Alaska Nitrogen Products, LLC
Kenai Plant
Ammonia Synthesis, & Converter Loop
Systems 17, 18, 19, 22, 67, 68, 69, & 72
Process Hazards Analysis Revalidation

Final Report

September 7, 1999

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Project No.: K00S18R1
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1.0 ABOUT THIS STUDY

The Process Hazards Analysis, K00S0018 conducted between August 16, 1994 to September 24, 1994 was revalidated at Unocal’s Kenai Plant on August 9th, 10th, & 11th, 1999. The original PHA, as well as the revalidation, focused on the Ammonia Synthesis & Converter Loop, Systems 17, 18, 19, 22, 67, 68, 69, & 72.

EPA RMP 40 CFR Part 68 Section 112®(7) and OSHA Rule 1910.119, "Process Safety Management of Highly Hazardous Chemicals" requires that the initial Process Hazard Analysis (PHA) for a covered process be updated and revalidated by a knowledgeable team at least every five years. The objective of PHA revalidation is to assure that the PHA is consistent with the current process. The PHA is revalidated, by evaluating and addressing the following questions:

- Have significant new hazards been created or introduced into the process?
- Has the possible occurrence of a catastrophic release in the process unit become significantly more likely?
- Have consequences of previously identified toxic or flammable material releases become more severe?
- Have consequences that could go "off-site" been identified?
- Have previously identified safeguards become compromised or challenged?

Methodologies

**Baseline PHA**

The original, or baseline, PHA was conducted primarily using the HAZOP deviation guideword technique and the "What-If" technique.

**HAZOP Deviation Guideword Technique**

The guidewords, in conjunction with key process parameters, prompt the Process Hazards Analysis team to brainstorm possible causes and potential consequences of deviations from expected operation. For example, the deviation of "NO FLOW" would prompt the leader to ask the team, "What could cause no flow in this section or line segment?" The "Possible Cause/Potential Consequence" scenarios were documented in the report worksheets along with "Existing Systems and Safeguards," that either reduce the likelihood of the cause occurring or reduce the potential consequences. For scenarios involving significant risk, "Recommendations," which the team believed, may further reduce the risk or improve the operability of the facility were also documented.

The specific steps of the HAZOP methodology used in the baseline PHA were:

- Choose study node
- Apply a deviation (parameter + guideword)
- Brainstorm causes of the deviation
- For each cause, identify ultimate global consequences
- Identify existing safeguards
- Qualitatively assess the risk of the scenario
- If warranted, make recommendation(s) to reduce risk and/or improve the operability of the facility

This process is repeated for each deviation and node until the entire process has been analyzed.
**What-If Technique**

The "What-If" technique involves asking questions that require the team to analyze deviations from the procedure. An example is, "What-If"...the drying step were left out of the procedure?" The team then develops consequences of this (or inaction) and documents the safeguards in a manner similar to HAZOP. The "What-If" scenario is then ranked for risk, and recommendations are made if appropriate, similar to the HAZOP technique.

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**Revalidation**

The PHA procedure used to revalidate the Ammonia Synthesis & Converter Loop, Systems 17, 18, 19, 22, 67, 68, 69, and 72, was the Guideword/Checklist PHA Revalidation Method. This methodology was organized into the following tasks, and are described below:

1. Collection of Information
2. Information Review
3. Revalidation Study Sessions (with PHA Team)

**Collection of Information**

The following information was collected prior to the Revalidation Study Sessions:

1. Baseline PHA, including worksheets, Action Item list, P&IDs reviewed, and status of recommendations.
2. Documented changes to the design or operation of the process since the baseline PHA (including MOCs).
3. Documented incident reports from this unit.
4. Latest revision of Piping and Instrument Diagrams (P&IDs) that describe the process.
5. Other Process Safety Information, such as PRV design basis and data and Standard Operating Conditions and Limits (SOCLs).

**Information Review**

The collected information; was reviewed by the Revalidation Team Leader and Unocal representatives on August 9th, 10th, and 11th, 1999. The purpose of the Information Review is to screen the baseline PHA for content and quality, and to identify concerns and issues that need to be reviewed by the Revalidation Team during the study sessions. This resulted in the generation of an agenda or work plan for the sessions. The Information Review included the following tasks required to identify items for discussion with the team:

1. Review the baseline PHA and complete the Initial PHA Content Checklist, see Attachment 2, and the Baseline PHA Screening Checklist, see Attachment 3. Evaluate the baseline PHA to ensure that off-site consequences were adequately discussed and addressed.

