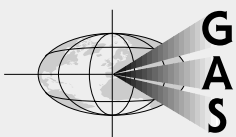


Sulfur Measurement Handbook



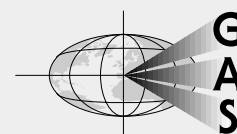
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Glossary of Terms

Coking	Formation of carbon in the tubing or glass tube of a total sulfur hydrogenation furnace. It is the result of the incomplete reaction of a hydrocarbon with hydrogen.
CSA	Canadian Standards Association.
FM	Factory Mutual.
FID	Flame Ionization Detector
FPD	Flame Photometric Detector
Hydrogenation	Reaction where hydrogen displaces another molecule in a compound.
NEMA	National Electric Manufacturers Association.
NEMA 12	Enclosures intended for indoors to provide a degree of protection from dust, falling dirt and non-corrosive dripping liquids.
NEMA 4	Enclosures intended for indoors or outdoors to provide a degree of protection from wind blown dust and rain, and hose directed water.
NEMA 4X	Enclosures intended for indoors or outdoors to provide a degree of protection from corrosion, wind blown dust and rain, and hose directed water.
NEMA 7	Enclosures designed for explosion proof areas.
Odorant	Normally a mixture of methylethyl sulfide (MES) and tertiary butyl mercaptan (t-BuSH) added to natural gas to warn users of its presence.
PFPD	Pulsed Flame Photometric Detector
Permeable Membranes	When used in the context of sulfur measurement, these devices will pass a constant rate of a pure sulfur compound based on concentration on either side of a membrane. These devices are useful as dilutors for measuring high concentrations of H ₂ S.
Rateometric	Term used to describe using the rate of a chemical reaction to calculate the concentration of one of the reactants.
TRS	Total Reduced Sulfur. Common term used in the pulp and paper industry for the sulfur emitted from a Kraft process. TRS is the sum of H ₂ S, methyl mercaptan, ethyl mercaptan and dimethyl disulfide.
Total Sulfur	The sum of all sulfur compounds in a stream expressed normally in ppm of elemental sulfur by weight.
UL	Underwriters Laboratories Inc.



The Hazards of H₂S

1ppm = .0001% (1/10,000 of 1%)	Detectable by odor.
10ppm = .001%	Allowable for 8 hours' exposure. (OSHA)
OVER 20ppm PROTECTIVE EQUIPMENT WILL BE NECESSARY.	
100ppm = .01%	Kills smell in 3 to 15 minutes. May burn eyes and throat.
200ppm = .02%	Kills smell rapidly. Burns eyes and throat.
500ppm = .05%	Loses sense of reasoning and balance. Respiratory disturbances in 2 to 15 minutes. Needs prompt artificial resuscitation.
700ppm = .07%	Will become unconscious quickly. Breathing will stop and death results if not rescued promptly. Immediate artificial resuscitation.
1000ppm = .10%	Unconscious at once. PERMANENT BRAIN DAMAGE MAY RESULT UNLESS RESCUED PROMPTLY.

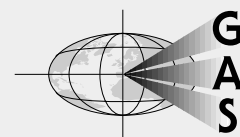
H₂S is colorless, smells like rotten eggs. The sense of smell must not be depended upon as a detection method. A continuous diffusion type (H₂S detection system) should be used to protect personnel against loss of life.

Common Sulfur Compounds

Name	Chemical Formula	Abbreviation	Molecular Weight	Boiling Point (°C)
Sulfides				
Hydrogen Sulfide	H ₂ S	H ₂ S	32.08	-60.7
Carbonyl Sulfide	COS	COS	60.07	-50.2
Dimethyl Sulfide	CH ₃ SCH ₃	DMS	62.13	37.3
Methylethyl Sulfide	CH ₃ SCH ₂ CH ₃	MES	76.16	66.65
Diethyl Sulfide	CH ₃ CH ₂ SCH ₂ CH ₃	DES	90.19	92.1
Diallyl Sulfide	CH ₂ CHCH ₂ SCH ₂ CHCH ₂	DAS	114.21	139
Dipropyl Sulfide	CH ₃ (CH ₂) ₂ S(CH ₂) ₂ CH ₃	DPS	118.24	142.38
Dibutyl Sulfide	CH ₃ (CH ₂) ₃ S(CH ₂) ₃ CH ₃	DBS	146.3	185
Mercaptans				
Methyl Mercaptan	CH ₃ SH	MeSH	48.11	6.2
Ethyl Mercaptan	CH ₃ CH ₂ SH	EtSH	62.13	35
Propyl Mercaptan	CH ₃ CH ₂ CH ₂ SH	PrSH	76.17	67
iso - Propyl Mercaptan	(CH ₃) ₂ CHSH	i-PrSH	76.17	52.56
Normal - Butyl Mercaptan	CH ₃ (CH ₂) ₃ SH	n-BuSH or BuSH	90.19	98.46
Secondary - Butyl Mercaptan	CH ₃ CH(SH)CH ₂ CH ₃	s-BuSH	90.19	85
iso - Butyl Mercaptan	(CH ₃) ₂ CHCH ₂ SH	i-BuSH	90.19	88.72
Tertiary - Butyl Mercaptan	(CH ₃) ₃ CSH	t-BuSH	90.19	64.22
Disulfides				
Carbon Disulfide	CS ₂	CS ₂	76.13	46.3
Dimethyl Disulfide	CH ₃ S ₂ CH ₃	DMDS	94.2	109.7
Methylethyl Disulfide	CH ₃ S ₂ CH ₂ CH ₃	MEDS	108.23	N/A
Diethyl Disulfide	CH ₃ CH ₂ S ₂ CH ₂ CH ₃	DEDS	122.25	154
Dipropyl Disulfide	CH ₃ (CH ₂) ₂ S ₂ (CH ₂) ₂ CH ₃	DPDS	150.31	193.5
Tetrahydro Thiophene	CH ₂ CH ₂ CH ₂ CH ₂ S	THT	88	115-124

Common Hydrocarbon Compounds

Name	Chemical Formula	Abbreviation	Molecular Weight	Boiling Point (°C)
Methane	CH ₄	C ₁	16	-164
Ethane	CH ₃ CH ₃	C ₂	30.1	-88.6
Propane	CH ₃ CH ₂ CH ₃	C ₃	44.1	-42.07
normal - Butane	CH ₃ (CH ₂) ₂ CH ₃	n-C ₄	58.1	-0.5
iso - Butane	(CH ₃) ₂ CHCH ₃	i-C ₄	58.1	-0.5
normal - Pentane	CH ₃ (CH ₂) ₃ CH ₃	n-C ₅	72.1	36.07
iso - Pentane	(CH ₃) ₂ CHCH ₂ CH ₃	i-C ₅	72.1	27.85
neo - Pentane	C(CH ₃) ₄	neo-C ₅	72.1	9.5
normal - Hexane	CH ₃ (CH ₂) ₄ CH ₃	n-C ₆	86.2	68.95
normal - Heptane	CH ₃ (CH ₂) ₅ CH ₃	n-C ₇	100.2	98.42
normal - Octane	CH ₃ (CH ₂) ₆ CH ₃	n-C ₈	114.2	125.66
Ethylene	CH ₂ =CH ₂	28.1	-103.71	
Propene	CH ₂ =CHCH ₃		42.1	-47.4
Butene	CH ₂ =CHCH ₂ CH ₃		56.1	-6.3
Benzene	C ₆ H ₆		78.1	80.1
Toluene	C ₆ H ₅ CH ₃		92.1	110.6
Methanol (Methyl Alcohol)	CH ₃ OH	MeOH	33	64.96
Ethanol (Ethyl Alcohol)	CH ₃ CH ₂ OH	EtOH	46.1	78.5
Carbon Monoxide	CO	CO	28	-191.5
Carbon Dioxide	CO ₂	CO ₂	44	-78.5
Air			29	-194.22
Hydrogen	H ₂	H ₂	2.02	-252.87
Oxygen	O ₂	O ₂	32	-182.96



