

UOP Amine Guard™ FS Technology for Acid Gas Removal



UOP
A Honeywell Company

Agenda

- Overview of the Amine Guard FS process
- UCARSOL™ Solvent characteristics
- Amine Guard FS flow scheme comparison
- Equipment features
- UOP technology transfer
- UOP Experience and Technical Services
- Summary



Overview of the Amine Guard FS Process

- Licensed amine technology
- Removal of CO₂ & H₂S to low levels or
- Selective H₂S Removal
 - Low H₂S spec, with as much as 75% CO₂ slip
- UCARSOL Formulated Solvent from Dow
- Several flow scheme options available
- UOP MD™ Trays or Raschig Super Rings to maximize performance



Amine Guard FS Process Do's and Don'ts

Do's

- Remove CO₂ & H₂S
- Selective H₂S removal
- Natural Gas to pipeline specs
- Natural Gas to LNG specs
- Downstream of a membrane for CO₂/H₂S polishing
- Treat Synthesis gas for H₂, NH₃ or other applications

Don'ts

- Mercaptan Removal

Overview of the Amine Guard FS Process

Markets served include:

- **Synthesis gas treating for CO₂ removal in synthesis gas plants, such as direct iron ore reduction**
- **Synthesis gas treating for selective H₂S removal in integrated gasification combined cycle (IGCC) plants**
- **Natural gas treating for selective removal of H₂S and partial removal of CO₂ for pipeline specifications**
- **High CO₂ partial pressure service for reduced energy consumption compared with conventional amines, such as steam reformed ammonia plants**

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UCARSOL AP-800 Series Solvent Features:

- **State of the art amine technology**
- **MDEA based solvent with low concentrations of activator**
 - **Activator accelerates slow overall kinetics of CO₂ reaction with MDEA**
 - **Solvent formulation is chosen to provide the desired amount of CO₂ slip**
 - **AP-814 used for LNG applications to achieve very low residual H₂S & CO₂ content of product gas**
 - **Activator significantly reduces packed heights of towers**

UCARSOL AP-800 Series Solvent Features (cont'd):

- **High thermal and chemical stability**
- **Non-corrosive (no corrosion inhibitors needed)**
- **No solvent reclaiming or purging for typical applications**
- **Non – foaming**
- **Inventory stored in worldwide locations**

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Amine Guard FS Flow Scheme Options

- Feed CO₂ & H₂S partial pressures vs. product specs
- Higher PP allows exploitation of flash regeneration
- Low level H₂S product specifications require some thermal regeneration
- Each application will have its own optimal flow scheme solution



