MORGAN® SCHAFFER

Leading supplier of
Dissolved Gas Analysis,
data, equipment, and informatics
for the global electrical industry

Prepared by:

Stephan Brauer , Ph.D.
R&D Director

MORGAN® SCHAFFER

COMMITMENT

- We do what we say we will do
- 98% to 100% delivery track record
- Interoperability and teamwork

VALUE

- Best-in-market accuracy
- Proven technology
- Predictable Total Cost of Ownership

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SERVICE

- Responsiveness: 24 Hr. policy
- Designated Field Personnel
- USA Operations
- Best Standard Warranty on the market: 2 years +

EXPERIENCE

- > 8k monitors deployed worldwide, over 600 under extreme weather conditions
- 7 scientists, 26 engineers

Calisto Premium DGA Monitors

Calisto and **Calisto 2** – Fault detection

Calisto 5 and **Calisto 9** – DGA diagnostics

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Calisto and Calisto 2

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 (H_2 and CO) in oil

Measurement technology	Proprietary Morgan Schaffer cell

Proprietary Morgan Schaffer thermal-conductivity cell → H_2 and CO

- 20 years field experience
- Long-term reliability
- High DGA accuracy **throughout product lifetime**
- Field calibration not required (no consumables)

→ Low false alarms

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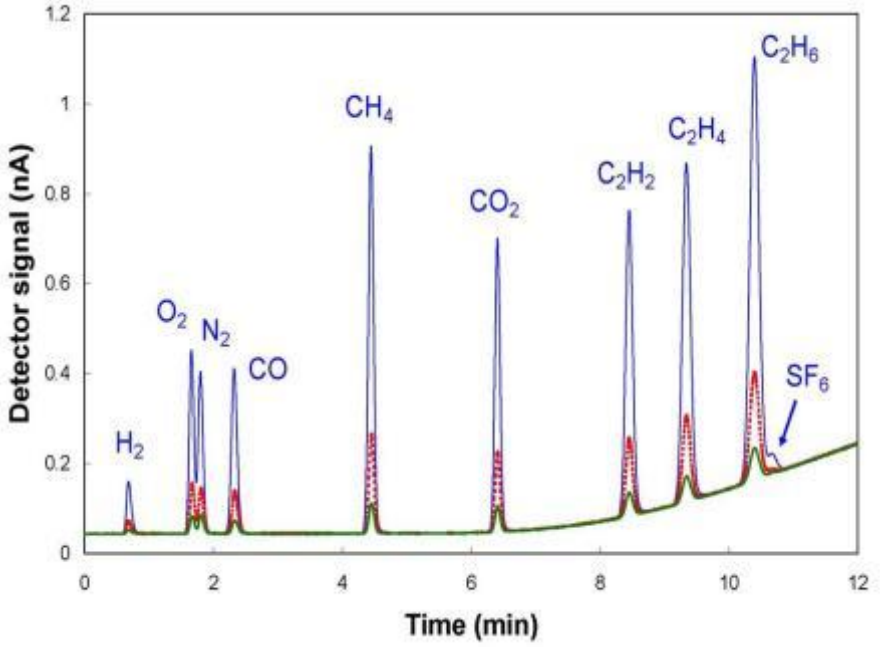
Calisto 5 and Calisto 9

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	Electrical isolation rated for substation environments

Unique single-column industrial GC + proven Calisto platform



- Long-term reliability
- Low detection-limits
- High DGA accuracy **throughout product lifetime**

→ Low false alarms

All Calistos

Application	
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30 years of field experience

