

8.3 Ammonium Nitrate

8.3.1 General¹⁻³

Ammonium nitrate (NH_4NO_3) is produced by neutralizing nitric acid (HNO_3) with ammonia (NH_3). In 1991, there were 58 U. S. ammonium nitrate plants located in 22 states producing about 8.2 million megagrams (Mg) (9 million tons) of ammonium nitrate. Approximately 15 to 20 percent of this amount was used for explosives and the balance for fertilizer.

Ammonium nitrate is marketed in several forms, depending upon its use. Liquid ammonium nitrate may be sold as a fertilizer, generally in combination with urea. Liquid ammonium nitrate may be concentrated to form an ammonium nitrate "melt" for use in solids formation processes. Solid ammonium nitrate may be produced in the form of prills, grains, granules, or crystals. Prills can be produced in either high or low density form, depending on the concentration of the melt. High density prills, granules, and crystals are used as fertilizer, grains are used solely in explosives, and low density prills can be used as either.

8.3.2 Process Description^{1,2}

The manufacture of ammonium nitrate involves several major unit operations including solution formation and concentration; solids formation, finishing, screening, and coating; and product bagging and/or bulk shipping. In some cases, solutions may be blended for marketing as liquid fertilizers. These operations are shown schematically in Figure 8.3-1.

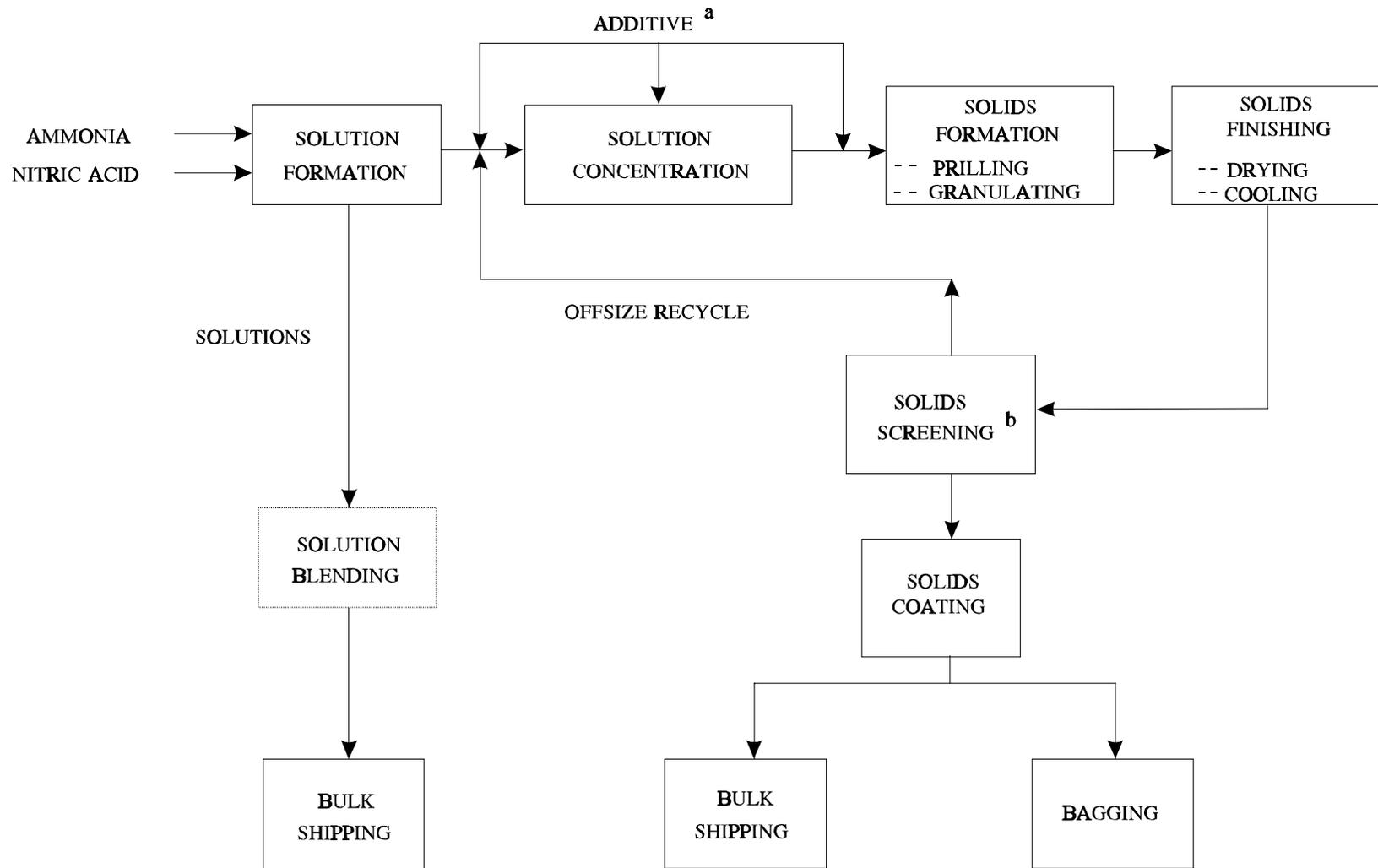
The number of operating steps employed depends on the end product desired. For example, plants producing ammonium nitrate solutions alone use only the solution formation, solution blending, and bulk shipping operations. Plants producing a solid ammonium nitrate product may employ all of the operations.