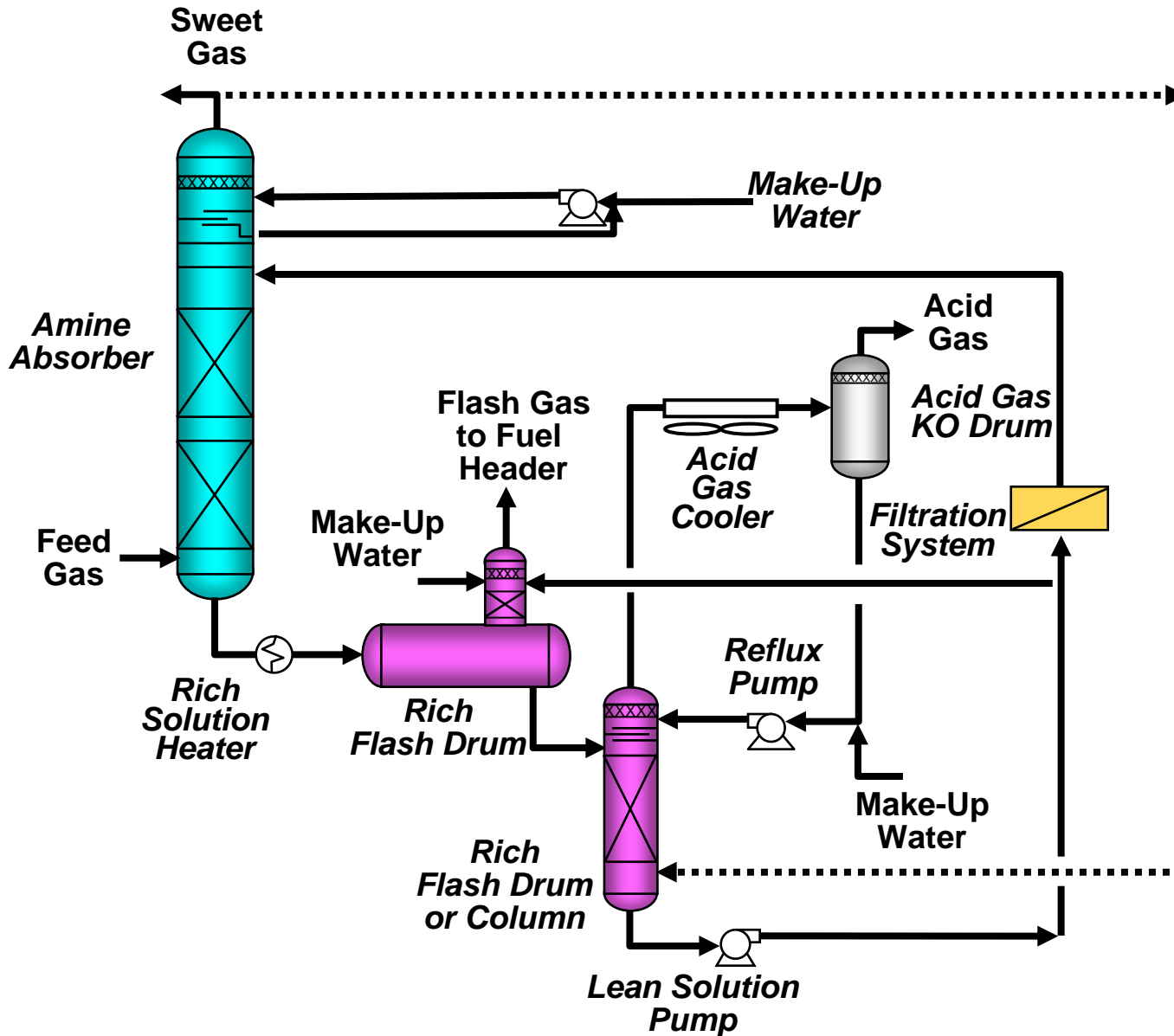
Four Main Amine Guard FS Flow Schemes

- **Flash only**
- **Conventional (absorber + thermal regeneration)**
- **1-Stage (absorber + flash column + thermal regeneration)**
- **2-Stage (1-stage system that also includes semi-lean solvent stream)**



