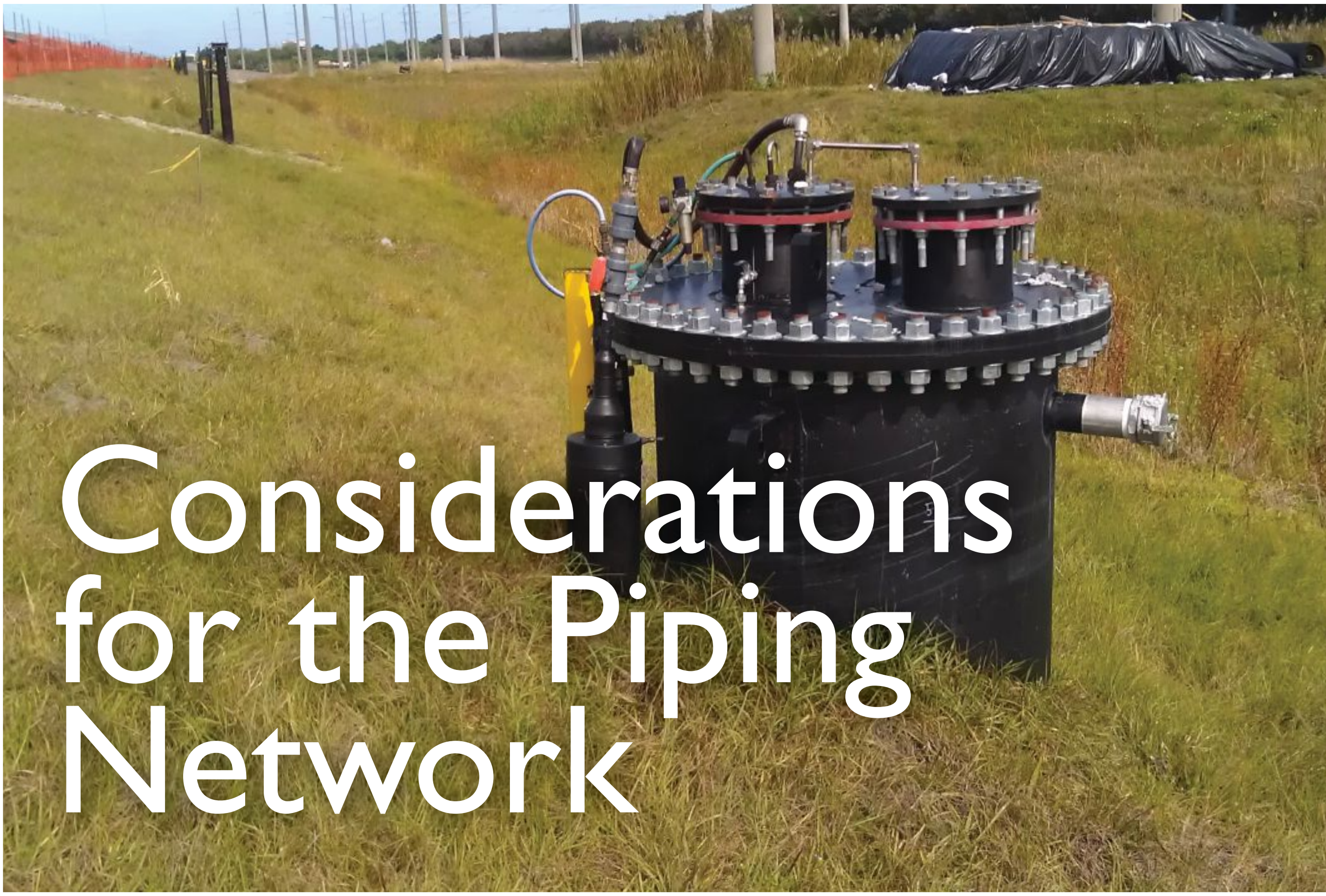

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Considerations for the Piping Network

The elements needed for a piping network in a gas collection and control system

BY ALI KHATAMI, SRIVIDHYA VISWANATHAN, AND DAVID FISHER

An essential part of landfills accepting organic matter is the gas collection and control system (GCCS) for controlling odors and landfill gas (LFG) emissions into the environment. Due to the inherent nature of LFG, significant environmental and regulatory requirements are established in the federal, state, and local regulations to address the safe handling of LFG to protect human health and the environment. GCCS design and construction have evolved significantly over the past four decades, from passive venting trench systems to a sophisticated and elaborate piping system with specialized components for handling LFG, landfill liquids, and condensate flowing through the piping system.

