

GENERAL SPECIFICATION

RESERVOIR ENGINEERING

GS EP RES 101

**Core and plugs preparation and preservation for
Dean Stark measurements**

00	07/2016	First issue
Rev.	Date	Purpose of the revision

Owning entity: DSO/GIS	Managing entity: DSO/GIS
Other Approving entity(ies):	

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1. Scope

This General Specification defines the requirements and recommendations relative to on-site core plug sampling, preservation and transport to the laboratory in charge of the measurements of the in situ water saturation.

This document focuses on the usual technique used for measuring in situ water saturation, the Dean Stark method referred to as DS below. This technique also enables assessing the brine salinity in hydrocarbon-bearing zones.

This document applies to everyone taking part in the sampling of plugs and water from hydrocarbon reservoirs: Company and contracted personnel in affiliates and headquarters.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published at the effective date of this document.

Reference	Title
Not applicable	

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published.

Reference	Title
GS EP GIN 308	Indexing and storing physical well and field samples
GS EP RES 302	Instructions for expedition of fluids at atmospheric conditions and in small tank volumes

3. Key points

This General Specification provides a single reference method yielding high quality results, equivalent to the ones obtained by the Company.

Depending on the type of reservoir encountered, as well as the type of mud used:

- Specific equipment for the DS and mud samples have to be available on the rig site and have to be used following this General Specification.
- The preservation of the samples, and their transport to the laboratory in charge of the measurements, is to be strictly respected in order to maintain their integrity as best as possible.

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4. Requirements for operations and equipment

4.1 Requirements

The DS technique provides the water saturation of the plug in its original state as delivered at laboratory.

{Rule 1:

To ensure that the water saturation of the sample has not evolved between down-hole and surface conditions, the following requirements shall be fulfilled.}

- Samples are to be taken from the hydrocarbon zone where the water is almost immobile, i.e. above the transition zone.
- The drilling mud is to be an oil-based mud in order to minimise invasion by water.
- Coring is to be performed using low-invasion core heads, and the overbalance has to be carefully controlled.
- The trip out speed has to follow the coring guide recommendations to prevent core damage and changes in saturation due to the gas drive effects.
- The modification of water saturation during surface operations is to be minimized as much as practically possible by rapidly preserving the samples at the well-site (minimising the exposure time to air at the surface and preventing any contact with any external source of water).

To ascertain that the sample is not invaded by the water phase of the mud, it is recommended to dope the water phase of the mud with a tracer, particularly for high permeability reservoirs. Sw results with a non aqueous based mud (referred to as NABM below) are considered valid if the tracer is detected in the mud sample but not in the rock samples. The tracer selection should be evaluated on a case by case basis with the support from PERM/PETRO in TOTAL. Typical tracers include LiCl (Lithium Chloride) at a typical concentration of 200 ppm per litre of mud. The dosage in the chemical lab of Li⁺ ions is used to quantify the invasion.

The mud tracing technique requires taking one mud sample before each core run.

4.2 Well-site specific equipment

{Rule 2:

The following plug coring equipment shall be available at the well site prior to core plugging operations.}

1. Portable Gamma-Ray (measuring while the core barrel is vertical in the derrick if possible);
2. For consolidated core only: a plug-coring machine (recommended internal diameter of 38 mm), using low toxicity oil, not water as a lubricant;
3. For unconsolidated core only: a thin bevelled edge steel tube called "plunge cutter" for the sampling. The dimensions recommended by TOTAL's laboratory are: internal diameter 38 mm, length 70 mm maximum. (Figure 1);

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4. For unconsolidated core only: A manual cutter pushing tool, allowing proper alignment, and centralization of the cutter against the core face, and providing sufficient force to ensure a penetration of 8 cm minimum into the core. (Figure 1, Figure 2);
5. For unconsolidated core only: Viton sleeves of the proper diameter (the recommendation is 38 mm) and pre-cut at 12 cm of length (Figure 3);
6. PVC disks (2 pieces per sample) to cover each end of the sample. These disks have a special fitting to facilitate disk removal. (Figure 4);
7. Silicon sealant to seal the end caps of the viton sleeve and prevent subsequent changes of water saturation before laboratory analyses (Figure 5);
8. Plastic film and aluminium foil to wrap each sample.
9. Sealable plastic bags: zip lock (1 per sample) to protect the sample and secure a moisture barrier.
10. Adhesive tape.
11. 1 litre polyethylene bottles with screw caps (2 for each core run) to collect the mud samples.
12. Thermally-insulated cool boxes for the transport of the preserved plugs, and gel ice packs. (Figure 6)
13. An ambient monitoring data logger to control the temperature during the transport. (Figure 7)

Items from 2 to 11 can be provided by the CST JF TOTAL laboratory if required in advance (4 weeks delay for order and shipment), or obtained from core laboratories.

5. Recommendations for plug sampling on cores

5.1 Selection of sampling points

{Rule 3:

The plug sampling programme shall meet the following criteria.}

- Covering the whole reservoir interval above the transition zone (evaluation of saturation and brine salinity versus height above contact called HAFWL),
- Avoiding sampling plugs containing shale lamina as it would bias the Sw determination using Dean Stark technique,
- Covering the various facies roughly identified on well-site based on core gamma-ray (clean or shaly), cuttings, and indicative facies observed at the core cut faces,
- Covering the zones with ambiguous or dubious resistivity logs deserving specific calibration (eg LRS or shale/sands laminated zones, but considering the potential biases linked to boundary effects),
- Avoiding sampling at the top and bottom of the entire core section where mud-filtrate has penetrated the exposed core ends within the core barrel.