JOHN ZINK HAMWORTHY COMBUSTION®

CARBON ADSORPTION VAPOR RECOVERY SYSTEMS

Vapor Control Like No Other

Whether you need to reduce emissions through the recovery of valuable product or the destruction of waste gas, John Zink Hamworthy Combustion's vapor control solutions simplify the process to make your operations cleaner and more efficient. We have more than 2,000 vapor combustion and vapor recovery installations worldwide. Our vapor control technologies are recognized as the "Best Demonstrated Technology" and the "Maximum Achievable Control Technology" by the U.S. Environmental Protection Agency. And our engineering and process expertise is recognized as leading the industry.

The Most Advanced Vapor Recovery Technology In The World, Customized To Meet Your Needs

Our Carbon Adsorption Vapor Recovery Units (VRUs) safely prevent harmful volatile organic compounds (VOCs) from being released into the atmosphere during operations that involve the transfer of evaporative hydrocarbons. Because our VRUs are highly adaptable for a variety of applications, our engineers can customize an emission control solution that optimizes your specific system. Our VRU systems are available with Adsorption-Absorption (ADAB™) and Adsorption-Condensation (ADCON™) configurations, as well as varying vacuum technologies to best suit specific facility needs.

Our VRUs are designed to meet worldwide standards such as ASME, ANSI, DIN, ATEX, EN, NEC, IEC and CENELEC.

- Marine terminals
- Process vents
- Railcar loading facilities
- Storage tank vents
- Truck loading racks

VAPOR RECOVERY ADVANTAGES

Vapor recovery has many advantages when compared with vapor control technologies. For example, vapor recovery:

- Can be installed in a hazardous area
- Requires no flame to serve as an ignition source
- Delivers a positive rate of return on investment (due to the value of the recovered product)
- Requires no vapor conditioning in marine loading
- Produces no trade-off pollutants
- Has no supplemental fuel requirements

John Zink Hamworthy Combustion vapor recovery solutions have earned worldwide acceptance as the standard for evaporative hydrocarbon vapor control, offering:

- Near ambient pressure and temperature operation, no vapor holder, no refrigeration
- Proven reliability
- Easy operation and maintenance
- The highest emission control efficiency
- Low capital and operating costs
- Minimal utility requirements (only electricity)
- Worldwide service and support with emergency call-out available 24/7

Our VRUs are configured in modular packages for greater flexibility.

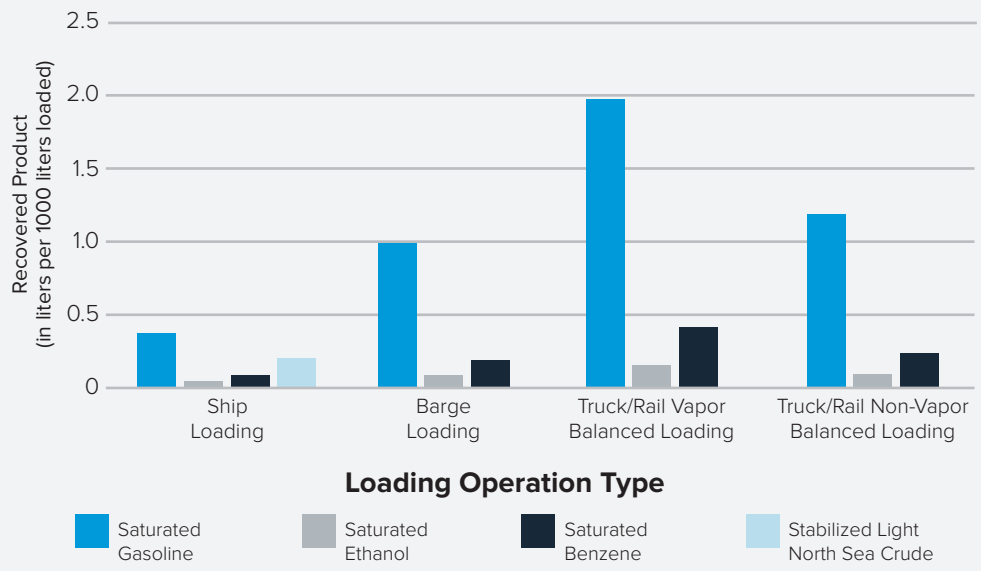
Chemicals Suitable For Vapor Recovery

Our vapor recovery technology can be applied to a variety of applications involving a wide variety of chemicals.

