	<b>VG MPFM Product Description</b>	
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## 1. VG MPFM

The VG Surface Multiphase Flow Meter (MPFM) is a device designed and manufactured to measure the three phase flow rates of oil, water, and gas flowing through a pipe in real time without fluid separation or sampling. In service, the meter is connected in-line with the piping. The fluid mixture flows through the meter where the individual oil, water, and gas flow rates are measured. The primary outputs of the VG are the total mass flow rate, the Water Liquid Ratio (WLR) at line conditions, which is the content of water inside the liquid phase, and the Gas Volume Fraction (GVF) at line conditions, which is the volume of gas flowing inside the pipe. The secondary outputs are derived from the primary outputs and are Oil, Water, and Gas flow rates at line conditions and the relevant ratio such as the gas-oil relation. Measured flow rates at line conditions are converted to standard conditions by using an embedded PVT model.

VG MPFM combines a differential pressure measurement generated by a Venturi, with a gamma fraction measurement set at the throat of the Venturi and a capacitance-based water cut meter.

The main elements of VG meters can be split as follows (Figure 1):

- A Venturi spool causes a line size restriction between the inlet of the vertical section of the tool and the throat. A differential pressure sensor records the change in pressure caused by the restriction between the inlet and throat.
- A gamma-ray Cesium-137 radioactive source (<6mCi), located within a shock and radiation-protected holder and a gamma-ray detector located on the other side of the spool that measures the gamma-ray counts passing through the fluids at the Venturi's throat. The gamma rays are emitted via a collimated beam directed toward the detector. To be able to work with a low-intensity source, isolation between the flow line and the source/detector assemblies is achieved via a high-pressure PEEK window, ensuring that few gamma rays are attenuated by the isolation material. Using normal metallic materials would have required a much stronger source.

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- A capacitance-based water cut meter measures the amount of water content in the multiphase flow. Since the dielectric constant of water (68-80) and oil (2.5) are very different, the water content can be determined. When the water content changes, the electronics at the end of the measurement section send an electric signal. Indeed, this method is based on the high electrical difference between the water phase and hydrocarbons (oil and gas).
- A pair of pressure and temperature sensors; the pressure sensor measures the line pressure at the throat of the Venturi section while the temperature is recorded at the end of the inlet blind-T section, where fluid mixing ensures the most representative measurement.

All data from the 4 sensors (pressure, temperature, differential pressure, and gamma-ray detector) are sent to the data acquisition unit (DAU) where calculations are made. It is important to highlight that all measurements are taken at the same point in the tool (the Venturi throat), thus ensuring the compactness of the assembly for one, but also removing any requirement to correlate events recorded at different locations within the flow line.

The blind tee is used to condition the flow upstream of the flowmeter. It creates a so-called mixing effect for stable and intermittent flow regimes that are encountered in multiphase flow streams. The blind tee also prevents any interaction from upstream devices, such as chokes, elbows, and valves. This means that any pipe configuration can be made upstream of the blind tee and it will not affect the meter performance.



