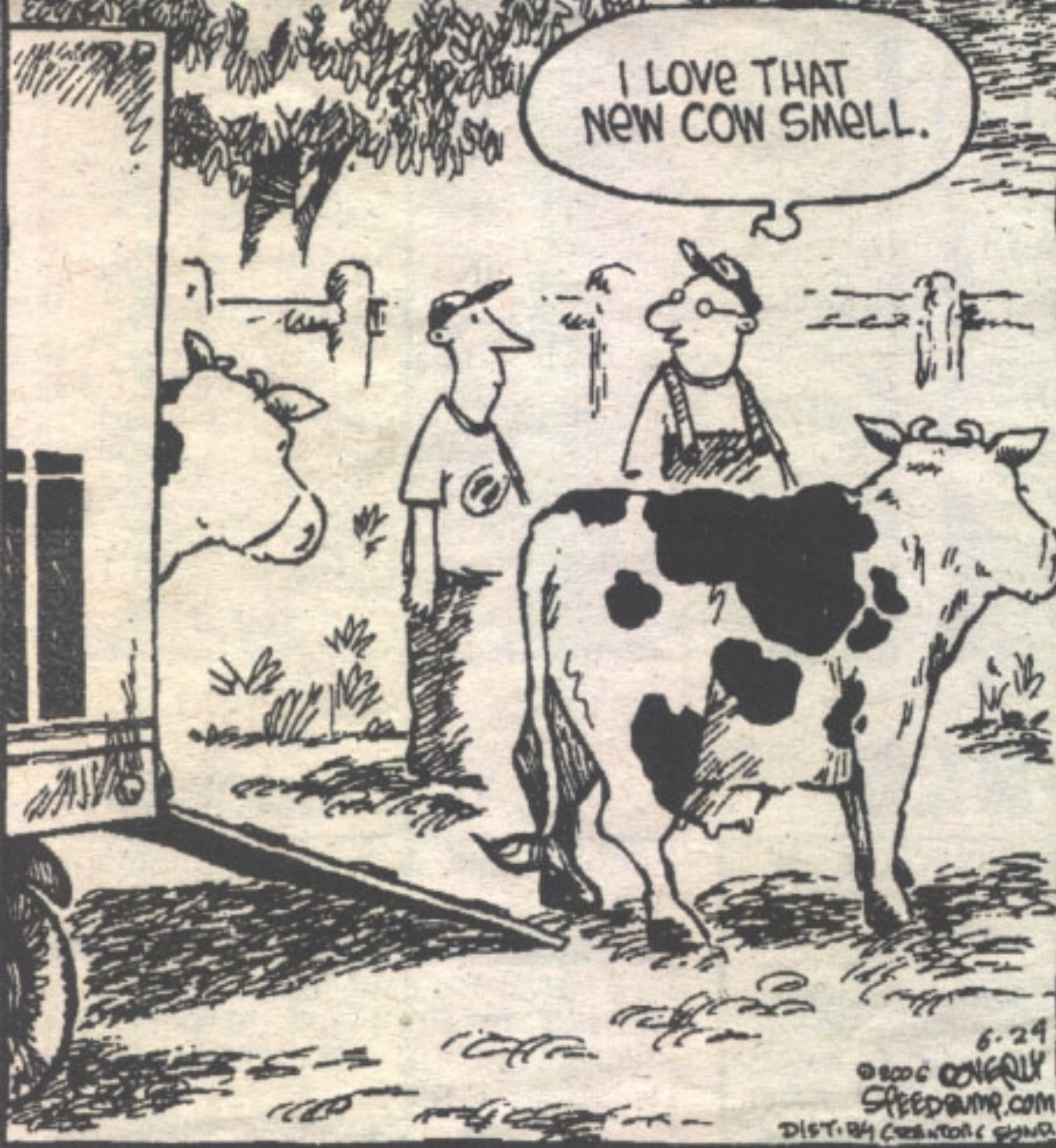




Conducting a Hazard Evaluation of an On-Farm Anaerobic Digester and Related Systems

Nellie J. Brown, M.S., C.I.H.
Director – Workplace Health
and Safety Program

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NEW COW SMELL.