2. Review and verify the documented status of recommendations from the baseline PHA, and any project PHAs affecting this unit.

3. Review all incidents occurring in the system since the baseline PHA, and develop a list of those pertinent to the revalidation process.
4. Develop a list of all changes that have occurred to the design or operation of the process since the baseline PHA, see Attachment 5. This is done by comparing the latest P&IDs with the P&IDs reviewed during the baseline PHA, and by reviewing those changes to the design or operation of the process that have been analyzed by the MOC process.

5. Develop an agenda, or work plan for the study sessions, see Attachment 1.

Revalidation Study Sessions (with PHA Team)

The revalidation study was discussed and prepared by a multi-disciplined team. Knowledgeable in the process and in the PHA method used. At the beginning of the session, the Team Leader reviewed the PHA revalidation scope and purpose, and reviewed the completion of the Initial PHA Content Checklist and the Baseline PHA Screening Checklist. The group was then lead through the revalidation procedure, which included:

1. General discussion regarding open recommendations from the baseline PHA, see Attachment 4;
2. General discussion regarding incidents occurring in the process since the baseline PHA; see Attachment 8;
3. A review of those documented changes since the baseline PHA, see Attachment 5;
4. The completion of the Change Evaluation Checklist, see Attachment 6;
5. The completion of the Human Factors Issues Checklist, see Attachment 7;
6. A review of the Revalidation Guideword List, see Attachment 8;
7. Consideration of those scenarios with potential off-site consequences, see Attachment 9; and
8. The completion; of the Wrap-up Discussion Checklist, see Attachment 11.

"What-If" – The team utilized the "What-If" technique to identify potential hazards and areas of concern when it was determined that those hazards or concerns were not adequately addressed by the baseline PHA, such as potential off-site consequences. The "What-If" technique was also utilized to evaluate potential hazards caused by new or modified equipment as the review team deemed appropriate. OSHA recognizes the "What-If" as an acceptable method of evaluating process hazards. Those scenarios evaluated using the "What-If" technique can be found in Attachment 9.

The "What-If" technique involves asking questions that require the team to analyze deviations from the design intent. An example is: "What-If...the drying step were left out of the procedure?" The team then develops consequences of this action (or inaction) and documents the safeguards in a manner similar to HAZOP. The "What-If" scenario is then ranked for risk, and recommendations are made if appropriate, similar to the HAZOP technique. Attachment 10 shows the criteria for applying risk rankings to various scenarios.

Other Issues

Facility Siting – The Alaska Nitrogen Products, LLC, Kenai Plant has recently completed a plant-wide facility siting study, which adequately addresses those issues; therefore, the Facility/Plant Siting Issues checklist was not utilized.

Compliance with OSHA Rule 1910.119 and EPA RMP Rule

This study complies with OSHA rule 1910.119, "Process Safety Management of Highly Hazardous
Chemicals" and EPA 40CFR Part 68 Section 112®, "Risk Management Program."

In particular, this study complies with paragraph (e,6) of the OSHA rule that states; "At least every five years after the completion of the initial process hazard analysis. The process hazard analysis shall be updated and revalidated by a team, meeting the requirements in paragraph (e)(4) of this section to assure that the process hazard analysis is consistent with the current process." The study also complies with Subpart D (68.67) of the RMP Rule covering the same requirements as OSHA 1910.119 and potential off-site consequences.

The study was completed within five years of the baseline PHA. A multi-disciplined team, including at least one person with knowledge and experience in the process, discussed and prepared the study in a manner to ensure that the baseline PHA is consistent with the current process.

Process Hazards Analysis Team (e,4)

The PHA Revalidation was discussed and prepared by a team with expertise in engineering and operations, with at least one employee having specific expertise in the process being evaluated.

The Process Hazards Analysis Revalidation was conducted on August 9th, 10th, & 11th 1999 at Unocal’s Kenai Plant in Kenai, Alaska.

