Secondary Containment at AD Plants: An Industry Guide

Produced by ADBA's Training, Safety and Environment Working Group

Version 1

July 2016

Summary

This document has been prepared by ADBA's Training, Safety and Environment Working Group as a guide to secondary containment at anaerobic digestion (AD) plants. The guide accompanies a secondary containment classification tool that has also been developed by the working group and provides background and explanation to that tool. Both are held on ADBA's website.

Both the guide and the classification tool draw upon the principles and methodologies within CIRIA 736 *'Containment systems for the prevention of pollution: Secondary, tertiary and other measures for industrial and commercial premises'*. The principles within CIRIA 736 are generally accepted as good practice in the design and construction of containment systems. The principles of CIRIA 736 are distilled into this accessible guide, which attempts to draw out the parts relevant to the AD sector. However, it is recommended that CIRIA 736 is referred to at the points indicated in the guide at the very least.

Should CIRIA 736 be revised significantly, then this guide will be reviewed by the working group.

Containment is a major consideration in the design of all AD plants due to the storage of significant volumes of digestate, liquid wastes and other substances, that could be harmful to sensitive receptors should they be released into the environment. The industry is committed to ensuring the consistent application of good practice across the sector. The principles and methodologies within this guide are relevant to all sizes and types of AD plant.

The key recommendations of this guide are:

- Consider secondary containment at site selection stage and undertake a CIRIA assessment as per this guide.

- Consult the relevant regulatory body at an early stage and at decision stages throughout plant development.

- Be aware that securing planning permission does **not** guarantee that your secondary containment plans will satisfy regulators.

By following the above recommendations, this will give you the best chance of avoiding undue and unforeseen costs and delays in the development of your plant.

Document Control

Version	**Date**
V1	July 2016

1.0 Introduction

1.1 AD plants often contain large volumes of liquid food waste/crop substrate/digestate at different stages of processing. In recent years there have been a disproportionately high number of AD plant failures resulting in major digestate spillages, when compared to similar industries.

1.2 The large amount of potentially polluting liquid at AD plants and poor design standards of primary containment in tanks and secondary containment in bunds has led to these pollution incidents. As a result the AD industry is issuing guidance to simplify the complex issues of designing, constructing and operating containment systems.

1.3 This document explains the issues around the design of secondary containment, however choosing the location for the AD Plant will have a significant bearing on the secondary containment system required. Hence it is essential that this issue is considered at the time of site selection and outline design.

1.4 The volumes in any AD plant will vary from hundreds of cubic metres/tonnes to tens of thousands of cubic metres/tonnes and if the material was allowed to escape from the site tanks, the material could pose a serious pollution threat to the surrounding environment. This threat is often dealt with by surrounding the tanks by an impermeable bund with a capacity of 110% of the largest tank (or 25% of the combined volume of tanks - whichever is the greater) and this is a standard referred to by regulators.

1.5 However, the design of such a bund is not actually as straightforward as this and there is a guidance document which provides a methodology for designing bunds (referred to as secondary containment). The current guidance document is known as CIRIA 736 'Containment systems for the prevention of pollution'. The document was issued in 2014 and replaced the previous version known as CIRIA164.

1.6 The document provides a methodology for the design of secondary containment systems for all materials which have the potential to pollute and there are three different levels of containment known as class 1, 2 and 3 where 1 is the lower level of protection and class 3 the highest.

1.7 In order to decide the classification it is necessary to carry out and document a risk assessment according to the method set out in CIRIA 736. This requires quite a lot of information about the surrounding environment and AD plant and drainage design to be gathered for analysis.

1.8 It cannot be stressed enough that this risk assessment should be carried out at the earliest opportunity, as the plant is initially designed at the site selection/layout/footprint stage, as the bund needs to be part of the civils package and can be very difficult and expensive to change at a later stage. This is a key point as environmental regulators can allow a plant to be built but may prevent its commissioning until the secondary containment complies with CIRIA 736.

