

**Harmon
Systems
International, LLC**

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We provide solutions that benefit the world

National Organic Standards Board
C/O Robert Pooler, Agricultural Marketing Specialist
USDA/AMS/TM/NOP
Room 2510-So., Ag Stop 0268
P.O. Box 96456
Washington, D.C. 20090-6456

August 1, 2003

Re: Amendment to the Harmon Systems International petition for sulfurous acid for inclusion on the National List

Mr. Pooler:

A few days ago, I sent to you HSI's petition seeking the use of sulfurous acid for inclusion on the National list. This letter is to inform you that on page 4, the following notations were omitted in error and will need to be added. Please make note of it and I am sorry for the inconvenience.

Sincerely,

Terry R. Gong
Manager
Harmon Systems International, LLC

**2201 Coy Avenue
Bakersfield, California 93307**

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The Solution

Solving this problem will involve a two-step process.

First, farmers everywhere must be educated and made aware of how costly and detrimental using poor quality irrigation water has been.

Second, currently, since there isn't a practical and approved way for organic farmers to acidify their irrigation water at this time, we need to identify a method that is compatible.

We believe that the Harmon SO₂/Sulfurous Acid Generator may be that method, and the reason for petitioning for it to be recognized and added to the National List.

By using a unique type of equipment called the Harmon SO₂/Sulfurous Acid Generator, our process is designed to oxidize an existing OMRI approved sulfur (Yellowstone Brand High Purity Prills made by the Montana Sulphur Company), into a form (SO₂) where it can be captured with water, to create an aqueous solution containing sulfurous acid (H₂SO₃), which can then be used to amend and improve irrigation water to a quality (reduced alkalinity) that is similar to normal rain (see pH chart).

It is important to note that sulfuric acid (H₂SO₄) and sulfurous acid (H₂SO₃) are two different acids and are not the same. While both acids have a close resemblance to each other in chemical formation, and are able to acidify and can reduce the amount of bicarbonates/carbonates in water and soil, they are separate because they are produced and formed differently, have different characteristics, and have chemical reactions that are different. Despite the many myths and confusion that may have spawned over the years, Harmon SO₂/Sulfurous Acid Generators do not produce and are incapable of producing sulfuric acid (see formula by Dr. Thomas Ruehr).

Unlike sulfuric acid, which requires a synthetic and unnatural process to produce, sulfurous acid is compatible because it truly is a substance created by nature. For example, when elemental sulfur is used to amend soil, or when it is used as a dusting powder, the reason why it works is because a microbe called Thiobacillus oxidizes it into SO₂ and combines it with moisture from the soil and/or the air to create sulfurous acid. It is the nature of Thiobacillus bacteria to produce both sulfite (SO₃²⁻) and sulfurous acid (H₂SO₃) through the natural oxidation of sulfur, but also when it naturally reduces sulfate (SO₄²⁻) in the absence of oxygen. Therefore, we submit that the Harmon SO₂/Sulfurous Acid generation process merely mimics what nature in fact already does.

Depending on its application, this equipment can be operated using either water pressure or negative air pressure (vacuum), and because the sulfur is 99.9% pure and is the only material used, once it is ignited, its oxidation continues as long as air and the necessary sulfur remains available. The oxidation of sulfur produces SO₂ gas that is confined and drafted by the equipment's unique venturi aspirator, where it can immediately be combined with a portion of the irrigation water to form sulfurous acid contained in an aqueous solution with a pH between 2.0 to 2.5 (an acidity that is very similar to lemonade, safe to handle and gargle with, and never becomes sulfuric). This solution can then be use in a variety of ways (see Uses & Applications).



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We provide solutions that benefit the world

National Organic Standards Board
C/O Robert Pooler, Agricultural Marketing Specialist
Room 2510 – So., Ag Stop 0268
P.O. Box 96456
Washington, D.C. 20090-6456

July 30, 2003

Mr. Robert Pooler:

We hope that this petition will be helpful in providing: a more accurate depiction as to what has been causing most of the problems in agriculture today and how we can solve them; a compelling explanation as to why *sulfurous acid* is a substance that can be produced both naturally and by using the Harmon SO₂ Generator acidification process; and why sulfurous acid is worthy for inclusion on the National List.

We applaud the NOSB's efforts of helping farmers throughout the world to become more sustainable and to adopt the organic approach. We are grateful for your consideration of our petition and look forward to hearing from you.

If you have any further questions or need additional information please do not hesitate to call us.

Sincerely,

Terry R. Gong
Manager
Harmon Systems International, LLC

**2201 Coy Avenue
Bakersfield, California 93307**

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California Certified Organic Farmers

June 24, 2003

National Organic Standards Board
c/o Robert Pooler, Agricultural Marketing Specialist
USDA/AMS/TM/NOP
Room 2510-So., Ag Stop 0268
P. O. Box 96456
Washington D.C. 20090-6456

Regarding: Harmon Systems International petition for evaluation of material for inclusion on the National List.

Mr. Pooler,

CCOF Certification Services LLC is providing this letter to support the petition for evaluation of sulfuric acid as petitioned by Harmon Systems International. Use of this material is germane to operations intending to comply with organic certification standards. CCOF Certification Services requests evaluation of this material by the NOSB so as to determine compliance to the National Organic Standards.

Thank You

A handwritten signature in cursive script, appearing to read 'John McKeon', is written over the 'Thank You' text.

John McKeon
CCOF Certification Services Associate
CCOF Certification Services LLC

cc. Harmon Systems International, Allterra Organics

PETITION BY:

HARMON SYSTEMS INTERNATIONAL, LLC

2201 COY AVENUE
BAKERSFIELD, CA 93307
Phone: (661) 396-3570
E-mail: h2so3generators@aol.com

FOR:

Synthetic substance allowed for the use in
organic crop production

&

Synthetic substance allowed for the use in
organic livestock production

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Introduction

Although *water* may be widely recognized as the foundation for life, it is rather amazing that after all of these years, and the knowledge that we have gained, we can find ourselves still overlooking and taking it for granted. As agriculture's greatest and most important input material, water has the unique ability to influence and alter agronomic conditions for better or worse. We can no longer afford to be primarily focused on its *quantity*, but instead, begin concentrating a lot more of our efforts and attention concerning the *quality* of it. Doing so will enable us to understand why and how our modern day agricultural practices evolved, and to recognize the kinds of changes we need to make in order to improve.

Most farmers are simply unaware and never consider just how important a role water quality has had to their overall operations. Instead of examining the quality of their water source, many of them just assume that it is good and use it because it is also the only water that they have. As a result, without even realizing it, they have trapped themselves into becoming a totally *reactive* farming operation that will commit an enormous amount of time, labor, material, equipment, and financial resources to counter and respond to the conditions their irrigation water has left them with.

Whether they know it or not, whether they like it or not, their water has literally been dictating what they will do, when they will do it, and why they will do it.

Currently, the debate regarding the downward spiral and continual loss of productive farmland has been directed mainly on the addiction and dependency by farmers and their use of toxic synthetic agro-chemical inputs, over tillage, depletion of organic matter, and GMOs, etc. While these things are important, cause great harm and contribute to the overall problem, a better and even more compelling case can be made that these activities are merely symptomatic responses to what is really happening, and that the real problem may actually be from the use of *imperfect water* and the *domino effect* it has created more than anything else.

Before true knowledge can be handed down, it must be understood. The use of imperfect water is revealing because it exposes how little has been learned. Previous generations farmed with nature not necessarily because they believed in or understood it, but because they literally had no other choice. As a result, they were incapable of teaching us the many benefits that farming with nature provides, and why it should be continued.

The challenge for our generation is great. Not only must we return to a more natural way of farming, we must be able to understand it, explain why it is so important, and most of all, demonstrate how to do it. This will allow us to pass it on.

The Problem

Long ago, with human ingenuity, we have been able to: develop canals and dikes; build dams and reservoirs; create intricate water conveyance systems that can push and pull water up through pipes and over great distances; drill and develop deep water wells; harness the power of electricity and fossil fuels to operate powerful pumps and equipment. From these achievements, we have been able to partially wean ourselves from being totally dependent on yearly rainfall to maintain our existence and to irrigate our crops. However, due to dramatic increases in global population, we cannot go back, and farmers throughout the world must now rely and depend on using those alternative water sources (well water in particular) more than ever before. Regardless of where it comes from, when compared to the purity of rainwater, all of these waters will vary in terms of pH, contain various amounts of dissolved minerals, salts, and other contaminants, which make them different and imperfect. Using such waters has caused a slow and almost imperceptible degradation to our farmland, and in a relatively short period of time, significantly altered and influencing the way we do things.

Soil always assumes the same characteristics of the materials applied to it, and since the largest input is water, it should be obvious that our concern be towards finding a way of removing at least some of the unwanted elements found in it, and to make it more like rain.

Although at this time it is still impractical to remove all of the dissolved materials (salinity) contained in these waters, by utilizing a process of acidification, it is possible and cost effective to either eliminate or at least reduce the main culprits, which in our view are the amount of carbonates/bicarbonates (alkalinity).

It is important to do so because upon drying on the soil to which it is applied, these materials react with calcium and form into lime (calcium carbonate), which seal the soil. Irrigation water that contains 1 meq/liter of bicarbonates has the potential to form approximately 200 lbs. of lime whenever one acre-foot of that water is used. Although the actual amounts will be different depending on the volume of water used, type of crop that is being grown, climate and soil conditions, etc., the overall effect remains the same, and that is, a sealing of the soil/air interface, and the start of a *domino effect* that will compound and grow into a much bigger problem.

First, in the process of forming into lime, carbonates/bicarbonates will strip calcium from dominating soil exchange sites, allow sodium to replace it, causing the soil to become more sodic which results in collapsing the soil and a loss of porosity.

Second, with lime now formed throughout the soil, dissolved salts and heavy metals are unable to leach. This causes them to accumulate at the surface and root zone.

Third, with the loss of soil permeability and porosity, water infiltration decreases, uneven penetration occurs, and water is wasted due to remaining on the surface longer and evaporation. When the plants cannot get enough water, farmers try to compensate by using more water. This only makes matters worse by increasing water logging, more water waste, increased pumping costs, and the unnecessary application of additional salts and carbonates/bicarbonates to the soil.

Fourth, with the soil/air interface sealed, significant amounts of vital aerobic microorganisms suffocate and die, creating an imbalance in microbial diversity. This prevents the farmer from receiving the many benefits he would have received from the symbiotic role microbes have in protecting plants from pathogens, decomposing and sequestering organic matter into natural and nutrient rich plant food. With their plants suffering, in an attempt to overcome this problem, the next thing the farmer does is to buy and use more synthetic inputs chemicals such as soil amendments, fertilizers, pesticides, fungicides, etc.

