



HYDRO-PAC INC.

High Pressure Hydrogen Compressors



*Hydro-Pac Hydrogen Compressor Model C12-40-7000LX
12,000 psi (80MPa), 40 hp (30 KW)*

Since the 1980s, Hydro-Pac has manufactured compressors for high-pressure hydrogen applications. We have developed the techniques to safely and reliably compress this difficult gas.

Our initial experience was the design and manufacture of ultra high-pressure hydrogen compressors for pressures of 30,000 psi to 120,000 psi (200 to 825 MPa).

The recent interest in hydrogen gas as an energy source has prompted us to expand our product offerings for this important application. In addition to the ultra-high pressure machines, we manufacture units for pressures of 1,000 psi to 15,000 psi (7 to 100 MPa) and flow rates of 1 scfm to 350 scfm (3 to 1200 kg/day).

Today, our hydrogen compressors are in use at fixed and mobile fueling stations, industrial sites, research and development facilities, and backup power systems.

Features

Hydro-Pac hydrogen compressors feature:

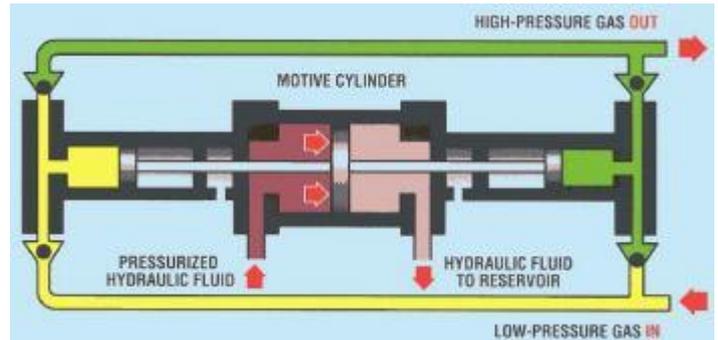
- Oil-free nonlubricated gas pistons and cylinders protect against oil contamination of the process gas.
- Full stroke length distance pieces isolate the hydraulic drive from the gas cylinders. This prevents contamination of the gas by the hydraulic drive oil.
- Hydro-Pac gas compressors work over a wide range of inlet pressures. In many cases inlet pressure regulators are not required.
- Intensifiers are ideally suited for high-pressures due to the simple geometry, slow operating speeds and in-line loads.
- Long slow stroke and small dead volume in the compressor cylinders result in a high volumetric efficiency.
- Water-cooled gas cylinders lower operating temperatures, which increases packing life.
- Hydraulically driven intensifiers allow control of both discharge pressure and gas flow rate by controlling the hydraulic drive. This may be important when matching the flow rate of the compressor to that of a reformer or electrolyzer.
- Straightforward arrangement and patented free piston design of Hydro-Pac compressors simplifies maintenance.
- Gas pressure assists in the compression stroke improving the overall efficiency of the machine.

HYDRO-PAC Intensifiers

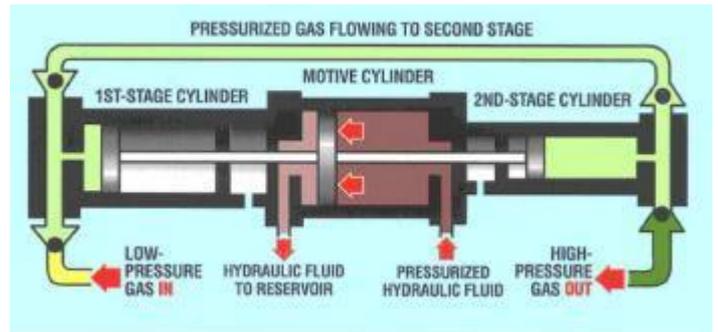
The heart of every Hydro-Pac high-pressure hydrogen compressor is a hydraulically driven intensifier. An intensifier consists of a hydraulic cylinder (motive cylinder) coupled with two gas cylinders. The most common arrangement is a hydraulic cylinder in the center with a gas cylinder on each side of the hydraulic cylinder.

In operation, the force of the hydraulic pressure acting on a hydraulic piston is balanced by gas pressure acting on the gas piston. As the hydraulic cylinder strokes, gas is compressed and displaced from one gas cylinder while simultaneously filling the other gas cylinder.

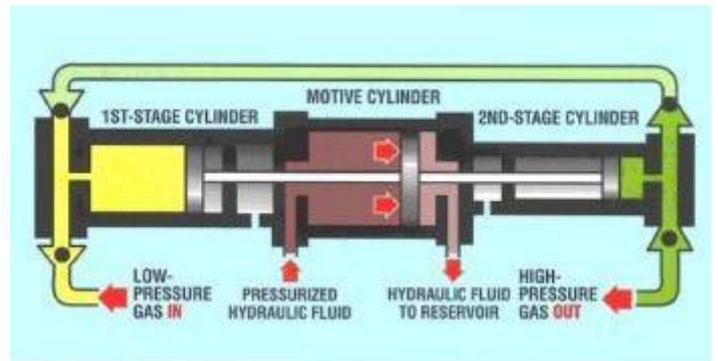
Intensifier designs are flexible and multiple arrangements are possible. The most common arrangements are double-ended machines that are either single stage or two stage units. Single ended units are also available.



