SMART VOC RECOVERY SYSTEM

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ATMOS'FAIR 2010

LYON (F)

29th SEPTEMBER 2010

Agenda

- *Company presentation*
- *Vent gas cryogenic condensation*
- *Adsorption technology for VOC recovery*
- *Internal Reflux Distillation*
- *The technology value chain*

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COMPANY PROFILE

- **Polaris** is a **private company** established in **1996** by technicians coming from **multinational pharmaceutical and gas processing industries.**

- Since then the Company **core business** has been the **design**, the **construction** and the **turn-key** supply of **plants** for the **chemical** and **pharmaceutical** industry in Italy and abroad, and **effluent treatment plants** for **process industries**

- The close cooperation between Polaris and other connected companies gives to Polaris a **wide operating flexibility** in the utilisation of further human and technical resources, by coupling the promptness of the little company to the managing capability of the bigger one

- Most **units** are fully **prefabricated**, for better construction control and cost reduction

- The Polaris Quality System **complies** with the Norm **UNI EN ISO 9001:2000**, certified by **TUV**

- It is Polaris policy to **pursue innovation** in the processes and technologies. This approach gave, as a return, the development of many new **technologies** also **patented**

- To date Polaris has implemented successfully **more than 200 tailor made plants**, operating in Italy and in many European and extra-European countries

- **Polaris and PRAXAIR** have established an **international partnership for VOC recovery**, which has brought to many applications in Italy and abroad

WHAT WE DO – Main technologies

	PAINTING	PRINTING	COATING	PHARMACEUTICAL	RECYCLE (CFC and HCFC abatement)	CHEMICAL PETROCHEMICAL	GRAVURE
Vent gas Cryogenic Condensation with solidification of VOC compounds (European Patent)	✓		✓	✓	✓	✓	
Internal reflux distillation column (European Patent, US Patent)		✓		✓		✓	✓
VOC adsorption on active carbons with nitrogen dry regeneration (European Patent, US Patent pending)	✓	✓	✓	✓	✓	✓	✓
VOC adsorption on macroporous resins (patent pending)	✓	✓	✓	✓	✓	✓	✓

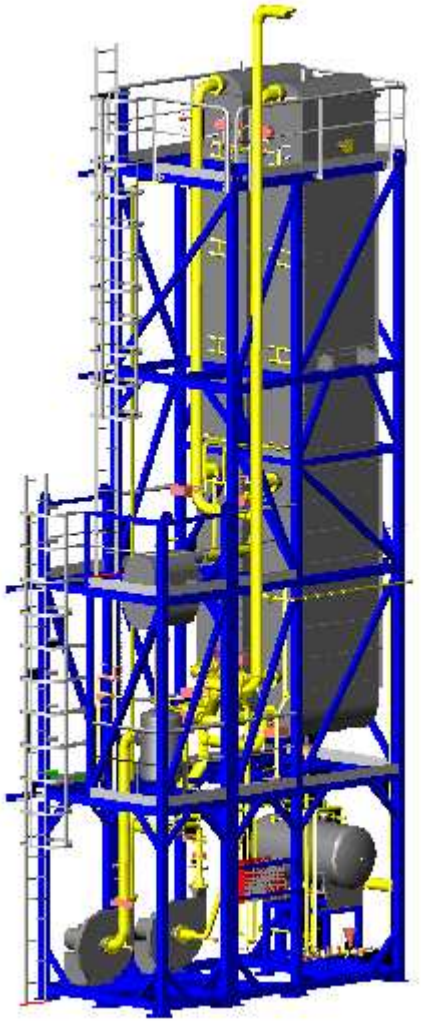
OUR APPROACH

For each project, very promptly all engineering activities are programmed, from the conceptual design to the construction and testing steps, thus obtaining the **compliance with** the agreements taken with the **customers** as far as timing, costs, standards and procedures are concerned.

The **Polaris** structure is **flexible** and able to manage different level projects, and contracts having different scopes and features, **engineering** services supply as well as **turn-key plants** supply.

Polaris has developed with accuracy the techniques of design and construction of **prefabricated systems**, also having big dimensions. With such approach, Polaris is able to **supply** the customers **in all countries** with complete plants with a big reduction of costs, construction and erection works, difficulties or delays in the testing procedures and discomfort to the customers due to the presence on-site of work-shop activities.

To give guarantees to the clients about the **follow-up assistance** after delivery and start-up, the Polaris plants are equipped with **telemetry systems** connected by modem to the Polaris central station, and the company is available for supplying **maintenance services**.



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- *Internal Reflux Distillation*
- *The technology value chain*

Vent gas cryogenic condensation - What is it?

Polaris has developed and improved in the years the original process (European patent, 1994) based on the use of liquid nitrogen (LIN) for the progressive cryogenic cooling and condensation of the polluted effluents till the freezing of the residual traces of pollutants.

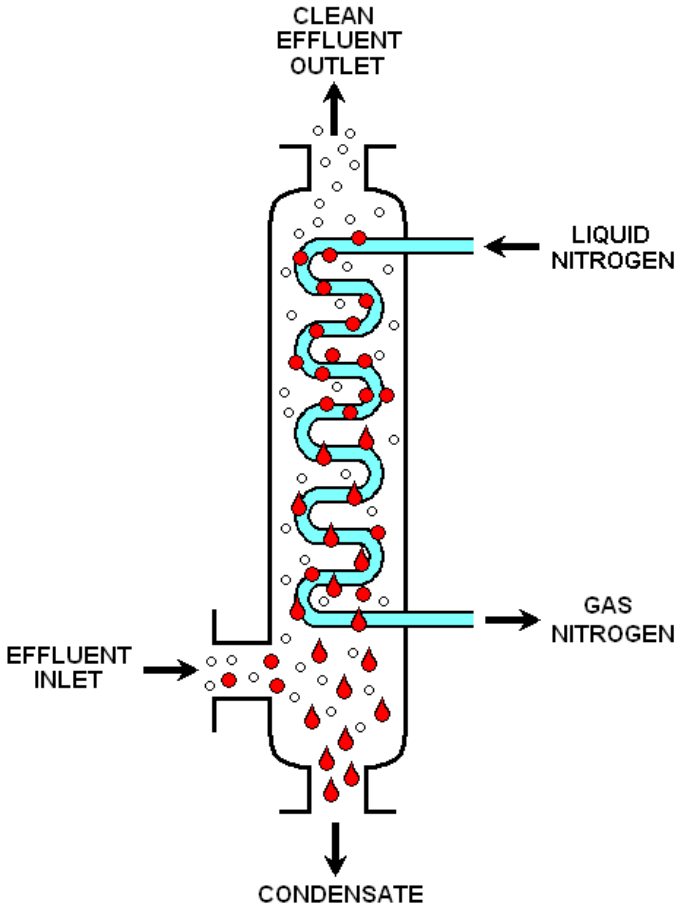
The gaseous nitrogen (GAN) formed, in pressure, enters the nitrogen network of the factory, to be reused.

