# HAZARDOUS AREA CLASSIFICATION FOR WASTEWATER TREATMENT PLANTS USING BY DECREE AND STANDARD

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***Abstract***
*In the case of explosive technology, if there is a technological situation that has a fundamental impact on safety, there may be several possible solutions. This paper investigates this question at a biogas technology system of a wastewater treatment plant. The hazardous area classification of the plants in the exemplary wastewater treatment plant, based on the Decree 3/2009 (II.4.) of Ministry of Local Government on Technical Requirements for the Fire Protection of Installations using Renewable Energy Sources - Biogas, Bioethanol, Biodiesel and the MSZ EN IEC 60079-10-1:2021 Explosive atmospheres. Part 10-1: Classification of areas. Explosive gas atmospheres (IEC 60079-10-1:2020)".*

***Keywords:*** *hazardous area classification, explosive atmosphere, ATEX, wastewater treatment plan*

## 1. Introduction

The wastewater treatment plant used as an example in this present research is a conventional, continuous aerobic technology, as illustrated in Figure 1. The main units of the technology are:

- wastewater reception, mechanical and biological treatment,
- disinfection, wastewater disposal,
- sludge treatment (sludge reception, thickening, filtration and dewatering facilities),
- anaerobic sludge digestion,
- biogas treatment, biogas recovery and chemical plants.

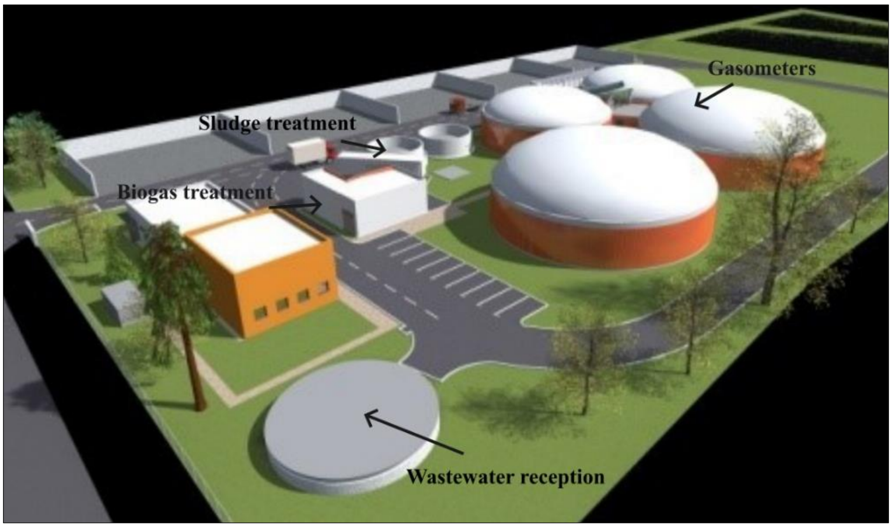


***Figure 1.*** *An example of typical biogas technology plant* (*http://heket.hu/portfolio-view/biogaz-eromu)*

This technology involves a number of explosive devices. Defining the optimum conditions for safe operation as an objective may at first seem idealistic, but in order to remain grounded in reality, a position, an acceptable safety, technical and economic level must be defined (Pekalsi et al., 2005).

It is important to highlight that the investment and operating costs of potentially explosive technologies are significantly determined by the type and extent of the explosive zones that are identified. Compared to the cost of standard industrial design equipment, explosion-proof is 2-3 times more expensive for Zone 2 spaces, 4-6 times more expensive for Zone 1 spaces and 8-10 times more expensive for Zone 0 spaces (Vianello et al., 2019). For this reason, it has paramount importance to know the cost level at a plant can be designed and operated.

## 2. Technology description

The sludge treatment aims anaerobically stabilising (Biniaz et al., 2021; Sing et al., 2018) and dewatering the raw sludge and biological sludge generated at the site. After cleaning and conditioning, the resulting biogas is used to generate electricity in a gas engine and heat in a boiler room.