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Health and Safety Program

**Hazard Evaluation from
combination of**

Process Hazard Analysis

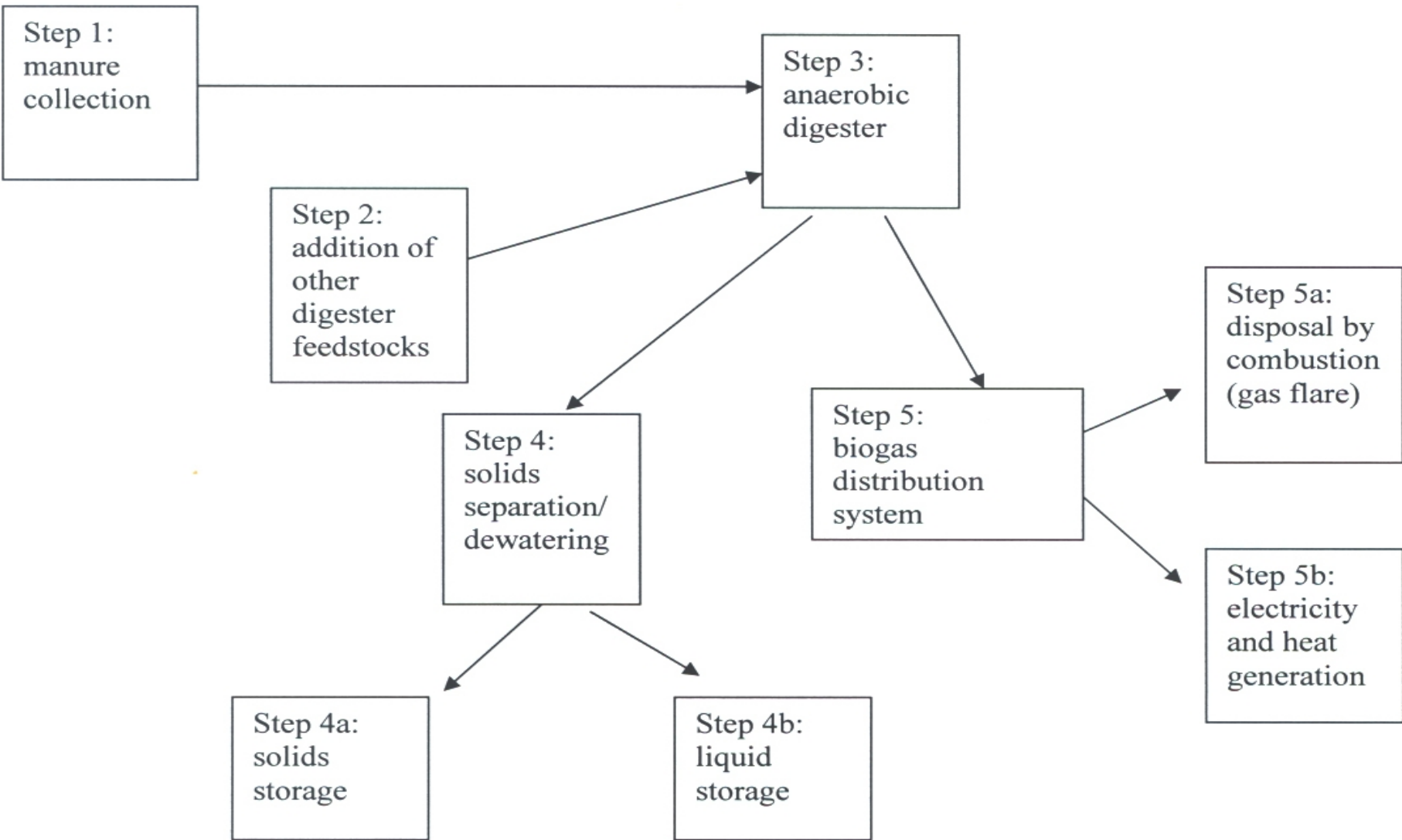
and

Job Hazard Analysis

Hazard and Operability Analysis (HAZOP)

A process failure analysis technique which examines each step or unit operation to explore all of the possible ways that failures can occur.