The study team consisted of the following people

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<thead>
<tr>
<th>Name</th>
<th>Title</th>
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<tr>
<td>Bill Switzer</td>
<td>Advising Chemical Engineer</td>
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<tr>
<td>William D. Gregg</td>
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<tr>
<td>Steve E. Dornelly</td>
<td>&quot;A&quot; Operator Plant 4</td>
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<td>Dana L. Basset</td>
<td>Sr. Safety Inspector</td>
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<td>Robert A. Ross</td>
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<td>Michael A. Bethune</td>
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<tr>
<td>Steve A. Morgan</td>
<td>Inspector</td>
<td>26</td>
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<tr>
<td>Edward J. Aisenbrey</td>
<td>PHA Facilitator/PSM Coordinator</td>
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<tr>
<td>Licia Piceno</td>
<td>Project Aide/Scribe</td>
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Process Description

General Information

Process Description Plant #1 Syngas Compressor System

SYSTEM PURPOSE and DESCRIPTION:

Syngas Compressor

The make-up gas from the gas reform section entering the compression section is cooled by heat exchange with the recycle gas from the synthesis section in the 1E138 cold exchanger. The gas leaving shell side of the cold exchanger passes through the 1F119 cold exchanger separator where the condensate is removed. The level in the 1F119 cold exchanger separator is automatically controlled, by sending the condensate to the PC Stripper or the GES. The gas then flows through
the 1D111 synthesis gas saturator where it is cooled by direct contact with cold ammonia (NH₃) from the refrigeration section and where the last traces of water are removed.

The synthesis gas saturator is a packed tower where the gas flows counter currently to a continuous flow of liquid NH₃ circulated by the saturator circulating pump.

The NH₃ is supplied from the refrigeration section in the quantity required to maintain the liquid level in the saturator. A side stream of NH₃ is taken from the bottom of the saturator and joins the flow of product to storage, which prevents excessive buildup of water and heat in the saturator. The make-up flow to the saturator is automatically controlled to maintain the saturator level.

The saturator is equipped with a demister and a high level Syngas compressor trip to avoid carryovers of liquid NH₃ to the Syngas compressor.

The flow of NH₃ re-circulating in the saturator and, indirectly, the temperature of the exit gas is controlled manually; and a flow control valve, FCV602, controls the side stream flow to the NH3 product line.

The make-up gas leaving the saturator is compressed by several wheels in the first stage of the synthesis gas compressor, and then sent to the 1E122 primary interstage Syngas cooler (an air-cooled exchanger) where it is cooled to about 90°F before the 1E128A/B Secondary Interstage Synthesis Gas Cooler (an NH₃ cooled exchanger).

Before entering the high case suction of the compressor, the gas passes through the 1F121 First Stage Synthesis Gas Separator where the NH₃ condensed in the 1E128A/B exchangers is separated and sent to the saturator as part of the make-up. 1F121 is equipped with a high level Syngas compressor trip column.

The pressure of the gas is again increased in the high case of the compressor. The gas is then mixed with the recycle gas from the synthesis converter section and the mixture enters the final stage (recycle wheel) where the pressure is raised as required and sent to the 1D110 converter for the synthesis reaction.

The compressor is driven by two tandem steam turbines. The high-pressure turbine draws steam from the 1500 psig steam system and discharges to the 550 psig steam header. The low-pressure turbine uses 550 psig steam, as required to maintain speed, and exhausts to vacuum in the 1E124 steam condensers.

The compressor is supplied with a package oil system, which provides the lubricating oil for the compressors and drivers, governor control oil for the drivers, and seal oil for the compressors.
Plant #1 Converter and Converter Loop

SYSTEM PURPOSE and DESCRIPTION:

**Synloop**

The function of the Synthesis Section is to combine hydrogen and nitrogen to produce ammonia (NH₃), and to separate the NH₃ from the synthesis gas.

The gas supplied for this purpose is the synthesis make-up gas produced in the reforming section and received by the compression section.

The unconverted gas is recompressed in the compression section and mixed with the make-up gas for further conversion and NH₃ recovery in the synthesis loop.

The synthesis gas (recycle gas and make-up gas from the reforming section) from the Syngas Compressor enters the synthesis section and passes through the shell side of the Feed Gas Preheater (1E135) where it is heated with converter exit gas before entering the NH₃ converter.

The gas then exits the converter from the bottom nozzle to the 1E139A/B Boiler Feed Water (BFW) Preheater (tube side) where it is cooled while heating the boiler feed water used in the (shell side) 1500 psig steam system in the gas reform section. The gas is further cooled in the 1E135 Feed Gas Preheater (tube side) in exchange with the incoming synthesis gas. After the 1E135, the gas enters the 1E136 Synloop Air-Cooled Condenser where it is cooled with air.

About two-thirds (2/3) of the NH₃ production condenses in the 1E136s.

The outlet of the Synloop Air-Cooled Condenser enters the 1F131 Primary Separator where the condensed NH₃ is collected and sent to the letdown tank through a letdown valve.