Amine Guard FS Process

Flash Only

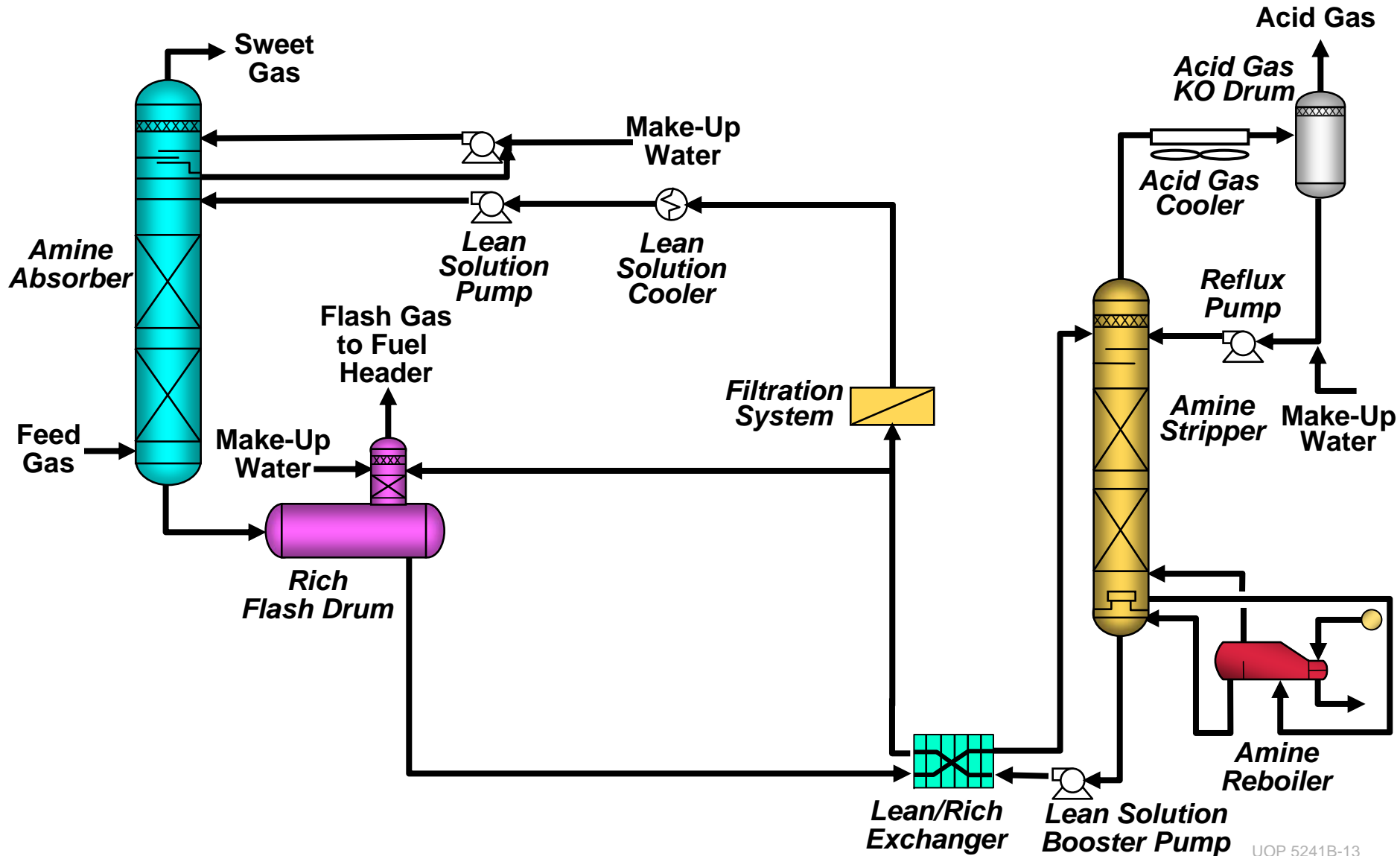


Flash-Only Flow Scheme - Application

- **Simple flowscheme and therefore relatively inexpensive**
- **Low energy requirements**
- **Ideal for bulk removal of CO₂**
- **Partial removal of H₂S**

