Internship-Report

# Rashtriya Chemicals & Fertilizers Limited, Mumbai

## Study on Manufacturing Process of High Pressure Nitric Acid


**Submitted by**

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# 1.Fundamentals

Fundamentals of High Pressure Nitric Acid
Chemical Properties of Nitric Acid:
Nitric acid is a strong oxidizing agent, highly corrosive, and has the chemical formula $HNO_3$.
It exists as a colorless or yellow liquid and is typically concentrated at around 68-70% by weight in water at room temperature.
In high-pressure environments, the properties of nitric acid can change slightly due to its behavior as a dense liquid.
High-Pressure Conditions:
High-pressure conditions generally refer to pressures higher than 1 atmosphere (atmospheric pressure). In industrial processes, nitric acid may be handled at pressures ranging from several bar (e.g., 10-100 bar) to supercritical pressures above 200 bar.
At elevated pressures, nitric acid's boiling point increases, and its density and reactivity can also change. This can influence reaction kinetics, mass transfer, and solubility of gases or liquids in the solution.
Manufacturing Process of Nitric Acid:
Nitric acid is commonly produced using the Ostwald process, which involves the oxidation of ammonia ($NH_3$) to nitrogen oxides (NO and $NO_2$) and then dissolving these oxides in water to form nitric acid.
In high-pressure applications, nitric acid is often produced or consumed in reactors that are designed to withstand elevated pressure, particularly in the production of ammonium nitrate for fertilizers or explosives.
Applications of High Pressure Nitric Acid:
Fertilizer Production: High-pressure nitric acid is a key component in the production of ammonium nitrate ($NH_4NO_3$), a commonly used fertilizer. This process requires high-pressure nitric acid to convert ammonia into nitric acid efficiently.
Explosive Manufacturing: Nitric acid is used in the production of explosives like TNT (trinitrotoluene) and dynamite. High-pressure systems are used to achieve the necessary concentrations of nitric acid for the nitration reactions.

Metallurgical Processing: High-pressure nitric acid is also used in the extraction and purification of certain metals, particularly in the production of metals like uranium, where high-pressure systems help in achieving more efficient dissolutions and reactions. Safety Concerns:

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# 2 .Design Data

Designing systems for handling high-pressure nitric acid (HPNA) requires careful consideration of several factors related to the pressure, temperature, corrosion resistance, safety, and efficiency. Below are the key design data and considerations for systems involving high-pressure nitric acid: 1. Pressure and Temperature Conditions Pressure Range: High-pressure systems typically operate above 10 bar (atmospheric pressure) and can go up to 100 bar or more, depending on the specific application. In some cases, supercritical pressures (>200 bar) may be encountered. Temperature: Nitric acid's boiling point increases with pressure. At atmospheric pressure, concentrated nitric acid boils at around 83°C, but at high pressures, this temperature can be much higher. Designers must account for the specific boiling point curve for the acid at the intended pressure levels. Typical operating temperatures for HPNA processes are often in the range of 100°C to 200°C. 2. Material Selection High-pressure nitric acid is highly corrosive and requires special materials to prevent damage to equipment, especially in reactors, piping, and storage vessels. Suitable materials include: Stainless Steels (e.g., 316L, 317L): Common for handling concentrated nitric acid, although the presence of chloride ions in the environment may reduce their effectiveness. Nickel Alloys (e.g., Hastelloy C-276, Inconel 625): More resistant to corrosion and pitting in high-pressure, high- temperature nitric acid environments. Titanium: Offers excellent resistance to corrosion and is used in high-pressure nitric acid systems in some applications. Tantalum: Extremely resistant to corrosion but expensive, so it’s used selectively in highly critical applications. Glass-Lined Steel: In some cases, glass-lined steel may be used for nitric acid storage and processing due to its high resistance to corrosion, though it is generally limited to lower pressure applications. 3. Design Considerations for Equipment Pressure Vessels: Reactors or storage tanks for high-pressure nitric acid should be designed according to ASME Boiler and Pressure Vessel Code (BPVC) or similar national/international standards. These vessels must be able to withstand both the high internal pressures and the corrosive effects of nitric acid. Piping: High-pressure piping should be designed with appropriate material thickness to handle internal pressures safely. High-strength materials such as nickel alloys or duplex stainless steel are often chosen. Seals and Gaskets: High-performance gaskets and seals are required to ensure leak-proof operations. Common materials include PTFE (Teflon) or elastomers designed to withstand nitric acid and high pressures.