Sulfur Concentration Conversion Factors

Galvanic

1 Grain	= 0.0648 grams	
1cu ft.	= 28.316 liters	= 0.28316m ³
Molecular wt. H ₂ S	= 34.08	
Molecular wt. S	= 32.064	
1 gram mole gas	= 22.414 litres	@0°C & 14.75 PSI @-STP
1 gram mole gas	= 23.718 litres	@60° & 14.73 ST(commonSTP)
1 grain H ₂ S/100 SCF	= 22.88 mg/m ³	
1 grain H ₂ S/100 SCF	= 15.05 ppmv H ₂ S	@0°C & 14.75 PSI @ STP
1 grain H ₂ S/100 SCF	= 15.26 ppmv H ₂ S	@ 60°F & 14.73 PSI @STP
1 grain Sulf/100 SCF	= 15.99 ppmv/Sulfur	@ 0°C & 14.75 PSI @STP
1 grain Sulf/100 SCF	= 16.92 ppmv/ Sulfur	@ 60°F & 14.73 PSI @ STP
1 grain H ₂ S/100 SCF(Methane)	= 32 ppm wt./wt.	@ 0°C & 14.75 PSI @STP
1 grain H ₂ S/100 SCF(Methane)	= 33.9 ppm wt./wt.	@ 60°F & 14.73 PSI @ STP

Dow Gas Conditioning Fact Book

Multiply U.S.	By	To Obtain
Grains per Gallon	17.1	Parts per Million by weight
Grains H ₂ S per 100 SCF	0.001588	Mole percent H ₂ S
Grains H ₂ S per 100 SCF	1588 X 10 ⁻⁸	Mole Fraction
Grains H ₂ S per 100 SCF	15	ppm (w/v)
Mole Percent H ₂ S	615	Grains H ₂ S per 100 SCF

Conversion Factors Commonly used by pipeline transmission companies for H₂S in Natural Gas

ppm to mg/m ³	multiply by 1.4331
mg/m ³ to grains/100SCF	multiply by 0.0437
ppm to grains/100 SCF	multiply by 0.0626285
grains/100 SCF to mg/m ³	multiply by 22.88277
mg/m ³ to ppm	multiply by 0.69778
grains/100SCF to ppm	multiply by 15.967

Specification for Sulfur Levels

Tariff Limits - H₂S

TCPL	23mg/m ³ OR 1 grain/100 SCF/100 SCF OR 16 ppm
NOVA	23mg/m ³ OR 1 grain/100 SCF/100 SCF OR 16 ppm
TRANS GAS	6mg/m ³ OR .26grain/100 SCF OR 4.2 ppm

Tariff Limits - Total Sulfur

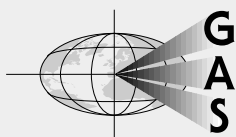
TCPL	460 mg/m ³ OR 20.1 grains or 321 ppm
NOVA	115 mg/m ³ OR 5.03 grains OR 80 ppm
TRANS GAS	23mg/m ³ OR 1.00 grains OR 16 ppm

Total Sulfur Limits by Environment Canada

Gasoline	360 ppm,	Recommended interim measure as of January 1, 1997
	30 ppm by 2005	Canadian Environmental Protection Act, Registration SOR/97-110
Diesel	0.05 wt%	

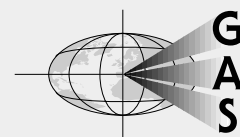
Total Sulfur Limits by United States Environmental Protection Agency Code of Federal Regulations, Title 40, Part 79, Section 79.55

Methane Base Fuel Specification	16 ppmv
Propane Base Fuel Specification	123 ppmw
Methanol Base Fuel Properties	40 ppmw
Ethanol Base Fuel Properties	40 ppmw
Gasoline Base Fuel Properties	339 ppmw
Diesel Base Fuel Properties	0.05 wt%



Sulfur Measurement ASTM Methods

ASTM #	Title	Application
D 4045-99	Sulfur in petroleum products by hydrogenolysis and rateometric colorimetry.	Injection by syringe 20 ppb to 10 ppm by weight of sulfur in liquids into a lead acetate paper tape H ₂ S analyzer equipped with a hydrogen reaction furnace.
D 2420-96	Hydrogen sulfide in liquefied petroleum (LP) gases (lead acetate method).	Manual pass/fail test for ppm of sulfur using lead acetate paper tape.
D 4323-97	Hydrogen sulfide in the atmosphere by rate of change of reflectance.	Covers 1 to 3000 ppb by volume of H ₂ S in air using a lead acetate H ₂ S analyzer.
D 4468-95	Total sulfur in gaseous fuels by hydrogenolysis and rateometric colorimetry.	Covers 1 ppb to 20 ppm by volume of sulfur in gaseous fuels using a lead acetate H ₂ S analyzer equipped with hydrogen reaction furnace.
D 4810-94	Hydrogen sulfide in natural gas using length-of-stain detector tubes.	Covers .5 ppm to 40 % H ₂ S in natural gas using lead acetate in glass tubes. (commonly referred to the Drager test)
D 4084-94	Analysis of hydrogen sulfide in gaseous fuels (lead acetate reaction rate method).	Covers 1ppm to 16ppm (up to 100 % using dilution methods) by volume of sulfur in gaseous fuels using a lead acetate H ₂ S analyzer.
D 5504-98	Standard test method for determination of sulfur compounds in natural gas and gaseous fuels by gas chromatography and chemiluminescence.	Covers 0.07 ppm to 690 ppm of individual sulfur compounds in gaseous fuels including natural gas, using sulfur chemiluminescence.
D 5623-99 (1999)	Standard test method for sulfur compounds in light petroleum liquids by gas chromatography and sulfur selective detection.	Covers 0.07 to 690 ppm of individual sulfur compounds in light petroleum gases using sulfur chemiluminescence.

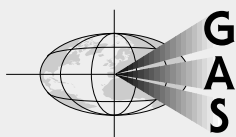


Electrical Area Classifications

North American		Europe	
	FM,UL,CSA		CENELEC
Class I	Flammable gases, vapors and combustible liquids	Class I	Flammable gases, vapors and combustible liquids
Class II	Combustible dusts.	N/A	
Class III	Ignitable fibers or filings	N/A	
Division I	The hazardous combustible could be present under normal and fault conditions	Zone 0 & Zone 1	Zone 0 is when the hazardous combustible is considered to be there all the time and Zone 1 is when the hazardous gas could be there under normal operations or repair or under fault conditions.
Division II	The hazardous combustible will only be present in fault conditions	Zone 2	The hazardous combustible will only be present in fault conditions
Group A	Gases containing acetylene	Group IIC	Gases containing acetylene and hydrogen
Group B	Gases containing hydrogen	Group IIC	Gases containing acetylene and hydrogen
Group C	Ethylene or ethyl ether	Group IIB	Ethylene or ethyl ether
Group D	Natural gas, acetone, ammonia	Group IIA	Natural gas, acetone, ammonia

