



Lightning Mitigation Design Strategy

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1. Overview

This report provides an outline of Acorn Bioenergy's mitigation strategy for potential lightning strikes at its operational biomethane gas generating facilities.

The report is split into three main sections. The first outlines the importance of lightning protection systems and explains the different regulations. The second section explores the various forms of protection methods available and how they work. The final section explains Acorn Bioenergy's specific approach and introduces some examples.

1.1. Importance of Lightning Protection at Biomethane Generating Facilities

Lightning will always take the path of least resistance to the ground. Irrespective of the material, it will take the easiest path, whether it is through buildings, trees or people. The typical lightning bolt has a voltage of 300 million Volts, comparing this to the standard voltage of wiring in UK homes of 120 Volts, it shows the risk it possesses

Given the gas generation process at biomethane generating facilities, it is important that key steps are taken, and guidelines and standards are followed to provide robust resilience against lightning strike events.

Safety incidents of all types are extremely rare at biomethane generating plants in the UK. In terms of lightning strikes, specifically where facilities are fitted with appropriate protection, the plants carry on operating safely even when struck by lightning¹. Furthermore, there are no safety repercussions to the surrounding area in such circumstances. Whilst biomethane generating facilities are susceptible to lightning due to their large surface area and tall structures, with the appropriate design, protective measures and adherence to regulations, the risks are fully controlled and the effects of lightning rendered negligible.

1.2. Regulations and Standards

The main two regulations in the UK that place a duty on site owners and operators to mitigate the risk of lightning are set out below.

The first regulation is the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002. This is a goal-setting regulation, supported by an Approved Code of Practice (ACOP). These set out the legal expectations for explosion prevention, including a Lightning Protection (LP) risk assessment. Under the DSEAR process, all biomethane generating facilities must assess and control risks associated with flammable gases, vapours and other hazardous substances.

The DSEAR assessment identifies potential explosion or fire hazards and ensures that appropriate mitigation measures are designed and implemented to protect personnel, equipment and the environment. The DSEAR assessment is supported by two key structural hazard review processes, the Hazard Identification (HAZID) and the Hazard and Operability Study (HAZOP). The outcome of the HAZID is a register of potential hazards and corresponding mitigation actions, which are then addressed through design development and procedural controls. The outcome of the HAZOP is a

¹ The facilities at Cassington and Wallingford, both in Oxfordshire, which were subject to lightning strikes and damaged as a result, did not have the full array of lightning protection installed having opted for just an internal tank protection system. Acorn Bioenergy's lightning mitigation strategy applies both internal and external protection systems. There have been no damaging lightning strikes to facilities where both tiers of lightning protection have been installed.

detailed action log specifying required design changes, control measures, or operational procedures to eliminate or mitigate identified risks.

The second regulation is BS EN 62305:2011, Parts 1-4, which is what the DSEAR regulations refer to when setting out the expectations for lightning protection design and implementation. These regulations emphasise the importance of risk assessment, protection zone classification, robust design, proper installation, testing and regular inspection and maintenance.

1.3. Regulatory Enforcer

Whilst there is no specific regulatory body overseeing the design and installation of LPS, the Anaerobic Digestion and Bioresources Association (ADBA) provides industry guidance and best-practice standards, as well as offering a third-party quality audit. Acorn plans to adopt the ADBA-developed Anaerobic Digestion Certification Scheme (ADCS), which is a voluntary quality assurance scheme that audits biomethane generating facilities on their operational, environmental and safety performance criteria. ADCS was developed in line with recognised best practice to improve the performance and safety of facilities across the UK. Facilities that have been accredited under the ADCS have demonstrated enhanced operational safety with no recorded serious incidents since its implementation.

In addition, all Acorn Bioenergy sites undergo a comprehensive technical due diligence process carried out by a third-party engineering consultancy called Fichtner. They also act as owner's Engineer throughout the construction period, so not only do they review the design to ensure compliance with the relevant standards and best practice, but also inspect the installation works on-site and verify that all certifications provided by the LPS designer are valid and compliant for construction completion to be awarded to the Electrical Contractor.

The combination of ADCS accreditation and independent technical due diligence ensures that all Acorn facilities are designed, constructed, commissioned, and operated to the highest possible standards of quality and safety.

