1.0 Fuel Gas Basics

Natural Gas
Natural gas is a fossil fuel extracted from deep underground wells. It is a physical mixture of various gases, typically containing 85 to 95% methane, 7 to 12% ethane and small amounts of propane, butane, nitrogen, and carbon dioxide. The proportions vary from field to field and sometimes from well to well. Natural gas is odorless and colorless when it comes from the wellhead. As a safety measure, an odorant is added so gas leaks can be detected. Commonly known as mercaptans, the odorant is a blend of organic chemicals containing sulfur. The odor of the mercaptans can be detected long before there is sufficient gas to cause a fire, explosion or asphyxiation. Unlike propane, natural gas is lighter than air. Natural gas typically has a specific gravity of 0.6, meaning that it weighs about 0.6 times as much as air. The term specific gravity refers to the weight of the gas as compared to the weight of air. Not all mixtures of gas and air will burn. Some mixtures have too little gas, while others have so much gas there is not enough air left to burn. The two cutoff points between combustible mixtures and non combustible mixtures are called the Explosive Limits.

- The Lower Explosive Limit (LEL) for natural gas is approximately 5%. At concentrations below the LEL, there is insufficient gas to cause a fire or explosion.
- The Upper Explosive Limit (UEL) for natural gas is approximately 15%. At concentrations above the UEL, there is insufficient air to cause a fire or explosion. The ideal mixture for combustion of natural gas is approximately 10% and the ignition point is 1208° F.

Propane Gas
Propane is a gas derived from natural gas and petroleum. It is found mixed with natural gas and petroleum deposits. Propane is called a fossil fuel because it was formed millions of years ago from the remains of tiny sea animals and plants. When the plants and animals died, they sank to the bottom of the oceans and were buried by layers of sediment and sand that turned into rock. Over time, the layers became thousands of feet thick. The layers were subjected to enormous heat and pressure, changing the energy-rich remains into petroleum and natural gas deposits. Eventually, pockets of these fossil fuels became trapped in rocks, much as a wet sponge holds water. Propane is one of the many fossil fuels included in the liquefied petroleum gas (LPG) family. Because propane is the type of LPG most commonly used in the United States, propane and LPG are often used synonymously. Butane is another LPG often used in lighters. The chemical formula for propane is C3H8

Just as water can change its physical state and become a liquid or a gas (steam vapor), so can propane. Under normal atmospheric pressure and temperature, propane is a gas. Under moderate pressure and/or lower temperatures, however, propane changes into a liquid. Propane is easily stored as a liquid in pressurized tanks.
Propane takes up much less space in its liquid form. It is 270 times more compact in its liquid state than it is as a gas. One (1) thousand gallon tank holding gaseous propane would provide a family enough cooking fuel for one week. A thousand gallon tank holding liquid propane would provide enough cooking fuel for more than five years! When propane vapor (gas) is drawn from a tank, some of the liquid in the tank instantly vaporizes to replace the vapor that was removed. Propane is nicknamed the portable gas because it is easier to store and transport than natural gas, which requires pipelines. Like natural gas, propane is colorless and odorless. An odorant called mercaptan is added to propane (as it is to natural gas) to serve as a warning agent for escaping gas. And, like all fossil fuels, propane is a nonrenewable energy source. We can’t make more propane in a short period of time.

**Butane Gas**

Butane is a saturated hydrocarbon gas with the chemical formula C₄H₁₀. It is an alkane with four carbon atoms. Butane is a gas at room temperature and atmospheric pressure but is easily turned into a liquid by cooling or applying moderate pressure. **Butane is a safe, efficient and clean fuel that powers many standard mobile heating appliances.** A far higher boiling point than propane makes butane only suitable for outdoor use during milder months. As low winter temperatures may mean the liquid will not boil to produce vapor to burn.

Butane, is a saturated hydrocarbon gas with the chemical formula C₄H₁₀, belongs to the Alkanes (previously known as Paraffin’s) family of hydrocarbon gases. The ability to liquefy under modest pressure distinguishes butane from natural gas. When liquefied, the volume occupied significantly reduces, making it easy to store and transport in specially constructed pressure vessels.

