Hydrogen Safety – H₂

John Christensen
Account Manager – ES – DS Additives Group
November 20th, 2019

Hydrogen Sulfide – H₂S

Why Should We Care?

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**H₂S – What is It?**

- Colorless Gas That is Flammable & Explosive
- Odor of Rotten Eggs – If Concentration is Low
- Heavier Than Air & Corrosive
- Occurs Naturally
- Toxic

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**H₂S – What Does it Do?**

- Broad-Spectrum Poison
  - Affects Several Systems
  - Primarily Nervous System
- Toxicity Comparable to CO
  - At Lower Concentrations:
    - Eye Irritation
    - Sore Throat & Cough
    - Shortness of Breath
    - Nausea
- Short Term – High Level Exposure
  - Immediate Collapse & Loss of Breathing
  - It Kills If Necessary Precautions Are Not Taken
  - Binds with Fe Preventing Cellular Respiration
  - Uncontrolled Death of Brain Cells & Cerebral Edema
  - Fluid in the Lungs
- Long-Term Exposure
  - Fatigue
  - Loss of Appetite
  - Headaches & Dizziness
  - Irritability & Memory Loss

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**Concentration (ppm) - Physiological Effect**

<table>
<thead>
<tr>
<th>Concentration (ppm)</th>
<th>Physiological Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3</td>
<td>Odor, Threshold</td>
</tr>
<tr>
<td>5 - 10</td>
<td>Slight Headache</td>
</tr>
<tr>
<td>10 - 50 (0.001%)</td>
<td>Headache, Nausea, Throat and Eye Irritation</td>
</tr>
<tr>
<td>50 - 100</td>
<td>Unconsciousness, Respiratory Tract Irritation, Memory Paralysis</td>
</tr>
<tr>
<td>100 - 300</td>
<td>Conjunctivitis (Pink Eye), Respiratory Tract Irritation, Memory Paralysis</td>
</tr>
<tr>
<td>300 - 500</td>
<td>Cerebral Edema (Pink Eye), Respiratory Tract Irritation, Memory Paralysis</td>
</tr>
<tr>
<td>500 - 1,000</td>
<td>Immediate Collapse with Respiratory Paralysis, Risk of Death</td>
</tr>
<tr>
<td>1,000 – 2,000</td>
<td>Immediate Collapse with Respiratory Paralysis, Risk of Death</td>
</tr>
</tbody>
</table>

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**Santa Elena Canyon, Texas & CHRUshash**
H₂S – What Does it Do?

- 1000 & Up ppm – Unconsciousness at Once
  - Immediate Collapse – Even After Inhalation of a Single Breath
  - Early Loss of Breathing
  - Death within a Few Minutes
  - Death May Occur Even if Individual is Removed to Fresh Air at Once

H₂S – Limits

- NIOSH – National Institute for Occupational Safety & Health
  - REL – Recommended Exposure Limit – 10 ppm
  - IDLH – Immediately Dangerous to Life & Health (Interferes with Ability to Escape – 100 ppm)

- OSHA – Occupational Safety and Health Administration
  - PELs – Permissible Exposure Limit (Enforceable)
    - General Industry Ceiling Limit – 20 ppm
    - General Industry Peak Limit – 50 ppm
    - Construction 8-hour Limit – 10 ppm
    - Shipyard 8-hour Limit – 10 ppm

- ACGIH – American Conference of Governmental Industrial Hygienists
  - TLV – Threshold Limit Value 8-hour – 1 ppm
  - STEL – Short Term Exposure Limit – 5 ppm
  - Canadian Provinces – Some Are Legally Bound
  - Under Review – Accurate Equipment (<10 ppm)

- General Refining and Petroleum Guideline
  - 10 ppm – Personal Monitor Level
H₂S – What Does it Do? – Corrosion

- Electrochemical – Acid or Direct Attack of Iron
  - Shallow Round Pits or FeS Film Formation
  - Aggressive in Nature
  - Tank Headspace, Within Tank & Pipes

\[ \text{H}_2\text{S} + \text{Fe} + \text{H}_2\text{O} \rightarrow \text{FeS}_\text{prod} + \text{H}_2 \]

- Tank Headspace
  - Brinell Headspace

H₂S – How is it Measured?

- Electronic & Explosion Meters
- Direct Reading & Alarm Only Gas Monitors
- Detector Tubes

Dräger Tubes
  - Increments from 0.2 – 5 ppm to 100 to 2000 ppm
  - Utilize Chemical Reaction – Pb, Cu or Hg Salts

ASTM D-5705 Can Test Modified
  - Measures H₂S in Vapor Phase (Equilibrium Headspace)
  - Utilizes a 500g Asphalt Sample
  - Put in a Quart Can, Heat it for 2 hours & Shake it up for 30 sec
  - < 325°F – Open Can
  - ≥ 325°F – Closed Can

Isla Mujeres, Quintana Roo
H₂S – Where Is It?

- Often Produced by Microbial Breakdown of Organic Matter in the Absence of Oxygen
  - Swamps & Sewers
  - Volcanic & Natural Gases (Up to 90%)
  - Well Water & Springs
  - Wastewater Treatment, Landfills and Agriculture (Manure)
  - Petroleum
    - Oil Field
    - Crude Itself & Distillates
    - Asphalt

H₂S – In Asphalt

- Sweet Crude = H₂S in your Asphalt
- Sour Crude = More H₂S in your Asphalt
  - H₂S Can be as High as 12,500 ppm
- High Sulfur Crudes – More Prevalent
- < 10 ppm?
- What About PMA?
  - Asphalt Testing – N = 2
    - Supplier 1 – PG 64-22, < 100 ppm; PG 76-22, 600 ppm
    - Supplier 2 – PG 64-22, ~ 150 ppm; PG 76-22, ~1000 ppm

H₂S – How Do We Deal With It?

- PPE
  - Personal H₂S Monitors & Electric Meters
  - Supplied Air Respirators (SAR) or SCBA
- Reduce Exposure
  - Training, Training & Training
    - What to Do if Alarm Sounds
    - Where to Stand When Opening a Hatch – Wind Direction
    - What to Do If Someone is Overcome – Emergency Response
    - Resources Available (Asphalt Institute)
- Develop Procedures to Minimize Exposure
H₂S – How Do We Deal With It?

Safe Work Practices
- Know Where it’s Expected (Tank Vapor Space)
- Monitor Wind Direction
- Know the Volumes & Temperatures
- Loading & Discharging – Avoid Close Proximity
- Wear Personal Monitors

Engineering Controls
- Ventilation & Carbon Canisters
- Temperature
- Get Upwind

Questions???