Biogas Projects – Process Hazard Analysis

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November 18, 2020

Overview

- What is Process Hazard Analysis (PHA)?
  - Goals of the PHA
- Most common methodologies
  - Pros and Cons
- Application to digester process evaluation

What is a PHA?

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Process Hazard Analysis

Process Hazard Analysis (PHA)

- Identify and understand the hazards of the process
- Understand potential hazardous events
- Prevent/mitigate hazards with safeguards
- Ask the right questions
- Look for impacts to:
  - Health and personnel safety
  - Environment
  - Business

PHA Methodologies

- Hazard and Operability Study (HAZOP)
- What If/Checklist
- Structured What If Technique (SWIFT)
- Tools
  - Process and Instrumentation Diagrams (P&IDs)
  - Site Layout
- People
  - Design team (Process, Mechanical, Electrical, I&C)
  - Safety team
  - Operations and maintenance team

HAZOP

- Separate process into “nodes”
- Use “guide words” to identify potential hazards
- Steps:
  - Define nodes throughout P&IDs
  - Evaluate each node without safeguards and identify hazards
  - Assign preliminary risk
  - Put in safeguards (instruments, control elements, etc.)
  - Assign revised/residual risk
  - Determine whether additional safeguards are required or recommended

PARAMETERS	GUIDEWORDS	DEVIATION
PRESSURE	LOW/NO/VACUUM - HIGH	Low Pressure - high pressure - Vacuum
TEMPERATURE	LOW – HIGH	Low Temperature – High Temperature
FLOW	REVERSE/MISDIRECTED – LOW/NO – HIGH	Low/No Flow – High Flow – Reverse Flow
LEVEL	HIGH – LOW	Low Level – High Level
MIXING/SEPERATION	LESS – MORE - INADVERTANT	Less Mixing – More Mixing – Inadvertent Mixing
REACTION	LESS - MORE	Less Reaction – More Reaction
VISCOSITY	HIGH - LOW	Low Viscosity – High Viscosity
COMPOSITION	WRONG	Wrong Composition

Risk Matrix

MONTROSE TECHNOLOGICAL RISK MATRIX									
RISK CLASS	**Severity Types**				**Likelihood / Frequency**				
	Health & Safety	**ENV**	**Business**	**RR**	**L 1**	**L 2**	**L 3**	**L 4**	**L 5**
					RARE Physically possible, but unknown to have occurred anywhere in life of all similar processes.	**EXTREMELY UNLIKELY** Potential to occur once in the lifetime of several similar processes	**VERY UNLIKELY** Potentially could occur once in the lifetime of this process	**UNLIKELY** Potentially could or has occurred once in this process within last 5-10 years.	**LIKELY** Potentially could or has occurred in this process, more than once per year.
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Risk Matrix – Likelihood/Frequency

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		Likelihood / Frequency				
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OK	**S 1**	**2**	**3**	**4**	**5**	**6**

Risk Matrix – Risk Class

					process
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Risk Matrix – Identifying Risk

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What If/Checklist

- Generate a series of “What If” questions – what could go wrong in the process?
- Brainstorm hazards and subsequent mitigation measures/actions based on design standards, prior knowledge

Figure 1 - Example Worksheet Excerpt from What If/Checklist PHA Methodology
C= Consequence Class, L= Likelihood Class, R = Risk Class

What If...	Consequences/ Hazard	Safeguards	C	L	R	Recommendations/ Action
Emergency Shutdown Valve 23 (ESD - 23) fails to close when needed? (This can occur due to extremely cold weather, reliability due to inspection/ testing/maintenance or design problems) ❶ ❸	Release of highly flammable materials in the operating area. Potential for fire/explosion with employee injuries/fatalities ❶ ❸	1. Specific Inspection/testing/ maintenance program for ESDs 2. Valve actuator sizing 3. ESD-23 is fail closed design ❷	4 ❹	2 ❹	B ❹	1. Due to cold weather modify MI procedures to increase ESD valve testing to 1/2wks. 2. Inspection records for ESD 23 not in file, follow-up to assure ESD-23 inspected as required by MI procedures 3. No equipment data sheet was found for actuator for ESD-23, follow-up with engineering to assure design is correct. 4. Consider over sizing valve actuator

