: N/A

Oxidation byproduct

Acid (Nuetralization Number)

14.3% ▲

BEFORE 0.03 → AFTER 0.02

*IEEE VALUE: 0.03

Oxidation byproduct

IFT (Interfacial Tension)

3.3% ▲

BEFORE 37.8 → AFTER 39.1

*IEEE VALUE: 38.0

Liquid Power Factor

PF 100° C

30.3% ▲

BEFORE 1.14 → AFTER 0.80

*IEEE VALUE: 3.0

Dielectric Breakdown Voltage

D1816 2mm kV

34.0% ▲

BEFORE 36.9 → AFTER 49.6

*IEEE VALUE: 45-55-60

Aggregate oil quality data across 950+ moisture reduction service renderings, demonstrating improvement in aging-related oil quality metrics beyond moisture alone.

**IEEE acceptable values come from C57.106 Table 2.*

IEEE C57.106, *Guide for Acceptance and Maintenance of Insulating Mineral Oil in Electric Equipment*, presents testing limits for new mineral oil received in new equipment or after filling, prior to energization. The effects of online liquid filtration for moisture reduction showed improvement in both moisture and other oil qualities, maintaining or surpassing those 'new oil' limits. This data led to the development of a technology to address the question:

> *Is there a process or piece of equipment that can keep the insulation of a key asset in* ***optimal condition****, thereby advancing the concept of a* ***maintenance-free transformer****?*

Questions were also raised about the metrics above, including whether there are other issues to address to make a unit as close to fully reliable as possible throughout its life. This led to the concept of permanently installing our drying unit on a power transformer to keep these undesirable aging metrics in check.



Technology

HOW IT WORKS:

Four Main Functions. One Always-On System.

InsulMax is an oil purification system permanently installed on a transformer. It is a rugged, substation-grade piece of equipment designed to address the conditions that accelerate aging 24 hours a day, 365 days a year. Unlike periodic service intervals, InsulMax operates continuously. It performs four critical functions:

Moisture Reduction

Maintains moisture at the lowest measurable levels—well under IEEE limits in both ppm and % relative saturation—keeping insulation under prescribed thresholds.

Acidic Byproduct Removal

Filters out acidic oxidation byproducts as they form, preventing accumulation in the insulation paper that drives degradation.

Partical Filtration

Removes particles down to the 2–5 micron level, maintaining very high dielectric strength in conjunction with low moisture.

Hydrogen Monitoring

Monitors hydrogen as a key indicator gas, providing early detection of developing faults before they become failures



Case Study Brief

10-YEAR FIELD VALIDATION:

Critical GSUs & Auxiliary Transformers



The Challenge

The owners of four large, mission-critical transformers — two generator step-up units (GSUs) and two auxiliary power transformers — recognized that these assets were too important to leave to chance. The units were part of a prominent power-generating site. The units ranged in age from 30 to 50 years at the start of the study period. Their oil quality met the new IEEE C57.106 liquid guidelines (Table 2), but the owners wanted them to remain acceptable with the best possible protection for the full remaining life of the assets.

The Solution

InsulMax was permanently installed on each unit. Annual site inspections were conducted with a comprehensive oil testing regimen measuring the following parameters in accordance with ASTM standards:

- Acid Number (ASTM D974)
- Interfacial Tension (ASTM D971)
- Liquid Power Factor (ASTM D924)
- Dielectric Strength (ASTM D1816)
- Hydrogen Content (ASTM D3612C)

Moisture, temperature, and hydrogen gas levels were tracked continuously and posted to Transformer Dashboard to be reviewed monthly by the SDMyers technical team.



GSUs are known to run hot, making them especially susceptible to oxidation, moisture generation, and gassing. The goal was to demonstrate that InsulMax could maintain or improve already acceptable oil quality metrics under real operating conditions over a decade.



The Results

After 10 years of continuous operation, every aging-related metric either held steady or decreased from its already acceptable starting point, as verified by annual testing by SDMyers. The data below represents each metric with average values before and after installation.

In addition to the oil quality values shown in the chart, there was no evidence of a hydrogen-generating fault. Hydrogen levels remained in single digits across all units throughout the study period.

