

**DETAILED TECHNO-ECONOMIC FEASIBILITY REPORT (TEFR) FOR AN INTEGRATED WNA & AN PLANT:**

**Submitted To:**

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**Submitted By:**

**Date: March 22, 2022**

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**EXECUTIVE SUMMARY & RECOMMENDATIONS**

1. **Executive Summary**

**AN Market Environment**

* Overall, the AN market is expected to be approximately double from 933KMT in 2021 to 1814KMT in 2030— growing demand and advantages of ANFO over other Blasting Agents, making it a lucrative market to operate and generate revenues.
* Deepak Fertilizer is a significant competitor as it has dedicated plants to manufacture AN in both forms ( Melt and Granular) for higher market reach. DFPCL is only manufacturer of ammonium nitrate in prill/ granule/solid form giving it an advantage of PAN India market coverage as AN Melt has limitation of transportation beyond 1,000 KM
* Except for NFL, each manufacturer operates at minimum 70% (two-third operating efficiency and will reach high operating efficiency at a level of 85% (GNFC), 90% (DFPCL), 95% (RCF) by 2030. Capacity Utilization is linked with the proximity of market (Primarily Up to 1000 KM) and market penetration
* All manufactures have disadvantages to the proximity of eastern region market. New plant DFPCL in Gopalpur, Odisha (East Coast) will offer an advantage
* GNFC, RCF, and NFL produce AN melt as an intermediatory product in the production line of calcium ammonium nitrate as fertilizer industry is their key focus although Deepak Fertilizer has their key focus on AN market
* Key demand of Ammonium Nitrate is utilized for the demand for explosives—In India overall explosives market, Coal India Limited is the largest customer: over 64% of the demand. In AN based explosives market, Coal India Limited has a share of approximately 80%. Out of the total East India region demand (40%), the primary demand is from states— Jharkhand (26.06%), Odisha (24.86%), Chhattisgarh (17.93%), West Bengal (9.93%)
* A high demand-supply gap exists starting from 105KMT in 2022 and reaching at the level of 597KMT in 2030,considering the new plant of Deepak Fertilizer in east India by 2025.
* Even considering the unlikely scenario, such as an approved plant of Chambal Fertilizer and initiative towards higher capacity utilization of NCF, there is still a significant demand-supply gap to be capitalized by a new player with a planned capacity of 100KMT to operate at least at 50% operating efficiency. However, 2025 is expected to be a challenging year as most of the capacities will get introduced this year.
* All manufactures will be profitable as there would always be a Demand Supply Gap in all scenarios (Optimistic, Pessimistic and Realistic Scenarios, excluding the 2025 (Realistic) and 2025 and 2026( Pessimistic).
* Export market potential is an added opportunity for all manufactures.
* Increasing Tariff on Imports will always be beneficials for all manufactures.

A substantial business opportunity exists, but there would always be a threat of new players entering the market, specifically those companies with the advantage of in-house Ammonia. The early entrant will influence the entry plans of possible another entrant.

East India is a strategic location to be tapped. Deepak fertilizer’s new plant will have an early mover advantage.

* Overall, the WNA market is expected to be approximately 66% more, from 1,456 KMT in 2021 to 2,415 KMT in 2030
* Gujarat is the largest manufacturer of fertilizers in India accounting to more than 25% of the total production of nitrogenous as well as phosphatic fertilizers in the country. The state has more than 14% of the India's total installed capacity of fertilizers.
* Most of the WNA is used by its producers in the vertically integrated production of a wide range of chemical products such as fertilizers, ammonium nitrate, concentrated nitric acid, nitro aromatic compounds, etc.
* A high demand-supply gap exists starting from 95KMT in 2022 and reaching at the level of 483KMT in 2030,considering the new plant of Deepak Fertilizer in east India
  + Even considering the unlikely scenario, such as an approved plant of Chambal Fertilizer and GNFC, including the initiative towards higher capacity utilization of NCF, there is still a significant demand-supply gap to be capitalized by a new player with a planned capacity of 200 KMT to operate at least at 50% operating efficiency.
* Export market potential is an added opportunity for all manufactures

A substantial business opportunity exists, but there would always be a threat of new players entering the market, specifically those interested in manufacturing AN and Fertilizers. The early entrant will influence the entry plans of possible another entrant.

* Approximately 13% (231KMT) market belongs to the merchant market.
* Out of 13% merchant market, 35%(81KMT) and 27% (62KMT) is consumed in West and South region respectively. East (22%) and North India (16%) jointly contribute 38% (88KMT)

Although the cumulative merchant market of WNA in the South and East regions stands at 68%, the competitive intensity is very high because all current manufacturers are in the west region. Deepak fertilizer’s new plant will have an early mover advantage, but still, there is no player present in North India.

* In Domestic market, from the coverage point of view, (up to 1,000 KM)
  + Ammonium Nitrate: Shahjahanpur and Hazira cover 59% and 47% demand respectively
  + Weak Nitric Acid: Shahjahanpur and Hazira cover 45% and 60% respectively
* In Exports markets, Hazira has advantage because of the proximity of JNPT port.
* In the case of WNA, Kribhco will always have an advantage in Shahjahanpur because of the absence of WNA manufacturers in North India with competition from only Deepak fertilizer’s new plant in East India.
  + To operate in West and South Regions will become more complicated if the proposed plans of existing players (GNFC, RCF) see the light of implementation. In addition, the situation will become more competitive if Chambal Fertilizer’s plant becomes operational.

**TechSci recommends that Kribhco should set up AN and WNA plants at Shahjahanpur location to have more comprehensive market coverage, get competitive location advantage with an aim to generate additional revenue sources.**

**Market Environment**

The installed capacity of Ammonium Nitrate in India was 1,098 thousand metric tons in FY2015 which increased to 1,100 thousand metric tons in FY2021. The installed capacity of Ammonium Nitrate is further expected to increase to 1,587 thousand metric tons by FY2025.

The production of Ammonium Nitrate in India stood at 575 thousand metric tons in FY2015, further increasing to 744 thousand metric tons in FY2021. The production of Ammonium Nitrate in India is anticipated to reach to 1,217 thousand metric tons by FY2030.

In India, ammonium nitrate domestic consumption stood at 933 thousand metric tons in FY2021, it is expected that domestic consumption of ammonium nitrate will increase at a CAGR of 7.8% by FY2030F and reach up to 1,814 thousand metric tons.

**Demand-Supply Gap**

TechSci has followed three approaches which are realistic approach (forecast CAGR of 7.8%), optimistic approach (forecast CAGR of 10.8%), and pessimistic approach (forecast CAGR of 6.4%). The pessimistic approach is based on the historic CAGR considering business as usual.

**Realistic Approach @CAGR 7.8% (Historical CAGR has been @6.6%)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | FY15 | FY16 | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 |
| Capacity | 1,098 | 1,098 | 1,098 | 1,098 | 1,098 | 1,098 | 1,100 | 1,211 |
| Production | 575 | 616 | 637 | 719 | 837 | 700 | 744 | 888 |
| Operating rate (%) | 52% | 56% | 58% | 65% | 76% | 64% | 68% | 73% |
| Import | 90 | 190 | 326 | 220 | 273 | 268 | 218 | - |
| Export | 12 | 22 | 22 | 26 | 31 | 21 | 14 | - |
| Inventory | 11 | 12 | 13 | 14 | 17 | 14 | 15 | - |
| Domestic Consumption | 641 | 771 | 928 | 898 | 1,062 | 933 | 933 | 993 |
| Demand Supply Gap | - | - | - | - | - | - | - | -105 |
|  | **FY23** | **FY24** | **FY25** | **FY26** | **FY27** | **FY28** | **FY29** | **FY30** |
| Capacity | 1,211 | 1,587 | 1,587 | 1,587 | 1,587 | 1,587 | 1,587 | 1,587 |
| Production | 888 | 1,056 | 1,088 | 1,107 | 1,127 | 1,168 | 1,198 | 1,217 |
| Operating rate (%) | 73% | 67% | 69% | 70% | 71% | 74% | 75% | 77% |
| Import | - | - | - | - | - | - | - | - |
| Export | - | - | - | - | - | - | - | - |
| Inventory | - | - | - | - | - | - | - | - |
| Domestic Consumption | 1,059 | 1,134 | 1,217 | 1,310 | 1,415 | 1,533 | 1,665 | 1,814 |
| Demand Supply Gap | -172 | -78 | -129 | -204 | -288 | -365 | -467 | -597 |

*References: TechSci Analysis, Secondary Sources, Primary Interviews*

**Optimistic Approach @CAGR 10.8% (Historical CAGR has been @6.6%)**

**India Ammonium Nitrate Market, Demand-Supply Gap, By Volume (Thousand MT)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | FY15 | FY16 | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 |
| Capacity | 1,098 | 1,098 | 1,098 | 1,098 | 1,098 | 1,098 | 1,100 | 1,211 |
| Production | 575 | 616 | 637 | 719 | 837 | 700 | 744 | 888 |
| Operating rate (%) | 52% | 56% | 58% | 65% | 76% | 64% | 68% | 73% |
| Import | 90 | 190 | 326 | 220 | 273 | 268 | 218 | - |
| Export | 12 | 22 | 22 | 26 | 31 | 21 | 14 | - |
| Inventory | 11 | 12 | 13 | 14 | 17 | 14 | 15 | - |
| Domestic Consumption | 641 | 771 | 928 | 898 | 1,062 | 933 | 933 | 999 |
| Demand Supply Gap | - | - | - | - | - | - | - | -112 |
|  | **FY23** | **FY24** | **FY25** | **FY26** | **FY27** | **FY28** | **FY29** | **FY30** |
| Capacity | 1,211 | 1,587 | 1,587 | 1,587 | 1,587 | 1,587 | 1,587 | 1,587 |
| Production | 888 | 1,056 | 1,088 | 1,107 | 1,127 | 1,168 | 1,198 | 1,217 |
| Operating rate (%) | 73% | 67% | 69% | 70% | 71% | 74% | 75% | 77% |
| Import | - | - | - | - | - | - | - | - |
| Export | - | - | - | - | - | - | - | - |
| Inventory | - | - | - | - | - | - | - | - |
| Domestic Consumption | 1,079 | 1,318 | 1,455 | 1,582 | 1,725 | 1,886 | 2,068 | 2,275 |
| Demand Supply Gap | -192 | -262 | -367 | -475 | -597 | -718 | -871 | -1,059 |

*References: TechSci Analysis, Secondary Sources, Primary Interviews*

**Pessimistic Approach @CAGR 6.4% (Historical CAGR has been @6.4%)**

**India Ammonium Nitrate Market, Demand-Supply Gap, By Volume (Thousand MT)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | FY15 | FY16 | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 |
| Capacity | 1,098 | 1,098 | 1,098 | 1,098 | 1,098 | 1,098 | 1,100 | 1,211 |
| Production | 575 | 616 | 637 | 719 | 837 | 700 | 744 | 888 |
| Operating rate (%) | 52% | 56% | 58% | 65% | 76% | 64% | 68% | 73% |
| Import | 90 | 190 | 326 | 220 | 273 | 268 | 218 | - |
| Export | 12 | 22 | 22 | 26 | 31 | 21 | 14 | - |
| Inventory | 11 | 12 | 13 | 14 | 17 | 14 | 15 | - |
| Domestic Consumption | 641 | 771 | 928 | 898 | 1062 | 933 | 933 | 980 |
| Demand Supply Gap | - | - | - | - | - | - | - | -92 |
|  | **FY23** | **FY24** | **FY25** | **FY26** | **FY27** | **FY28** | **FY29** | **FY30** |
| Capacity | 1,211 | 1,587 | 1,587 | 1,587 | 1,587 | 1,587 | 1,587 | 1,587 |
| Production | 888 | 1,056 | 1,088 | 1,107 | 1,127 | 1,168 | 1,198 | 1,217 |
| Operating rate (%) | 73% | 67% | 69% | 70% | 71% | 74% | 75% | 77% |
| Import | - | - | - | - | - | - | - | - |
| Export | - | - | - | - | - | - | - | - |
| Inventory | - | - | - | - | - | - | - | - |
| Domestic Consumption | 1,032 | 1,090 | 1,155 | 1,228 | 1,309 | 1,399 | 1,501 | 1,614 |
| Demand Supply Gap | -144 | -34 | -67 | -121 | -181 | -232 | -303 | -397 |

*References: TechSci Analysis, Secondary Sources, Primary Interviews*

**Even while considering the pessimistic approach, taking the forecast CAGR of 6.4% there is still a significant demand supply gap of 397 thousand metric tons by FY2030 and so a scope for KRIBHCO to operate in the market.**

In India, weak nitric acid domestic consumption stood at 1,456 thousand metric tons in FY2021 growing from 1,275 thousand metric tons with a CAGR of 2.2%. The major demand for WNA comes from the ammonium nitrate industry which constitute approximately 39% of overall domestic consumption followed by fertilizers manufacturing with 26% market share. Other consumption sectors are concentrated nitric acid manufacturing, dyes & paints, explosives, nitroaromatics, etc. manufacturing. Owing to the increasing demand for weak nitric acid from end use segments, it is expected that domestic consumption will increase at a CAGR of 4.8% by FY2030F reaching up to 2,414 thousand metric tons.

**India Weak Nitric Acid Market, Demand-Supply Gap, By Volume (Thousand MT)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | FY15 | FY16 | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 |
| Capacity | 1,628 | 1,628 | 1,628 | 1,628 | 1,810 | 1,810 | 1,814 | 1,814 |
| Production | 1,319 | 1,399 | 1,421 | 1,546 | 1,596 | 1,553 | 1,471 | 1,565 |
| Operating rate (%) | 81% | 86% | 87% | 95% | 88% | 86% | 81% | 86% |
| Import | 0 | 0 | 4 | 27 | 36 | 30 | 26 | - |
| Export | 17 | 14 | 11 | 16 | 11 | 13 | 12 | - |
| Inventory | 26 | 28 | 28 | 31 | 32 | 31 | 29 | - |
| Domestic Consumption | 1,275 | 1,357 | 1,385 | 1,527 | 1,589 | 1,539 | 1,456 | 1,660 |
| Demand Supply Gap | - | - | - | - | - | - | - | -95 |
|  | **FY23** | **FY24** | **FY25** | **FY26** | **FY27** | **FY28** | **FY29** | **FY30** |
| Capacity | 1,814 | 2,111 | 2,177 | 2,177 | 2,177 | 2,177 | 2,177 | 2,177 |
| Production | 1,565 | 1,704 | 1,782 | 1,852 | 1,904 | 1,904 | 1,931 | 1,931 |
| Operating rate (%) | 86% | 81% | 82% | 85% | 87% | 87% | 89% | 89% |
| Import | - | - | - | - | - | - | - | - |
| Export | - | - | - | - | - | - | - | - |
| Inventory | - | - | - | - | - | - | - | - |
| Domestic Consumption | 1,797 | 1,950 | 2,250 | 2,268 | 2,293 | 2,325 | 2,365 | 2,414 |
| Demand Supply Gap | -232 | -246 | -468 | -416 | -389 | -421 | -433 | -483 |

*References: TechSci Analysis, Secondary Sources, Primary Interviews*

As of FY2022 there is demand-supply gap in weak nitric acid; there is a shortage of supply by 95 thousand metric tons. However, the gap is expected to increase in the forecast period owing to the increasing demand from ammonia nitrate and fertilizers applications sectors. The market is estimated to observe a demand-supply gap of 483 thousand metric by FY2030.

