

***Axens Multibed™
Systems
for the
Dehydration of Natural
Gas***

G rard Jochem

Contaminants in natural gas

- ❑ **CO₂**
- ❑ **H₂S**
- ❑ ***Mercaptan (RSH)***
- ❑ ***Carbonyl sulfide (COS)***
- ❑ ***Carbon sulfide (CS₂)***
- ❑ **H₂O**
- ❑ **Hg**

**The degree of removal depends on
downstream requirements**

**In LNG plants contaminants
must meet the following limits**

- ✘ **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)**

The aging of molecular sieves leads to loss of adsorption capacity and deterioration of mechanical properties

Causes of Aging

- Insoluble water***
- Liquid entrainment (hydrocarbon, water)***
- High water partial pressure at high temperature (above 150°C)***
- Amine carryover***
- CO₂, Carbonic acid formation***
- H₂CO₃ + (Na⁺, Ca⁺⁺, K⁺) → Na₂CO₃ - NaHCO₃ - CaCO₃ - K₂CO₃***
- Decomposition of mercaptans during regeneration***
- Presence of chlorides***
- Mercury***

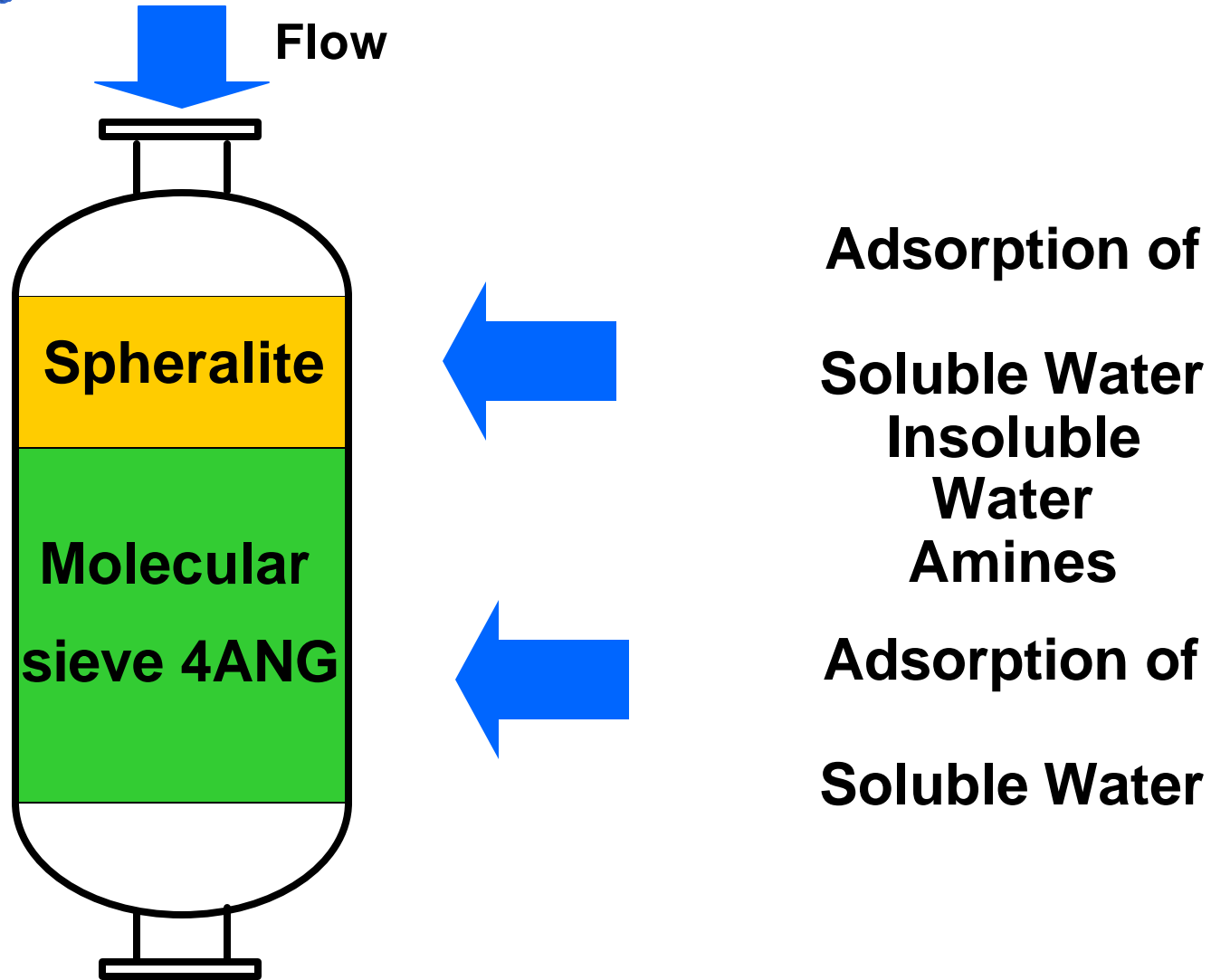
- **Solution**



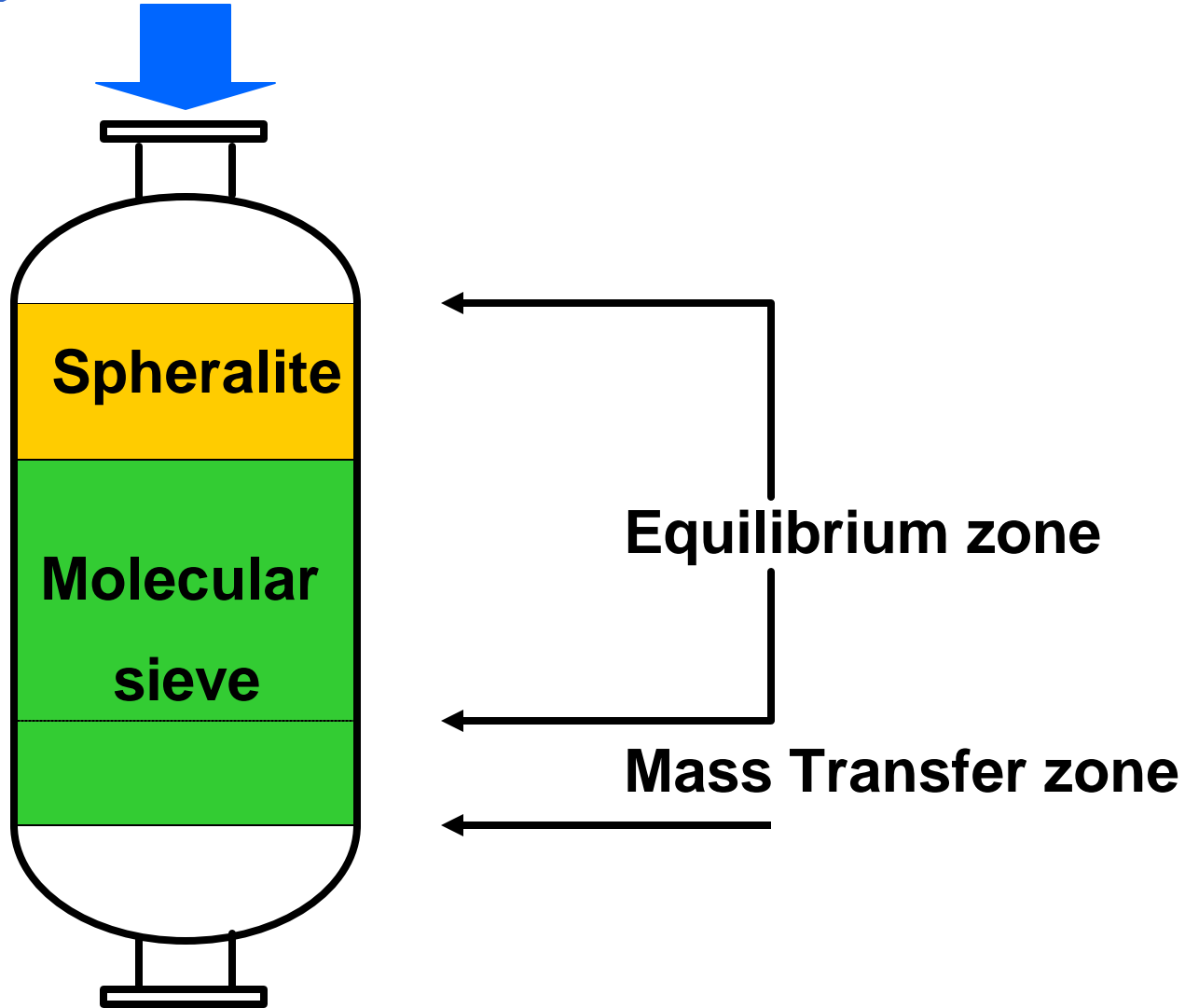
Axens Multibed™ technology!

- **Technology uses the synergy generated by combining aluminas and molecular sieves**
- **Liquid, Gas and Natural gas streams**
- **Dehydration**
- **Contaminant removal**

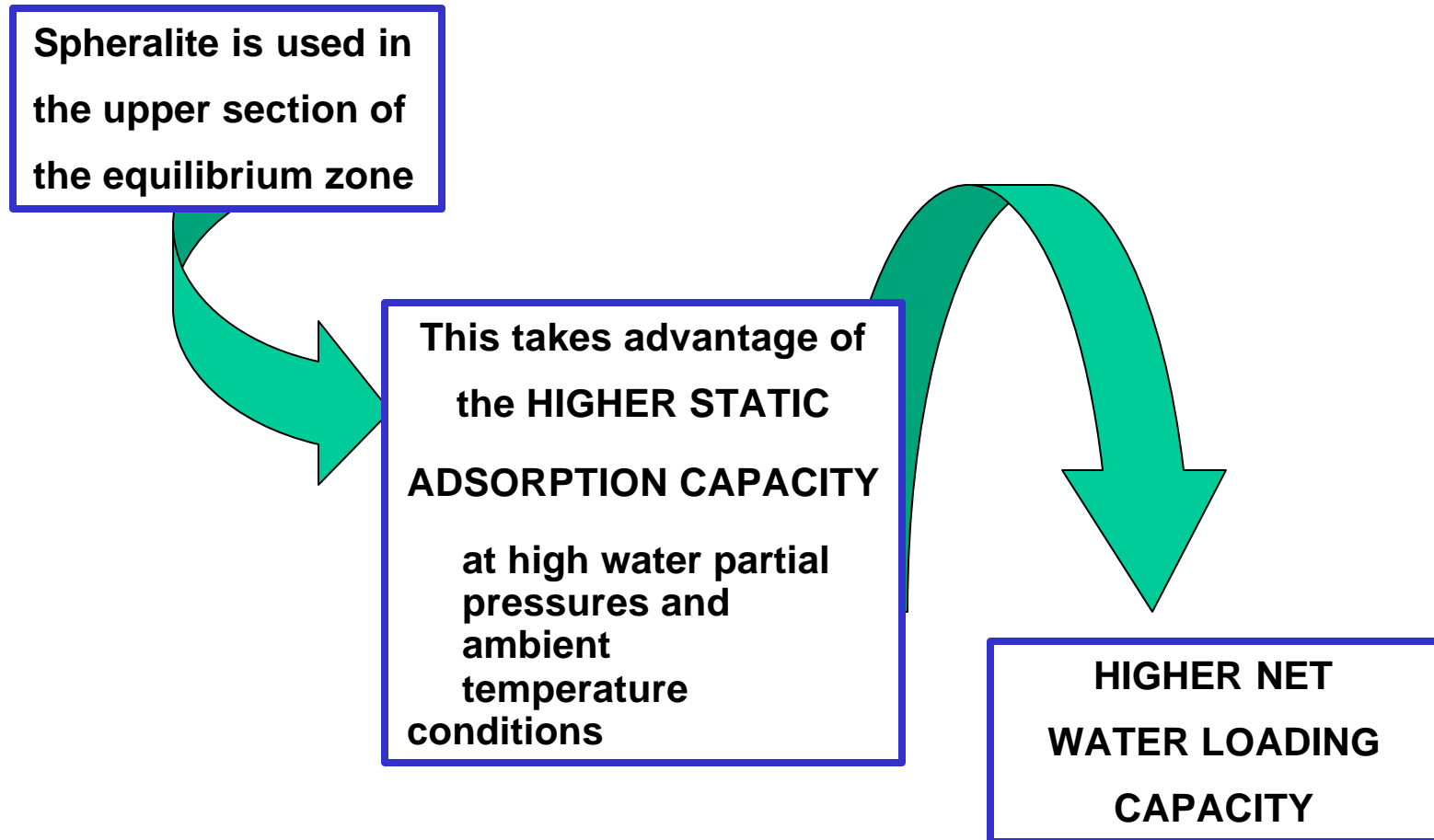
Multibed System: Dehydration



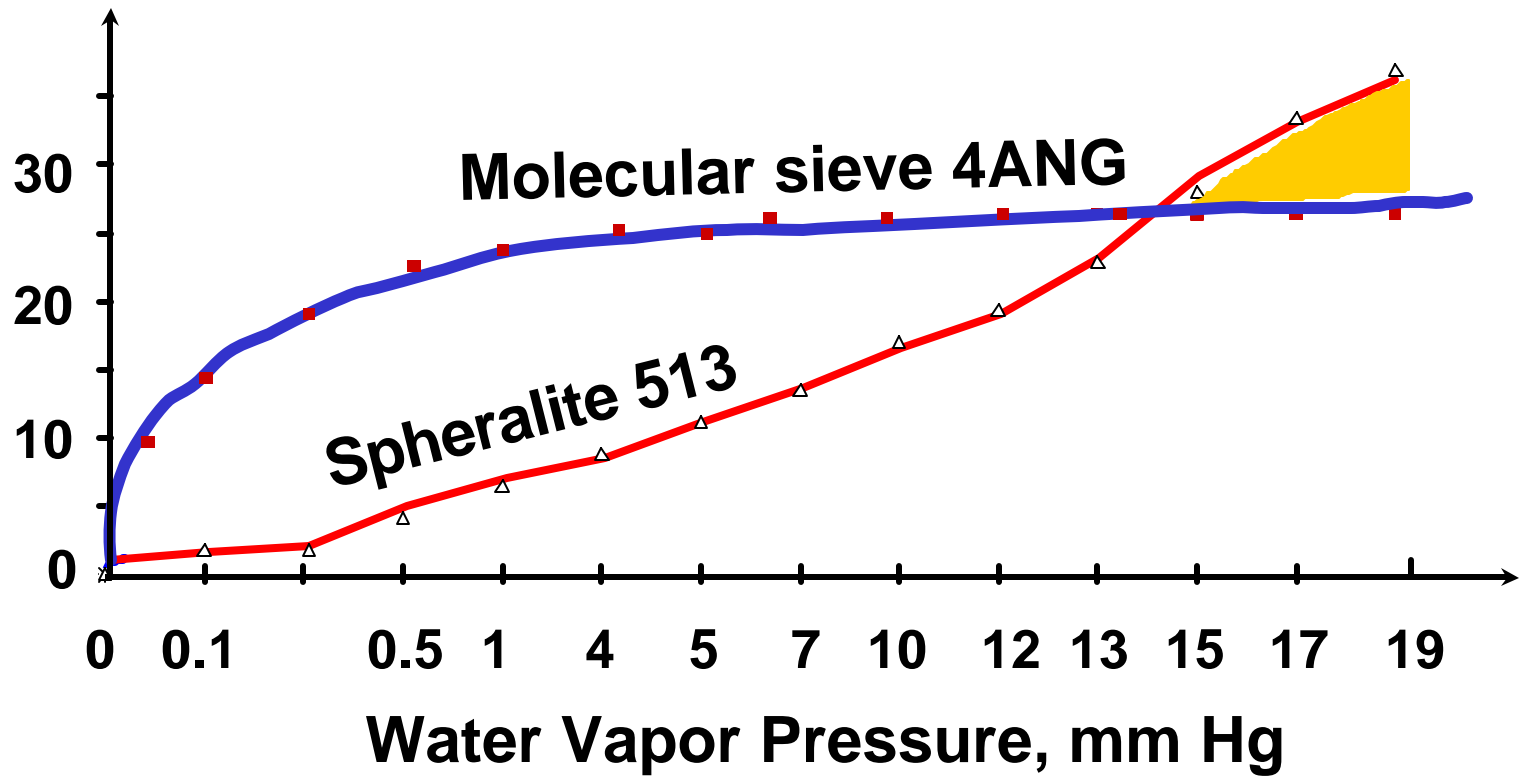
Multibed Dehydration Zones



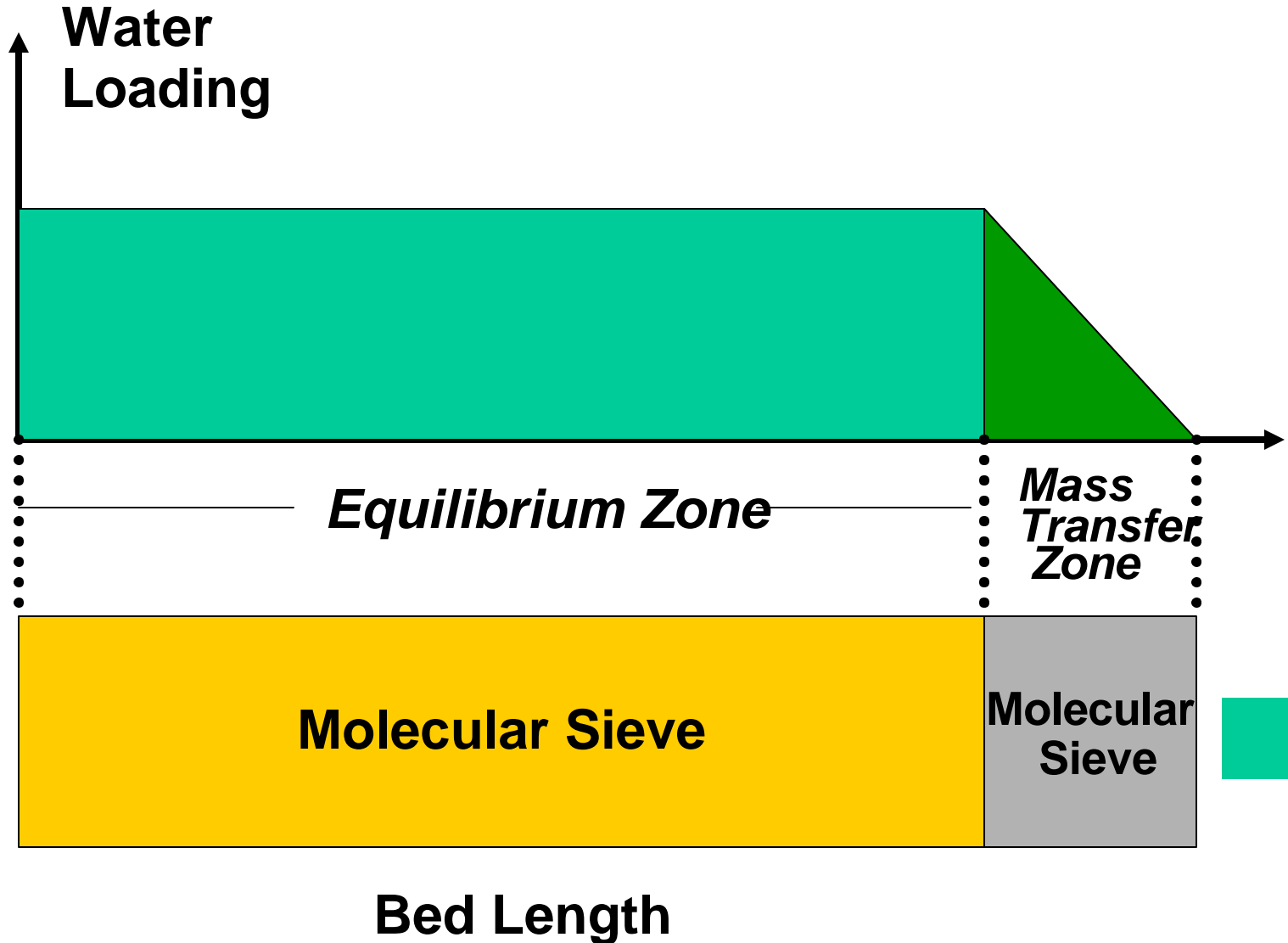
Multibed System for Dehydration



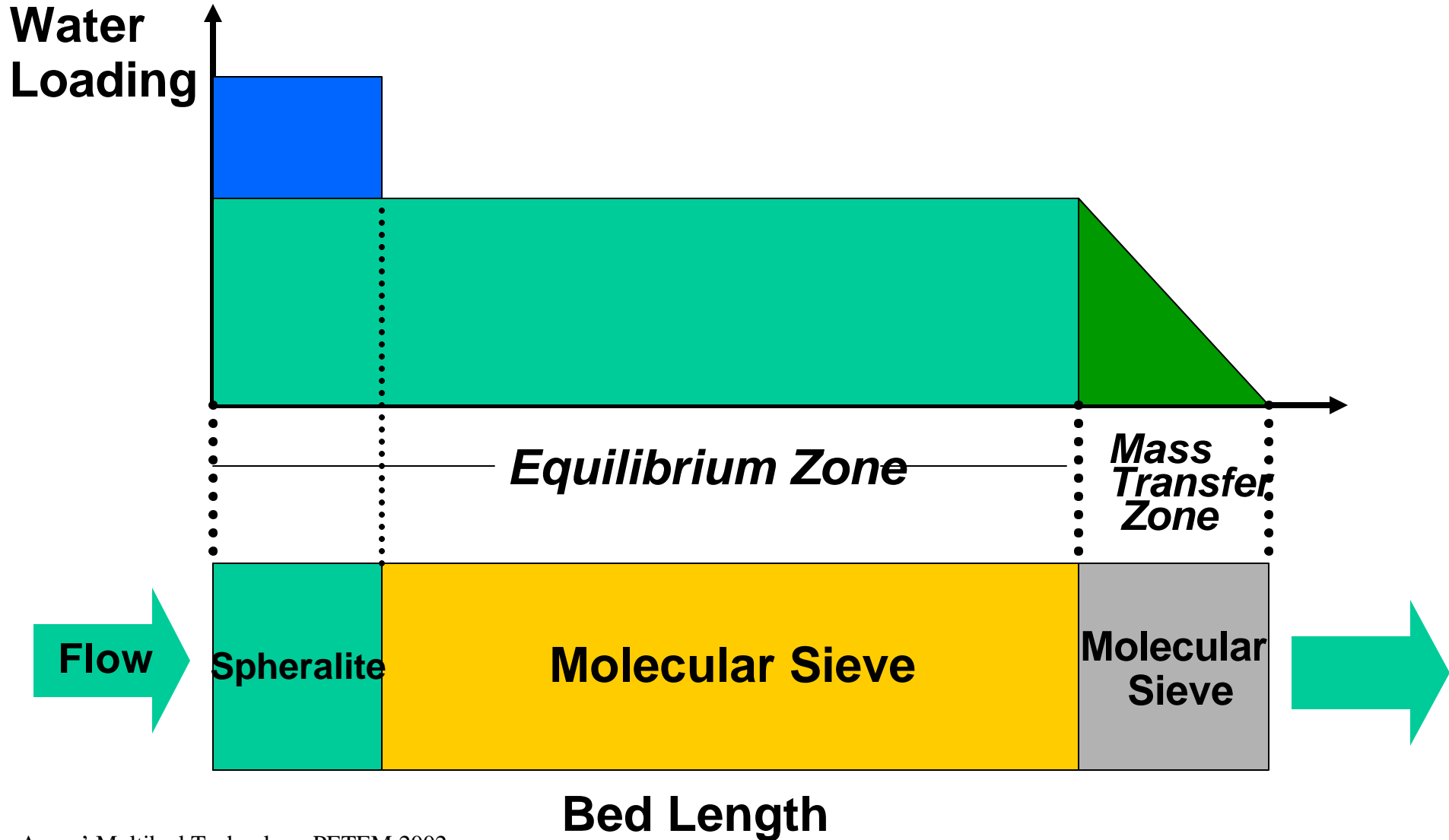
**Static Adsorption Capacity at 25°C,
kg H₂O / 100 kg MS**



Water Loading Profile for Conventional Scheme

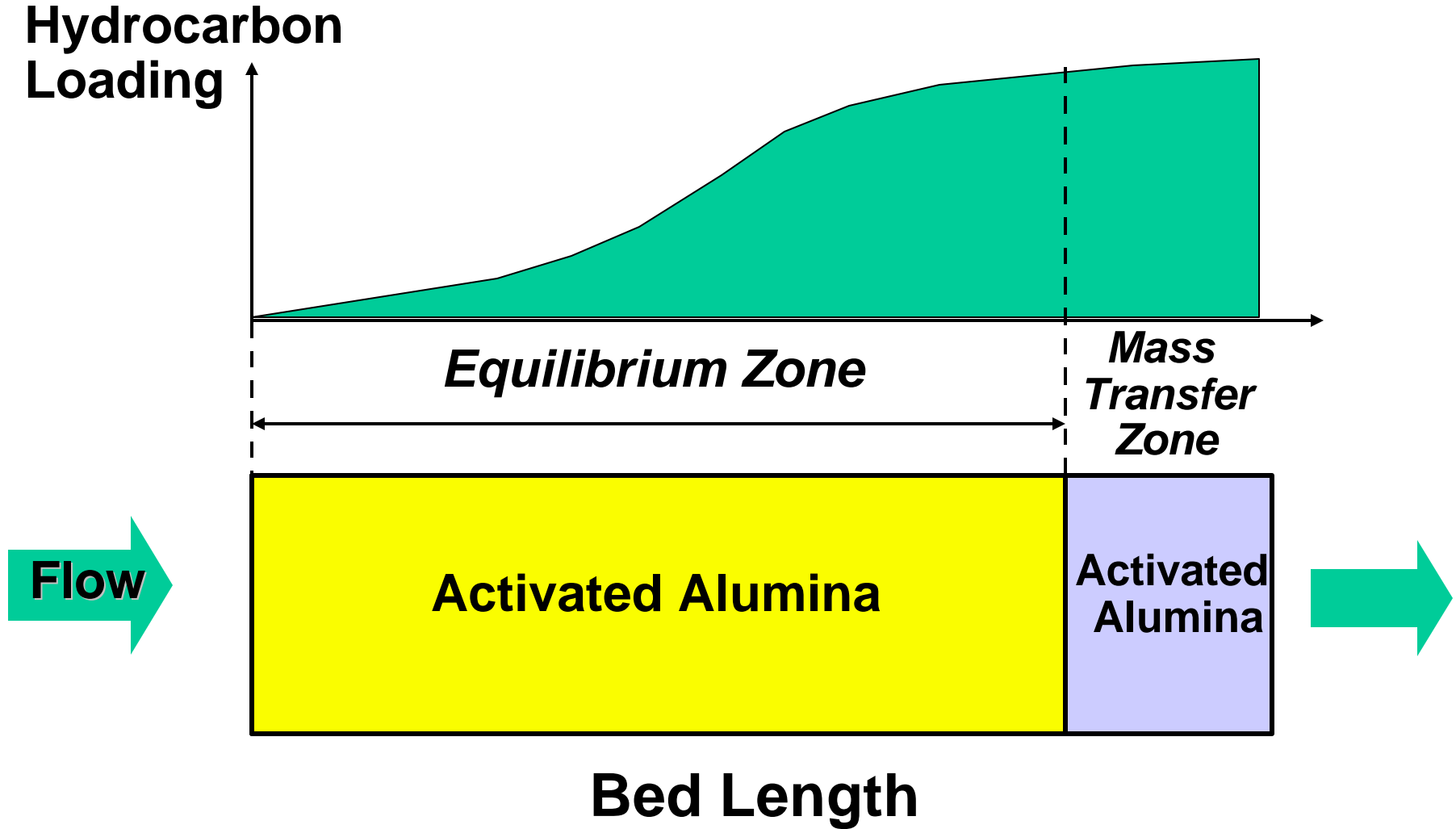


Water Loading Profile for Multibed Scheme

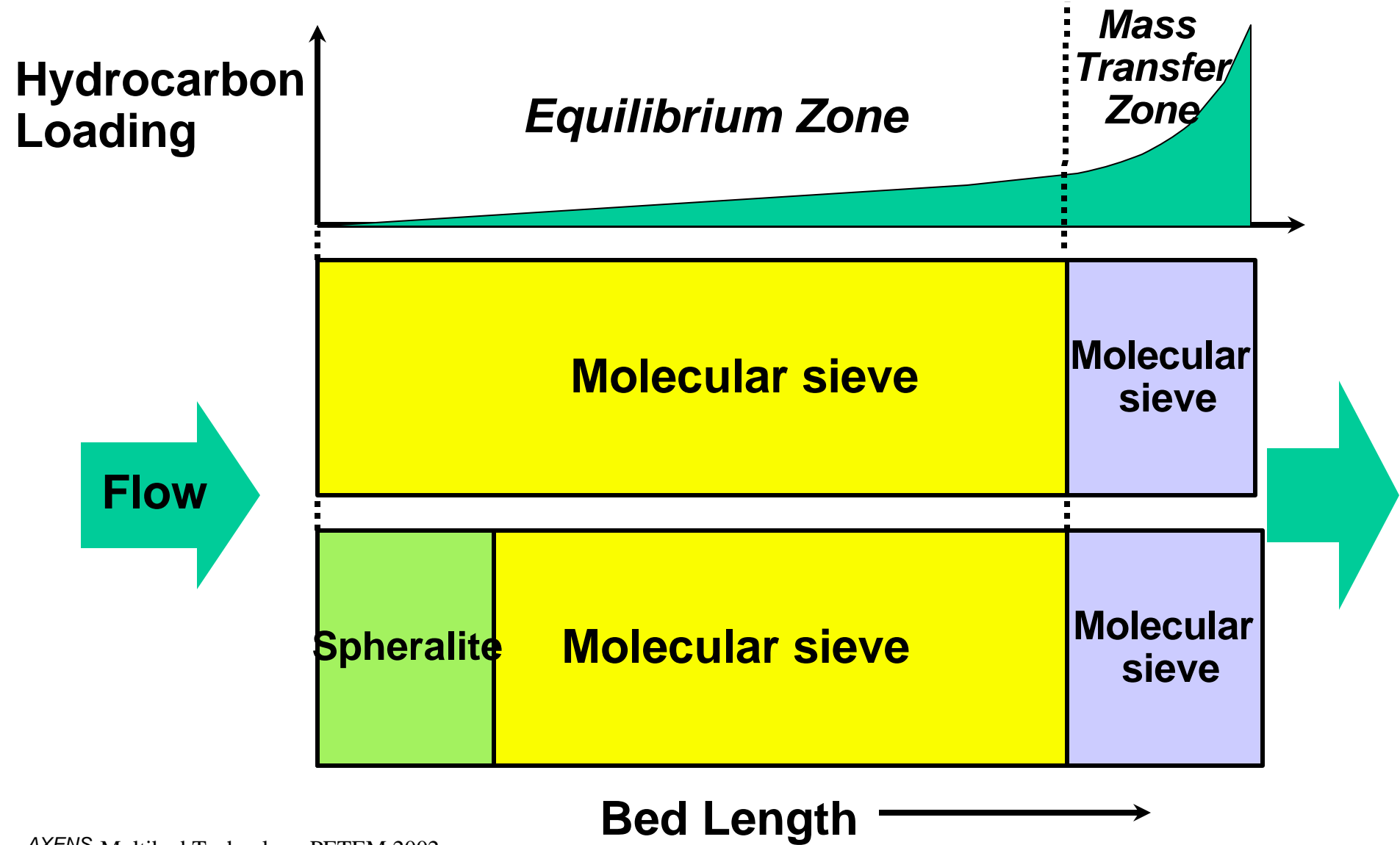


The Spheralite used in the upper section of the equilibrium zone does not increase hydrocarbon co-adsorption as compared to a molecular sieve system.

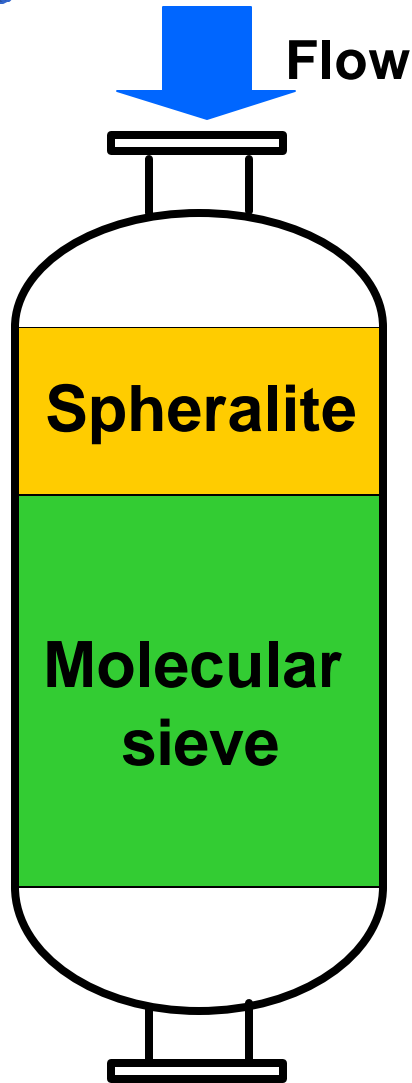
Hydrocarbon Co-adsorption on Activated Alumina Alone



Hydrocarbon Co-adsorption on MS Alone and Multibed



Multibed Purification System



**Hydrolysis of
COS**

Adsorption of:

**Soluble Water
Insoluble Water
Amines**

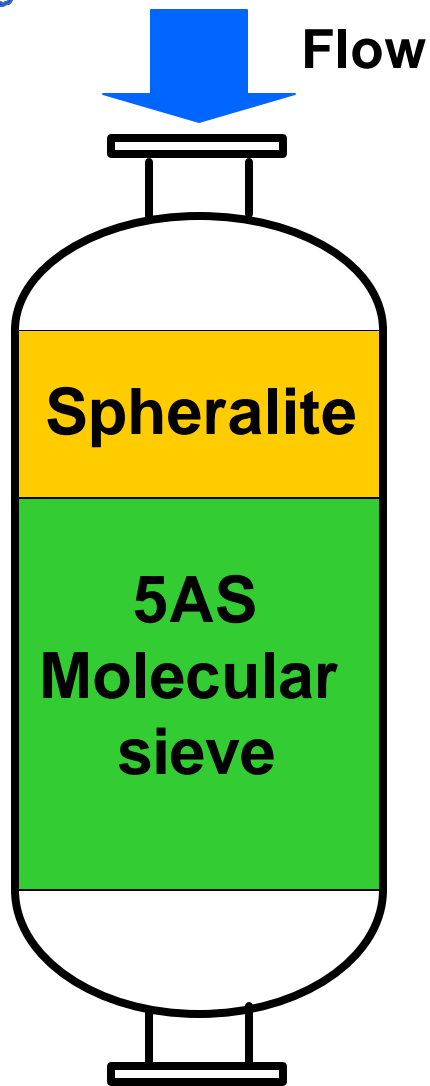
Heavy metals

Adsorption of:

**Soluble Water
Sulfur species
COS, H₂S, CO₂, NH₃**

- Dehydration and purification are linked
- Use of Spheralite in upper section of the adsorbent bed provides:
 - ❑ Higher static adsorption capacity
 - ❑ Promotion of catalytic reaction
 - *COS hydrolysis*
 - *Chloride adsorption*
 - ❑ Adsorption of chemical species
 - *amines*
 - *heavy metals*

Multibed Systems for Removing Water and Light Sulfur Compounds



COS Hydrolysis

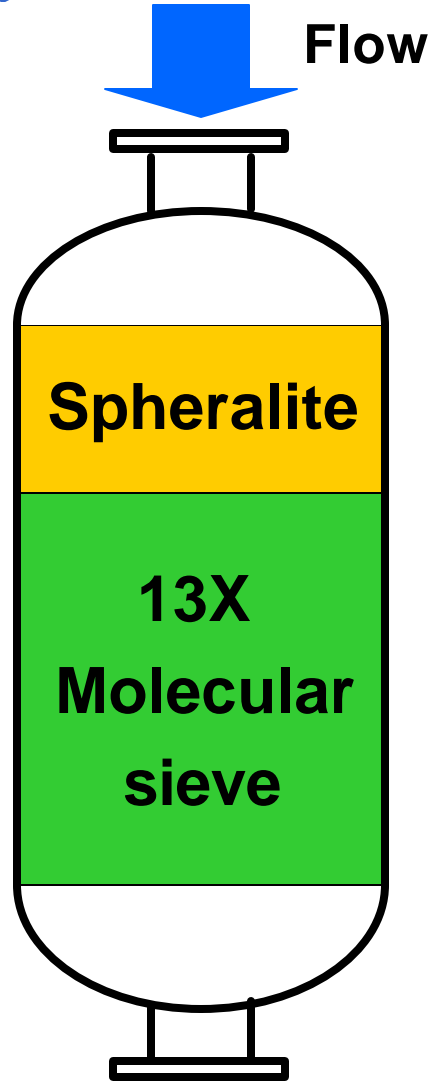
Adsorption of:

- Soluble water
- insoluble water

Adsorption of:

- Soluble Water
- H₂S, COS
- Light mercaptans

Multibed Systems for Removing Water and Mercaptans



Adsorption of:

- Soluble water
- insoluble water

er

Adsorption of:

- Soluble Water
- Mercaptan

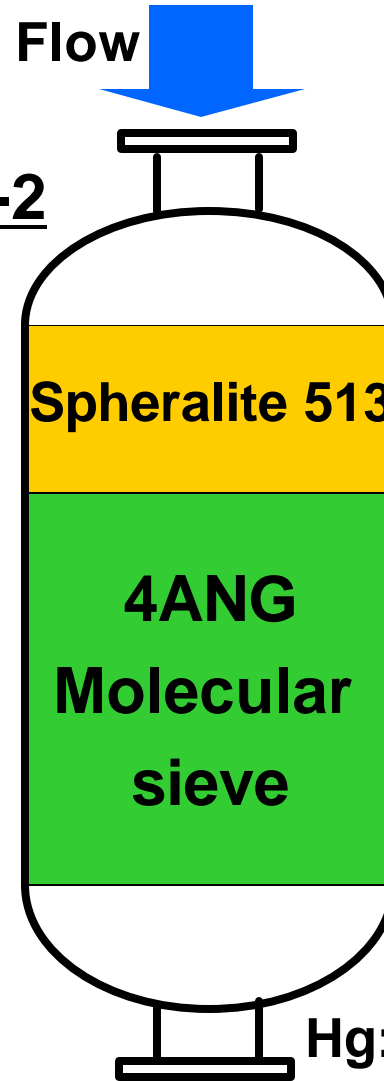
Multibed System for Water and Mercury Removal

Step-1



Hg: < 0.01 $\mu\text{gr}/\text{Nm}^3$

Step-2

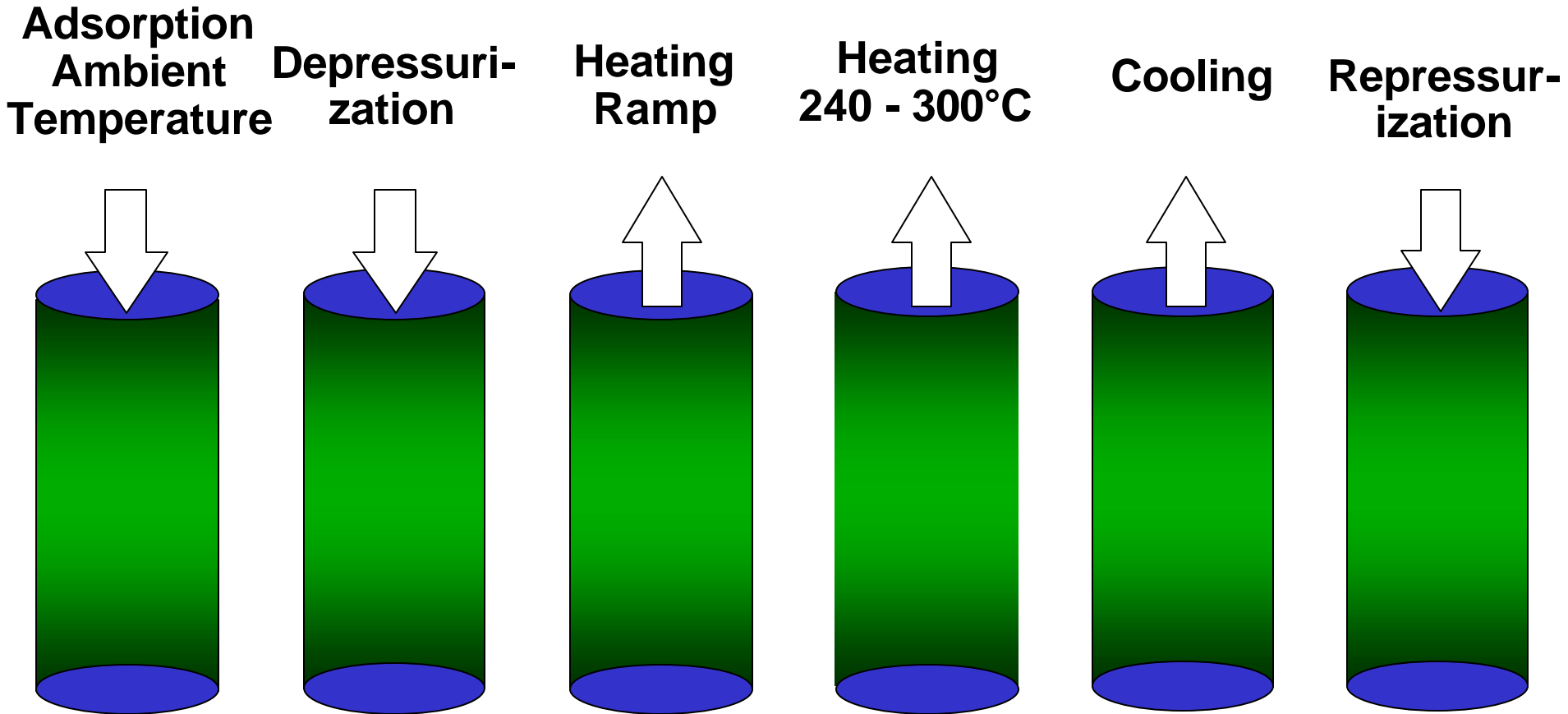


Hg: < 0.01 $\mu\text{gr}/\text{Nm}^3$

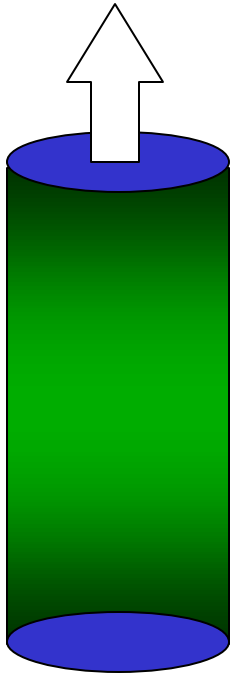
Water: < 0.1 ppmv

Dryers

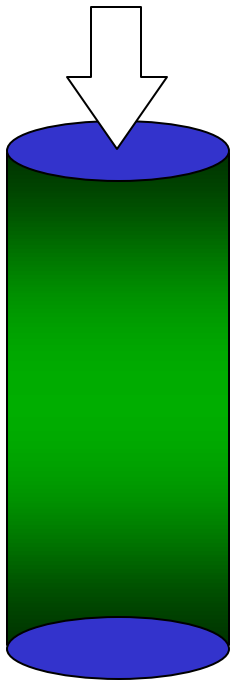
In natural gas treatment, Multibed technology uses the same operating parameters as conventional molecular sieve systems for both adsorption and regeneration.



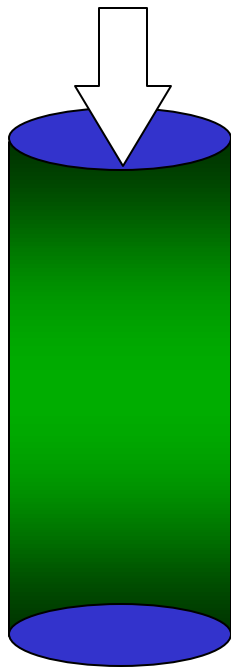
Adsorption
Ambient
Temperature



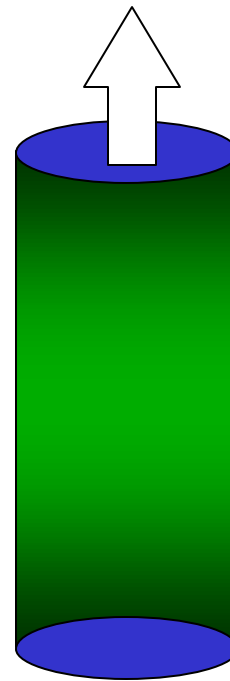
**Depressur-
ization,
Draining**



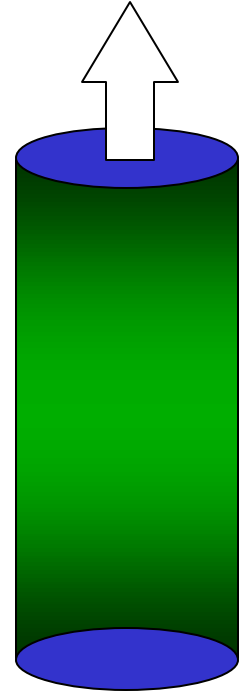
Heating
220 - 300°C



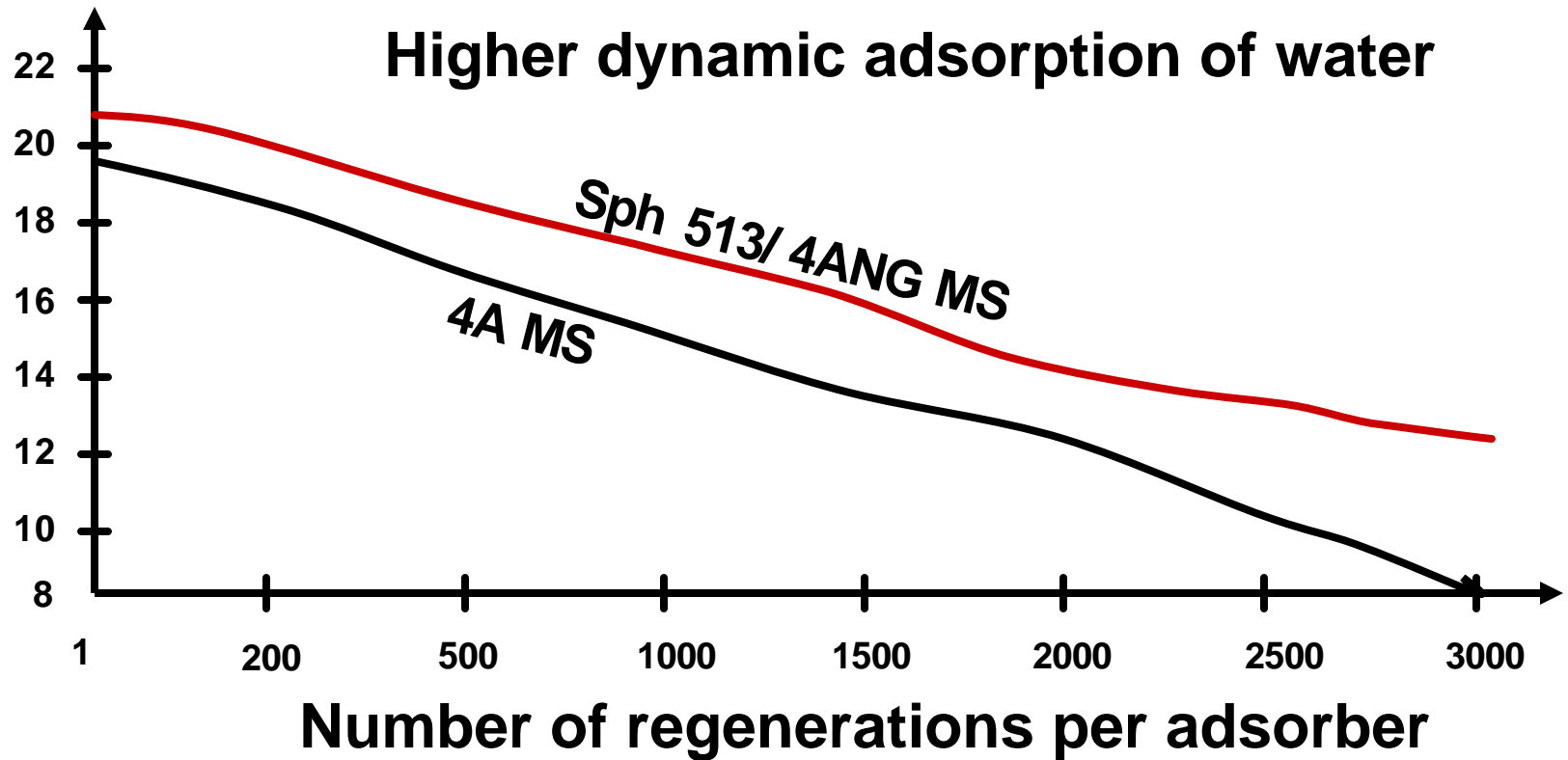
Cooling **Repressur-
ization**



Filling



Dynamic Adsorption
capacity, wt%



Ambient temperature, Water saturated feed Pressure: 50-60 bar

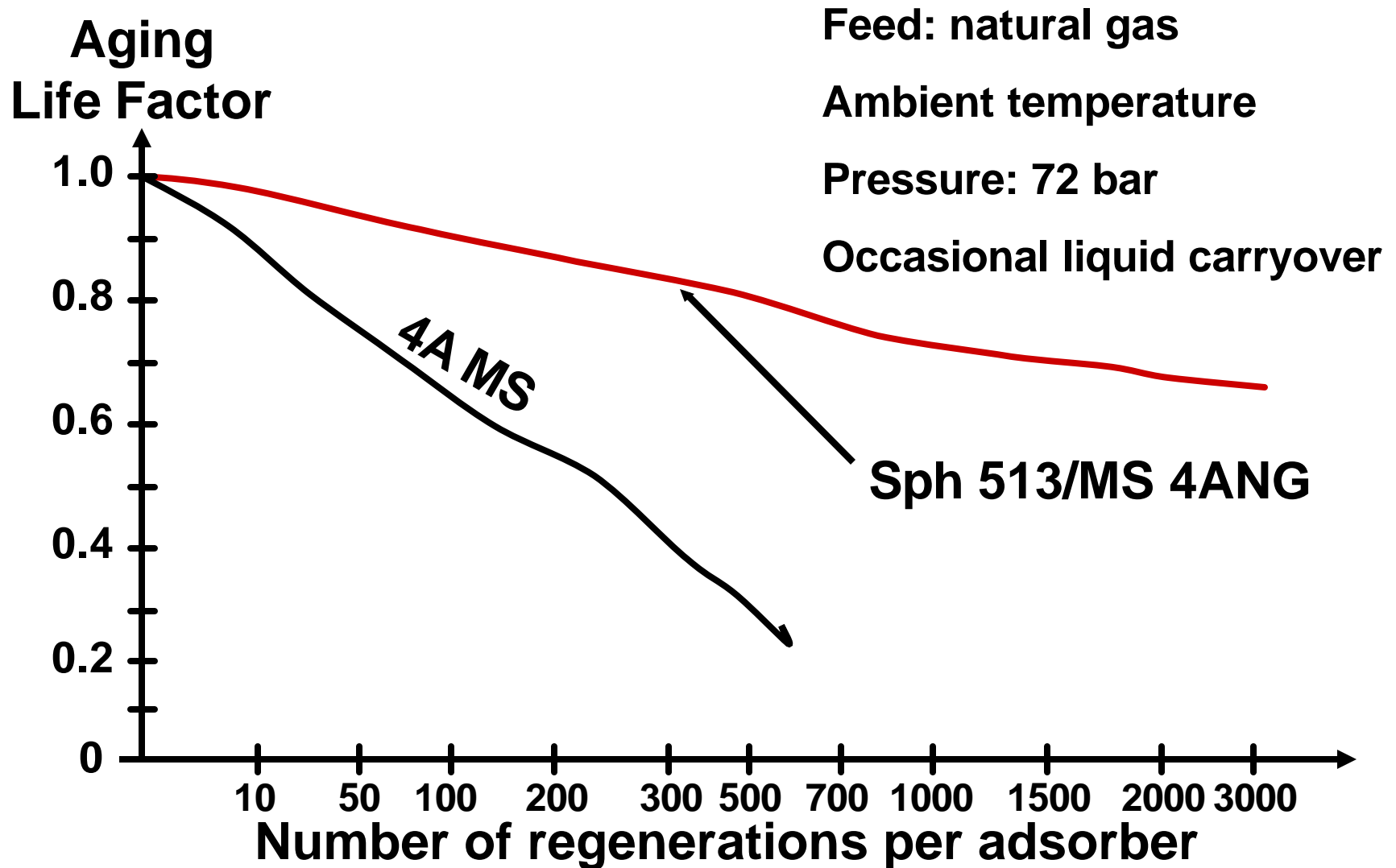
Adsorption phase

- ❏ Eliminates effects of free water, CO₂ and traces of amines**
 - prevents effect of free water on mechanical and adsorptive properties of the zeolite**
 - prevents carbonic acid formation in the presence of free water and CO₂**
 - Eliminates risk of salt formation resulting from the reaction of carbonic acid and the cation located in the zeolite crystal**

Regeneration step

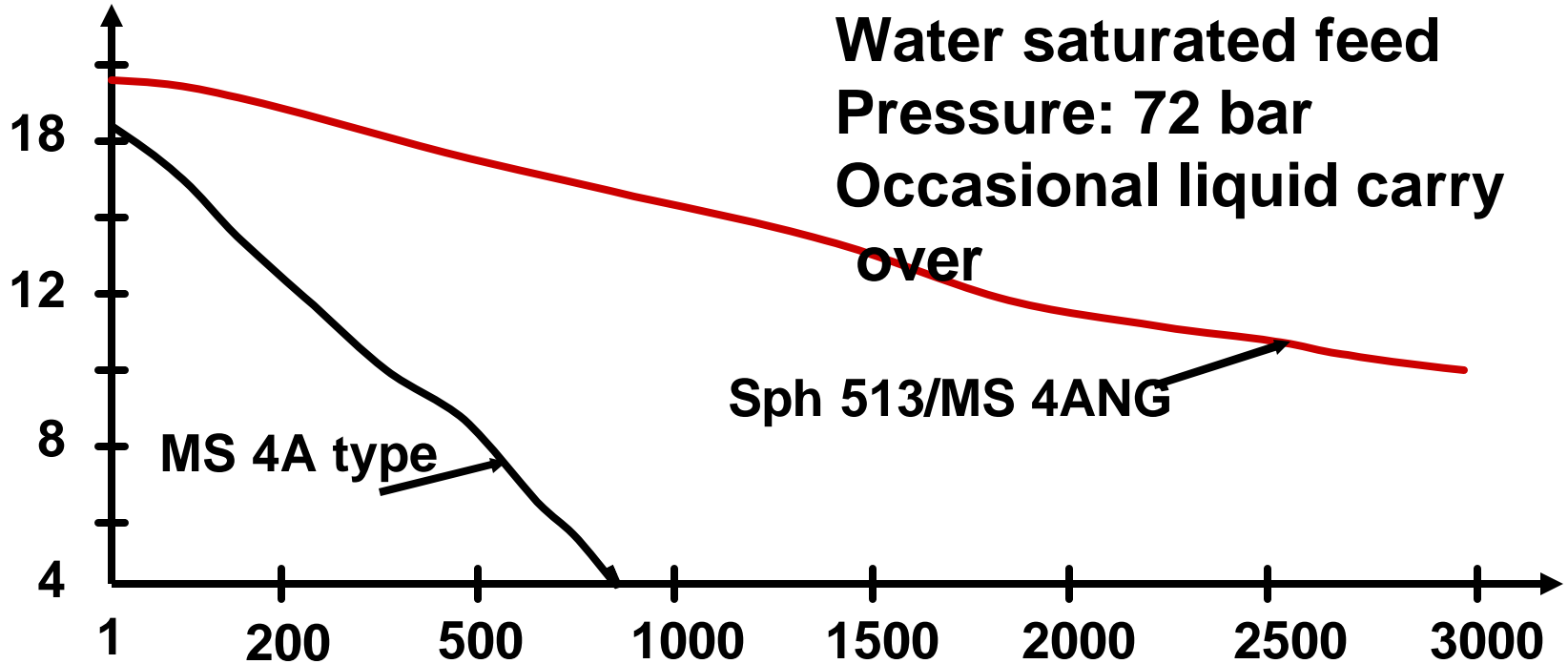
- ⊗ Minimizes aging of the adsorbent under high pressure regeneration conditions.**
 - The Spheralite resists the effect of water condensation occurring at start of heating step at the cold section of the adsorber.**

Natural gas	In (ppmv)	Out (ppmv)
<u>Dehydration</u>		
- H ₂ O	1300	< 0.1
<u>Purification</u>		
- H ₂ O	3300	< 0.1
- H ₂ S	120	< 5
- COS	20	< 5
- Hg	10 µgr/Nm ³	0.01 µgr/Nm ³



Multibed System Advantages

Dynamic Adsorption capacity, wt%



Commercial data

Ambient temperature

Water saturated feed

Pressure: 72 bar

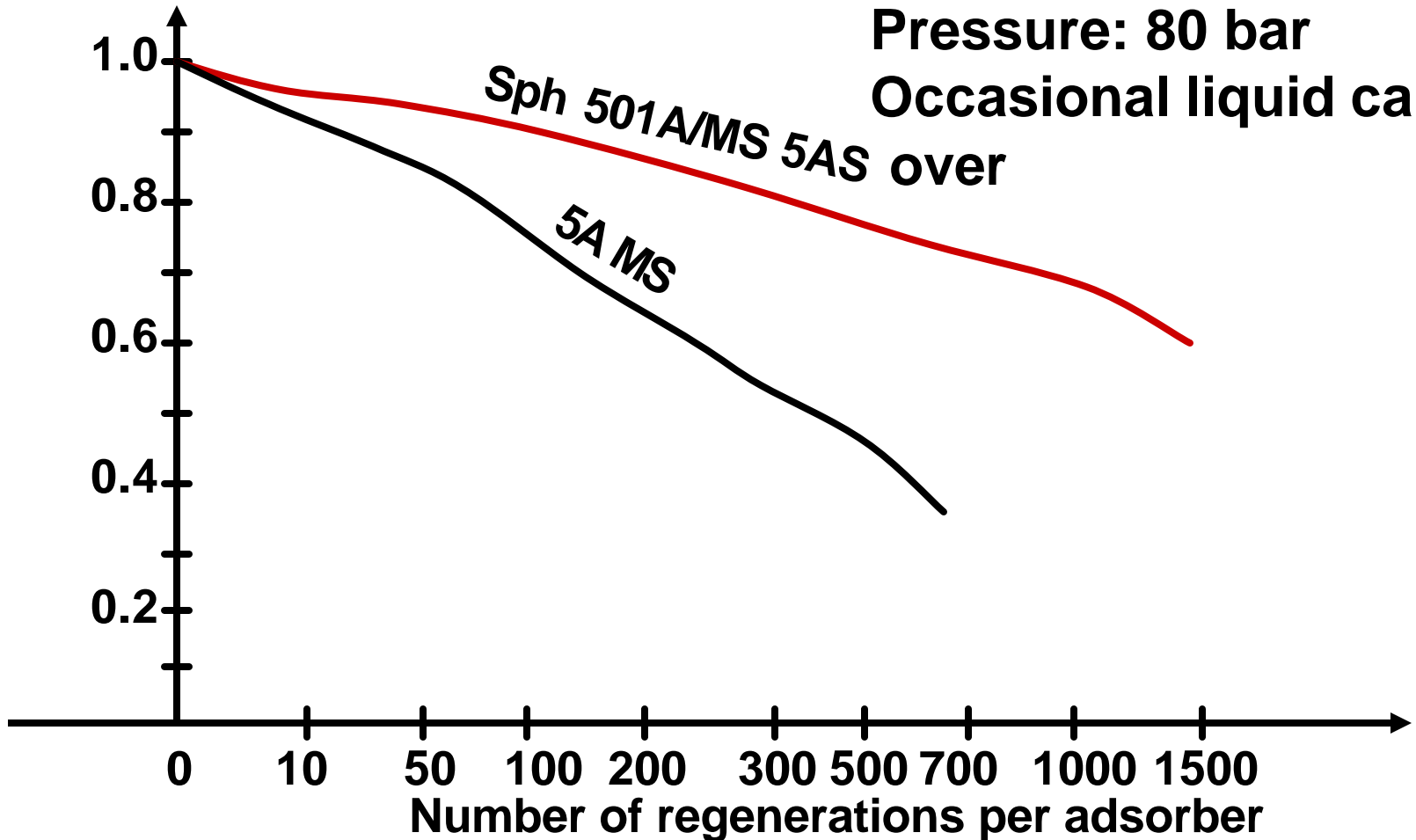
Occasional liquid carry over

Sph 513/MS 4ANG

Number of regenerations per adsorber

**Aging
Life factor**

**Feed: natural gas
Ambient temperature
Pressure: 80 bar
Occasional liquid carry**





**One single package for drying
and purification**



Improved adsorption capacity



Improved purification capability



Improved lifetime of adsorbents