Fluor Solvent Testing at Technology Center Mongstad (Project 70814)

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Disclaimer

This material is based upon work supported by the U.S. Department of Energy under Field Work Proposal FWP-70814.

ABOUT FLUOR

- **One of the world's largest** engineering, procurement, fabrication, construction and maintenance companies
- Providing **innovative** and **integrated** solutions for industrial facilities of varying sizes across the globe
- More than **55,000** employees executing projects globally
- Delivering capital efficient solutions
- Proprietary CO_2 Technology: Econamine FG+
  - Recently developed a lean water solvent for CO2 Capture

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Fluor's Gas Treating Solutions

- Fluor offers various gas treating solutions
- **Fluor Solvent^{SM}** – Physical solvent to absorb H_2S and CO_2 at high pressure
- **Econamine^{SM}** – Uses diglycolamine (DGA) for H_2S and CO_2 removal from natural gas streams
- **Econamine FG Plus^{SM}** – Removal of CO_2 from low pressure, post-combustion flue gases
- Fluor has built over 425 gas processing facilities
  - Includes 30 Econamine FG+ plants built or licensed

What is the Relevance of Water Lean Solvents?

- Carbon capture solvents typically contain 60 to 65% water by weight
- Fluor's target is a solvent with less than 40 to 50% water
  - ~5% reduction expected in heat rate and ~20% reduction expected in solvent circulation rate
- Water provides a medium for ionic reactions to take place
- But, water has several drawbacks
  - High heat of vaporization
  - High volatility
  - High specific heat
  - Low capacity for CO_2
- Replacement of a portion of the water with other solvents offers an opportunity for energy consumption reduction

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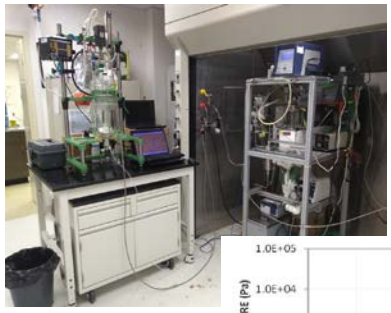
Lean Solvent Formulation

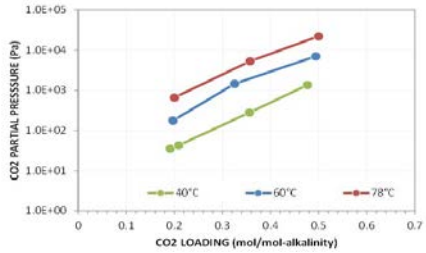
- In 2016 Fluor developed a water lean solvent that showed promise for a more energy efficient CO_2 capture
- Fluor worked with PNNL to measure the VLE of the new solvent system
- To establish the environmental performance of the solvent, Fluor conducted a degradation test at SINTEF in Norway

Solvent Performance Testing

- VLE and kinetic data were measured for several different solvent mixtures
  - Thermodynamic and kinetic data developed
  - Solvent composition optimized



PNNL's Wetted Wall Column Capability



- Solvent degradation testing at SINTEF
  - 5-week testing with synthetic flue gas: 3.0 vol% CO2, 12% O2, and 10 ppmv NOx. Absorber/ desorber temps: 40C/ 117C.
  - One solvent component found to produce an undesirable degradation product – replaced with alternate component

SINTEF's Solvent Degradation Rig

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Funding

- Based on the results:
  - DOE approved funding for the demonstration of the new solvent at Technology Center Mongstad (TCM), Norway
  - Subsequently, TCM also provided approval and funding for the test at their facility at Mongstad

Contracts

- DOE/PNNL:

  Contract May 8, 2018

  Fluor/PNNL managed the DOE-funded portion of the project:
  - Proprietary equipment (Solvent Maintenance System)
  - Solvent purchase
  - Installation of proprietary equipment and hook-ups
  - Solvent disposal
  - Deployment of personnel and travel costs
- TCM Contract:

  Contract June 18 2018
  - Use of the demonstration plant
  - All utilities
  - Operating staff
  - Emissions measurements
  - Analytical laboratory services
  - Office Facilities

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Test Campaign Timeline (2019)

- January 23 – start of test campaign with Combined Heat and Power (CHP) Plant flue gas
- April 3 – begin transition to Refinery Fluid Catalytic Cracker (RFCC) flue gas configuration
- April 28 – operation fully changed to RFCC flue gas
- May 27 – final day of original test campaign
  - 2,700 hours of operation on CO_2 capture plant
- May 28 – Started test campaign extension period
- June 27 – end of test campaign
  - 3400 total hours of operation on CO_2 capture plant

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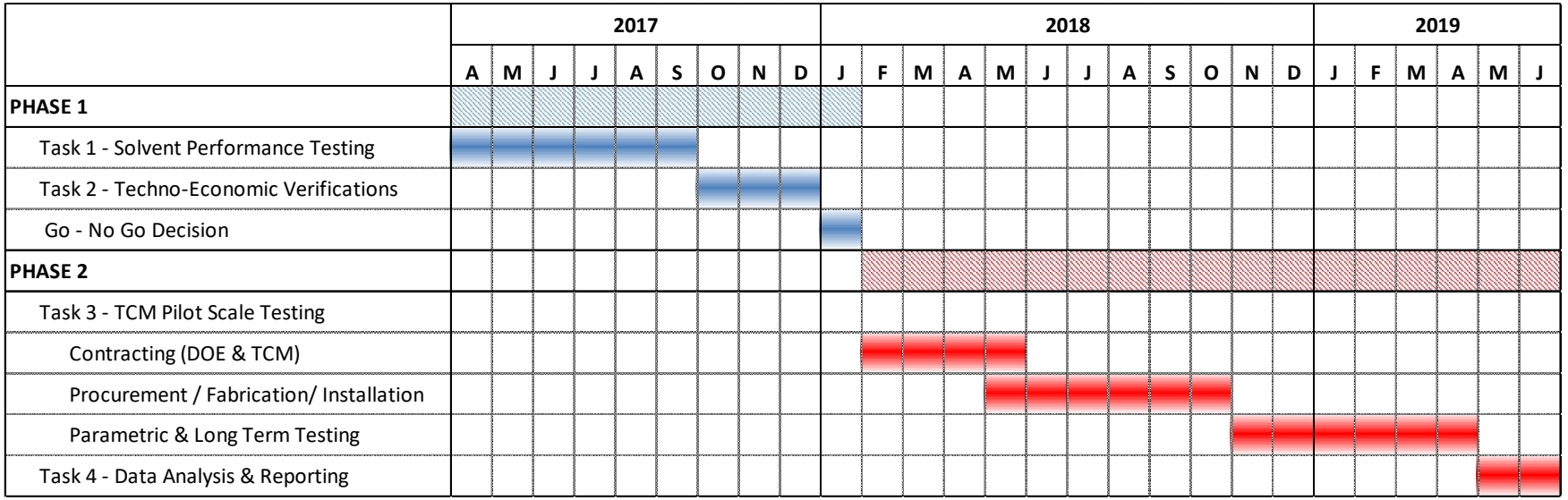
Project Schedule & Budget



DOE Funding:

Phase 1:	$284k
Phase 2:	$2,396k
Extended testing (6wks) :	$425k
Total:	$3,105k

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Technology Center Mongstad

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Testing at TCM

- CHP Flue Gas Test Phase
  - January 23 to April 2
  - CHP Flue Gas Average Conc: 3.3 vol% CO_2, 15.6 vol% O_2
- RFCC Flue Gas Test Phase
  - April 3 to June 27
  - RFCC Flue Gas Average Conc: 12.6 vol% CO_2, 8.6 vol% O_2

Absorber Emissions During CHP Test Phase

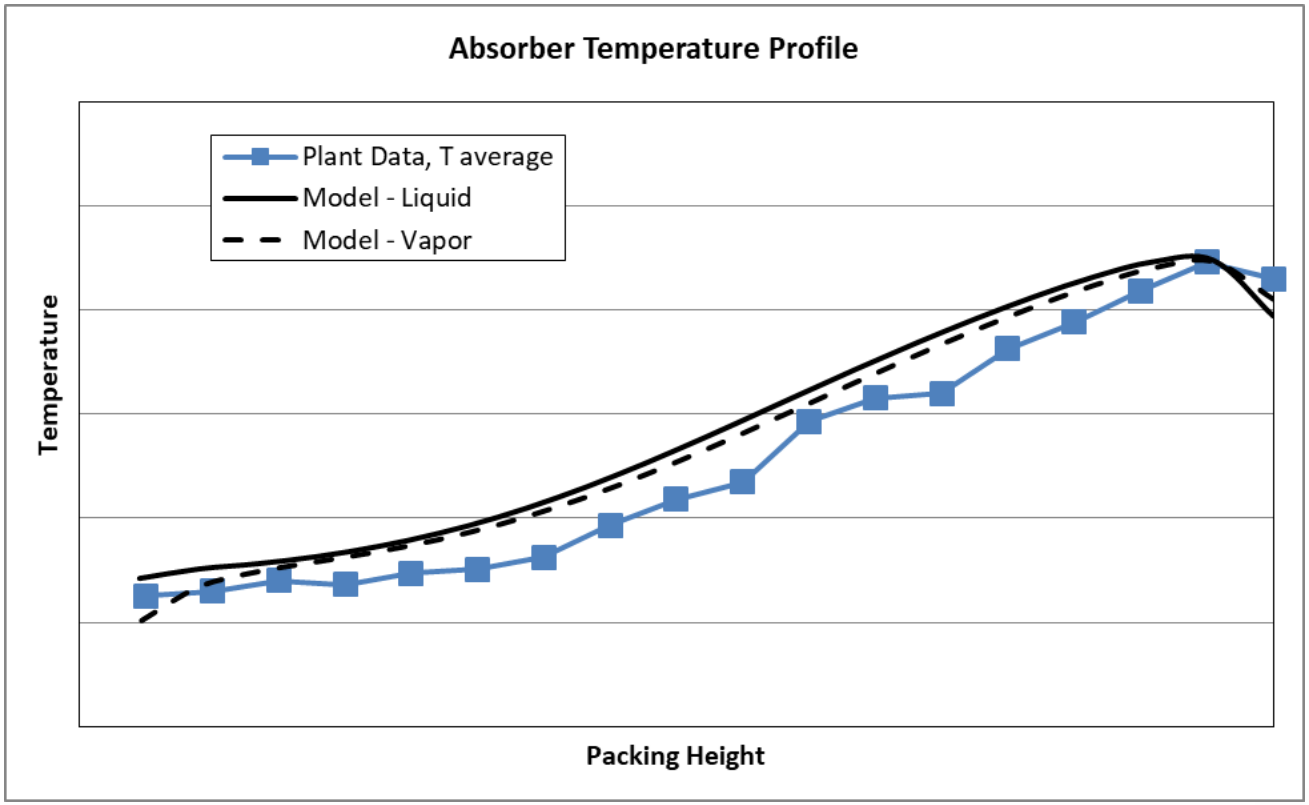
- Average Absorber emissions during CHP test:
  - Component A: < 0.01 ppmv, Component C: < 0.01 ppmv, NH_3: < 3 ppmv
- Average Absorber emissions during RFCC test:
  - Component A: < 0.1 ppmv, Component C: < 0.2 ppmv, NH_3: < 3 ppmv

Simulator Performance

- Results of Aspen Plus model developed by Fluor were compared to plant measurements
- Good agreement for absorber performance, but observed stripper performance was poor compared to simulated performance
  - Analysis of stripper performance using a tuning parameter in the simulator revealed that the stripper was underperforming
  - Lean Water Solvent circulation rate was too low
  - Poor performance of stripper packing attributed to plant operating below minimum hydraulic design