All ammonium nitrate plants produce an aqueous ammonium nitrate solution through the reaction of ammonia and nitric acid in a neutralizer as follows:



Approximately 60 percent of the ammonium nitrate produced in the U. S. is sold as a solid product. To produce a solid product, the ammonium nitrate solution is concentrated in an evaporator or concentrator. The resulting "melt" contains about 95 to 99.8 percent ammonium nitrate at approximately 149°C (300°F). This melt is then used to make solid ammonium nitrate products.

Prilling and granulation are the most common processes used to produce solid ammonium nitrate. To produce prills, concentrated melt is sprayed into the top of a prill tower. In the tower, ammonium nitrate droplets fall countercurrent to a rising air stream that cools and solidifies the falling droplets into spherical prills. Prill density can be varied by using different concentrations of ammonium nitrate melt. Low density prills, in the range of 1.29 specific gravity, are formed from a 95 to 97.5 percent ammonium nitrate melt, and high density prills, in the range of 1.65 specific gravity, are formed from a 99.5 to 99.8 percent melt. Low density prills are more porous than high density prills. Therefore, low density prills are used for making blasting agents because they will absorb oil. Most high density prills are used as fertilizers.



a ADDITIVE MAY BE ADDED BEFORE, DURING, OR AFTER CONCENTRATION

b SCREENING MAY BE PERFORMED BEFORE OR AFTER SOLIDS FINISHING

Figure 8.3-1. Ammonium nitrate manufacturing operations.

Rotary drum granulators produce granules by spraying a concentrated ammonium nitrate melt (99.0 to 99.8 percent) onto small seed particles of ammonium nitrate in a long rotating cylindrical drum. As the seed particles rotate in the drum, successive layers of ammonium nitrate are added to the particles, forming granules. Granules are removed from the granulator and screened. Offsize granules are crushed and recycled to the granulator to supply additional seed particles or are dissolved and returned to the solution process. Pan granulators operate on the same principle as drum granulators, except the solids are formed in a large, rotating circular pan. Pan granulators produce a solid product with physical characteristics similar to those of drum granules.

Although not widely used, an additive such as magnesium nitrate or magnesium oxide may be injected directly into the melt stream. This additive serves 3 purposes: to raise the crystalline transition temperature of the final solid product; to act as a desiccant, drawing water into the final product to reduce caking; and to allow solidification to occur at a low temperature by reducing the freezing point of molten ammonium nitrate.