1.4. Why is the Lightning Design Post Planning?

The potential for lightning strikes at biomethane generating plants is specific to each site, with regards to design, e.g. the height of the tanks, technology provider, presence of people, surrounding topography and local weather conditions. Acorn Bioenergy does not support a generic lightning protection approach. This is because the site risk assessment should be in line with BS EN 62305-2 and be conducted by a suitable and certified lightning protection assessor.

The DSEAR process can only be undertaken once the project has reached the post-planning and detailed design stage, as it requires full knowledge of the site layout, equipment specifications, process flow diagrams, and control philosophies. Without these details, it is not possible to accurately define hazardous zones, ignition sources or appropriate control measures. Conducting these assessments after the detailed design phase allows for accurate evaluation of real process conditions. If the specialist assessment is conducted too soon, then the lightning protection design will be invalidated.

The sequence of DSEAR assessments is important to coincide with the appointment of the LPS designer. The HAZID is conducted soon after planning permission is received to help identify the broad hazards, including potential lightning and explosion risks. The HAZOP is conducted after this, at the detailed design stage, once process flow and piping and instrumentation diagrams are available. It focuses on process safety, temperatures and ignition risks. At this point, the LPS designer is typically

appointed, after the HAZOP review but before or during the final DSEAR assessment. The HAZOP needs to be completed first so that any process design changes (e.g. gas pipework routing, vent stack locations, digester configuration) are finalised. These directly affect the LPS design, since lightning protection relies on the accurate positioning of conductive and hazardous elements. Once the final layout and equipment list are confirmed post-HAZOP, the LPS designer can carry out detailed calculations and produce a compliant design in line with BS EN 62305.

The DSEAR assessor then reviews the LPS as part of the site's ignition risk management, ensuring it integrates correctly with other electrical and safety systems.

As the report will describe in the next section, there are various forms of lightning protection. The most suitable can only be attributed to each piece of equipment and building once the final HAZOP risk assessment has been conducted.

2. Biomethane Facility Specific Preventative Measures

- 2.1. Lightning rods are used on buildings to attract lightning and provide a safe pathway to earth. The electric current travels through the rod and into a grounded wire, diverting it away from the building and its components. A thick copper cable connects the rod to a grounding rod buried in the earth. Thus, the high voltage is safely diverted away. Lightning Protection System (LPS)

The aim of the LPS system is to provide a low-resistance pathway from above the building to the ground, protecting people and equipment from dangerously high voltages. External lightning protection is essential for the primary and secondary digester tanks and for the gas upgrading equipment. Internal protection is also provided at the digesters as part of the tank design, but not at the gas upgrading equipment.

The main components of an LPS system comprise:

1. The subdivision of the facility into Lightning Protection Zones (LPZ) and a risk assessment carried out in each zone.
2. The rapid grounding of the electric current away from infrastructure as much as possible. Multiple low-resistant pathways are better than one.
3. Surge Arrestors to prevent electrical energy from affecting the wider network and other grounding cables and protect the power supply system.

2.1.1. Internal Protection

Copper rings are installed at the top of the digester tank walls and between the roof, which is then grounded. This is not visible once the tank is constructed and is therefore supplied by the tank installer. The aim is to prevent dangerous sparking inside the structure by installing bonding conductors that link the metal components, such as the roof and the walls.

There is a visible ring around the base of the digester, which is connected to the top ring and distributes the lightning current safely into the ground.

In addition to the internal protection, and to comply with regulations and standards specific to the UK, methods of external protection must be adopted alongside it.

2.1.2. External Protection

The purpose of the external system is to intercept lightning strikes by conducting the electrical current from the point of strike to the ground and dispersing it without causing damage to the structure.

The Rolling Sphere method is usually used to ensure the mast height is sufficient. A sphere of a predefined radius is applied between the adjacent masts; surfaces that overlap or touch with the exclusion zone are unprotected and require more or higher masts. This is shown in Figures 1 and 3 below, the HVI Conductor with a Single Conductor is not providing enough height to protect the exclusion zone, more height is needed as provided with the Telescopic Mast. The first method of external protection is to install **standalone Steel Telescopic Lightning protection masts**. These are

installed in the natural soil or on the foundation and can reach heights of upto 25m, making them important for protecting the gas domes, which are often one of the tallest pieces of infrastructure.