Unit Operations



HAZARD AND OPERABILITY STUDY (HAZOP)

| GUIDE WORDS | DEVIATION | POSSIBLE CAUSES | CONSEQUENCES | ACTION |
|--------------------|------------------|------------------------|---------------------|---------------|
| NO or NOT | | | | |
| MORE | | | | |
| LESS | | | | |
| AS WELL AS | | | | |
| PART OF | | | | |
| REVERSE | | | | |
| OTHER THAN | | | | |

When Performing HAZOP...

Consider as potential causes:

- Human error
- Design problems
- Fire
- Natural disasters such as
 - Earthquake
 - Flood
 - Wind, tornado, hurricane
 - Ice
- Power failure
- Sabotage
- Vandalism

When Performing HAZOP...

Consider as potential consequences:

- Human injury or illness
- Injury or illness to animals
- Environmental contamination
- Damage to property
- Fire or explosion
- Contaminated product(s)
- Loss of product(s)
- Monetary losses
- Loss of time

Conducting a job hazard analysis

| Steps | Hazard(s) | Evaluation | Preventive Measure(s) |
|-------|-----------|------------|-----------------------|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |
| Etc. | | | |

JOB HAZARD ANALYSIS

Consider:

**Regular procedures for both operations
and maintenance**

Off-specification procedures

**Unusual or infrequently done
procedures**

Consider any and all types of hazards and combinations

- **chemical:** adverse health effects; reactivity, fire, explosion
- **biological:** disease, allergy, inflammation, infection
- **ergonomic:** strains, sprains, over-exertions (acute or cumulative)

Consider any and all types of hazards and combinations

- **occupational stress:** including shiftwork and scheduling
- **physical:** radiation, thermal, EMF, vibration, noise
- **trauma:** slips, falls, impact, compression, cuts, amputation

Consider any and all types of hazards and combinations

- **violence:** verbal harassment, threats, physical assaults, property damage
- **indoor air quality:** non-industrial workplaces

Fatalities in Livestock Manure Storage and Handling Facilities

Principal findings for 1975 - 2004:

- 77 fatalities and 21 severe injuries
- >50% involved dairy operations
- 34% of deaths – during repair or maintenance on manure handling equipment
- 22% of deaths were performing rescue of another person

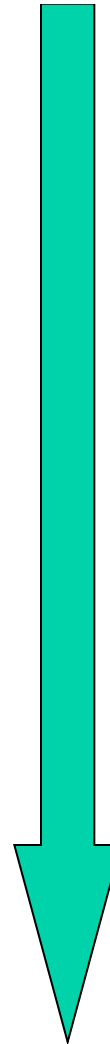
Newly-constructed biogas plant in southwestern Germany Explosion, Dec. 2007