The relevant regulators are:

- England – Environment Agency
- Northern Ireland – Northern Ireland Environment Agency
- Scotland – Scottish Environment Protection Agency
- Wales – Natural Resources Wales

1.9 CIRIA 736 recommends a three step approach to the risk assessment which is detailed in Section 3 below. A general point throughout CIRIA is that the regulator should be consulted at all decision stages of the process.

Step 1 – apply the source – pathway – receptor model to determine the **Site Hazard Rating** presented by the inventory of potentially polluting materials on site to the surrounding environment. This provides a **site hazard rating** of high, medium or low. The process can be ended at this point if sufficient assessment has been made to arrive at a decision of the **class of containment**.

Step 2 – considers the likelihood of a loss of containment. Combining this with the site hazard rating provides a **site risk rating.**

Step 3 – the **site risk rating** leads to recommendation of the **class of containment.**

Definitions

It is worth pointing out the following definitions which are used for these purposes:

Hazard is the intrinsic property of a dangerous substance or physical situation, with a potential for creating damage to human health and/or the environment.

Risk is the likelihood of a specific effect occurring within a specified period or in specified circumstances.

2.0 Class of Containment

2.1 Containment is classified into three levels where class 1 provides the lowest level of protection and class 3 the highest.

2.2 Three key differences shown below (which can have a major impact on civils cost) of the three classes of containment are best described in tables 6.2 and 6.5 of CIRIA 736. These are shown below from table 6.5 however, only recommendations c, g, and h are shown; consult CIRIA 736 for the others.

Table 1: Examples of key performance recommendations by class *(from Table 6.5 CIRIA 736)*

Recommendation	**Class1**	**Class2**	**Class3**
c. No structure within the bund to be closer than its own height to the bund wall	Not necessary	Desirable	Recommended
g. Take account of possible jetting failure	Desirable	Recommended	Recommended
h. Take account of surge effects	Desirable	Recommended	Recommended

2.3 A major issue is that of height of bund wall and distance from tank to bund wall which sets out the design footprint of the site and hence impacts on area required and therefore the civils and planning application costs. For recommendation c. a class 3 bund would require the distance of bund wall to tank to be at least the height of any tank or other item of plant.

2.4 For recommendation g., if jetting (release of a jet of liquid from a hole in the tank) is to be taken account of then the calculation in CIRIA 736 Box 6.1 (Method for calculating bund geometry to prevent jetting) should be used. This shows that the bund wall to tank distance should be no less that the distance of the height of liquid in the tank minus the bund wall height. For example, if the liquid level is 8m and the bund wall is 2m high, the bund must be 8-2= 6m from the tank.

2.5 Taking surge effects into consideration also requires similar distance/height calculations and force calculation of a catastrophic failure. An additional 250mm of bund wall height (above that for 110% capacity) is also recommended to allow for surge.

2.6 If these recommendations and hence cost are to be avoided it will be necessary to demonstrate that a class 1 bund is satisfactory. This document identifies how this can be achieved through location choice and site design.

3.0 Site Hazard Rating

Step 1 – Source, Pathway, Receptor

3.1 The first step of the risk assessment process is to determine the Site Hazard Rating. This will be either high, medium or low and this is assessed by combining factors associated with:

Source (the site inventory of polluting materials)

Pathway (the route from the site tanks to the receptor) and

Receptor (the part of the environment which could be polluted)

<u>Source Hazard</u>

3.2 List all of the materials and the amounts that are on site which could cause pollution e.g. by fire or if the primary containment failed (i.e. tank, IBC, drum etc.) and the substance escaped into the drains or ground. This is best shown in a table as per the 'bunding spreadsheet'.

3.3 This should also take into account any products which may be changed in a fire and any firefighting water or cooling water which could foreseeably be required to keep parts of the plant safe whilst others were on fire.

3.4 The list of substances should be complete and include any chemicals used in the site processes. On AD plants the main source hazard will usually be digestate/substrate as many plants will have thousands of tonnes of liquid substrate/digestate.

