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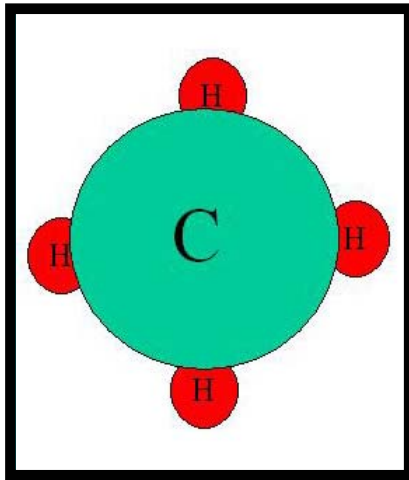
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LEL

NATURAL GAS - "THE SCOPE"

Natural Gas:

Facts, Reminders, Basic Metering, & Tactical Considerations.



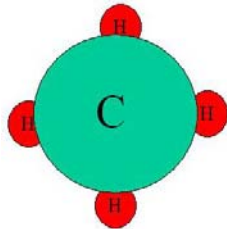
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Natural gas is usually a safe and efficient form of energy. However, once natural gas escapes from its container, especially in a confined space, it becomes a ticking time bomb.

Almost everyday the fire department is called on to mitigate the effects of leaking natural gas. Firefighters should be aware that natural gas calls are all but routine and require a high index of suspicion and caution. Calls involving natural gas should be treated with the same patience, planning, and foresight afforded to bomb and HazMat calls.

This document intends to reintroduce natural gas to the firefighter, to review its chemical composition, to review associated dangers, to develop thought processes for managing natural gas emergencies, and to review the scope and limitations of our metering abilities.

NATURAL GAS: CHEMISTRY/PROPERTIES



Methane molecule

The following chart provides a clear picture of the basic chemical composition of natural gas.

Composition of Natural Gas		
Methane	CH ₄	70-90%

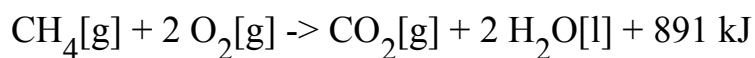
Ethane	C ₂ H ₆	0-20%
Propane	C ₃ H ₈	
Butane	C ₄ H ₁₀	
Carbon Dioxide	CO ₂	0-8%
Oxygen	O ₂	0-0.2%
Nitrogen	N ₂	0-5%
Hydrogen sulfide	H ₂ S	0-5%
Rare gases	A, He, Ne, Xe	trace

While methane is the primary component of natural gas, any or all of the other compounds can also be found in natural gas. Natural gas is formed by the decay of organic material and is classified as a fossil fuel.

Lower Explosive Limit (LEL)/ Upper Explosive Limit (UEL)

The rest of our discussion will rest heavily on the reader understanding the concepts of the upper and lower explosive limits. Our determination of hot, warm, and cold zones is made using LEL and UEL readings. Our policies and action plans should also be based on these numbers.

In order for gases to burn (in most cases) they require oxygen to be present. Chemically, this process consists of a reaction between methane and oxygen. When this reaction takes place a great deal of energy is released.



One molecule of methane (the [g] referred to above means it is gaseous form) combined with two oxygen atoms, react to form a carbon dioxide molecule, two water molecules (the [l] above means that the water molecules are in liquid state) and 891 kilajoules (kJ)

of energy. [By way of comparison when an AED “shocks” a patient it starts out with 200J (joules) of energy. The combustion of one molecule of methane releases 891(kJ) or 891,000 joules]^[1]

It is not enough for oxygen to be present though, it must be present in the proper ratio. The terms we use to describe this ratio of gas to air are lower and upper explosive limit.

The lower explosive limit is the absolute minimum concentration of gas that supports combustion. Conversely the upper explosive limit is the absolute maximum concentration that will support combustion. If the concentration of gas is too far to either side of these extremes then combustion cannot occur.

Each combustible gas has a different set of values for lower and upper explosive limit. The meters that we use to determine LEL and UEL work by passing air an air sample over a small burner. Based on the rate at which the gas in the sample burns the meter determines what percentage of the LEL is present.

Each gas has a different LEL and UEL. So how do our meters know the difference? The answer is that they don't. Each meter is calibrated for a certain gas, pentane or hexane usually. While the meter will burn any combustible gas the LED read-out of the LEL is only accurate when reading the gas it is calibrated for. If the meter is reading a different gas the value must be adjusted. The HazMat team has charts for this.

