# Air Pollution Control

*The only technical information publication dedicated to readers dealing with air pollution control in industrial environments*

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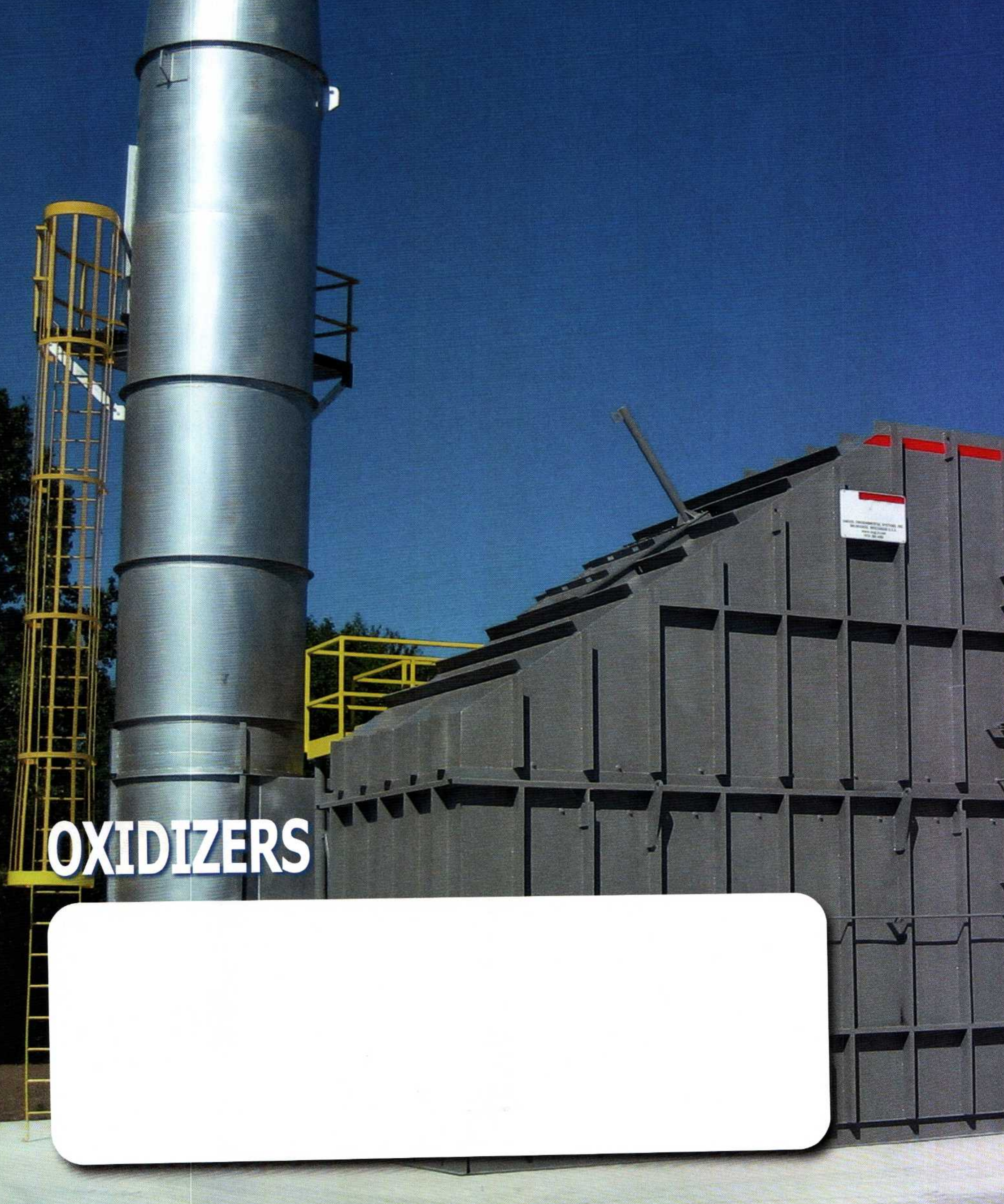


## OXIDIZERS

CASE HISTORY

# Oxidizer case histories in the pharmaceutical industry

**The pharmaceutical industry faces unique challenges in complying with environmental pollution and emission control regulations. Three pharmaceutical process case studies are examined: fluidized bed drying, tablet coating and reaction vessels, and batch operations.**

Recently, a contract drug manufacturing company faced violation of their state operating permit, costly fines, and potential Title V permit classification. To avoid penalties, a more robust abatement device had to be installed, one that met the necessary emissions standards for volatile organic compounds (VOCs).

