Town of Hanover

Technical Memorandum
Anaerobic Digesters Assessment

May 2020

Ainley Project:120035

1.0 Introduction

The majority of the existing digester complex at Hanover WWTP was constructed in 1980-1981 (the existing secondary digester predates 1980). Digester facility upgrades were done in 1994. The digester complex generally incorporates the following:

- One primary digester (with a fixed steel type cover & gas mixing system)
- One secondary digester (with a steel floating 'pontoon' type cover)
- Sludge piping
- A digester gas handling room (with mixing compressor)
- A waste gas burner
- A boiler room (with a combined boiler/sludge heat exchanger unit)
- A sludge piping control building including a basement

2.0 Objectives

The objectives of this Technical Memorandum (TM) is to review the status of the existing digester complex and to assist the Town in determining if/what changes or upgrades are required to various parts of the digester complex to bring the complex up to date with the various codes, especially the Digester Code CSA B149.6-15 and TSSA DLB 2016.

3.0 Anaerobic Digesters Covers

3.1 Primary Digester

- The digester is an anaerobic primary digester that is heated and mixed.
- Size: 15.2 m diameter x 7.13 m SWD with a 2.28 m deep cone (50 ft diameter x 23.4 ft x 7.5 ft deep cone).
- Liquid Volumes: 1294 m^3 (w/o cone), 1432 m^3 (w/cone).
- Operating pressure: 3.0 kPa (12 in WC)
- Side skirt: +/- 2,050 mm deep
- Volume of gas stored within cover (above LL): 183 m^3
- Cover: Is a fixed steel cover, with exterior insulation. Cover has internal support beam system and a side skirt. The cover is supported on top of the concrete tank by steel brackets that are bolted to the concrete. The brackets are of an older design that does not incorporate a sliding movement effect. A sliding type bracket helps mitigate any issues caused by temperature differences that could affect material stress of both the steel cover and the concrete tank.
- Access Hatches on Cover: The cover is equipped with 2 large access hatches: One hatch is 1050 mm diameter (bolt down aluminum flanged type) and the other is 750 mm diameter (non-sparking aluminum quick release type). Both hatches are as per code.
- Sampling Hatches on Cover The cover also is equipped with 6 x 200 mm diameter sampling hatches. The hatches have 200 mm diameter pipes that extend down into and below the liquid, which prevents gas loss when retrieving sludge samples.
- On the top of the cover is a gas hut that incorporates a 3-way lubricated plug valve and a set of dual pressure/vacuum relief valves (all as per code).

- Attached to the hut are 2 valved gas draw-off pipes that allows the digester gas to be transferred to the gas room. One pipe is for gas transfer to utilities (waste gas burner and boiler) and the other transfers gas to the mixing compressor. The gas pipes are insulated as per code. However, the insulation and cladding needs repair or replacement.
- The digester is equipped with a 1200 mm diameter side wall access hatch (as per code).

3.2 Secondary Digester

- The digester is not heated or mixed, but acts as a settling tank with supernatant removal.
- Size: 15.2 m diameter x 6.715 m SWD with a 1.523 m deep cone (50 ft diameter x 22 ft x 5.0 ft deep cone).
- Liquid Volumes: 1218 m3 (w/o cone), 1310 m3 (w/cone).
- Operating pressure: +/- 2.5 kPa (+/-10 in WC)
- Side skirt: +/-600 mm deep
- Cover: Is a floating 'pontoon' type steel cover, with no exterior insulation. Cover has external and internal skins forming a hollow interior with internal support truss/beam system and a side skirt. The cover has a 610 x 610 mm square hatch for access into the interior of the cover and many vents. This type of cover stores no gas.
- The moving cover has rollers at several points around the circumference that allows to the cover to move up and down freely and keep the cover centred in the tank. The rollers also help in preventing the cover from tilting, that would otherwise cause the cover to jamb. The rollers do not appear to be located in fixed side mounted metal guides. The guides would help prevent the rollers damaging the concrete wall and keep the cover from rotating.
- The liquid level in the secondary digester is about 900 mm lower than the primary digester level. This allows for an automated sludge transfer by gravity to the secondary digester every time raw sludge is pumped into the primary digester.
- The cover is equipped with 1 large access hatch of 686 mm diameter (bolt down aluminum flanged type). This does not comply with code requirements. The cover should have the same number and size of hatches as the primary cover.
- The cover also is equipped with 1 x 200 mm diameter sampling hatch. The hatch has a 200 mm diameter pipe that extends down into the liquid, which prevents gas loss when retrieving sludge samples.
- On the top of the cover is a gas hut that incorporates a 3-way lubricated plug valve and a set of dual pressure/vacuum relief valves (as per code).
- Attached to the hut is a valved gas draw-off pipe that allows the digester gas to be transferred to the gas room. The draw-off pipe has a flexible connection on it between the moving cover and the fixed pipe part on the building. The flexible connection allows the cover to move up and down based on variations of liquid level. The gas pipe is insulated as per code. However, the insulation and cladding needs repair or replacement.
- The digester is equipped with a 1200 mm diameter side wall access hatch (as per code).

