Gas Units Defined and Mechanical Gas Extraction from Drilling Fluids White Paper

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ABSTRACT:
A definition of a mud logging gas unit and the mechanical extraction of Gas Units from drilling fluids, otherwise known as mud or drilling mud.

GAS UNITS - QUICK ANSWER:
In a perfect world, Gas Units are a relative percentage of an unknown mix of gaseous hydrocarbons in air times 100. This is why the term "units" is used instead of a known value such as "Methane". **Examples:** If there were 10% pure Methane in air, it would be defined as 1,000 Gas Units on an instrument. If there were a mix of 5% Methane, 2% Ethane, 2% Propane, and 1% Butane with the other 90% being air, it would also be defined as 1,000 Gas Units on an instrument.

Some companies use a half scale in which 10% of pure Methane in air would be defined as 500 Gas Units instead of 1000. Generally this is to keep some people from freaking out when larger numbers are seen.

GAS UNITS - LONG ANSWER:
The first high tech gas detector was using a canary in a mine. Canaries are known to have an extremely loud chirp and do so often and also a delicate respiratory system. As such, it was said that when a canary was about to die, it would start to shake and be very agitated inside the cage. If the canary started this, the miners knew to remove themselves from the mine. If the canary was not making any noise at all, they knew to make a quick exit as something had caused the canary to die suddenly.[1] Obviously, the percentage of air was a factor in the health of the canary and the miners.

[1] http://ehstoday.com/industrial_hygiene/instrumentation/gas-detection-ages-0501

The next device to be invented was the Davy lamp in 1815. The Davy lamp and its steel mesh construction allowed a combustion of an oil inside the mesh without the propagation of the flame outside the steel mesh. When a flammable gas mixture such as Methane was present around the lamp, the flame and glow of the Davy lamp burned larger with a more blue tinge. Some lamps had a metal gauge attached to the side to note the increase in flame size and shape. Also, the miners could place the safety lamp close to or on the ground or in a depression to help detect carbon dioxide, which is more dense than air. In such a case, if the mine was low on oxygen, the lamp flame would be low or even be extinguished.[2] In order for the lamp to operate, the percentage of air was a significant factor.

The electronic detection of hydrocarbons was invented around 1926 when Dr. Oliver Johnson working for Standard Oil invented a catalytic combustion sensor in common jars using a very thin piece of Platinum wire and placed it inside of a Wheatstone bridge configuration.[3] The wires were driven to high temperatures. The meter deflection would allow the user to detect the presents of flammable hydrocarbons in the presence of air. More so, without the component of an air percentage, there would be no combustion and no deflection on the meter.

As this sensor technology was perfected over time, and evolved into more reliable and better equipment, many thousands of instruments were built and used for many years using Platinum and then also Nichrome wire filaments.

The next version of gas detector was an improvement over the hot wire technology, but not by much. This was known as a Catalyst bead Platinum detector or Pellistor[4]. This is sometimes called the “CC” detector in many systems. This detector type and style that was developed in the 60’s is still used in many gas detection systems today. This style detector has a tiny Platinum wire surrounded by a doped bead of catalyst combustion material. This catalyst acts with the Platinum and an appreciable amount of air and either heats up the Platinum wire more or less based on the amount of flammable hydrocarbons in the immediate air atmosphere around the catalyst bead.

As such, the presence and percentage of air vs. hydrocarbon gasses as a value of the detected hydrocarbons has been a standard for over one hundred years.

[2] http://en.wikipedia.org/wiki/Davy_lamp
[3] RKI Instruments
[4] http://sgx.cdistore.com/datasheets/e2v/vq21_2013.pdf

As the electronic age emerged and the systems became more advanced, reliable, and precise, the simple deflection on the face of a meter was not acceptable for long-term logging while drilling a well. As the 70’s and 80’s came of age, more digital equipment found its way into the logging arena. As such, the semi-digital equipment was not able to compute or display decimal points or parts of a percentage.