Fifth, with a soil/water solution now above the ideal pH range (6.8) and the soil/air interface sealed, the condition is unsustainable because it wastes inputs. For example, when soil/water has a pH reading of 7.4 or higher, a significant amount of nitrogen ammonia is lost because it volatilizes and won't hold in solution, and from evaporation due to slower water infiltration. This causes the farmer to waste his money, and adds more residual chemicals and pollutants to the soil and air.

Sixth, in preparation for the next crop, farmers then attempt to break the seal and reopen the soil that has now become hardpan by plowing. This disturbance leads to compaction, over tillage, and further destruction of the beneficial activity provided by a natural *soil food web*.

Seventh, with the soil ripped and tilled, it is unable to bond and hold itself together due to losing the biodiversity needed to aggregate and provide soil structure. As a result, it is now in a condition in which rainwater can easily run off, carrying silt, precious topsoil, chemical residues, and other non-point source pollutants, into our creeks and rivers.

Eighth, in the past, when the only water applied to the soil was from rain, we could plow it with animals. Now, we need deep ripping chisel plows pulled by powerful wide tracked tractors because of the lime that has formed and the hardpan that has been created. Needless to say, such equipment is costly, and many farms have "changed hands" by an owner's decision to "bet the entire farm" by financially committing to the purchase of equipment before understanding that they needed to fix their water first.

Ninth, the use of imperfect water and its domino effect has taken an enormous toll and influence on human society. When we start to realize the countless number of farms, both corporate and family, the health and financial well being of people and their families, the prosperity and commerce of small towns and communities, the continued exodus away from the noble production of food and fiber, the acceleration of valuable farm land taken out of production, the lost of wildlife and environmental damage that occurs from water waste and non-point source pollution, etc., can we truly understand how critical that we improve the quality of our irrigation water.

Sadly, this toxic agro-chemical/deep ripping/unsustainable cycle is set to repeat itself again and again, year after year. In less than 100 years, irrigating with imperfect water has created the situation and dilemma most farmers find themselves in – reduced yields, poor quality, increased input and production costs, marginal profits, etc., and a mindset that fails to recognize that they are really no longer *working with nature*, but against it. And, they have been doing it this way for quite a long time. Obviously, continuation of this will lead to catastrophic ruin unless we stop it.

The Solution

Solving this problem will involve a two-step process.

First, farmers everywhere must be educated and made aware of how costly and detrimental using poor quality irrigation water has been.

Second, currently, since there isn't a practical and approved way for organic farmers to acidify their irrigation water at this time, we need to identify a method that is compatible.

We believe that the Harmon SO₂/Sulfurous Acid Generator may be that method, and the reason for petitioning for it to be recognized and added to the National List.

By using a unique type of equipment called the Harmon SO₂/Sulfurous Acid Generator, our process is designed to oxidize an existing OMRI approved sulfur (Yellowstone Brand High Purity Prills made by the Montana Sulphur Company), into a form (SO₂) where it can be captured with water, to create an aqueous solution containing sulfurous acid (H₂SO₃), which can then be used to amend and improve irrigation water to a quality (reduced alkalinity) that is similar to normal rain (see pH chart).

It is important to note that sulfuric acid (H₂SO₄) and sulfurous acid (H₂SO₃) are two different acids and are not the same. While both acids have a close resemblance to each other in chemical formation, and are able to acidify and can reduce the amount of bicarbonates/carbonates in water and soil, they are separate because they are produced and formed differently, have different characteristics, and have chemical reactions that are different. Despite the many myths and confusion that may have spawned over the years, Harmon SO₂/Sulfurous Acid Generators do not produce and are incapable of producing sulfuric acid (see formula by Dr. Thomas Ruehr).

Unlike sulfuric acid, which requires a synthetic and unnatural process to produce, sulfurous acid is compatible because it truly is a substance created by nature. For example, when elemental sulfur is used to amend soil, or when it is used as a dusting powder, the reason why it works is because a microbe called Thiobacillus oxidizes it into SO₂ and combines it with moisture from the soil and/or the air to create sulfurous acid. It is the nature of Thiobacillus bacteria to produce both sulfite (SO₃²⁻) and sulfurous acid (H₂SO₃) through the natural oxidation of sulfur, but also when it naturally reduces sulfate (SO₄²⁻) in the absence of oxygen. Therefore, we submit that the Harmon SO₂/Sulfurous Acid generation process merely mimics what nature in fact already does.

Depending on its application, this equipment can be operated using either water pressure or negative air pressure (vacuum), and because the sulfur is 99.9% pure and is the only material used, once it is ignited, its oxidation continues as long as air and the necessary sulfur remains available. The oxidation of sulfur produces SO₂ gas that is confined and drafted by the equipment's unique venturi aspirator, where it can immediately be combined with a portion of the irrigation water to form sulfurous acid contained in an aqueous solution with a pH between 2.0 to 2.5 (an acidity that is very similar to lemonade, safe to handle and gargle with, and never becomes sulfuric). This solution can then be used in a variety of ways (see Uses & Applications).

Uses & Applications

The aqueous solution containing sulfurous acid can then be used in a variety of ways for both crop and livestock production.

1. It can be introduced and diluted into irrigation water to reduce and/or eliminate carbonates/bicarbonates from irrigation water in order to achieve a rain-like pH of 6.5 to 6.8, and to prevent and neutralize the formation of lime in soil.
2. It can be diluted with water for use as a soil drench to accelerate the neutralization of existing hardpan soils.
3. Since the process of amending includes the reduction of carbon and the oxidization of bacteria in the water, its use also provides a natural method to suppress and control algae and bacterial growth in irrigation systems without the use or toxicity of chemicals.
4. It can be atomized and used as an alternative to dusting sulfur.
5. It can be used as a "foot-bath" for dairy cows and to eliminate the use of copper sulfate, which is extremely toxic to dairy lagoons and our environment.
6. It can be added directly into dairy and animal wastewater lagoons for the purpose of reducing the excessive alkaline conditions that inhibit the full restoration of a balanced and bio-diverse environment needed to: improve and protect the health of animals; protect air quality by naturally sequestering nutrients from volatilizing into the atmosphere by recycling them into useful nutrient rich/pathogen suppressing compost tea which can later be applied on to soil.

Environmental Concerns

Independent environmental testing has determined that due to the unique design of the scrubbing system contained in the Harmon SO₂/Sulfurous Acid Generator, 99.9% of the SO₂ produced is captured, making this equipment extremely efficient, and meeting all air quality requirements for emissions (see Pape & Steiner report).

It should be noted that sulfur is a basic element and an essential nutrient for all living organisms known. Although it is naturally abundant, in many soils it has been depleted, at sub-optimal levels, and/or in a state that is unavailable for most microorganisms and plants to utilize. In order for it to become available, sulfur must first be converted into sulfate.

Since sulfurous acid reacts and produces sulfate only, it not only solves the alkalinity problems in water/soil, it can also serve as a means of returning and replenishing sulfur back into the soil, and in the form in which it can be readily used, but most importantly, a way that is sustainable and full compatible with our environment because there are no harmful or residual substances left behind.

Summary

Water has the unique ability to influence agronomic conditions for better or worse. Since we can no longer depend on using rain alone, we have become increasingly dependent on alternative water sources such as deep wells to irrigate our crops more than ever before. Such waters are usually high in pH, and contain significant amounts of dissolved salts, carbonates/bicarbonates, and other contaminants, which makes their use *imperfect*.

Over the years, these impurities have accumulated on soils, causing a *domino effect* that has compounded into even bigger problems, including the formation and sealing of the soil with lime, salt accumulation, water waste, and the suffocation of vital and beneficial aerobic microorganisms needed in a healthy and balanced bio-diverse *soil food web*.

By failing to recognize the important role water quality has, many farmers have inadvertently trapped themselves and their operations into becoming totally *reactive*, and have adopted agricultural practices that are unwise, unsustainable, and environmentally harmful. In less than 100 years, the use of imperfect water has led to the situation and dilemma modern agriculture now finds itself in – facing possible catastrophic ruin.

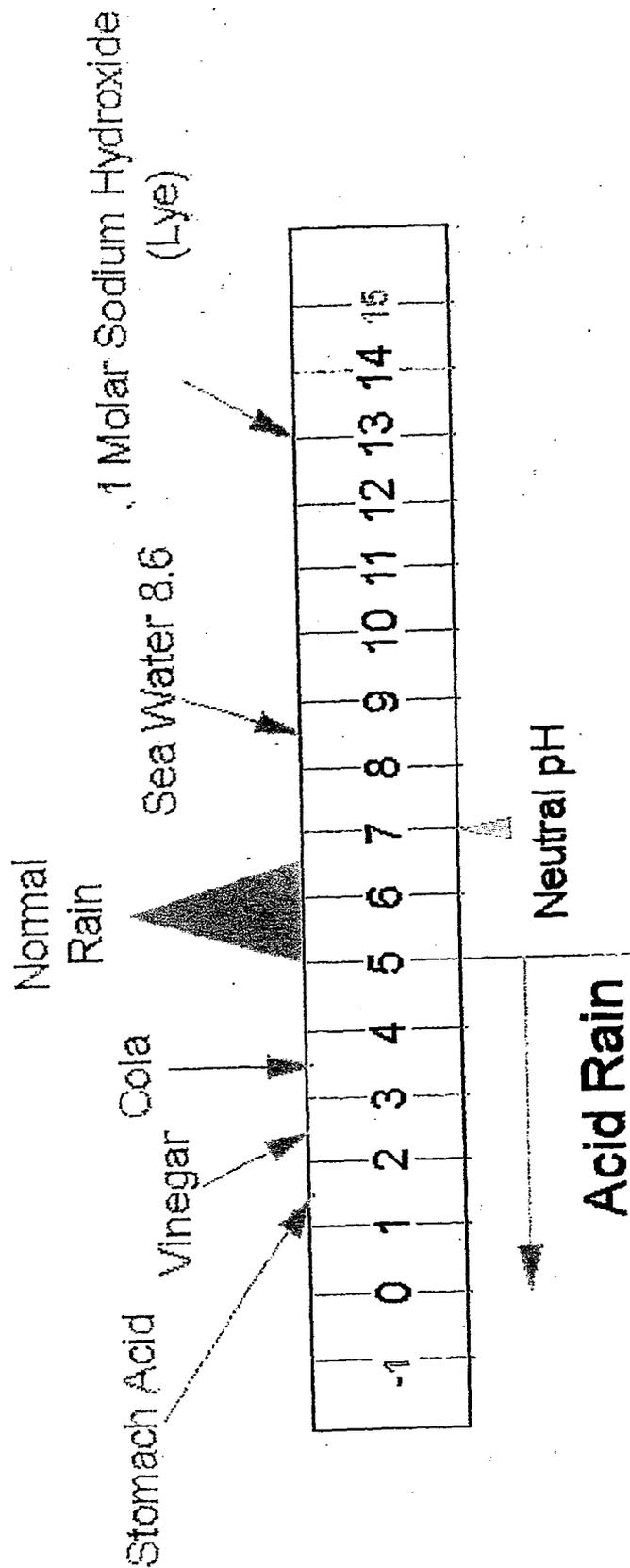
While at this time, it is not practical or cost effective to remove all of the dissolved materials in water; we can eliminate and/or reduce the main culprits, which are the lime forming carbonates/bicarbonates. To do this requires that we identify an acidification method that is compatible for organic use. We believe we have that method and that is why we are petitioning for it to be recognized and added to the National List.