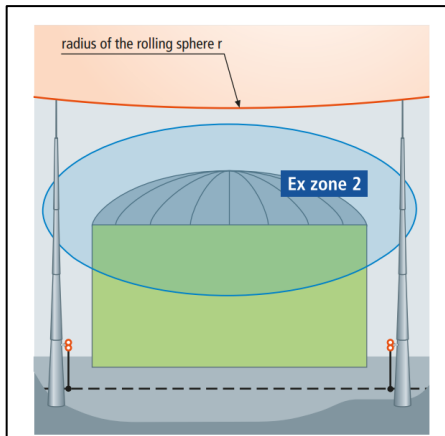


Figure 1: Telescopic Mast

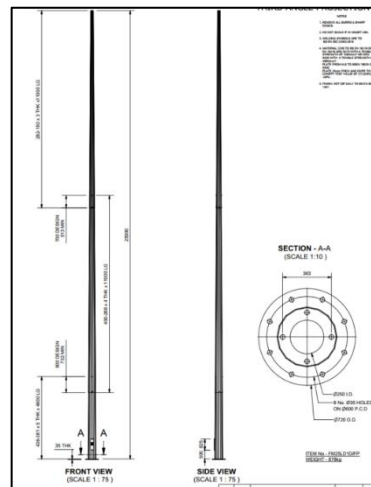


Figure 2: Telescopic Mast Detail

The second method is a **rod with an HVI Conductor** attached to the outside of the digester tanks or specific pieces of equipment. The HVI Conductors are high-voltage resistant, insulated conductors with a special outer sheath.

As Figures 3,4 and 5 show, there can be **HVI Conductors with 2 insulated wires** attached to the outside of the digester tank (one inside the supporting tube and one outside), providing multiple pathways for the lightning current. Alternatively, HVI conductors can have just one conductor, inside or outside the supporting tube.

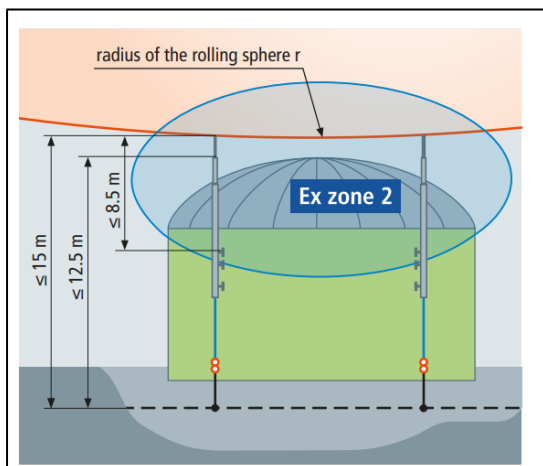


Figure 3: HVI Conductor with Single Conductor

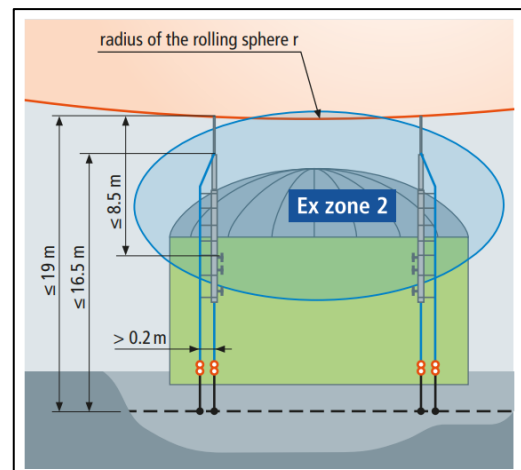


Figure 4: HVI Conductor with Double Conductor

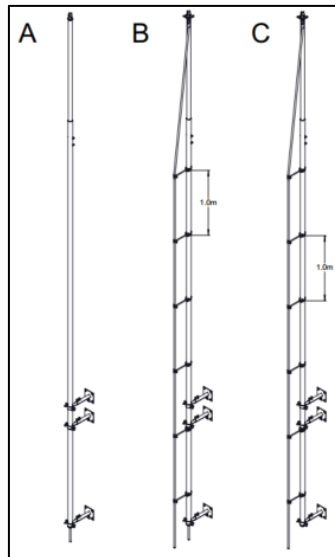


Figure 5: Different Types of HVI Conductor

The third method is with **Self-Supporting Masts** (see Figures 6 and 7 below), which require a pre-cast

