



Best Practices of Chemical Injection System Design for Oil & Gas Production

A White Paper

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ABSTRACT

The injection of chemicals in a controlled and reliable process is a key factor in the productivity and profitability of Oil & Gas production. This white paper documents some of the considerations and best practices that help specify the most appropriate system.



Best Practices of Chemical Injection System Design

Power

Source

There are numerous methods available to power chemical injection pumps/systems and there can be many variables to consider when choosing the proper source. The most common are:

- **Location:** Often this is the most limiting factor. Sometimes choosing a power source simply comes down to what's available. Isolated sites may not have electrical utilities and are often in climates that do not support solar power.
- **Environmental impact:** Increasing concern has been given to the impacts that process equipment have on the surrounding environment. Venting natural gas after utilized for process equipment is sometimes unfavorable and in some cases not permitted. This can limit pneumatic equipment that is not designed for use with a gas recovery system. Electrical or alternative energy sources may be considered in lieu of pneumatically actuated and/or powered systems.
- **Cost of energy:** All energy is accompanied by an associated cost. Electric utility costs are surprisingly high given the amount of energy used to run a typical chemical injector motor. Solar panels and batteries are very expensive, especially when battery replacements are numerous resulting from a poorly designed system. The most cost effective method may be to utilize a pneumatically powered gas recovery injection system.

Motive System

There are many ways to power a chemical injection system. The constraints of location as well as the availability of reliable power drive the pump motor specification. Typically, chemical injection systems are powered in one of three ways: pneumatically, utility/municipal electricity, or solar powered.

- **Pneumatic:** Pneumatically powered systems create motive force by utilizing compressed air or gas to power a motor of some sort. The motor applies forces to a plunger or diaphragm system, which in turn injects the chemical at a measured rate. Often, chemical injectors are powered by natural gas given its availability at most well sites. It is important to understand and become familiar with acceptable venting practices associated with each site. If venting used



motive gas is not acceptable then a gas recovery injection system may be warranted. Gas recovery systems have a means to recapture the gas used for pneumatically powered equipment. This allows the motive gas to be either injected back into the process line to be sold or safely flared off.

- **Electrical:** Electrically powered systems create motive force by utilizing municipal/utility or generated electricity to power an electric motor. The motor applies forces to a plunger or diaphragm system, which in turn injects the chemical.
- **Solar:** Solar powered systems utilize solar cells to create electricity via the photovoltaic effect. Sunlight excites the atoms of a semi-conductor, which cause the flow of electrons (electrical current). This electrical current makes its way into a battery bank. The battery bank, in turn, powers a DC electric motor. Designing a solar powered system is much more complex than designing a typical electrical or pneumatically powered system. It is crucial that the manufacturer utilizes the most efficient components and understands how to best combine these components. Make absolute certain that the manufacturer of the solar system utilizes sealed gel or matted glass batteries that are designed specifically for deep cycle solar applications. Also, it is imperative to specify the desired days of autonomy; or the number of days that a system should be designed to operate without sunlight. Typically these values should be at least 5-7 days in the Southern US, 2-4 days in the Middle East, and up to 30 days for locations such as Canada, northern Russia and the Arctic.

Chemicals

The type of chemicals that are to be injected must be considered when properly designing or specifying a chemical injection system.

- **Compatibility:** Today's chemicals are more effective in aiding the petroleum production process; but they also present a host of problems on injection equipment. Typically, chemicals are becoming more concentrated and powerful. Unfortunately, this does not bode well for the materials used to transport, house, or inject said chemicals. It is vital that all materials of construction are rated for use with the chemicals they come in contact. This is especially important for pressure containing components and soft goods such as static and dynamic seals.
- **Viscosity:** Viscosity is an often over looked chemical variable. It is very important to consider viscosity ratings at the various temperatures that a system will be subjected. Viscosity will have an effect on flow rate, pressure, and wear. Also, flow meters are very erratic when it comes to varying viscosities. Make



sure the proper meter is chosen; one that can handle the flow ranges at each extreme of the possible operating temperatures.

