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INDUSTRIAL PLANTS II

Chapter three:
Plants for the service of the fuels

DOUBLE DEGREE MASTER IN

“PRODUCTION ENGINEERING AND MANAGEMENT”

CAMPUS OF PORDENONE

UNIVERSITY OF TRIESTE

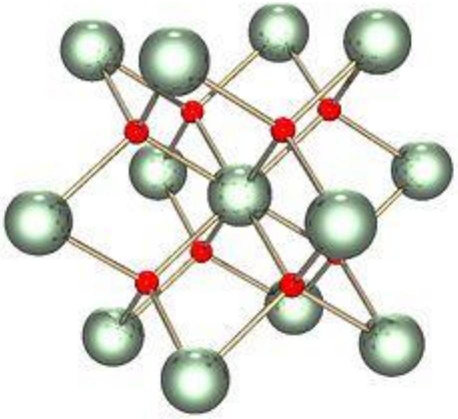
Plants for the service of the fuels - Generality

In industrial plants we have production processes that, in most cases, require the use of fuels (plants for the production of thermal energy).

Thei **plants for the service of the fuels** have different characteristics depending on the type of fuel (solid, liquid, gas) and therefore it is interesting to illustrate the characteristics of these systems and the main criteria for selection and design.

Classification of fuels and regulations on plants for the service of fuels

A **fuel** is a chemical substance that is oxidized in the combustion process, a chemical reaction of oxidation, producing thermal energy. Is characterized by an **higher** and **lower calorific value**.



The **higher caloric value** is the amount of heat that it makes available to effect the complete combustion at constant pressure of the unit mass of the fuel, when the combustion products are reported to the initial temperature of the fuel and the combustion air.

We define **lower caloric value** as the upper calorific value decreased by heat of condensation of water vapor during combustion.

Classification of fuels and regulations on plants for the service of fuels

The fuels can be divided into:

- **traditional fossil fuels** (natural gas, oil and its derivatives, coal);
- **alternative fuels** (biomass, hydrogen).

As regards conventional fuels, the fuels are of technical interest and of common use, and are fossil fuels derived from petroleum consist of mixtures of hydrocarbons (compounds of hydrogen and carbon) and trace of elements / inorganic compounds (sulfur, nitrogen, oxygen, metals etc.).

Classification of fuels and regulations on plants for the service of fuels

The fuels can be divided into:

a) based on fields of application-utilization:

- device type and/or use: internal combustion engine, generator heat etc.;
- calorific value.

b) based to the physical state of aggregation:

a) gas, which are divided into:

- natural: methane, natural gas etc.;
- derivatives: coke over gas, refinery gas, acetylene etc.;

b) liquid, which are divided into:

- natural: crude oli;
- derivatives: diesel oil, fuel oil etc.;

c) solid, which are divided into:

- natural (coal);
- derivatives: coke, charcoal etc.

Classification of fuels and regulations on plants for the service of fuels

The industrial treatment and storage of mineral oils and fuels has been governed by Royal Decree 11.2.1933, n. 1741, and the approval of its executive regulation under Royal Decree of 07.20.1934, n. 1303, and approval of safety standards for the processing, storage and use of mineral oils as required by the Ministerial Decrees of 31.07.1934 and of 12.05.1937, and subsequent Ministerial Decrees of 17.06.1987, n. 280, the Circular of February 1962, n. 132 on the safety of deposits and plants of mineral oil products and Circular Letter prot. n. 1607/4112 of 23.01.1976 for the custody, lighting, alarms and fences for deposits of mineral oils.

Classification of fuels and regulations on plants for the service of fuels

Subsequently, with the Decree of the Ministry of Industry of January 11, 1995, n. 15824 have been identified minor works subject to authorization under a simplified procedure or a notification in processing plants and storage of mineral oils.

We recall, finally, the Decree of the Ministry of the Environment of 20 October 1998 laying down the technical requirements for the construction, installation and operation of underground tanks and its implementing regulation provided for by the Decree of the Ministry of the Environment of 24 May 1999, n. 246.

Plants for the service of solid fuels

The solid fuel is generally brought from the Country of extraction to the nearest port to the company to use.

You download the ships with the traditional method for unloading bulk material by means of grab crane or continuous dischargers.

Plants for the service of solid fuels

The downloaded material can be stationed on a provisional basis in heaps in the park of the port or can be picked up by harbor cranes and loaded on the most suitable means of transport (truck, railway wagon, coal pipe etc.) to be started at the factory.

Both trucks that the wagons are specially shaped to easily download the solid fuel by lift and tilt of the body itself by the hydraulic pistons or opening of the side doors of the body.

Plants for the service of solid fuels

Come inside the factory, comes put at open park or in bunkers covered by the gantry crane or at gantry, equipped with wheels to move in rectilinear motion on rails, while along the horizontal beam is suspended the winch or the bucket or other systems handling (conveyors).

Plants for the service of solid fuels

The solid fuel in brindle is prone to spontaneous combustion at temperatures above 70°C so that the storage is considered to be at high risk activity and for this reason there is a complex regulation. To reduce the loss of the lower calorific value of the fuel as a result of the phenomenon of spontaneous combustion, which is about 1% per year, it is appropriate to cover the overlapping of solid fuel with a layer of fuel of small particle size, which may fit in the interstices and platters, removing in this way the oxygen necessary for the phenomenon of spontaneous combustion.

To prevent it from being dispersed into the air is periodically wet!!!

Plants for the service of solid fuels

For subsequent use, the fuel is taken from the bunker and started by belt conveyors to the mill, whether at hammer, at jaws etc. for crushing the material in size smaller.

Plants for the service of solid fuels

The material is then started, with a belt conveyor to silo for temporary storage from which is then transported to the mill, which may be a hammer, to gravity, rolling etc.. where it is reduced to a fine powder, which can be used in the burners of the steam generators to which arrives through a pneumatic transport system in flotation.

