

THE GASHOLDER – SHAPED BY ITS FUNCTION. THE ITALIAN EXAMPLE.

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Keywords

History and construction of specific objects; structural analysis and the development of structural forms; recording, preservation and conservation; the theory and practice of construction history.

Abstract

Gasholders were introduced at the beginning of the nineteenth century for storage of locally produced coal gas, which was used for public illumination and later also for domestic use. These emerging iron structures presented a new kind of industrial architecture, which changed the cityscape substantially. The gasholder's function determined its structure and was initially built with a water-sealed system composed of a water tank, a guide framing and lifts. Over the century the development went from the bell-type and telescopic gasholder (column and spiral guided), working with a water-sealed system, to the waterless or dry gasholder (piston gasholder). Today the historic gasholders are industrial relicts and have often been demolished.

With the analysis of a selection of important gasholders in Italy this paper underlines the significance, development, shape and structure of the gasholders as a part of the engineering and industrial heritage.

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INTRODUCTION

Gasholders were introduced at the beginning of the nineteenth century for storage of locally produced coal gas, which was used for the public illumination and later for domestic use.

The history of gasholders shows an interesting evolution from small, hardly visible bell-type gasholders to the tall piston gasholders, which also became important urban landmarks for the cities. In Chicago Illinois the world's largest MAN-patented piston gasholder was built for *The Peoples Gas Light and Coke Company*. This gasholder was put in service in 1928 – only 14 years after the first piston gasholder – with a capacity of 566.000m³ (20.000.000ft³), a diameter of 85m and a height of 114m (MAN 1930). Unfortunately this gasholder was destroyed by a plane crash in 1943 (MAN 1959).

This paper is part of a PhD-project, which examines low-pressure gasholders in the nineteenth and early twentieth century for public illumination in Italy. Thus middle- or high-pressure gasholders like the membrane or sphere gasholder are not a part of this present research (neither the cable-guided types). The Centro Tedesco di Studi Veneziani supported this research project in 2013/14.

GASHOLDER OR GASOMETER - ETYMOLOGY

It is necessary to begin by drawing a precise distinction between the words *gasometer* and *gasholder* because they are often colloquially used in the wrong sense. The suffix '-meter' stands for an instrument for measurement - a *gasometer* therefore is an instrument for the measurement of an amount of gas. A *gasholder* on the contrary is a functional building, which is used for the storage of locally manufactured gas.

GAS LIGHT – INVENTION FOR PUBLIC ILLUMINATION

Public illumination with gas was introduced for the first time in London in 1808. At this time the British engineers William Murdoch and his student Samuel Clegg were working on the improvement of gas plants and their machines (Schilling 1860).

The production of lighting-gas involved a complex set of different machines and tubes through which the gas had to pass before being stored in gasholders. In general the production of coal gas at the end of the nineteenth century was divided in three phases:

1. Distillation (or decomposition of coal),
2. Condensation of the liquid products of the distillation (or physis purification),
3. Chemical purification.

The coal was inserted into the horizontal, vertical or inclined chambers, the so-called *retorts*, which were heated by a furnace. The distillation process of the coal began by reaching the 1000°C-mark in the retorts. Raw gas was obtained and had a dense brown vapor at this stage, because it contained volatile, liquid and solid by-products from the distillation process. This mixture first had to pass the water-syphon of the retorts where most of the tar was removed. Then the hot gas was cooled down. To obtain a good illuminating power of gas there was a complex range of machines for (chemical) purification, which separated harmful and unnecessary substance, e.g. hydrogen sulfide, carbon disulfide, and ammonia (Calzavara 1899). Finally the purified gas was measured in a kind of counter – for which the nomenclature *gasometer* was adopted. At this point the production-phase ended and the storage-phase began: the gasholder became the central element. The gas was introduced into the gasholder through a subterranean pipe (inlet pipe) and

stored. Through the outlet tube the gas was transported to the public network, after having passed a device for the regulation of pressure. The gasworks generally were in service for 24 hours.

