Vapor Recovery Unit (VRU)

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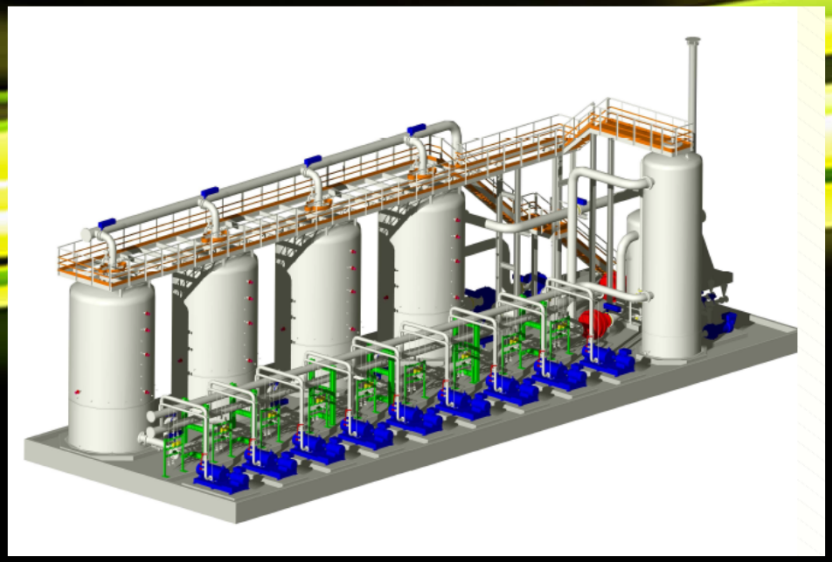

March , 2017

What is VRU?

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Recovery of vapors
(mainly volatile hydrocarbons) in form of liquid, during loading/unloading process to/from road, rail or marine tankers

Why VRU?!

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The cost of:

- ✓ **Safety in the terminal**
- ✓ **Environmental impacts of hydrocarbon and chemical components, on both human health and pollution of troposphere**
- ✓ **Venting of unrecovered product during loading/unloading processes (Simply, money!)**

HC Emission Norms

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US EPA: 35 mg of HC vapor emitted per liter of liquid loaded

European norms (European Directive EC94/63): 35 mg of HC vapor emitted per liter of vapor at VRU outlet

Some European Countries (like France and Russia): 10 mg of HC vapor emitted per liter of vapor at VRU outlet

Germany (TA-Luft 01), Switzerland (LRV) and Netherlands (NER): 0.15 mg of HC vapor emitted per liter of vapor at VRU outlet

Sultanate of Oman: 0.035 mg of HC vapor emitted per liter of vapor at VRU outlet

Various Technologies

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- Carbon Adsorption
- Lean Oil Absorption
- Refrigeration
- Membranes

Why Carbon Adsorption?

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- ✓ Well-proven in practice
- ✓ Relatively easy to operate and maintain
- ✓ The only required utility is electricity
- ✓ Relatively low energy consumption
- ✓ Low vapor concentration at VRU outlet with a single stage unit
- ✓ Near ambient pressure and temperature, no vapor holder, no refrigeration