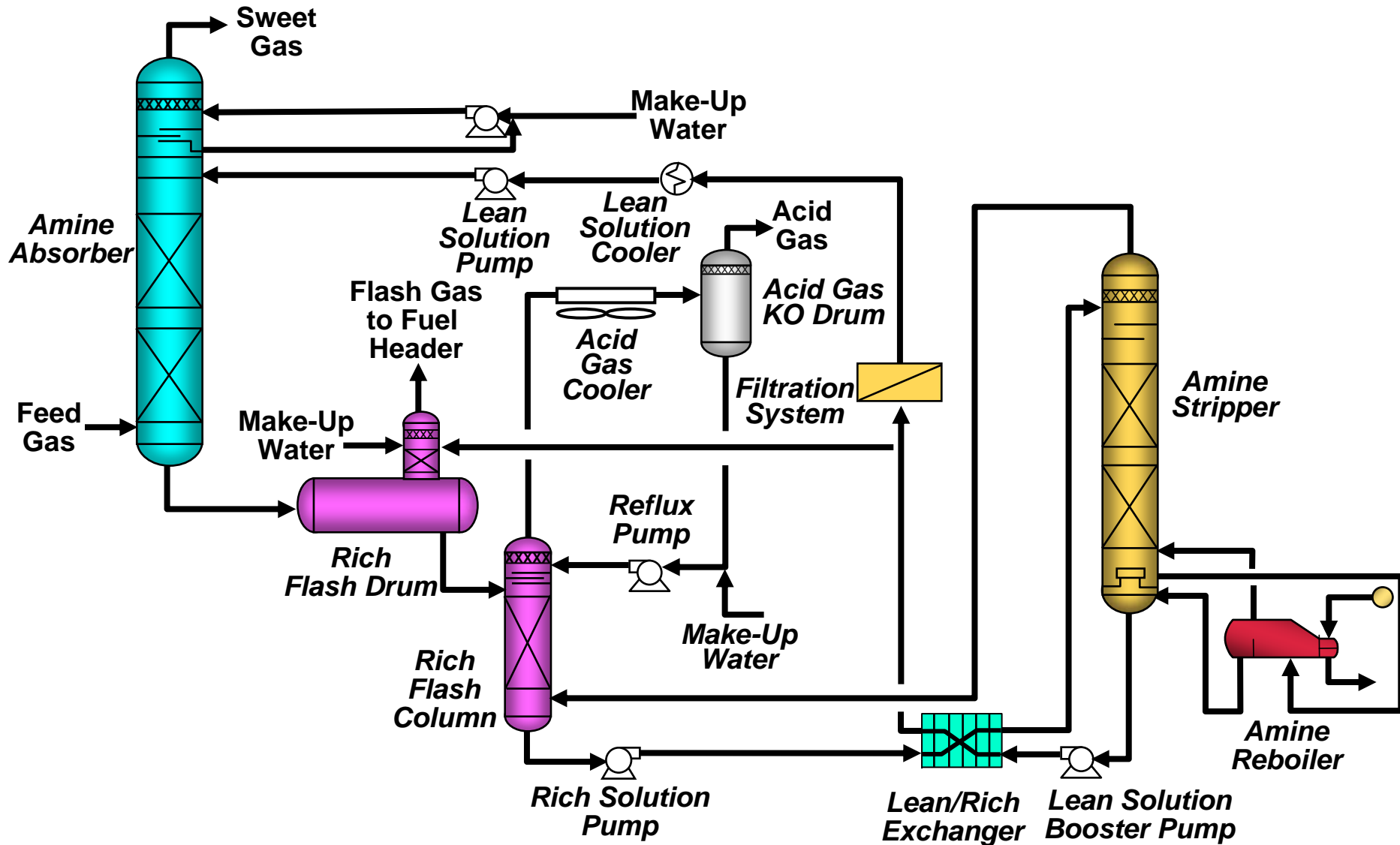
Amine Guard FS Process

Conventional



Amine Guard FS Process

1-Stage

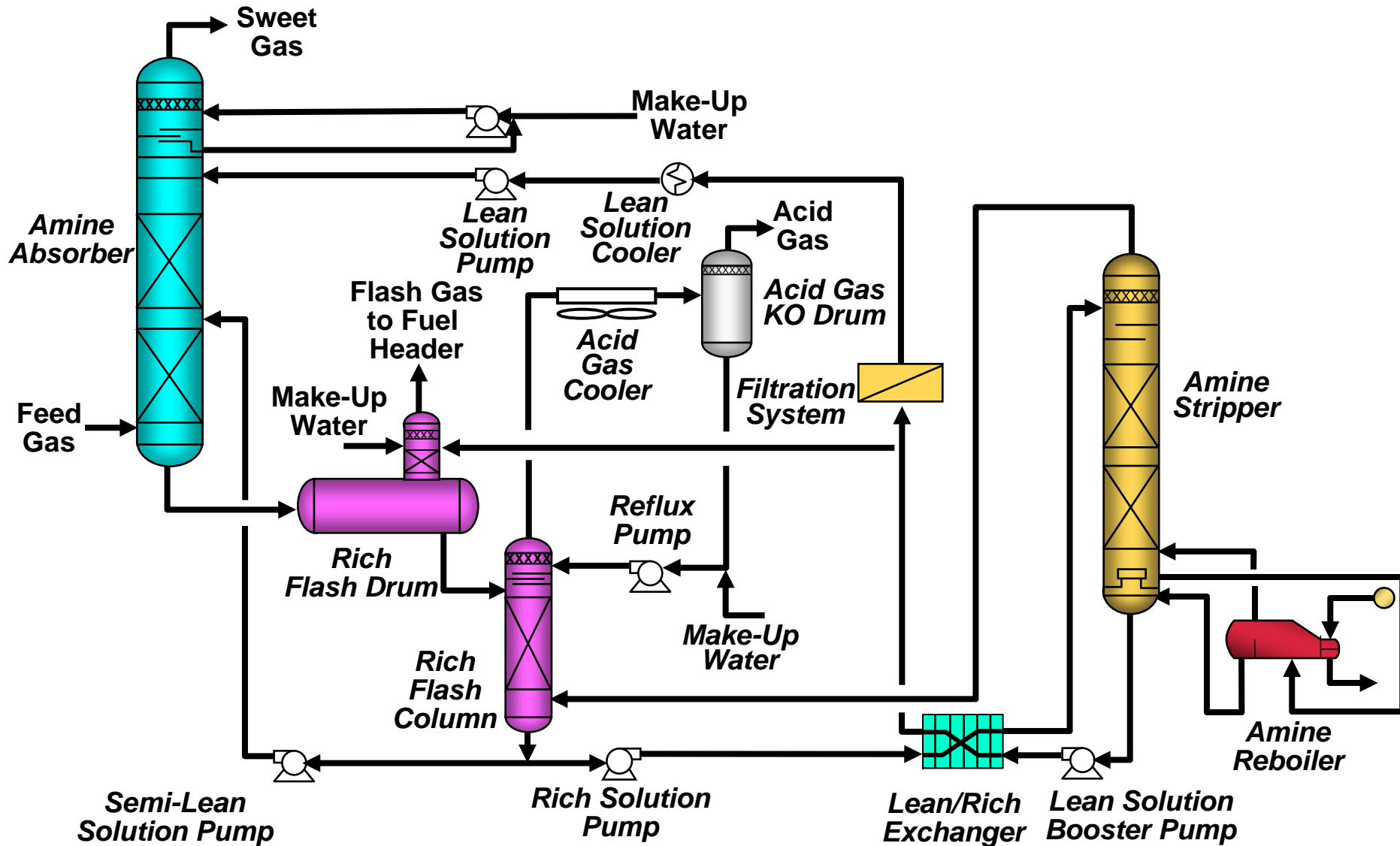


Conventional and Single-Stage Flow Schemes - Application

- **Can achieve CO₂ levels below 50 ppm for LNG specifications**
- **Lower solvent requirements than flash-only system**
- **Thermal regeneration for higher level of removal**

Amine Guard FS Process

2-Stage



2-Stage Flow Scheme - Application

Advantages

- **Much lower duty requirements than single-stage system**
- **Flexibility to trade-off solvent flow rate for thermal regenerator duty or vice-versa**

Disadvantages

- **Solvent requirements always higher than those for single-stage system, resulting in higher capital costs (absorber, pumps, and piping)**

Flow Scheme Comparison

Flash Only Flowscheme

- Simplest flowscheme and therefore relatively inexpensive
- Low energy requirements
- Ideal for bulk removal of CO₂
- Partial removal of H₂S

Conventional and 1-stage Flowschemes

- Can achieve CO₂ levels below 50 ppm for LNG specifications
- Lower solvent requirements than flash-only system
- Thermal regeneration for higher level of removal