A high demand-supply gap exists starting from 95KMT in 2022 and reaching 483KMT in 2030

**Strategic Relevance of Proposed Locations Shahjahanpur Vs Hazira**

**Shahjahanpur: Ammonium Nitrate and Weak Nitric Acid Market Coverage Based on Distance**

**Ammonium Nitrate**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ammonium Nitrate: Demand Coverage With Respect to Distance( KM) At Proposed Facility : Shahjahanpur(Volume MT)** | | | | | | | | | | |
| **End-Use** | **%** | **MT** | **0-300** | **301-500** | **501-800** | **801-1000** | **1001-1400** | **1401-1700** | **1701-2000** | **> 2000** |
| Explosive | 8,18,399 | 88% | - | - | 2,72,799 | 2,29,152 | 2,61,887 | 54,559 | - | - |
| Mining | 42,947 | 5% | - | - | 3,767 | 21,044 | 14,473 | 2,920 | 743 | - |
| Commercial & infrastructure | 25,197 | 3% | - | - | 9,070 | 2,268 | 3,275 | 2,016 | 5291 | 3275 |
| Pharmaceuticals | 21,156 | 2% | - | 1,269 | 1,904 | 2,538 | 7,405 | 4,019 | 4019 | - |
| Others | 25,495 | 3% | - | 765 | 1,275 | 3,825 | 5,608 | 6,374 | 7649 | - |
| Domestic Demand MT | 9,33,194 | 100% | - | 2,039 | 2,88,908 | 2,58,842 | 2,92,680 | 69,759 | 17607 | 3359 |
| Domestic Demand Coverage % | | | **0%** | **0.22%** | **31%** | **28%** | 31% | 7% | 2% | 0.4% |

**Total % Demand Coverage Up to 1000 KM: 59%**

**Weak Nitric Acid**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **End-Use** | **%** | **MT** | **0-300** | **301-500** | **501-800** | **801-1000** | **1001-1400** | **1401-1700** | **1701-2000** | **> 2000** |
| **Fertilizers** | 60% | 1,38,585 | 12,472 | 15,244 | 23,559 | 18,016 | 30,489 | 13,858 | 9,702 | 15,244 |
| **CNA** | 10% | 23,098 | 692 | 5,082 | 6,006 | 1,848 | 3,233 | 2,541 | 2,309 | 1,385 |
| **Others** | 30% | 69,293 | - | 4,157 | 6,237 | 9,700 | 22,868 | 13,165 | 13,165 | - |
| **Domestic Demand** | | 2,30,975 | 13,182 | 24,486 | 35,808 | 29,566 | 56,576 | 29,552 | 25,157 | 16,648 |
| **Domestic Demand Coverage %** | | | **6%** | **11%** | **16%** | **13%** | 24% | 13% | 11% | 7% |

**Total % Demand Coverage Up to 1000 KM: 46%**

**Hazira: Ammonium Nitrate and Weak Nitric Acid Market Coverage Based on Distance**

**Ammonium Nitrate**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ammonium Nitrate: Demand Coverage With Respect to Distance( KM) At Proposed Facility: Hazira (Volume MT)** | | | | | | | | | | | |
| **End-Use** | | **%** | **MT** | **0-300** | **301-500** | **501-800** | **801-1000** | **1001-1400** | **1401-1700** | **1701-2000** | **> 2000** |
| Explosive | 88% | | 8,18,399 | - | 136,400 | - | 253,703 | 18,823 | 81,840 | - | 327,360 |
| Mining | 5% | | 42,947 | - | 1,657 | - | 6,228 | 8,160 | 9,835 | 16,320 | 742 |
| Commercial & infrastructure | 3% | | 25,197 | 2,016 | 1,008 | 2,520 | 9,323 | 6,048 | 1,008 | - | 3,275 |
| Pharmaceuticals | 2% | | 21,156 | 4,231 | 3,597 | 1,693 | 3,597 | 6,769 | 635 | 423 | 212 |
| Others | 3% | | 25,495 | 4,589 | 3,825 | 1,785 | 4,844 | 7,904 | 1,020 | 510 | 1,020 |
| Domestic Demand MT | | | 9,33,194 | 10,805 | 146,373 | 6,030 | 277,713 | 47,769 | 94,379 | 17,404 | 332,444 |
| Domestic Demand Coverage % | | | | **1%** | **16%** | **1%** | **30%** | 5% | 10% | 2% | 36% |

**Total % Demand Coverage Up to 1000 KM: 48%**

**Weak Nitric Acid**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand Coverage with Respect to Distance (KM) At Proposed Facility: Hazira (Volume MT)** | | | | | | | | | | |
| End-Use | % | Volume | 0-300 | 301-500 | 501-800 | 801-1000 | 1001-1400 | 1401-1700 | 1701-2000 | > 2000 |
| Fertilizers | 60% | 1,38,585 | 29,103 | 13,858 | 18,016 | 20,788 | 18,016 | 9,702 | 5,543 | 23,559 |
| CAN | 10% | 23,098 | 1,848 | 2,541 | 2,309 | 5,774 | 4,850 | 924 | 462 | 4,389 |
| Others | 30% | 69,293 | 22,173 | 11,088 | 5,542 | 6,237 | 13,165 | 4,158 | 1,385 | 5,542 |
| Domestic Demand MT | | 2,30,975 | 53,114 | 27,476 | 25,879 | 32,803 | 36,019 | 14,786 | 7,395 | 33,503 |
| Domestic Demand Coverage % | | | **23%** | **12%** | **11%** | **14%** | 16% | 6% | 3% | 15% |

**Total % Demand Coverage Up to 1000 KM: 60%**

Key demand of Ammonium Nitrate is utilised for the demand for explosives, with Coal India Limited being the largest customer in the country capturing over 64% of the demand generated.

Majority demand for explosives comes from states such as Jharkhand, Odisha, Chhattisgarh, West Bengal, Madhya Pradesh, Telangana, Maharashtra etc.

Jharkhand holds dominating share of 26.06% in demand for explosives, followed by 24.86% of Odisha, 17.93% of Chhattisgarh, 9.93% of West Bengal etc.

**Competitive Business Environment: AN Market**

* DFPCL has maximum installed capacity (44%) and will have a share of 61% by 2030 of India’s total capacity in absence of new plant
* Except for NFL, each manufacturer operates at minimum 70% (two-third operating efficiency and will reach high operating efficiency at a level of 85% (GNFC), 90% (DFPCL), 95% (RCF) by 2030. Capacity Utilization is linked with the proximity of market (Primarily Up to 1000 KM) and market penetration
* DFPCL is only manufacturer of ammonium nitrate in prill/ granule/solid form giving it an advantage of PAN India market coverage as AN Melt has limitation of transportation beyond 1,000 KM
* DFPCL has higher market penetration primarily because of its offerings of ammonium nitrate in prill/ granule/solid form
* DFPL is the only manufacturer of Pharma-grade AN, offering it an added advantage
* Perceived quality of DFPL is high over to other manufactures
* All manufactures have disadvantages to the proximity of eastern region market. New plant DFPCL in Gopalpur, Odisha (East Coast) will offer an advantage
* GNFC, RCF, and NFL produce AN melt as an intermediatory product in the production line of calcium ammonium nitrate as fertilizer industry is their key focus although Deepak Fertilizer has their key focus on AN market
* All manufactures will get benefited as there would always be Demand Supply Gap (Optimistic, Realistic and Pessimistic)
* Export market potential is an added opportunity for all manufacturers
* Increasing Tariff on Imports will always be beneficials for all manufacturers

**Concluding Remarks**

* Overall, the AN market is expected to be approximately double from 933KMT in 2021 to 1814KMT in 2030— growing demand and advantages of ANFO over other Blasting Agents, making it a lucrative market to operate and generate revenues.
* Deepak Fertilizer is a significant competitor as it has dedicated plants to manufacture AN in both forms ( Melt and Granular) for higher market reach.
* A high demand-supply gap exists starting from 105KMT in 2022 and reaching at the level of 597KMT in 2030,considering the new plant of Deepak Fertilizer in east India by 2025.
* Even considering the unlikely scenario, such as an approved plant of Chambal Fertilizer and initiative towards higher capacity utilization of NCF, there is still a significant demand-supply gap to be capitalized by a new player with a planned capacity of 100KMT to operate at least at 50% operating efficiency. However, 2025 is expected to be a challenging year as most of the capacities will get introduced this year.
* All manufactures will be profitable as there would always be a Demand Supply Gap in all scenarios (Optimistic, Pessimistic and Realistic Scenarios, excluding the 2025 (Realistic) and 2025 and 2026( Pessimistic).
* Export market potential is an added opportunity for all manufactures.
* Increasing Tariff on Imports will always be beneficials for all manufactures.

A substantial business opportunity exists, but there would always be a threat of new players entering the market, specifically those companies with the advantage of in-house Ammonia. The early entrant will influence the entry plans of possible another entrant.

Key demand of Ammonium Nitrate is utilized for the demand for explosives—In India overall explosives market, Coal India Limited is the largest customer: over 64% of the demand. In AN based explosives market, Coal India Limited has a share of approximately 80%. Out of the total East India region demand (40%), the primary demand is from states— Jharkhand (26.06%), Odisha (24.86%), Chhattisgarh (17.93%), West Bengal (9.93%)

East India is a strategic location to be tapped. Deepak fertilizer’s new plant will have an early mover advantage.

* Overall, the WNA market is expected to be approximately 66% more, from 1,456 KMT in 2021 to 2,415 KMT in 2030
* Gujarat is the largest manufacturer of fertilizers in India accounting to more than 25% of the total production of nitrogenous as well as phosphatic fertilizers in the country. The state has more than 14% of the India's total installed capacity of fertilizers.
* Most of the WNA is used by its producers in the vertically integrated production of a wide range of chemical products such as fertilizers, ammonium nitrate, concentrated nitric acid, nitro aromatic compounds, etc.
* A high demand-supply gap exists starting from 95KMT in 2022 and reaching at the level of 483KMT in 2030,considering the new plant of Deepak Fertilizer in east India
  + Even considering the unlikely scenario, such as an approved plant of Chambal Fertilizer and GNFC, including the initiative towards higher capacity utilization of NCF, there is still a significant demand-supply gap to be capitalized by a new player with a planned capacity of 200 KMT to operate at least at 50% operating efficiency.
* Export market potential is an added opportunity for all manufactures

A substantial business opportunity exists, but there would always be a threat of new players entering the market, specifically those interested in manufacturing AN and Fertilizers. The early entrant will influence the entry plans of possible another entrant.

* Approximately 13% (231KMT) market belongs to the merchant market.
* Out of 13% merchant market, 35%(81KMT) and 27% (62KMT) is consumed in West and South region respectively. East (22%) and North India (16%) jointly contribute 38% (88KMT)

Although the cumulative merchant market of WNA in the South and East regions stands at 68%, the competitive intensity is very high because all current manufacturers are in the west region. Deepak fertilizer’s new plant will have an early mover advantage, but still, there is no player present in North India.

* In Domestic market, from the coverage point of view, (up to 1,000 KM)
  + Ammonium Nitrate: Shahjahanpur and Hazira cover 59% and 47% demand respectively
  + Weak Nitric Acid: Shahjahanpur and Hazira cover 45% and 60% respectively
* In Exports markets, Hazira has advantage because of the proximity of JNPT port.
* In the case of WNA, Kribhco will always have an advantage in Shahjahanpur because of the absence of WNA manufacturers in North India with competition from only Deepak fertilizer’s new plant in East India.
  + To operate in West and South Regions will become more complicated if the proposed plans of existing players (GNFC, RCF) see the light of implementation. In addition, the situation will become more competitive if Chambal Fertilizer’s plant becomes operational.

**TechSci recommended that Kribhco should set up AN and WNA plants at Shahjahanpur location to have more comprehensive market coverage, get competitive location advantage with an aim to generate additional revenue sources.**

**Financial Environment**

**Fixation of plant capacity & Project configuration**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Product** | **Capacity (MTPA)** | **Raw Materials** | **Per MT consumption** | **Unit** | **Annual Quantity Required** | **Unit** |
| **Weak Nitric Acid** | 82500 | Anhydrous Ammonia (Liquid) | 0.2875 | MT | 23719 | MT |
| Platinum (94%)/Rhodium (6%) Gauze (Catalyst)\* | 0.00028 | Kg | 23 | Kg |
| **Ammonium Nitrate** | 100000 | Weak Nitric Acid (WNA) | 0.747 | MT | 74700 | MT |
| Anhydrous Ammonia (Liquid) | 0.213 | MT | 21300 | MT |

**Product Specifications**

When the plant is operated the following product specifications shall be met:

|  |  |
| --- | --- |
| Nitric Acid | |
| Concentration | Not less than 60 wt.% Nitric Acid |
| Dissolved oxides of nitrogen | Not more than 0.01 wt.% expressed as HNO2 |
| Chlorides | Not more than 20 ppm w |
| Sulphates as H2SO4 | Not more than 20 ppm w |
| Residue on ignition | Not more than 250 ppm w |
| AN Solution | |
| Concentration | Not less than 88 wt.% Nitric Acid |

Manufacturing Process & Available Process Technology of WNA & AN

To manufacture weak nitric acid and ammonium nitrate, many technology providers are in the race to weak nitric acid and ammonium nitrate plants. Thyssenkrupp is the primary technology provider to the Indian WAN and AN manufacturing company. Casale SA and Stamicarbon are the other providers of technology of ammonium nitrate to Indian manufactures. However, Kribhco has signed an agreement with KBR as the technology licensee for weak nitric acid and ammonium nitrate plant.

KBR offers two process to manufacture weak nitric acid:

**Dual pressure:** The Weatherly Dual-Pressure Nitric Acid plants from KBR provide more effective heat recovery, which results in lower running costs. The technology reduces the overall plant plot plan using its tried-and-true vertical reactor and heat recovery design, which lowers capital costs for pipes and structural steel.

**Mono pressure:** KBR Weatherly's high mono-pressure design uses less energy. The technology uses a single, high-pressure level. Smaller, less expensive plant equipment is possible with this high-pressure strategy, which greatly lowers capital costs.

Mono-pressure technology is recommended by KBR for this size plant. This technology is most relevant for Kribhco as per the planned capacity.

**Unit Consumption of Raw Materials and Utilities**

**Amount Per Metric Ton Acid (100% Basis)- 250 MTPD: Nitric Acid**

|  |  |
| --- | --- |
| Ammonia (100% basis) (m. ton) | 0.2875 |
| Gross Platinum Catalyst g (Note 1) | 0.280 |
| 1900 kPag Steam Export (superheated to 360 °C) (m. ton) | <0.645> |
| Low Pressure Steam Import (m. ton) | 0.0475 |
| Boiler Feedwater (m. ton) (Note 2) | 1.07 |
| Steam Condensate Export (m. ton) | <0.0475> |
| Cooling Water Cubic meters (Note 3) | 132.7 |
| Turbine Condensate Export (m. ton) | <0.0278> |
| Electric Power 400 v KWh (Note 4) | 8.34 |

*Notes:*

*1. Based on using platinum recovery gauze and a platinum filter net burn off is 0.085 gm/mt.*

*2. Makeup feedwater to be of suitable quality to permit 1% blowdown while generating 4100 kPag steam.*

*3. Based on a cooling water temperature rise of 9.2 °C.*

*4. Includes pumps, lighting, and instrumentation.*

**Amount Per Metric Ton AN- 300 MTPD: Ammonium Nitrate**

|  |  |
| --- | --- |
| Ammonia (100% basis) (m. ton) | 0.213 |
| Nitric Acid (100% basis) (m. ton) | 0.747 |
| Electricity kWh (1) | 6.0 |
| Cooling Water Cubic meters (2) | 15.0 |
| 345 kPag Steam Import (m. ton) | 0.02 |
| Steam Condensate Export (m. ton) | <0.02> |
| Process Condensate Export (m. ton) | 0.284 |

***Notes:***

*1. Includes pumps, lighting, and instrumentation.*

*2. Based on a cooling water temperature rise of 10 °C.*

**Process Chemistry- Nitric Acid Plant– Mono Pressure Technology**

**Nitric Acid**

**Reaction No. 1**

4NH3 + 5O2  4NO + 6H2O

Ammonia Oxygen Nitric Water

Oxide

**Reaction No. 2**

2NO + O2  2NO2

Nitric Oxygen Nitrogen

Oxide Dioxide

**Reaction No. 3**

3NO2 + H2O  2HNO3 + NO

|  |  |  |  |
| --- | --- | --- | --- |
| Nitrogen | Water | Nitric | Nitric |
| Dioxide |  | Acid | Oxide |

The overall reaction of Reaction Nos. 1 through 3 is shown by the following:

NH3 + 2O2  HNO3 + H2O

Ammonia Oxygen Nitric Acid Water

**Ammonium Nitrate**

NH3 + HNO3  NH4NO3

**List of Hazardous Waste:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No.** | **Name of waste** | **Source of generation** | **Disposal Method** |
| 1 | Discarded containers, drums | Receipt, storage, and handling of raw/packing materials | Collection in drums, storage and transportation to authorized recyclers /authorized TSDF |
| 2 | Used/Spent Oil | Process / rotary machines / transformers | Collection in drums, storage, transportation, and sales to authorized recyclers. |
| 3 | Spent Catalyst | Process | Regeneration / Recycle through catalyst supplier |
| 4 | NOx abatement Spent Catalyst | Nitric Acid Plant | Collection in drums, storage, and transportation to authorized recyclers /authorized TSDF. |
| 5 | Chemical sludge from wastewater treatment | Wastewater treatment schemes | Chemical Sludge from wastewater treatment scheme is being disposed to cement plants for co-processing / TSDF, Udaipur |
| 6 | Contaminated cotton waste or other cleaning materials | Maintenance and cleaning activities | Collection, storage and transportation to Common incinerator |

**Government Standards for Ammonium Nitrate and Weak Nitric Acid Effluent:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S. No.** | **Parameter** | **Standards** | | | |
|  |  | **Inland surface water** | **Public sewers** | **Land of irrigation** | **Marine coastal areas** |
| 1 | Ammonical  Nitrogen (as N), mg/l Max. | 50 | 50 | -- | 50 |
| 2 | Free ammonia (as NH3) mg/l, Max | 5 | -- | -- | 5 |

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Industry** | **Parameter** | **Standards** |
| 1 | Nitric Acid | Oxides of Nitrogen | 3 kg/tonne of weak acid (before concentration) produced |

**Project cost estimation**

|  |  |  |
| --- | --- | --- |
| **Particulars (INR Crore)** | **Shahjahanpur** | **Hazira** |
| Total Project cost | 418 | 418 |
| Total Production Cost (Weak Nitric Acid) | 90.17 | 97.13 |
| Total Production Cost (Ammonium Nitrate) | 138.66 | 150.24 |

**Profitability projections**

**Shahjahanpur-**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 280 | 379 | 379 | 379 |
| Total Operating Cost | 161 | 234 | 249 | 260 |
| Income bef. Depr., Int.& Taxes | 119 | 146 | 131 | 119 |
| Gross Margin (%) | 43% | 38% | 34% | 31% |
| Profit Before Tax (PBT) | 64 | 106 | 110 | 99 |
| PBT Margin (%) | 23% | 28% | 29% | 26% |
| Profit after Tax (PAT) | 64 | 70 | 68 | 59 |
| PAT Margin (%) | 23% | 18% | 18% | 15% |

**Hazira-**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 280 | 379 | 379 | 379 |
| Total Operating Cost | 173 | 252 | 268 | 280 |
| Income bef. Depr., Int.& Taxes | 106 | 127 | 111 | 99 |
| Gross Margin (%) | 38% | 34% | 29% | 26% |
| Profit Before Tax (PBT) | 51 | 88 | 90 | 78 |
| PBT Margin (%) | 18% | 23% | 24% | 21% |
| Profit after Tax (PAT) | 51 | 58 | 55 | 45 |
| PAT Margin (%) | 18% | 15% | 14% | 12% |

**Financial Indicators**

|  |  |  |
| --- | --- | --- |
| **IRR** | **Shahjahanpur** | **Hazira** |
| Project | 7.53% | -0.41% |
| Equity | 1.05% | -20.14% |

**Recommendations Based on Key observations**

**Most Suitable plant Set-up location:**

Shahjahanpur is observed as the most favorable location for the plant set-up of integrated weak nitric acid (WNA) and ammonium nitrate (AN) due to much lower raw material price i.e., ammonia (major raw material).

