

**MORGAN[®]
SCHAFFER**

Transformers - The Inside View



Calisto

Online Dissolved Gas Monitors

Calisto

complete DGA - moisture



Calisto

hydrogen - moisture



Benefits

- Monitor large fleets of transformers cost effectively
- Detect and monitor incipient faults using interference-free hydrogen readings
- Correlate moisture behavior with load while monitoring long term trends
- Compatible with dry-out and degassing operations
- Very low maintenance and worry-free dependability

Features

- Precise and accurate hydrogen and moisture readings
- Built-in oil circulation and flow monitoring
- Continuous enclosure and oil conditioning
- DNP3 and Modbus standard, IEC 61850 optional
- Vacuum tolerant
- Substation hardened communication electronics
- Built-in moisture and solubility coefficients for all common insulating fluids

Calisto

hydrogen - moisture
carbon monoxide



Benefits

- Be alerted to accelerated aging of solid insulation
- Make informed maintenance decisions
- Easily install and integrate monitor within existing operations
- Be alerted to any monitor malfunction and low oil circulation
- Easily replaced with Calisto 5 or Calisto 9 if required

Features

- Additional measurement of dissolved carbon monoxide
- Built-in oil circulation and flow monitoring
- Continuous enclosure and oil conditioning
- DNP3 and Modbus standard, IEC 61850 optional
- Vacuum tolerant
- Substation hardened communication electronics
- Built-in moisture and solubility coefficients for all common insulating fluids

Benefits

- Identify arcing at the earliest onset
- Add continuous Duval Triangle diagnosis to incipient fault detection
- Ensure concurrence with laboratory data, short term and long term
- View data and monitor status on-site without tools or computer
- Low cost of ownership

Features

- Additional measurement of Duval Triangle gases
- Acetylene measurement from 0.2 ppm
- Automated self-calibration using certified primary grade gas
- Intuitive front-panel display interface
- Built-in oil circulation and flow monitoring
- Continuous enclosure and oil conditioning
- DNP3 and Modbus standard, IEC 61850 optional
- Vacuum tolerant
- Substation hardened communication electronics
- Built-in moisture and solubility coefficients for all common insulating fluids

Calisto
5 fault gases - moisture



Benefits

- Accurately monitor all atmospheric and fault gases
- Identify and monitor faults using any diagnostic method
- Be alerted to unintended air ingress or accelerated oxidation
- Ensure total combustible and dissolved gases remain within safe limits
- Monitor any gas profile from very low to extremely high concentrations

Features

- Measures all seven fault gases plus oxygen and nitrogen
- Industry leading detection limits
- Automated self-calibration using certified primary grade gas
- Intuitive front-panel display interface
- Built-in oil circulation and flow monitoring
- Continuous enclosure and oil conditioning
- DNP3 and Modbus standard, IEC 61850 optional
- Vacuum tolerant
- Substation hardened communication electronics
- Built-in moisture and solubility coefficients for all common insulating fluids

Calisto
complete DGA - moisture



	Calisto	Calisto 2	Calisto 5	Calisto 9
Hydrogen (H ₂)	√	√	√	√
Carbon monoxide (CO)		√	√	√
Methane (CH ₄)			√	√
Acetylene (C ₂ H ₂)			√	√
Ethylene (C ₂ H ₄)			√	√
Ethane (C ₂ H ₆)				√
Carbon dioxide (CO ₂)				√
Oxygen (O ₂)				√
Nitrogen (N ₂)				√
SF ₆ gas (optional)				√
Moisture	√	√	√	√
Programmable alarming	√	√	√	√
Oil flow monitoring	√	√	√	√
Compatible mounting	√	√	√	√
Sampling rate – every 3 hours	√	√	√	√
Real-time on hydrogen	√	√		
Duval Triangle ready			√	√
Full diagnostic ready				√
DNP3-Modbus	√	√	√	√
IEC 61850 (optional)	√	√	√	√
CE marked-FCC compliant	√	√	√	√
IP 56 enclosure	√	√	√	√
Commissioning time	2 hours	2 hours	4 hours	4 hours

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Morgan Schaffer is ISO/IEC 17025:2005 accredited by the Canadian Standards Council for all its oil testing activities. Morgan Schaffer is also compliant to ISO 9001:2008



MS MORGAN SCHAFFER

Transformers - The Inside View

Technical Specifications

Application

Early detection of transformer incipient faults using continuous monitoring of dissolved hydrogen in insulating fluids. Monitoring dissolved carbon monoxide as a key indicator of cellulose degradation (Calisto 2 only). Continuous moisture monitoring.