Unlike *sulfuric acid* (H_2SO_4), which requires a synthetic and unnatural process to produce, *sulfurous acid* (H_2SO_3) is a true and naturally occurring substance, and the Harmon SO₂/Sulfurous Acid Generator is an acidification process that merely mimics what nature in fact already does.

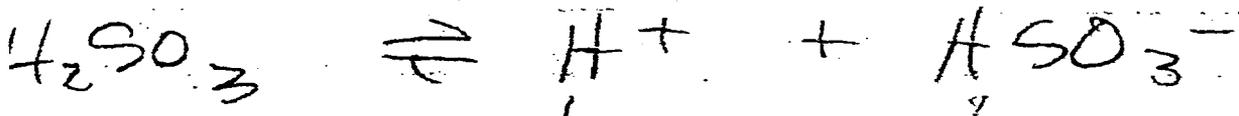
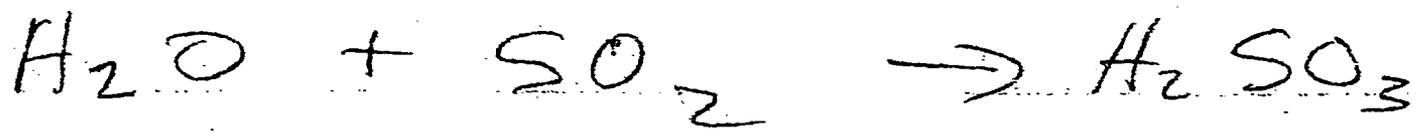
Although sulfurous acid can be used in a variety of ways, such as algae control and as a footbath for dairy cows, its primary use will be to amend irrigation water to a quality that is similar to rain.

The immediate and overall benefits from this will be significant, because by using improved and rain-like irrigation water, we will be able to prevent further degradation to our farmland, begin a process of restoration, use less water, and enable more of our farmers to become sustainable and organic.

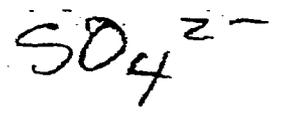
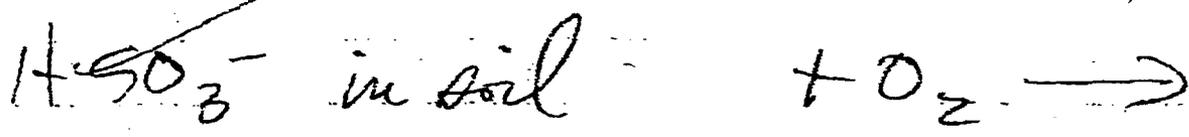
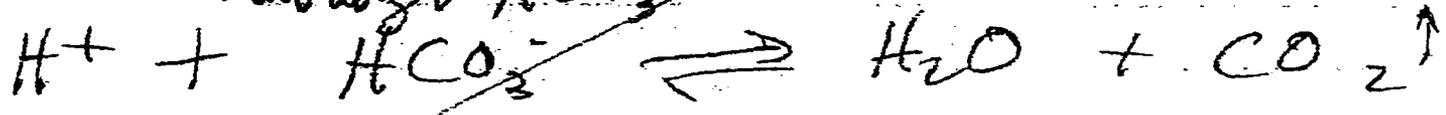
The pH Scale



pH is a measure of how much hydrogen ion is in solution and is equal to the negative log of the hydrogen ion concentration. The term pH is derived from the French words "pouvoir hydrogen" meaning "power of hydrogen". A pH scale extending from 0 to 14 covers the range of pH of most common solutions. A few extremely acidic solutions such as concentrated battery acid can actually have a negative pH, and a few highly caustic (basic) solutions have pH values of 15 or even slightly higher.



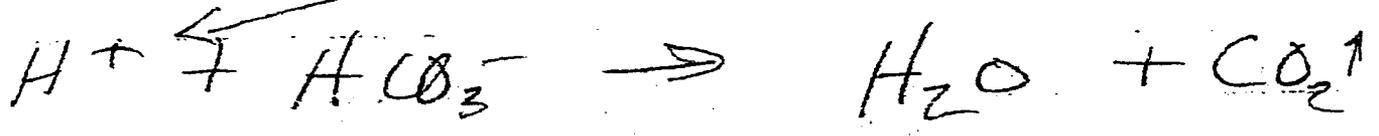
neutralizes HCO_3^-



+ H^+
sulfuric acid



reacts with more HCO_3^-



CAL POLY

California Polytechnic State University
San Luis Obispo, CA 93407

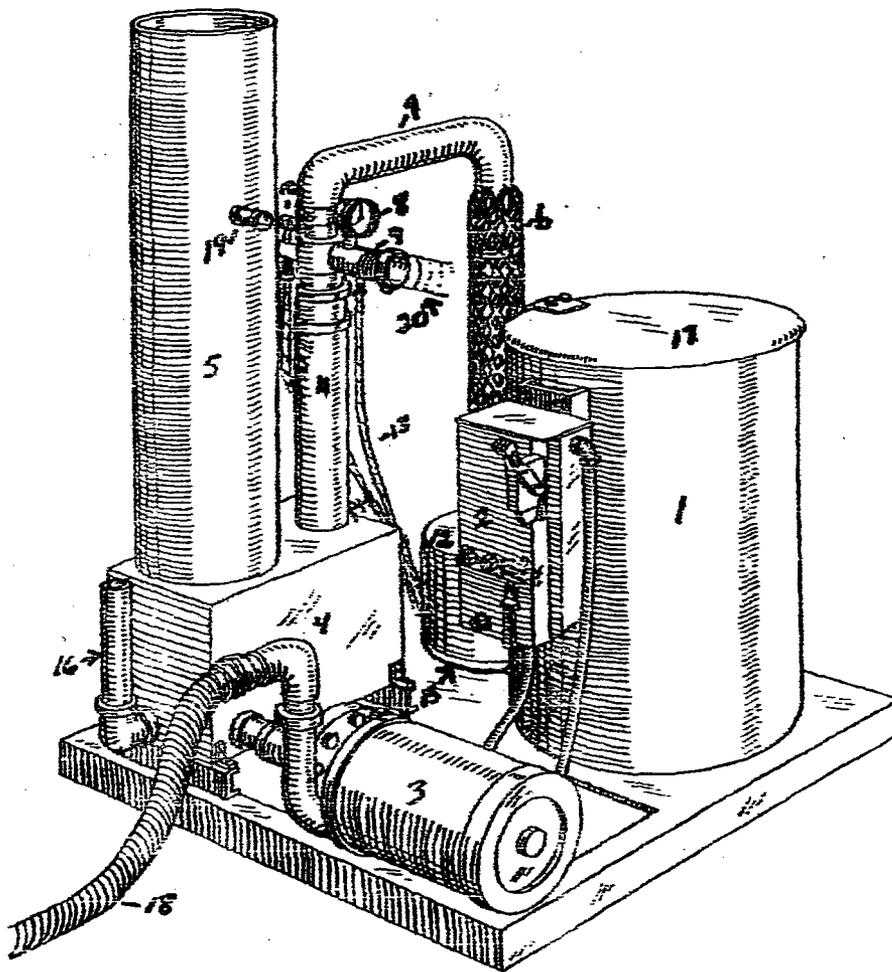
THOMAS A. RUEHR
Professor
Soil Science Department

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Email: truehr@calpoly.edu

The differences between sulfuric acid vs. sulfurous acid

The nature of *sulfuric acid* (H_2SO_4) is to release its two acidifying $+H$ ions immediately when it is introduced to water. Upon doing so, they react with the bicarbonates/carbonates to form additional water and CO_2 , which simply vents out of the water and lowers the pH between 6.5 and 6.8, a range preferred by most growers. Since the *sulfate* portion (SO_4) is already balanced, no further reaction occurs.

The following should explain why *sulfurous acid* is different and so advantageous. While both acids have two acidifying $+H$ ions, unlike sulfuric, the nature of sulfurous acid (H_2SO_3) is that it can acidify and achieve the same pH range by donating a single $+H$ ion instead of two. Since the other $+H$ ion remains covalently bonded as HSO_3 , it is incapable of adding to the overall acidity of that solution until after the *sulfite* portion (SO_3) has reacted to become sulfate (SO_4), either by oxidizing with bacteria in the water, bacterial slime in the irrigation system, and/or organic matter after it reaches the soil.



- | | |
|--------------------------|--------------------------------------|
| 1. HOPPER | 10. GATE VALVE |
| 2. ELECTRICAL PANEL | 11. INDUCTION PIPE |
| 3. PUMP AND MOTOR | 12. BURNER |
| 4. ACID TANK | 13. PLASTIC HOSE TO ASPIRATOR |
| 5. SCRUBBER TOWER | 14. PLASTIC HOSE FROM ASPIRATOR |
| 6. HEAT GUARD | 15. COOLING RING |
| 7. INDUCTION PIPE | 16. DRAIN PIPE |
| 8. PRESSURE GAUGE | 17. HOPPER LID |
| 9. ASPIRATOR | 18. HOSE PUTTING ACID BACK IN SYSTEM |
| 19. SPREADER BAR | |
| 20. HOSE TO WATER SOURCE | |

(ON ELECTRICAL PANEL THE ON & OFF SWITCH, START BUTTON, & RESET BUTTON ARE CLEARLY MARKED).



OMRI

Listed

Organic Materials Review Institute
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541-343-7600 • Fax: 541-343-8971
info@omri.org • www.omri.org

OMRI has reviewed the following material based on the *OMRI Generic Materials List*, the *OMRI Operating Manual for Review of Brand Name Products*, and documentation provided by the manufacturer or distributor to support the product application.

Product Name

Yellowstone Brand High Purity Prills

OMRI Status*

Regulated

OMRI Product No.

nsc-9477

OMRI Generic Category*

soilfr, elemental

OMRI Class*

CFM

Supplier

Montana Sulphur and Chemical Co
Bruce Loftus
P.O. Box 31118, Billings, MT 59107-1118
voice 406-252-9324, fax 406-252-8250
sales@montanasulphur.com, www.montanasulphur.com

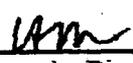
Issue Date

June 15, 2001

Expires

June 1, 2004


Product Review Coordinator


Executive Director

This listing is not OMRI certification or endorsement and cannot be construed as certification or listing by any of OMRI's subscribing certifiers. Final decisions regarding the acceptability of use of the product and any restrictions on its use under any particular certifier's program are made by the certifier that still has the right to decline OMRI's recommendation. Producers and handlers still need to contact their certifiers for information as to whether or not this material may be used in organic production or handling.

