



Condensation of volatile  
organic compounds (VOCs)—  
when and how . . .  
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Condensation is the process of removal of compounds by lowering the temperature of the gas stream containing them. It is one of the options for treatment of VOCs.

Since vapor pressure decreases with temperature, in simple cases, e.g., for ethylene glycol or other compounds with a high boiling point and high enthalpy of vaporization, the process can be sufficient for reducing emissions to legal limits. Lower boiling compounds, especially nonpolar ones, require extremely low temperatures to meet the emission limit and are best treated in a hybrid process where condensation is only a part of the process.

In Figure 1, there are three emission limits for reference – 1mg/Nm<sup>3</sup> for carcinogenic or other highly toxic compounds, 20mg/Nm<sup>3</sup> as often applied as the emission limit, and 500mg/Nm<sup>3</sup> which is not normally allowed to be emitted directly but is acceptable as input for a final treatment step or reuse in the process without boosting operating costs. It can easily be recognized that requirements for cooling are reduced when allowing higher concentrations of VOCs in the treated gas.

Nevertheless, there are a couple of important applications where condensation only is useful to achieve the emission limit.

Figure 2 shows a layout used when no other removal technique other than condensation is applied. Precooler and redundant recuperator stages are used for water removal and energy recovery, and also for removal of some VOCs. The low-temperature condenser is applied to bring down emissions to the legal limit. These cases include

treatment of the erratic flow of a chemical reactor, standby (reserve) filters for vessels and tanks as well the removal of chlorinated compounds like CFC recovery from recycled fridges.

Safety concerns can also be a reason to choose the scheme shown in Figure 2. According to ATEX, such a simple device with no internal ignition sources can be more easily certified for (internal) zone 1 applications than other removal processes.

Figure 2: Typical Layout of Pure Condensation

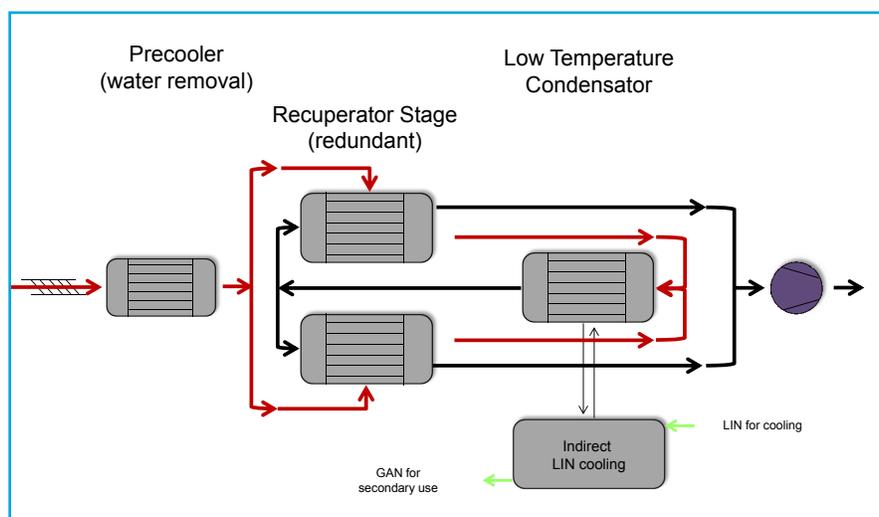
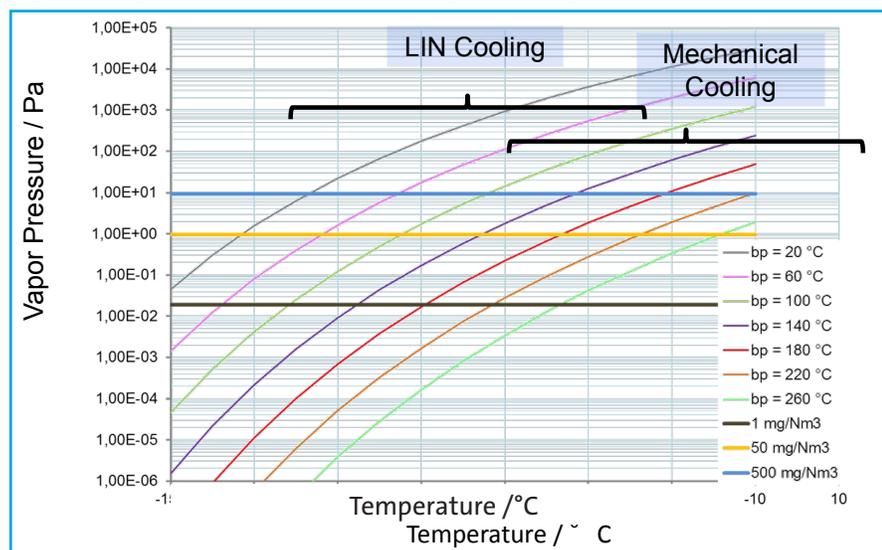
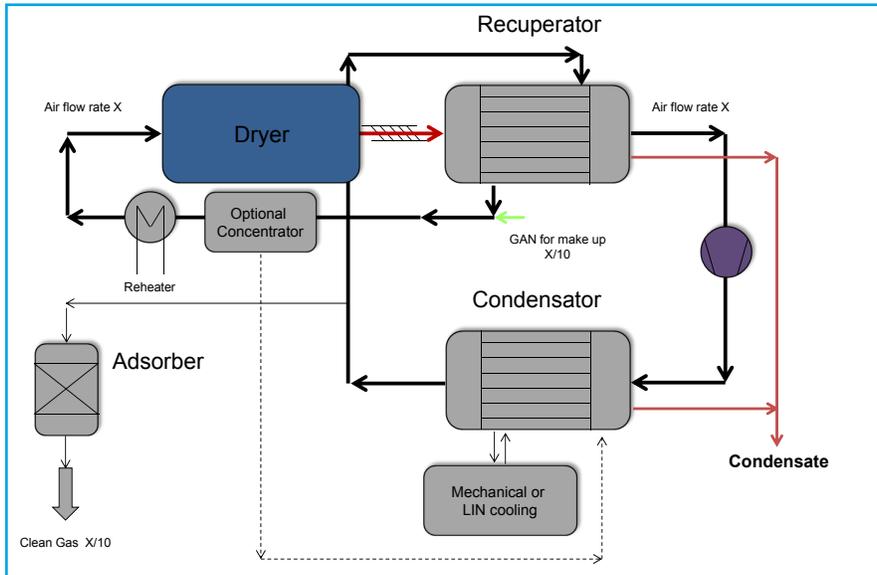


