Steel Digester Covers

Steel digester covers are either fixed or floating:

- Fixed covers are dished upward and anchored to the top of the tank wall.
- Floating type covers move vertically in the tank and are designed to float either on the liquid surface or on digester gas.
    - Covers that float on a liquid surface are called floating covers and those that float on and store gas are gasholders.
    - Combination covers float on a liquid surface when gas is not present and float on and store gas when gas is present.

The main working element of all steel covers of any type is the shell that makes up the sides and top. Typically the shell is ¼ inch thick carbon steel plate. The plate separates the interior from the atmosphere and allows the anaerobic condition to form in the digester and gas pressure to build up under the cover. Sufficient gas pressure is necessary to force the gas downstream to the point of use. Floating covers, gasholders and combination covers are designed to develop a specific working pressure by adding the proper amount of ballast to the cover.

In addition to the shell, all covers have structural elements to accomplish several requirements such as:

- Assist in keeping the components together during field erection of the shell
- Stiffening of the shell, integrating the guide system with the shell for floating type covers
- Support of the ballast necessary to achieve the design working pressure
- Support of any localized or concentrated dead or live loads

There are two basic approaches to the structural design of steel digester covers:

- **Frame / Truss Type Design**
    - One approach is to design a structurally sound framework that will carry all the components of the cover including the plate that makes up the shell, guide system, and ballast.
    - The frame consists of a series of radial trusses, or beams in the case of a fixed cover, that extend from a center ring to the skirt plate near the tank wall.
    - The radial members are interconnected with purlins that run between the trusses or beams.

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- The shell is constructed by laying sections of plate on the frame and welding all the seams to each other and to the frame.

- The plate is not taken into account as contributing to the strength of the framework, although once welded together the composite structure is significantly more structurally substantial than the framework alone.

- This is a conservative approach used for over 70 years that takes into account the corrosive atmosphere of a digester.

- Field assembly of a frame / truss structure is well adapted to the experience available through a general contractor.

- **Membrane Type Design**

  - The other approach is to design the shell to be self-standing, or more specifically as a membrane using shell design methodology.

  - Membrane (or plate) design is more mathematically complicated than simple truss or beam design.

  - It was not commonly applied to the design of digester covers due the complexity of the analysis and design until the advent of computer plate design programs.

  - The membrane design approach has long been used by the oil and water tank industry.

  - It allows the designer to use the absolute minimum amount of steel in a plate structure.

  - More experienced field crews are necessary to construct shell structures properly and to maintain the quality control necessary to maintain the structural integrity.

  - In some instances factory assemblies are promoted as away to deal with various erection issues.

The frame/truss design and the membrane design use essentially the same shell so the only significant difference is in the framework.

- The frame / truss design method provides a structurally sound framework that carries the dead load of the shell.

- The membrane design method counts on the inherent stiffness and strength of the shell and disregards the framework except for the sole purpose of cover erection.

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- Some specifications for membrane type covers require that structural members are to be considered for only erection purposes and not contribute to the overall strength of the finished structure. However, this approach is not consistent with the load distribution and stresses in the elements of the finished structure.

- Unless framework used for temporary support of the plate is removed, the structural elements of the framework will carry load as it becomes part of the final structural assembly.

- Since the structural members will absorb load from both live load and dead load, they should be designed for their total loadings.

- A true membrane dome designed for a 40 psf live load and 20 psf snow load, constructed with plate only and with any temporary framework removed would require a shell thickness of approximately 0.7" thick.

Over a long period of time it is ultimately the failure of the coating system that allows corrosion to occur and, if not corrected, will eventually result in a leak:

- Fixed covers and gasholders with frame/truss design or membrane design, digester gas will escape to the atmosphere.

- Floating covers or combination covers with a frame/truss design, sludge and possibly gas will enter the attic space.

- Floating covers or combination covers with a membrane design, sludge and possibly gas will escape to the atmosphere.

Some advantages of the frame/truss type floating cover or combination cover include:

- A full two-deck structure that protects the main structural elements (trusses) from the atmosphere and provides excellent insulation.

- Greater area of scum suppression.

- Insulating concrete may be place over the complete area of the ceiling plates, inside the attic space so it is not exposed to the deteriorating affects of the atmosphere.

- The attic space is large enough to allow complete inspection of the interior.

- Ballast on the floating cover is located in the attic space that eliminates the deteriorating affects of outside exposure.

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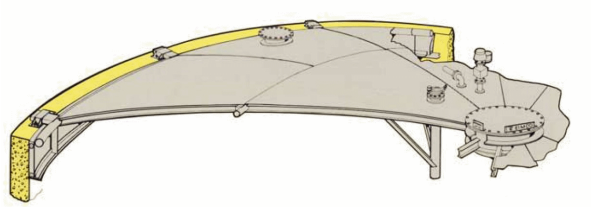
Fixed Covers

Fixed covers are dished upward and anchored to the top of the tank wall and used in primary digesters where the liquid surface is normally held constant. The frame consists of arched radial beams or sometime trusses that extend from a center ring to the skirt plate near the tank wall.

