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Methanization: how can the sector be developed without increasing the risks?

Methanization is one of the key technologies of the circular economy and green growth. Within the framework of the Energy Transition Act, France has set itself the target of ensuring that 10% of the gas it consumes will originate from renewable sources by 2030. The development of methanization is one of the main levers to achieve this objective. The sector is expanding rapidly with 80 additional installations and the doubling of the production of biomethane injected into the natural gas networks in 2017. To achieve the objective by 2030, the Renewable Energy Liberation Plan provides for various incentive mechanisms. These include simplification measures at the regulatory level.

The adaptation of the French ICPE (Classified Installations for the Protection of the Environment) nomenclature thresholds (section 2781) will thus allow for a large number of installations to be installed (capacity < 100 t/d, as opposed to 60 t/d previously) and then operated according to the simplified "registration" procedure, providing for a reference to standard requirements. This simplification should not obscure the detailed analysis that operators must conduct for the implementation of these requirements with regard to their installations. A precise list of specifications to be observed must be established. It requires even more attention as it is part of an emerging sector that is still being developed. Several recent accidents (the events recorded in the ARIA database were up 82% in 2017 compared to the average over the previous 5 years) remind us that methanization is a real industrial process that needs to be seen as such. An overview of the risks associated with these installations is provided on page 3.

ARIA 50490 - 15-09-2017 - FRANCE

In a methanization plant, the membrane on a digester burst, ripping away pieces of a concrete cast wall. The liquid digestate storage bladder was punctured and its contents were released.

The bursting was due to the presence of matter emulsion in the digester, probably formed due to an organic overload. The high level alarm in the digester had not been triggered. The production of gas on the inside of the bladder resulted in a rapid increase in pressure, causing it to burst. The manufacturer had not considered this scenario when selecting safety equipment and in the design of the monitoring and control system. The operator implemented the following measures following the accident:

- more frequent verification of the level probes;
- installation of new raise safety valves with goosenecks;
- implementation of a more gradual load increase to minimise the risk of foaming;
- implementation of an instruction involving the verification of the digester's contents through the observation ports.

What is methanization?

Methanization involves an anaerobic fermentation process, which consists of the degradation of organic matter by the successive actions of micro-organisms, under controlled conditions and in the absence of oxygen. This degradation process produces biogas (essentially composed of CH4 and CO2), and a residue called "digestate".

The methanized materials can be of agricultural (animal waste, crop residues, etc.), agro-industrial (food-processing, chemical and pharmaceutical industries, etc.) or municipal origin (fermentable fraction of household waste, sewage sludge, etc.).

Four sectors can thus participate in the development of methanization: agriculture, industry, waste processing and water purification. The ARIA database lists accidents in each of these 4 sectors.

Puncture of a liquid digestate storage bladder (source: SDIS, departmental fire and rescue service)

ARIA 51342 - 04-04-2018 - FRANCE

An explosion followed by a fire occurred on the post-digester gasometer of an agricultural methanization unit. A subcontractor was performing maintenance on the post-digestion tank's agitator. The post-digester had been degassed, then uncovered and the agitator had been reassembled. The explosion occurred during the initial operational test of the agitator. Faulty installation was the cause of the incident: the agitator's support system was not connected to the site's ground terminal on its metal casing. When the power supply to the agitator was switched off, the exposed conductive part of the agitator discharged on the agitator guide system causing an electric arc (ignition source and fire in the ATEX zone). The certified bodies had not detected the problem during the initial visit and the periodic inspections.

ARIA 49833 - 16-06-2017 – FRANCE

In a sewage treatment plant, biogas discharges were occurring at the sludge digestion plant over a period of 3 days. The releases coincided with unplanned plant shutdowns. The automated trips were caused by 2 methane sensors failing on the gasometer's double-walled casing. These failures, which occurred at midday, were caused by sensors overheating as a result of direct exposure to solar radiation.

The shutdown of the systems downstream of the digesters caused the pressure in these vessels to increase, triggering the opening of the safety valves. The biogas was directed to a flare tower. However, the automated control system, which had initiated the emergency stops, also extinguished the flare in an abnormal manner. The biogas was thus released into the atmosphere without prior combustion.

Following the accident, the operator modified the PLC so that the flame tower would not be extinguished during emergency stops. It plans to protect the CH4 sensors from solar radiation by means of "caps" or to replace them with sensors that use another technology.

ARIA 49145 - 20-01-2017 - FRANCE

Offensive odours, coming from the wastewater retreatment plant of a cheese factory, inconvenienced the residents over a period of 4 days. The operator noted the following:

- a significant imbalance in the methanizer's operation due to the fact that some of the effluents to be treated arrive directly to the pumping station;
- the soda used to correct the pH entering the methanizer had frozen during cold temperatures due to a faulty heating element on the injection circuit;
- a significant increase in the level of odorous gases resulted in the failure of the initial regulation of the air treatment system.

The release of odours was amplified by the contextual increase in the volumes of effluent injected into the methanizer.

