4 Technical Solution for Sulfolane-Based Acid Gas Sweetening & Purification

Target Users

Natural gas processing plants, coal chemical syngas facilities, gas field procurement buyers from the Middle East & Central Asia, petrochemical trading groups

Application Scope

High-sulfur natural gas, coal chemical crude syngas containing H_2S, CO_2, COS, methyl mercaptan and dimethyl sulfide; covers sulfolane-amine composite system comparison, absorption efficiency test data, low-temperature operating parameters, solvent regeneration and procurement budgeting

Catalog

1 Core Process Principle of Sulfolane-Amine Synergistic Absorption

Sulfolane is a strong polar physical solvent compounded with alkanolamine (MDEA/DIPA) to form mixed sweetening liquid with dual absorption advantages:

1. Low partial pressure (<0.1 MPa acid gas): MDEA chemical reaction dominates for deep H_2S removal to meet pipeline standard 6 mg/m³

2. High partial pressure (>0.5 MPa high-sulfur feed): Sulfolane physical dissolution drastically increases total acid gas loading, single cubic meter liquid absorbs 110~130 m³ acid gas, far exceeding single MDEA solution
3. Exclusive organic sulfur removal capacity: Only sulfolane-amine system can efficiently capture COS, methyl mercaptan and dimethyl sulfide; single amine solution fails organic sulfur removal
4. Superior thermal stability: Sulfolane boiling point 285°C with ultra-low vapor pressure, cutting annual fresh solvent procurement by over 40% vs glycol ether physical solvents

2 Performance Comparison of Main Sulfolane-Amine Composite Formulas

2.1 Standard Industrial Mass Ratio Formulas

表格

System Type	Sulfolane Content	Alkanolamine Content	Deionized Water	Core Application Scenario
Pure Aqueous MDEA	0%	40%	60%	Low-sulfur natural gas, only H_2S removal without organic sulfur
Sulfolane-MDEA Selective Sweetening (SFMDEA)	20%~30%	45%~55%	15%~25%	High-sulfur feed, selective H_2S removal, coal chemical syngas, simultaneous organic sulfur capture
Sulfolane-DIPA Full Removal (Sulfinol-D)	30%	50%	20%	High organic sulfur gas field, synchronous deep removal of CO_2, COS & mercaptan

2.2 Full-Dimension Performance Benchmark (7.5 MPa, 25°C Reference)

表格

Benchmark Index	Pure 40% MDEA	Sulfolane-MDEA (30:50:20)	Sulfolane-DIPA (30:50:20)
H_2S Removal Rate	99.85%	99.96%	99.97%
COS/Methyl Mercaptan Removal Rate	<35%	78%~86%	92%~97%

Benchmark Index	Pure 40% MDEA	Sulfolane-MDEA (30:50:20)	Sulfolane-DIPA (30:50:20)
H_2S Residual in Sweet Gas	30~40 mg/m³	≤15 mg/m³	≤6 mg/m³ (Pipeline Standard Compliant)
Acid Gas Loading (m³/m³ Liquid)	65~72	105~120	115~130
Regenerator Steam Consumption (kg/ton Acid Gas)	145~160	118~128	125~135
H_2S Concentration in Regenerated Acid Gas	22%~28%	38%~45%	32%~38%
Liquid Viscosity (25°C, mPa·s)	4.2	12.8	15.3
Liquid Viscosity (-5°C, mPa·s)	7.5	48.6	62.1
Equipment Corrosion Rate	Medium (0.12 mm/a)	Low (0.05 mm/a)	Ultra-Low (0.03 mm/a)
Liquid Foaming Tendency	High	Low	Ultra-Low
Heavy Hydrocarbon Co-Absorption	Low	Medium	High

Formula Selection Conclusion for Buyers

1. Coal chemical syngas & high-sulfur natural gas with COS: Prioritize sulfolane-MDEA for balanced H_2S selectivity, organic sulfur removal and low energy consumption
2. Sichuan-Chongqing/Middle East high organic sulfur gas field requiring total sulfur deep removal: Adopt sulfolane-DIPA full removal system
3. Low-sulfur shallow gas without organic sulfur & tight budget: Pure MDEA with post molecular sieve organic sulfur removal (higher overall operation cost)