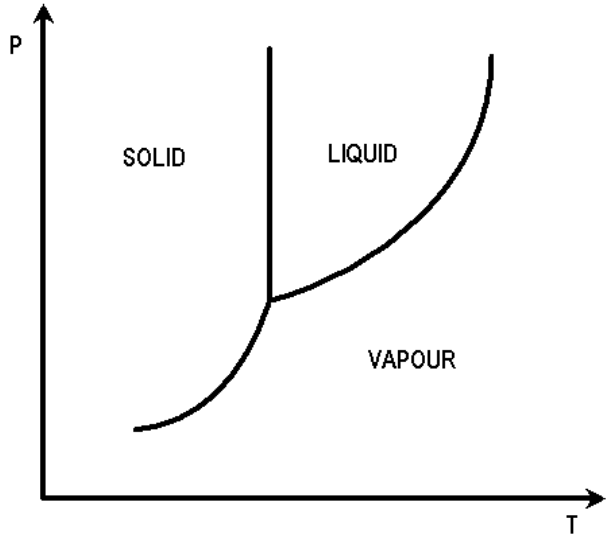
For such process, special heat exchangers are used, having fractionation capacity (also including the internal reflux column technology for the most difficult cases where the pollutants must be recovered separately).

Thanks to this fractionation capacity, it is possible to get only fractions of ppm of volatile organic compounds (VOC) or other pollutants in the final effluent to the atmosphere, really obtaining the compliance with the theoretical thermodynamic equilibrium temperature/vapour pressure.

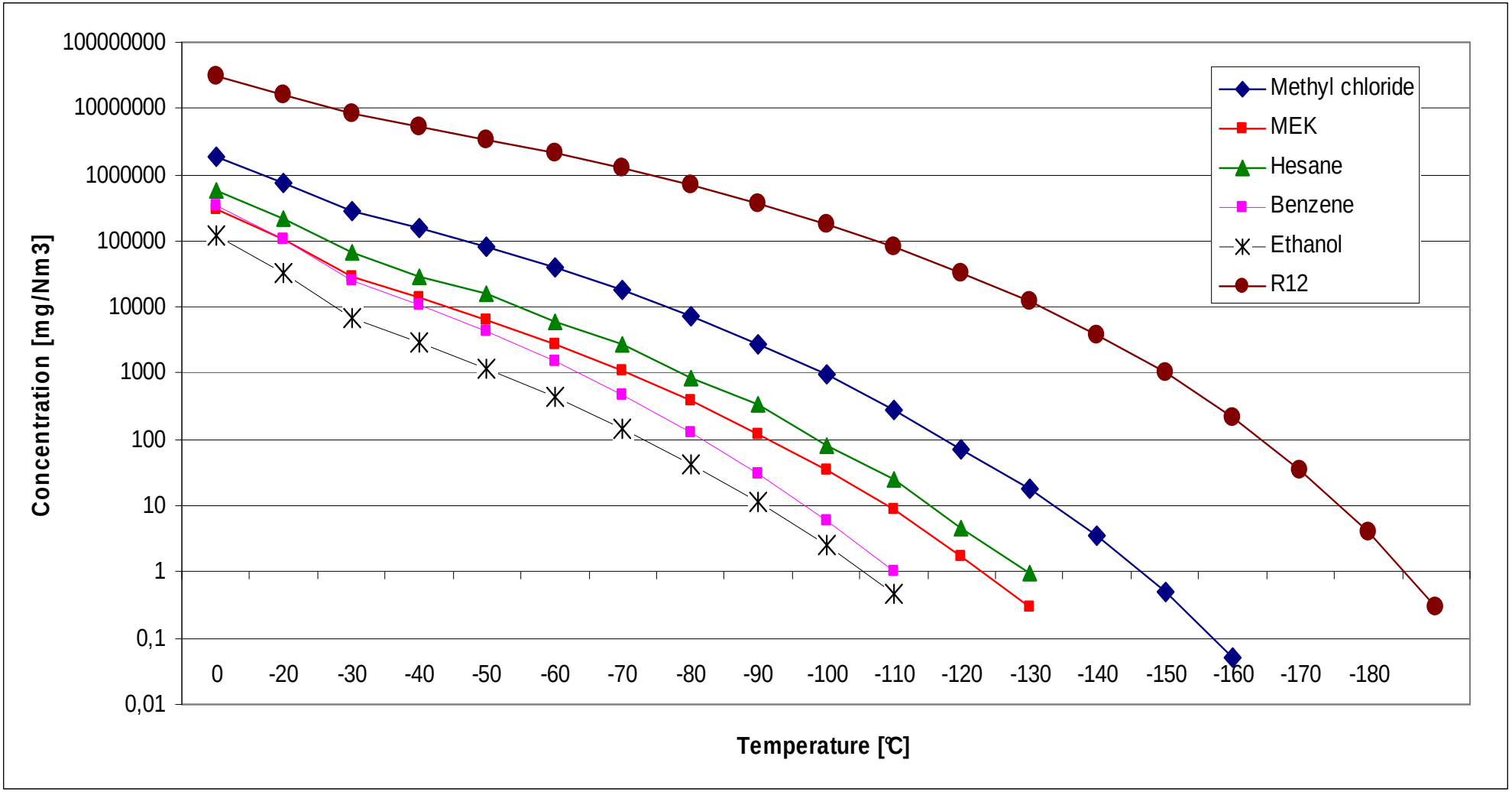
The Polaris technology, operating at process temperatures till -170 °C, allows to meet the most restrict ive law limits for the industrial emissions in Europe, not requiring a further finishing treatment with active carbons.

Vent gas cryogenic condensation - How does it work?





Vent gas cryogenic condensation – Any limitations?