Some of these chemicals are:

- Benzene
- Butane
- Carbon Tetrachloride
- Chlorobenzene
- Chloroethane
- Chloroform
- Crude Oil
- Cyclohexane
- Dichloroethane
- Diesel Fuels
- Distillate Fuels
- Ethanol
- Ethyl Tert-Butyl Ether
- Ethylbenzene
- Gasoline
- Hexane
- Hexene
- Isobutane
- Jet Fuels
- Methanol
- Methyl Tert-Butyl Ether
- Methylene Chloride
- Naphtha
- Pentane
- Pentene
- Perchloroethylene
- Propane
- Toluene
- Trichloroethane
- Trichloroethylene
- Xylene

RECOVERED PRODUCTS FOR VARIOUS LOADING OPERATIONS



Proven To Meet The Most Stringent Standards

In typical installations such as truck, rail, tank and marine loading, our VRUs achieve emission control efficiencies of 99% or better. Most systems are designed to meet 1 – 10 milligrams of VOC released per liter of product loaded, or 1 – 10 grams per cubic meter of vapor vented. We have designed VRUs that meet stricter emissions standards including the TA Luft I standard of 150 milligrams of VOC released per normal cubic meter of vapor vented. We can also offer customized engineering evaluations and solutions to meet the TA Luft II standard.

Carbon Adsorption-Absorption Process with Dry Vacuum Pump

Our ADAB vapor recovery design is suitable for a wide variety of applications. It is most commonly used to control hydrocarbon vapor emissions at terminals handling petroleum fuel products. Our VRUs combine physical adsorption with absorption to recover hydrocarbon vapors and return the recovered product to storage.

Dry vacuum pump (DVP) technology offers significant advantages over other vacuum technologies:

- Reduced power consumption
- Elimination of ethylene glycol and associated equipment from system
- Decreased maintenance costs
- No product contamination
- Greater flexibility with products that can be loaded into the VRU

1

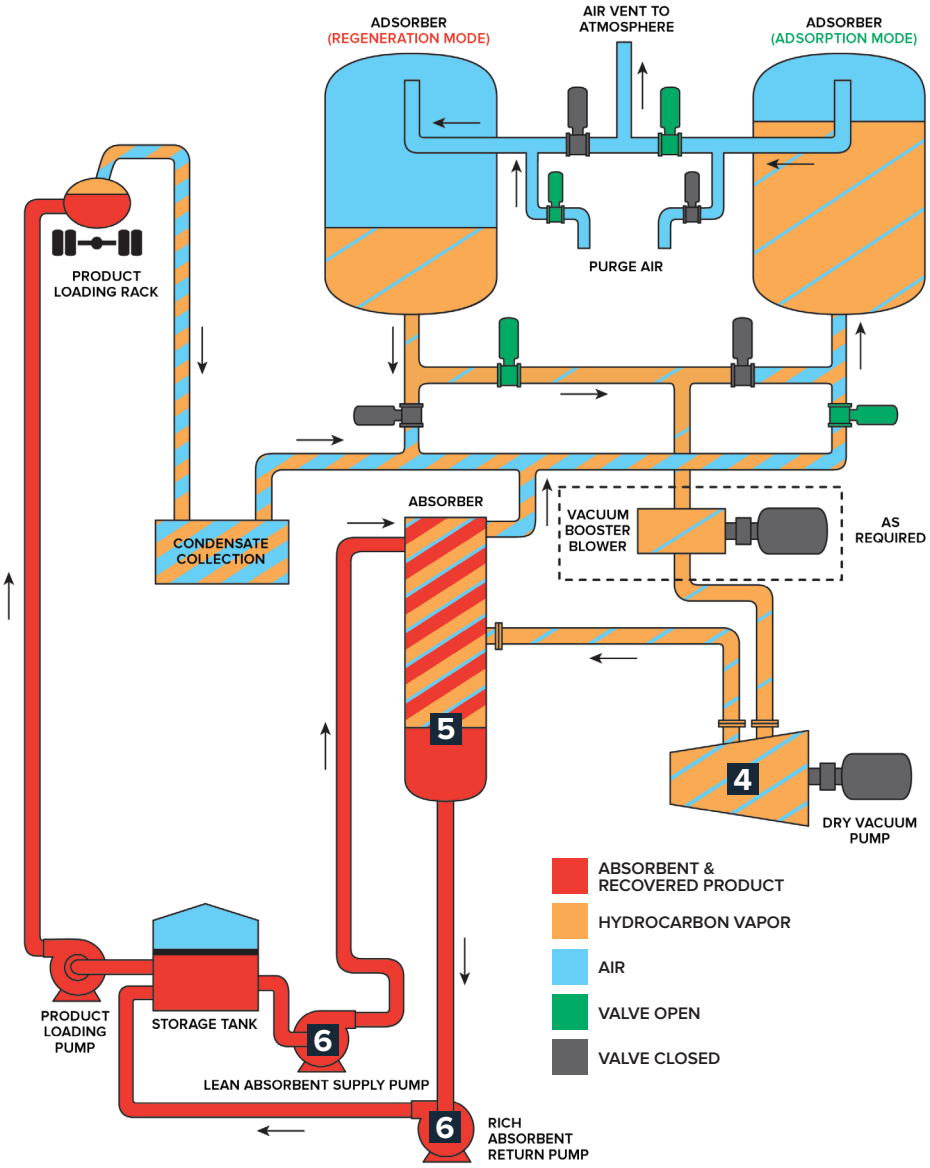
The VRU is equipped with two identical adsorber vessels filled with activated carbon. One adsorber is on stream receiving vapors in the adsorption mode while the other adsorber is off stream in the regeneration mode. Switching valves are provided to automatically alternate the adsorbers between adsorption and regeneration, which assures uninterrupted vapor processing capability. The VRU will automatically start when a loading operation is ongoing and shutdown in a standby mode when the operation is complete.

2

During adsorption, the inlet hydrocarbon vapor-air mixture to be processed flows up through the on stream adsorber vessel. In the adsorber, the activated carbon adsorbs the hydrocarbon vapor and allows clean air to vent from the bed with only minimal hydrocarbon content.

3

During regeneration, previously adsorbed hydrocarbon vapor is removed from the carbon and the carbon's ability to adsorb vapor is restored. Carbon bed regeneration is accomplished with a combination of high levels of vacuum and purge air stripping. At the end of the regeneration cycle, the adsorber vessel is re-pressurized and then is placed back on stream.



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A dry vacuum pump (DVP) is the source of vacuum for carbon regeneration. The DVP extracts concentrated hydrocarbon vapor from the carbon bed, and discharges directly into the recovery device, a vertically packed absorption column. To limit the vapor temperature inside the DVP, absorbent is circulated through the outside jacket and is injected directly into the vacuum pump.

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In the absorber vessel, the hydrocarbon vapor from the DVP flows up through packing, while a hydrocarbon liquid flows down through packing. Inside the absorber, the vapor is liquefied, and the recovered hydrocarbon is returned back to the absorbent storage tank. A small stream of air and residual vapor exits the top of the absorber and is recycled to the on stream carbon bed for re-adsorption.

6

A lean absorbent supply pump and a rich absorbent return 6 pump are provided to circulate the required absorbent.

Carbon Adsorption — Absorption Process With Liquid Ring Pump

Liquid ring VRU systems operate along the same principles as dry systems, but with a liquid ring vacuum pump (LRVP) to regenerate the carbon beds. LRVPs have a proven history of successful operation and are available in a variety of configurations that can be tailored to fit your specific needs. In addition, we offer a specially formulated vacuum pump seal fluid — Z-SEAL™ — for use in this service.

1

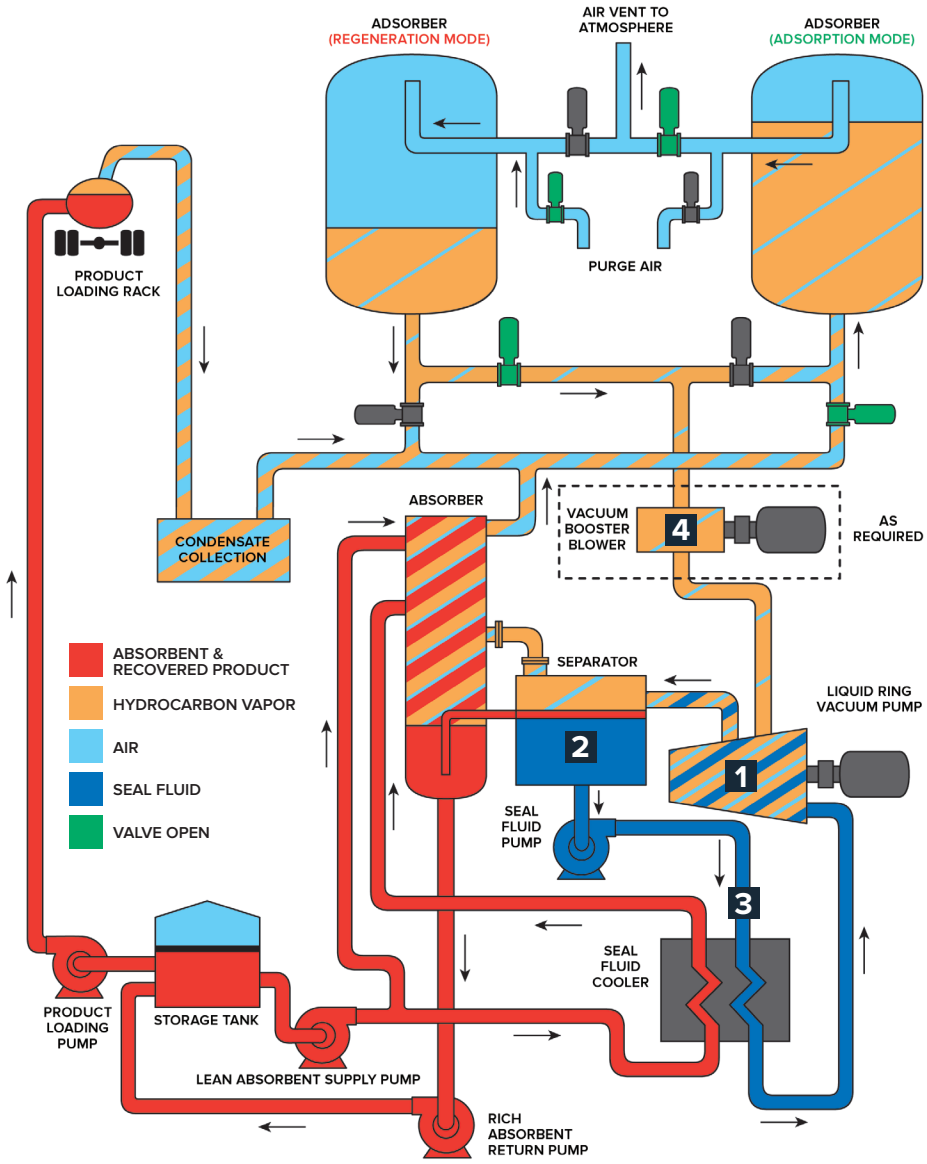
The LRVP strips the rich hydrocarbon vapor stream from the adsorber and discharges it into a three-phase separator. Each LRVP requires a specially blended ethylene glycol-based sealing fluid to operate.