Anaerobic (digestion) is the process of decomposition in which organic material is transformed biologically in an enclosed environment. This process produces methane-rich gas and biological manure. The biogas composition contains approximately 40-70% methane (Karthick et al., 2022).

The primary and excess sludge from the sewage treatment plant is anaerobically digested in mesophilic digesters. The digesters are fed with the sludge and the sludge is pumped to the digesters by pumping stations, which are generally located next to the digestion tanks/pool, usually in a reinforced concrete shaft. These stations consist of additional screw pumps.

The biogas storage system consists of a buffer space filled with gas above the liquid surface, followed by a separating - moving - membrane and an upper membrane made of weatherproof material (UV, wind and snow load), filled with air and stretched by the internal pressure (Khan et al., 2017). The space between the upper and the inner moving membrane is operated by continuous air injection (1 operational, 1 reserve), thus providing both a stable base pressure and a variable biogas volume flow rate. The operating pressure is 2-5 mbar(g).

Further conditioning of the biogases is carried out in a station consisting of a condensate separator, an activated carbon biogas filter and pressure boosting units. It is also where the biogas is measured for quantity and quality.

From the conditioning station, the primary use of the cleaned and pre-compressed biogas can be in the gas engine - generator unit.

The biogas utilisation system can be equipped with a safety biogas combustion device, and a flare (US EPA Sec. 3, 2017).

Figure 2 shows a simplified flow chart of wastewater treatment plants.

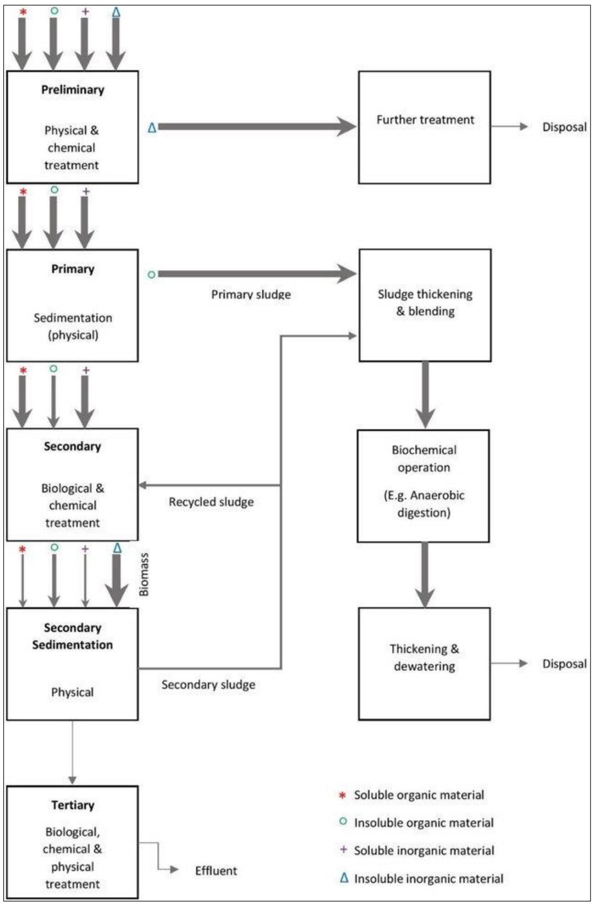


***Figure 2.*** *Flow chart of wastewater treatment plants (Mohsenpour et al., 2021)*

## 3. Hazardous area classification of potentially explosive atmospheres in a wastewater treatment plant

The biogas in the technology contains high amount of methane, so according to Point (1) (an) of Article 9.§ of the BM Decree 54/2014 (XII.5.) (BM Decree 54/2014 (XII.5.), 2022), "biogas" combustible gas or vapor are classified as "Highly inflammable or explosive" due to their use in the process (because of high methane).