Plants for the service of solid fuels

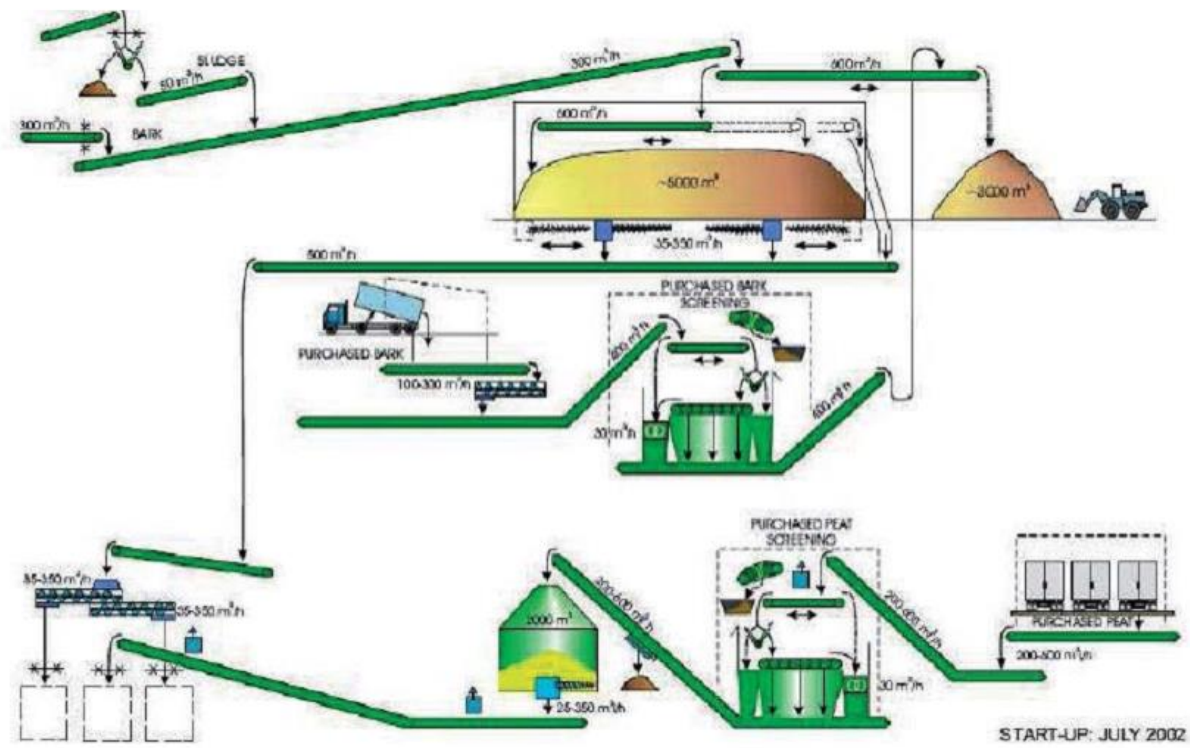
The ashes of the combustion process are conducted in a suitable deposit and then be reused in the cement plants or possibly sent to landfill.

The costs of transport and stockpiling of solid fuels are proportional to the distance, excluding the costs of loading/unloading from the means of transport.

Combustion is a chemical reaction, which involves the oxidation of a fuel by a combustion (which is typically represented by the oxygen present in the air), with evolution of heat and electromagnetic radiation, and often light radiation. Is an oxy-reduction exothermic, as a compound is oxidized, while another is reduced (in the case of hydrocarbons, the carbon is oxidized, oxygen is reduced) with the release of energy and the formation of new compounds, mainly carbon dioxide and water.

Plants for the service of solid fuels

A diagram of a storage facility, transport and milling of solid fuel is shown in the figure, while downstream of the same are positioned filters for dust abatement (electrostatic or at sleeves), and the desulfurization unit.



Plants for the service of liquid fuels

From the Country of origin, the transport of oil is through a pipeline or tanker, which starts in a refinery.

Plants for the service of liquid fuels

The refinery turns it into fuel oil (BTZ oil, diesel fuel, etc.) and are started at the factory through a pipeline or rail tankers or tankers where it is stored in suitable tanks.

A pipeline is a pipeline particular, used for the transport of hydrocarbons in the liquid state.

The oil belongs to the category of heavy distillates obtained from petroleum, and has a density at 15°C around 980 kg/m^3. Can be produced by cracking or straight-run, depending on which is produced by a cracking plant or topping. It is an oil with a low sulfur content (BTZ) with less than 1%

Plants for the service of liquid fuels

Fuel oils can be classified, according to the D.M. 31 July 1984 in three categories according to the flash point.

Category	Type	$T_{flammability}$	Examples
A	Liquids in which the vapors may give rise to burst	$T_i < 21°C$	Crude oils for refinery, gasoline etc.
B	Flammable liquids	$21°C < T_i < 65°C$	Refined oil, turpentine, alcohols etc.
C	Combustible liquids	$65°C < T_i < 125°C$	Diesel oil

Plants for the service of liquid fuels

The same Decree divides the deposits of mineral oils into classes, depending on the nature of the fuel, the danger and the actual capacity.

Class	Capacity (m^3)	Type
Categories A and B		
1	> 3500	Underground/above ground
2	301 – 3500	Underground/above ground
3	101 – 300	Underground/above ground
4	75 – 100	Underground
5	16 – 75	Packaged goods
6	< 25	Gasoline distributors
7	2 – 15	Packaged goods
Category C		
8	> 1000	Underground/above ground/warehouses of packaged goods
9	25 – 1000	Underground/above ground/warehouses of packaged goods
10	< 25	Underground

Plants for the service of liquid fuels

Each fuel oil can be characterized by a composition in weight (% di C, H_2, S ecc.), density (kg/m^3), kinematic viscosity (m^2/s), flash point, higher calorific value and less etc.

The D.M. July 31, 1934 imposes the rules governing the construction of buildings for factories and warehouses where the produce, handling or storing mineral oils.

Plants for the service of liquid fuels

Buildings must:

- be constructed of non-combustible materials and fire resistant, with spaces of sufficient width or fire walls;
- have closures at shutter, at scrolling or doors that open to the outside;
- have vents at trap in the lower part and aerators provided with metal grid in the upper part;
- with the exception of the premises for lubricating oil, you should have raised thresholds of at least 20 cm above the floor on concrete or hard wood, but not metal, stone or bitumen;