Performance

Dissolved gases (H₂ and CO) in oil measurement

Measurement technology

Proprietary Morgan Schaffer Gen2 cell

Gas extraction technology

Oil immersed PTFE tubing

Detection range

H₂: 2 - 50,000 ppm
CO: 25 - 100,000 ppm

Accuracy (ref: MS oil standards)

H₂: Greater of ±5 ppm or ±5%
CO: Greater of ±25 ppm or ±15%

Repeatability

H₂: Greater of ±3 ppm or ±3%
CO: Greater of ±25 ppm or ±10%

Resolution

H₂: 1 ppm
CO: 5 ppm

Step response (typical conditions)

H₂: 50% in 60 min.
CO: 90% in 6 hours

Interference

H₂: < 0.3% of other gases
CO: < 5% from C₂H₂, < 3% from CH₄, C₂H₂, C₂H₆

Moisture (H₂O) in oil measurement

Measurement technology

Oil immersed RS sensor

Detection range

2 ppm - saturation, 2 - 100% RS

Accuracy (ref: MS oil standards for ppm and RS)

± 3 ppm or ± 3% RS

Repeatability

± 2 ppm or ± 2% RS

Resolution

1 ppm, 1% RS

Step response (typical conditions)

95% in 20 min.

Reliability

Power interruption protection

250 ms advanced power loss system

Expected Operating Life (EOL)

> 15 years

Operation

Operating temperature range (standard)	-40 to 55°C
Storage temperature range	-30 to 75°C
Operating oil temperature range	-40 to 120°C
Oil pressure operation range	Full vacuum to 40 psi
Operating humidity range	0 - 100% RH
Storage humidity range	5 – 95% RH, non-condensing
Altitude range	Up to 4,000 m

Construction

Width x Height x Depth	381x 483 x 325 mm (15 x 19 x 12.8 in)
Weight	22.7 kg / 50 lbs
Enclosure	S.S. 304 gauge 16, lockable
Oil circulation	Anti-cavitation reciprocating pump, 10-60 ml/min
Oil flow monitoring	Proprietary Morgan Schaffer system
Oil lines (standard)	3/8" OD copper with brass compression fittings
Enclosure temperature conditioning	Thermoelectric feedback
Oil temperature conditioning	Passive heat exchanger Thermoelectric feedback
Cooling	Forced air convection
Safety protection	Thermal cut-off fuse, rated at 77°C Over-current protection fuse
Oil sampling	External quick-connect port with sampling accessories

Installation

Calibration	No calibration required
Maintenance	Annual visual inspection
Electrical entry holes (standard)	4 x 22.2 mm / 0.875 in diameter
Commissioning time	2 hrs
Mounting	Shock mounts. Morgan Schaffer Calisto Mounting Stand recommended
Power requirements	100 – 240 VAC, 50-60 Hz, 320 W, 1 ø
Power conductor size	Max. 2.05 mm / AWG 12
Oil supply line length	1.5 - 10.5 m / 5 - 35 ft
Oil return line length	1.5 - 10.5 m / 5 - 35 ft

Communication & Data

Display	112 x 16 pixel vacuum fluorescent, day/night
Local	USB 2.0 port (cable provided)
Permanent connection	RS-485 port (1,500 V isolation) RS-232 port (1,500 V isolation) Ethernet port (1,500 V isolation) Independent H ₂ , CO and H ₂ O analog outputs, 4-20 mA (1,500 V isolation) Oil temperature analog input, 4-20 mA (1,500 V isolation)
Communication protocols	MSSP (Morgan Schaffer Systems Protocol) Modbus, DNP3 Level 1 Optional IEC 61850 kit
Measurement Alarms	Programmable dual-level and trend alarms for H ₂ , CO and H ₂ O
Alarm Relays	5 NO/NC contacts, configurable for setup, self-test and measurement alarm conditions (5 A, 240 V)
Data update	8 readings/day, validated H ₂ and CO 1 reading/5 sec., continuous H ₂ and H ₂ O
Data storage	3000 (1 year)
Calisto Access interface software	Win 98 / 2000 / NT / XP / Vista / 7

Regulatory

CE Marking	Low Voltage Directive 2006/95/EC EMC Directive 2004/108/EC WEEE Directive 2002/96/EC, amended 2003/108/EC RoHS Directive 2002/95/EU
EMC (Electromagnetic Compatibility)	IEC/EN 61326 FCC part 15 (US) Class A, ICES-003 (Canada)
Electrical safety	IEC/EN 61010
Degree of protection	IEC/EN 60529, IP56
Vibration	IEC 60255-21-1, Class 1

Shipping

Gross Weight	30.8 kg / 67.8 lbs
Packaging (H x W x D)	508 x 584 x 470 mm (20 x 23 x 18.5 in)