An expansion ratio of approximately 233:1 from its vapor to liquid state means one volume of liquid butane produces 233 volumes of gas. Butane vapor is around 2.08 times denser than air, meaning it sinks to a low level when released in the atmosphere. For this reason, butane cylinders cannot be stored below ground or near drains and cellar openings. Butane-fuelled appliances must not be used within cellars or basements.

Butane mixed with correct proportions of air produces a highly flammable mixture, with flammability range of between 1.8% and 9.5%, by volume of gas in air. Outside this range the mixture is either too lean or rich to propagate a flame.

The Calorific Value (CV) of a fuel mixture is the amount of energy released when a known fuel quantity undergoes combustion. Butane has a CV of 126MJ/m³ whereas natural gas has a CV of 38MJ/m³, giving it a far greater heat energy release per unit volume, as well as a difference in air requirement and other combustion characteristics.

Butane-fuelled appliances must therefore have adequate means of ventilation, to ensure complete fuel combustion. Regular servicing by suitably qualified and competent individuals will ensure these
requirements are met and appliances perform correctly and safely.

Butane is less volatile than propane. A boiling point of approximately -0.5°C and a vapour pressure of around 2 bar / 30 psi (at 15°C) makes it more suitable than propane for appliances where LPG cylinders may be used indoors.

Butane is a colorless and odorless gas. For safety reasons a stenching agent of mercaptans (mainly ethyl mercaptan) and organic sulphides is added to butane to ensure leakages are easily detected by the distinctive and unpleasant smell.

Most butane cylinders are blue. However the butane cylinders from BP Gas, Flogas, Handy Gas & MacGas which use the 21mm butane regulator (CG4) are usually a beige/grey/gold colour whereas the butane bottles from these same suppliers which use the 20mm butane regulator (CG5) are blue. All Calor Gas butane bottles are blue and only use the CG4 regulator apart from the 4.5kg bottle which uses CG3.

**LPG**

LPG (liquefied petroleum gas) is the generic name for commercial propane and butane. They are by-products of the refining of oil and natural gas with approximately 40% of all LPG coming from the refining of crude oil and 60% from the separation of gas products. It can be stored in gas cylinders/gas bottles or in bulk storage containers either above or below the ground. The pressurized cylinders are supplied up to about 80% full to allow for thermal expansion.

LPG is liquid inside the container but immediately transforms to gaseous state when released. It is liquefied so that it can be stored economically and transported easily. A gallon of liquid of LPG in a container will need a truck 270 times bigger if stored in vapor form.

Like any other liquid, LPG expands and contracts with changes in temperature. A gallon of LPG expands at 10°F. This is why LPG containers are never filled to their full capacity to give allowance for expansion of liquid.

LPG is non-toxic or non-poisonous. However, because it is heavier than air in vapor form, it pushes out air inside the room causing a shortage of oxygen and this might suffocate any person in that room.

LPG is colorless, tasteless, and odorless, but an odorizing agent called Ethyl Mercaptan is added to give a peculiar smell so that any leak can be easily detected.

LPG dissolves natural rubber. Thus, it is important that all materials used in LPG installations must be LPG resistant. LPG in air will ignite if it is within its flammability limit. The flammability limit is within 2% to 9% mix with air.

If the released gas is not properly dissipated, it will readily ignite upon contact with sparks, open flames, or any other sources of ignition. The fire, however, may not be so serious unless the gas is confined. In that case, an explosion may occur, the intensity of which will depend upon the degree of commitment.
In open air, flaming LPG vapor will travel at about 15 feet per second depending on the atmospheric conditions and the concentration of the gas. There will be spots where there is not enough air and the travel will be retarded until air is in correct proportion.

Heating value is the amount of heat given off during combustion. The heating value of LPG is 46,800 BTU/kg.

Fuel (LPG) and air must be mixed in the right proportion in order to burn. LPG has a flammability limit from two percent to nine percent (2% - 9%). This means that the mixture of LPG must contain no less than two percent LPG and not more than nine percent in order to burn.