### 3.1. Identified explosion risks due to gases, vapours and mists - based on the Decree 3/2009 (4.II.) of Ministry of Local Government

The hazardous area classification of the wastewater treatment plants mentioned in the study was carried out on the basis of the Decree 3/2009 (II.4.) of Ministry of Local Government (Decree 3/2009 (II.4.), 2009). The extent of the identified explosive atmospheres is shown in Table 1. The identified explosion hazard areas are presented in a visual representation in Figure 2.

Based on Section 6 (1) of the Decree 3/2009 (II.4.) of Ministry of Local Government, Zone 0 explosive atmosphere area was established

- in the interior of the gasometer,
- up to the upper edge of the digestion tanks/pool (above the liquid level),
- the interior of the biological desulphuriser,
- inside the technological equipment of the conditioning station,
- the interior of process piping.

The gasifier basin is not specified in the decree, so it is identified as a gas pre-treatment and dehydration basin for technological purposes.

Based on Section 6 (2) of Decree 3/2009 (II.4.) of the Ministry of Local Government, Zone 1 explosive atmosphere area was established

- within a radius of 3.0 m around the sampling points,
- within a radius of 3.0 m from the upper edge of the digestion tanks/pool,
- the interior of the pump shaft
- 1.0 m radius around the cleaning pump,
- 3.0 m radius around the safety valve.

Based on Section 6 (3) of Decree 3/2009 (II.4.) of the Ministry of Local Government, Zone 2 explosive atmosphere area was established

- within a radius of 3.0 m around the sampling points (beyond the Zone 1 explosive area),
- within a radius of 3.0 m from the upper edge of the digestion tanks/pool (beyond the Zone 1 explosive area),
- up to a height of 0.8 m from the top of the pump shaft and 2.0 m laterally from the edge of the shaft,
- within a radius of 3.0 m around the cleaning pump (beyond the Zone 1 explosive atmosphere),
- within a radius of 3.0 m around the safety valve (beyond the Zone 1 explosive atmosphere).

***Table 1.*** *Explosion atmosphere defined by Decree 3/2009 (II.4.) of the Ministry of Local Government*

| No. | Type | Location | Zone type | Zone extent | | Note |
|---|---|---|---|---|---|---|
| | | | | Vertical [m] | Horizontal [m] | |
| 1. | Flange joints, fittings | Biogas pipeline | 2 | 3.0 | 3.0 | The interior Zone 0. |
| 2. | Safety valve | Gasometer | 1+2 | 3.0 + 3.0 | 3.0 + 3.0 | The gasometer interior Zone 0. |
| 3. | Liquid surface | Digester tank/pool | 0 | To the upper edge of pool/tank (above the liquid level). | | - |
| 4. | Liquid surface | Digester tank/pool | 1+2 | 3.0 + 3.0 | 3.0 + 3.0 | From the upper edge of the pool/tank. |
| 5. | - | Biological desulphurisation | 0 | Total interior space | | - |
| 6. | - | Conditioning station | 0 | Total interior space | | - |
| 7. | Flange joints, fittings | Sampling point | 1+2 | 3.0 + 3.0 | 3.0 + 3.0 | - |
| 8. | Flange joints, fittings | Pump shaft | 2 | 0.8 | 2.0 | The interior of the shaft is Zone 1. |
| 9. | Flange joints, fittings | Cleaning pump | 1+2 | 1.0 + 3.0 | 1.0 + 3.0 | - |

For a given technology, not all devices may be included in the layout drawings, for the following reasons:

- the representation of a piping system or smaller equipment would make the drawing cluttered and uninterpretable,
- the final layout does not yet exist, working drawings are available,
- not avoided, some equipment is not shown.

For similar reasons, not all emission sources are shown in Figure 3, but the more relevant ones, which are the purpose of the study, are shown. (Figures 3 and 4 illustrating the explosive hazard areas are not consistent with Figure 1.)

