GAIA

GAS ADSORPTION ISOTHERM APPARATUS

Front view of air bath model showing safety systems of blow-out panel with cage and hydrocarbon gas monitoring system

Rear view of air bath model showing air actuated valves that control gas flows

ERC SCIENTIFIC

GAIA - an integrated system for high pressure / high temperature gas adsorption isotherm determinations

GAIA is a stand-alone, fully integrated, automated system for high pressure, high temperature gas adsorption isotherm determinations. It is particularly suited to geological materials such as coals and shales but can be used to determine gas adsorption characteristics of any solid materials where neither the gas nor the material is highly corrosive nor toxic.

Multiple Determinations in Parallel

The GAIA is capable of performing either 2 or 4 determinations simultaneously at the same temperature. The number of determinations depends on the number of cells ordered. Single samples can also be run.

Each sample cell is associated with its own reference cell to ensure the highest quality of data. Sample and reference cells are paired. Their volumes determined at the factory by helium expansion techniques.

Air Bath Technology

GAIA utilises an air bath (oven) for precise temperature control. The air bath incorporates an integrated air chiller system, allowing precise temperature control over the range of +10° to +200°C. Traditional systems using water or oil baths require the bath temperature to be 5° above ambient for precise temperature stability.

Note: water bath models are also available.

Comparison of Various Methods for Isothermal Temperature Control

	Temperature			Chemical Hazards
	Minimum	Maximum	Stability	
GAIA air bath	**10°C**	**200°C**	**excellent at all temperatures**	**none**
Standard oven	ambient +5°	200°C	good at all temperatures	none
Water Bath	ambient +5°	80°C	excellent at low temperature poor at high temperature	none
Glycolated water bath	ambient +5°	80°C	excellent at low temperature good at high temperature	ethylene glycol
Oil Bath	ambient +5°	160°C	excellent at all temperatures	silicone oil

Temperature Control

Temperature is monitored in three locations: (1) inside the oven; (2) inside the sample cell and; (3) inside the reference cell. The oven has a spatial variability of ±0.5°C and is controlled to ±0.1°C. Adsorption calculations use the measured temperatures inside the reference and test cells, which are determined to 0.1°C.

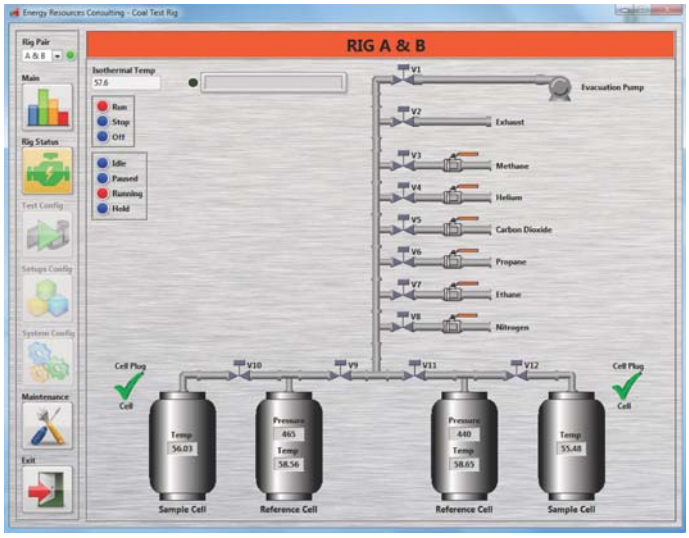
Fully Automated

The system is fully automated using purpose built software. It is highly flexible with the user specifying the number of adsorption points (up to 30), their end pressures and the test gas. The system performs all necessary procedures, including evacuations, adsorption testing and dead volume determination (with helium). The user is required to enter sample details, the test gas and the temperature. The number of adsorption points and their end values can also be altered for individual samples or default values used.

Data can be seen numerically and graphically in real time. The status of various valves, temperature probes and pressure transducers can also be seen in a graphical schematic of the apparatus.

Screen capture during a live run showing pressure and temperature within each cell in real time as well as the pressure step within the overall run

Note that without the optional gas booster system, the maximum pressures obtained are those available in the gas cylinders at the time of analysis.



Screen capture during a live run showing status of valves (open or closed) and pressure and temperature within cells

Data Processing

Raw data collected by GAIA is saved in text files, which include full operational details. A summary file is saved which contains only start and end pressures and temperatures of each adsorption step, as well as summary sample and rig details. This summary file is imported into a spreadsheet where all necessary calculations take place to determine the adsorption. Graphical and tabulated outputs are obtained, including the Langmuir constants. Both Gibbs and absolute adsorption can be calculated.

The calculation spreadsheet forms part of the GAIA package.

Pressure Vessels

Certified, custom built pressure vessels are used. The vessels have a wide mouth to facilitate loading and unloading of samples as well as cleaning. The base of the vessels is flat so that they stand easily during sample loading and handling. Internal volume of the standard cells is approximately 150 cc.

