iX77™ Rheometer

The ***iX77***™ Rheometer is a coaxial cylinder type Rheometer designed to measure fluid rheologies under high pressures and temperatures with a high degree of safety. The FANN design is based on a machine developed by the Sandia National Laboratories. It was designed with oil well and geothermal drilling fluids in mind, but has applications in many other fields. It features extensive safety interlocks through not only the internally mounted computer but also mechanical and smart electronic hardware.

Specifications of the ***iX77***™ Rheometer allow operation to 600°F (316°C) and 30,000 psig (206,840 kPa). Optionally, a chiller may be attached and controlled by the software to allow operation below ambient temperatures.

The control software is intended to automate the operation, data collection, reporting and notification functions of the ***iX77***™ Rheometer to the greatest extent practical, thus allowing the operator maximum flexibility.

The goal in designing the software was to automate as much as possible, while still permitting the machine to be configured and operated as needed by the advanced user.

This system uses a unique magnetic sensor to detect the motion of the jewel mounted torsion assembly in the test cell. The sensor system can be calibrated to ± one degree (equivalent to one centipoise at 300 RPM).

Test pressures are generated by an air operated high pressure hydraulic pump and controlled by a smart back pressure controller, high pressure valve and pressure transducer. The pressurization fluid fills the upper portion of the Test Cell. The pressurization fluid is in direct contact with the quiescent sample, above the sample in the measurement area. The contact area is small to minimize mixing.

The Rheometer's one-piece bench top design makes it suitable for use on a well site as well as in a laboratory. Special consideration should be given for moving and installing because of its weight (350 lbs) and its stature. A strong low profile (22 inch high) bench top is recommended for easier cell removal.

The system may be operated in "Simulation Mode" for training and support purposes. In this mode, the software "pretends" that it is a fully functional ***iX77***™ Rheometer. Results generated in "Simulation Mode" should never be construed as meaningful.

FUNCTIONAL OVERVIEW

The ***iX77***™ Rheometer software runs on the Windows® XP Professional operating system, and was developed using National Instruments LabVIEW™. The operating system controls and records, temperature, pressure, and rotor speed. It derives all of the fluid property measurements from the angle of rotation of the internal bob, as reported by the magnetometer and calibrated using a standard fluid. There are two data collection modes, manual and automatic. In manual mode, the user turns on data collection from a screen and provides the necessary set points. In the automatic mode, a test profile is either generated from a list of pressure and temperature test points or retrieved from a file. The automatic profile generation is based on a template set up by the installer. In addition to the testing functions, the software provides for calibration, setup, and tuning to allow the Rheometer to be used for a wide variety of tests.

Shear stress values are calculated based on a "look up" table developed during calibration. The calibration file is loaded on startup, and evaluated for evidence of hysteresys. Excessive hysteresys indicates a likely mechanical problem, and a dialog is displayed when it is detected.

If the system starts up and detects it is under pressure (for instance after a power failure), it will use the detected pressure as its manual pressure set point. This is done to avoid decompressing the system suddenly. Temperature set point is always set to zero on startup.

Provision has been made to control an optional external Chiller by connecting via a serial cable to the chiller. The operational parameters for using the chiller will be set up by the installer.

SPECIFICATIONS

INSTRUMENT SPECIFICATIONS FOR STANDARD R1 ROTOR, B1 BOB AND F1 TORSION SPRING

Instrument Geometry	Coaxial Cylinder
Rotor Speed, rpm (normal)	1 to 600
Rotor Radius, cm	1.8415
Bob Radius, cm	1.7245 (B1 Bob)
Bob Height, cm	3.805 (B1 Bob)
Shear Gap in Annulus, cm	.1168
Torsion Spring constant, K_1 N-cm/degree deflection	0.00386 (F1 Torsion Spring)
Bob Surface constant, K_2 cm^{-3}	0.01323 (B1 Bob)
Shear Rate constant, K_3 sec^{-1} per rpm	1.7023
Overall Instrument Constant, K centipoise-rpm/degree	300
Shear Stress Accuracy	± 0.5% F.S
Maximum Use Temperature, F°, C°	600° (316°C)
Minimum Use Temperature, F°, C°	23° (-5°C)
Maximum Use Pressure, psi, kPa	30,000 (206843 kPa, 2041 atmospheres)
Sample Volume, in^3, cm^3	7.76 in^3 (175 cm^3) (nominal)
Power Requirements	230 Volts, 60/50 Hz, 1 KVA
Viscosity Range, cP	0-300 @ 300 rpm
Minimum Viscosity, cP	5 @ 600 rpm
Maximum Viscosity, cP	300 @ 300 rpm
Weight & Dimensions	
Test Cell Size, inches, (cm)	16-1/4 high, 4-3/4 diameter (41.3 X 12.1 cm)
Test Cell Weight, pounds (kg)	36 (16.4 kg)
Instrument Size, inches (cm)	41-1/2H,43-1/2W,24D (105.4x110.5x61cm)
Instrument Weight, pounds (kg)	350 (159 kg)

TECHNICAL DESCRIPTION

Test Cell Materials

The primary parts of the Test Cell; Cap (top), Coupling (center) and the Cell (bottom) are made of INCONEL® alloy 718. These parts are non-magnetic to insure proper functioning of the magnetic drive and torque sensing.