Single Stage Compressor



Stage 1 Compression



*Stage 2 Compression
TWO STAGE COMPRESSOR*

Types of machines

Our hydrogen compressor product line consists of three types of machines in various sizes. The types of machines we manufacture are classified as multi-stage, single-stage and hybrid models.

Each type of machine has specific features that make it well suited for its intended purpose.

The multi-stage machines boost hydrogen gas from inlet pressures as low as 70 psi (0.5 MPa) to discharge pressures as high as 15,000 psi (100 MPa). These units are often used to fill storage tanks. They can be sized to match the flow of hydrogen gas produced by a reformer or electrolyzer. Some customers have powered our compressors with the electricity generated by windmills.

The single stage machines are perfect for moving



*Multi-stage 6,000 psi (40 MPa) Unit 70 to 140 psi
(0.5 - 1 MPa) Inlet Pressure*

large amounts of gas when high inlet pressures are available. The ability to work with high inlet pressures allows even small units to move significant amounts of gas. These machines are favorites for rapidly filling vehicle tanks, moving gas between storage vessels and emptying high-pressure tube trailers.

Hybrid machines share features with the multi-stage and single stage units. When inlet pressures are low, hybrid compressors act as conventional multi-stage units and boost low-pressure inlet gas to high discharge pressures. When high inlet pressures are available, hybrid machines act as a single stage compressor and take advantage of the naturally higher capacity that is possible with the higher inlet pressures.

Materials of Construction

All Hydro-Pac compressors are manufactured of materials suitable to resist the affects of hydrogen embrittlement at the expected operating conditions.

Fueling Strategies

Hydro-Pac compressors are well suited to a number of fueling strategies including:

- Direct fill; the compressor fills the tank directly.
- Cascade fill; the compressor fills individual storage cylinders, which are then equalized sequentially with the vehicle.
- Low-pressure storage, high-pressure fill; the compressors are sized to utilize storage at 3,000 to 6,000 psi (20 to 40 MPa) to fill a high-pressure vehicle tank at 6,000 to 12,000 psi (40 to 80 MPa). This eliminates the need for high-pressure storage tanks yet allows the compressors to displace a large quantity of gas when operating with a higher inlet pressure during the vehicle fill.
- Scavenge scenarios on multiple storage tank installations; the compressors scavenge gas from the lower pressure tanks and quickly fill the higher-pressure tanks. This allows faster vehicle fill times.



Single stage 12,000 psi (80 MPa) Unit 5,000 to 6,000 psi (35-40 MPa) Inlet Pressure



Hybrid 6,000 psi (50 MPa) Unit 140 to 300 psi (1-2 MPa) Inlet Pressure as Multi-stage Unit 1,000 to 5,000 psi (7-35 MPa) Inlet Pressure as a Single Stage Unit.

- Parallel/Series compressor arrangements; two or more single stage units act in parallel to move large quantities of gas when pressure differentials are low and then switch to series operation when pressure differentials increase.

In many instances, careful selection of the compressors will minimize the cost of the gas storage tanks by reducing the amount of storage required and the pressure rating of that storage.

Worldwide Experience

Hydro-Pac has supplied hydrogen gas compressors to many major gas suppliers and automakers all over the world.

Capacity Information

Information about the performance of our compressors can be found by clicking on any of the following links:

[Capacity Chart: 70 to 140 psi Inlet](#)

[Capacity Chart: 140 to 300 psi Inlet](#)

[Capacity Chart: 300 to 600 psi Inlet](#)

[Capacity Chart: 1,000 to 6,000 psi Inlet](#)

Compressors or Packages

In addition to stand-alone compressors, Hydro-Pac also manufactures complete compressor packages. A basic package includes inlet and discharge pressure switches, motor starter with hour meter, cooling water flow switch and meter as well as a PLC controller to control the operation of the unit.

More sophisticated packages are available that include options such as proportional pressure and or flow control, temperature monitoring, and closed loop cooling systems. Please consult Hydro-Pac and our engineering team will be happy to help you select a package for your application.

Applicable Standards

Hydro-Pac compressors are available to meet the Japanese High-Pressure Gas Safety Law (HPGSL) as well as European standards. Including the CE and the Pressure Equipment Directive (PED).

Other Products

Hydro-Pac designs and manufactures a wide variety of pressure generating and containment equipment. Our product line includes:

Gas compressors for:

- Gas assist injection molding.
- Hot isostatic pressing.
- Air bag inflator filling.
- Instrument calibration and testing.
- Leak testing.
- Supercritical extraction.
- Inert gas foaming.
- Fuel studies

Liquid pumps for:

- Pressure forming.
- Pressure testing.
- Cold isostatic pressing.
- Cyclic pressure testing.
- Hydrostatic extrusion.
- Pressure sterilization.
- High-pressure homogenizing.
- Burst testing.

- Autofrettage

ASME sec. VIII, div.1, 2, and 3 pressure vessels for:

- High pressure gas storage
- Hot and cold isostatic pressing
- Pressure test systems