3.5 In rating the source hazard, the CIRIA document includes Appendix A2 which lists examples of inventory which would suggest a high source hazard irrespective of the quantity stored. Appendix A2 contains a 'list of hazardous substances' which should be considered as pollutants. In the list of main pollutants there is 'substances that have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD and COD)'. In the list of broad classes of materials with the potential to pollute water there is 'other organic compounds (including foodstuffs), and microbial contamination (E.coli etc.)'. These factors suggest that all AD substrate/digestate would qualify as a hazardous substance. However the fact that the material can be safely spread on fields under controlled conditions would suggest that final digestate material is a relatively moderate high hazard material.

3.6 The CIRIA document includes a graph (fig 2.6) which indicates source hazard ratings for different levels of tonnage and toxicity. This can be used for chemicals on site but as the maximum tonnage is only 100t it does not relate to the majority of AD plants which contain many thousands of tonnes.

3.7 In conclusion it would appear difficult to assign any source hazard rating other than 'high' to the inventory on an AD Plant.

3.8 As a result of this, in order to achieve an overall Site Hazard Rating of 'Low' which is required to enable a class 1 containment system to be specified, then both other aspects i.e. 'pathway' and 'receptor' must be assigned a low hazard rating.

<u>Pathway</u>

3.9 The pathway is the route from the primary containment to the receptor. There can be a number of different pathways and all should be considered. The following issues are highlighted in CIRIA for consideration in the risk assessment: The aim being to avoid having any transport route from source to receptor or at least minimise the ease by which polluting liquid can leave the site. The design of the secondary containment and overall site and surrounding drainage must to be taken into consideration.

The pathway will also depend on the physical characteristics and form of the material being stored, for example digestate may be in liquid or sludge form.

Proximity of receptors

3.10 When choosing the site location carry out a study of the potential receptors and if possible locate the tanks a good distance away from any streams, rivers etc. so that any loss of containment is not immediately transported into the receptor.

Site Layout and Drainage

3.11 Avoid hardstandings around the primary containment sloping toward a surface receptor.

3.12 Protect routes to surface water or foul drainage as these can convey the spillage to streams, rivers or sewage treatment plants which the spillage could overload.

3.13 Avoid permeable ground around the primary containment, ensure it is designed and impermeable e.g. engineered clay lining, concrete with permeability of less than 10^{-9}.

3.14 Ensure that the ground under the site is fully understood or fully protected such that old man made pathways are not present e.g. old mine workings, storm drains, culverted watercourses.

3.15 Avoid rainwater soakaways in the vicinity of the primary and secondary containment.

Topography, geology and hydrogeology

3.16 Avoid having a raised site as this will make flow to a receptor a greater risk.

3.17 Avoid having a site directly above an aquifer, if possible.

3.18 Carry out geotechnical and hydrogeological surveys unless the ground conditions are well known.

Climatic conditions

3.19 Ensure that the site is unlikely to be affected by climatic effects. The full volume of the bund is always kept available by engineering the drainage system to drain the bund of liquid (from precipitation) unless a primary containment leakage incident occurs.

3.20 Ensure that any persistent layer of deep snow or ice which could cause a reduction in available bund volume could be removed.

Fire Fighting Water

3.21 In the majority of AD Plants none of the AD tanks contain flammable liquid and it is not anticipated that any significant fire-fighting foam or water will be used for fighting a fire or cooling a tank to protect it from an adjacent tank on fire. A fire/explosion of biogas will be short lived as there is a very small inventory of biogas at low pressure on site.

3.22 Demonstrate that any other fires on site would not result in significant volumes of firewater or firefighting water products. Ideally ensure that fire water can be tankered away without impacting on the bund.

3.23 A further concern is the effect that fire may have on the flow properties of the pollutant, particularly in the drainage system and the risk of drains becoming blocked due to debris.

3.24 As all of the AD substrate and digestate are essentially aqueous mixtures from 80% to 95% water content there will be no effects on the materials in a foreseeable fire.

3.25 Site drains could become blocked under a catastrophic event but this would not present a problem as blocked drains will simply allow the bund to fill as it has been designed to.