Overall, the operating cost of production of weak nitric acid and ammonium nitrate in Shahjahanpur has been much lower than the operating cost of production in Hazira.

The overall cost of production per ton of weak nitric acid in Shahjahanpur is INR 10995 per ton, around INR 800 per ton lower than the cost produced in Hazira which impacts the overall cost of production ammonium nitrate solutions in both the locations.

When comparing the production cost of ammonium nitrate in both the locations, Shahjahanpur has a cost advantage of around INR 1158 per ton over Hazira impacting the overall profitability of plant.

The less the ammonium nitrate cost of production in the location, the more feasible and profitable the plant.

The location possesses strategic advantage from both market and financial point of view which offers competitive benefit to Kribhco.

It should be preferred due to low operating cost of production per ton of WNA and AN produced, further supported by attractive IRR and Payback Period.

Moreover, the percentage margin observed in Shahjahanpur has been around 5% higher than that is observed in Hazira. In addition to this, profit before and after-tax percentage margin is also observed to be much higher.

Furthermore, the project and equity IRR in Shahjahanpur location is 7.53% and 1.05%, respectively representing the profitable operations of the plant in the forecast period.

In Conclusion, Shahjahanpur location is the most suitable for the Integrated WNA – AN plant.

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**Weak Nitric Acid & Ammonium Nitrate Manufacturing Process**

**Fixation of plant capacity & Project configuration**

Kribhco has captive production of anhydrous ammonia in liquid form for weak nitric acid and ammonium nitrate. Therefore, based on ammonia availability, a maximum of 82.5 KTPA plants of weak nitric acid and 100 KTPA ammonium nitrate can be set up. As per the information received by the KBR, for both 82.5 KTPA WNA and 100 KTPA AN plant, the below-mentioned raw materials and catalysts in the table are utilized with specific consumption norms. Platinum (94%)/Rhodium (6%) Gauze is used as a catalyst in the manufacturing process of weak nitric acid. On the other hand, no catalyst is used to produce ammonium nitrate.

Manuf**acturing Process & Available Process Technology of WNA & AN**

To manufacture weak nitric acid and ammonium nitrate, many technology providers are in the race to weak nitric acid and ammonium nitrate plants. Thyssenkrupp is the primary technology provider to the Indian WAN and AN manufacturing company. Casale SA and Stamicarbon are the other providers of technology of ammonium nitrate to Indian manufactures. However, Kribhco has signed an agreement with KBR as the technology licensee for weak nitric acid and ammonium nitrate plant.

KBR offers two process to manufacture weak nitric acid namely, mono pressure and dual pressure.

The Weatherly Dual-Pressure Nitric Acid plants from KBR provide more effective heat recovery, which results in lower running costs. The technology reduces the overall plant plot plan using its tried-and-true vertical reactor and heat recovery design, which lowers capital costs for pipes and structural steel.

KBR Weatherly's high mono-pressure design uses less energy. The technology uses a single, high-pressure level. Smaller, less expensive plant equipment is possible with this high-pressure strategy, which greatly lowers capital costs.

Mono-pressure technology is recommended by KBR for this size plant.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Product** | **Capacity (MTPA)** | **Raw Materials** | **Per MT consumption** | **Unit** | **Annual Quantity Required** | **Unit** |
| **Weak Nitric Acid** | 82500 | Anhydrous Ammonia (Liquid) | 0.2875 | MT | 23719 | MT |
| Platinum (94%)/Rhodium (6%) Gauze (Catalyst)\* | 0.00028 | Kg | 23 | Kg |
| **Ammonium Nitrate** | 100000 | Weak Nitric Acid (WNA) | 0.747 | MT | 74700 | MT |
| Anhydrous Ammonia (Liquid) | 0.213 | MT | 21300 | MT |

**Manufacturing Process: Nitric Acid Plant– Mono Pressure Technology**

1. Nitric acid is produced using ammonia and ambient air as primary materials. These raw components are mixed and subjected to high pressure and temperature before being passed over a platinum catalyst, where the ammonia and oxygen are reacted.
2. The process gas that results is then sent via a heat exchanger train, where most of the the reaction's energy is recovered as heat. In the cooler condenser and absorber, where nitric oxide, nitrogen dioxide, oxygen, and water mix to form nitric acid, the process gas is further cooled and oxidized.
3. Reheating the tail gas to generate power for the air compressor by driving a hot gas expander uses some of the reaction energy recovered in the heat exchanger train.
4. A two-stage inlet air filter is used to filter atmospheric air. The air compressor then compresses the filtered air. A hot gas expander and a steam turbine power the air compressor. The hot gas expander provides roughly 90% of the necessary compressor power.
5. In the air/tail gas interchanger, air from the compressor discharge is heated by the tail gas supplied to the tail gas heater, which then cools the air. Following the air/tail gas interchanger, a part of the air is isolated for use as bleach air and is sent through the bleacher section of the absorber with manual flow control.
6. The air heater, which is a component of the process gas heat exchanger train and is heated by process gas, receives the primary process air stream after that. Prior to entering the ammonia/air mixer, it is subsequently filtered in a high efficiency sintered metal filter.
7. Before entering the ammonia vaporizer, the liquid ammonia feed to the plant is filtered in a cartridge type filter to remove suspended particulates. The majority of the ammonia used as feed for the nitric acid plant is vaporized by the ammonia vaporizer using waste heat from the cooling water.
8. As soon as ammonia is fed, it is superheated with 345 kPag steam in the auxiliary ammonia vaporizer/superheater to prevent any liquid carryover that can harm the platinum catalyst. A high efficiency sintered metal filter is used to filter the ensuing superheated ammonia vapor stream in order to get rid of any potential impurities and safeguard the platinum catalyst.
9. The ammonia flow to the ammonia air mixer is directly adjusted to manage catalyst temperature. This control method has been widely employed in Weatherly nitric acid plants since it has shown to be quite successful at maintaining steady catalyst temperatures.
10. The ammonia/air mixer thoroughly combines the clean air and ammonia streams before dispersing the combination over the catalyst, where a reaction creates nitric oxide and water vapor. The heat recovery system, which comprises of the expander gas heater, waste heat boiler, steam superheater, an oxidation spool, the tail gas heater, the platinum filter, and the air heater, subsequently processes the high temperature process gas that results.
11. The steam superheater superheats the 4100 kPag steam produced by the waste heat boiler to a temperature of 400 oC. After meeting all the steam requirements for the air compressor set steam turbine driver, the steam so created is adequate to supply a steam export. The tail gas heater recovers more energy to reheat tail gas, which boosts power recovery in the hot gas expander.
12. The platinum filter, which recovers platinum particles lost from the platinum gauze during operations, receives process gas from the tail gas heater. To improve heat recovery in the air heater, where the process gas is further chilled by heating the process air feed to the ammonia/air mixer, the platinum filter's shell provides volume for extra oxidation.
13. The process gas then moves into the cooler condenser, where cooling water is used to chill it. The gas stream's nitrogen dioxide and condensed water vapor react to produce mild nitric acid. The outflow channel of the cooler condenser separates the weak acid and process gas. While the weak acid is delivered into the absorber's weak acid sump and then pumped to the proper absorber tray by weak acid pumps, the gas enters the absorber column in a separate line.
14. The absorber column is a sieve tray absorber with a process gas conditioning zone and a product acid bleacher section in the bottom half. An appropriate quality of absorber feedwater is fed into the absorber's top tray.
15. The nitrogen oxides removed from the product acid are combined with the bleach air stream as it exits the bleacher section using the process gas from the cooler condenser. The oxygen needed for the ongoing reoxidation of nitric oxide to nitrogen dioxide in the absorber column is provided by this additional air.
16. Before reaching the first absorption tray, the mixed gas stream enters the absorption column and travels through a gas conditioning zone. By passing the gas through trays that have cooling coils and on which a liquid level is automatically maintained by further continuous condensation of a tiny amount of weak acid from the process gas stream, the heat of the oxidation reaction in this zone is eliminated. This extra weak acid goes into the absorber's weak acid sump, where it joins the weak acid that has already condensed in the cooler condenser.
17. When the process gas exits the gas conditioning zone, it travels uphill through absorption trays where it interacts counter-currently with absorber feedwater and weak acid to create the necessary strength of nitric acid.
18. From the bottom absorption, product acid goes to the bleacher area. The residual dissolved nitrogen oxides in the product acid are removed from it in the bleacher when it comes into contact with a counter-current flow of bleach air. After that, the stream of whitened, clear acid is permitted to flow under pressure to storage. Cooling water running via coils on the trays in the column removes the heat created by the oxidation and absorption reactions. The tail gas leaves the absorber and travels to the tail gas reheating system after having its NOx level decreased to about 250 ppm by volume.
19. The air-tail gas interchanger's shell side is where tail gas first enters the steam tail gas preheater, where it is preheated with 345 kPag steam. To perform the final step of tail gas preheating, air from the compressor output is exchanged with tail gas. The tail gas heater is then supplied the exhaust gas. To prevent process gas condensation in the tail gas heater, the tail gas is suitably preheated.
20. The tail gas is heated to about 339 °C in the tail gas heater. The expander gas heater is where it continues to heat it up, reaching a temperature of 649 oC. The N2O Abator receives tail gas from the expander gas heater. Nitrous oxide (N2O) is catalytically destroyed by the N2O Abator by around 95% before being delivered to the hot gas expander. Before entering the NOx abator, recovered tail gas and tail gas egress from the hot gas expander are combined in the ammonia/tail gas mixer with a short stream of ammonia vapor. The tail gas NOx content is lowered to less than 25 ppm by volume in the NOx abator.
21. A start-up heater that is situated upstream of the NOx abator is utilised to warm the tail gas and abator prior to gauze light-off during startup and controlled shutdowns. The abator and tail gas are heated to about 204°C by the start-up heater using 4100 kPag steam that is imported from battery limitations. To help create a nearly colorless tail gas stack, this ensures that the NOx abator can operate during start-up and controlled shutdown.
22. The heated tail gas in the hot gas expander is used to generate most of the compression power needed for the plant. The expander releases the tail gas, which then passes via the NOx abator and the economizer to warm the boiler feedwater. The stack is then used to release the tail gas into the atmosphere.

**Unit Consumption of Raw Materials and Utilities: Nitric Acid Plant– Mono Pressure Technology**

When the plant is operated in strict accordance with the procedures recommended by KBR-Weatherly Inc., KBR-Weatherly expects that the plant will consume the following quantities of raw materials and utilities per metric ton of nitric acid (100% basis) produced.

**Amount Per Metric Ton Acid (100% Basis)- 250 MTPD**

|  |  |
| --- | --- |
| Ammonia (100% basis) (m. ton) | 0.2875 |
| Gross Platinum Catalyst g (Note 1) | 0.280 |
| 1900 kPag Steam Export (superheated to 360 °C) (m. ton) | <0.645> |
| Low Pressure Steam Import (m. ton) | 0.0475 |
| Boiler Feedwater (m. ton) (Note 2) | 1.07 |
| Steam Condensate Export (m. ton) | <0.0475> |
| Cooling Water Cubic meters (Note 3) | 132.7 |
| Turbine Condensate Export (m. ton) | <0.0278> |
| Electric Power 400 v KWh (Note 4) | 8.34 |

Source: KBR

***Notes:***

*1. Based on using platinum recovery gauze and a platinum filter net burn off is 0.085 gm/mt.*

*2. Makeup feedwater to be of suitable quality to permit 1% blowdown while generating 4100 kPag steam.*

*3. Based on a cooling water temperature rise of 9.2 °C.*

*4. Includes pumps, lighting, and instrumentation.*

**Process Design Features-** **Nitric Acid Plant– Mono Pressure Technology**

**High Purity Air to Process:** High purity air is essential for both high ammonia conversion efficiency and extended gauze runs. The design features which ensure the required high purity air are:

1. High efficiency air intake filtration.

1. Corrosion resistant materials of construction in the air flow path between the inlet air filter and the gauze.
2. A final discharge air filter before the ammonia/air mixer

a) Inlet Air Filter

Two stage filtering is employed for the air intake to the air compressor set. The filter unit contains multiple individual filtration cells, each containing one pair of rigid aluminum frame first and second stage filter elements. The first stage element removes the bulk of atmospheric contaminants. This washable element can be removed on the run for washing and/or replacement with a clean element, without disturbing either the second stage element or its seal to the filter housing frame. The second stage element is not washable and has an expected life of 1 year.

b) Materials of Construction

The ductwork from the inlet air filter to the air compressor, the discharge piping from the air compressor to the ammonia/air mixer are all stainless steel.

c) Discharge Air Filter

As final protection against casual contamination, the discharge air filter uses stainless steel sintered metal washable elements. These durable high efficiency elements are subjected to a two-stage washing and rinsing procedure as required and are returned to service with complete renewal of the original performance.

**High Purity Ammonia:** For extending gauze life and boosting ammonia production, clean ammonia is just as crucial as clean air. Before the liquid ammonia enters the vaporizer system, KBR-Weatherly plants use a single liquid ammonia filter to get rid of most impurities. This filter has disposable cartridge-style parts that are simple to replace when the catalyst needs to be changed.

Only stainless-steel objects are permitted to come into touch with the ammonia from this point to the gauze, including all piping, the ammonia vaporizer, and the auxiliary ammonia vaporizer/superheater. Sintered metal filter elements with great efficiency and washability are used for the final vapor ammonia filtration.

**Ammonia/Air Mixing:** In a static mixing system, ammonia and air are mixed. The gas stream is divided and redistributed by this stationary in-line mixer using many small intersecting channels, leaving the unit with a homogeneous gas mixture.

**Converter Basket Design:** Long gauze life is produced by clean raw material streams and uniform mixing, but efficient ammonia conversion also necessitates a converter basket design that forbids bypassing the catalysts outside edges.

High ammonia conversion efficiencies have been successfully demonstrated using the KBR-Weatherly catalyst basket design, which has been developed and tested over a long period of plant experience. All of the most recent platinum recovery gauze systems can be used with the basket design**.**

**Absorber Design**: Bubble cap trays are used in the KBR-Weatherly standard nitric acid plant absorber design. In KBR-Weatherly nitric acid facilities less than 750 tpd, bubble cap tray absorbers had long been the norm. Sieve trays are more frequently utilized for facilities that produce more than 750 tpd.

**Compressor Selection:** The compressor set has properly matched impellers and is entirely centrifugal in construction. This feature makes the design of the entire plant much simpler while doing away with the changeable stator geometry that is frequently used in axial/axial and axial/centrifugal systems. Interstage blow-off is not necessary for anti-surge control or during startup. The anti-surge control system's design is significantly simplified as a result. Furthermore, this kind of air compressor set's wide range of stability enables turndown to be accomplished without resorting to the expander's complicated changeable stator shape through changes in compressor set speed. All of this is done with the least amount of electricity possible thanks to intercooling and unique, high-efficiency impellers**.**

**Corrosion Control:** Process design is a tool used by KBR-Weatherly to prevent situations that cause corrosion issues in nitric acid plants. To prevent corrosion issues brought on by acid condensation from process gas on the interior tube walls at the low temperature end of each unit, the temperature cut-off points for heat recovery in gas-to-gas exchangers in the tail gas and the air heaters have been specially chosen. Only the tubes of the cooler-condenser, which has zirconium tubes and zirconium-clad S.S. tube sheets for long life in this corrosive environment, experience acid condensation from process gas**.**

**Plant Capacity:** On a planned summer day, the nitric acid plants are intended to produce acid at the nominal design rate. The possibility to reduce production rate or operate the plant at "over capacity" is built into the design, assuming ambient circumstances are suitable.

Under ideal environmental circumstances, the KBR-Weatherly nitric acid plant is generally intended to run continuously between 70% and 110% of design production capacity**.**

**On-Stream Time:** Nitric acid production plant is planned to run 96% of the time. The converter design, which includes the mixed gas inlet stream, considers the requirement for a minimal amount of downtime and labor during catalyst upgrades. Total production downtime is often only six to eight hours with an experienced team because of the converter's comparatively compact size and detachable catalyst basket.

**Personnel Requirements:** One-fifth of a control room operator and one-fourth of a field operator will be needed for the nitric acid plant to run normally. For startup and shutdown, there must be one operator in the control room and one in the field**.**

**Turndown:** Bypassing the converter and routing air to the tail gas system, which maintains mass flow through the expander and controls the plant pressure, is how a plant can be turned down. Since pressure directly affects the absorber's ability to produce nitric acid, maintaining high plant pressure ensures that NOx abatement is effective even at decreased production rates. It is possible to reduce the design production rate by about 70%.