3.3 Third Party Inspection:

The primary and secondary digesters have been in service for a long time as both digester covers were installed around 1981. The last cover inspection was done in 2013 by Landmark Municipal Services. The inspection was limited to visual inspection as the primary digester still had sludge in it - which posed a health/safety risk for entering the tank. The report had general observations as follows:

- Internal cover coating showed signs of some coating deterioration and rust in spots,
- Internal piping looks to be intact with buildup of external material,
- External steel cover side wall (not covered by roofing) shows signs of coating deterioration and rust in a lot of spots,
- External steel cover could not be observed due to the built-up roofing being intact.

3.4 Recommendations for Upgrades:

- Based on the length of service of the digester covers (40 years) and limited repairs/maintenance - it is recommended that the covers be replaced with new covers. The primary cover should be the same fixed type, but with sliding type support brackets. The secondary cover should be replaced with a floating gas holder type cover that holds some gas (not like the current floating pontoon type). Most of the existing gas safety equipment and some of the hatches can be reused after inspects and replacing of seals/gaskets, etc.
- Preliminary digester cover quotes have been obtained for estimation purposes and are included in Section 8 as part of an overall digester facility upgrade.
- The primary digester has 2 large diameter hatches and gas safety equipment as per code. The hatches and safety equipment should be investigated and possibly reused by just replacing the sealing gaskets, etc. However, the digester code now requires that an additional hatch be provided – an emergency pressure relief hatch designed to automatically relieve any internal pressure caused by a malfunction of the gas safety pressure/vacuum devices on top of the cover.
- Since a new secondary cover is recommended – all new hatches (including the emergency relief hatch) and gas safety equipment will be provided for this cover.

4.0 Primary Digester Gas System:

The gas room is located at grade level and is connected to the primary digester and the digester control building. The gas room has two doorways at 180 deg from each other. The gas room, also, is connected to the boiler/sludge heat exchanger room, both separated by a solid wall. The boiler room has a separate entrance door.

- **Primary Digester gas piping**: Two - 100 mm dia. draw-off pipes from the primary digester enter the gas room at the south-east roof corner. One pipe is dedicated to the utilities (waste gas burner and boiler) and the other is dedicated to the gas mixing compressor. The primary digester gas flow pipe that is dedicated to the utilities reduces down to 75 mm dia. and passes through a condensate accumulator, a flame trap assembly (flame arrester/thermal valve) and continues to the boiler/sludge heat exchanger unit. The condensate accumulator is equipped with an internal cooling coil,

which receives a cooled recirculated water flow from a cooling unit, located in an adjacent room. Downstream of the branch pipe to the boiler, the primary digester gas flow pipe has a branch line with a 75 mm dia. pressure regulating valve (PRV-1) and connects to the gas pipe from the secondary digester flow.

- **Boiler/Sludge Heat Exchanger gas piping:** The boiler digester gas flow pipe incorporates a flow meter (with a bypass) and isolation valves to the boiler. The gas pipe size to the boiler is 32 mm dia. The flow meter pipe size is very small dia. The boiler/sludge heat exchanger was recently replaced and was not part of this review.
- **Secondary Digester gas piping:** A 100 mm dia. gas pipe from the secondary digester enters the gas room at the south-east roof corner. The gas flow pipe reduces down to 75 mm dia. and passes through a condensate accumulator, a flame trap assembly (flame arrester/thermal valve) and connects to the gas pipe from the primary digester flow**.**
- **Waste Gas Burner gas piping:** Downstream of the primary and secondary gas flow connection point the gas flows to the waste gas burner. The gas passes through an isolation valve, another 75 mm dia. pressure regulating valve (PRV-2), a flow meter (with a bypass) and a flame trap assembly (flame arrester/thermal valve). The piping system for the waste gas burner has a pressure switch on it which provides a control signal to the burner natural gas pilot that allows to the pilot flame to start-up just prior to the digester gas being released to the burner. The pipe size to the waster gas burner is 75 mm dia. and the flow meter pipe size is very small dia.

4.1 Comments:

For the primary digester gas pipe, the recirculating cooling unit for the condensate accumulator maybe ‘over-kill’. To save energy and maintenance it is recommended to remove the recirculating unit and keep the internal cooling coil and just run cool water through it. As per the digester code a continuous trickle of water flow through the accumulator should be adequate to keep the accumulator and the water trap primed/sealed and cool enough to condense moisture from the gas.

The gas piping system seems to be complicated in terms of arrangement and operation. The gas lines from the digesters are separate, have no common interconnection until after the boiler branch line. The system incorporates 2 – 75 mm dia. pressure regulating valves in series (PRV-1 set at 300 mm WC & PRV-2 set at 150 mm WC). The system requires some manual operation of valving on the secondary digester system when gas flow from the secondary digester needs to be introduced or controlled or redirected into the main gas flow piping. This is complicated and should be modified to a simpler system that does not require any routine manual intervention.

The boiler gas flow line does not have a back pressure sustaining valve. This type of valve would protect the digesters from seeing a vacuum condition, should the boiler gas system safety devices fail. Normally this type of valve is set at 100 mm WC (4 inches).

The digester code requires that low-pressure sediment/condensate trap tanks have a continuous water flow into the tank to ensure that a cool water reservoir (at bottom of tank) is able to cool down the gas to collect the condensate on the tank side walls. As well the digester code requires all low-pressure condensate capture points of piping systems have continuous

water flow drip traps instead of the manual drip traps. The continuous water flow helps ensure continuous-automatic removal of condensate and a water sealed trap at all times (should the trap accidently dry out). The condensate trap tank, seal water traps (including those at low point piping) should also have a sight glass on them to ensure water at all times in the seals.

The waster gas burner system uses a pressure switch to pre-start the waste gas burner pilot flame prior to the digester gas being released to the burner. The TSSA now requires that all waster gas burners have a continuous burner pilot flame at all times, whether burning digester gas not. This should be modified to comply with the TSSA requirements.

4.2 Recommendations for Upgrades:

- The gas piping system/accumulators, etc. should be reviewed for sizing to minimize head-losses and be simplified for flow and operation purposes and without manual control intervention.
- The primary and secondary digester gas inlet piping should be connected to a common header that allows the gas to pass through 2 condensate accumulators in parallel at the same time. Either accumulator can then be isolated for maintenance with gas from both digesters flowing through at least one accumulator. Each accumulator should have water trickling through it for a constant prime and water trap sealing.
- Downstream of the accumulators the gas piping should combine into a common header. The common header will have 2 branches. One pipe branch for the boiler system that incorporates an isolation valve, a flow meter (with bypass) a back pressure regulating valve set at 100 mm WC (4 inches) and a flame trap assembly. Another branch for the waste gas burner system that incorporates an isolation valve, a flow meter (with bypass) a pressure regulating valve set at +/- 280-300 mm WC (11-12 inches) and a flame trap assembly. The 2 existing 75 mm dia. regulating valves can be reused to be repurposed into the new system layout as they are an appropriate size. The system as described above would be more simplified and be able to operate without any manual intervention.

5.0 Primary Digester Mixing System:

The primary digester gas mixing system is located in the gas room. The primary digester gas flow/pipe that is dedicated to the gas mixing compressor enters the gas room at the south-east roof corner. The mixing system generally consists of inlet piping (with special fittings), a recycle gas mixing compressor, discharge piping (with special fittings), a distribution header, distribution pipes into the digester and un-confined gas type diffusers in the digester.

- **Mixing Compressor (inside gas room):** The compressor is a sliding vane positive displacement, oil lubricated type with a 7.5 kW (10HP) motor. The compressor is equipped with a pressure lubrication system designed to lubricate the sliding vanes and the bearing of the compressor. The lubrication system is equipped with a Low Pressure (LP) safety shut-off switch should lubrication system run out of oil. Since the compressor is a positive displacement type, the discharge piping is equipped with a recycle PRV that is piped back to the inlet side piping.