Treatment Plants

3.26 Protect routes to surface water or foul drainage as these can convey spillages to sewage treatment plants which could potentially become overloaded. If necessary this could be achieved by normally closed penstock valves which would contain any leakage, but could be opened to release any accumulated rainwater.

Mitigating and Exacerbating Effects

3.27 Consider the likelihood of dilution in drains on route to a sewage treatment plant – are there other industrial sites discharging large quantities of aqueous effluent.

3.28 Chemical reactions – chemical reactions should not occur with substrate or digestate but could do if strong acids or alkalis are released. Digesting substrate could generate some biogas which could cause explosive atmospheres in drains or culverts.

3.29 Evaporation – e.g. volatile solvents – the potentially polluting substances are essentially aqueous.

3.30 Absorption – this will take place in any permeable ground outside the bund – ensure that there is limited transport to a receptor from there.

3.31 Settling – this could be an issue e.g. if viscous substrate blocks drains – however this could also restrict any pollution potential.

3.32 Flooding – avoid sites in a flood plain unless the height of the site is above any predicted flood level – this fact will probably mean that there is added risk from the site due to downhill flow. If the chosen site is within the a flood risk zone, a Flood Risk Assessment is likely to be required as part of a planning application and Environmental Permit application, and the plant should be designed taking this into account.

3.33 The combination of all the above factors should ensure that the overall assessment of the transport potential is low.

Receptor

3.34 It was mentioned above that the proximity of receptors should be known to assess the transport potential of any loss of containment. It's equally important to understand the types and sensitivity of the receptors and there is much information available free on the internet e.g. the EA's 'What's in your back yard?' or Natural England's 'MAGIC' search facility (there are equivalent search facilities for Scotland, Wales and Northern Ireland.

3.35 Consideration should be given to the following potential adverse effects

- Kill fish or other aquatic life
- Damage to freshwater or estuarine habitats
- Disruption of drinking water supply
- Aesthetic effects
- Public reaction.
- Harm to human health via fish accumulation or via contact water sports
- Damage to groundwater

3.36 Locating an AD Plant close to the following sensitive receptors – (or with an uncontrolled pathway) would be unlikely to enable a low receptor rating to be assigned hence would most likely result in a class 2 or class 3 containment system being required.

- Rivers above potable water supplies
- Aquifers used for public supply
- High quality waters with high grade game or coarse facilities
- Rivers where water is abstracted for agricultural or horticultural purposes
- Waters with aquatic ecosystems of particular value
- Waters used extensively for recreational purposes
- Treatment works whose function could be adversely affected or whose capacity overwhelmed by a release of pollutant.

3.37 If it can be demonstrated that the sensitivity of receiving waters is low the overall assessment of the damage potential to the receptor can be assigned a rating of low.

4.0 Overall Site Hazard Rating

This is shown simply in CIRIA 736 in box 2.1.

To determine the rating of each factor, the Source: Pathway: Receptor are combined as follows respectively in order to provide an overall site hazard rating.

Table 2: Suggested combinations of hazard ratings to give overall site hazard rating *(taken from Box 2.1, CIRIA 736)*

Possible combination	Overall Hazard Rating	Indicated class of secondary containment
HHH, HHM, OR HMM	**HIGH**	**Class 3**
HHL, MMM, OR HML	**MEDIUM**	**Class 2**
MML, HLL, OR LLL	**LOW**	**Class 1**

The assessment may be ended at this stage if it is decided that conclusions on the containment can be made based on the site hazard rating. It can be seen from the above thorough site hazard assessment process that site selection and design can lead to a low site hazard assessment and if this is the case it would be appropriate to provide a class 1 containment system for the site.

Alternatively the assessment can be developed further to combine the site hazard rating with the likelihood of all events which could lead to loss of containment in order to arrive at an overall site risk rating, which is again used to classify the secondary containment.

5.0 Site Risk Rating

5.1 To assess the site risk it is necessary to consider all the events that may lead to release of the inventory from the primary containment (tanks).

1. Identification of all the events that are capable of causing loss of containment.
2. Assessment of the likelihood of occurrence of each event.