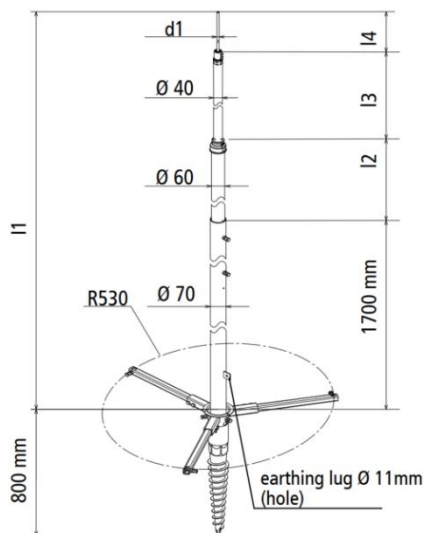


Figure 6: Self-Supporting Mast Screw-In



Figure 7: Self-Supporting Mast Tripod

concrete base or to be screwed into the ground. The screw-in mast types can reach heights of up to 11m, whilst the self-supporting mast on a tripod can reach heights of 14m.

The masts and conductors in Figure 8 below illustrate a generic example of how they function within the overall design. They effectively create a safety net around the plant, as shown by the red area. Lightning will not strike any gas processing equipment within this zone; instead, it will pass through the different rods and/or masts to the ground. Anything within the red zone is protected, as the rods/masts become the 'path of least resistance' to the ground.

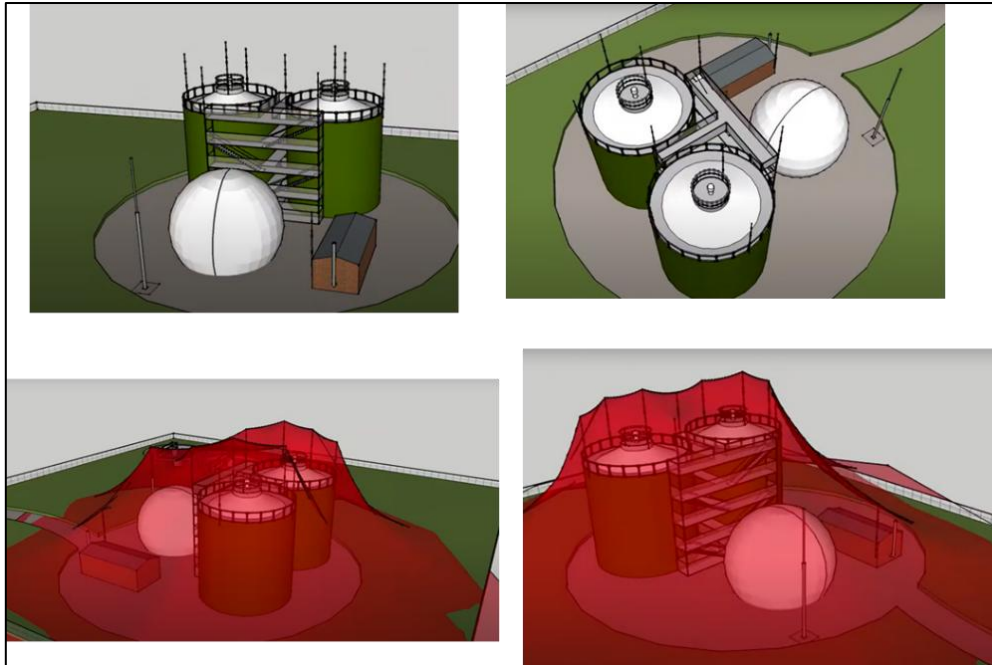


Figure 8: Example Zone of Protection – the safety net

3. Acorn Bioenergy Lightning Mitigation Approach

Acorn ensures that the guidance outlined in the relevant standards is followed when the chosen company designs the LPS. Furthermore, the HAZID and HAZOP studies are carried out with plenty of time for the design to be conducted well in advance of producing biomethane.

ADBA closely monitors the severity and frequency of thunderstorms around the UK. With the likelihood increasing due to climate change, it is essential to stay up to date with the most innovative technology, protective measures, and regulations. This highlights the need for a reputable company to design the lightning protection system.

3.1. Acorn Approach

For the lighting design, Acorn Bioenergy instructs a reputable and specialist company to design the LPS. To date² Acorn Bioenergy has worked with Sibor Limited. Sibor conducts risk assessments, designs, implements, and certifies installations in collaboration with Omega Red Group Limited, another reputable company in the UK. Omega Red Group helps Sibor conduct the site survey and design the protection.