The boiling point of a liquid is the temperature at which boiling occurs when the pressure above the liquid is atmospheric or 14.7 psig. The boiling point of LPG is 10°F or -12°C.

Most LPG cylinders and tanks in the Philippines are color blue which is the standard color for Butane cylinders in other countries.

We can then say based on the similarity of gas characteristics of Butane and LPG in the Philippine the gas used locally is Butane.

Propane is used dominantly in cold climates because of its low temperature boiling point. Butane has a higher boiling point temperature and is use in countries like the Philippines. In cold countries Butane does not produce flame except during summer or mild hot weather.

![Propane cylinder](image)

In other countries Propane cylinders are colour red.

### 2.0 Fuel Gas Piping

#### Standards

The minimum fuel gas piping standard protection for public safety is based on the following Code and Standards:

- Philippine Mechanical Engineering Code 2012 Chapter 18 Fuel Gas Piping
- Philippine Mechanical Engineering Code 2012 Chapter 7 Air Ventilation for Combustion
- NFPA 54 Fuel Gas Code
The Standards cover from the point of LPG gas delivery to the point of connection to the gas utilization equipment. This means that the gas meter is included in the scope of standard requirement. It shall not apply to those listed in Section 1801.0 (C).

**Gas Meter**

Gas Meters should be located in accordance with the requirement of Section 1809.1 Location.

(A) Gas meters shall be located in ventilated spaces readily accessible for examination, reading, replacement, or necessary maintenance. [NFPA 54: 5.7.2.1]

(B) Gas meters shall not be placed where they will be subjected to damage, such as adjacent to a driveway; under a fire escape; in public passages, halls, or coal bins; or where they will be subject to excessive corrosion or vibration. [NFPA 54: 5.7.2.2]

(C) Gas meters shall be located at least 3 feet (0.9 m) from sources of ignition. [NFPA 54:5.7.2.3]

(D) Gas meters shall not be located where they will be subjected to extreme temperatures or sudden extreme changes in temperature. Meters shall not be located in areas where they are subjected to temperatures beyond those recommended by the manufacturer.[NFPA 54: 5.7.2.3]
Figures 1.0, Figure 2.0 and Figure 3.0 shows where the gas meters should be located in compliance with outside the building in compliance to Section 1809.1 (A). The reason for this is that LPG is heavier than air and any leak in the gas system, LPG would seek the lowest level where it can increase the flammability ratio to an explosive situation. Unlike natural gas, having a lighter density than air would flow upwards. With this characteristic LPG meters should not be located in the basement. For LPG in 11 kilogram cylinders it should be located in a naturally ventilated location and separated by a wall from the inside part of the building.

LPG meters should not be located in public passage way or along the corridors used as fire exit or egress. LPG meters should not be located along the driveways, places where it is exposed to high temperature and corrosive environment.

LPG meters should comply with Sections 1809.6.2, 1809.6.3 and 1809.6.4. LPG meters should be supported, with protection against overpressure, back-pressure and vacuum pressure. Shown in Figure 4.0 is a typical LPG meters installed in an aboveground basement of a residential building.

Gas Piping

In Sections 1802.0 and 1811.5 of the PME Code the maximum design operating pressure for gas piping system shall not exceed 5 pounds per square inch (34kPa) within the property lines of any building or structure..
In Section 1811.5.3 it states: *A chase shall be ventilated to the outdoors and only at the top. The openings shall have a minimum free area (in square inches) equal to the product of one-half of the maximum pressure in the piping (in psi) times the largest nominal diameter of that piping (in inches), or the cross-sectional area of the chase, whichever is smaller. Where more than one fuel gas piping system is present, the free area for each system shall be calculated and the largest area used.* [NFPA 54: 7.4.3]

As shown in Figure 6.0 is an example of gas pipe chase for LPG specifically Butane which is heavier than air. Provision for vent to the outside is also provided at the bottom of the chase.
Another type of gas pipe installation is shown in Figure 7.0. The pipe is located at the exterior of the building walls.

Another way to install gas pipes on chases is shown in Figure 9.0 where each floor are closed with concrete slab and is provided with vents on top and bottom of the floor. The vents should be fireproof.