5.2 The potential failures and the reasons for failure include:

- operational failures, such as failure of plant, or human failure by operators
- shortfalls in design – lack of alarms and fail-safe devices
- structural failure – materials, components, detailing, corrosion or when exposed to heat or flame e.g. from a site-wide fire, whole vessel failure, pipe failures
- abuse – inappropriate change of use or other misuse
- impact, e.g. from a vehicle or plane crash
- vandalism, terrorism, force majeure etc.
- flood, fire or explosion
- geological factors – subsidence, earthquakes etc.
- ageing or deteriorating assets/sub-components.
- Small failures such as single IBC

Multiple credible potential failure scenarios should also be considered.

5.3 Detailed assessments of the potential for all of these failures and others should be made and can often be part of the HAZOP (or other formal risk/hazard) process carried out for many AD plant developments, though the HAZOP is often carried out post site selection and layout design. In order to consider the aspects such as jetting which requires tanks to be a certain distance from bund walls, the HAZOP and site risk rating need to be defined prior to the site layout being fixed.

5.4 In assessing the risks CIRIA recommends the use of historical failure data for tanks and associated infrastructure.

5.5 By analysing the events and circumstances that may occur it is then necessary to arrive again at a high, medium or low risk rating. Technology providers should be able to provide this data for equipment they are supplying.

A useful guide for this is as follows in table 2.3 from CIRIA 736 – Frequency of loss of containment.

Table 3: Frequency of loss of containment *(Table 2.3 CIRIA 736)*

Risk of loss of containment	**Annual probability of loss of containment**
High	Greater than 1% (1 in 100)
Medium	Between 1% (1 in 100) an 0.0001% (1 in 1 million)
Low	Less than 0.0001% (1 in a million)

5.6 The site hazard rating (H, M, L) is then combined with frequency of loss of containment (H, M L) to arrive at the overall site risk rating which is shown is the following table (Box 2.2 in CIRIA 736).

Table 4: Overall site risk rating as defined by combining ratings of site hazard and probability of containment failure *(Box 2.2 CIRIA 736)*

Possible combination	**Overall Risk Rating**	**Indicated class of secondary containment**
HH, HM, OR MH	**HIGH**	**Class 3**
MM, HL, OR LH	**MEDIUM**	**Class 2**
LL, ML, OR LM	**LOW**	**Class 1**

5.7 In Section 3 the means of achieving a low hazard rating and hence providing a case for a class 1 secondary containment system was shown. In order to achieve a similar low overall risk rating it will be necessary to demonstrate that the frequency of failure is less than 1%.

5.8 CIRIA 736 states that sites scoring a low risk rating are not likely to require further assessment. However, when any of the source, pathway or receptors are assessed as a high hazard then a detailed risk assessment should be carried out by a competent person. As the source for an AD plant is likely to be high (as per Section 3.7 above) this should be considered.

5.9 Where the risk assessment shows that there is an intolerable risk of causing significant environmental damage the following mitigation methods are suggested, which are largely discussed above and are not straightforward.

- Reduce the site inventory – provide smaller tanks
- Choose an alternative location
- Improve the proposed containment systems
- Modify pathways to minimise escape of pollutant
- Change operational and/or management practices

6.0 Summary

6.1 Carry out a CIRIA Assessment on your proposed AD plant at the time of site selection such that costs of civils for secondary containment can be known.

6.2 Be aware that planning permission can be achieved without any regulator requiring a CIRIA assessment to be carried out – this can result in significant costs later in the project for example if the regulator requires improvements to containment via an improvement notice, or prevention of commissioning.

6.3 It is considered that understanding the ground conditions and environmental sensitivities of the site at an early stage is highly beneficial, as this will help ensure that the chosen site is suitable for the proposed activities and that the plant is designed, constructed and operated appropriately for that site.

References

ADBA Training, Safety and Environment Working Group and PROjEN (2016) *AD Containment Classification Spreadsheet*. Go to http://adbioresources.org/library

CIRIA (2014) *Containment systems for the prevention of pollution: Secondary, tertiary and other measures for industrial and commercial premises (CIRIA 736).* Go to www.ciria.org.