Carbon Adsorption

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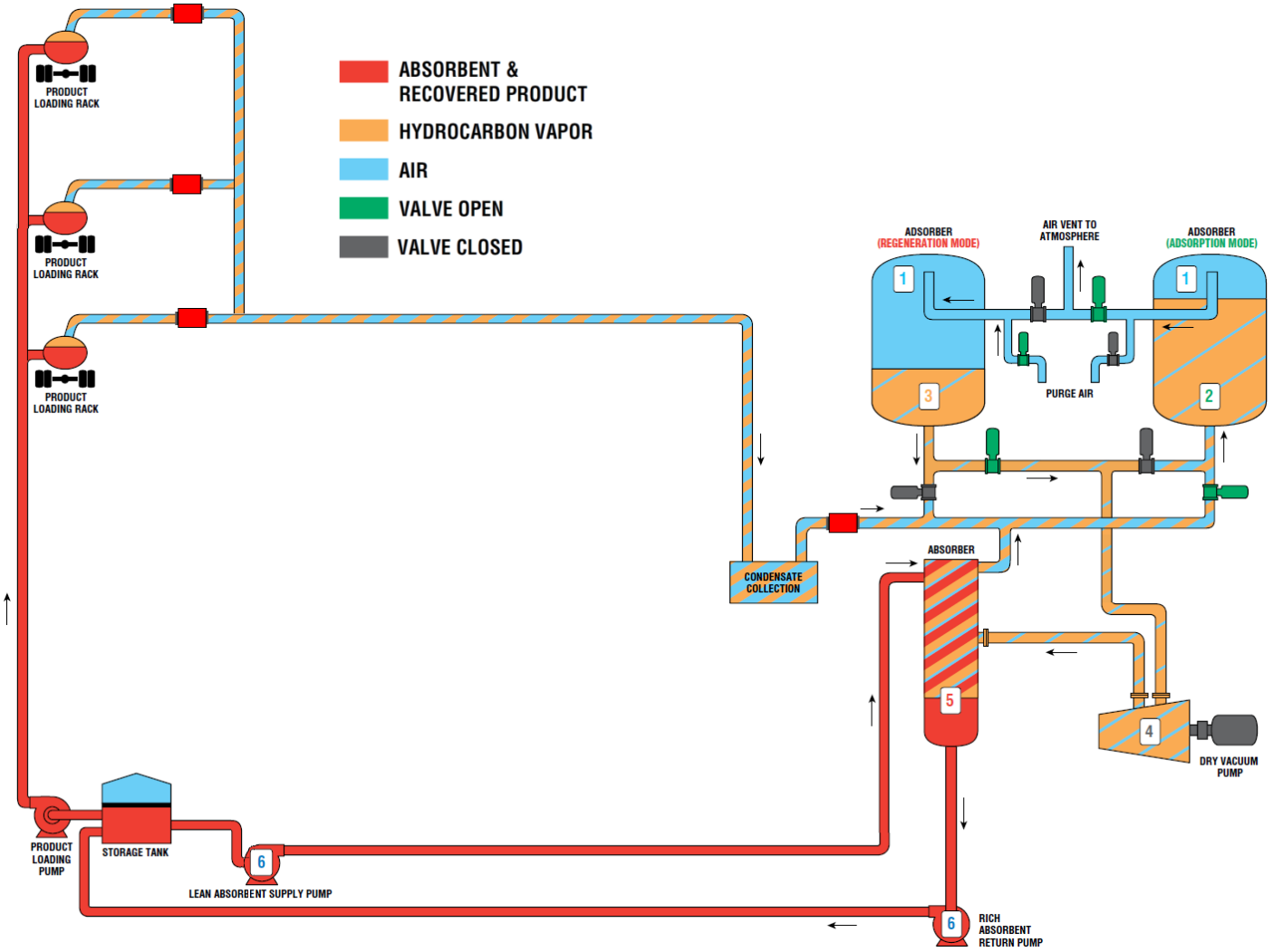
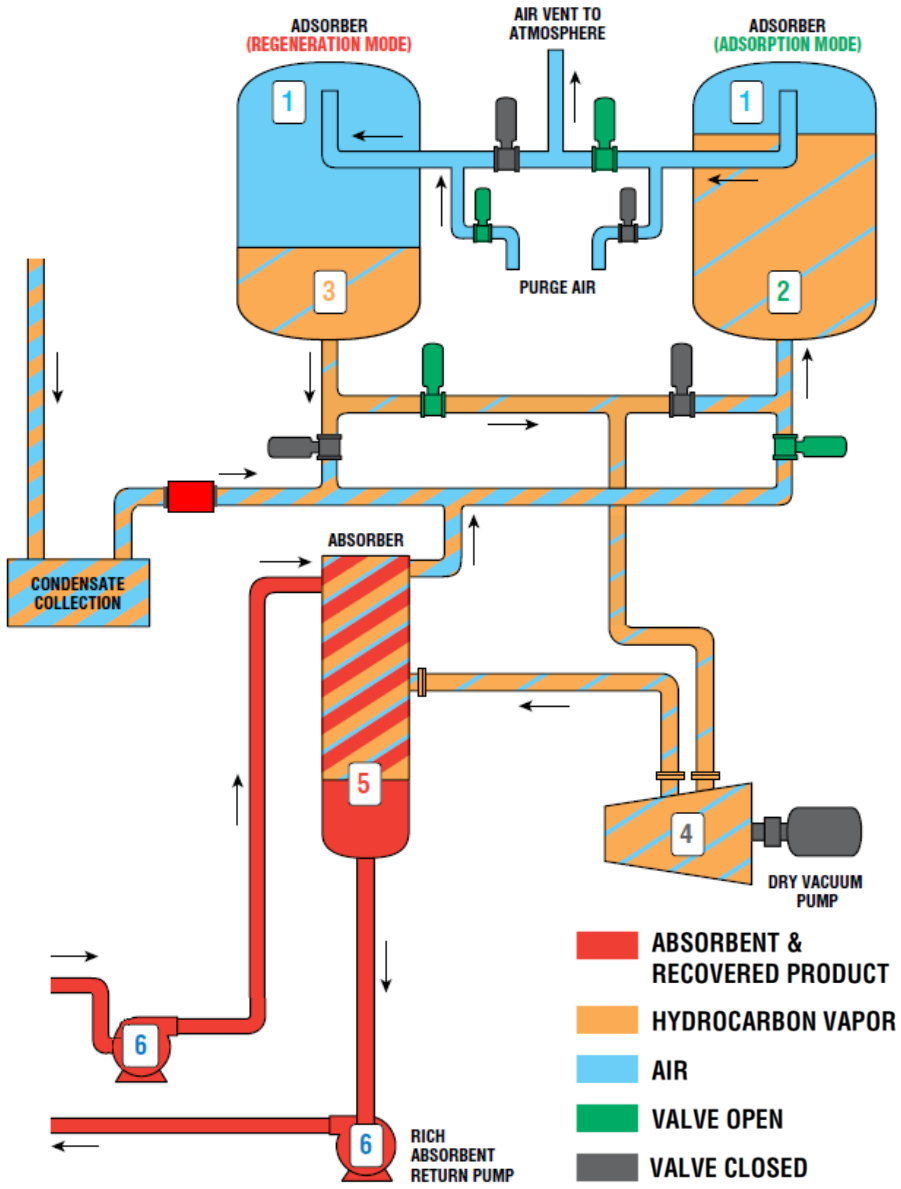