4. Corrosion Resistance Nitric Acid Concentration: The concentration of nitric acid directly impacts it corrosivity. At higher concentrations, nitric acid is more aggressive and requires more resistan materials. For example, concentrated nitric acid (≥65%) is much more corrosive than dilute solution Acidity and Oxidizing Power: Nitric acid's strong oxidizing nature can lead to pitting and crevic corrosion in metals, which is why corrosion-resistant alloys and coatings are critical. 5. Reactor Desi Catalysts: In processes like the Ostwald process for producing nitric acid, catalysts are used t promote oxidation reactions at elevated pressures and temperatures. The reactor design should allo proper catalyst loading and unloading. Heat Transfer: Heat exchangers are often integrated into high pressure nitric acid systems to control temperature, as reactions involving nitric acid can b exothermic. The heat exchanger should be designed to prevent local overheating, which could degra the nitric acid or cause hazardous situations. Mixing: Good mixing is required to ensure uniformity i reactions. A suitable reactor design (e.g., stirred tank reactor, jet loop reactor) is essential for effecti mixing under high-pressure conditions. 6. Safety and Control Systems Pressure Relief Valves: High pressure systems must be equipped with relief valves to prevent overpressure situations, which coul lead to catastrophic failures. Leak Detection: Given the highly corrosive and toxic nature of nitric acid leak detection systems (e.g., hydrogen gas sensors, infrared detectors) should be incorporated into t design to detect potential leaks early. Explosion Protection: Nitric acid, when exposed to organi materials or other chemicals, can react violently. Adequate explosion protection (e.g., explosion ven flame arrestors, inerting) must be designed into the system. Temperature Control: Temperature shou be monitored and controlled, particularly in processes where high exothermicity is involved Automated temperature regulation is often necessary to avoid thermal runaway reactions. 7. Storag and Transport Storage Tanks: For large-scale operations, high-pressure storage tanks are necessary These tanks are often equipped with secondary containment to prevent accidental releases. Tank must be designed for both high pressure and corrosion resistance, with automated systems fo pressure regulation and temperature control. Transport Systems: Nitric acid is often transported und high pressure in specially designed containers or pipelines. Design of transport vessels must ensur proper sealing and prevent leaks, especially at junctions or fittings.

# 3 .Description of the plant

A High-Pressure Nitric Acid (HPNA) Plant is a specialized industrial facility designed to produce nit acid under elevated pressure conditions. Nitric acid produced in these plants is essential for a wi range of applications, including fertilizer production, explosives manufacturing, and metal processi The design and operation of a high-pressure nitric acid plant must ensure safe handling of corrosi and reactive chemicals while maximizing efficiency and minimizing environmental impact. Below is detailed description of a typical high-pressure nitric acid plant: 1. Purpose and Key Applicatio Fertilizer Production: The primary application for nitric acid produced in HPNA plants is the producti of ammonium nitrate ($NH_4NO_3$), a key ingredient in nitrogen-based fertilizers. Explosiv Manufacturing: HPNA plants are also used in the production of explosives, including TNT a dynamite, where concentrated nitric acid is used for nitration reactions. Metal Processing: Hig pressure nitric acid is used in various industries to purify or extract metals, particularly uranium a other valuable materials. 2. Key Components of a High-Pressure Nitric Acid Plant a. Ammon Oxidation Section (Ostwald Process) The Ostwald process is the foundation of most HPNA plants. this section, ammonia ($NH_3$) is oxidized to form nitrogen oxides (NO and $NO_2$) in the presence of and a catalyst. Reactor: The ammonia oxidation reactor is designed to operate at high temperatur (about 850°C) and pressures (10-20 bar). The catalyst typically consists of platinum or rhodiu supported on a base metal. Process: Ammonia is mixed with air and passed over the catalyst, where reacts to form nitrogen monoxide (NO). The nitrogen monoxide then reacts with oxygen to for nitrogen dioxide ($NO_2$), which is absorbed in water to produce nitric acid. b. Nitrogen Oxid Absorption and Nitric Acid Production The nitrogen oxides (NO and $NO_2$) generated in the ammon oxidation reactor are absorbed in water or dilute nitric acid to produce concentrated nitric acid (HNO Absorption Tower: The nitrogen oxides are passed through an absorption tower, where they react w water to form nitric acid. The absorption tower is typically designed with multiple stages of gas-liqu contact to maximize absorption efficiency. Dilute Nitric Acid: The gas mixture is absorbed into water form dilute nitric acid (approximately 50- 60% concentration). Concentration of Nitric Acid: The dilu nitric acid is then concentrated by removing excess water through a concentration column evaporator, where the acid is concentrated to 68-70%. c. High-Pressure Nitric Acid Section T concentrated nitric acid is further processed under high pressure for applications like ammoniu nitrate production or explosives synthesis.