The fixed cover has the framework exposed to the interior of the digester with the shell on the outer surface. The large surface area of plate used is vulnerable to the long-term affect of corrosion. If corrosion penetrates the plate, a leak will occur. In the case of a membrane type cover, the main structural element is then compromised. In the case of a Walker Process frame/beam design, loss of the plate does not compromise the main supporting structure.



Membrane Type Fixed Cover

The underside of this cover that is exposed to the interior of the digester is all flat plate.

If corrosion penetrates the shell, the main structural element is compromised and gas leaks to the atmosphere.

Walker Process Frame/Beam Fixed Cover

The Walker Process fixed cover is designed with beams or trusses that are covered with roof plates.

If corrosion penetrates the shell, gas will leak to the atmosphere but the main structural element (the framework) is not necessarily compromised.

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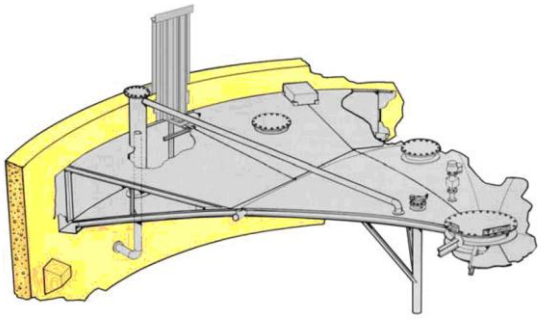
Floating Covers

Floating Covers float directly on the sludge, allowing variable sludge levels. However, practically no gas storage is available and the gas volume is relatively constant.

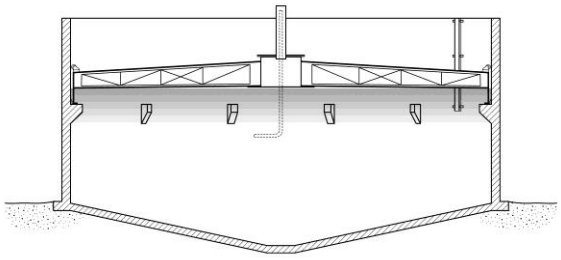
Floating covers move vertically upward and only a few require peripheral guides to keep the cover centered in the tank and to keep it from rotating.

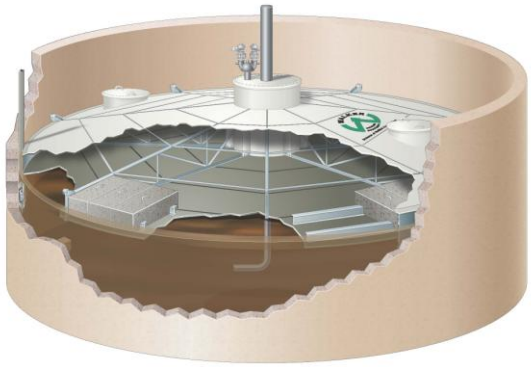


Membrane Type Floating Cover

The underside of this cover that is exposed to the interior of the digester is all flat plate. The outer portion will be submerged and some area near the center will be above the sludge level. Ballast is located on the top of the cover and exposed to the atmosphere.

If corrosion penetrates the bottom shell, the main structural element is compromised and sludge will enter the peripheral (buoyant) area or leak gas to the atmosphere if the leak occurs near the center.





Walker Process Frame / Truss Type Floating Cover

The Walker Process floating cover is designed with trusses above the ceiling plate and protected from the outside atmosphere with roof plates. The underside of this cover is all flat plate. Ballast is located in the attic space. The bottom chord of the truss is sloped upward to the center so the outer portion will be submerged and some area near the center will be above the sludge level.

If corrosion penetrates the bottom shell, the main structural elements are not compromised and sludge will enter the attic area where it may readily be observed during routine inspections that allows corrective action prior to damage of the main structural components (the trusses).

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Gasholders

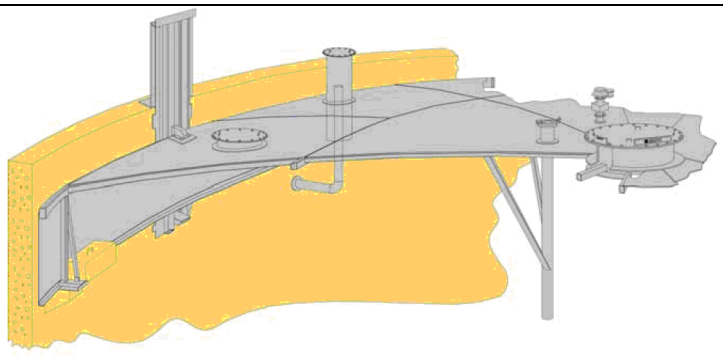
Gasholder covers provide for gas storage by riding on a constant pressure, variable volume of gas. This type of cover has a relatively deep skirt plate and one steel membrane over its structural framework.