3 Multi-Working Condition Absorption Efficiency Industrial Test Data

Unified test benchmark: 12 m packed absorption column, operating pressure 7.0~8.0 MPa, gas-liquid ratio 1200:1; feed H_2S 8~14 mol%, CO_2 6~9 mol%, total organic sulfur 120~180 mg/m³

3.1 Sulfolane-MDEA Absorption Efficiency by Pressure

表格

Inlet Gas Pressure	H_2S Removal Rate	COS Removal Rate	Total Sulfur in Sweet Gas (mg/m³)	Acid Gas Loading (m³/m³ Liquid)
3.0 MPa	99.92%	76.3%	72.4	92
5.5 MPa	99.95%	83.7%	36.8	108
7.5 MPa	99.96%	85.9%	14.4	118
9.0 MPa	99.97%	87.2%	11.6	126

3.2 Impact of Sulfolane Mass Fraction on Sweetening Performance (7.5 MPa Fixed Pressure)

表格

Sulfolane Mass Fraction	H_2S Residual (mg/m³)	COS Removal Rate	Steam Saving vs Pure MDEA	Liquid Viscosity (25°C)
10 wt%	26.7	62.1%	6.2%	7.4
20 wt%	18.2	77.5%	10.5%	9.6
30 wt%	14.4	85.9%	16.3%	12.8
40 wt%	12.1	89.4%	18.1%	16.7

Optimal engineering range: 25~30 wt% sulfolane balancing removal efficiency, energy consumption and transportation viscosity; >35% drastically increases heavy hydrocarbon absorption and risks sulfur recovery tail gas over-limit.

3.3 Coal Chemical Crude Syngas Low-Pressure Data (2.2 MPa)

Coal gas characteristics: Low pressure, high CO_2, fluctuating H_2S with trace COS

- H_2S removal rate: 99.91%, sweet gas H_2S <20 mg/m³
- COS removal rate: 72%~79%, matching hydrolysis unit for total sulfur <0.1 ppm
- Acid gas loading increased by 42% vs pure MDEA, liquid circulation volume cut by 30%, circulation pump power consumption down 22%

4 Complete Low-Temperature Operating Data for Cold Climate Gas Fields (-10°C~15°C)

Sulfolane solidification point 26°C; sharp viscosity rise under low temperature causes pump cavitation, column maldistribution and mass transfer efficiency drop. Test data & standardized anti-freeze solutions for Central Asia & Russian gas fields.

4.1 Liquid Viscosity & Efficiency Attenuation vs Temperature (30% Sulfolane + 50% MDEA)

表格

Lean Liquid Inlet Temp	Liquid Viscosity (mPa·s)	H_2S Removal Attenuation	COS Removal Attenuation	Pump Power Increase
25°C (Benchmark)	12.8	0%	0%	100% Reference
15°C	21.4	0.2%	1.1%	+18%
5°C	36.9	0.7%	3.5%	+41%
-5°C	48.6	1.6%	7.2%	+68%
-10°C	72.3	3.1%	12.8%	+115%

4.2 Three Standard Low-Temperature Control Schemes

Scheme 1 Lean Liquid Constant Temperature Heat Tracing (Mainstream)

Low-pressure steam heat tracing added to lean/rich heat exchanger, stabilize lean liquid inlet temp at 20~25°C; column liquid temp maintained >15°C even with -10°C feed gas

- Effect: Viscosity controlled within 22 mPa·s, removal efficiency attenuation <1%, additional steam consumption only 4.5 kg/ton feed gas

Scheme 2 Formula Water Content Adjustment for Anti-Freeze

Water content increased from 20% to 24%~26% for cold climate to lower system solidification point & viscosity (30 sulfolane : 48 MDEA : 22 water, viscosity 35 mPa·s at -5°C without crystallization risk)

- Trade-off: Acid gas loading slightly down 4%, regeneration steam slightly up 3%, overall benefit far outweighs shutdown loss

Scheme 3 Full Insulation & Heat Tracing for Tanks & Pipelines

30°C warm water heat tracing & insulation for sulfolane storage tanks; polyurethane full insulation for all solvent pipelines with heat tracing jackets on valves & filters; molecular sieve drying cylinder on tank breathing valve to isolate low-temperature moisture ingress

4.3 Special Acceptance Standard for Sulfolane Procurement in Cold Regions

Ordinary industrial grade prohibited, mandatory indicators:

1. Water content ≤20 ppm to avoid water separation under low temperature
2. Color APHA ≤5 without trace polymer to prevent packing blockage under cold conditions
3. Free acidity ≤0.0005% to slow pipeline corrosion under low temperature & high humidity

5 Complete Sulfolane-Amine Process Flow

Feed gas buffer → Absorption Column → Rich Liquid Flash Drum → Lean/Rich Heat Exchanger → Regenerator → Reboiler Heat Source → Overhead Condenser → Cooled Lean Liquid → Filter/Ion Exchange Purification → Recycle to Absorption Column

Key Unit Explanation

1. Absorption Column: Feed gas upward flow, constant 20~25°C lean sulfolane-amine liquid sprayed from top; 22~28 trays for high-pressure high-sulfur feed; mandatory lean liquid heat tracing for low-temperature facilities
2. Flash Drum: 0.3~0.5 MPa flash to remove dissolved methane/ethane and avoid excessive hydrocarbon in regenerated acid gas
3. Regenerator (micro vacuum -15 kPa): Bottom temp controlled at 122~128°C, strictly below 170°C to prevent sulfolane oxidation decomposition; high-concentration H_2S acid gas overhead sent to sulfur recovery unit
4. On-line solvent purification: 3% circulating liquid continuously passed through anion exchange resin tower to remove sulfonate and metal ion, stabilize pH 6.8~7.5 and cut solvent loss & corrosion

6 Solvent Regeneration, Loss Control & Annual Consumption Calculation

6.1 Four Sources of Sulfolane Loss & Control Measures

1. Vapor Volatilization Loss (45% of total loss): Concentrated in regenerator overhead vent; 5°C ethylene glycol cold trap installed for 70% volatile loss reduction, full nitrogen blanketing of all tanks to isolate air oxidation
2. Thermal Oxidation Degradation (35% hidden loss): Triggered by air leakage, temp >180°C, pH <6.0; continuous ion exchange neutralization, regenerator kettle temp capped at 130°C, full LDAR leak repair within 48 h
3. Mechanical Leakage (15%): Double PTFE mechanical seal for all high-temperature solvent pumps, metal wound gaskets for high-temp pipelines, monthly hydraulic leak test
4. Residue Entrainment Loss (5%): Thermal extraction of sulfolane from regenerator tar residue with recovery rate ≥90%, residue incinerated as hazardous waste

6.2 Benchmark Unit Loss Before & After Optimization

- Simple plant without purification & cold trap: 0.11~0.14 kg/ton feed gas
- Standard plant with ion exchange & cold trap: 0.05~0.07 kg/ton feed gas

- Cold climate heat tracing plant: Loss slightly increased to 0.06~0.08 kg/ton feed gas

6.3 Annual Fresh Sulfolane Procurement Calculation Formula

Annual fresh procurement = Annual feed gas throughput × Unit loss benchmark − Waste solvent recovery volume

Calculation Example: 1,000,000 tons annual gas processing, unit loss 0.06 kg/ton, theoretical annual demand 60 tons; 18 tons recovered from residue extraction, actual annual procurement 42 tons

7 Equipment Anti-Corrosion & Foam Suppression Long-Term Operation Plan

7.1 Corrosion Mechanism & Graded Material Selection

Sulfolane oxidation generates sulfonic acid & sulfuric acid; chloride enrichment accelerates corrosion under low temperature & high humidity

1. Absorption column & ambient pipeline: Carbon steel with 3 mm corrosion allowance, 304 stainless steel trays
2. Regenerator & lean/rich heat exchanger (120°C high temp): 316L stainless steel tubes
3. Regenerator bottom & high-temp rich liquid pipeline: 2205 duplex stainless steel mandatory for cold climate gas fields
4. Storage tank: Carbon steel lined with solvent-resistant epoxy coating & inner passivation treatment