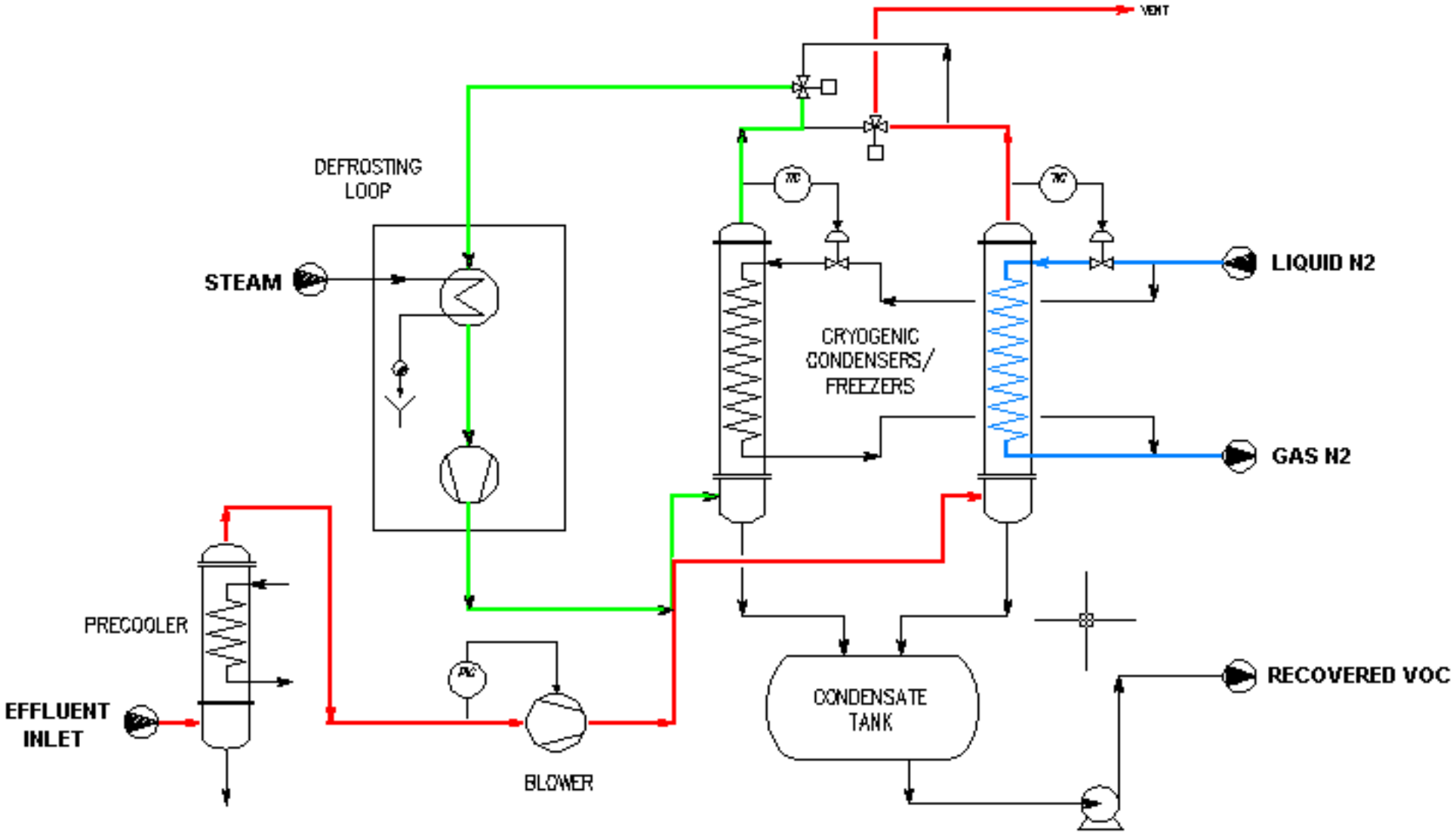


Vent gas cryogenic condensation – Where?

WHERE SOLVENTS ARE PRESENT

- ➔ ***PHARMACEUTICAL industry***
- ➔ ***CHEMICAL industry***
- ➔ ***PETROCHEMICAL industry***
- ➔ ***TANK FARMS***
- ➔ ***SHIP LOADING TERMINALS***
- ➔ ***RECYCLE industry***
  (CFC and HCFC abatement)

Vent gas cryogenic condensation - Schematic



Vent gas cryogenic condensation - Some samples 1

- size 1100 Nm3/h
- pollutant: mixed solvents
- methylene dichloride contract limit: < 20 mg/m3
- test run performances: < 5 mg/m3
- FDA approved
- customer: Novartis/Biochemie, Italy

- size 400 Nm3/h
- pollutant: mixed solvents
- methylene dichloride contract limit: < 20 mg/m3
- test run performances: < 5 mg/m3
- customer: SICOR/TEVA, Italy

Vent gas cryogenic condensation - Some samples 2

- size 400 Nm3/h
- pollutant: freon R11
- customer: SIRA, Italy

- size 200 Nm3/h
- pollutant: acrylonitrile
- contract limit: < 5 mg/m3
- test run performances: < 1 mg/m3
- customer: Polimeri Europa, Italy

- size 500 Nm3/h
- pollutant: mixed solvents
- customer: Poli Chimica, Italy

Vent gas cryogenic condensation – Why?

Vs THERMAL OXYDATION Systems

- lower operating costs - Gas nitrogen can be recovered
- maximum safety, even in presence of highly flammable compounds
- suitable for most common substances (no catalyst poison effect)
- suitable for halogenated compounds
- possible reuse of recovered compounds
- compliance with emission limits required by the more strict norms
- no secondary emissions (e.g. combustion products, NOx and CO)
- No need of air dilution

Vs ADSORPTION Systems

- Highest recovery performances on saturated streams
- no hydrolysis and corrosion problems
- no waste water treatment costs (no volume increase due to steam dilution)
- easier recovery of the separated organic compounds (no dilution with steam)
- highest safety
- highest flexibility
- highest reliability
- no need of air dilution

Vent gas cryogenic condensation – Main characteristics

- Flowrate: up to 2.000 Nm3/h (or more in special cases)
- VOC concentration: any concentration is acceptable
- Solvents:
  - Methylene chloride
  - Methyl chloride
  - Benzene
  - Ethanol
  - Ethyl Acetate
  - Propanol
  - Vinyl chloride
  - Acrylonitrile
  - Halogenated solvents
  - Freons
  - Any others
  - Solvents mix
- Effluent outlet temperature: ambient
- Strengths:
  - Safety
  - Operating costs (if nitrogen is recovered)
  - Flexibility
  - No steam required
  - No sensitive to catalyst poisons
  - No secondary emissions NOx and CO

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- *Company presentation*
- *Vent gas cryogenic condensation*
- ***Adsorption technology for VOC recovery***
- *Internal Reflux Distillation*
- *The technology value chain*

VOC adsorption with inert dry regeneration - What is it?

This system is capable of removing and recovering the volatile organic compounds (VOC) from the process laden air.

The purpose of the plant is:

- **remove volatile VOC from gas streams coming from production processes;**
- **recover with the highest efficiency the VOC in order either to reuse in process or to use for other applications.**

The system is based on VOC adsorption technology on adsorbent material (e.g. activated carbons, microporous resins) with "dry regeneration".

The solvents laden air after dust filtration and pre-cooling is sucked by the blowers and sent to the section operating in adsorption. Here the solvents are adsorbed in the adsorbent material and the outcoming purified effluent is sent to atmosphere. In the same time, in the section operating in regeneration mode, the VOC adsorbed in the preceding step is removed with a procedure of heating the bed of adsorber by means of inert gas (e.g. nitrogen) in a closed loop, and following with desorption under vacuum to get the quantitative removal of the adsorbed compounds. Then only a minimum overflow from the regeneration loop, but saturated with the desorbed compounds, is treated with liquid nitrogen in a cryogenic condenser while the produced gaseous nitrogen enters the regeneration circuit.