3. Key Process Equipment Reactors: Specially designed high-pressure reactors for oxidation and nitration processes, often equipped with catalysts. Absorbers: Columns where nitrogen oxides are absorbed in water or nitric acid. Evaporators: Used to concentrate dilute nitric acid by evaporating water, resulting in concentrated $HNO_3$. Heat Exchangers: Employed throughout the plant to manage thermal energy, preheating incoming feed gases and cooling down products or waste streams. Pumps and Compressors: High-pressure pumps and compressors are used to move gases and liquids throughout the plant under controlled conditions. Cooling Systems: To maintain optimal temperatures in the reactors and absorption columns, cooling systems (e.g., cooling towers, air coolers) are necessary. 4. Safety Features Pressure Relief Systems: To prevent over-pressurization, safety valves and pressure relief systems are critical in all parts of the plant, especially in reactors and storage vessels. Explosion-Proof Equipment: Since nitric acid is highly reactive, especially with organic materials, explosion- proof equipment is used in areas where volatile reactions may occur. Emergency Shutdown Systems: Automated systems that detect abnormalities in pressure, temperature, or flow rates, triggering an emergency shutdown to prevent accidents. Leak Detection: Continuous monitoring for leaks of nitrogen oxides $(NO)_x$ or nitric acid vapors is important to protect workers and the environment. Safety Interlocks: Systems that ensure equipment only operates under safe conditions (e.g., safe pressure, temperature) and prevent unsafe operation. 5. Environmental Control Systems NOx Scrubbers: Nitrogen oxides $(NO)_x$ produced during the ammonia oxidation and absorption stages are toxic and must be treated. Scrubber systems neutralize these emissions to reduce pollution. Wastewater Treatment: Spent water or acid- containing waste streams may require treatment before being released into the environment to neutralize any residual acidity or toxic substances. Emission Control: The plant must be designed to limit the release of nitrogen oxides, sulfur dioxide, and other potentially harmful gases into the atmosphere. This includes scrubbers, catalytic converters, and other air pollution control devices. Waste Heat Recovery: The plant may incorporate waste heat recovery systems to improve energy efficiency by using heat from exothermic reactions to generate steam or preheat incoming reactants 6. Automation and Control Systems Distributed Control System (DCS): A DCS is typically used for monitoring and controlling the various processes in the HPNA plant. This system allows operators to control pressure, temperature, flow rates, and concentrations throughout the plant.

