SLIMHOLE DIGITAL OILFIELD LOGGING

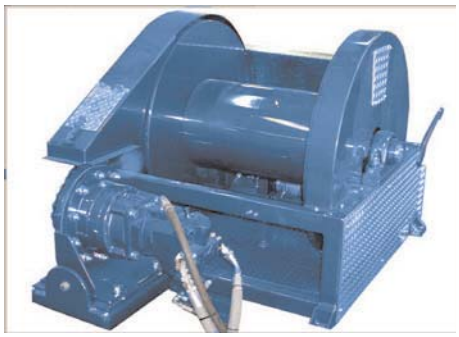
ROBERTSON GEOLOGGING LIMITED

RG slim oilfield digital logging equipment is designed for oil/gas and CBM methane operations. The maximum working temperature is 125degC and maximum pressure is 12,500psi. Tool diameter is t 2.5" (63mm).The RG digital surface system runs the industry-standard log acquisition software, Warrior™, marketed by Scientific Data Systems Inc.

Tool designs have been optimised for responses in boreholes up to 12" diameter. The designs are supported by Monte Carlo modelling (nuclear tools) and finite element analysis (resistivity tools) and bench-marked against industry- standard formations. Environmental correction algorithms are included within the acquisition software.

The string currently consists of 6 modules. These are connected with field joints to allow assembly in the borehole using a C make-up plate. Module 1, the telemetry sub is always required and is the uppermost module in the string. The remaining modules can be included or omitted as required.

Module1: telemetry, CCL, natural-gamma, borehole deviation (inclination), mud-resistance
Module 2:dual-receiver ultra-sonic gas detector
Module 3: dual detector neutron
Module 4: litho-density, caliper
Module 5: dual-induction/ temperature
Module 6: temperature (for use when module 5 is omitted)



The system is designed for use with RG-supplied or third-party hydraulic winches and logging wirelines. RG can custom build logging vehicles and skid units for on or off-road use in all climatic conditions. Hydraulic winches come complete with integral depth and tension measurement and spooling equipment. Maximum operating cable length is 3000m (9848') x 7-conductor 5/16" cable and 4500m+ (14760'+) x 7-conductor 7/16" cable.

TELEMETRY/ NATURAL GAMMA MODULE

The telemetry module is the topmost tool in the stack. Its main function is to collect and combine digital data from all other tools and to transmit this in a digital form via the logging wireline to the surface acquisition system. It also provides control functions and tool power to the other logging tools.

PRINCIPLE OF DATA COMMUNICATIONS:

All tools in the stack communicate with the telemetry module over a common internal RS485 data bus. The telemetry module organises this data and transmits it to the surface in a single digital packet containing up to 32 x 4byte channels. Data is acquired on a depth basis with a sample interval that can be selected to optimise measurement resolution and/or logging speed. Data transmission rates (baud rates) can also be changed to maximise transmission rates on a particular wireline.

The wireline telemetry requires a minimum of 4-conductors. Industry-standard 5/16" 7-core cable offers a good compromise between electrical characteristics and mechanical strength.

FEATURES

Bi-directional digital transmission with variable baud rate

Compatible with industry standard cables and cableheads

MEASUREMENTS

Natural gamma
Mud resistivity (optional)
Casing-collar locator (CCL) (optional)
Borehole inclination (optional)

APPLICATIONS

Natural gamma
Lithology indication
Shale measurement
Bed- boundary/ bed thickness measurement
Correlation between logs and wells

Mud resistivity
Correction of resistivity/conductivity logs

Casing collar locator
Lcation of casing shoe
Depth correlation between logs

Borehole tilt (optional)
QA of borehole construction
Bed thickness correction

OPERATING CONDITIONS

Borehole type:
4" to 12"open hole

SPECIFICATIONS

Diameter:	63mm (2.5")
Length:	2.1m (83")
Weight:	25kg (55lb)
Max. temperature:	125°C
Max. pressure:	86MPa (12,500psi)

