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9.2.1 Fertilizer Application

9.2.1.1 General¹⁻⁴

The role of fertilizers in the agriculture industry is to supply essential plant nutrients to improve crop production. There are 16 essential elements or nutrients necessary for plant growth, three of which (carbon, hydrogen, and oxygen) are supplied from the atmosphere or water. The other 13 elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, copper, zinc, boron, manganese, iron, chlorine, and molybdenum) are principally supplied through the soil medium. Concentrations of some of these elements are limited in most soils and must be supplemented by fertilizers.

Fertilizers are produced by the following types of industries: fertilizer plant foods; nitrogen and organic fertilizers; and phosphate potash and other fertilizers. Fertilizers are distributed through agricultural supply retailers, farmers' cooperatives, and fertilizer dealers. Application is performed by farmers and by fertilizer dealers using specialized application equipment.

9.2.1.2 Process Description³⁻⁶

Fertilizer application is based on the physical form of the fertilizer, i. e., a gaseous, fluid, or solid form.

Gaseous Fertilizer -

Anhydrous ammonia, which supplies nitrogen, is the only gaseous fertilizer used. Farmers usually hire trained specialists to apply the 5.7 million tons of ammonia used annually in the United States. Anhydrous ammonia is typically stored in a liquid form, most commonly under pressure, and to a lesser degree, under refrigeration. Anhydrous liquified ammonia is applied by subsurface injection. The ammonia quickly vaporizes, but is captured by several components in the soil including water, clay, and other minerals.

The equipment for the injection of anhydrous ammonia consists of a vehicle (tractor), a pressurized tank containing anhydrous ammonia, a metering system, manifolds, and injection knives. The critical components of the injection system are the metering assembly and injection knives. The meter assembly controls release of the fertilizer in direct proportion to the speed of the vehicle. Generally, the depth settings

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for injection are from 4 to 10 inches (10 to 25 centimeters) below the surface, depending on soil type, soil conditions, and spacing of injection knives. Figure 9.2.1-1 shows a simplified trailer used to apply anhydrous ammonia and liquid fertilizers.

Fluid Fertilizer -

Fluid fertilizers are typically classified as either solutions or suspensions. Solution fertilizers are free of solid particles. Suspension fertilizers are two-phase fertilizers in which solid particles are maintained in suspension in the aqueous phase.

The equipment for surface spraying of fertilizers consists of the vehicle, a tank holding the fluid, a metering system, manifolds, and spray nozzles. The manifolds are mounted inside long booms (20 to 40 feet) having no more than 20 nozzles. Fluid fertilizers are most commonly sprayed onto the surface of freshly tilled soils. Figure 9.2.1-2 shows a side view and rear view of a typical spray nozzle system. By varying the height of the nozzles above the ground and the flow of the fluid fertilizer, the applicator can apply the fertilizer in discrete bands (band and row) or as overlapping coverage (broadcast).

Solid Fertilizers — In the United States, solid fertilizers are typically either straight nitrogen fertilizers (urea or ammonium nitrate) or mixed fertilizers containing nitrogen and phosphate, potassium, and other nutrients. The equipment for broadcast application of fertilizers consists of the vehicle, a dry hopper containing solid fertilizer, a metering system, and either fan-type spreaders or boomed spreaders. The flow is controlled by a sprocket-driven belt that feeds the dry fertilizer into the spreader. The application rate is dependent on the position of the spinner blades, the position where the fertilizer drops on the spinner blades, the spinner speed, and the particle size of the fertilizer. Figure 9.2.1-3 shows an example of a centrifugal spreader.