The Pivot/Thermowell in the inside center of the Cell is made of 17-4PH stainless steel (17 Cr - 4 Ni - 4 Cu) bar stock in the age-hardened condition H 1150-m. The three Port Adapters screw into the high pressure ports of the Test Cell and are made of 17-4 PH stainless steel.

In normal operation, only the Coupling, Pivot/Thermowell, and Cell come in contact with the test fluids.

The Test Cell internal parts are made of Stainless Steel Type 303, with these exceptions:

In the bottom of the Test Cell in contact with the sample:

1. Sapphire V-Jewel
2. Tungsten Carbide Pivot
3. Steel Angular Contact Bearing
4. Bronze Rotor Bushing
5. Samarium-Cobalt, rare earth Driven magnet
6. 17-4PH stainless steel Pivot Bushing
7. 17-4PH stainless steel Backup Ring
8. Titanium Bob Shaft

In the top portion of the Test Cell these parts normally contact the pressurization fluid:

1. Upper Torsion Magnet
2. Sapphire V-Jewel
3. Tungsten Carbide Pivot
4. Titanium Upper Magnet Mount and Limit Stop
5. Beryllium-Copper Torsion Spring and Upper Pivot Spring
6. Aluminum-Spring mandrels, Clamping Sleeves, and the Zeroing Sleeve
7. 17-4PH stainless steel Backup Ring

Temperature Control

Test sample heating is produced by an electric resistance heater attached to the wall of the Heater Well. During a test, the sample portion of the Test Cell rests in the Heater Well. Heater temperature is monitored and automatically controlled to a limit not to exceed 750°F allowing a lower voltage heater to be safely used.

The sample temperature is sensed by means of a single J type Thermocouple that is permanently mounted in the center of the Heating Well. The thermo-well is located in the center of the Rotor Pivot, which supports the Rotor. This places it near the center of the fluid sample.

The sample is sheared constantly to aid in minimizing thermal lag. External flutes on the Rotor generate flow up the inside wall of the Test Cell. It then flows down through the Baffle, the center of the Bob (the stationary part of the concentric cylinders), and the holes near the bottom of the Rotor. The holes direct it back to the wall, to re-circulate.

Cooling is accomplished by injecting a controlled flow of tap water or other coolant into the narrow gap between the Test Cell and the Heater Well. The expended steam and water is vented through a drain in the bottom center of the Heater Well. Cooling is activated automatically when a lower temperature set point is entered or the end of the test has been reached. The system automatically applies air or water depending on pre-set default values. For testing at temperatures below ambient, an optional external chiller is used. The software controls the Chiller automatically allowing for totally automatic cooling and heating integration in a Test Sequence

Shear Rate Control

The Rotor is magnetically driven through the wall of the Test Cell. A powerful samarium-cobalt permanent magnet is attached to the bottom of the rotor. It magnetically locks to a cylindrical permanent magnet, which rotates with an insulating can, around the heaters of the Heater Well. Any rotor speed between 1 and 600 RPM is available, including standard 600, 300, 200, 100, and 3 RPM, which is equal to 1021, 511, 340, 172, and 5.1 reciprocal seconds (S^{-1}). Speed regulation is ± .5 revolutions per minute.

Pressure Control and Measurement

Test sample pressurization is achieved by an air operated, gate valve controlled, piston pump. The air pressure to this pump is controlled by an Electro-Pneumatic Proportional Valve for reaching the pressure with minimal overshoot. The pressure is then finely controlled by a Controller coupled with a 30,000 psig Back Pressure Air-Op Valve and a Pressure Transducer.

Pressure release is primarily through a high pressure, air operated, non-rotating stem valve that is operated as a dump valve at the end of the test activated through a solenoid valve. A high pressure manual valve is also provided and is primarily used to purge the system if a loss of pressure occurred while heating. The manual valve can also be used if all other systems fail to safely remove pressure from the system. A nominal 35,000 psig replaceable rupture disc provides additional safety relief. All released pressurization fluids are returned to a waste bottle.

When ordering specify Material No. 101543382 – *iX77*™ Rheometer

Optional Chiller

For viscosity testing below ambient temperatures Fann offers an optional chiller for the iX77 Rheometer. The Model D4004 Chiller provides controlled sample cooling and is capable of regulated sample cooling from ambient temperature to -10°C.

Ordering Information

Chiller 115/120 Volts - Part No. 204160
Chiller 220/230 Volts - Part No. 381464

Fann Instrument Company offers a complete line of Instrumentation for use in testing drilling fluids in accordance with American Petroleum Institute publications:

API Recommended Practice 13B-1, ANSI/API 13B-1/ISO 10414-1,
API Recommended Practice 13B-2, & API Specification 13A

For more information on the iX77 Rheometer and the complete line of Fann Fluid Testing Instruments, contact Fann at the address below

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