Plants for the service of liquid fuels

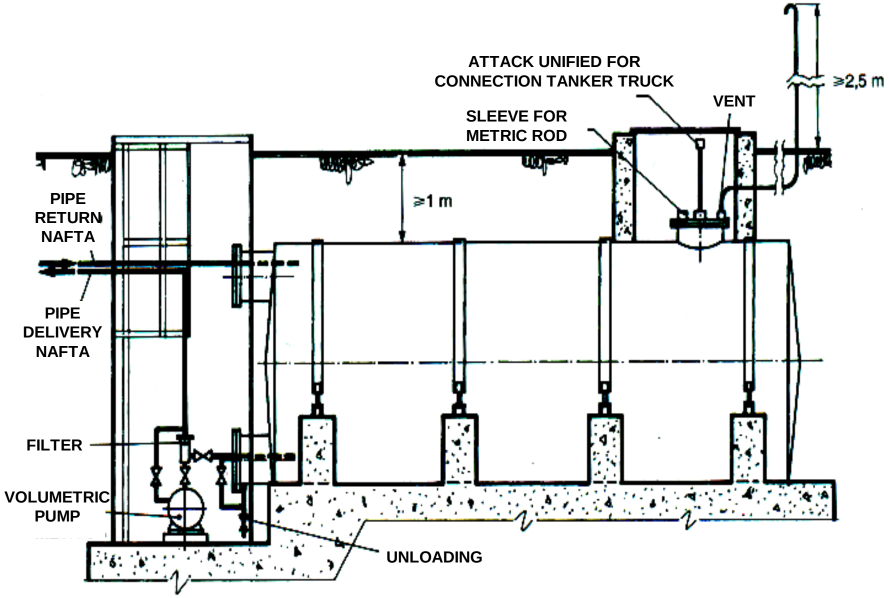
Buildings must:

- be surrounded by a fence made of non-combustible material, with no openings, except the entrance, and at least 2.5 m high on the ground level outside. The minimum distance of manufactured and reservoirs from such enclosure depends on the class of the deposit, even if the same shall separate aboveground tanks arranged on multiple lines (protection zone);
- have electrical systems for lighting and power, including engines, guards against atmospheric discharges, must comply with CEI 64-2 and 81-1. The power lines must not pass superiorly to the locations of transfer of deposit, as well as containment basins of flammable liquids.

Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

a) underground or basements tanks



Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

a) underground or basements tanks

They are generally made of steel, with a minimum thickness of the sheet of 5 mm, and cylindrical shape, with a horizontal axis. Are allowed in the concrete only fuel oils and lubricants. The metal tanks are placed on a bed of gravel or concrete saddles to a depth such that the upper generatrix of the floor surface must be not less than 70 cm if the decking is passable by vehicles. The minimum distance between two underground tanks or between the tank and the outer wall of the building must not be less than 0.5 m.

Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

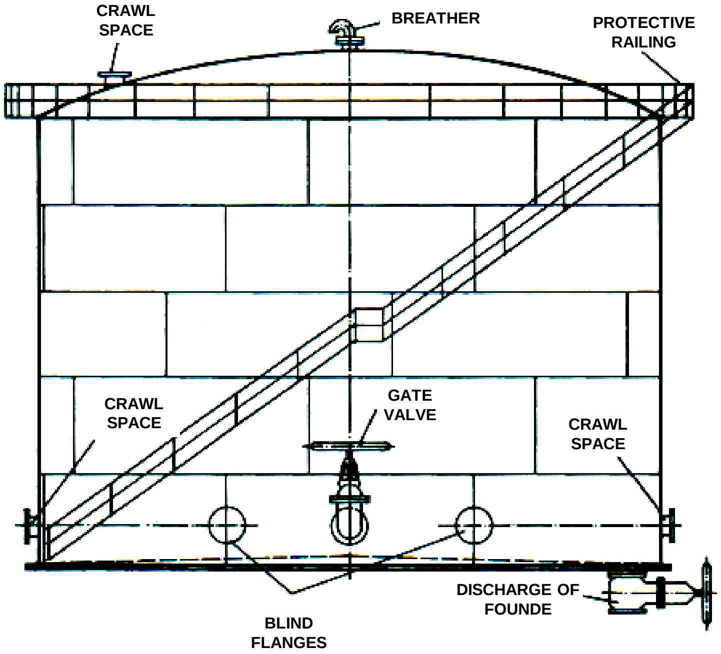
a) underground or basements tanks

The tank must be equipped with an automatic valve and pressure depression for liquids of categories A and B, while for category C you need a vapor venting tube, having a height of at least 2.5 m from the ground or from openings nearby. It must also have a manhole, which forms an opening that allows the inspection, the maintenance and the cleaning of the tanks, consisting of a sump pond, covered by metallic manhole with key lock and whose edges must be kept at at least 10 cm from the ground higher circumstances, in order to prevent the infiltration of water.

Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

b) tanks above ground



Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

b) tanks above ground

The tanks must be installed in special rooms at no less than 50 cm above the floor on a special pedestal in masonry; the walls of the room where it is installed the tank must withstand REI 120. The threshold saddle of the door must be raised, so that in case of loss of the local reservoir may contain the spilled fuel from the latter. The walls of the room must be distant from the tank of at least 0.60 m between the ceiling and the highest part of the tank at least 1,00 m in the case that the tank both inside the building.

The minimum distance between the tanks above ground must not be less than 1,5.

Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

b) tanks above ground

For liquids of categories A and B, the tanks must be made of metal and a vertical axis, and must also have:

- two manholes in the lower part, diametrically opposed;
- for capacity greater than 10 m^3, level gauges transparency, accessed via a metal staircase and equipped with shut-off. These indicators are provided in fixed tanks, while those in mobile roof the liquid level coincides with the position of the roof and is reported outside by means of the indicators operated by references to rope;
- the sockets for loading of the fuel;
- the socket for unloading of the fuel;
- the grounding;
- the safety devices;

Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

b) tanks above ground

For liquids of categories A and B, the tanks must be made of metal and a vertical axis, and must also have:

- a water plant at pressure for spraying the walls and extinguishing agents;
- a coating of the external walls with materials with a high reflecting power and insulating;
- a scale for access to the roof, which must be surrounded by a protective railing in accordance with the safety regulations, while in the case of roof tanks mobile must have a pedestrian walkway positioned on the outer perimeter of the upper end.

The tanks of accumulation can be distinguished:

b) tanks above ground

The tanks in category C are cylindrical or parallelepiped and are made of steel, reinforced concrete with protective epoxy paint or other non-combustible materials.

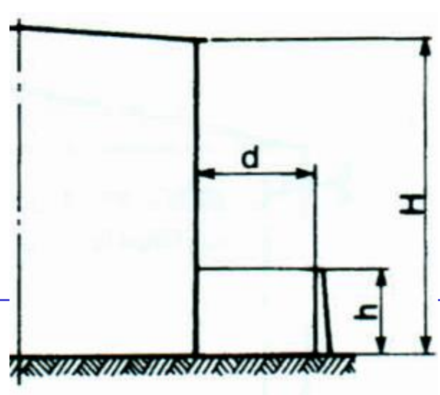
The above-ground tanks for liquid fuels must have the containment basins, which are made from earth embankments or walls, such that the distance between these and the storage tank d is:

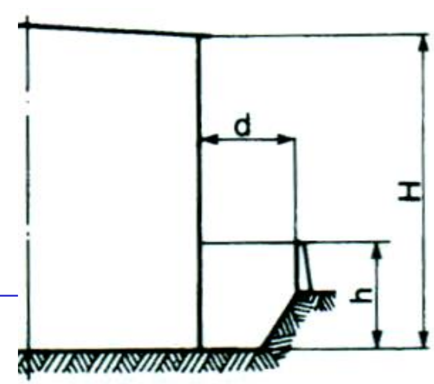
$$d \geq \frac{H-h}{2}$$

where:

H = height of the storage tank;

h = height of the walls or levees of containment.





Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

b) tanks above ground

The foundations of cylindrical tanks with vertical axis are its elevated relative to the plane of campaign to prevent the infiltration of rainwater and are made of concrete or sand and gravel pressed and contained by a ring of concrete.

Regarding the height of the cylindrical tank with a vertical axis, it is almost equal to the diameter for low capacity, while it is lower for higher capacities also for limiting the costs of mounting.

The thickness of steel sheets for the cylindrical tank with a vertical axis varies depending on the distribution of the hydrostatic pressure of the liquid (maximum at the base and minimum to the top of the tank).

The tanks of accumulation can be distinguished:

b) tanks above ground

Applying the formula of Hamburg [Cal09] we get the sheet thickness s (cm):

$$s = \frac{\gamma \cdot D \cdot H}{2000 \cdot 9{,}81 \cdot \sigma_{amm} \cdot Z}$$

where:

γ = specific gravity of the liquid fuel (N/dm^3);

D = diameter of the tank (cm);

H = height of the liquid fuel in the tank (cm);

σ_{amm} = maximum allowable stress (12000-14000 N/cm^2);

Z = degree of efficiency of the welds between the metal sheets (= 0,85 if they are provided radiographic controls).

Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

b) tanks above ground

Other calculation procedure of the storage tanks instead expected to know the K coefficient, which expresses the unit mass of steel for m^3 volume of the tank, and the unit cost per m^3 of tank C. These two are inversely proportional to the diameter D of the tank and the volume of tank V, having height h. They are convenient tanks with diameter and volume high, although for values of D and V above a certain limit (for example VV $\geq$ 2000 m^3), the values of K and V reach the asymptotic values

Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

b) tanks above ground

The maximum pressure at the bottom of the tank pmax (N/m^3) is equal to:

$$p_{\max} = \rho_{olio} \cdot g \cdot h$$

where:

ρolio = oil density (kg/m^3);

g = acceleration of gravity (m/s);

h = height of the tank (m).

The stress on the bottom plate of the fuel tank liquid σ (N/m2) is equal to:

$$\sigma = \frac{p_{\max} \cdot D}{2 \cdot s}$$

with:

σ_{amm} = maximum allowable stress (N/m^2);

s = thickness of the metal sheet (m).

Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

b) tanks above ground

Substituting the stress with the allowable stress σamm, the sheet thickness of the mantle of the storage tank above ground s (m) is:

$$s = \frac{p_{\max} \cdot D}{2 \cdot \sigma_{amm} \cdot Z}$$

having denoted by Z degree of efficiency of the welds between the metal sheets (= 0,85 if they are provided radiographic controls).

The volume of oil in the situation of maximum capacity V_{olio} (m^3) is equal to:

$$V_{olio} = \frac{\pi \cdot D^2}{4} \cdot h$$

while the mass of the tank $M_{acciaio}$ in steel is:

$$M_{acciaio} = \rho_{acciaio} \cdot V_{acciaio} = \rho_{acciaio} \cdot \pi \cdot D \cdot s \cdot h$$

Storage tanks for liquid fuels

The tanks of accumulation can be distinguished:

b) tanks above ground

The steel mass per unit volume ($kg_{acciaio}/m^3$) is:

$$K = \frac{M_{acciaio}}{V_{olio}} = \frac{\rho_{acciaio} \cdot \pi \cdot D \cdot s \cdot h \cdot 4}{\pi \cdot D^2 \cdot h} = \frac{4 \cdot s \cdot \rho_{acciaio}}{D}$$

Pointing with $C_{u\ peso}$ the unit cost of the steel weight, the unit cost per m^3 of tank $C_{u\ volume}$ is equal to:

$$C_{u\ volume} = C_{u\ \ peso} \cdot K = C_{u\ \ peso} \cdot \frac{4 \cdot s \cdot \rho_{acciaio}}{D} = C_{u\ \ peso} \cdot 4 \cdot s \cdot \rho_{acciaio} \cdot \sqrt{\frac{\pi \cdot h}{4 \cdot V_{olio}}}$$

The coefficient K and the cost Cu volume decrease with increasing the diameter D and the volume of the tank Volio For values of Volio the order of 2000 m^3, the value of K has reached the asymptotic value. In this case, if h = 5 m, ·

$$D = \sqrt{\frac{4 \cdot 2000}{\pi \cdot 5}} \cong 22{,}6\ \ m$$

Storage tanks for liquid fuels

The fuel oil at low temperatures has of the high values of viscosity which correspond to a laminar flow inside a pipe. If the oil increases its temperature, the viscosity drops and it passes to a turbulent flow (increase of Reynolds number) with minor losses.

The Reynolds number Re, dimensionless group proportional to the ratio between the inertia forces and the viscous forces, is defined by the relation:

$$\mathrm{Re} = \frac{v \cdot d}{\upsilon}$$

where:

v = average velocity of the liquid fuel (m/s);

d = diameter of the pipe (m);

ν = kinematic viscosity of the liquid fuel (m^2/s), defined by:

$$\upsilon = \frac{\mu}{\rho}$$

with:

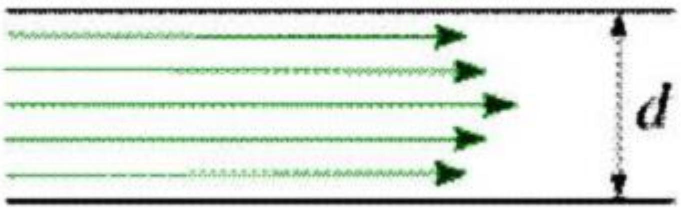
μ = dynamic viscosity of the liquid fuel (kg/m·s);

ρ = density of the liquid fuel (kg/m^3).