The gas, containing about 4.3% NH₃, is sent back to the compression section as recycle gas, where it mixes with the make-up gas before it is recompressed and recycled back to the converter.

The NH₃ collected in the Primary Letdown Tank is sent to the Fourth Stage Flash Drum in the refrigeration section, where it is cooled down before being sent to the 3F623 Ammonia Storage Tank or to other users.

The liquid levels, in the Primary and Secondary Separators are controlled by level controllers. The pressure in the Primary Letdown Tank is controlled on the tank vent line. The temperature in theSecondary Separator is controlled by regulation of the cooling liquid NH₃ flow through 1E137A/B.

Because of the continuous re-circulation of unconverted gasses, the inert gasses [mainly methane (CH₄) and argon (Ar)] build up in the synthesis loop and must be purged in order to maintain the desired concentration. The inerts in the synthesis loop are purged downstream of the Secondary
Separator (Recycle Gas Stream). The purge stream is cooled down in the Purge Gas Condenser 1E141A/B by heat exchange with liquid NH$_3$ from the refrigeration section.

The gas exit from the purge gas condenser passes through the Purge Gas Separator 1F135, where the condensed NH$_3$ is separated and sent to the Primary Letdown Tank. The non-condensable portion is sent to the Purge Recovery System in Plant 4.

The vent gas from the Primary Letdown Tank (containing the inerts that left the synthesis loop with the condensed NH$_3$) are mixed with the vent gas from the refrigeration section and cooled down in the vent condenser by heat exchange with liquid NH$_3$ from the refrigeration section. The exit from the condenser passes through the Vent Gas Separator where the condensed NH$_3$ is separated and sent to the refrigeration section. The non-condensable portion is sent to the vent gas section of the Purge Recovery Unit in Plant 4 or to the 1B101 Primary Reformer to be used as fuel.

The temperatures in both the Purge and the Vent Condensers are controlled automatically by means of flow control of the liquid NH$_3$ through the exchangers.

The rate of purging and consequently the concentration of inerts in the Synthesis Loop are manually controlled from the control room Moore console through a flow control valve.

The rate of vent gas is a function of the volume of NH$_3$ entering the Primary Letdown Tank and is controlled by a pressure control valve on the Primary Letdown Tank.

NH$_3$ synthesis is carried out through the exothermic reaction of H$_2$ and N$_2$ at elevated pressure for high equilibrium conversion, at elevated temperature for high rate of reaction, and over a catalyst in order to activate the reaction and improve the approach to equilibrium. There is only one chemical reaction involved in the synthesis of NH$_3$:

$$N_2 + H_2 = 2NH_3 + \text{Heat}$$

The equilibrium point of this reaction is shifted to the right by higher pressures and lower inlet temperatures. The outlet temperature must be maintained at a high level in order to improve the rate of reaction and activate the catalyst.

The NH$_3$ Converter Startup Heater is used during startup to bring the temperature of the synthesis gas to the reaction level. The converter is equipped with a series of thermocouples and alarms to indicate the temperature throughout the catalyst beds and warn the operator of abnormal conditions.

The startup heater is a gas fired furnace where the exit temperature of the gas is controlled by regulating the fuel gas flow to the heater. It is also equipped with a safety system to shut off the fuel gas if conditions exceed normal operating limits.
Plant #4 Syngas Compressor System

SYSTEM PURPOSE and DESCRIPTION:

Syngas Compressor

The make-up gas from the gas reform section entering the compression section is cooled by heat exchange with the recycle gas from the synthesis section in the cold exchanger. The gas leaving the cold exchanger passes through the cold exchanger separator where the condensate is removed. The level in the cold exchanger separator is automatically controlled, by sending the condensate to the PC Stripper. The gas then flows through the synthesis gas saturator where it is cooled by direct contact with cold ammonia (NH\textsubscript{3}) from the refrigeration section.

The synthesis gas saturator is a packed tower, where the gas flows counter currently to a continuous flow of liquid ammonia circulated by the saturator circulating pump.

The ammonia is supplied from the refrigeration section in the quantity required to maintain the liquid level in the saturator. A side stream of ammonia is taken from the bottom of the saturator and joins the flow of product to storage, which prevents excessive buildup of water in the saturator. The make-up flow to the saturator is automatically controlled to maintain the level.

The saturator is equipped with a demister to avoid carryovers of liquid ammonia to the Syngas compressor.

The flow of ammonia re-circulating in the saturator, and indirectly the temperature of the exit gas, is controlled manually. A flow control valve automatically controls the side stream flow to the ammonia product line.

The make-up gas leaving the saturator is compressed by several wheels in the first stage of the synthesis gas compressor and sent to the interstage Syngas cooler where it is cooled to 90°F before entering the second stage of compression. The gas leaving the second stage of compression is sent to interstage cooling comprised of a Primary Interstage Synthesis Gas Cooler (an air cooled exchanger), and a Secondary Interstage Synthesis Gas Cooler (an ammonia-cooled exchanger).

Before entering the third stage, the gas passes through the First Stage Synthesis Gas Separator where the ammonia condensed in the exchangers is separated and sent to the saturator as part of the make-up.

The pressure of the gas is again increased in the third stage of the compressor. The gas is then mixed with the recycle gas from the synthesis converter section and the mixture enters the final
stage (recycle wheel) where the pressure is raised as required and sent to the converter for the synthesis reaction.

The compressor is driven by a multi-stage double case steam turbine. The high-pressure turbine case draws steam from the 1500 psig steam system and discharges to the 550 psig steam header. The low-pressure turbine uses 550 psig steam, as required to maintain speed, and exhausts to the 4E224 steam condensers.

The system is complemented with the steam condenser, condensate return pumps, steam air jet ejectors, and the necessary instrumentation and controls.

The compressor is supplied with a package oil system, which provides the lubricating oil for the compressors and drivers, governor control oil for the drivers, and seal oil for the compressors.

Plant #4 Converter and Converter Loop

SYSTEM PURPOSE and DESCRIPTION:

Syn-Loop

The function of the Synthesis Section is to catalytically combine hydrogen (H₂) and nitrogen (N₂) to produce ammonia (NH₃), and to separate the ammonia from the synthesis gas.

The gas supplied for this purpose is the synthesis make-up gas produced in the reforming section and received from the compression section. The conversion of this gas to ammonia and the recovery of the ammonia occur as a result of several passes through the synthesis loop.

The unconverted gas is recompressed in the compression recycle section and mixed with the make-up gas for further conversions and ammonia recovery in the synthesis loop.

The synthesis gas (recycle gas and make-up gas from the reforming section) from the Syngas Compressor enters the converter loop and passes through the shell side of the Feed Gas Preheater where it is heated with converter effluent gas before entering the ammonia converter.

The ammonia converter is a vertical vessel comprised of a catalyst section (divided into three beds), two internal exchangers, and an annular space between the catalyst and the shell where the incoming synthesis gas keeps the shell from overheating while picking up some heat from the exothermic conversion reaction. One portion of the synthesis gas passes through the annular section of the converter and is heated; the rest is split into two streams, which are injected directly to the middle and lower catalyst beds to control their temperature.
The gas leaving the annular section at the top of the converter enters the converter through the bottom nozzle located in the outlet fitting. It flows through the bottom internal exchanger tube-side where it is heated by cooling the third bed outlet gas. Then it goes to the interchanger located at the center of the second bed where it is heated by heat exchange with the gas leaving the second bed and finally enters the first bed. In the first bed the flow pattern is inward from the sides and the gas collects at the center outlet collector. The balance of the converter feed gas is quench gas to control the temperature at the inlet of the second bed. In the second bed, the gas flows inward, from the sides to pass in the interchanger shell-side where it is cooled by the incoming gas as on the tube side, said before. The gas passes into the third bed with inward flow pattern from the sides and then through the bottom exchanger shell-side where it is cooled by heating the feed gas on the tube side. The converted gas leaves the converter from the bottom fitting.

The converted gas leaving the converter then passes successively through the following heat exchangers to bring the temperature down to ammonia condensation level:

- Boiler Feed Water (BFW) Preheater (tube side) where it is cooled while heating the boiler feed water used in the (shell side) 1500 psig steam system in the gas reform section
- Feed Gas Preheater where it is cooled with the incoming synthesis gas
- Air Cooled Condenser where it is cooled with air

About two-thirds (2/3) of the ammonia production condenses in the Air Cooled Condenser. The gas then passes to the Ammonia Cooled Condenser where the temperature is brought down by heat exchange with cold liquid ammonia, and the rest of the ammonia production is condensed.

The outlet of the Ammonia Cooled Condenser enters the High Pressure Separator where the condensed ammonia is collected and sent to the Primary Letdown Tank through a letdown valve.

The gas, containing about 4.3% ammonia, is sent back to the compression section as recycle gas, where it mixes with the make-up gas before being recompressed and recycled back to the converter.

The ammonia collected in the letdown tank is sent to the refrigeration section via the ammonia-cooled condenser, where it is cooled down before being sent to the atmospheric storage tank or to other users.

Level controllers control the liquid levels in the High Pressure Separators. A valve on the tank vent line controls the pressure in the letdown tank. The temperature in the High Pressure Separators is controlled by regulation of the cooling liquid ammonia flow to the Ammonia Cooled Condenser and the 4E236 fans.
Because of the continuous re-circulation of unconverted gasses, the inert gasses Methane (CH₄) and Argon (Ar) build up in the synthesis converter loop and must be purged in order to maintain the desired concentration. The inerts in the synthesis converter loop are purged at the outlet of the High Pressure Separator (Recycle Gas Stream). The purge stream is cooled down in the Purge Condenser by heat exchange with liquid ammonia from the refrigeration section.

The exit gas from the condenser passes through the purge separator where the condensed ammonia is separated to be mixed with the ammonia flow from the refrigeration section. The non-condensable portion is sent to the Purge Recovery System.

The vent gas from the Primary Letdown Tank (containing the inerts that left the synthesis loop with the condensed ammonia) are mixed with the vent gas from the refrigeration section and cooled down in the vent condenser by heat exchange with liquid ammonia from the refrigeration section. The exit from the condenser passes through the Vent Gas Separator where the condensed ammonia is separated and sent to the refrigeration section. The non-condensable portion is sent to the vent gas section of the Purge Recovery Unit (PRU).

The temperatures in both the Purge and the Vent Separator are controlled automatically by means of flow control of the cooling ammonia.

The rate of purging and consequently the concentration of inerts in the Synthesis Loop are manually controlled from the control room board panel through a flow control valve.

The rate of vent gas is a function of the volume of ammonia and entrained gas entering the letdown tank and is controlled by a pressure control valve on the letdown tank.

Ammonia synthesis is carried out through the exothermic reaction of H₂ and N₂ at elevated pressure to increase equilibrium conversion, at elevated temperature to increase rate of reaction, and over a catalyst in order to start the reaction and improve the approach to equilibrium. There is only one chemical reaction involved in the synthesis of ammonia:

\[ \text{N}_2 + 3\text{H}_2 = 2\text{NH}_3 + \text{Heat} \]

The equilibrium point of this reaction is shifted to the right by higher pressures and lower temperatures. However, the temperature must be maintained at a high level in order to improve the rate of reaction and activate the catalyst.

The ammonia converter is complemented with the startup heater, which is used during startup to bring the temperature of the synthesis gas to the reaction level. The converter is equipped with a series of thermocouples and alarms to indicate the temperature throughout to catalyst beds and warn the operator of upset conditions.
The startup heater is a gas-fired furnace where the exit temperature of the gas is controlled by regulating the fuel gas flow to the heater. It is also equipped with a safety system to shut off the fuel gas on upset conditions.

**Process Safety Information**

**Study P&IDs**

The following Process & Instrument Diagrams (P&IDs) were studied during the PHA:

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<th>DESCRIPTION</th>
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<td>Synthesis Gas Compression Process</td>
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Due to the size of the P&IDs used for this study, the actual drawings will not be included in this report. The P&IDs used during the study have been retained by Alaska Nitrogen Products, LLC, PSM Group, and will be maintained in the PHA Revalidation P&ID file drawer.

**Other Available PSI**

Operating Procedures, Standard Operating Conditions and Limits (SOCLs), and Material Safety Data Sheets were available for review by the revalidation team as needed. Included in the SOCLs are the consequences of deviating from established safe operating limits. Design criteria and maintenance history for relief devices in this system were available for review as necessary.
2.0 RECOMMENDATIONS

Along with appearing in the revalidation study sheets, suggested recommendations identified by the study team are documented below. The recommendations are divided into three categories:

- "Actions" are relatively simple tasks that were assigned to team members, and could be completed before the end of the study.
- "Recommendations" are those tasks that require more evaluation, and possibly engineering or management direction.
- "Operability Recommendations" are those recommendations that have no impact on Safety or Environmental concerns, but would assist plant operability and/or efficiency.

