

Fertilizer Grade Ammonium Nitrate Production by KBR Process

PEP Review 2021-12
February 2021



Contacts

Rajesh Verma

Associate Director, Process Economics Program
rajesh.verma@ihsmarkit.com

RJ Chang

Vice President, Process Economics Program
rj.chang@ihsmarkit.com

PEP Review 2021-12

Fertilizer Grade Ammonium Nitrate Production by KBR Process

Rajesh Verma, Associate Director

Abstract

Fertilizers play an important role in providing nutrients to the soil and plants to grow and to increase the crop yield. Ammonium nitrate (AN) is the most popular form of nitrogen fertilizer in most European countries and some other temperate-zone countries. In 2019, the global production and apparent consumption of ammonium nitrates amounted to 21.2 million metric tons, which can be broken down as 17.0 million metric tons AN (80.2%) and 4.2 million metric tons calcium–ammonium nitrate (CAN) (19.8%). Because of the safety issues associated with AN, there has been an increase in the production of CAN.

The world ammonium nitrate (AN) capacity, production, and consumption are dominated by Eastern Europe, Western Europe, China, and the United States. Combined, these four regions accounted for 69.8% of capacity, 71.5% of production, and 64.1% of consumption in 2019. Increases in capacity in recent years have affected operating rates for the industry, as well as the prices. Some of the high-cost plants may be idled because of declining prices.

In 2016, KBR Inc. acquired Weatherly Inc. (Weatherly). Weatherly is a North American company with extensive experience in providing nitric acid and ammonium nitrate proprietary technologies and services to the fertilizer market. With the acquisition of Weatherly, KBR is uniquely positioned as a top global provider of fertilizer technologies and claims to offer low total installation cost, better plant operation, and superior emissions performance.

IHS Markit PEP has worked out the Stamicarbon ammonium nitrate production process economics in two previous PEP Reports, RP 127A (published in 1980) and RP 127B (published in 1999). This PEP Review evaluates the KBR/Weatherly Inc. process for ammonium nitrate production and provides its economics for a plant located at the US Gulf Coast. The review also shows the integrated plant economics for NH₃, HNO₃, and ammonium nitrate plants. This review also includes the market status assessment of supply and demand trends for ammonium nitrate, and an iPEP Navigator tool (an interactive cost module) is also attached to the electronic version of this review.

The process design and economics of the above-mentioned process is IHS Markit PEP's independent interpretation based on the companies' patent literature and other open source information and may not reflect in whole or in part the actual plant configuration. However, IHS Markit PEP believes that they are sufficiently representative of the above-mentioned processes, to estimate the plant economics within the range of accuracy for economic evaluations of the conceptual process designs.

Contents

1	Introduction	5
2	Summary	7
	AN production process and economics	8
	Environmental footprints	11
	Economics for an integrated AN plant with Ammonia and Nitric acid plants	11
3	Technology review	14
	Plant nutrients and the role of fertilizers	14
	Macro or primary nutrients: Nitrogen, phosphorus, and potassium	14
	Nitrogen (N)	14
	Phosphorus (P)	14
	Potassium (K)	14
	Major or secondary elements: Calcium, magnesium, and sulfur	15
	Calcium (Ca)	15
	Magnesium (Mg)	15
	Sulfur (S)	15
	Micronutrients or trace elements: Iron, zinc, chlorine, boron, selenium, copper, molybdenum, and manganese	15
	AN product properties	16
	Industry status	17
	Process chemistry	19
	Overview of AN manufacturing processes:	21
	AN production processes	25
	Comparison of commercial processes	33
4	Fertilizer grade ammonium nitrate production by KBR/Weatherly process	35
	Process design basis	35
	Storage facility	36
	Material of construction	36
	Process description	36
	Neutralization section	36
	Concentration section	37
	Prilling section	37
	Finishing section	38
	Product handling and bagging	38
	Bagged storage and dispatch	38
	Process discussion	44
	Neutralization section	44
	Concentration section	46
	Prilling section	46
	Finishing section	47
	Degradation and caking of AN	47
	Heat integration for $\text{NH}_3\text{--HNO}_3\text{--AN--CHP}$ complex	48
	Emissions and wastes	49
	Liquid, gaseous, and particulates emission	49
	Wastewater	50
	Process wastewater treatment	50
5	Cost estimates	51
	Fixed capital costs	51
	Production costs	51
	Appendix A—Cited references	58

