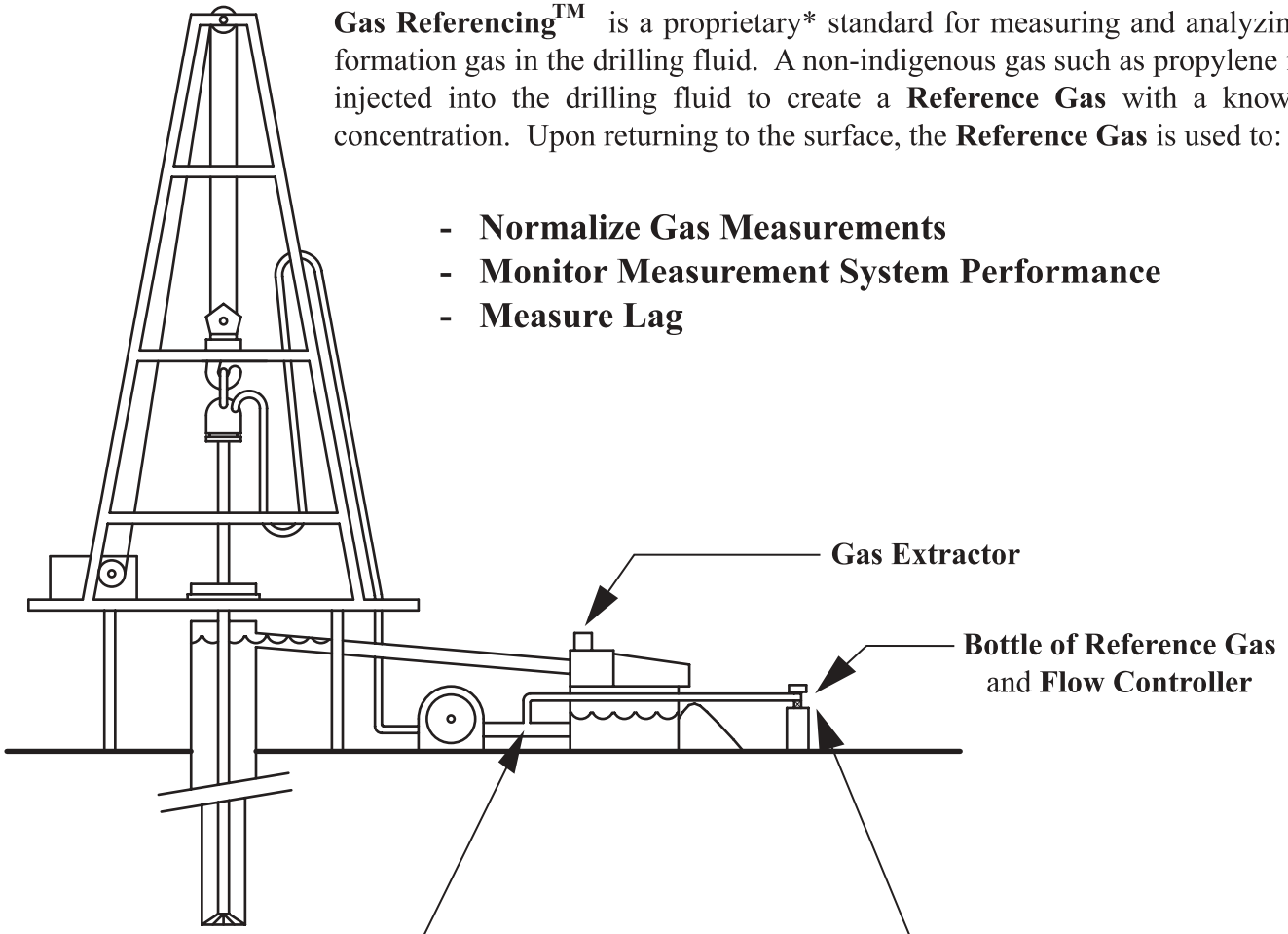
Using Gas Referencing™

Gas Referencing™ is a proprietary* standard for measuring and analyzing formation gas in the drilling fluid. A non-indigenous gas such as propylene is injected into the drilling fluid to create a **Reference Gas** with a known concentration. Upon returning to the surface, the **Reference Gas** is used to:

- **Normalize Gas Measurements**
- **Monitor Measurement System Performance**
- **Measure Lag**



Reference Gas is injected into the drilling fluid through an **Injection Port** installed between the mud pump and pits.