# 4 .Commissioning of the plant

The commissioning of a high-pressure nitric acid (HPNA) plant is a critical phase in the constructio and startup process, where the plant is prepared to operate safely and efficiently. Commissionin involves testing systems, equipment, and processes to ensure everything is functioning as designe and that the plant meets performance, safety, and regulatory standards. The commissioning proce is typically broken down into several stages, each focused on verifying and validating differen aspects of the plant. 1. Pre-Commissioning Activities Before the actual commissioning begin certain preparatory tasks need to be completed to ensure a smooth transition to operational statu These activities include: a. Engineering and Documentation Review

- Review of Design Documents: Ensure that the design and construction documents (P&ID, process flow diagrams, electrical schematics, etc.) are up to date and aligned with the built plant.
- Verification of Compliance: Check that the plant complies with local regulations, industry standards, and safety guidelines.
- Review of Safety Procedures: Confirm that safety protocols, emergency procedures, and operational manuals are in place, and that emergency response plans are documented.

b. Inspection of Equipment and Installation

- Visual Inspections: Inspect the entire plant for correct installation, quality of work, and proper integration of components. This includes checking valves, pumps, tanks, instrumentation, and piping for correct positioning and condition.
- Mechanical Completion: Verify that all mechanica systems (reactors, absorbers, heat exchangers, etc.) are assembled, and their connectior (welds, flanges, gaskets) are intact.
- Electrical Systems: Check that all electrical system including motors, control panels, alarms, and emergency shutdown systems, are installed correctly.
- Instrumentation and Control: Verify the installation of instruments like temperature, pressure, flow, and level sensors. Ensure that these instruments are correctly wired and calibrated.

2. Mechanical and System Testing Once the plant components are installed, mechanical and sys testing can begin to verify the functionality and integrity of the systems before introducing chemicals or feedstocks. a. Pressure Testing Hydrostatic Testing: Pressurize all vessels, pipes, pressure-containing equipment with water or an inert fluid to check for leaks and ensure they c safe handle the maximum operating pressure. Leak Testing: Perform leak tests using inert gase nitrogen or helium, particularly for highly pressurized areas such as reactors and storage tan ensure all seals, welds, and fittings are intact. b. Functional Testing of Equipment Pum Compressor and Fans: Test all moving equipment such as pumps, compressors, and fans for co rotation, flo rates, pressures, and proper mechanical operation. Instrumentation: Calibrate a verify th performance of all instruments and control loops. Ensure that sensors and actuators a accurate an responsive. Control Systems: Test the Distributed Control System (DCS) programmable log controllers (PLC) to ensure proper communication with all field devices. Te alarms, shutdowns, an interlocks to verify they are functioning as expected. c. Electrical Syste Testing Power Distributio Verify that all electrical connections are intact and that the plant capable of being powered up witho issues. Check transformers, switchgear, and electri distribution panels for proper operation. Contr System Functionality: Ensure that the control sys functions correctly with all field devices and that can monitor and control process paramete effectively. 3. Dry Run and Pre-Startup Testing In th phase, the plant is run through a "dry ru meaning no chemicals or feedstocks are introduced, but th systems are tested as if the plant we operational. a. Dry Run of the Plant No-Feed Operation: Opera the plant with water or inert mat instead of actual process chemicals.