The first step in the design process is a risk analysis, followed by an assessment to reduce the risk level. Secondly, calculations using specialist software are used to work out the optimal separation distances. Following this, the lengths of the rods and the length of the earth electrodes are determined. The proposed system must include internal and external protection, full equipotential bonding between metal components, and protection of the hazardous zones.

As outlined in BS EN 62305:2011, the site is split into 2 distinguishable zones. The first distinguishes loss of life (known as Level II), and the second distinguishes loss of economic value (known as Level IV). The equipment is then assessed, for example, within the bunded area there are the digester tanks and gas holders. In the gas area, there is the upgrading equipment and compressed gas. Both those areas have loss of life and hazardous zones, meaning it is essential for Lightning Protection. However, within the loss of economic value zone are the steel-framed buildings, which, according to British Standard, can use the internal structure as a form of lightning protection. This is illustrated in Figure 9 below, where the red areas represent loss of life risk and the blue areas represent loss of economic value.

² Sibor Ltd are Acorn Bioenergy's chosen Electrical Contractor who were responsible for designing, implementing and certifying the LPS for the first two consented biomethane generating facilities.

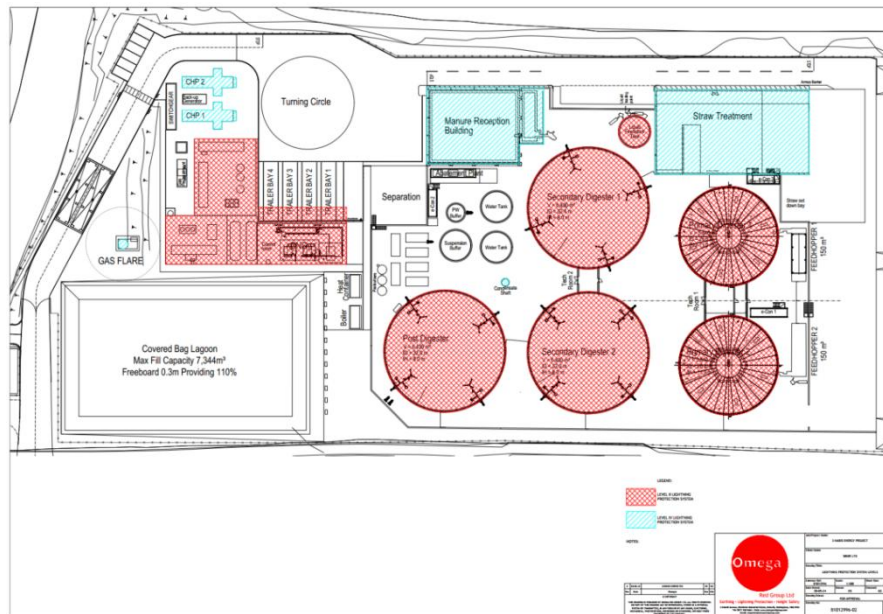


Figure 9: Lightning Protection System (LPS) Levels by Omega Red Ltd

The best type of lightning mast and conductor is then selected, based on the height of the mast needed, the building/equipment to be protected, the hazardous area classification and the foundation requirements. As shown in Figure 10 below, various protection methods are used across the site depending on layout and locations.