Carbon Adsorption



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Principals

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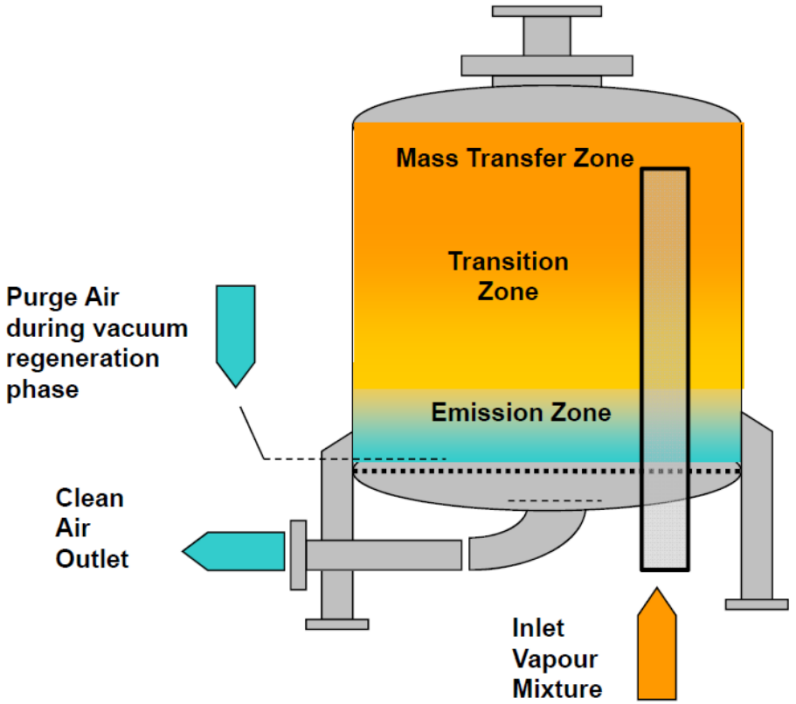
- ✓ The mass transfer zone removes the bulk of the HCs
- ✓ The transition zone provides a buffer for variations in flow rate and concentration
- ✓ The emission level depends on level of vacuum:
  - 100 mbar for 1000-5000 mg/m^3
  - 30 mbar for 50-100 mg/m^3