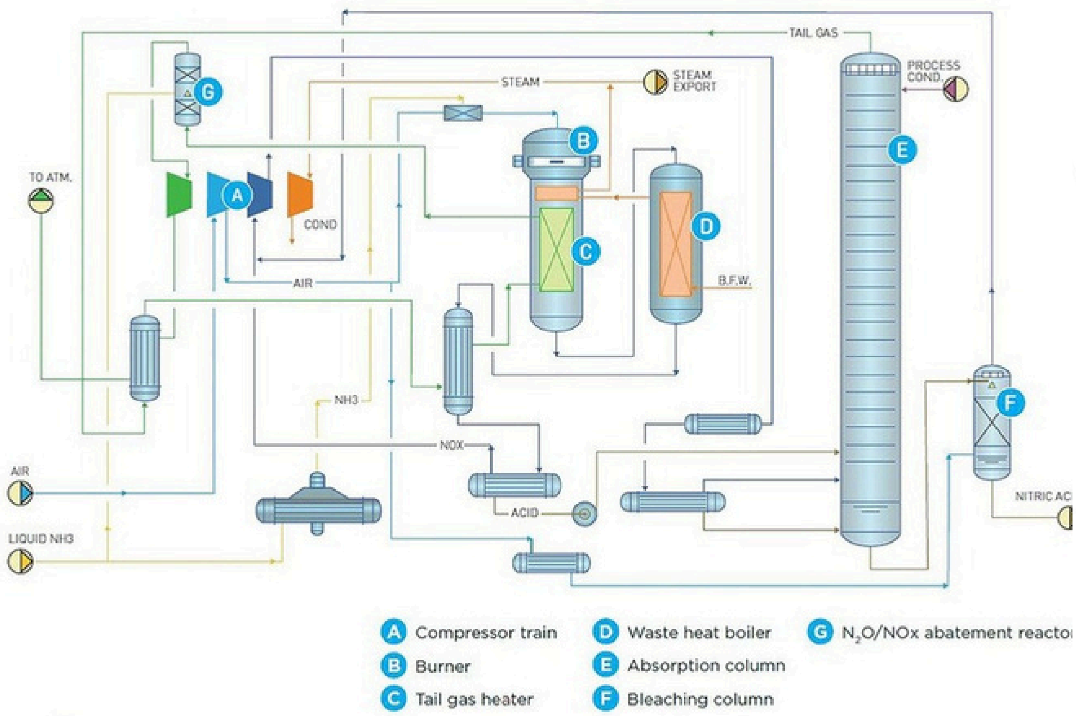
# 5 .Start of plant

The start of a plant's growth involves a process known as germination, which occurs when a se begins to grow and develop into a new plant. Here’s an overview of the key stages involved: Seed Formation Seeds are produced by mature plants after fertilization. They contain the embr of a new plant, nutrients, and a protective seed coat. 2. Germination This is the process where t seed starts to grow. It requires specific conditions such as moisture, temperature, and sometim light. Absorption of Water: The seed absorbs water, causing it to swell and soften the seed coa Activation of Enzymes: Water activates enzymes that break down stored nutrients (like starche in the seed, providing energy for the growing plant. Radicle Emergence: The first part of the pla to emerge is the radicle, or embryonic root, which anchors the plant and starts to absorb wat and nutrients. Shoot Growth: The shoot, containing the stem and leaves, begins to grow upwar seeking light for photosynthesis. 3. Seedling Development After germination, the young plant, no a seedling, continues to develop. Photosynthesis: The seedling develops leaves and begins perform photosynthesis, producing food for further growth. Root System: The roots continue grow and expand, helping the plant take up water and minerals from the soil. 4. Maturation As t plant matures, it grows taller and stronger, develops flowers (in flowering plants), and eventua produces new seeds, continuing the cycle. Factors Influencing Germination: Water: Essential f breaking the seed coat and activating the enzymes. Temperature: Seeds typically require a certa temperature range to germinate. Oxygen: Seeds need oxygen for respiration during germinatio Light: Some seeds require light to germinate, while others may require darkness. This enti process allows plants to propagate and start new generations, contributing to the growth a diversity of plant life.After germination, the young plant, now a seedling, continues to develo Photosynthesis: The seedling develops leaves and begins to perform photosynthesis, produci food for further growth.

# Shutdown of plant

The shutdown of a plant, particularly in the context of industrial, power, or manufacturing plant refers to the process of safely ceasing operations. This can be due to scheduled maintenanc decommissioning, or emergency circumstances. The shutdown process ensures safet environmental protection, and compliance with regulations. Below is an outline of the typical st and reasons for a plant shutdown: 1. Reasons for Plant Shutdown Planned Shutdow Maintenance: Routine or preventive maintenance to ensure equipment reliability, safety, an optimal performance. Upgrades: Installing new equipment, technology, or improvements systems. Seasonal Changes: In industries like agriculture or energy, seasonal adjustments ma require shutting down operations temporarily. Unplanned Shutdown: Emergency: In response t unforeseen events, such as equipment failure, fire, or accidents. Regulatory Compliance: Due t safety violations, legal requirements, or environmental concerns. Economic Reasons: Due to a d in demand, economic challenges, or a decision to cease operations. 2. Shutdown Process Th shutdown process typically involves several key steps to ensure safety, efficiency, and prope handling of equipment and systems: Preparation and Planning: Define the scope and schedule o the shutdown. Inform stakeholders, including employees, contractors, and authorities. Ensur proper risk assessments, safety measures, and contingency plans are in place. Isolation of Syster Disconnect electrical systems, gas lines, and other energy sources to prevent accidents during th shutdown process. Close valves and shut down machinery to ensure systems are safely offlin Deactivation of Equipment: Sequentially turn off machinery, devices, and reactors (in a power p or chemical plant, for example) in a controlled manner. Shut down the plant’s critical contr systems, ensuring everything is safely powered down to prevent any hazards. Environment Protection: Manage emissions, waste, and byproducts generated by the shutdown. In certa plants (like chemical or power plants), this is crucial for minimizing environmental harm.

