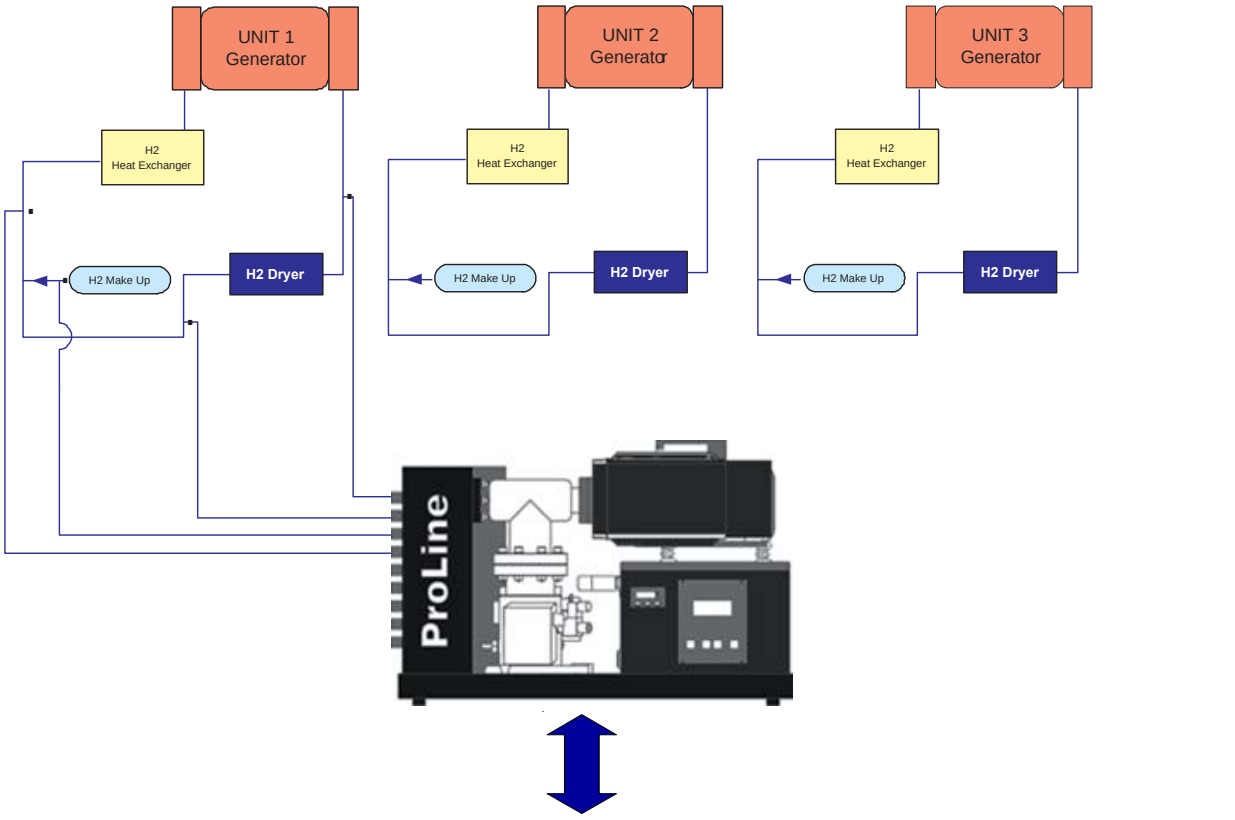
PROCESS INSTRUMENTS

Application Note

PROCESS

Economic Analysis of
Hydrogen-Cooled Power Plant Generators



UNIT 1 H2 Heat Outlet	
Hydrogen	95.535
Nitrogen	02.885
Oxygen	00.586
Water	00.921
Volatile CxHz	00.006
Oil CxHy	00.008

UNIT 1 H2 Make Up	
Hydrogen	95.125
Nitrogen	01.825
Oxygen	---------
Water	---------

UNIT 1 Dryer Inlet	
Hydrogen	96.782
Nitrogen	02.005
Oxygen	00.051
Water	00.855
Volatile CxHz	00.006
Oil CxHy	00.008

UNIT 1 Dryer Outlet	
Hydrogen	96.775
Nitrogen	02.005
Oxygen	00.050
Water	00.005
Volatile CxHz	---------
Oil CxHy	---------

Multi-Point, Multi-Component Analysis

Adds Powerful Diagnostics to Generator Purge Systems to Maximize Hydrogen Purity

Indirect- and direct-cooled power plant turbine generators rely on continuous hydrogen purge systems to remove dissipated heat energies from windings and core elements. Hydrogen gas offers superior heat transfer characteristics with low gas density, reducing the fluid friction (windage) between hydrogen gas and rotor. Hydrogen's ultra low density (0.0696) and heat transfer capabilities make it the ideal cooling medium for turbine generators. However, hydrogen molecules are easily displaced by contaminant molecules of nitrogen, oxygen, water, and trace hydrocarbons. Generator hydrogen purging systems are comprised of appropriate devices to remove heat energy from the cooling medium, and filter out entrained, contaminant molecules. Water-cooled heat exchangers, housed in the generator compartment, remove heat energy, while moisture is removed with external dryer modules. Trace hydrocarbons and oils are trapped in activated carbon beds located on dryer inlet lines. Atmospheric gas molecules, (nitrogen, oxygen, carbon dioxide), must be displaced by continuous make-up hydrogen feed from bulk storage tanks or cylinders.

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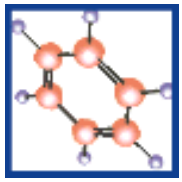


Precise, periodic monitoring of hydrogen purity is critical to the operating efficiency and safety of the turbine generator. As purity decreases, fluid friction (windage losses) and dissipated heat energies increase. During shutdown and maintenance procedures, the hydrogen coolant is purged with carbon dioxide gas, which is itself purged with air. The purging order is reversed when the generator is prepared for start-up. During these critical steps, the H_2 and CO_2 gases must be monitored continuously to avoid explosive environments and possible harmful side effects to plant personnel. Current hydrogen purity monitoring systems are sufficient for safety monitoring during the purge-out procedure and periodic measurement during operation. However, the technique of single-point, discrete measurement of H_2 purity is not sufficient for maximizing hydrogen purity levels or determining the source of contamination and health of purification systems.

Identifying the sources of contamination affecting the operating purity requires the ability to isolate and compare multiple sample streams for multiple components. AMETEK's ProLine Process Mass Spectrometer combines the versatility of multi-point sampling with the diagnostic capability of multi-component analysis in one analyzer. The compact packaging allows the analyzer to be transported and shared between power plant generator monitoring systems for periodic diagnosis and analysis of generator and purity system health and efficiency.

