UREA INFRASTRUCTURE
FOR UREA SCR NOX REDUCTION

Bruce Bunting
Manager, Aftertreatment Engineering
Cummins, Inc.
Columbus, IN
Outline of talk

• Introduction
• Applications
• Urea characteristics
• Urea infrastructure
• Quality problems
• Dye?
• Diesel cross-cut group
• Conclusions
Introduction

- Urea SCR is currently the only proven NOX aftertreatment for diesel engines
  - high NOX reduction possible
  - some SCR catalyst systems are robust against fuel sulfur
  - durability has been demonstrated
  - many systems in the field
  - long history in other markets
- Major limitations to acceptance
  - distribution of urea solution to end user
  - ensuring that urea solution is added to vehicle
“Easy” applications for urea

- Fixed location applications
  - power generation
- Fixed base fleets
  - municipal vehicles
  - single base truck fleets
  - single refueling point
- Fixed route fleets
  - several refueling sites
- ‘Educated’ users
“Difficult” applications for urea

- Trucks not running fixed routes
- Small industrial users
- Passenger car
- ‘General public’ users
- ‘Experimenters’
General urea considerations

- clear solution, slightly heavier than water
- 32 weight percent solution of urea in deionized water
- urea is considered non-hazardous, not DOT regulated
- Corrosive to brass, copper, and mild steel
- compatible with stainless steel, plastics, and some aluminums
- freezes at 11 deg. F
  - maintains concentration in ice and liquid
  - does not salt out
- decomposes above 280 deg. F
  - hot soak concerns
- can lose water by evaporation
- creeps through seals and fittings
- spills leave a lot of white residue
- urea solution is mild irritant
- urea solution costs about the same as diesel fuel
- may require periodic mixing in storage (evaporation/condensation inside of storage tank)

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Urea infrastructure - what’s already there

- natural gas
- air
- nitrogen production
  - ammonia
  - ammonium nitrate
  - urea
    - fertilizer
    - chemical feedstocks
    - animal feed
    - NOX control products
      - power plant SNCR
      - diesel SCR

16 U.S. producers
8 Canadian producers

22,000,000 tons/year world export market
5,700,000 tons/year U.S.
4,400,000 tons/year Canada

In bulk, we can have urea solution delivered to Columbus IN for $1.00 per gallon, today

tank pump units for service stations, truck terminals, or job sites

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How Cummins solved urea infrastructure for test work

DELIVERIES FROM UREA SUPPLIER

2500 GALLON POLYETHYLENE FARM TYPE TANK

STATIONARY POWER DURABILITY TEST

110 GALLON POLYETHYLENE TOTES FOR TEST CELLS AND FLEET TESTING

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Longer term Cummins plan for urea infrastructure

- Mainly aimed at stationary power
- Use Fleetguard / Nelson Division to mix and distribute urea
- 275 gallon totes or bulk deliveries
- Totes stocked at Cummins distributors to support local needs
- Solution available for public sale
## UREA QUALITY PROBLEMS FOUND IN THREE YEARS OF TESTING AT CUMMINS

<table>
<thead>
<tr>
<th>QUALITY PROBLEM</th>
<th>RESULT</th>
<th>HOW SOLVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIRT IN UREA</td>
<td>PLUGGING OR POOR SEALING</td>
<td>LET SOLUTION SETTLE, ADD FILTER</td>
</tr>
<tr>
<td>UREA CONCENTRATION TOO HIGH</td>
<td>EXCESS NOX REDUCTION, AMMONIA SLIP</td>
<td>ADJUST SOLUTION WITH DISTILLED WATER</td>
</tr>
<tr>
<td>UREA CONCENTRATION TOO LOW</td>
<td>NOT ACHIEVE NOX REDUCTION TARGETS</td>
<td>ADD ADDITIONAL UREA TO SOLUTION</td>
</tr>
<tr>
<td>SALT (NaCl) CONTAMINATION</td>
<td>CATALYST PLUGGING, EXHAUST SYSTEM CORROSION</td>
<td>DISCARD SOLUTION, CHANGE SUPPLIER</td>
</tr>
<tr>
<td>STRATIFIED SOLUTIONS (SMALL CONTAINERS)</td>
<td>UREA CONCENTRATION NOT CORRECT</td>
<td>MIX SOLUTIONS BEFORE USING</td>
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</tbody>
</table>

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Should urea solution be dyed?

- Identification of solution
- Safety alert to public
- Dilution detection by dye strength
- Need industry and regulatory consensus
Diesel cross-cut urea group

• Current members
  – Caterpillar
  – Cummins
  – Daimler Chrysler
  – Detroit Diesel
  – Ford
  – General Motors
• Group is soliciting input from other interested parties
  – common needs
  – concerns
  – technical solutions
Diesel cross-cut urea group

Infrastructure
- What are the fluid properties: freezing, evaporation
- Distribution: where to do the mixing
- Maintaining quality control
- Affordable retail outlet kit
- Metering and customer charges

Delivery to the vehicle
- Select an approach (will co-fueling work?)
- Design and develop the nozzle and fill port (all applications, backward compatibility)
- Communication system for independent turn-on and shut-off
- Demonstrate and conduct robustness trials

Tasks
- Agree on the goals and objectives
- Concept disclosure and selection
- Define specific projects and working groups
- Obtain approval and budget and initiate projects
- Recommendation for preferred system

Goal
- to be transparent to the end user

Not covered
- vehicle system design
- catalyst technology

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Conclusions

• Urea SCR is an effective method for NOX reduction
• Major drawbacks
  – distribution of urea
  – ensuring it is used
• Some applications are easier than others
  – stationary applications
  – fixed base operations
• Team work will be needed to bring SCR to wide usage
  – standards, specifications
  – manufacturing, distribution
  – filling method
  – public education