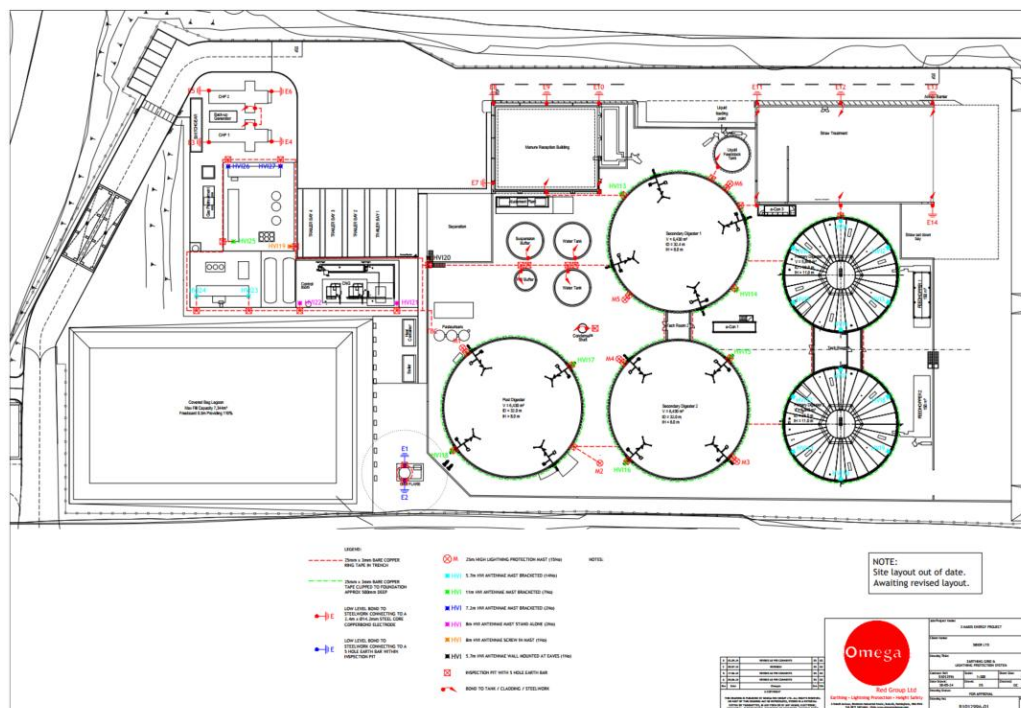


Figure 10: Lightning Protection System (LPS) by Omega Red Group Ltd

3.1.1. Lightning Protection at Acorn Bioenergy Consented Plants

Outlined below are some of the designs that have been adopted at Acorn Bioenergy's Three Maids (Winchester) and Horse Close (West Northamptonshire) biomethane generation facilities.

For the digester area at Three Maids, it is clear that a combination of Telescopic and HVI conductors was needed to create the red zone of protection (see Figure 11 below).

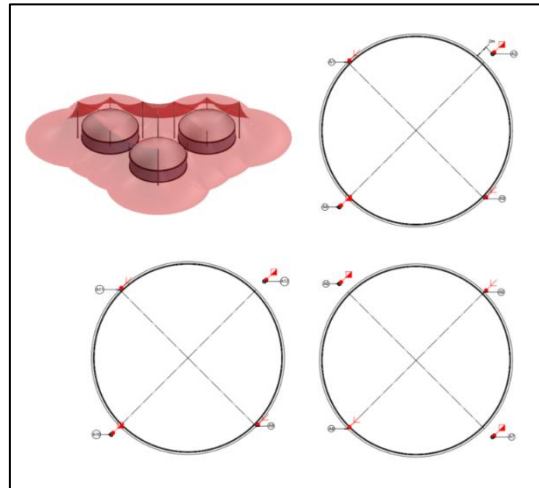


Figure11: Three Maids Bund Area

Figure 12 below shows the gas area at Three Maids. Given the different nature of buildings/equipment, a different design was needed of self-supporting masts and HVI conductors to cover all the ATEX areas and hazardous areas.

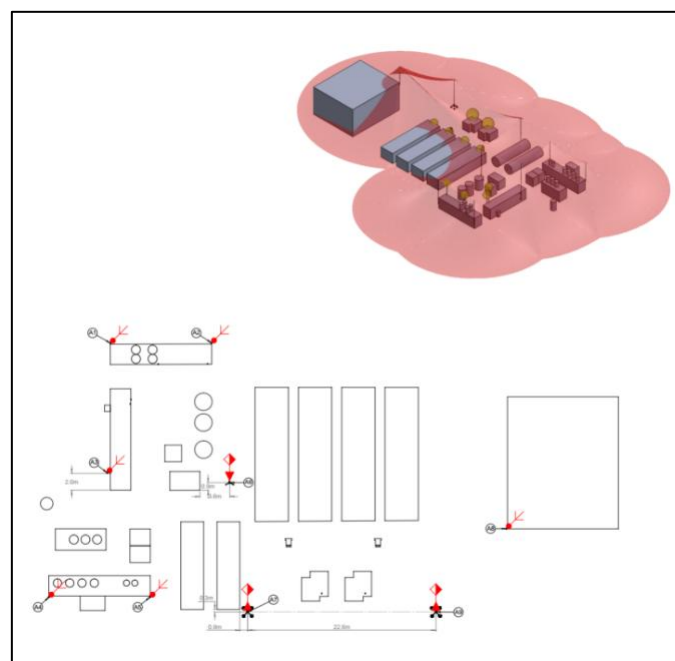


Figure 12: Three Maids Gas Area

At Horse Close, the bund area used all 3 types of masts (see Figure 13 below). A Telescopic Mast to create enough height for the domed digester gas holder and two self-supporting masts in the centre of the flat topped digesters. The rest were all HVI masts attached to the perimeter of the digester.