## Process case study 1: Fluidized bed drying

### Challenge

The solution also had to be designed to work within a range of varying exhaust volumes and high VOC loads, provide low operating cost, and include a heat-recovery solution that offered substantial return on investment.

It also needed to be designed to do the following:

- Provide continuous VOC destruction across operational range
- Provide high uptime reliability
- Be fully automatic, with no operator interface required
- Be installed easily
- Provide features that help minimize maintenance
- Integrate a waste heat boiler

The process includes multiple fluidized bed granular dryers and tablet coating stations that feed the new oxidizer. Each process exhausts a high concentration of methanol, acetone, and alcohol based VOCs. The lower explosive limit (LEL, sometimes referred to as *lower flammable limit*) from the process is expected to be approximately 40 percent LEL. This is considered a high LEL and requires certain expertise and equipment design features to safely handle the process exhaust stream.

A catalytic oxidizer was installed and integrated with a waste heat boiler (WHB) to provide approximately 8,000 lb / hr of 90 psig steam. The integration of the WHB with the catalytic oxidizer provides substantial operating cost savings compared to operating the current stand-alone boiler (Figure 1).

The current system installed is a regenerative thermal oxidizer (RTO). This technology incorporates a ceramic heat exchange media and valves designed to provide low gas consumption and consistent VOC destruction in low solvent loading applications.

RTOs are usually designed to accept only VOC concentrations from 5 to 10 percent LEL. For an RTO to work in this application, both a hot gas bypass and large amounts of dilution air must be introduced. The RTO is based on maximizing thermal efficiency at low VOC concentrations; therefore, the design is based on heat storage and release. When excess energy (in the form of VOC concentration) is introduced, the internal temperatures change fast. In that case, the RTO would experience a high-temperature shutdown or would not be capable of meeting the VOC destruction efficiency dictated in the plant's operating permit.

In this application, the pharmaceutical plant had many processes that contribute a range of VOC loadings to the oxidizer. To provide production flexibility, the oxidizer must be designed to accept any level of exhaust volume and VOC loading on a moment's notice.

## Solution

The solution was to evaluate the process and engineer a long-term, highly reliable VOC abatement system. During the evaluation phase, substantial natural gas was discovered being used in the plant's boiler system. An option was presented that used the excess heat from the VOC abatement process to produce 90 psi steam.

The decision was made to use a catalytic oxidizer (see Figure 1) to provide VOC abatement. Catalytic oxidizers use a noble-metals catalyst to initiate oxidation at lower temperatures than thermal oxidizers. Catalytic oxidizers are also capable of processing substantially higher VOC loads than regenerative thermal oxidizers and, more importantly, can provide a constant VOC removal efficiency greater than 99 percent, no matter what concentration is delivered to the oxidizer.

This system also incorporates a primary heat exchanger that reclaims heat created in the oxidation process as a means to lower natural gas cost.

## Results

The installation of the VECTOR-Series catalytic oxidizer (see Figure 1) provided the following results:

- Consistent 99 percent VOC removal efficiency
- High-temperature shut-down elimination that increased production throughput and eliminated lost batch waste
- A natural gas savings of $646,000 per year
- Reduction of the plant's greenhouse gas emissions by 5,405 tons per year
- A 9-month return on investment

**Figure 1**

**VECTOR Series catalytic oxidizer**

## Process case study 2: Tablet coating and reaction vessels

Faced with meeting the needs of their pharmaceutical Maximum Achievable Control Technology (MACT) Standards, one Fortune 100 pharmaceutical manufacturer was given the challenge of designing a system that was able to process the ultra-high LEL (high concentration of VOCs) and deal with corrosive acids produced in the process off-gas and the post-combustion gases.

