Gas Sweetening;

Acid Gas Absorption- Desorption Process

Using

H-MDEA®

HAMPA Energy Engineering & Design Company (HEDCO)

Research Institute of Petroleum Industry (RIPI)

1) Introduction

For years, Amine Units (Acid Gas Absorption/ Desorption process) in different large industrial scale complexes, has used patented technology and respective proprietary solvents in for sweetening of process synthesis gases.

Specifically, for most of existing Ammonia production plants and also entire new projects (under construction or in basic engineering phase), use of aforesaid technology is kept by default.

Now, "**HEDCO**" as a knowledge base and fully Iranian company, in conjunction with "**RIPI** (Research Institute of Petroleum Industry)", after years of effort and providing the required infrastructures is honored to introduce a specific and optimized solvent for Acid Gas Absorption/ Desorption process.

H-MDEA®, is our unique solvent.

2) H-MDEA® for Acid Gas Absorption/Desorption process

The activated Methyl Di-Ethanol Amine technology (using MDEA& PIPERAZINE) for recovery of Acid Gas from gas mixtures was developed in the 1970s and it was well-known as a low energy-consumption process. During decades, the focus points for future solvent development and process technologies has been:

- ✓ Lower energy consumption (more activated substances)
- ✓ Economic performance
- ✓ Lower corrosion rate
- ✓ Less foaming effects

After years of efforts and experience, **H-MDEA®** is presented with the following advantages:

- ✓ Fully Iranian "Process Modeling", "Engineering" & "Solution Supplying"
- ✓ Availability of **H-MDEA®** ingredients in Asian market
- ✓ Decreasing of Acid Gas slip (Absorption column)
- ✓ Lower Solution circulating rate (Higher efficiency)
- ✓ Negligible corrosion rate

3) Formulation

Modeling of Amine unit process is performed using HYSYS simulation engine, while reference to lab analysis, several calculation parameters of its existing thermodynamic packages are modified to obtain finest (real) physical/chemical properties of **H-MDEA®**.

Considering past experiences and hard work researches, made it possible to formulate a new solvent which contains benefits of different amines types while all of its desirable properties is kept. To achieve this goal, in comparison with available conventional activated Methyl Di-Ethanol Amine, concentration of Tertiary Amine (here MDEA) and PIPERAZINE is precisely modified. Alongside this, three other agents also are added.

4) Performance Test

4.1 Laboratory Test

"Research Institute of Petroleum Industry (**RIPI**)" as leadership of investigations in Iran oil engineering and production, is furnished with a wide range of facilities and equipment to measurement, transmission, monitoring and testing of most of physical& chemical properties belongs to different types of Amines and its characteristics.

In brief, the following tests are obtainable in RIPI well-appointed lab:

- ✓ Quantitative analysis and characterization of solution components includes measuring of:
  - Amine concentration (Total or specific Amines)
  - Acid gases and heat stable Anions concentration
  - Metals and Cations
  - Degradation products of Amine solvents
  - Water content
  - Particle size distribution of suspended solids
  - Concentration of Aromatics

- ✓ Analysis of most important properties includes measuring of:
  - Density, Viscosity, Heat Capacity, Surface Tension& Thermal Conductivity under different operating conditions
  - Acid Gas Loading
  - Kinetics of Acid Gas Absorption
  - Light hydrocarbons Absorption
  - Corrosion rate of different alloys
  - Vapor-Liquid equilibrium
  - Vapor Pressure

Analysis and measurement of **H-MDEA®** properties, is accomplished using **RIPI** laboratory. Wished analysis, is carried out by **RIPI**'s experienced professionals.

4.2 Pilot Test

In order to verify and evaluate performance of the sweetening solvents, **RIPI** is furnished with a world-class industrial pilot which is incomparable and matchless in whole Middle East countries.

The enhanced pilot contains a complete loop of Acid Gas Absorption/Desorption process (all from A to Z) and pertinent equipment in following characteristics:

- ✓ Absorption& Desorption Towers (Packed Bed type)
- ✓ Steam media Re-boiler (submerged)
- ✓ Water cooled exchangers
- ✓ Surge & flash drums
- ✓ Feed Station
- ✓ On-line analyzers
- ✓ Fully automated Control system (PLC base)

To approve reliable performance of our solvent at real operating conditions, in December 2013, an actual running test of **RIPI**'s Pilot with **H-MDEA®** is carried out. During two days of evaluation, all operational behavior of introduced solvent under actual situation and in different point of process is assessed. Also desired laboratory tests from chosen locations is done.

In this period, official high-level visits by senior managements and members of operating plants and petrochemical projects is carried out. Visitors thoroughly observed reliable operation of the pilot and pertinent lab happenings.

5) Measurement Results

Through **H-MDEA®** pilot operation and also laboratory measurements, the following findings are achieved:

5.1 Thermo-physical Properties

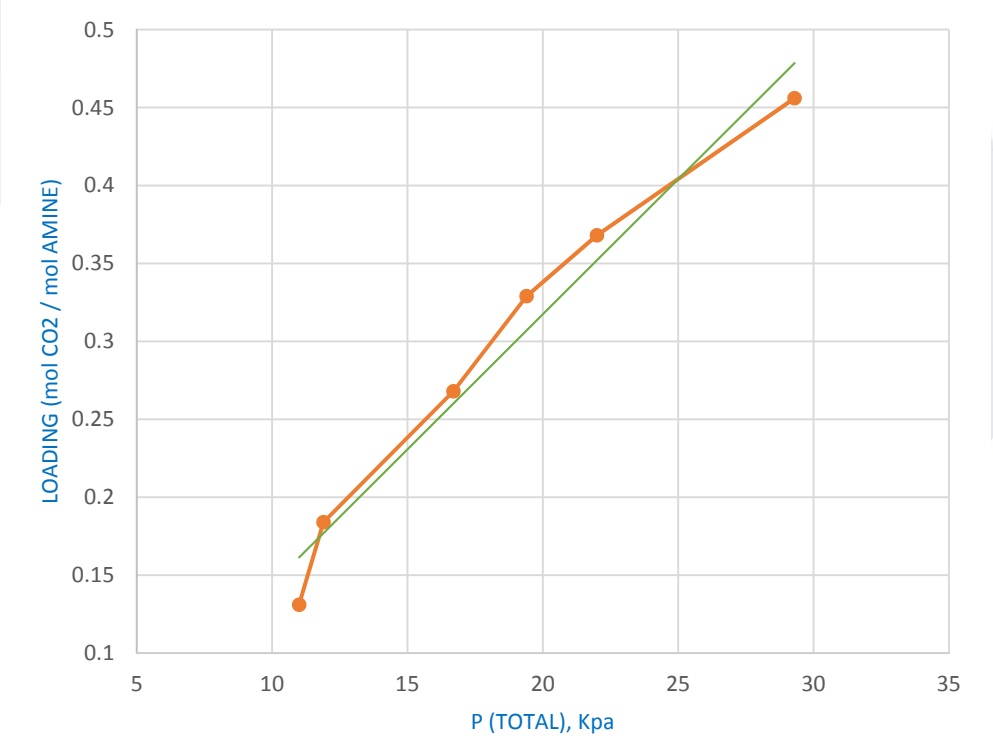
✓ **H-MDEA®**@ 20°C

▪ Density:	1.0415 ± 0.0104	g/cm3
▪ Viscosity:	7.82 ± 0.39	m.Pa.s
▪ Surface Tension:	54.3 ± 2.7	mN/m
▪ Heat Capacity:	3.42 ± 0.17	J/g.K
▪ Thermal Conductivity:	0.396 ± 0.020	W/m.K

✓ **H-MDEA®**@ 45°C

▪ Density:	1.0261 ± 0.0103	g/cm3
▪ Viscosity:	3.22 ± 0.16	m.Pa.s
▪ Surface Tension:	51.8 ± 2.7	mN/m
▪ Heat Capacity:	3.57 ± 0.18	J/g.K
▪ Thermal Conductivity:	0.439 ± 0.022	W/m.K

5.2 Solubility of CO2 in H-MDEA® (@40°C)



5.3 Corrosion

Corrosion behavior of introduced solution is deliberated by "Electrochemical Polarization Method" and also "Direct Contact Coupons Method". For second method, corrosion results are measured under different CO2 loading of **H-MDEA®** (@ two reference temperatures) and analyzing the results after 32 days direct contact of solution with carbon steel coupons.

#	Liquid Phase Corrosion (MPY)	Vapor Phase Corrosion (MPY)	Analysis Result
H-MDEA® @ 88°C (CO2 Loading 0.58)	1.3	0.15	No localized corrosion
H-MDEA® @ 129°C (CO2 Loading 0.022)	0.79	0.03	No localized corrosion

Results of investigations for both of the above mentioned measurements illustrate that general corrosion rate of said solution is lower than desirable rate (<5 MPY) and without any localized corrosion effect (1 MPY is equal to 0.0254 mm/Year).

6) Conclusions

Based on all said experiments and review of the measurement results, performance of introduced solution undoubtedly is confirmed. Absorption/desorption behavior and specific properties of **H-MDEA®** are comparable with known a-MDEA; insofar it is absolutely feasible to replace (or even mix) existing Amine solution of production plants with this new solution.

Since **HEDCO** and **RIPI** jointly provide and supply **H-MDEA®**, certainly the right performance of this solution is guaranteed, while warranty terms are related to both of them. Consequently, **H-MDEA®** has the support and companionship of **Iran Oil Ministry**.