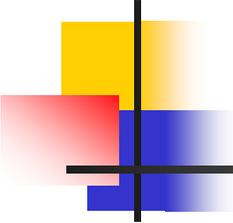


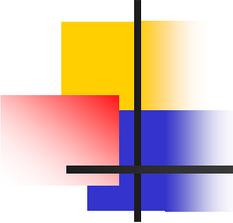
Technical Losses in Natural Gas Transportation, Distribution, and Storage

- Paul Metro – Pennsylvania Public Utility Commission



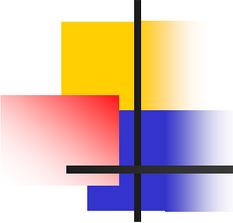
Unaccounted for Gas (UFG or Technical Losses)

- Unaccounted for gas is the difference between gas sales billed and gas sendout
- During a given period, the quantity of gas sold will differ from the quantity sent into the distribution system



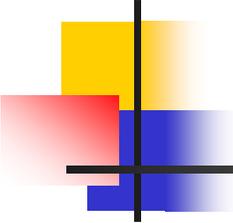
UFG

- The term, “unaccounted-for gas,” does not always indicate a leak. Leakage is only one of a number of factors contributing to unaccounted-for gas. There are 17 or more conditions that may contribute to unaccounted-for gas. For a given gas leak, each system will be affected differently by these conditions because there are no two systems exactly the same as to piping and customer mix.



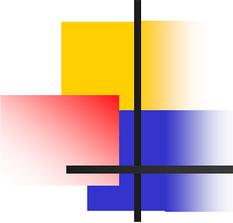
UFG

- The causes for unaccounted-for gas can be grouped into two categories. One is leaks and the other gas measurement. Leaks are defined as gas escaping to the atmosphere at a given rate at an unknown location. The rate of gas loss is dependent on the pressure and the size of the hole. Normally, gas leakage will be at a fairly constant rate and will increase gradually with time if not located and repaired. Gas lost through measurement or the lack of measurement is very deceptive and at times very difficult to detect. Gas measurement is defined as the accounting of all gas bought and sold.



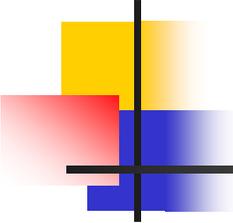
UFG

- UFG must be added to gas sales to determine the total gas requirement
- Total gas requirement is needed for forecasting, revenue calculations, gas purchasing



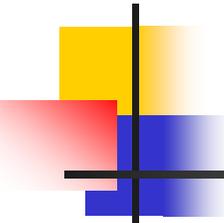
UFG

- All UFG is lost revenue
- Economic reasons for reducing UFG
- Cost of lowering UFG versus savings



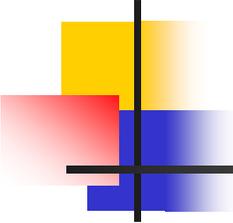
UFG

- Three causes of UFG
 1. Line losses and theft of services
 2. Differences between interstate transmission line meters (large meters) and residential meters (small and great numbers)
 3. Discrepancies caused by the lag between the time when gas is supplied to the mains and when the gas is recorded as sendout (meter reading lag)



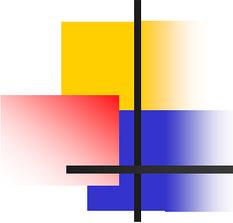
UFG Line Losses and Theft of Service

- Line losses are associated with:
 1. Corrosion -leaky cast iron and unprotected bare steel pipelines and services
 2. Line Hits – excavation damage
 3. Theft of Service is negligible



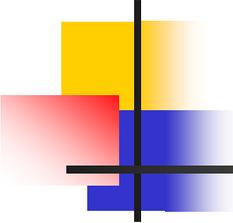
Gas Safety

- Unaccounted for Gas - Gas lost through leaks, company use, metering problems
- Average Unaccounted for in Pennsylvania - 4%
- Reduce Unaccounted for through reduction in leaks
- Pipeline Replacement



Gas Safety

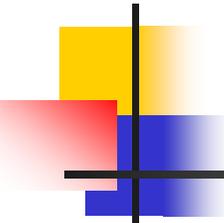
- Pipeline Replacement
- Pennsylvania has 3,600 miles of cast iron and 9,000 miles of unprotected bare steel pipes
- Bare Steel and Cast Iron pipes account for 27% of distribution pipe and 95% of leaks
- Reliability and Safety Issue
- Replacement Costs - \$13 Billion over 20 Years



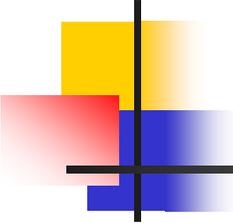
Gas Safety

- Risk Assessment Strategies
- Damage Prevention, Corrosion, Operator Qualification
- Through re-focused inspections reduce gas interruptions and outages
- Distribution Integrity Management