- *Frequency of injection:* Injection frequency must be considered when procuring a chemical injection system. Some chemicals require a rather infrequent dosing protocol while other chemicals require continuous flow characteristics to achieve the desired effect on the system. Make sure the chemical injection system is designed to produce the desired flow rate at the prescribed frequency.

⇒ *H₂S scavengers* typically require a truly constant flow regime. It should be noted that this cannot be accomplished with merely a chemical pump injecting at a high frequency. Best practices require the use of several other pieces of equipment sized particularly for the prescribed flow rate and discharge pressure. **Timer controlled systems are generally not recommended for continuous flow conditions.**

General Design Parameters

The most common information used to design or size a chemical injection system are discharge pressure, prescribed chemical flow rate, and supply gas pressure and gas composition (pneumatic system).

- *Discharge pressure:* The discharge pressure is a result of the system, pipeline, or wellhead operating pressure. Basically, this is the pressure that the chemical injector must overcome at the injection site/collar in order to inject the desired chemical into the system. Generally, as discharge pressure climbs, so does the robustness of the chemical injection system. It is very important to make sure that the injector and all fittings, tubing, valves, etc. are rated for the MAWP of the system. Also, it is highly recommended to properly size and install a PRV (pressure relief valve) set at a value less than or equal to the MAWP.
- *Flow rate:* The flow rate is usually dependent on the type of chemical, chemical concentration, process conditions, and various other parameters. This value is often set or recommended by the chemical manufacturers and is highly dependent on the chemicals interaction with the process medium and the rate of reaction. It is absolutely critical to inject the prescribed chemical at the recommended dosage rate for a variety of reasons. Improper dosing can keep the chemical from reacting in the proper manner, which can lead to damaged equipment, hydrate formation, excessive fines, and process system downtime. Also, the cost of over injecting chemical can be extreme given the number of chemicals injected and their assorted costs. The chemical injection equipment must be designed not only to handle and achieve the desired flow rates, but also designed to maintain the same rates after the initial system calibration.



- ⇒ Chemical injectors should always be compliant with or exceed the various metrics as per **API 674, 675**. Request chemical injector system manufacturers to furnish linearity and steady state dynamic tests where applicable.
- *Supply gas:* Pneumatically powered injection systems require pressurized gas to power the injector motor. Special attention must be given to the available pressure and volume from an instrument air system or natural gas source. Basically, enough gas needs to be available to prevent starving the motor from the necessary volume it takes to operate effectively. There must be sufficient pressure to allow the motor to create enough force to overcome the counteractive force of the process conditions acting on the plunger or diaphragm. Another important concern is the chemical make-up or gas composition of a natural gas source. Many natural gas sources have moderate to high concentrations of H₂S, CO₂, and other detrimental constituents which can lead to various failure modes; the most common being corrosion stress cracking/fatigue which can accelerate the failure of metallic, plastics, and elastomer components.
- ⇒ Make sure that all natural gas items are compliant with **NACE MR0175** standards.

Control System Design

SCADA systems have rightfully become more popular in today's chemical injection systems. Unfortunately, there are too many sites with too many variables to expect dedicated personnel to effectively manage and maintain chemical injection systems. SCADA systems are being utilized more than ever to not only report and control system measurements such as flow rates and discharge pressures, but they are now being designed to predict an upcoming system upset through properly defined diagnostics. This enables service providers to schedule routine system "health" maintenance. There is no reason to dedicate resources to emergency type situations where an injector or crucial component has failed. Energy Companies are quickly realizing the value in a proactive approach to chemical injection management. If a controlled system makes sense, then there are several areas of concern that should be discussed or evaluated with the chemical injection system provider.