9.2.1.3 Emission And Controls^{3,5-8}

Both particulate matter (PM) and gaseous air emissions are generated from the application of nutrients as fertilizers or manures. Emissions from the storage and application of animal wastes and green manures are not considered in this section; see Section 9.4.1, Cattle Feedlots; 9.4.2 Swine Feedlots; 9.4.3, Poultry Houses; and 9.4.4 Dairy Farms. For emissions from the production of commercial dry manure fertilizers, see Section 9.5.4, Manure Processing. Emissions may be immediate (occurring during or shortly after application), and latent (occurring days or weeks following application). Four possible sources of uncontrolled emissions have been observed with the process of fertilizer application. These sources are (1) soil reactions with the applied fertilizer generating increased gaseous emissions including NO, N₂O,

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NH₃, and SO₂, (2) volatilization of the fertilizer immediately behind the vehicle generating gaseous emissions including NH₃ and the fertilizer itself, (3) soil disturbance creating PM emissions with constituents that become airborne, and (4) volatilization of the fertilizer immediately above the solid fertilizer trailer, generating gaseous emissions including NH₃ and the fertilizer. Figure 9.2.1-4 shows these sources for emissions.

Recent scientific papers discussing the biological mechanisms for NO_x emissions from the soil have cited evidence to show that essentially all (over 90 percent) NO_x emissions are in the form of NO and little, if any, are in the form of NO₂. The formation of NO₂ occurs through the rapid oxidation of the NO by ozone present in the soil or the air immediately above the soil surface. There is no evidence to conclude that appreciable quantities of NO₂ are formed directly in the soil.

Wind-blown dust is created immediately during the application of dry fertilizers and later from disturbances caused by mechanical operations (e. g., tilling) and/or wind erosion. Gaseous air emissions can be generated after application by the immediate volatilization of gaseous fertilizers (i. e., anhydrous ammonia) or after some period of time by the chemical/biological transformation of nitrogen (N) added as fertilizers or manures to the soil. Table 9.2.1-1 provides equivalent nitrogen contents of common chemical fertilizers.

Emission factors are not presently available for PM. A number of heavy elements listed as Hazardous Air Pollutants in the 1990 Clean Air Act Amendments have been identified in soils treated with phosphate, nitrogen, and manure fertilizers, and could become airborne with fugitive dust. These elements are: cadmium, mercury, nickel, selenium, chromium, manganese, lead, and cobalt. Some of these elements also occur naturally in some soils. Research is needed to quantify fertilizer and manure contributions to airborne heavy metals.

At present, only gaseous air emission factors have been developed for nitrogen fertilizers. These emission factors, which are shown in Table 9.2.1-2, are based on equivalent nitrogen applied to the soil. Note that the studies that were used to develop these emission factors indicate that emissions can exhibit substantial temporal and spatial variability. Factors that affect this variability include soil type and composition, soil properties such as moisture content and pH, and ambient temperature. These factors result in wide differences in emissions from site-to-site as well as day-to-day variations and diurnal emission variation at a given site. Consequently, the emissions factors shown in Table 9.2.1-2 should be used with caution because data from the 15 studies used to develop them were extremely variable. The variability is

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partly due to variances in soils, temperatures, and precipitation between sites, and is also partly due to differences in experimental procedures.

It should not be inferred from these data that any degree of emission control could result from the use of different types of fertilizers. To date, the best form of emission control is through "nutrient management." In other words, the form, placement, and timing of the fertilizer relative to the need of the fertilizer is the best available control of the uncontrolled emissions of fertilizer application.