Dry Vacuum Pump (DVP)

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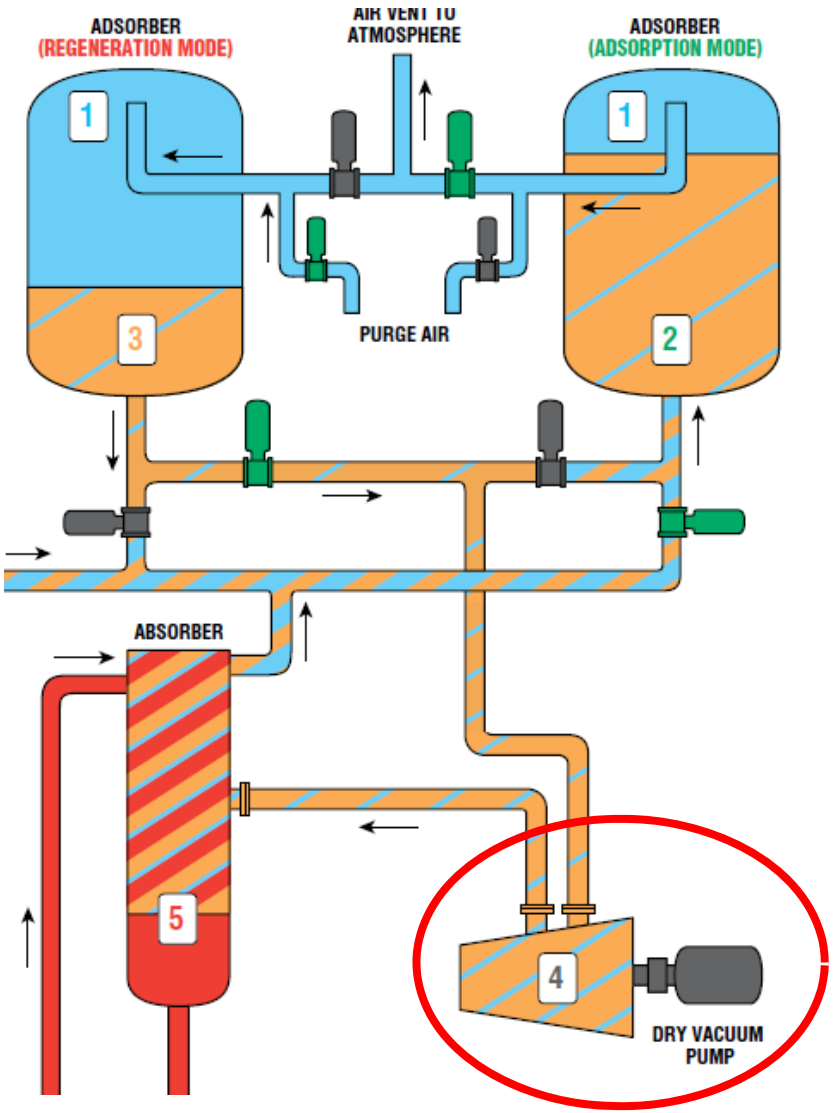
- ✓ Small size compared to LRVPs
- ✓ Less complexity
- ✓ Reduced power consumption (up to 40%), due to use of VFD
- ✓ No ethylene glycol and associated equipment, no chance of corrosion and abrasion
- ✓ Less maintenance requirements (no need to change glycol)



Dry Vacuum Pump (DVP)