Sample Lag Time vs. Tubing Size and Flowing Pressure

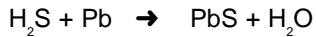
Tube Size	Tube Gage	I.D Inches	I.D. cm.	Flow SCFH	Flow Std. cc/m	Pressure PSIA	Time Lag per 100 ft Minutes	Time Lag per 100 ft Seconds
3/8	20	0.319	0.81026	5	2359	800	36.30	2178
3/8	20	0.319	0.81026	5	2359	200	9.07	544
3/8	20	0.319	0.81026	5	2359	50	2.27	136
1/4	20	0.181	0.45974	5	2359	800	11.69	701
1/4	20	0.181	0.45974	5	2359	200	2.92	175
1/4	20	0.181	0.45974	5	2359	50	0.73	44
1/8	24	0.081	0.20574	5	2359	800	2.34	140
1/8	24	0.081	0.20574	5	2359	200	0.59	35
1/8	24	0.081	0.20574	5	2359	50	0.15	9



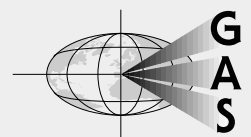
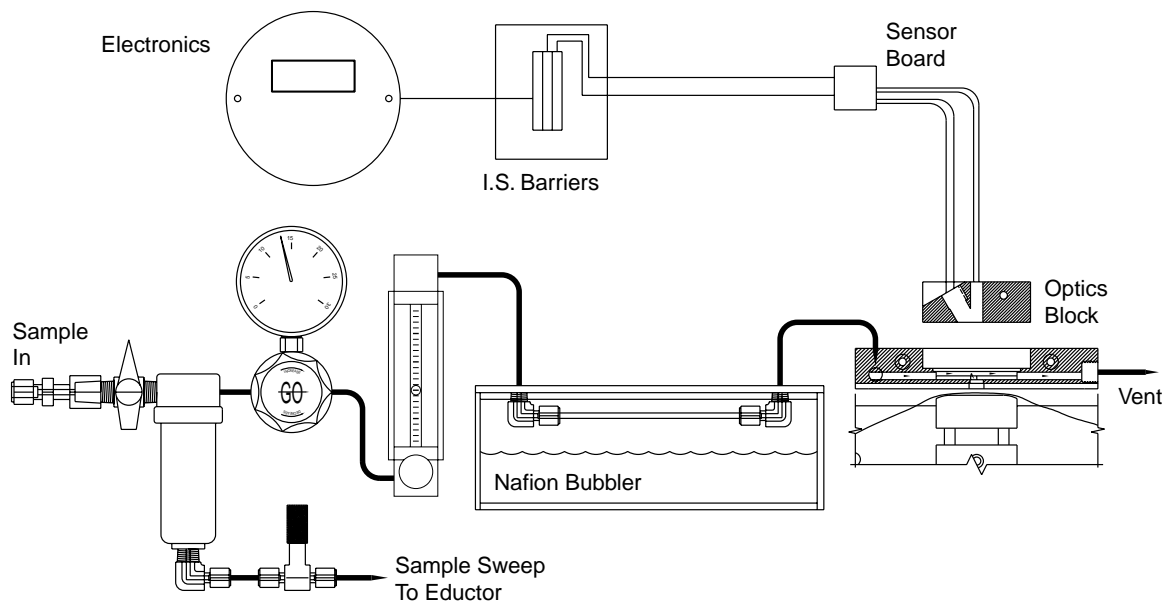
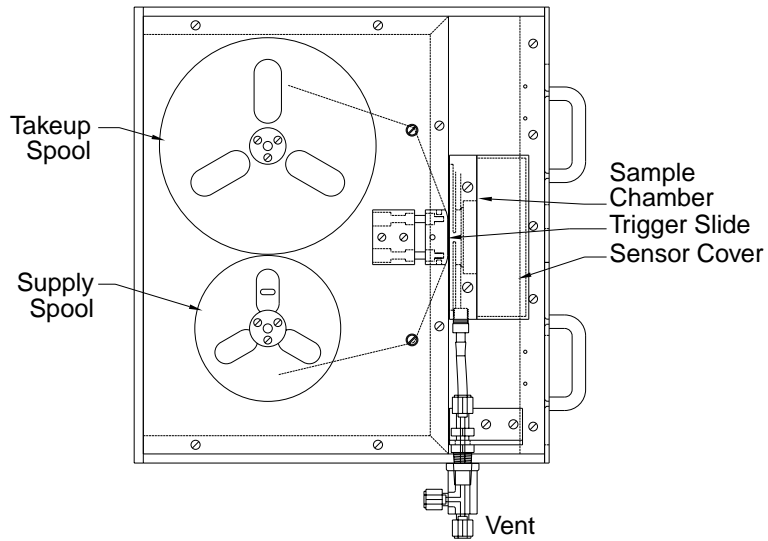
Theory of Lead Acetate Tape

Principle of Operation

The lead acetate tape method for the detection of hydrogen sulfide (H_2S) in gaseous streams is based on the established principle that H_2S reacts with lead acetate to form lead sulfide.



A gaseous sample containing H_2S is bubbled through a solution of 5% per volume of acetic acid in water. This action humidifies the gas to 100% to help facilitate the reaction with lead acetate and to eliminate any variation in the rate of reaction due to changing humidity of the sample gas. The solution is acidic to prevent any H_2S from dissolving in the solution. The humidified gas is then passed by a 1/2 " wide paper tape that has been impregnated with lead acetate. The H_2S in the sample gas reacts with the lead acetate to form lead sulfide which is left on the tape as a brown stain. The darkness of the stain is proportional to the amount of H_2S present in the sample. The diagrams show the basic design for a lead acetate tape analyzer.

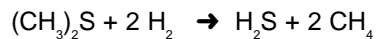


Total Sulfur Measurement

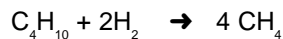
The lead acetate tape method can be employed to measure total sulfur in addition to H₂S. In this method, a sample stream is mixed with hydrogen and passed through a pyrolyzer furnace at 900°C. All sulfur bearing compounds will be converted to H₂S while any hydrocarbons heavier than methane will be cracked to methane. This type of reaction is called hydrogenation. The H₂S formed in the hydrogenation reaction can then be measured with the lead acetate tape method to obtain a total sulfur concentration.

For hydrocarbon streams heavier than methane a large excess of hydrogen must be used to ensure that the hydrocarbons are cracked completely and that all sulfur bearing compounds are reduced to H₂S. Below are some examples of hydrogenation reactions.

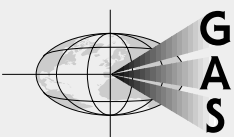
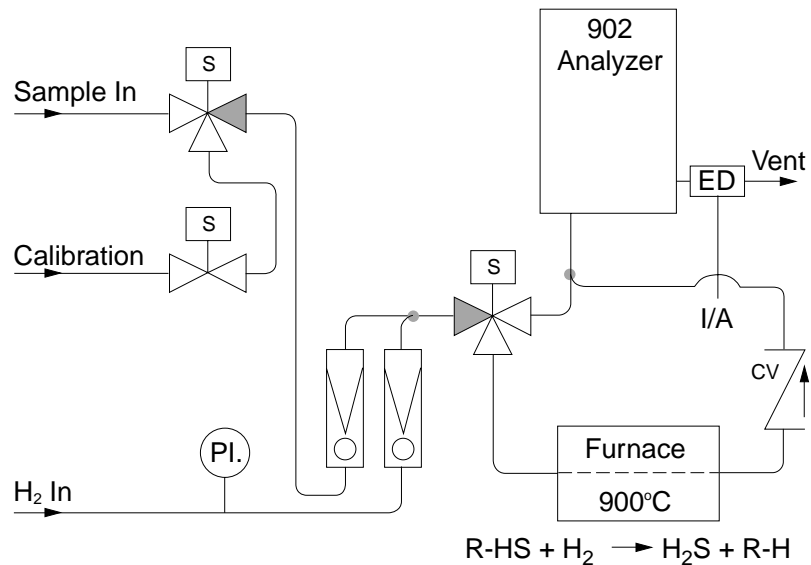
Conversion to H₂S



Hydrocarbon cracking

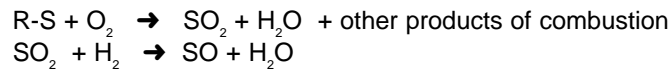


The diagram below shows a typical flow diagram for a total sulfur lead acetate tape analyzer.