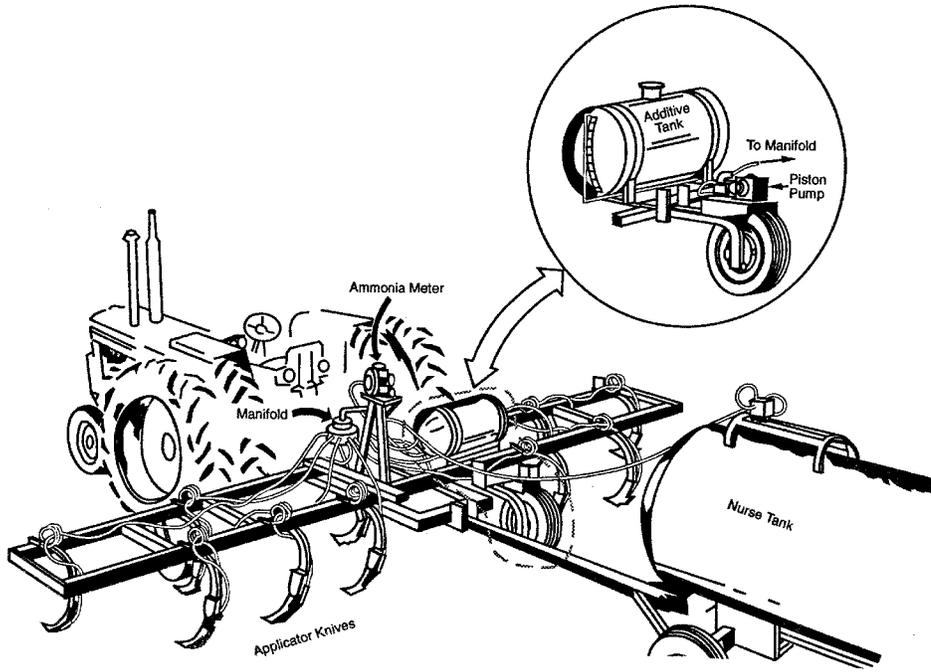


Figure 9.2.1-1. Typical trailer for application of anhydrous ammonia and fluid fertilizers.

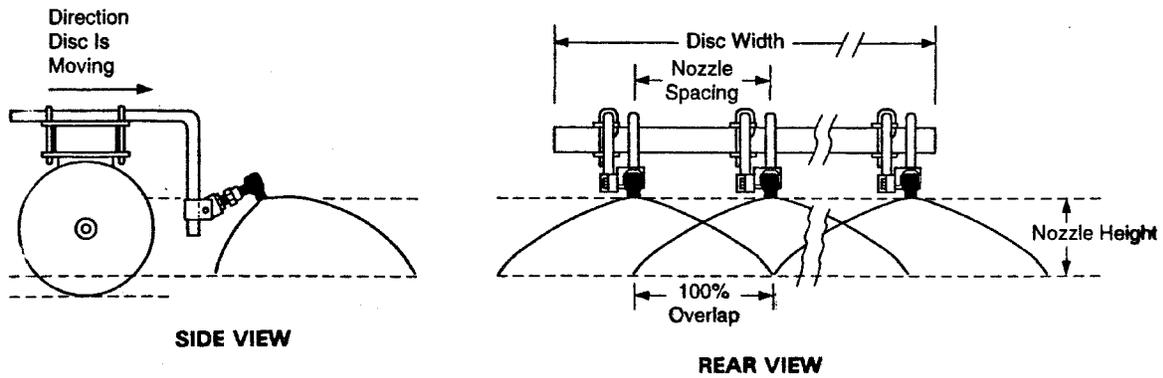


Figure 9.2.1-2. Side view and rear view of a typical spray nozzle system used for application of fluid fertilizers.