Appendix B—Process flow diagrams

62

Tables

Table 1.1 Grades of ammonium nitrate (percent)	6
Table 2.1 Material balance for fertilizer grade ammonium nitrate production unit by KBR/Weatherly process	9
Table 2.2 Fertilizer grade AN process, key performance parameters, and economic summary	10
Table 2.3 Fertilizer grade AN process—Environment footprint	11
Table 2.4 Economics for an integrated AN plant with ammonia and nitric acid plants by KBR/Weatherly process—Production costs	12
Table 3.1 World nameplate capacity for ammonium nitrate	17
Table 3.2 World production capacity for ammonium nitrate	18
Table 3.3 World apparent consumption of ammonium nitrate	19
Table 3.4 Heat of reaction of ammonia and nitric acid in ammonium nitrate synthesis	21
Table 3.5 Typical process parameters and designs of AN production plant	34
Table 4.1 Design basis and assumptions for KBR/Weatherly's Ammonium Nitrate process	35
Table 4.2 Fertilizer grade ammonium nitrate production by KBR/Weatherly process—Major stream flows	39
Table 4.3 Fertilizer grade ammonium nitrate production by KBR/Weatherly process—Major equipment	41
Table 4.4 Fertilizer grade ammonium nitrate production by KBR/Weatherly process—Utilities summary	44
Table 5.1 Fertilizer grade ammonium nitrate production by KBR/Weatherly process—Total capital investment	52
Table 5.2 Fertilizer grade ammonium nitrate production by KBR/Weatherly process—Capital investment by section	53
Table 5.3 Fertilizer grade ammonium nitrate production by KBR/Weatherly process—Variable costs	54
Table 5.4 Fertilizer grade ammonium nitrate production by KBR/Weatherly process—Production costs	55

Figures

Figure 2.1 A typical ammonium nitrate plant block flow diagram	8
Figure 2.2 Effect of natural gas feed price on AN product value in an integrated AN plant	13
Figure 3.1 Ammonium nitrate processing steps	22
Figure 3.2 High-density ammonium nitrate process flow diagram	23
Figure 3.3 Low-density ammonium nitrate prilling process flow diagram	24
Figure 3.4 Drum granulation or pan granulation process flow diagram	25
Figure 3.5 Stamicarbon ammonium nitrate process (pressure reactor)	26
Figure 3.6 ICI Ammonium nitrate process	26
Figure 3.7 UCB ammonium nitrate process	27
Figure 3.8 NORSK hydro ammonium nitrate process (pressure reactor)	27
Figure 3.9 Mississippi chemical ammonium nitrate process	28
Figure 3.10 Chemico ammonium nitrate process	28
Figure 3.11 Sumitomo ammonium nitrate process	29
Figure 3.12 Espindesa ammonium nitrate process	29
Figure 3.13 Hydro agri ammonium nitrate process	30
Figure 3.14 Ammonium nitrate solution AZF pipe reactor process	31
Figure 3.15 Ammonium nitrate dust prilling process (Fison)	32

Figure 5.1 Effect of plant capacity on investment costs	56
Figure 5.2 Effect of ammonia feed price on net production cost and product value	56
Figure 5.3 Effect of nitric acid feed price on net production cost and product value	57
Figure 5.4 Effect of plant operating level on net production cost	57

Appendix B Figures

Figure C.1 PFD 1 of 2: Fertilizer grade ammonium nitrate prills by KBR/Weatherly process	63
Figure C.2 PFD 2 of 2: Fertilizer grade ammonium nitrate prills by KBR/Weatherly process	64

IHS Markit Customer Care:

CustomerCare@ihsmarkit.com

Asia and the Pacific Rim

Japan: +813 6262 1887

Asia Pacific: +604 291 3600

Europe, Middle East, and Africa: +44 1344 328 300

Americas: +1 800 447 2273

Disclaimer

The information contained in this presentation is confidential. Any unauthorized use, disclosure, reproduction, or dissemination, in full or in part, in any media or by any means, without the prior written permission of IHS Markit or any of its affiliates ("IHS Markit") is strictly prohibited. IHS Markit owns all IHS Markit logos and trade names contained in this presentation that are subject to license. Opinions, statements, estimates, and projections in this presentation (including other media) are solely those of the individual author(s) at the time of writing and do not necessarily reflect the opinions of IHS Markit. Neither IHS Markit nor the author(s) has any obligation to update this presentation in the event that any content, opinion, statement, estimate, or projection (collectively, "information") changes or subsequently becomes inaccurate. IHS Markit makes no warranty, expressed or implied, as to the accuracy, completeness, or timeliness of any information in this presentation, and shall not in any way be liable to any recipient for any inaccuracies or omissions. Without limiting the foregoing, IHS Markit shall have no liability whatsoever to any recipient, whether in contract, in tort (including negligence), under warranty, under statute or otherwise, in respect of any loss or damage suffered by any recipient as a result of or in connection with any information provided, or any course of action determined, by it or any third party, whether or not based on any information provided. The inclusion of a link to an external website by IHS Markit should not be understood to be an endorsement of that website or the site's owners (or their products/services). IHS Markit is not responsible for either the content or output of external websites. Copyright © 2021, IHS Markit®. All rights reserved and all intellectual property rights are retained by IHS Markit.

