SCR And SNCR Reagent Cost MINIMIZATION

David L Wojichowski, Principal

De-NOx Technologies, LLC

James T Egan, President

Colonial Chemical Company

Overview

- Applies equally to SNCR and SCR.
- Reagent is most significant controllable cost to both.
- Basic reagent options are ammonia, aqua ammonia, and urea.
- All are readily available commodity chemicals.

Anhydrous Ammonia

- Anhydrous ammonia is always the least expensive form of nitrogen (min 20% less than urea)
- It is the most concentrated form of nitrogen (82% by weight).
- Stored under pressures as high as 250 psig.
- Is caustic and causes severe chemical burns.

Anhydrous Con't

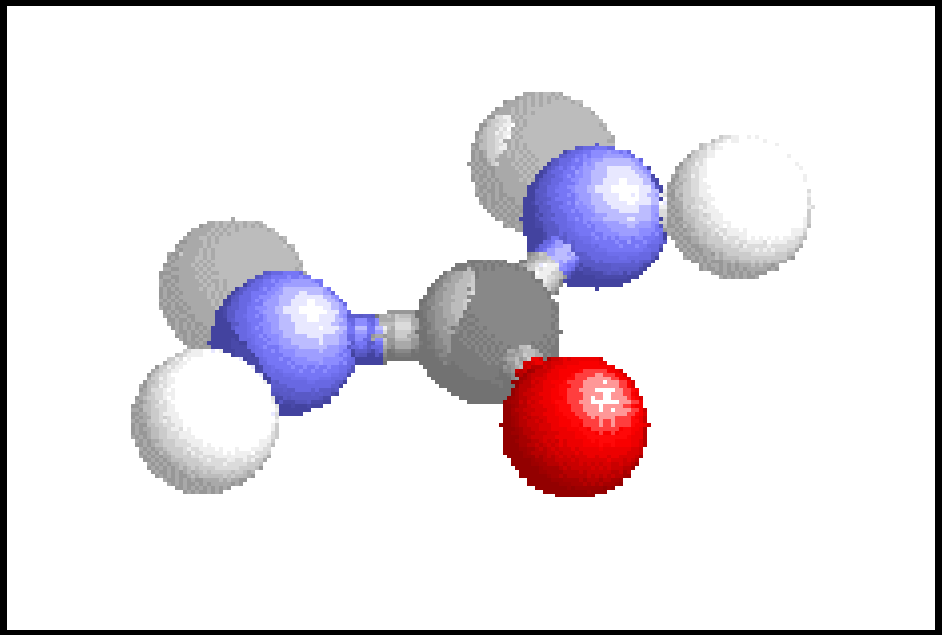
- Siting new facilities can be an issue.
- Federally regulated (40 CFR 1910) above 10,000 lbs.
- Some states not allowing new installations.
- Capital costs increasing (double lined tanks, sub-grade containment, total enclosure, etc.).
- Local concerns.
- Post 9/11 issues.

Aqueous Ammonia

- Generally available as a 28wt% solution.
- Hauling cost disadvantage if distances are moderate or high.
- Still subject to ammonia regulations and siting concerns.
- Delivered cost similar to urea solutions.

Urea

- An international commodity chemical used primarily as nitrogen fertilizer.



Urea Basics

- In pure (dry) form, is 46% nitrogen.
- Produced by the combination of ammonia and carbon dioxide at high temperature and pressure.
- Price is dependant upon agricultural demand (90%) and natural gas supply.
- Advantage is ease and safety of transport, storage, and use.

Urea Cost Parameters

- Uncontrollable cost of natural gas.
- Cost drivers for domestic consumption.
- Unique requirements for the power industry.
- Implicit risks of urea supply.
- Critical service component of urea distribution.

Liquid Urea Service Considerations

- Quantities
- High Quality
- Peak Demands
- Process Controls
- Tanker Stock

SCR Unique Requirements

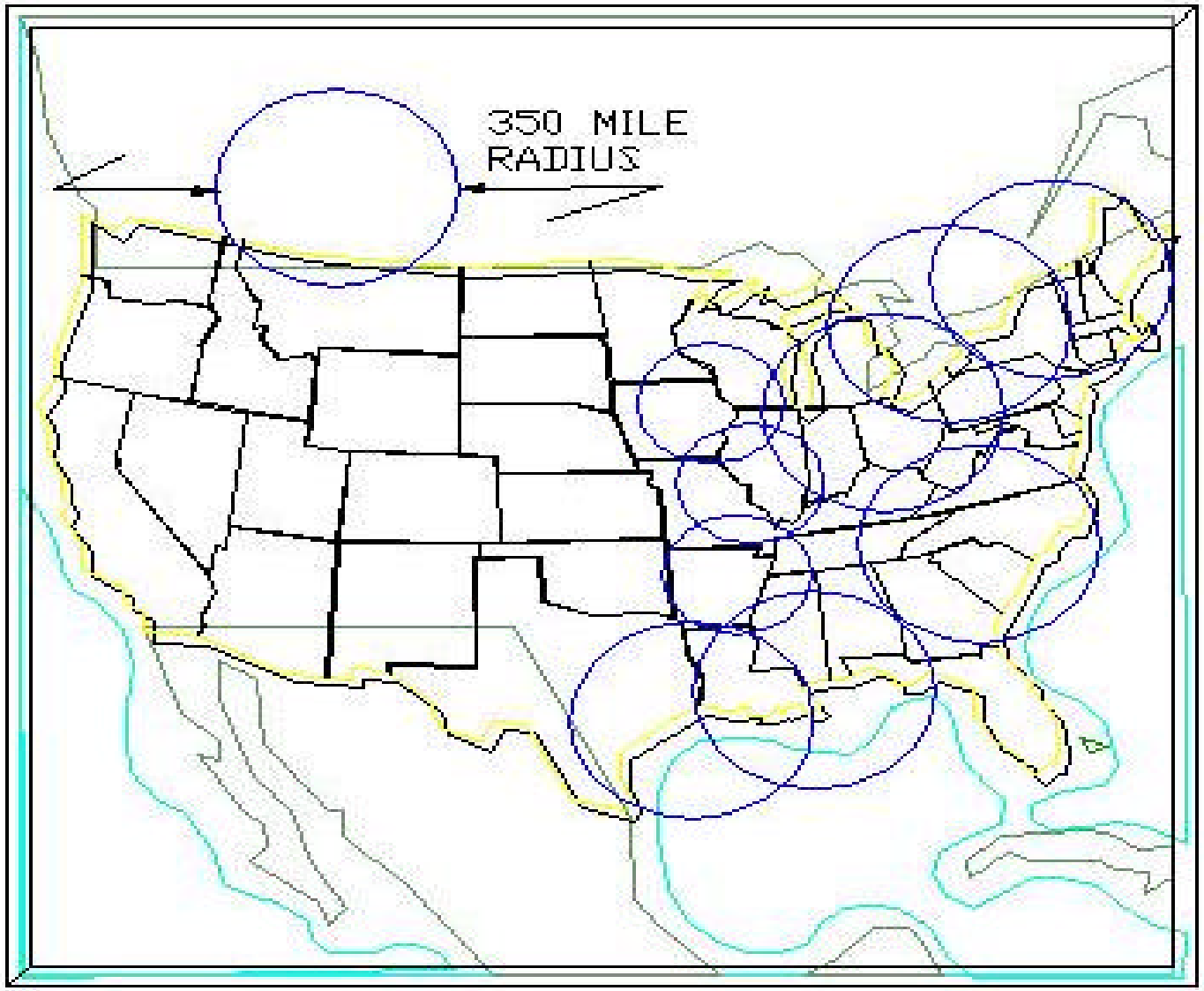
- All bulk dry material
- Cost Minimization through favorable seasonal contracts
- Must deliver high volume during peak load operating conditions
- Limited On-site footprint to accommodate large quantities of dry urea
- Just-in-Time delivery minimizes on-site capital and problems

Summary

- Supplier should have access to world markets
- Supplier should have geographic distribution and storage terminal
- Supplier should have a proper dedicated truck fleet
- Service rather than on-site capital
- Quality is the Key

On-site Urea Systems

- Transportation costs for dry urea is significant. Limited number of suppliers.
- Need to decide receiving method first.
- Receiving, storage, and handling options are many.


350 MILE
RADIUS

Delivery Options

- Rail – lowest cost option for plants with high quantity requirements and direct rail siding. Timing and reliability is an issue.
- Dump trailer – best second option. Very competitive costs. Quick response. Needs receiving system.
- Bulk pneumatic truck – convenient to load into silos, generally expensive option.
- Supersack – for small quantity users. Surprisingly cost effective. Needs add'l on-site handling. Premium moisture protection.

Relative Costs - Delivery

- Rail – 100 ton payload per car. Marginal cost per additional mile is low.
- Dump trailer – typical cost $1.5-2.5 per mile. Backhaul ???
- Bulk pneumatic – Higher cost 30-50%.
- Supersack – cost similar to dump trailer. Add $10 per ton for filling and bag replacement.

Delivery Summary

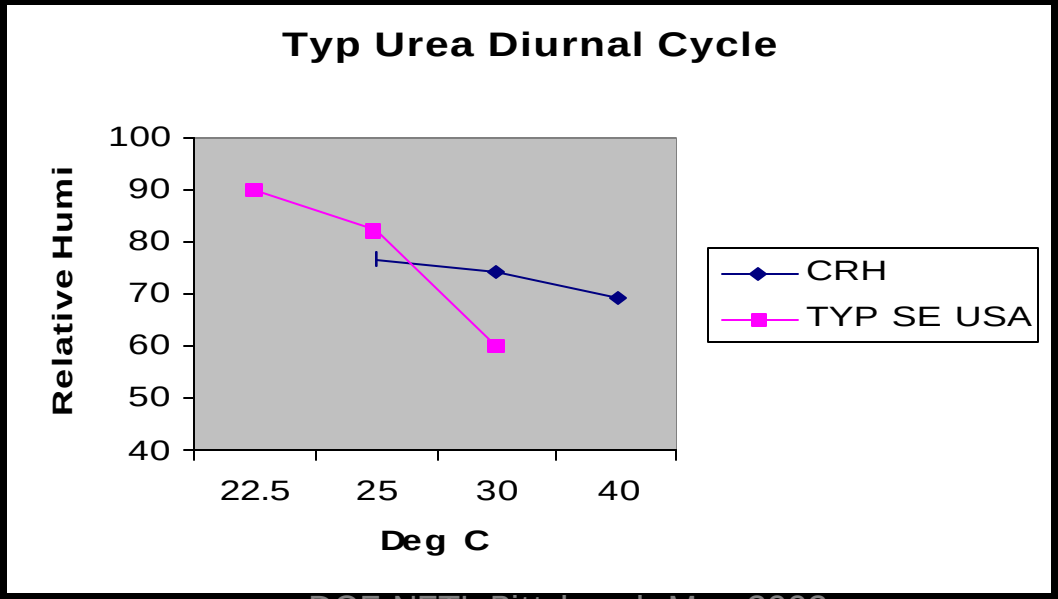
- Transportation cost is a substantial fraction of the delivered cost.
- Distance from manufacturer/distributor effectively limits supply options.
- Dump trailers should be considered first if rail not available.

Urea Receiving and Storage

- Key consideration is moisture protection. Dry urea is hygroscopic.
- Recommended design parameters:
  - Bulk density: 46 lb/cf
  - Angle of repose: 27 degrees
  - Maximum stacking height: 35-45 ft
  - Critical Relative Humidity: 76.5% @ 77F

Urea Storage – Diurnal Cycle

- When above CRH, urea will gain water – and vice versa.
- Prill surface forms crystals, and eventually cakes together.