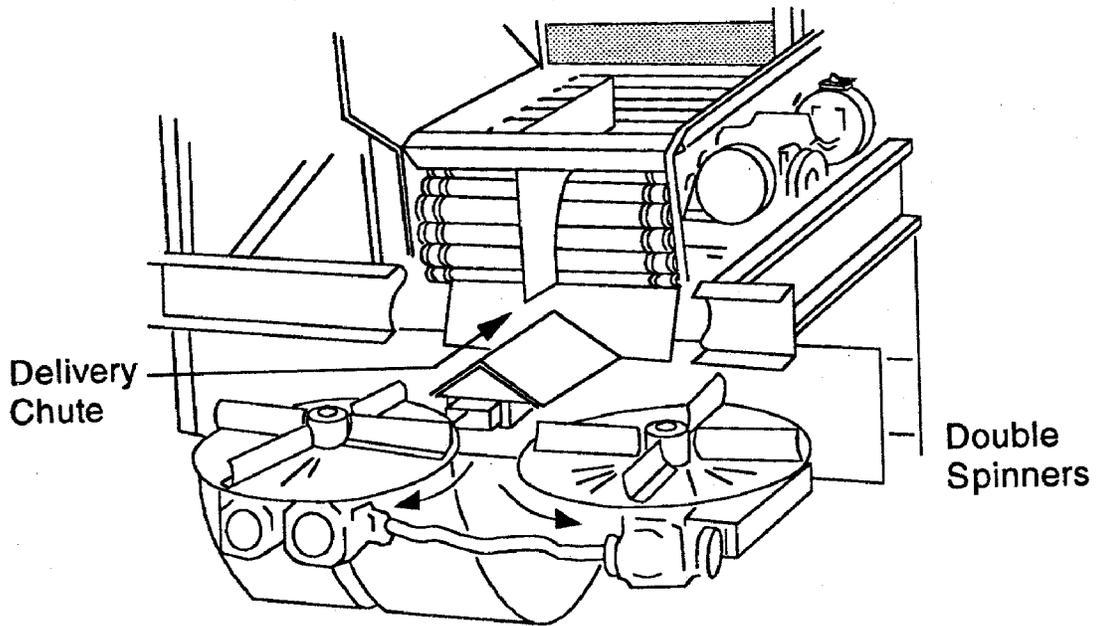
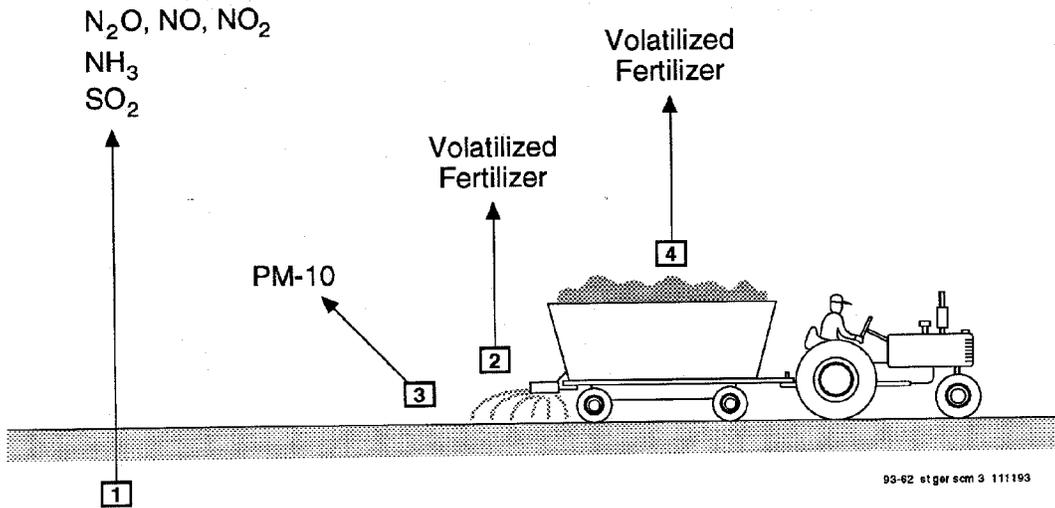


Figure 9.2.1-3. Example of centrifugal spreader.



- 1** Reactions with soil to generate emissions
- 2** Immediate emission due to broadcasting the fertilizer. Believed to be negligible.
- 3** Generation of fugitive dust
- 4** Immediate emission due to volatilization of fertilizer. Believed to be negligible.

Figure 9.2.1-4. Emission sources from fertilizer application.

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Draft Table 9.2.1-1 EQUIVALENT NITROGEN CONTENT
OF COMMON CHEMICAL FERTILIZERS^a

Type of fertilizer	Chemical formula	Nitrogen content ^b (weight percent)	Equivalent nitrogen content, lb fertilizer per lb N ^c
Anhydrous ammonia	NH ₃	82.3	1.2
Urea	CO(NH ₂) ₂	46.7	2.1
Ammonium nitrate	NH ₄ NO ₃	35.0	2.9
Ammonium sulfate	(NH ₄) ₂ SO ₄	21.2	4.7
Ammonium chloride	NH ₄ Cl	26.2	3.8

^aEquivalents for pure chemicals.