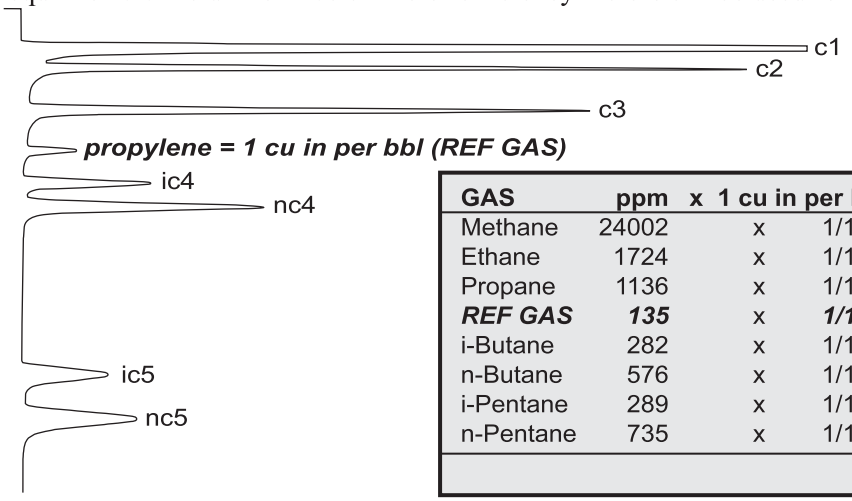
The logging computer sends signals to the **Flow Controller** to regulate the injection of **Reference Gas** as the pump rate changes.

Using Gas Referencing™ to: Normalize Gas Measurements

Gas Referencing™ is used to derive meaningful volumetric measurements of "Volume of Gas at Surface per Volume of Cuttings" in place of "Gas Units".

Step 1: Use Reference Gas to Calibrate Gas-in-Air to Gas-in-Mud:

For this example, propylene is the reference gas injected at one cubic inch per barrel. The propylene result of one cubic inch per bbl = 135ppm is used to convert the formation gas measurements to cubic inches per barrel. (This assumes each component's extractor efficiency factor relative to propylene is equal to 1.0. Actual relative extractor efficiency factors can be used for more precision.)



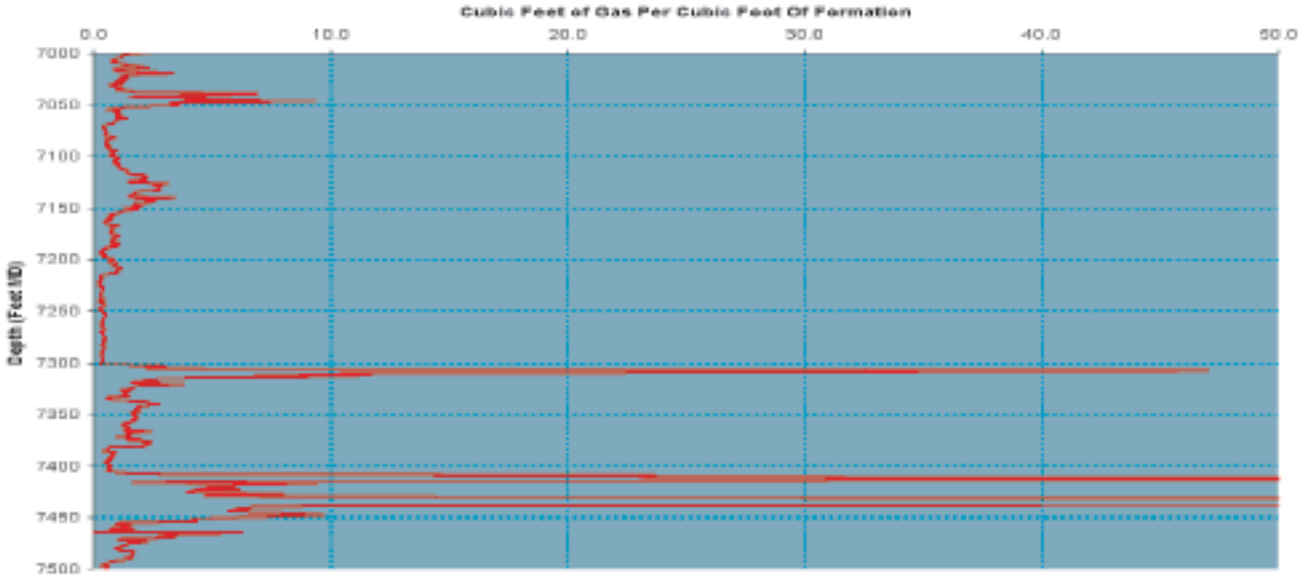
GAS	ppm	x	1 cu in per bbl / 135ppm	=	cu in per bbl
Methane	24002	x	1/135	=	177.8
Ethane	1724	x	1/135	=	12.8
Propane	1136	x	1/135	=	8.4
REF GAS	***135***	x	***1/135***	=	***1.0***
i-Butane	282	x	1/135	=	2.1
n-Butane	576	x	1/135	=	4.3
i-Pentane	289	x	1/135	=	2.1
n-Pentane	735	x	1/135	=	5.4
					TOTAL: 213 cu in per bbl