SALES INFORMATION

Probe:

75 002 006	Telemetry/ Natural Gamma
75 012 006	+ CCL
75 022 006	+CCL, Mud resistivity
75 032 006	+CCL, Borehole tilt
75 042 006	+CCL, Mud resistivity, Tilt

Accessories:

80 000 004	Natural gamma calibrator
80 000 003	^{137}Cs test source for calibrator
80 000 011	Makeup plate
80 000 012	Assembly wrench

ULTRASONIC NOISE MODULE

The noise module detects points of entry of high-pressure gas into an open borehole by listening for an ultrasonic signature.

PRINCIPLE OF MEASUREMENT:

Sound energy caused by gas entering a borehole is focussed by a conical acoustic mirror within the probe onto a microphone. The microphone is tuned to measure the acoustic energy in a frequency band centred at 40kHz., characteristic of entry of high-pressure gas through a narrow orifce.

FEATURES

Dual detectors in a differential configuration to reduce background noise

High sensitivity microphones with acoustic focussing

Fully digital telmetry combines with density, neutron and other logging probes

Easy field access for replacement of microphones.

MEASUREMENTS

Mean acoustic energy in a fixed passband centred at 40kHz

APPLICATIONS

Gas detection

OPERATING CONDITIONS

Dry open hole only. Microphones will be destroyed by 10psi water pressure!

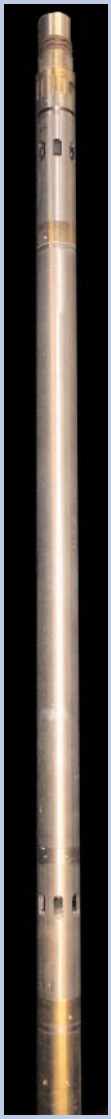
SPECIFICATIONS

Diameter:	63mm (2.5”)
Length:	1.73m (163”)
Weight:	21kg (64b)
Max. temperature:	125°C
Max. pressure:	Gas-filled hole only

SALES INFORMATION

Probe:

75 002 005	Ultrasonic noise probe



COMPENSATED NEUTRON MODULE

The dual neutron module provides an environmentally compensated porosity log in mud-filled open holes. An epithermal detector configuration is available for air/gas filled holes.
The tool design has been optimised to provide good performance at acceptable logging speeds while still using a relatively small 92GBq ^{241}Am-Be source. It is combinable with the litho-density and dual induction log in a single run.

PRINCIPLE OF MEASUREMENT:

The dual neutron measurement uses two ^{3}He proportional detectors and a side-door-entry sealed neutron source. Fast neutrons emitted by the source are scattered and slowed down by light elements (principally hydrogen) in the formation. The ratio of the neutron flux reaching the detectors depends on the formation hydrogen index/ formation porosity.

Neutron porosity measurements are affected by the borehole environment. These effects are compensated in software by algorithms calculated by Monte Carlo modelling and benchmarked to standards at the Callisto faclity in Leicestershire, UK.

FEATURES

Well characterised tool response based on computer calculations for limestone, sandstone and dolomite

Fully digital telmetry combines with density, induction and other logging probes

Low strength source requirement for safe handling and cost reduction

Choice of thermal or epithermal near detectors for mud-filled/ dry holes

High resolution measurement. Maximum data sampling rate is 1cm (0.4")

MEASUREMENTS

Porosity (phi)
Ratio long/ short (NRAT)
Raw long amd short-spacing counts

APPLICATIONS

Porosity evaluation
Lithology identification (in conjunction with other logs)
Detection of gas or light hydrocarbons
Correlation between logs

OPERATING CONDITIONS

Borehole type: 4" to 12" mud-filled open or cased boreholes. Epithermal version can be used in gas-filled boreholes (with reduced accuracy)

SPECIFICATIONS

Diameter:	63mm (2.5")
Length:	2.07m (81")
Weight:	27kg (59lb)
Max. temperature:	125°C
Max. pressure:	86MPa (12,500psi)
Porosity range:	-15% to +45% limestone