## 3.2. Identified explosion risks due to gases, vapours and mists - based on the MSZ EN IEC 60079-10-1:2021 Explosive atmospheres. Part 10-1: Classification of areas. Explosive gas atmospheres (IEC 60079-10-1:2020)

The area classification of the wastewater treatment plants used as an example in the study, according to *MSZ EN IEC 60079-10-1:2021 "Explosive atmospheres. Part 10-1: Classification of areas. Explosive gas atmospheres (IEC 60079-10-1:2020)"* standard (Hungarian Strandards Institute, 2021).

In the case of this standard, it allows the classifier of the areas to be more technical and therefore not always necessary to deviate towards excessive conservatism.

By that, author do not mean that the standard gives a completely free hand in defining hazardous areas. It is known that Annex C uses mathematical relationships to determine the extent and type of hazardous areas. The descriptions of these relationships are not the subject of this study.

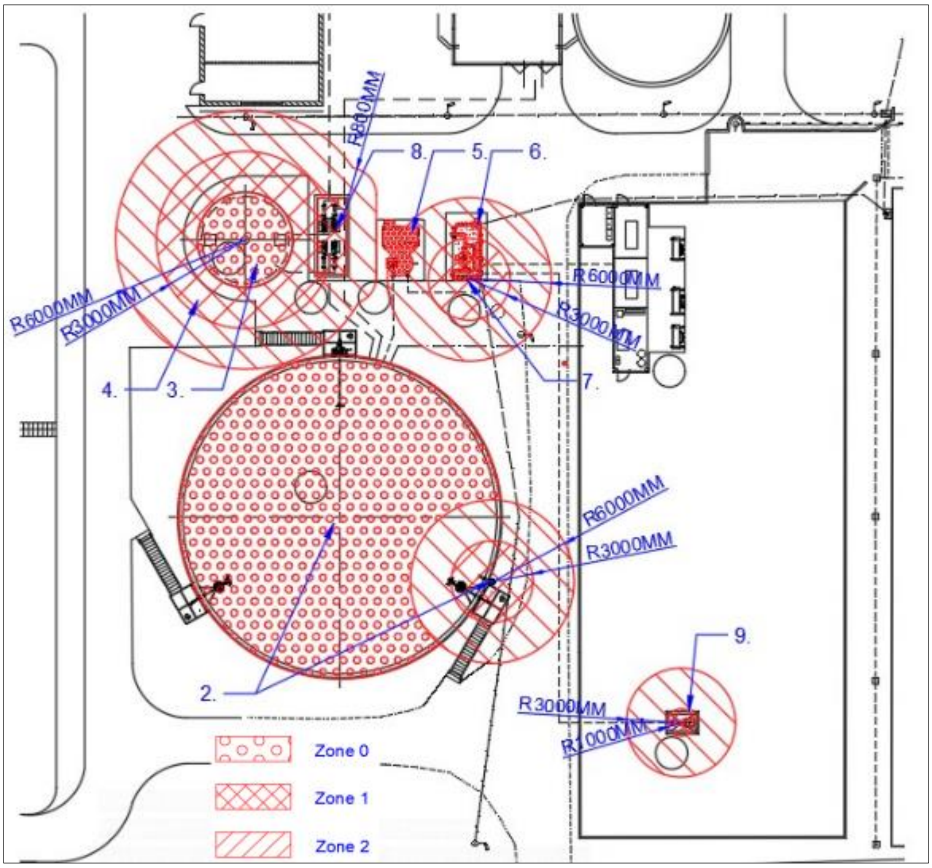


***Figure 3.*** *Representation of Potentially Explosive Atmospheres, Wastewater Treatment Plant - Technology Equipment - Decree 3/2009 (II.4.) of the Ministry of Local Government*

The extent of the identified explosive atmospheres are shown in Table 2 by standard. The identified explosion hazard areas are presented in a visual representation in Figure 4.

Under normal operating conditions, the oxygen level in the interior of biogas storage and transport equipment and pipelines is very low due to the anaerobic process. Accordingly, the risk of an explosive atmosphere forming in the interior is reduced. During the dismantling of the pipe sections, maintenance works, ambient air may enter the system and oxygen is introduced at the digesters, thus the interior of the biogas line is defined as Zone 2 hazardous area.

