



Fars EOR Technology

Company



Introduction

Fars EOR Tech. Manufactures and supplies wide ranges of laboratory instruments for both upstream and downstream petroleum industries. This company Also provides laboratory services and training courses for exploration and production (E&P) projects. The main services are Routine Core Analysis (RCAL) and Special Core Analysis (SCAL) tests. Also, our team of technical specialists with more than 17 years of experience works closely with clients to develop Artificial Intelligence (AI) based software to resolve the field problems, reduce the risk and uncertainties in a cost-effective manner.

Generally, our laboratory instruments and services are grouped under several main headings namely Routine Core Analysis, Special Core Analysis, Core Preparation, Pumps, Training Courses and Software.

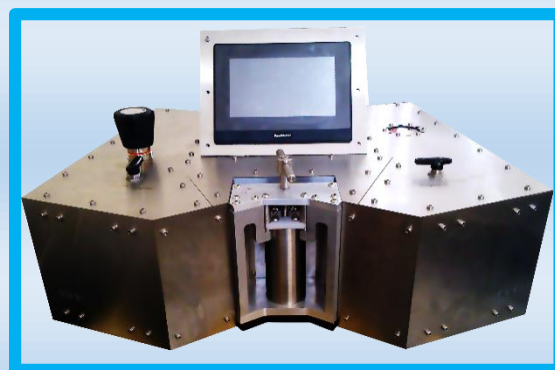
In addition, Fars EOR Tech. not only performs an intensive training program for each equipment but also provide long term spare parts and maintenance for enhancing the efficiency of its product.

Products and services:

RCAL

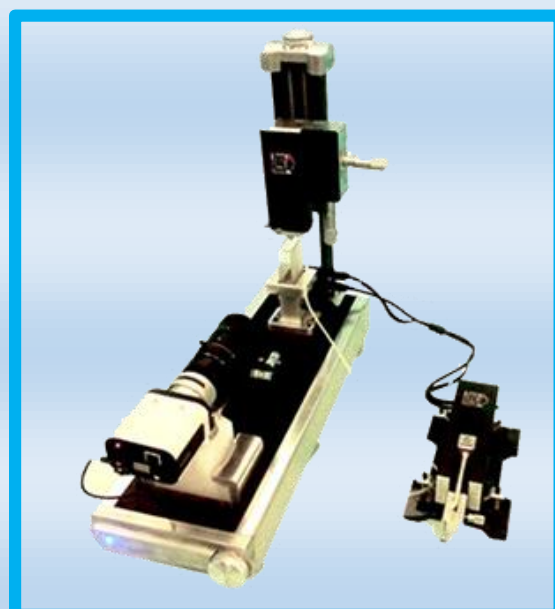
- Porosity and Permeability Measurements.
- Core Cleaning System.
- Thermal Conductivity Measurement.

- Core Plugging Machine and Cutting Apparatus.
- Core Saturator System.
- Electrical Conductivity Measurement.



SCAL

- High Pressure-High Temperature and ambient conditions IFT & Contact Angle Measurement System.
- Relative Permeability Measurement System.
- High Pressure and High Temperature Viscometer.
- PVT Apparatus.
- GOR Apparatus.
- Asphalting Size Analyzer System.



EOR

- MEOR Core Flooding System.
- Gas Core Flooding Apparatus.
- Chemical Core Flooding Apparatus.
- Steam Flooding Apparatus.
- Core Acidizing Apparatus.



General

- High Pressure Pump.
- Core-holders.
- Accumulator.
- High Pressure Hydrocarbon Sampling Accumulators (Shipping Bottle).
- Gasometer.
- Porosity and Permeability Check Plugs.



EOR Laboratory Apparatus

Core Flooding Apparatus

Core flooding system is the main part of any petroleum laboratory in the academic or research institutes. Different types of experiments is possible to be conducted using this apparatus such as; conventional fluid injection, chemical flooding, gas injection, MEOR, acidizing, porosity and permeability measurements, and many other tests required on the reservoir rock samples under reservoir condition.



Specifications:

- Corrosion resistant materials.
- User friendly design.
- Covering wide range of core plug sizes.
- Minimum dead volume design.
- Max Pressure 6000 Psi.
- Max Temperature 120 ° C.
- Max Back pressure 6000Psi.
- Max Confining Pressure 10000 Psi.