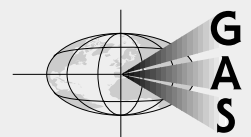
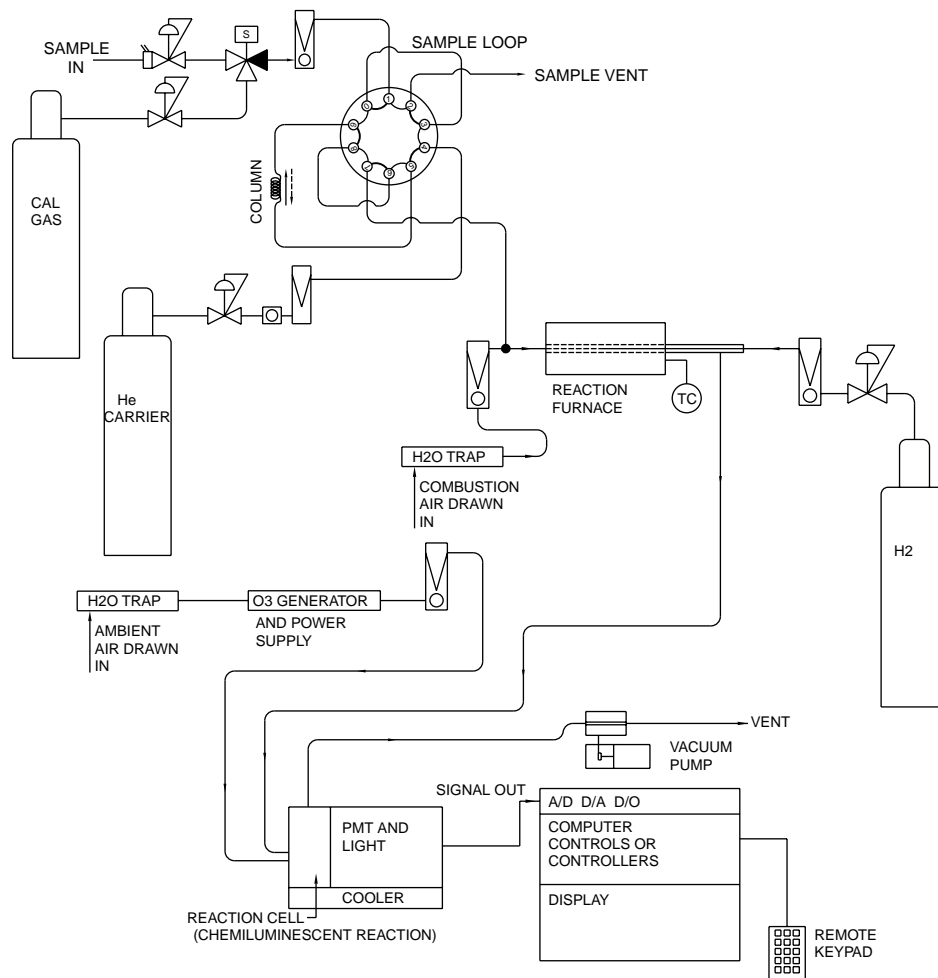
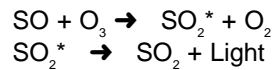


Theory of Sulfur Chemiluminescence

Sulfur chemiluminescence is a series of chemical reactions, which ultimately produce a photon of light. The chemiluminescence detection system is comprised of two parts: the reaction furnace and the chemiluminescence chamber. The reaction furnace consists of two externally heated ceramic tubes. Air and sample are passed through a larger tube while hydrogen flows countercurrent to the air and sample mixture down a smaller tube. Air, sample and hydrogen meet in the middle of the larger tube and the products of the reaction are drawn off through the annulus of the two tubes under vacuum. This configuration allows for the combustion conditions of a hydrogen flame without having an actual flame present. One of the products formed in the reaction chamber is sulfur monoxide (SO), which is the key intermediate in the chemiluminescence process.



The sulfur monoxide produced in the reaction furnace is then transferred under vacuum to the chemiluminescence chamber where it is combined with ozone to produce an electronically excited state of sulfur dioxide which releases light upon relaxation.



The light released is detected by a photomultiplier tube and is directly proportional to the amount of sulfur present.

The nature of this measurement makes the detector specific only to sulfur compounds and free from interference from the hydrocarbon component of the sample. The reduction of the sulfur compounds to a common species produces a true equimolar response allowing for a single component calibration to be used. Sensitivity into the parts per billion range is easily attained and the detector has a linear range of five orders of magnitude.

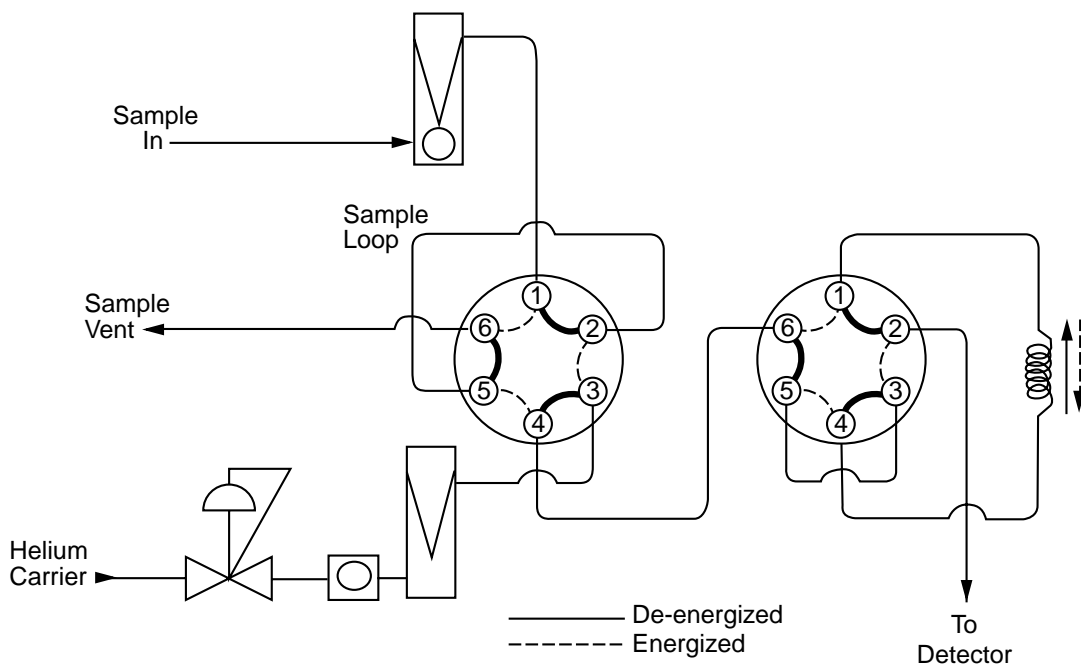
Installation of the appropriate chromatograph valve(s) and column(s) makes the measurement of individual sulfur compounds possible. The concentrations of the individual sulfur compounds can be added up to arrive at a total sulfur concentration. A more simple application is to inject a sample directly to the detector with no upstream chromatography to obtain a single total sulfur peak.