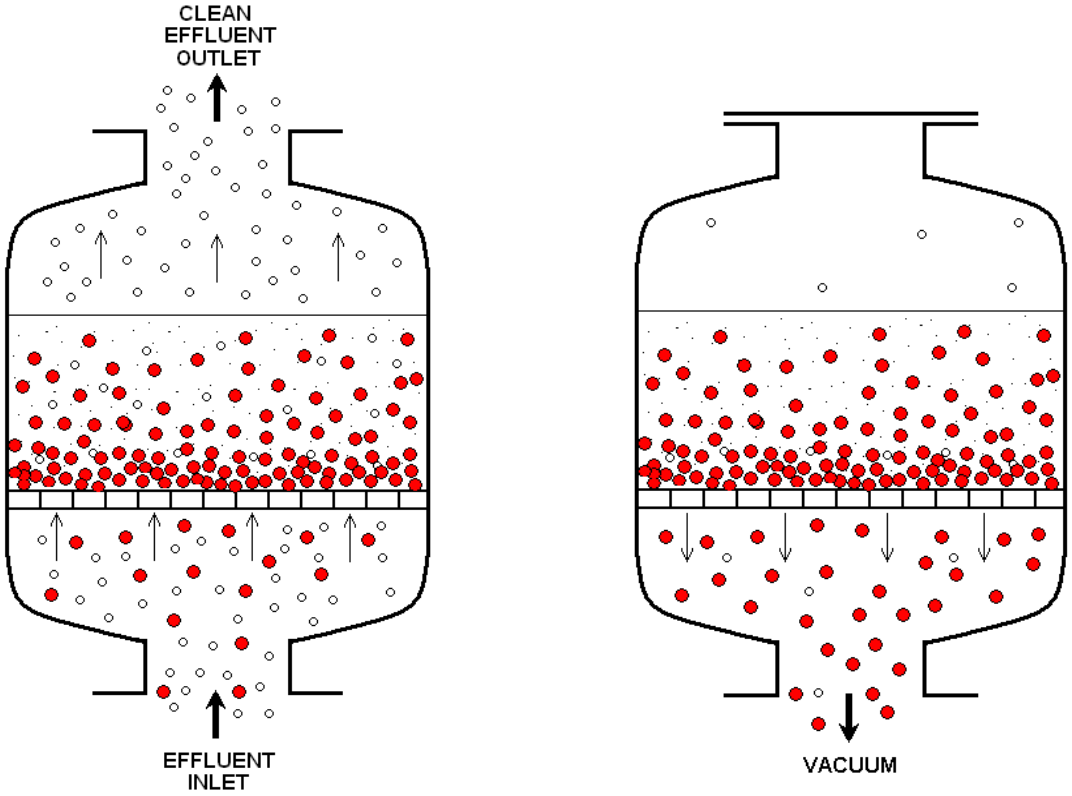
The "dry regeneration" process was developed by Polaris in 2001, in order to find an adequate solution for VOC recovery from high flowrate streams, and patented in 2002. It has been optimized by Polaris thanks to a specific experience in VOC abatement applications and nowadays more than 20 plants are operating with this technology in different typology of industries.

The operating costs are lower than other alternative recovery technologies thanks to a rational and efficient use of the cooling and heating energy.

Finally, this technique is particularly suitable for the regeneration of macroporous resins used for innovative and high performances adsorption technologies.

VOC adsorption with inert dry regeneration - How does it work?

PRINCIPLE OF THE PROCESS



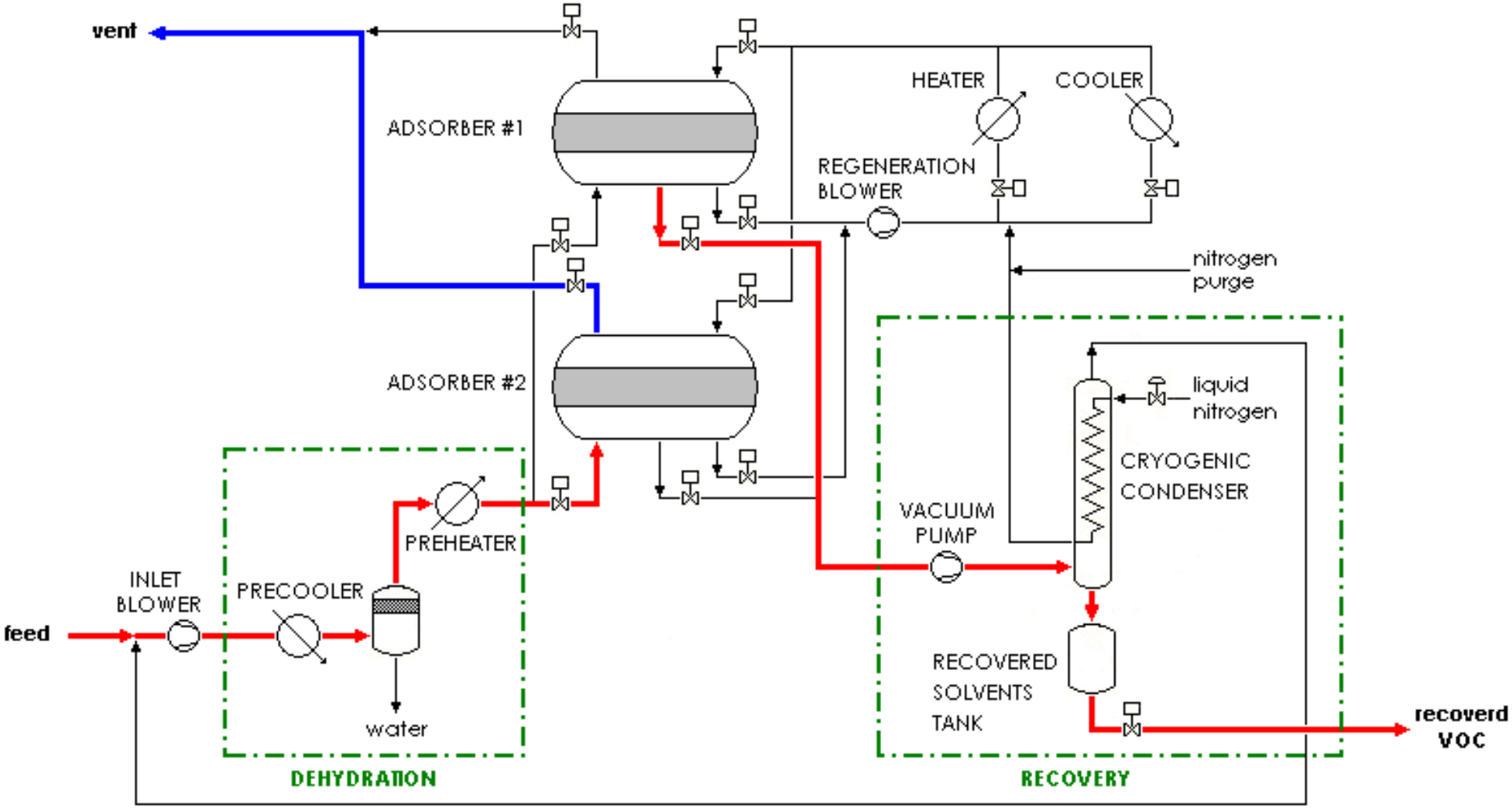
VOC adsorption with inert dry regeneration - Where?

