ROCHEM TECHNICAL SERVICES
Established in1978

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Powerful. Efficient. Reliable.

# PROCESS COMPRESSOR CLEANING

## FAQs

1. What are the methods of cleaning fouled process compressors?

   There are basically two methods to clean a fouled process compressor; on-line and off-line cleaning.

   On-line cleaning
   On-line cleaning is the preferred cleaning method for process compressors. The advantage of on-line cleaning is that the process compressor can be cleaned during normal operation. There is no need to shut down the unit and the cleaning operation can be performed in a matter of minutes.

   A suitable cleaning chemical will be injected by means of a specially designed nozzle system installed in the process compressor suction line. The atomized cleaning chemical will be entrained by the process gas thereby wetting all the process compressor internals. On-line cleaning will not only clean the gas passages, but also between the impellers and diaphragms.

   Depending on the application and fouling level, on-line cleaning can be performed periodically or on a continuous basis. For process compressors where buildup on the diaphragm surface is a problem, continuous flushing with a cleaning chemical may be required.

   Given the fact that the atomized cleaning chemical is evenly distributed inside the process compressor casing, there is no risk of flow instability. Any material buildup will be gradually removed thereby minimizing the risk of increased vibration levels and/or accumulation in downstream process equipment.

   The positive effect of on-line cleaning will be visible instantly. The process parameters can be monitored and the cleaning operation can be adjusted as required.

   Off-line cleaning
   To enable off-line cleaning, the process compressor must be shut down and isolated. During off-line cleaning, the process compressor casing will be filled with a suitable cleaning chemical. Care shall be taken not to overfill the casing; the maximum liquid level shall remain below the shaft end seal level. Furthermore, the shaft end seals must remain pressurized to prevent liquid from entering the shaft end seal cavities and bearing areas.

   While injecting the cleaning chemical into the process compressor casing, the rotor should be rotated slowly (<20 rpm). The process compressor internals should be soak washed this way for at least 15 minutes. When completed, the liquid can be drained from the casing and a sample should be taken to determine the amount of suspended and dissolved particles. Depending on the results, the procedure should be repeated as required.

   Off-line cleaning is an alternative option to on-line cleaning. However, a major disadvantage is that the process compressor must be taken out of service which, in case of no backup, results

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in a complete plant shutdown. The costs associated with such an unscheduled shutdown could be enormous and adversely affect plant profitability.

Another negative aspect of off-line cleaning is its effectiveness. The process compressor casing can only be filled below the shaft end seal level. The top half of the casing, containing the top half of the diaphragms, cannot be soak washed. Given the fact that any material buildup in this area most likely cannot be removed, off-line cleaning could result in the additional risk of flow instability which potentially could cause increased vibration levels. Furthermore, chunks of dirt may eventually dislodge from the top half and move within the process compressor thereby aggravating the risk of increased vibration. Some will accumulate in the aftercooler inlets or knockout drums resulting in high pressure drops.

2. What are the effects of on-line cleaning on the downstream process?

   Fouling inside process compressors can be the result of two possible causes:

   A. Foulants being entrained by the upstream process gas and deposited inside the process compressor (among others)
   B. Fouling buildup inside the process compressor resulting from (1) polymerization due to high stage temperatures or (2) seal oil reacting with process gas components (in case oil seals are being used).

   A cleaning chemical mixed with good quality (demineralized) water will be injected in the process gas upstream of the process compressor (suction side). The foulants inside the process compressor will be washed away (diluted) and leave the process compressor with the process gas downstream of the process compressor (discharge side).

   During on-line cleaning, the cleaning chemical and foulants will end up in the process system downstream of the process compressor.

   When we consider a process whereby the fouling mechanism falls into category A, on-line cleaning will most likely not affect the downstream process. In this case, the fouling is not limited to the process compressor alone, but already present throughout the complete process system both up- and downstream of the process compressor. It is assumed that the customer has taken appropriate measures to control the degree of fouling and/or implemented a preventive maintenance schedule to periodically clean the complete process system.

   When we consider a process whereby the fouling mechanism falls into category B, on-line cleaning could affect the downstream process. In this case, the fouling is limited to the process compressor and not present throughout the complete process system. The possible implications of foulants originating from the process compressor being entrained by the process gas into the downstream process system shall be studied in close cooperation with the customer.