Main Compartments:

- Core holder (Hassler).
- Fluid accumulators.
- Constant temperature Oven.
- High pressure precision pump.
- Digital data logging.
- Rosemount Pressure Transmitter.
- Back Pressure Regulator.
- Enerpac Hydraulic Pump.
- Stainless Steel Material.



- Gasometer with Liner Encoder.
- Software.

MEOR Flooding Apparatus

Different types of in-situ and ex-situ experiments are possible to perform using MEOR flooding apparatus. The latest designed and constructed MEOR apparatus is a very flexible and modular one; therefore it is possible to perform various types of upstream oil and gas researches studies.

In addition, miniature type-core holders and saturators are specifically designed for those MEOR experiments which dead volume is highly effective and the efficiency of the used microbes and living organism for enhanced oil recovery purposes is low.



Steam Injection Apparatus

The past EOR field experiences in the world show that steam is the most popular agent for more oil recovery from unconventional (heavy) oil reservoirs. Respect to this, a special core flooding apparatus was

designed to conduct different steam injection patterns using various gases such as CO_2 and N_2 in a long fractured model while it is assisted by gravity drainage.

SAGD Core Flooding Apparatus

This apparatus is designed in a way that it is possible to perform different experiments at reservoir conditions utilizing whole core samples such as:

- Primary oil recovery.
- Thermal methods for heavy and light oil.
- Gas injection and gravity drainage.
- Chemical, microbial and solvent injection.
- Fracture to matrix fluid transfer.



Specifications:

- Specially designed long core holder.
- Vertical and horizontal fractures.
- Corrosion resistant materials.
- User friendly design.
- Covering wide range of core plug sizes.
- Minimum dead volume.
- Wide range of pressure (Up to 10000 psi).
- Wide range of temperature (Up to 400°C).
- Wide range of flow rate (0.01 to 50cc/min).
- Precise digital data logging and control system with remote access option.

Core Acidizing Apparatus

The core acidizing is designed to inject an acid solution into a rock sample at reservoir conditions to improve the permeability of the rock by removing the fine particles of the rock. Besides, the data logging systemable one to record the acid response curve in terms of pressure drop or permeability versus time or amount of injected acid.

Core Acidizing equipment

- Wide range of core acidizing experiments.
- Minimum acid wetted area.
- Corrosion free fluid accumulator (even with severely active acids).
- Digital data logging and control system.
- User friendly application.
- Wide range of temperature and pressure experiments.
- Handling of different solvents (Liquid/Gas) for online injection into the cell.



SCAL Laboratory Apparatus

Wax & Asphaltenes Size Analyzer Apparatus

Asphaltenes and waxes are of the most dreadful and expensive challenges of hydrocarbon systems. Precipitation of such complex mixtures is a major factor that causes severe difficulties in oil recovery and processing.

Asphaltene detection and analyzing system

This apparatus is specially designed to precisely study different aspects of asphaltene precipitation at actual conditions. Flexibility and specifications of this equipment make it appropriate for conducting comprehensive research in different areas of petroleum engineering, specially wettability alteration, and flow assurance in reservoir formations, and transportation pipelines.

Specifications:

- Working at reservoir pressure and temperature.
- Simulating EOR gas injection process.

Accurately control of flow rate



- High resolution monitoring of asphaltene flocculation process.
- Online processing of microscopic images (still/video) using very accurate image processing software.



IFT & Contact Angle Measurement Systems

IFT as the indication of energy at the interface of two immiscible fluids; is a vital parameter for any EOR process. The EOR agents such as surfactants, alkaline and polymers tend to reduce the IFT between oil and water to decrease capillary forces and recovering more residual oil.

Our interfacial tension measurement instruments package consisted of three different IFT apparatuses including spinning drop, pendant drop and IFT-400.

Spinning Drop Apparatus (Ultra-Low IFT Measurement):

The measurement of ultralow interfacial tension is of crucial interest in oil-water systems. Ultra low interfacial tensions which is utilized by special types of chemicals results in high oil recovery through IFT reduction and wettability alteration. The traditional types of tensiometers cannot measure the low values of IFT between oil and chemical solutions.

There are few techniques available for measuring ultralow interfacial tension (IFT) which the spinning drop method is the most favorable one.