Gas holder type covers (by any manufacturer) are inherently unstable because their center of gravity is high and the entire cover is supported on gas only when in operation. Either a vertical or spiral guide system provides for cover travel and to maintain stability throughout its travel range. The ballast is located at the bottom of the skirt to lower the cover's metacenter and increase its stability.

All manufacturers of digester covers have slightly different detail in their approach to their cover guide systems. Walker Process provides a heavy large diameter cast iron wheel assembly or on some occasions a plastic slide block. The wheel design has proven successful on installations for over 50 years and remains the most common type specified and used today. The suggestion that a manufacturer's patented device has rendered any other type obsolete is completely incorrect and unfounded.

The frame/truss type gasholder has trusses exposed to the interior of the digester with the shell on the outer surface. The structural elements that make up the truss are all seal welded and ground smooth as are all the edges of the structural shapes. The large surface area of plate used in either the frame/truss design or the membrane design is no more or less vulnerable to the long-term affect of corrosion.

If corrosion penetrates the plate, a leak will occur in a cover of either design. In the case of a membrane cover, the main structural element is then compromised. In the case of a frame/truss design, loss of the plate does not compromise the main supporting structure.



Membrane Type Gasholder Cover

The underside of this cover that is exposed to the interior of the digester is all flat plate. Ballast is located low on the skirt.

If corrosion penetrates the shell, the main structural element is compromised and gas will leak to the atmosphere.

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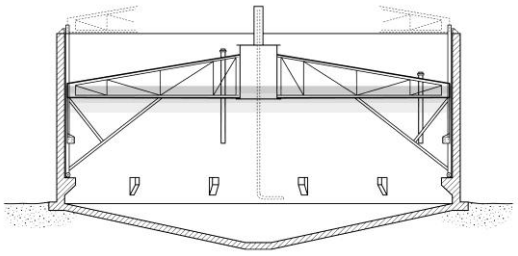
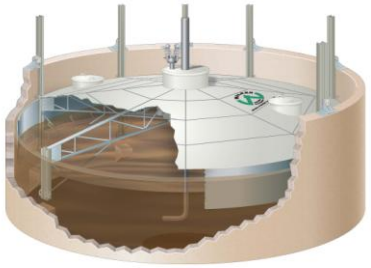


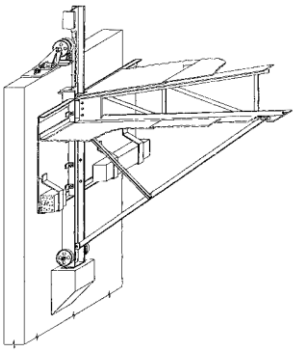


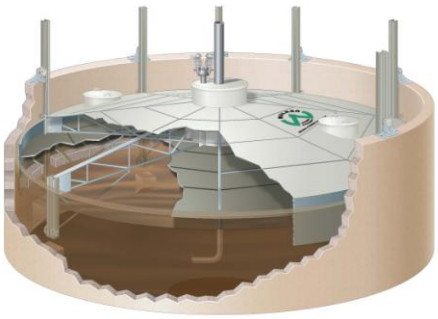
Walker Process Truss/Frame Gasholder Cover

The Walker Process gasholder is designed with trusses that are covered with roof plates. Ballast is located low on the skirt.

If corrosion penetrates the shell, gas will leak to the atmosphere but the main structural element (the trusses) are not compromised.

Combination Floating Cover/Gasholder





Walker Process Frame/Truss Combination Floating Cover/Gasholder

The Walker Process combination cover is both a floating cover that can “float” on a variable liquid level and a gasholder that can store a variable volume of gas at constant pressure. The design of this cover is essentially the same as a conventional floating cover, but with an extended skirt. The trusses are above the ceiling plate and protected from the outside atmosphere with roof plates. The underside of this cover is all flat plate. The bottom chord of the truss is sloped upward to the center so that when floating on the surface of the sludge, the outer portion will be submerged and some area near the center will be above the sludge level.

If corrosion penetrates the bottom shell, the main structural elements are not compromised.

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Summary

In considering the use of frame / truss design versus membrane design for a steel cover over the corrosive atmosphere of an anaerobic digester, the membrane design, which uses the minimum amount of material, may not be the best long-term structural selection. The frame / truss design has a long successful history, is very conservative with a large inherent factor of safety and produces a structure that is readily repaired even after years of neglect.

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