Inspection and Maintenance:




Flowsheet

Figure 1- FLOWSHEET OF CNA PRODUCTION

## 7.Normal operation

The normal operation of a high nitric acid plant involves a series of complex chemical processes aimed at producing concentrated nitric acid ($HNO_3$) from ammonia ($NH_3$) and oxygen ($O_2$) as primary feedstocks. The key steps in this process are as follows: 1. Ammonia Oxidation (Catalytic Oxidation)

- Reactants: Ammonia ($NH_3$) and oxygen ($O_2$) Catalyst: Platinum-rhodium (Pt-Rh)
- catalyst In this stage, ammonia is oxidized in the presence of oxygen at high
- temperatures (around 850–900°C). This reaction forms nitrogen monoxide (NO) and water vapor: 4NH3+3O2→2N2+6H2O4 $NH_3$ + 3 $O_2$ \rightarrow 2 $N_2$ + 6 $H_2$O4NH3+3O2 →2N2+6H2O The nitrogen monoxide (NO) produced in this reaction is then oxidized further in the next stage.
-

2. Oxidation of Nitrogen Monoxide to Nitrogen Dioxide ($NO_2$)

- The nitrogen monoxide (NO) formed in the first step is oxidized in the air to nitrogen dioxide ($NO_2$) at ambient temperature: 2NO+O2→2NO22 NO + $O_2$ \rightarrow 2 $NO_2$2NO+O2→2NO2 This reaction is typically performed in a converter or absorption
- tower.

3. Absorption of Nitrogen Dioxide in Water

- The nitrogen dioxide ($NO_2$) gas is then absorbed into water to form nitric acid ($HNO_3$). The absorption takes place in an absorber tower, where the $NO_2$ reacts with water to produce a mixture of nitric acid and nitrous acid ($HNO_2$): 2NO2+H2O→HNO3+HNO22 $NO_2$ + $H_2O$ \rightarrow $HNO_3$ + $HNO_2$2NO2+H2 O→HNO3+HNO2 Nitrous acid ($HNO_2$) is then typically further oxidized to nitric
- acid ($HNO_3$) in the next stages.

4. Concentration and Purification

- The product is a dilute nitric acid solution, which is concentrated through distillation, typically using a series of evaporators. Nitrous acid and other impurities are removed
- to achieve the desired concentration of nitric acid (typically around 68-70% concentration for industrial uses). The final concentrated nitric acid is then cooled and stored for distribution.
-

condense and will leave the top of the column as vapor & dilute the product nitric acid vapor .The steam is controlled by temperature control loop 104 in the lower part of the column. The vapors leaving the top of column are passed to the main condenser E102 via DN800 glass lined steel Pre-bleacher column C102.The concentrated nitric acid condensing in E102 contains a significant quantity of dissolved NOx as can be seen by the dark brown color of the acid in the line leaving the condenser. This acid is fed to the top of Pre-bleacher column C102 where much of the NOx is removed by contact with incoming nitric acid vapor. The liquid CNA leaving C102 is then fed to the top of glass DN450 bleach column C103 where it is contacted with air to bleach the acid water white. After bleaching CNA is cooled by product cooler E104. The WSA leaving the bottom of C101 at 155 0C by mixing with recycled cold WS before passing to interchanger E101, which cools the WSA to about 1000C (and also preheat the WNA feed to 140 0C). On leaving E101 the WSA is cooled to 40 0C by cooler E105 before passing to T104 for export to storage.