## Challenge

Many processes use halogenated VOCs. A halogenated VOC is an organic hydrocarbon that contains chlorine (Cl). The combustion reaction of oxidizing a chlorinated (halogen) hydrocarbon is shown in Eq. 1:

$$C_xH_yCl_z + O_2 => CO_2 + H_22O + HCl \quad \text{[Eq. 1]}$$

Therefore, as the reaction shows, the postcombustion gases will contain HCl. Even low concentrations of HCl are corrosive, and special engineering has to be considered in the design, material selection, and auxiliary equipment to provide a long-lasting system. To meet the needs of local regulations and the MACT standards, HCl also must be removed from the exhaust stream before atmospheric release.

## Solution

The halogen VOCs this system is designed to destroy are corrosive and require the use of a unique combination of alloys that address corrosive resistance, structural stability, and high temperatures. This special metallurgy can cost upwards of 15 times what traditional carbon steel materials cost. Consequently, the downstream auxiliary acid scrubber is also smaller, which saves on both initial cost and water use.

The issue of scrubbing the acid gases out of the exhaust stream also had to be evaluated. To meet the high VOC-removal rates for halogenated VOCs, the oxidizer needs to operate at 1,500°F. But a scrubber cannot directly accept air temperatures greater than 300°F. Therefore, a quencher is used to cool the gases after the combustion chamber and before being introduced to the scrubber. A quencher works by using water mist to cool and saturate the hot exhaust before entering the scrubber system. Once cooled, the acid-containing exhaust stream is directed to a counter-crossflow scrubber. The acidic gases are directed into the bottom of the scrubber for eventual release through the top of the scrubber. A caustic solution, typically a 25 percent solution of sodium hydroxide (NaOH) is used as an acid neutralizer. This chemical reaction "scrubs" the acid from the exhaust stream for safe release to atmosphere.

## Results

The combination of the QUADRANT-NRV thermal oxidizer (Figure 2) with the quencher and scrubber results are as follows:

- Allows for more than 99.9 percent removal of all VOCs and HAPs entering the system
- Greater than 99.9 percent removal of HCl gases
- The system incorporates a sophisticated control system that precisely monitors and controls the entire operation for safety, economy, and regulatory verification.

## Process case study 3: Batch operations

Pharmaceutical manufacturers routinely operate their production in batch operations. All companies need the ability to identify finished product with a specific batch number. Some manufacturers need to process several products on one piece of equipment or make relatively small quantities of product.

## Challenge

In some cases, several processing steps are required (such as mixing followed by drying, followed by granulation, followed by post-drying, followed by cooling). In such cases, a single batch processor is often less expensive and easier to operate than a continuous processor having multiple processing zones.

Some steps in batch operations may include agglomeration and granulation. This involves spraying a fine mist of binder solution onto the product. Another step in the operation may involve coating. Coatings may be used to provide a controlled dissolution rate (timed release), or to add a surface agent needed for downstream processing. Depending on the products being manufactured, part of the process can include solvents. Typical solvents can be alcohol-based; ethanol and methanol are very common. When solvents are used in the process environment, considerations may dictate the use of after-treatment or air pollution control equipment.

As a result of the numerous steps in a batch process, some batch operators may have higher air volumes and lower VOC concentrations. One such pharmaceutical manufacturer's plant is located in California, where strict compliance with VOC and $NO_x$ emissions are required. The plan called for a

**Figure 2**

**QUADRANT NRV Series thermal oxidizer**

VOC abatement device that could operate throughout a range of batch operations, provide consistently high VOC removal efficiency, and produce very low levels of $NO_x$. VOC and $NO_x$ are precursors to ground level ozone, or smog.

## Solution

The use of a VOC polishing chamber provides an added step in lowering final emissions to the atmosphere. Sometimes called a puff chamber, the system captures the small volume of untreated gases that result from the switching of the valves. The chamber stores and recirculates the VOCs for an added level of destruction (Figure 3).