* See the most current *OMRI Generic Materials List* for more information plus annotations and restrictions.

YELLOWSTONE BRAND SUGARHOUSE FLAKED SULFUR 99.9% S.
YELLOWSTONE BRAND FLAKE SULFUR 99.9% S
YELLOWSTONE BRAND SULFUR PRILLS 99.9% S
YELLOWSTONE BRAND GROUND SULFUR 99.5% S
YELLOWSTONE BRAND FEED GRADE SULFUR 99.5% S
YELLOWSTONE BRAND DISINTEGRATING SULFUR GRANULES 90.0% S
(LABEL INFORMATION ALSO APPLIES TO OUR GENERIC
ELEMENTAL SULFUR PRODUCTS INCLUDING:
LUMP & SOLID SULFUR)

Produced by
MONTANA SULPHUR & CHEMICAL COMPANY
Billings, Montana U.S.A. 59107-1118

IMPORTANT PRODUCT SAFETY INFORMATION

Caution, handle this material properly and safely. Do not use near sparks or open flame. Handle dry sulfur products with suitable electrically grounded, non-sparking equipment. Dry solid sulfur products may produce static electricity and sparks from friction during handling and conveying. Sulfur dust, when suspended in air, may explode or burn if ignited by sparks or flame. The thermal ignition point in air is about 504 Degrees F. Prevent accumulation near hot surfaces such as exhausts, light bulbs, appliances, etc. Do not store near explosive or oxidizing materials such as nitrates.

If fire does occur, stay upwind to avoid toxic, irritating gases (Sulfur Dioxide - smells like burning match heads). Severe exposure to combustion products may induce coughing, eye / throat / respiratory irritation. Treat as for smoke inhalation: get to fresh air immediately. Restore normal breathing. Flush eyes with cool, clean water. Do not rub eyes. Seek medical attention.

Extinguish burning sulfur with water fog or flood or smother fire (cut off its air) with dirt or sand, for example. Post fire watch; flames may rekindle. Sulfur burns with a tenacious, short, blue flame.

Prolonged exposure to dust may result in eye or respiratory irritation. While using, do not rub your eyes. Avoid dust. Wash hands and face after using. If eye irritation from dust occurs, wash out eyes with plenty of cool, clean water. Where prolonged exposure to dust is possible, good work practice advises use of dust resistant eye protection and dust masks such as 3M-Company #8710 or equivalent. This material is not intended for human consumption, nor for use by persons other than those experienced in the proper handling of agricultural or industrial chemicals. Refer to Material Safety Data Sheet for more detailed information.

Montana Sulphur & Chemical Company invites questions about this product and its safe handling. CALL:
(406) 252-9324

Material Safety Data Sheet
Solid Elemental Sulfur
SUGARHOUSE FLAKED SULFUR
GROUND SULFUR
FEED GRADE SULFUR

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YELLOWSTONE BRAND PRODUCTS
REGULAR FLAKED SULFUR
DISINTEGRATING SULFUR GRANULES
HIGH PURITY SULFUR PILLLS

SECTION 1. GENERAL INFORMATION.

Manufactured by: MONTANA SULPHUR & CHEMICAL COMPANY, P.O. Box 31118, Billings, Montana 59107-1118 USA.
Offices and Plant, East of Billings, Montana, 627 Exxon Road
Emergency Telephone Numbers: (406) 252-7101 or (406) 252-9324
FAX (406) 252-8250

Chemical Name: Sulfur, elemental
Chemical Symbol: S
Trade Names: YELLOWSTONE BRAND Feed Grade Sulfur; Flaked Sulfur; Ground Sulfur; Disintegrating Sulfur Granules for Agriculture; Lump Sulfur.
Other Synonyms: Brimstone, Crude Sulfur, Elemental Sulfur, Sulphur, Lump Sulfur, Crushed Sulfur, Sulfur Flour.
DOT Shipping Name: SULFUR, 9, NA1350, PG III. [See 49 CFR § 172.101 Hazardous Materials Table, and 49 CFR § 172.202 Description of Hazardous Material on Shipping Papers.]
DOT Hazard Class: YELLOWSTONE BRAND SULFUR (with the exception of Bulk Packaged Ground Sulfur) is NOT considered Hazardous Material per [49 CFR § 172.102(c)(1) Code/Special Provision 30].
DOT #: NA1350
DOT LABELS: NONE REQUIRED (with the exception of Bulk Packaged Ground Sulfur) per [49 CFR § 172.102(c)(1) Code/Special Provision 30]. CLASS 9 for Bulk Packaged Ground Sulfur.
EPA TOSCA & CAS#: [7704-34-9]
DOC Schedule B No: 2503.10.0000 Ck Dgt 6

SECTION 2. INGREDIENTS (exceeding 1% by weight)

Elemental Sulfur, S-; Chemical Family: Sulfur.

| | | |
|--|--|-----------------------|
| Flaked & Sugarhouse purity | 99.9% min. S | TLV-none established* |
| Ground | 99.5% min. S | TLV-none established* |
| Feed Grade | 99.5% min. S | TLV-none established* |
| Lump or Crude | varies ca.99% | TLV-none established* |
| Disintegrating types (for agriculture only) | 90.0%** min. S & 10.0%** max. bentonite clay* | TLV-none established* |

[**Disintegrating Type sulfur content may be different depending on formulation; consult actual package label, invoice, or manufacturer. Disintegrating type sulfurs are intended only for agricultural use as plant nutrient and soil amendment materials. The clays are used as an aid to product disintegration in the soil. YELLOWSTONE BRAND 90% Disintegrating Sulfur for example is typically 90% (minimum Sulfur) and up to 10% clay/earth (bentonite)].

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*No standards exist for elemental sulfur or bentonite exposure. (Bentonite clays may contain some free silica; the OSHA PEL for silica is 30 mg/m³ (%SiO₂ + 2 total dust)]. OSHA TWA is 0.1mg/mg *(respirable). The Nuisance Dust Recommendation should govern exposure to solid sulfur and/or sulfur-clay mixtures in the absence of other standards, in the opinion of this writer. For Nuisance Dusts: OSHA = 15 mg/m³ (total) and 5 mg/m³ (as respirable dust); ACGIH = 10 mg/m³ (total dust) or 5 mg/m³ (as respirable dust).

Since the combustion of sulfur is not uncommon and since its combustion product in air is SULFUR DIOXIDE, the exposure limits for this gas are shown: Sulfur Dioxide -OSHA=5 ppm TWA*; ACGIH TLV=2 ppm & STEL=5ppm. [Abbreviations Key: mg/m³ designates milligrams per cubic meter; ppm designates parts per million (volume). ACC designates Acceptable Ceiling Concentration; TWA designates Time Weighted Average; PEL is Permissible Exposure Limit].

SECTION 3. PHYSICAL DATA

Melting point: 231 - 246 Degrees F depending on temperature history;
Boiling point: 832.3 degrees F at one atmosphere pressure;
Specific gravity at room temperature: 2.07;
Vapor pressure at 140 Degrees F: 1.15 x 10⁻⁴ mm Hg;
Vapor Density @ boiling point: 0.2278 pounds/cubic foot. (>1 (air=1);
Solubility in water: nil; Evaporation Rate: <<1 (ether=1);

Appearance and odor: Bright yellow flakes, crystals, pastilles, prills, powders or granules. Odor: very slight - sweet to mercaptany. Melted sulfur changes from lemon yellow color to orange to red to black as temperature increases. Strong "sulfuric" odor at liquid state. Viscosity of molten sulfur increases rapidly with temperature and then falls back off with further temperature increase. Note: Yellowstone Disintegrating sulfur is pale greenish yellow in color rather than yellow.

SECTION 4. FIRE AND EXPLOSION DATA

Auto-ignition point (air): 478-511 degrees F.; Flash Point: 335+F. Mixtures of dust suspended in air may be easily ignited at all ambient temperatures by sparks or static electricity, if the oxygen content is above 8%. Dust explosions may result, similar to flour or sawdust explosions. AVOID CREATING AIR-DUST MIXTURES. Flammable Limits: LEL Dust 35 g/m³; UEL Dust 1400 g/m³>>. NOTE: May vary considerably depending on particle size and dispersion.

Extinguishing media: Water, water fog, dirt, sand, or carbon dioxide blanket. Seal Closable Tanks to smother fire. Hi-velocity jets of water or gas should be avoided as these will tend to spread and splash burning material over a larger area. Gentle water sprays or flooding are best. Damage to product can be minimized by smothering (closing off air) or with carbon dioxide flooding.

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Special fire-fighting procedures: Protect product and containers from ignition during nearby fires if possible. As a precaution, keep exterior of tanks, bins cool with water spray to help prevent ignition and to help control sulfur fire if ignition occurs. If sulfur ignites: Stay upwind to avoid irritating-toxic sulfur dioxide gas. Protect skin from molten sulfur burns. Indoors, especially, wear self-contained breathing apparatus of the positive pressure type. Protect eyes. Combustion products (sulfur dioxide) will cause severe coughing/eye & throat pain/and distress. **DO NOT INHALE!** Avoid raising dust. After fire is controlled, post fire watch for at least 4 hours. Small fires are easy to miss and can linger for hours. Re-ignition may occur.

Unusual fire and explosion hazards: Combustion product is sulfur dioxide, an irritating toxic gas which smells like burning match heads. Dust air mixtures are highly flammable/explosive. Sulfur fires are deep blue at night, with very short flames. Fire is invisible by daylight except for smoke and heat. Burning material, however, turns deep red-black.

SECTION 5. HEALTH HAZARD DATA

Threshold limit value: none established for sulfur

Effects of overexposure: Prolonged exposure to dust may cause skin dryness, skin and eye irritation, respiratory irritation, or possible dermatitis in sensitive persons. Do not take internally. Avoid breathing dust.

General Hygiene: Wash exposed skin and hair thoroughly after use. Launder clothing. If eye irritation occurs, flush eyes with cool clean water. If eye or skin irritation persists, consult a physician.

ELEMENTAL SULFUR ROUTES OF ENTRY & FIRST AID PROCEDURES:

Inhalation (smoke, Sulfur Dioxide or H₂S): Remove victim to fresh air. Start artificial resuscitation and/or CPR if not breathing. Call a physician.

Eyes: Flush eyes w/water for 15 minutes. Irritation may be delayed several hours; usually disappears after exposure ceases. Unless irritation is obviously minor, consult physician. Also see THERMAL BURNS below.