# 8. Healthy and safety hazard data

Nitric acid ($HNO_3$) is a highly corrosive, toxic, and reactive chemical. Proper handling, storage, and disposal are critical to ensuring health and safety in its use. Below is an overview of the health and safety hazards associated with nitric acid:

1. Physical and Chemical Properties

- Appearance: Colorless to pale yellow liquid
- Odor: Pungent, acrid odor (strongly irritating)
- Boiling Point: ~83°C (181°F)
- Melting Point: ~−42°C (−44°F)
- Solubility: Miscible in water, forms highly exothermic solutions.
- Flammability: Non-flammable but can support combustion in the presence of flammable materials.

2. Health Hazards

- Acute Toxicity
  - Inhalation: Breathing nitric acid vapors or mist can cause severe respiratory irritation, coughing, shortness of breath, and, in extreme cases, pulmonary edema or chemical pneumonia. Prolonged or high exposure can cause serious lung damage.
  - Skin Contact: Direct contact with nitric acid can cause severe skin burns and tissue damage. Even dilute solutions can be highly irritating and corrosive to the skin.
  - Eye Contact: Nitric acid is extremely irritating to the eyes and can cause severe burns, corneal damage, or permanent blindness if not immediately washed off with water.
  - Ingestion: Swallowing nitric acid can result in severe burns to the mouth, throat, esophagus, and stomach. It may cause nausea, vomiting, abdominal pain, and shock.

- Chronic Health Effects
    - Repeated Exposure: Chronic exposure to low levels of nitric acid vapors may cause respiratory issues such as chronic bronchitis, nasal irritation, or reduced lung function.
    - Sensitization: Prolonged exposure can lead to increased sensitivity to inhaled vapors, further exacerbating respiratory problems.
- 3. Safety Hazards
    - Corrosivity: Nitric acid is a strong oxidizing agent and can cause severe corrosion to metals, tissue, and organic materials. Reactivity: Nitric acid reacts violently with many
    - substances, including organic compounds, reducing agents, and metals such as copper, which can lead to the formation of dangerous gases like nitrogen oxides ($NO_x$). The reaction with bases generates large amounts of heat. Vapor Hazards: Nitric acid vapor is harmful and can cause
    - serious health effects if inhaled, as it can irritate the respiratory tract and lungs.
    - Decomposition Products: Upon decomposition, nitric acid can produce nitrogen oxides ($NO_2$, NO), which are highly toxic and harmful to the environment.
- 4. Environmental Hazards
    - Toxicity to Aquatic Life: Nitric acid is toxic to aquatic organisms, causing damage to ecosystems. It lowers the pH of water bodies, which can disrupt aquatic life.
    - Acid Rain: When released into the atmosphere, nitric acid can contribute to the formation of acid rain, which can damage ecosystems, soil, and buildings.
    -

# 10. Equpment list

The equipment used in a nitric acid ($HNO_3$) plant is designed to handle the corrosive, reactive, and hazardous nature of nitric acid and its intermediates. Below is a typical list of equipment used in the production of nitric acid, focusing on key process steps, safety, and environmental control.

1. Ammonia Oxidation Section

- Ammonia Compressor: Compresses ammonia gas ($NH_3$) from storage to the required pressure for the oxidation process.
- Ammonia Oxidation Reactor: A high-temperature, high-pressure reactor where ammonia reacts with oxygen in the presence of a platinum-rhodium (Pt-Rh) catalyst to form nitrogen monoxide (NO) and water.
- Catalyst Beds: Contain platinum-rhodium catalyst for the oxidation of ammonia to NO.
- Heat Exchanger: Cools the gas mixture from the ammonia oxidation reactor and recovers heat for use in other parts of the process.

2. NOx Oxidation Section

- Nitrogen Monoxide (NO) to Nitrogen Dioxide ($NO_2$) Converter: This is where the nitrogen monoxide (NO) produced in the ammonia oxidation reactor is oxidized to nitrogen dioxide ($NO_2$), typically using air or oxygen.
- Cooling Towers: Cool the gas mixture after NO oxidation before it enters the absorption towers.