3. Are there any restrictions regarding the type of shaft end seals being utilized?

   Process compressor shaft end seals can be divided into three main categories:

   - Clearance seals (e.g. labyrinth seals, restrictive-ring seals)
   - Oil seals (e.g. liquid-film seals, mechanical (contact) seals)

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- Self-acting dry gas seals (e.g. dry running seal).

On-line cleaning
In principle, process compressors equipped with oil seals or self-acting dry gas seals can be cleaned on-line. However, this shall be studied and confirmed on a case-by-case basis, since each process compressor application is different and designed according to site specific conditions (minor modifications of the shaft end seal and/or seal support system may be required).

Process compressors equipped with clearance seals are not suitable for on-line cleaning. There is a high risk of foulants washed away by the cleaning chemical accumulating in these seals thereby affecting the proper functioning.

Off-line cleaning
In principle, process compressors equipped with clearance seals, oil seals or self-acting dry gas seals can be cleaned off-line. However, this shall be studied and confirmed on a case-by-case basis, since each process compressor application is different and designed according to site specific conditions.

4. What process compressor types are suitable for cleaning?

   In principle, cleaning is limited to continuous flow compressors of axial and centrifugal design or a combination thereof.

5. What are the signs of a fouling process compressor?

   To determine whether a process compressor is fouling, it is important to monitor the performance. Operating parameters, such as pressure, temperature, flow rate, speed and gas analysis data, shall be collected on a continuous basis and compared against original design values.

   Some operators have developed their own software tools to predict when a maintenance shutdown is required for performance reasons and/or to assist in troubleshooting possible aerodynamic problems. This can be very complex, since the operating point and gas composition will continuously change.

   Apart from the trend analysis described above, there are a few practical signs that a process compressor could be suffering from fouling.

   Pressure ratio
   The process compressor head is directly proportional to the pressure ratio. Trends obtained by monitoring the pressure ratio will be similar to monitoring head. A fouling process compressor will show a gradual drop in pressure ratio.

   Temperature rise
   Monitoring temperature rise will be an indication of total work input. If the temperature rise goes up for a given flow and speed then this is an indication that the efficiency of the process compressor has gone down.

   Flow

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Fouling will result in increased frictional losses and/or internal recirculation. This increase in resistance effectively reduces the capacity of the process compressor. Over time, a fouling process compressor will show a gradual reduction in flow.

Speed
A process compressor driven by a gas turbine, steam turbine or variable speed drive system, may see a gradual increase in speed because of fouling. The process control system will try to maintain the required discharge pressure and can only achieve that by increasing the speed of the process compressor.

Thrust bearing load
Dirt buildup inside the process compressor could affect axial rotor balance. The axial thrust (movement) of the rotor will be absorbed by the thrust bearing. A gradual increase in thrust bearing load (displacement, temperature) could be an indication of a fouling process compressor.

6. What kind of information is required to prepare a proposal?

   The information requirements are listed in the Process Compressor Cleaning Questionnaire which should be completed by the customer. The collected information will be analyzed by one of our specialists followed by a site visit and technical review meeting. Once all the technical details have been clarified with the customer, Rochem will be able to submit a commercial proposal.

   Please contact us for a copy of the Process Compressor Cleaning Questionnaire.

7. Is on-line cleaning in recycle mode an option?

   On-line cleaning of the process compressor shall only be performed during normal operation, i.e. with the recycle valve in fully closed position.

   Foulants washed away entering the recycle line could affect the proper functioning of the recycle valve thereby jeopardizing the safe operation of the process compressor. Furthermore, on-line cleaning in recycle mode would just circulate these foulants through the process compressor casing which could potentially aggravate the problem.

8. Is a shutdown required to install the injection nozzle system?

   The specially designed injection nozzle system will be installed in the process compressor suction line. Normally, a suitable piping or instrument connection close to the process compressor suction can be used for this purpose.

   To enable installation of the injection nozzle system, the process compressor should be taken out of operation. Provided all necessary preparations have been made, installation of the injection nozzle system can be completed in a matter of hours.

9. At what frequency should on-line cleaning be performed?

   The cleaning frequency very much depends on the degree and speed at which fouling of the process compressor occurs. Some processes, such as gas crackers, are known for their

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particularly troublesome fouling problems. Costs associated with cracked gas compressor fouling are high and they can increase exponentially as conditions deteriorate.