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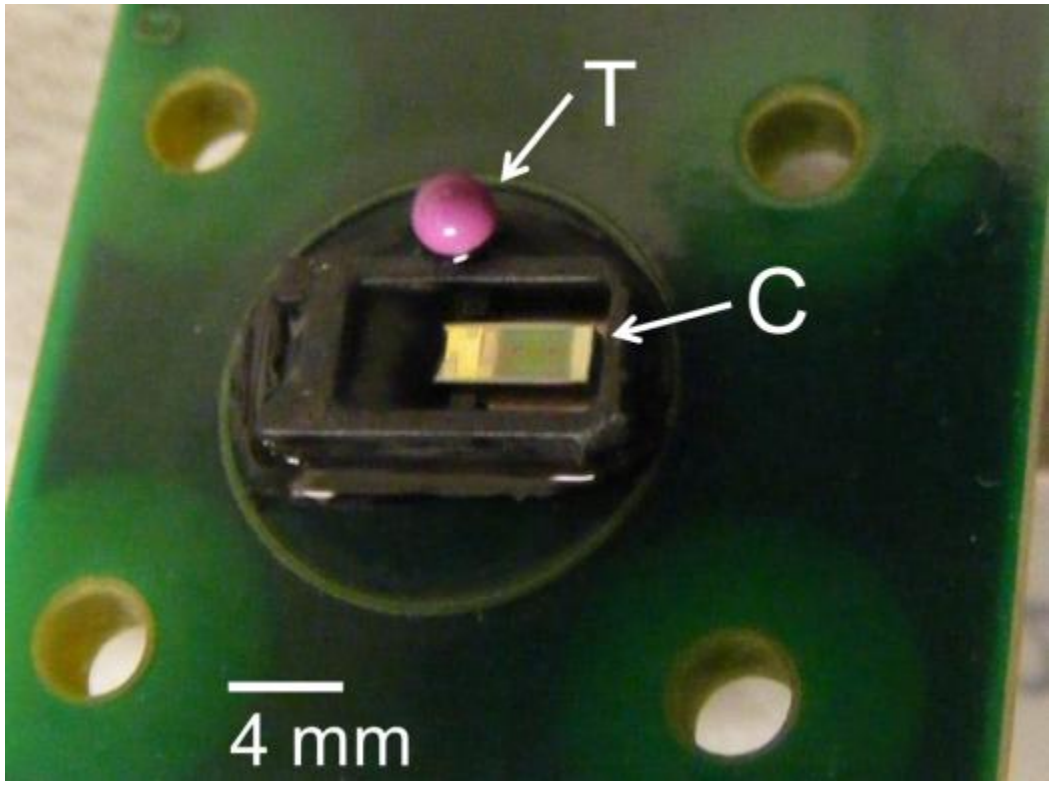

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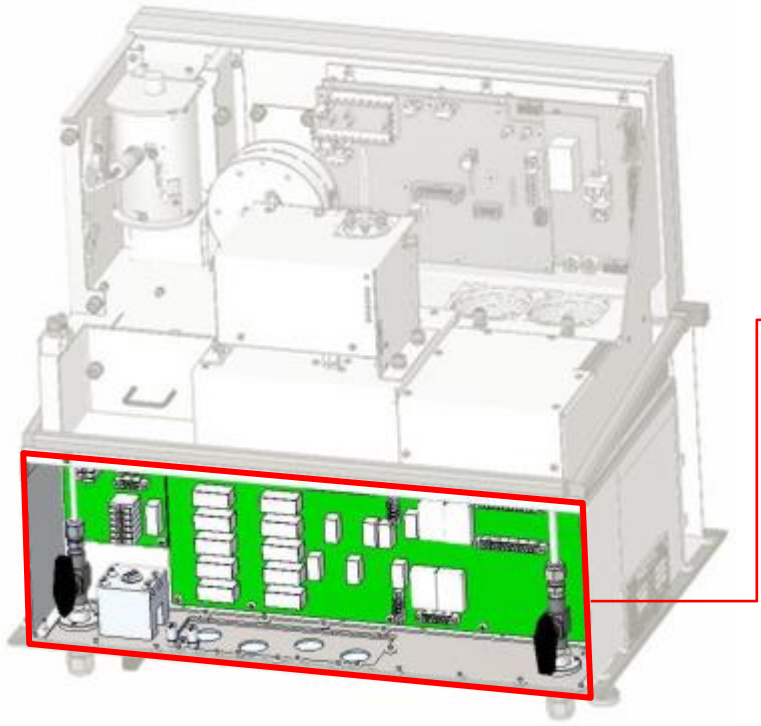

- Field proven industrial-grade electronics
- 5kV surge isolation on all network connections