To offset this shortcoming of the early electronic equipment, the percentage display and output was shown as a 5 digit number instead of a 3 digit percentage number in air with two precision accuracy.

That is why we generally have 0-10,000 Gas Units being represented as 000.00 to 100.00 percent flammable hydrocarbons in air.

GAS UNITS - WHERE ARE THEY:

Drilling fluid or Drilling Mud or sometimes just Mud, is used to lubricate and cool the rock cutting tip at the end of the drill string. This drilling fluid is also used to bring back up the rock cuttings. Deep in the earth at the producing formation layers, as the drilling and cutting head penetrates the formation, the entrapped gasses in the formation are forced into the drilling fluid at tremendous pressures and temperatures.

Much like carbon dioxide being released from a soda pop bottle when opened, as the drilling fluid is returned to the surface, the lower atmospheric pressures generally will allow these entrapped gasses to escape from the drilling fluid.

A gas extractor at the point of surface return will allow for the enhanced extraction and collection of these formation gasses for analyzation.

GAS UNITS - THE MUD:

The drilling fluid for any rig is unique. This is not a generalization. Every well is different at any given time during the drilling process. The drilling fluid can be as thin as water or seemingly as thick as peanut butter. The drilling fluid is always a witches brew based on need at the time the drilling is being performed. Most of the time the drilling fluid is collected at the end of the well and re-used at another well. There are whole companies dedicated to only monitoring drilling fluid parameters.

The drilling fluid can contain any or all types of Diesel oil or fuel, water, hardeners, thickeners, seed husks, cotton, nut shells, sawdust, coagulants, gels, acids, bases, ash, paper pulp, and any other amounts of a thousand items to better suit the drilling fluid to their immediate needs and it can change daily.

Because of this witches brew of materials, the ability of the drilling fluid to dissolve and carry gasses will vary some from day to day. These changes will also affect the ability to extract the gasses from the drilling fluid.

GAS UNITS - BROKEN DOWN:

What is in a Gas Unit when it is collected? If the Gas Unit is coming from drilling fluid or mud, it is usually comprised of some, part, or all of Methane, Ethane, Propane, Butane, Pentane, and Hexane. If drilling with Diesel fuel or like oil compound, there will be Diesel fumes present as a percentage of the gas mix in air as well. These Diesel fumes can contain long hydrocarbon chains from C_8H_{18} to $C_{15}H_{28}$.

Generally on a vertical oil well drilling operation, when at the top of a new productive formation, it will be comprised of almost all Methane. When at the bottom or oil-water boundary layer of the productive formation it will usually contain a reduced amount but still mostly Methane with an almost logarithmic progression of heavy gaseous hydrocarbons. When drilling through oil producing formations, the heavy hydrocarbons will be present in much larger quantities.

At general atmospheric pressures and temperatures, generally anything above Hexane C_6H_{14} is not generally released from the drilling fluid since at such surface pressures and temperatures it would generally remain a liquid in the drilling fluid and not be released by a general gas extractor except in a fractional fume state.

If using Diesel fuel or like drilling fluid, detecting anything above Hexane is generally not reliable or feasible since the average and general chemical formula for Diesel fuel is comprised of long hydrocarbon chains from C_8H_{18} to $C_{15}H_{28}$.[5] In such a situation, detecting anything higher would also require an extractor that would either heat the extracted drilling fluid past the boiling point of the heavy hydrocarbons or pulling an extremely high vacuum or both; neither of which is advisable in such a hazardous environment. More so, all you would be getting is the chemical make-up of the Diesel fuel, not the formation below.

GAS UNITS - RECIRCULATION:

Another not-well-known item in detecting Gas Units is the recirculation of drilling fluid that still contains dissolved gasses back down the drill string and the possible problems it can cause.

When Hydrocarbons are pressed into the drilling fluid and returned to the surface, many of the entrapped gasses remain in the fluid in solution. This is because in this situation the drilling fluid, either water or oil based, is the solvent and the entrapped gasses are dissolved in it. There is a very good chance that an appreciable amount of these dissolved gasses is still in the drilling fluid when it is pumped back down the drill string. As such, these recirculated dissolved gasses can cause extended detection of heavy hydrocarbon gasses.