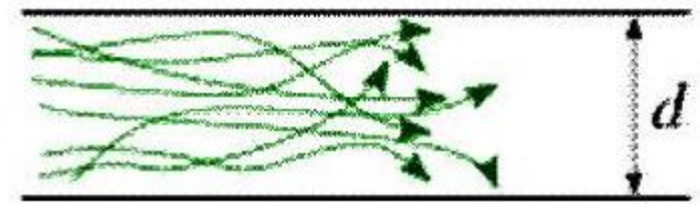
Storage tanks for liquid fuels

In the flow inside a cylindrical tube, you experience the following Reynolds numbers:

- laminar regime: Re < 2300;



- transition regime: 2300 > Re > 10^4;
- turbulent regime: Re > 10^4.



Storage tanks for liquid fuels

In the transition from laminar flow to turbulent, there is a period of instability with dangerous pulses of the pipeline, which you seek of eliminate, maintaining the fuel oil warm during the stops.

At low temperatures, the kinematic viscosity of the liquid fuel ν is relatively high and, consequently, the Reynolds number Re is low; it is established a laminar flow with pressure loss Δp proportional to kinematic viscosity ν and volumetric flow Q, according to the relation:

$$\frac{\Delta p}{\rho} = 32 \cdot \upsilon \cdot \frac{l}{d^2} \cdot v \quad \propto \quad Q$$

where:

l = length of pipe (m).

Storage tanks for liquid fuels

At high temperatures the kinematic viscosity of the liquid fuel ν decreases and the Reynolds number Re is high, it establishes a turbulent motion with losses proportional to v_2 and Q_2, from which it appears:

$$\frac{\Delta p}{\rho} = \lambda \cdot \frac{l}{d} \cdot \frac{c^2}{2} \quad \propto \quad Q^2$$

To keep the liquid fuel around 30-40°C, even during the stops, it insulates the pipes, it heats the fluid by means of electrical resistors or with the intermediate fluid (steam, superheated water etc.). The advantages achieved are due to lower pressure drop and better atomization of the fuel to the burners.

Storage tanks for liquid fuels

Instead of feeding the liquid fuel directly from the storage tank to the user, it is preferred to send the fuel to a day tank, thermally isolated, which is directly followed by the installation of distribution to the burners of utilities. Even the distribution network must be insulated.

You can have of systems of heating of the liquid fuel in large storage tanks initial. Are used of the heating heads consist of heat exchangers fed by steam or electric resistances placed in the lower part of the tank in the vicinity of the extraction of the product.

Storage tanks for liquid fuels

The security organs, that are positioned between the tank and the burner, are used in case of fire to prevent the liquid fuel reaches the burner flames, to avoid that during the refueling of fuel that the tank is too full to vent the gas that is formed inside the tank etc.

The security organs are:

- overflow valve;
- level indicator;
- vent tube;
- curve with mesh flame-resistant in stainless steel;
- gate valve at quick-closing.

Plants for the service of gaseous fuels

The gaseous fuels can be directly extracted from deposits (such as methane), or may be derived from distillation of crude compounds (high volatility), or can be obtained from the pyrolysis or gasification of solid fuels (coal, biomass etc.), or by chemical synthesis.

Plants for the service of gaseous fuels

The gaseous fuels can be classified into:

a) gaseous fuels natural

Derive from deposits of mixtures of combustible gases of different composition, having origins similar to those of oil, and include methane, propane, butane, ethylene, propylene, nitrogen, carbon dioxide, hydrogen sulphide etc.. The average calorific value of about 35,000 kJ/Nm3, while the pressure is around 100-200 bar at the mouth of the extraction wells. These gases need a decompression prior to pipeline transport.




Plants for the service of gaseous fuels

The gaseous fuels can be classified into:

a) gaseous fuels natural

Natural gases undergo processes of “degasolinaggio”, desulfurization and dehydration.

The “degasolinaggio” is a treatment used in the petroleum industry, which are subjected natural gases so-called 'wet' or 'rich' before being placed in the duct for distribution to the consumer, for the purpose of separating the higher hydrocarbons, particularly fine (extraction of propane and butane), and reduce the possibility of condensation in the ducts.

The desulfurization is a transaction whereby is reduced, sometimes to the complete elimination, the sulfur content and or sulfur compounds present in a substance. Abandoned the desulphurisation purely chemical (based washings with soda and the like), simple but expensive, it is claimed the catalytic processes, which all lead to the elimination of the sulfur as hydrogen sulfide. It is finally imposed the hydrodesulfurization process (hydrocracking).

The dehydration is an operation with which it has forced the subtraction of water from a gas.

Plants for the service of gaseous fuels

The gaseous fuels can be classified into:

b) gaseous fuels artificial

Result from transformations performed from solid and liquid fuels and are:

- **gas of distillation of coal**:

is obtained by heating the coal progressively until reaching the 900-1000°C, in the absence of oxygen, which gives way before the moisture that contains (water vapor) and then the volatile substances of higher calorific value (hydrocarbons), and then the less wealthy. At the end of the process, the coal is reduced to a spongy mass, the coke is used for heating and domestic steel industry. The calorific value is between 16,000 and 20,000 kJ/Nm^3;

Plants for the service of gaseous fuels

The gaseous fuels can be classified into:

b) gaseous fuels artificial

Result from transformations performed from solid and liquid fuels and are:

- **gas of gasification of coal**:

is a process that occurs in a reactor, in which the coal is reacted with oxygen and steam, producing the synthesis gas (carbon monoxide, hydrogen and other gaseous compounds). The oxygen is fed in defect and varies from 1/3 to 1/5 of the stoichiometric value. The process of thermal degradation occurs at elevated temperatures (above 700-800°C), in the presence of a sub-stoichiometric proportion of an oxidizing agent: typically oxygen in the air (ranging from 1/3 to 1/5 of stoichiometric value) or steam. The resulting gaseous mixture constitutes what is called synthesis gas (syngas) and is itself a fuel with a lower calorific value of between 9,000 and 10,000 kJ/Nm^3;

Plants for the service of gaseous fuels

The gaseous fuels can be classified into:

b) gaseous fuels artificial

Result from transformations performed from solid and liquid fuels and are:

- **gas of blast furnace**:

is a gas mixture which is obtained as a byproduct of the cast iron in the blast furnace. Its average composition is: 60% N_2, 24% CO, 12% CO_2, 4% H_2 and ash. In the lower part of the furnace (tuyeres) is blown oxygen-enriched air preheated to about 1000°C. This comes in contact with the coke that is ignited with the production of CO and CO_2 according to the Boudouard equilibrium. The gas rise the blast furnace (tino conical) reducing the iron oxide to metallic iron, but not all of the CO is oxidized to CO_2. The gases leaving the furnace (blast furnace gas) are still rich in CO and thus can be used as fuel, after the separation of the ash. The calorific value is close to 4,000 kJ/Nm^3;

Plants for the service of gaseous fuels

The gaseous fuels can be classified into:

b) gaseous fuels artificial

Result from transformations performed from solid and liquid fuels and are:

- **gas of liquefied petroleum** (**GPL**):

is a mixture of alkanes hydrocarbons of low molecular weight (propane, butane, ethylene, propylene, butylene) resulting from the processing of petroleum and with lower calorific value of between 90,000 and 121,000 kJ/Nm^3.