2-stage Flowscheme

- Much lower duty requirements than single-stage system
- Flexibility to trade-off solvent flow rate for thermal regenerator duty or vice-versa

Flow Scheme Comparison - Reboiler Duty

1000's BTU/lbmol CO₂ Removed

Conventional	45-60
1-stage	32-40
2-stage	12-18
Flash only	8-10

Higher feed CO₂ PP yields lower duty

Flow Scheme Comparison – Example 1

	<i>1-Stage</i>	<i>2-Stage</i>
Feed gas rate (MM SCFD)	250	
CO₂ and H₂S in feed (mole %)	12.1	
Absorber pressure (psi)	600	
Lean solvent rate (gal / min)	2280	1378
Semi-Lean solvent rate (gal / min)	-----	7924
Total pump electricity usage (kW)	1010	3372
Thermal regenerator duty (MM Btu / hr)	101	59
Absorber diameter large section (ft)	9.5	12.5

Flow Scheme Comparison – Example 2

	<i>1-Stage</i>	<i>2-Stage</i>
Feed gas rate (MM SCFD)	410	
CO₂ and H₂S in feed (mole %)	18.0	
Absorber pressure (psi)	1070	
Lean solvent rate (gal / min)	6251	2835
Semi-Lean solvent rate (gal / min)	-----	9676
Thermal regenerator duty (MM Btu / hr)	235	125
Total pump electricity usage (kW)	4071	7389
Absorber diameter large section (ft)	12.0	14.0

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Amine Guard FS Process Equipment Features

- **Raschig Super-Rings packing or MD Trays for absorber, flash, and thermal regenerator internals to minimize tower diameter and pressure drop**
- **Welded plate and frame heat exchangers for Lean/Rich exchanger typically specified**
 - **Conventional design is Shell and Tube exchangers**
 - **P&F is lower cost, smaller plot space**
 - **P&F also tighter approach temperature, for additional heat integration**
- **Power Recovery Turbines**
- **UOP specialists assess the optimal equipment for each application**

Exchangers – recent example

- S&T design required 8 shells
 - TIC - \$6MM
- P&F, with tighter approach, 2 in parallel plus 1 warehouse spare
 - TIC - \$1.4 MM (with spare)
 - Also, 10% reduction in reboiler duty
 - \$1.3MM/yr in steam savings

Power Recovery Turbines

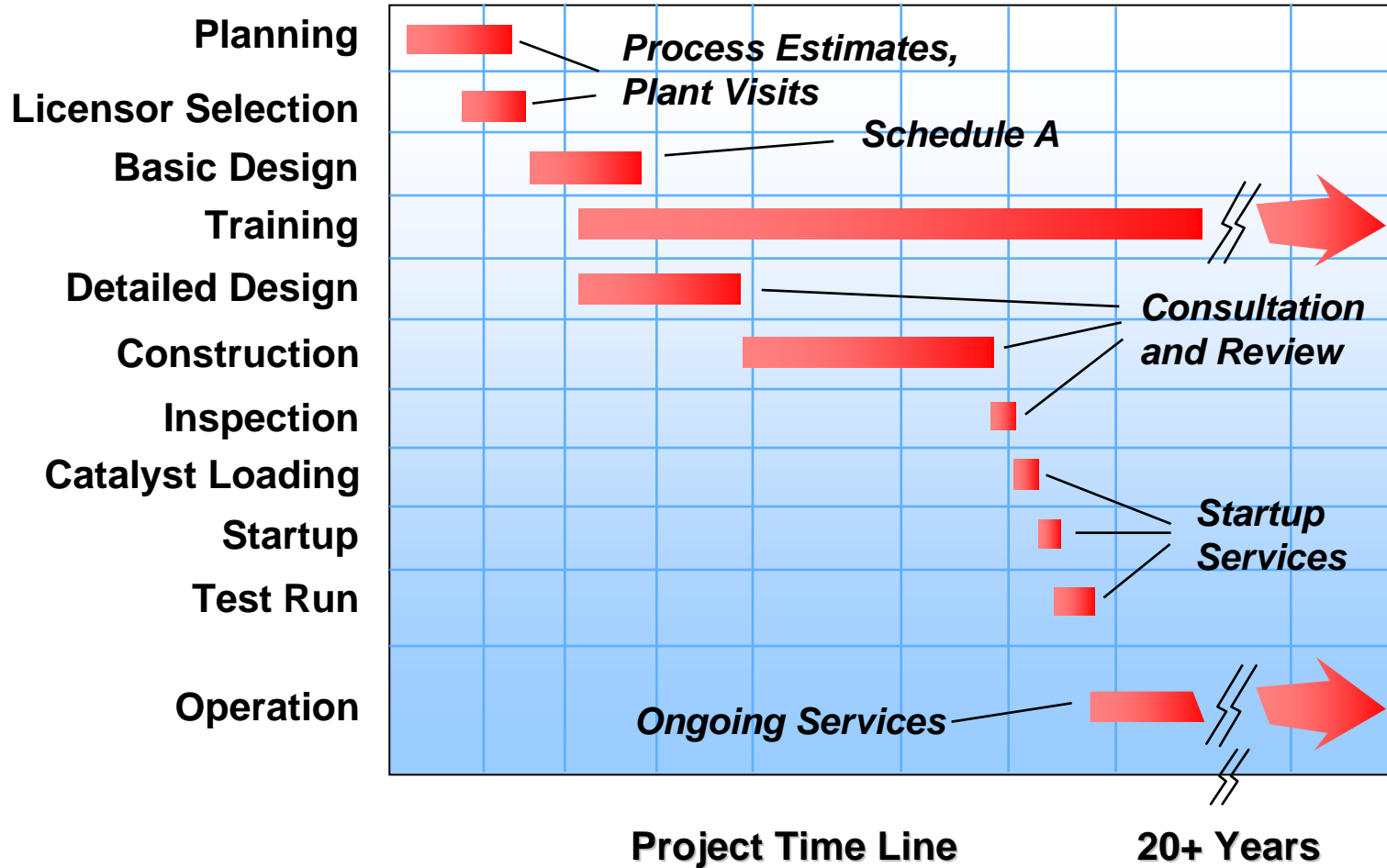
- **Large Natural Gas Applications may be able to justify Power Recovery on Amine pressure let down from high pressure absorber to low pressure regenerator**
- **Recovered mechanical power can justify investment through power consumption savings**
- **Recent example – 2200 kW savings**
 - **\$700,000/yr electrical savings**
 - **PRT equipment cost - \$400,000**