I conducted one such experiment in 2009 on a vertical well in north Oklahoma. This well used a water based drilling fluid using fresh water. At this well, the geologist was using a Carbide sample on a connection to produce an Acetylene return kick so that the geologist could get a good idea as to

[5] http://en.wikipedia.org/wiki/Diesel_fuel

the round trip time of the drilling fluid. As such, the gas detection equipment saw the Acetylene and the geologist was satisfied.

However on a second well a few months later, with the same water based scenario, the geologist used 1 quart of gasoline for the same purpose. This produced 5 kicks over time as the gasoline was recirculated back down and then back up the hole. This geologist had a general 8000 gallon tank that was being used as the collection and return tank. NOTE: Such a method is not easily used on Diesel based drilling fluids since gasoline will generally show the same background gas (fumes) as the Diesel.

GAS UNITS - MUD WEIGHT[6]:
As the drilling fluid collects more dissolved gasses down the hole, it will become physically lighter. This is also known as a mud gas-cut.[7] This weight difference is measured in the physical weight of the mud before it is pumped down the drill string, and right after it returns.

Many people have many theories as to how much weight displacement and differences by dissolved gas will give you an approximation of Gas Units. Because of the vast differences in materials, chemicals in the drilling fluid itself, and losses in the returns, there can be no accurate representation of Gas Units and mud gas-cut. However, a generalization can be made over time based with the use of instrumentation and a standardized extractor.

MECHANICAL GAS EXTRACTION - QUICK ANSWER:
Mechanical gas extraction is the mechanical agitation of drilling fluid to better release the entrapped and dissolved gasses within for analyzation by a detector of some sort.

MECHANICAL GAS EXTRACTION - LONG ANSWER:
When the drilling fluid returns to the surface, it may contain entrapped gasses. Much of these gasses would remain as a solution within the fluid.

To better extract these gasses for analyzation, the drilling fluid should be shaken, stirred, or beaten vigorously in order to release the entrapped gasses. This is much the same principal as shaking up a soda pop with the lid open.

1) The larger the container that holds the drilling fluid to be agitated, the more gas can be liberated from it.

2) The more drilling fluid that would be in the container to be agitated, the more gas will be liberated from it.

3) The more violent the agitation within the container that holds the drilling fluid, the more gas will be liberated.

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[6] http://en.wikipedia.org/wiki/Mud_weight
[7] http://www.glossary.oilfield.slb.com/en/Terms.aspx?LookIn=term%20name&filter=gas-cut%20mud

4) The more drilling fluid flowing past and presented to the agitation within the container, the more gas will be liberated.

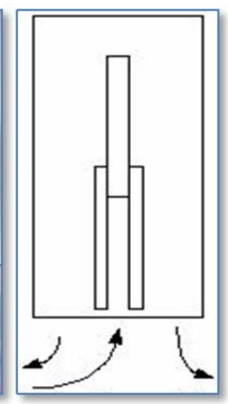
5) The tighter the container that holds the drilling fluid, the more gas <u>will be collected - not liberated</u>.

MECHANICAL GAS EXTRACTION - DRILLING FLUID CONTAINER SIZE
Size matters. Too large of a collection container, and the machine may not fit readily into the return point of the drilling fluid. Too small of a collection container, and it may not be able to contain enough drilling fluid for low gas volume wells.

MECHANICAL GAS EXTRACTION - DRILLING FLUID LEVEL WITHIN THE CONTAINER
There have been many experiments with the level of drilling fluid within the container itself. With the agitation and fluid level being constant, the more drilling fluid in the extractor, the more gas will be liberated.

MECHANICAL GAS EXTRACTION - DRILLING FLUID AGITATION WITHIN THE CONTAINER
As with the fluid level, there have been many experiments (personally done) with different methods and types of agitation of the drilling fluid itself. With an amount of drilling fluid presented to the agitation mechanism, the more agitation of the fluid, the more gas will be liberated. However, is has been shown that if too much agitation is presented, a point of diminishing returns appears.