The flanged joints of pipelines and fittings are technically considered "Normally Sealed" according to Annex B B.2 of the standard MSZ EN 1127-1:2019 (Hungarian Strandards Institute, 2019) and are identified as secondary sources of release. The assemblies, as secondary sources of release, have been identified as a negligible (NE) Zone 2 explosion hazard area of 0.5 m in their environment, taking into account the biogas operating parameters and natural ventilation.

For the selection and operation in hazardous areas of negligible extent (NE), there is no explosion protection requirement for the product.

Only a height of 0.5 m from the surface of the liquid in the digester tank/pool is considered a Zone 2 explosive atmosphere. No other explosive area has been identified due to the lower concentration and the ventilation resulting from the openness of the equipment.

The equipment (pumps) operating at the pumping stations belonging to the gasometer were not a potential source of releases, as methane is not well soluble in the transported medium. In the event of a leakage during a mechanical seal failure of the pumps, the amount of methane escaping from the medium is considered to be negligible from an explosion protection point of view, and therefore the explosive atmosphere was not determined.

Below the open-air end of the digester and biogas tank safety valve, a conical space with a radius of 0.5 m vertically downwards and 1.0 m horizontally 1.0 m vertically and 2.0 m horizontally 1.5 m horizontally above is considered a Zone 2 hazardous area.

Taking into account the liquid seal and the water solubility of the biogas, no explosive space has been identified in the interior of the condensate collection shaft.

***Table 2.*** *Explosion atmosphere defined by MSZ EN IEC 60079-10-1:2021*

| No. | Type | Location | Zone type | Zone extent | | Note |
|---|---|---|---|---|---|---|
| | | | | Vertical [m] | Horizontal [m] | |
| 1. | Flange joints, fittings | Biogas pipeline | (NE) 2 | 0.5 | 0.5 | The interior Zone 2. |
| 2. | Safety valve | Gasometer | 2 | Up: 2.0<br>Down: 0.5 | 1.0 + 1.5 | The gasometer interior Zone 2. |
| 3. | Liquid surface | Digester tank/pool | 2 | Up to 0.5 m from the surface of the liquid. | | - |
| 4. | - | Biological desulphurisation | 2 | Total interior space | | - |
| 5. | - | Conditioning station | 2 | Total interior space | | - |
| 6. | Flange joints, fittings | Sampling point | 2 | 1.0 | 1.0 | - |

## 4. Summary

The difference in zone types and extents of the area classification carried out for the biogas technological system of a wastewater treatment plant according to two methods is thought-provoking. Is operation with smaller zone extents acceptable, does it provide sufficient security?

The answer is already in the relevant decree 3/2009. (II. 4.) of the Ministry of Local Government was formulated, as it describes that "if, during the establishment, it is desired to create a zone classification of a different type and extent than that specified in the text of the decree, it can only be implemented in accordance with the provisions of the relevant standards or in accordance with an equivalent technical solution. This is proven by the documentation prepared by the designer, which includes the classification of explosive zones (Decree 3/2009 (II.4.), 2009)."

Basically, it can be stated that if the classification of potentially explosive areas are made in accordance with a correctly applied, relevant technical regulation – in this case the MSZ EN IEC 60079-10-1:2021 standard – it can be taken responsibility for both operator safety and regulatory compliance. In the present case, the legal discount described above confirms this.

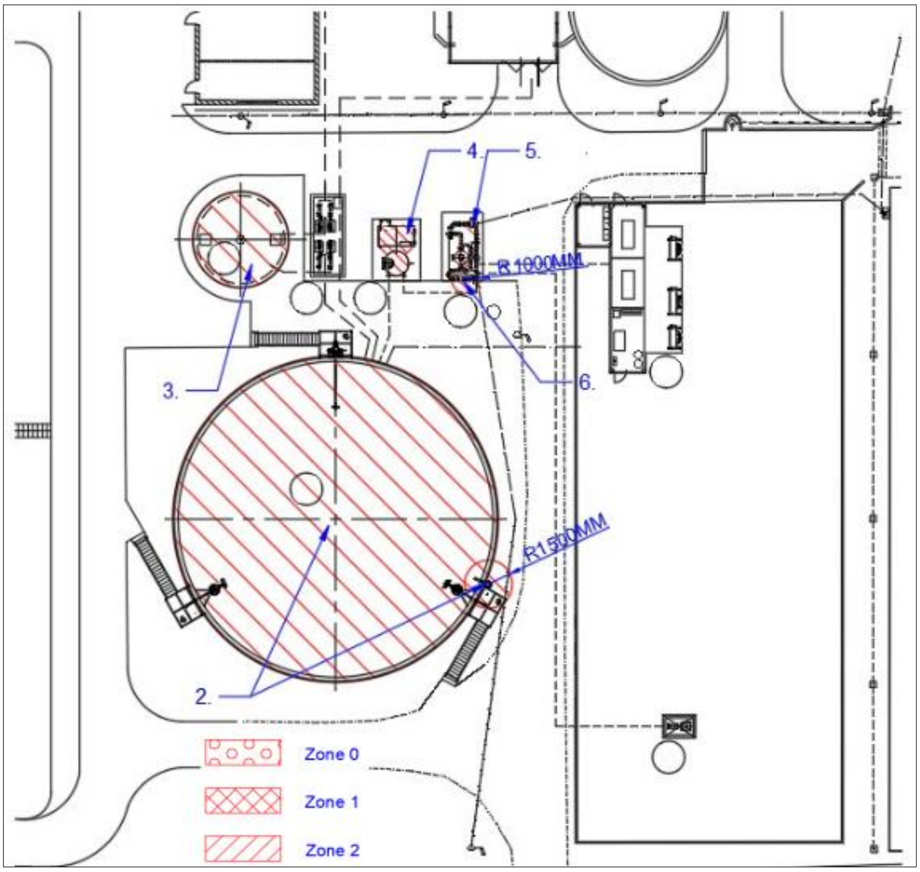


***Figure 4.*** *Representation of Potentially Explosive Atmospheres, Wastewater Treatment Plant - Technology Equipment - MSZ EN IEC 60079-10-1:2021*

Only explosion-proof luminaires, switches, electrical cabinets, sensors, transmitters, etc. of the type of zone may be installed and used in hazardous areas. If these installations are selected in accordance with the Regulation, this may mean electrical and non-electrical installations of more than 50 or even up to 100. However, the number of such devices is stagnant between 15 and 25 according to the standard, although this depends on the technical requirements of the designer and operator. Some examples of the price differences between normal and explosion-proof equipment are shown in Table 3. In many cases, prices from the manufacturer are not available, only from distributors (3200BEP, 3150BEP & 3300BEP EXPLOSION-PROOF STROBE, 2023; Eaton Limit Switch, 2023; Explosion Proof Switch, 2023; Explosion Proof Visual Signal, 2023; Explosion-Proof Temperature Transmitter, 2023; Normal Visual Signaling Devices, 2023; Rosemount 3144P Temperature Transmitter, 2023; Selector Switch, 2023; Siemens Switch, 2023; TTW Weatherproof Immersion Temperature Transmitter, 2023). This means that the prices of the products describe a wide range.

***Table 3.*** *Normal and explosion-proof equipment prices*

| | Visual signaling lamp | | Swith | | Temperature transmitter | |
|---|---|---|---|---|---|---|
| Equipment | Normal | Ex-proof | Normal | Ex-proof | Normal | Ex-proof |
| Price [USD] | 135 - 1060 | 1536 - 2040 | 92 - 124 | 155 - 529 | 459 - 1057 | 1344 - 1844 |

As a final word, it should be noted that economic or other interests or acts that intentionally or unintentionally deteriorate the technical level can never lead to violating the basic safety and health protection requirements, i.e. endangering human health and life.

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