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Calisto 5 and Calisto 9

Performance

	H_2	CO	CH_4	C_2H_2	C_2H_4	C_2H_6	CO_2	O_2	N_2	SF_6[3]	H_2O
Lower detection limit (LDL)	ppm[1]										2 ppm, or 2 %RS
	0.5	10	0.2	0.2	0.2	0.2	15	500	2,000	2	
Top of range[1]	ppm										Saturation, or 100%RS
	20,000	30,000	100,000	100,000	200,000	200,000	100,000	100,000	150,000	2,500	
Accuracy[2]	± (LDL plus X% of reading) ppm										± 3 ppm, or ± 3 %RS
	X=5	X=5	X=5	X=5	X=5	X=6	X=5	X=15	X=15	X=15	
Repeatability	± (LDL plus Y% of reading) ppm										± 2 ppm, or ± 2 %RS
	Y=3	Y=3	Y=3	Y=3	Y=3	Y=4	Y=3	Y=10	Y=10	Y=10	
Resolution at LDL	ppm										1 ppm, or 1 %RS
	0.5	2	0.2	0.2	0.2	0.2	5	200	1,000	2	
Measurement interval	User configurable: 3 hour, 2 hour, 1 hour. Conditional cycle on alarm.										6 seconds
Step response (typical)	In 1 hour: 95% H_2; 90% CO, CH_4, CO_2, O_2, N_2; 80% C_2H_2, C_2H_4, C_2H_6; 50% SF_6.										95% in 20 minutes

Grey color is Calisto 9 only, 1) all ppm in mineral oil, 2) Reference: Morgan Schaffer ISO 17025 accredited laboratory, 3) Model C900S.

Overall best in industry

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Calisto 9

Performance

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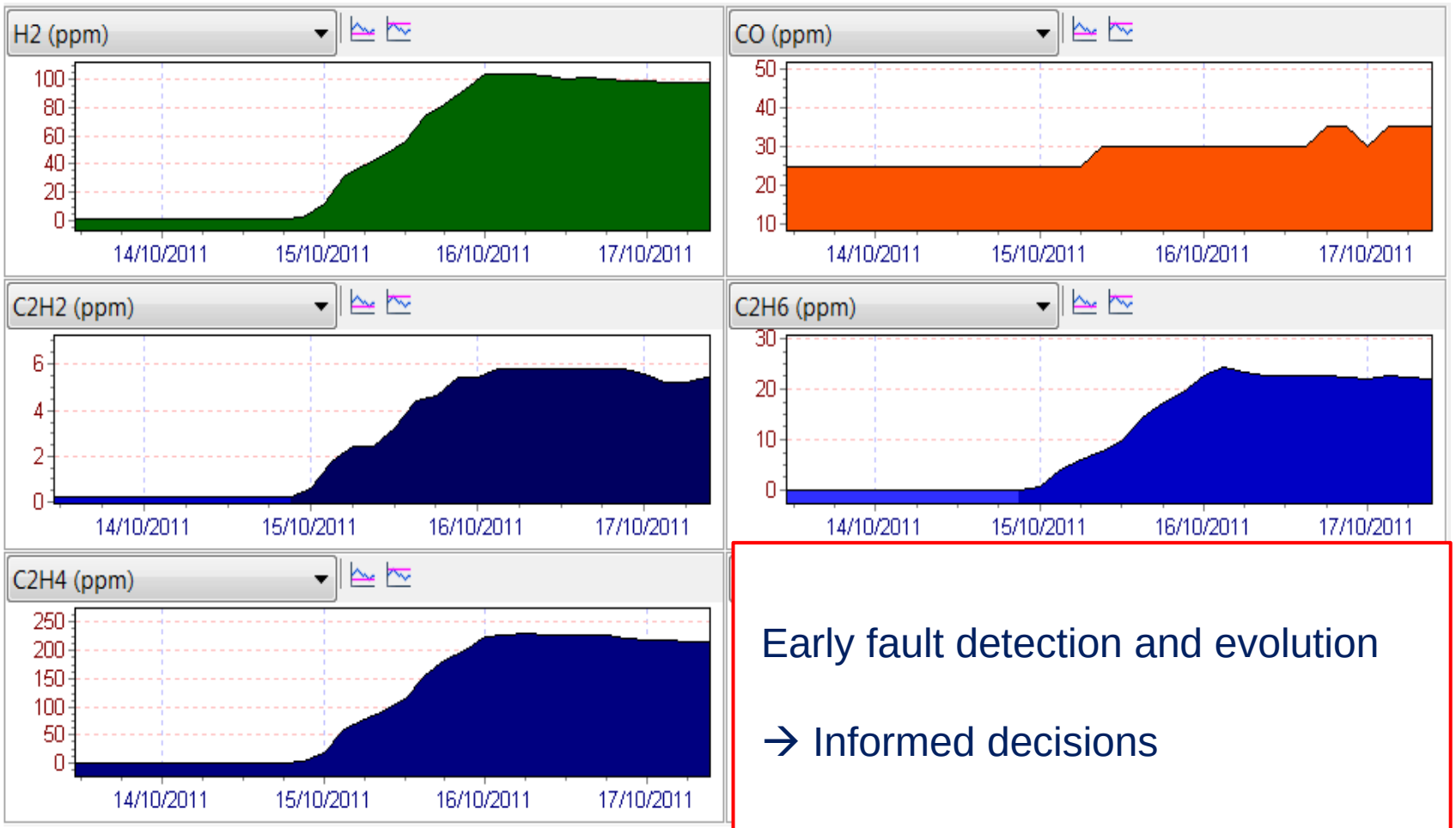