Standard Package

	1 x USB cable
	1 x CD Calisto Access interface software
	1 x Calisto 2 Installation & Operation manual
	1 x Quick connect sampling tube
	1 x Factory test certificate

	4 x S.S. shock mount assembly
	2 x Copper tubing – 3/8" OD x 25 ft
	1 x Thermal cut-off fuse
	2 x Automotive brass elbow - 1/2" NPT (M) - 3/8" Tube
	4 x Automotive brass sleeve - 3/8" Tube
	1 x Extra-strong shipping box

Options

	Morgan Schaffer Calisto Mounting Stand
	Calisto Precision Oil Temperature Probe (4-20mA)
	Insulation kit (for -50 to 55°C operation)
	Stainless steel braided flex lines
	IEC 61850 Ethernet communication kit
	900 MHz radio modem over RS-485
	2.4 GHz radio modem over RS-485
	Ethernet outdoor connectivity kit
	Quick-connect dust plug
	Calisto MultiTrack software
	Extended warranty up to 5 years
	On-site commissioning assistance

Warranty & Support

Morgan Schaffer's Calisto and Calisto 2 monitors are backed by a 3-year factory warranty. Calisto and Calisto 2 and other MS monitoring systems are available through Morgan Schaffer's worldwide network of authorized distributors and agents.

Note: continuous research and improvements may result in specification or appearance changes at any time.

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 Morgan Schaffer is also compliant to ISO 9001:2008



Preliminary Technical Specifications

Application

Online monitoring of fault gases, air components and moisture in transformer insulating fluids.

Technology

Gas measurements	Proprietary chromatographic method
Gas extraction	Oil immersed Teflon® tubing
Moisture measurements	Oil immersed Relative Saturation (RS) sensor
Communications	Isolation on all ports rated for substation environments

Performance

	H ₂	CO	CH ₄	C ₂ H ₂	C ₂ H ₄	C ₂ H ₆	CO ₂	O ₂	N ₂	H ₂ O
Lower detection limit (LDL)	ppm ¹									
	0.5	10	0.2	0.2	0.2	0.2	15	500	2,000	2 ppm, or 2%RS
Top of range ²	ppm									
	20,000	30,000	100,000	100,000	200,000	200,000	100,000	100,000	150,000	Saturation, or 100% RS
Accuracy ³	± (LDL plus X% of reading) ppm									
	X=5	X=15	X=5	X=5	X=5	X=6	X=5	X=15	X=15	± 3 ppm, or ± 3%RS
Repeatability	± (LDL plus Y% of reading) ppm									
	Y=3	Y=10	Y=3	Y=3	Y=3	Y=4	Y=3	Y=10	Y=10	± 2 ppm, or ± 2%RS
Resolution	ppm									
	0.5	5	0.2	0.2	0.2	0.2	5	200	1,000	1 ppm, or 1%RS
Measurement interval	User configurable: 3 hours standard mode, 1 hour fast mode, daily measurement of high-range O ₂ and N ₂									
Step response (typical)	95% in 3 hours									

Grey color is Calisto 9 only, 1) all ppm in mineral oil, 2) including daily measurements at high range, 3) Reference: Morgan Schaffer ISO 17025 certified laboratory

Reliability

Power interruption protection	250 ms advanced power loss system
Expected operating life (EOL)	> 15 years

Operation

Operating temperature range	-50 to +55 °C
Storage temperature range	-40 to +75 °C
Operating oil temperature range	-40 to +120 °C
Operating oil pressure range	Full vacuum to 40 PSI
Operating humidity range	0 – 100% RH
Storage humidity range	5 – 95% RH, non-condensing
Altitude range	Up to 4,000 m