The LEL on the meter's LED is displayed as a percentage. It is the percentage of the LEL (whatever that is) that has been reached. In other words, when the meter reads 14% that does not mean that the room has 14% of hexane in it. It means that the room has 14% of the lower explosive limit concentration of hexane in it. So say for the sake of argument that the LEL for hexane is 10%. If your meter reads 4% that means that the concentration of hexane in the container is 4% of 10 or 4%.

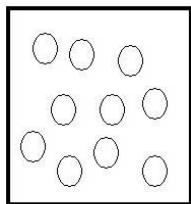
If the LEL for hexane is 30% and your meter reads 5%, what is the concentration of hexane in the container?

Answer: {It is 5% of 30 which is 1.5% .

One final way to look at the issue is this. When the meter reaches 100% of the LEL you have just entered the explosive range of the gas it is calibrated for.

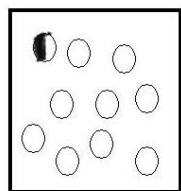
Now that we have talked it out lets take a look at some examples.

(For these examples we will use a square to represent a container. The clear circles in the container are room air and the dark circles are a gas that we will call X. For the sake of discussion we will say the flammable range of gas X is 10%-30%. This means the LEL is 10% and the UEL is 30%.)



air only

It has 0% gas in it. It only has air.



below LEL

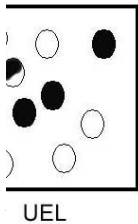
50% of the LEL.

gasX present in the container. However, it is below the LEL of 10%. Gas X of the total volume but what would your meter read? *Your meter would read because the LEL is 10% or one of the dark circles. You are halfway there or*

#3

Now with one whole dark circle you have reached the LEL. What would your meter read? *It would read 100%.*

#4 You are still in the flammable range here. Your meter however has maxed out at 100%. All the meter knows is that you reached 100% of the LEL. It does not care about anything above that.



concentration of gas X is 35% of the container. However, your meter has read the LEL for some time now. At this point you could light a match in the with no problem because the mixture is too rich to burn. You have passed the explosive limit.

You may be wondering why our meters are set to alarm at 10% of the LEL when do not always know what gas we are measuring for. What we have done is built in a safety factor. The meter will burn all combustible gases but only accurately for the gas it is calibrated for. The conversion factors for different gases vary widely. So the department sets the meters to alarm for the gas with greatest conversion factor, usually xylene. When the meter is reading 10% and it is reading xylene you are at 100% of the LEL for xylene. Fortunately xylene is rarely seen outside of industrial settings.

This is another reason why it is important to have the HazMat team on site for major gas leaks. The HazMat team can determine, using other methods, exactly which gases are present and can determine individual concentrations of each.

Not all units carry LEL meters some carry gas-tracs or other sensors that allow you to track gas using ticks and LED lights. For each of these meters it is important to consult the user manual. Each of the different displays correlates to different percentages of the LEL. However, unless you know what the lights or the tick rates mean you are just guessing on the concentrations of gas.

Metering Tips

No matter what kind of meter you are using it is important for the meter to be turned on in a clean environment and before you arrive at the scene. Meters need some time for the sensor to warm up and be ready to measure accurately. Also, as we discussed earlier the combustion process requires oxygen to work. If the oxygen levels in a space are low then the meter will not be accurate. If there is any possibility of low O2 levels a meter that reads O2 levels needs to confirm that O2 levels are sufficient for accurate LEL readings. Most times O2 levels are only an issue in confined spaces or in places that use Halon or CO2 extinguishment systems. Think about this possibility always. When in doubt consult with the HazMat team.

Meter readings are not instantaneous. It takes time for the air sample to pass into the meter, be combusted, and then the concentration to be displayed. Don't walk through a house or business at break neck speed and expect to get accurate readings.

In order to read the gas you are looking for your meter needs to be where the gas is. In other words you should not hold your meter at hip level when looking for natural gas, it will be at the ceiling level.

You should approach a structure with a reported gas leak with your meter already on, warmed up, and in your hand. If you start to get high reading on approach you know that there is a large problem. Natural gas is lighter than air, tends to dissipate easily and concentrates at the highest level of the container. If you are reading it 10 feet from the front of a building you know that you need to slow down and re-evaluate your tactical

approach.

So far our talk has centered on closed containers. However, the metering you do in real life will rarely involve closed containers. You will have to take air currents, ventilation systems, opening and closing doors into account when making decisions about where to look and what the actual dangers are. One room may be completely clear and the room next to it can have an LEL of 45%.