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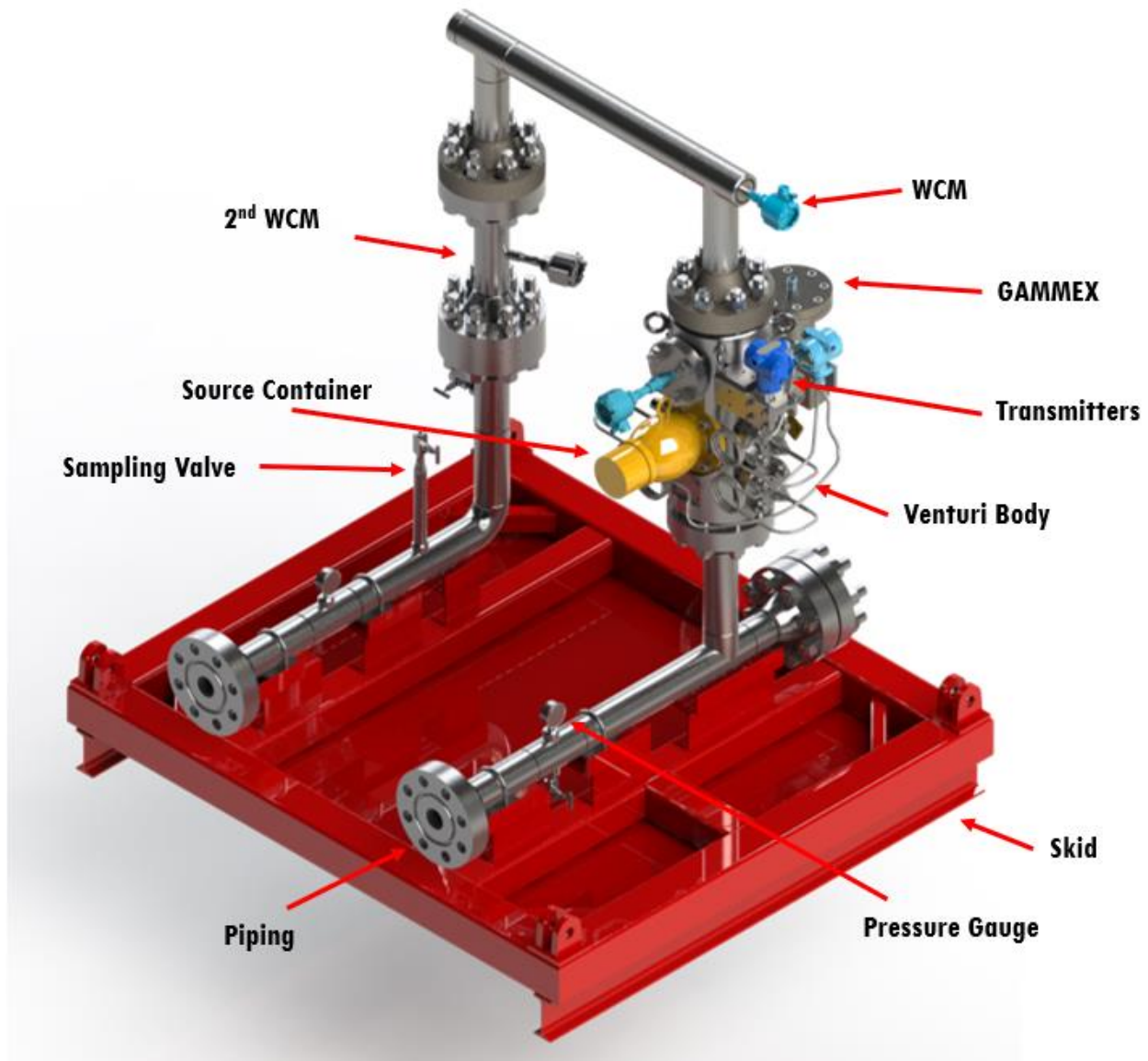



Figure 1: Main components of VG-3200

All primary measurements occur at the Venturi throat in a confined area. The differential pressure measurement based on the inlet pressure and throat pressure is directly correlated to the total mass rate and follow the guideline described in ISO 5167 (International Standard Organization). The nuclear data acquisition system provides the volumetric fraction measurement at high frequency (45Hz) of at least 3 individual phases (oil, water, and gas).

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P & T measurements provide the pressure and temperature at the throat to feed into the fluid PVT model. The data is gathered and processed in real-time at high frequency inside the DAU (Figure 2). In Figure 3, a summary of VG workflow is illustrated which shows flow rates at both line and standard conditions.