The recommendations are numbered based on the attachment/worksheet in Section 3.0 where the cause/consequence scenario and the recommendation is documented. If there is more than one recommendation per worksheet, they are numbered chronologically. Where there are multiple/similar recommendations across several worksheets (i.e., drawing updates), they will be combined and presented as one, and tracked as a single recommendation. This list is to be used by management to resolve and document resolution of the suggested actions by the Process Hazards Analysis Revalidation team.

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<tbody>
<tr>
<td>Update P&amp;ID (R1I-1060) to show 1-1/2&quot; globe valves, MOC 800072.</td>
</tr>
<tr>
<td>(Reference: Attachment 5, page 1, of this report.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RECOMMENDATION: 5-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update P&amp;ID (R1I-1060) to show 251 psig (PSV620) and Out-of-Service.</td>
</tr>
<tr>
<td>(Reference: Attachment 5, page 1, of this report.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RECOMMENDATION: 5-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update P&amp;ID (R1I-1061) to show addition of a gate valve and a ¾&quot; globe valve between the 1500# steam line (S1500-140) and the LP bucket trap, MOC 501603.</td>
</tr>
<tr>
<td>(Reference: Attachment 5, page 2, of this report.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RECOMMENDATION: 5-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing incorrect. Correct numbering and valve size (PSV635A/B); and update P&amp;ID (R1I-1061 &amp; R1I-1062), MOC 501702.</td>
</tr>
<tr>
<td>(Reference: Attachment 5, page 3 &amp; 5, of this report.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RECOMMENDATION: 5-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update P&amp;ID (R1I-1061), original drawing shows ½&quot; S550-16-905 coming off of 3&quot; S550-12. The new drawing shows it coming off of the 2&quot; S550-12-905, which is incorrect (see redline drawing changes).</td>
</tr>
<tr>
<td>(Reference: Attachment 5, page 3, of this report.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RECOMMENDATION: 5-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add the rest of missing line to drawing (line ¼&quot; WC21-1535) and update P&amp;ID (R1I-1061).</td>
</tr>
</tbody>
</table>
RECOMMENDATION: 5-7
Update P&ID (R1I-1061) to show missing line from (PSV323A/B) R3I-3080 16" V632-1534 (see redline drawing changes).
(Reference: Attachment 5, page 4 of this report.)

RECOMMENDATION: 5-8
Return all FO/FC back to P&IDs.
(Reference: Attachment 5, pages 6, 8, 9, 14 & 15, of this report.)

RECOMMENDATION: 5-9
Assign instrument number to FM and update P&ID (R1I-1070).
(Reference: Attachment 5, page 6, of this report.)

RECOMMENDATION: 5-10
Update P&ID (R1I-1070) to show FIT10030 is upstream of control valve PCV708.
(Reference: Attachment 5, page 6 of this report.)

RECOMMENDATION: 5-11
Update P&ID (R1I-1070) to show the missing line number 1" AL707-908 (1F135).
(Reference: Attachment 5, page 7, of this report.)

RECOMMENDATION: 5-12
Update P&ID (R1I-1070) to show V10440 as a 16" valve and V10441 as a 10" valve (1E139 and 1E135).
(Reference: Attachment 5, page 8, of this report.)

RECOMMENDATION: 5-13
Correct number on missing PIs on inlet and outlet converter and update P&ID (R1I-1070).
(Reference: Attachment 5, page 9 of this report.)

RECOMMENDATION: 5-14
Update P&ID (4I-4060) to show the installation of a ΔP indicator on converter inlet/outlet (MOC 95-4-03).
(Reference: Attachment 5, page 9, of this report.)

RECOMMENDATION: 5-15
Add HEX valve and correct tap location and update P&ID (R4I-4060).
(Reference: Attachment 5, page 10, of this report.)

RECOMMENDATION: 5-16
Remove TI215 (Line 12" GS2003-GN) and update P&ID (R4I-4060).
(Reference: Attachment 5, page 10, of this report.)

RECOMMENDATION: 5-17
Remove level glass on P&ID (R4I-4070).
(Reference: Attachment 5, page 11, of this report.)

RECOMMENDATION: 5-18
Update P&ID (R4I-4070) to show numbering of instruments on 4F232A/B.
(Reference: Attachment 5, page 11, of this report.)

**RECOMMENDATION: 5-19**
Update P&ID (R4I-4120) to show the addition of vent to atmosphere on seal steam line 3" SE2023-AG (4GCT222B).
(Reference: Attachment 5, page 14, of this report.)

**RECOMMENDATION: 6-1**
Review the battery purchasing practice. Team suggests looking for another source of batteries.
(Reference: Attachment 6, page 2, of this report.)