**Emergency power:** Emergency power is recommended for the following items:

1. Lube oil pump for air compressor
2. DCS

**Energy Conservation Features for Nitric Acid Plant– Mono Pressure Technology**

The KBR-Weatherly nitric acid plant design includes an integrated system of energy utilization which recovers process heat to minimize energy losses in cooling water and stack tail gas**.**

**Process Heat Recovery and Ammonia Vaporization with Waste Heat:** In the expander gas heater, waste heat boiler, and tail gas heater, the air-NOx combination is cooled while retaining process heat.

The quick oxidation of NO to NO2, which reaches approximately 90% completion at the exit of the heat recovery system, is made possible using high-pressure process gas (11.7 bar at the gauze), which contributes to the very high heat recovery. At lower process gas pressures, a large portion of the oxidation heat created would not be accessible and would be lost to cooling water in the cooler condenser and absorber tower.

In the cooler condenser, the process gas is finally cooled. The subsequent evaporation of ammonia recovers this energy**.**

**Tail Gas Reheating and Power Recovery:** Since the expander—the most effective source of power in a nitric acid plant—can employ both heat and pressure energy, tail gas reheating is the main application for recoverable process energy. The power recoverable in the expander using established gas expander technology ranges from 89 to 95% of the air compressor set requirements for the different plant configurations**.**

**Steam System (mono pressure):** The high-pressure steam system is intended to produce 4100 kPag/400 °C superheated steam, which will satisfy the steam turbine's entire normal operating need. The leftover high-pressure steam is exported at 4100 kPag/400 °C to the plant battery limits. For supply to the steam tracer, auxiliary ammonia vaporizer/superheater, and steam tail gas preheater, low pressure steam at 345 kPag is imported**.**

**Process Chemistry- Nitric Acid Plant– Mono Pressure Technology**

Nitric acid is produced using ammonia and ambient air as primary materials. These raw materials are mixed and subjected to high pressures and temperatures before being passed through a platinum gauze catalyst, where the ammonia vapor combines with a significant amount of the oxygen in the atmosphere to create nitric oxide.

**Reaction No. 1**

4NH3 + 5O2  4NO + 6H2O

Ammonia Oxygen Nitric Water

Oxide

The resultant process gas is sent through a number of heat exchangers to remove and recover the heat produced by Reaction No. 1.

Nitrogen dioxide is created as a result of the nitric oxide combining with extra oxygen as the process gas is cooled via heat recovery.

**Reaction No. 2**

2NO + O2  2NO2

Nitric Oxygen Nitrogen

Oxide Dioxide

To encourage this reaction and enable recovery of the reaction heat in the heat exchangers, large oxidation spools are added to the heat exchanger train.

Nitrogen dioxide interacts with the water created in Reaction No. 1 as the process gas enters the cooler condenser to create nitric acid. More water is introduced to the process in the absorber, where it continues to make nitric acid.

**Reaction No. 3**

3NO2 + H2O  2HNO3 + NO

|  |  |  |  |
| --- | --- | --- | --- |
| Nitrogen | Water | Nitric | Nitric |
| Dioxide |  | Acid | Oxide |

The cooler condenser shell and the absorber cooling coils both contain cooling water that removes the heat produced by this reaction. Nitric oxide produced in reaction number three reacts once more with reaction number two. The bleach air provides extra oxygen to encourage nitric oxide's conversion to nitrogen dioxide. Nitric acid is continuously produced by reactions No. 3 and 2 up through the absorber trays up until the level of nitrogen oxides in the gas is below required emissions standards. To speed up the reactions and take the heat out of the processes, chilled coolant is employed in the cooling coils of the upper absorber trays.

The overall reaction of Reaction Nos. 1 through 3 is shown by the following:

NH3 + 2O2  HNO3 + H2O

Ammonia Oxygen Nitric Acid Water

**Consumables and Catalyst- Nitric Acid Plant– Mono Pressure Technology**

**Consumables:** The following consumables will be required for operation of the nitric acid plant:

Item: Lubricants

Description: Lubrication of equipment as required per vendors’ recommendations.

Item: Hydrogen

Conditions: Supplied in 10 m³ commercial cylinders by owner.

Remarks: Not required for normal operation. During startup approximately one-third to one-half a cylinder is required to light the gauze catalyst using the hydrogen torch.

**Catalyst:** The nitric acid plant uses a pad made of many layers of woven platinum gauze as an ammonia conversion catalyst. Additional sheets of gauze containing Pd or other noble metals are added when a "getter" gauze is used. On these layers, Pt and Rh are captured but extra Pd is preferentially lost.

It is also possible to employ specialized proprietary gauze support packs. Utilizing lower catalyst loadings may be made possible by these specific support packs.

**Life Of Catalyst Charge:** Over the course of a manufacturing run, the efficiency of the conversion of ammonia to nitric oxide gradually decreases, raising operating expenses. Sometimes the run period for a single catalyst charge is increased to accommodate pressing production needs.

A regular length run should last between 70 and 90 days. The first catalyst charge may be exposed to impurities from the newly built process system during first operations, which would shorten its life. The working life of succeeding catalyst charges will lengthen as impurities are gradually removed from the system and the rate of catalyst poisoning declines.

**Changing Catalyst:** For convenience of catalyst replacement, the catalyst is installed in a basket that is detachable from the converter. The converter design accounts for the requirement for fast catalyst changes, including the mixed gas inlet system. With an experienced crew, switching converter baskets takes four to five hours when using a second preloaded basket. With only six to seven hours of total downtime, the facility may be restarted.

**Catalyst Recovery Systems:** The nitric acid plant is made to enable the use of platinum recovery gauzes, often known as "getters," directly below the platinum catalyst. These systems typically catch 60 to 70 percent of the total catalyst burn off. They are mostly made of palladium, and for every gram of recovered platinum, they lose about 0.45 grams of palladium.

**Manufacturing Process: Ammonium Nitrate Solutions Plant**

1. Ammonium nitrate is produced by the reaction between ammonia and nitric acid.
2. The neutralizer's sparger is metered with ammonia vapor. Battery limits provide nitric acid to the neutralizer. Approximately 95–97% of the nitric acid is delivered to a sparger in the neutralizer under ratio control and pH trim. To neutralize unreacted ammonia that has left the neutralizer, the residual nitric acid is delivered to the scrubber. The neutralizer's output of ammonium nitrate overflows into the AN SURGE Tank.
3. A little amount of unreacted ammonia and steam that is released as a result of the heat of reaction created in the neutralizer are carried overhead into the scrubber. A packed bed in the scrubber comes into touch with these off-gases to apply diluted acidic ammonium nitrate. When the diluted AN solution is circulated back to the scrubber packing, the condensed water from the steam regulates the concentration of ammonium nitrate in the scrubber and, as a result, the neutralizer. The diluted AN solution is chilled externally in the circulating AN cooler. This diluted ammonium nitrate spills over into the primary neutralizer in part.
4. In the condensing section, which recovers process condensate for use as absorber feedwater in the nitric acid plant, the leftover off-gas and condensate from the vaporizer are subsequently transferred. The process condensate pumps, circulation condensate chiller, and vent scrubber make up the condensing section. The leftover process steam from the neutralizer and vaporizer comes into touch with the process condensate as it is cooled and circulated over a packed bed. Over the packed portion, the condensate is completely condensed, and the remaining inerts vent to the atmosphere as the condensate flows into the process condensate tank. The process condensate is then used as the feedwater for the absorber.

**Unit Consumption of Raw Materials and Utilities: Ammonium Nitrate Solutions Plant**

When the plant is operated in strict accordance with the procedures recommended by KBR Inc., KBR expects that the plant will consume the following quantities of raw materials and utilities per metric ton of AN Solution produced.

**Amount Per Metric Ton AN- 300 MTPD**

|  |  |
| --- | --- |
| Ammonia (100% basis) (m. ton) | 0.213 |
| Nitric Acid (100% basis) (m. ton) | 0.747 |
| Electricity kWh (1) | 6.0 |
| Cooling Water Cubic meters (2) | 15.0 |
| 345 kPag Steam Import (m. ton) | 0.02 |
| Steam Condensate Export (m. ton) | <0.02> |
| Process Condensate Export (m. ton) | 0.284 |

Source: KBR

***Notes:***

*1. Includes pumps, lighting, and instrumentation.*

*2. Based on a cooling water temperature rise of 10 °C*.

**Process Design Features: Ammonium Nitrate Solutions Plant**

The following are the main characteristics of the AN Solutions plant's design:

1. Limiting emissions through accurate pH control in the neutralizer.
2. Proven design of the Neutralizer and AN Scrubber.
3. The AN Scrubber and Vent Scrubber's packed parts worked in condensing mode.

The AN Particulate Demister is a feature of the vent scrubber. The AN Particulate Demister's function is to remove AN particulate from the vent stream before it enters the atmosphere. A candle-style filter is the AN Particulate Demister. A cage made of stainless steel supports the fiber bed that serves as the filter material. 90% of particles 1 micron and larger and 99% of particles 3 micron and larger are normally removed by the demister. Gravity will be used to restore the collected AN particle to the process.

Generating feedwater for the absorbers that the nitric acid plant can use.

The ammonia vaporizer, which uses process steam to evaporate ammonia for the ammonium nitrate operations, is passed through by the scrubber overheads.

**Process Chemistry: Ammonium Nitrate Solutions Plant**

The raw materials for producing ammonium nitrate are ammonia and nitric acid. The materials are reacted in the neutralizer/scrubber which then flows by gravity to the solution mix tank.

NH3 + HNO3  NH4NO3

**Product Specifications- Nitric Acid Plant– Mono Pressure Technology & Ammonium Nitrate Solutions Plant**

When the plant is operated in accordance with the guidelines established by KBR the following product specifications shall be met:

|  |  |
| --- | --- |
| Nitric Acid | |
| Concentration | Not less than 60 wt.% Nitric Acid |
| Dissolved oxides of nitrogen | Not more than 0.01 wt.% expressed as HNO2 |
| Chlorides | Not more than 20 ppm w |
| Sulphates as H2SO4 | Not more than 20 ppm w |
| Residue on ignition | Not more than 250 ppm w |
| AN Solution | |
| Concentration | Not less than 88 wt.% Nitric Acid |

**Effluent & Emissions and Technologies Available**

While manufacturing ammonium nitrate, particulate matter, ammonia, and nitric acid emissions are produced. Ammonia and nitric acid emit gases principally when they are used in granulators and neutralizers to create solutions (neutralizers and concentrators). The most significant source is particulate matter, which is released continuously when solids are formed. The two primary sources of particles are prill towers and granulators. In addition, orifices can become blocked by micro prills, which increases emissions and fine dust loading.

Ammonium nitrate solids are banged against the screens and each other during screening processes, which causes emissions. Most of these screening processes are enclosed or partially covered to limit emissions. During the mixing process in the rotating drums, the coating of products may also produce some particle emissions. In most cases, this dust is collected and repurposed for coating storage. Bagging and bulk loading are additional dust sources, particularly during final filling when dust-filled air is ejected from bags.

Wastewater from nitric acid and ammonium nitrate-producing plants contains both these chemicals and ammonia. Therefore, ammonium nitrate must be created by neutralizing wastewater that contains both ammonia and nitric acid.

**Leakage Of Ammonia from Storage Tank / Plant**:

1. In case of vapour leakage, water must be sprayed to mitigate the vapour loss, which may increase the effluent quantity.
2. Generally, effluents are not allowed to discharge into the stormwater drain, but if required in any case of emergency, then the stormwater drain must be equipped with a bund/barrier so that it won’t allow the effluent to pass further and can be treated lately.
3. Ammonia should be neutralized immediately on transferring contaminated effluent to ETP, and a person should be there to monitor the ammonia level near the gates.
4. If, in case, contamination is more than the Threshold Limit Value (TLV) i.e 25 PPM, the chief emergency controller must inform police to initiate the off-site emergency.
5. All the associated valves must be isolated, and tanker unloading must be stopped, if any.
6. All the pumps are also to be stopped.

**Process Emissions from Nitric Acid Manufacturing:**

Nitrous oxide (N2O), trace amounts of nitric acid (HNO3) mist from the filling of acid storage tanks, nitric oxide (NO), nitrogen dioxide (NO2), and nitrogen oxide (NOx) from the tail gas of the acid absorption tower, and ammonia are the primary process emissions from nitric acid plants (NH3). **Recommendations to prevent and control NOx emissions include the following:**

1. Make sure that the oxidizer and absorber are given an adequate amount of air.
2. Ensure high-pressure conditions are maintained, especially in columns that absorb nitric acid.
3. Prevent high temperatures in the cooler-condenser and absorber
4. Create a maintenance schedule to avoid malfunctioning pumps or compressors, which can cause leaks and lower pressures while decreasing plant productivity.
5. Improving the effectiveness of the current process absorption tower or adding another absorption tower reduces NOX emissions.
6. Apply a catalytic reduction process to treat tail gases from the absorption tower
7. Install active molecular sieves to selectively adsorb NO and catalytically oxidize NO to NO2, bringing the thermally stripped NO2 back to the absorber.
8. Install wet scrubbers with an aqueous solution of alkali hydroxides or carbonates, ammonia, urea, potassium permanganate, or caustic chemicals (e.g., caustic scrubbers with sodium hydroxide, sodium carbonate, or other strong bases), recovering NO and NO2 as nitrate or nitrate salts

**Recommendations to prevent and control N2O emissions include the following:**

1. Install selective catalytic reduction (SCR) units that operate at 200 degrees Celsius with a variety of catalysts (such as platinum, vanadium pentoxide, zeolites, etc.), or, less frequently, non-selective catalytic reduction (NSCR) units.
2. Increase the residence period in the oxidation reactor by integrating a decomposition chamber into the burner to lessen the creation of N2O.
3. Use a selective de-N2O catalyst in the oxidation reactor's high-temperature zone (between 800 and 950 ºC).
4. Between the final tail gas heater and the tail gas turbine, install a combined N2O and NOX abatement reactor. Two catalyst layers (Fe zeolite) plus an intermediary injection of NH3 make up the reactor.
5. Emissions from an adequately run plant's tail gas should not include acid mist. Before entering the catalytic reduction unit or expander, small amounts present in the absorber exit gas streams should be removed by a separator or collector.

**Process Emissions from Ammonium Nitrate Manufacturing Process:**

Ammonia and dust are the principal process emissions produced by neutralizers, evaporators, prill towers, granulators, dryers, and coolers. Ammonia fugitive emissions come from process equipment and storage tanks.

Recommendations to prevent and control emissions include the following:

1. To reduce emissions of ammonia and ammonium nitrate in the steam from neutralizers and evaporators, install steam droplet separation techniques (e.g., knitted wire, mesh demister pads, wave plate separators, and fibre pad separators using, for example, polytetrafluoroethylene (PTFE) fibres) or scrubbing equipment (e.g., packed columns, venturi scrubbers, and irrigated sieve plates). Ammonium nitrate particulate emissions should be eliminated using a combination of droplet separators and scrubbers. Any free ammonia should be neutralized with nitric acid.
2. Utilize methods like stripping with air or steam and the addition of alkali to liberate ionized ammonia if necessary or use distillation and membrane separation technologies like reverse osmosis, to treat and reuse polluted condensate.
3. Use the lowest practical melt temperature to limit ammonia and ammonium nitrate emissions from prilling and granulation processes.
4. By neutralizing in a wet scrubber, ammonia emissions from prilling and granulation are removed. Wet scrubbers typically circulate an acidic solution. Wet scrubbers often recycle their solution back into the process.
5. Remove ammonium nitrate fumes from prilling through scrubbing.
6. Remove minute ammonium nitrate particles (miniprills) by passing air through cyclones, bag filters, and wet scrubbers.
7. Adopt an enclosed granulation process instead of prilling technique where feasible.
8. To stop fugitive emissions of particles, install an extraction, capture, and filter system for ventilation air from locations with dust-generating product handling operations.

**Effluents from Nitric Acid Plants:**

Liquid effluents from a nitric acid plant include the following:

1. For a time, following plant start-up, dilute ammonium nitrite/nitrate solution from frequent washing (usually once per day) of the NOX compressor and from the cooler-condenser drain.
2. Aqueous ammonia solution from evaporator blowdown.
3. Blow-down of water containing dissolved salts from the steam drum.
4. Occasional emissions from the purging and sampling of nitric acid solutions.

Recommended pollution prevention and control measures include the following:

1. Steam-inject the NOX compressor to avoid any liquid effluent.
2. Arrange for acidification during start-up to avoid the need to drain the cooler-condenser.
3. Conduct steam stripping to recover the ammonia into the process and limit emissions of aqueous ammonia from the evaporator blowdown.

**Effluents from Ammonium Nitrate (AN) Plants**

Ammonium nitrate (AN) plants generate excess water that must be treated before being discharged or maybe recycled to other units in the complex that produces nitrogenous fertilizers. Their process effluents typically include ammonium nitrate and nitric acid from plant wash-down as well as condensates with up to 1% ammonia and 1% ammonium nitrate from reactors (neutralizers) and evaporator boil-off.

Pollution prevention and control measures for ammonium nitrate plants include the following:

1. Internally recovering ammonia and ammonium nitrate (e.g., scrubber liquor from the granulation plant air cleaning section being recycled through the further evaporation stages on the granulation plant).
2. Integrate AN plant with nitric acid production.
3. Treat ammonia or ammonium nitrate-contaminated steam before condensation using droplet separation methods and scrubbing apparatus.
4. Process water (condensate) can be treated via ion exchange, distillation, membrane separation, stripping with air or steam and the addition of alkali to release ionized ammonia as needed.