4/4 TRANSFORMERS remained within control or showed improvement

24 MVA	200 MVA	24 MVA	200 MVA
5,900-gallon capacity	16,820-gallon capacity	14,300-gallon capacity	11,500-gallon capacity

Moisture

% Saturation

13% ▲

AVG. BEFORE	AVG. AFTER
5.1 →	5.0

*IEEE VALUE: N/A

Oxidation byproduct

Acid (Nuetralization Number)

27% ▲

AVG. BEFORE	AVG. AFTER
0.03 →	0.02

*IEEE VALUE: 0.03

Oxidation byproduct

IFT (Interfacial Tension)

1% ▲

AVG. BEFORE	AVG. AFTER
40.3 →	40.8

*IEEE VALUE: 38.0

Liquid Power Factor

PF 100° C

4% ▲

AVG. BEFORE	AVG. AFTER
0.37 →	0.33

*IEEE VALUE: 3.0

10-year oil quality data for four critical transformers equipped with InsulMax. Each aging-related metric remained controlled or improved throughout the study period, as verified by annual testing and data transmission. In addition to the oil quality values shown, there was no evidence of a hydrogen-generating fault. Hydrogen for all units remained in single digits.

**IEEE acceptable values come from C57.106 Table 2.*

Key Finding

Over 10 years of monitoring, InsulMax maintained or improved every aging-related oil quality metric across four large, mission-critical power transformers—including units running at elevated temperatures where oxidation risk is highest.

Cost of Ownership

THE ECONOMICS

Low Cost of Ownership—A Financially Justifiable Investment

Long-term field data from the case study units provides a clear picture of InsulMax operating costs:

32 million Gallons Processed

Over 32 million gallons of mineral oil processed with minimal filter changes. Each filter exchange uses patented green technology—which is recycled and reused—producing zero waste.

Filter Longevity

Across four units over 40+ operating years, the filtering columns required minimal total exchanges—averaging roughly one exchange every 2.5 years.

ROI Context

InsulMax has proven to protect large, mission-critical transformer assets that can be valued at $2 million or more. At $300/month, that's less than 0.2% of asset value annually—a fraction of the cost of a single failure event.

Total Cost of Ownership

When amortized over a 50-year asset life, the total cost of ownership (purchase, installation, and maintenance) can run as low as $300 - $500 per month per unit.

The Economics Case in One Line

For less than the cost of a single service call per month, InsulMax delivers continuous moisture control, acid removal, particle filtration, and hydrogen monitoring—protecting a $2M+ asset around the clock.

Applications

Three Ways to Deploy InsulMax®







InsulMax is designed for flexibility across the transformer lifecycle.

01 New Unit at Commissioning (Recommended)

Installing InsulMax at commissioning prevents moisture and oxidation from ever establishing a foothold, offering the maximum compounding benefit and the best-case life extension trajectory.

02 Aging Unit in Acceptable Condition

This is the scenario documented in this case study. Older units in good, but likely not perfect, condition would have InsulMax permanently installed for a slight improvement and to maintain those qualities throughout their life.

03 Remediated Unit

Units that have progressed along the path of oxidation would be addressed with a general service rendering, which may include regasketing, electrical testing, oil reclamation, and corrective maintenance. Then InsulMax is installed permanently to maintain those restored qualities.

Supplementary InsulMax® information and ancillary maintenance factors toward a fully executed program.

While InsulMax stands guard over the metrics shown in the study, there are other facets of a comprehensive maintenance condition that are important:

Equipment design: InsulMax's sealless, magnetically coupled pump has only one (1) moving part and exhibits a very low maintenance cost. The unit has several environmental safeguards and includes outdoor substation-quality construction, powered by a low-amp, 110 V, single-phase service.

Remote monitoring: InsulMax has a cellular connection that monitors operating data, including moisture in, temperature (allowing % saturation to be calculated), moisture out, hydrogen, pump pressure, total run hours, and run hours since the last filter change

Sustainability: InsulMax filtering media is a green technology. Columns are verified as needing service based on transmitted data and then changed. The media is recycled and reused.

Maintenance of aging gaskets: This is a function of age and is a known maintenance procedure often prescribed for radiators and bushings within 30 years.

Electrical Testing: NFPA 70B contains guidance for electrical testing every five (5) years. This testing can discover issues related to a multitude of electrical conditions.