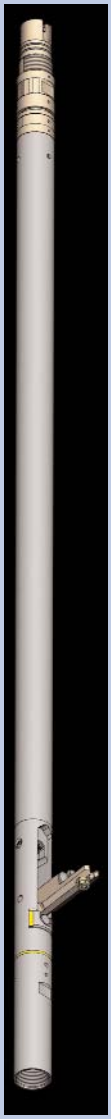
SALES INFORMATION

Probe:

75 002 003	Dual neutron probe (2 x thermal detectors)
75 012 003	Dual neutron probe (1 x thermal and 1 epithermal detector)

Accessories:

80 000 002	92GBq ^{241}Am-Be source
80 000 007	Source holder
80 000 005	Source transport pig
80 000 006	Source handling tool set
80 000 019	Field check jig
80 000 016	Bow spring
80 000 024	Spare blade for bow spring



LITHO-DENSITY MODULE

The litho-density tool combines a borehole-corrected bulk density measurement with a photoelectric lithology log (P_e). The radioactive source and detectors are mounted in an articulated skid that is maintained in contact with the borehole wall by a powered backup arm to minimise borehole rugosity effects. The arm also doubles as a caliper measurement. The tool may be combined with compensated neutron and focussed induction measurements in the classic 'triple-combo' configuration.

PRINCIPLE OF MEASUREMENT:

Gamma radiation from a ^{137}Cs source in the tool is Compton scattered by the formation and detected by two scintillation detectors. The relative intensities of the radiation at each detector provides a measurement of formation bulk density.

The photoelectric measurement is derived from the ratio of the gamma intensities in high and low energy windows at a detector. The P_e measurement depends in the atomic number of the formation and is a good lithology indicator.

Both density and Pe measurements are influenced by the borehole environment. These effects are minimised by corrections calculated by extensive Monte Carlo modelling and benchmarked to standards at the Callisto faclity in Leicestershire, UK.

FEATURES

Drift eliminated by digital circuitry and active calibration loop based on internal reference source

Well characterised tool response based on computer calculations

Tungsten carbide coated wearplate on skid can be easily replaced in the field

High resolution measurement. Maximum data sampling rate is 1cm (0.4")

MEASUREMENTS

Bulk density (rhoB)
Correction indicator (delta-rho)
Photoelectric effect (P_e)
Stabilisation loop indicator

APPLICATIONS

Matrix identification
Formation fluid analysis
Porosity

OPERATING CONDITIONS

Borehole type: 4" to 12"open hole

SPECIFICATIONS

Diameter:	63mm (2.5")
Length:	3.23m (127")
Weight:	75kg (165lb)
Max. temperature:	125°C
Max. pressure:	86MPa (12,500psi)
Density range:	1.5 to 2.95g/cc
P_e range:	1 to 10 Barns
Caliper range:	75mm (3") - 400mm (12")

SALES INFORMATION

Probe:

75 002 000	Litho-density probe

Accessories:

80 000 001	37GBq ^{137}Cs source
80 000 010	Source holder
80 000 008	Source transport pig
80 000 009	Source handling tool set
80 000 013	Density/ Pe calibrator
80 000 015	Caliper calibrator
80 000 014	Spare wearplate

DUAL INDUCTION MODULE

The dual induction probe provides conductivity logs with deep and medium depths of investigation to profile borehole fluid invasion into the formation. The tool uses an 'array' technique where multiple sets of in-phase and out-of-phase receiver responses are processed and summed to emulated the vertical and radial responses of classic 6FF40 ILD and ILM logs. The tool may be combined with other measurements and is run at the base of the stack. The probe includes a fast-reponse platinum resistance thermometer for measurement of external borehole temperature.

PRINCIPLE OF MEASUREMENT:

An oscillating high-frequency magnetic field created by a transmitter coil within the probe induces an alternating electrical current within the surrounding conductive formation. This current, in turn, induces voltages within multiple receiver coils in the probe proportional to formation conductivity. The transmitter-receiver spacings determine the depth of investigation of the measurements.