Guidelines for this sector's emissions and effluents are shown in the table. The sector's recommended values for process emissions and effluents reflect accepted global industry norms from nations with well-established regulatory systems. Applying the pollution prevention and control strategies covered in the earlier sections of this paper will allow facilities that are adequately constructed and run to meet these recommendations under typical operating conditions.

|  |  |  |
| --- | --- | --- |
| **Air Emissions Levels for Nitrogenous Fertilizers Manufacturing Plants** | | |
| **Pollutant** | **Unit** | **Guideline Value** |
| **Nitric Acid Plants** | | |
| NOX | mg/Nm3 | 200 |
| N2O | mg/Nm3 | 800 |
| NH3 | mg/Nm3 | 10 |
| PM | mg/Nm3 | 50 |
| **AN Plants** | | |
| PM | mg/Nm3 | 50 |
| NH3 | mg/Nm3 | 50 |

***Notes:***

*1.**NOx in flue-gas from the primary reformer. The other emissions are from process, prilling towers, etc.*

*2.NOx in all types of plants: temperature 273K (0°C), pressure 101.3 kPa (1 atmosphere), oxygen content 3% dry for flue gas.*

**List of Hazardous Waste:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No.** | **Name of waste** | **Source of generation** | **Disposal Method** |
| 1 | Discarded containers, drums | Receipt, storage, and handling of raw/packing materials | Collection in drums, storage and transportation to authorized recyclers /authorized TSDF |
| 2 | Used/Spent Oil | Process / rotary machines / transformers | Collection in drums, storage, transportation, and sales to authorized recyclers. |
| 3 | Spent Catalyst | Process | Regeneration / Recycle through catalyst supplier |
| 4 | NOx abatement Spent Catalyst | Nitric Acid Plant | Collection in drums, storage, and transportation to authorized recyclers /authorized TSDF. |
| 5 | Chemical sludge from wastewater treatment | Wastewater treatment schemes | Chemical Sludge from wastewater treatment scheme is being disposed to cement plants for co-processing / TSDF, Udaipur |
| 6 | Contaminated cotton waste or other cleaning materials | Maintenance and cleaning activities | Collection, storage and transportation to Common incinerator |

**Government Standards for Ammonium Nitrate and Weak Nitric Acid Effluent:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S. No.** | **Parameter** | **Standards** | | | |
|  |  | **Inland surface water** | **Public sewers** | **Land of irrigation** | **Marine coastal areas** |
| 1 | Ammonical  Nitrogen (as N), mg/l Max. | 50 | 50 | -- | 50 |
| 2 | Free ammonia (as NH3) mg/l, Max | 5 | -- | -- | 5 |

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Industry** | **Parameter** | **Standards** |
| 1 | Nitric Acid | Oxides of Nitrogen | 3 kg/tonne of weak acid (before concentration) produced |

**Financial Analysis:**

**Assumptions**

1. Raw material consumption norms are taken same as provided by KBR.
2. Per unit consumption of utilities, prices of raw material per tonne, catchem, overhead cost per tonne have been considered in financial modelling.
3. Salaries & wages calculations is based on the required number of employees needed in the operations of both the product. (Primary interviews)
4. The means of finance is taken as 25% equity share capital and 75% term loan.
5. Working capital is used to fund operations and meet short-term obligations for the unit.
6. The total annual sales value is calculated by multiplying the price of each product (INR/Tonnes) by the 100% annual production of WNA and TAN.
7. The total salaries & wages are calculated by multiplying the number of employees by the annual CTC each employee is offered.
8. Means of finance represents the aid of financing the capital investment of the project.
9. For the calculation of total capital investment, equipment cost is derived through conducting various primary interviews with industry experts.
10. To calculate the total capital investment, the standard norms have been considered against the cost of basic plant and machinery. The below listed are the following norms-
    1. Auxiliary equipment and pollution control equipment at 5%
    2. Freight charges at 1%
    3. Insurance charges at 2%
    4. Erection and foundation at 7.5% of plant machinery
    5. Stores and spares at 2%

Note- The total capital investment includes the equipment cost plus the above-listed parameters.

1. ISBL facility includes equipment required in the process to manufacture weak nitric acid and ammonium nitrate. OSBL facility includes wastewater treatment plants, effluent treatment plants, different types of wet scrubbers to mitigate GHG emissions.
2. Operating cost is being calculated separately for weak nitric acid (WNA) and ammonium nitrate.
3. Some of the parameters in calculating the operating cost will have the common values like Labour (Salary and Wages), Maintenance and repairs, Plant Overhead and Administrative Costs, therefore, to avoid double counting, those have been considered in the WNA operating cost.
4. For calculating some of the parameters, the following standard norms have been considered for total capital investment-
   1. Maintenance and repairs: 2% of Total Capital Investment
   2. Plant Overhead and Administrative Costs: 3% of Maintenance and repairs + Labour
5. Expenditure of capital investment will be in the following phase-
   1. 40% of Total Capital Investment: 2023
   2. 60% of Total Capital Investment: 2024
6. Operating Revenue is bifurcated between-
   1. 7800 tons weak nitric acid merchant sale.
   2. 100000 tons ammonium nitrate merchant sale.
7. Operating revenue for each year is calculated by multiplying the capacity utilization for respective year to the annual sales revenue @ 100 percent capacity utilization.
8. Operations will start in 2025.
9. Cash flow has been calculated for 15 years.
10. Total operating cost is calculated based on capacity utilization at that period.
11. Four following cases are taken into consideration for sensitivity analysis-
    1. Raw Material Price increases by 10%
    2. Project Cost decreases by 5%
    3. Selling Price increases by 10%

**Project cost estimation**

|  |  |  |
| --- | --- | --- |
| **Particulars (INR Crore)** | **Shahjahanpur** | **Hazira** |
| Land | 0 | 0 |
| Site development and building | 8 | 8 |
| Plant and Machinery | 325 | 325 |
| Miscellaneous fixed assets | 15 | 15 |
| Design and detailed engineering | 20 | 20 |
| Preliminary & Pre-operative expenses | 2 | 2 |
| Provision for contingency | 37 | 37 |
| Margin for working capital | 10 | 11 |
| **Total Project cost** | **418** | **418** |
| Interest During Construction | 34 | 34 |

**Cost of production-**

**Shahjahanpur-**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **82.50 KTPA Weak Nitric Acid** | **INR Crore** |  |  |  |
|  | **2025** | **2030** | **2035** | **2039** |
| **Manufacturing Cost** | **62.94** | **67.45** | **71.82** | **74.93** |
| Variable Cost | 62.94 | 67.45  71.82  74.93 | | |
| Anhydrous Ammonia (liquid) | 62.94 |
| Fixed Cost | 27.77 | 29.85 | 31.90 | 33.65 |
| Catalyst & Chemicals | 15.56 | 16.73 | 17.88 | 18.86 |
| Labour (Salary and Wages) | 3.50 | 3.76 | 4.02 | 4.24 |
| Maintenance and repairs (2.0% of fixed-capital investment) (Capex) | 8.35 | 8.98 | 9.60 | 10.12 |
| Plant Overhead and Administrative Costs (3.0% of 10 + 15) | 0.36 | 0.38 | 0.41 | 0.43 |
| **Total Production Cost** | **90.71** | **97.21** | **103.51** | **107.98** |
| **100 KTPA Ammonium Nitrate Plant** | **INR Crore** |  | | |
| **Manufacturing Cost** | **138.66** | **148.59** | **158.22** | **165.06** |
| Variable Cost | 138.66 | 151.53  161.35  168.32 | | |
| Anhydrous Ammonia (liquid) | 56.52 |
| Weak Nitric Acid | 82.13 |
| Fixed Cost |  | 0.00 | 0.00 | 0.00 |
| Catalyst & Chemicals | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total Production Cost** | **138.66** | **148.59** | **158.22** | **165.06** |

**Hazira-**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **82.50 KTPA Weak Nitric Acid** | **INR Crore** |  |  |  |
|  | **2025** | **2030** | **2035** | **2039** |
| **MANUFACTURING COST** | **69.36** | **74.33** | **79.15** | **82.56** |
| Variable Cost | 69.36 | 74.33  79.15  82.56 | | |
| Anhydrous Ammonia (liquid) | 69.36 |
| Fixed Cost | 27.77 | 29.86 | 31.92 | 33.66 |
| Catalyst & Chemicals | 15.56 | 16.73 | 17.88 | 18.86 |
| Labour (Salary and Wages) | 3.50 | 3.76 | 4.02 | 4.24 |
| Maintenance and repairs (2.0% of fixed-capital investment) (Capex) | 8.36 | 8.99 | 9.61 | 10.13 |
| Plant Overhead and Administrative Costs (3.0% of 10 + 15) | 0.36 | 0.38 | 0.41 | 0.43 |
| **Total Production Cost** | **97.13** | **104.19** | **111.06** | **116.23** |
| **100 KTPA Ammonium Nitrate Plant** | **INR Crore** |  | | |
| **MANUFACTURING COST** | **150.24** | **161.01** | **171.44** | **178.84** |
| Variable Cost | 150.24 |  | | |
| Anhydrous Ammonia (liquid) | 62.29 |
| Weak Nitric Acid | 87.95 |
| Fixed Cost |  | 0.00 | 0.00 | 0.00 |
| Catalyst & Chemicals | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total Production Cost** | **150.24** | **161.01** | **171.44** | **178.84** |

**Profitability projections**

**Shahjahanpur-**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 280 | 379 | 379 | 379 |
| Total Operating Cost | 161 | 234 | 249 | 260 |
| Income bef. Depr., Int.& Taxes | 119 | 146 | 131 | 119 |
| Gross Margin (%) | 43% | 38% | 34% | 31% |
| Profit Before Tax (PBT) | 64 | 106 | 110 | 99 |
| PBT Margin (%) | 23% | 28% | 29% | 26% |
| Profit after Tax (PAT) | 64 | 70 | 68 | 59 |
| PAT Margin (%) | 23% | 18% | 18% | 15% |

**Hazira-**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 280 | 379 | 379 | 379 |
| Total Operating Cost | 173 | 252 | 268 | 280 |
| Income bef. Depr., Int.& Taxes | 106 | 127 | 111 | 99 |
| Gross Margin (%) | 38% | 34% | 29% | 26% |
| Profit Before Tax (PBT) | 51 | 88 | 90 | 78 |
| PBT Margin (%) | 18% | 23% | 24% | 21% |
| Profit after Tax (PAT) | 51 | 58 | 55 | 45 |
| PAT Margin (%) | 18% | 15% | 14% | 12% |

**Financial Indicators**

|  |  |  |
| --- | --- | --- |
| **IRR** | **Shahjahanpur** | **Hazira** |
| Project | 7.53% | -0.41% |
| Equity | 1.05% | -20.14% |

**Sensitivity Analysis**

* + 1. **Raw Material Price increased by 10%**

|  |  |  |
| --- | --- | --- |
| **IRR** | **Shahjahanpur** | **Hazira** |
| Project | -0.19% | Not Feasible |
| Equity | -19.21% | Not Feasible |

**Shahjahanpur**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 280 | 379 | 379 | 379 |
| Total Operating Cost | 173 | 252 | 268 | 280 |
| Income bef. Depr., Int.& Taxes | 107 | 128 | 111 | 99 |
| Gross Margin (%) | 38% | 34% | 29% | 26% |
| Profit Before Tax (PBT) | 51 | 88 | 91 | 79 |
| PBT Margin (%) | 18% | 23% | 24% | 21% |
| Profit after Tax (PAT) | 51 | 58 | 55 | 46 |
| PAT Margin (%) | 18% | 15% | 15% | 12% |

**Hazira**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 280 | 379 | 379 | 379 |
| Total Operating Cost | 187 | 272 | 289 | 302 |
| Income bef. Depr., Int.& Taxes | 93 | 108 | 90 | 77 |
| Gross Margin (%) | 33% | 28% | 24% | 20% |
| Profit Before Tax (PBT) | 37 | 68 | 69 | 56 |
| PBT Margin (%) | 13% | 18% | 18% | 15% |
| Profit after Tax (PAT) | 37 | 45 | 41 | 31 |
| PAT Margin (%) | 13% | 12% | 11% | 8% |

* + 1. **Project Cost Estimation decreased by 5%**

|  |  |  |
| --- | --- | --- |
| **IRR** | **Shahjahanpur** | **Hazira** |
| Project | 8.94% | 1.13% |
| Equity | 3.71% | -16.02% |

**Shahjahanpur**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 280 | 379 | 379 | 379 |
| Total Operating Cost | 160 | 233 | 248 | 259 |
| Income bef. Depr., Int.& Taxes | 120 | 147 | 131 | 120 |
| Gross Margin (%) | 43% | 39% | 35% | 32% |
| Profit Before Tax (PBT) | 64 | 108 | 111 | 100 |
| PBT Margin (%) | 23% | 28% | 29% | 26% |
| Profit after Tax (PAT) | 64 | 71 | 68 | 59 |
| PAT Margin (%) | 23% | 19% | 18% | 16% |

**Hazira**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 280 | 379 | 379 | 379 |
| Total Operating Cost | 173 | 251 | 267 | 279 |
| Income bef. Depr., Int.& Taxes | 107 | 128 | 112 | 100 |
| Gross Margin (%) | 38% | 34% | 29% | 26% |
| Profit Before Tax (PBT) | 52 | 90 | 91 | 79 |
| PBT Margin (%) | 18% | 24% | 24% | 21% |
| Profit after Tax (PAT) | 52 | 59 | 55 | 46 |
| PAT Margin (%) | 18% | 16% | 15% | 12% |

* + 1. **Selling Price increased by 10%**

|  |  |  |
| --- | --- | --- |
| **IRR** | **Shahjahanpur** | **Hazira** |
| Project | 15.23% | 10.16% |
| Equity | 20.17% | 7.33% |

**Shahjahanpur**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 306 | 416 | 416 | 416 |
| Total Operating Cost | 161 | 234 | 249 | 260 |
| Income bef. Depr., Int.& Taxes | 146 | 182 | 167 | 156 |
| Gross Margin (%) | 48% | 44% | 40% | 37% |
| Profit Before Tax (PBT) | 90 | 143 | 146 | 135 |
| PBT Margin (%) | 30% | 34% | 35% | 32% |
| Profit after Tax (PAT) | 90 | 93 | 91 | 82 |
| PAT Margin (%) | 30% | 22% | 22% | 20% |

**Hazira**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Particulars | 2025 | 2030 | 2035 | 2039 |
| Operating Revenue | 306 | 416 | 416 | 416 |
| Total Operating Cost | 173 | 252 | 268 | 280 |
| Income bef. Depr., Int.& Taxes | 133 | 164 | 147 | 135 |
| Gross Margin (%) | 43% | 39% | 35% | 33% |
| Profit Before Tax (PBT) | 78 | 124 | 127 | 115 |
| PBT Margin (%) | 25% | 30% | 30% | 28% |
| Profit after Tax (PAT) | 78 | 82 | 79 | 69 |
| PAT Margin (%) | 25% | 20% | 19% | 17% |

**Government Policies and Regulatory Issues**

**Ammonium Nitrate Rules, 2012**

The Ammonium Nitrate Rules, 2012 was established by Government of India in the Ministry of Commerce and Industry (Department of Industrial Policy and Promotion) under the Explosive Act, 1884.

The definition of Ammonium Nitrate as per the rule is mentioned below:

"Ammonium Nitrate" means the compound having the chemical formula NH4NO3 and includes any mixture or compound having more than 45 percent Ammonium Nitrate by weight including emulsions, suspensions, melts, or gels (with or without inorganic nitrates) but excluding emulsion or slurry explosives and non-explosives emulsion matrix and fertilizers from which the Ammonium Nitrate cannot be extracted by any physical or chemical process.

**Scope of Applicability of Rules and Exemptions**:

1. These rules are applicable all over India for regulating the manufacturing, conversion, import, export, stevedoring, bagging, transport, and possession for sale or use of the Ammonium Nitrate.
2. Nothing in these rules shall apply to the possession, use, transport or import or export of Ammonium Nitrate by –
   1. any of the, Armed Forces of the Union and Ordnance Factories or other establishments of such Forces for own use in accordance with the rules or regulations made by the Central Government.
   2. the Indian Railways and its authorized carriers while acting as carrier.
   3. the Port authority.
   4. any person employed under the Central Government or State Government in exercise of any power under the Act or these rules.
3. Nothing in these rules shall apply to the possession and use of ammonium nitrate of quantity not exceeding five kilograms by the established laboratories, educational institutions, medical institutions, hospitals and health clinics for scientific and educational purpose: Provided the local police is informed of the quantity under possession for the aforesaid purpose.

**General Provisions**

**Control over manufacture, conversion, stevedoring and bagging, import, export, transport, possession for sale or use of Ammonium Nitrate:**

No person shall undertake manufacture, conversion, stevedoring, import, export, transport or possess for sale or use Ammonium Nitrate except as authorized or licensed under these rules.

**Pre-requisite for grant of license:** No license shall be granted unless all the relevant provisions laid down under these rules and all conditions contained in the license forms under Part-2 of Schedule II annexed to these rules are complied with:

Provided that all the existing manufacturers, converters, users, transporters, stevedores, sellers, possessors, importers and exporters shall apply for license within six months and shall comply with the provisions of these rules within a period of one year from the date of publication of these rules.

**General Restrictions:**

**Restriction on manufacture** - The Ammonium Nitrate shall not be manufactured at any place other than the place indicated in the licence.

**Restriction on storage and conversion;** -

1. The Ammonium Nitrate storehouse shall not be located in populated areas.
2. No Ammonium Nitrate shall be converted at any place except at converter's premises duly licensed.
3. No person shall extract Ammonium Nitrate from any fertilizer including by any chemical or physical process.

