Vapor Recovery Developments in Emission Standards and Applications

Simon Shipley
2nd June 2015
Zeeco Company Profile

- Privately held by a family who has been involved in Process Engineering and Combustion Technology for over 80 years.
- Headquarters in Broken Arrow, near Tulsa, Oklahoma
- More than 20 Worldwide locations.

Process Burners / Burners Power Industry / Duct Burners
BMS Management and Control Systems
Flares and Flare Systems
Thermal Oxidation / Incineration
Vapor Recovery Systems
Vapor Combustion Systems
Flare Gas Recovery Systems
Mechanical Vapor Recovery
Land Fill Combustion Systems

A Global Presence
Environmental Control

Environment Legislation:
reduction of hydrocarbon emissions to the atmosphere, improving air quality and operational safety.

Nearly Always the Key Driver

Economics:
recovery of valuable petroleum products that would otherwise be lost to atmosphere.

Rarely a driver for the implementation of control measures.
- **Vapor – Volatile Organic Compound (VOC).**
  - Vapor generated through evaporation / hydrocarbon saturation of the air / inert gas above a hydrocarbon liquid.
  - Gasoline / Crude Oil / Naphtha / Condensate / Benzene / Xylenes

- **Vapors recovered from:**
  - Road Truck Loading - (Vapor Displaced from the Truck / Rail Car / Vessel during filling).
  - Rail Car Loading.
  - Ship / Barge Loading.
  - Tank Venting. Vapours displaced through filling and or thermal growth / evaporative effects in the tank.
Historical Growth

- Truck Loading Applications in the US: 1970 / 80s
  - Vapour Recovery Systems and Vapour Combustion Systems

- Legislation introduced into Europe in the 1990s
  - Covering Gasoline Loading Operations.
    - EU Directive 94/EU/63

- Other Countries Followed: Far East / Middle East / Russia

- Environmental legislation driver for other emission controls legislation.
  - Advancing The Legislation in Terms of Applications and Emissions Requirements.

<table>
<thead>
<tr>
<th>Geo-Area</th>
<th>Market Saturation</th>
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<tbody>
<tr>
<td>US / Nth America</td>
<td>100%</td>
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<td>Europe</td>
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<td>Russia CIS</td>
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<td>Middle East</td>
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Types Of Vapour Control Technologies

- Activated Carbon Adsorption Vapor Recovery – BAT
- Cold Liquid Absorption Vapor Recovery
- Membrane Vapor Recovery
- Pressurised Absorption Vapor Recovery
- Vapour Combustion Vapor Control Measures
## PROCESS SELECTION

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- **VAPOUR INLET**
- **Absorbent In from storage tanks**
- **Absorbent Recycle**
- **Absorber**
- **Vacuum Pump**
- **Carbon Beds**
- **Clean Air Vent**

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**ZCA - Activated Carbon Vapour Recovery**

Best Available Technology (BAT)

- Simple Reliable Process
- Wide Turn Down Capability: 0 to 100% of Design (Flow and Inlet HC Concentration)
- Wide Range of Products.
- Wide Range of Applications: Truck Loading Through to Ship Loading.
- Good Wide Range of Emissions Capabilities.
- Relatively Low Power Requirements.
- Good Overall Operating Efficiency – i.e. Recovered Product / kW
- Low Maintenance Requirements
- Familiar Construction
Activated Carbon Vapour Recovery Process

- VAPOUR INLET
- Absorbent In
- Absorbent Rtn
- Absorber
- Vacuum Pump
- Carbon Beds
- Absorber Recycle
- Clean Air Vent
- Absorbent supply from storage tanks
- Absorbent Rtn
- Vacuum Pump
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### Cold Liquid Absorption

- **Vent**
- **VAPOUR INLET**
- **Absorber**
- **Stripper**
- **Cooling**
- **Heat**
- **Post Absorber**