Skin Contact: Wash skin/hair thoroughly with soap and water after use to prevent irritation and transferring material to eyes from fingers/hair. Prolonged contact with skin causes skin dryness. [Has been used as an acne treatment for this reason] Lotions and moisturizers may be useful in prevention. For THERMAL BURNS see below.

Ingestion: If ingested consult a physician. Sulfur is not considered highly toxic. Has been used medically in years past in "laxatives, alteratives, antiseptics, antiparasitics."

Thermal Burns: Flood EYES and/or SKIN with cool water at once! Unless skin burn

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is obviously minor/superficial, seek medical attention. See that solidified sulfur is carefully and gently removed without tearing flesh. If eyes are involved seek medical attention at once.

Medical Conditions that may be aggravated by exposure to sulfur fumes/hydrogen sulfide/sulfur oxides include respiratory disease or infections; cardiovascular diseases. [It should be noted however that this company has successfully employed persons with pre-existing heart disease and emphysema without adverse results and that sulfur has been known and used since antiquity with remarkable safety].

Sulfur is NOT listed as Carcinogen or Potential Carcinogen under the National Toxicology Program of IARC or OSHA.

SECTION 6. REACTIVITY DATA

Elemental sulfur is stable by itself at ambient temperatures. Conditions to avoid: mixtures of air and sulfur dust, sparks or open flames, mixtures of sulfur and oxidizing agents in general, large accumulations of sulfur dust which could become airborne in an explosion or process disruption caused by other materials. Examples of common oxidizing agents are PERCHLORATES, NITRATES, CHLORATES, PERMANGANATES, PEROXIDES, OXYGEN, HALOGENS, etc. Good housekeeping is important to minimize fire danger.

General Information: Solid sulfur is satisfactorily compatible with common materials of construction including steel and aluminum. Molten sulfur may attack and degrade rubber and some plastics. At still higher temperatures sulfur will react with hydrocarbons evolving poisonous hydrogen sulfide gas in the absence of air. The gas is also flammable. Sulfur is both an OXIDIZING AGENT and a REDUCING AGENT. Sulfur will form sulfides with most metals, including iron, and reacts vigorously with metals in the Sodium and Magnesium groups on the periodic table. Sulfides of iron will oxidize fairly rapidly in moist air. In the presence of other readily oxidized combustibles (such as some oily materials) under certain conditions, the heat liberated may be sufficient to result in spontaneous ignition. This phenomenon has not been observed with these pure Sulfur products or Disintegrating Sulfur in contact with unprotected steel at ordinary ambient temperatures, however. Users are cautioned against allowing inadvertent mixtures of sulfur, iron, and miscellaneous oils to remain. Oxidation is accelerated by higher temperatures. Heat buildup and ignition can be prevented by keeping the sulfides wet until oxidation is complete.

The literature on sulfur is extensive. Consult a chemist before compounding.

Hazardous combustion products: Sulfur dioxide gas: Poisonous, irritating, choking gas. Smells like burning match heads (which also liberate Sulfur dioxide). Do not inhale, If exposed get to fresh air at once. Treat as for smoke inhalation.

SECTION 7. SPILL OR LEAK PROCEDURES

Avoid setting fire to spill material. Have fire fighting media at hand. Avoid creating dust and sparks with tools. Wear eye and face protection, as small brief fires may flare up if a spark is struck. Small spills may be cleaned up with shovel and broom. Large spills may be cleaned with front end loaders etc. Post fire watch until all danger of fire is past. Personnel should wash thoroughly all exposed skin and hair to prevent irritation from dust.

Waste Disposal: Burial, landfill. Local farmers may want to use the material as a plant nutrient or soil amendment provided the only contamination is dirt, and provided they have received competent advice from a soil chemist recommending the application of sulfur and appropriate application rates.

SECTION 8. SPECIAL PROTECTION INFORMATION

Respiratory protection recommended - dust masks suitable for use with irritating dust. Indoor use areas should have sufficient local exhaust to remove dust as it is released into the air.
Eye protection is recommended around dust for personal comfort.

Skin & General: Work gloves and long sleeved shirt etc. help keep material off of skin of sensitive persons prone to skin irritation or dermatitis. Use of a good skin moisturizer before and after work helps to avert dry skin problems and discomfort. Be sure to select a skin care product which you are not allergic to.

Remember also: Fire fighting tools/media should be readily available: Water or dirt and shovels.

SECTION 9. SPECIAL PRECAUTIONS and MAINTENANCE NOTES

Handling and Storage: Handle only with well grounded non-sparking equipment. Dry sulfur materials may generate static electricity and sparking. Avoid handling solid sulfur at high velocity in air. Inert gas blanketing is useful in preventing fires and explosions in processing and grinding equipment. Do not use near sparking equipment or open flames. Do not allow large amounts of waste to accumulate. Enclosed equipment containing dust in air must be adequately explosion-vented or strong enough to withstand the pressures developed in a dust explosion. Do not store near oxidizing materials, or near hot equipment. In the presence of moisture over long periods of time, some sulfur will convert to sulfuric acid which, of course, is corrosive to metals and attacks paper, concrete, wood products, etc. Store product in a dry place.

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Repair & Maintenance Notes: Be familiar with all information on this sheet and use common sense. Have fire fighting media at hand. **Vessel Entry.** Isolate vessel from process and heat input. Do not enter hot tanks. If molten sulfur has been generated in the process, be advised that sulfur may remain molten under a crust for a considerable time. Ventilate enclosed tanks with fresh air and purge of all potentially explosive air/dust mixtures before and during entry. Check air in enclosed spaces for flammability and oxygen and suspended dust before entry. If fires have occurred check for Sulfur Dioxide. Wet down residual sulfur on walls to control dust and fire hazard while cleaning and working. Open-topped vessels may be swept clean wet or dry with non sparking brooms. Wear dust protection for eyes and breathing, long sleeved shirt/pants. If vessel is not to be re-used at once, rinse and dry thoroughly to limit corrosion. **Welding/Cutting/Grinding:** Remove bulk sulfur from equipment or wet down thoroughly or blanket with inert gas to prevent ignition. Fully protect material in nearby equipment/containers from sparks or remove it. Eliminate all sources of sulfur dust suspended in air in welding/cutting/grinding area. Wet work is usually preferable. Welding/cutting combustion products will contain sulfur dioxide as well as noxious metal oxides. Do not breathe fumes. Ventilate properly or wear breathing protection suitable for both sulfur dioxide and welding fumes. Posting fire watch during and after work for 4 hours recommended. For further information see also sections 4,5,6,7, & 8 especially.

Montana Sulphur & Chemical Company will be pleased to work with customers in developing safety rules and procedures for particular situations - Contact us.

NOTICE: The information and judgments contained herein are based on experience and data considered accurate, however, no warranty is expressed or implied regarding accuracy or the results to be obtained from use. Vendor assumes no responsibility for injury to vendee or third person proximately caused by the material if reasonable safety procedures are not adhered to. Additionally, vendor assumes no responsibility for injury to vendee or third persons proximately caused by abnormal use of the material even if reasonable and normal safety procedures are followed. Furthermore, vendee absolutely assumes full responsibility for the risks in his use of the material.

Prepared by Lawrence Zink, Chemist
Montana Sulphur & Chemical Company -- January 23, 1997
Last Revision 01/01/94.
[This sheet printed September 22, 1997] words=2277

PERFORMANCE TESTING OF A
HARMON SO₂ GENERATOR

July 28, 1983

Prepared for

D&J Harmon Company, Inc.
3737 Gilmore Avenue
Bakersfield, California 93308

Prepared by

Pape & Steiner Environmental Services
5801 Norris Road
Bakersfield, California 93308

Purchase Order No. 1023

Report PS-83-137/Project 5123-83

Appendix B

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SECTION 1
INTRODUCTION

At the request of D&J Harmon Company, Inc., Pape & Steiner Environmental Services conducted performance testing of SO₂ emissions from a SO₂ generator north of Bakersfield (Unit No. 378392A16) on July 28, 1983. The testing was performed to determine the emission limits for a typical unit.

Section 2 of the report describes the test matrix for this program. Section 3 presents the results and Sections 4 and 5 describe the procedures used to sample and analyze the emissions. All raw data and calculations used to obtain these results may be found in the Appendix.

SECTION 2
TEST PROGRAM

D&J Harmon Company retained Pape & Steiner Environmental Services to perform a series of emission tests on a typical SO₂ generator they manufacture. The exhaust gases from one of these units had been previously checked using a Draeger tube. More rigorous tests for SO₂ in the exhaust gases were deemed necessary prior to shipping a number of these units to Saudi Arabia.

D&J Harmon selected a typical SO₂ generator (#378392A16) located north of Bakersfield for this test program. Harmon personnel operated the unit in a normal fashion while Pape & Steiner personnel collected three one-hour samples of the exhaust gases to determine the SO₂ concentration. In addition, measurements were made to determine the O₂, CO₂ and H₂O content of these gases. Finally, velocity and temperature measurements were made to calculate an emission rate of SO₂ leaving the unit.

Section 3 of the report presents the results of these tests.

SECTION 3

RESULTS

Table 3-1 summarizes the results of the tests conducted on the SO₂ generator north of Bakersfield. The average SO₂ concentration was 14.24 ppm. The average SO₂ emission rate was very low (0.0042 lb/hr) since there are very little combustion products leaving the burner.

TABLE 3-1. SUMMARY OF SOURCE EMISSION TEST DATA

UNIT TESTED: 378392A16

LOCATION: north of Bakersfield

| | 1 | 2 | 3 | Avg |
|----------------------------------|----------|----------|----------|--------|
| Test number | | | | |
| Date | 07/28/83 | 07/28/83 | 07/28/83 | |
| Test condition | normal | normal | normal | |
| Barometric pressure (in. Hg) | 29.80 | 29.85 | 29.85 | |
| Stack pressure (in. Hg) | 29.80 | 29.85 | 29.85 | |
| Stack area (Ft ²) | 0.5185 | 0.5185 | 0.5185 | |
| Elapsed sampling time (min) | 60 | 60 | 60 | |
| Volume gas sampled (dscf) | 43.9186 | 42.9758 | 43.7638 | |
| F factor | | | | |
| GAS DATA | | | | |
| Average gas velocity (fps) | 0.9 | 1.0 | 1.0 | |
| Average gas temperature (°F) | 77.5 | 79.0 | 78.6 | |
| Gas flowrate (dscfm) | 28.69 | 29.94 | 29.97 | |
| Gas analysis (dry percent basis) | | | | |
| Carbon dioxide | 0.5 | 0.0 | 0.0 | |
| Oxygen | 9.5 | 8.0 | 6.5 | |
| Carbon monoxide | 0.0 | 0.0 | 0.0 | |
| Water | 4.29 | 4.38 | 4.41 | |
| EMISSION CONCENTRATION | | | | |
| Filterable particulate (gr/dscf) | | | | |
| Total particulate (gr/dscf) | | | | |
| Total sulfate (gr/dscf) | | | | |
| SO ₃ (ppm) | | | | |
| SO ₂ (ppm) | 9.43 | 19.18 | 14.12 | 14.24 |
| NO _x (ppm) | | | | |
| EMISSION RATE | | | | |
| Filterable particulate (lb/hr) | | | | |
| Total particulate (lb/hr) | | | | |
| Total sulfate (lb/hr) | | | | |
| SO ₃ (lb/hr) | | | | |
| SO ₂ (lb/hr) | 0.0027 | 0.0057 | 0.0042 | 0.0042 |
| NO _x (lb/hr) | | | | |
| Lb/MMBtu-EMISSION FACTOR | | | | |
| Filterable particulate | | | | |
| Total particulate | | | | |
| Total sulfate | | | | |
| SO ₂ | | | | |
| NO _x | | | | |
| Lb/Bbl-EMISSION FACTOR | | | | |
| Total particulate | | | | |
| Total sulfate | | | | |
| SO ₂ | | | | |
| NO _x | | | | |

SECTION 4
SAMPLING EQUIPMENT AND PROCEDURES

This section of the report describes the sampling equipment and procedures used to conduct the SO₂ tests on this program.