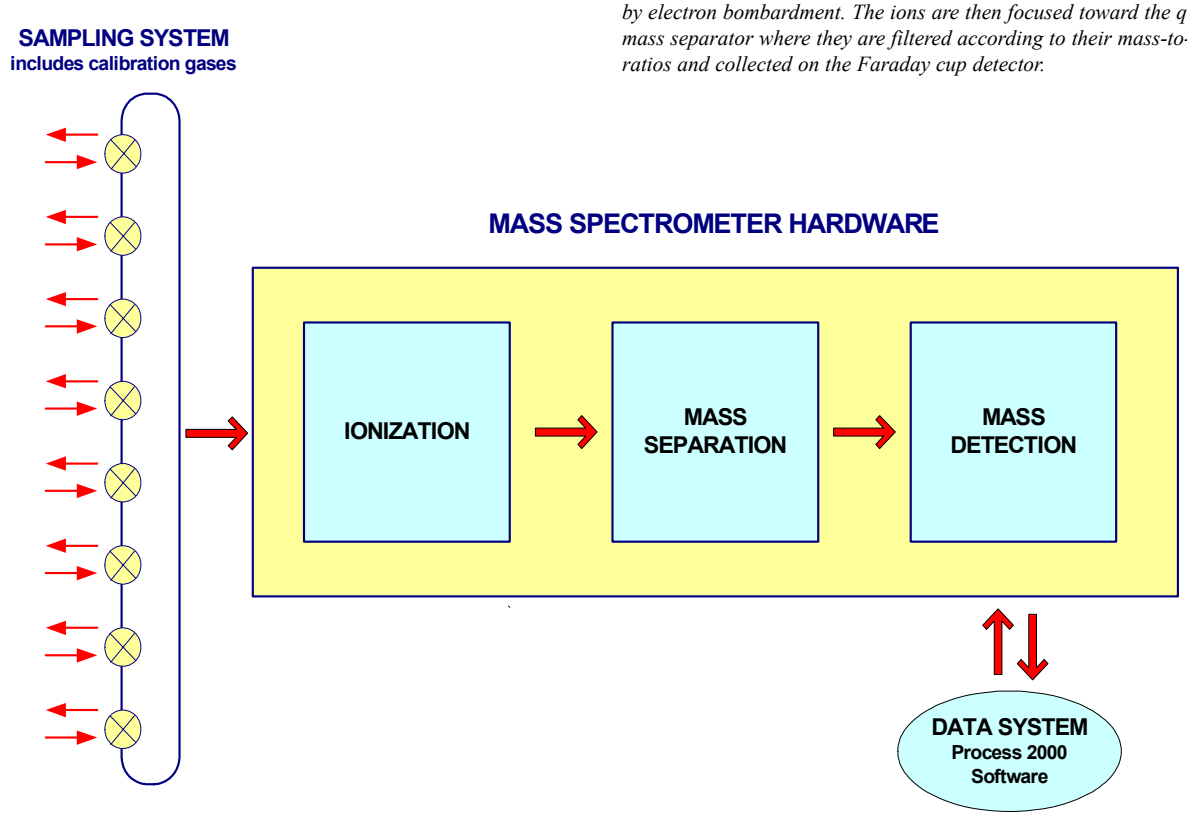
AMETEK ProLine

Description

The front-end, multi-port sampling system consists of 8 manifold-mounted valves and a capillary restriction in an enclosure heated to prevent condensation. The inlet arrangement is designed for fast clearing and offers the choice of continuous flush on any valve position. The capillary restriction tube transports the sample molecules to the ionization chamber where all of the molecules are converted to ions by process of electron bombardment (Figure 1). Once ionized, the molecular fragments are focused toward the quadrupole mass separation section. Using DC and RF voltages the ionized fragments are filtered according to their mass-to-charge (m/z) ratios and collected on the Faraday cup mass detector. As the positive charged ions strike the Faraday cup detector they produce a current. The magnitude of the current generated is proportional to the quantity of ions striking the detector. The Process 2000 Software data system interprets, stores, and presents the data generated from the ion emission currents produced on the Faraday cup detector. The overall system provides a way to identify and quantify multiple components in a single gas stream. The ProLine provides the means to analyze several sample streams for their individual components.

Figure 1.

Sample molecules enter the ionization chamber where they are converted to ions by electron bombardment. The ions are then focused toward the quadrupole mass separator where they are filtered according to their mass-to-charge (m/z) ratios and collected on the Faraday cup detector.



Data System

ProLine operation is fully automatic, providing unattended analysis of multiple sample streams and calibration gases. Process 2000 software controls the ProLine system, acquisition of data, and access to collected data. Custom generator purge diagnostic tests are easily created using the straightforward menu-driven screen setup. Each port on the multi-port sample system is identified and displayed as is the current valve switching sequence. Powerful data manipulation tools, (isolate, identify, subtract background, compare to stored data, trend results) are available to analyze test results. External inputs for temperature and pressure can also be included with trended data to determine the specific health of internal generator components.

Examples of Custom Tests

Health and condition of hydrogen shaft seals

1. Isolate source by sequencing sampling valves: Port 1 Dryer Outlet, Port 4 Heat Ex. Outlet.
2. Compare Port 1 gas components to Port 4 gas components.
3. Subtract background, display Oxygen and Oil (CxHy).
4. Trend Oxygen and Oil with external input for oil temperature.

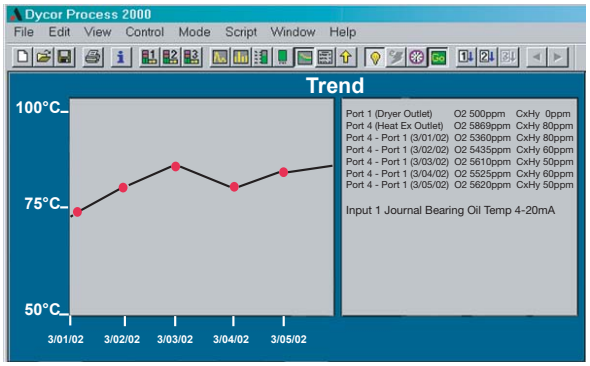


Figure 3. *Trend in oil temperature fluctuation compared with O2 migration across the seal.*

Rate of thermal decomposition of insulation

1. Isolate source by sequencing sample valves: Port 1 Dryer Outlet, Port 4 Heat Ex. Outlet.
2. Compare Port 1 gas components to Port 4 gas components.
3. Subtract background, display Volatile CxHz.
4. Compare current data to stored data.
5. Trend current and stored data vs. time for rate of decomposition.

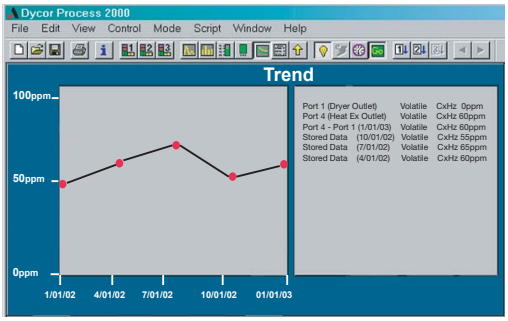


Figure 4. *Trend in quarterly measurements of outgassed volatiles from winding insulation to determine normal rate of decomposition.*

Dryer efficiency and activated carbon filter health

1. Isolate source by sequencing sample valves: Port 2 Dryer Inlet, Port 1 Dryer Outlet.
2. Compare Port 2 gas components to Port 1 gas components.
3. Subtract background, display H_20 and Oil CxHy.
4. Compare current data to stored data from last regeneration cycle.

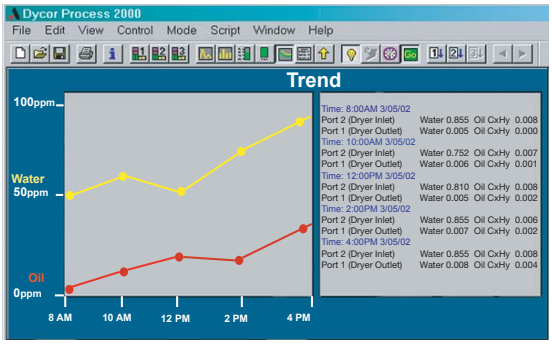
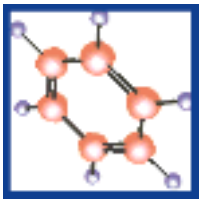