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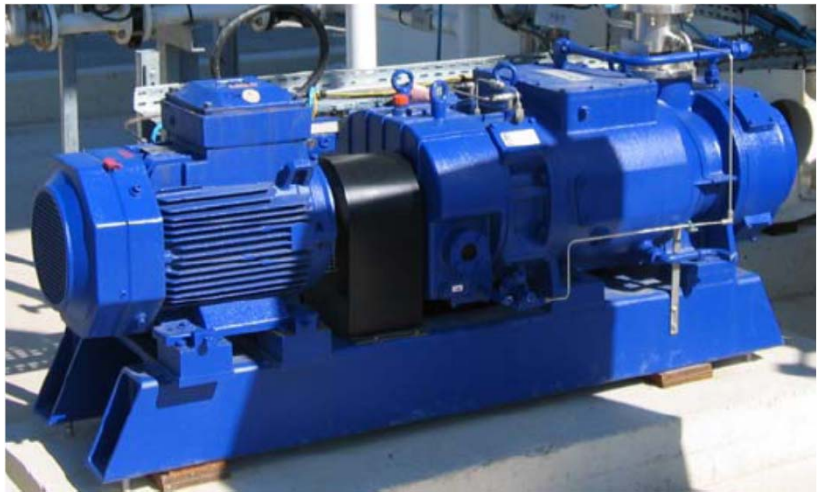
- ✓ No product contamination
- ✓ No internal touching (metal) parts, no wear
- ✓ Can handle liquid slugs
- ✓ Overhaul required after 40,000 hours of operation, comes with 3 years guarantee and after sales services
- ✓ Proven technology since 1999



Energy Consumption

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Based on 1200 g/m^3 HC in the vapor inlet to the VRU:

Emission (g/m^3)	35 EU / US	20	10	1 (Optimum)	0.15
Energy Required (kWh/m^3)	0.08	0.09	0.09	0.1	0.2
g/m^3 recovered	1179	1188	1194	1199.4	1199.92

Activated Carbon

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Wood based:

- 1200~1800 m^2/g of surface
- Low density
- Even distribution of micro, meso and macro pores
- Activated by phosphoric acid
- More sensitive to hot spot formation

CECA ACX:

- Reactivity is tempered by a special resin, which gives the carbon a hygroscopic property and reduces the heat of adsorption
- Expected life is more than 15 years in combination with DVS

Activated Carbon

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Coal based:

- 1200~1800 m^2/g of surface
- Many more mini pores
- More sensitive to aging (formation of oily heel)
- Less sensitive to hot spot formation

VS50:

- Mini pores are super-activated
- Expected life is more than 15 years in combination with DVS

Safety Features

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- ✓ All valves in the system are automatic and pneumatically operated. This will eliminate system failures due to malfunctioning of the electrically operated sequential valves and limit switches.
- ✓ All the sequential valves are of double eccentric butterfly type with S.S disk and PTFE seal rings.
- ✓ In case of lack of instrument air in site, a small standard ATLAS COPCO twin piston compressor with air buffer is supplied
- ✓ All instruments within the package are ATEX certified
- ✓ The unit resists the pressure of an eventual internal explosion

Safety Features

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- ✓ Precise monitoring of the explosion prone locations in the unit:
  - Inlet vapor line (flame arrestor equipped with TAHH)
  - Carbon Adsorbers (TAHH)
- ✓ Monitoring of discharge temperature of DVPs
- ✓ Monitoring of operational parameters of DVPs
- ✓ Monitoring of sequential valve positions
- ✓ Independent high and low level switches on the re-absorber
- ✓ Double fail closing valves on each absorbent line
- ✓ Level switch on the condensate drain pot at the inlet to the VRU
- ✓ …

Control and ESD

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- ✓ As soon as the loading is finished and the activated carbon has been properly desorbed, the unit automatically switches to standby mode. All the pumps will be stopped and all the valves are closed.