WHERE SOLVENTS ARE PRESENT

- ➔ ***PRINTING industry***
- ➔ ***GRAVURE industry***
- ➔ ***PAINTING industry***
- ➔ ***COATING industry***
- ➔ ***PHARMACEUTICAL industry***
- ➔ ***CHEMICAL industry***
- ➔ ***RECYCLE industry***
  (CFC and HCFC abatement)

The process is suitable for most common substances, also the more volatile ones, for which the other conventional regeneration techniques are not effective

VOC adsorption with inert dry regeneration – Schematic – Active carbon



VOC adsorption with inert dry regeneration – Two examples

VOC adsorption with inert dry regeneration – Schematic – Macroporous Resins

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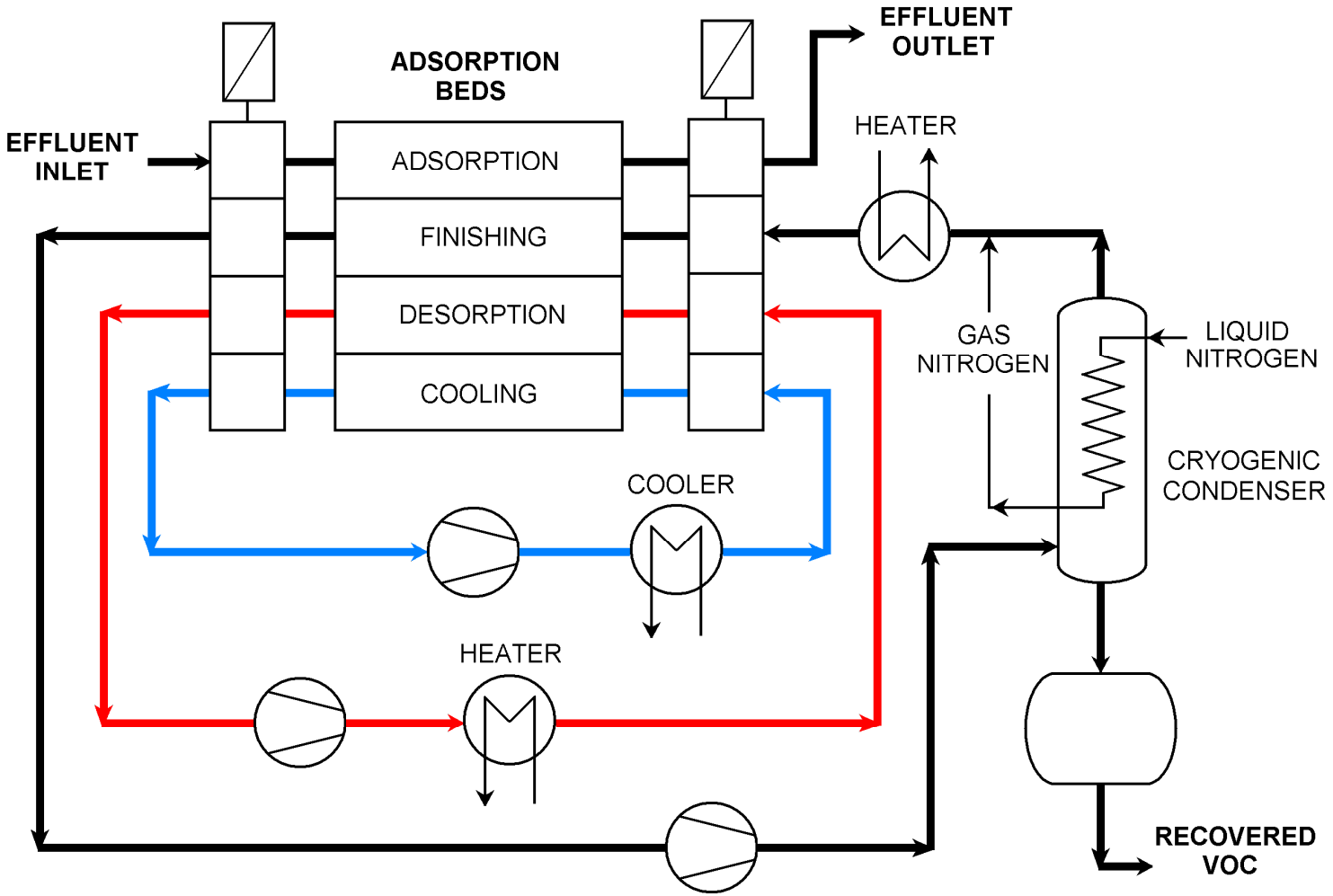

BENEFITS OF ADSORPTION ON MACROPOROUS RESINS

- ***Lower investment costs***
- ***Smaller footprint requirements for plant installation***
- ***Absence of active sites of catalysis (metal oxides): highly recommended with ketones and esters***
- ***Resins are hydrophobic: small quantities of water are adsorbed and hydrolysis is avoid or reduced***
- ***Adsorption and desorption energies are lower (one half) compared with activated carbons***
- ***Resins can be easily regenerated at low temperature***
- ***Resins allow the highest safety conditions respect to other adsorption media***
- ***Reduction of desorption stream***
- ***Resins have a mechanical resistance higher than activated carbons with a longer lifetime***

VOC adsorption with inert dry regeneration - Why?

Vs OXYDATION Systems

- lower operating costs
- maximum safety, even in presence of highly flammable compounds
- no costs in stand by mode
- operating in few minutes after switch on
- suitable for most common substances (no catalyst poisonning effect)
- suitable for halogenated compounds
- solvents recovered can be reused in the process
- compliance with emission limits required by the more strict norms
- no secondary emissions NOx and CO

Vs ADSORPTION with STEAM regeneration Systems

- lower operating costs
- better compatibility with compounds that present hydrolysis and corrosion problems
- reduction of waste water treatment costs (no volume increase due to steam dilution)
- easier recovery of the separated organic compounds (no dilution with steam)

Vs ADSORPTION with OTHER DRY regeneration Systems

- lower operating costs
- more compact plant size
- higher adsorption capacity after regeneration step
- suitable for lower regeneration temperature

VOC adsorption with inert dry regeneration – Main characteristics

- Flowrate: 500 to 100.000 Nm3/h (or more in special cases)
- VOC concentration: 1 - 30 g/Nm3
- Solvents:
  - Ketons (MEK, MIBK, …)
  - Esters
  - Ethyl Acetate
  - Alcohols (Propanol, Ethanol, …)
  - Aromatics (Toluene, Benzene, …)
  - Halogenated solvents
  - Freons
  - Solvents mix
- Effluent outlet temperature: ambient
- Strengths:
  - Safety
  - Operating costs
  - Flexibility
  - No steam required
  - No stand by mode at standstill
  - Operating in few minutes after switch on
  - No sensitive to catalyst poisons
  - No secondary emissions NOx and CO

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- *The technology value chain*

Internal Reflux Distillation - What is it?

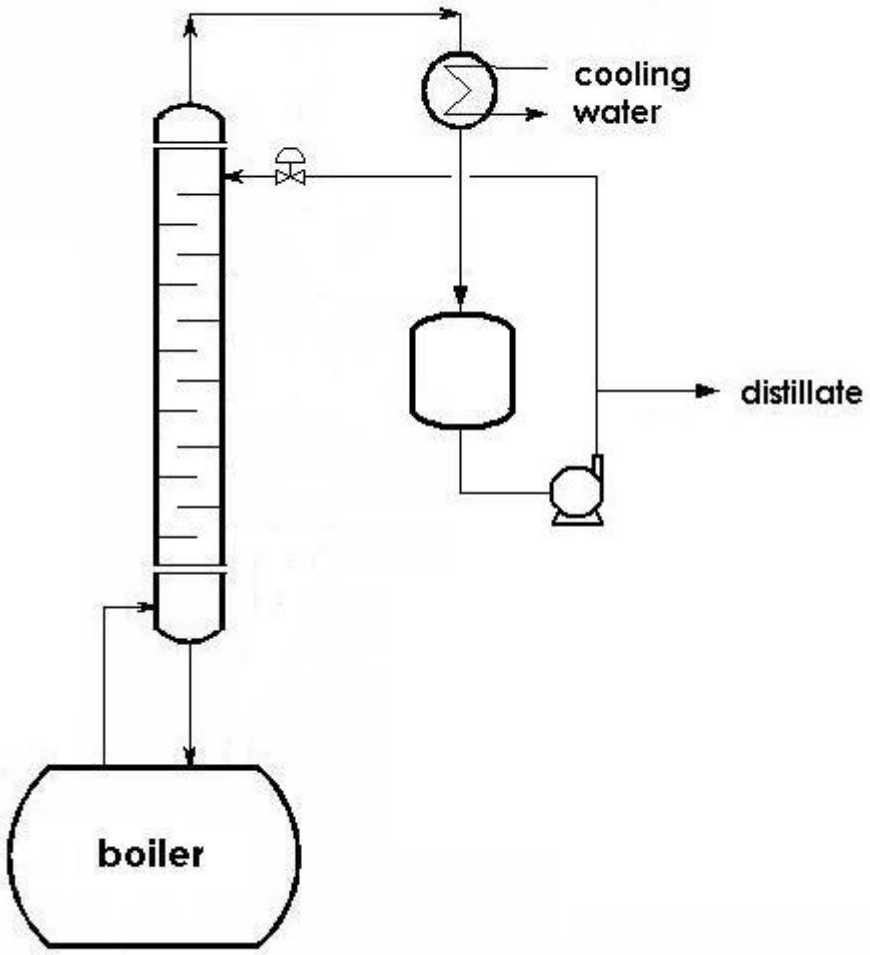
This technique is based on the use of a special column which performs mass and heat transfer (necessary to fractionate the mixed vapours at the boiling point from a multi-component liquid mixture) by means of vertical coils of finned tubes internally fed in counter-current with a cooling medium.

It is particularly suitable in the batch fractionation of solvents for which a very high quality of distillate is required, or from very complex mixtures for which the other available techniques are not adequate or involve not acceptable recovery costs.
Both circumstances are common in the chemical pharmaceutical industry.

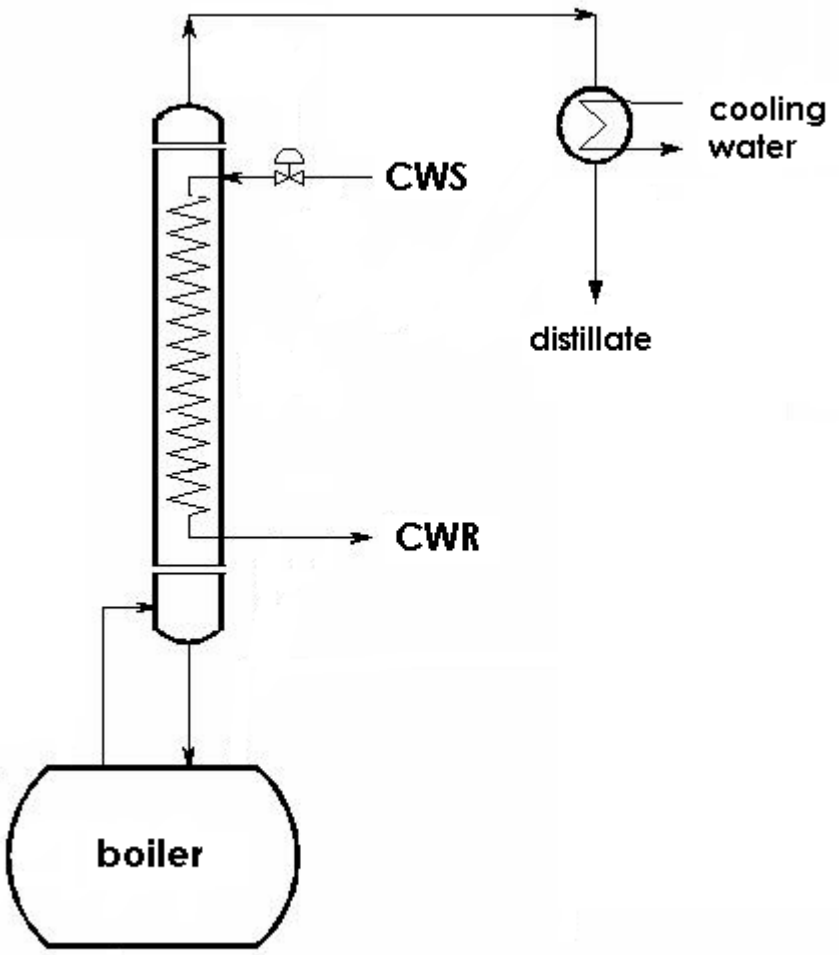
The unique feature of this technology is the almost complete absence of hold-up inside the column as well as in the condensation circuit, which gives significant advantages for all transitory phases (e.g. start-up, multi-component distillation etc.).

If a cryogenic medium (e.g. liquid nitrogen) is used as cooling medium in the coils, it is possible to fractionate also a mixture of several gases, to be got liquid or not, also obtaining a quantitative separation from the incondensable fractions possibly present (i.e. industrial gases purification).

Internal Reflux Distillation - How does it work?