FEATURES

Multiple coil 'array' measurement using computer processing to synthesize tool responses. Raw data is also stored for post-log processing

Internal temperature compensation for low drift

Oil filled and pressure balanced mandrel

Fully digital telmetry combines with density, neutron and other logging probes

High resolution measurement. Maximum data sampling rate is 1cm (0.4")

Includes external temperature measurement

MEASUREMENTS

Deep conductivity (ILD)
Medium conductivity (ILM)
Raw conductivity channels
Temperature and differential temperature

APPLICATIONS

Hydrocarbon saturation
Porosity
Lithology (in conjunction with other logs)
Correlation between wells

OPERATING CONDITIONS

Borehole type: **4" to 12" mud or air--filled openhole**

SPECIFICATIONS

Diameter:	63mm (2.5")
Length:	4.13m (163")
Weight:	28kg (62lb)
Max. temperature:	125°C
Max. pressure:	86MPa (12,500psi)
Resistivity range:	0 to 200ohm-m
	(Qualitative indication up to 2000ohm-m)
Depth of investigation:	
	ILD 60"
	ILM 30"

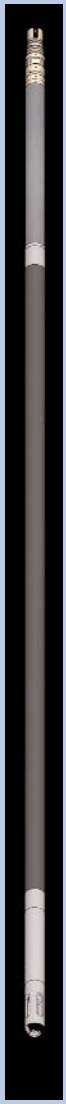
SALES INFORMATION

Probe:

75 002 004	Dual induction probe with temperature

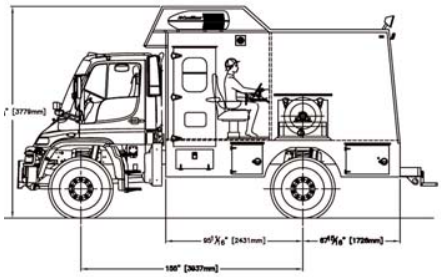
Accessories:

80 000 017	Calibration loop
80 000 018	Stand-off (2 required)



RG will arrange manufacture of complete logging vehicles based on chassis supplied by ourselves or by a client. We can also supply skid-mounted logging cabins and draw-works for local mounting on a client's vehicle.

We can recommend specifications and layouts for on or off-road use in climates from desert to extreme cold. We customise all designs to client's individual requirements. Typical installations include a thermally insulated aluminium operator's cab with a separate compartment for drawworks. Internal fittings include benching and lockable storage, operator's control panel, a/c, heating and main and emergency lighting. External fittings include draw works and spooling system, sonde and equipment storage, rear and side flood lighting and a diesel generator set.

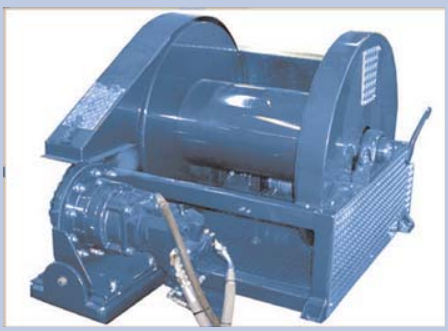


Hydraulic draw-works are available in single drum configurations with capacities up to 4500m (14,760 ft). Typically these feature a 2-speed hydraulic motor with electric shift and closed loop hydraulic system driven from the vehicle PTOor a stand-alone diesel set. All include band brakes and a cable-spooling system with control from the operator's console

LOGGING VEHICLE

All-terrain logging vehicle (desert specification)

Based on 4x4 Mercedes Unimog single axle chassis



DRAWWORKS

Single-drum hydraulic drawworks

Capacity 3,000m (9840') 5/16" cable

Speed range (core) 8 - 200m/min
(rim) 14 - 320m/min

Pull range (core) 1,700 - 3,200kg
(rim) 900 - 1,800kg