

Integrating lessons learned from accidents into operators' behaviour and equipment design

As part of its technical due diligence activity plant operators ZEBEC commissioned PROJEN BioEnergy to identify the frequency and causes of accidents on AD plants. The study involved an internet word search on a set of words related to AD accidents [e.g. Biogas, accident, incident, explosion, fire, death, anaerobic digester]. These were translated into German, French, Spanish, Danish and Swedish and used as search terms on internet search engines, the most useful of which was Google. The terms brought to light newspaper reports of accidents in the language local to the incident. These newspaper articles were then translated to English and analysed for clues as to the type of accidents on AD plants, the frequency of accidents and more importantly the cause of the accidents. The report highlights 13 deaths world-wide from 2003 to 2010, [India, one explosion 4 deaths; Germany, gas incident 4 deaths; Philippines, gas incident 4 deaths; UK, gas incident 1 death]. In addition there were 11 Serious Injuries [including serious burns from explosions and near fatal gas related injuries]. There were also 13 other noted Injuries [including 11 firemen- mainly gas related]. The population of digesters these accidents relate to was close to 10,000 in Europe and over a million others world-wide.

The report lists 36 biogas plant explosions or serious fires reported on the internet in newspaper articles since 2003. In earlier years, internet reporting by local newspapers may not have been as comprehensive as it is currently. In addition there were 39 pollution incidents through valve or tank failures most small and related to the type of incidents common on farms but some were large tank failures. Most people were killed or injured by H₂S poisoning including the fire fighters. Some of the explosion injuries were very serious, a 22 year old trainee has 50% burns (25% is life threatening). Others were permanently deafened by the detonation from the explosion. Many of the newspaper reports show photographs of devastated sites and these are shocking. However, put into context, the total number represents about half of one per cent of plants. Every one of the incidents could have been avoided if only the time honoured procedures adopted by the UK chemical industry had been implemented in the AD plants. The equipment makes gas and stores gas. The actions required to remove the dangers, so well-rehearsed in the UK chemical industry, are listed below.

- 1. Explosions.** Some plants detonated with deafening explosions. This indicates a large amount of air was confined with 5%-15% methane and then ignited. Solutions include integrity of design, integrity of construction, HAZOP procedures, DSEAR/ATEX procedures, gas meters and gas alarms, removal of ignition sources [no smoking, no welding], permits to work, (Hot work permits especially), Risk Assessment Method Statement (RAMS) procedures in place.

2. **First Commissioning.** At least five plants are reported exploding when they were being commissioned for the first time. There are industry standards for commissioning of process plant and they clearly have not been followed by the manufacturers including pressure testing, inert gas purging and permits for hot work especially for welding work which is indicated in a number of plants prior to the explosion.
3. **Materials Certificates.** One plant was reported in the press as being built with sub-standard bolts on the tanks that failed in service during the commissioning phase. Materials control and building control failures should not occur and there are standard ways of working to avoid this, including procedures to review and approve material certificates for critical components. This is all about good project management in the office and on site on site.
4. **First maintenance** of the digester tanks (containing gas) is a common time for explosions and toxic gas incidents. Welding and entry into the confined space of a biogas tank are both indicated as dangerous maintenance activities. Repairing rotating equipment fouled by the digester contents can be especially hazardous. Confined space training and the industry standard procedures for 'first commissioning' apply.
5. **H₂S.** In 2005 at an AD plant, use of a reception tank with its safety features manually disabled allowed H₂S to escape from the mixing organic wastes so quickly four men were killed instantly. Blending organic wastes from different sources that may produce H₂S on contact is inherently dangerous. The functional design safety features and operator training are crucial for safe operation.

Zebec has lead the way by means of this report and incorporation of the findings into their operating behaviour and equipment design has set a standard for the industry to follow.

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With thanks to Zebec.

REFERENCE:

ZEBEC report 3458, HSE Incidents in Biogas Plants, 09/02/2011