Deterioration of a digester by corrosion (source: DREAL)

Recent accidents show that we are dealing with a sector that is currently undergoing structuration and which has not yet reached maturity. Design errors were responsible for this situation. Operators must therefore be especially vigilant when designing, accepting and testing equipment prior to commissioning. All control and safety chains must be tested and validated. Beyond the safety rules specifically applicable to each sub-system of the methanization facility (digester, biogas lines, flare tower, etc.), **some recommendations** can be made:

- **Monitor** the nature of incoming materials. Even if this is not provided for in the regulations, establish specifications defining the quality of eligible materials with the associated verification criteria. Adapt operating procedures to the nature/quantity of materials processed (ARIA 49145, 50072, 50490). Attention should be paid to the consequences of modifications made to the process during degraded phases, such as works (ARIA 30686).
- **Provide** technical hazards training for all employees, including temporary workers/subcontractors (particularly important in agricultural facilities, often operated with less resources and a less developed safety culture than large-scale industrial methanizers). Monitor the work performed by subcontractors.
- **Pay particular attention** to the acceptance of facilities prior to the start of operations to ensure compliance and suitability of their design (ARIA 33948, 40476, 42076, 48311, 51174). Be particularly vigilant during commissioning operations, and restarting after stop/testing, etc. (ARIA 42923, 44510, 33948, 50490).
- **Ensure** a rigorous maintenance and monitoring plan for ageing of installations (corrosion, fatigue, etc.), as the materials involved in methanization are corrosive (ARIA, 43900, 44662, 47989, 49095, 32817, 41671, 51174). Frequently check the integrity of equipment, including electrical installations (ARIA 47799, 44748, 33097, 38944).
- **Ensure** that alarm systems and safety automatisms are operating properly for effective recovery in the event of operational deviations. Take feedback into account following malfunctions (ARIA 47989, 49983, 51335, 47809, 45391).
- **Ensure** that the installations are rugged enough to withstand meteorological and climatic phenomena (frost, high heat, lightning, wind, heavy precipitation/flooding, etc.): ARIA 49169, 42739, 47807, 47808, 35673, 47764, 48227, 51053, 51058).

For further information: consult the INERIS documents regarding methanization (in French)

These studies target agricultural methanization practices, targeted primarily by the government to develop the sector, but their recommendations can be transposed to installations that process urban waste, industrial effluents or treatment plant sludge.

Overview of the risks associated with methanization activity (according to the *Good practices in agricultural methanization*, INERIS, March 2018)

A process involving physical, chemical and biological reactions, methanization presents various situations that are sources of emissions and risks that must be controlled.

Dangerous phenomena	Units/Activities concerned	Examples
Fire: Combustible materials are likely to burn uncontrollably in the presence of air and a source of ignition (sparks, heat, hot spot operations, etc.).	Combustibles present: • solid inputs, even some liquid inputs; • biogas; • flexible tarp, miscellaneous construction materials; • waste, combustible dust, oily residues; • active carbon (used for the pre-treatment of biogas); • fuel for engines, heating oil, etc.	• Electrical fire in a service room (ARIA 38944); • Fire in the methanization residue drying tunnel (ARIA 51011); • Fire on a digester sludge conveyor dryer (ARIA 42076); • Fire on the net metering electrical meter (ARIA 45489); • Fire on the roof of a methanizer (ARIA 35673); • Fire following welding operations in a digester (ARIA 42342).
Explosion: Flammable gases (biogas, gases used during hot spot work) and powdery combustible dust suspended in a confined space mixed with air may generate an explosion (ATEX) should they come into contact with an ignition source.	Confined environments present: • inside of silos containing powdery products; • digester interior/biogas buffer storage (accidental inlet of air in the presence of biogas); • inside rooms containing biogas piping (plant rooms, cogeneration rooms, etc.).	• Explosion of a digester following work (ARIA 46329); • Explosion of a biogas storage facility (ARIA 42322); • Explosion in a post-digester during a maintenance operation (ARIA 51342).
Physical rupture or bursting: Inside digesters and gas storage tanks, over pressurization can occur, leading to rupture or pneumatic bursting. The consequences are pressure effects, discharge of the digestate, mixing of the biogas released into the air (explosion/fire risk).	• Digester and post-digester; • Biogas storage (built into the digester and/or post-digester or in a gasometer).	• Overpressure inside digesters due to malfunction of a flare tower and safety valves caused by freezing temperatures (ARIA 42739); • Bursting of 2 digesters during start-up (ARIA 32040).
Gaseous emissions: In addition to ducted emissions (stack) and diffuse emissions (open-air storage facilities, etc.), fugitive emissions can come from a variety of equipment (pipes, pumps, etc.) and result in biogas leaks (environmental, health and fire or explosion risks).	• During normal operation of the facility: emissions from the digester's hydraulic valve, leaks on flanges, malfunction on the flare tower, diffuse emissions from the open feedlot runoff storage areas, digestates, etc. • In an emergency situation: pull-out of the biogas line, membrane lifting/stripping/tearing, etc.	• Biogas leak on piping (ARIA 44662), on valve/seal (ARIA 44307, 47799); • Ripping away of a biogas line (ARIA 42731); • Biogas leak on a digester (ARIA 29407, 42923); • Stripping/ripping of a flexible membrane (ARIA 40476, 47764); • Release of biogas to the digester's safety valve following a flare tower malfunction (ARIA 42739, 47808); • Emissions of NH3 during digestate storage (ARIA 48883).
Release of liquid or semi-liquid materials: Releases are possible in the event of a rupture (massive release) or loss of integrity. These releases may result in water and soil pollution.	All structures with liquid or semi-liquid materials: storage steps, digester, post-digester, liquid materials network.	• Loss of digester integrity as a result of corrosion (ARIA 41671, 43900); • Spillage caused by valves left open (ARIA 43753); • Spillage associated with foaming in a digester (ARIA 49169) or in a storage/mixing tank (ARIA 45391, 50072); • Spillage following a level sensor failure (ARIA 41701); • Puncture of a flexible storage bladder containing liquid digestate (ARIA 50490); • Aquatic pollution following the spillage of input 'juices' (ARIA 46437).
Release of contaminated rainwater: If it is impossible to keep and store a large quantity of rainwater contaminated by the materials on the site. Potentially resulting in the pollution of nearby rivers and soils.	Storage of solids, pre-treatment steps of the materials when they are located outdoors.	• Contamination of a river, most likely the result of a malicious act (ARIA 37842); • Spillage of polluted waters in the natural environment (ARIA 50461).