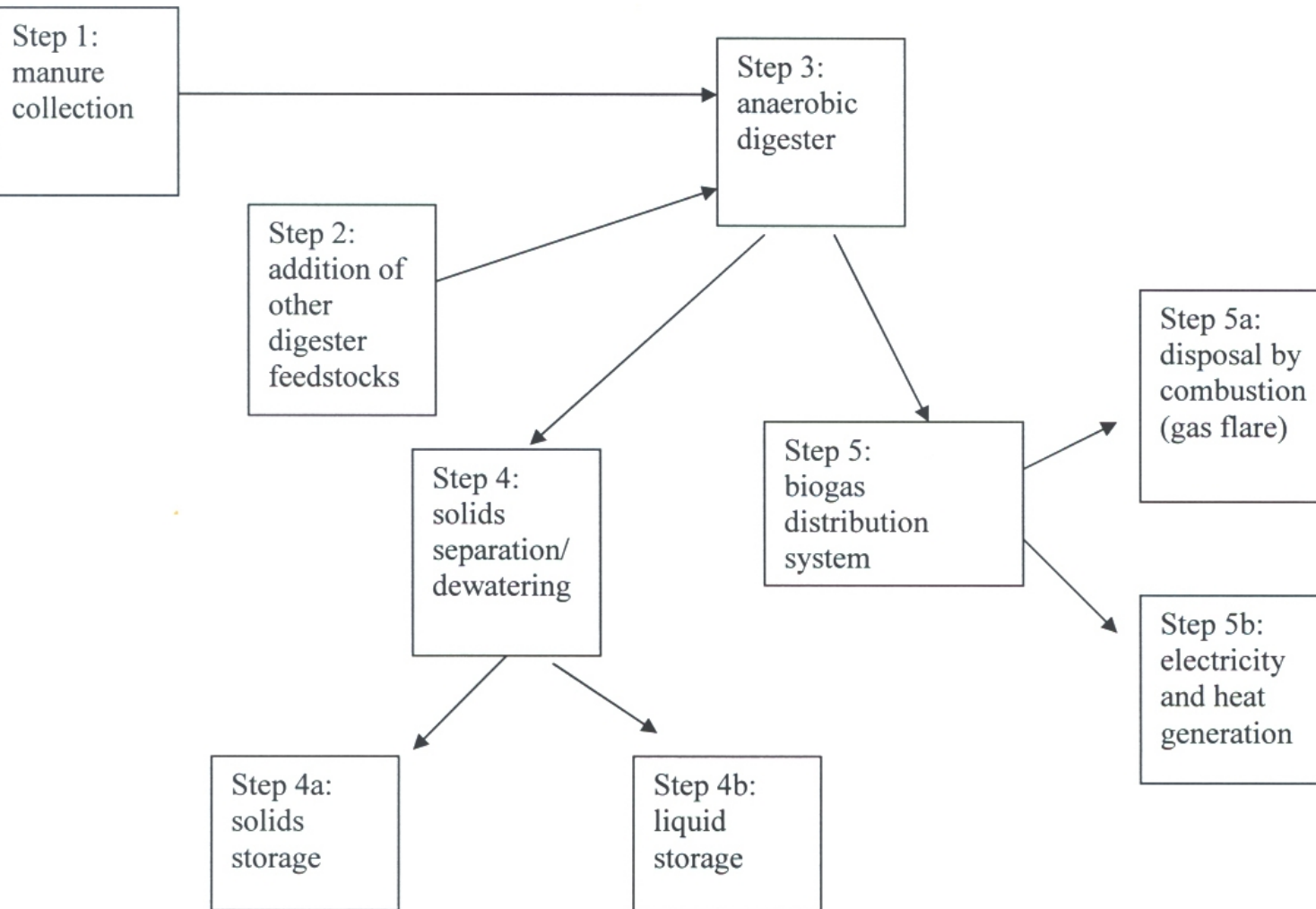
Hierarchy of Controls

- Source Reduction
 - Hazard substitution
 - Process change
- Engineering Controls
 - Enclose process
 - Mechanize process
 - Barriers / isolate hazard
 - Local exhaust ventilation
 - General dilution ventilation
- Administrative Controls
 - Housekeeping
 - Work practices
 - Sampling, testing, monitoring
 - Preventive maintenance
 - Training
- PPE (respirators, clothing, gloves)

Best



Self-Assessment Tool – some results



Manure generators



Figure 1

Alley scraper



Figure 2

Drive motor without guard - operations



Figure 3

Drive motor - Maintenance

- Lockout/de-energize electrical service
- Remove guard
- Block/chock take-up spindle

Manure pit

- Confined space
- Pump and/or agitator maintenance
- Removal of foreign object from barn
- If agitator turns on during entry, air stripping of hydrogen sulfide could be IDLH

