Double Membrane Gas Holder

Very Large Capacity  Constant Pressure  Variable Volume
Introduction:
The Walker Process Double Membrane Gas Holder is a durable air supported structure specifically designed for the purpose of biogas storage. Typically, the Gas Holder is installed as part of the anaerobic digestion system in a wastewater treatment plant, agricultural digestion schemes, landfill sites and combined heat-and-power plants that use digested organic materials to generate biogas as an energy source.

Typical Installation:
The gas holder is installed between the digester and the gas consumption equipment:

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**Bio-Gas System Schematic**

A Typical Gas-Holder installation is designed to store approximately 20 hours worth of gas production volume. Storage volumes can be designed to suit the process production and consumption requirements; Smaller units may be required as a buffer storage on a continuously operated plant, but larger gas storage units may be specified to hold the gas for use during the local peak-power requirement period, when energy produced can be sold on at a better price.
The Double Membrane Gas Holder: OUTER MEMBRANE
The Gas Holder structure comprises two spherically shaped membranes and a flat bottom membrane mounted onto a concrete base slab.

The outer membrane is a permanently inflated textile structure. The membrane is inflated by the use of electrically operated blowers – usually specified in matched pairs for Duty/Standby cycles. Non-return valves are fitted in the air supply line to isolate each blower when in standby mode. A regulator valve is fitted on the outer membrane exhaust duct.

WALKER PROCESS EQUIPMENT will specify the blowers to ensure that the membrane remains fully inflated under all conditions of gas filling and consumption. This usually requires the blower to be rated at 1½ to 2 times greater throughput than the maximum gas consumption rate of the plant.

An important point to understand here is that the Outer Membrane Regulator Valve critically controls and maintains the whole system pressure. This valve does not just regulate the gasholder outer membrane, but effectively regulates the pressures throughout; at the digester, the flare stack and the POWER PLANT plant. (See later discussions relating to plant design and pressure systems).
The outer membrane is designed to all appropriate international codes for air-supported structures. The textile membrane is designed to withstand the internal air pressure forces as well as external dynamic forces from wind and snow. WALKER PROCESS EQUIPMENT uses a range of membrane materials of up to 1,011 lbf/2 inches (9,000 N/5cm breaking strain) – the strongest textile membrane currently commercially available. The membranes are manufactured from polyester yarn with a PVC coating. The coating is applied to our own specifications with additives and treatments for protection against sulphur and other components found in biogas. The membrane is specified for a low methane permeability of 167-ml/m²/day/bar pressure. The external membrane receives additional additives for increased protection against Ultra Violet radiation. Typical life expectancy of the external membrane is 20 years in an exposed, high-UV location. Longer durations can be expected in countries where UV levels are reduced. Over the lifetime of the structure, the outer membrane will become embrittled and begin to crack up, exposing the polyester yarns. At the end of its lifespan, the outer membrane can be easily replaced. Inner membranes (see later discussion) do not suffer from the same UV aging process and will outlast the outer membrane by a minimum factor of 2:1. Each roll of membrane material is 100% tested by both computer and human visual inspection techniques.

The membrane shape is manufactured in standard sizes to use the most economical use of standard base material widths. Alternative, specific sizes can be produced but it may not be commercially advantageous to do so.

The membrane form is achieved by precisely cutting the textile roll to accurate design patterns. These patterns are based on over 20 years experience of the behaviour of the textile under pressurised conditions, and have become a very specialised shape to ensure even stress distribution throughout the structure. The lapped joints between the components are high frequency welded under controlled conditions to ISO.9001. Total traceability is maintained for every metre of membrane weld for our quality records. Test welds are produced before each new roll of fabric is set up on the welding machine, and every 82 feet (25m) of weld throughout the construction of the welded membrane.

Fittings through the membrane, such as the viewing port, crown, inlets and outlets, and the base peripheral joint are reinforced with encapsulated stainless steel endless ropes. Each rope is manufactured to the exact size required for each individual project:

Encapsulated, endless stainless steel rope

100% traceable High-frequency welded joints
The Double Membrane Gas Holder: INNER MEMBRANE:

The inner membrane forms the variable volume gas containment within the outer membrane. The inner membrane and bottom membranes are sealed with a gas-tight compression seal around the periphery of the structure on the concrete base. As the volume of stored gas increases, the inner membrane rises to accommodate it. The pressure within the gas containment, and therefore the gas pipelines, is maintained by the air pressure within the outer membrane bearing on the surface of the inner membrane. The pressure differential across the outer air containment and inner gas containment is minimal – due only to the weight of the inner membrane (the gas containment pressure is 0.145 – 0.022psi (1 to 1.5 mBar higher)).