The temperature of the ammonium nitrate product exiting the solids formation process is approximately 66 to 124°C (150 to 255°F). Rotary drum or fluidized bed cooling prevents deterioration and agglomeration of solids before storage and shipping. Low density prills have a high moisture content because of the lower melt concentration, and therefore require drying in rotary drums or fluidized beds before cooling.

Since the solids are produced in a wide variety of sizes, they must be screened for consistently sized prills or granules. Cooled prills are screened and offsize prills are dissolved and recycled to the solution concentration process. Granules are screened before cooling. Undersize particles are returned directly to the granulator and oversize granules may be either crushed and returned to the granulator or sent to the solution concentration process.

Following screening, products can be coated in a rotary drum to prevent agglomeration during storage and shipment. The most common coating materials are clays and diatomaceous earth. However, the use of additives in the ammonium nitrate melt before solidification, as described above, may preclude the use of coatings.

Solid ammonium nitrate is stored and shipped in either bulk or bags. Approximately 10 percent of solid ammonium nitrate produced in the U. S. is bagged.

8.3.3 Emissions And Controls

Emissions from ammonium nitrate production plants are particulate matter (ammonium nitrate and coating materials), ammonia, and nitric acid. Ammonia and nitric acid are emitted primarily from solution formation and granulators. Particulate matter (largely as ammonium nitrate) is emitted from most of the process operations and is the primary emission addressed here.

The emission sources in solution formation and concentration processes are neutralizers and evaporators, primarily emitting nitric acid and ammonia. The vapor stream off the top of the neutralization reactor is primarily steam with some ammonia and NH_4NO_3 particulates present. Specific plant operating characteristics, however, make these emissions vary depending upon use of excess ammonia or acid in the neutralizer. Since the neutralization operation can dictate the quantity of these emissions, a range of emission factors is presented in Tables 8.3-1 and 8.3-2. Units are expressed in terms of kilograms per megagram (kg/Mg) and pounds per ton (lb/ton). Particulate emissions from these operations tend to be smaller in size than those from solids production and handling processes and generally are recycled back to the process.

Table 8.3-1 (Metric Units). EMISSION FACTORS FOR PROCESSES IN AMMONIUM NITRATE MANUFACTURING PLANTS^a

EMISSION FACTOR RATING: A (except as noted)

Process	Particulate Matter		Ammonia	Nitric Acid
	Uncontrolled (kg/Mg Of Product)	Controlled ^b (kg/Mg Of Product)	Uncontrolled ^c (kg/Mg Of Product)	Controlled ^d (kg/Mg Of Product)
Neutralizer	0.045 - 4.3 ^e	0.002 - 0.22 ^e	0.43 - 18.0 ^e  	0.042 - 1 ^e
Evaporation/concentration operations	0.26	ND	0.27 - 16.7	ND
Solids formation operations				
High density prill towers	1.59	0.60	28.6	ND
Low density prill towers	0.46	0.26	0.13	ND
Rotary drum granulators	146	0.22	29.7	ND
Pan granulators	1.34	0.02	0.07	ND
Coolers and dryers ^f				
High density prill coolers	0.8	0.01	0.02	ND
Low density prill coolers	25.8	0.26	0.15	ND
Low density prill dryers	57.2	0.57	0 - 1.59	ND
Rotary drum granulator coolers	8.1	0.08	ND	ND
Pan granulator coolers	18.3	0.18 ^d	ND	ND
Coating operations ^g	≤ 2.0 ^d	≤ 0.02 ^d	NA	NA
Bulk loading operations ^g	≤ 0.01 ^d	ND	NA	NA

^a Some ammonium nitrate emission factors are based on data gathered using a modification of EPA Method 5 (See Reference 1).

ND = no data. NA = not applicable.

^b Based on the following control efficiencies for wet scrubbers, applied to uncontrolled emissions: neutralizers, 95%; high density prill towers, 62%; low density prill towers, 43%; rotary drum granulators, 99.9%; pan granulators, 98.5%; coolers, dryers, and coaters, 99%.