Sulfur Chromatography

In cases where the concentration of individual sulfur compounds in a sample stream are desired, chromatographic techniques will need to be used. Chromatography is defined as the separation of complex mixtures such that the individual components of that mixture can be identified and quantified. Any chromatograph consists of three major components: a sample injection system, a column and a detector.

The Injection System

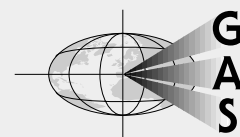
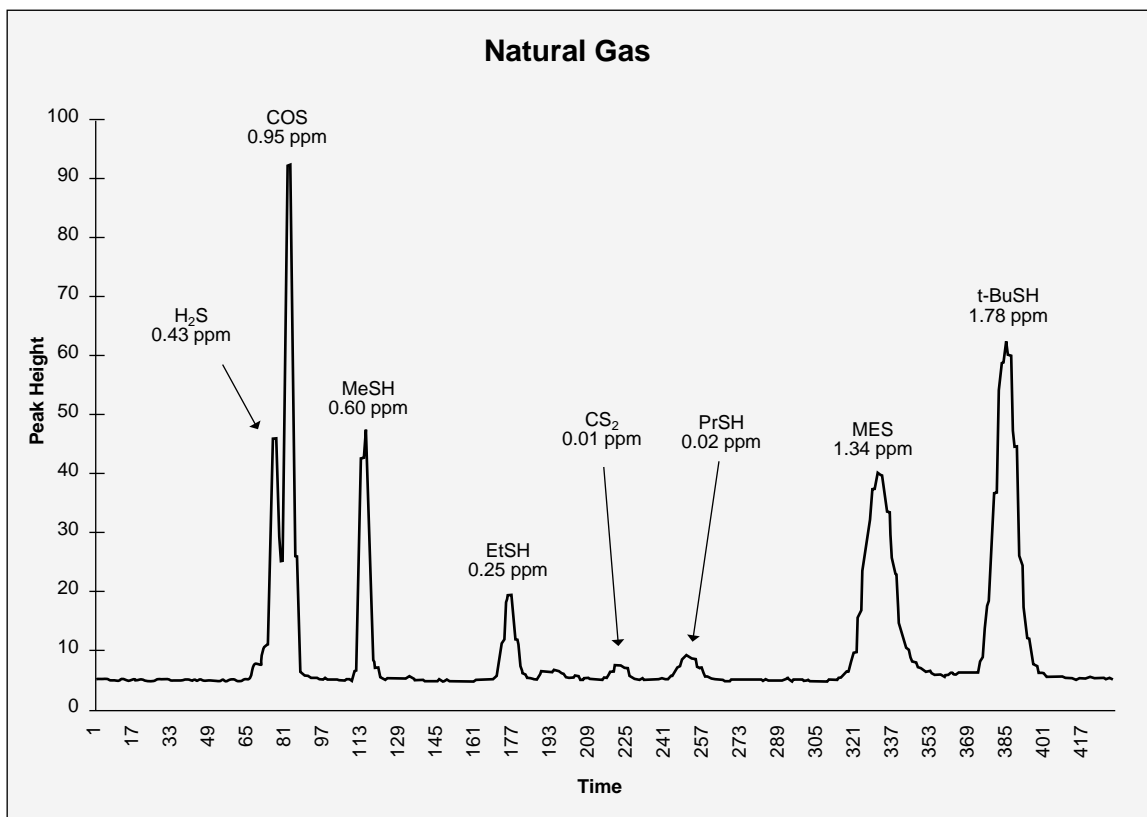
The purpose of the injection system is to deliver a fixed and repeatable volume of sample onto the column for analysis. This is done using a pneumatically actuated chromatograph valve with a fixed volume sample loop. Galvanic uses two basic types of valves. The first is a piston operated diaphragm valve for all complex valving functions and sample injection of gas phase samples up to C4. The second type is a grooved stem liquid injection valve designed to inject a small volume of liquid and immediately vaporize it. This type of valve is used in the analysis of heavier refined liquids. Galvanic does not use rotary or slider valves due to the maintenance requirements for these valves. The diagram below shows a typical injection system consisting of two 6-port valves. One valve is used to inject the sample while the other is used to backflush the column.



Columns

Galvanic uses two column technologies. Metal coated capillary columns allow for the advantages in resolution from capillary columns coupled with field durability and the ability to backflush. The use of capillary columns eliminates the need for complex valving techniques when performing complex separations. The second type of column is a 1/8 " packed column. These columns are useful for light sulfur compound separations. Complex separations with packed columns generally require complex valving techniques. The selection of either column configuration is entirely application dependent with reliability, stability and peak resolution being the primary objectives.

The diagram below shows a typical chromatogram of sulfur compounds in natural gas using a metal coated capillary column.



Lead Acetate Tape or Chemiluminescence?

In general, lead acetate tape is the method of choice for H_2S because it is so H_2S specific, simple to operate and cost effective. For total sulfur measurement in lighter hydrocarbon streams (lighter than C_4) and ranges greater than 0 - 10 ppm, lead acetate tape with a hydrogenating furnace is usually recommended because of cost and simplicity of operation.

In cases where there are liquids present or hydrocarbons heavier than C_4 , the sulfur chemiluminescence approach is strongly recommended. For gas streams chemiluminescence is recommended for total sulfur measurement for ranges less than 0 - 10 ppm, with 0 - 1 ppm being the lowest available range.

For applications where all or any portion of the sulfur compounds must be specified, chemiluminescence in combination with the appropriate chromatography is the only choice.

Calibration of Sulfur Analyzers

It is important to use reliable calibration standards to ensure the best accuracy of any sulfur or H_2S analyzer. The simplest and most reliable standards are bottled gases. Choosing a reliable sulfur standard can be problematic due to the reactive nature of sulfur compounds. Below are some points to bear in mind when choosing a bottled calibration gas.

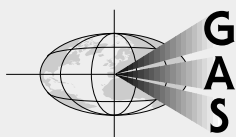
- H_2S in a background of nitrogen is the most stable standard. Most calibration gas manufacturers will guarantee an H_2S in nitrogen standard for six months at concentrations below 10 ppm and for one year at concentrations above 10 ppm.
- Using hydrocarbon backgrounds such as methane or propane is not recommended. This is because these gases are more likely to contain water or other impurities which could react with H_2S or other sulfur compounds which would change the concentration of the calibration standard.
- Mixing more than one sulfur compound in a single gas mixture is not recommended. Sulfur compounds will tend to react with each other, the walls of the container and impurities in the background gas to form other sulfur species. The proportions of several sulfur compounds in a single mixture will not be stable.

Lead Acetate Tape Analyzers

Lead acetate tape analyzers should be calibrated at 80 % of full scale. For example, a 20 ppm full scale analyzer should be calibrated with a 16 ppm H_2S in nitrogen standard.

Sulfur Chemiluminescence Analyzers

The inherent large linear range and equimolar response of sulfur chemiluminescence allows for a single component, single point calibration. It is not necessary to have all sulfur compounds present in the standard when doing individual sulfur component analysis.