The inner membrane is made from the same textile fabric as the outer membrane. The inner membrane has reduced UV protection because it is not exposed to this radiation, but has an additional anti-static coating to eliminate the possibility of static being caused by the movement of the membrane during operation. Despite the unstressed service condition of the inner membrane, it is always specified to be the same strength as the outer membrane. In the unlikely even of an outside membrane failure, the inner membrane will maintain structural integrity against all loading conditions (internal pressure and environmental).
The Double Membrane Gas Holder: GAS PIPEWORK & PRESSURE RELIEF:

With over 20 years of development and a wide range of installations throughout the world we believe this system is the optimum arrangement of the gas supply pipework and pressure relief.

It is important that gas is supplied by one pipeline and consumed through a second pipeline – even in a system where the gasholder is used as a simple buffer. Biogas is a mixture of methane and carbon dioxide, and this mixture can settle out during periods of stagnation. With a two-pipeline system the gas within the containment is continually in motion – even during periods when production and consumption are equally matched.

The gas supply and consumption pipes are routed underneath the base slab to the centre of the base. The pipes and membranes are sealed using bolted compression sealing flanges. For diagrammatic purposes below, the two pipes are shown opposing each other. In practice, these two pipes would run parallel to each other, radially across the base. The pipework must be specified at the correct size to accommodate the volume flow rate and pressure of each individual plant’s requirements.

The Hydraulic Pressure Relief valve must always be installed on the gas supply line to the Double Membrane Gas Holder. When installed on the supply line, the valve will protect the membrane structure from over-pressure within as well as over-pressure situations caused by a rapid surge in gas production. Each valve is individually manufactured to fixed dimensions to provide the pressure relief necessary for each installation’s combinations of pressure and flow-rates. The valve is constructed from type 316 stainless steel, and uses a 100% glycol anti-freeze fluid inside to maintain the pressure trap. The fail-safe valve operates on the simple principle of hydraulic pressure differentials. The valve must be regularly maintained and checked for level of the fluid contents. In the event of a blow-off situation, humidity suspended within the biogas will condense out in the colder valve fluid and the level will increase. The valve body is supplied complete with a level viewing window, ball-valve drain cock, and a fill-level plug.

Both the supply and consumption pipes must be laid to falls so that any condensate forming within the pipes drains away. Condensate traps must be fitted close to the gasholder to facilitate the removal of the condensate. Typically, the condensate traps are installed in a pit just outside the tank base slab (see illustration on page 1).
The Double Membrane Gas Holder: CONTROL EQUIPMENT:

The standard scope of supply for Double Membrane Gas Holders includes:

1) Ultrasonic Level transducer and instrument.

2) Gas detector transducer and instrument.

• The Ultrasonic level transducer is situated in a housing at the crown of the Outer membrane. The transducer is hard-wired back to the instrument from where the readings can be read and control signals supplied via a 4-24mA control circuit interface for other PLC control equipment. The instrument provides for up to six relays for switching control circuits, for example, for starting the waste gas burner when the gas storage is nearing maximum, etc.

• The Gas Detector transducer is mounted in the outer membrane pressure regulation valve. The unit serves to maintain a continuous check for methane leakage into the outer membrane air containment. The transducer must be hard wired back to the instrument that provides for alarm and relay switching. The instrument is typically configured to provide alarms at 20%, 40% and 60% of the LEL (Lower Explosive Limit) for methane in air. In the event of the third alarm condition, the control system should shut the plant down so that the alarm can be investigated before any leakage reaches a flammable concentration of methane in the outer containment.
The Double Membrane Gas Holder: STANDARD SCOPE OF SUPPLY:

The Standard WALKER PROCESS EQUIPMENT package includes:

- Internal membrane, fabricated to dimensions to suit required volume containment, designed to withstand all in-service conditions. Standard colour: Yellow.

- External membrane, fabricated to dimensions to suit required volume containment, designed to withstand all in-service conditions. Standard colour: White. (Other colour available at additional cost). The external membrane comes complete with:
  - 1-21 inch (550mm) acrylic viewing port, complete with frame and fixings and reinforced opening in membrane.
  - Reinforced openings for air supply hose and air exhaust hose.
  - Housing (top-mounted) for ultrasonic level transducer.
  - Fixing tabs for cable ties for wiring to the crown housing.