Custom built pressure vessels incorporate a thermocouple to measure temperature inside the cell

The pressure vessels are designed such that the temperate in the middle of cell (i.e. in the middle of the sample) is accurately measured with a thermocouple. Fine 0.5 µm particle filters prevent powdered samples from contaminating the system. Such powders are commonly used for geological samples such as coal.

Sample Requirements

In order to minimise error due to dead volume, the sample cells should contain as much test material as possible. In the case of coals, approximately 100 g of low ash coal is necessary; for high ash coal about 120 to 130 g will be required, the exact amount relating to the mineral content of the individual sample. For coals, samples are normally crushed and sieved to a top size of 0.212 mm. Further preparation may be necessary, such as the establishment of equilibrium moisture conditions.

Laboratory Requirements

GAIA is a free standing, on-floor system. It is best installed in a fully air conditioned environment. It is manufactured in Australia to Australian standards. An electrical transformer will be supplied to convert local power to comply with that of the instrument. It will require:

Gas Supplies

Gases are sourced locally at the expense of the laboratory. Cylinders are commonly of "G" size or equivalent (approximately 50 litres water volume) but smaller sized cylinders may also be used. Gases required are:

- Helium for dead volume determinations
- Test gases e.g. CH_4, C_2H_6, CO_2, N_2 *Note: GAIA is NOT suitable for toxic and corrosive gases such as H_2S*
- Compressed air for air actuated valves. *Note: compressed air should be free of contaminants such as water and oil. The use air compressors without suitable filters and drying devices will void warranty. We recommend using commercially available cylinders of compressed air of suitable quality*

Gas Regulators

Regulators are required to deliver the gas from the cylinders to the instrument. Regulators are sourced locally by the laboratory to meet specific local requirements of the gases and their cylinders.

Gas Inlet Ports

The GAIA is supplied with 1/4" tubing for gas inlets. Specific connections will be identified at time of purchase depending on local conditions.

Gas Booster

The use of an in-line gas booster is optional but highly recommended. A gas booster can be supplied at additional cost with the instrument. A gas booster will allow for greater utilisation of expensive gases as well as allow for test pressures to be achieved that exceed the pressure of the supplied gas. For example, CH_4 is commonly supplied at a cylinder pressure of around 22 MPa; a gas booster can be used to achieve a testing pressure of 30 MPa or greater.

Ventilation

Test gases will require to be ventilated to the atmosphere. They cannot be released into the laboratory environment. GAIA is supplied with a 1/4" tubing vent port. This will need to be connected to a suitable system that allows ventilation to atmosphere.

Sample Preparation Equipment

All sample preparation equipment is the responsibility of the purchaser.

Balances

A balance capable of weighing 2 kg to 0.01 g is necessary to determine the sample mass.

Moisture / ash-yield determination

Moisture and ash yield are required both before and after the adsorption isotherm determination. It is highly desirable to have the necessary equipment in-house, especially for the moisture determination.

Calibrations

Pressure and temperature sensors should be calibrated as required by a local supplier

Water Bath Models

Mains pressure water connection and drain are required.

Models

Model No	No. Test Cells	Maximum Pressure	Maximum Temperature	
			Air bath	Water Bath
GAIA 20/00-2	2	20 MPa (2900 psi)	100°C	80°C
GAIA 20/00-4	4			
GAIA 35/00-2	2	35 MPa (5000 psi)		
GAIA 35/00-4	4			
GAIA 40/60-2	2	40 MPa (5800 psi)	160°C	
GAIA 40/60-4	4			

Note: water bath models can be supplied and a suffix "W"should be given e.g. GAIA 20/00-2W

Specifications

Dimensions (air bath models)
Height: 1750 mm
Width: 1200 mm
Depth: 1000 mm
Weight: approx 250 kg

Test Cells
Construction material: steel of suitable grade for maximum P/T conditions of model selected
Internal volume: approx. 150 cc

Test Gases
Suitable for: CH_4, C_2H_6, C_3H_8, CO_2, N_2 and other non-corrosive, non-toxic gases
NOT Suitable for corrosive, toxic gases such as H_2S

Temperature Measurement
Air bath control - thermocouple +/- 0.1°C
Reference Cell - thermocouple +/- 0.1°C
Sample Cell - thermocouple +/- 0.1°C

Pressure Measurement
Standard (not available on GAIA 40/60 models)
Accuracy: ± 0.04% full scale
Stability: ± 0.1% full scale per annum

High accuracy (available on all models)
Accuracy: ± 0.01% full scale
Stability: ± 0.01% full scale per annum

Safety Features
- Blowout panel and cage to reduce chamber pressure in the event of an explosion caused by ignition of gases within the chamber
- Stainless steel fan and impeller in order to minimise the risk of ignition within the chamber
- Hydrocarbon gas monitoring of free air in oven can be incorporated
- Software control to ensure maximum pressure and temperature ratings are not exceeded

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