^c Given as ranges because of variation in data and plant operations. Factors for controlled emissions not presented due to conflicting results on control efficiency.

^d Based on 95% recovery in a granulator recycle scrubber.

^e EMISSION FACTOR RATING: B.

^f Factors for coolers represent combined pre-cooler and cooler emissions, and factors for dryers represent combined pre-dryer and dryer emissions.

^g Fugitive particulate emissions arise from coating and bulk loading operations.

Table 8.3-2 (English Units). EMISSION FACTORS FOR PROCESSES IN AMMONIUM NITRATE MANUFACTURING PLANTS^a

EMISSION FACTOR RATING: A (except as noted)

Process	Particulate Matter		Ammonia	Nitric Acid
	Uncontrolled (lb/ton Of Product)	Controlled ^b (lb/ton Of Product)	Uncontrolled ^c (lb/ton Of Product)	Controlled ^d (lb/ton Of Product)
Neutralizer	0.09 - 8.6 ^e	0.004 - 0.43 ^d	0.86 - 36.02 ^d	0.084 - 2 ^{d,e}
Evaporation/concentration operations	0.52	ND	0.54 - 33.4	ND
Solids formation operations				
High density prill towers	3.18	1.20	57.2	ND
Low density prill towers	0.92	0.52	0.26	ND
Rotary drum granulators	392	0.44	59.4	ND
Pan granulators	2.68	0.04	0.14	ND
Coolers and dryers ^f				
High density prill coolers	1.6	0.02	0.04	ND
Low density prill coolers	51.6	0.52	0.30	ND
Low density prill dryers	114.4	1.14	0 - 3.18	ND
Rotary drum granulator coolers	16.2	0.16	ND	ND
Pan granulator coolers	36.6	0.36 ^d	ND	ND
Coating operations ^g	≤ 4.0 ^d	≤ 0.04 ^d	NA	NA
Bulk loading operations ^g	≤ 0.02 ^d	ND	NA	NA

^a Some ammonium nitrate emission factors are based on data gathered using a modification of EPA Method 5 (See Reference 1).

ND = no data. NA = not applicable.

^b Based on the following control efficiencies for wet scrubbers, applied to uncontrolled emissions: neutralizers, 95%; high density prill towers, 62%; low density prill towers, 43%; rotary drum granulators, 99.9%; pan granulators, 98.5%; coolers, dryers, and coaters, 99%.

^c Given as ranges because of variation in data and plant operations. Factors for controlled emissions not presented due to conflicting results on control efficiency.

^d Based on 95% recovery in a granulator recycle scrubber.

^e EMISSION FACTOR RATING: B.

^f Factors for coolers represent combined pre-cooler and cooler emissions, and factors for dryers represent combined pre-dryer and dryer emissions.

^g Fugitive particulate emissions arise from coating and bulk loading operations.

Emissions from solids formation processes are ammonium nitrate particulate matter and ammonia. The sources of primary importance are prill towers (for high density and low density prills) and granulators (rotary drum and pan). Emissions from prill towers result from carryover of fine particles and fume by the prill cooling air flowing through the tower. These fine particles are from microprill formation, from attrition of prills colliding with the tower or with one another, and from rapid transition of the ammonia nitrate between crystal states. The uncontrolled particulate emissions from prill towers, therefore, are affected by tower airflow, spray melt temperature, condition and type of melt spray device, air temperature, and crystal state changes of the solid prills. The amount of microprill mass that can be entrained in the prill tower exhaust is determined by the tower air velocity. Increasing spray melt temperature causes an increase in the amount of gas-phase ammonium nitrate generated. Thus, gaseous emissions from high density prilling are greater than from low density towers.

Microprill formation resulting from partially plugged orifices of melt spray devices can increase fine dust loading and emissions. Certain designs (spinning buckets) and practices (vibration of spray plates) help reduce microprill formation. High ambient air temperatures can cause increased emissions because of entrainment as a result of higher air flow required to cool prills and because of increased fume formation at the higher temperatures.