**Lean Absorbent In**

**Rich Absorbent Rtn**
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**Diagram:**

- Scrubber
- Absorbent
- Inlet Vapour Compressor
- Vapour Inlet
- Absorbent Rtn
- Vacuum Pump
- Membrane
- Clean Air Vent
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**Pressurised Lean Oil Absorption (PLA)**

- **Vent**
- **Lean Absorbent**
- **Rich Absorbent**
- **VAPOUR INLET**

Date Month 2012 Slide 13
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Development

- Products Loaded
- Vacuum Pump Technology Developments
- Tightening of Emission Requirements
- Widening Range of Applications
- Increase in the Loading Rates – Size of VRUs
Development

- Products Loaded
- Vacuum Pump Technology developments
- Tightening of Emission Requirements
- Widening Range of Applications
- Increase in the Loading Rates – Size of VRU’s
Products

- Gasoline [Truck / Ship / Rail Car]
- Crude Oil [Ship / Rail Car]
  - Variable Compositions / Physical Properties
  - H₂S Concentrations
- Aromatics – Benzene / Xylenes [Truck / Ship]
- Naphthas / Condensates [Ship / Tanks]
- Ethanol / Methanol [Truck / Tanks / Ship]
Development

- Products Loaded
- Vacuum Pump Technology developments
- Tightening of Emission Requirements
- Widening Range of Applications
- Increase in the Loading Rates – Size of VRU’s
Rotary Vane Vacuum Pump

Screw Vacuum Pump

Liquid Ring Vacuum Pump
Development

- Products Loaded
- Vacuum Pump Technology developments
- Tightening of Emission Requirements
- Widening Range of Applications
- Increase in the Loading Rates – Size of VRU’s
# Emission Regulations

<table>
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<th>Region</th>
<th>Emission Limit</th>
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<tbody>
<tr>
<td>EU (gasoline)</td>
<td>35 g/Nm³ (Vented)</td>
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<tr>
<td>USA</td>
<td>35 g/Nm³ (Loaded)</td>
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<tr>
<td>India</td>
<td>5 g/Nm³</td>
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<tr>
<td>Denmark</td>
<td>150 mg/Nm³</td>
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<tr>
<td>Germany / NL</td>
<td>50 mg/Nm³</td>
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<tr>
<td>Oman</td>
<td>35mg/Nm³</td>
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<td>Middle East</td>
<td>Typically 95% Recovery Efficiency although depends on the individual application.</td>
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- Recovery Rates: 1 to 2 ltrs per 1000 ltrs loaded
  - 10 g/Nm³ – A common standard adopted by designers and operators
  - Aromatics (Benzene / p-xylene) – 1 mg/Nm³ to 10 mg/Nm³;
  - Crude Oil Vapours: Typically 78% to 95% m Recovery Efficiency Dependent on Crude Oil.
Extreme Emission Requirements $<100\text{mg/Nm}^3$

Zeeco Activated Carbon Adsorption/Absorption (ZVA)

Safe Area Location

VAPOUR INLET

Absorbent In

Absorber Recycle

Absorber

Vacuum Pump

Carbon Beds

Air Inlet Concentration Control

CTO / RTO

Electrical Power Or Natural Gas

VENT

Absorbent Rtn

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Development

- Products Loaded
- Vacuum Pump Technology developments
- Tightening of Emission Requirements
- Widening Range of Applications
- Increase in the Loading Rates – Size of VRU’s
➢ Vapour Recovery Applications

- Vapours Recovered Directly from Truck and/or Railcar Loading

- Vapour Balancing

- Tank Filling

- Tank Breathing
VRU-Applications – Maritime & Crude Oil

- Gasoline
- Crude Oil Loading
- Naphtha & Condensates
- Chemicals - BTX
- On-Shore (Quay Side)
- Off Shore
  - Shuttle Tanker
  - FPSOs
Ship Loading Applications

- Continuous Loading Operations
- Large Flow Rates
  - 2000m³/hr to 67,000m³/hr
- Power Requirements: 500kW up to 5MW (Potentially Higher)
- Wide Range of Products
- Complex Loading Dynamics
Truck Loading Applications