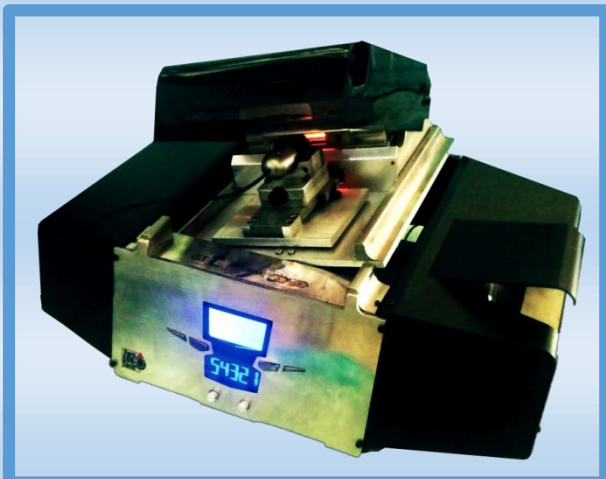
Pendant Drop Apparatus:

Drop shape analysis (pendant drop method) is a convenient way to measure surface tension. Pendant drop tensiometry, enhanced by video-image analysis, has been considered as a very accurate method for measuring the IFT of fluid/fluid interface for a wide range of IFT values. In this method, video images of pendant drops are digitized to determine the interface loci, then measuring the IFT through the solution of the Young-Laplace equation.

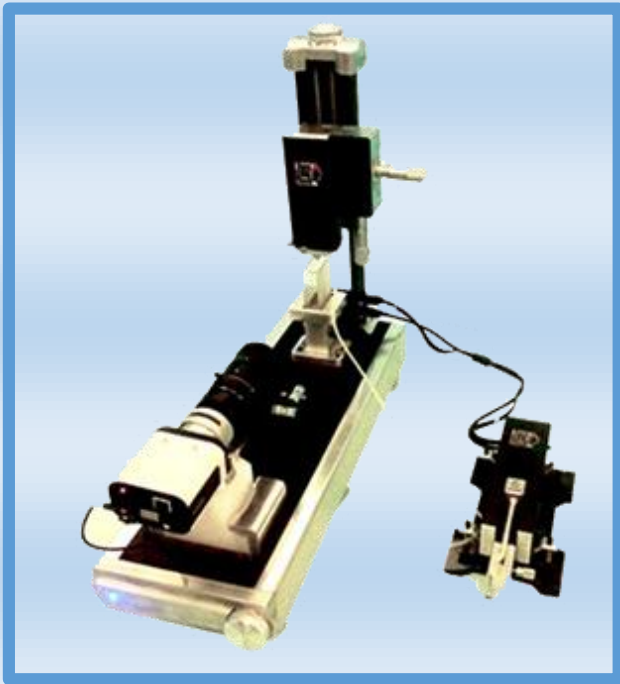
Contact Angle Measurement

Wettability of the reservoir rock and interfacial tensions between the reservoir fluids play the most important role on the oil recovery efficiency. The outcomes of several research works in EOR Research Center are utilized to design these two apparatuses for accurate wettability and IFT measurement.

- Interfacial Tension (IFT) and contact angle measurements are the main feature of these two equipment's.



- Both pendant drop and spinning drop methods are used to find wide ranges of IFTs.
- Contact angles (advancing/receding) are accurately measured using monitoring devices and image processing software.



IFT-400 & VIT-700 Apparatus (IFT and MMP measurement at reservoir condition):

Measurements of interfacial tension at reservoir conditions are critical both as an indication of the IFT changes at reservoir harsh condition and for minimum miscibility pressure (MMP) measurement if gas is used as the EOR agent. This recent technique is called Vanishing Interfacial Tension (VIT) as an alternative to very expensive and time consuming slim tube/rising bubble apparatus methods.



GOR Apparatus

The purpose of the GOR apparatus is to flash pressurized liquids and measure the gas oil ratio at equilibrium conditions. The liberated gas is measured with the gasometer at ambient conditions while the dead oil flashed is determined by gravity technique.



The GOR apparatus features the capability of recirculating the evolved gas back through the on board high pressure oil pycnometer and gas pycnometer. This recirculation ensures vapor liquid equilibrium and allows the operator easy access to representative homogeneous samples of atmospheric pressure vapor and liquids. The establishment of equilibrium is essential for high pressure volatile liquids such as those encountered in reservoir fluid studies.