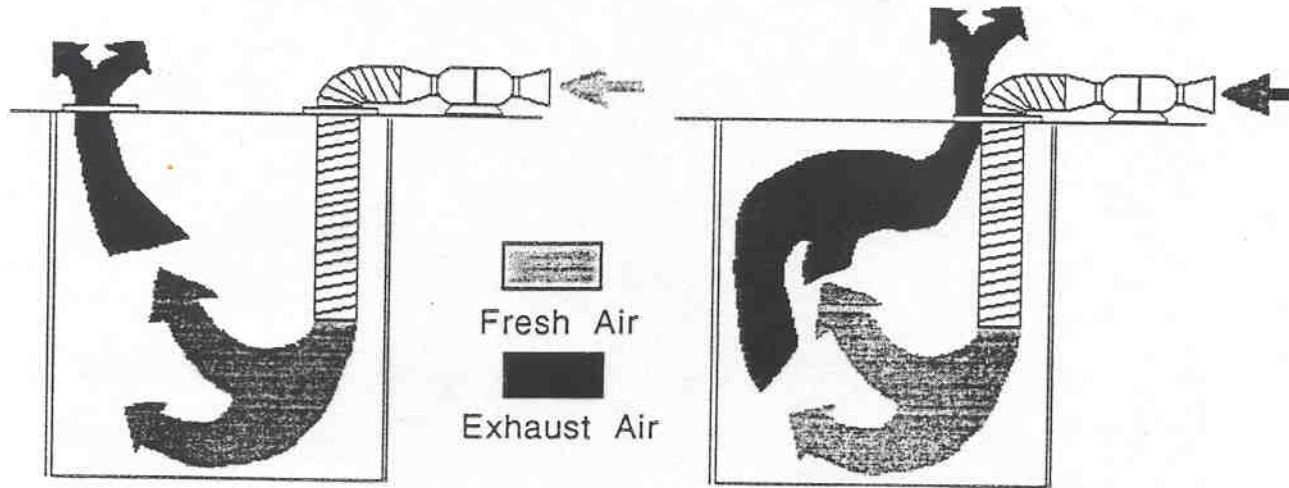
Solutions:

- Lockout/de-energize equipment
- Extract equipment for maintenance
- If entry necessary, have procedure with air testing, ventilation, & rescue

RECOMMENDATIONS BY USDHHS/ CDC/NIOSH: Manure pits on farms should be treated like any other type of confined space.

- all manure pits should be ventilated,
- the atmosphere within the pit should be tested before entry,
- a standby person should be in constant contact and ready to lift the worker to safety with mechanical lifting equipment (winch, hoist, or pulley), and
- anyone entering a manure pit should wear a safety belt or harness with a lifeline tied to the mechanical lifting device.

Ventilation of Confined Spaces



Ventilate the manure pit as per ANSI/ASABE S607

Source:

NYS. 1994. Confined space: awareness and safety. NYS Department of State. Office of Fire Prevention and Control

Tank covers



HAZARDS:

- Wooden hatch covers can weaken; even be unable to support people or equipment.

EVALUATION:

- Fall into tank with possible trauma. Engulfment (drowning) is a serious, potentially life-threatening risk.

PREVENTIVE MEASURES:

- Select materials or grides which can support weight and resist corrosion.

Digester



Figure 6

ANAEROBIC DIGESTER

MAINTENANCE TASKS

- Repair of agitators in digester.
- Cleaning of digester tank, probably after many years of operation.
- Patching of cover; from accidental damage, sabotage, or vandalism.
- Remove foreign objects which entered the system from the barn.

Biogas piping (notice scorching)

