TECNOCRYO'S FILLING STATIONS INNOVATION POINTS

We here below summarize the innovations applied to our filling stations.

Item	Automatic component	Function / Advantages
1	Suction automatic valve + fast degassing (rapid cooling system)	• Fast pump cold down • Initiate pump cold down only when necessary (limit the increase of tank pressure) • Exploit the gas phase of the storage tank for purging and reduce the tank pressure
2	Automatic purge valve	Pump start without counter pressure (reduced pump stress) Implement by-pass cycles before stopping the pump and during the finishing of filling.
3	Cold filling system	Filling time reduction (filling end pressure reduced) -> increase productivity
4	Automatic relief valve	Avoid overpressure caused by liquid entrapment in the vaporizer at the end of filling (avoid unwanted safety valve opening) Automatic purge of the lines at the end of pump usage
5	Buffer system	Useful as capacity when there are few cylinders to fill Gas recovery from the lines at the end of filling and each time the lines are purged Exploit of capacity for: Usage of gas as a secondary component (without needs to start the pump -> energy saving) Time saving (usage of gas in the capacity while the pump is in cold down)
6	Inverter	Energy recovery each time the pump piston moves back. Energy saving during the current peak phases. Soft start (mechanical stress reduction and increased pump lifetime). Automatic rotation reversal at each pump start (considered a maintenance operation performed in automatic. Allows for a

		longer lifetime of the motor).

Additional descriptions

The CFS - Cold Filling System.
The CFS is a filling system that operates at low controlled temperatures and is used to achieve a filling process that is able to compensate, at least partially, the heating of the gas in the cylinder due to compression. In order to achieve this, the control system collects part of the downstream liquid, that was vaporized upstream using a valve. It has an on/off regulating switch and is controlled by two thermal elements installed in series on the line. The filling temperature is set by the operator according to the safety values. If the temperature immediately after vaporizing reaches the set alarm limit (minimum settable limit –40°C) the pump and the alarm will be halted.

The SFS - Static Filling System.
The Static Filling System is a control system that fills the cylinders at a pre-set pressure value, without any losses in load due to various filling branches or sections of different types of valves, having any influence on the final value. This system also has a pump soft start option where the pump is always started without any counter-pressure
Each time the pump is started, the by-pass valve on the pump opens automatically and then closes when the set soft start time expires.
When the set stop value is reached, the system opens and closes the pump by-pass valve according to the times set to achieve the desired filling pressure.
The valve that monitors the SFS can also, (according to the version) be manually operated from the TS, only when the pump is idle, to discharge the gaseous phase from the container. This option makes it possible to decrease the pressure in the container using the collected gas for wash phases.

The PCS – Pressure Controlled System.
The Pressure Controlled System is a system that manages the safety valves when the cylinders are filled with different maximum filling pressures 200 / 300 bars. This system foresees that the safety valve that protects the maximum level (PN 300 bar) is always connected to the filling line, whilst the valve that protects the minimum level (PN 200 bar) is connected to the filling line via a pneumatic valve. This NO, normally open, type valve, leaves the safety valve most suitable for filling at low pressure, connected by default. If it is necessary to use a higher pressure, the operator must close the breaker valve on the safety valve calibrated for lower pressure. To do this, the operator must enter a special password which modifies the alarm and stop pump set points.
When the filling process has been completed, as soon as the system detects a bleed and the pressure therefore returns to pressure values that are lower than the safety valve calibrated settings for lower pressure filling, it opens the pneumatic valve again, which enables the protection of the lower level and the alarm and stop pump set points are automatically realigned at lower values. The valves will have to be enabled following the above procedure each time the filling process requires higher filling pressures. This system ensures that the operator is able to gauge and monitor the filling of cylinders at different maximum pressures in complete safety; please note that the operator must

control the maximum filling pressure of the cylinders connected to the station. This system is used on certain versions of the station.

The RCS – Rapid Cooling System.

The Rapid Cooling System of the pump is ensured by a specific valve. It can be present in the fully automatic installations together with high-flow rate pumps. The sizes of the high-flow rate pumps often require long cooling times just in relation to the mass of metal of which they are made. In a typical installation, which is not provided with such system, the cooling time is based on the capability of the phase separator to evacuate the gas from the suction system. Such separator is normally enough to carry out this task during the normal operation, as the pump is already cold, but it slows down the initial cooling. The RCS, with the support of the reading of the suction temperature, can bypass the separator during the cooling initial phase in a fully automatic way. In this way the pump is, through communicating vessels, flooded by the liquid and taken to the start-up temperature in few seconds. Once the pump has reached the required temperature, such bypass is automatically closed and the separator activates. This system is not applied in case of thermosiphon tank version.