In Figure 10 the gas pipe are provided with chase at the exterior wall and is provided with decorative grilles allowing the pipes to be provided with natural ventilation.
Pipe exposed to elements that will cause corrosion to the pipes should comply with Section 1811.2

Piping installed aboveground shall be securely supported and located where it will be protected from physical damage (also see 1211.1.4). Where passing through an outside wall, the piping shall also be protected against corrosion by coating or wrapping with an inert material approved for such applications. Where piping is encased in a protective pipe sleeve, the annular space between the gas piping and the sleeve shall be sealed at the wall to prevent the entry of water, insects, or rodents. [NFPA 54: 7.2.1]
If an external riser is to be hidden within an enclosure in the outer fabric of the building, it should be itself sealed from entry to the building and open to the outside air. Openings to the outside air should be provided at the top and bottom of the riser (additional ventilation openings can be provided at intermediary positions if desired). The
minimum free area of each opening must be 5,000mm² or 1/500th the cross sectional area of the enclosure, which ever is greater. All pipings in concealed building spaces should comply with Section 1811.3.

Where gas piping is to be concealed, unions, tubing fittings, right and left couplings, bushings, swing joints, and compression couplings made by combinations of fittings shall not be used.

Figure 11.0
Gas Valves

Gas valve should be install upstream of the gas meter as shown in Figure 13.

In Figure 14 the Shut-off valve should indicate the direction of the lever on an On-position and on an Off-position.

In multiple Gas Meter installation an area Shut-off Valve should be installed upstream of the Gas Meters as shown in Figure 15.0. This is in compliance with Section 1811.10.2 (A) and (B)

(A) Accessibility of Gas Valves. Main gas shutoff valves controlling several gas piping systems shall be readily accessible for operation and installed so as to be protected from physical damage. They shall be marked with a metal tag or other permanent means attached by the installing agency so that the gas piping systems supplied through them can be readily identified.[NFPA 54: 7.9.2.1]

(B) Shutoff Valves for Multiple House Lines.

In multiple-tenant buildings supplied through a master meter, or through one service regulator where a meter is not provided, or where meters or service regulators are not readily accessible from the equipment location, an individual shutoff valve for each apartment or tenant line shall be provided at a convenient point of general accessibility.
In a common system serving a number of individual buildings, shutoff valves shall be installed at each building. [NFPA 54:7.9.2.2]

**Figure 15.0**

An emergency isolation valve should be installed located outside the building to comply with Section 1811.10.3.

An exterior shutoff valve to permit turning off the gas supply to each building in an emergency shall be provided. The emergency shutoff valves shall be plainly marked as such and their locations posted as required by the Authority Having Jurisdiction. [NFPA 54: 7.9.2.3]

**Earthquake Actuated Valves**

Seismic Valves or earthquake actuated valves should be installed in accordance with Section 1811.18.
Earthquake actuated gas shutoff valves, conforming to California Referenced Standard 12161, shall be provided for buildings. Earthquake actuated gas shutoff valves which do not conform with California Referenced Standard 12161 shall be prohibited in buildings open to the public.

Gas Pressure Regulators

Gas Pressure Regulator should be installed in gas piping line system where the gas pressure supply is higher than the designed pressure of gas utilization equipment. It is in compliance with the requirements of Section 1802.0 and 1809.7.

Gas Pressure Regulator when installed should be provided by a venting piping system to the outside of the building. This is in compliance to Section 1809.7.5. Vents leading to the outdoor should prevent water from entering the piping system and also should prevent blockage of insects and foreign matter.

Shut-off Valves should be installed within 6 feet of the gas utilization equipment in order to comply with Section 1812.4.

Connecting the gas utilization equipment to the gas piping system should comply with Section 1812.0
Provide end caps for all gas piping outlets that are not in use to comply with Section 1811.8.2

Figure 19.0

Excess Flow Valves

Excess Flow Valve shown in Figure 19.0 when use should be listed and approved by the Approving Agency in California. [Section 1810.0]

Air Ventilation for Combustion

Gas utilization equipments requires outside air for efficient combustion of gas fuel, ventilation and dilution of air. In order to meet this requirement the building should comply with Sections 701.2 through Section 701.8.3 of the Philippine Mechanical Engineering Code (PME Code).

