**Loss Control Fact Sheet #2012-2**

Preventing Methane Gas Explosions –

Serious Incident Investigation Highlights

In April 2009, a methane gas explosion occurred at a municipal owned domestic waste water treatment plant in Southeast Pennsylvania. The explosion occurred in one of two active anaerobic sludge digesters at the 4,000,000 gallon per day plant. Methane is a potentially explosive by-product of anaerobic digestion of wastewater solids. The process building was equipped with general dilution ventilation and a fixed explosive gas monitoring system. The building’s electrical systems were of ordinary construction – not explosion proof. The explosion seriously injured a veteran operator and caused extensive property damage. The cause of the explosion was traced to a leak in the sludge gas conveyance system piping, at a condensation drip trap – gas piping component. The source of ignition could not be identified due to the extent of damage.

Following the explosion, collection system piping and associated equipment at several wastewater treatment plants were monitored for methane leaks using a portable flame ionization detector – FID. Methane gas leaks, commonly occurring at the condensation drip traps, were identified as a problem at 5 of 6 plants studied.

Testing was done following EPA air pollution control methodology including use of a portable FID to test for methane at low ppm concentrations. This may be a cost-effective screening tool to verify the integrity of methane collection system piping and components at wastewater treatment plants, landfills, and other biogas producing facilities.

The results of the study indicate that it is critical to conduct periodic methane fugitive emission monitoring, along with regular inspection and cleaning of drip traps, especially seating surfaces – per Groth Corp. – 2003 literature, as well as inspection of other piping components.

Although rare, the potential for methane gas explosions poses a significant concern which needs to be addressed.

The attached advisory, summarizing best engineering practices for preventing methane explosions in anaerobic sludge digester processes, was developed based on current editions of the following standards and guidelines:

Pennsylvania DEP domestic wastewater facilities manual – 1997

NFPA 820 – Standard for Fire Protection and Wastewater Treatment and Collection facilities – 2008

NFPA 54 – National Fuel Gas Code – 2009

NFPA 85 – Boilers and Combustion Systems – 2011

NFPA 86 – Standards for Ovens and Furnaces – 2011

American Society of Mechanical Engineers – CSP – 1, Controls and Safety Devices for Boilers – 2009

OSHA 29 CFR 1910.119 – Process Safety Management of Highly Hazardous Chemicals – 2011

**Excerpts From Professional Safety** – April, 2012

Thanks to Peter Erndwein, Director of Risk Control at Delaware Valley Insurance Trust for permission to refer our members to this important advisory. The memo regarding Methane Explosion Controls is below.

The industrial hygiene consultant used for monitoring for this project was One Source Safety and Health, located in Exton, PA. Contact – Harry O’Neill – 1 – 888 – 873 – 9983. Website: www.1SSH.com

If you have any questions regarding the above, or if we can be of any additional assistance, please contact Statewide’s Edge at 732 – 446 – 5958.

**Memo**

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To: DVIT and DVWCT Members with WWTP Performing Anaerobic Sludge Digestion

From: Peter Erndwein, Director of Risk Control

cc: Rick Lee, Trust Administrator
Date: January 11, 2009

Re: Methane Explosion Controls

**Background:**

Anaerobic sludge digestion is a volume reduction process which occurs at certain wastewater treatment plants (WWTP). The process which takes place in a vessel generates quantities of sludge gas as a byproduct. Sludge gas is composed of methane, carbon dioxide and hydrogen sulfide. Methane is an invisible, odorless and tasteless flammable gas. The sludge gas is normally collected and burned as a fuel in a steam boiler which in turn supplies heat to the anaerobic digestion process.

In April 2009, a DVWCT member experienced a methane gas explosion at one of its WWTP anaerobic sludge digesters. The methane leaked from a gas collection line in the piping gallery and was ignited by an unknown source. The explosion and fire caused major damage to the building and seriously burned a veteran operator. As of December 2009, the operator remains out of work and continues to undergo rehabilitation. The sludge digester remains off-line resulting in increased operational costs and lost revenue.

The Risk Control Department is issuing this memo to DVWCT and DVIT members who perform sludge digestion in order to raise awareness and offer effective controls to avoid a recurrence of this tragedy. The recommendations that follow were compiled from several sources and were independently reviewed by Mr. Vincent Scarcella, CNA Equipment Breakdown Risk Control Director.

