Worldwide Pollution Control Association

IL Regional Technical Seminar

September 13-15,2011

Visit our website at www.wpca.info

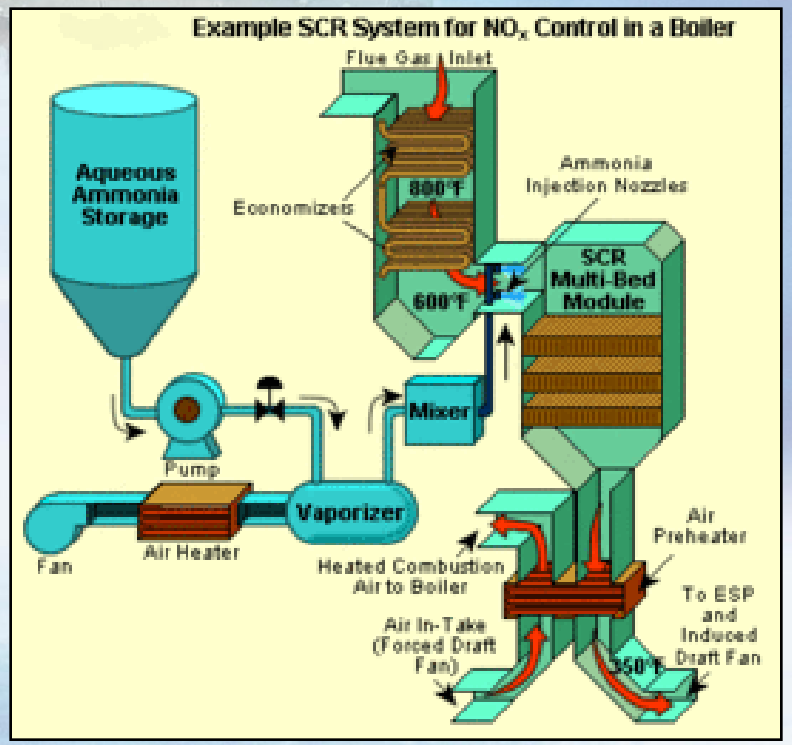
WAHLCO, INC.®

Ammonia System Configurations, Site Planning, and Safety

WPCA 2011

www.wahlco.com

NH_3 SCR APPLICATIONS OVERVIEW



Overview

- Ammonia is the primary reagent for DeNO$_x$ with SCR or SNCR applications
- Typically three forms of ammonia used; Anhydrous, Aqueous (19% or 29% U.S.), or Urea

Important Factors to Consider

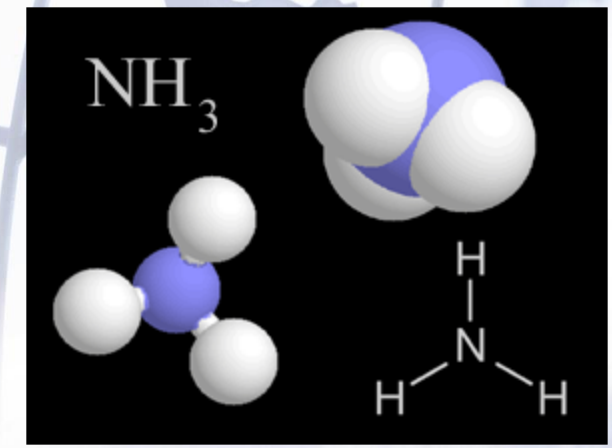
- Cost
- System size (lb/hr required)
- Permitting and Local Regulations
- Utilities available
- Site conditions
- Safety

WAHLCO, INC.®

HEALTH EFFECTS OF AMMONIA

Effect	Ammonia ppm
Least perceptible odor	5 ppm
Readily detectable odor	20-50 ppm
No discomfort or impairment of health for prolonged exposure	50-100 ppm
General discomfort and eye-tearing; No lasting effect on short exposure	150-200 ppm
Severe irritation of eyes, ears, nose and throat; No lasting effect on short exposure	400-700 ppm
Coughing, bronchial spasms	1,700 ppm
Dangerous, less than ½ hour exposure may be fatal	2000-3000 ppm
Serious edema, strangulation, asphyxia, rapidly fatal	5000-10,000 ppm
Immediately fatal	>10,000 ppm