Earthquakes

The Philippines and California shares a common earthquake zone being both located at what we call the “Pacific Ring of Fire”. Most of this lecture is based on the experiences of California during earthquakes as reported by the California Seismic Commission.

The fires following the 1906 San Francisco earthquake are a constant reminder to California communities of the potential consequences of post-earthquake fire. The combination of fire ignitions with conditions amenable to rapid fire growth and spread can greatly increase the level of post-earthquake fire damage. –Improving Natural Gas Safety in Earthquakes Report Adopted July 11, 2002 California Seismic Commission

On January 17, 1994, at 4:31 AM, the Northridge, California, earthquake had a moment magnitude of 6.7. The epicenter was located in the city of Reseda, near the center of the San Fernando Valley. Data on MMI shaking intensity were recorded by local postmasters and processed by the US Geological Survey. The earthquake resulted in the total loss of electric power to the City of Los Angeles and adjacent areas. The Northridge earthquake is the only earthquake in the United States for which adequate detailed data exists on fire ignitions, building damage, and appliance damage.

As reported The City of Los Angeles, this includes the San Fernando Valley, sustained 77 of the 110 earthquake-related fire ignitions on the day of the earthquake. Fifty-five of these occurred in residential structures: 35 in one- or two-family residences and 20 in multi-family residences. A total of eight fire ignitions occurred in schools, offices, or commercial properties. Preliminary statistics on fire ignition response by the Los Angeles Fire Department indicate that 13 fire ignitions had a natural gas appliance as the source of heat ignition. The Los Angeles Fire Department conducted a separate investigation within a few months following the Northridge earthquake, and identified 38 incidents where natural gas may have contributed to the fire ignition. Of these, 27 were in single- or multi-family residences and 22 involved gas appliances with water
heater damage, accounting for 16 fire ignitions. With 225,000 wood-frame structures exposed to ground shaking of MMI VIII or greater (OES/EQE, 1995) and assuming that 50% to 90% of these structures had natural gas service, the average rate of occurrence of gas related fire ignition for any individual structure in the Northridge earthquake is estimated to have been 0.024% to 0.044%, or roughly 1 to 2 chances in 4,500. Thus, the rate of occurrence of a gas related fire ignition was approximately 10% of the rate of occurrence of sustaining significant structural damage.

In the Loma Prieta Earthquake in San Francisco that occurred in October 17, 1989 with a moment magnitude of 7.2 about 34% of the fire was cause by natural gas while 56% are electrical related.

<table>
<thead>
<tr>
<th>Fire Department</th>
<th>Earthquake Fire Ignitions</th>
<th>Gas-Related Earthquake Fire Ignitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beverly Hills</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Burbank</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>City of Los Angeles</td>
<td>77</td>
<td>38</td>
</tr>
<tr>
<td>Costa Mesa</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Covina</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Glendale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>El Monte</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fillmore</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Glendale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Inglewood</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Long Beach</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Newport Beach</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pasadena</td>
<td>1</td>
<td>?</td>
</tr>
<tr>
<td>Santa Monica</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Santa Paula</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>South Pasadena</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Los Angeles County</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>Ventura County</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>110</td>
<td>54</td>
</tr>
</tbody>
</table>

Table 2. Northridge Earthquake Fire Statistics for Structures on January 17, 1994

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Wiring</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td>Electrical Equipment</td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>Stove (gas or electric)</td>
<td>9</td>
<td>29</td>
</tr>
<tr>
<td>Water Heater</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Other Gas Appliance</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Gas Explosion</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 4. Causes of Fire Ignitions in San Francisco from the Loma Prieta Earthquake
Table 2.0

In the report’s summary it found thru experience that (Refer to Table 1.0) "...gas-related fire ignitions can be expected to be 20% to 50% of all post-earthquake fire ignitions. While an earthquake may produce numerous leaks in the customer's gas system, the potential for
fire ignition from natural gas will be low compared to the number of leaks”.