Plants for the service of gaseous fuels

The gaseous fuels can be classified into:

b) gaseous fuels artificial

The transport in the gas phase in conduct (pipeline) is the typical transport of this fuel at a great distance, which exploit the high pressure output from the extraction wells. Typical of gas fuels artificial (GPL) is the transport in the liquid phase. At a temperature of 20°C these gases pass to the liquid state at low pressure (2 bar to 7 bar for butane and propane), so that they are transported and handled in a liquid state in ship transport of liquefied GPL very well isolated (pressure 1 bar and temperature -162°C) and used in the gaseous state. They are transported in tanks of cylindrical shape with funds rounded, loaded on rail cars or trucks




Plants for the service of gaseous fuels

The fuel gas may be transported in cylinders for localized use, in this case there is the drawback that, since the cylinder at constant volume, the pressure of the gas supplied to the use decreases over time.

The artificial gases, especially those at low pressure, can be accumulated in gasometers (bell simple or telescopic, at dry) that have the characteristic of maintaining a constant pressure of the gas accumulated by varying the volume of the gasometer in function of levies occurred, while the natural gas, especially those at high pressure, are accumulated in tanks under pressure, so if the accumulation volume is constant and decreasing the pressure is variable depending on the withdrawal of gas from the utilities.

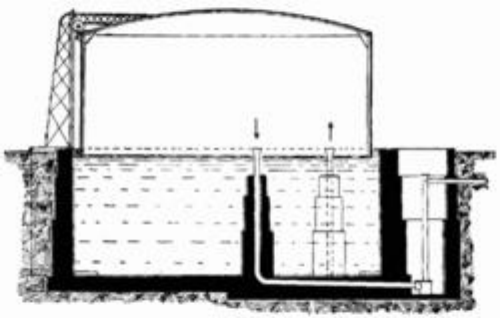


Fig. 1.

Plants for the service of gaseous fuels

The regulation of storage facilities for natural gas follows the DM 24 November 1984, that shall apply to the stores from which the gas is stored in tanks or cylinders and other mobile containers to be later distributed to the users directly inside the factory, or through the distribution network of the town.

The deposits can be classified into:

- category I: capacity greater of 120.000 m^3;
- category II: capacity including between 20.000 and 120.000 m^3;
- category III: capacity less of 20.000 m^3.

Plants for the service of gaseous fuels

A deposit for the storage of natural gas in the tanks is composed by:

- storage tanks;
- supply and exhaust pipes :
- any compression stations and cabins of decomposition of gas;
- control, operating and safety equipment.

The storage capacity of tanks C is given by the relation:

$$C = V \cdot \frac{p}{p_o}$$

where:

V = volume of the tank (m^3);

p = maximum absolute pressure (bar);

p_o = absolute atmospheric pressure (1 bar).

Plants for the service of gaseous fuels

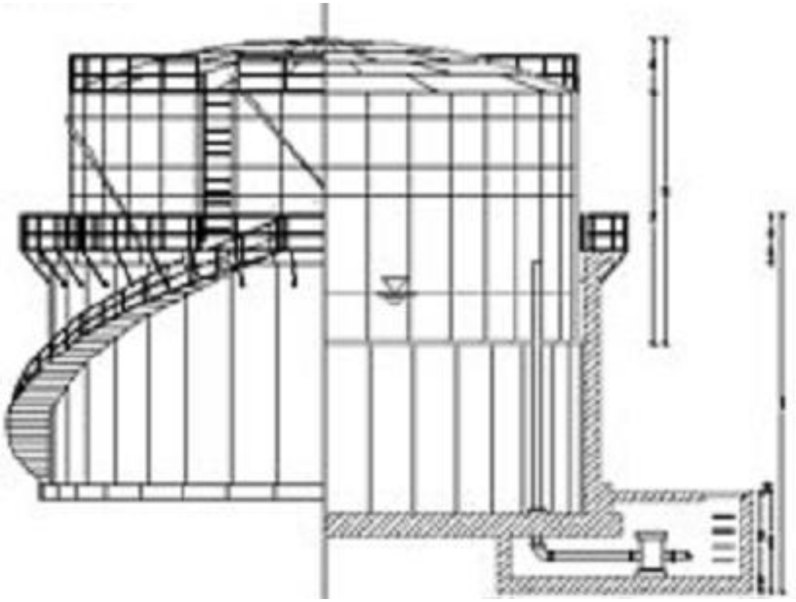
The maximum operating pressures of the tanks are:

- **for accumulators pressostatic**, which are containers in rubberized fabric, variable-volume, fixed to the ground so semi-permanently and used for the accumulation of biogas: 0.05 bar. The roofing system consists of a membrane upper and lower separate, realized with tissues biaxial reinforced on both sides. The product is available for all the silos present in trade up to a diameter of 50 meters;

Plants for the service of gaseous fuels

The maximum operating pressures of the tanks are:

- **for gasometers**, it has a maximum pressure of 0.5 bar. The gasometers are used for storage of the biogas produced by an anaerobic digestion plant, and regulate the difference between the production of gas and its consumption. Also maintain a uniform pressure of gas use and their height varies in function of the quantity of gas accumulated.



Plants for the service of gaseous fuels

The maximum operating pressures of the tanks are:

- **for gasometers**

  They consist of a cylindrical tank in steel, with the end closed and open bottom and immersed in the water of containing tank. The volume is variable and obtained through of sealing devices, between the movable and the fixed one, of a dry type or hydraulic which allow the movement of the telescopic bell. The dome has a manhole, a safety valve against overpressure and depression, and a protective railing. Externally the planking are provided a ladder to access the dome and a series of tubes helical guide. The protective treatments consist of a sand-blasting, in a primer and an epoxy paint in thick on the whole structure;

Plants for the service of gaseous fuels

The maximum operating pressures of the tanks are:

- **for tanks above ground**, which are of metal containers to horizontal or vertical axis, or spherical, permanently installed and not overlapping. Have a maximum pressure between 30 and 50 bar for a volume of the reservoir respectively greater than or less than and equal to 50 m^3;

Plants for the service of gaseous fuels

The maximum operating pressures of the tanks are:

- **for pipes-tanks**, which are of the buried metallic pipes of large diameter (> 500 mm) consisting of sections of pipe of limited length arranged in various ways (at comb, serpentine, lattice) and connected together. You can reach pressures up to 120 bar.

Plants for the service of gaseous fuels

The methane gas arrives at the factory through the distribution network that starts from the supply and delivery cabins of gas to the various municipalities. The underground pipes are divided into:

- **medium pressure** (up to 4.5 bar), for the transport distance up to large loads or up to the low pressure;
- **low pressure** (up to 0.02 bar), which serves the utilities and is powered by a cabin of "second jump" which reduces the pressure.

The Ministerial Decree of November 24, 1984 shall apply to indoor installations of industrial users and derivations of user pressure greater than 0.04 bar.

Plants for the service of gaseous fuels

The pipelines are classified into seven species according to the maximum operating pressure at which the plant can be army.

Species	Pressure (bar)
I	> 24
II	12 – 24
III	5 – 12
IV	1,5 – 5
V	0,5 – 1,5
VI	0,04 – 0,5
VII	< 0,04

The pipes shall be of steel, seamless and welded longitudinal or helical, with electric resistance welding, induction or at glitter, arc welding protected.

The minimum thickness for pipes s_{min} (mm) with a maximum operating pressure of more than 5 bar, is calculated from the relation:

$$s_{\min} = \frac{p \cdot d}{20 \cdot \sigma_{amm} \cdot E - 2 \cdot p}$$

where:

p = pressure of design (bar);

d = internal diameter of the pipe (mm);

σ_{amm} = permissible tension (N/mm^2) defined by:

$$\sigma_{amm} = \frac{R}{k}$$

R = unit load to the limit guaranteed minimum elongation for that material (N/mm^2);

k = safety factor (1.4 to 1.75 for conduct of Ia species and 3.5 for pipelines IIa and IIIa species);

E = efficiency factor of the joint.

Plants for the service of gaseous fuels

For pipes with maximum working pressure up to 5 bar can be in:

- steel, ductile iron and polyethylene pipelines for IVa, Va and VIa species;
- polyethylene, up to an outside diameter of 315 mm, for pipelines of Va species;
- polyethylene, up to maximum working pressure of 4 bar and outside diameters up to 160 mm, for pipelines of IVa species.

Plants for the service of gaseous fuels

Are valid for the other pipes the formulas above, for the pipes in propylene the minimum thickness admitted s_{min} should not be less than the thickness determined by the relationship:

$$s_{\min} = \frac{p \cdot d_e}{20 \cdot \sigma_{amm} + p}$$

where:

p = pressure of design (bar);

de = external diameter of the pipe (mm);

σ_{amm} = permissible tension (N/mm^2) defined by:

$$\sigma_{amm} = \frac{S}{k}$$

S = tension guaranteed minimum tensile to which the pipe is able to withstand for 50 years at 20°C (N/mm^2);

k = safety factor (= 3,25)

Plants for the service of gaseous fuels

As regards the installations of pressure reduction can have of plants for reduction of the gas pressure corresponding to cabins of the first and second jump, for industrial uses. In the cabins of first jump, there are air-conditioning plants (heating of the expanding gas to prevent the formation of ice) and of odorisation with tetrahydrothiophene and mercaptans (to make the detectable presence of gas in the air which, by its nature, is odorless).

Plants for the service of gaseous fuels

The interior installations to industrial utilities consist of:

- **a pipeline**, that transports gas from the external network to the system pressure reduction and of measurement of the users, constituting the supply pipeline. Is forbidden that this conduct pass under the buildings or the crossing of the buildings entering the body of the same, while it is allowed to overtake a building;

Plants for the service of gaseous fuels

The interior installations to industrial utilities consist of:

- **a plant of pressure reduction and measurement of consumption**

If the maximum pressure allowed is 25 bar, the system must be placed against the wall of fence enclosing the area of the property, and if between 5 and 25 bar must be located as far away as possible from buildings or warehouses.

If the pressure is below 5 bar, safety distances must not be less than 2 m;

Plants for the service of gaseous fuels

The interior installations to industrial utilities consist of:

- **a network of pipes from this plant to user appliances, constituting the supply network**.

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

a) oxigen

The industrial needs can be met:

- installing within the plant a central production

Can be realized with technology PVSA (Vacuum Pressure Swing Absorption) and the oxygen is obtained directly in the gas phase by passing air through a bed of zeolite. The zeolite adsorbs the nitrogen and the carbon dioxide, but not the oxygen, thus enriching its content in the air supply. The degree of purity standard oxygen thus produced is 93% and can go up to a maximum of 95.5%. The productive capacity typical of these plants varies from a minimum of 600 Nm^3/h to a maximum of 4000 Nm^3/h

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

a) oxigen

The industrial needs can be met:

- installing within the plant a central production

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

a) oxigen

The industrial needs can be met:

- realizing a deposit of liquid oxygen through cryogenic tanks, where the liquid is kept at a temperature of -183°C. Upon use, the liquid is converted into gas by means of a vaporizer.

The cryogenic fuel is a fuel that requires to be stored at extremely low temperature to enable it to maintain the liquid state. They are, in fact, generally constituted by the liquefaction of gases such as, for example, liquid oxygen. It is mistakenly called "cryogenic fuel", but it is more correct to identify it as oxidizing and not as a fuel.

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

a) oxigen

The industrial needs can be met:

- connecting, with an underground pipe, a central of external production;
- by oxygen tanks in the gaseous state with pressures up to 200 bar, that arrive to the plant arranged on metal frames or cylinder trucks, which constitute a unit load of easy handling. They are then inserted into a storage and connected to a device for reduction and regulation, from which branches off of the supply network to the loads

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

a) oxigen

The industrial needs can be met:

- one or more oxygen tanks close to the users in the case of limited consumption

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

a) oxigen

One must be careful not to reach pressures and speed of oxygen too high in the feed pipes to utilities, as shock and friction of particles suspended in oxygen can cause sparks that can cause fires (you can not have higher speed of 25 m/s with pressures up to 20 bar).

Known the pressure and speed, and thus the flow, of oxygen, it is possible to determine the internal diameter of the pipes d (mm) according to the relation:

$$d = \sqrt{353{,}5 \cdot \frac{Q}{p \cdot v}}$$

where:

Q = flow relative to atmospheric pressure (m^3/h);

p = absolute pressure (bar);

v = velocity (m/s).

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

a) oxigen

The feeding of the deposit to the user occurs in seamless steel pipes without welding, preferably above ground and outside of the building. If underground pipes, are arranged inside the larger diameter pipes to protect them from corrosion and eddy currents. They must not be placed near the fuel pipes or high temperature liquids. The joints are made by welding. The curves must have a radius of at least 5 times the diameter of the tube. The networks can be a mesh or a comb. The connecting pipes between the main network and the utilities must start from the top of the main pipe and be fitted with a bronze valve, an indicator that it is O_2, a pressure reducer and a removable cap on the terminal of pipe;

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

b) acetylene

It can be powered by a generator or by a group of cylinders or from an external network, with or without the interposition of gasometer. If the acetylene is supplied in special steel cylinders, these contain a porous mass, which prevents the ignition of acetylene. The acetone or dimethylformamide introduced in filling phase behave as solvents and allow to considerably increase the capacity of storage.

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

b) acetylene

For the pipes follow the advice made for oxygen. Along the networks, however, stand in the way of the flame and overpressure safety devices to the network is installed above ground and outside of buildings.

Safety is an aspect for which can not be ignored in any way. Sampling points by lines centralized and pressure on single cylinders must be equipped with a valve of flow check. Annually goes checks to verify the correct operation of systems and leak detection.

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

b) acetylene

The storage of acetylene cylinders, such as those of oxygen, shall be constructed of incombustible materials and be ventilated. If you put in the same room, they must be separated, providing for a separation with fire-rated walls (partitioning). Cylinders should be placed in a vertical position so that they can not fall or collide; recommended is the use of a suitable rack;

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

c) hydrogen

It is stored in cylinders or in tanks, according to the safety standards of other flammable gases. For storage tanks must be provided in the side protectors reinforced concrete shell and anti-burst.

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

c) hydrogen

The nets are made of steel tubes and welded joints, and for sizing you follow the same criteria used for the compressed air.

Plants for the service of gaseous fuels

Are followed to describe the systems used in industrial plants for particular gaseous fluids:

d) nitrogen and argon

They are delivered to the plant in the liquid phase and stored in special tanks tested at the required pressures. Downstream are installed a vaporizer and a pressure reducer. The power supply to the consumers are accomplished through a network of pipes, whose sizing follows the compressed air. You avoid installing pipes local small and poorly ventilated.

Requirements for small cylinders used in the gas phase, which deposit shall be provided away from sources of heat and very windy environment. The cylinders are stored vertically and with the appropriate racks.

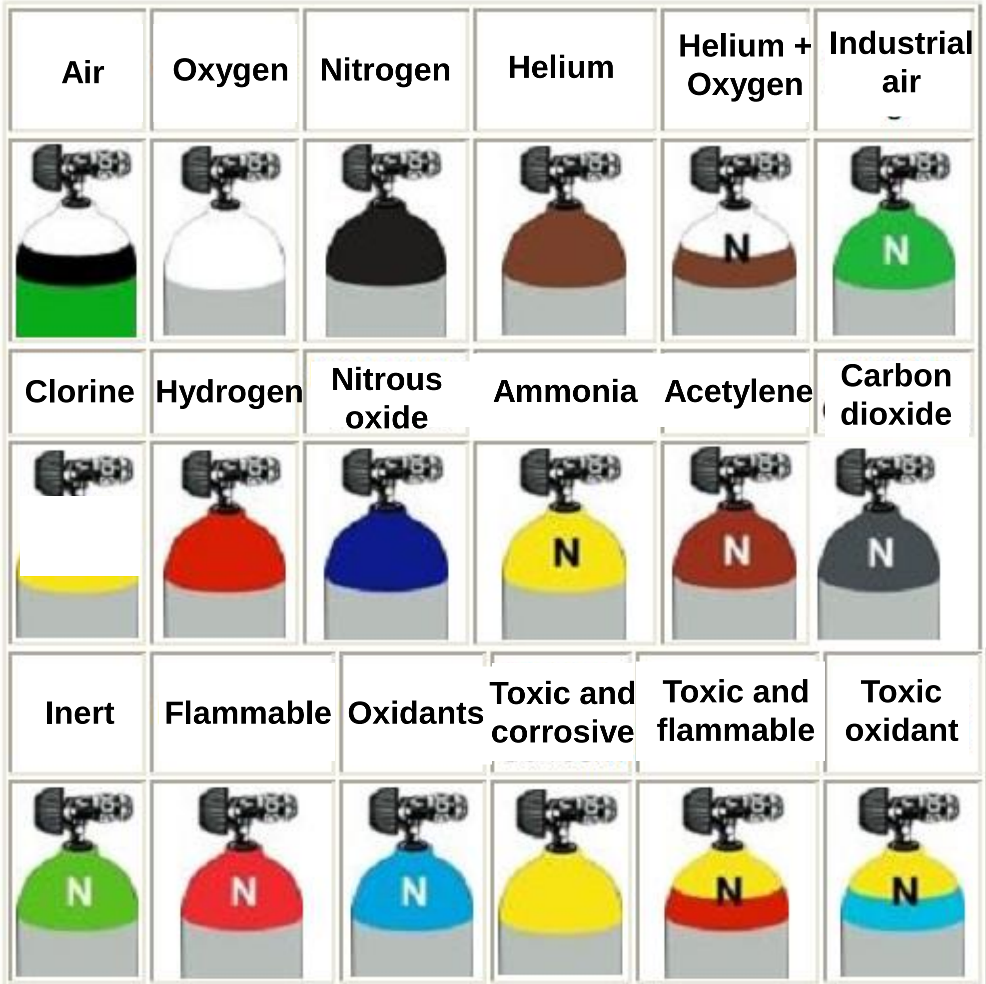
Colors distinctive of the cylinders

The UNI EN ISO 7225:2007 requires that cylinders containing compressed gas, liquefied or pressurized dissolved bear a label indicating the contents. The UNI EN 1089-3:2005 lists the cresting of the same cylinders, with a colored area in the upper part of about 10 cm (Figure).

UNI EN ISO 7225:2007 “Bombole - Etichette informative”

UNI EN 1089-3:2005 “Bombole trasportabili per gas - Identificazione della bombola (escluso GPL) - Parte 3: Codificazione del colore

Colors distinctive of the cylinders



Air: white + black, oxygen: white, nitrogen: black, helium: brown, helium + oxygen: white + brown + N, industrial air: light green + N, chlorine: yellow, hydrogen: fire red, nitrous oxide, purple , ammonia: yellow + N, acetylene: brown + N, carbon dioxide. dark gray + N, inert very light green + N, flammable: red + N, oxidants: light blue + N, toxic and corrosive: yellow, toxic and flammable: fire red + yellow + N, + toxic oxidants: yellow + blue + N