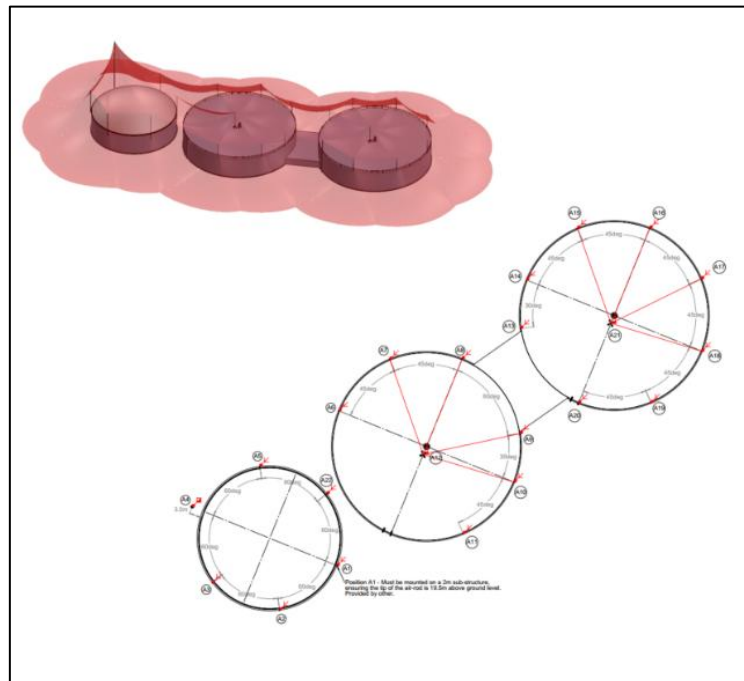


Figure 13: Horse Close Bund Area

In the gas area at Horse Close, HVI masts and self-supported masts were used (see Figure 16 below). No telescopic masts were needed due to the lower height of the equipment. The different forms of protection create a suitable zone of protection over the whole site.

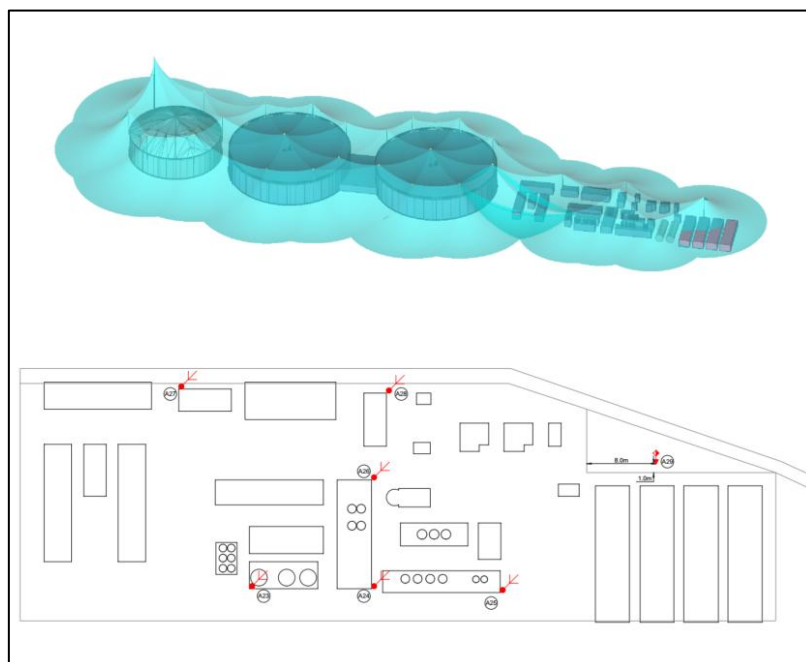


Figure 14: Horse Close Gas Area

Finally, after the installation, a report is provided to prove that it meets the appropriate standards. The report certifies it is working as expected and achieving the required earth resistance values. An example of this can be seen in Appendix A, which presents an example certification. This particular one was provided by Omega Red Group, which demonstrates that the Three Maids plant had been designed and installed to meet Level II and Level IV of BS EN 62305:2011. This was then checked and approved by our Owner's Engineer, Fichtner.