Source: OSHA

PHA Methodologies – Pros and Cons

- **Hazard and Operability Study (HAZOP)**
  - Pros: very structured and thorough
  - Cons: very time-consuming (weeks)
- **What If/Checklist**
  - Pros: shorter duration (days); easier to apply; more likely to identify issues outside process boundaries
  - Cons: less structured; quality of outcome depends on team focus
- **Structured What If Technique (SWIFT)**
  - Combines the structure of the HAZOP, including using the Risk Matrix and Guidewords with the brainstorming of the What If/Checklist

Application to Digester Process

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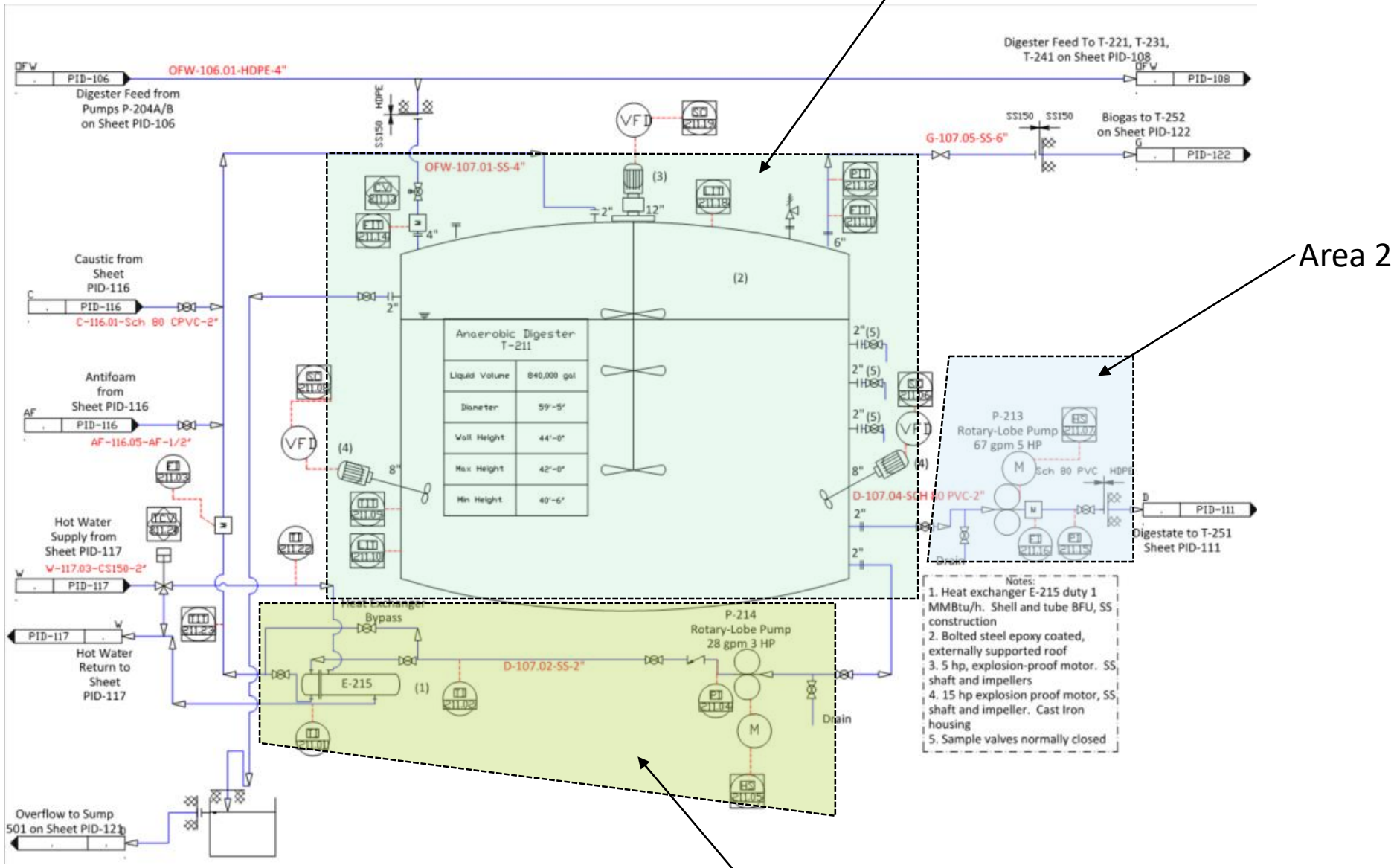
SWIFTApproach