**Restriction on bagging and possession for sale or use**:

1. No person shall undertake bagging and possession for sale or use Ammonium Nitrate except under conditions of a licence granted under these rules at a licensed store house as specified therein.
2. No person shall store, process, deliver, receive, handle or transport any Ammonium Nitrate contaminated fully or partially with any organic material, metal powder or scraps, or sulphur, phosphorous etc.

**Restriction on import or export:**

1. No person shall import or export any Ammonium Nitrate except under and in accordance with the conditions of licence granted under these rules.
2. No Ammonium Nitrate shall be imported or exported except at its ports notified by the Central Government.
3. The Ammonium Nitrate shall not be imported into India by Sea except through the ports which are duly approved for this purpose by the Ministry of Shipping and Transport, Government of India, in consultation with the Chief Controller and declared as Customs Ports by the Commissioner of Customs.
4. The Ammonium Nitrate imported into India by sea shall not be stored in the port.

**Restriction on transport**:

1. The Ammonium Nitrate shall not be transported with any other explosives, inflammable substances, oil, gases, carbonaceous matter, etc.
2. No Ammonium Nitrate shall be transported in any carriage vessel plying for or carrying passengers on hire.

**Restriction on delivery or dispatch:**

1. No person shall deliver or dispatch any Ammonium Nitrate to anyone other than a person who-
2. is the holder of a licence to possess the Ammonium Nitrate or the agent of a holder of such a licence duly authorised by him in writing on his behalf; or
3. is entitled under these rules to possess the Ammonium Nitrate without a licence.
4. The Ammonium Nitrate so delivered or dispatched shall in no case exceed the quantity at any point of time for which the person is holding a licence under these rules.
5. No person shall receive Ammonium Nitrate from any person other than the holder of a licence granted under these rules.

**Restriction on use:**

Ammonium Nitrate shall not be used for blasting either alone or in combination with other ingredients unless permitted under the Explosives Rules, 2008.

**Packing of Ammonium Nitrate:**

No person shall import, export, transport, possess or sell Ammonium Nitrate unless.

1. it is duly packed in a suitable waterproof bag or container or is suitably bagged by converter.
2. the container or package is marked in accordance with the provisions of rule 8.
3. the packages conform to the relevant standard of Bureau of Indian Standards or other standards accepted and approved by the Chief Controller; and
4. the packages of Ammonium Nitrate for export or import conform to the requirements of the tests as specified under International Maritime Dangerous Goods Code (hereinafter referred to as the IMDG Code in these rules) or United Nations recommendations on the transport of Dangerous Goods.

**Marking on Ammonium Nitrate packages:**

Each bag or container containing Ammonium Nitrate shall be marked in conspicuous indelible characters, by means of stamping or painting with-

1. the words "Ammonium Nitrate”.
2. purity in percentage.
3. the name, address and licence number of manufacturer or converter or importer.
4. identification number of the package or bar coding.
5. the net weight of Ammonium Nitrate.
6. gross weight of the package.
7. date of bagging and batch number.
8. name, address, licence number and unique identification number of stevedoring agent, if any.

The bags shall be serially numbered with date of bagging by means of stencilling, bar-coding, by RFID tags or any other means by the manufacturer or importer as directed by the Chief Controller.

**Restriction on unauthorized persons, provision of guards and safety distance for storehouse:**

The premise used for manufacture of the Ammonium Nitrate or conversion of melt into solid form of Ammonium Nitrate or vice versa and the storehouse shall be surrounded by a wall of at least two meters height of such strength and construction as to effectively prevent entry of unauthorized persons.

The Ammonium Nitrate storehouse shall maintain.

1. for storage not exceeding 30 MT, safety distance of 4.5 meters from store house to the compound wall and 45 meters from any protected works.
2. for storage exceeding 30 MT, safety distance of 9 meters from storehouse to the compound wall and 90 meters from any protected works.

The storehouse may be adjacent to the bagging unit of the manufacturing, conversion or explosives or nitrous oxide manufacturing plants, but shall observe the provisions of clauses (i) and (ii) of sub-rule (a) of rule 4.

The storehouse shall be:

1. constructed at ground level without any mezzanine floor, upper floor or any basement.
2. with the floor (plinth) level not less than forty-five centimeters from the ground level and well ventilated.
3. with at least 23 centimeters thick walls built of brick or stone mortar, or concrete with roof of RCC or Asbestos or Fibre or GI sheet.
4. with enough doors made of steel of minimum three millimeters thick and opening outwards.

Any store house used for possession for sale or possession for use of Ammonium Nitrate shall have a floor area not less than one square meter per 2.5 MT of Ammonium Nitrate and the store house holding capacity shall not exceed 5000 MT storage:

Provided that one stack of bagged Ammonium Nitrate shall not exceed 500 MT and a minimum clearance of 2 meters shall be maintained between the adjacent stacks and at least 0.6 meters wide gangway shall be maintained between the stacks and the walls of the store house:

Provided further that the maximum stack height shall not exceed 4.0 meters from the floor level and the same shall be prominently marked on the walls of the store house.

The storage tank meant for storage of Ammonium Nitrate melt shall be –

1. constructed of stainless steel or any other compatible material according to sound engineering practice conforming to a national or international code accepted by the Chief Controller and adequately insulated and supported so as to ensure safety and stability during loading and unloading of Ammonium Nitrate melt into or from such storage tank.
2. with a secondary containment in the form of dyke enclosure made of cement concrete and its holding capacity shall not be less than the capacity of largest tank situated within such enclosure.
3. observing safety distance of 4.5 meters within the compound wall and plant facilities and 45 meters from any protected works.
4. with single storage tank capacity not exceeding 200 MT; and
5. provided with a suitable hard stand adjacent to it for loading and unloading and such a hard stand shall be located so that its centre maintains a minimum safety distance of 4.5 meters all around.

**Provisions for manufacture, conversion, possession, sale, and use of Ammonium Nitrate**

**Safety and Security Management Plan:**

A person intending to manufacture, convert, bag, possess for sale or use, transport, import or export Ammonium Nitrate shall submit Safety and Security Management Plan to licensing authority and to the District Authority with the security aspect duly vetted by the police authorities for approval.

Every person engaged in the manufacturing factory shall be imparted training in safety and security aspects by competent persons periodically during manufacture, handling, transportation, and storage of the Ammonium Nitrate and records of such trainings shall be maintained in the factory.

**Provisions for import and export of Ammonium Nitrate**

**Import of Ammonium Nitrate:**

* Ammonium Nitrate shall be imported by the importer only in bagged form and for captive consumption only and the importer shall authorize licensee having valid licence in Form P2 for suitable packing if required.
* The P2 Licensee shall maintain records of Ammonium Nitrate received and dispatched to each importer to ensure accountability, identification and traceability and file returns.
* The imported Ammonium Nitrate shall be immediately removed from the port to the licensed storehouse in form P2 situated beyond 500 meters from the port notified area and the Ammonium Nitrate shall be dispatched from the licensed storehouse only in bagged form and each bag of Ammonium Nitrate shall be marked in accordance with rule.
* Declaration by importer - A person holding an import licence granted under these rules shall furnish a declaration to the licensing Authority and the Chief Controller.

1. in Form R-3 under Part of Schedule II as soon as ship carrying Ammonium Nitrate sails from the port of loading.
2. in Form R-4 under Part 3 of Schedule II as soon as any shipment of Ammonium Nitrate is cleared at the port of import.

* Declaration by master of ship or by the ship's agent-

1. the master or every ship carrying Ammonium Nitrate or the agent for such ship shall give the Conservator of the port not less than forty-eight hours' notice of its intended arrival at the port.
2. the master of every ship carrying Ammonium Nitrate shall deliver to the pilot before entering any port, a written declaration in Form CE-1, under Part 4 of Schedule II, provided that if in anticipation of a ship's arrival, the agent for such ship delivers to the Conservator of the port a written declaration, as aforesaid under his signature, no such declaration needs to be made by master of the ship.
3. Every declaration delivered to a pilot under clause (b) of sub-rule (5) shall be made over by him without delay to the Conservator of the port and all declarations received by the Conservator of the port shall be forwarded by him, with all convenient despatch to the Commissioner of Customs.

* Restrictions on import by air: The Ammonium Nitrate shall not be imported by air.

**Export of Ammonium Nitrate:**

1. **Restrictions on export by air** - The Ammonium Nitrate shall not be exported by air.
2. **Declaration by exporter or his agent** - The exporter or his authorised agent shall give notice to the conservator of the port before forty-eight hours that he intends to bring the Ammonium Nitrate to port for export and shall not bring the Ammonium Nitrate to any part of the port without prior permission in writing from the said officer.
3. Export of Ammonium Nitrate shall only be in the bagged form and marked in accordance with the provisions of rule 9.

**Provision for transport of Ammonium Nitrate - General**

**Procedure to be followed during transportation:**

Every consignment of Ammonium Nitrate or Ammonium Nitrate melt transported shall be accompanied by a pass issued by the consignor in Form R-11(b) of Part-3 of schedule II.

The pass shall be attached to the waybill, invoice or bill of entry or dispatch note as the case may be.

**General requirements and documents to be available during transport**

1. The Ammonium Nitrate or Ammonium Nitrate melt shall be transported only by consignors holding valid license in Form P-4.
2. The tanker for transportation of Ammonium Nitrate melt shall be:
   1. constructed of stainless steel or any other compatible material, properly and adequately insulted according to sound engineering practice conforming to national or international code accepted by the Chief Controller and secured or mounted over a vehicle chassis ensuring total safety and stability during transportation.
   2. with gross carrying capacity of such Ammonium Nitrate melt tanker not exceeding the maximum load limit prescribed by the Road Transport Authority for such vehicle.
   3. with inlet and outlet valves of such construction and design to permit its secured locking and sealing; and
   4. with vent pipe(s) suitably covered to prevent pilferage of the product.
3. The Ammonium Nitrate shall not be transported along with any other material including hazardous material.

**Provision for possession, sale, or use of Ammonium Nitrate**

**Possession in licensed premises:**

1. A person holding license for possession of Ammonium Nitrate granted under these rules shall store the Ammonium Nitrate only in the premises specified in the license.
2. The premises in which Ammonium Nitrate is kept shall be used only for possession and sale or use of such Ammonium Nitrate and for no other purposes.
3. No person shall sell Ammonium Nitrate from any premises other than those licensed under these rules.
4. The Licensed storehouse shall be kept securely closed or locked except when Ammonium Nitrate is taken in or taken out.
5. The keys of the Licensed storehouse shall be kept in the license holder's custody or with his authorized agent and shall be produced for opening the storehouse whenever so required by the inspecting officer.
6. The name, address and passport size photograph of the authorized agent with whom the keys will be kept shall be furnished to the licensing authority and the district authority having jurisdiction.

**Quantity of Ammonium Nitrate to be purchased in a given period of time:**

A license holder for possession, sale or use of Ammonium Nitrate in and from a storehouse shall purchase only such quantity of Ammonium Nitrate in a given period as may be specified in the license.

**Grant or refusal of approval, license, amendment, transfer, and renewal**

**Grant of a License:**

1. The license issuing authority, on being satisfied with the documents received for grant of license, in the Form specified in Schedule II and after making such inquiry, if any, as it may consider necessary, shall object to the other provisions of the Act and these rules, by order in writing either grant the license or refuse to grant the same.
2. License for transport of Ammonium Nitrate or Ammonium Nitrate melt in Form P-4 shall be granted only to the valid license holders in Form P1, P-2, P-3, or P-5.
3. The licensing authority may verify the facilities of the licensed premises and on satisfaction shall endorse the license.
4. The licensing authority, if necessary, may impose additional conditions to the license.
5. The District Authority may refer to the Chief Controller for seeking any expert opinion, if required.

**Licenses And Licensing Authority**

|  |  |  |
| --- | --- | --- |
| **Form of license** | **Purpose for which granted** | **Licensing Authority** |
| P-1 | License to manufacture and possess for sale of Ammonium Nitrate or convert melt to solid and vice versa and possess for sale of Ammonium Nitrate | Chief Controller or Controller authorized by Chief Controller |
| P-2 | License to bag and store Ammonium Nitrate | Chief Controller |
| P-3 | 1. License to possess for sale or use of Ammonium Nitrate from a store house not exceeding 30 MT; or | District Authority |
| 1. b) License to possess for sale or use of Ammonium Nitrate from a store house exceeding 30 MT; or | Chief Controller or Controller authorized by Chief Controller |
| 1. License to possess for use of Ammonium Nitrate from a store house attached to explosives manufacturing/Nitrous Oxide manufacturing unit; or | Chief Controller or Controller authorized by Chief Controller |
| 1. License to possess for use of Ammonium Nitrate for agriculture purpose from a storehouse | District Authority or Officer authorized by District Authority |
| P-4 | 1. License to transport Ammonium Nitrate for licenses granted by District Authority for possession for sale or possession for use; or | District Authority or Officer authorized by District Authority |
|  | 1. License to transport Ammonium Nitrate for licenses granted by the Chief Controller or Controller for possession for sale or possession for use. | Chief Controller or Controller |
| P-5 | 1. License to import Ammonium Nitrate; or 2. License to export Ammonium Nitrate | Chief Controller |

**License Forms**

|  |  |
| --- | --- |
| **Form No.** | **Purpose** |
| P-1 | License to manufacture and possess for sale of Ammonium Nitrate or convert melt to solid and vice versa and possess for sale of Ammonium Nitrate |
| P-2 | License to bag and store Ammonium Nitrate |
| P-3 | 1. License to possess for sale or use of Ammonium Nitrate from a store house not exceeding 30 MT; or 2. License to possess for sale or use of Ammonium Nitrate from a store house exceeding 30 MT; or 3. License to possess for use of Ammonium Nitrate from a store house attached to explosives manufacturing/Nitrous Oxide manufacturing unit; or 4. License to possess for use of Ammonium Nitrate for agriculture purpose from a storehouse |
| P-4 | License to transport Ammonium Nitrate |
| P-5 | 1. License to import Ammonium Nitrate; or 2. License to export Ammonium Nitrate |

**Application Forms**

|  |  |
| --- | --- |
| **Form No.** | **Purpose** |
| A-1 | Application for license to manufacture and possess for sales of Ammonium Nitrate or convert melt to solid and vice versa and possess for sale of Ammonium Nitrate |
| A-2 | Application for license to bag and store Ammonium Nitrate |
| A-3 | Application for   1. License to possess for sale or use of Ammonium Nitrate from a store house not exceeding 30 MT; or 2. License to possess for sale or use of Ammonium Nitrate from a store house exceeding 30 MT; or 3. License to possess for sale or use of Ammonium Nitrate from a store house attached to explosives manufacturing/Nitrous Oxide manufacturing unit; or 4. License to possess for sale or use of Ammonium Nitrate for agricultural purposes from a storehouse. |
| A-4 | Application for license to transport Ammonium Nitrate |
| A-5 | Application for license to   1. Import Ammonium Nitrate; or 2. Export Ammonium Nitrate |

**References:** <https://www.dgms.net/Ammonium%20Nitrate%20Rules%202012.pdf>

<https://peso.gov.in/web/ammonium-nitrate-amendment-rules-2021>

**Note:** *Major amendments (as of August 2021) has been mentioned above. For other details regarding the amendments refer to:* [*https://peso.gov.in/web/ammonium-nitrate-amendment-rules-2021*](https://peso.gov.in/web/ammonium-nitrate-amendment-rules-2021)

**Rules for Explosives Supplier:**

Pricing and Marking:

1. The packing and marking of goods should be according to explosives rules, acts and PESO guidelines.
2. Invoice should be quoted in reference to running contract number, date and subsequent amendments, if any, for any change in price, extension of delivery dates.
3. No supply should include any order or orders against the running contract invoice.
4. A self-attested copy of valid PESO license and valid DGMS certificate should attached with running contract of supply of explosives accessories.
5. Following certificate should be attached, whichever is applicable:
   1. In case of consignee vans:
      * Van number and date of dispatch must be mentioned to the consignee.
      * An acknowledgement memo and materials details acknowledged by consignee, or his representative of the same date as above must be attached.
      * Other claims must be as per purchase order and schedule to the same.
   2. In case of suppliers’ vans:
      * Van number and date of dispatch must be mentioned to the consignee.
      * An acknowledgement memo of the same date as above and materials acknowledged must be attached.
      * Other claims must be as per purchase order and schedule to the same.
6. Along with acknowledgement memo, voucher mentioned in the certificate must be attached with each invoice.
7. The explosives should be transferred through PESO approved vans.
8. Supply of extra quantity:
9. If an RC holder, failed to supply the cartridge explosives or accessories, the balanced/unsupplied quantity may be cancelled/reduced from the RC holder after giving due notice to him. The cancelled quantity must be re-distributed among RRC holders and other suppliers within that subsidiary company.
10. The extra quantity must be supplied on ex-stock basis and the opportunity must be given to RC holder, if they failed to meet the said quantity then to RRC holders. The extra quantity, distributed among the RC/RRC holder may be done preferably in equitable manner but suppliers are must to ensure that the supplies must not be delayed on this ground. The subsidiaries have the liberty to procure extra supply from any/all the RC/RRC holder.
11. If the required amount exceeds 40% of the RC quantity and RC holder is not able/willing to supply, the subsidiary company may allocate the additional quantity to RRC holder.
12. From the date of issue of first allocation the RRC holder shall commence the supply within 15 days.
13. Liquidated Damages
14. The buyer has the following rights if the supplier fails to comply with the terms and conditions or fails to deliver or despatch the goods or equipment by the specified length of time or date as stated in the supply order:
15. For each week or portion of a week during which the delivery of such stores may be delayed, up to a maximum of 10% of the total contract value, to recover from the successful bidder as agreed liquidated damages a sum not less than 0.5% of the cost of any equipment/stores that the successful tenderer has not been able to supply as stated, or
16. To make a different purchase after giving the winning bidder due notice and at their own risk, such as purchasing similar items elsewhere without cancelling the supply order for the consignment that isn't yet ready for delivery, or to revoke the supply order, all or part of it, and, if desired, to acquire the stocks and/or equipment at the risk and expense of the defaulting provider and also,
17. To extend the delivery window with or without a fee if deemed appropriate and fit. If a penalty is assessed, it cannot exceed the previously mentioned agreed-upon liquidated damages.
18. To forfeit the security deposit fully or in part.
19. The buyer shall be entitled to recover any amount owing to and payable by the supplier under this contract by appropriating a portion of it or the entire amount and subtracting any amount that may later become due to the winning tenderer under this or any other contract. The winning tenderer must give the buyer the remaining balance immediately if the amount is insufficient to cover the entire amount that can be recovered. The provider won't be eligible for any profit from such a purchase.
20. The basic for destination price must be considered when determining the liquidated damages amount. Taxes and tariffs are not considered for determining LD.
21. Risk Purchase:
    1. The consignee or its subsidiaries have the right to purchase the stores from another supplier after giving the defaulting supplier due notice, at the risk and expense of the defaulting supplier, if the supplier fails to deliver or despatch the stores within the stipulated date/period of the supply order or if any of the terms and conditions mentioned in the supply order/contract are broken. The supplier's earnest money deposit, security deposit, performance security, bills submitted against the same contract, any other contract pending in the same subsidiary Co., and/or in any other, may be used to cover the cost of the risk purchase exercise in the event of the supplier's failure as described above.
    2. Risk purchase action may be initiated by subsidiary companies under any of the following conditions:

* Even after extending the delivery period, the supplier still failed to provide the materials.
* When the supplier ignores buyers' requests for the materials and refuses to offer any justification that is thought to be genuine for the supply delay.
* When the provider fails to properly fulfil an order because they have violated one or more terms and conditions of the supply order or contract.