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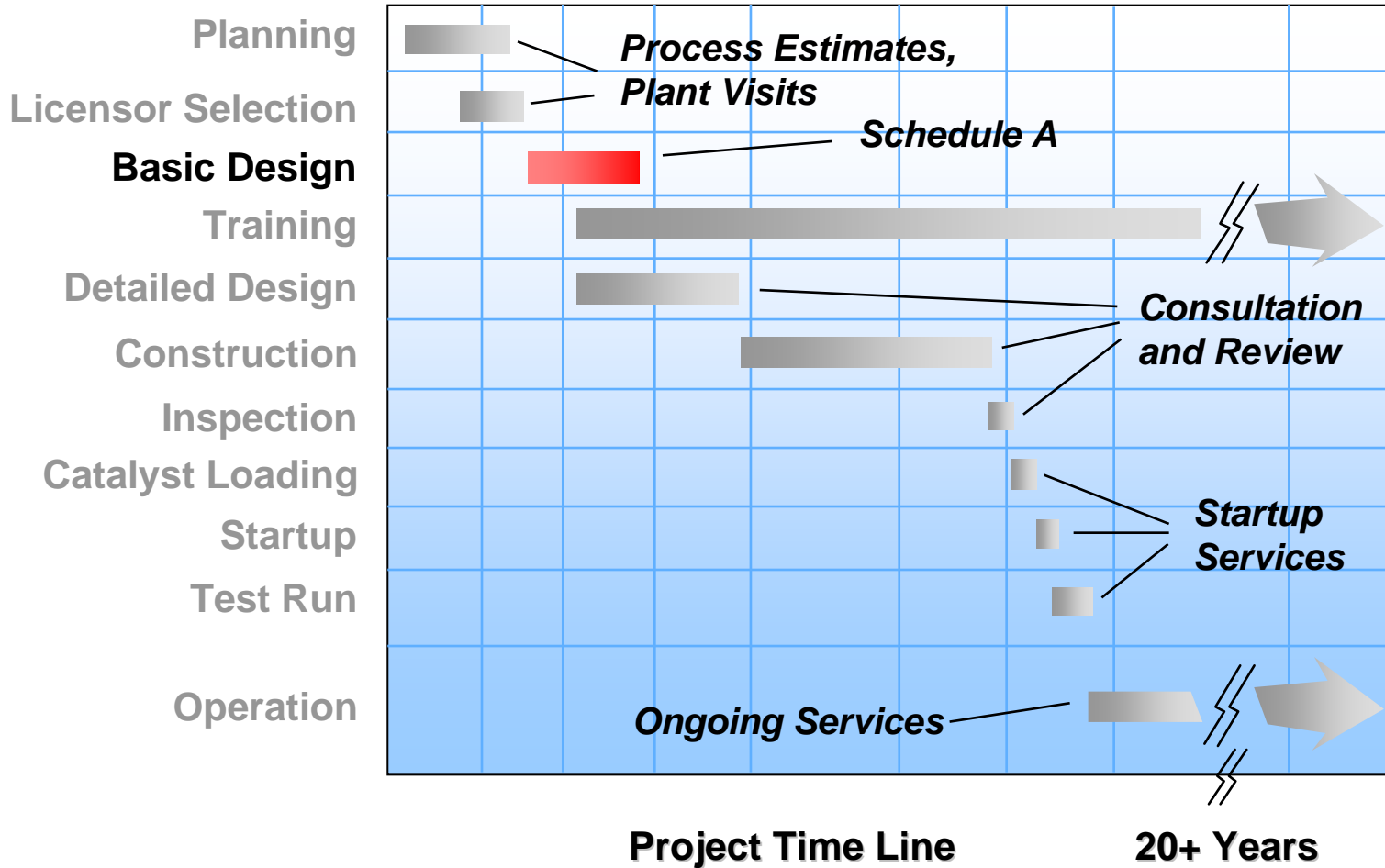