Early fault detection and evolution

→ Informed decisions

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Calisto 5 and Calisto 9

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- Best in industry fault gases
- Accuracy in-use, throughout the product lifetime
- Benchmarked to Morgan Schaffer ISO17025 laboratory
- **Good decisions require good data.**

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All Calistos

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

Maximum up-time

All Calistos

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Expected operating life (EOL)	> 15 years

Economically serviceable life

All Calistos

Operation	
Operating temperature range	-50 to + 55 °C, Cold start -50 °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

- Unique -50°C cold-start rating

All Calistos

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Calisto 9 running at 4200 m in Peru

All Calistos

Construction	
Enclosures	Instrument: 304 S.S., gauge 16, lockable Carrier gas manifold: 304 S.S., gauge 14, lockable option
Oil circulation	Anti-cavitation reciprocating pump, 10-60 ml/min
Oil flow monitoring	Proprietary Morgan Schaffer system
Oil lines	3/8" OD stainless steel
Air bubble elimination	Proprietary Morgan Schaffer system
Enclosure temperature conditioning	Thermoelectric feedback
Oil temperature conditioning	Passive heat exchanger plus thermoelectric feedback
Oil sampling	External quick-connect port plus sampling accessories

Unique cylinder-pressure monitoring Calisto 5/9

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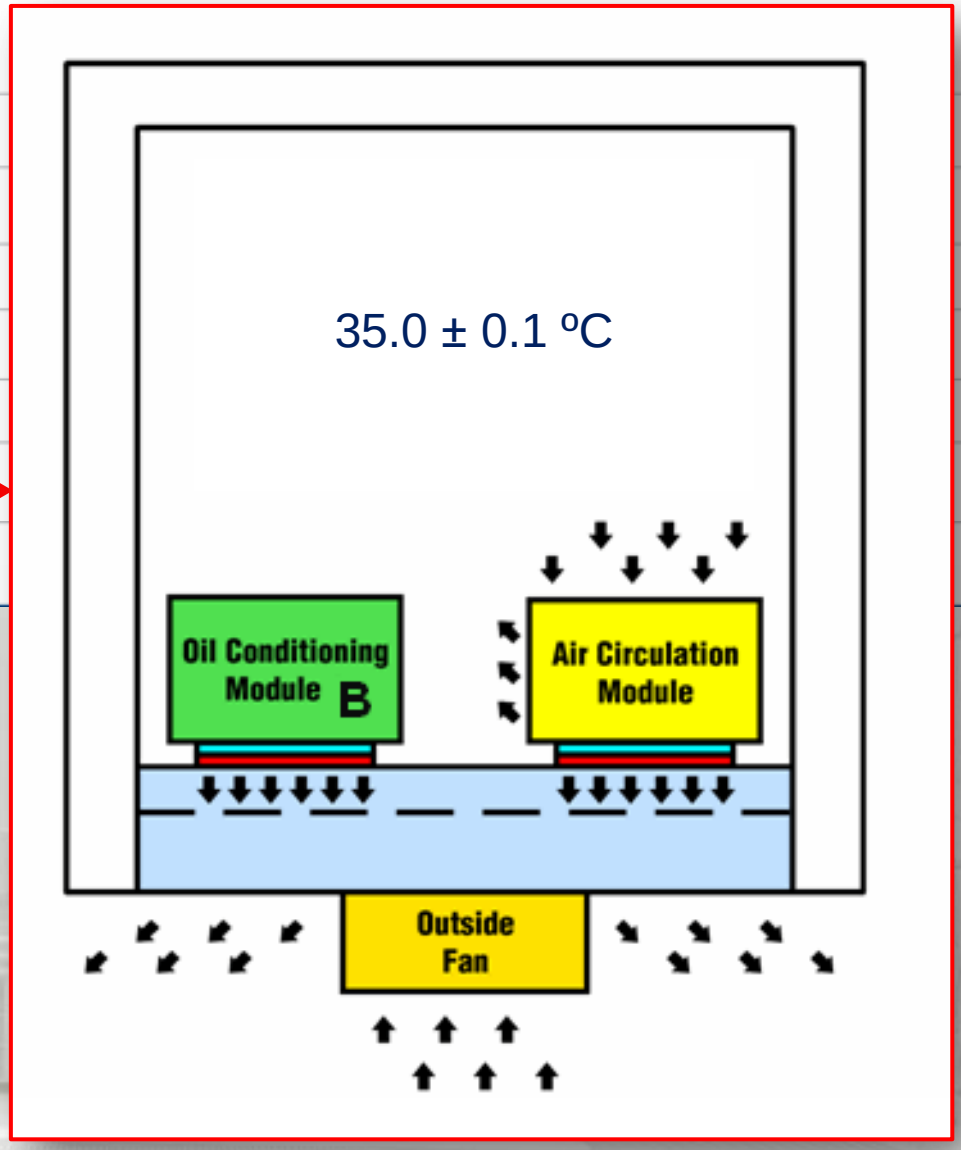
All Calistos