Automatic rotation reverse

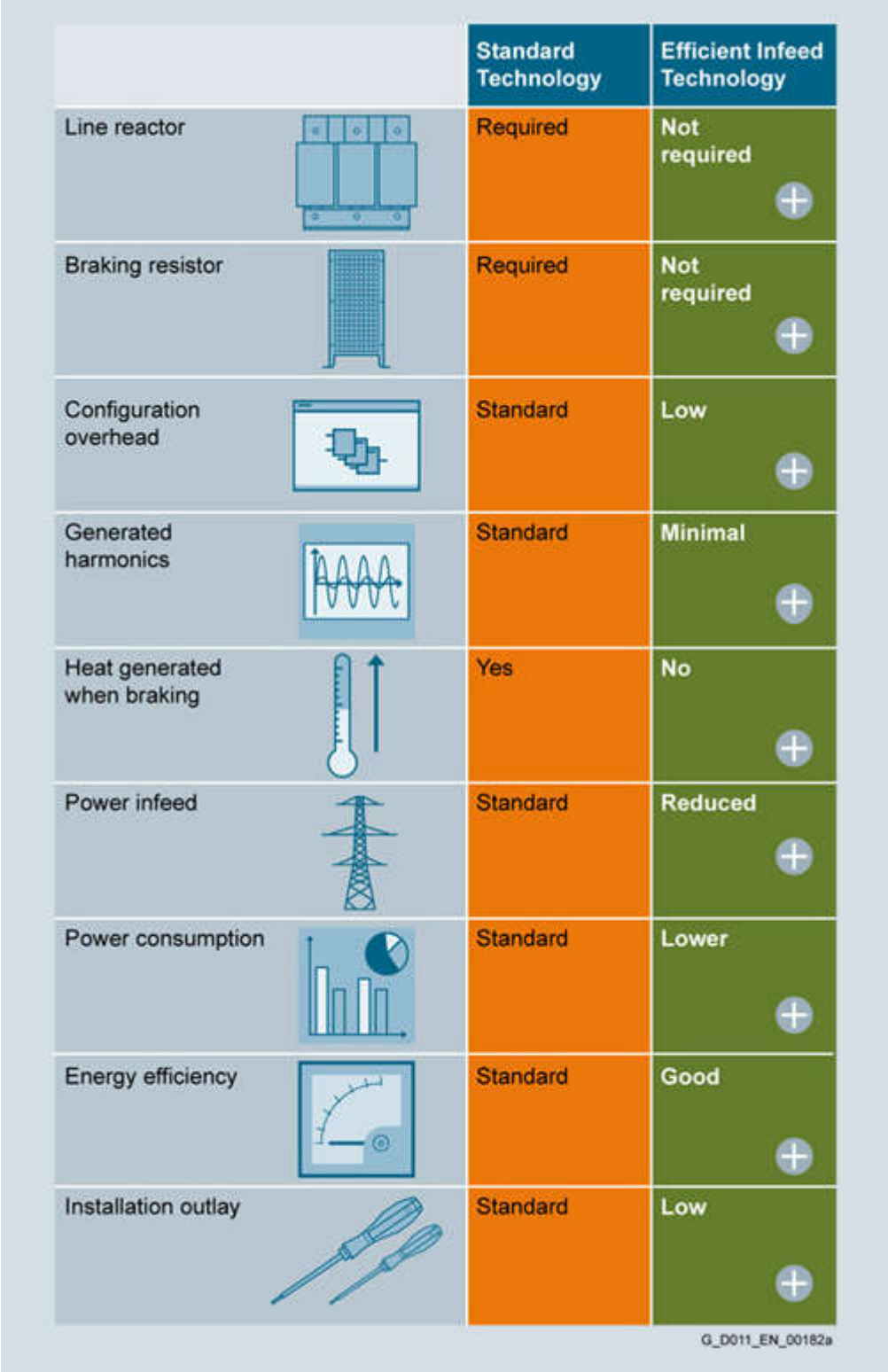
When is installed the inverter to drive the motor, each time the pump starts, the rotation (Jog) is reversed automatically. This permit a correct consumption of the mechanical parts of the pump.

Energy generation with regenerative inverter (Efficient infeed technology).

The inverter is a regenerative type and this allow for the generation of electricity during the alternative motion and, in particular, when the pump piston moves back. The generated energy is reversed into the grid.

Potential savings thanks to Efficient Infeed Technology

The table below shows the advantages of the technology as compared to conventional 2-quadrant inverters.



Three technical criteria are of particular significance:

- Regenerative feedback
  - 100 % braking power is fed back, allowing continuous braking. This is possible using braking resistors which take up a lot of space and are expensive.

- A braking resistor does not need to be configured.
- No need for installation, thermal monitoring, etc. of external components.

- Minimal reactive power distortion
  - Low reactive power distortion thanks to current consumption that is almost block-shaped, the power factor λ is virtually 0.9. The transformer throughput rating is therefore lower than that required for inverters with a standard DC link.
  - In order to achieve such a low harmonic content (line harmonics) for an inverter with a conventional DC link, a line reactor with a u_K = 6 % is required.
  - This results in approx. 22 % lower current consumption which corresponds to approximately 40 % lower losses in the supply system.
  - The load on the power supply system is therefore reduced.

- Improved offset factor cos φ
  - Slightly capacitive at input ≅ 0.95 capacitive.
  - Compensates the reactive power of motors and other inductive loads on the same supply.
  - The power draw of the entire system is reduced. In a system comprising one inverter with motor and another motor on the same supply, the total power draw is reduced by up to 12 %.

Line supply conditions

Inverters with Efficient Infeed Technology have a much lower harmonic content (and therefore lower reactive current component) than a standard inverter. The harmonics up to and including the 11th harmonic are significantly lower than specified in the standard. These relevant harmonics are less than half the magnitude stipulated by the relevant standard (EN 61000-3-12).

Permissible ratio between network short-circuit power S_{K_line} and inverter apparent power $S_{inverter}$:

$S_{K\_line} \geq 100 \times S_{inverter}$ according to $u_K \leq 1$ %