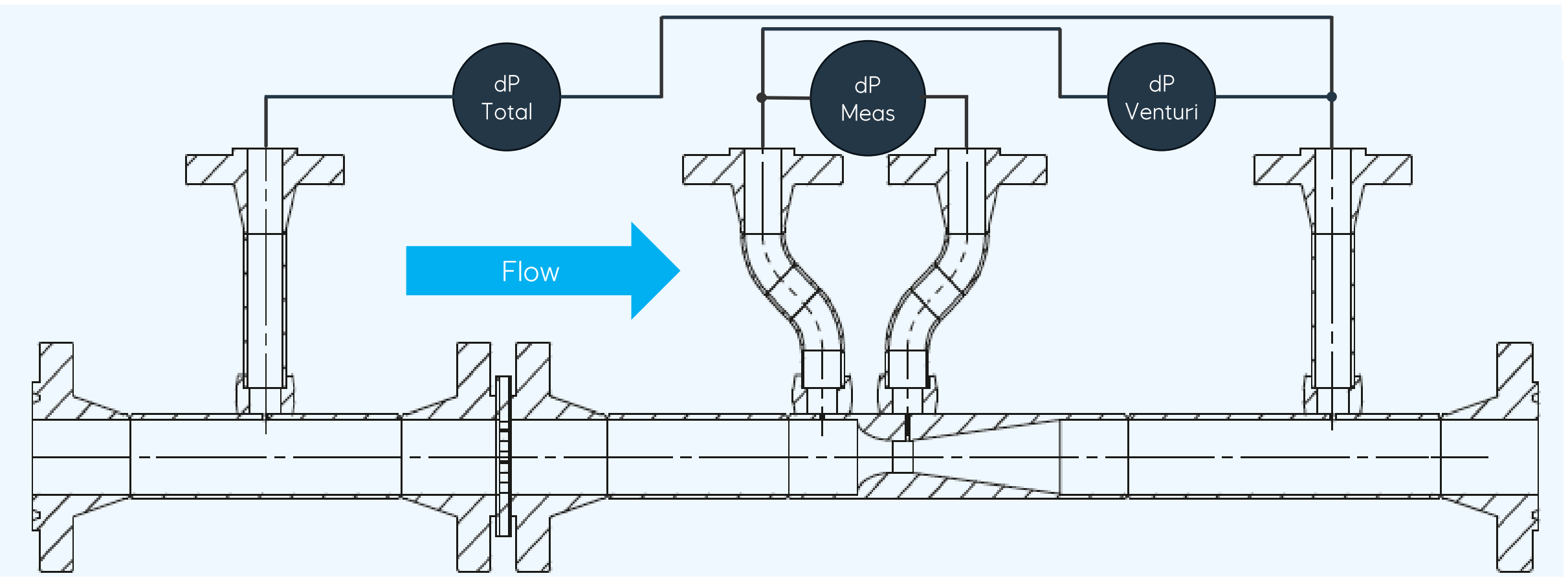


Differential pressure flow meter for oil wells with multiphase flow

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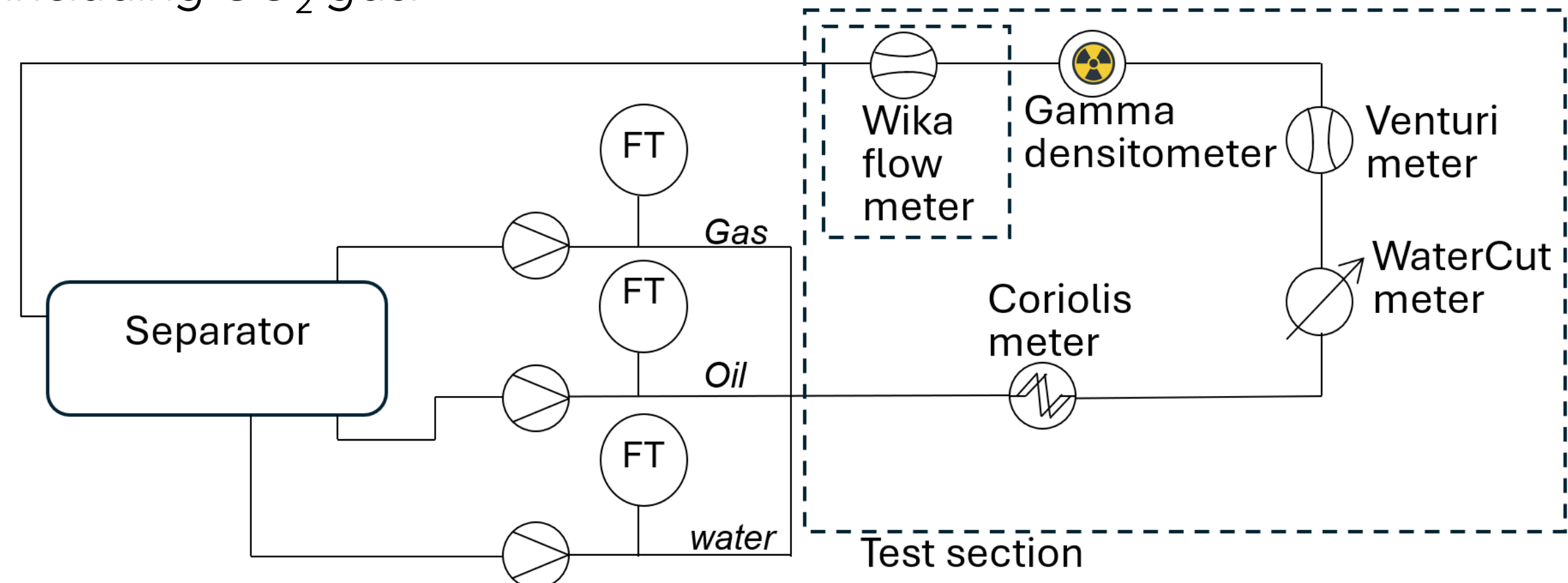
Introduction
 In the oil and gas sector, it is essential to determine well flow rates for production optimization, production allocation, and to comply with regulatory bodies. Traditionally, MultiPhase Flow Meters (MPFMs) are employed to determine well phase flow rates (gas, oil, and water). However, high installation and maintenance cost render MPFM less appealing for widespread adoption in various fields. The differential pressure flow meter in conjunction with virtual flow meter (VFM) solutions address these challenges through its innovative design, aiming for high measuring accuracy and low energy loss. The meter consists of a flow conditioner and a special designed venturi-nozzle.



Wika differential pressure flow meter

Flow loop testing and results for single and multi-phase flow

A comprehensive series of flow testing experiments was conducted at Equinor’s multiphase flow loop facility in Porsgrunn. The experiments were designed to replicate all anticipated conditions over the lifetime of a production well such increasing water, phase inversion, and variations in gas fraction, flow rate, pressure, and temperature. The differential pressure flow meter instrument was installed horizontally. Single phase tests were also conducted for oil, water, and gas – including CO₂ gas.