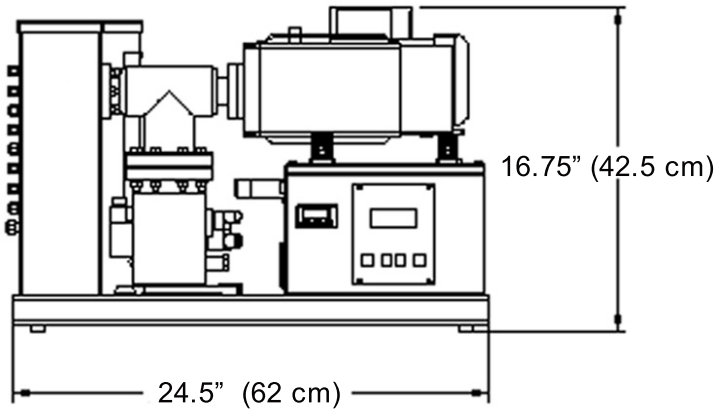
Figure 5. *Hourly trend indicates saturation of dryer carbon bed filter and subsequent oil breakthrough.*

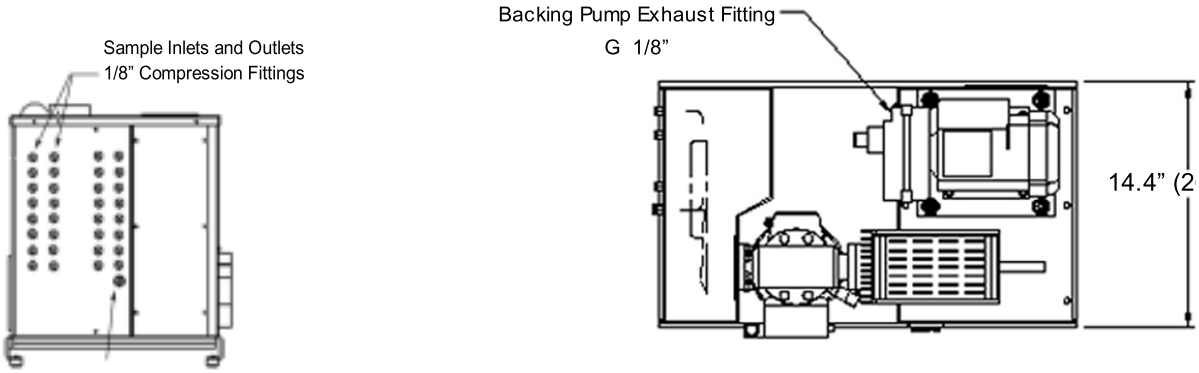
Other Measurements for Generator Purge Monitoring Systems

- Verify accuracy and calibration of system purity and dew point analyzers.
- Verify quality of H_2 make-up feed, cylinder to cylinder.
- Detect leakage in water-cooled H_2 heat exchangers.
- Analyze overall purge system integrity.
- Monitor for residual gases during maintenance purge-out and refill.



Dimensions





Specifications

Sample Ports:	8 or 16 stream selection manifold
Inlet Pressure:	2 to 20 PSIG (14 to 140 kPa)
Detection Range:	1 PPM to 100%
Accuracy:	0.5% of Measured Value
Power Requirement:	115/230VAC, 50/60 Hz. 500W
PC Requirements:	Pentium equivalent, 600MHz or better, Windows 98, ME, NT, 2000 or XP
Dimensions:	14 3/8" X 24" X 15 ½” (36.5 cm x 61 cm x 39.37 cm)
Weight:	80 lb. (36kg.)

AMETEK has more than 20 years of experience in mass spectrometer design and manufacture, with many thousands of analyzers already operating reliably. The ProLine Process Mass Spectrometer places the diagnostic power of multi-point, multi-component analysis in the hands of those who need to know the most about power plant generator operation and maintenance. The Process 2000 software provides data that is easily displayed and understood by all generator process personnel.

Though fully capable of continuous on-line monitoring, the ProLine is equally valuable as a diagnostic tool that can be shared among all plant generator purge systems. ProLine can provide health and efficiency information that will maximize hydrogen purity and minimize generator damage from failing systems.

One of a family of innovative process analyzer solutions from AMETEK Process Instruments. Specifications subject to change without notice.

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H2 Generator ProLine (02/04)

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