- ✓ Three levels of shut-down:
  - ESD push button acting on main switch
  - Normal shut-down by main PLC

  - Independent second level shut-down by the second PLC (watch dog)

Control and ESD

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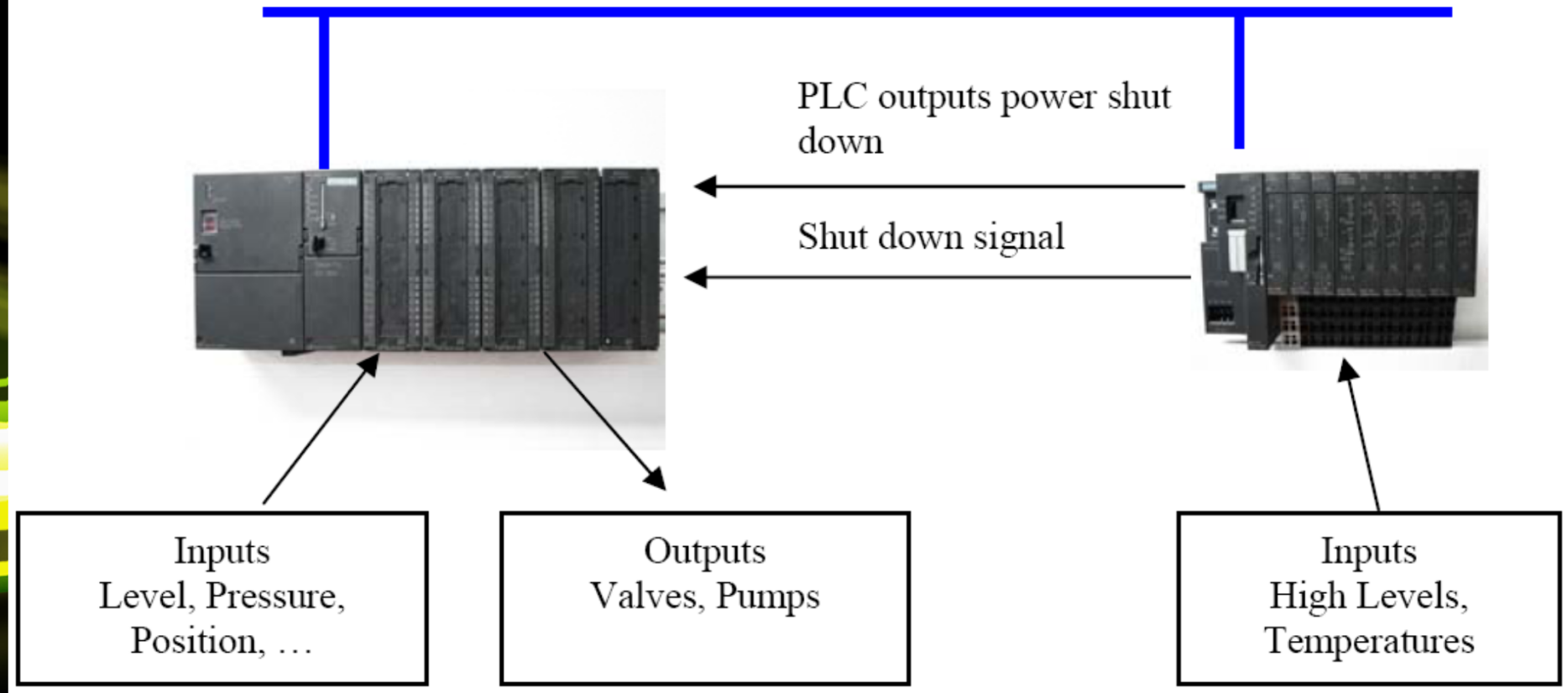

Oman Raysut Revamp

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- **PROJECT:** EPC of Raysut Terminal Revamp
- **CLIENT:** Sultanate of Oman, Ministry of Oil and Gas (MOG)
- **CLIENT REPRESENTATIVE:** Oman Oil Refineries and Petroleum Industries Company (ORPIC)
- **PMC:** Mott MacDonald & Company LLC (MMC)
- **CONTRACTOR:** Rampco International Technical Services (RITS)
- **ENGINEERNG:** Hampa Energy Engineering and Design Company (HEDCO)
- **LOCATION:** Raysut, Salalah, Dhofar, Sultanate of Oman

Oman Raysut Revamp

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Raysut Terminal is an onshore terminal operated by ORPIC. The terminal has Gas Oil, MOGAS and II Jet A-1 storage tanks and a tanker loading area with loading pumps and gantries to supply the products to the Salalah and Dhofar region of South.