FUNCTION

The gasholder was created by the necessity to store the local manufactured gas in a suitable recipient. This structure had to fulfill two basic requirements:

1. A variable capacity depending on the actual production and consumption of gas.
2. A gas tight construction to avoid gas emissions.

A simple principal met both of the requirements: the water-based system, which allows a changing volume and a water-sealed device. This system worked with two primary elements: a water tank and a lift for the gas. This lift was a kind of vessel, which was closed on the top and open on the bottom. The lift was immersed into the tank and rose and fell according to the actual content of the gas. The lift was also a kind of indicator or *meter* of the actual content. If the lift wasn't visible at all, the gasholder was empty. But if it reached the top, it was obviously full. The simple lift was often called *bell* reflecting its form.

The installation of a guide framing guaranteed the correct movement of the bell. Often some weights were put on top or on the inner bottom of the bell to reach the right pressure. These earlier gasholder forms were based on a low-pressure system: 75-125mm water column, respectively 7-12,5mmbar (Calzavara 1899).

Thus the gasholder's first architectural form reflected its function.

FORM AND STRUCTURE

The first gasholders for public illumination had a small capacity because they served primarily for the main squares and streets of the cities. In the nineteenth century there was advantage of manufactured gas not only for public, but also for private use. The gasholders' shape and structure became bigger and more significant in the cityscapes as a new kind of industrial architecture.

In the nineteenth und early twentieth century there were generally two different kinds of water sealed gasholders:

1. Bell-type gasholder (or single-lift gasholder), linear (column) or spiral-guided,
2. Telescopic gasholder (or multi-lift gasholder), linear (column-guided/ guide-framed) or spiral guided.

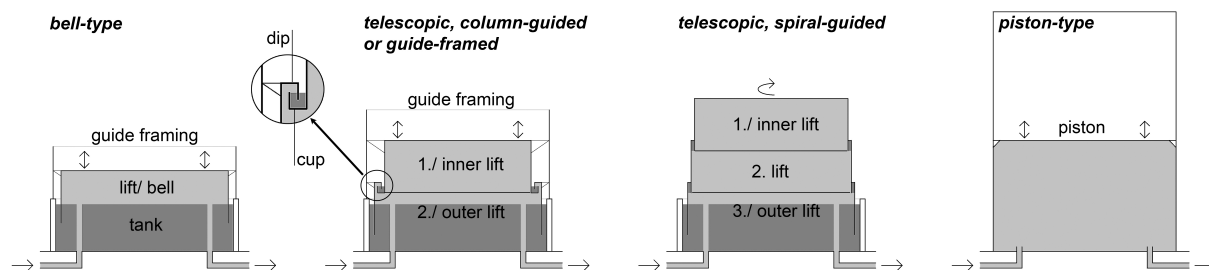


Figure 1: The principal development of the gasholder (from left to right): Bell-type gasholder – Telescopic gasholder, column-guided or guide-framed – Telescopic gasholder, spiral-guided – Piston gasholder (Drawing: Berger 2014).

THE BELL-TYPE GASHOLDER, COLUMN-GUIDED

The first structural form of a gasholder was the *bell-type gasholder* (also *single-lift gasholder*). This gasholder was composed of a water tank, a single lift (bell) and a guide framing. First the gasholders had a rectangular ground plan, but soon were changed into a cylindrical form. The water tanks were built with wood, bricks, cast iron, steel or concrete. The position of the tank varied: from completely to partially underground or aboveground. Some designs also included banks, which surrounded the tank wall (Thomas, 2014).

The guide framing ensured a linear movement for the lift and was usually designed as a riveted iron structure with columns of cast iron that were connected through horizontal framework girders at the top. Because of the appearance of the columns this kind of guiding was called *column-guided*. The former guide framings even had pillars of brick often in combination with a completely underground water tank.