Engineering With YOU Every Step of the Way



Experience IS the Difference

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Experience IS the Difference

The Schedule A Package

- **First step in comprehensive transfer of technology**
- **Design data to YOUR preferred contractor**
- **Ensures your unit is:**
 - Bid accurately
 - Constructed as designed
 - Reliable

Experience IS the Difference



UOP Schedule A Package

Equipment Specifications

- Columns, Vessels, and Reactors
- Fired Heaters
- Exchangers
- Pumps and Compressors
- Instruments
- Piping
- Hydraulics
- Operating manual

Drawings

- Process Flow Diagrams
- Piping and Instrument Diagrams
- Material Selection Diagram
- Mechanical Equipment
- Typical Plot Plan

Standard Specifications

- Additional design information
- Design basis
- Stream and heat transfer data
- Hydraulics
- Operating manual

UOP Engineering Experience

- **Schedule A Designs: 150 - 200 per year**
- **Process Studies: 50 - 75 per year**
- **Revamps: 100 - 150 per year**



- **Several Study & Design package options as starting points for customizing to best evaluate options & meet project objectives**
- **Work with EVERY major contractor worldwide**
- **Gas Processing Operations Experts**
- **Secure Private On line Transfer Server (SPOTS) enables IMMEDIATE secure transfer of project design data via the web**
- **UOP leading the industry to the next generation of design systems optimization (ZyCad) ⇒ fastest and lowest cost projects**