$$^b\text{Nitrogen content (weight percent)} = \frac{\text{atomic weight of nitrogen}}{\text{molecular weight of fertilizer}} * 100\%$$

$$\text{e.g., for ammonia: wt\%} = \frac{14}{17} * 100\% = 82.3\%$$

To determine the pounds of nitrogen per ton of fertilizer, multiply the nitrogen content (weight percent) times the tons of fertilizer. Then convert tons to pounds by multiplying by 2000.

e.g., for one ton of urea:

$$1 \text{ ton} \times 46.7 \times \frac{1}{100} = 0.467 \text{ tons of nitrogen}$$

$$0.467 \text{ tons} \times 2,000 \text{ lb/ton} = 934 \text{ lb of nitrogen/ton of urea}$$

For fluid fertilizers, the weight of the solvent should not be included in calculating the weight of the fertilizer.

^cAmount of fertilizer (lb) to produce 1 lb equivalent nitrogen application. To convert pounds of nitrogen to pounds of fertilizer, multiply pounds of nitrogen by the equivalent nitrogen content.

$$\text{e.g.: } 934 \text{ lb N} \times \frac{1.2 \text{ lb ammonia}}{\text{lb N}} = 1,121 \text{ lb ammonia}$$

Draft Table 9.2.1-2 SUMMARY OF EMISSION FACTORS FOR FERTILIZER APPLICATION^a

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EMISSION FACTOR RATING: E

Fertilizer/application	PM-10	NH ₃	NO	N ₂ O
Gaseous fertilizer:				
• Injection				
-- Anhydrous ammonia	NA	12 ^b 0.41 ^c	ND	ND
Fluid fertilizer:				
• Injection or deep band				
-- Aqueous ammonia	NA	ND	ND	ND
-- Urea	NA	ND	ND	ND
-- Ammonium nitrate	NA	ND	ND	ND
-- Nitrogen mixtures ^d	NA	ND	ND	ND
• Band, row, and broadcast application ^e				
-- Urea	ND	ND	140 ^f	10 ^g
-- Ammonium nitrate	ND	ND	29 ^f	3.0 ^h
-- Nitrogen mixtures ^d	ND	ND	ND	ND
-- Calcium nitrate	ND	NA	7.6 ^j	1.7 ^k
-- Sodium nitrate	ND	NA	5.1 ^m	ND
-- Ammonium chloride	ND	ND	58 ^f	ND
-- Ammonium sulfate	ND	ND	ND	39 ⁿ 290 ^p
• Aerial				
• Irrigation				
Solid fertilizer:				
• Broadcast application ^e				
-- Urea	ND	260 ^q	ND	ND
-- Ammonium nitrate	ND	ND	240 ^r	160 ^s
-- Nitrogen mixtures ^d	ND	ND	ND	
-- without manure				16 ^t
-- with manure				120 ^u
-- Ammonium sulfate	ND	ND	140 ^v	12 ^v

^a ND = no data available. NA = not applicable. All emission factors in terms of pounds of pollutant per ton of nitrogen in fertilizer applied (lb pollutant/ton N applied). To convert from lb/ton to kg/Mg, multiply by 0.5.

^b References 13-14, 18. Volatilization immediately (1-3 hr) after application.

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Draft Table 9.2.1-2 (cont'd)

- ^c Reference 18. Fugitive emissions (6 to 9 hours).
- ^d Fertilizer mixtures in which nitrogen is the predominant component.
- ^e Latent emissions from soil reactions.
- ^f Reference 11.
- ^g References 11-12,15.
- ^h References 11-12.
- ^j Reference 23.
- ^k Reference 15.
- ^m References 11,23.
- ⁿ References 15,24. Conventional till plots.
- ^p Reference 24. Zero-till plot.
- ^q Reference 17.
- ^r References 9,21.
- ^s References 9,19,21-22.
- ^t Reference 16.
- ^u Reference 10. Mixture of feedlot cattle manure and added nitrogen source (ammonium nitrate, urea).
- ^v Reference 20.

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