**Rule for Vendor Registration**

For What?

1. Tenderers shall offer duly insulated Stainless Steel (SS) Tankers with a Minimum carrying capacity of 24 MT and offer minimum 7 tankers.
2. The respective Tenderers shall own the offered Tankers. The ownership mode may be under Firm or Partner or Company or Proprietor. The tenderers may also offer tankers owned by others, provided they submit an Affidavit on Non-Judicial Stamp Paper from the owner of each of those tankers declaring the attachment of Tanker with the tenderer for the entire period of this contract with IOCL. Note: If more than one bidder offers the same Tanker, none of the bidders' claims for the said Tanker (s) will be considered.
3. All tankers the tenderer offers should be in their name, i.e., Firm or Partner or Company or Proprietor.
4. Age (As mentioned in RC book) of Tankers offered shall not exceed 15 years as of the closing date of bid submission. All offered Tankers should have valid RTO registration.
5. The tenderer shall submit a self-declaration on letterhead that Tankers offered shall comply with all statutory provisions under Ammonium Nitrate Rules 2012 apart from relevant provisions under MV Act and shall also fulfil any other requirements specified by Ammonium Nitrate Suppliers viz. RCFL.
6. Earnest Money Deposit for tenders is waived against submission of Bid Security Declaration (on letterhead) from bidders in lieu of EMD. Bidders must submit Bid Security Declaration as per the attached format.
7. The tenderer is required to upload readable documents. Notwithstanding any other condition/provision in the tender documents, bidders are required to submit complete documents pertaining to QPC along with their offer. Failure to meet the QPC will render the bid to be summarily rejected. IOC reserves the right to complete the evaluation based on the details furnished by the bidder, with or without seeking any additional supporting documents/ clarifications.

**Time Schedule of Total Project**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PROJECT IMPLEMENTATION SCHEDULE** | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Activity** | **Month** | | | | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | # | 21 | # | # | # |
| 1. Kick Off Meeting, Detailed Engineering and Licensing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **1. Engineering** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Basic Engineering / Documents |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Detail Engineering/ Documents |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **2. Civil Work** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Finalization of Building Design |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Invitation of Tenders and Award |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Factory Shed |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Auxiliary Building |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Administrative Block |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Other Construction |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Disbursal of Finances |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **3. Plant and Machinery** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Specification Detailing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Invitation of Quotations |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mechanical Piping & fitting |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Placing Orders |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Delivery at Plant Site & Inspection |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Installation and Commissioning |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Check-up of the Plant & Machinery |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **4. Arrangement of Power/Water** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **5. Other Items** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Finalize Management Reporting |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Finalize Official Practices |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Executive Systems |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **6. Training and Personnel** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **7. Start -up/ Commercial Production** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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**ANNEXURE**

**ANFO Manufacturing:**

ANFO explosives are a mixture of ammonium nitrate and fuel oil. These are primarily used as blasting agents in industry and mining. ANFO explosives consists of 94% ammonium nitrate and 6% fuel oil by composition. They have a bulk density between 0.8 and 0.9 kg / L.

The ammonium nitrate particles used for ANFO are porous and spherical. The porosity of ammonium nitrate is one of the most important parameters while manufacturing explosives. Porosity is associated with the effectiveness of the material as an adsorbent, which is particularly important in the case of AN/mineral oil mixtures (ANFO).

AN provides a greater number of initiation points with high sensitivity to detonation, also called hot spots owing to its air cavities enclosed in the micropore structure of the particles. These initiation points are adiabatically compressed as a result of mechanical action and transfer the initiation energy through the load. The fuel oil is then absorbed by the ammonium nitrate particles to produce a free-flowing particulate mixture which can be detonated.

Despite its low detonation pressure and detonation velocity, ANFO is characterized by a significant destructive power due to the large volume of detonation gases. ANFO is most widely used explosives in the mining industry over other emulsion explosives in the market because of its uncomplicated manufacturing technology, small number of its components, and low production costs compared to EEs.

Ammonium nitrate is used as a component of many explosives, such as ANNM, amatols, and ammonals. However, ANFO explosives are relatively safe while maintaining the properties similar to other emulsion explosives.

**Comparison of Detonation Composition and Detonation Velocity in Commonly Used, Industrially Prepared Ammonium-Nitrate-Based Explosives**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Explosive** | | |
| **ANFO** | **ANNMAL** | **Amatol** |
| Composition (wt%) | AN-94 | AN-66 | AN-50 |
| FO-6 | NM (nitromethane)-25 | TNT-50 |
|  | Al-5 |  |
|  | C-3 |  |
|  | TETA (triethylenetetramine)-1 |  |
| Density (kg/m3) | 917.86 | 1158.13 | 1496.12 |
| Typical detonation velocity (km/s) | 5269.93 | 5359.94 | 6289.91 |

*References: Secondary Sources*

**Comparison of Energetic Properties of Typical ANFO and EE Formulations**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **ANFO** | **EE** |
| Critical diameter (mm) | 50–80 | 16–46 |
| Loading density (g∙cm−3): | 0.75–0.85 | 0.90–1.20 |
| Detonation model: | Non-ideal | Ideal (provided it contains no stable components) |
| Detonation velocity (m∙s−1): | 1800–3300 | 3800–5100 |
| Water-resistance | No | Yes |
| Components | Ammonium nitrate (>90 wt%), FO (1–10) wt% | Oxidising agents, organic fuels, inorganic fuels, water, emulsifying agents, sensitizing agents, modifying agents |
|
| Manufacturing technology | Uncomplicated | Complicated |
| Price | Low | High |
| Trauzl lead block test (cm3/10 gPb) | 211.83 | 360 |
| Ballistic mortar test (%) | 51.09 | 80.4–84.4 |

*References: Secondary Sources*

**PFD UFD (WNA & ANS)**

**Manufacturing Process & Available Process Technology of WNA & AN**

**Plants and Operating Technology:**

Many technology providers are in the race to weak nitric acid and ammonium nitrate plants. Thyssenkrupp is the primary technology provider to the Indian WAN and AN manufacturing company. Casale SA and Stamicarbon are the other providers of technology of ammonium nitrate to Indian manufactures.

Thyssenkrupp is a global conglomerate of enterprises with about 100,000 workers that consists primarily of independent industrial and technological companies. Materials Services, Industrial Components, Automotive Technology, Steel Europe, Marine Systems, and Multi Tracks are the six business segments that make up the company. With a wealth of technological expertise, firms create solutions that are both affordable and resource-friendly for today's and tomorrow's concerns.

Casale, a privately owned Swiss Company, wholly owned by Casale Holding, headquartered in Lugano (Switzerland). Casale SA acquires the melamine manufacturing, nitric acid, ammonium nitrate, urea ammonium, and other critical fertiliser production technology from Borealis in 2013-2014. Additionally, it purchases the reputable Czech EPC contractor Chemoproject Nitrogen, renaming it Casale Project. Thereafter, combining Ammonia Casale, Urea Casale, Methanol Casale, and Casale Chemicals into one business, Casale SA is formed to streamline the company's structure.

Stamicarbon has been in the forefront of creating and granting licences for technology for the urea industry since 1947. Nitric acid business entry by Kribhco in 2017 with a dual pressure plant idea at capacities >600 MTPD. 2017 saw the purchase of 20% of Pursell Agri-Tech to produce fertilizer with controlled release. The business advanced in 2021 by introducing a small-scale green ammonia technology that paves the path for more environmentally friendly fertilizer production.

When M.W. Kellogg and Brown & Root Engineering and Construction joined in 1998, one of the top engineering, procurement, construction (EPC), and services businesses in the world was born: KBR. The business split from Halliburton in 2006, and it successfully completed an IPO on the New York Stock Exchange. We have expanded to offer comprehensive science, technology, and engineering solutions for a variety of areas, including aerospace and defense, industrial, intelligence, and more. These acquisitions include Ecoplanning, Energo, Granherne, GVA, HTSI, PLINKE, SGT, Weatherly, Wyle, and more.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No.** | **Plant** | **Technology provider** | **Process/technology** | **Client** |
| 1 | Ammonium nitrate melt (AN melt) | Thyssenkrupp | uhde® Vacuum Neutralisation | Gujarat Narmada Valley Fertilizers & Chemicals Limited |
| 2 | Technical Ammonium Nitrate (TAN) | Casale SA | AN2000/Dual Pipe reactor | Smartchem Technologies Ltd. (a subsidiary of Deepak Fertilizer), (**Planned)** |
| 3 | Ammonium nitrate (AN) | Thyssenkrupp | uhde® Vacuum Neutralization | Deepak fertilizers, Taloja plant |
| 4 | Ammonium nitrate melt (AN melt) | Stamicarbon | ODDA process | Rashtriya Chemicals and Fertilizers Limited |
| 8 | Weak Nitric Acid (WNA) | Thyssenkrupp | uhde® dual pressure nitric acid process | Gujarat Narmada Valley Fertilizers & Chemicals Limited |
| 9 | Weak Nitric Acid (WNA) | Weatherly Inc. (U.S.A.) (KBR’s Subsidiary) | Weatherly Dual Pressure Nitric Acid Technology | Deepak Fertilizers |
| 10 | Weak Nitric Acid (WNA) | Thyssenkrupp | uhde® dual pressure nitric acid process | Rashtriya Chemicals and Fertilizers Limited |

**Thyssenkrupp: The Uhde dual-pressure process**

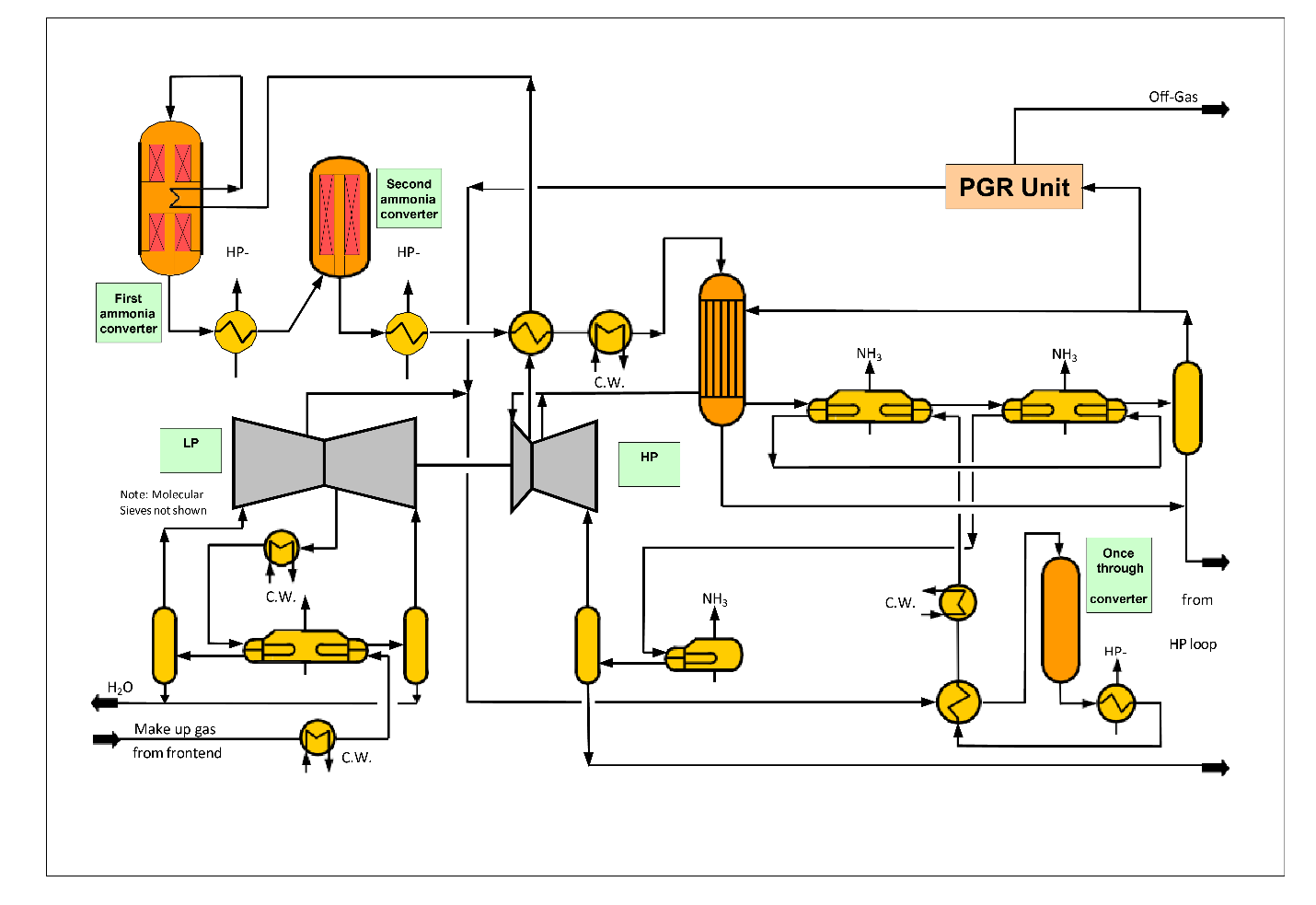
Thyssenkrupp Industrial Solutions is best positioned to serve the industry with tried-and-true, cost-effective, and environmentally friendly processes thanks to its more than a hundred years of involvement in nitric acid plant design and construction, more than 80 years of experience in the fertilizer sector, and more than 360 plants engineered and delivered.

Based on their patented and well-known licensed technology, the company can supply a range of plants to make single-component and mixed nitrogenous fertilizers. They can provide azeotropic nitric acid plants for the non-fertilizer industry. Their nitric acid plants are environmentally benign because they use the EnviNOx ® tail gas treatment technology, which is the industry benchmark for performance in terms of reducing N2O and NOx emissions.

The company is the world's largest licensor of nitric acid technology and has constructed more than 55 plants since 1980. In 1905, Dr. Friedrich Uhde, the company's founder, collaborated with Prof. Wilhelm Ostwald to design and build a pilot plant to synthesize nitric acid by burning ammonia with air in the presence of a catalyst. High reliability, profitability, and on-stream time are characteristics of the plants planned and built by ThyssenKrupp Industrial Solutions. Nowadays, shutdown times are mostly reserved for equipment checks and catalyst replacements.

Manufacturing Process-

1. Ammonia is mixed with atmospheric air and converted to nitrogen oxides over a platinum/rhodium catalyst. The design of ammonia burner ensures the even distribution of reactants resulting in very high conversion efficiencies.
2. Steam and hot tail gas is produced to recover the heat of reaction. Now, the hot tail gas and a part of steam is used in turbines that drive the plant compressors, and the rest of steam is exported.
3. Now, the cooling of process gas below the condensation temperature leads to form the first nitric acid.
4. The next step is absorption, took place in cooled absorption tower where nitrogen oxides are absorbed in water. The nitrogen oxides remaining in the tail gas are at a low concentration enhancing overall plant efficiency.
5. After absorption, the remaining nitrogen oxides are treated in EnviNox tail gas treatment, to reduce the nitrogen oxides to very low level to meet the emission regulations.



