Sandia National Laboratories

Flow Visualization and Processes Laboratory

Automated Two-Phase Flow Test System

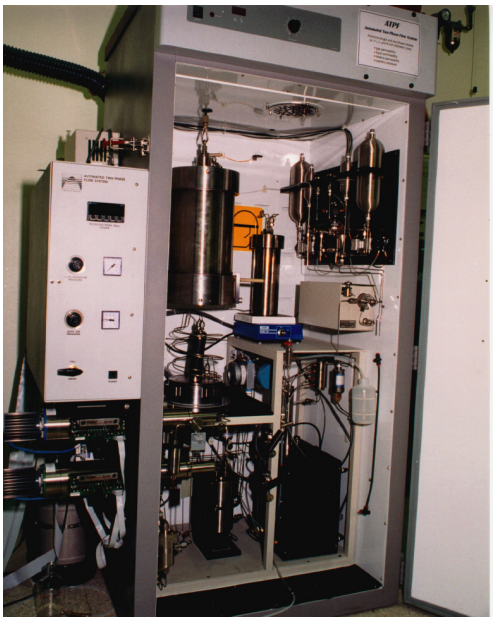
Need

Laboratory-measured rock and flow properties are used in numerical analysis to evaluate liquid and/or gas flow such as for a nuclear waste repository to determine if fluid flow is within limits set by regulatory agencies, to determine whether a reservoir or repository seal material is effective, or to characterize flow in a hydrocarbon reservoir. The Automated Two-Phase Flow Test System (ATPF) measures flow properties of low-permeability porous media under simulated *in situ* pressure conditions. An auxiliary test system, the OPP-610, can measure single-phase properties such as gas permeability and porosity.

System Description

The ATPF measurement capabilities include steady-state single-phase permeability, gas/liquid relative permeability and threshold pressure for low permeability porous media. The system was designed to perform tests using nitrogen or helium gas and liquids such as brines and oils (e.g., decane, OMS, and silicon oil). Flow tests can be performed under elevated pressure to simulate *in situ* conditions.

The ATPF can perform tests on cylindrical samples ranging in size from 1.5 to 6 inches in diameter, and from 2 to 10 inches long. The system was designed to test low-permeability rocks (i.e., those with permeability within the 10^{-15} to 10^{-19} m^2 [millidarcy to 0.1 microdarcy] range). Hydrostatic confining pressure from 400 to 3000 psi and pore fluid pressure up to 2000 psi can be applied to the sample during the tests. The test system is contained within a temperature controlled environmental chamber. Tests can be run at temperatures up to 40° C minimizing problems caused by room temperature fluctuations.



Automated Two-Phase Flow Test System.

Test Description

To perform a test, a specimen is first inserted into a rubber sleeve to protect it from contamination by the confining pressure fluid during testing. Stainless steel endcaps are placed at each end of the sleeve and clamped onto thespecimen. The jacketed sample is then placed onto the overburden core holder (OCH) baseplate, and the stainless steel pore pressure lines are attached. The OCH is lowered over the jacketed specimen assembly and locked onto the baseplate. The OCH is then filled with water and the

sample is subjected to a predetermined hydrostatic confining pressure to simulate *in situ* or reservoir conditions. The appropriate pore fluid is introduced into the sample and a pre-specified pore pressure is established within the specimen. The specimen is then allowed to stabilize prior to the initiation of tests. Once the confining pressure, pore pressure, and temperature have stabilized, a differential pressure is applied linearly across the specimen using gas or liquid causing the fluids to move through the specimen.

The PC-driven system automatically performs test sequencing and data collection.

Applications

Quantification of fluid flow and rock properties for oil and gas reservoirs and nuclear waste repositories and barriers:

- Direct measurement of single-phase gas or liquid permeability
- Direct measurement of gas-liquid relative permeability
- Direct measurement of threshold pressure
- Quantification of flow properties for determination of containment properties of caprock, underground geologic storage material, or spill-containment material
- Determination of potential for gas, liquid, or contaminant flow from a repository

Advantages

The ATPF is a unique, self-contained test system specially designed for characterizing two-phase flow properties of low-permeability porous media. Tests can be designed to meet customer needs.

Contacts

Peter B. Davies
Department Manager
Geohydrology Department
Sandia National Laboratories
P.O. Box 5800, MS 0735
Albuquerque, NM 87185-1324
Phone: (505) 844-3072
Fax: (505) 844-4426
pbdavie@sandia.gov

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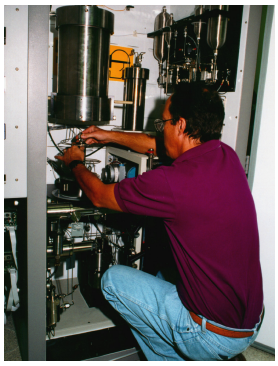

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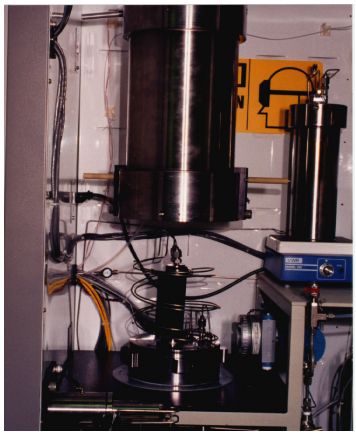

(d)

(e)

(a) Rock specimens ready for insertion into sleeves and then testing. (b) A rock specimen is placed inside a sleeve in preparation for testing. (c) A stainless steel pore fluid line is attached to an endcap of a sleeved rock specimen. (d) Sleeved rock specimen in place ready for the overburden core holder to be lowered. (e) Pretest inspection of the upper limit set for the confining pressure.