MECHANICAL GAS EXTRACTION - PUMP TYPE OR SPITTERS
Some mechanical gas extractors pull sample gasses up through the bottom of the extractor and push them out the side through a hole of some sort and design. Others will draw the drilling fluid up through the center and push it down and out. These designs are similar to centrifugal pumps. This extractor design can constantly present new drilling fluid to the agitation in the container, which will liberate more gas.



MECHANICAL GAS EXTRACTION - SEALED CONTAINERS
Much like filling up a balloon with air, with a given volume of drilling fluid, and a given amount of agitation, the more closed off to air or atmosphere the container that contains the drilling fluid is the more liberated gasses will be collected within the container. This can be accomplished on most extractors by closing all or part of the vent holes on the top or side of the extractor.

MECHANICAL GAS EXTRACTION - CONSTRUCTION
The construction of the extractor can be of any material, however steel is preferred and if cost is of no concern, stainless steel is better. I have built hundreds out of steel with a plastic powder coating which protects the extractor from corrosion.

You can create and weld your own if you are on a budget and a little creative. There are a hand full of companies out there that will sell you one too.

MECHANICAL GAS EXTRACTION - OVERKILL, AIR INJECTION, AND THE KITCHEN SINK

One company has gone to great lengths to create an expensive, heavy, and all-inclusive of an extraction device that incorporates every theory known to man and place it into a patent application. That is US patent US8632625. If you like reading patents, you should be impressed.

RELATIVITY - BALANCE OF THEORY

From time to time we will receive calls that there is not enough gas being seen in the instrument or too much gas being seen on the instrument or “we have a well that is 1000 ft. away” and it is not reading the same gas readings as before.

As shown here, small differences in placement, deployment, and any one of a hundred variables can make the acquired Gas Units higher or lower in any setting. Every rig-up will be different.

The logger or geologist setting up and rigging up can rig up incorrectly and not account for all the variables causing too much or too little gas to be collected from the drilling fluid.

Generally speaking, it is possible to set the extractor up to extract too much gas from the drilling fluid. It is also possible to set up the extractor to pick up too little gas from the drilling fluid. Usually it is easier to set up the extractor to pick up too little.

As defined in the Gas Units section, and as defined in the Mechanical Gas Extractor section, it is easy to see that the two are not separate and should both be taken into account when rigging up and a balance set at the extractor.

It is possible to have an almost totally enclosed extractor with good drilling fluid flow through it and have it collect almost 100% hydrocarbon gas and have the attached instrument show too high gas readings.

Conversely, it is possible to have the same extractor set-up with poor drilling fluid flow through it and large open vent holes which allow too much gas to escape causing the attached instrument to show too low of gas readings.

As an example, consider the following scenarios on a theoretical perfect setup for discussion with only one variable:

1) If the gas detection instrument draws 1 liter per minute and there is 1 liter per minute of liberated gasses coming from the extracted agitated mud, then the instrument will likely see close to 100% gas.

2) Same instrument same extractor: If the gas detection instrument draws 2 liters per minute and there is 1 liter per minute of liberated gasses coming from the agitated mud, then the instrument will likely see close to 50% gas, the other 50% being air.

Or perhaps consider this second set of scenarios on a theoretical perfect setup for discussion with only one variable:

1) If the gas detection instrument draws 1 liter per minute and there is 1 liter per minute of liberated gasses coming from the extracted agitated mud, then the instrument will likely see close to 100% gas.

2) Same instrument same extractor: If the gas detection instrument draws 1 liters per minute and there is 1/2 liter per minute of liberated gasses coming from the agitated mud because the flow through the extractor is cut in half, (for any reason) then the instrument will likely see close to 50% gas, the other 50% being air.

CONCLUSION:
Care has to be taken when setting up any extractor at any site as well as setting up the instrumentation for good and consistent readings throughout the process. Adjustments at the extractor and instrument are necessary for this.

SHAMELESS PLUG: