

From Purification to Liquefaction Gas Processing with Axens' Technology

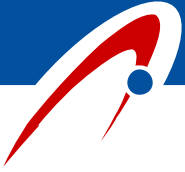
Laurent Savary, Axens



Contaminants in natural gas:

- **CO_2**
- **H_2S**
- ***Mercaptans (RSH)***
- ***Carbonyl sulfide (COS)***
- ***Carbon sulfide (CS_2)***
- **H_2O**
- **Hg**

The degree of removal depends on downstream requirements.



In LNG plants, contaminants must meet the following specifications:

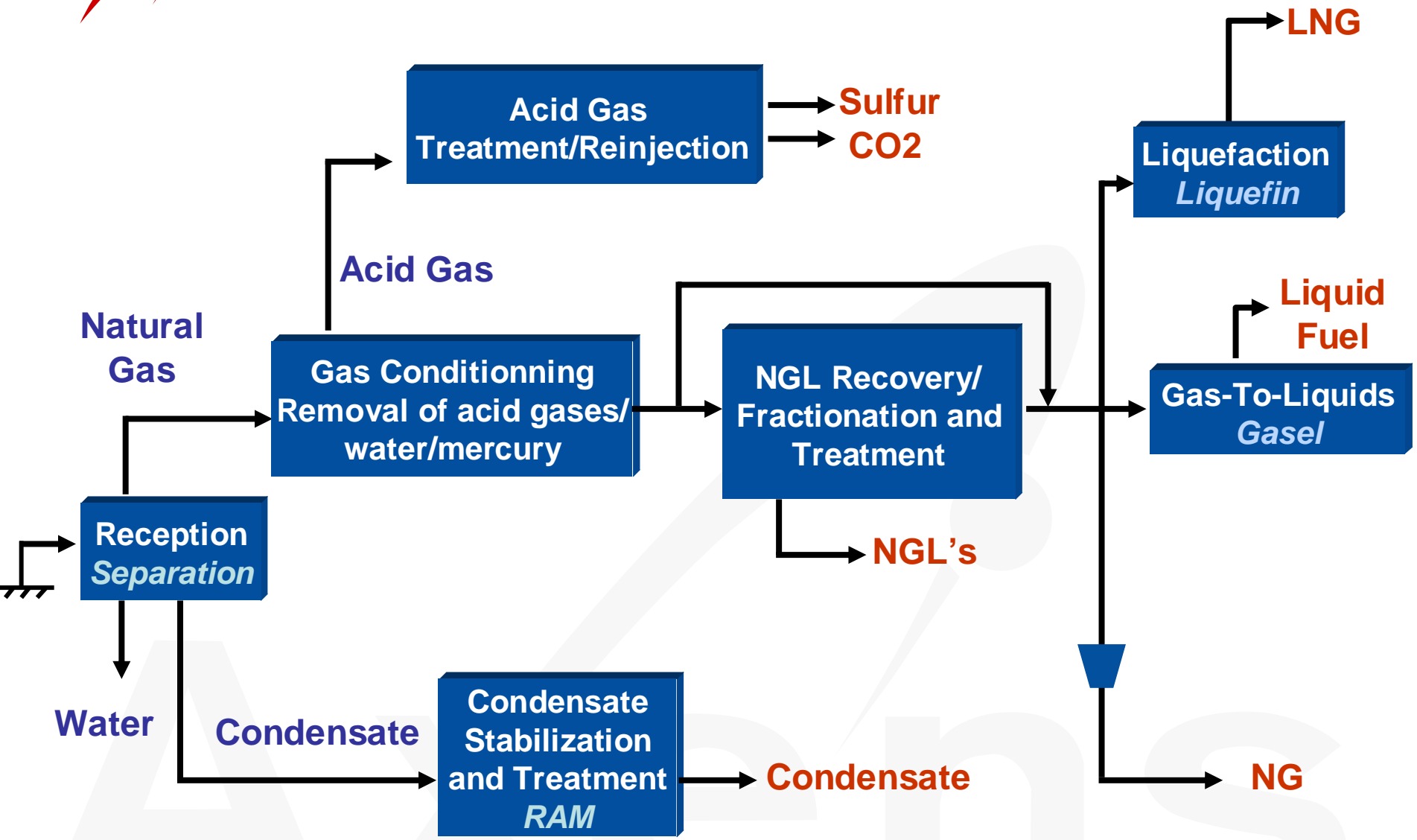
CO_2 < 100 ppmv (freezing and equipment plugging)

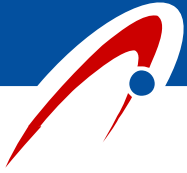
H_2S < 4 ppmv (sales gas specification)

H_2O < 1 ppmv (freezing and equipment plugging)

Hg < 0.01 $\mu\text{gr}/\text{Nm}^3$ (corrosion in aluminum exchangers)

Gas Processing Chain



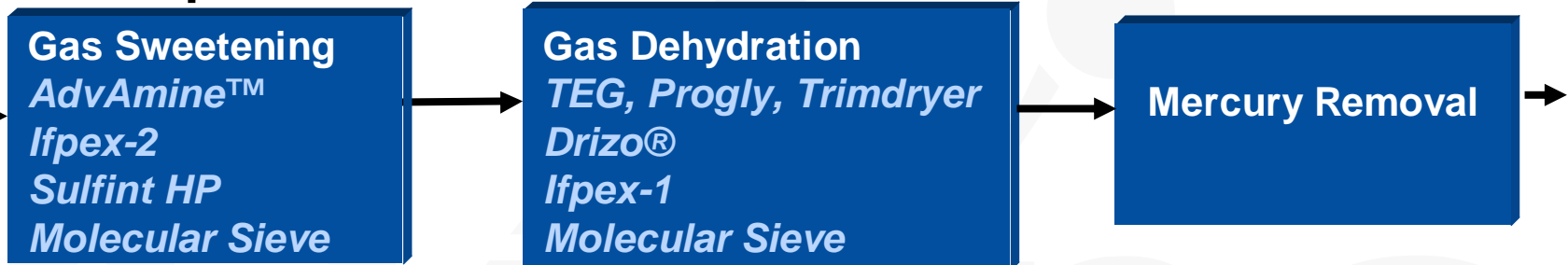


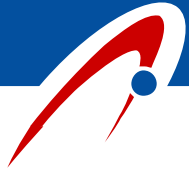
Gas Conditioning



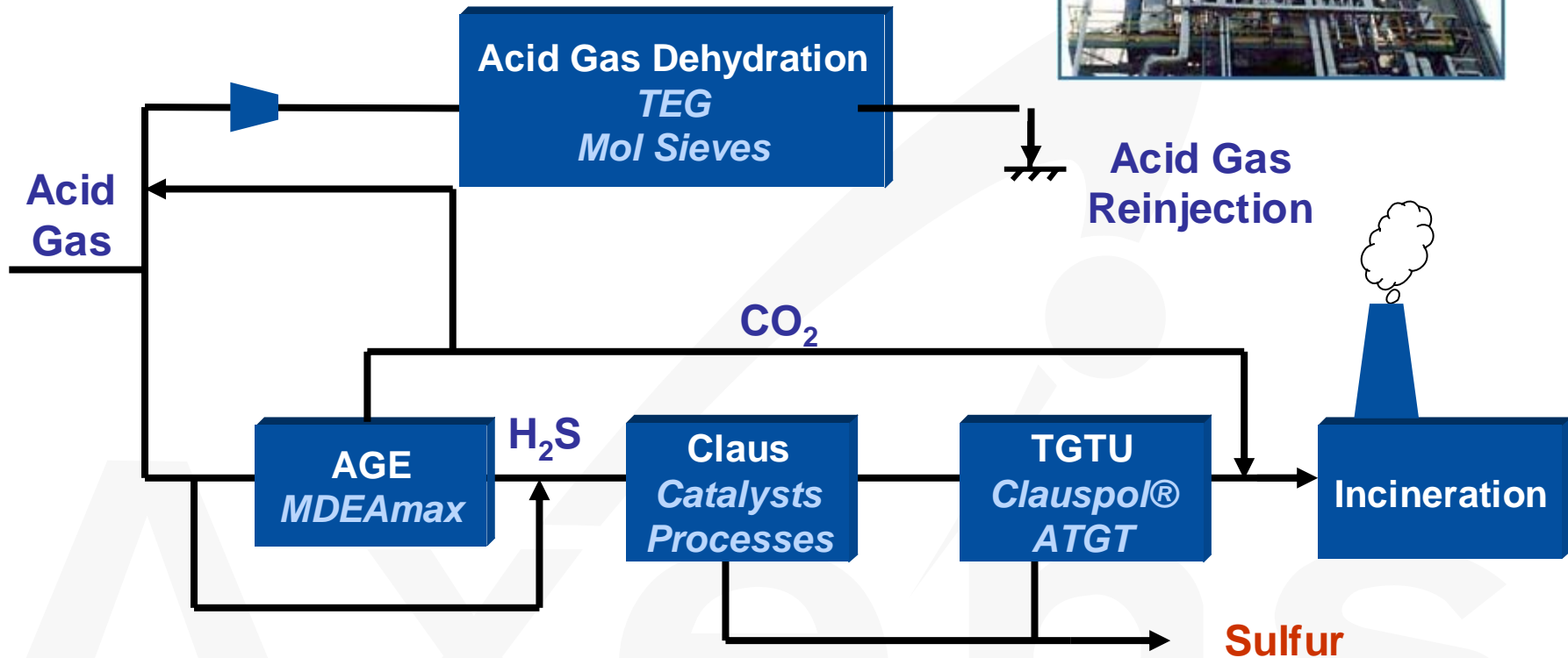
MEG units in Iran - Prosernat

Acid Gas



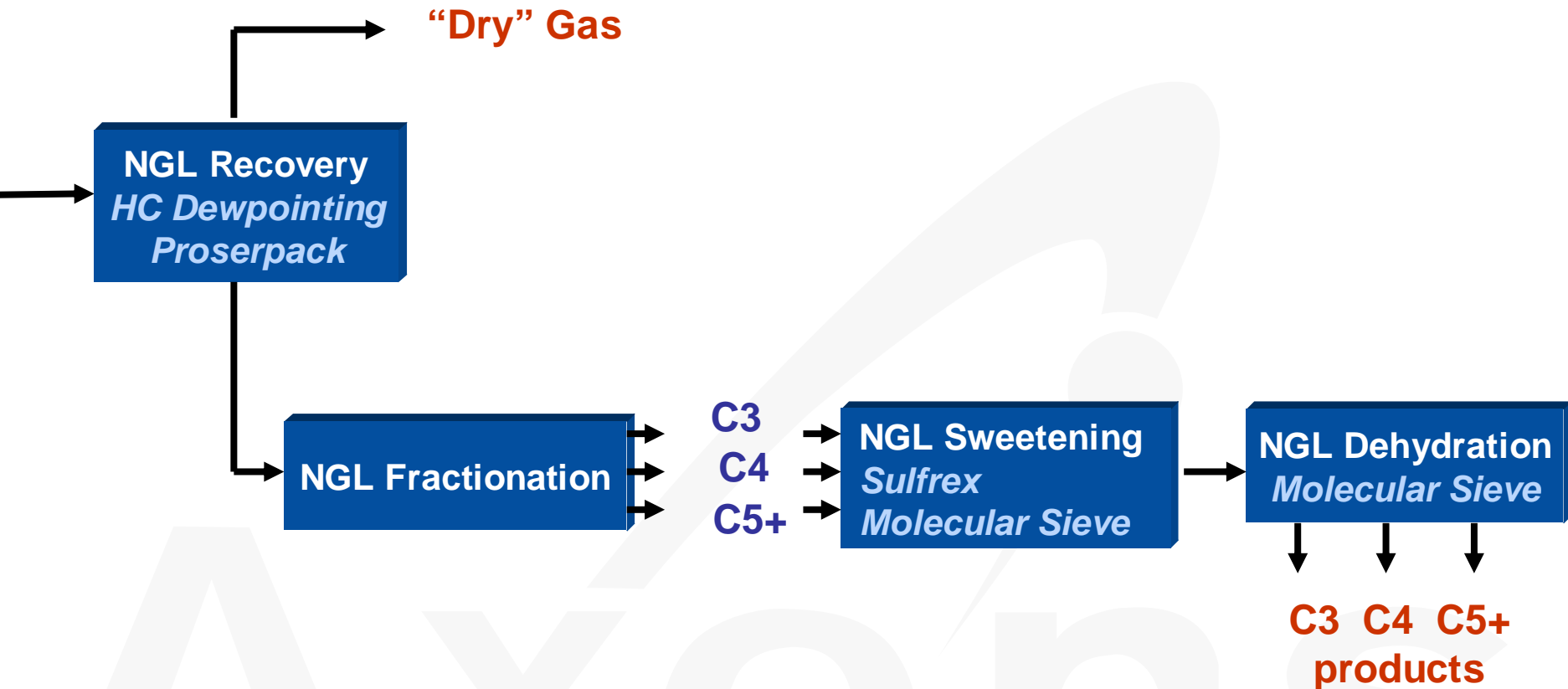


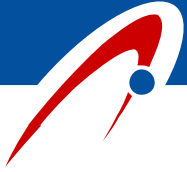
Acid Gas Treatment





NGL Recovery





Combining Sulfrex & Molecular Sieves for LPG Sweetening

Synergy between Process and Adsorbent

Axens



Sulfrex Process Objectives

- **Obtaining negative Doctor Test on final product**
- **Odor improvement**
- **Meet sulfur specifications on LPG or C₃/C₄ cuts**
- **Meet C₃/C₄ olefinic cuts sulfur specs required for olefins upgrading process (Alkylation, Oligomerization)**



Typical C₄ Cut Impurities

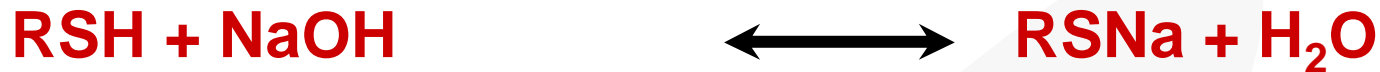
- **Mercaptans**
 - methyl mercaptan: CH₃-SH up to 1000 ppm mole
 - ethyl mercaptan: C₂H₅-SH up to 5000 ppm mole
- **H₂S: traces**
- **COS: traces (*)**

(*) : In C₃ cut COS content can be as high as several hundred ppm



Main Reactions

Extraction

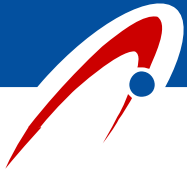


Oxidation and Caustic Regeneration

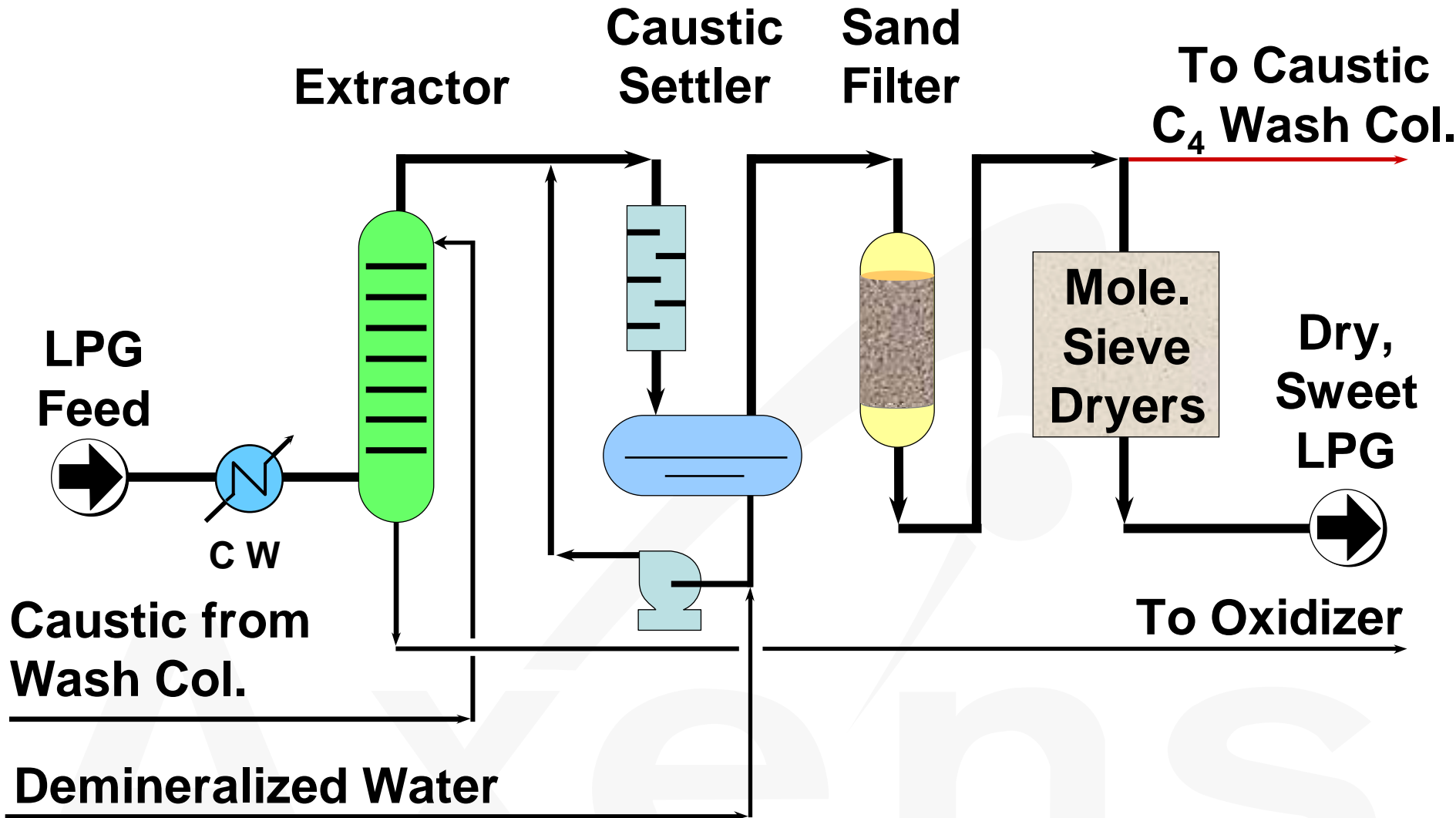


Global Reaction

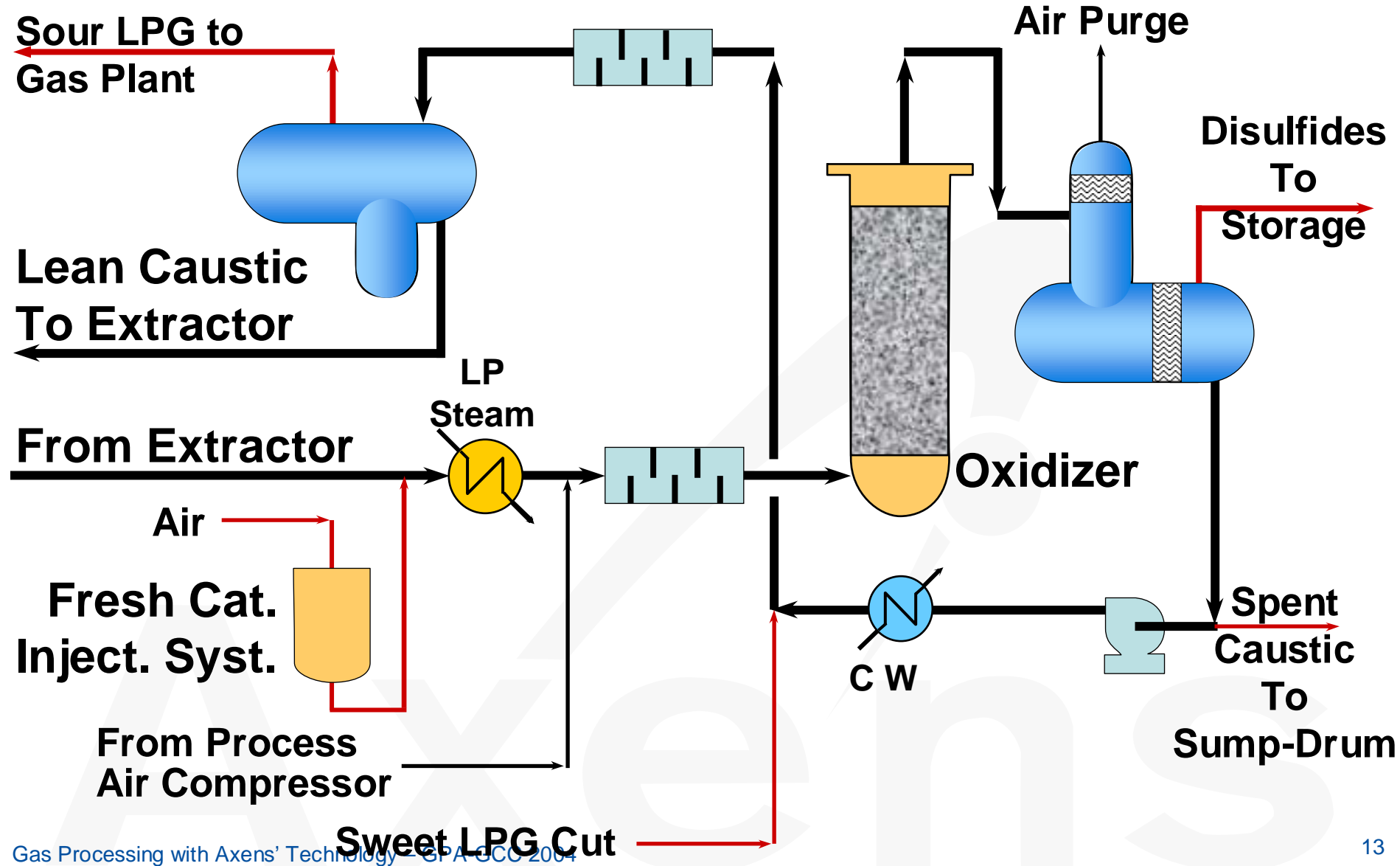
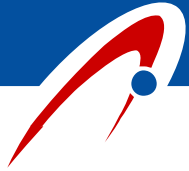


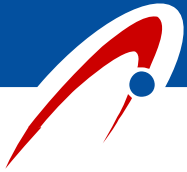


Extractive Sulfrex, Extraction Section



Extractive Sulfrexx™ Caustic Regeneration Section





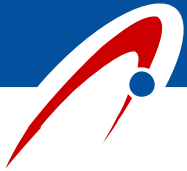
17 licensed units

6.2 millions tons per year of capacity

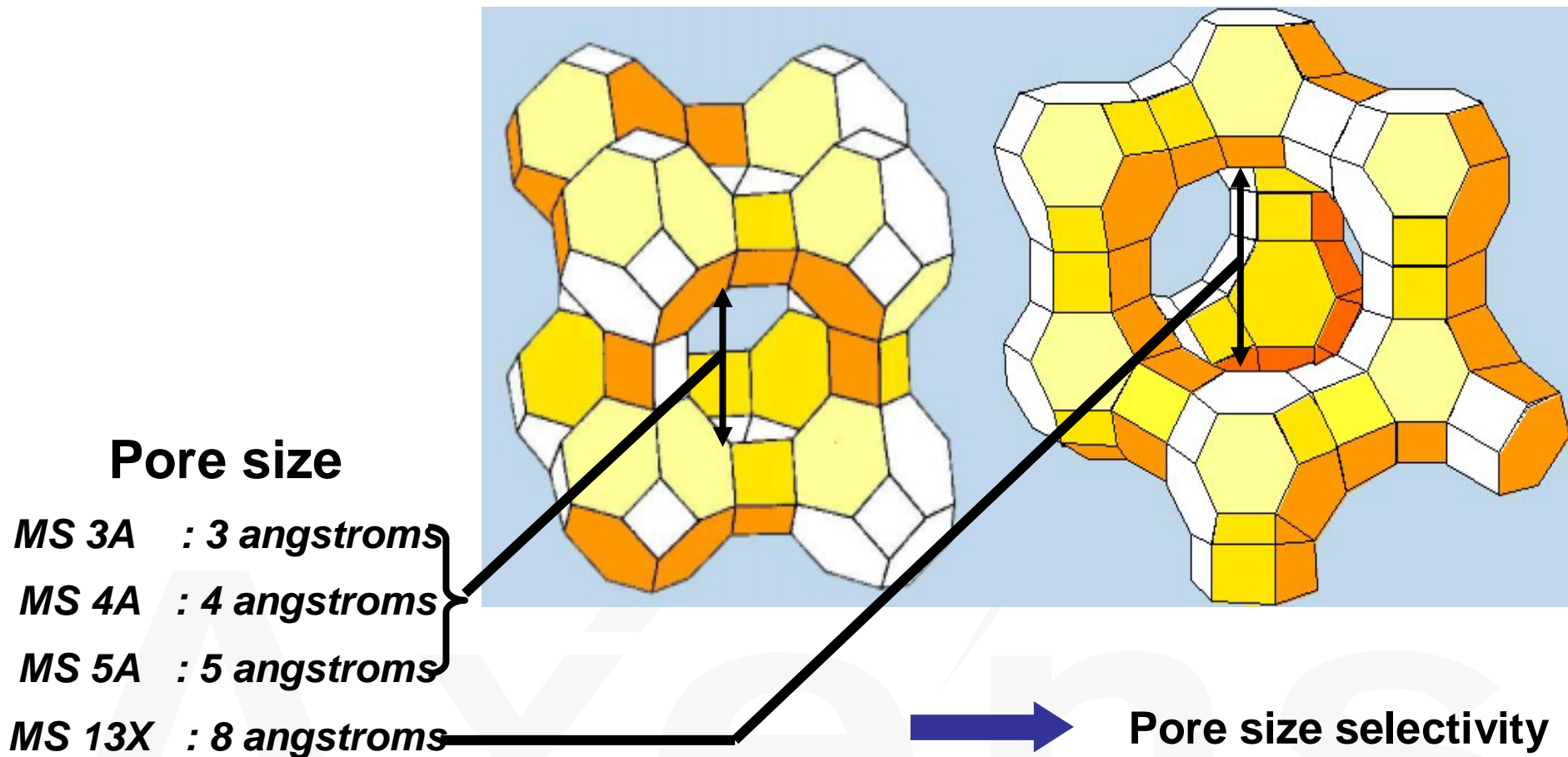


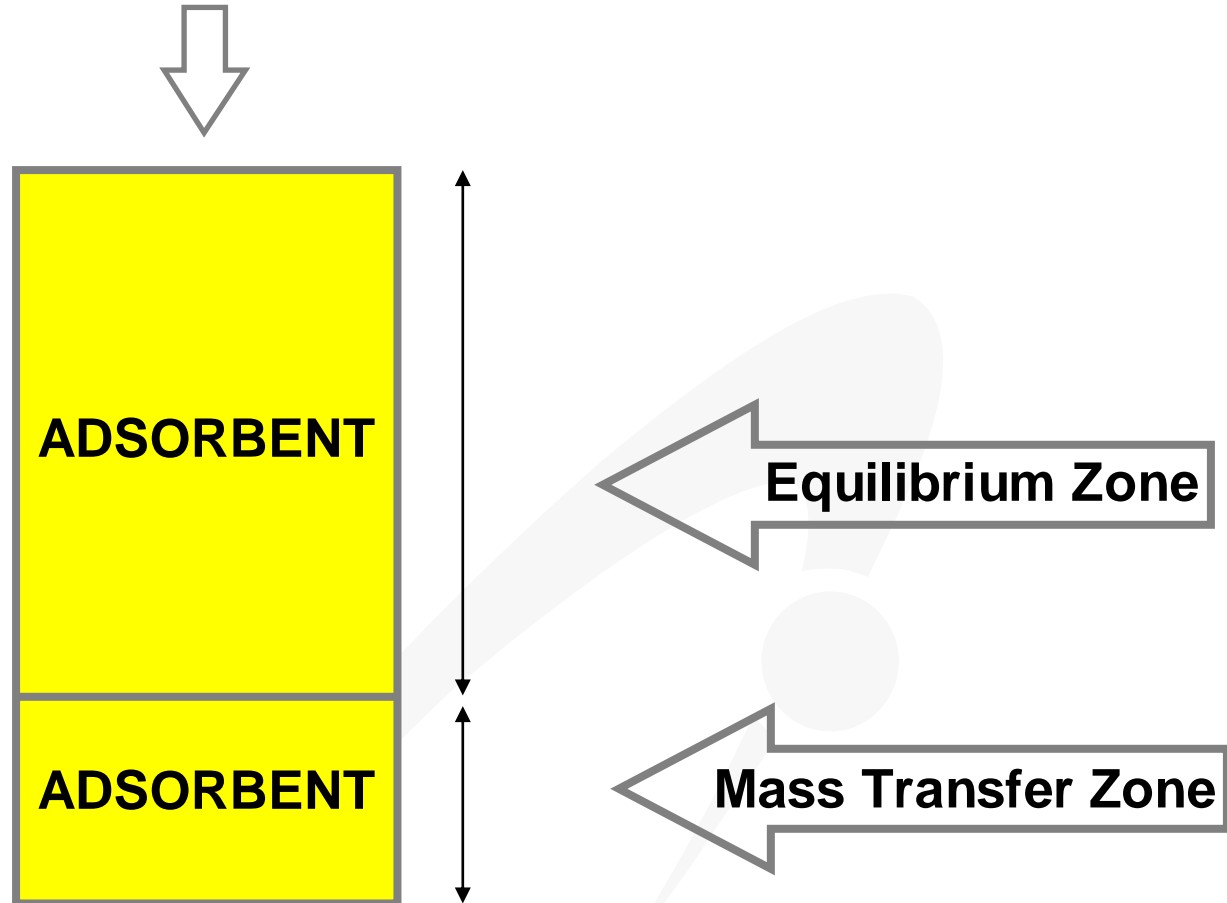
Possibility to add molecular sieves to:

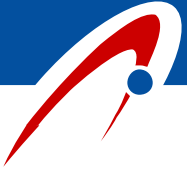
- decrease the size/investment of Sulfrex unit
- insure low RSH outlet concentration



Molecular Sieve Structure



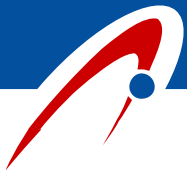




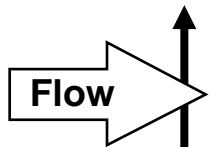
- **The adsorbent is saturated with adsorbate at the operating temperature and pressure, according to the isotherm**
- **The adsorbate concentration is constant throughout the equilibrium zone**



- **The adsorbate concentration is lower than in the equilibrium zone - an almost linear gradient between the concentration at the interface with the equilibrium zone and the adsorbent bed outlet (zero).**



Water concentration

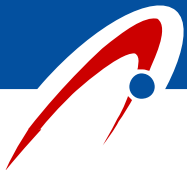


ZE

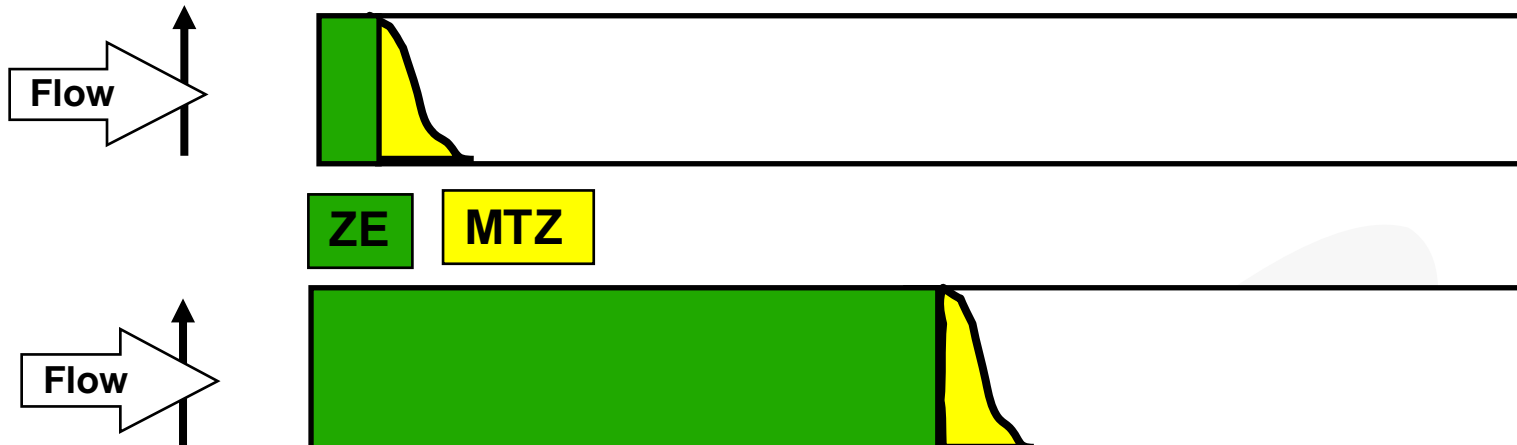
MTZ

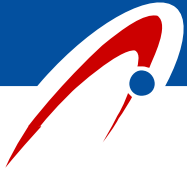


time

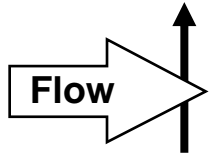


Water concentration

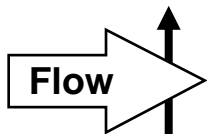
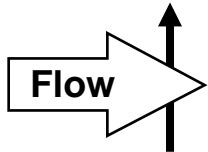




Water concentration

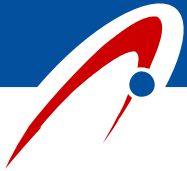


ZE **MTZ**

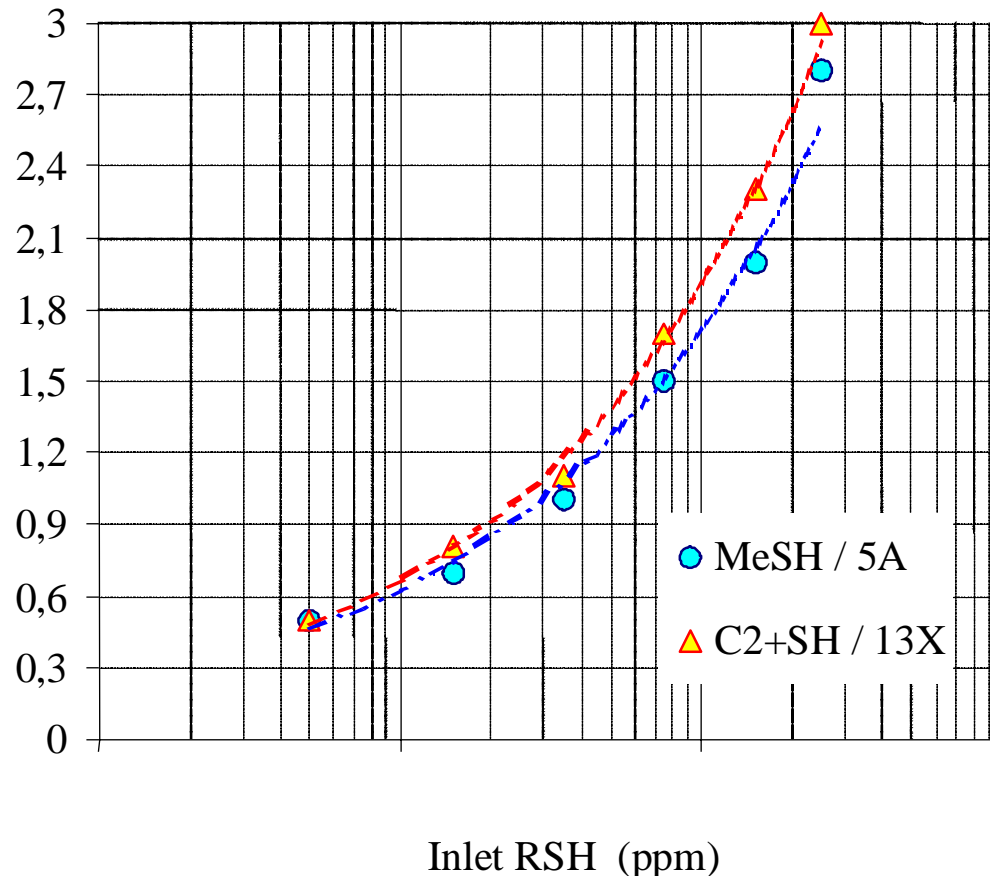


water
breakthrough

time

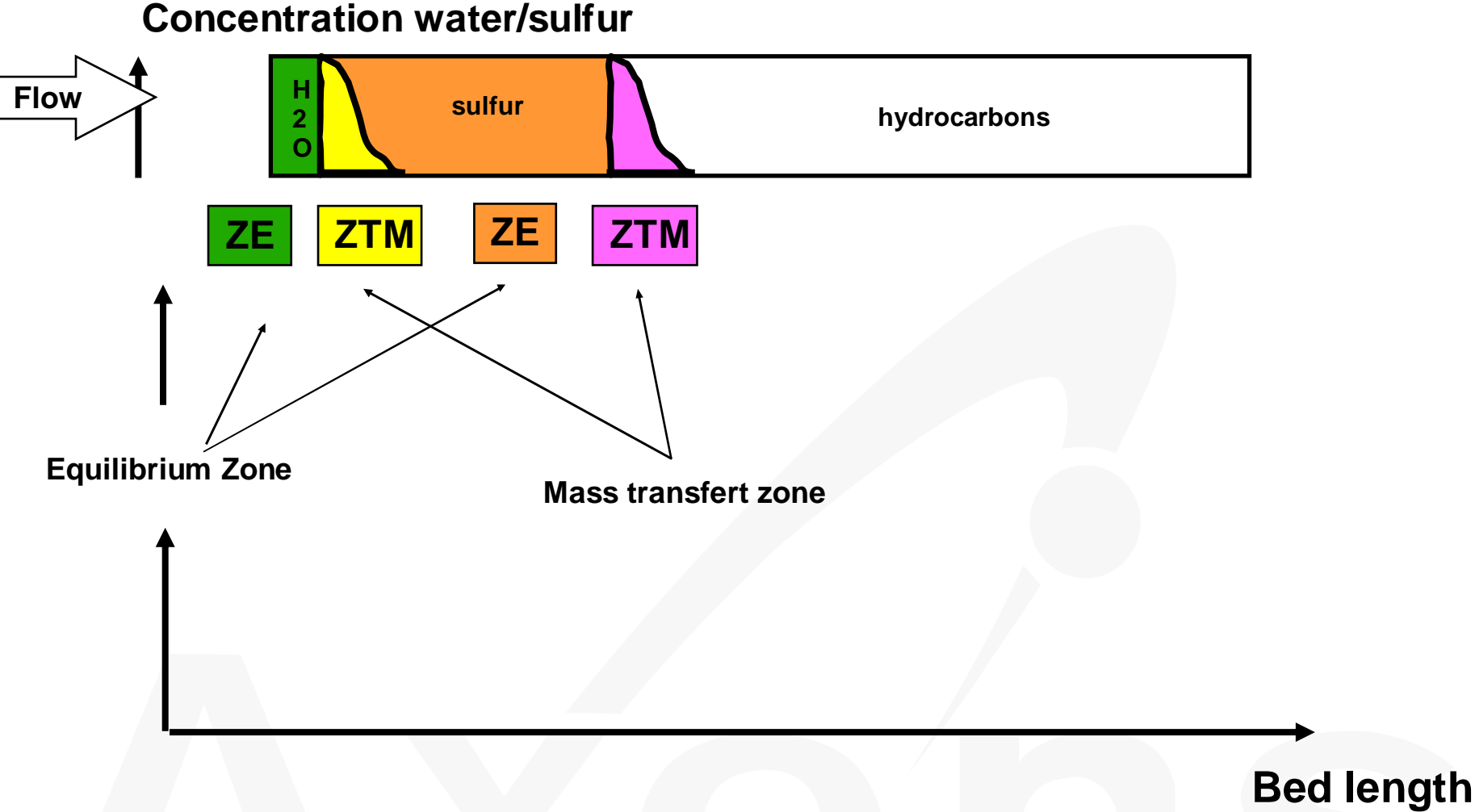


Isotherm RSH Adsorption



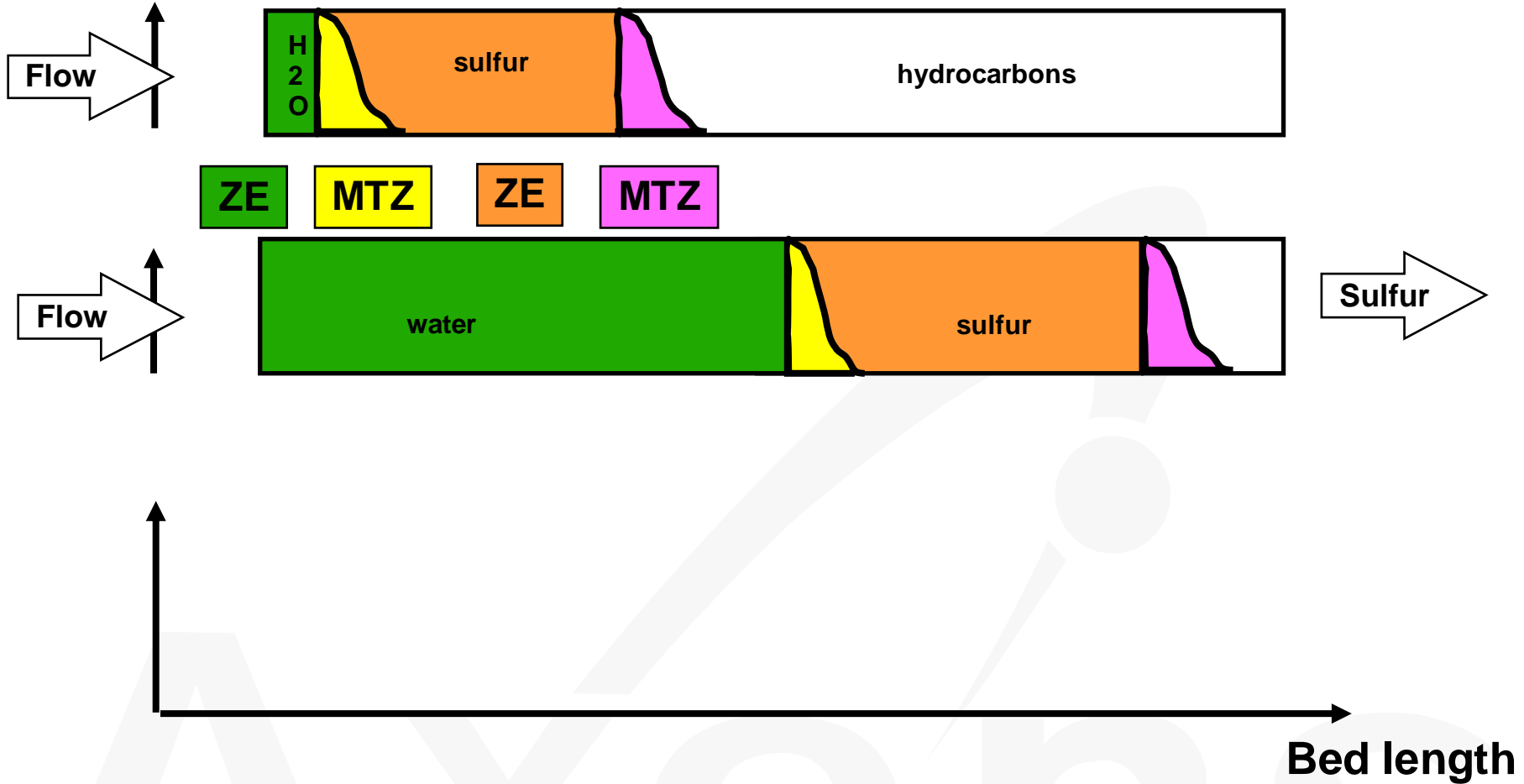
Low RSH capacity : not possible to remove RSH alone if RSH concentration > 100 ppm RSH

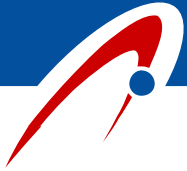




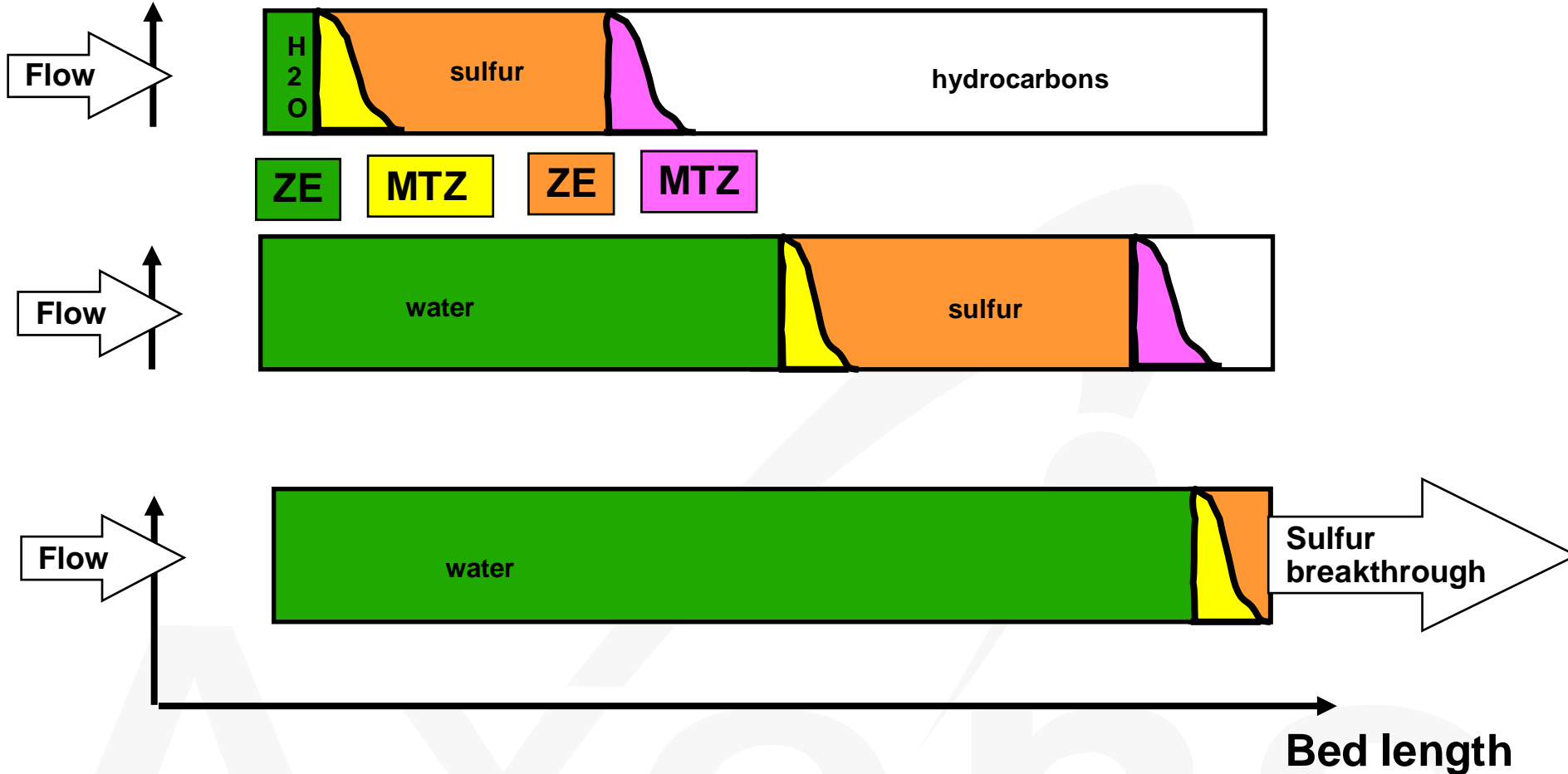


Concentration water/sulfur



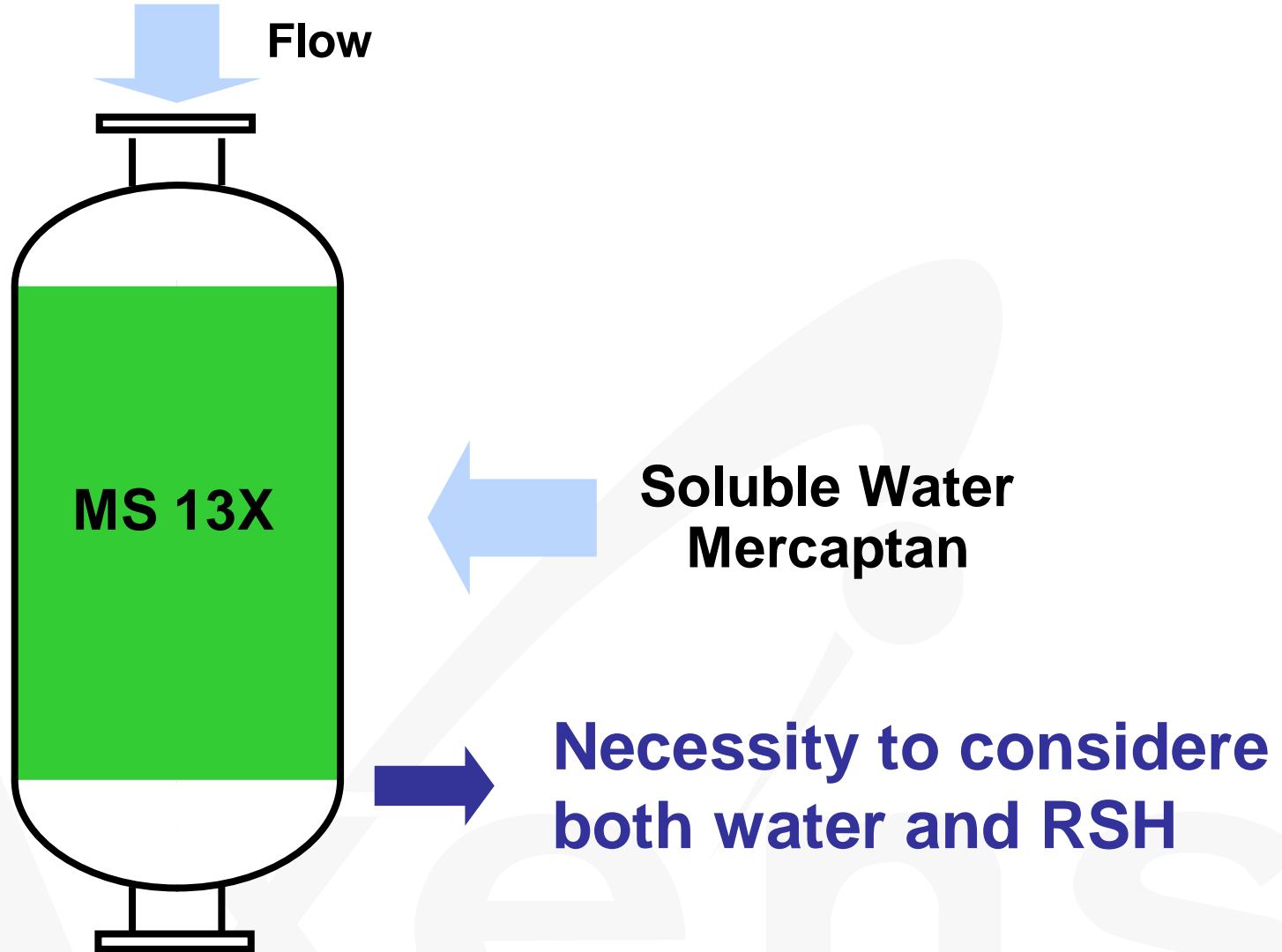


Concentration water/sulfur

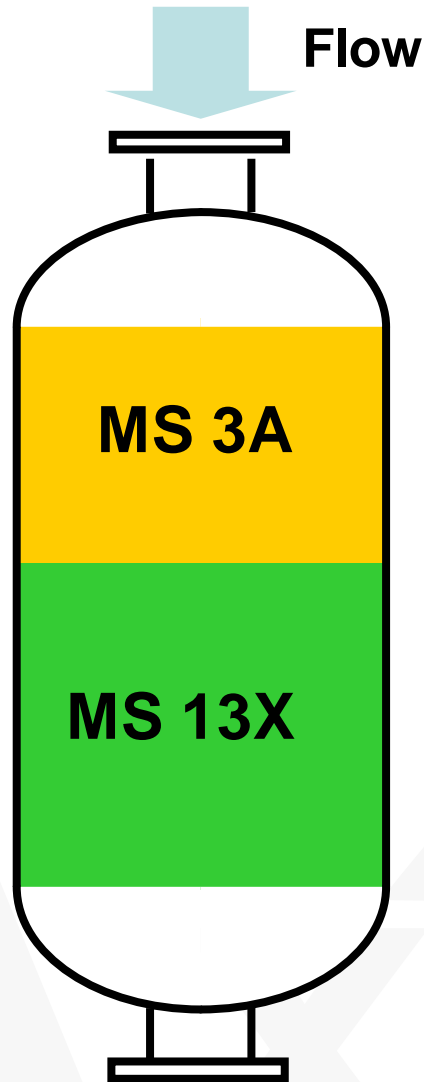


Necessity to remove water before RSH

Molecular Sieves for Removing Water and Mercaptans



Multibed Systems for Removing Water and Mercaptans

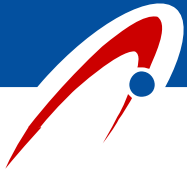


Adsorption of :

Soluble water

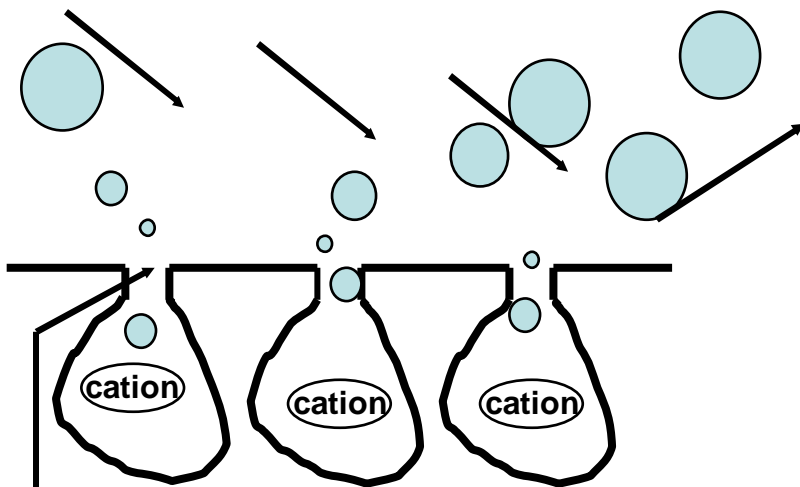
Mercaptan

Preferred configuration



Molecular Sieve vs Activated Alumina

Molecular Sieves



Pore size

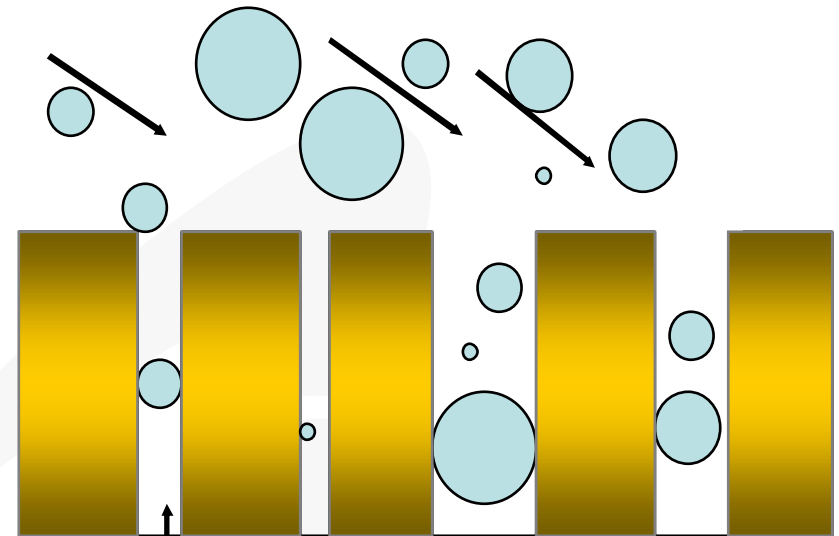
MS 3A : 3 angstroms

MS 4A : 4 angstroms

MS 5A : 5 angstroms

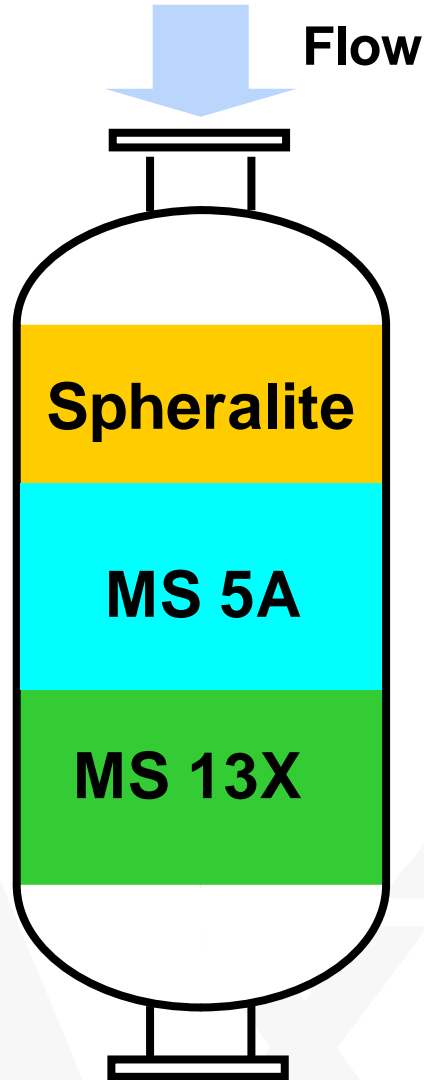
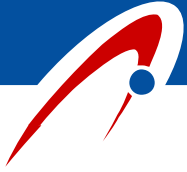
MS 13X: 8 angstroms

Activated Aluminas



Pore size : 20- 60 angstroms

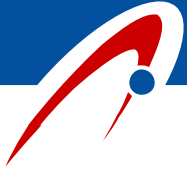
Multibed Systems for Removing Water and Mercaptans



Adsorption of:

**Soluble water
Free water**

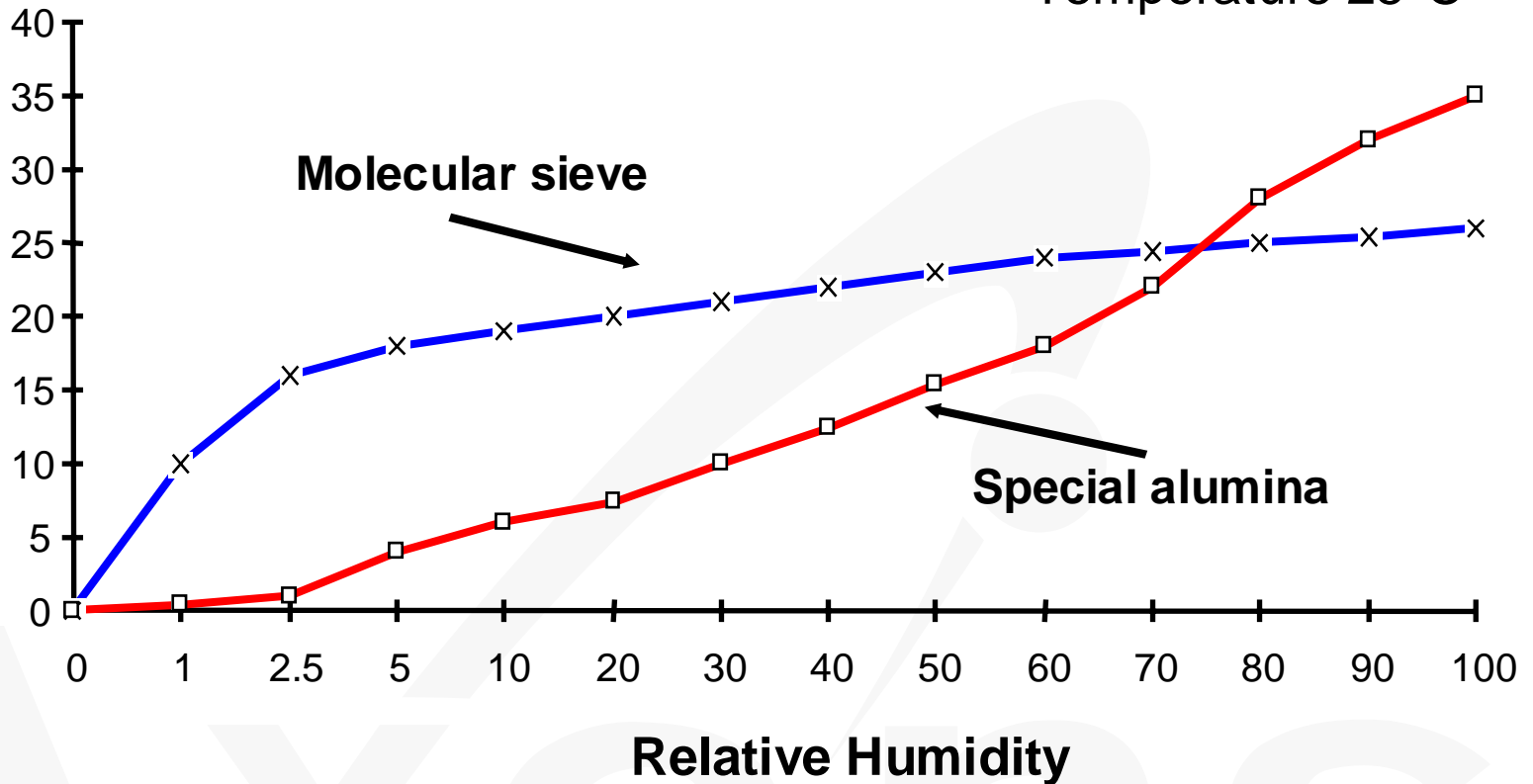
**Soluble Water
Mercaptan**

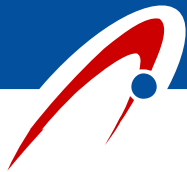


Isotherm Water Adsorption

Static adsorption capacity
(Kg of H₂O /100 Kg of MS)

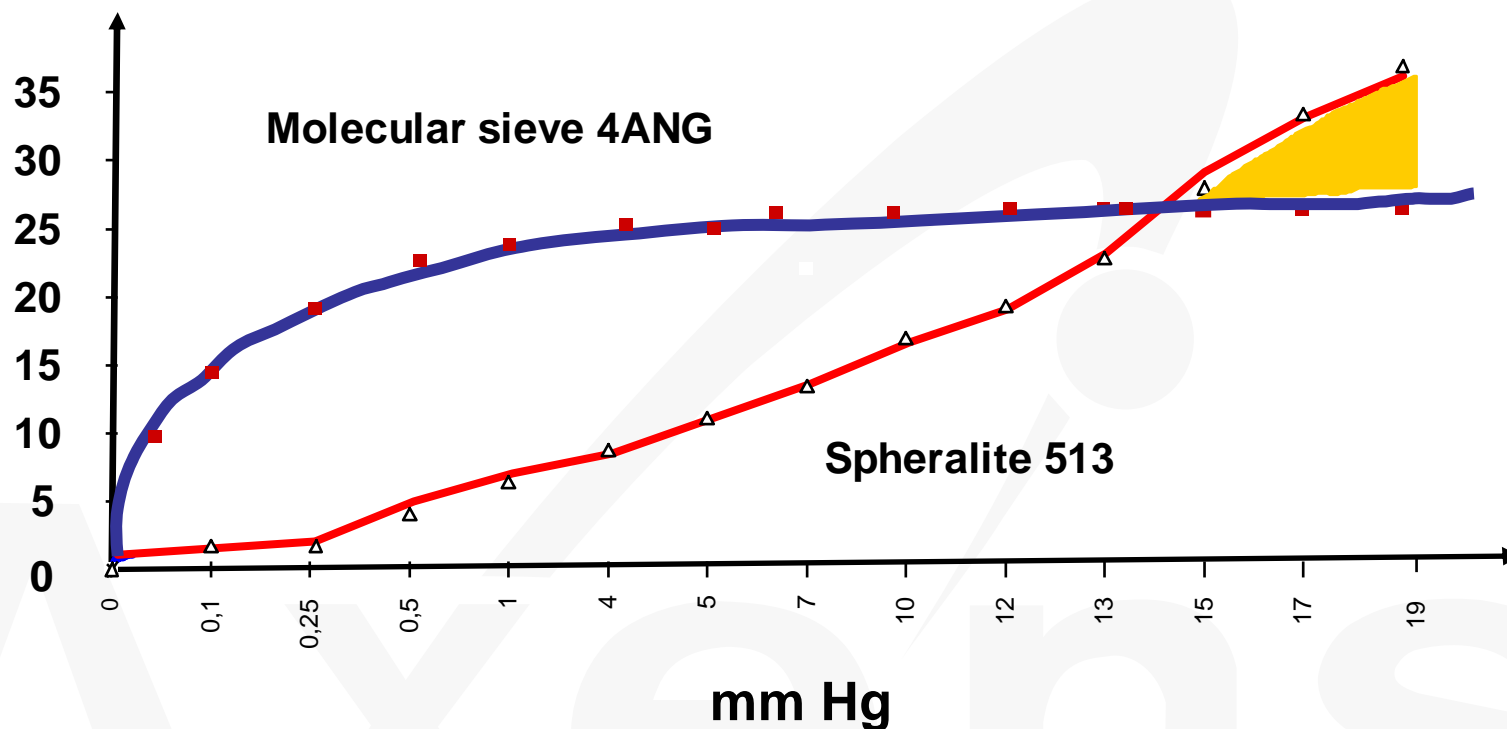
Temperature 25°C





Temperature 25°C

Static Adsorption Capacity (Kg of H₂O /100 Kg of MS)



Conventional Scheme Water Loading Profile



Water Loading



Bed Length

Equilibrium Zone

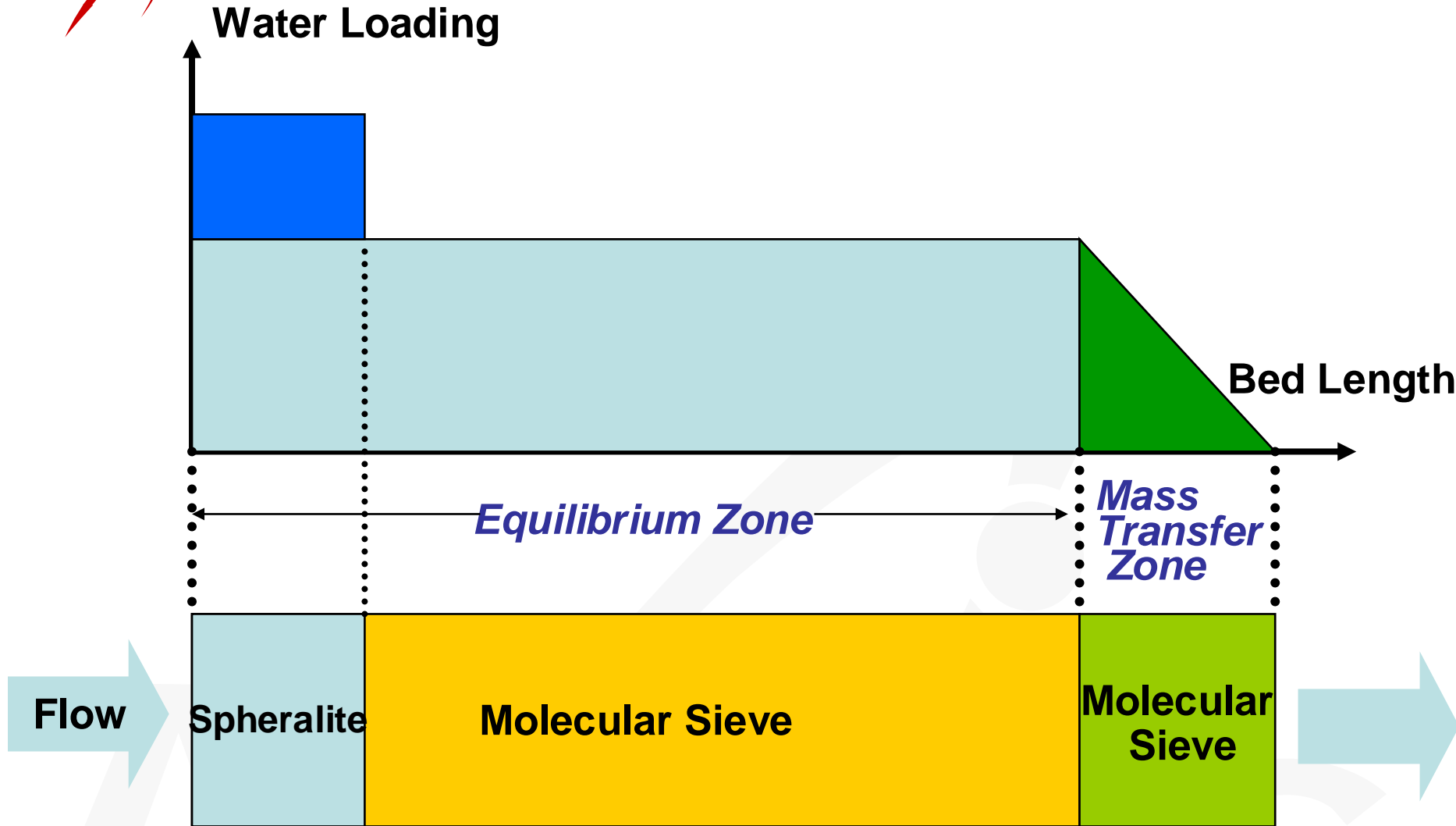
Mass Transfer Zone

Flow

Molecular Sieve

Molecular Sieve

Multibed™ Scheme Water Loading Profile



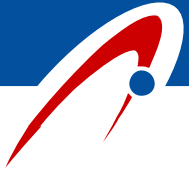
Real increase of capacity



The Spheralite used in the upper section of the equilibrium zone does not increase the co-adsorption of hydrocarbons as compared to a molecular sieve system



- **Axens' complete offer for gas treatment, together with Prosernat**
- **Proven technologies that allows optimizing project's economics and performances**
 - **H₂S removal : Amine Treatment & Molecular Sieves**
 - **Drying unit : Glycol Treatment & Molecular Sieves**



- **Appropriate solution for any contaminant**
- **Efficient adsorbent technologies for drying and purification**
- **Wide experience in feedstock purification for petrochemicals, refining, natural gas and chemical industries**
- **On-going research and development**