Construction

- Enclosures
- Oil circulation
- Oil flow monitoring
- Oil lines
- Air bubble elimination
- Enclosure temperature conditioning
- Oil temperature conditioning
- Oil sampling



- External air circulation
- Internal air circulation
- Thermoelectric heating/cooling

→ **Laboratory measurement conditions**

Fan lifetime 9 y internal, 11 y external.

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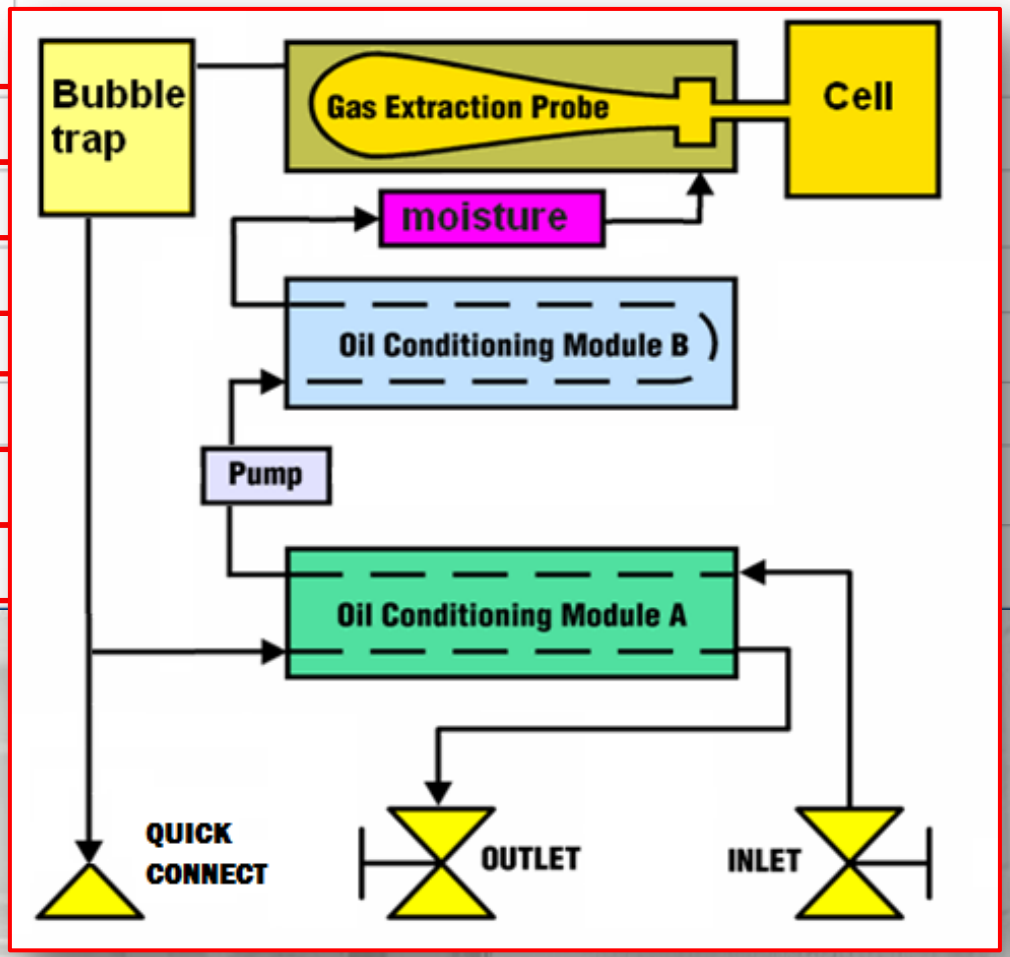
All Calistos