UFG – Flow Measurement Leakage

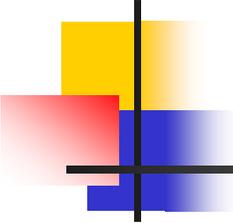


- Most UFG is caused by limitation of flow measurement devices
- Inaccurate measurement devices because of poor operation, application, and maintenance
- Accounting loss versus actual green house gas escape



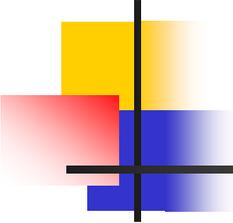
UFG – Flow Measurement

- Review historic data
- Examine trends
- Determine relevant factors effecting trends (weather, maintenance dollars, age of meters)
- Isolate sources of UFG and run cost benefit analysis to determine whether economical to correct



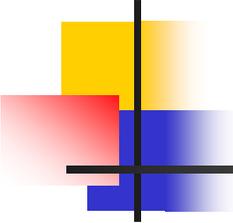
UFG Measurement

- Meters
 1. Age, testing and replacement policy
 2. Random testing for accuracy
 3. Temperature and pressure compensated
 4. Accurate meter reads
 5. Maintenance



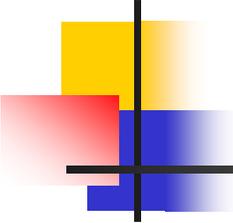
UFG Measurement

- Check large meters for discrepancies
- More gas flow, greater magnification of errors
- Calibrate large meters annually or bi-annually
- Install Meter drips for wet gas



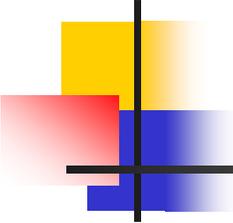
UFG Example

- Let's start with the gas purchase station. This station is normally owned and maintained by the seller of the gas to the gas utility and is normally called a gate station. Very few small utilities have check meters to monitor the accuracy of these gate stations to ensure the accuracy of the measurement. It is important to know what size cubic foot of gas is being purchased. Normally the gas volume at a gate station is corrected to a temperature of 60°F at a base pressure of 4 oz. If the gas being sold is not corrected to the same conditions, there will be unaccounted-for gas.



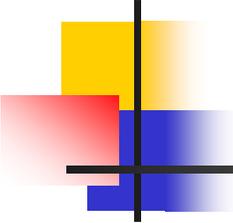
UFG

- Gas Safety Division designing metrics for UFG
- Initial threshold 4%
- Proposed reduction of .5% per year
- Pennsylvania Utilities with majority of plastic pipe have less UFG
- Utilities with temperature and pressure compensated meters reduce UFG dramatically, however, it's a cost benefit issue



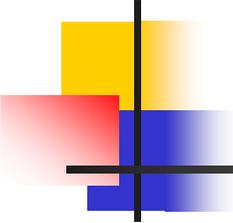
UFG Examples

- Let's see how temperature can affect accuracy. The purchased gas volume was calculated at 60°F. At what temperature is the gas being sold? Naturally the ambient temperature affects the gas temperature. The amount of the effect is determined by the depth of the pipeline in the ground. The deeper the pipe, the more insulation the ground offers and the closer the gas temperature will be to 60°F. If the gas mains and services are aboveground or close to the surface, the gas temperature is relatively close to the air temperature on any given day.



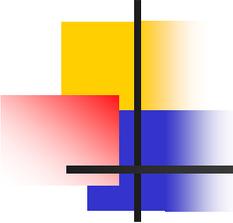
UFG Examples

- For every 5°F above or below 60°F, the gas volume will change by about 1 percent. This may not sound like much; however, if the average winter temperature for a 3-month period is 30°F, 6 percent unaccounted-for gas can be expected for this period. This loss can only be corrected by the use of temperature compensated meters. No temperature multiplier can be used to correct the volume unless a temperature volume instrument is used on the sales meter. Gas utilities sell the majority of their gas during the winter months so the small amount of gas sold during the hot summer will offset the losses.



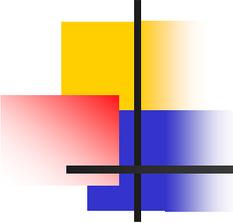
UFG Examples

- How does metering pressure affect unaccounted-for gas? Gas is purchased at a 4-oz. pressure or at least the volume is corrected to 4 oz. As the pressure increases above the 4-oz. base, the volume of gas becomes smaller. For every 2-oz. change above the 4 oz., there is an expected loss of about 1 percent. Therefore, if the service regulators are delivering 8-oz. gas through the meters, approximately 2 percent unaccounted-for gas can be expected. For delivery at 10 oz., approximately 3 percent unaccounted-for gas can be expected. Pressure compensated indexes are not normally used for domestic house meters. However, they are available for the large commercial and industrial meters. If a pressure compensated index is used, care must be taken to ensure that the meter pressure is the same as the index pressure. The pressure compensated index will only correct for a constant pressure.



