

# Spectral Pulsed Neutron service

## Formation evaluation and reservoir monitoring

The **Spectral Pulsed Neutron (SPN) service** can undertake a broad scope of reservoir evaluation and management applications, including reservoir saturation and produced fluids monitoring, formation evaluation, production profiling, workover and well abandonment evaluation, borehole diagnostics, location of bypassed oil, gas detection and quantification, and identification of water production.

The service uses an advanced, slim-hole, multifunction, pulsed neutron reservoir monitoring tool and is ideally suited for acquiring data through tubing. The tool is flexible with multiple operating modes that are selectable by surface commands. The tool is also very efficient with multiple sensors that enable faster tool movement while performing data acquisition. The SPN service combines multiple acquisition modes, reducing multiple passes down to one pass, without compromising data quality, resulting in logging times reduced by up to 66%.

The Spectral Pulsed Neutron tool employs three high-density high-resolution gamma ray detectors and an advanced digital downhole acquisition system. The reliable high output neutron generator produces gamma ray counts

up to 3 times higher than conventional instrumentation providing the most accurate and efficient measurements in the industry. The enhanced detectors and electronics measure both the arrival time and energy of detected gamma rays. The generator is pulsed at distinct frequencies, and the data acquisition system operates in various timing modes to obtain the different gamma ray measurements.

Data acquisition through casing is enabled by the high energy neutrons emitted from the non-chemical pulsed neutron source, even in complicated well completions utilizing multiple tubing and casing strings and sizes. The instrumentation combines multiple nuclear measurements in one system with industry-leading accuracy and precision. Carbon/Oxygen (C/O) and Pulsed Neutron Capture (PNC) measurements acquired with the SPN tool provide formation fluid saturations, porosity, three-phase holdup determination, and oxygen activation measurements for the detection of water flow in annuli and channels.

Extensive physical characterization of the SPN tool is conducted at our Houston Technology Center. The characterization provides forward-

### Applications

- Formation evaluation
- Reservoir monitoring and management
- Borehole diagnostics
- Workover applications

### Features and benefits

- Higher count rates and improved signal-to-noise ratio significantly reduces logging times
- Innovative mixed acquisition mode provides a complete pulsed neutron data set all in the same pass
- Multiple modes for operating versatility
- Flexible deployment on e-line
- Pre-job MCNP modelling to provide accurate quantitative fluid saturation

looking pulsed neutron measurement response predictions for well candidate evaluation and data analysis. The tool's measurements are interpreted using Monte Carlo N-Particle (MCNP) transport mode modelling to provide accurate saturation profiles in a wide range of borehole, casing, formation, and fluid conditions.

The Spectral Pulsed Neutron service includes modelling of unique downhole conditions to ensure that the analysis of

the reservoir is as accurate as possible. Extensive pre-job planning tools are available for the design of a data acquisition program that optimizes the answers provided by the service.

Spectral Pulsed Neutron Service data can be matched with previous-generation **RPM™ reservoir performance monitor service** measurements for easy comparison in mature fields. For remedial work and time-lapse monitoring, the data

can be overlaid with existing log measurements in real time, allowing rapid workover planning.

The SPN hardware is combinable with other production logging instruments. It is constructed in short, modular sections to facilitate shipping and handling.

## Applications description

### Formation evaluation

- Salinity-independent quantitative measurement with the **GasView™ gas saturation service**
- Salinity-independent quantitative measurement with the **OmniView™ three-phase fluid saturation service**
- Salinity-independent quantitative measurement in light oil reservoirs with the **OilView™ two-phase fluid saturation service**
- Quantitative measurement in light oil or high salinity reservoirs with the **FluidView™ multiphase saturation service**
- Formation resistivity, neutron porosity, and density data with **NEO™ openhole log emulation**
- Porosity evaluation

### Reservoir monitoring and management

- Reservoir management base logs
- Monitoring fluid contacts
- Time-lapse fluid saturation monitoring
- Production and reservoir depletion
- Identification of pressure-depleted sands
- Monitoring wells with air or gas filled boreholes
- Gas flood monitoring for steam, CO<sub>2</sub> sequestration and EOR projects
- Steam envelope build up in steam-assisted gravity drainage (SAGD) wells

### Borehole diagnostics

- Production and hold-up monitoring in horizontal wellbores
- Identification of water channeling
- Annular injection profiling in multiple-string completions

### Workover applications

- Location of bypassed and irreducible hydrocarbons, residual oil saturation independent of water salinities
- Re-evaluation of marginal fields
- Gravel pack evaluation and monitoring

## Tool specification

Description	Specification
Tool diameter	1.80 in. (w/ Boron coating)
	19 ft
Tool length	29.75 ft (w/ telemetry, GR and CCL)
Temperature	350°F
Pressure	20,000 psi
Minimum restriction	1.90 in.
Maximum hole size	12.25 in.
Tool compressive strength	570 lb
Tool tensile strength	22,000 lb
Maximum bend rate	30°/100 ft
Crystals	BrillLance 380

## Logging speed

Mode	Speed
PNC	30 fpm
C/O	2 to 6 fpm
PNC3D	20 fpm
PNHI	20 fpm
Hydrolog	2 to 150 fpm
Mixed mode	2 to 6 fpm