Acid Gas / Sulphur Re-injection

A Layman's Overview

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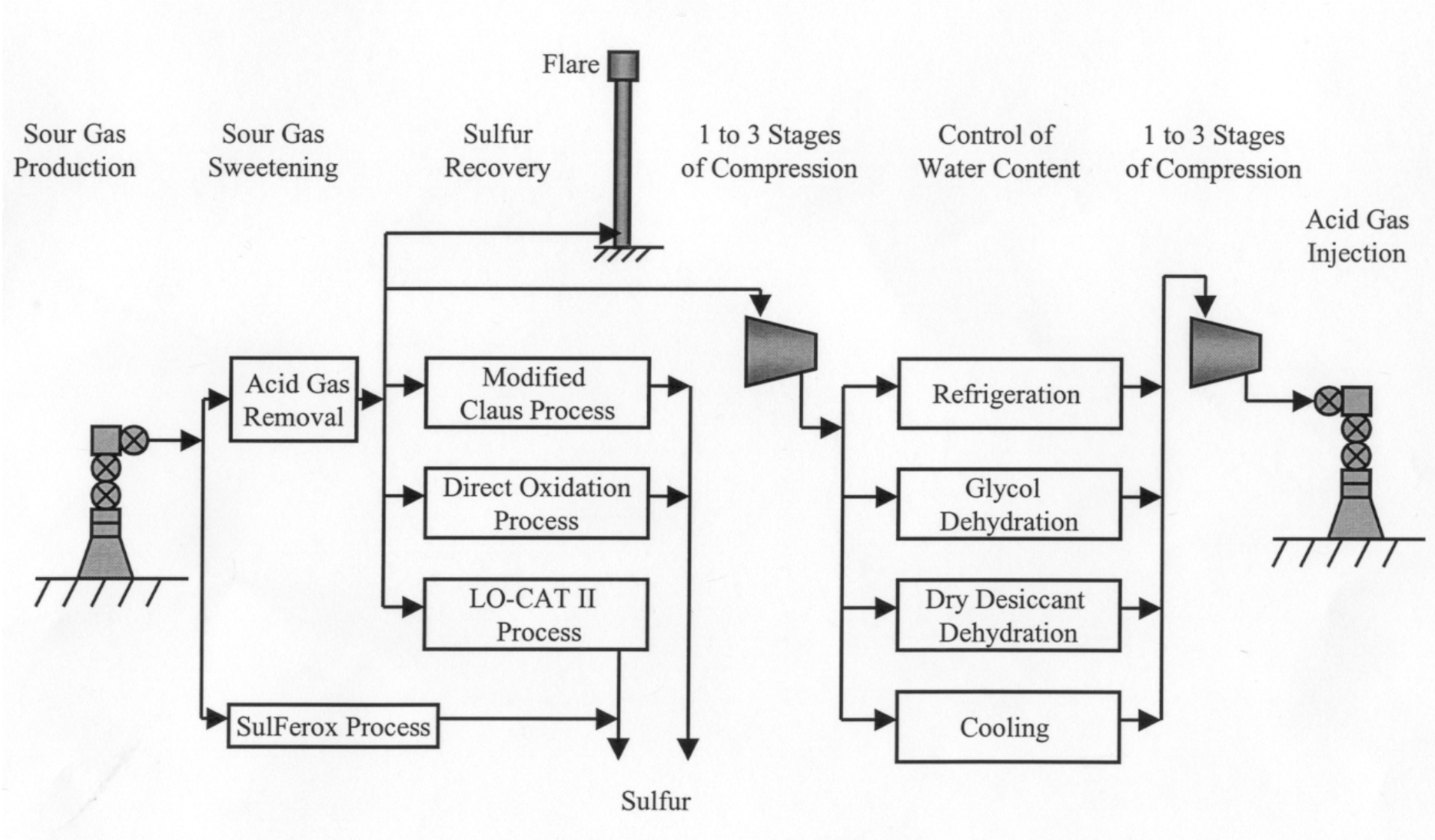
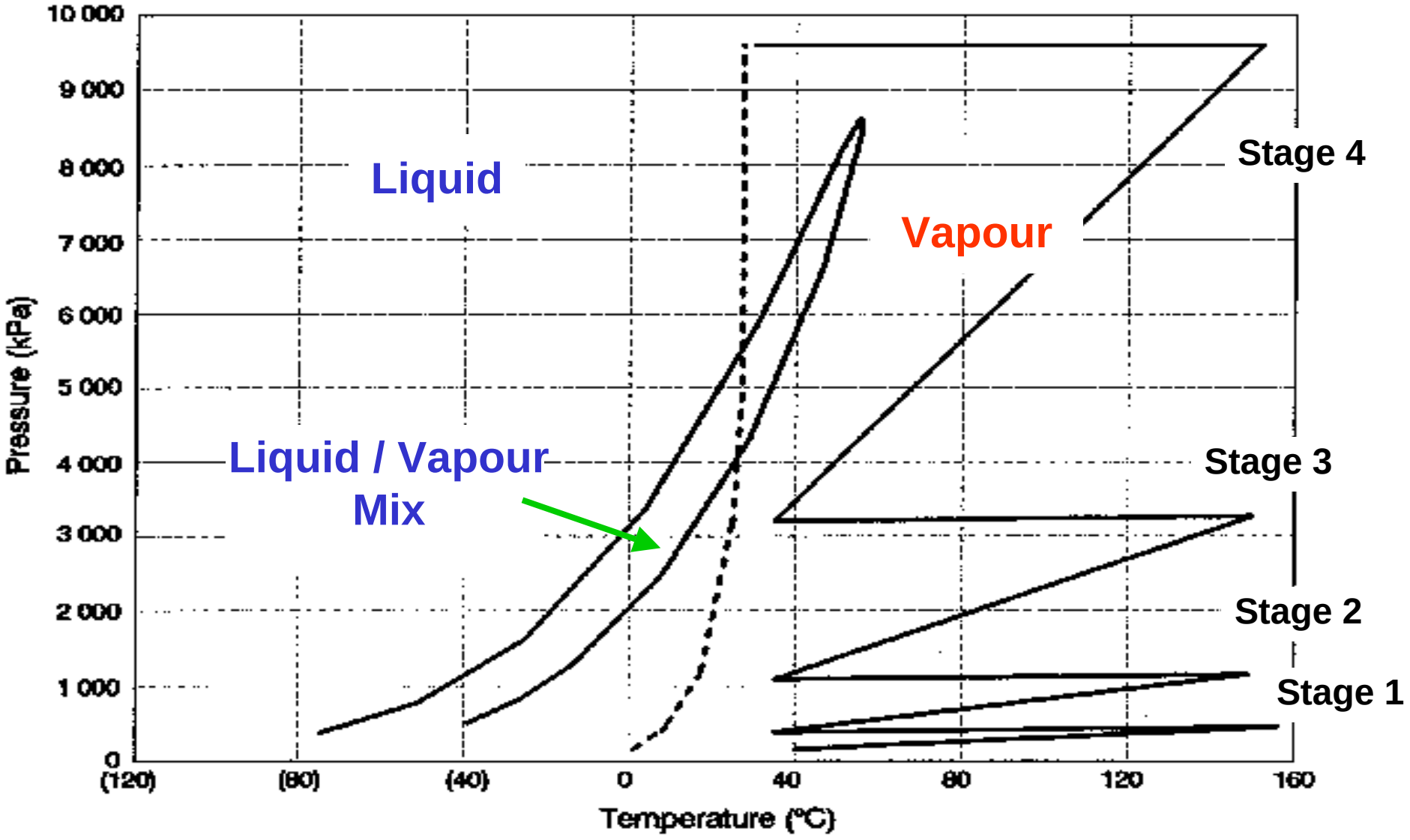
Acid Gas Injection - AGI

- Acid gas is the concentrated H_2S and CO_2 by-product that is removed from the raw gas by an amine unit during the sour gas processing
- Acid gas injection is a process that stores or disposes of the acid gas in an isolated subsurface reservoir
- 3 main processing systems used for injection in Western Canada
  - ➔ gas phase - compress gas to greater pressure than reservoir
  - ➔ liquid phase - compress gas & then cool to liquid phase - gravity fed or pump to reservoir
  - ➔ water soluble- inject into water / brine and pump into reservoir
- AGI is becoming more widely accepted:
  - ➔ Technically feasible and cost competitive
  - ➔ Reduces CO_2 & SO_2 (from H_2S) emissions
  - ➔ Reduces flaring - a significant public concern

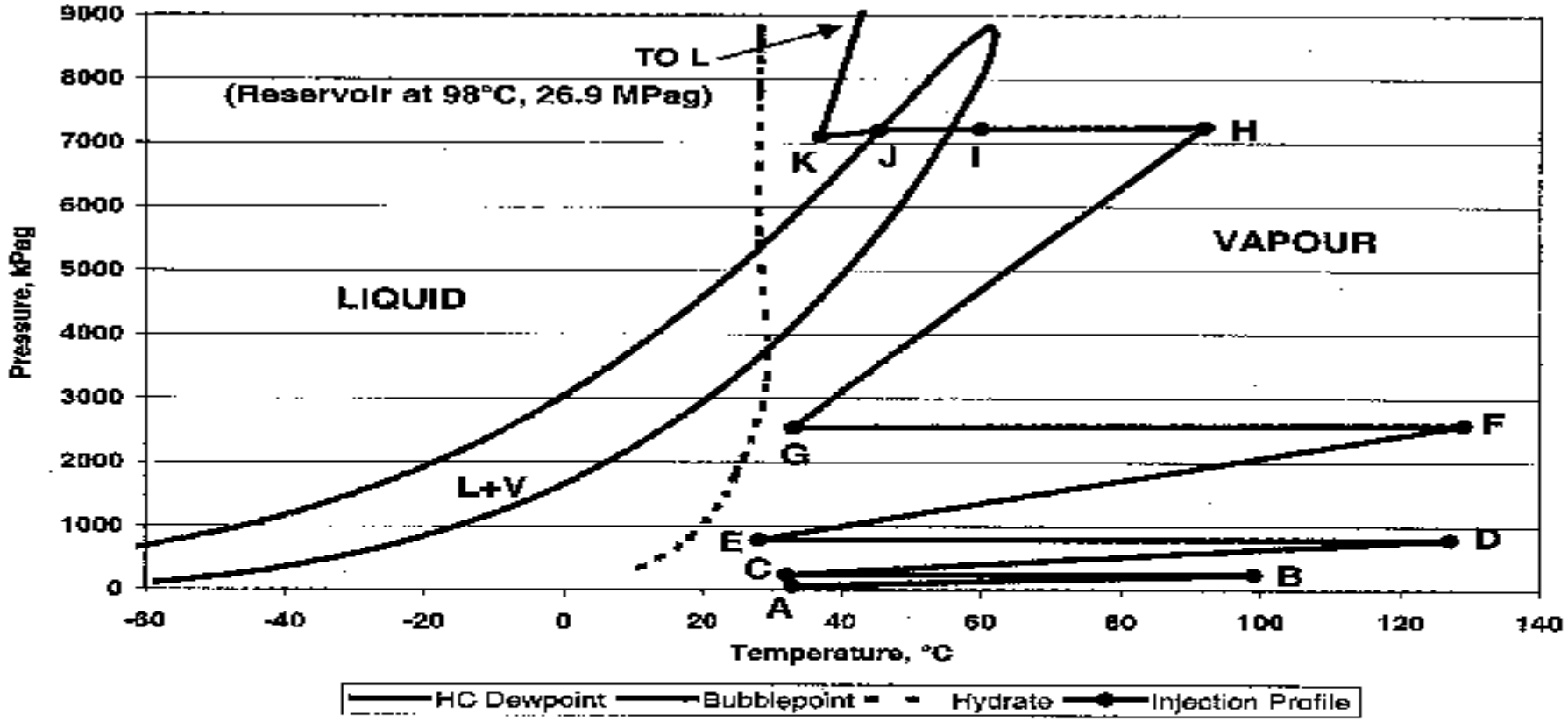
Options for Handling of Acid Gas

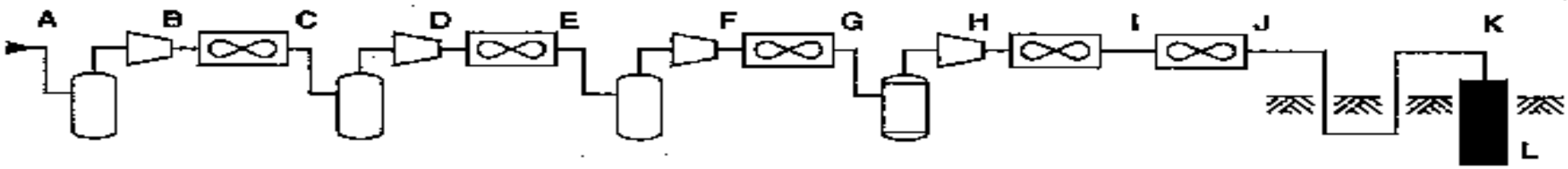


Four-Stage Acid Gas Compression showing Pressure Rise and Temperature Variations



Typical 4-Stage Compression Scenario





Alternative for Acid Gas Injection

- **Disposal of acid gas by injecting it into a suitable deep subsurface zone located below the production reservoir or plant, which generally contain unusable salt water**
- **Storage of the acid gas in an underground reservoir until some later date when it may be economical to recover the sulphur/ CO_2 (either a depleted reservoir or the producing formation)**
- **Acid gas is miscible with oil and when it is injected to maintain reservoir pressure or to sweep oil or wet gas to production wells, it may increase the recovery of oil or gas liquids**

Requirements for AGI

- Suitable disposal site within close range to gas processing plant
- Appropriate pipeline metallurgy (carbon steel to stainless steel)
- Premium equipment designed to handle corrosive nature of gas mix and flexibility of mixes that may occur during injection process
- Equipment and pipelines designed to handle acid gases at required temperatures and pressures
- Extremely high safety levels
- Emergency blow-out options & plans
- First class preventative maintenance plan and reliable, experienced maintenance staff

Storage Site - Geological Considerations

- **Size : need reservoir that is large enough to contain waste acid gases from the whole project's production**
- **Location and state of offsetting wells in area and understanding of how well contents might be impacted by injection of fluids**
- **Baseline temperature and pressure in disposal zone**
- **Caprock analysis - identification of any breaches in caprock from faults or fractures along which the injected fluid could migrate to other formations, ground water or to the surface**
- **Cavern makeup - in carbonate reservoirs, CO_2 may dissolve some of the rock matrix thus increasing its permeability**

Storage Site - Geological Considerations con't

- **Stratification of the injection zone, homogeneity & permeability of layers**
- **Chemical composition of formation water including total dissolved salts (affects portability) & naturally occurring H_2S and CO_2**
- **Two pressure measurements:**
  - **Caprock Threshold Displacement Pressure - the pressure required to remove the water that saturates the caprock, (which creates the seal that keeps the gases in the reservoir) thus leaving the way free for gas to permeate the caprock to upper levels**
  - **Fracture Pressure - the pressure level that would cause the caprock to fracture thus permitting the disposed gases to escape**

Benefits of Acid Gas Injection

- Can significantly increase oil and liquids recovered from some production reservoirs
- Eliminates the cost of marketing, transporting or disposal of recovered sulphur from poor locations
- Reduces capital costs and operating costs
- High on-line reliability - average over 99%
- Option can maximize conservation & minimize environmental impact
  - ➔ Zero continuous sulphur emission sites
  - ➔ Reduced carbon emission (greenhouse gases) as CO_2 is injected rather than released to atmosphere
  - ➔ Smaller land space requirements i.e. no sulphur plant /block required
- Reduced royalty payments
- Better flexibility to handle variable H_2S/CO_2 ratio mixtures and throughput rates

Drawbacks of Acid Gas Injection

- Suitable disposal site must be located close to the plant
- Disposal site/ storage reservoir must be geologically isolated and have a well of sufficient injectivity and capacity
- Extra safeguards and procedures are required to transport large volumes of high pressure acid gas
- Energy normally liberated by the combustion of H_2S is no longer available to the plant
- Potential to contaminate surrounding reservoirs / ground water if system not designed safely
- Acid gas can corrode equipment and pipeline quickly (days) if system not designed correctly to dehydrate acid gas

Examples of Where AGI Use Considered

Encana Saddle Hills, Canada

- 400t/day sulphur, no railway, site constantly losing money
- AGI not implemented as there was no suitable reservoir

West Coast Pine River - Canada

- 870t/day sulphur, gas field expansion, current sulphur processing plant at maximum production level
- AGI implemented - straddle plant added to remove additional incremental H_2S/CO_2 and inject in depleted reservoir

Exxon Wyoming, USA

- 2,000 LT/day sulphur, 30 yr old gas field containing 35% methane & 2% helium (money maker) - anticipate long-term future economical production. Existing Claus unit needed replacing
- AGI plans implemented - difficult sulphur economics, save cost of Claus unit - injection possible via edge wells. Start up in mid-2004

Kashagan, Kazakhstan

- Reserves 40 Bn barrels- conventional recovery methods net 7-9 Bn barrels/yr vs. with re-injection into production site which will net 11 - 14 Bn barrels/yr.
- AGI planned - injection site under extreme high pressure (> 850 bars) - will require specialized equipment and processes - Phase I - 3 M t sulphur gas injected & 1 M t sulphur produced, Phase II - 6 M t sulphur gas injected & 2 Mt sulphur produced - plan includes future production of stored sulphur when economical - startup 2007

Conclusions

- There are so many variables that each individual injection scheme will have to be uniquely evaluated and designed.
- At sulphur values of less than US $80 - 100 /t, all new sour gas production facilities will try to find a suitable injection reservoir in preference to the high capital and operating costs resulting from the increased sulphur recovery ratios legislated today.
- No one can predict the amounts of sulphur injection vs. production; but its safe to say that during the next 10 - 20 years there will be significant sulphur / H_2S injection and significant sulphur produced.