- Internal bottom membrane. Standard colour: Yellow

- All necessary perimeter clamping rails, sealant strips. Stainless steel expanding-type anchor bolts for fixing the clamping rails.

- Duty and Standby blowers rated according to the pressure and volume flow requirements of the system. All necessary air hose, type 304 stainless steel ‘Y’ piece. Non-return valve for each blower (constructed from stainless steel and aluminium for non-sparking operation).

- Air exhaust hose and balanced regulator valve, rated according to the pressure and volume flow requirements of the system. Regulator valve constructed from stainless steel and aluminium for non-sparking operation. Valve provided with ¼” port, tapped and plugged, for manometer/pressure gauge connection.

- Ultrasonic level transducer and instrumentation.

- Gas detection transducer and instrumentation.

- Under-base pipework for gas supply and consumption. Pipework rated according to the pressure and volume flow requirements.
The Double Membrane Gas Holder: SYSTEM / PLANT DESIGN CONSIDERATIONS:

As noted above, the Gas Holder maintains the pressure throughout the gas production and consumption system. It is vital that the required operating pressure of the Gas Holder is determined at an early stage in the design of the plant and process so that an accurate quotation can be provided first time.

In any system related to the flow of gas or fluids, there are pressure drops caused by friction of the fluid in motion against the walls of the pipes, through valves and fittings, etc. In a system such as a biogas digestion and POWER PLANT, the pressure will not be the same at any point whilst the gas is flowing. The plant will have a pressure profile that is directly related to the design of the pipework, valves, and plant items involved:

As can be seen in the above diagram, the pressure at the Gas holder is less than at the digester, but greater than at any point throughout the gas consumption distribution. The pressure drop across each section of the plant is directly related to the size and length of the pipework involved, and the number of valves and other fitting through which the gas must flow.

In the simple example provided, the actual pressure required at the digester and gasholder must be worked backwards through the system from the specifications and requirements at the POWER PLANT. Depending upon the length and complexity of the system, the pressure at the digester might be considerably higher than that needed at the POWER PLANT in order that system as a whole can flow the gas at the volume and pressure required.

The use of a gas booster situated before the POWER PLANT is always worthy of consideration. A booster can provide the pressure required at the consumption unit whilst allowing the rest of the system up-stream to be configured for reduced operating pressures. Introducing a gas booster can have a significant effect on reducing over-all plant investment costs as both the gas holder and digester will become cheaper when designed for lower operating pressures. The additional running costs of a gas booster are usually fairly well balanced against the reduced running costs of the smaller blowers required to maintain the pressure at the gasholder. In
addition, a gas booster will only need to operate when there is a demand on the consumption side, thereby contributing further to the balancing of the operating costs.

**The Double Membrane Gas Holder: TANK RIM-MOUNTED GAS HOLDER:**

Double Membrane Gas Holders can also be supplied to provide a storage volume directly on top of a tank wall. In this configuration, the product can offer notable investment savings by eliminating the requirement for a traditional pressure-retaining tank roof and removing the requirement for a separate concrete base for the gasholder itself.

Tank rim-mounted gasholders can be installed onto both concrete and steel tanks, provided that the forces imposed onto the shell have been accommodated into the tank design.

![Diagram of Double Membrane Gas Holder](image)

In its simplest format (above), the two membranes are anchored to the top of the tank wall, with the gas containment formed between the inner membrane and the tank shell and liquid contents. The Outer Membrane is air supported and permanently inflated. Containment volumes can be provided to suit the requirements, with the height of the structure being determined as a product of the volume requirement and tank diameter. As the stored volume of gas is depleted, the inner membrane would float on top of the tank liquid contents.

More complex variations of the tank rim mounted gasholder may be required. These may be configured with a central support column and a system of supporting ‘under belts’ that span from the column to the tank wall to support the inner membrane when the containment is depleted.
Toroidal (or doughnut shaped) rim mounted gas holders can be supplied for attachment to a central mast or column, or where a centrally located gas dome is required:

![Diagram of toroidal membrane gas holder with centrally located gas take-off dome.]
A further development of the toroid allows for gasholders to be mounted on top of tanks with centrally supported mixers: