White Paper

Garo®

An Ingersoll Rand Business

Liquid Ring Technology
for Dry Chlorine Compression

DRY CHLORINE
Application Overview

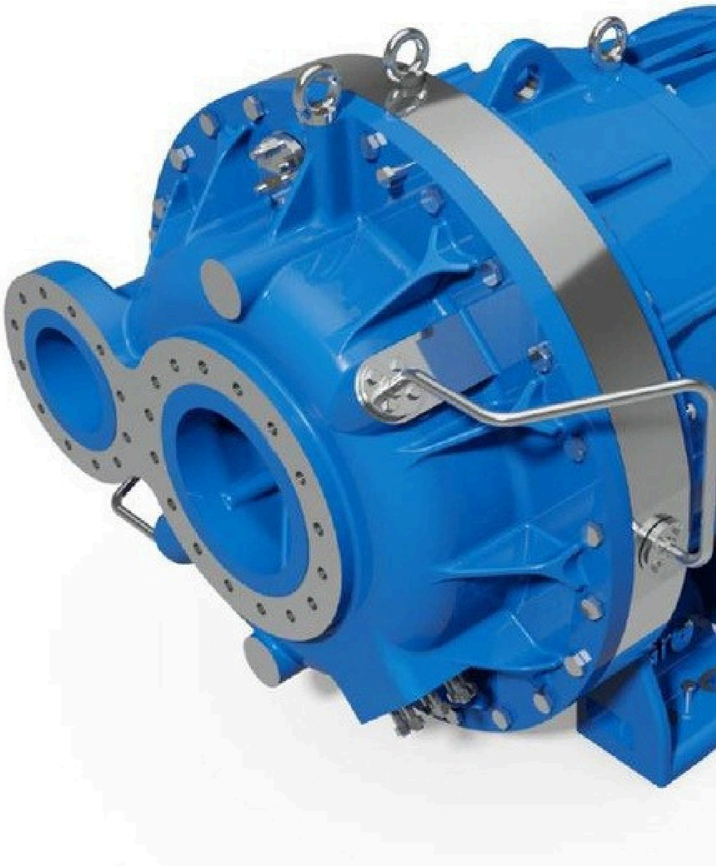
Alongside fluorine and bromine, chlorine is considered an integral component in the chemical industry. As a basic inorganic chemical, chlorine and chlor-alkali products have seen a rising demand in a number of end-use industries, including the production of PVC, organic, inorganic, and agro chemicals. Additionally, chlor-alkali products have been widely used for water treatment, paper bleaching, and as a key component in household and industrial cleaning products.

According to Grand View Research Inc., this spike in demand for chlorine products will have a significant impact on the global chlorine compressor market, which is expected to grow to $83.7 million USD by 2025.

As a toxic, lethal, and extremely corrosive substance, chlorine production processes require equipment that complies with a number of international environmental and safety standards, and provides a high degree of reliability. Additionally, most chlorine production processes operate at atmospheric pressure, and require that chlorine gas is compressed and liquified for transport and storage purposes.

Alessandro Pertusati
Commercial & Projects Director
Garo

Garo®
An Ingersoll Rand Business



Boasting a lower capital expenditure, when compared to centrifugal compressors, liquid ring compressors (LRC) have proved a popular alternative for plants where the maximum reachable capacity does not exceed approximately 5 – 6 units running in parallel. With worldwide investments focusing on small/medium capacity plants, demand for liquid ring compressors is projected to be far higher than for competing technologies, such as centrifugal compressors.

In addition to cost, the projected increase in demand for liquid ring compressors (LRC) is also driven by the unique characteristics of Liquid Ring Technology:

Safety

The isothermal properties of the liquid ring allow LRCs operate at much lower temperatures than other technologies, lowering the risk of corrosion and damage.

Compatibility

LRCs can support a number of different ‘seal liquids’, allowing them to be easily tailored to the application. In dry chlorine applications sulfuric acid is the only seal liquid allowed.

Reliability

With a single moving part, LRCs exhibit less opportunity for failure, and are able to handle occasional carry-over of particles such as salt or organic materials.

Affordability

LRCs exhibit longer mean time between failure (MTBF) and a lower total cost of ownership (TCO) than competing technologies.

Functionality

In addition to their ability to fully dry chlorine during compression, LRCs are also able to handle a smaller gas flow, as well as effectively manage sulphuric acid mist emitted from the drying tower.

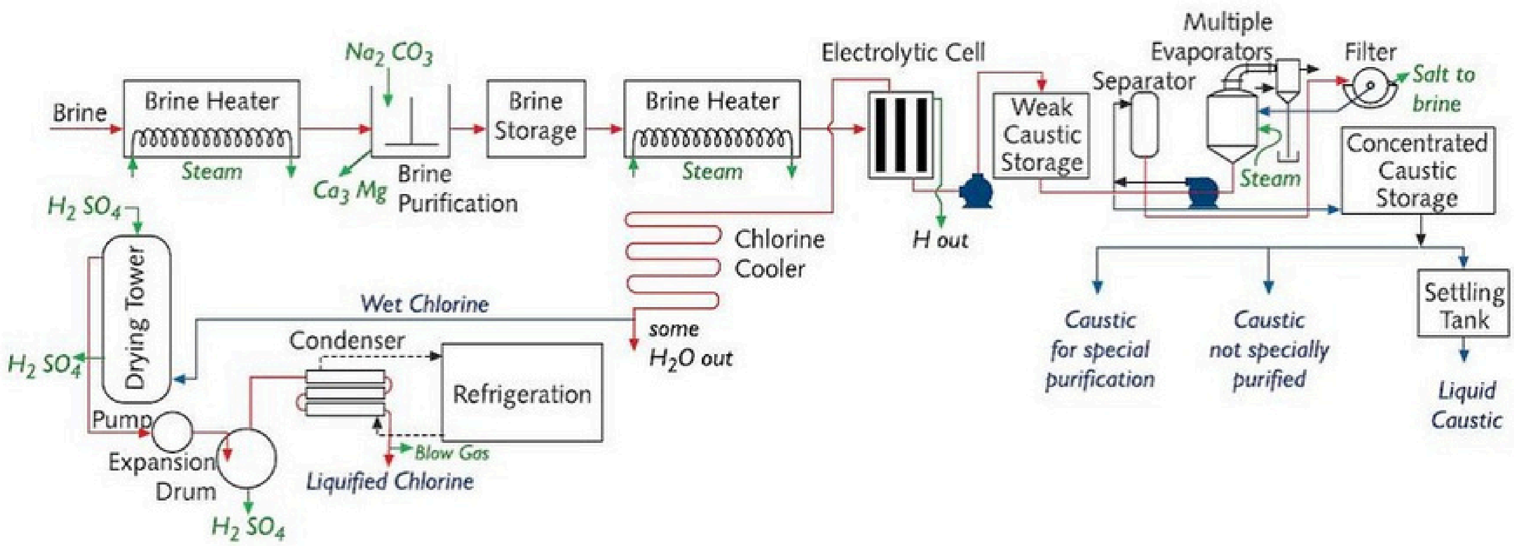
Dry Chlorine
High/Low Pressure Applications

Most chlorine is produced using the process of electrolysis, where chlorine, hydrogen gas and caustic soda are produced from salt brine. Upon leaving the electrolytic cells the gas, which is saturated with moisture, passes through coolers and a sulfuric acid drying tower. The dry chlorine (defined as containing less than 100 ppm water vapor) gas then enters the liquid ring compressor to begin the compression/ liquefaction process.

During the drying process, the gas sustains a slight pressure loss, and usually reaches the compressor at a negative pressure of 4-10” of water, though newer generation electrolyzers ensure a higher pressure to LRC (0.1 bar g). In order to reduce moisture, and in turn corrosion, the temperature of the gas at the compressor inlet should be no more than 100°F (37.8°C).

Additionally, using a seal liquid with a high concentration of sulfuric acid (typically 96/97%, but more effectively at 98%) allows the process to be handled by steel or iron equipment.

Once compressed, the chlorine gas is then liquefied through cooling. The cooling process requires strict temperature and pressure controls in order to work effectively. GARO compressors play a key role in the cooling process, by ensuring that the required discharge pressure is achieved prior to the chlorine being passed to the after-condenser for the condensation process. Discharge pressure is determined by the temperature of the coolant being used, as well as the condensing temperature of chlorine.



Depending on the end use, chlorine can be compressed at either low-pressure (LP) or high-pressure (HP). In both instances, the chlorine gas can be sent directly to users, or it can be further purified.

Dry Chlorine is a lethal, toxic, and extremely corrosive gas. Low pressure chlorine gas applications using high concentration sulfuric acid can be handled by a standard nodular cast iron (containing +1.5% nickel) compressor. With lower operating temperatures and sulfuric acid as a seal liquid, there is little to no risk of rust occurring in the iron, making cast iron a more cost effective choice than more exotic materials such as Austenitic Stainless Steel or Hastelloy C.

Conversely, high pressure applications require a compressor casing made from Austenitic Stainless Steel (316L or HC276 for certain applications), with ancillaries in the steel to cater for proper corrosion allowances. Functioning at higher temperatures, and with a lower concentration of sulfuric acid (94% - 95%), Austenitic stainless steel provides a far greater resistance to corrosion when compared to cast iron.

Dry Chlorine

High/Low Pressure Range and Application

	Pressure Range	Application
Low Pressure	36-65 psig (2-4.5 bar)	Chlorine gas can be sent directly to users, or further purified through a liquefaction process, by using an additional, dedicated liquefaction package, which eliminated pollutants like Oxygen, Nitrogen and Hydrogen gas.
High Pressure	72-123 psig (5-8.5 bar)	Chlorine gas can be sent directly to users, or further purified through a liquefaction process, using a simple gas liquefier to eliminate pollutants like Oxygen, Nitrogen, and Hydrogen gas by simple cooling of the high pressure compressed gas at dew point.

For both low and high pressure applications, a stainless steel shaft with specialized gaskets and packing is used. Additionally, in both instances, it is recommended that a seal liquid with a high concentration of sulfuric acid be used.

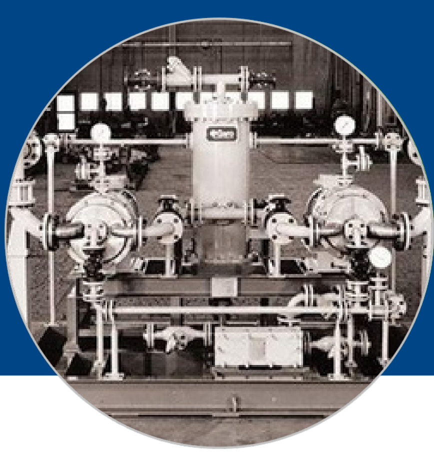
With this in mind, chlorine compressors are usually designed with Hastelloy C shaft sleeves, and utilize special stuffing boxes, packing, or mechanical seals which can withstand harsh service and use of an acid based seal.

Typical Considerations

Further to this, there are a number of considerations that must be taken into account when working with compressed chlorine gas:

Did you know?

There are 1,054 Chemical GARO Liquid Ring Compressor installations globally. The first GARO Liquid Ring Compressor for the Chlorine Industry was installed in 1954.



Concentration of the Acid Seal

The seal liquid used must contain a high concentration of sulfuric acid. The absolute minimum is 94% H_2SO_4, with chlorine plants usually opting for 96 –98% H_2SO_4. The required concentration is often determined by the compressor material used, with cast iron being able to withstand a minimum concentration of 96%, compared to stainless steels 94% minimum. Compressor life and reliability is directly tied to the concentration of the seal liquid, as compressor parts can rapidly deteriorate when acid concentration falls below the minimum threshold.

Temperature of the Acid Seal

Corrosion of the liquid ring compressor and its parts is directly related to temperature. To keep corrosion to a minimum, temperature of the liquid seal should be kept as low as possible, without dropping below 68°F (20°C) to prevent issues with viscosity. Depending on the application, chilled or cooling water is typically used to maintain correct acid seal temperature. Low pressure applications normally use chilled water, whereas high pressure applications typically require cooling water, particularly where liquefaction is performed without an additional chilling unit.

Operating discharge temperature and LRC Method of Cooling

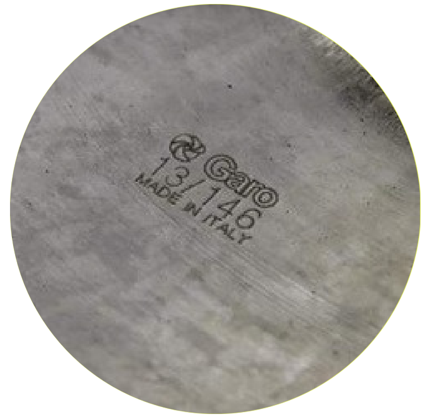
Low pressure, cast iron units cannot operate at temperatures higher than 113°F (45°C) due to issues that arise due to corrosion. High pressure processes, on the other hand, require higher operating temperatures to avoid chlorine condensation/ liquefaction inside LRC unit.

Quantity of Sulfuric Acid

In order to cool the seal liquid and maintain the temperatures required for safe and reliable operation, operators need to know the amount of acid that is required to create the seal. Inaccurate volumes can lead to miscalculations, which can accelerate wear and corrosion of equipment, affecting the efficiency, reliability, and safety of the system.

Compressor Sizing

To ensure 100% capacity on long term operations, liquid ring compressors for dry chlorine applications are typically over-sized by 15% on the projected requirements.



Other Considerations

Operators also need to consider the acid coolers required for their installation. Acid coolers are classed as specialty equipment that needs to be configured to a particular system/installation, as such it is advised that they are obtained from heat exchanger manufacturers with extensive experience in dry chlorine applications.

Additionally, the discharge separator needs to be large enough to allow retention time for heavy material from the recirculated system to settle, and also needs to be periodically flushed. Manual or automatic acid make up is also required to maintain the acid concentration within the required specification. Hastelloy C membrane type instruments (level and pressure transmitters) are also normally recommended to reduce overall material corrosion.

Liquid Ring Technology for Wet Chlorine Applications

Liquid ring systems for wet chlorine applications (defined as > 100 ppm water vapor) are similar to those used for dry chlorine, with the exception of the materials used in the system and seal liquid. In wet chlorine applications, titanium compressors are required, and titanium is also necessary for the seal cooler, separator tank, and system piping. If capital expenditure is a concern, different materials, such as CS PTFE lined piping and valves, and CS PTFE or fiberglass reinforced plastic (FRP) separators can be used.

Due to the fact that there is no need to dry the chlorine, water is used as the recirculated seal liquid in wet chlorine processes. As a result, wet chlorine processes require compressors constructed from titanium, to eliminate the risk potential and risk of corrosion.

GARO: Experts in Liquid Ring Technology for Chlorine Applications

With over 70 years of experience designing, manufacturing, and delivering custom liquid ring compressors and systems, only GARO can provide you with the knowledge to develop a system tailored to your operations.

GARO has an extensive installed base and a wealth of expertise in delivering custom engineered systems for low and high pressure chlorine applications. With a comprehensive product portfolio catering to a variety of performance and materials requirements, all GARO systems are backed by a global technical service and support base.

About Garo

Garo delivers a broad range of compressors and custom designed packages to end-user and OEM customers worldwide. We provide reliable and efficient equipment that is put to work in a multitude of demanding industrial process applications.

Our products and systems serve industries including chemical, petrochemical, oil & gas, and pulp & paper. Our global offering also includes a comprehensive suite of aftermarket products and services to complement our products.

Garo®

An Ingersoll Rand Business

For further information please visit
www.garocompressors.com

WP-GDG-DC-1157 2/18