Products are delivered to the terminal by means of ship from port of Salalah. Two pipelines deliver products from ship to the terminal and store them inside nine storage tanks.

Oman Raysut Revamp

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Bay No.1	Diesel
Bay No.2	Gasoline
Bay No.3	II Jet A-1 (no vapor arm)
Bay No.4	Gasoline
Bay No.5	Diesel

VRU Design Inputs

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Emission value: 35 mg/m^3 of vented vapor
Gasoline: max. VP 0.7 / 06 (winter / summer)
Design Ambient (Absorbent) Temperature: 40 °C

4 bays in simultaneous operation: 4 x 137 = 548 m^3/h
T-4 max. filling rate: 600 m^3/h

Instantaneous Flow rate (Q_i):	548 + 600	1148	m^3/h
Cycle Throughput (Q_c):	0.25 (4x137 + 600)	287	m^3/h
4 Hour Throughput (Q_{4h}):	4 (4x137 + 600)	4592	m3/h
Daily Throughput (Q_d):	96 x 36.4 + 3880	7375	m^3/h

Electricity: 415 VAC, 3PH, 50Hz
No other utility available

VRU Design Outputs

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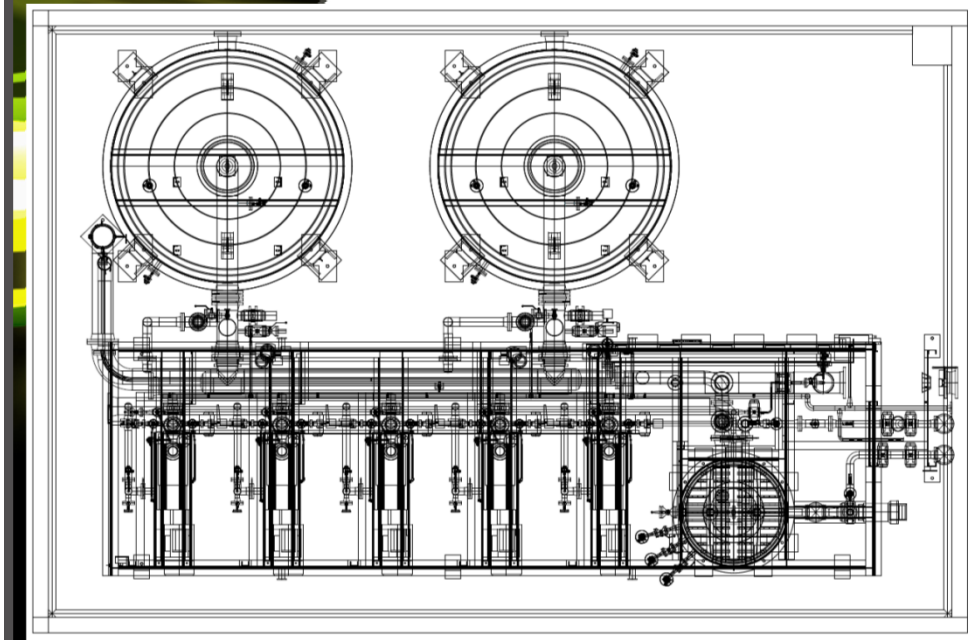
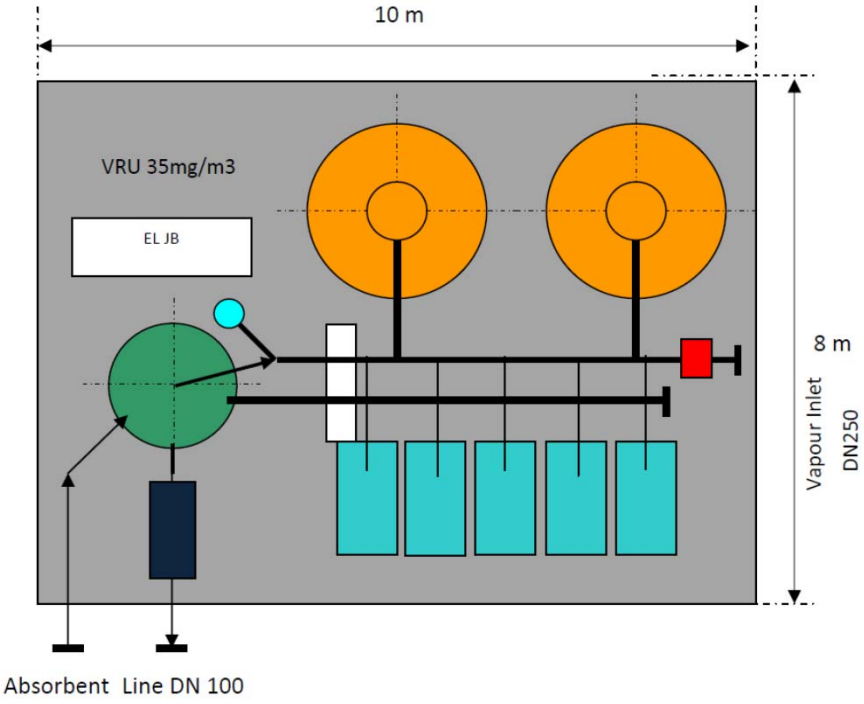
Size of Vapor line to VRU:	10”
Max. absorbent flow rate required:	70 m^3/h
Size of Absorbent lines:	4”
VRU Skid Size:	8 x 10 x 10 (m)
Weight of Skid:	80 tons
Electrical Consumption: (5x30 + 2x15 + 5)	185 kW