PVT System

The instrument is a compact PVT system designed for the study of PVT, thermodynamic properties and phase behavior of black oil samples, gas and gas condensates systems requiring a small volume of fluid sample, in a cost effective manner. The PVT cell is composed of a stainless steel high pressure high temperature vessel enclosed at one end by a piston and at the other end by a dedicated head equipped with a high pressure two sight glass PVT cell. The Head also incorporates a sampling valve situated at the top of the cell.

This system permits the complete removal of the gas phase without danger of the equilibrium liquid changes. The cell is provided with an electric heating mantle for

homogeneous temperature control along the cell.

The windows along with a digital camera with a light permit observation of fluids which enter and leave through the outlet sampling valve. During Differential Vaporization and Flash test, the removal of the gas phase at constant pressure from the cell is facilitated by the full visibility of the gas/oil interface through the window of the cell.



High Pressure and High Temperature Viscometer

Rolling Ball Viscometer (RBV 400)

The RBV-400 viscometer is designed for the viscosity measurement of fluids at reservoir condition. The fluid viscosity is important in any EOR development plan, reservoir fluid characterization, oil production optimization, thermal EOR process, asphaltting onset measurement, and

supercritical fluid studies at elevated pressure and temperature. The operation principle is to measure the time it takes for a metal ball to roll on an inclined plate inside a fluid medium. This high pressure/high temperature viscometer utilizes less than 40 ml of sample per measurement. In addition the RBV-400 incorporates a digital pressure gauge and temperature and time indicator. It is mercury free to be environmentally friendly. All parts are corrosion-resistant type allowing operator to even measure aqueous electrolyte solutions viscosity.



Specification:

- Viscosity range: 0.2-1000 cp.
- Wetted materials Stainless Steel.
- Maximum temperature: 120 °C
- Maximum pressure: 6000 psi.
- Cylinder slope 23, 45, 70 ° and angle between these.
- Power 220 V.

Relative Permeability Apparatus

The most efficient laboratory method to obtain relative permeability is the unsteady state method. The bench top core flood system is an apparatus for performing core flood tests at reservoir conditions using refined or live fluids to determine specific, effective, and relative permeability. In the designed Systems, the core holder, valves, accumulators, produced fluid separator and necessary plumbing are mounted in a way that providing easy access to all components during the test. Confining pressure is controlled using the manual confining pressure system using a hydraulic pump and its components. The control allows calculating different parameters such as production history, relative permeability curves based on the different approaches.

Features:

- Unsteady state relative permeability tests.
- Enhanced oil recovery tests.
- Formation damage and remediation tests.

Specifications:

- Maximum confining pressure: 10,000 psi

- Maximum pore pressure: 6000 psi (higher pressures available with different pumps).
- Maximum operating temperature: 300 °F (150 °C)
- Core length: 1" to 3" standard (other lengths available upon request).
- Core diameter: 1.0" and 1.5" (optionally 30 mm).
- Flow rate range: 0.001 to 30cc/min with pump.
- Pore fluid wetted parts: Stainless Steel.

measured and/or working liquid with a high accuracy.



High Pressure & High Temperature Pycnometer

Density determination by pycnometer is a very precise method. It uses a working liquid with well-known density, such as water. This fine hole releases a spare liquid after closing a top-filled pycnometer and allows for obtaining a given volume of

RCAL Laboratory Apparatus

Porosity and Permeability Measurement Systems

Porosity and permeability measurements of the rocks are essential for reservoir description and determination of the potential of hydrocarbon storage and production. These two main properties are also used in geotechnical studies and other non-petroleum applications. The amount of pores in a rock and their configuration determines the rocks porosity and permeability. The porosity of a material is defined as the ratio of the volume of open space (pore volume) to the total volume (bulk volume). The permeability of a material is a measure of the ease with which a gas or liquid can move through the porous media.

Porometer

Helium porosity can be measured on sidewall samples, drill cuttings and standard plug samples, up to full diameter cores.



Gas Perm

GasPerm is designed for permeability determination at steady state (constant pressure and flow through the sample).

The GasPerm is a research quality instrument but it can be used for routine core analysis when rapid sample turnaround and throughput is desirable. A selectable, separate back pressure flow facility permits accurate control of steady state gas flow and core pressure over the range of 0-2,000 cc/min and 0-150 psi, enabling a greater control on Darcy flow conditions in cores with permeabilities in the range from less than 0.1 mD to in excess of 10 D.