**Risk Control Explosion Prevention Recommendations:**

In order to minimize the risk of methane fueled explosions at municipal WWTP’s:

1. Ignition Control - Given the potential for the generation and accumulation of methane gas anywhere wastewater is handled, ignition sources should be carefully controlled at WWTPs and in the collection system. This is best accomplished through the following:

1. Restricting smoking to limited outdoor areas. Smoking outside of these areas should be strictly prohibited.
2. Implementing a formal hot work permit program. This requires monitoring of atmospheres to ensure their safety prior to engaging in any work involving open flame or spark producing equipment. The results of such testing should be documented in a formal written hot work permit issued by a qualified member of management. A sample hot work permit program is included in Attachment A.
3. Using non-sparking tools whenever feasible.
4. Providing employees with calibrated portable gas meters equipped to measure lower explosive limit (LEL), oxygen and hydrogen sulfide levels. Work should not proceed if the LEL is 10% or greater.

2. Mechanical Integrity - Routinely (i.e., quarterly or semi-annually) inspect sludge gas collection piping to ensure that piping is not corroding or leaking. As part of this inspection, a portable gas meter should be used to confirm the structural integrity of the piping system. Any leaks should be investigated and promptly repaired by qualified personnel using compatible materials.

3. Gas Monitoring – Install, calibrate and properly maintain a fixed flammable gas monitoring system with sensors installed in the gas collection gallery and boiler/control rooms. The sensors should be set to alarm at 10% LEL. The alarm should enunciate audibly and visually so that operators are notified of hazardous conditions before entering the building. Additionally, the alarm should enunciate in the central control room. The reason for the alarm should be displayed (e.g., an indicator should display the actual LEL measurement).

4. Safety Equipment – Pressure relief valves, vacuum relief valves, flame traps and automatic safety shutoff valves should be provided and protected from freezing. Water seal equipment should not be installed.

5. Gas Piping and Condensate - Gas piping should have a minimum diameter of four inches. A smaller diameter pipe at the gas meter is acceptable. Gas piping should slope to condensation traps at low points. The use of float controlled condensation traps is not permitted. Condensation traps should be protected from freezing.

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1. Gas Utilization Equipment – Gas burning boilers should be located in separate, well ventilated rooms not connected to the digester gallery. Gas supply lines to the boilers should be equipped with suitable flame traps.
2. Waste Gas Burner (i.e., Flare) - The sludge digestion process should be equipped with a functional waste gas burner located at least 50 feet away from any plant structure. The waste gas burner should be equipped with automatic ignition, such as a pilot light or a device using a photoelectric cell sensor. Consideration should be given to the use of natural gas or propane gas to ensure reliability of the pilot light. Gas piping should be sloped a minimum of two percent up to the waste gas burner with a condensation trap provided in a location not subject to freezing.
3. Ventilation – Any underground enclosures connecting with the digestion tanks or containing sludge or gas piping or equipment should be provided with forced ventilation. Ventilation if continuous shall provide at least six complete air changes per hour. If intermittent, at least 30 complete air changes per hour. The piping gallery for digesters should not be connected to other passages.
4. Gas Meter – Gas meters may be of orifice plate, turbine or vortex type. Positive displacement meters should not be utilized. The meter must be specifically designed for contact with corrosive and dirty gases.
5. Basic Fire Protection - Buildings should be equipped with Type ABC portable fire extinguishers and be located near a functional fire hydrant.
6. Electrical Equipment - Buildings and processes should comply with the electrical classification guidelines specified in NFPA 820 as follows:

*Inside anaerobic digestion tank* => Class 1; Division 1

*Outside anaerobic digestion tank with fixed roof or floating cover;*

* Envelope 10 feet vertical from the highest point and 5 feet from any wall => Class 1; Division 1
* Envelope 10 to 25 feet vertical from the highest point and 5 to 10 feet from any wall => Class 1; Division 2

*Anaerobic digestion tanks located inside buildings;*

* No ventilation or less than 12 air changes per hour => Class 1; Division 1
* Continuous forced air ventilation of 12 air changes per hour;