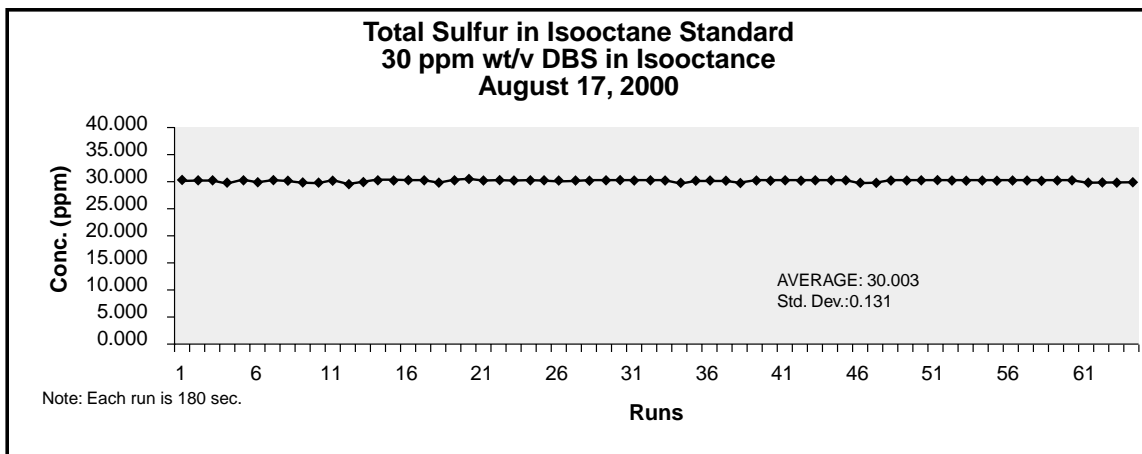
841 Application Notes

Application #1: 0 - 40 ppm wt_{sulfur}/volume Total Sulfur in 30 ppm Isooctane Standard

Valve Temperature: 200°C.

Injection Volume: 1 uL

Standard Deviation: +/- 0.131 ppm

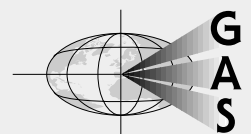
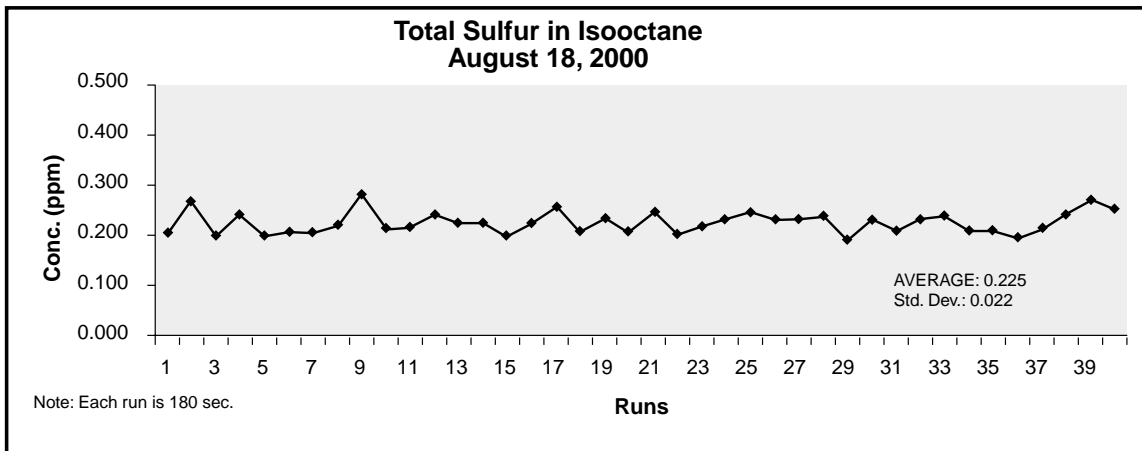


Application #2: 0 - 0.5 ppm wt_{sulfur}/volume Total Sulfur in Isooctane

Valve Temperature: 200°C

Injection Volume: 1 uL

Standard Deviation: +/- 0.022 ppm

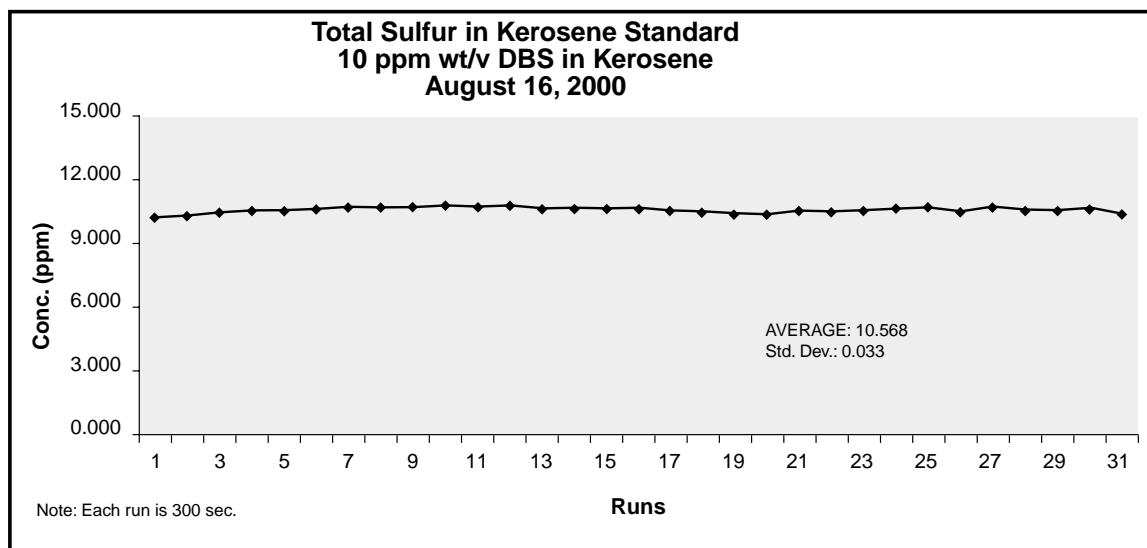


Application #3: 0 - 15 ppm wt_{sulfur}/volume Total Sulfur in 10 ppm Kerosene Standard

Valve Temperature: 200°C

Injection volume: 1 uL

Standard deviation: +/- 0.133 ppm

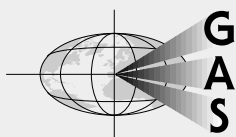
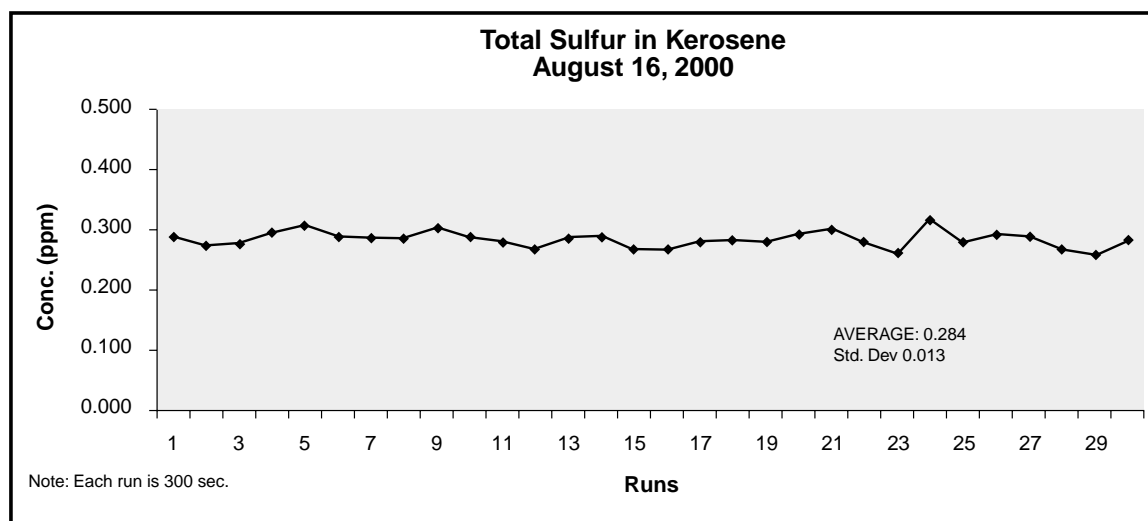