Tap Changers: Some power-transformer issues are not oxidation- or moisture-related. One example is faults associated with the deterioration of the de-energized tap changer. This is a common repair, usually diagnosed by the presence of the combustible gas profile and its trending. It typically involves higher-temperature gases such as acetylene and ethylene. From a physical chemistry standpoint, hydrogen is usually created along with acetylene in a 2:1 ratio. Since installing a multi-combustible gas monitor on economically viable filtering equipment is often prohibitive, a hydrogen sensor was selected to accompany the instrumentation.

Technical Specifications

Weight	1,200 lbs.
Dimensions	36”W x 69”H x 20”D
Construction	Stainless steel cabinet, free-standing, rugged construction
Electrical	10-amp circuit, 120V single-phase power 50ft power cable U.L. listed components
Pump	Magnetically coupled, sealless oil pump
Filters	Recyclable filtering media columns (x2) Patented green technology Discharge 1-micron bag-type filter
Monitors	Hydrogen sensor Temperature monitor Digital and analog pressure monitoring
Connections	Self-sealing, quick-disconnect hydraulic couplings ¾” - 50ft hoses included and rated at 1,000+ psi Inlet and discharge sample ports
Display	Inlet and discharge moisture levels (% Saturation + PPM) Hydrogen gas level (PPM) Pump pressure (PSI) Bottom valve oil temperature (°C) Equipment run status and alarms
Safety	Pressure relief on pump - 60 psi Pressure safety valve on filter column - 75 psi Pressure alarm if pressure exceeds - 50 psi Leak detection with alarm and auto-shutdown Solenoid valve that isolates the transformer in the event of a leak/alarm
Connectivity	Remote VPN cellular monitoring
Support	Technical support and data monitoring by SDMyers 24/7 access to SDMyers Transformer Dashboard®

Conclusion

InsulMax®

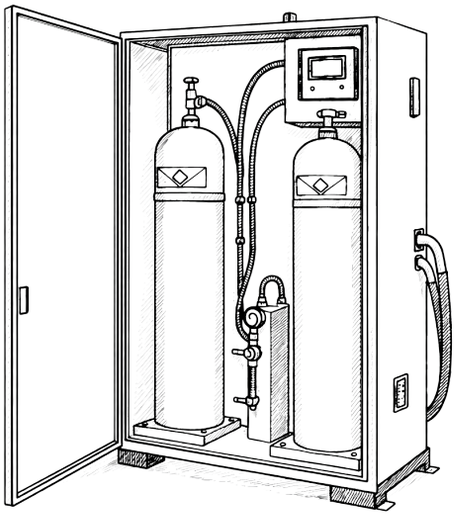
A Proven Path to Transformer Life Extension

Based on two decades of data from over 950 transformers, including a 10-year life-extension case study, InsulMax has been field-validated as a viable means of attaining best-in-class transformer life extension and reliability.

THE DATA IS CLEAR:

> *When the conditions that accelerate insulation aging are continuously managed from installation onward, transformers maintain better-than-new oil quality, reduce lifecycle risk, and **extend service life by up to 3x** compared to unprotected units.*

The four (4) large GSU and auxiliary transformers with InsulMax permanently installed continued to show slight improvements in already-acceptable reliability metrics. The online passive dryer units on 950+ transformers, undergoing moisture reduction, resulted in improved oil qualities associated with oxidation and aging. This involved processing more than 5 billion gallons of mineral oil for moisture reduction. The last 12 years of this span included remote cellular monitoring and engineering project supervision by SDMyers.



The Bottom Line for Asset Owners and Design Engineers

If you are specifying, commissioning, or managing a critical power transformer, the question is not whether you can afford InsulMax — it's whether you can afford to operate without it.



Summary

• **10 years of annual data** confirming no deterioration in oil quality across four critical units.

• **32 million gallons of processed oil** over 10 years in 4 units with minimal filter changes—demonstrating exceptional mechanical reliability.

• **A total cost of ownership as low as $300-$500/month per unit**—economically sound for any $2M+ asset.

• **Early warning hydrogen monitoring** that catches developing faults before they become failures.

• **Green, recyclable filtration media**—producing zero waste.

Next Steps

Contact a Transformer Expert

The SDMyers engineering team is ready to discuss InsulMax for your application—whether you're commissioning a new unit, managing aging assets, or evaluating lifecycle risk across a transformer fleet.

sdmyers.com/insulmax

(330) 630-7000

info@sdmyers.com

180 South Avenue
Tallmadge, OH 44278

SCAN ME

InsulMax®

Substation-Grade
Oil Purification System

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A Good Place Company



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