2

The separator is provided to allow efficient separation between the vacuum pump's seal fluid, hydrocarbon condensate, and the non-condensed hydrocarbon vapor. The non-condensed hydrocarbon vapor is discharged from the separator vessel and recovered by means of a packed-bed absorber column in the same manner as previously described.

3

The seal fluid is pumped from the separator through aseal fluid cooler to remove the heat of compression.



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The ADAB VRU based upon either dry vacuum pump or liquid ring vacuum pump technology may be provided with a high efficiency (HE-ADAB) vacuum system. The enhanced vacuum system consists of a rotary-lobed vacuum booster blower operating in series with the vacuum pump. The addition of the booster blower allows the carbon beds to be regenerated under a higher vacuum (lower absolute pressure) and provides significantly higher pumping capacity at high vacuums than is possible through the use of only the vacuum pump. An enhanced vacuum system more thoroughly regenerates the activated carbon and can, as a result, provide several potential benefits including use of less carbon, the achievement of lower emission levels, reduced system power requirement, and less overall capital cost.

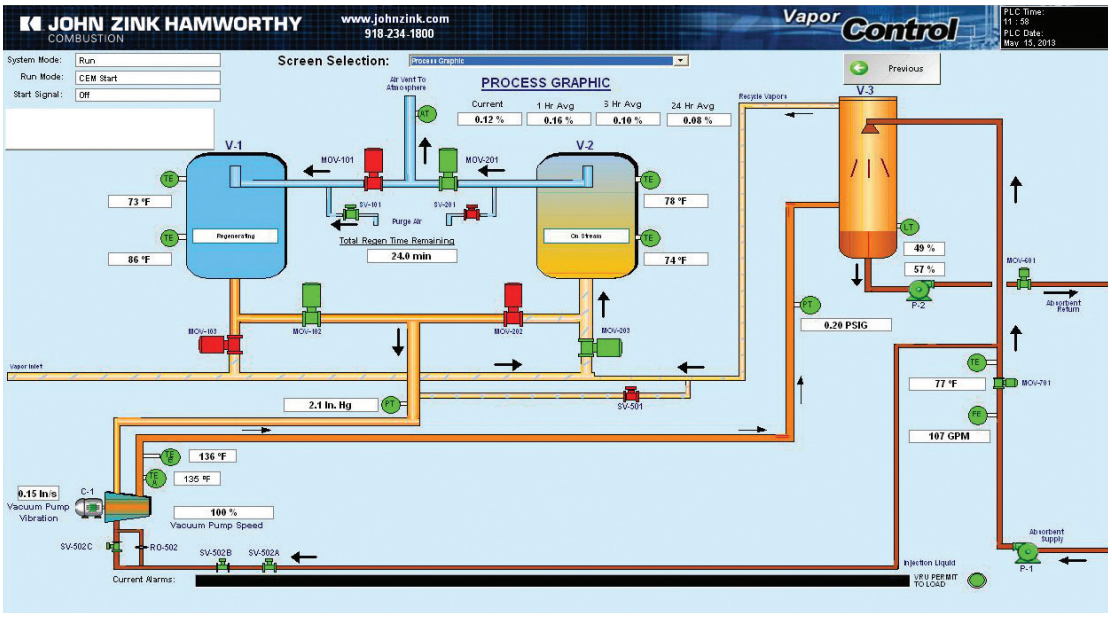
Continuous Emission Monitoring System

Our optional Continuous Emission Monitoring System (CEMS) includes an analyzer to measure hydrocarbon content in the VRU vent stream. The CEMS performs emission data averaging and can achieve VRU energy savings when utilizing the CEM Start mode of operation. The carbon beds are left on stream until their effective adsorption capacities have been expended before regeneration occurs. Typical energy savings using this mode of operation have averaged about 50%.