Application #4: 0 - 0.5 ppm wt_{sulfur}/volume Total Sulfur in Kerosene

Valve Temperature: 200°C

Injection Volume: 1 uL

Standard Deviation: +/- 0.013 ppm

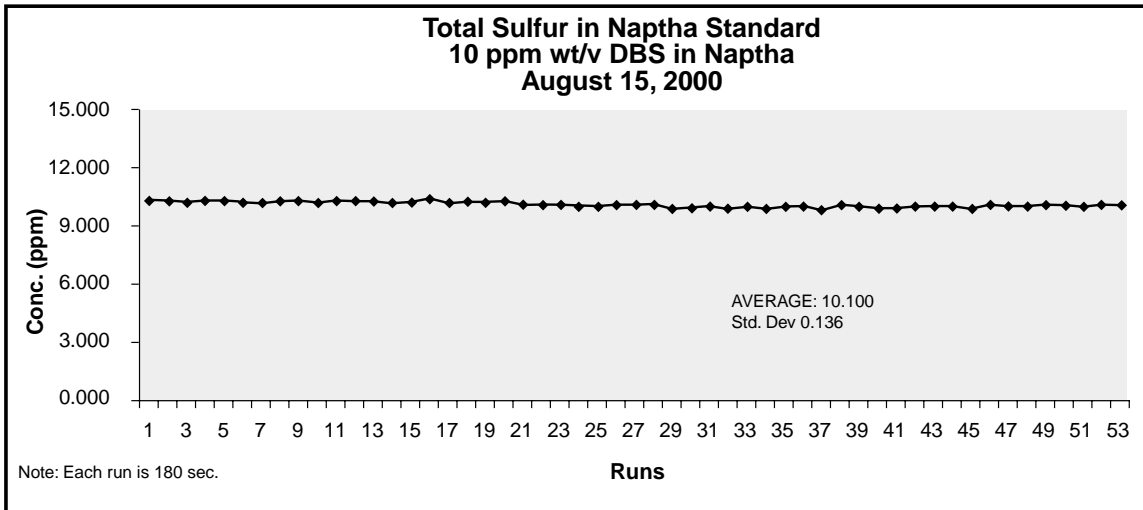


Application #5: 0 - 15 ppm wt_{sulfur}/volume Total Sulfur in 10 ppm Naptha Standard

Valve Temperature: 200°C

Injection Volume: 1 uL

Standard Deviation: +/- 0.136 ppm

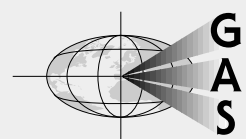
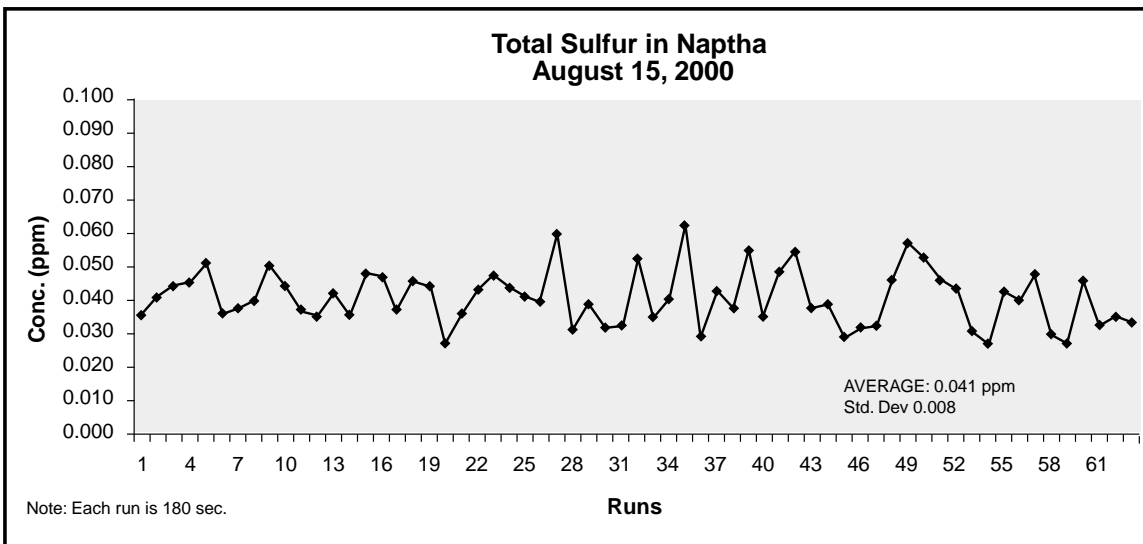