EXTERNAL REFLUX

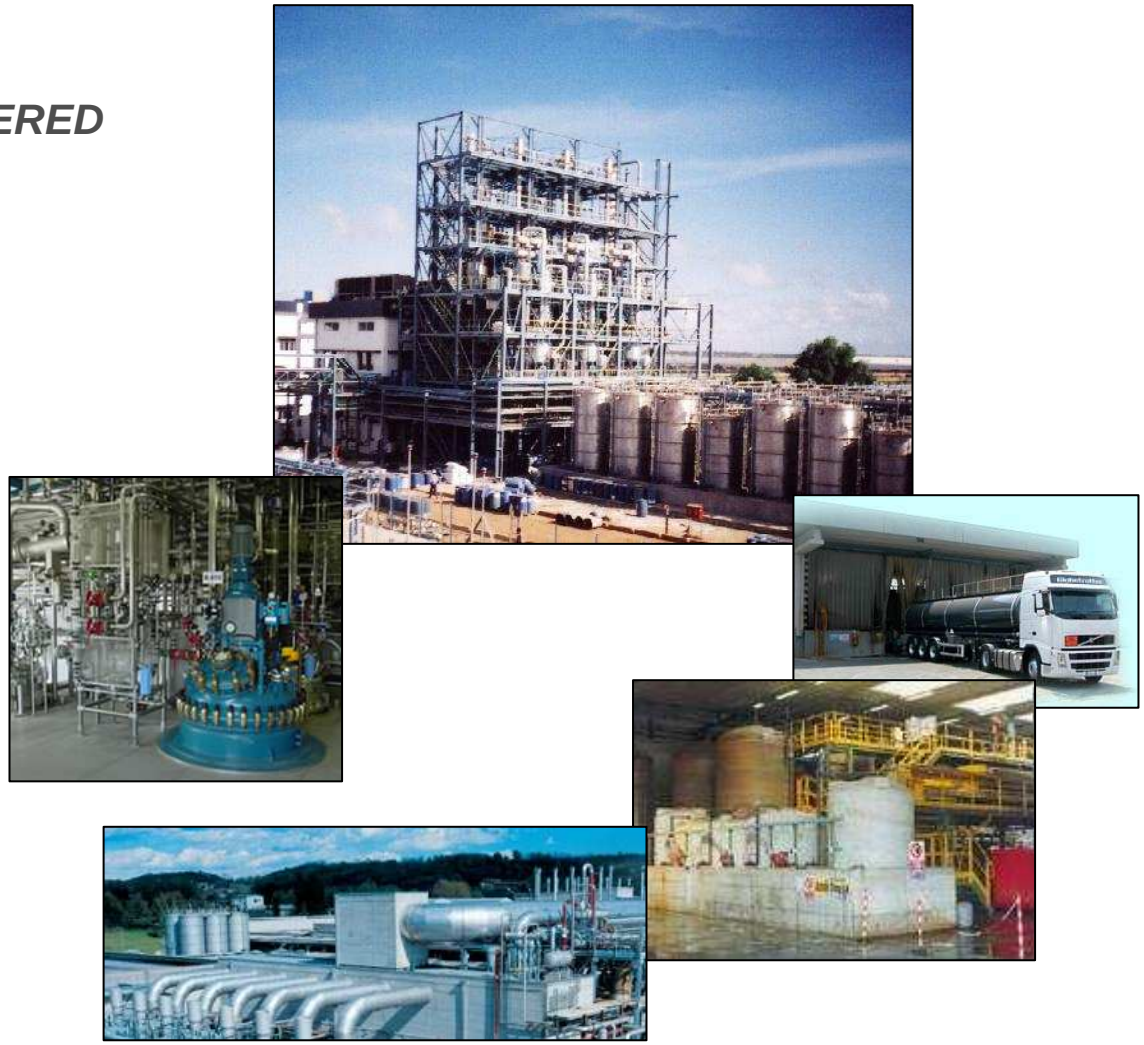


INTERNAL REFLUX

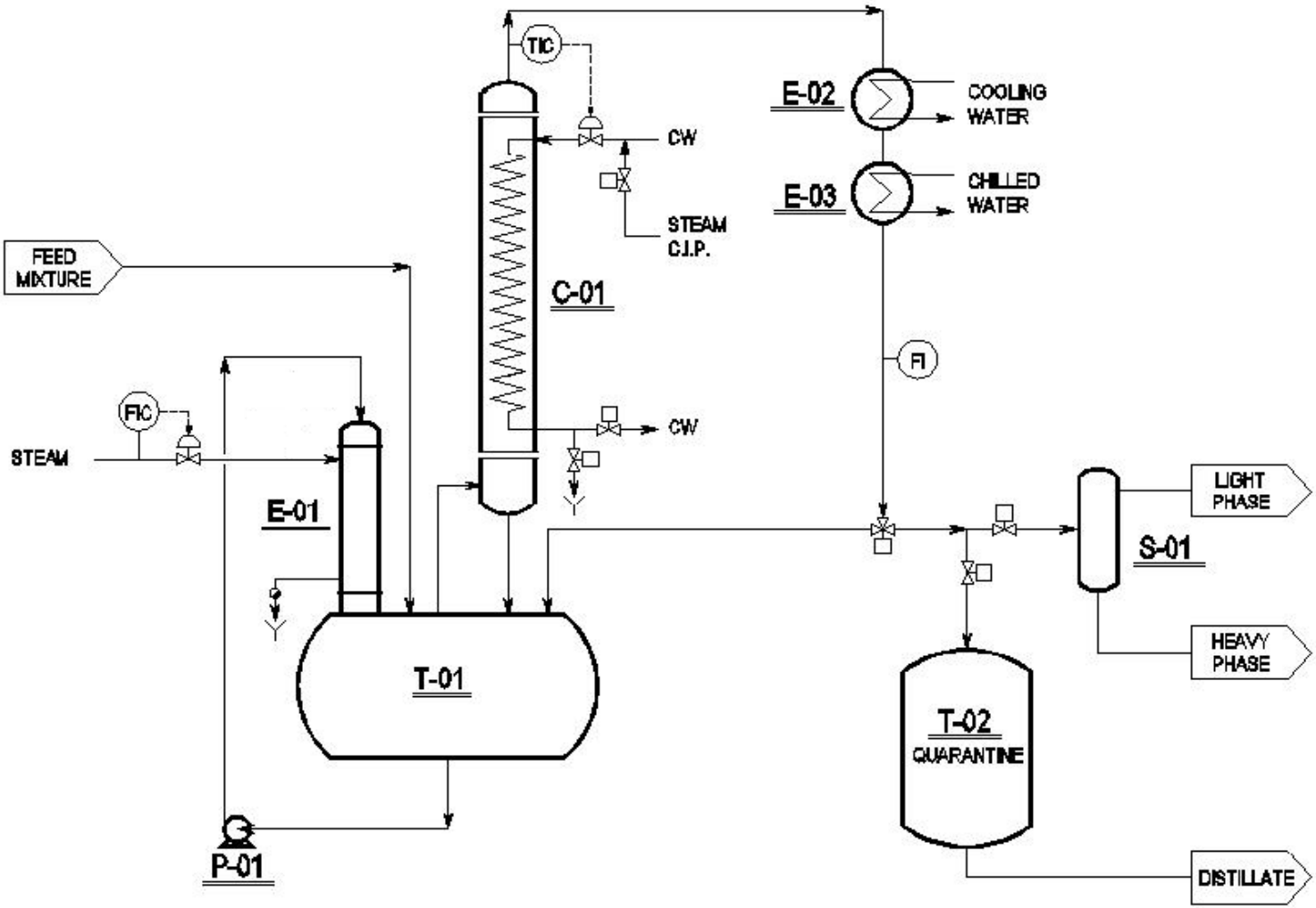
Internal Reflux Distillation – Where?

WHERE SOLVENTS CAN BE RECOVERED OR NEED TO BESEPARATED

- ***PHARMACEUTICAL industry***
- ***CHEMICAL industry***
- ***PETROCHEMICAL industry***
- ***GRAVURE industry***
- ***PRINTING industry***
- ***ENVIRONMENTAL industry***



Internal Reflux Distillation - Schematic



Internal Reflux Distillation – applications

Distillation unit
for methanol recovery
(client: Wyeth Lederle Corp.)

Distillation unit
under erection

Distillation pilot unit

Internal Reflux Distillation – Why?