In Table 2.0 are listings of Valves and Alarm Devices That Assist in Limiting Natural Gas to Customer Facilities. Namely:

- Manual Shut-Off Valve
- Earthquake Actuated Valve
- Excess Flow Valves
- LPG (Butane) Detectors
- Hybrid Systems

<table>
<thead>
<tr>
<th>ALTERNATIVE</th>
<th>Human action required to make situation safe</th>
<th>Reduce chance of unnecessary gas shutoff</th>
<th>Reduce chance of building structural damage</th>
<th>Reduce chance of gas line break</th>
<th>Reduce release of gas</th>
<th>Reduce change of gas-related ignition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Shutoff Valve and Wrench</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methane Detector</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appliance Bracing or Reinforcement</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excess Flow Valve</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seismic Actuated Valve</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural Improvements</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. More information on various alternatives is provided in Section 9.0. 
2. Refer to the Homeowner’s Guide to Earthquake Safety for discussion of structural improvements.

Table 8. Comparison of Alternatives to Improve Gas Safety in Earthquakes

Table 3.0 shows the comparison between alternatives to improve safety during earthquakes.

In the report there are five (5) proposed recommendations. Four (4) are related to policy recommendations and one (1) is related to valves. The report recommends the strict implementation of installing earthquake actuated valves and excess flow valves.

Roles of the Communities to Insure Gas Safety:

LPG Gas Utility
The natural gas utility is responsible for designing, constructing, maintaining, and operating the natural gas system safely and efficiently. This includes all the facilities used in the delivery of gas to any customer up to and including the point of delivery to the customers’ gas piping system. Utilities meet this responsibility through compliance with existing regulations, coordinating their emergency planning with local governments, and incorporating earthquake-resistant design considerations into their maintenance activities and new construction.

Customer
Customers are responsible for using gas safely on their property and within their buildings and other facilities. Customers meet this responsibility by maintaining their gas appliances in good working condition, assuring that only qualified individuals are engaged to modify or maintain their gas service and facility piping, and knowing what to do before and after earthquakes to
maintain the safe operation of their LPG gas service.

Local Governments
City and county governments are typically responsible for ensuring the overall safety of their communities. Local governments assess safety needs, identify potential risks to meeting those needs, and determine alternatives to reduce the risks. Alternatives often include local guidelines and ordinances to assure safe construction and practices. Other equally important alternatives may focus on reducing the impacts of earthquakes or other emergencies through rapid response and recovery measures that are often coordinated with the private sector, industry, and other government agencies. Local authorities also have a responsibility to consider the impacts of earthquakes in urban planning decisions related to building construction methods and materials, building density, capacity of fire protection services, and traffic management. Finally, local governments are responsible for informing their communities of potential earthquake risks and actions the local population is expected to follow to reduce or manage those risks.

References:

2. National Fire Protection Association (NFPA) 54
3. Board Gas Network
4. California Seismic Commission

About The Author
Fernando S. Guevara is the President of Fernando Guevara and Partners, Inc. He is the Past President of the American Society of Heating, Refrigerating Air Conditioning Engineers (ASHRAE) Philippine Chapter (2012 to 2013), Technical Committee Chairman of the Philippine Society of Mechanical Engineers, Inc. (PSME) and the Philippine Society of Ventilating Air Conditioning Refrigerating Engineers (PSVARE). He is a licensed Professional Mechanical Engineer and Professional Engineer of California and Minnesota. (July, 2012)

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Appendix 1

Gas Pipe Sizing

1. To determine the gas input for each appliance use table or nameplate on appliance.
2. Determine the length of pipe from the gas meter to each outlet, if length falls between lengths shown go to next higher column.
3. Figure the lateral pipe sizes for individual appliances.
   Outlet A - Use 60’ column-demand load 30 cfh minimum pipe size \( \frac{3}{4}'' \)
   Outlet B - Use 60’ column-demand load 25 cfh minimum pipe size \( \frac{1}{2}'' \)
   Outlet C - Use 60’ column-demand load 65 cfh minimum pipe size \( \frac{1}{2}'' \)
   Outlet D - Use 40’ column-demand load 150 cfh minimum pipe size \( \frac{3}{4}'' \)
4. Figure the size of the main pipe feeding more than one appliance. Go to the most remote outlet, it is 60’ from the meter so use 60’ column. Then determine various pipe sizes based on demand load for each section.