VRU Design Outputs

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Size of El. Panels (incl. VFDs): 3 x (1000 x 2000 x 500 (mm)
Size of Control Panel (incl. PLC): 1000 x 2000 x 500 (mm)
Supervision PC: Conventional Desktop Size

Sub-vendors

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ITEM DESCRIPTIONS	VENDOR	COUNTRY
Vacuum Pump	BUSCH	Switzerland
Absorbent Pump	Hermetic	Germany
Absorbent Pump	Hermetic	Germany
Blower	FIMA	Germany
Blower	MIDDLE EAST ENGINEERING LTD. CO. (MEELSA)	KSA
Blower	HITACHI PLANT TECHNOLOGIES LTD TSUCHIURA WORKS	Japan
Detonation Arrestor	ENARDO	USA
Motors	ABB	Finland
Butterfly valves	KSB S.A.S. AMRI DIVISION	France
Angle Globe Valve	DRESSER PRODUITS INDUSTRIELS	France
Thermal Expansion Valve	LESER GMBH AND CO KG	Germany
Pressure Safety Valve	LESER GMBH AND CO KG	Germany
Level Indicator	DANIEL MEASUREMENT AND CONTROL FLOW PRO	
Level Switch	MAGNETROL INTERNATIONAL NV	Belgium
Level Transmitter	DRESSER ITALIA SPA MASONEILAN PLANT	Italy
Temperature Indicator	WIKA ALEXANDER WIEGAND GMBH AND CO	Germany
Temperature Transmitter	WIKA ALEXANDER WIEGAND GMBH AND CO	Germany
RTD	WIKA ALEXANDER WIEGAND GMBH AND CO	Germany
Pressure Switch	WIKA ALEXANDER WIEGAND GMBH AND CO	Germany
Pressure Transmitter	VEGA GRIESHABER KG	Germany
Solenoid Valve	THOMPSON VALVES PART OF NOGREN LIMITED	United Kingdom
IR online concentration measurment	DETCON INCORPORATED	USA
LV Motor	ABB OY ELECTRICAL MACHINES LV MOTORS	Finland
PLC	SIEMENS AG A AND D AS EWK	Germany
Panels	RITTAL GMBH AND CO	Germany

Thank You for
your attention