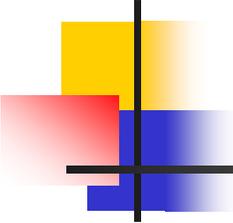
UFG

- Pressure and temperature errors in gas measurement are second only to leaks as a contributing factor to unaccounted-for gas. By calculating unaccounted-for gas as a percentage of the total gas purchased, it can be determined whether the loss is due to leaks or gas measurement.



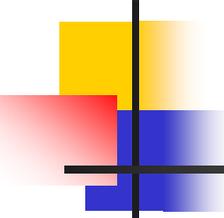
UFG

- If all the loss is due to leaks, there will be a higher percentage of unaccounted-for gas during the summer months. The percentage due to leaks may be slightly higher in the winter if the gas system pressure is raised, but it will not normally be very noticeable. Gas loss due to pressure differences will, if the pressure at the meter is the same in the summer and winter, show the same percentage of unaccounted-for gas throughout the entire year.



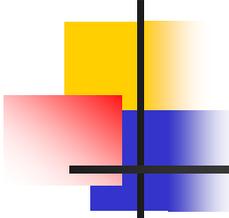
UFG

- Loss due to temperature will show a higher percentage during the cold months, and, after leaks, can be the most costly. In summary, if the percent of unaccounted-for gas is up during the summer months, look for leaks. If it increases during the winter months, look for measurement errors probably caused by temperatures.



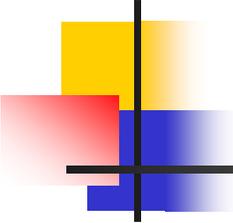
UFG

- There are many other causes for unaccounted-for gas, one being inaccurate gas meters. To determine the overall accuracy of the meters, take a random sample of meters of all ages and test them. By averaging the accuracy of the sample meters, the overall accuracy of the meters in the entire distribution system can be estimated. Taking the average of the meters brought in during a regular change-out will only indicate the accuracy of the meters that have been installed for a long period. If the overall accuracy is poor, it may indicate that the change-out period should be shortened to improve accuracy.



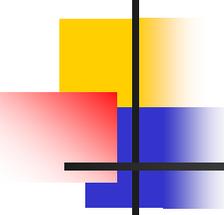
UFG

- Gas theft, bad meters, or dead meters will normally show up in the monthly billing, so always be on the lookout for unexplained reductions in gas usage for a particular customer. Remember that fill comparisons, supplemented by an alert meter reader, are the best way to detect gas thefts. The hardest theft to detect is when only a small amount of gas is stolen each month. This can be accomplished by reversing the meter in the line for a few days a month or with a meter bypass. Gas theft, accomplished via bypass or by other methods, will cause hazardous conditions that warrant a safety investigation. The thief in some cases is nearly impossible to catch unless elaborate means are taken to seal the meter, the meter nuts, stopcocks, regulators, and other related equipment. The old adage, "if there is a will, there is a way," applies to the gas thief.



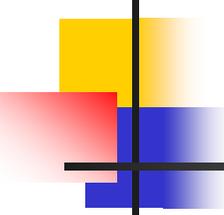
UFG New Technologies

- The new measurement technology that Enron is using is the Hi-Flow Sampler™, which was developed by the Gas Research Institute (GRI). This measurement technology is unique because it measures actual emission rates from sources that traditionally were not easily measured. As a result, Enron personnel can make informed decisions on the reductions that are cost-effective to perform, and then focus their time and efforts on reducing emission sources with the greatest payback.



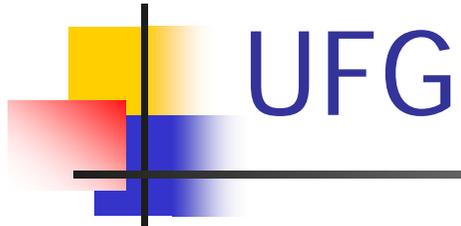
UFG Management Practices

- Columbia Gas reports that it has completed its efforts to ensure that appropriate reporting procedures are followed
- Columbia will begin to report gas used in the conduct of operational and maintenance activities.
- Columbia Gas states that it also changed its software program to further its efforts in this area.

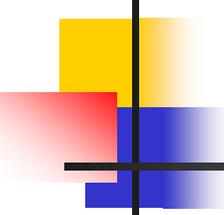


UFG Management Practices

- Columbia Gas states that it is currently monitoring its program of installing thermal conversion measurement devices at storage fields. Columbia Gas asserts that it is collecting data in order to determine whether any adjustments to storage Btu assumptions are necessary, which could in turn, impact UFG



- The meter is the cash register for the distribution system



References

- U.S. Department of Transportation, Office of Pipeline Safety
- “Finding Unaccounted for Gas”, E.L. Upp