Section 1-serves outlets A and B total demand 55 cfh-minimum pipe size \( \frac{1}{2}'' \)
Section 2-serves outlets A, B, and C total demand 120 cfh-minimum pipe size \( \frac{3}{4}'' \)
Section 3-serves all outlets total demand 270 cfh-minimum pipe size 1\( \frac{1}{4}'' \)
**PERMIT REQUIREMENTS**

Installation or alteration of gas piping requires a permit. The permit can be issued to the property owner or licensed contractor. A plan showing the layout of gas piping system and sizing is required for new or when adding to an existing gas piping system. This plan should show the proposed location of piping, size of different branches, and the load demands.

**INSTALLATION REQUIREMENTS**

Acceptable materials are schedule 40 metallic piping (galvanized or black), or corrugated stainless steel tubing (CSST). CSST can only be installed by persons who have been trained and certified by the manufacturer. For underground installations, piping with a factory corrosion-resistant coating is allowed, or polyethylene plastic pipe (PPE) when installed by certified technicians. Underground pipe requires a minimum of 18 inches of cover. Piping installed on the exterior above ground shall be a minimum of 6 inches above grade, securely supported and located where it will be protected from damage. Required shutoff valves must be accessible, in the same room, and in most cases within three feet of the appliance. When flexible connectors are used, they shall be of a minimum practical length and not pass through any walls, ceilings, floors, and not used in concealed locations.

**INSPECTION REQUIREMENTS**

All new gas piping is required to be visually inspected, tested and approved prior to covering. Inspection will include verification of gas piping size, material, and that installation meets code requirements. The inspector will need to witness a pressure test to confirm there is no leakage. The person doing the work is responsible for providing the proper gauge, performing the gas piping pressure test, and scheduling the inspection.

**PRESSURE TESTING REQUIREMENTS**

When new branches are installed from the point of delivery to new appliances, only new piping is required to be tested. The air pressure test must hold for 10 minutes with no drop in pressure. Use a test gauge with 1/10lb. increments, with a pressure range no more than twice the test pressure.

**SIZING GAS PIPE**

You can size gas piping by using the information in this brochure, or by providing us with the proper information request assistance from the building department. A drawing showing piping layout, lengths, size, type of appliance and demand would be needed in order for us to help you.

| Approximate Gas Input for Residential Appliances (From Table 12-1 of the 2007 UPC) |
|-------------------------------|-------------------|
| **Appliance**                  | **Btu/h**         |
| Furnace                       | 100,000           |
| Water heater 30 to 40 gal.    | 35,000            |
| Water heater 50 gal.          | 50,000            |
| **Water Heater Instantaneous** |                   |
| Capacity at 2 gal./Minute     | 142,800           |
| Capacity at 4 gal./Minute     | 285,000           |
| Capacity at 6 gal./Minute     | 428,400           |
| Range, freestanding           | 65,000            |
| Built-in oven or broiler unit | 25,000            |
| Built-in cooktop              | 40,000            |
| Clothes dryer                 | 35,000            |
| Gas fireplace direct vent     | 40,000            |
| Gas log                       | 80,000            |

These demand ratings are approximate, actual appliances may have higher, refer to appliance nameplate for specific Btu/h ratings. The tables used to size gas piping are based on cubic feet per hour (cfh). To convert Btu/h to cfh, divide Btu/h by 1,000. (Per PGE-EI)

<table>
<thead>
<tr>
<th>Schedule 40 Metallic Pipe (Black or galvanized iron pipe)</th>
<th>Maximum Capacity of Gas Pipe in CFH (Cubic Feet Per Hour) (From Table 12-2 of the 2007 UPC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Sizes</td>
<td>Distance from Meter to Most Remote Appliance in Feet on Each Branch</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>172</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>360</td>
</tr>
<tr>
<td>1&quot;</td>
<td>678</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
<td>1,390</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>2,090</td>
</tr>
</tbody>
</table>