The lift's structure was based on a cylindrical ring with a crown. Both were built with riveted single panel sheets on an interior substructure. With special wheels the lift ran along the vertical rails of the guide framing.

Today there are only a few original bell-type gasholders still remaining (e.g. in Salò). Later the spaces between the columns were also reinforced with wind bracing elements between the columns for stability (e.g. in Florence).



Figure 2: Florence, San Frediano: Bell-type gasholder, column-guided with an ornate ending “flame” on top of the columns, building year: 1882, erected by: V-Ve-Moussy-Constructeur-Lyon, capacity: 8.000m³. This was one of the smallest gasholders in Italy. In the 1955 this gasholder got a second so-called *flying* lift and augmented its capacity to 14.000m³. See the following chapter (Photo: Berger 2013).

THE TELESCOPIC GASHOLDER, COLUMN-GUIDED/ GUIDE-FRAMED

Because of the increasing demand for gas in the second half of the nineteenth century gasholders with a larger storage were required. In London a system was developed which added a second telescopic lift. So the original bell-type gasholder was upgraded to a two-lift-gasholder or *telescopic gasholder* that almost doubled its capacity. The most complex feature of this construction was the gas tight connection of the upper and the lower lift. This was resolved with an U-shaped cup (upstand) on the bottom edge of the inner lift filled with water for sealing. When the inner lift was full of gas its cup engaged with the down-turned cup (or dip) of the outer lift and

pulled it up. Also the guide framing was extended with a second level, so that both lifts could run up and down linearly.

In the early days of the telescopic gasholder the column-guided structure was used for the guide framing. But the invention of the *guide-framed* design, an iron framework construction brought the advantage of a greater stability due to the inclusion of wind bracing elements and the possibility of prefabrication. Generally the guide framings number of horizontal levels stood for the number of lifts (that's not always valid for modern gasholders). This telescopic system was gradually increased to *multi-lift gasholder* with about seven lifts per gasholder.

Furthermore the telescopic concept allowed it to easily add another lift on existing gasholders (e.g. in Venice). This was a fast method to extend the storage capacity and also cheap since it did not require extending the guide framing. This so-called *flying lift* rose over the top of the guide framing and was only supported by the second lift (e.g. in Milan, Florence).



Figure 3a (left): Rome, San Paolo: Telescopic/ 5-lift gasholder, guide-framed, patent of: August Klönne, Dortmund, building year: 1936, capacity: 200.000m³. This in Rome called *gazometro* is one of the tallest remaining gasholders in Italy (Photo: Berger 2013).

Figure 3b (right): Next to Klönne-type gasholder are three more telescopic gasholders, which were built with the patent of Sam Cutler & Sons, London. The gasholder in the foreground was built in 1912 and had a capacity of 60.000m³ (Photo: Berger 2013).

Another special architectural form of the telescopic gasholder had its own *gasholder housing*. This massive cylindrical facing formwork covered the real gasholder completely. Due to its often ornate and articulated façade (windows, cornice, pilaster, etc.) the gasholder housing seemed to belong rather to a sacred building than to a functional building. The advantages were the possibility of mounting the guide framing on this additional element and it protected the gasholder from abnormal weather and mechanical conditions (especially for the water sealing). The disadvantages were the increase of construction costs and the extended time of completion of construction.

The Gasholder – Shaped by its Function. The Italian example.



Figure 4: Trieste, Broletto: Telescopic/ 2-lift gasholder, guide-framed with an architectonical ornate gasholder house, building year: 1901, capacity: 20.000m³ (Photo: Berger 2014).

Today the majority of surviving gasholders in Italy are the multi-lift ones (e.g. in Milan, Turin, Venice, Treviso), but most of them are in a bad condition. Only a few gasholders have been repaired or even re-used with new functions like warehouses or parking lots (e.g. Rome).