Distillation unit
multipurpose
customer: Ribbon, Italy

BENEFITS OF INTERNAL REFLUX DISTILLATION

- Low investment costs for low-medium size units
- Highest flexibility
- Easy to operate - completely automated
- Higher purification performances compared with traditional batch distillation
- Higher recovery performances compared with traditional batch distillation
- Applicable to complex mixtures for recovery of valuable compounds
- Applicable to complex mixture for waste reduction

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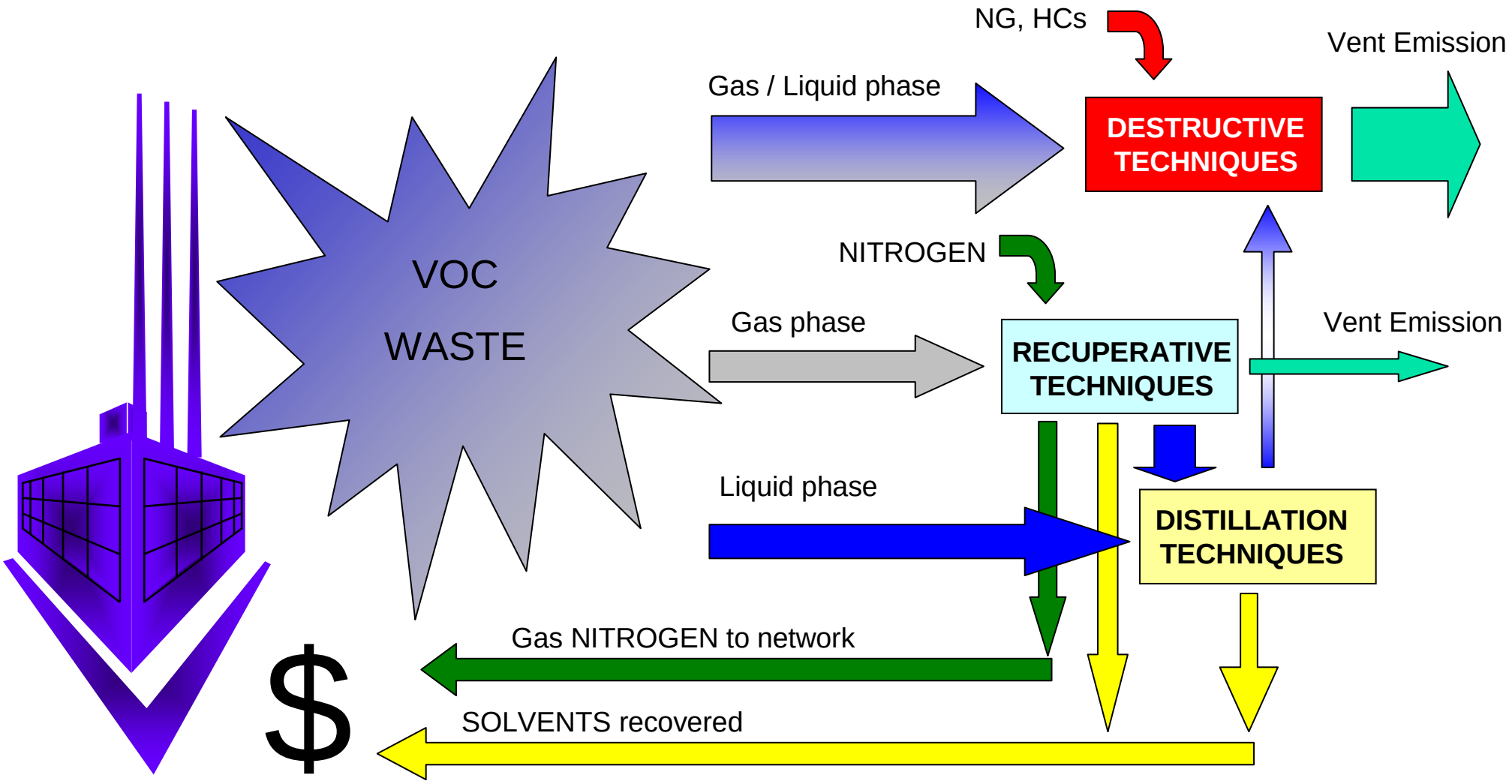
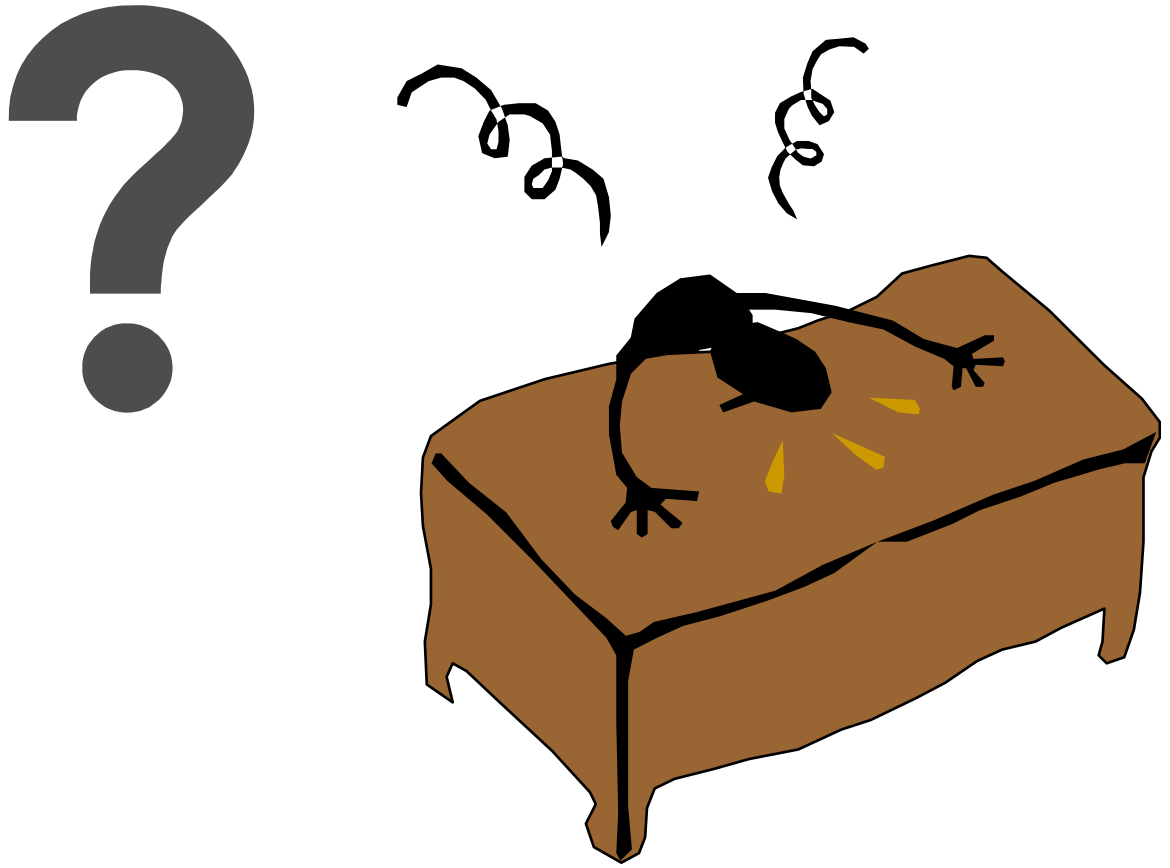
POLARIS TECHNOLOGY – The value chain





Thanks for your attention