Simulator Performance

- Good agreement between simulated Absorber temperature profile and plant data



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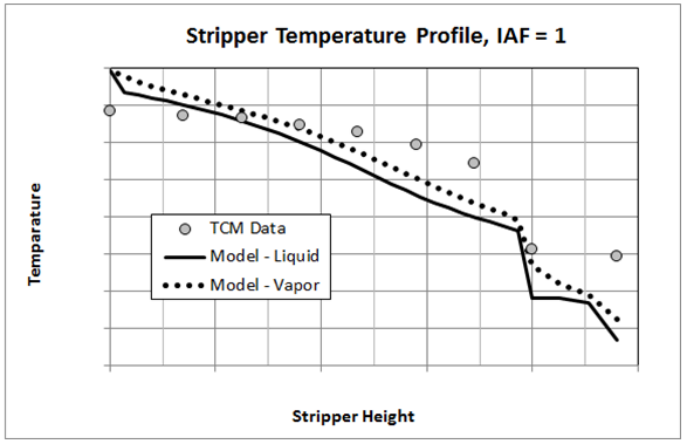
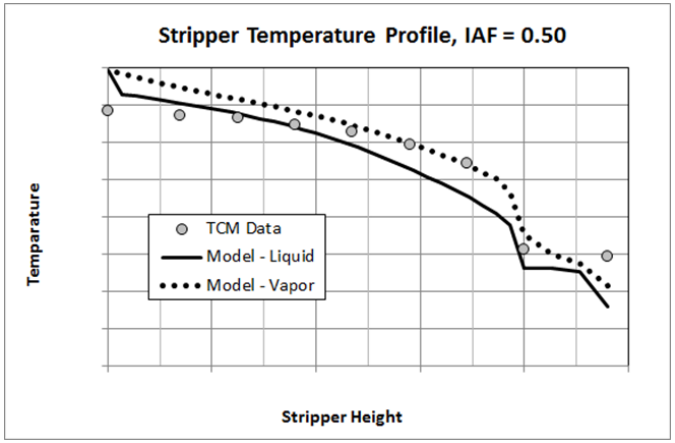
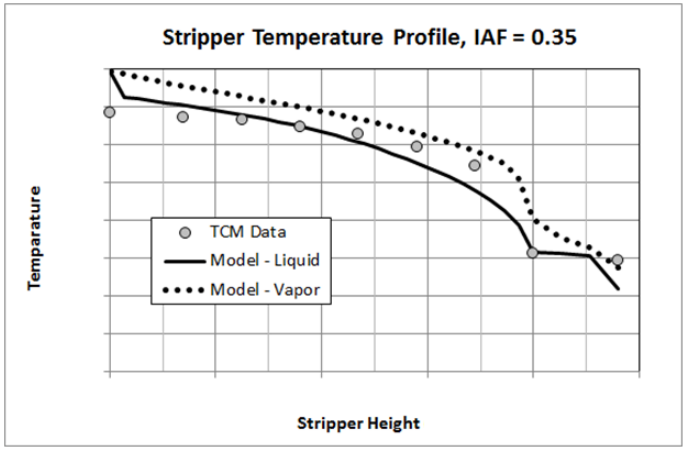
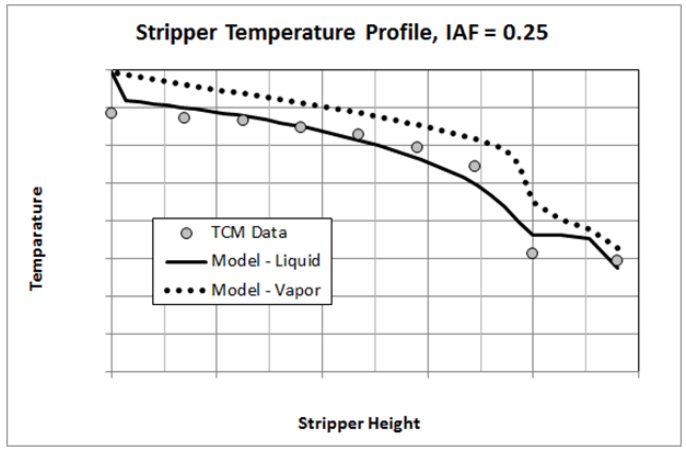
Simulator Performance

- Interfacial Area Factor (IAF) adjusted to match simulated profile to plant data
- Low IAF (0.35~0.5) needed to match simulated stripper profile to plant data









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Solvent Maintenance System

- Installation at site

Solvent Maintenance System

- HSS levels stable when in operation
- Excellent Solvent Recovery
  - 93 to 95% solvent recovery (mass basis)
  - Very small waste production
  - No foaming with Lean Water Solvent
- Low metal concentration in solution
  - Low degradation rate

Test Campaign Highlights

- Successfully tested new water-lean solvent formula:
  - Heat Rate reduced by 5 to 6% compared to the current EFG+ solvent
  - Amine Circulation reduced by 20%
- Very low Absorber emissions:
  - Average amine emissions < 0.2 ppmv
  - Average ammonia emissions < 3 ppmv
- Validated Solvent Maintenance System on Lean water Solvent
  - 660 hours logged
  - Unit test successfully at up to 110% design capacity
  - 93 to 95 % solvent recovery on average
- Solvent Maintenance System able to maintain impurities at a negligible concentration

Acknowledgements

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- Thanks to the Technology Center Mongstad (TCM) for their funding, superb field support and guidance

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QUESTIONS