- **Compressor Inlet Piping:** The inlet piping is equipped with: an isolation valve, a sediment/condensate trap tank(*) (with a manual drip trap), a flame trap/thermal valve assembly(*), an inlet filter (c/w bypass and manual drip trap), an automatic safety shut off valve (ASSOV) and a Low Pressure (LP) safety shut-off switch(*). Note: Items with an (*) after are as required by code. The inlet piping does not have a check valve upstream of the discharge PRV. The check valve would help prevent any possible high pressure from getting back into the digester, which could cause damage to the digester cover.
- **Compressor Discharge Piping:** The discharge piping is equipped with: an oil accumulator, a check valve, an isolation valve, a High Temperature safety shut-off switch(HTS)(*), a High Pressure discharge safety shut-off switch (HPS)(*), a PRV valve (connected to inlet)(*), a check valve(*). Note: items with an (*) after are required by code. The oil accumulator helps capture oil and reduces the amount of oil entering the sludge. Due to the high pressure of the compressor the oil accumulator requires a manual drip trap.
- **Gas Pipe Distribution Header:** The header consists of a wall mounted horizontal pipe that distributes the recirculated digester gas to each of the 8 mixing diffusers via separate gas feed lines. Each gas feed line is equipped with an orifice plate. The orifice plates create a constant back pressure in the header pipe allowing for equal flow distribution. The orifice plates have isolation valves for maintenance purposes. Each gas feed line has a flushing connection for the purpose of flushing out the line and the diffuser should they become clogged with sludge. The discharge header pipe from the mixing compressor is partly located outdoors on the roof of the gas room. The level of this outdoor pipe is located above the liquid level of the primary digester, which (along with the discharge check valve) helps to prevent syphoning of any sludge back into the compressor.
- **Mixing Diffusers (inside digester):** There are 8 un-confined type gas mixing diffusers evenly distributed around the tank's sloped floor. The diffusers create a vertical spiral-roll mixing pattern of the sludge contents.

5.1 Comments

The mixing compressor uses oil for lubrication. Oil has been leaking from the compressor and has made the floor slippery and a health/safety concern. The gas mixing system is complicated and has a lot of safety components.

The current inlet condensate trap is made of carbon steel – TSSA considers the traps part of a piping system and will probably require that the current tank be replaced with a stainless-steel unit properly outfitted as per code (without a manual drip trap).

A general process review of the digester system was undertaken which indicates that the existing mixing system at the current energy rating is inadequate for the size of the primary digester.

5.2 Recommendations for Upgrades:

- The existing mixing compressor should be replaced with a larger size unit of the same type and capacity.

- Before a new compressor is contemplated a design, review should be considered to determine if a more simplified and efficient mixing system would be better suited for the mixing application.
- Should a mixing compressor system remain in use it is recommended to install a check valve upstream where the PRV recycle connection is located. As well an oil containment lip/catchment area should be provided on the concrete base to help capture oil that would otherwise leak onto the floor.
- Compressors generally use a typical motor type oil – however, the oil is a contamination issue for the sludge, if the sludge is to be used for say agricultural purposes. An alternative to the motor type oil is to use a ***bio-oil product*** that works just as well as the motor oil for lubrication of the compressor. If the alternative oil is used the sludge would not be contaminated and there would be no need for the oil accumulator.

6.0 Gas Room Building Services:

- ***Electrical:*** The digester code requires the gas room to be a classified area and all components be suitable for such environment. Most of the electrical work (ie: conduits/cabling, compressor, ventilation, etc.) seem to comply with code.
- **Gas Detection System:** The room is equipped with gas monitoring and alarm. The alarm consists of outdoor red lights at each of the 2 doorways. The plant has a standby-power unit which supplies power to various parts of the plant, including the plant alarm system and gas detection. This complies with the digester code.
- **Gas Room Ventilation:** The gas room is equipped with a single supply fan. The fan seems to have only one ventilation rate. The fan switch is inside the gas room. The digester code requires that the ventilation has 2 flow rates: 1) low rate at 6 air changes per hour (acph) running at all times, 2) a higher emergency rate at 12 acph, 3) fan switches outdoors at each doorway. The switches are to turn on the fan emergency high flow rate as an operator enters the room. As well the gas detection system is to automatically start the fan emergency high flow rate.
- **Mixing Compressor Control:** Each doorway has an emergency shut-off button - complying with the digester code.
- **Floor drains:** The floor drains of the gas room that interconnect with other rooms are required by the digester code to have a trap priming system. The existing trap priming tank is located in the boiler room.
- **Secondary Sludge/Sampling Sink Room:** This room comes under the jurisdiction of the digester code. The digester code requires that the room to be a classified area and all components be suitable for such environment, including ventilation, etc. similar to the gas room. Most of the electrical work (ie: conduits/cabling, ventilation, etc.) seem to comply with code.