***How the VOC polishing chamber works.*** A booster fan draws one or more of the VOC-laden exhaust from the process lines into the system (Figure 4). From there, VOCs are directed into one of the system's regenerators, an internally insulated vessel containing ceramic media. The contaminated gases are passed through the first regenerator, where energy is transferred from the ceramic media to the gas to elevate the temperature. This elevated temperature approaches the ignition level for the solvent and then is directed from the ceramic bed into the combustion chamber. As the stream exits the ceramic bed and travels through the internally lined combustion chamber, minimal heat is added to ensure a proper oxidation temperature, and a designed dwell time is maintained for the ultimate destruction of the streams' VOCs. The oxidized gases are then directed to the second regenerator to absorb the heat energy. As the ceramic media loads with sufficient heat, valves switch, and the gases are reversed through the system where the heating and oxidation process continues.

For the spilt second it takes for the valve switch to occur, a "puff" of untreated gases is released to the atmosphere. This small concentration of VOC lowers the removal efficiency in standard two-regenerator systems. By adding a polishing chamber between the RTO and the exhaust stack, the RTO is able to recirculate the puff's untreated gases to the RTO for increased destruction efficiency. The VOC polishing chamber is comprised of a third valve and a holding vessel.

The use of natural gas injection (NGI) is a technique used to raise the concentration of the incoming exhaust gas high enough so that the natural gas burner can be turned off. By eliminating combustion of natural gas in the burner, thermal $NO_x$ is eliminated and the system operates safely without formation of $NO_x$.

***How NGI works:*** A precise volume of natural gas is injected into the inlet manifold before the RTO. The natural gas mixes with the air and other VOCs to form a homogenous mixture of VOCs that is the precise quantity necessary to sustain combustion without the use of fuel to the natural gas burner. The natural gas burner is actually used only to warm and "idle" the RTO. During operation, the NGI modulates the gas flow and the burner ceases operation. NGI is a proven technique that helps lower operating costs and eliminate $NO_x$ emissions. However, it requires certain design considerations to gain necessary approvals and to operate in a safe and reliable manner.

## Results

The installation of the TRITON II-Series regenerative thermal oxidizer provided the following results:

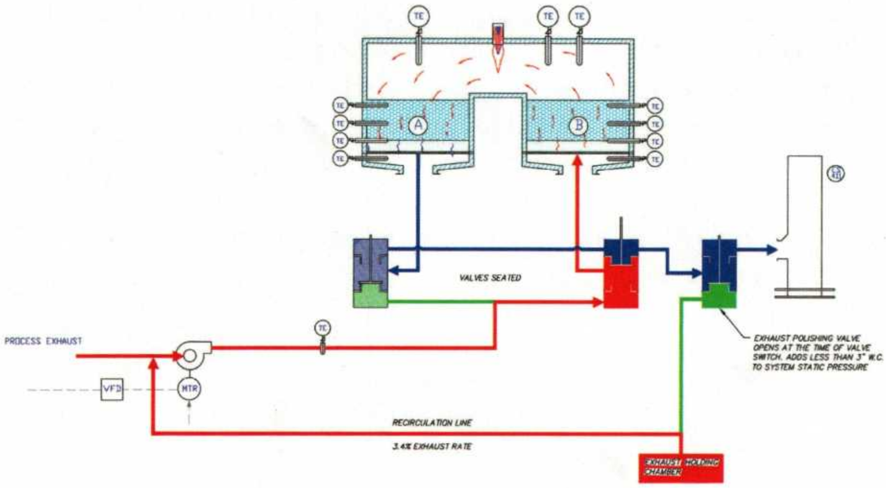
- Consistent 99.5 percent VOC removal efficiency

**Figure 3**

**TRITON II Series regenerative thermal oxidizer**

## Figure 4

**VOC polishing**




## Figure 5

**TRITON Series regenerative thermal oxidizer**

- Natural gas injection eliminates $NO_x$ emissions and lowered operating cost by 15 percent.
- A natural gas savings of $12,000 per year.
- Reduction of the plant's GHG emissions by more than 100 tons per year.
- A 15-month payback
- Factory assembly offers a low cost, drop in place installation (see Figure 4).

## Conclusion

Environmental pollutions and emissions-control solutions exist for many challenges faced by the pharmaceutical industry. By determining the problem and working with the right manufacturer for your pollution control needs, new regulations can be met while simultaneously lowering your operating costs.

APC

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