Step 2: Use Gas-in-Mud, Background Gas, Drill Time, Pump Rate and Bit Size to Normalize Gas:
(express results in *Cubic Feet of Gas at Surface per Cubic Foot of Formation*)

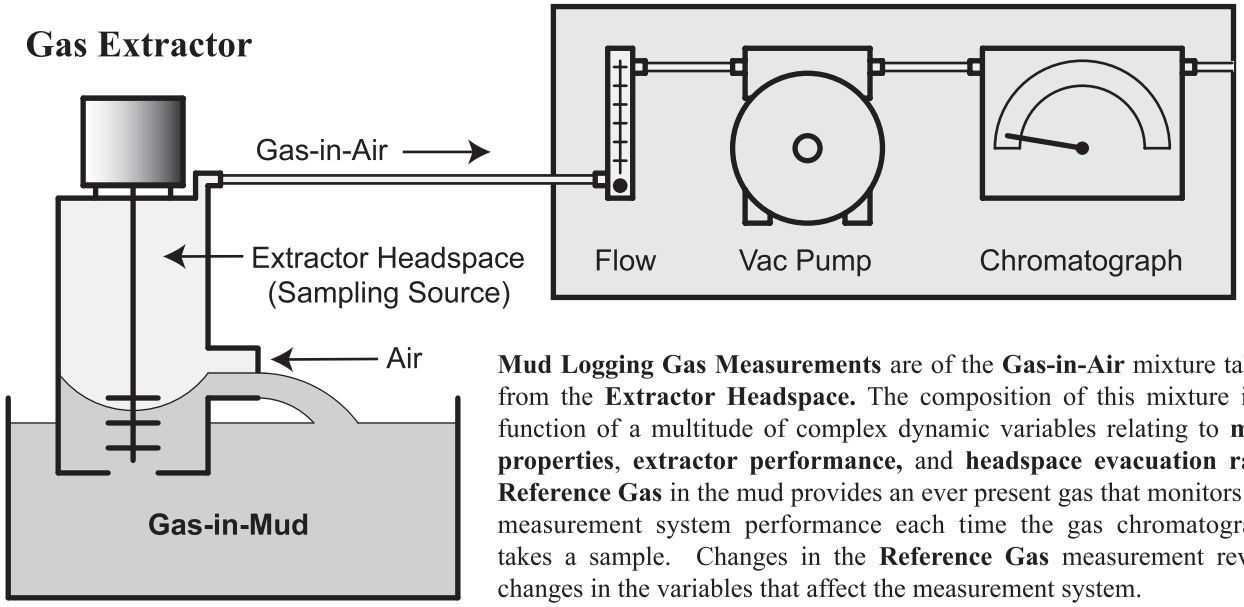
Given:
- Gas-in-Mud = 213 cu in per bbl
- Background Gas = 0.0 cu in per bbl (derived by inspection of previous data)
- Drill Time = 1.5 minutes per foot
- Pump Rate = 4.0 barrels per minute
- Bit Size = 7.5 inches dia

Normalized Gas = Volume Gas at Surface / Volume of Cuttings
= (Gas-in-Mud - Background Gas) x Drill Time x Pump Rate / Volume of Cuttings
= ***2.4 (cu ft gas per cu ft formation)***

Step 3: Tabulate Data and Plot Log:



Using Gas Referencing™ to: Monitor Measurement System Performance

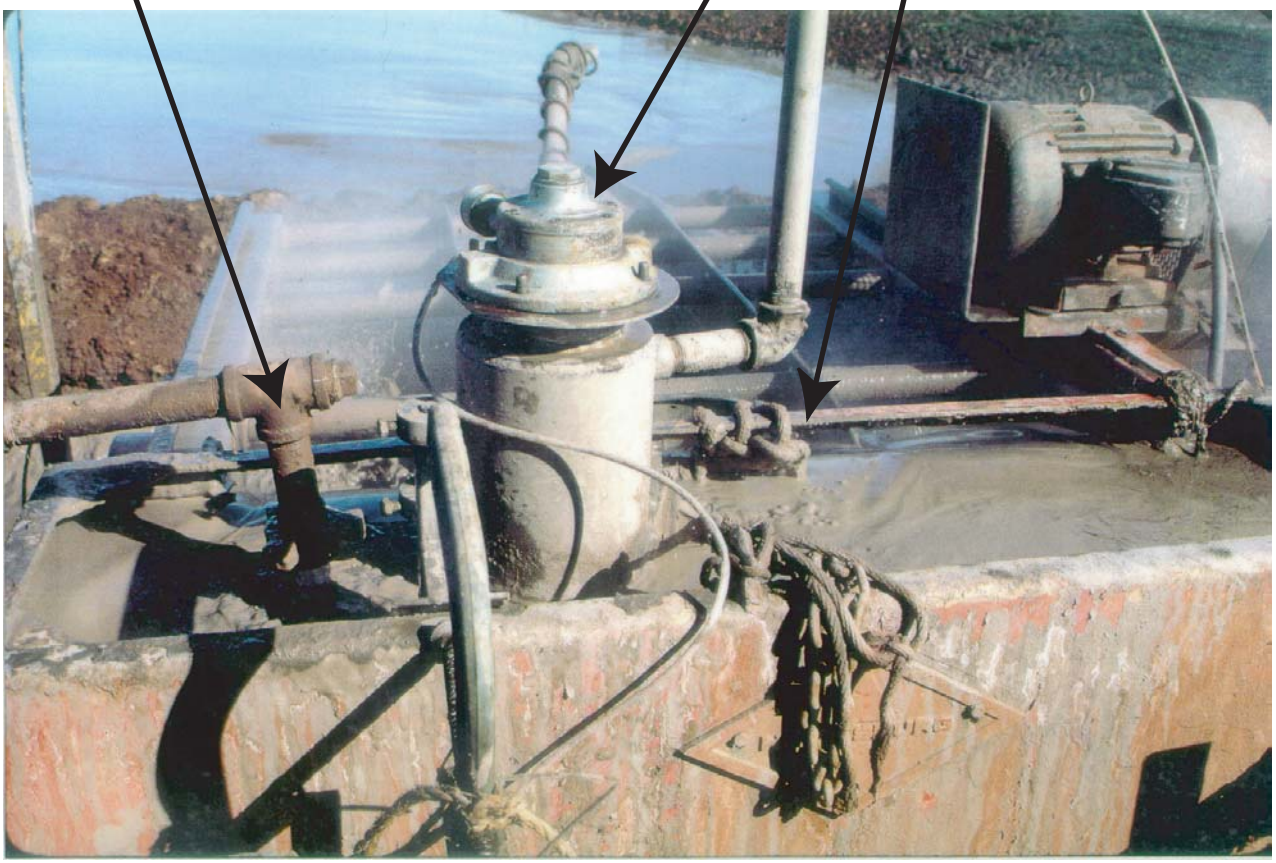


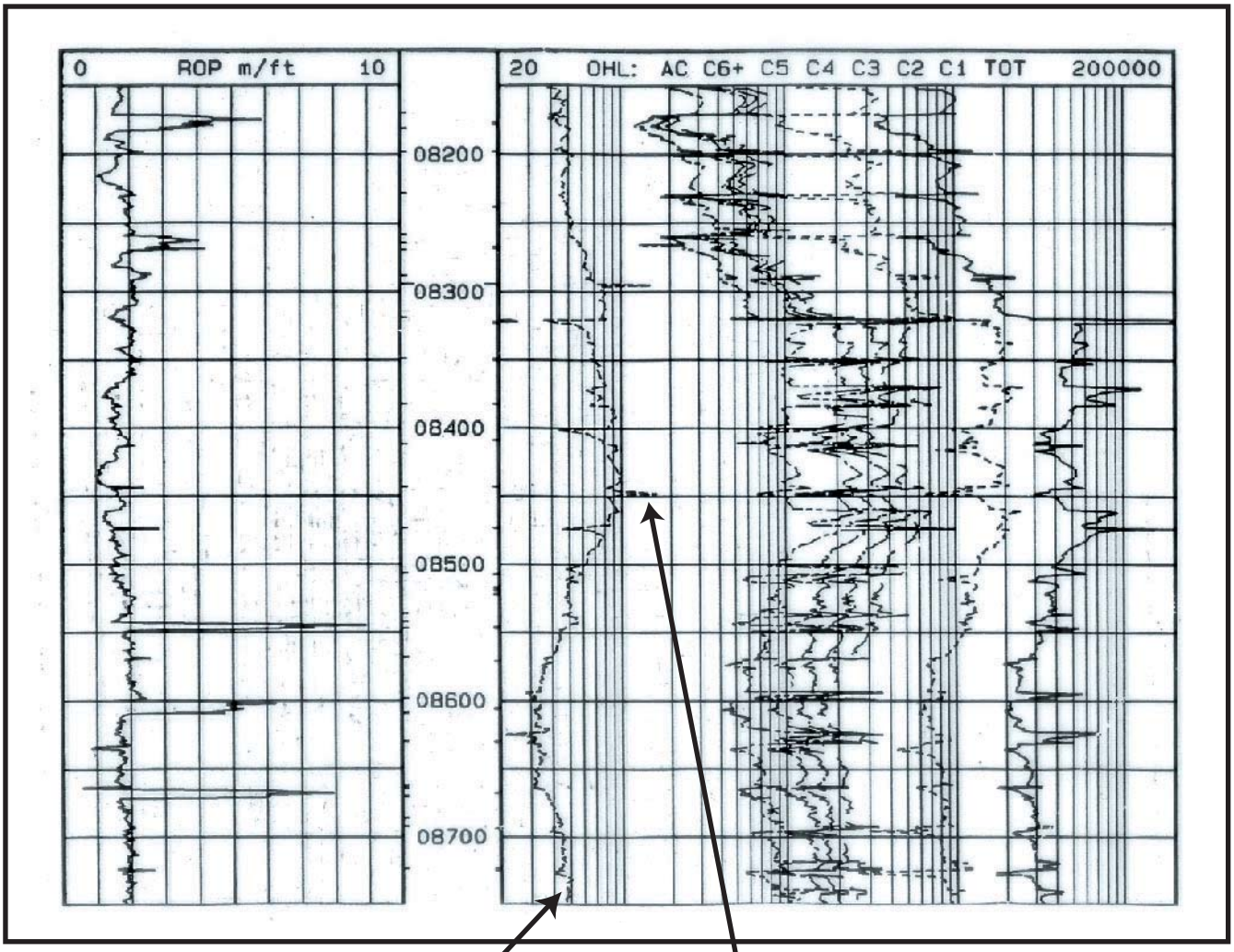
Mud Logging Gas Measurements are of the **Gas-in-Air** mixture taken from the **Extractor Headspace.** The composition of this mixture is a function of a multitude of complex dynamic variables relating to **mud properties**, **extractor performance,** and **headspace evacuation rate. Reference Gas** in the mud provides an ever present gas that monitors the measurement system performance each time the gas chromatograph takes a sample. Changes in the **Reference Gas** measurement reveal changes in the variables that affect the measurement system.

Water from pipe is diluting mud next to extractor. (in the shadow)

Mud viscosity changes air motor rpm, changing agitator speed and extractor efficiency.

Mud level flaps change amount of mud being processed.





Notice how the Reference Gas curve reveals a changing Measurement System. The Reference Gas values change from 90 ppm around 8460' to 30 ppm around 8600' showing a three fold decrease in overall extractor efficiency. This shows that the general downward trend of Formation Gas values starting around 8460' to 8600' is due to the Measurement System, not from changes in formation. It would be difficult to arrive at this conclusion without Gas Referencing™.

Using Gas Referencing™ to: Measure Lag

The third use of Gas Referencing™ is to Measure Lag. A Lag Tracer is created by momentarily increasing the Reference Gas injection rate. In addition to being more convenient and reliable than dropping carbides or aquarium gravel, this technique is safer and non-intrusive. Potential damage to downhole tools and motors from adding solid materials as lag tracers is eliminated. (see Reference Gas spike at 8448' in figure above)