3. Absorption and Nitric Acid Formation

- Absorption Towers (Absorbers): Gas-phase $NO_2$ is absorbed into water in the absorber towers. The absorption leads to the formation of a mixture of nitric acid ($HNO_3$) and nitrous acid ($HNO_2$).
- Scrubber: Removes excess nitrogen oxides (NOx) and unreacted gases from the exhaust to reduce environmental pollution. Scrubbers are

# P & ID’s

General Components of a Nitric Acid Plant P&ID

1. Ammonia Oxidation (Catalytic Oxidation) Section
    - Ammonia Compressor (C-100): Pumps ammonia gas from storage into the reactor.
    - Ammonia Flowmeter (FM-101): Measures the flow rate of ammonia entering the reactor.
    - Oxygen Flowmeter (FM-102): Measures the oxygen feed into the ammonia oxidation reactor.
    - Ammonia Oxidation Reactor (R-100): The primary reaction vessel where ammonia reacts with oxygen to produce nitrogen monoxide (NO).
    - Temperature and Pressure Transmitters (T-100, P-100): Monitor the reactor's operating conditions.
    - Catalyst Beds (CB-100): Contain platinum-rhodium catalyst to facilitate the oxidation reaction.
    - Heat Exchanger (E-100): Cools the reactor effluent before further processing.

2. NOx Oxidation Section
    - NOx Converter (R-200): Converts nitrogen monoxide (NO) to nitrogen dioxide ($NO_2$) in the presence of air or oxygen.
    - Cooling Tower (T-200): Cools the gas stream coming from the converter.
    - Gas Flowmeter (FM-201): Measures the flow rate of the gas leaving the converter.

3.



12. EQUIPMENT DETAILS

# interlocking Description

1 . Ammonia Oxidation Section Interlocks

- Ammonia Flow Control:

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  Purpose: Prevents unsafe conditions from insufficient ammonia supply, which can lead to unreacted ammonia in the reactor or lower nitric acid yield.

  Reactor Temperature Control:

- 
  - Interlock: If the temperature in the ammonia oxidation reactor exceeds a predetermined limit (e.g., 900°C), the system automatically reduces the oxygen feed or activates cooling systems to bring the temperature down.
  - Purpose: Prevents overheating of the reactor, which could lead to catalyst degradation or safety hazards like pressure buildup.

- Pressure Control in Reactor:
  - Interlock: If reactor pressure exceeds a safe threshold (e.g., 10 bar), a pressure relief valve is activated, and the reactor may be shut down if pressure rises too quickly or cannot be brought down promptly.
  - Purpose: To prevent reactor overpressure that could lead to rupture or catastrophic failure.

# Conclusion

In the operation of a nitric acid plant, interlocking systems play a vital role in ensuring safe, efficient, and controlled production. These systems are designed to automatically detect deviations in key process parameters such as flow, temperature, pressure, and concentration, and respond by shutting down or adjusting processes to prevent unsafe conditions or damage to equipment. The primary purpose of interlocks is to protect both personnel and the environment from hazards such as overpressure, gas leaks, and unsafe chemical reactions, while maintaining process control to ensure product quality and consistency.

Key interlocking mechanisms in a nitric acid plant include:

- Temperature and Pressure Control: Prevents dangerous conditions like overheating or overpressure in reactors and absorbers.
- Flow Control: Ensures the correct flow ratios of ammonia, oxygen, and other reactants to maintain an efficient oxidation reaction.
- Environmental Safeguards: Includes vent gas scrubbers and gas leak detection systems to ensure compliance with environmental standards, particularly concerning nitrogen oxides (NOx) emissions.
- Emergency Shutdown Systems: Responds to failures like power loss or equipment malfunctions to prevent uncontrolled reactions and protect critical plant infrastructure.

Through the use of these interlocks, a nitric acid plant can minimize operational risks, ensure continuous production under safe conditions, and comply with regulatory requirements. Additionally, interlocking systems contribute to the overall sustainability of the plant by reducing the potential for accidents, minimizing waste, and protecting the plant from both operational and environmental hazards.