- Mature Product Development
- Non-Continuous Loading Operation
- Small to Medium Sized Systems
- Power Requirements; Typically 50 to 120kW
- Typical Loading Capacities: 500 to 980m$^3$/hr : 10,000m$^3$/day
- Emissions from 35g/Nm$^3$ to 35mg/Nm$^3$
- Positive Return on Investment
Tank Venting

- Continuous Duty Application
- Tanks Vents or Balanced Vapour Systems Combined with Either Truck Loading or Ship Loading.
- Vapour Concentrations: Generally Should Be Considered as Saturated.
- Emissions from:
  - Tank Filling
  - Thermal Growth
  - Draw Out Emissions
Carbon Vacuum Pressurised Condensation

Activated Carbon Adsorption/Pressurised Condensation (CVPC)

VAPOUR INLET

Vent

Carbon Beds

Condensor

Compressor

Vacuum Pump

Recovered product Vessel. 6 – 7 barg

Recovered Product

© ZEECO, INC.
Development

- Products Loaded
- Vacuum Pump Technology developments
- Tightening of Emission Requirements
- Widening Range of Applications
- Increase in the Loading Rates – Size of VRUs
Loading Rates

- **Truck Loading**: Relatively Low Loading Volumes
  - Typically 100m³/hr up to 980m³/hr (32,000 to 260,000usgph)

- **Ship Loading**:
  - **Low end**: 800 to 1000m³/hr (5000 – 6300bph)
  - **Mid Range**: 2000 to 10,000m³/hr (12,600 – 63,000bph)
  - **High Mid Range**: 15000 to 25,000m³/hr (94,300 – 157,250bhp)
  - **High End**: 36,000m³/hr – 45,000m³/hr (226,500 – 283,000bph)
    - **50,000m³/hr to 65,000m³/hr**: (314,500 – 408,800bph)
      - Vapour Flows: 80,000m³/hr (352,000gpm)
OPEX / ROI

- The through-put of the terminal
- The gasoline / diesel split
- Vapour pressure of the product
- The efficiency of the VRU
  - How well is it maintained
  - Are energy saving operations incorporated into the design
  - Utility prices, i.e. electrical power
- The value of the product itself (can vary significantly)
- Where is the product taxed
  - (At the refinery or at the loading racks?)
- Whether Stage II recovery has been implemented
Typical Product Recovery Rates

- Empirical data based on over 200 VRU’s in operation:
  - Recovered product qty between 1 and 1.5 ltrs/1000 ltrs loaded
  - These figures are based on average hydrocarbon concentrations in vapour, typically varying from 25 to 40%.

- At a 5,000,000 ltr/day terminal:
  - Product recovered : 5,450 ltrs to 10,000 ltrs
  - Value of recovered product: EUR 2,500 to 4,600/day

- Medium sized terminal – 1,500,000 m³/yr throughput.
- Typical VRU purchase price : Euro 500,000
- Typical installation cost : Euro 1,000,000
-   - Typically 2 – 3 times the cost of the VRU
- Total est. installation cost : Euro 1,500,000
- Annual electrical costs : Euro 10,500
-   - Based on electrical cost of Euro 0.065/kWh
- Annual maintenance costs : Euro 8,300
-   - Assumes reasonable spares & utility usage
- Typical annual operating cost : Euro 18,800

![Return on Investment](chart.png)
Vapor Combustors

- Primary Customers
  - Loading Terminals
  - Tank Batteries
- Often used in place of VRU or as backup to VRU
Portable Vapour Combustors
Aftermarket and Service
Aftermarket and Service: Service Capabilities

We can provide our own Field Service Engineers who are fully trained on all of Zeeco’s equipment.

Our engineers are trained in:
• Health and Safety of the operation of combustion equipment.
• Supervision of installation and erections.
• Pre-commissioning activities.
• Commissioning activities.
• Start-up of equipment.
• Pre-inspection of equipment for retrofitting.

Zeeco engineers are also offshore trained
THANK YOU!!
Please visit www.zeeco.com