Source: Thyssenkrupp

Key Features-

1. High reliability and high on-stream time
2. Easy maintenance
3. Cost-effectiveness
4. Energy efficiency
5. Low emissions (BAT technology)

**Weatherly Inc. (U.S) (KBR’s Subsidiary)- Dual Pressure Nitric Acid Technology:**

When M.W. Kellogg and Brown & Root Engineering and Construction joined in 1998, one of the top engineering, procurement, construction (EPC), and services businesses in the world was born: KBR. The business split from Halliburton in 2006, and it successfully completed an IPO on the New York Stock Exchange. We have expanded to offer comprehensive science, technology, and engineering solutions for a variety of areas, including aerospace and defence, industrial, intelligence, and more. These acquisitions include Ecoplanning, Energo, Granherne, GVA, HTSI, PLINKE, SGT, Weatherly, Wyle, and more.

KBR is constantly expanding and changing. They'll be at the fore, paving the way with ground-breaking products and services that will address problems of tomorrow and define progress for years to come as global demands and markets shift.

Manufacturing Process-

1. Raw material used for producing nitric acid is atmospheric acid and ammonia. Atmospheric air used in production of nitric acid must be filtered, compressed, heated, and filtered again. Approximately 90% of horsepower is extracted, needed for compression from heated tail gas which is a highly efficient design feature.
2. Liquid ammonia is prepared separately by filtration, vaporization, superheating and filtration again. After preparation of raw material, next stage is conversion and heat recovery.
3. Next steps include the well mixing of air and ammonia and to evenly distribute over platinum catalyst. An exothermic reaction between ammonia and oxygen occurs which produce nitric oxide and water vapors.
4. Now, the process gas is passed through the heat exchanger and major portion of reaction energy is recovered as heat and used to reheat the tail gas to provide power for the air compressor by driving a hot gas expander.
5. The process gas is cooled and produced weak nitric acid. Before feeding into the absorption system nitric acid and remaining process gas are separated.
6. Finally, nitric oxide, nitrogen dioxide, oxygen and water are combined in an absorber column, forming nitric acid of the desired strength.

Diagram

Description automatically generatedSource: KBR

Key Features-

1. Low capital cost
2. Pressure than competing processes, so equipment is smaller and less
3. Expensive, reducing the overall plant investment
4. Extremely high ammonia conversion is achieved by prioritizing clean raw materials, complete mixing, even distribution, and steady temperature in the design. Additionally, conversion is considerably improved by the catalyst basket design. The system consistently maintains efficiency of 95% or more.
5. Low catalyst cost - the method combines the newest platinum recovery systems with KBR Weatherly's high ammonia conversion to produce extremely effective platinum utilization.
6. KBR has low NOX emissions. Superior NOX emissions performance is provided by Weatherly's tried-and-true extended absorption design; even lower emissions are achievable when coupled with catalytic NOX reduction systems.
7. Reduced maintenance costs since the vertical equipment design reduces piping runs and expansion issues.
8. BR Weatherly's operations are vertically arranged and use smaller equipment; therefore, the site area needs are minimal.
9. KBR's plant design achieves energy recoveries of up to 5.23 GJ per metric ton (4,500,000 BTU per short ton). Each plant is unique to reduce costs.

**Weatherly Inc. (U.S) (KBR’s Subsidiary): Ammonium nitrate solution**

KBR, Inc. is a multinational technology, engineering, procurement, and construction company that provides services to the government services and hydrocarbon industries. It has been operated in 40 countries and employs over 25,800 people worldwide.

Engineering & Construction, including Offshore Oil & Gas, LNG/GTL, Onshore Oil & Gas, Refining, Chemicals, Differentiated EPC, Petrochemicals, and Industrial Services; Technology & Consulting, including proprietary technology in refining, ethylene, gasification and ammonia and fertilize; and Niche Consulting and Know-How through Subsidiaries Granherne, GVA, and Energo; The capabilities of Government Services, which includes KBRwyle, cover the entire range of government mission needs, including R&D, testing, engineering, logistics, deployed operations, and life-cycle sustainment.

Manufacturing Process-

1. The interaction between ammonia and nitric acid results in ammonium nitrate.
2. The neutralizer's sparger is metered with ammonia vapour. Battery limits provide nitric acid to the neutraliser. Approximately 95–97% of the nitric acid is delivered to a sparger in the neutraliser under ratio control and pH trim. To neutralise unreacted ammonia that has left the neutraliser, the residual nitric acid is delivered to the scrubber. The neutralizer's output of ammonium nitrate overflows into the AN SURGE Tank.
3. A little amount of unreacted ammonia and steam that is released as a result of the heat of reaction created in the neutraliser are carried overhead into the scrubber. A packed bed in the scrubber comes into touch with these off-gases to apply diluted acidic ammonium nitrate. When the diluted AN solution is circulated back to the scrubber packing, the condensed water from the steam regulates the concentration of ammonium nitrate in the scrubber and, as a result, the neutraliser. The diluted AN solution is chilled externally in the circulating AN cooler. This diluted ammonium nitrate spills over into the primary neutraliser in part.
4. In the condensing section, which recovers process condensate for use as absorber feedwater in the nitric acid plant, the leftover off-gas and condensate from the vaporiser are subsequently transferred. The process condensate pumps, circulation condensate chiller, and vent scrubber make up the condensing section. The leftover process steam from the neutraliser and vaporiser comes into touch with the process condensate as it is cooled and circulated over a packed bed. Over the packed portion, the condensate is completely condensed, and the remaining inerts vent to the atmosphere as the condensate flows into the process condensate tank. The process condensate is then used as the feedwater for the absorber.

**Thyssenkrupp: Vacuum Neutralization and evaporation**

Thanks to its more than a century of involvement in nitric acid plant design and construction, more than 80 years of experience in the fertiliser sector, and more than 360 plants engineered and delivered, Thyssenkrupp Industrial Solutions is best positioned to serve the industry with tried-and-true, economical, and environmentally friendly processes.

The company can supply the whole spectrum of plants to create single-component and mixed nitrogenous fertilisers based on their own proprietary and well-known licensed technology. For the non-fertilizer industry, they can offer plants that produce azeotropic nitric acid. Because they employ the EnviNOx ® tail gas treatment technology, which is the industry standard for effectiveness in terms of decreasing N2O and NOx emissions, their nitric acid plants are environmentally friendly.

Manufacturing Process-

1. Ammonium nitrate is produced from gaseous ammonia and aqueous nitric acid in an exothermic reaction as follows:

NH3 + HNO3 → NH4NO3 – 3HR

1. The reaction took place in a slightly pressurized and neutralizer to minimizing the ammonia loss by boiling in the mixing and reaction section.
2. Now, the solution is flashed into a vacuum through a restriction orifice adjacent to the vapor separator and utilizing the reaction heat for water evaporation.
3. To achieve 95 wt% solution concentration, feed of 60 wt% nitric acid is required but the ammonium nitrate concentration is limited to 92 wt% due to control and safety reasons.

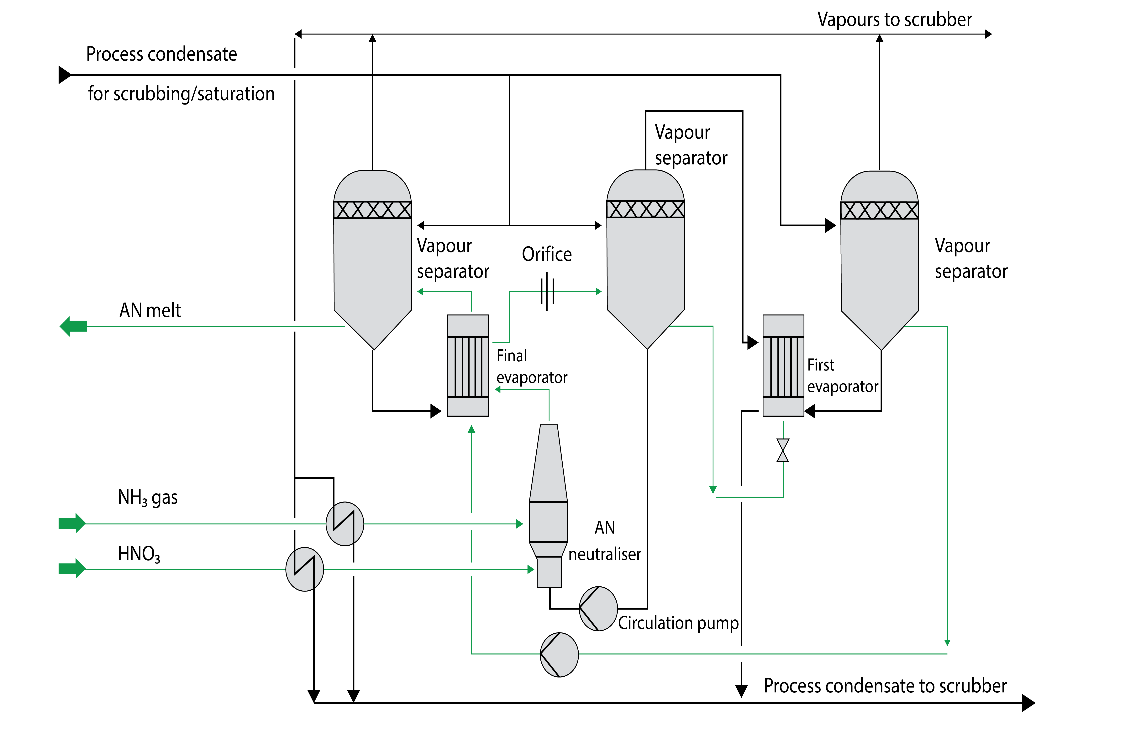
Diagram

Description automatically generatedSource: Thyssenkrupp

**Pressure neutralization:**

To utilize the heat of reaction more efficiently, the process vapor system operates above atmospheric pressure. Two major pressure neutralization alternatives for heat recovery are:

1. The heat stored in the ammonium nitrate solution, leaves the neutralizer used directly for the final concentration stage. There is no need to import additional steam even if 97 wt% concentration is required.



Source: Thyssenkrupp

1. For final concentration of ammonium nitrate solution, heating steam is imported while part of the heat of reaction is utilized to generate low pressure steam at approximately 5 bar abs.

Diagram

Description automatically generated with medium confidence

Source: Thyssenkrupp

1. In both the above case, flash steam produced from the vapor separator at 2 – 4 bar abs are used for intermediate concentration of the weak ammonium nitrate solution and the remaining process vapours are used for feedstock preheating, surplus vapours are condensed.
2. Depending on how the vapours condensate is to be used, some or all the vapours need to be scrubbed before condensation in a separate vapor scrubber.

Key Features-

1. High reliability and high on-stream time
2. Process design low maintenance, low temperatures offer advantage of low corrosion
3. Cost-effectiveness
4. Excellent safety standards by process principle, control, and design
5. Energy efficiency
6. Very low liquid effluent contamination, virtually no gaseous effluents

**Stamicarbon: ODDA Process-**

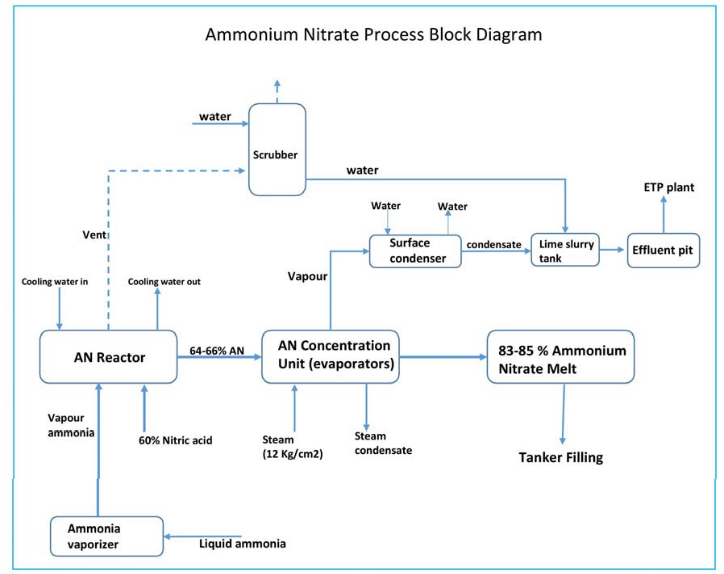
The innovation and licensing division of the Maire Tecnimont Group is called Stamicarbon. They are the pioneering company in the fertilizer sector with the foresight necessary to help feed the planet and raise everyone's standard of living. They are pioneer in fertilizer technologies, with more than 250 urea plants licensed and more than 100 revamping and improvement projects finished.

The company’s industry-leading position is supported by more than 70 years of experience in licensing and upheld by ongoing innovation in technologies, goods, and materials. Stamicarbon is based in Sittard, the Netherlands, and has representative offices in Russia and China in addition to a sales office there.

They apply their expertise, knowledge, and experience to numerous solutions, fertilizer production technologies, emission reduction technologies, and all technologies for the integration of urea and adjacent processes as the global market leader in design, licensing, and development of various plants.

Manufacturing Process-

1. Ammonia vaporizers and auxiliary vaporizers evaporate liquid ammonia that has been supplied from an ammonia plant. A shell and tube heat exchanger known as an ammonia vaporiser uses cooling water on the tube side to evaporate ammonia on the shell side.
2. Ammonia super heaters use 2.5 kg/cm2 steam to heat the vaporised ammonia from ammonia vaporizers to 45 to 50C. The correct ratio of vaporised ammonia and nitric acid (60 percent concentration) is delivered to the reactor.
3. A vertical back mixing reactor is the AN Reactor. The following reactions between ammonia and nitric acid result in 65 percent concentrated ammonia nitrate:
   * 1. NH3 (g) + HNO3 (lq) = NH4NO3 (lq) ................∆H = - 26.94 kcal/mole
4. Exothermic is the nature of reaction. The cooling water removes heat produced during reaction. The reactor has three cooling zones, each of which is composed of a network of tubes filled with cooling water.
5. Reactor temperature is kept between 60 and 65 degrees Celsius, and its pH is kept between 7.0 and 7.2. A holding tank that circulates with the reactor receives diluted ammonium nitrate (Dil. AN) (65%) from the reactor.
6. Level control valves are used to keep the reactor's level constant. Dil. AN is pumped from the holding tank to the buffer tank (Dil. AN storage tank). Gases leaving the reactor are scrubbed using a connection between the reactor vent and scrubber.



Source: RCF EIA report

**Casale SA: AN2000TM-**

Casale is a privately held Swiss company with its corporate headquarters in Lugano that is owned entirely by Casale Holding (Switzerland). At that time, only Badische Anilin and Soda Fabrik ("BASF") produced ammonia industrially in Germany using its unique Haber-Bosch method. Due to the relatively low synthesis pressure utilized in this method, the product ammonia was captured as an aqueous solution, which would then go through additional purifying stages to produce pure ammonia.

Luigi Casale, an italian chemist, devised an innovative scheme deciding to operate the ammonia synthesis at a much higher pressure than BASF’s one, thus obtaining directly liquid ammonia. Ammonia Casale, the original company’s name, was therefore established in Lugano (Switzerland) in 1921 with the purpose to license the newly patented process. Lugi Casale’s flair of innovation has been preserved and continuously nurtured over the decades-long history of his Company and still deeply permeates the culture of today’s Casale.

Manufacturing Process-

1. The AN2000™ is the process to produce ammonium nitrate solution (ANS), based on Casale's pipe reactor technology.
2. Preheated ammonia and nitric acid feeds are mixed in a specially designed tubular reactor at 7 - 8 bar pressure. Instant formation of ammonium nitrate occurs by releasing a significant amount of heat.
3. Finally, the hot ammonium nitrate solution enters a vessel/separator where the steam is released vigorously from the solution and the liquid ammonium nitrate solution is collected from the bottom of vessel and sent to storage.
4. While collecting steam from the tubular reactor, it carries some mist of ammonium nitrate solution and traces of ammonia vapors which is eliminated by multiple process: Scrubbing: In the Venturi-type scrubber, the process steam is de-superheated, and an acidic scrubbing liquor is fed through a sprayer and a reaction occurs with the ammonia traces present in the process steam. A Cyclonic Column is present at the downstream of venturi-type scrubber, which is responsible for the recirculation of the liquor.
5. To recover the ammonium nitrate aerosol, the de-superheated process steam passes through a set of high efficiency demisters before the steam leaves cyclonic column. The excess of scrubbing liquor generated from the cyclonic column is directly discharged to the ANS solution tank or the pipe reactor.
6. The steam leaving from the scrubbing system is used to preheat the nitric acid feed, to vaporize and superheat the ammonia feed and to clean the concentrated process condensates.

Diagram

Description automatically generated

Source: Casale

Key Features-

1. Reaction zone’s intrinsically low residence time offers higher safety
2. Low OPEX, since highly concentrated ANS is directly obtained without any concentrator
3. Low CAPEX, due to reduced equipment compared to traditional process
4. Easy and fast start-up and shutdown
5. Clean process condensate recovery with AN concentration less than 30 ppm

**Disclaimer**

The contents of this report are based on information generally available to the public from sources and primary interviews which are believed to be reliable. No representation is made that it is timely, accurate or complete. TechSci Research has taken due care and caution in compilation of data as this has been obtained from various sources including primary interviews which it considers reliable and firsthand. However, TechSci Research does not guarantee the accuracy, adequacy or completeness of any information and it is not responsible for any errors or omissions or for the results obtained from the use of such information and especially states that it has no financial liability whatsoever to the subscribers / users of this report. The information herein, together with all estimates and forecasts, can change without notice. All the figures provided in this document are indicative of relative market size and are strictly for client’s internal consumption. The usage of the same for purpose other than internal will require prior approval of TechSci Research

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