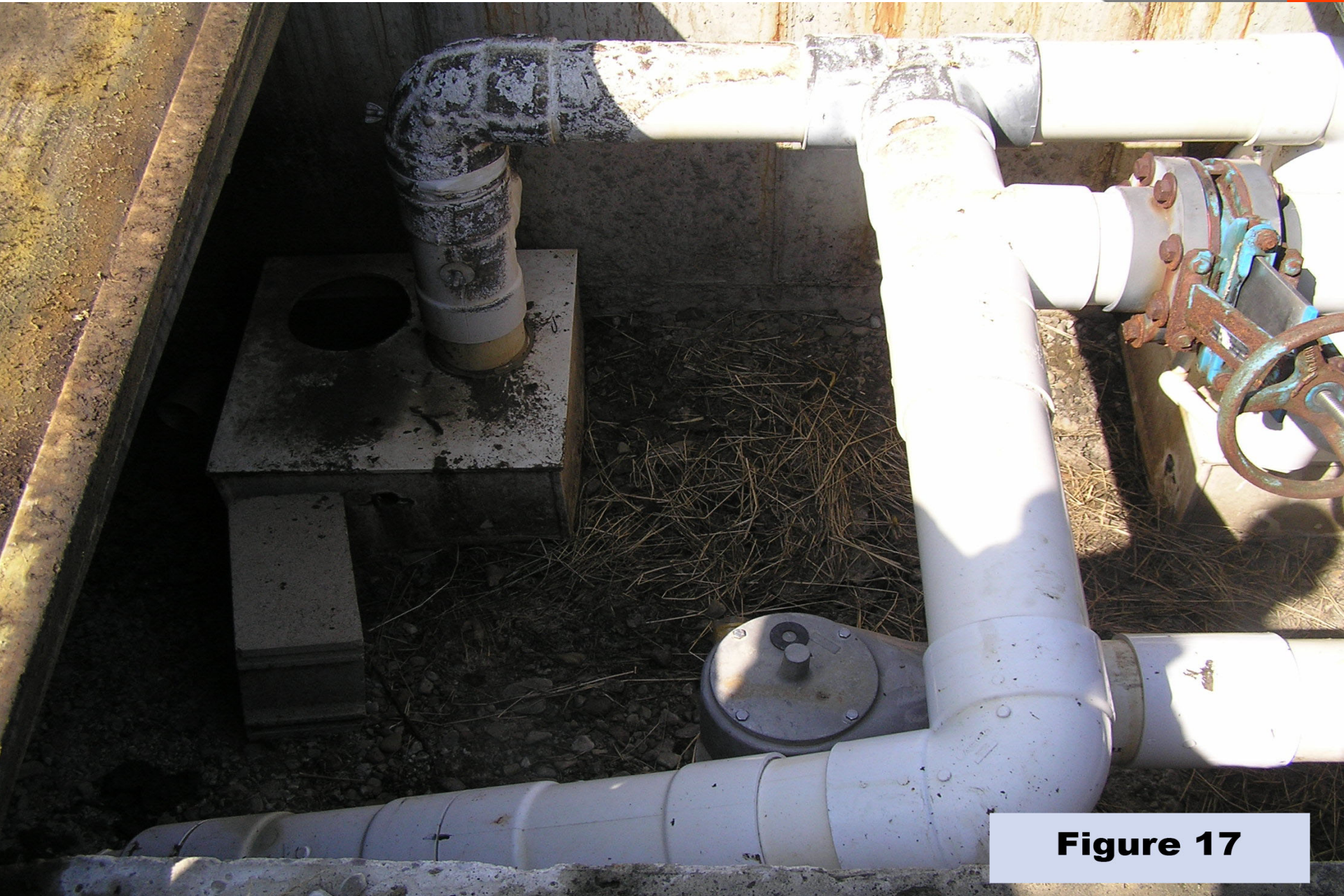


Figure 17

Biogas system

HAZARDS:

- Pit is confined space
- Reverse biogas flow from flare

CONTROLS:

- Fill in pit/elevate piping
- Flame arrestor or flash arrestor

Flare



Figure 12

Dewatering of digester solids

Thermal burns from hot screw press.

Fall to lower level through hole in floor.