Construction

Width x Height x Depth	Instrument: 502 x 489 x 337 mm (19.8 x 19 x 13.3 in), Carrier gas manifold: 213 x 292 x 122 mm (8.4 x 11.5 x 4.8 in), plus mounting flanges
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Weight	Instrument: 35 kg / 75 lbs Carrier gas manifold: 5 kg / 11 lbs
Enclosures	Instrument: 304 S.S., gauge 16, lockable Carrier gas manifold: 304 S.S., gauge 14, lockable
Oil circulation	Anti-cavitation reciprocating pump, 10-60 ml/min.
Oil flow monitoring	Proprietary Morgan Schaffer system
Oil lines	3/8" OD stainless steel
Enclosure temperature conditioning	Thermoelectric feedback
Oil temperature conditioning	Passive heat exchanger plus thermoelectric feedback
Cooling	Forced air
Equipment protection	Thermal cut-off fuse (77 °C), Over-current mains fuse
Oil sampling	External quick-connect port plus sampling accessories
Installation	
Calibration	On-board NIST traceable calibration gas, automatic calibration
Carrier gas requirements	99.9999% He
Maintenance	Visual inspection each 12 months Carrier and calibration gas replacement each 24 months
Electrical entry holes (standard)	6 x 22.2 mm / 0.875 in diameter
Commissioning time	5 hours installation, overnight stabilization, 4 hours commissioning
Mounting	Shock mounts. MS Calisto Mounting Stand recommended
Power requirements	100 - 240 VAC, 50-60 Hz, 350 W, 1ø
Power conductor size	Max. 2.05 mm / AWG 12
Oil supply line length	1.5 – 10.5 m / 5 – 35 ft
Oil return line length	1.5 – 10.5 m / 5 – 35 ft
Communication and Data	
Front panel controls	256 x 64 pixel display, vacuum fluorescent, day/night 3 weatherproof, UV resistant buttons
Front panel interface	Menu driven functions for readings, alarms, databank, setup, and maintenance
Communication protocols	MSSP (Morgan Schaffer Systems Protocol), Modbus, DNP3 Level 1, Optional IEC 61850 kit
Local communication port	USB 2.0 (cable provided)
Isolated communication ports (5 kV impulse, 2.6 kVac)	RS-485, RS-232, Ethernet
Isolated analog ports (5 kV impulse, 2.6 kVac)	10 assignable 4-20 mA outputs (5 for Calisto 5) 3 assignable 4-20 mA inputs

Measurement alarms	Programmable dual-level and trend alarms for all readings
Relay outputs (5A, 240V)	10 NO/NC contacts (5 for Calisto 5) assignable for setup, self-test and measurement alarm conditions
Data storage	3 years
Interface Software	
Calisto Manager™	Local and remote configuration, maintenance and data downloads for Calisto 5 and Calisto 9 Tracking of multiple Calisto ⁴ , Calisto 2, Calisto 5, Calisto 9 monitors Database of transformers, Calistos, and tracked data
Platforms	Windows 98 / 2000 / NT / XP / Vista / 7
Regulatory	
CE Marking	Low Voltage Directive 2006 / 95 / EC EMC Directive 2004 / 108 / EC WEEE Directive 2002 / 96 / EC, amended 2003 / 108 / EC RoHS Directive 2002 / 95 / EU
EMC (Electromagnetic compatibility)	IEC/EN 61326 IEC/EN 61000-6-5 IEC/EN 61850-3 FCC part 15 (US) Class A, ICES-003 (Canada)
Electrical Safety	IEC/EN 61010 IEC/EN 60255-27
Degree of protection	IEC/EN 60529, IP 56
Shipping	
Gross Weight	Instrument: 40 kg / 90 lbs Standard accessories: 10 kg / 22 lbs
Packaging	Instrument: 600 x 584 x 410 mm (24 x 23 x 16 in) Standard accessories: 510 x 510 x 254 mm (20 x 20 x 10 in)
Options	
	Morgan Schaffer Calisto Mounting Stand Calisto Precision Oil Temperature Probe (4-20mA) Dissolved SF ₆ monitoring and alarms (Calisto 9 only) IEC 61850 Ethernet communication kit 900 MHz radio modem over RS-485 2.4 GHz radio modem over RS-485 Ethernet outdoor connectivity kit Quick-connect dust plug Extended warranty up to 3 years Morgan Schaffer on-site maintenance program On-site commissioning assistance
4) Newer version only	

Warranty and Support

1-year factory warranty (standard)
Morgan Schaffer worldwide agent network for sales and support

Note

Continuous research and product improvements may result in specification or appearance changes at any time.

	Calisto	Calisto 2	Calisto 5	Calisto 9
Hydrogen (H ₂)	√	√	√	√
Carbon monoxide (CO)		√	√	√
Methane (CH ₄)			√	√
Acetylene (C ₂ H ₂)			√	√
Ethylene (C ₂ H ₄)			√	√
Ethane (C ₂ H ₆)				√
Carbon dioxide (CO ₂)				√
Oxygen (O ₂)				√
Nitrogen (N ₂)				√
SF ₆ gas (optional)				√
Moisture	√	√	√	√
Programmable alarming	√	√	√	√
Oil flow monitoring	√	√	√	√
Compatible mounting	√	√	√	√
Sampling rate – every 3 hours	√	√	√	√
Real-time on hydrogen	√	√		
Duval Triangle ready			√	√
Full diagnostic ready				√
DNP3-Modbus	√	√	√	√
IEC 61850 (optional)	√	√	√	√
CE marked-FCC compliant	√	√	√	√
IP 56 enclosure	√	√	√	√
Commissioning time	2 hours	2 hours	4 hours	4 hours

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