Our Continuous Emissions Monitoring System typically yields around 50% in energy savings in the CEM Start mode of operation.

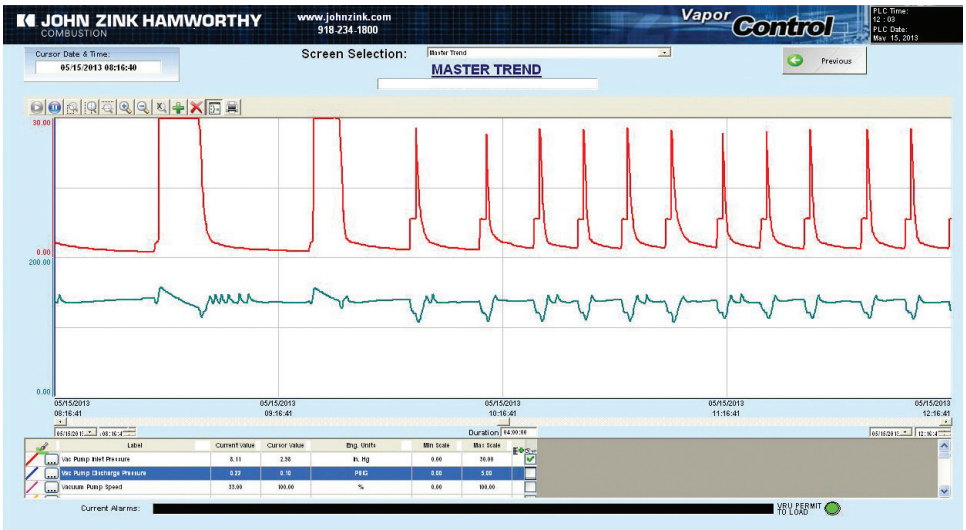
VaporWatch™

With VaporWatch™, engineers and maintenance personnel can securely access real-time online operating data directly from their computer, anywhere around the world. This remote access capability ultimately results in more efficient equipment operation, reduced downtime for loading terminal operations, and lower operating and maintenance costs.



With VaporWatch, you can monitor key system parameters and view real-time and historical data to identify trends.

This enhanced maintenance package records system data including pressures, temperatures, flows, and other vapor control parameters, and can be configured to output useful reports on system performance. Technicians can reference these reports to help diagnose and eliminate operational difficulties, predict equipment failures, and service equipment.



Equipment Rental

To keep you up and running during installation, retrofitting or maintenance, we offer equipment rental including the PECS® (Portable Emission Control System), a self-contained, trailer-mounted vapor combustor that ensures stable, smokeless combustion and maintains temperature control over a wide range of vapor combustion.

Bundle a PECS rental with other John Zink services such as installation, start-up, on-site operator assistance and training, or dismantling to save both time and money.

We Back You Up Like No Other

The John Zink Hamworthy Combustion worldwide service organization is the largest, most technically savvy team of its kind. Our service technicians are trained in the latest technologies to evaluate existing systems for upgrades and retrofits, to troubleshoot operations, and to help plan your next turnaround. Our experts are available on emergency call-out 24 hours a day, 7 days a week. We also provide additional support by offering world-class education through comprehensive vapor control courses held at the John Zink InstituteSM. These courses help vapor control operators and engineers optimize their equipment and address issues at their facilities.

Koch Engineered Solutions (KES) is a global solutions provider that encompasses products, services, and expertise across a wide range of industries. KES companies design, manufacture and install process, pollution control, and sustainability solutions for industries and cities around the world. More information is available at KochEngineeredSolutions.com.

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