- Envelope 10 feet above and around tank cover at its highest point and five feet from any wall => Class 1; Division 1 - Remaining space => Class 1; Division 2

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*Gas collection piping areas located inside a building*

* No ventilation or ventilation less than 12 air changes per hour => Class 1; Division 1
* Continuous forced ventilation of 12 air changes per hour; - Within 5 feet of equipment => Class 1; Division 1 - Outside of 5 feet of equipment => Class 1; Division 2

*Control/furnace building*

* No ventilation or ventilation less than 12 air changes per hour => Class 1; Division 1
* Continuous forced ventilation of 12 air changes per hour; enclosed areas containing equipment => Class 1; Division 2
* Continuous forced ventilation of six air changes per hour with area physically separated from gas handling equipment => Unclassified

*Waste gas burner/flare*

* Envelope of 10 feet around waste gas burner and associated piping => Class 1; Division 1

**Questions:**

Members who may have questions or concerns regarding the contents of this memo should contact Peter Erndwein at 267-781-0612 or perndwein@dvit.com.

**References:**

Domestic Wastewater Facilities Manual, 1997, Pa. Department of Environmental Protection, Document No. 362-0300-001

<http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-48793/362-0300-001.pdf>

NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities, 2008 Edition

NFPA 54 National Fuel Gas Code

NFPA 85 Boilers and Combustion Systems

NFPA 86 Standards for Ovens and Furnaces

ASME CSD-1 Controls and Safety Devices for Boilers

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**Attachment 1**

**Sample Hot Work Program and Permit**

**STANDARD OPERATING GUIDELINE:**

**FIRE PREVENTION AND CONTROL PRACTICES**

1.0 APPLICABILITY

This procedure details the requirements for preventing and responding to facility fires. 2.0 RESPONSIBILITIES

2.1 Management is responsible for providing fire-safe facilities, communicating the requirements of this procedure to the workforce and enforcing compliance.

2.2 Employees are responsible for complying with the fire prevention and control practices. 3.0 PROCEDURES

3.1 All facilities shall undergo a documented fire risk inspection by a qualified individual on a periodic basis (e.g., quarterly). The inspection shall target at a minimum:

* Excessive fuel loading inside facilities
* Unrestricted access to fire extinguishers
* Emergency egress and emergency lighting
* Sprinkler head clearance
* Electrical systems and components
* Utility rooms and installations
* Container grounding and bonding practices

3.2 Fire extinguishers shall be visually inspected monthly, and serviced on an annual basis. Free and clear access to fire extinguishers shall be maintained.

3.3 Employees shall be trained in emergency response procedures and in the use of fire extinguishers to put out start-up fires. Training shall occur upon hire/transfer and whenever there is a significant change to facilities or operations.

3.4 Sprinklers shall be inspected and flow tested on an annual basis.

3.5 Smoking shall be restricted to designated areas in which appropriate containers for collecting butts are provided. Smoking shall not occur in areas where flammables or combustibles are present.

3.6 Work areas shall be kept clear of debris. Accumulations of combustible materials inside structures (paper goods, wood, clothes) shall be kept to a minimum to reduce the fuel load. Utility rooms shall not be used for storage of combustible materials.

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3.7 Flammable liquids shall be stored in approved containers. Whenever feasible, flammable liquids shall be stored in approved flammable liquid storage cabinets, modular storage facilities or rooms. Combustibles shall not be stored in the vicinity of flammable liquid storage cabinets. Grounding and bonding shall be used when dispensing flammable liquids.

3.8 Each facility shall have a written emergency action plan. With respect to fire, the plan shall address:

* Procedures for reporting a fire or emergency
* Procedures for emergency evacuation, including type of evacuation and exit route assignments
* Procedures for employees who remain to perform critical facility operations before they evacuate
* Procedures to account for all employees after the evacuation
* Procedures for employees performing rescue or medical duties
* The name or job title of the individual employees can contact to get more information about the plan or an explanation of their duties under the plan

3.9 Hot work (work involving welding, brazing or cutting) shall be performed in a designated hot work area or shall be subject to a hot work permit. Requirements for the hot work program include:

* Flame and spark-producing equipment shall be inspected to ensure it is in good repair.
* Verify sprinklers where provided are operational and will not be taken out of service while the hot work is performed.
* Verify that no combustible gases, vapors, dusts, fibers or liquids are in the vicinity of the work area. Verify tanks and equipment previously containing such materials have been cleaned and purged. If there is a possibility of a leak developing in nearby piping, equipment or tanks, monitor the area continuously. A combustible gas monitor shall be utilized to monitor oxygen levels and lower explosive level. Acceptable levels are as follows:

Oxygen Between 19.5 and 23.5%

Lower explosive limit Less than 10%

* In stable work environments, monitoring need only occur once per shift at the start of the hot work. In environments subject to change (e.g., welding in a confined space, work in sewers), monitoring shall be performed continuously.
* If arc welding will occur, welding flash curtains shall be utilized to confine slag and ultraviolet light.
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* Surrounding floor areas shall be swept clean of debris. If the flooring is combustible, the floor shall be wet down.
* A fire extinguisher shall be available within 10 feet of the hot work area.
* All combustible materials shall be relocated at least 35 feet from the hot work area. If relocation is not possible, protect fixed combustible materials with metal guards or flame proof covers or other non-combustible spark barriers.
* Protect all floor and wall openings within 35 feet of the operation by tightly covering or providing non-combustible spark barriers.
* Identify a qualified individual to serve as a fire-watch. This individual shall watch for dangerous sparks in the hot work area, as well as on floors above and below.
* Document that all fire prevention activities are complete in the attached hot work permit. Hot work permits are valid for one shift only. After completing the hot work, the permit shall be kept on file for one year.
* The hot work area shall be patrolled for at least one half hour after work has been completed to look for hot spots.

4.0 ADDITIONAL RESOURCES

<http://www.osha-slc.gov/SLTC/emergencypreparedness/index.html>

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**HOT WORK PERMIT**

(Post permit at jobsite. When complete, archive for 1-year)

Name and Location of Work Area:

Work to be Performed:

For Emergencies, Contact:

Permit Valid From: \_\_/\_\_/\_\_ Time: \_\_:\_\_ to: \_\_/\_\_/\_\_ Time: \_\_:\_\_ (Valid One Shift) Results of Atmospheric Monitoring:

Test Equipment Used (Name & Serial Number):

Parameter Result Acceptable

Oxygen% \_\_\_\_\_ 19.5 to 23.5%

LEL% \_\_\_\_\_ Less than 10%

Required Signatures

Worker(s):

Fire Watch:

Hot Work Supervisor:

=Over for Compliance Checklist=>

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**HOT WORK CHECKLIST (CHECK TO VERIFY)**

\_\_\_\_ The work cannot be performed in a designated hot work area?

\_\_\_\_ Has the flame or spark producing equipment been inspected and found to be in good repair?

\_\_\_\_ Sprinklers where provided are in working order and will not be taken out of service while hot

work is performed?

\_\_\_\_ Atmospheric monitoring has verified the absence of explosive/flammable atmospheres (gases,

vapors, dusts, fibers) in the vicinity of the work area?

\_\_\_\_ Piping, tanks and equipment previously containing explosive/flammable/ combustible

materials have been isolated and purged?

\_\_\_\_ If there is a possibility of a leak developing in nearby piping, equipment or tanks, provisions for

continuous gas monitoring have been made?

\_\_\_\_ The work will be confined to the area or equipment specified in this permit?

\_\_\_\_ If arc welding, flash curtains have been installed to protect observers?

\_\_\_\_ Surrounding floors have been swept clean and if combustible, wet down?

\_\_\_\_ Proper class fire-extinguisher is available in the vicinity of the work area?

\_\_\_\_ All combustibles have been relocated at least 35 feet from the work area. If relocation is not

feasible, has equivalent protection been provided in the form of metal guards, flame proof tarps or other non-combustible covers?

\_\_\_\_ All floor and wall openings within 35 feet of the operations have been tightly covered?

\_\_\_\_ A trained fire watch has been assigned to watch for dangerous sparks in the work area as well

as in areas above and below?

\_\_\_\_ Arrangements have been made to patrol the area at least one half hour after work is completed

to ensure no smoldering fires exist?

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