Multi-function Neutron Imaging System (MNIS)

Tool Background

Funded and developed by Advanced Applied Physics Solutions (AAPS), a nationally designated Centre of Excellence for Research and Development established at TRIUMF – Canada's national laboratory for particle and nuclear physics, the MNIS technology was created and developed by Frontier Sonde, Inc. (FSI) for application in the oil and gas market to target bypassed pay, cavern interface requirements, time-lapse monitoring and as an open hole log alternative at the FSI campus in Vancouver, British Columbia.

System Description and Hardware

The MNIS system integrates advantages of neutron-gamma and neutron-neutron measurements in one pass. The technology measures multiple well parameters and provides imaging of neutron/gamma decay in addition to gas index and the most accurate and precise saturation information available via downhole measurement. The MNIS is suitable for high, medium and low-salinity environments as well as high, medium and low-porosity formations. Through design iterations, the MNIS features optimal detector layout, guaranteeing the performance of the tool and the information derived from the wellbore. Through extensive design and testing, sourcing components from accredited and audited vendors, the MNIS provides superior performance with excellent reliability.

- Pulsed neutron generator
- Pulsed neutron generator simulator
- Detector section
- High speed telemetry with GR/CCL/TBH
- Surface front-end panel and laptop

Principle and Methodology

The pulsed neutron generator (PNG) emits "fast" neutrons at 14 MeV and bombards the surrounding formation nuclei. The formation information is then extracted by recording the interactions that occur during the process of a neutron's life cycle; specifically, the MNIS records and processes the thermal neutron absorption (die-away). The speed of thermal neutron die-away is proportional to the macro-capture cross section (Σ) of the logged formation while the energy level of the incident gamma rays are used to differentiate gas, oil and water in the pore space of the formation. The decay of the emitted fast neutron and resultant gamma rays produced during thermal neutron absorption by the formation and fluids within the formation are used to accurately quantify the makeup of the formation and its (bound) fluid. The Σ output, decay and energy levels of the released gamma rays are used to calculate formation water saturation. The multi-detector array also provides the formation gas index.

Applications

- Evaluate cavern interface, static or dynamic
- Evaluate steam chamber development in SAGD applications
- Determine saturations in high/medium/low salinity and high/medium/low porosity formations
- Re-evaluate old wells to locate bypassed hydrocarbons, locate water entry and flow behind casing, enhance oil recovery
- Evaluate and monitor reservoir residual oil and gas index in cased hole
- Evaluate new cased holes and perform time-lapse logging to monitor reservoir saturation

Benefits

- The MNIS provides accurate data in open-hole and cased-hole environments, oil, gas and water wellbores, vertical and horizontal wells
- The MNIS measures 43 mm in diameter and can be run through casing and tubing with no need to kill well yielding reduced cost and down time
- On-site interpretation and processing ensuring the desired information is recorded and delivered before leaving location

Features

- High precision macro-capture cross section (Σ) benefits from neutron and gamma detection, dynamic time-window optimizing and improved data processing

Features (continued)

- Neutron and gamma detection provide accurate and precise saturation from low to high porosity and salinity reservoirs
- Improved interpretation distinguishes between gas reservoirs and low-porosity formations
- Determine saturation and porosity reservoir parameters simultaneously
- Multi-detector array, multi-parameter data acquisition and data imaging
- Reliable modular design yields reliability and repeatability of the formation evaluation results
- Versatile data acquisition platform, on-site data processing and interpretation yielding definitive results

MNIS	
Dimensions and ratings	
Maximum O.D.	1.69 in (43 mm)
Maximum Pressure	15 kpsi (103.4 Mpa)
Maximum Temperature	302◦F (150◦C)
Minimum Csg/Tbg ID	2.05 in (52 mm)
Maximum Csg/Tbg ID	9.625 in (24.45 cm)
Weight	110 lbs (50 kg)
Length	22.87 ft (697 cm)
Hardware characteristics	
Source Type	14-MeV DT neutron generator, lifetime up to 800 hours
Number of Sensors	4 (three capture detectors and one natural gamma detector), CCL and TBH
Sample Rate	10 - 40 variable samples per meter
Measurements	
Vertical Resolution	~ 16 in (40 cm) @ typical formation
Depth of Investigation	~ 6 in (15 cm) inelastic/ ~ 12 (30 cm) in capture @ typical formation
Primary Curves	macro capture cross section Σ, near/far/long capture CR, near/long CR ratio, inelastic CR, near/far/long time spectrum
Secondary Curves	Σ, porosity ϕ, gas index etc