Construction

Enclosures	
Oil circulation	5 pump failures in 20 years
Oil flow monitoring	Proprietary, no moving parts
Oil lines	
Air bubble elimination	Simplified installation
Enclosure temperature conditioning	
Oil temperature conditioning	35.0 ± 0.1 ºC
Oil sampling	For laboratory comparisons



→ **Accuracy as good or better than a DGA lab**

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All Calistos

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
Ingress protection	IEC/EN 60529, IP 56

Best in industry ratings for EMC and Safety → **Reliability**

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Calisto 5 and Calisto 9

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)	5 x 22.2 mm / 0.875 in diameter
Commissioning time	5 hours installation, plus 4-12 hours before first readings

Redundant provisions against erroneous calibration:

- Low calibration gas pressure error
- Only use validated calibration runs
- Validation= **fitted peak areas** agree with factory, air contamination limits, baseline limits
- Invalid calibration run generates immediate Calibration error
- After 7 invalid calibrations → all gases go to INIT status

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Mounting	Shock mounts. MS Calisto Mounting Stand recommended
Power requirements (no selection required)	100 - 240 VAC ±10%[4], 50 - 60Hz, 1Ø, 350W 100 - 220 VDC ±10%[4], 350W
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

Recommended:
Air Liquide Alpha Gas 2

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- Carrier and calibration gas cylinder **pressure monitoring**
  - 1 hour pressure-drop error, 12 hour pressure-drop error, small leak error, weeks remaining (linear regression)
- Ease of service for client-replaceable parts (e.g. fans)

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Summary of Calisto Benefits

- Reliability even in extreme operating environments

  → **Predictable cost of ownership** (maintenance, false alarms, down-time)
- Best in market DGA accuracy throughout the product lifetime

  → **Good decisions require good measurements**
- Morgan Schaffer commitment

  → **50 years of DGA focus, best-in-market responsiveness**

Communication and IT Integration

Communication and IT Integration

Communication and Data

Front panel interface	256 x 64 pixel display, vacuum fluorescent, day/night 3 weatherproof, UV resistant buttons Menu driven functions for reading, alarms, databank, setup, and maintenance
Communic	SCADA: Modbus, DNP3 Level 2, Optional IEC61850 kit Time Synchronization: SNTP HTTP: Calisto Web Server Integrator: MSSP (Morgan Schaffer System Protocol)
Local comn	USB 2.0 (cable provided)
Isolated co	RS-485, RS-232, Ethernet
Isolated an	10 assignable 4-20 mA outputs (5 for Calisto 5) 3 assignable 4-20 mA inputs
Measureme	Programmable dual-level and trend alarms for all readings
Relay outpu (250VAC, 5A	10 NO/NC contacts (5 for Calisto 5) assignable for setup, self-test and measurement alarm conditions
Data storag	6 years
Self Diagno	192 error codes with intuitive descriptions and recommended client actions

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Isolated communication ports (5 kV impulse, 2.6 kVac)	RS-485, RS-232, Ethernet
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Measurement alarms	Programmable dual-level and trend alarms for all readings
Relay outputs (250VAC, 5A; 48VDC, 1.5A)	10 NO/NC contacts (5 for Calisto 5) assignable for setup, self-test and measurement alarm conditions
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Protocols