4.1 VOLUMETRIC FLOWRATE MEASUREMENTS

Just prior to conducting the SO₂, gas composition, and moisture determinations for a given run, volumetric flowrate measurements were made using a Davis Instruments Model ERDA 5 vane anemometer. The vane anemometer was placed directly in the gas flow and a reading in feet per minute was obtained.

4.2 STACK GAS COMPOSITION

The O₂, CO₂, and CO content of the stack gases was measured in accordance with EPA Method 3. The sampling train consisted of a stainless steel probe, a 4-foot Tygon line, and a Fyrite analyzer kit. A grab sample of the stack gases was collected during the duration of each SO₂ test. The collected sample was analyzed using the Fyrite analyzers.

4.3 STACK GAS MOISTURE

The stack gas moisture content was measured in conjunction with the EPA Method 8 SO₂ test. An integrated sample of the stack gases was collected during the duration of each SO₂ test. The amount of water condensed in the train was determined gravimetrically.

4.4 PREPARATION OF THE SO₂ SAMPLING TRAIN

Prior to the field tests, the SO₂ sampling train components were cleaned in the laboratory (soap and water, tap water rinse, distilled water rinse, and IPA rinse) to remove grease and eliminate previous contamination.

EPA Method 8 equipment was used to measure SO₂ (and moisture) and consisted of the following components:

- a 4-foot Teflon line to connect the stack to the impinger train;
- an impinger train immersed in an icebath (impinger #1 contained 100 ml of 80-percent IPA; a 47-mm Pyrex glass filter holder containing a Reeve-Angel 934 AH filter to remove acid mist; impingers 2 and 3 contained 100 ml of 3-percent H₂O₂; impinger 4 contained a known amount of silica gel);
- a control module containing a vacuum pump, a dry gas meter and an orifice meter to measure temperature, pressure and flowrate throughout the sampling train.

The impinger train was charged in the laboratory with freshly prepared reagents. Blanks of the 80-percent IPA and 3-percent H₂O₂ were collected for subsequent analysis. Each impinger was weighed to the nearest 0.1 gm and then placed in the impinger case. The train was sealed and transported to the SO₂ generator.

4.5 SAMPLING PROCEDURES FOR SO₂

At the sampling site, the train components were assembled and leak checked at 15 inches mercury to insure the leakage rate was less than 2 percent of the sampling rate. The Teflon sampling probe was positioned near the center of the stack. A sample of the stack gases was collected at a constant rate at that sampling location. Each test was 60 minutes long. A total of three runs were used to characterize the sulfur generator emissions. After completing a test, the sampling train was leak checked at 15 inches mercury and then purged for 15 minutes with clean ambient air. The impinger train was sealed and taken back to the laboratory for analysis.

4.6 SAMPLE RECOVERY PROCEDURES FOR SO₂ SAMPLING TRAIN

Each impinger was removed from the icebath and wiped dry. Each impinger was weighed to the nearest 0.1 gm to determine the weight of condensed moisture. The contents of impinger 1 was discarded. The acid mist filter was discarded. The contents of impingers 2, 3, and 4 were transferred to a clean, labeled polyethylene bottle. All sample exposed surfaces of these impingers and their U-tube connectors were rinsed with distilled water. These rinsings were also put in the polyethylene sample bottle. The silica gel impinger was weighed and the silica gel was discarded. The chain-of-custody form was completed and the samples were submitted for analysis.

SECTION 5
ANALYSIS PROCEDURES

The samples collected on this test program were analyzed in accordance with EPA Method 8 procedures as described below.

5.1 ANALYSIS OF SO₂ SAMPLES

The volume of sample in the polyethylene bottle was measured to the nearest 1 ml. A 10-ml aliquot of this sample was diluted to 100 ml in a volumetric flask using distilled water. A 10-ml aliquot of this sample was titrated using 0.0100N BaCl₂ which was previously standardized against a 0.0100N H₂SO₄ Dilut-it standard purchased from VWR Scientific, Inc.

5.2 QUALITY ASSURANCE/QUALITY CONTROL FOR SO₂ SAMPLES

For this test program, two of the three samples were analyzed in duplicate and another of the samples was spiked with 0.0100N H₂SO₄ to determine recovery efficiency. Table 5-1 summarizes the results of the QA/QC checks.

TABLE 5-1. QA/QC RESULTS

| <u>Run No.</u> | <u>Type of Check</u> | <u>Result (%)</u> |
|----------------|----------------------|-------------------|
| 1 | Duplicate | 100.0 |
| 2 | Duplicate | 100.9 |
| 3 | Spike | 101.0 |

APPENDIX

- Field Data Sheets
- Sampling Handling/Log-in
- Analytical Report
- Volumetric Flowrate Calculations
- Gaseous Calculations

Date 7-28-83 Barometric Pressure 29.80
 Test Location 328392A16 Static in. wg. 0
 Run Number 1 Probe Type/Length R-flange
 Stack Diameter 9.25" Pitot Coefficient none
 Operator O. Walsh Meter Box No. 18634/1.00%
 Filter No. none Nozzle No./Size none

| Contents | Impinger Volumes/Weights | | | Gas Composition | | | |
|----------------------------|--------------------------|---------|-------|-----------------|------|-----|----|
| | Final | Initial | Net | Time | CO2 | O2 | CO |
| 100 ml 2% H ₂ O | 573.3 | 543.4 | -31.1 | 10:45 | 1.0 | 9.5 | |
| 100 ml 2% H ₂ O | 560.0 | 534.2 | 25.8 | 11:30 | 0.0 | 9.5 | |
| 100 ml 2% H ₂ O | 581.2 | 559.1 | 22.1 | | | | |
| S.G. | 746.6 | 720.9 | 25.7 | Leak Rate | cfm | "Hg | |
| | | Total | 48.5 | Initial | 1000 | 15 | |
| | | | | Final | 1002 | 17 | |

| Sample Point | Time | ΔP in wg | ΔH in wg | Gas Meter Volume Ft ³ | Stack | Temperature of | Probe | Oven | Imp. | Gas Meter | | Pump Vacuum in. Hg | Comments |
|--------------|-------|----------|----------|----------------------------------|--------|----------------|-------|------|------|-----------|-----|--------------------|--------------------|
| | | | | | | | | | | In | Out | | |
| center point | 10:35 | 0.60/Min | 2.0 | 835.207 | 78° | 83 | | | | 90 | 90 | 10 | |
| | 15 | | 2.0 | 879.03 | 78° | 79 | | | | 95 | 90 | 11 | H ₂ O 1 |
| | 10 | | 2.0 | 883.02 | 78° | 76 | | | | 92 | 92 | 16 | 832301 |
| | 15 | | 2.0 | 896.86 | 77° | 79 | | | | 101 | 96 | 15 | |
| | 20 | | 2.0 | 890.62 | 77° | 80 | | | | 103 | 98 | 15 | |
| | 25 | | 2.0 | 894.89 | 78° | 78 | | | | 104 | 100 | 15 | |
| | 30 | | 2.0 | 898.53 | 77° | 78 | | | | 107 | 103 | 15 | |
| | 35 | | 2.0 | 902.61 | 77° | 73 | | | | 109 | 105 | 15 | |
| | 40 | | 2.0 | 906.48 | 77° | 76 | | | | 111 | 117 | 15 | |
| | 45 | | 2.0 | 910.48 | 77° | 76 | | | | 111 | 108 | 15 | |
| stack | 50 | | 2.0 | 914.72 | 77° | 76 | | | | 118 | 109 | 15 | |
| | 55 | | 2.0 | 918.49 | 77° | 78 | | | | 113 | 110 | 15 | |
| | 60 | | | 932.476 | | | | | | | | | |
| | stack | | | 104.83 | 100.61 | | | | | | | | |
| | | | 2.0 | 470.2690 | 72.5 | | | | | 102.75 | | | |

Date 7-28-83
 Test Location J283-22A16
 Run Number 2
 Stack Diameter 9.75"
 Operator Chalak
 Filter No. none
 Barometric Pressure 29.85
 Static in. wg. 0
 Probe Type/Length Teflon/4'
 Pitot Coefficient none
 Meter Box No. 18 644C 11.0046
 Nozzle No./Size none

| Impinger Volumes/Weights | | | | Gas Composition | | | |
|--------------------------|-------|---------|-------|-----------------|-----|-----|----|
| Contents | Final | Initial | Net | Time | CO2 | O2 | CO |
| Water to 100 | 530.0 | 553.1 | -23.1 | 12.18 | 0.0 | 8.0 | |
| to 100% H ₂ O | 568.2 | 540.0 | 28.2 | | | | |
| to 100% H ₂ O | 554.9 | 541.9 | 13.0 | | | | |
| S.G. | 114.7 | 690.3 | 24.4 | Leak Rate | cfm | "Hg | |
| | | Total | 42.5 | Initial | CO2 | 17 | |
| | | | | Final | CO2 | 15 | |

| Sample Point | Time | ΔP in wg | ΔH in wg | Gas Meter Volume Ft ³ | Stack | Temperature °F | | | Gas Meter In | Gas Meter Out | Pump Vacuum in. Hg | √ΔP | Comments |
|----------------|------|----------|----------|----------------------------------|-------|----------------|------|------|--------------|---------------|--------------------|-----|------------------------------|
| | | | | | | Probe | Oven | Imp. | | | | | |
| contin. period | 0 | | 2.0 | 933.813 | 77° | | | 67 | 113 | 112 | 8 | | |
| | 5 | | 2.0 | 937.96 | 77° | | | 71 | 115 | 113 | 9 | | no measurable velocity |
| | 10 | | 2.0 | 942.81 | 77° | | | 71 | 116 | 113 | 13 | | |
| | 15 | | 2.0 | 946.04 | 77° | | | 71 | 116 | 113 | 13 | | |
| | 20 | | 2.0 | 949.22 | 80° | | | 72 | 117 | 114 | 13 | | |
| | 25 | 2.0 | 2.0 | 953.44 | 80° | | | 73 | 117 | 114 | 13 | | H ₂ O 2 832302 |
| | 30 | | 2.0 | 957.15 | 80° | | | 74 | 117 | 114 | 13 | | H ₂ O 3 832303 |
| | 35 | | 2.0 | 961.11 | 80° | | | 75 | 117 | 114 | 13 | | |
| | 40 | | 2.0 | 965.09 | 80° | | | 75 | 117 | 115 | 13 | | |
| | 45 | | 2.0 | 969.07 | 80° | | | 75 | 117 | 115 | 13 | | |
| | 50 | | 2.0 | 970.03 | 80 | | | 75 | 118 | 115 | 13 | | |
| | 55 | | 2.0 | 977.02 | 80 | | | 76 | 117 | 115 | 13 | | |
| stop | 60 | | | 981.006 | | | | | | | | | |
| | | | | purge 15 min | | | | | | | | | |
| | | | | | | | | | 116.42 | 113.83 | | | |
| | | | 2.0 | 47.193 | 79.0 | | | | | 15.13 | | | |

