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Biogasclean - Safe injection of air or pure oxygen into biogas

Why is atmospheric air or pure oxygen injected into the biogas?

The removal of H_2S in the Biogasclean systems is an aerobic biological process. Accordingly, for the process to work, oxygen must be present in the biogas. If the biogas is to be combusted in gas engines or boilers, the oxygen is provided by injection of atmospheric air which is composed of 21% oxygen (O_2) and 79% nitrogen (N_2). Air is also used in case the biogas is upgraded to biomethane or RNG (Renewable Natural Gas) with amine or water scrubber technologies where the H_2S is removed from the CO_2 stream (tail-gas). In case the biogas shall be upgraded by other technologies, such as membranes or PSA, requiring H_2S removal upstream the upgrading unit pure oxygen can be used instead of air to avoid dilution by nitrogen. The safety issues related to injection of air/oxygen are described below.

When can an explosion occur?

Three basic elements must be present before an explosion in biogas can take place:

- Methane in sufficient quantity to produce an explosive mixture
- Oxygen in sufficient quantity to produce an explosive mixture
- Source of ignition - a spark or high heat – to ignite the explosive mixture

All three elements must exist simultaneously. If any one of the three elements is missing, an explosion cannot occur.

Explosive mixtures

The lower and upper limits of gas to air ratio where explosions can occur are expressed as lower explosive limit (LEL) and upper explosive limit (UEL). For methane LEL is 4.4% and UEL 16.4%. In addition, minimum 57% air (12% oxygen) is required to create an explosion with methane. Outside these limits there is no danger of explosion

Controlled air injection

The volume of air injected will depend on the H_2S level in the raw biogas. The injection of air is made by a frequency-controlled air blower. The injection is adjusted to the actual biogas flow so only the air needed for the process is injected. The main part of the O_2 is used for oxidation of the H_2S to sulfate (SO_4), and the oxygen in the clean gas will normally be approx. 1.5%.

The air injection is controlled by 2 independent sensors, i.e. the flow meter (measuring the biogas flow through the scrubber tank) and the oxygen meter (measuring the oxygen in the clean gas). The injection of air will stop in case of a failure in the flow meter or the oxygen meter.

The signal from the oxygen meter has 3 functions; if the O_2 level exceeds 2% the air blower will go on minimum and stop if the O_2 reaches 3%. In case the O_2 level should reach 4% the safety relay will shut down as if the emergency stop was triggered. As mentioned above minimum 12% oxygen is required to create an explosive mixture with methane. Accordingly, the threshold values used by Biogasclean are very conservative.

The PTU is the engine room in the Biogasclean system

The Process Technique Unit - the PTU - is the engine room and contains PLC controller board, circulation pump, air blower, valves, flow meters and – if required – also heating system installed in a custom built open or closed fiberglass container. The PTU is not connected to the gas system but there are pipe connections for air, spray and drain between the PTU and the scrubber tank.

If the PTU is a closed room an unintended emission of methane can potentially create an explosive mixture. Therefore, the PTU is forced ventilated and supplied with a gas detector system as described below.

Closed PTU with gas detector and standard components

The room is forced ventilated (the air is changed at least 4 times per hour) with a standard fan. Forced ventilation is monitored; if it falls out, the system will be rendered powerless. With this ventilation, the room is classified as Zone II with an extension of 0 meters.

The safety principle of the plant is with constant ventilation to prevent that an explosive mixture may occur in the room. If ventilation fails, potential ignition sources are removed by switching off the electrical system. Therefore, the power supply and electrical signals go to a sub-switchboard (LEL switchboard) which is located outside the PTU in an unclassified Zone. In case of ventilation failure or if the CH_4 detector should detect 25% of the LEL or if an internal fault in the gas detector should occur, the power supply from the LEL switchboard to the main switchboard inside the PTU will automatically be disconnected.

As the ignition source is thus removed at the risk of an explosive mixture, it is possible to use standard components in the control boards and PLC, motors, pumps, fans, flow meters, circuit breakers, etc. The only components that are EX rated are the gas detector and the EX ventilation fan.

Communication to control rooms and other external sources is done from the LEL board. This is also where the control system must be reset after a shutdown alarm.

There are usual general warning signs and emergency stop at the entrance to the PTU.