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Calisto = Slave

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Calisto 5 and Calisto 9

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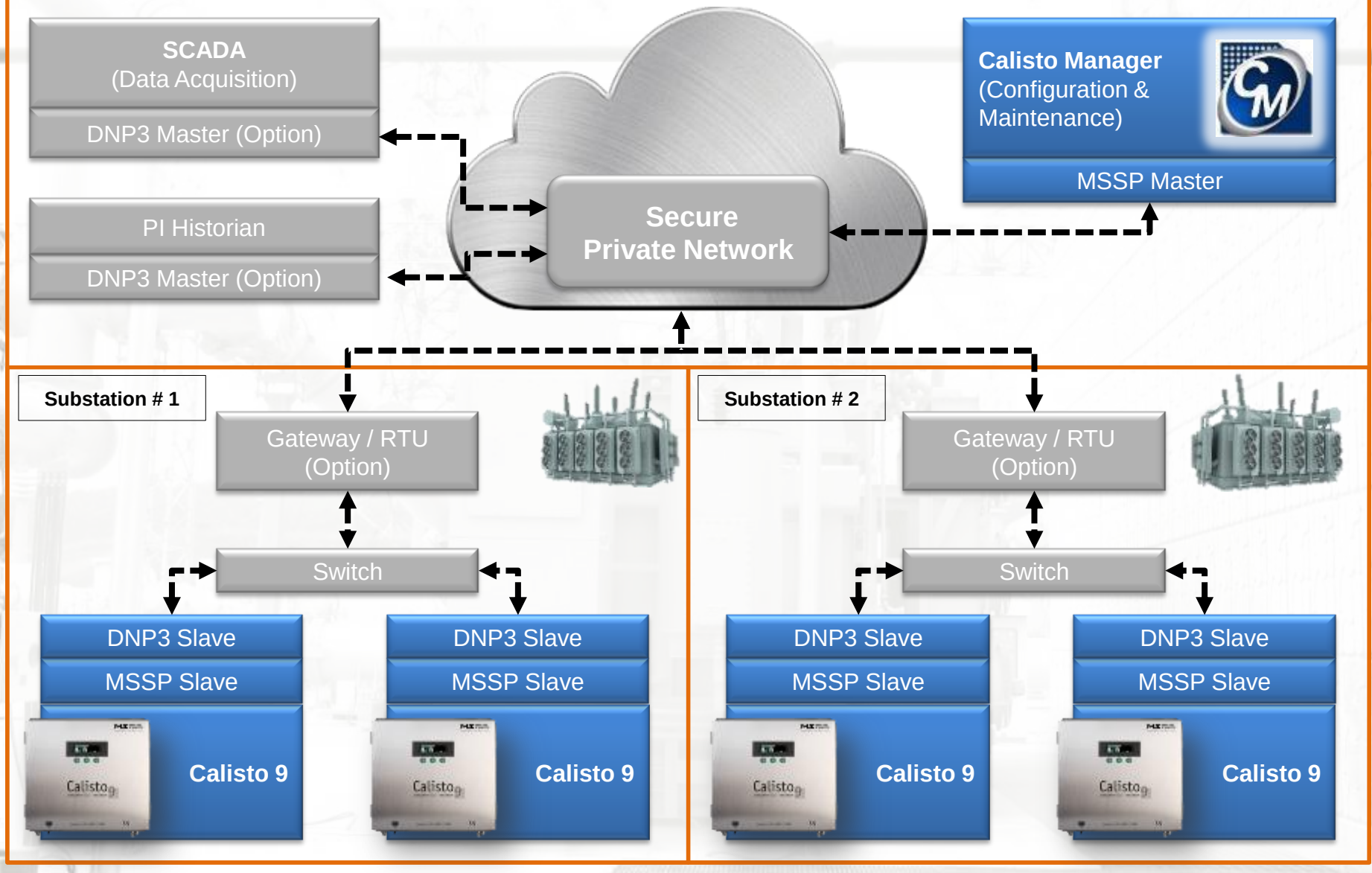
ARCHITECTURE DIAGRAM FOR **CALISTO INTEGRATION** via DNP3



Calisto Manager

FOR ALL CALISTOS

- Commissioning (Settings)
- Status (Measurements, Alarms, Errors, Instrument)
- History (Measurements, Events)
- Maintenance (Recommended client actions, FW upgrades, Diagnostic downloads)
- Mini SCADA: Tracking multiple Calistos, with email and SMS notifications

Questions

MORGAN® SCHAFFER

Leading supplier of
Dissolved Gas Analysis,
data, equipment, and informatics
for the global electrical industry

Prepared by:

Stephan Brauer , Ph.D.
R&D Director

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