Date 2-28-83
 Test Location 32839A16
 Run Number 3
 Stack Diameter 9.75"
 Operator Oshtak
 Filter No. none
 Barometric Pressure 29.85
 Static in. wg. 0
 Probe Type/Length Teflon/4'
 Pitot Coefficient none
 Meter Box No. 18 6444/10046
 Nozzle No./Size none

| Impinger Volumes/Weights | | | Gas Composition | | | | |
|--|-------|---------|-----------------|-----------|-----------------|----------------|-----|
| Contents | Final | Initial | Net | Time | CO ₂ | O ₂ | CO |
| 20 ml 80% IPA | 506.6 | 530.4 | -23.8 | 1350 | 0.0 | 6.0 | |
| 20 ml 2% H ₂ O ₂ | 591.9 | 564.5 | 27.4 | 1408 | 0.0 | 7.0 | |
| 20 ml 3% H ₂ O ₂ | 553.9 | 537.5 | 16.4 | | | | |
| S.G. | 718.7 | 695.1 | 23.6 | Leak Rate | | cfm | "Hg |
| | | Total | 43.6 | Initial | | .001 | 15 |
| | | | | Final | | .001 | 15 |

| Sample Point | Time | ΔP in wg | ΔH in wg | Gas Meter Volume Ft ³ | Stack | Probe | Temperature °F | | | Gas Meter In | Gas Meter Out | Pump Vacuum in. Hg | √ΔP | Comments |
|--------------|------|----------|----------|----------------------------------|-------|-------|----------------|------|--------|--------------|---------------|--------------------|-----|---|
| | | | | | | | Oven | Imp. | Imp. | | | | | |
| 1370 | | | 2.0 | 991.605 | 78 | | | 81 | 116 | 116 | 6 | | | |
| | 5 | | 2.0 | 990.91 | 78 | | | 76 | 119 | 116 | 6 | | | |
| | 10 | 607/111 | 2.0 | 999.64 | 78 | | | 73 | 119 | 116 | 9 | | | |
| | 15 | | 2.0 | 1003.64 | 78 | | | 73 | 119 | 116 | 10 | | | |
| | 20 | | 2.0 | 8.15 | 78 | | | 74 | 120 | 117 | 10 | | | |
| | 25 | | 2.0 | 11.67 | 79 | | | 75 | 121 | 118 | 10 | | | H ₂ O ₂ BL. 832300 |
| | 30 | | 2.0 | 15.66 | 79 | | | 76 | 121 | 118 | 10 | | | |
| | 35 | | 2.0 | 20.00 | 79 | | | 77 | 121 | 118 | 10 | | | |
| | 40 | | 2.0 | 23.72 | 79 | | | 77 | 121 | 118 | 10 | | | |
| | 45 | | 2.0 | 27.76 | 79 | | | 77 | 120 | 118 | 10 | | | |
| | 50 | | 2.0 | 31.84 | 79 | | | 77 | 120 | 118 | 10 | | | |
| | 55 | | 2.0 | 35.89 | 79 | | | 75 | 120 | 118 | 10 | | | |
| stop | 60 | | | 1039.945 | | | | | | | | | | |
| | | | | purge 15 min | | | | | | | | | | |
| | | | | | | | | | 119.75 | 117.25 | | | | |
| | | | | | 78.58 | | | | | 118.50 | | | | |
| | | | 2.0 | 48.340 | | | | | | | | | | |

SAMPLE HANDLING/LOG-IN

Date 7/28/83 Test Location Nx J Harrison

| | Sample Type | Volume | Comments |
|-----|---|--------|----------|
| 1. | 832300 <u>MB</u> <u>DIH₂O₂</u> <u>1,2,3</u> Meth Sample Test | | |
| 2. | 832301 <u>MB</u> <u>H₂O₂</u> <u>1</u> Meth Sample Test | | |
| 3. | 832302 <u>MB</u> <u>H₂O₂</u> <u>2</u> Meth Sample Test | | |
| 4. | 832303 <u>MB</u> <u>H₂O₂</u> <u>3</u> Meth Sample Test | | |
| 5. | | | |
| 6. | | | |
| 7. | | | |
| 8. | | | |
| 9. | | | |
| 10. | | | |
| 11. | | | |
| 12. | | | |

CHAIN OF CUSTODY

ANALYTICAL REPORT

SAMPLE TYPE: SO₂ DATE: 7/29/83
 SAMPLe COMPONENT: H₂O₂ ANALYST: jmp
 REQUESTED BY: D+J Harmon
 ANALYTICAL METHOD: Barium-thion titration

| Sample ID No. | Test No. | Sample Volume | Sample Aliquot | Titer mls or (Absorbance) | Analytical Result (total sample) mg. H ₂ SO ₄ | |
|-----------------|----------|--|----------------|---------------------------|---|-----------------|
| | | | | | Uncorrected | Blank corrected |
| | 1 | 320 | 10 | 3.05 | | 47.824 |
| | 2 | 370 | 10 | 5.25 | | 95.183 |
| | 3 | 320 | 10 | 4.55 | | 71.344 |
| | Blank | 100 | 10 | 0 | | 0 |
| Standardization | | | | | | |
| | | 0.0100 NH ₂ SO ₄ | 5 | 5.00 | $\frac{5(-.01)}{5} =$ | 0.01000 |
| | | BaCl ₂ | 5 | 5.00 | | |

100% Dup.
 100.9% Dup.
 101% Spike

ISOKINETIC CALCULATIONS

Standard temperature, S_t 60 (XEQ 60 or 68); 29.92 inches Hg

Test 1 Date 7/28/83 Location 378392A16

| | | | |
|-------------------------|------------------------|-------------------|---------------------------------|
| T_m <u>102.75</u> | V_m <u>47.269</u> | O_2 <u>9.5</u> | Stack ID " <u>9.75</u> |
| T_s <u>77.5</u> | θ <u>1.0046</u> | CO_2 <u>0.5</u> | Stack Area Ft^2 <u>0.5185</u> |
| $\sqrt{\Delta P}$ _____ | P_b <u>29.80</u> | Static <u>0</u> | Test Time <u>60</u> |
| ΔH <u>2.0</u> | V_{1c} <u>42.5</u> | C_p <u>none</u> | N_d <u>none</u> |

1. Volume of dry gas sampled at standard conditions (dscf)

(R-17)

$$V_{m, std} = \left(\frac{S_t + 460}{29.92} \right) (\theta) V_m \left(\frac{P_b + \frac{\Delta H}{13.6}}{T_m + 460} \right) = 43.9186$$

2. Stack gas moisture condensed at standard conditions (scf)

(R-18)

$$(V_{m, std} + V_{w, std}; R-04) \quad V_{w, std} = 8.9148 \times 10^{-5} (S_t + 460) (V_{1c}) = 1.9702$$

3. Stack gas proportion of water vapor, by volume

(R-19)

$$B_{wo} = \frac{V_{w, std}}{V_{w, std} + V_{m, std}} = 0.0429$$

4. Stack gas dry molecular weight (lb/lb mole)

(R-21)

$$MW_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2 + \%CO) = 28.4600$$

5. Stack gas molecular weight (lb/lb mole)

(R-22)

$$MW_s = MW_d(1 - B_{wo}) + 18(B_{wo}) = 28.0109$$

6. Pressure stack, in. Hg

(R-23)

$$P_s = P_b + \left(\frac{P_{static}}{13.6} \right) = 29.8000$$

7. Stack gas velocity, at stack conditions (ft/sec)

(R-24)

$$V_s = 85.49(C_p)(\sqrt{\Delta P})_{avg} \sqrt{\frac{T_s + 460}{P_s(MW_s)}} = 0.9222$$

8. Stack gas volume at standard conditions (dscfm)

(R-26)

(ACFM; R-25)

$$Q_s = 60(1 - B_{wo}) V_s A_s \left(\frac{S_t + 460}{T_s + 460} \right) \left(\frac{P_s}{29.92} \right) = 28.6904$$

9. Test percent isokinetic

(R-02)

$$\%I = \frac{9142.88(T_s + 460)(V_{w, std} + V_{m, std})}{(S_t + 460) \theta V_s P_s (D_n)^2} =$$

GASEOUS CALCULATIONS

1. SO₃ concentration in ppmv

$$C_{SO_3} = 8.6599 \left(\frac{\text{mg H}_2\text{SO}_4}{V_{m,\text{std}}} \right)$$

$$= 8.6599 \left(\frac{\quad}{\quad} \right) =$$

2. SO₃ emission rate, lb/hr

$$ER_{SO_3} = 12.475 \times 10^{-6} (Q_s) (C_{SO_3})$$

$$= 12.475 \times 10^{-6} (\quad) (\quad) =$$

3. SO₂ concentration in ppmv

$$C_{SO_2} = 8.6599 \left(\frac{\text{mg H}_2\text{SO}_4}{V_{m,\text{std}}} \right)$$

$$= 8.6599 \left(\frac{47.82}{43.9186} \right) = 9.43$$

4. SO₂ emission rate, lb/hr

$$ER_{SO_2} = 9.983 \times 10^{-6} (Q_s) (C_{SO_2})$$

$$= 9.983 \times 10^{-6} (28.69) (9.43) = 0.0027$$

5. NO_x concentration in ppmv

$$C_{NO_x} = \frac{29628(\text{mg NO}_2)}{(V_f - 25\text{ml}) \left\{ \frac{P_f}{T_f + 460} - \frac{P_i}{T_i + 460} \right\}}$$

$$= \frac{29628(\quad)}{(\quad - 25) \left\{ \frac{\quad}{+ 460} - \frac{\quad}{+ 460} \right\}} =$$