ANHYDROUS AMMONIA PROPERTIES



- Definition of Anhydrous is "without water" (0.2-0.5% water content)
- Pungent, colorless gas
- Commonly stored as liquid under pressure or refrigerated
- Flammable compressed gas
- Boiling point = -28 F
- Pressure varies greatly with temperature

  50 F = 75 psig

  90°F = 164 psig

ANHYDROUS REAGENT OVERVIEW

Benefits

- Lowest reagent cost
- Lowest capital equipment cost
- Lowest operating cost
- Simplistic design

NH_3 System Types

- Pressure build system
- In-line vaporization system
- Flash vaporization system

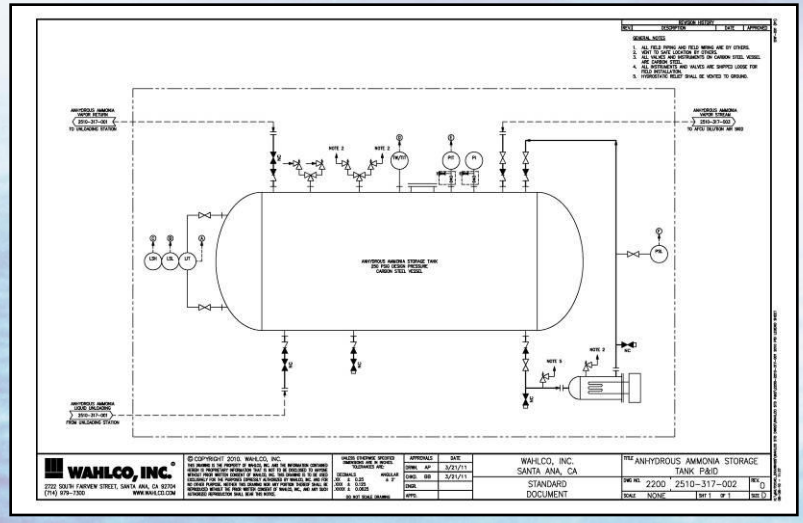
Cons

- Most inherent safety risk
- Permitting
- Delivery of reagent
- Storage of reagent

System Specifications

- Carbon steel
- Design pressure ~250-300 psig
- Governed by ANSI K61.1 B
- Dilution air is not required to be pre-heated

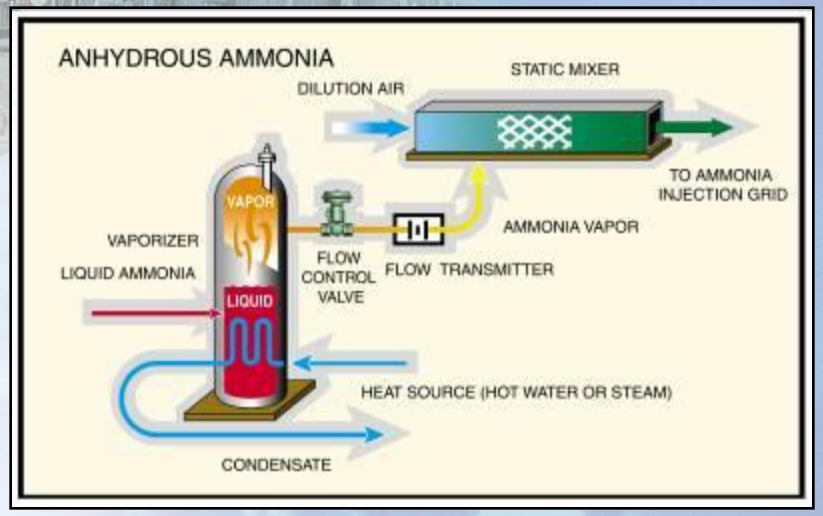
PRESSURE BUILD SYSTEM



- Utilizes a heater attached to the storage tank system
- Electric pod style vaporizer/heater
- Good for low usage systems <300 lb/hr
- Tank should be located relatively close to injection point
- Provides saturated vapor from the tank off-stream
- No pumping required
- Full system: unloading, storage, and afcu
- Economical option but size and site location limited

WAHLCO, INC.