Primary Vacuum Conveyance Line

LFG headers that extend from a blower skid to the LFG piping network in the landfill are the primary vacuum conveyance lines to the LFG wells inside the landfill. The LFG header integrity over the life of the facility is of vital importance. Any damage to the pipe or collapse occurring in the LFG header can potentially cause the LFG extraction system to be shut down for an extended period. If the extracted LFG feeds a gas-to-energy system, interruptions in LFG flow can have financial and contractual consequences. Moreover, if located in an urban area, there can be associated air quality and odor issues which can cause regulatory compliance problems and complaints for the landfill operator.

As the primary vacuum conveyance system to the LFG piping network, headers are in service from the first day the GCCS is activated and continually function to prevent any interruption in the LFG extraction service. The first segment of the LFG header is typically constructed and placed in service along with the LFG disposal facility flare system, LFG-to-energy conversion system, and other structures. As the landfill grows in size and additional LFG wells are required, the LFG header system expands to serve the expanding network of LFG wells.

Conveying Condensate—Slope and Gravity

As LFG moves from LFG wells to the LFG header, the LFG temperature drops and water vapors in the LFG begin falling out of the gaseous state into the liquid state. This condensation results in water or condensate flowing inside the LFG header moving toward the lowest point in the piping system. Condensate generation begins just after LFG enters a lateral pipe and continues through the system and the LFG header until reaching a collection point.

Condensate generated in the GCCS piping network must be removed to prevent partial or total "watering-out" of the conveyance pipes, a hydraulic blockage at a depressed location in the piping system to the point when LFG removal is not fully realized. Removal requires designing and constructing the piping network, using gravity to maintain the flow throughout the network to the collection point. Any dip in a pipe could become a blockage point in the system, and LFG flow may be partially or fully restricted.

The flow of condensate in the LFG piping network is partly guaranteed if the slope of each pipe segment is such that condensate can flow under gravity toward the collection point. Landfill designers need to be conscious of changes to the pipe slope over the life of the facility and should design the system maintaining a positive flow of condensate toward the collection point as the landfill expands, and the piping network becomes larger over time.

Isolation Valves on LFG Header Inside Waste Boundary

In more massive landfills, the GCCS piping network design connects each branch of the piping network to a specific condensate sump. Each branch may include one or more lateral header pipes and many other laterals connecting the LFG wells to a condensate collection system. Alternatively, some designs incorporate connecting one condensate sump to more than one branch of the piping network. For maintenance purposes, installing isolation valves in the piping network functions to isolate a specific part of the overall network. By using isolation valves, the majority of the LFG collection system can remain in service while taking a segment of the network out of service for maintenance.

Isolation valves also play a cost-saving role when expanding the LFG piping system. The expanded portion may be constructed and connected to the existing network while isolating points of connection with valves, thus preventing impact to the existing network.

LFG Header Crossing an Anchor Trench

LFG headers extending into the landfill footprint will cross the lining system anchor trench at the landfill perimeter when the LFG disposal unit is outside of the landfill footprint. When landfills are in the early stages of development and landfill slopes are not fully developed yet, the LFG header crossing the lining system anchor trench is commonly positioned directly above the anchor trench. If the LFG header is in contact with the lining system anchor trench, expect costly complications during construction of the final cover at the crossing point. Positioning the LFG header against the lining system anchor trench prevents the welding of the final cover geomembrane to the lining system geomembrane along the landfill perimeter. When closing a slope, relocating or elevating the LFG header to create the space needed below the LFG header for welding the final cover geomembrane to the bottom lining system geomembrane is not sensible; therefore, the crossing point of the LFG header becomes a weak point in the system and a potential pathway for LFG leaks.