6.1 Recommendations for Upgrades:

- Confirm that the electrical work and all components and equipment in the classified rooms, comply with the digester code.
- Determine the ventilation flow rate(s) and make necessary flow upgrades/changes as per code.
- Provide ventilation fan switches, externally, at each room doorway.

7.0 Sludge Piping:

The sludge piping for the digester complex is located in several rooms: the lower basement/gallery level, a primary digester supernatant room and secondary digester sludge/supernatant room (the latter 2 rooms at ground level).

- Basement/gallery level: Most of the sludge piping for the digester complex is located in the basement area and consists mostly of ductile iron pipe and is in reasonably good shape. Some small amounts of sludge piping have been changed to stainless steel when some pumps have been replaced. Raw sludge piping that feeds the primary digester is 150 mm diameter. The sludge transfer piping from primary to secondary digester via gravity is 150 mm diameter. Sludge emergency overflow piping (to drain) for both digesters is only 150 mm diameter.
- Sludge/supernatant rooms: These 2 rooms house the supernatant piping, the emergency overflow piping and the overflow control box for both digesters.
- The sludge emergency overflow piping (to drain) for both digesters is only 150 mm diameter.

7.1 Recommendations for Upgrades:

- As per the digester code the emergency overflow piping for both digesters should be one size larger than the sludge feed/transfer piping. The feed sludge piping is 150 mm - thus the emergency overflow piping should be changed to 200 mm diameter. The overflow piping should be replaced to the larger size from each digester to the overflow box and from the overflow box to the discharge point.
- The existing drawings indicate that the discharge point is to one set of existing aeration tanks. The digester overflow and/or supernatant contains higher amount of ammonia and solids that can create an abnormal load on the aeration tanks causing potential aeration upsets.
- Recommend that the discharge point be reviewed and while being up-sized as required – possibly re-directed to either the primary clarifiers or the raw sewage pump station.

8.0 Conceptual Cost Estimate:

Conceptual level cost estimates were developed to give an idea of the magnitude expected. These values represent an ***"Estimate of Probable Costs (Class D)***" and have been prepared from the information available at this stage of the conceptual design. The final costs of the project will depend on actual labour, equipment and material costs, competitive market conditions, final project scope, implementation schedule, and other variable conditions. The costs presented in Table below excludes the following:

- Town of Hanover costs
- Approvals costs, Geotechnical/hydrogeological investigations
- Engineering fees.
- Construction Contingency
- Impacts due to inflation and escalation
- H.S.T.

Table 1 – Conceptual Level Cost Estimates

Description	Subtotal ($)	Installation ($)	Total ($)
Removals: -Sludge removal from both digesters -Remove both steel covers -Sludge overflow piping	 300,000 30,000 50,000	 included	 380,000
Digester covers (carbon steel w/SS side skirts): -Ovivo (quote 1): Prim & secondary = $919,000 US x 1.35 = $1,241,000 CDN ***-Westech (quote 2): Prim & secondary = $1,130,000***	 1,130,000	 300,000 (30% for erection only)	 1,430,000
Digester Coatings both covers (interior & exterior)	165,000	included	165,000
Digesters – scaffolding for erection & internal coatings	150,000	included	150,000
Digester insulation (primary only)	20,000	included	20,000
Digester hatches/gas safety equipment, etc.	100,000	included	120,000
Digester Mixing: -Ovivo-LM reciprocating disc (7.5 HP cover mounted) $170,000US = 230,000CDN + 30% (for erection & electrical) = 230,000 + 70, 000 = +/-$300,000 (Quotation 1) -Ovivo-Mechanical draft tube (15 HP cover mounted) = 175,000US = 236,000 + 30% (for erection & electrical) = 236,000 + 71, 000 = +/- $307,000 (Quotation 2) ***-Brooks/Vaughan pump mixing (20 HP installed in basement) = 77,500 + 40% for install/elec + piping (piping for prim digester only) (Quotation 3)***	 77,500	 -31,000 (30%) -150,000 (pipe)	 258,500
200 mm dia sludge overflow piping (incl u/g to pump station & mods at overflow box)	375,000	included	375,000
Digester Gas piping & mods to existing gas piping	120,000	included	120,000
HVAC -upgrade to gas room ventilation	10,000	included	10,000
Electrical – miscellaneous	30,000	included	30,000
General miscellaneous	--	--	300,000
TOTAL ESTIMATE			**$3,358,000**