INLINE VAPORIZATION SYSTEM



- Utilizes inline vaporizers downstream of storage
- Can be steam, electric, or gas
- Some examples are water baths, kettle vaporizers, and aluminum block vaporizers
- Good for all system sizes
- Continuous style vaporizers can provide super heated vapor
- Batch style vaporizers provide saturated vapor
- Full system: unloading, storage, pumping, vaporization, and afcu
- Most common system, but higher capital cost

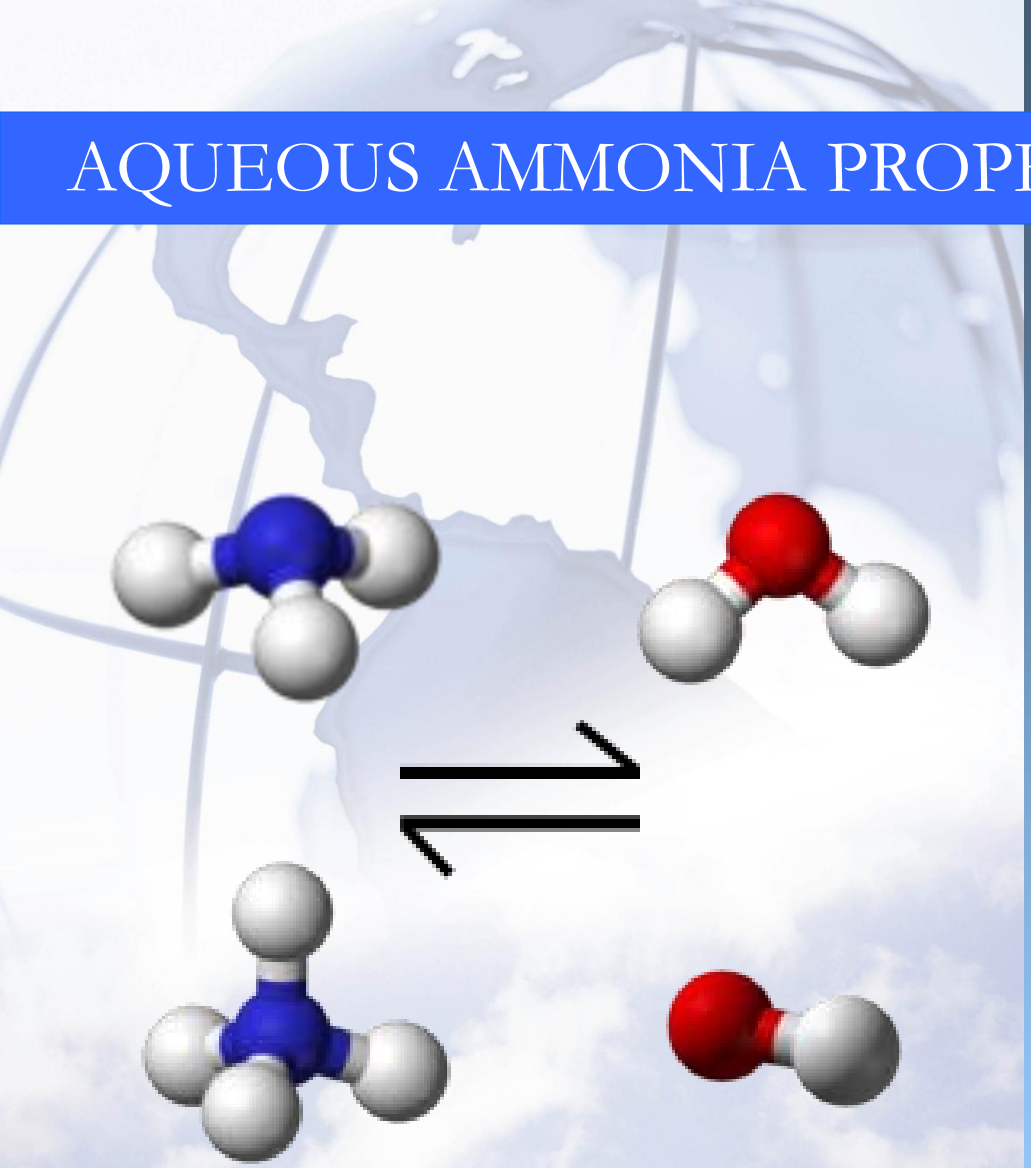
WAHLCO, INC.®

FLASH VAPORIZATION SYSTEM

- Utilizes a pressure drop across a control valve or orifice to flash vaporize the liquid
- Can be used for any system size
- Provides saturated vapor downstream of the control valve or orifice
- Can be seen as bad system design as it will ice equipment due to the joule-thomson effect
- Full system: unloading, storage, pumping, and afcu
- Most economical option but may not be allowed by end user

WAHLCO, INC.®

AQUEOUS AMMONIA PROPERTIES



- Typical dilution concentrations <20% , <30% (U.S.), <25% (U.K.)
- Pungent, colorless liquid
- Properties function similar to an ideal solution
- Specific gravity of 19% is 0.9302 at 60 °F
- Freezing point

  19% = -66 °F
- Boiling point

  19% = 212 °F
- Considered much "safer" then anhydrous but still hazardous

WAHLCO, INC.®

AQUEOUS REAGENT OVERVIEW

Benefits

- "Safer" than Anhydrous
- Less stringent permitting
- Delivery of reagent
- Storage of reagent

Aqueous NH_3 System Types

- Spray vaporization system
- TEMA vaporizer system
- Direct Injection

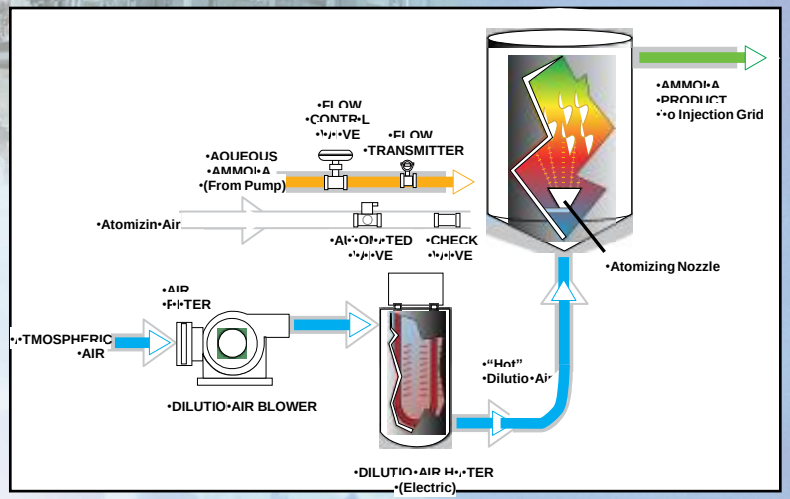
Cons

- Larger volumes
- High capital cost
- High operation cost
- Reagent cost

System Specifications

- Stainless steel preferable
- Design pressure ~25-100 psig
- Dilution air is required to be pre-heated

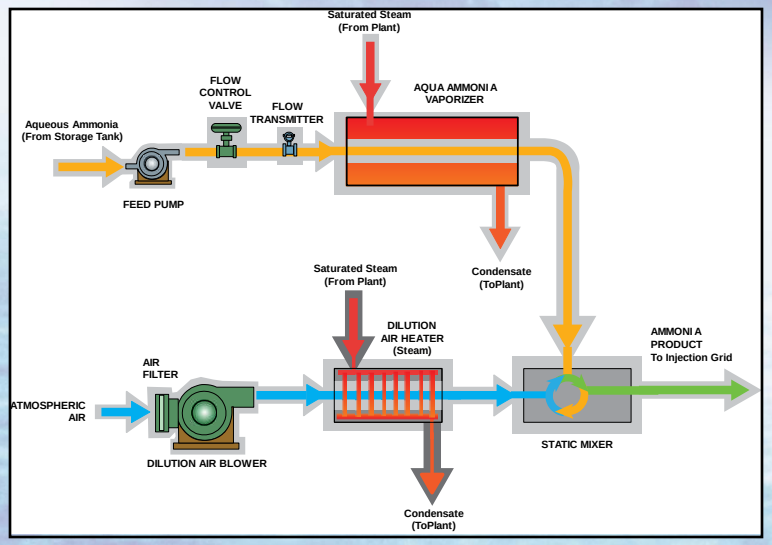
SPRAY VAPORIZATION SYSTEM



- Utilizes heated air which vaporizes atomized ammonia
- Electric (air must be heated to ~650 ^{0}F)
- Good for low usage systems <500 lb/hr (~500 kW)
- Provides super heated vapor diluted <5% in air
- Single skid for vaporizer and AFCU
- Full system: unloading, storage, pumping, vaporizer afcu
- Economical option for skids under 500 lb/hr

WAHLCO, INC.®

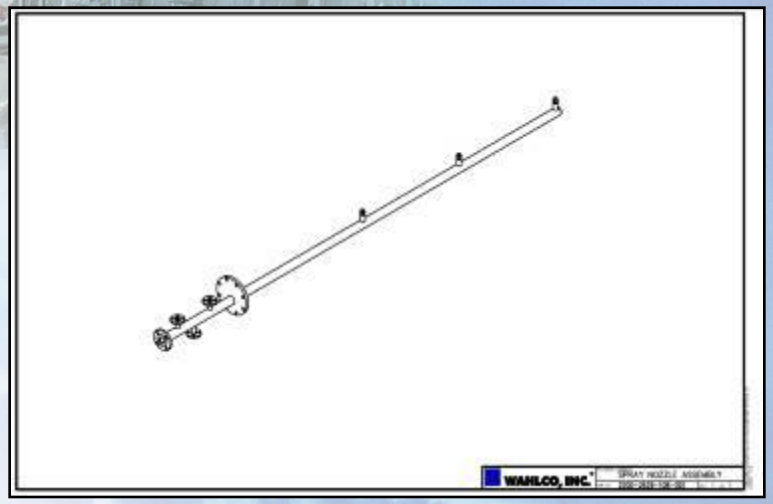
TEMA VAPORIZATION SYSTEM

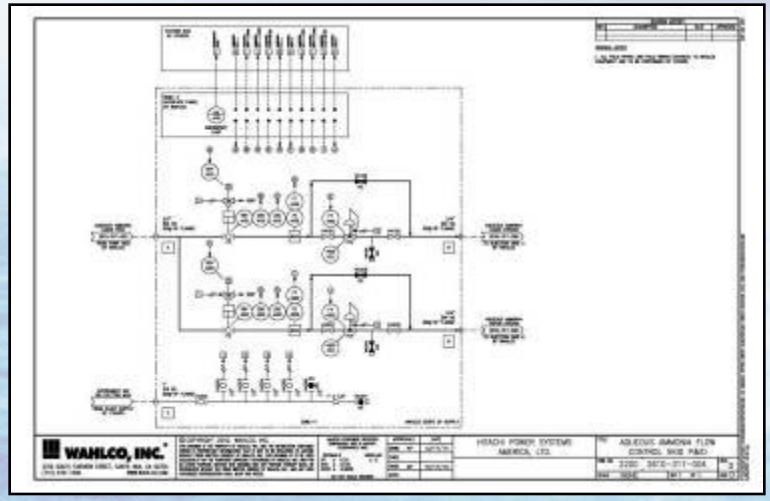


- Utilizes inline vaporizers
- Typically steam (150 psig saturated)
- NEN, BEU, and BKU type.
- Good for all system sizes
- NEN and BEU can provide super heated vapor at outlet
- BKU vaporizers provide saturated vapor at outlet
- Dilution air must be heated
- Full system: unloading, storage, pumping, vaporization, and afcu
- Most common system, but typically higher capital cost

WAHLCO, INC.®

DIRECT INJECTION

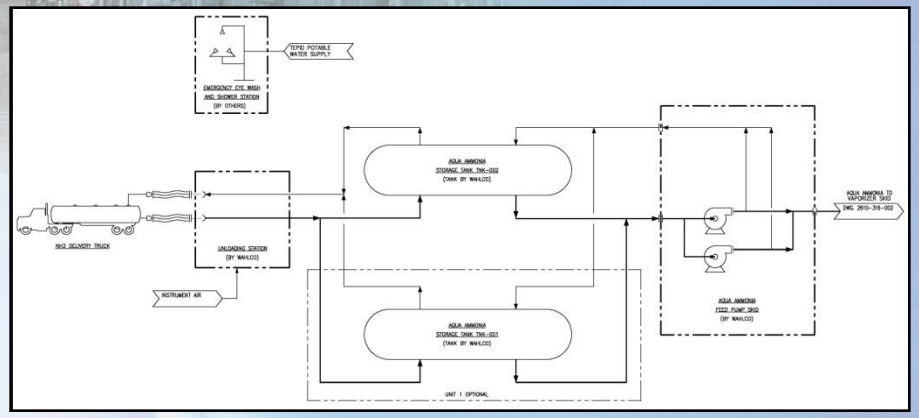


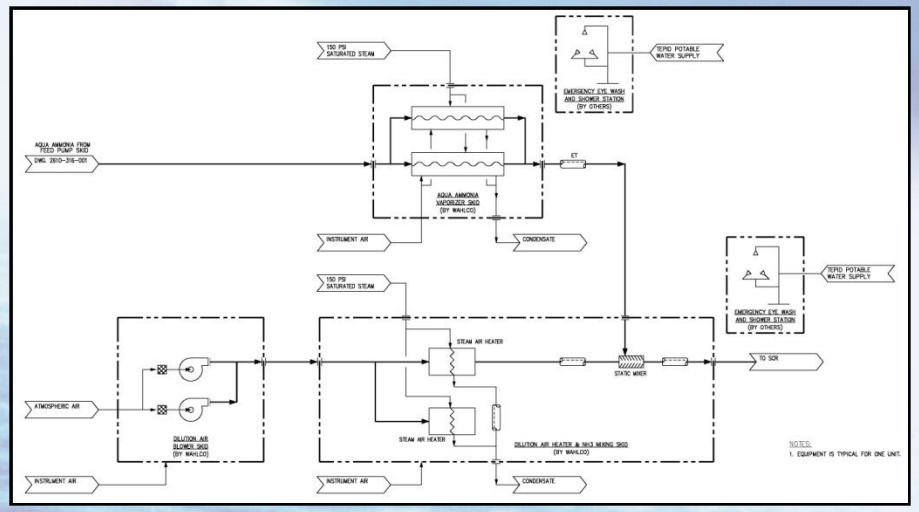


- Directly injects aqueous ammonia without dilution air or vaporization
- Relies on flue gas for vaporization and mixing
- Dependent on site conditions
- Requires special injection lances to prevent bearding, clogging and insure proper mixing and vaporization
- Full system: unloading, storage, pumping, and flow control
- Most economical option but can only be used for some specific systems due to obstacles within design

WAHLCO, INC.

AMMONIA SITE PLANNING

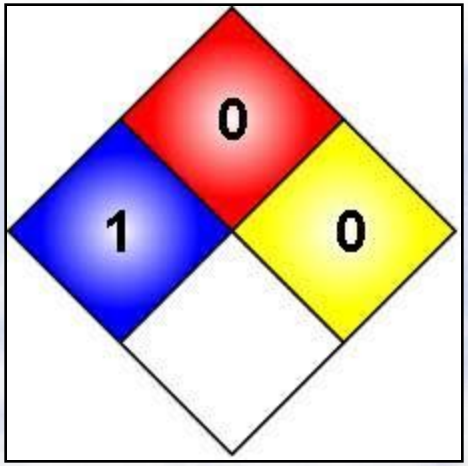




- Unloading, pumping, and storage to be located together near truck delivery area
- Ammonia vaporizer preferred to be located near boiler to minimize heat tracing and pipe insulation
- Dilution air blower to be located near AIG to minimize pressure drop, heat tracing, and insulation

WAHLCO, INC.®

UREA PROPERTIES



- Urea available in dry or 32% to 70% solution form
- White solid granular shape
- Non-flammable
- Non-toxic
- Not regulated by DOT
- Exposure to urea causes only slight irritation