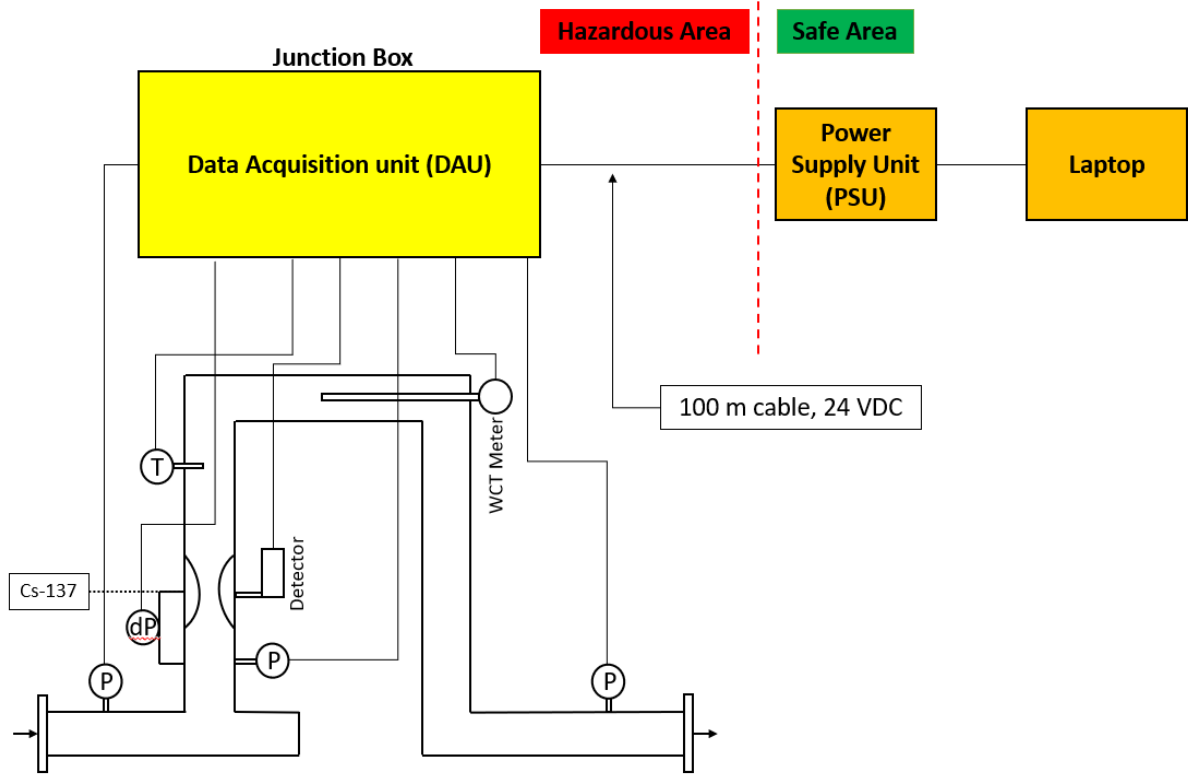



Figure 2: Illustration of measurement principles and the communication cables

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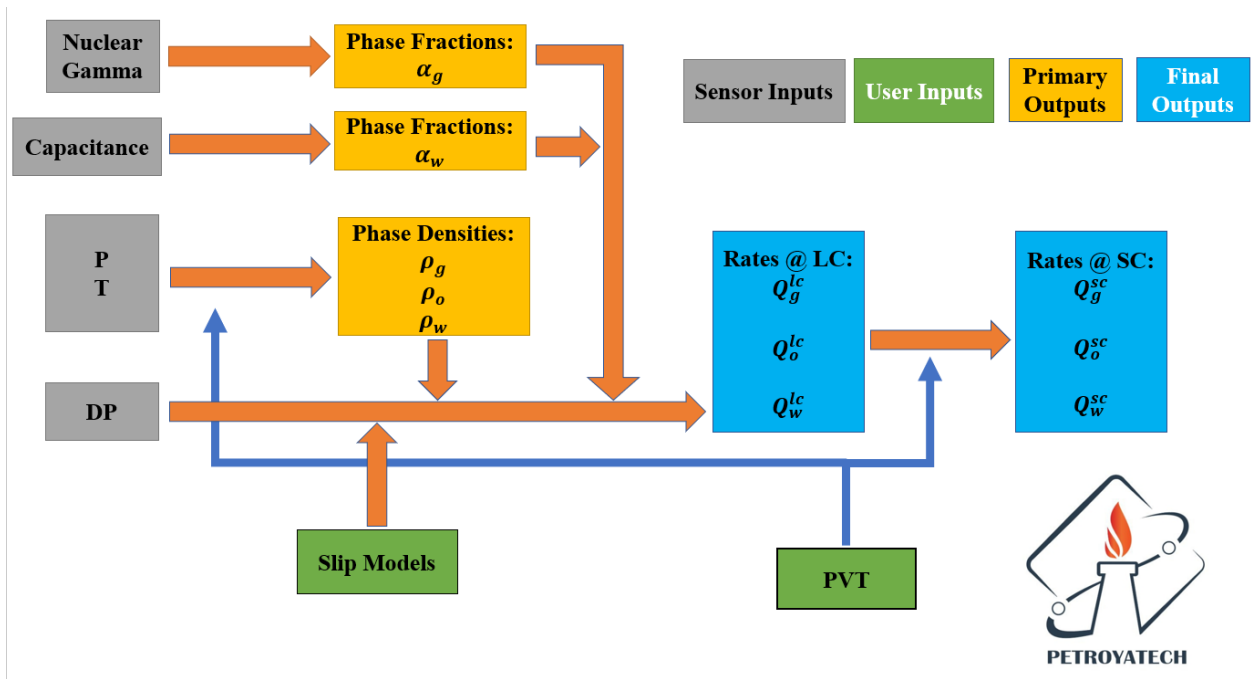


Figure 3: VG MPFM workflow