Torsten Fischer of Krieg + Fischer Ingenieure discusses a legal investigation related to deficiencies of a silage plate at a biogas plant in Germany

First-person sleuthing, investigation of a silage plate

Torsten Fischer, founder and managing director at Krieg + Fischer Ingenieure, has been an expert legal witness for more than 10 years, covering 120 cases, and wrote his first report about a biogas plant accident more than 15 years ago. In this personal account, Fischer discusses a legal dispute between the construction firm and the owner and operator of a farm-based biogas plant, exclusively for *Bioenergy Insight*.

Setting

The court asked me to take evidence and write a report about the potential deficiencies of a silage plate at a biogas plant. The facility was a typical German standardised biogas plant system, with mostly corn silage used as the input substrate.

My reaction

There is no subject on which I wrote more court reports than silage plates.

The job

Court reports must follow certain rules: the judge outlines the questions and the technical expert must answer them. The short version of the questions in this case was: "Is the silage plate tight or can any leachate penetrate the plate?" and: "What are the reasons for the deficiencies?" Leachate in this case originates from the silage (corn) that is stored in the silage plate.

First visit and report

My first visit in 2015 resulted in a short report to the court, expressing that it would be impossible to answer the questions if the silage plate was not opened. No one could see from the top if leachate was penetrating or had penetrated the plate or not — and to open a silage plate means to destroy it, at least in a few areas. The first report was adequate enough to decipher that — based on photos from the construction phase back in 2010 and not existing documentation — it was very likely that poor craftsmanship was to blame and that relevant boundary conditions had not been paid enough attention to.

Figure 1

Figure 1 shows one of four chambers of the silage plate. The rest of the year's harvest can be seen in the background. All of the silage plate's walls were made from pre-fabricated concrete elements in the shape of an upside down 'T'. The bottom was made from asphalt in two layers: the asphalt surface course layer and asphalt base course layer below. Figure 2 shows water/leachate on the ground, passing somehow through the concrete elements, or underneath it from one chamber to the other. According to the operator, this first happened in 2011. Figure 3 is the most interesting. Throughout the asphalt surface there are a variety of 'asphalt hills'; these 'hills' appeared during rainfall and disappeared when the weather improved. The operator had observed that some kind of liquid came out of the holes. An important question that arose from this realisation was whether the 'hills' meant that the asphalt was no longer

Figure 2

Figure 3

Figure 4

Figure 5


Figure 6


Figure 7


Figure 8


Figure 9

sealed and if groundwater pollution was possible with the leachate from the silage leaking through the destroyed surface in those 'hill areas'.

The result of the first report was the decision from the court: open the silage plate. So I did.

Second visit and report

I decided to open the asphalt in four places and to remove five concrete elements. From a legal perspective this was not straightforward. When an expert witness (partly) destroys such a silage plate, who then is responsible for repairing it? The court agreed that this would not be my responsibility. Figure 4 shows how the asphalt was opened. Figure 5 shows that during the removal, there was a slight bending of the asphalt piece, which clearly shows that the asphalt was damaged and no longer stable. After removal, a yellow liquid was collected (Figure 6) from underneath the asphalt.

Later on, the laboratory investigation identified two samples from this yellow liquid as being leachate from the silage with chemical oxygen demand values of 22,100 and 46,300 mg/l. Figure 7 shows the horizontal separation of the asphalt surface and base course layers. It turned out that the base course layer was crumbling, with very limited coherence between the particles. At that time it became clear that leachate did get underneath the silage plate and that it had at least partly destroyed the asphalt. In two out of three asphalt openings, leachate was found. But how could this happen if the asphalt top layer was clearly intact?

Figure 8 shows the removal of one of the concrete elements. It is important to understand how such T-elements are connected. During the assembly of the wall between the elements, a form of gum string (foam backer rod) is placed. Such gum strings can be seen hanging loose in Figure 8. Additionally, Figure 8 shows the joint between two concrete elements on the left hand side; this joint was covered with mastic (sealant). The mastic is responsible for sealing the joint. In order to prevent the mastic from flowing freely into the joint, the gum strings needed to be placed properly. This meant that those gum strings were not the basis for the tightness, but poorly-set gum strings clearly allow leakages.

Figure 9 shows all the key elements. At the outside of the concrete element is the mastic (sealant). It is leaning towards the string. If this is not properly assembled, leachate will creep through the connection over the years and as the silage plate is filled and emptied every year, the mastic experiences wear and tear. As a result of the poor assembly during construction, I found that gum strings had been twisted and falsely positioned in several places. Underneath the concrete elements, massive amounts of leachate were found (Figure 9).

On the left hand side in Figure 9, the concrete section of the 'T-piece' is dark in colour. It is assumed that this shows the water/leachate level between the T-pieces.

Conclusion

The court report identified two reasons for the penetration of leachate through the silage plate. Firstly — although the ground report clearly depicted potentially high ground water levels — the construction company ignored every sign. This resulted in ground water pressure from underneath the silage plate, which was strong enough that in certain places the asphalt broke and 'hills' were created. Secondly, due to poor assembly of the joints between the concrete elements, leachate penetrated first through the mastic (sealant) via the gum strings into the ground.

The damage, therefore, originated from two sources: leachate travelling through the joints into the ground and leachate leaking through the asphalt 'hills' into the ground. It could be assumed that — due to high compaction because of the heavy load from the silage — the ground used to be quite hard and leachate was distributed horizontally underneath the silage plate. Over time, the ground softened and leachate also started to flow vertically.

The fine print

Concrete walls and an asphalt ground plate have been best practice for silage plates in Germany since 2008, if not before. Loads from the plant/silage heap and loads from the vehicles to unload and compact the fresh plants must be paid attention to. Basic engineering standards were ignored when this silage plate was built in 2010. 'Hills' have been reported many times on silage plates in general. Leachate works through the silage plate into the ground. Joints between the concrete elements require maintenance, which was described in the proper documentation for the silage plate. This documentation was to be delivered by the construction company. Supervision of the construction of any such silage plate by a third party was required.

Lessons learned

The basis for every silage plate design and construction is a proper description of loads. It is absolutely necessary to ensure proper ground water management, such as through drainage, especially if silage plates are constructed on ground with high groundwater levels. Operators need to understand that even something that seems as simple as a silage plate needs proper documentation and maintenance.

Note: not all details have been presented in full and some elements have been simplified.

For more information:
This article was written by Torsten Fischer, founder and managing director at Krieg + Fischer Ingenieure. Visit: www.kriegfischer.de