The key is to control fouling as it initiates rather than to implement a treatment program for an already fouled process compressor. In other words, regular cleaning will be much more effective than to postpone cleaning until such moment when the process compressor performance has already significantly dropped.

The optimum cleaning frequency will be determined in cooperation with the customer by collecting field operational data serving as input for regular performance verifications.

10. At what process operating conditions should on-line cleaning be performed?

    The operating zone of a process compressor is a region constrained by the following boundaries:

    - Surge limit line
    - Choke, or stonewall line
    - Line of maximum power
    - Lines of maximum and minimum pressure
    - Lines of maximum and minimum speed.

    By adding control margins to this region, a stable zone of operation will result, i.e. the actual operating zone of the process compressor.

    During the on-line cleaning operation, one must ensure that the operating point of the process compressor stays well within the limits of the stable zone of operation.

11. What quantity of cleaning chemical is required for on-line cleaning?

    On-line cleaning is normally performed by mixing one-part FYREWASH® concentrate (25 liters) with four parts of demineralized water into a stable solution (total quantity 125 liters per section).

    The flow rate at which the chemical solution will be injected will be determined on a case-by-case basis and is dependent on process compressor size and operating conditions.

    It is normally recommended that a post rinse with demineralized water is performed to ensure that both the injection nozzle system and process compressor are thoroughly cleaned.

    The above mentioned on-line cleaning procedure may need to be repeated depending on the degree of fouling and process compressor configuration.

    The optimum cleaning quantity will be determined in cooperation with the customer by collecting field operational data serving as input for regular performance verifications.

12. What type of cleaning chemical is used for on-line cleaning?

    In most cases, we recommend using the FYREWASH® F1 chemical, a high purity hydrocarbon solvent and surfactant formulation for heavy duty on-line process compressor cleaning.

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In case of environmental limitations, FYREWASH® F4, a highly bio-degradable water based detergent for on-line process compressor cleaning, could be an alternative option.

The type of cleaning chemical to be used will depend on the nature of the foulant and environmental circumstances of the installation concerned and will be determined in cooperation with the customer.

13. Can the cleaning chemical affect the material integrity of the process compressor internals?

    Based on the information provided with the Process Compressor Cleaning Questionnaire, one of our specialists will verify the material compatibility of the process compressor internals.

    Based on the current number of installations, no material compatibility issues have been reported by our customers.

14. What are the financial benefits of on-line cleaning?

    The costs of fouling can be significant thereby adversely affecting plant profitability.

    Cost savings of USD5M per event are common which can be attributed to:

    - Reduced equipment availability and reliability
    - Loss of revenue resulting from reduced plant throughput
    - Plant outage costs resulting from unscheduled maintenance
    - Direct and indirect equipment overhaul costs
    - Manhour costs.

15. How many injection nozzle systems are required when operating two or more process compressors in series?

    Each section of the process compressor should be equipped with a dedicated injection nozzle system.

    A section comprises all the process compressor stages between the suction and discharge nozzle. A section is sometimes also referred to as a ´stage group´ or ´process stage´.

    In case of a single casing process compressor comprising of two sections (or ´process stages´), we require two injection nozzle systems.

    In case of two or more process compressor casings in series (each comprising of one or more sections), we require a corresponding number of injection nozzle systems.

    In most cases, a single wash delivery skid will be sufficient to supply the FYREWASH® solution to the injection nozzle systems. However, there could be some applications where the installation of additional wash delivery skids could be required, e.g. large compression trains with multiple injection nozzle systems.

16. What are the risks of process compressor fouling?

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Apart from a clear decay in process compressor performance there are also some risks associated with process compressor fouling.

Because of fouling, the process compressor operating point will gradually move into the direction of reduced capacity. This could increase the risk of surge which, when not properly safeguarded, could result in a catastrophic equipment failure.

Fouling will also increase the risk of flow instability which potentially could cause increased vibration levels. Very often high axial thrust of the rotor assembly will cause a unit trip which, in case of a single unit, will result in a complete shutdown of the facility.

Fouling buildup on the rotor assembly itself could potentially also cause increased vibration levels with similar consequences.

The proper functioning of the shaft end seals may also be compromised because of fouling.