UREA TO AMMONIA OVERVIEW

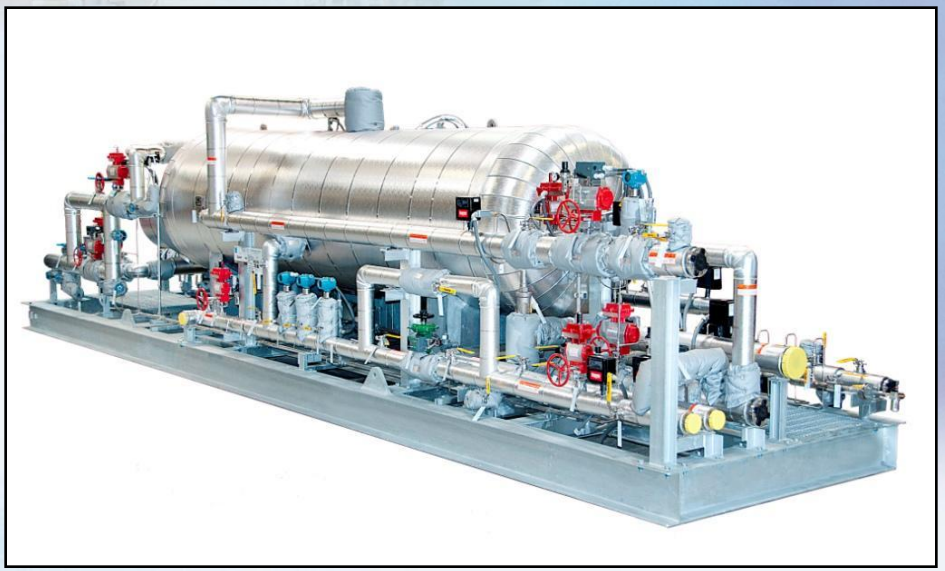
Benefits

- Eliminates ammonia transportation hazards
- Eliminates ammonia storage hazards
- Less energy required than aqueous ammonia vaporization
- Feedstock cheaper than aqueous ammonia
- Easier and less expensive to permit
- System sizes range from 10 lb/hr to 3500 lb/hr of ammonia

Cons

- Higher equipment capital costs
- Feedstock higher priced than anhydrous ammonia
- Dilution air is required to be pre-heated

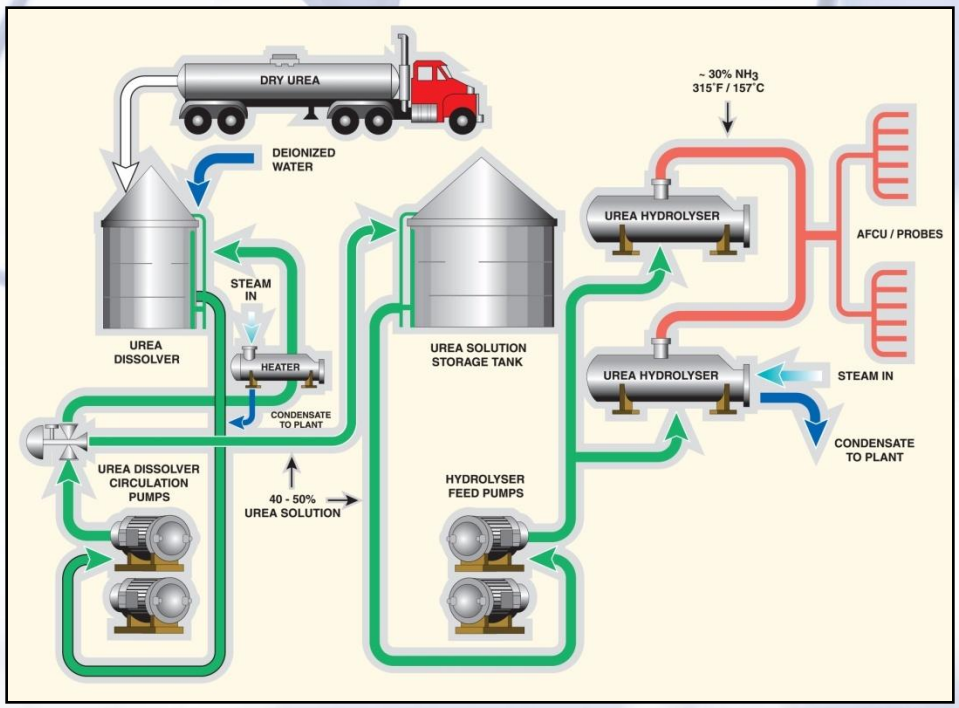
UREA TO AMMONIA - HYDROLYSIS



- Urea solution pumped to reactor
- Heat modulated to maintain set pressure of 40 to 120 psig
- Pressure required to maintain correct water balance
- Operating temperature of 310 °F
- 50% urea solution converts to gas mixture of:
  - 37.5% vol. ammonia
  - 18.7% vol. carbon dioxide
  - 43.8% vol. water vapor
- 1 lb of ammonia produced per 1.74 lb of urea
- 5 lb of 120 psig saturated steam per 1 lb of ammonia

WAHLCO, INC.®

UREA TO AMMONIA SITE PLANNING



- Larger systems utilize onsite dry urea dissolving
- Single hydrolyzer capable of feeding multiple boiler SCR's
- Locating hydrolyzer near storage tank avoids quench tank and transfer pump
- Ammonia product gas can be routed distances >1000'
- 12% dilution of ammonia is adequate as it is non-flammable

WAHLCO, INC.®

SELECTING A SYSTEM

- Permitting and Regulations
- Safety
- Utilities Available
- Site Conditions
- Size of the System

- Reagent Selection
- Steam vs. Electric vs. Gas
- Size constraints
- Customer preferences
- Cost vs. Optimum Design

Questions?

WAHLCO, INC.®