6. NO_x emission rate, lb/hr

$$ER_{NO_x} = 7.164 \times 10^{-6} (Q_s) (C_{NO_x})$$

$$= 7.164 \times 10^{-6} (\quad) (\quad) =$$

7. NH₃ concentration in ppmv

$$C_{NH_3} = 49.6976 \left(\frac{\text{mg NH}_4}{V_{m, \text{std}}} \right)$$

$$= 49.6976 \left(\frac{\quad}{\quad} \right) =$$

8. NH₃ emission rate, lb/hr

$$ER_{NH_3} = 2.662 \times 10^{-6} (Q_s) (C_{NH_3})$$

$$= 2.662 \times 10^{-6} (\quad) (\quad) =$$

ISOKINETIC CALCULATIONS

Standard temperature, S_t 60 (XEQ 60 or 68); 29.92 inches Hg

Test 2 Date 7/28/83 Location 378392 A16

| | | | |
|-------------------------|------------------------|-------------------|---------------------------------|
| T_m <u>115.13</u> | V_m <u>47.193</u> | O_2 <u>8.0</u> | Stack ID " <u>9.75</u> |
| T_s <u>79.0</u> | γ <u>1.0046</u> | CO_2 <u>0</u> | Stack Area Ft^2 <u>0.5185</u> |
| $\sqrt{\Delta P}$ _____ | P_b <u>29.85</u> | Static <u>0</u> | Test Time <u>60</u> |
| ΔH <u>2.0</u> | V_{1c} <u>42.5</u> | C_p <u>none</u> | N_d <u>none</u> |

1. Volume of dry gas sampled at standard conditions (dscf)

(R-17)

$$V_{m, std} = \left(\frac{S_t + 460}{29.92} \right) (\gamma) V_m \left(\frac{P_b + \frac{\Delta H}{13.6}}{T_m + 460} \right) = 42.9758$$

2. Stack gas moisture condensed at standard conditions (scf)

(R-18)

$$(V_{m, std} + V_{w, std}; R-04) \quad V_{w, std} = 8.9148 \times 10^{-5} (S_t + 460) (V_{1c}) = 1.9702$$

3. Stack gas proportion of water vapor, by volume

(R-19)

$$B_{wo} = \frac{V_{w, std}}{V_{w, std} + V_{m, std}} = 0.0438$$

4. Stack gas dry molecular weight (lb/lb mole)

(R-21)

$$MW_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2 + \%CO) = 28.3200$$

5. Stack gas molecular weight (lb/lb mole)

(R-22)

$$MW_s = MW_d(1 - B_{wo}) + 18(B_{wo}) = 27.8676$$

6. Pressure stack, in. Hg

(R-23)

$$P_s = P_b + \left(\frac{P_{static}}{13.6} \right) = 29.8500$$

7. Stack gas velocity, at stack conditions (ft/sec)

(R-24)

$$V_s = 85.49(C_p)(\sqrt{\Delta P})_{avg} \sqrt{\frac{T_s + 460}{P_s(MW_s)}} = 0.9626$$

8. Stack gas volume at standard conditions (dscfm)

(R-26)

(ACFM; R-25)

$$Q_s = 60(1 - B_{wo}) V_s A_s \left(\frac{S_t + 460}{T_s + 460} \right) \left(\frac{P_s}{29.92} \right) = 29.9431$$

9. Test percent isokinetic

(R-02)

$$\%I = \frac{9142.88(T_s + 460)(V_{w, std} + V_{m, std})}{(S_t + 460) \theta V_s P_s (D_n)^2} =$$

GASEOUS CALCULATIONS

1. SO
- ₃
- concentration in ppmv

$$C_{SO_3} = 8.6599 \left(\frac{\text{mg H}_2\text{SO}_4}{V_{m,\text{std}}} \right)$$

$$= 8.6599 \left(\frac{\quad}{\quad} \right) =$$

2. SO
- ₃
- emission rate, lb/hr

$$ER_{SO_3} = 12.475 \times 10^{-6} (Q_s) (C_{SO_3})$$

$$= 12.475 \times 10^{-6} (\quad) (\quad) =$$

3. SO
- ₂
- concentration in ppmv

$$C_{SO_2} = 8.6599 \left(\frac{\text{mg H}_2\text{SO}_4}{V_{m,\text{std}}} \right)$$

$$= 8.6599 \left(\frac{95.18}{42.9158} \right) = 19.18$$

4. SO
- ₂
- emission rate, lb/hr

$$ER_{SO_2} = 9.983 \times 10^{-6} (Q_s) (C_{SO_2})$$

$$= 9.983 \times 10^{-6} (29.94) (19.18) = 0.0057$$

5. NO_x concentration in ppmv

$$C_{\text{NO}_x} = \frac{29628(\text{mg NO}_2)}{(V_f - 25\text{ml}) \left(\frac{P_f}{T_f + 460} - \frac{P_i}{T_i + 460} \right)}$$

$$= \frac{29628(\quad)}{(\quad - 25) \left(\frac{\quad}{+ 460} - \frac{\quad}{+ 460} \right)} =$$

6. NO_x emission rate, lb/hr

$$ER_{\text{NO}_x} = 7.164 \times 10^{-6} (Q_s) (C_{\text{NO}_x})$$

$$= 7.164 \times 10^{-6} (\quad) (\quad) =$$

7. NH_3 concentration in ppmv

$$C_{\text{NH}_3} = 49.6976 \left(\frac{\text{mg NH}_4}{V_{m,\text{std}}} \right)$$

$$= 49.6976 \left(\frac{\quad}{\quad} \right) =$$

8. NH_3 emission rate, lb/hr

$$ER_{\text{NH}_3} = 2.662 \times 10^{-6} (Q_s) (C_{\text{NH}_3})$$

$$= 2.662 \times 10^{-6} (\quad) (\quad) =$$

ISOKINETIC CALCULATIONS

Standard temperature, S_t 60 (XEQ 60 or 68); 29.92 inches Hg

Test 3 Date 7/28/83 Location 378392 A16

| | | | |
|-------------------------|------------------------|-------------------|---------------------------------|
| T_m <u>118.50</u> | V_m <u>48.340</u> | O_2 <u>6.5</u> | Stack ID " <u>9.75</u> |
| T_s <u>78.58</u> | δ <u>1.0046</u> | CO_2 <u>0.0</u> | Stack Area Ft^2 <u>0.5185</u> |
| $\sqrt{\Delta P}$ _____ | P_b <u>29.85</u> | Static <u>0</u> | Test Time <u>60</u> |
| ΔH <u>2.00</u> | V_{1c} <u>43.6</u> | C_p <u>none</u> | N_d <u>none</u> |

1. Volume of dry gas sampled at standard conditions (dscf)

(R-17)

$$V_{m, std} = \left(\frac{S_t + 460}{29.92} \right) (\delta) V_m \left(\frac{P_b + \frac{\Delta H}{13.6}}{T_m + 460} \right) = 43.7638$$

2. Stack gas moisture condensed at standard conditions (scf)

(R-18)

$(V_{m, std} + V_{w, std}; R-04)$

$$V_{w, std} = 8.9148 \times 10^{-5} (S_t + 460) (V_{1c}) = 2.0212$$

3. Stack gas proportion of water vapor, by volume

(R-19)

$$B_{wo} = \frac{V_{w, std}}{V_{w, std} + V_{m, std}} = 0.0441$$

4. Stack gas dry molecular weight (lb/lb mole)

(R-21)

$$MW_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2 + \%CO) = 28.2600$$

5. Stack gas molecular weight (lb/lb mole)

(R-22)

$$MW_s = MW_d (1 - B_{wo}) + 18(B_{wo}) = 27.8071$$

6. Pressure stack, in. Hg

(R-23)

$$P_s = P_b + \left(\frac{P_{static}}{13.6} \right) = 29.8500$$

7. Stack gas velocity, at stack conditions (ft/sec)

(R-24)

$$V_s = 85.49(C_p) (\sqrt{\Delta P})_{avg} \sqrt{\frac{T_s + 460}{P_s (MW_s)}} = 0.9634$$

8. Stack gas volume at standard conditions (dscfm)

(R-26)

(ACFM; R-25)

$$Q_s = 60(1 - B_{wo}) V_s A_s \left(\frac{S_t + 460}{T_s + 460} \right) \left(\frac{P_s}{29.92} \right) = 29.97$$

9. Test percent isokinetic

(R-02)

$$\%I = \frac{.9142.88(T_s + 460)(V_{w, std} + V_{m, std})}{(S_t + 460) \theta V_s P_s (D_n)^2} =$$

GASEOUS CALCULATIONS.

1. SO₃ concentration in ppmv

$$C_{SO_3} = 8.6599 \left(\frac{\text{mg H}_2\text{SO}_4}{V_{m,\text{std}}} \right)$$

$$= 8.6599 \left(\frac{\quad}{\quad} \right) =$$

2. SO₃ emission rate, lb/hr

$$ER_{SO_3} = 12.475 \times 10^{-6} (Q_s) (C_{SO_3})$$

$$= 12.475 \times 10^{-6} (\quad) (\quad) =$$

3. SO₂ concentration in ppmv

$$C_{SO_2} = 8.6599 \left(\frac{\text{mg H}_2\text{SO}_4}{V_{m,\text{std}}} \right)$$

$$= 8.6599 \left(\frac{71.34}{43.7635} \right) = 14.12$$

4. SO₂ emission rate, lb/hr

$$ER_{SO_2} = 9.983 \times 10^{-6} (Q_s) (C_{SO_2})$$

$$= 9.983 \times 10^{-6} (29.97) (14.12) = 0.0042$$

5. NO_x concentration in ppmv

$$C_{NO_x} = \frac{29628(\text{mg NO}_2)}{(V_f - 25\text{ml}) \left\{ \frac{P_f}{T_f + 460} - \frac{P_i}{T_i + 460} \right\}}$$

$$= \frac{29628()}{(- 25) \left\{ \frac{ }{+ 460} - \frac{ }{+ 460} \right\}} =$$

6. NO_x emission rate, lb/hr

$$ER_{NO_x} = 7.164 \times 10^{-6} (Q_s) (C_{NO_x})$$

$$= 7.164 \times 10^{-6} () () =$$

7. NH₃ concentration in ppmv

$$C_{NH_3} = 49.6976 \left(\frac{\text{mg NH}_4}{V_{m, \text{std}}} \right)$$

$$= 49.6976 \left(\frac{ }{ } \right) =$$

8. NH₃ emission rate, lb/hr

$$ER_{NH_3} = 2.662 \times 10^{-6} (Q_s) (C_{NH_3})$$

$$= 2.662 \times 10^{-6} () () =$$