Figure 9

Biogas supplied to generator

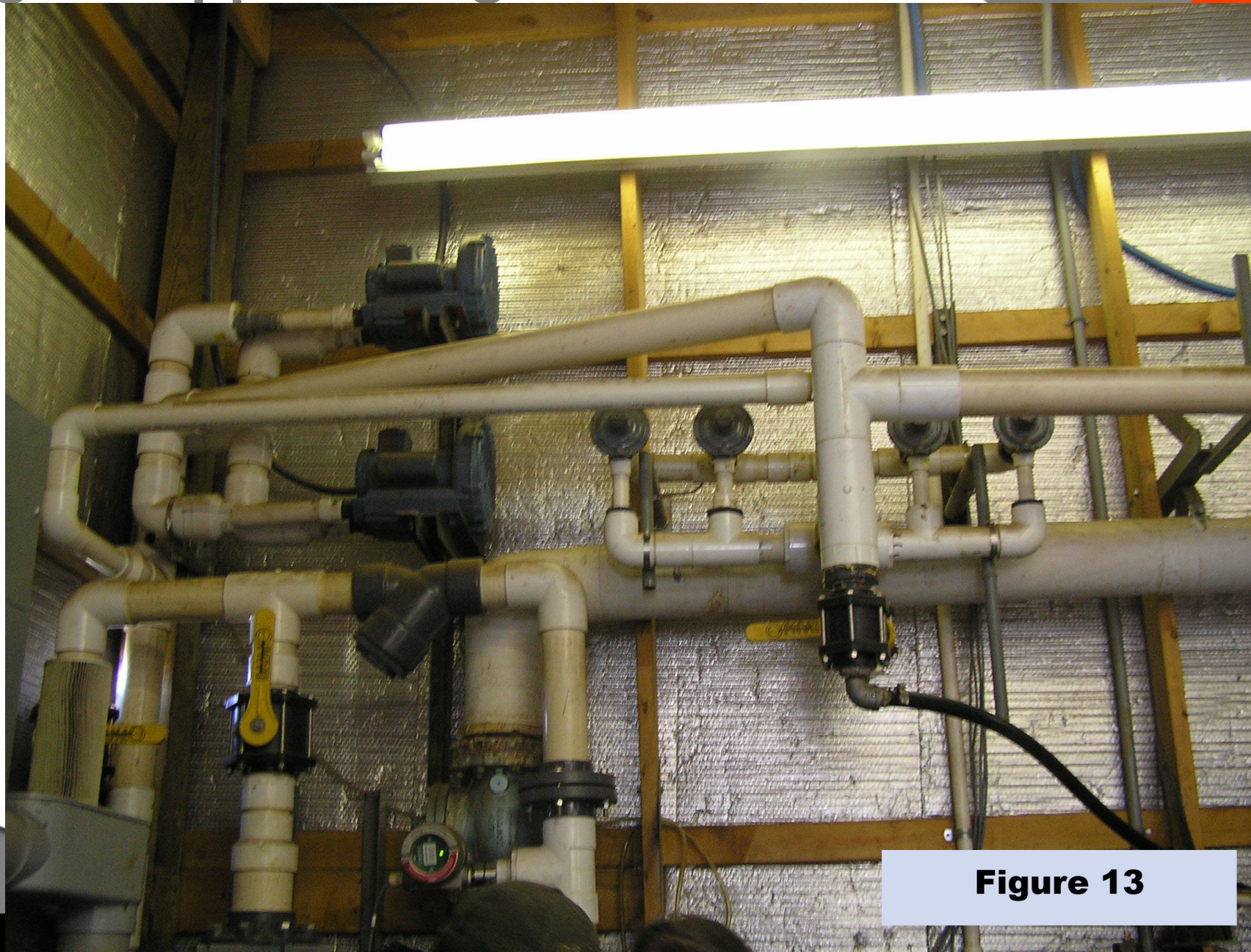


Figure 13

Biogas Piping

- Operations
 - Labeling of piping contents; direction of flow
 - Grounding and bonding for static electricity generated by non-conductive gas flowing through piping
 - Explosion-proof ventilation
- Maintenance
 - Lockout/line-breaking; isolation using valves or blanks
 - Ventilation during power failure
 - Non-sparking tools

Generator

Noise; electrical hazards; oil on floor.



Figure 20

From the on-farm safety analysis ...

...derived a Self-Assessment Protocol for use by farm owner/operators

Available at:

<http://digitalcommons.ilr.cornell.edu/manuals/13>

On-farm digester manuals for design, start-up, and operations (with safety/health) published June 2012.

Available at:

[http://www.manuremanagement.cornell.edu/Pages/Funded%20Projects/AD Workforce Development Project.html](http://www.manuremanagement.cornell.edu/Pages/Funded%20Projects/AD_Workforce_Development_Project.html)

Lessons learned from hazard evaluations of 8 digesters in NYS...

If designing a digester,

- consider maintenance tasks (not just operations tasks) and their hazards
- plan ways to avoid confined space entry
- flash arrestor

Lessons learned from hazard evaluations of 8 digesters in NYS...

If working with an existing digester:

- Develop a sensible and thorough confined space entry procedure
- Install a flash arrestor for accidental reverse gas flow
- Use strong & durable materials for tank covers and hatches
- Use good signage for confined space, flammability, and drowning hazards
- Provide adequate training for staff on the hazards and work procedures, etc.
intended to reduce risks

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