Application #6: 0 - 0.1 ppm wt_{sulfur}/volume Total Sulfur in Naptha

Valve Temperature: 200°C

Injection Volume: 1 uL

Standard Deviation: +/- 0.008 ppm

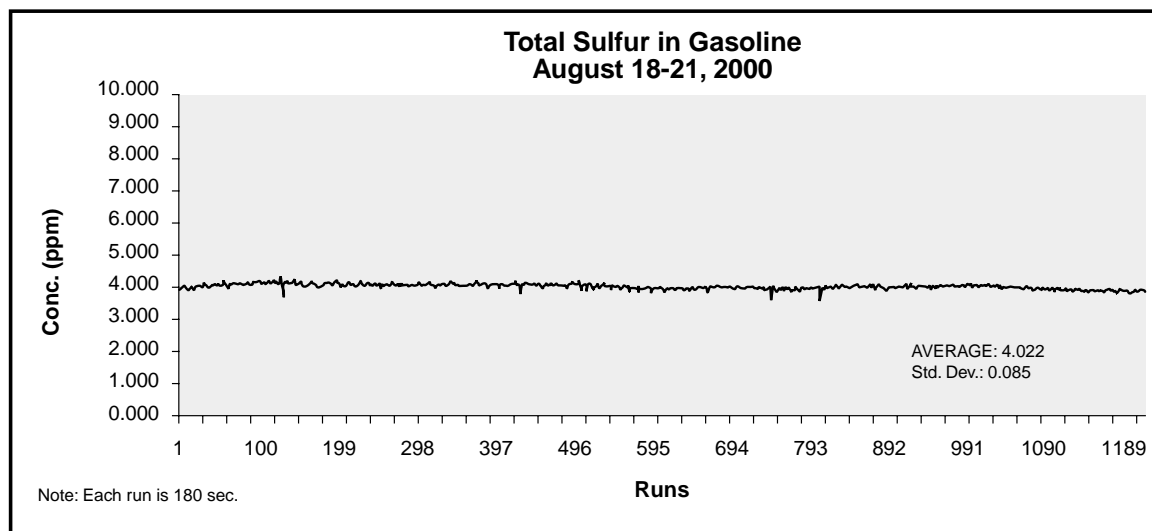


Application #7: 0 - 10 ppm wt_{sulfur}/volume Total Sulfur in Gasoline

Valve Temperature: 200°C

Injection Volume: 1 uL

Standard Deviation: +/- 0.085 ppm

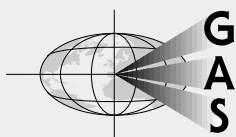
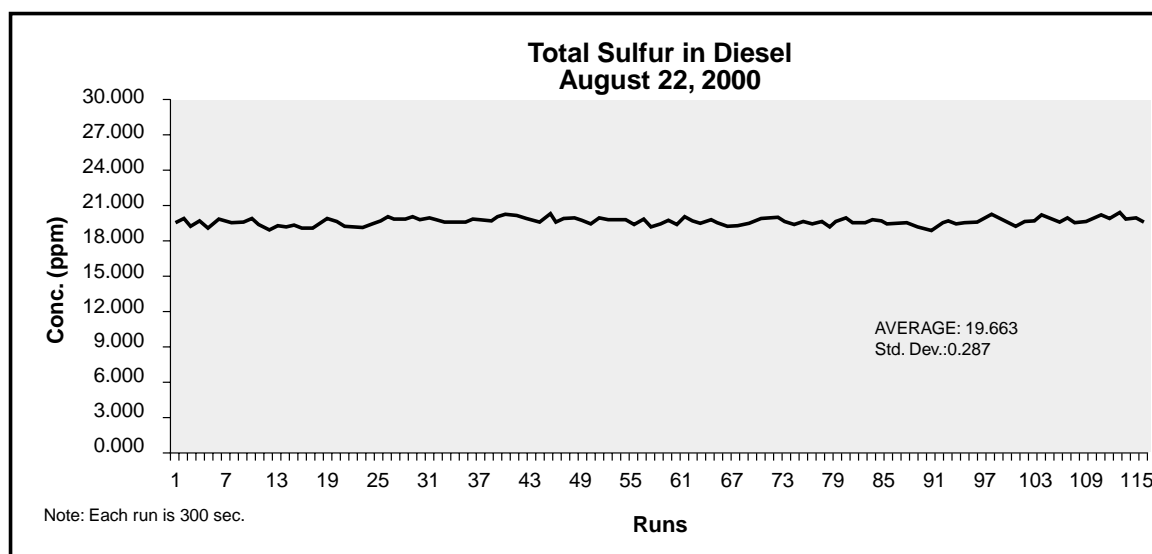


Application #8: 0 - 30 ppm wtsulfur/volume Total Sulfur in Diesel

Valve Temperature: 250°C

Injection Volume: 1 uL

Standard Deviation: +/-0.287 ppm



Electrical Enclosure Purging

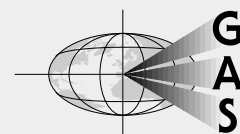
TERMS

- Alarm A piece of equipment that generates a visual or audible signal that attracts attention.
- Maximum operating pressure The maximum internal pressure permitted for an enclosure.
- Pressurization The process of supplying a protective gas at a sufficient flow rate to maintain a positive pressure within an enclosure, and preventing the entrance of atmospheric gas or vapour in to the enclosure.
- Protective gas The gas used to maintain pressurization or to dilute a flammable gas or vapour. The protective gas may be air, inert gas (e.g.: nitrogen), or other non-flammable gases.
- Purging The process of supplying a protective gas at sufficient flow rate to displace all atmospheric gas or vapor initially present within the enclosure.
- Type X purging and pressurizing A process that reduces the classification within the pressurized enclosure for Division 1 to ordinary non-hazardous location
- Type Y purging and pressurizing A process that reduces the classification within the pressurized enclosure from Division 1 to Division 2 hazardous location
- Type Z purging and pressurizing A process that reduces the classification within the pressurized enclosure form Division 2 to ordinary non-hazardous

PURGING TIMES

For the initial purge, the manufacturer shall provide test data or calculations to verify conditions, flow rate, pressure and time required to provide the following number of protective-gas changes:

- (a) Four (4) enclosure volumes; or
- (b) Ten (10) enclosure volumes for motors and generators.



Type Z Purged and Pressurized Equipment

A visual or audible alarm shall be provided to alert failure of the purging and pressurizing system. The alarm may be mechanical, pneumatic or electrical. If an electrical alarm is provided, it shall be suitable for Class I, Division 2, (applicable groups), Hazardous locations; unless it is located outside the hazardous area.

Type Y Purged and Pressurized Equipment

A visual or audible alarm shall be provided to alert failure of the purging and pressurizing system. The alarm may be mechanical, pneumatic or electrical. If an electrical alarm is provided, it shall be suitable for Class I, Division 1, (applicable groups), Hazardous locations; unless it is located outside the hazardous area. Equipment, devices, and components, within the pressurized enclosure shall comply with the requirements for Class I, Division 2 Hazardous locations, and for the same "Groups" as the external Division 1 hazardous location.

Type X Purged and Pressurized Equipment

A timing device shall be provided to prevent the electrical equipment, which are within the pressurized enclosure from becoming energized until:

- (a) The required volume of protective gas has passed through the enclosure; and
- (b) An internal pressure of at least 2.5 mm (0.1 inch) of water column is being maintained.

The timing device shall be suitable for the location in which it is installed.

A device shall be incorporated, so that upon failure of the purging and pressurizing system, it will automatically remove electrical power from all devices and components that are within the pressurized enclosure and are not suitable for Class I, Division 1 hazardous locations.

If the pressurized enclosure can be opened without the use of a key or tool, an interlock shall be provided, so that when the enclosure is opened, it will immediately de-energize all electrical devices and components that are within the pressurized enclosure and are not suitable for Class I, Division 1 hazardous locations.

The interlock, even though located within the pressurized enclosure, shall be suitable for Class I, Division 1, application Groups, hazardous locations.

Markings

The time required to provide the number of volume changes of the protective gas at a designed flow rate (or pressure), shall be permanently marked on the equipment as follows:

WARNING; ENCLOSURE SHALL NOT BE OPENED UNLESS THE AREA IS KNOWN TO BE NON-HAZARDOUS, OR UNLESS ALL DEVICES WITHIN THE ENCLOSURE HAVE BEEN DE-ENERGIZED. POWER MUST NOT BE RESTORED AFTER ENCLOSURE HAS BEEN OPENED UNTIL ENCLOSURE HAS BEEN PURGED FOR _____ MINUTES AT A FLOW RATE (OR PRESSURE) OF _____ m³/ min (or kPa)

The equipment shall be permanently marked with:

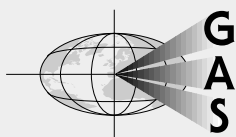
- a) The "Type" of purging and pressurizing; and
- b) Warning: the safety of this equipment relies on the provision of proper purging and pressurizing when used in hazardous locations. It must not be put into use without "special permission" from the inspection authority having jurisdiction.

Where either the internal component temperature or external surface temperature of the equipment exceeds 100°C at an ambient temperature of 40°C, the following cautions or warning shall be permanently marked on the equipment:

- a) Maximum internal component temperature, or corresponding temperature code;
- b) Maximum external surface temperature, or corresponding temperature code; and
- c) Warning: hot internal parts

Installation, operation and maintenance instructions shall be included in the equipment package.

Verification and tests — purging and pressurizing system



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