THE SPIRAL-GUIDED GASHOLDER

At the end of the nineteenth century a new design changed the appearance of the gasholders - *spiral-guided gasholder*. This gasholder also worked with the water-sealed system and one or more lifts – but without an external guide framing. The lifts rose and fell spirally. For this movement the guide framing was mounted directly on the lifts: inclined guiding rails were fixed on the outer surface of the lift's cylinder. Each lift went in an opposite direction of the other. In order to maintain the lifts a staircase was added per lift, which rose and fell with its lift. There were different designs for the stairs, but the most popular ones were the stairs with a triangular fix structure.

The spiral-guided gasholders had a fascinating mechanism, which made the gasholder almost vanish into the ground when empty.

Today in Italy historic spiral-guided gasholders are rare (e.g. Milan, Vicenza – both demolished). This type was more widespread in the United Kingdom.



Figure 5: Milan-Bovisa: Telescopic/ 4-lift gasholder, spiral-guided, building year: 1956, capacity: 130.000m³. The gasholder was demolished in 2002 (Photo: Archivio Storico Aem, Milan).

THE PISTON GASHOLDER

At the end of the nineteenth century the water-sealed gasholders were built to such large dimensions, that the limit of construction was reached: the huge diameter and volume of the water tanks exceeded the possible ground pressure. Furthermore the water tank always had to be heated in the winter periods. To avoid these problems at the beginning of the twentieth century a new building technique was invented: the waterless *piston gasholder*. This new design appeared like a closed cylinder. Not only the shape, but also the elements of construction were different. This gasholder was composed of a closed cylindrical structure and an inserted piston that ran up and down according to the actual gas-content. Hidden in its cylinder the piston was not visible anymore than the lifts. Along the edge of the piston a sealing system was adapted which guaranteed a gas tight contact between the piston and the shell of the cylinder. Due to its dry sealing, the gasholder was also called dry or waterless gasholder.

The first piston gasholder was patented by the German company *Maschinenfabrik Augsburg-Nürnberg (MAN)* in 1914. The shell had a polygonal ground plan and was constructed from vertical support beams with straight panel plates in between and a roof. The piston was built with a frame structure. The fluid-sealing medium from the water-sealed gasholders was developed further to the piston oil-sealing system that ran along the inner side of the cylindrical shell. This oil-film passed also the outer cup (dam) of the piston where a certain quantity of oil was always collected to ensure a positive gas seal. Both, the piston and the deck could be reached for maintenance by stairways and later also by elevators (MAN 1930; Leffer 2006).

August Klönne from Dortmund invented the second patent for piston gasholders. Compared to the MAN-type the structural and technological details were different: the ground floor was not polygonal, but circular. Furthermore the sealing of the piston was not based on a fluid system. Klönne's sealing worked with a dry rubber sealing that had blocks filled with grease along the outer edge of the piston (Steininger 1949).

Today only a few piston gasholders are preserved (e.g. Bologna, Brescia, Genova). After being put out of service these tall gas-towers were seen a rather disturbing features of the city-scapes and have been removed to make way for other buildings (e.g. Florence, Marghera, Trieste).



Figure 5: Brescia: MAN Piston-type gasholder, building year: 1947, capacity: 15.000m³ - the previous identical gasholder was built in 1932 and destroyed in the world war (Photo: Berger 2013). The first dry-sealed gasholder in Italy was built in 1930 in Bologna; patented: MAN Piston-type gasholder, capacity: 30.000m³.

CONCLUSIONS

- At the beginning of the nineteenth century the gasholder was a functional building that was created for the storage of local manufactured coal gas. This gas was an innovation for the new public illumination of cities.
- With the increasing demand for gas the gasholder's structure evolved: from the simple bell-type gasholder to the piston gasholder with a larger storage capacity.
- Today these gasholders aren't used anymore for the storage of gas. Their function has been replaced by underground high-pressure storage systems for natural gas. Thus the historical gasholders have become industrial relics, which are abandoned, inaccessible and many have been demolished, a process which is continuing today.
- My PhD project aims to underline the significance, shape and structure of the gasholders in order to preserve them as an important part of engineering and industrial heritage.

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