If LFG headers extend into the waste footprint, place the LFG header such that there will remain a minimum distance of 3 feet between the top of the anchor trench and the bottom of the LFG header enabling the future final cover geomembrane to secure to the bottom geomembrane.

Condensate Sumps—Inside Landfills

It is common to place condensate sumps inside the landfill at a low point in the piping network. This placement occurs typically when the LFG header enters the landfill footprint and follows a serpentine path with low and high points on the landfill surface. Condensate sumps are then designed to be located at the LFG header low points catching and removing condensate from the piping system. Condensate sumps located inside the landfill are prone to damage as the landfill settles. Also, the top of the condensate sump is very often set to provide access to the top area of the condensate sump during operation and before closure of the landfill slope around the condensate sump. Consequentially, the top of the condensate sump very often ends up too low to construct a final cover of several feet in thickness around the condensate sump. The condensate sump must be taken out of service to extend it vertically to keep the top above the final cover surface causing interruptions in the LFG collection system operation at a considerable cost. If condensate sumps are in position inside the waste footprint, the designer should construct the condensate sump with the top located above the location of the future final cover and allow for an access plateau or a ramp to the top area of the condensate sump for maintenance until the final cover is placed.

Condensate Force Main—Inside Landfills

Condensate collected in condensate sumps uses electric or pneumatic pumps for removal. The pumps push the condensate liquid into a force main extending from the condensate sump to a discharge location. The system at the discharge location could be a leachate force main, a leachate storage tank, an individual condensate sump or tank, or another liquids management system. The force main from the condensate sump is located in waste if the condensate sump location is inside the landfill footprint. The structural stability of the condensate force main, if buried below many feet of waste, is a design factor that LFG designers bear in mind. The condensate force main extending from a condensate sump located inside the landfill footprint should cross the lining system anchor trench at the landfill boundary and connect to a component of leachate, condensate management system outside the landfill. If the condensate force main is laid directly in contact with the lining system anchor trench during construction, welding of the final cover geomembrane to the bottom geomembrane at the crossing point will become another expensive issue in the future.

Pneumatic Pumps—Inside the Landfill

Condensate sumps running on pneumatic pumps need to have compressed air lines extended to them for powering the pneumatic pumps. Small diameter HDPE pipes extending from an air compressor located in a shed outside the landfill footprint provide the compressed air to each condensate sump. Sometimes a second compressed air line is dedicated to pneumatic pumps in LFG wells for removal of landfill liquids accumulating in the LFG wells.

For instances when the condensate sump location is inside the landfill footprint, the compressed air line must also extend into the landfill footprint, and possibly be buried below waste to reach the condensate sump. Similar to the case of the condensate force main discussed above, compressed air lines also need to be designed in consideration of the compressive loads of waste above the pipe. The compressed air line, similar to the condensate force main, will cross the landfill boundary to connect to a pneumatic pump inside a condensate sump or an LFG well. The design of the GCCS should accommodate the welding of the future final cover geomembrane to the bottom lining system geomembrane at the crossing point as previously discussed.

Collapsing LFG Header Buried Deep in Waste

Often large landfills which have been in service for several decades have several layers of LFG headers in the vertical profile, extending in various directions and elevations, buried in the waste. These LFG headers are constructed over time, supplying extra vacuum needed at new LFG wells or when the vacuum pressure in an LFG header buried deep in waste is insufficient. These headers can collapse under the waste surcharge loading and fail to provide enough vacuum to the LFG wells connected to the line. So measures are taken to add more vacuum, thus leading to the layering effect.

The monthly monitoring of LFG wells indicates whether vacuum to the LFG well is interrupted or reduced over time. When measures are taken to increase the vacuum to LFG wells, the existing LFG wells can connect to a new or existing LFG header at a higher elevation while the connection to the existing LFG header at the lower elevation remains. This process may be repeated a few times during the active life of a deep landfill without the need to extract waste.