Typically, four different ranges of mass flow meters including 0-20, 0-50, 0-500 and 0-2000 cc/min assist the operators to measure different ranges of permeability (0.01-10000 mD).





GasPerm can be operated in standalone mode or remotely through the optional PC interface. An excel report ready-to-use is provided. The operator (or the software) writes the data and the permeability is calculated automatically.

The instrument can be used with any standard Hassler-type core holder. Rapid changeover of core holder is permitted to switch from core diameter of 1" and 1 1/2" or any other diameter on request. Confining pressures up to 200psig can be applied to the cores, and displayed on the GasPerm console.



Liquid Permeability Measurement apparatus

The Liquid permeameter is dedicated to measure permeability to liquid of plug sized core samples at room conditions. The liquid permeability determination is based on the Darcy's law and assumes that one phase is present in the core and there is no rock fluid interaction. The instrument is provided with a Hassler core holder, a transparent fluid vessel, a console with pressure digital display, 3 interchangeable burettes for various permeability ranges, an electronic timer for flow rate calculation and an Excel spread sheet calculation template. This low cost apparatus is particularly interested for educational purposes.

Electrical Properties System

The Electrical Properties System is a basic teaching grade instrument for ambient electrical resistivity measurements using core plug samples. The manually operated instrument includes an ambient electrical properties cell for 1", 30 mm and 1.5" cores up to 3" in length, a resistivity meter and a brine resistance measurement dip cell. In addition, properties such as Formation Factor, Resistivity Index, Saturation Exponent "n", and Cementation Factor "m" can be determined.

Features:

- Enables bench-top measurements of formation factor and resistivity index at ambient conditions. System includes equipment for both rock and brine resistivity measurements. Standard cell offers 2 contact measurements.
 - Four terminal sleeve.
 - Adapters are available for 1.0", 30 mm and 1.5" diameter cores.
 - Silver or copper (optional upon request) membranes insure good electrical contact for accurate measurements.
- Computer data acquisition system is optional for automatic collection of resistance data.
- Plastic cover box included to prevent core drying out during a measurement.

- Standard sample sizes accommodated (Plug size): 1.0", 30 mm, 1.5" Length up to 3 inches.
- Standard pore wetted materials: stainless Steel, silver, plastic.



Thermal Conductivity Systems

Thermal properties of rocks would play an important role for extremely sensitive projects such as in underground transmission lines, oil and gas pipeline, radioactive waste disposal, and solar thermal storage facilities. Thermal conductivity depends on several factors: (1) chemical composition of the rock (i.e., mineral content), (2) fluid content (type and degree of saturation of the pore space); the presence of water increases the thermal

conductivity (i.e., enhances the heat transfer), (3) pressure (higher pressure increases the thermal conductivity by decreasing the porosity), (4) temperature, and (5) isotropy and homogeneity of the rock.

Thermal EOR methods such as steam flooding, steam stimulation, hot gas injection and institute combustion are very dependent on the thermal conductivity of the oil reservoir formation.

Besides, nanotechnology would assist thermal conductivity improvement through high conductive Nano materials injection into the formation.



Features:

Measuring thermal conductivity at the reservoir conditions.

No formation damage during the measurements.

Short time thermal equilibrium due to a proper isolation.

Accurate digital temperature controlling and measurement.

No saturation variation during the measurement due to the temperature elevation.

Thermal conductivity measurement for both wet and dry cores.

Core Cleaning Systems

Soxhlet

For many core analysis measurements, samples are cleaned out of pore fluids and contaminants then either measured in a dry state or with partial or full re-saturation. Cleaning and drying of rock samples can be achieved using many different techniques; Soxhlet is the fastest method. Hot Soxhlet solvent extraction can be used to rapidly clean samples. In the Soxhlet apparatus, the sample soaks in hot solvent that is periodically siphoned off, distilled and returned to the sample. The process continues until the siphoned-off solvent becomes clear. This may take from a few, to several hundred hours depending upon permeability and the viscosity of the oil in the pores.

Dean Stark System (Cleaning)

It is possible to obtain the initial water saturation and water composition from preserved core and core plugs through

distillation extraction. A complete unit consists of an electric heating mantle, boiling flask, thimble for holding the sample, trap or calibrated sidearm, and condenser.



CO₂ / Solvent Core Cleaner

The core Cleaner is a device for cleaning crude oil, drilling mud liquids, and water from a single piece of whole core or from a batch of core plug samples. The principle consists of filling the gas filled space in the core with solvent (e.g. toluene) by surrounding the core with a suitable solvent containing dissolved CO₂ gas and applying sufficient hydraulic pressure. The solvent mixes with oil in the core and subsequent

depressurizing to atmospheric pressure removes residual oil from the core. A number of repeated cycles are required to clean the core of hydrocarbons. The apparatus fits into a standard size floor hood. The cleaning chamber is a pressure vessel heated electrically with a two-kilowatt, 220-volt heater enclosed in an explosion proof housing. The solvent is pumped from an onboard supply tank to the cleaning vessel with a high pressure pump. A cyclone separator with a stainless steel-packed, water-cooled after-cooler is provided to separate the CO₂ and the used hot solvent when the vessel is drained. The used toluene drains into an explosion proof electric still where it is recovered and delivered back to the clean solvent supply. The still operation is automatic. The process controls are housed in a non-explosion proof box intended to be mounted outside of the hood.

Core Saturator

The manual saturator permits to perform a sequence of vacuum and saturation cycles on plug size samples. The standard apparatus includes a plug sized core cell, a vacuum pump, a hand operated pressure pump (2,000 psi output), a saturate vacuum tank and necessary hand operated valves and plumbing. A larger capacity cell to

accommodate full size core samples is also available.

BENEFITS:

- Rapid and efficient saturation.
- Can accommodate plug size sample and full sized core sample in option.
- Manual operations loading carrier for easy loading.
- Dead volume sets to minimize volume of saturate.



lock/release core clamping device to hold the core in place while trimming an end off. In addition, this equipment is offered for teaching environments such as universities and colleges with geology or petroleum engineering laboratories. All parts of the machine that are exposed to wetting are resistant to corrosion. This machine has a cooling feeding system, a coolant recovery pan and a splash guard. Also, this instrument is ideal for use in small labs and teaching environments.



Core Preparation

Core Cutting

The core cutting instrument utilizes the traditional radial blade design that has proven to be versatile and rugged for production use. It can be utilized to trim large rock samples or slab them into different shape. This technique offers an improved core handling feature, a quick

Core Drilling

The designed core plugging system is a heavy duty, manually operated floor standing drill press. Our plugging machine has the capability of drilling cores of different sizes from 1 to 1½ inches with high precision. Maximum coring length is 5 inches. It offers a 1.5 HP motor with up to 3800 RPM capabilities. The core pan/table height is adjustable with rack and pinion

hand crank movement, and can also be tilted to ± 45 degree. In addition, this machine has a cooling feeding system, a coolant recovery pan and a splash guard. The plug can be taken horizontally and/or vertically so the effect of orientation on the permeability can be investigated.

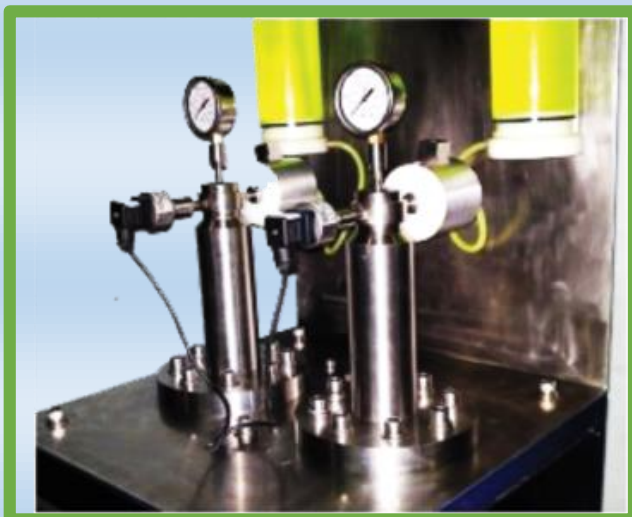


General Laboratory Apparatus

High Pressure Pump

The Positive Displacement High Pressure Pumps are designed for applications requiring accurate pulse less flow at constant pressure or constant flow rate for delivery of fluids, solvents, solutions or gas over wide ranges of pressure or flow rate. The pumps are designed to incorporate motor driven piston, HMI controlling unit, pressure and temperature measurement to meet the most application requirements in the lab.

Pumps consist of a general base unit which includes, Servo Motor, Gear Box and HMI based controlling unit. Each base can handle any of the following configurations by ordering only the cylinders needed. The cylinders could to be mounted/demounted very easily. Any two SBP(s) could be coupled together to work as double barrel pumps for fluid injection without any interruption.



Specifications:

- Constant flow rate and pressure control from 0.01 – 50cc/min; 400 – 1360 bar.
- Accurate flow injection rate at very low flow noise.
- Large operating pressure and flow rate ranges.
- Large volume capacity 100 – 1000 cc
- Corrosive resistance wetted parts
- Fast cylinder refill

This apparatus includes:

- PLC controller and data acquisition system for full control of the system parameters and monitoring them.
- Pressure and temperature sensors.
- HMI (Human Machine Interface) is specially designed to control the pumps consists of a 7" TFT touch screen display, 800*480 Resolution, USB and SD memories interfaces and a special user-friendly software developed for this purpose.

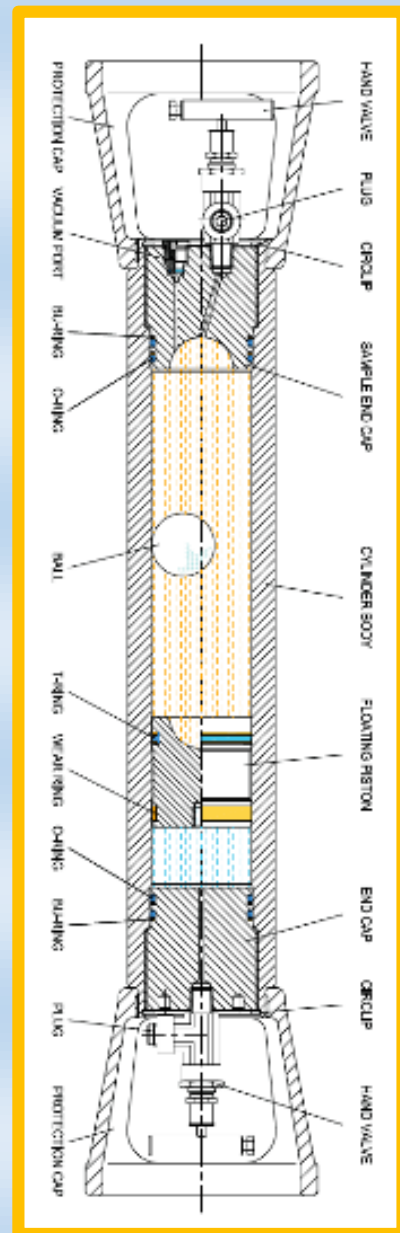


Shipping Bottle

The Piston Type Sample Cylinder is a shipping bottle designed for transportation and storage of pressurized samples, especially hydrocarbon samples.

To separate the sample fluid from a secondary driving fluid, the bottles are equipped with a floating piston. The piston has a single O-ring seal and a wear ring and is designed to minimize friction and reduce pressure load. A mixing ball is incorporated. The bottles are designed with a minimum of dead volume.

The two end caps are sealed with double O-ring seals and back-up rings. Both end caps are held in place by strong circlips. Right angle needle valves with 1/4" NPT female port connections are fitted to the 10,000 psi cylinders. A special fitting is provided on the sample side of the cylinder which allows for evacuation. 7/16" female port threads are machined into the end caps of the 15,000 psi cylinders. Valve protectors on both ends protect the valves during handling and transportation.



Gasometer

The manual gasometer is designed to measure gas volumes at ambient conditions of pressure and temperature. The gas enters the calibrated cylinder and raises the floating piston upwards, thus incrementing the volume space in the cylinder. A hand operated crank allows for the operator to adjust the position of the piston at the desired pressure and volume. The volume, temperature and pressure of the gas are continuously monitored and displayed. The gasometer is provided with inlet and outlet valves.

- Pressure accuracy : 0.5%
- Temperature resolution : 0.1°C
- Wetted parts : Stainless steel



Features:

- Volume : 4 liters
- Pressure : vacuum to 20 psi
- Volume accuracy : 0.1 ml



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