The granulation process in general provides a larger degree of control in product formation than does prilling. Granulation produces a solid ammonium nitrate product that, relative to prills, is larger and has greater abrasion resistance and crushing strength. The air flow in granulation processes is lower than that in prilling operations. Granulators, however, cannot produce low density ammonium nitrate economically with current technology. The design and operating parameters of granulators may affect emission rates. For example, the recycle rate of seed ammonium nitrate particles affects the bed temperature in the granulator. An increase in bed temperature resulting from decreased recycle of seed particles may cause an increase in dust emissions from granule disintegration.

Cooling and drying are usually conducted in rotary drums. As with granulators, the design and operating parameters of the rotary drums may affect the quantity of emissions. In addition to design parameters, prill and granule temperature control is necessary to control emissions from disintegration of solids caused by changes in crystal state.

Emissions from screening operations are generated by the attrition of the ammonium nitrate solids against the screens and against one another. Almost all screening operations used in the ammonium nitrate manufacturing industry are enclosed or have a cover over the uppermost screen. Screening equipment is located inside a building and emissions are ducted from the process for recovery or reuse.

Prills and granules are typically coated in a rotary drum. The rotating action produces a uniformly coated product. The mixing action also causes some of the coating material to be suspended, creating particulate emissions. Rotary drums used to coat solid product are typically kept at a slight negative pressure and emissions are vented to a particulate control device. Any dust captured is usually recycled to the coating storage bins.

Bagging and bulk loading operations are a source of particulate emissions. Dust is emitted from each type of bagging process during final filling when dust-laden air is displaced from the bag by the ammonium nitrate. The potential for emissions during bagging is greater for coated than for uncoated material. It is expected that emissions from bagging operations are primarily the kaolin, talc, or diatomaceous earth coating matter. About 90 percent of solid ammonium nitrate produced domestically is bulk loaded. While particulate emissions from bulk loading are not generally

controlled, visible emissions are within typical state regulatory requirements (below 20 percent opacity).

Tables 8.3-1 and 8.3-2 summarize emission factors for various processes involved in the manufacture of ammonium nitrate. Uncontrolled emissions of particulate matter, ammonia, and nitric acid are also given in Tables 8.3-1 and 8.3-2. Emissions of ammonia and nitric acid depend upon specific operating practices, so ranges of factors are given for some emission sources.

Emission factors for controlled particulate emissions are also in Tables 8.3-1 and 8.3-2, reflecting wet scrubbing particulate control techniques. The particle size distribution data presented in Table 8.3-3 indicate the emissions. In addition, wet scrubbing is used as a control technique because the solution containing the recovered ammonium nitrate can be sent to the solution concentration process for reuse in production of ammonium nitrate, rather than to waste disposal facilities.

Table 8.3-3 (Metric Units). PARTICLE SIZE DISTRIBUTION DATA FOR UNCONTROLLED EMISSIONS FROM AMMONIUM NITRATE MANUFACTURING FACILITIES^a

Operation	Cumulative Weight %		
	≤ 2.5 μm	≤ 5 μm	≤ 10 μm
Solids Formation Operations			
Low density prill tower	56	73	83
Rotary drum granulator	0.07	0.3	2
Coolers and Dryers			
Low density prill cooler	0.03	0.09	0.4
Low density prill predryer	0.03	0.06	0.2
Low density prill dryer	0.04	0.04	0.15
Rotary drum granulator cooler	0.06	0.5	3
Pan granulator precooler	0.3	0.3	1.5

^a References 5,12-13,23-24. Particle size determinations were not done in strict accordance with EPA Method 5. A modification was used to handle the high concentrations of soluble nitrogenous compounds.¹ Particle size distributions were not determined for controlled particulate emissions.

References For Section 8.3

1. *Ammonium Nitrate Manufacturing Industry: Technical Document*, EPA-450/3-81-002, U. S. Environmental Protection Agency, Research Triangle Park, NC, January 1981.
2. W. J. Search and R. B. Reznik, *Source Assessment: Ammonium Nitrate Production*, EPA-600/2-77-107i, U. S. Environmental Protection Agency, Cincinnati, OH, September 1977.
3. North American Fertilizer Capacity Data, Tennessee Valley Authority, Muscle Shoals, AL, December, 1991.
4. Memo from C. D. Anderson, Radian Corporation, Research Triangle Park, NC, to Ammonium Nitrate file, July 2, 1980.

5. D. P. Becvar, *et al.*, *Ammonium Nitrate Emission Test Report: Union Oil Company Of California*, EMB-78-NHF-7, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1979.
6. K. P. Brockman, *Emission Tests For Particulates*, Cominco American, Beatrice, NE, 1974.
7. Written communication from S. V. Capone, GCA Corporation, Chapel Hill, NC, to E. A. Noble, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 6, 1979.
8. Written communication from D. E. Cayard, Monsanto Agricultural Products Company, St. Louis, MO, to E. A. Noble, U. S. Environmental Protection Agency, Research Triangle Park, NC, December 4, 1978.
9. Written communication from D. E. Cayard, Monsanto Agricultural Products Company, St. Louis, MO, to E. A. Noble, U. S. Environmental Protection Agency, Research Triangle Park, NC, December 27, 1978.
10. Written communication from T. H. Davenport, Hercules Incorporated, Donora, PA, to D. R. Goodwin, U. S. Environmental Protection Agency, Research Triangle Park, NC, November 16, 1978.
11. R. N. Doster and D. J. Grove, *Source Sampling Report: Atlas Powder Company*, Entropy Environmentalists, Inc., Research Triangle Park, NC, August 1976.
12. M. D. Hansen, *et al.*, *Ammonium Nitrate Emission Test Report: Swift Chemical Company*, EMB-79-NHF-11, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 1980.
13. R. A. Kniskern, *et al.*, *Ammonium Nitrate Emission Test Report: Cominco American, Inc.*, Beatrice, NE, EMB-79-NHF-9, U. S. Environmental Protection Agency, Research Triangle Park, NC, April 1979.
14. Written communication from J. A. Lawrence, C. F. Industries, Long Grove, IL, to D. R. Goodwin, U. S. Environmental Protection Agency, Research Triangle Park, NC, December 15, 1978.
15. Written communication from F. D. McLauley, Hercules Incorporated, Louisiana, MO, to D. R. Goodwin, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 31, 1978.
16. W. E. Misa, *Report Of Source Test: Collier Carbon And Chemical Corporation (Union Oil)*, Test No. 5Z-78-3, Anaheim, CA, January 12, 1978.
17. Written communication from L. Musgrove, Georgia Department Of Natural Resources, Atlanta, GA, to R. Rader, Radian Corporation, Research Triangle Park, NC, May 21, 1980.
18. Written communication from D. J. Patterson, Nitrogen Corporation, Cincinnati, OH, to E. A. Noble, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 26, 1979.

19. Written communication from H. Schuyten, Chevron Chemical Company, San Francisco, CA, to D. R. Goodwin, U. S. Environmental Protection Agency, March 2, 1979.
20. *Emission Test Report: Phillips Chemical Company*, Texas Air Control Board, Austin, TX, 1975.
21. *Surveillance Report: Hawkeye Chemical Company*, U. S. Environmental Protection Agency, Research Triangle Park, NC, December 29, 1976.
22. W. A. Wade and R. W. Cass, *Ammonium Nitrate Emission Test Report: C.F. Industries*, EMB-79-NHF-10, U. S. Environmental Protection Agency, Research Triangle Park, NC, November 1979.
23. W. A. Wade, *et al.*, *Ammonium Nitrate Emission Test Report: Columbia Nitrogen Corporation*, EMB-80-NHF-16, U. S. Environmental Protection Agency, Research Triangle Park, NC, January, 1981.
24. York Research Corporation, *Ammonium Nitrate Emission Test Report: Nitrogen Corporation*, EMB-78-NHF-5, U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1979.