One of the most common dangers is the fire department arriving at a structure that is saturated with gas, above the UEL. When you ventilate such a structure it has to come back down through the flammable range before the concentration gets to zero. This is a dangerous operation. If you find areas above the UEL you can rest assured that some area nearby is in the flammable range. THIS IS A TRUE IDLH AND AS SUCH ALL IDLH RULES APPLY INCLUDING 2-IN/2-OUT AND RIT.

Meter maintenance

- Follow manufacture's guidance on calibration frequency.
- Ideally the meter should be bump tested before each use.
- Do not use your meter in known or possible corrosive atmospheres
- Silicone vapors desensitize combustible gas sensors. If they are used in the presence of silicone vapors they must be calibrated before using again. [\[2\]](#)
- Other vapors have different effects on the reliability of your meter. If there is the possibility of more than natural gas being present you should contact the HazMat team.

Methyl Mercaptan: The "natural gas odor"

Natural gas in its natural state is odorless and colorless. However, for the sake of safety the local gas distributor adds a chemical odorant to the gas. This allows you to detect the presence of gas at low concentrations with just your nose. Mercaptan is the rotten egg type smell you notice on gas leaks. Smelling is not enough when dealing with gas leaks. Mercaptan only allows you to know that gas is present but not to know in what concentrations.

Mercaptan is highly concentrated. It only takes one coffee mug full of Mercaptan to odorize one million cubic feet of natural gas. A few spilled drops of this can produce an odor over a large geographic area. It must be remembered that the presence or absence of the odor does not relate to the concentration of natural gas present.

There was a case in Bowie, MD in the early 70's when a gas line was compromised. Three or four blocks from the location of the leak a house exploded. There was no odor in the area. The mercaptan in the gas was filtered out in the soil but house was still within the flammable range. Since then the gas industry has made it harder for Mercaptan to be separated from natural gas but it is still possible.

It is also possible for the gas company to spill Mercaptan accidentally. When this odor is picked up in air currents you will get calls for gas leaks over a large area. However, if there was only odorant released you will not be able to get any readings on your meters.

If you smell gas but get no readings double check with a second meter. If you still get no readings then consider the possibility of a Mercaptan spill, consult with the gas company.

With all this said how do you deal with such a dangerous gas? It is important to remember that natural gas only becomes a danger when it is no longer in the container it was designed for. The simplest way to remove the hazard is to stop the flow of gas. In most cases this is as simple as shutting off the gas the meter. There are some cases where the gas has to be shut-off at remote or underground meters. Consultation with the gas company is critical here.

Ventilation

Natural gas tends to dissipate rapidly. The simple opening of windows tends to produce enough crosswinds to evacuate the gas. Check attic spaces and other confined spaces for accumulated gases. Positive pressure works great but you must start the fan in the cold zone and move it into the hot zone.

Ventilation is complete when the LEL is 0%.

Tactical Considerations

- Know your meters, know what the numbers mean.
- Make sure your meters are calibrated.
- Warm up your meters in a clean environment enroute to the call.
- DO NOT park in front of the structure reporting the leak.
- The safest place to park is at the corners of a building.
- Use the minimum number of personnel to investigate the leak.
- Other units should be staged away from the scene so that if an explosion occurs they can effect rescues after the blast.
- If you arrive after an explosion use caution. (gas explodes so rapidly that it may use up all the oxygen in the container and just be waiting for us to reintroduce more)
- Consider the need for evacuation. Remember you cannot control who is turns a light or whose phone will ring when surveying a building.
- When in doubt consult the HazMat team.
- Review the Natural Gas policy...it has guidelines for action.

- **Remember Static Electricity, Remember Static Electricity, Remember Static Electricity**
- When investigating a natural gas leak pick your feet up when you walk. This reduces your chance of building static electricity.
- Ground yourself in a clean environment before handling door handles on an affected building.
- Most recommend setting the hot zone at the 10% LEL area circumferentially, and the cold zone at the 1%LEL area circumferentially.
- If gas lines are burning do not extinguish the fire. Protect exposures until the gas company can get the gas shut-off. *If it is burning you know where it is.*
- Touching a plastic gas pipe can discharge up to 30,000 volts of energy.
- Do not pull electric meters, they arc, and gas can build up in the box.
- Do not operate knife switches or pull fuses, they arc too.
- Never base life and death decisions on one meter always use at least two.
- As always avoid light switches, door bells, cell phones, or anything else that could cause a spark.

[1] Natural Gas Association web site

[2] Industrial Scientific TMX412 Owner's Manual page 3