3.2. Installation Photos

The following pictures show the final installation at the Three Maids plant. They highlight the various types of masts that can be used and show examples of how they look in practice.



Figure 15: HVI Conductors and a Telescopic Mast to Digesters



Figure 16: Telescopic Mast



Figure 17: HVI Conductors to Flat Roof Digesters



Figure 18: HVI Conductor to Equipment



Figure 19: Self-Supported Mast in Gas Area



Figure 20: HVI Conductor to Building

A. AppendixExample Certification for Three Maids

<b style="color: red;">Lightning Protection System Completion Certificate BS EN 62305		
Client : Sibor Process Control Unit 19, Millsway Centre Boscombe Down Business Park Amesbury Wiltshire SP4 7AU	Site : Three Maids Energy Project Three Maids AD Plant Andover Road North Winchester SO21 2FT	
Omega Reference: B1013139		
Lightning Protection System The lightning protection system has been installed to Level II & IV BS EN 62305		
Air Termination/ Down conductor Network - Zone A <b style="color: red;">LHS Plant Area, CHP & CNG Area (Level II) Use of metallic nature of CHP's as its own conductor confirmed mechanically and electrically sound for this purpose and in compliance with the thickness requirements of Table 3 within BS EN 62305:2011, together with the following.		
2 x 7.2m HVI Masts bracketed by others to the structure(s) 1 x 11m HVI Masts bracketed by others to the structure(s) 2 x 5.7m HVI Masts bracketed by others to the structure(s) 4 x 8m HVI Masts standalone erected by Omega structure(s)		
Air Termination/ Down conductor Network - Zone B <b style="color: red;">Manure & Straw Reception, Buffer/Suspension/Water Tanks and Flare (Level 4) Use of metallic nature of Manure & Straw Reception/Water Tanks and Flare as their own conductor confirmed mechanically and electrically sound for this purpose and in compliance with the thickness requirements of Table 3 within BS EN 62305:2011, together with the following.		
<b style="color: red;">Post & Secondary Digesters (Level II) 6 x 25m Lamp Posts fitted and plinthed by others (supplied Omega) 6 x 11m HVI Masts standalone erected by Omega structure(s)		
<b style="color: red;">Primary Digesters 1 & 2 (Level II) 12 Use of 5.7m HVI antennae as their own conductors confirmed to be mechanically and electrically sound for this purpose		
Earth Electrode System <b style="color: red;">Manure & Straw Reception (Outside membrane area), CHP's Type "A" Earthing Arrangement: 14 No. 2.4m x 16mm dia. copper bond electrodes & linked to the Type "B" Earth ring.		
<b style="color: red;">All other areas Type "B" Earthing Arrangement: All positions interconnected via a 25x3mm copper ring tape laid in pre-prepared trenches approximately 600mm deep.		

Lightning Protection System Completion Certificate BS EN 62305



Surge Protection Devices

Surge protection devices are required as part of the lightning protection system under the R₁ risk category for a structure with a risk of explosion

The surge protection devices supplied and installed by others comply with BS EN 62305

Earth Resistance Values

The total Earth resistance of Zone A is 0.17 Ohms

The total Earth resistance of Zone B is 0.51 Ohms

Overall Earth resistance of both zones linked is 0.04 Ohms

Test meter reference:
OMG004

Calibration date:
24/04/2024

The installed structural lightning protection system is compliant to BS EN 62305

We certify that we have examined this installation in accordance with BS EN 62305. Non-disclosure of additional services entering or leaving the structure, sub-distribution systems or a change in building use may invalidate this certificate. The lightning protection system must be inspected in accordance with BS EN 62305 and the Electricity at Work Regulations 1989, at regular intervals from the date of this certificate.

Contract supervisor: Mark Ward
Designer & Estimator: G Cable
Issue date: 19th May 2025

Installation completion date:	16.4.25
First inspection due:	March 2026
Engineer's name: Paul Fenlon	