Step-wise through P&IDs, line-by-line, by equipment, by area; identify relevant process parameters and ask What If questions



P&ID Review

Underpressure of the Tank

- **Hazard: What If the tank pressure falls to vacuum?**
- **Consideration: the tank and/or roof could collapse**
- **What is the likelihood rating?**
  - L3 – could potentially occur once in the lifetime of the project
- **What is the consequence rating?**
  - S2 – moderate; single onsite permanent effects – damage to the tank
- **Assessed Risk: 5**
- **Mitigation: pressure/vacuum relief valve prevents underpressure**
  - Reduces likelihood to L2 – Residual Risk: 4

Digester Underpressure
100-1: Assessed Risk

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Digester Underpressure
100-1: Residual Risk

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P&ID Review

Overpressure of the Tank

- Hazard: What If the tank becomes over pressured?
- Consideration: the roof may blow off, explosion of gas, rupture the tank
- What is the likelihood rating?
  - L3 – could potentially occur once in the lifetime of the project
- What is the consequence rating?
  - S4 – major; fatality, offsite effects – launched debris
- Assessed Risk: 7
- Mitigation:
  - Pressure/vacuum relief valve prevents over pressure
  - Over pressure alarms
  - Tank overflow allows pressure to escape
- Reduces likelihood to L2 – Residual Risk: 6

Digester Overpressure
100-2: Assessed Risk

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Digester Overpressure
100-2: Residual Risk

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P&ID Review

Gas Leak from the Tank

- **Hazard: What If there's a gas leak from the tank?**
- **Consideration: explosion potential, H2S exposure to personnel**
- **What is the likelihood rating?**
  - L3 – could potentially occur once in the lifetime of the project
- **What is the consequence rating?**
  - S4 – major; severe injury, fatality, offsite effects – launched debris
- **Assessed Risk: 7**
- **Mitigation:**
  - Personal H2S monitors
  - Proper electrical hazard classified areas (C1D1, C1D2)
  - Open site layout to prevent gas accumulation
- **Reduces Risk Class to S3 – Residual Risk: 6**

Digester Gas Leak
100-3: Assessed Risk

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Digester Gas Leak
100-3: Residual Risk

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Risk Assessment Summary

Area 1 – Digester

Hazard Tag	Area	Category	Hazard	Consideration	Likelihood Rating	Consequence Rating	Assessed Risk	Mitigation	Residual Likelihood	Residual Consequence	Residual Risk	Comments / Action
100-1	1 - Digester	ENV/Business	Underpressure	collapse of tank/roof	L3	S2	5	PRVR	L2	S2	4	
100-2	1 - Digester	Health & Safety	Overpressure	blow off roof, explosion of gas, rupture tank	L3	S4	7	PRVR over pressure alarms/switches shut down, overflow line allows pressure release	L2	S4	6	
100-3	1 - Digester	Health & Safety	Gas leak	H_2S exposure to personnel; explosion potential	L3	S4	7	Personal H_2S monitors; Class 1 Div 1 zones around potential leak points and Class 1 Div 2 for additional nearby equipment; open areas to prevent gas accumulation	L3	S3	6	

Thank You