Figure 1: Vapor Pressure Curves of Nonpolar Compounds



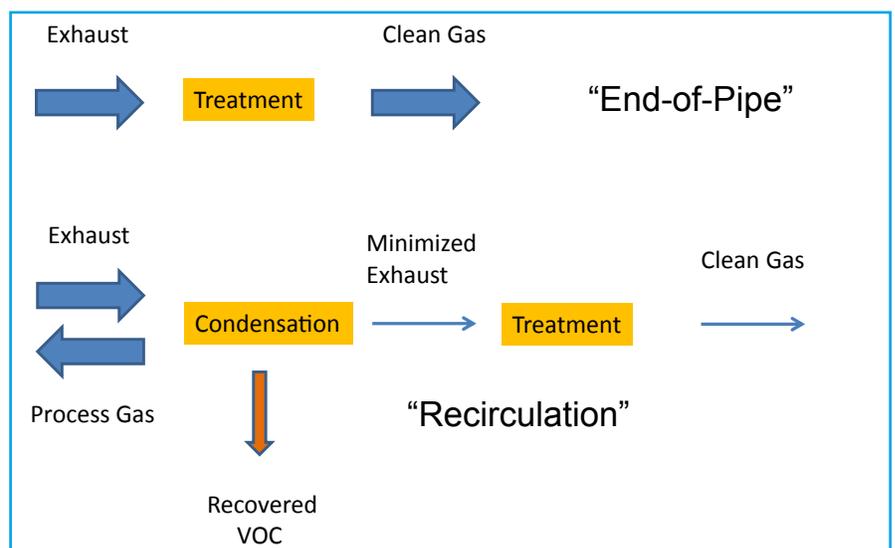
**Figure 3: Hybrid layout (example of dryer application)**



This hybrid process can contain adsorber, concentrator, or other process steps. The corresponding layout is shown in Figure 3. It is an example of an application from a dryer process where high concentrations of VOCs are generated in the (inertized) dryer so that condensation temperatures can be reduced according to the curves shown in Figure 1. The nitrogen used for inertization is recirculated and therefore not only saves cost, but does not need to be purified down to legal emission limits, thus saving even more costs by relaxing cryogenic conditions.

Figure 4 shows the process when changing from an end-of-pipe treatment to recirculation. In the recirculation case, only a small part of the original effluent stream needs “final treatment,” reducing the investment and running costs for that part of the installation. Recirculation recycles the gas stream at acceptable concentrations of VOC and generates a liquid VOC stream for reuse.

**Figure 4: Advantageous Change of Process Layout**



To find the best way through a variety of different options, you need an experienced supplier with references. Both can be found when choosing Air Products' CryoCondap® technology, offered in a partnership with HERCO GmbH. Speak with the specialists when you consider one of the following applications for VOC removal:

- Chemical reactor vent with erratic flows
- Tank and storage venting, e.g., ship unloading
- Toxic, e.g., chlorinated, compounds which cannot be treated with on-site oxidation
- Recovery of the VOC is intended for reuse
- Removal of VOC from a stream classified as ATEX zone 1

You will not only be presented with the best solution but also be part of an active discussion on how to transform your application into an efficient flow and cost management system.

For more information,  
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