Optimum Storage Options

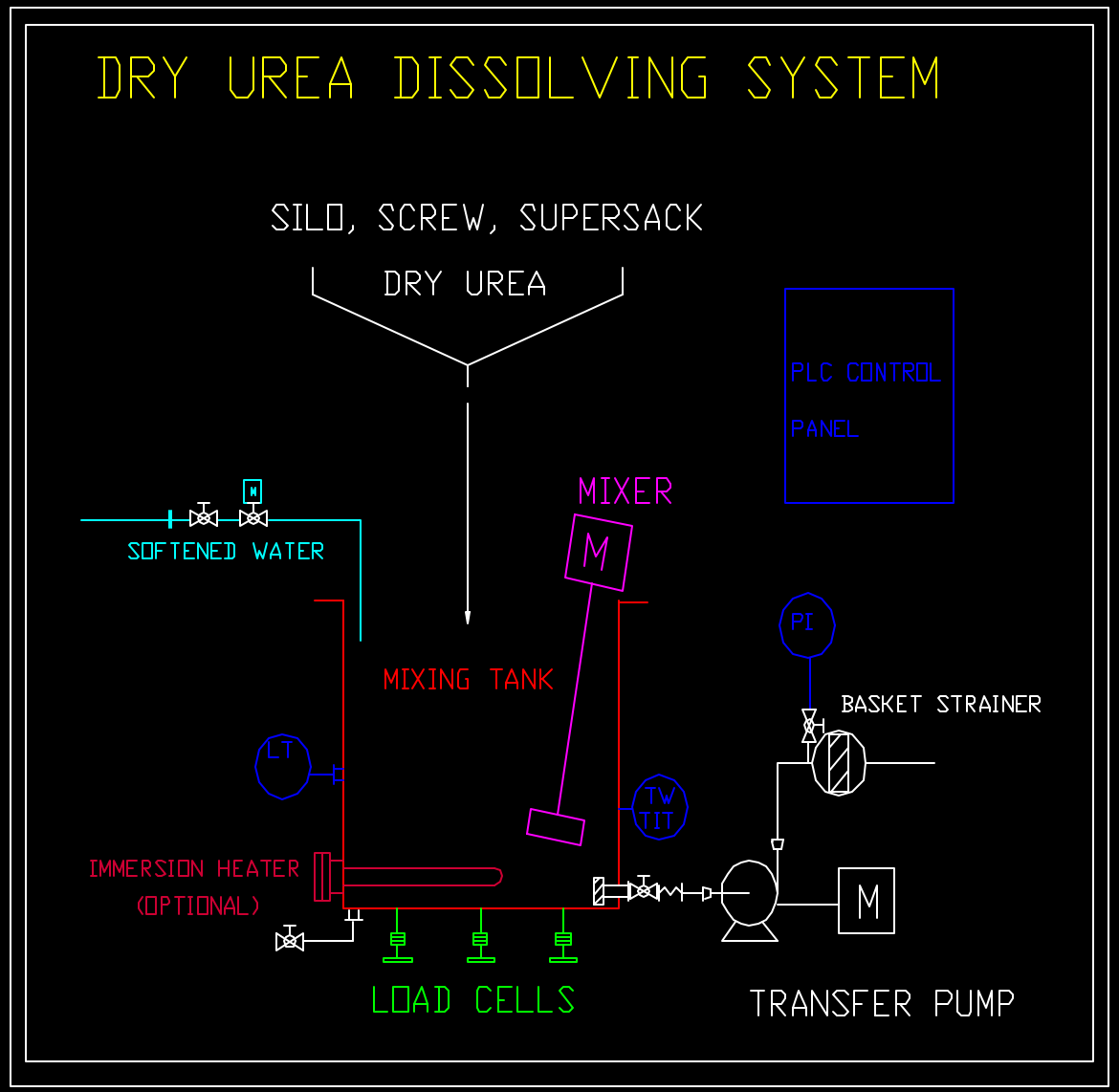
- Wet Storage – Convert to liquid when received and store in tanks. Avoids dry storage problems. Usually heat tanks to avoid re-crystallization.
- Building Storage – Large quantities, typical stacking/reclaiming mechanical equipment.
- Silos

Silo Storage

- Loaded from pneumatic truck or mechanically from dump hopper
- All welded silos – maximum quantity limited by height 150 tons ?
- Provide dry air blanketing.
- Expect occasional bridging.
- Minimize downstream material handling.

Dissolving Process

- Relatively simple.
- Endothermic - requires 110 BTU/pound of heat added.
- Will not dissolve quickly.
- Batch process is most common. Good control of product concentration.
- Batch process can be automated.
- Filtering is a must.


DRY UREA DISSOLVING SYSTEM
SILO, SCREW, SUPERSACK
DRY UREA
PLC CONTROL
PANEL
MIXER
M
SOFTENED WATER
PI
MIXING TANK
BASKET STRAINER
LT
TW
TIT
IMMERSION HEATER
(OPTIONAL)
M
LOAD CELLS
TRANSFER PUMP

8000 GPD Dissolving System

Cost Model

- Example – 3000 TPY dry urea, 1000 tons equivalent dry storage. Receive in dump trailers.
- Liquid tanks – Two 250,000 Gal coated and insulated CS tanks. Two 15,000 GPD batch dissolving systems.
- Silos – Eight 14’ Diam x 140 ton silos, each with dissolver in skirt.
- Building – 60’ x 100’ w/retaining walls, overhead tripper and underpile reclaimers. Two 15,000 GPD dissolvers.

Cost Summary

	INSTALLED COST	FOOTPRINT
	$	SQ FT
SILO	5,000,000	100’x40’
BUILDING	6,000,000	120’x60’
LIQUID	3,500,000	100’x65’

Conclusions

- Use ammonia if possible.
- If urea, on-site dissolving is economical if urea consumption is over 500 TPY dry equivalent.
- If on-site dissolving, consider immediate processing and liquid storage.