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Commercial Experience

Process

No. of Units

Amine Guard II

220+

Amine Guard FS

30+

Dow UCARSOL

550+

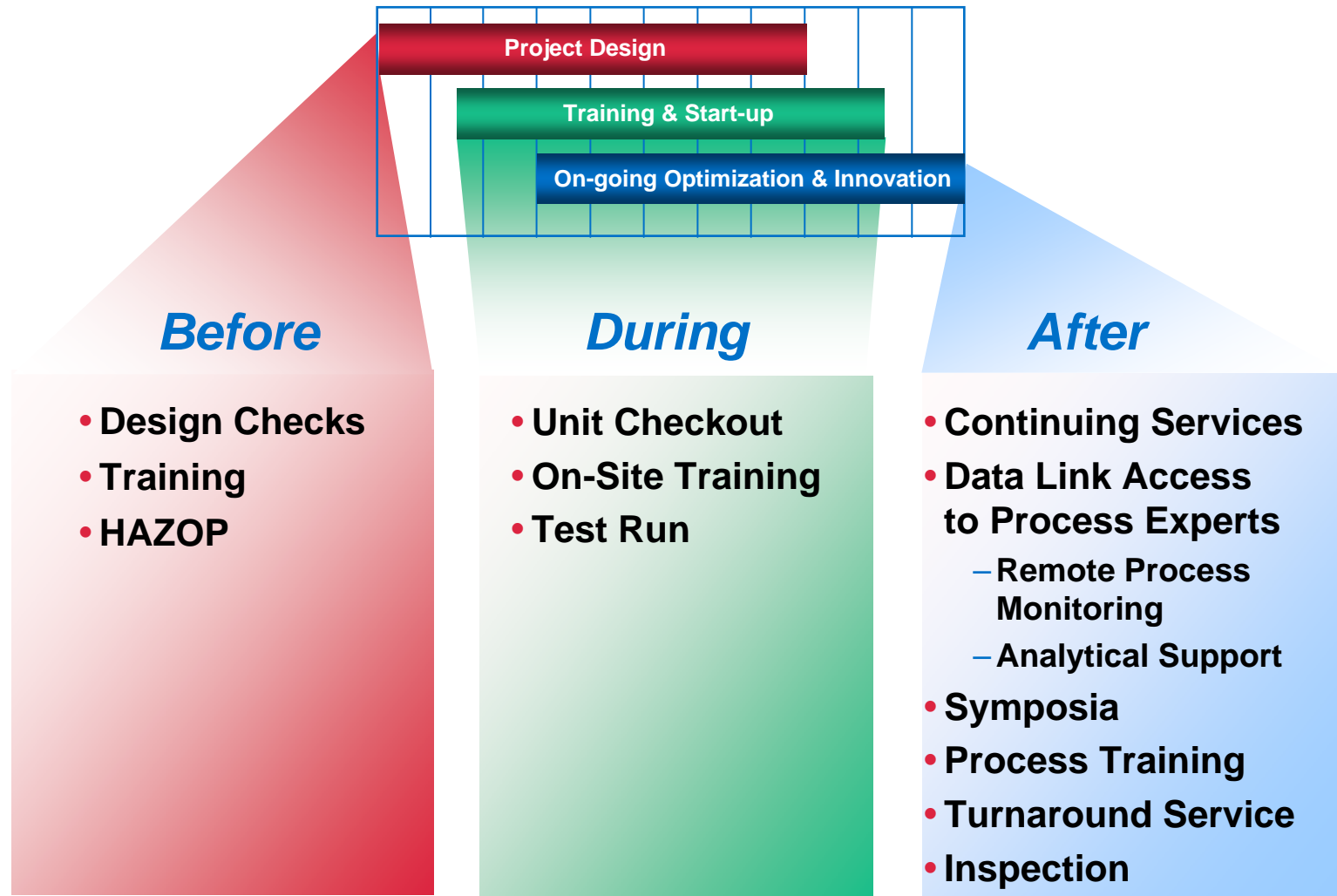
Amine Guard FS Units

<i>Project Location</i>	<i>Capacity MMSCFD</i>	<i>Feed CO₂/H₂S ppmv</i>	<i>Product CO₂/H₂S ppmv</i>	<i>S/U Date</i>
<i>Operating</i>				
Mid East	750	23,000/8,000	50/3	2004
Mid East	195	72,000/15,000	500/50	2002
Far East	51	30,000/60	80/4	2002
Mid East	520	83,000/10	29,000/4	2000
Mid East	52	143,000/17,900	5,000/4	1999
Mid East	122	52,000/540	30,000/8	1994
Mid East	93	40,000/6,000	100/4	1998

Amine Guard FS Units

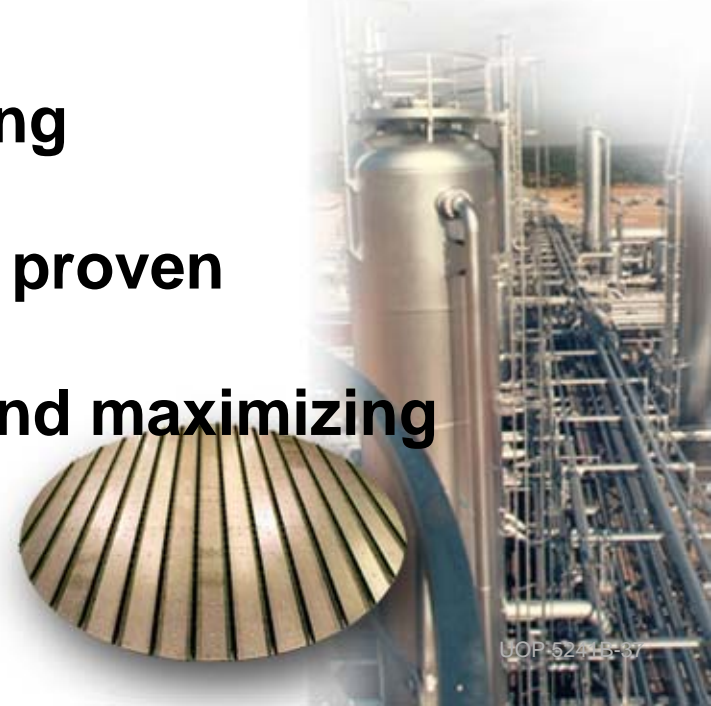
<i>Project Location</i>	<i>Capacity MMSCFD</i>	<i>Feed CO₂/H₂S ppmv</i>	<i>Product CO₂/H₂S ppmv</i>	<i>S/U Date</i>
<i>In Design / Construction</i>				
Mid East	750 x 2	23,000/8,000	50/3	2005
Mid East	750	23,000/8,000	50/3	2006
Far East	425	230,000/55	40,000/5	2005
Mid East	1,262	40,000/10,300	5,500/20	2006
Mid East	3,200	23,100/8,000	8,000/3	2006
Mid East	128	80,000/75	50/7	2006
Mid East	1,530 x 2	25,200/8,220	25/2	2007
Mid East	794	46,000/30,000	9,400/20	2007
Far East	800	230,000/38	3,000/1	2008

Guaranteed Performance



Amine Guard FS Process Summary

- **UOP has extensive commercial experience and technology expertise for acid gas removal**
- **Amine Guard FS utilizes state of the art UCARSOL Formulated Solvent**
- **Applicable to a wide variety of applications including natural gas and synthesis gas**
- **The Amine Guard FS process is a proven licensed technology**
- **Licensed approach provides ongoing technical service**
- **UOP Schedule A is an efficient and proven technology transfer system**
- **UOP can assist you in optimizing and maximizing the value of your project**



Q & A