- *Control protocol:* System parameters change constantly and with little or no warning in the Oil & Gas Industry. Just because a chemical injection system is installed properly and calibrated to the exact specifications doesn't mean that the system will continue to operate at peak efficacy even if the injector maintains the



dosage rate. Countless things can change such as process flow rates, process pressures, supply gas pressures, system carryovers, operating temperatures, etc. It only takes one of these modified variables to upset the conditions of a finely tuned system. It's crucial to have a system that recognizes these changes or the results of these changes and reacts appropriately by altering a parameter, such as injection rate, to harmonize the system. Therefore, it is important to have the provider explain or demonstrate the control system design. There are many ways to acquire data and react to that data, i.e. alter a system variable. Probably the most foolproof and industry proven way is the utilization of a closed-loop PID PLC governed control system. This type of control system measures certain variables via sensor system and compares these values to either the original set points or to a proportional value formula. If the variables of concern do not satisfy the logic then the PLC alters a variable until the system is stable.

- *Control system/RTU integration*: Provide as much information as possible on the user SCADA system. It will be crucial for the chemical injection system manufacturer/control system provider to understand the type and model of the RTU that will be communicating with the injection PLC. Also, it will need to be determined if the field RTU should be viewed as slave or master and a registry outlay will generally have to be provided to the injection system manufacturer to allow for the mapping of the PLC as per the RTU.
- *Communications*: The 3 most commonly used communications protocols are IP/Ethernet, Serial, and Fieldbus. There are various methods and specific types of standards with each of these protocols. It is important to specify which type of communications protocol is warranted to ensure that the PLC control device can communicate and receive control information from the RTU or other device per the SCADA system.

Reliability

Chemical injection systems are often subjected to extreme conditions. These systems are often placed in extreme environments where the elements alone can cause failure. In addition, these systems are required to inject some of the harshest chemicals at extreme flow rates and discharge pressures. The simple fact is that chemical injection systems will eventually fail. It's not of question of if, but rather when. This makes it imperative for chemical injector manufacturers to be forthcoming with reliability metrics. It's necessary for formulating a pro-active approach to managing the maintenance of chemical injection pumps and equipment.

- *MTBF*: Mean Time Between Failure. Request MTBF for any major equipment or components that are considered maintenance items.



- *Expected or average yearly downtime:* Rationally calculate the max allowable downtime per year. Most often this is a matter of hours rather than days for crucial or enabling equipment. Discuss this value or expectations with the chemical injection system provider and make sure metrics are made available to ensure extended downtime will be an anomaly rather than the norm. It could be that an exchange or emergency stock consignment program makes the most sense in ensuring that downtime is kept to an absolute minimum.

Quality Assurance

Today's Oil & Gas market is saturated with equipment manufacturers and service providers. It can be a daunting task to make sure that they have the best interest of the end user in mind and can repeatedly offer impeccable products and service in accordance with the quality and safety system of the end user. There are two easy ways to ensure that these needs can be satisfied.

- *QMS certification:* Does the designer/manufacture adhere to a quality management system and can they produce documentation of that system along with the proper certification? Every company that expects to compete for business in the Oil & Gas market must comply with a quality standard. Make sure you request proof of this when entering the procurement process. For example, more and more companies must be accredited to the ISO 9001 standard in order to win business. ISO 9001 is arguably one of the more robust and concise global standards. ISNetwork offers a database that aims to connect reliable, dependable, and safe companies that participate in the energy and other technical markets. Ask your provider if they are a part of the ISNetwork accredited network.
- *Quality procedures:* In addition to being an accredited member of one of the major QMS organizations; manufacturers of dynamic equipment must adhere to testing guidelines and quality control procedures. Request a copy of these procedures and if necessary ask the provider to offer testing specific to the actual field conditions. Also, it is highly recommended that large-scale projects are either field tested via pilot program or subjected to validated testing.



About CheckPoint Pumps & Systems

CheckPoint Pumps & Systems® is a leading provider of production solutions. We design, manufacture, and market the world's most reliable chemical injection pumps and pump packages, control panels, pressure test systems, green energy solutions, and process components. CheckPoint Pumps & Systems built a reputation for reliability in the oil & gas production and refining industries, and our products are selected wherever reliability and quality are essential. Our mission is to reduce operating costs for our customers by increasing the reliability of their production systems. With a worldwide presence and a genuine customer-focused culture, CheckPoint Pumps & Systems is large enough to handle the needs of the world's largest industrial companies, but small enough to care for the duration. We stake our reputation and our future on the performance of our products and our employees' 24/7/365.