LFG Header Above the Final Cover Geomembrane

LFG pipes including the LFG header, lateral header pipes, and other laterals may be constructed in waste above the final cover geomembrane or, more typically, in waste below the final cover geomembrane. Landfill operators installing the network above the final cover have the benefit of accessibility in the event that a reading indicates preventative or corrective measures are necessary, without opening the final cover geomembrane. Construction of LFG pipes above the final cover requires effective planning to minimize interruption in the LFG collection system operation and designing the penetrations of pipes through the final cover geomembrane to connect the system above to the system below the geomembrane.

For constructing the LFG headers above the final cover geomembrane, there is a possibility of conflict between the LFG header and down chute pipes in the surface water management system. Carefully design the down chute pipe in regards to the LFG header so that the gravity flow of condensate in the LFG header is not adversely affected while the water in the down chute can reach the bottom of the slope and to the perimeter drainage ditch. In most cases, the down chute pipe needs to be depressed into the landfill slope so that the crossing LFG header above the down chute pipe can still convey liquids inside the pipe to a condensate sump at a lower location on the slope, or outside the landfill boundary. At the down chute pipe's point of depression, the cover geomembrane is likewise depressed.

Several Benefits of Placing the LFG Header Outside the Waste Boundary

A proven beneficial design option during construction and operation is placing the LFG header and condensate sumps in the landfill perimeter berm. Construction of the LFG header and the condensation sumps may occur inside the landfill perimeter berm during construction of a new cell or a lateral expansion to the landfill footprint. More benefits are summarized below:

1. A single LFG header in the landfill perimeter berm eliminates the need for multiple layers of LFG headers buried in the landfill waste profile as the landfill grows or expands in vertical or lateral directions.
2. For berms with sloping surfaces, the LFG header may be constructed at a certain depth below the top of the berm to use the slope of the berm for gravity flow of condensate inside the LFG header. For flat berms, the LFG header may be buried in the berm with high and low points in the LFG header profile at certain intervals. The slope of the LFG header can be much less than the slope of an LFG header placed inside the landfill because settlement of the LFG header located inside the perimeter berm is not an issue, while the LFG header located inside the landfill should be constructed to accommodate for waste settlement in the long run.
3. Constructing the LFG header when cell construction is in progress provides significant cost savings compared to constructing an LFG header inside the landfill under a separate contract at a different time. The savings may come from reducing or eliminating the following:
   - Consulting fees for the development of a separate set of plans
   - An entirely independent CQA effort because the CQA party presiding over the cell construction will also take care of the LFG header construction
   - GCCS contractor mobilization or demobilization cost if the cell and LFG header construction can take place under one contract
   - The cost of excavation and relocation of waste spoil that comes out of trenches for an LFG header located in waste
4. The LFG header will be readily accessible throughout the active and post-closure life of the landfill. Because the system components are accessible:
   - Maintenance of the LFG header can be performed with minimal cost and effort.
   - New connections or modifications to the LFG header are easier and faster.
   - Condensate sumps located in the landfill perimeter berm are easily accessible for maintenance.
   - Condensate force main and compressed air lines to the pneumatic pumps inside the condensate sumps are readily accessible for maintenance, and future modifications if necessary.

Gas header cleanouts with isolation valves

In conclusion, the authors recommend that GCCS designers keep in mind construction of the final cover over landfill slopes and the interaction that GCCS components will have with the final cover components during the design stage of a GCCS. Careful attention to these details can potentially save significant modification costs and inconveniences for the landfill operator prior to and during construction of the final covers. Also, the authors recommend placing the LFG header in the landfill perimeter berm in consideration of all site conditions. The benefits described above emanating from such design practices may be only part of the benefits the landfill operator will experience during the long-term life of the landfill. MSW

***Ali Khatami**, Ph.D., PE, LEP, CGC, is a Project Director and a Vice President of SCS Engineers. **Srividhya Viswanathan**, PE, is a Senior Project Director with over 10 years of engineering experience. **David Fisher** is an SCS National OM&M Compliance Manager with 18 years of environmental experience.*