7.2 Liquid Foam Suppression Advantage of Sulfolane-Amine System vs Pure MDEA

Foaming threshold tripled vs single MDEA which requires continuous defoamer dosing

1. Source control: Sulfolane incoming color ≤5 APHA without polymer impurity
2. On-line series 1 μm PTFE filter to remove iron salt solid suspended matter
3. Only trace polyether defoamer dosed under extreme working condition; silicone defoamer prohibited (blocks sulfur recovery catalyst)

8 Differentiated Procurement Specifications for Natural Gas & Coal Chemical Industry

8.1 Procurement Grade Selection by Industry

1. Temperate natural gas plant (Middle East/Southeast Asia): Industrial grade ≥99.5%, water ≤50 ppm, metal ≤10 ppb, supplied via 200 L drums or IBC

2. Central Asian/Russian cold climate gas field: High-purity grade ≥99.9%, water ≤20 ppm, color ≤5 APHA to avoid impurity precipitation & packing blockage under low temperature
3. Large coal chemical plant with long-term bulk supply: High-purity grade, tank truck bulk delivery with 12-month fixed-price contract cutting unit cost by 12%~18%

8.2 Mandatory Rejection Red Line for Incoming Inspection

Reject consignments failing any index below:

- Sulfolane purity < 99.5 wt%
- Water content > 50 ppm
- APHA color > 10
- Free acidity > 0.001 wt%
- Total metal ion content > 15 ppb
  Excessive metal ions accelerate heat exchanger corrosion and trigger severe foaming of circulating liquid.

9 Full Technical Document Package Delivered to Overseas Low-Temperature Gas Field Clients

Part 1 Basic Batch Delivery Documents

1. Sulfolane sweetening-grade Technical Data Sheet (TDS), Chinese & English bilingual
2. Batch full-index Certificate of Analysis (COA)
3. 16-chapter GHS-compliant English Safety Data Sheet (SDS); sulfolane classified as non-hazardous chemical to simplify sea customs declaration
4. Sulfolane viscosity-temperature characteristic test curve report for low-temperature operation

Part 2 Process Design & Operation Technical Manuals

1. Complete PFD/PID flow diagrams of sulfolane-amine sweetening process with full parameter sets
2. HYSYS process simulation calculation model for absorption efficiency prediction
3. Design specification for low-temperature heat tracing & anti-freeze system
4. Standard Operation Procedure (SOP) for solvent regeneration and ion purification
5. Excel template for annual sulfolane consumption budgeting calculation

Part 3 Global Compliance Qualification Certificates for Middle East / European & American Gas Field Audits

1. REACH & TSCA chemical registration compliance certificates
2. Non-hazardous goods sea transportation appraisal report
3. ISO9001 & ISO14001 factory system certification
4. Equipment anti-corrosion material selection comparison table for sulfolane service

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5 Manual of Test & Analysis Methods for Finished & Circulating Sulfolane Solvent

Scope of Application

Incoming raw material acceptance, in-plant circulating solvent central control, finished product factory release, recovered regenerated solvent inspection

Covers complete testing protocols for industrial grade, polymer/pharmaceutical grade, lithium battery electronic grade, including instruments, reagents, operating steps, calculation formulas, pass/fail limits and abnormal troubleshooting

Table of Contents

1 General Test Specifications

1.1 Sampling Standards

1. Liquid samples at temperature ≥30°C without crystallization: stainless steel or glass sampling bottles, sealed under nitrogen blanketing. For winter solidified samples, heat to 35°C and fully homogenize before sampling.
2. On-line circulating solvent sampling: cool bypass stream to below 40°C to prevent thermal oxidative degradation during sampling.
3. High-purity polymer / electronic grade sampling: operate in glove box with dew point ≤ -30°C, use PTFE sampling tools with full air & moisture isolation.
4. Sample retention period: 7 days for industrial grade, 30 days for pharmaceutical & electronic grade; store sealed away from light at ≤30°C.

1.2 General Instrument Requirements