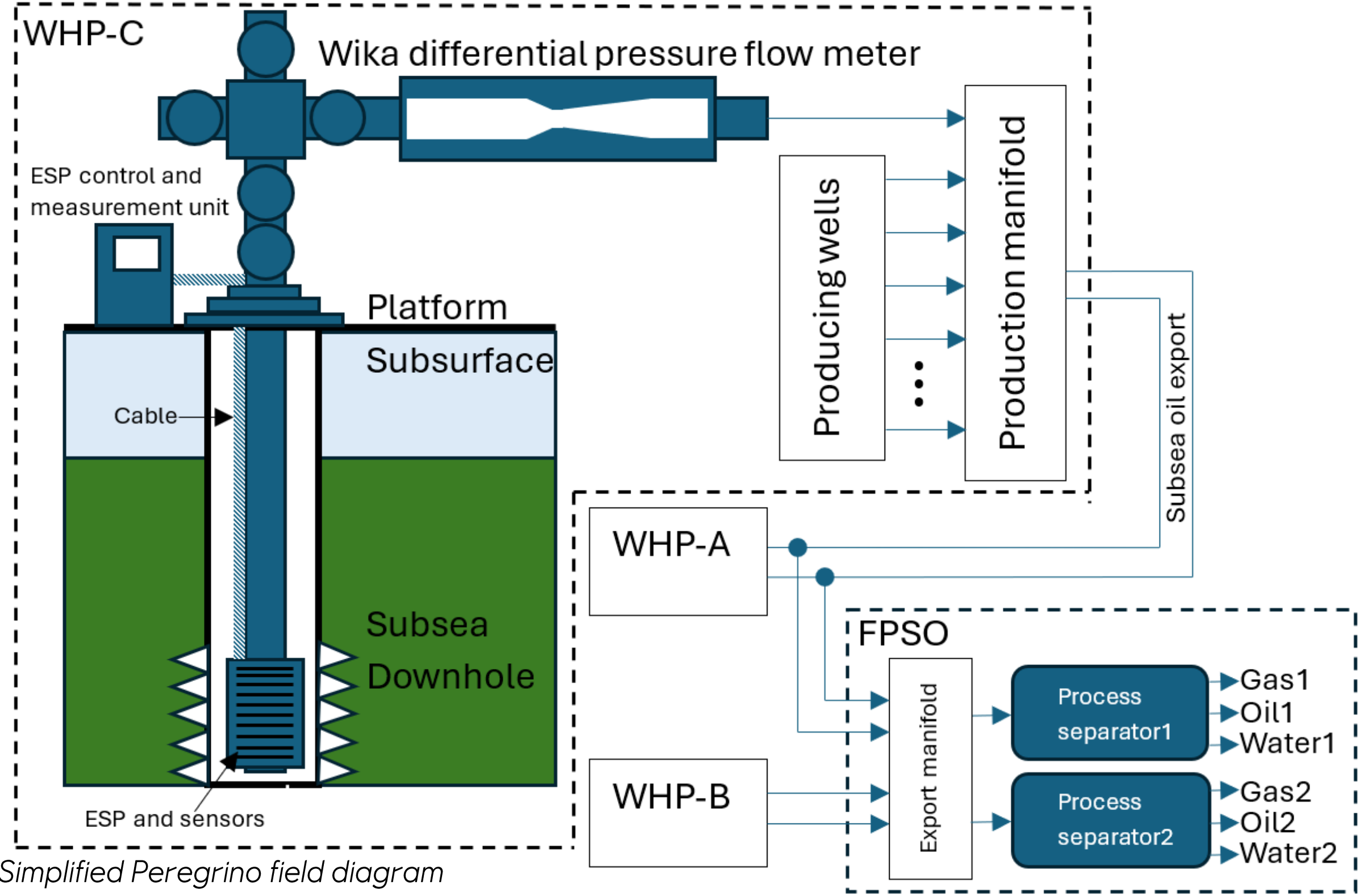


Sketch of the Equinor’s Porsgrunn multiphase flow loop (PLAB)



Multiphase flow loop test data with reference (black) and differential pressure flow meter (pink) rates in the upper plot. Water Liquid Ratio increased from 0 to 92 % (blue line, second plot) and GOR was around 100 Sm³/Sm³. The third plot shows mixed density (gamma densitometer, green dashed line) and the measured differential pressures from the flow meter used to calculate flow rate

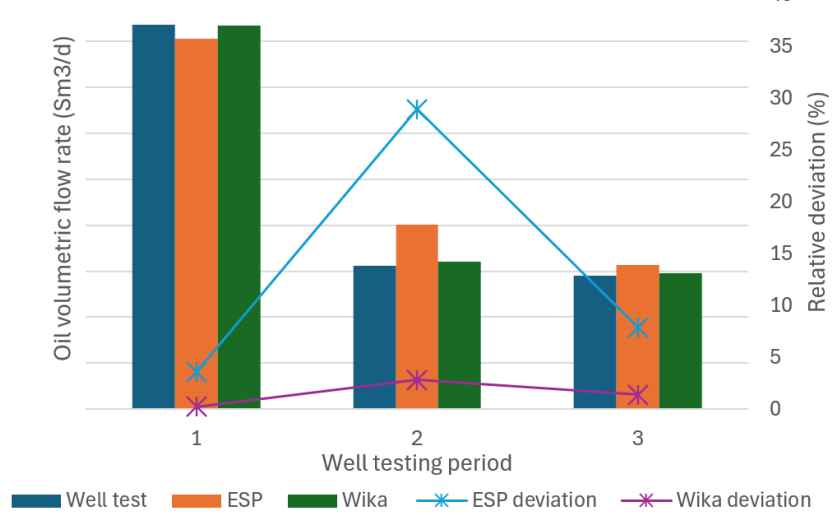
Peregrino field
 The Peregrino field comprises three wellhead platforms (WHPs), each connected to a Floating Production, Storage, and Offloading (FPSO) ship. Total produced oil rate is measured on the FPSO after phase separation through two parallel process trains. The allocation of individual well production is determined based on well models and periodic well deduction testing. All Peregrino wells are equipped with Electrical Submersible Pumps (ESPs), and the well flow rates are based on ESP models, on-line measurements and fluid properties. The algorithm relies on pump performance curves and measurements integrated in the ESP system. Several wells on WHP-C are equipped with differential pressure flow meters installed at the wellheads which enabling continuous production measurement for individual wells.



Simplified Peregrino field diagram

Field test results and lesson learn

The differential pressure flow meters have demonstrated consistent and reliable performance. Determined mass flow rates align with the ESP based rates when the water fraction is low (< 5%) and fluid properties are known. Furthermore, metering performance met operational expectations. Derived oil rates agreed with well test results, provided correct water fraction and fluid model to determine mixed fluid density. The differential pressure flow meter functions as a robust backup system for well flow rate measurement, enabling the identification of process anomalies and deviations influencing ESP model computations. Low permanent instrument pressure loss, minimizes power consumption.



Differential pressure flow meter installed on the wellhead (top left). Oil volumetric flow rate comparison between well deduction test, ESP model and differential pressure flow meter (bottom right). Total mass flow rate comparison between ESP model and differential pressure flow meter flow rate (right)