

GENERAL SPECIFICATION

Geosciences

GS EP GSR 101

**Sampling and inorganic analysis of waters from
aquifers and hydrocarbon reservoirs**

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1. Scope

This General Specification presents the requirements regarding the sampling and inorganic analysis of waters from hydrocarbon reservoirs and aquifers.

Inorganic analysis refers to the following parameters and elements to be analyzed:

1. pH, conductivity, total alkalinity, carbonates alkalinity
2. Major and trace anions: sulfates (SO_4^{--}), chloride (Cl^-), bromide (Br^-), nitrates (NO_3^-)
3. Major cations: sodium (Na^+), potassium (K^+), calcium (Ca^{++}), magnesium (Mg^{++})
4. Minor ions: lithium (Li^+), strontium (Sr^{++}), barium (Ba^{++}), iron (Fe), boron (B), silicon (Si)
5. Organic anions: formates, acetates, propionate, iso and normal butyrates
6. Isotopes: δD , $\delta^{18}\text{O}$, $^{86/87}\text{Sr}$, $\delta^7\text{Li}$, $\delta^{34}\text{S}$ of sulfates, $\delta^{18}\text{O}$ of sulfates

The objective of this document is to ensure the representativeness of the samples and the validity of all measured results with the aim of providing reliable chemical and isotopic data of water samples from hydrocarbon reservoirs and aquifers for exploration, development and production purposes.

It applies to everyone taking part in the sampling and analysis of waters from hydrocarbon reservoirs and aquifers: 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	

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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 301	Instructions for expedition of pressurised fluids
GS EP RES 302	Instructions for expedition of fluid samples at atmospheric conditions and in small tank volumes

3. Glossary

DST: Drill Stem Test.

Eh_{SHE}: Redox potential (Standard Hydrogen electrode).

EOR: Enhanced Oil Recovery.

Site: rig, sampling site, in the field.

PE: Polyethylene.

PP: Polypropylene.

PVT conditions: Pressure Volume Temperature, conditions representative of reservoir.

Technician: technician specifically trained or certified by the headquarters laboratory.

WFT: Wireline Formation Testers, such as MDT (Modular Dynamic Tester), RCi (Reservoir Characterization instruments), etc.

WSOR: Well Statement of Requirements.

4. Importance and challenges of water sampling and analysis

4.1 Importance of water sampling

Formation water is crucially important for formation evaluation: impact on resources assessment, development schemes, design of the surface facilities.

Here are the main objectives for performing appropriate water sampling and analysis:

- Establish salinity which is a requirement for the assessment of water saturation (Sw) and log interpretation.
- Determine water density for accurate water head calculation.
- Determine water chemical and isotopic compositions for characterizing water origin and evaluate hydrological connectivity.
- Provide complete water chemical composition for the evaluation of compatibility with production/injection strategies and efficient water management.

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- Ensure reliability of the data in order to avoid erroneous interpretations that can have costly consequences during water management of producing oil & gas fields as, for example, scaling risk, formation damage, EOR polymer degradation, etc.

4.2 Challenges of water analysis

In hydrocarbon reservoirs and aquifers, water analysis is difficult because waters at reservoir conditions are generally:

- Hot and they may precipitate minerals during cooling.
- Gaseous (CO_2 , CH_4 , H_2S , etc.) and they degas immediately after sampling.
- Salty and they need to be diluted before analysis; this dilution can be a source of additional uncertainties.
- Reduced ($E_{\text{H}_{\text{SHE}}} < 0$ mV) and they react with atmospheric oxygen, causing the oxidation of oxygen sensitive elements.
- Rich in organic matter, which can be used as nutrients by microorganisms and can modify the water chemistry.

These five common characteristics can result in strong modifications of the water chemistry and potentially lead to erroneous data because the sample is no longer representative of the formation water. An additional challenge in high salinity waters is matrix effects during analysis. This aspect is discussed in section 14.

For a good-quality analysis, the formation water has to be sampled with the same care as the hydrocarbons, and the gas has to be analyzed with the water under reservoir pressure and temperature conditions.

5. Objectives and associated sampling methods

5.1 Sampling method according to the objectives

Three types of water samples (Minimum, Advanced, Complete), each associated with a different sampling and analytical procedure, are defined according to the objectives.

{Rule 1:

The sampling method to be performed depending on the targeted objectives shall be specified in the WSOR.}

The table below summarizes the objectives, applications, sampling equipment, transfer, final conditioning for export to lab and labeling for each type of water sampling.

A mix between the 3 types of water samples at the scale of an exploration zone (reservoir, basin, ...) is recommended. It is necessary to document all the parameters needed for all the purposes described hereafter with an optimum cost.

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	Minimum sample	Advanced sample	Complete sample
Reservoir temperature	Any temperature	<100°C	Any temperature
Objectives	Salinity	Salinity	Salinity
		Density	Density
	$\delta^{18}\text{O}$, δD	Water chemistry and isotopes	Water chemistry and isotopes
			Dissolved gas chemistry
Applications	Saturation (Sw)	Saturation (Sw)	Saturation (Sw)
	Rough connectivity	Connectivity	Connectivity
		Water origin	Water origin
		Scale risk (T reservoir <100°C)	Scale Risk
		Water compatibility (T reservoir <100°C)	Water compatibility
		Corrosion	Corrosion
		EOR development	EOR development
			Dissolved gas chemistry
			Sour gas risk (H ₂ S, CO ₂)
			Gas origin (bio vs thermo, ...)