**RECOMMENDATION: 6-2**
Implement routine calibration of gas detectors in Compressor Building (Plants 1 and 4).
(Reference: Attachment 6, page 4, of this report.)

**RECOMMENDATION: 6-3**
Repair MOV2954 to ensure packing integrity.
(Reference: Attachment 6, page 5, of this report.)

**RECOMMENDATION: 6-4**
Engineering to determine cause and repair exchanger head as necessary.
(Reference: Attachment 6, page 5, of this report.)

**RECOMMENDATION: 7-1**
Plant 4—Build a platform to allow access to hand-jacks.
(Reference: Attachment 7, page 1, of this report.)

**RECOMMENDATION: 7-2**
Plant 4—Provide MOVs for 1500# steam inlet block valve to GCT222A and 550# extraction valve.
(Reference: Attachment 7, page 1, of this report.)

**RECOMMENDATION: 7-3**
Plant 4—Team recommends replacing 550# extraction valve on Syngas turbine MOV (Plant 4).
(Reference: Attachment 7, page 2, of this report.)

**RECOMMENDATION: 7-4**
Plant 1—Review the feasibility of repositioning speak or installation of an additional speaker in Compressor Building (Plant 1).
(Reference: Attachment 7, page 3, of this report.)

**RECOMMENDATION: 7-5**
Team recommends covering all trip switches on DCS trip panel (Plant 1).
(Reference: Attachment 7, page 6, of this report.)

**RECOMMENDATION: 7-6**
Review the possibility to have a separate distinct tone for critical alarms (Plant 1).
(Reference Attachment 7, page 7, of this report.)
<table>
<thead>
<tr>
<th>RECOMMENDATION: 7-7</th>
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<tbody>
<tr>
<td>Continue to upgrade control valve sizing as applicable (active project in Engineering) for Plants 1 and 4.</td>
</tr>
<tr>
<td>(Reference: Attachment 7, page 11, of this report.)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>RECOMMENDATION: 7-8</th>
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<tbody>
<tr>
<td>Increase staffing level for Plant 1 and Plant 4.</td>
</tr>
<tr>
<td>(Reference Attachment 7, page 11, of this report.)</td>
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</tbody>
</table>

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<thead>
<tr>
<th>RECOMMENDATION: 8-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team feels that updated completion date is needed. (AR-27-98 has been assigned to FAMiller.)</td>
</tr>
<tr>
<td>(Reference: Attachment 8, page 3, of this report.)</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>RECOMMENDATION: 11-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update headers and footers on the P&amp;IDs that have missing information used during this revalidation study.</td>
</tr>
<tr>
<td>(Reference: Attachment 11, page 10, of this report.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RECOMMENDATION: 11-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate the frequent packing failures, and develop and implement a solution to prevent further failures.</td>
</tr>
<tr>
<td>(Reference: Attachment 11, page 14, of this report.)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>RECOMMENDATION: 11-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase insulation group staffing during summer months to catch up on insulation backlog.</td>
</tr>
<tr>
<td>(Reference: Attachment 11, page 29, of this report.)</td>
</tr>
</tbody>
</table>
### 3.0 STUDY WORKSHEETS & ATTACHMENTS

The following attachments were used throughout the PHA Revalidation and may be found on the following pages:

<table>
<thead>
<tr>
<th>Attachment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment 1</td>
<td>Revalidation Agenda</td>
</tr>
<tr>
<td>Attachment 2</td>
<td>Initial PHA Content Checklist</td>
</tr>
<tr>
<td>Attachment 3</td>
<td>Baseline PHA Screening Checklist</td>
</tr>
<tr>
<td>Attachment 4</td>
<td>Discussion of Recommendations from Baseline PHA</td>
</tr>
<tr>
<td>Attachment 5</td>
<td>Change Summary Worksheet</td>
</tr>
<tr>
<td>Attachment 6</td>
<td>Change Evaluation Checklist</td>
</tr>
<tr>
<td>Attachment 7</td>
<td>Human Factors Issues</td>
</tr>
<tr>
<td>Attachment 8</td>
<td>Revalidation Guideword Checklist</td>
</tr>
<tr>
<td>Attachment 9</td>
<td>&quot;What-If&quot; Worksheets</td>
</tr>
<tr>
<td>Attachment 10</td>
<td>Risk Ranking Matrix</td>
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<tr>
<td>Attachment 11</td>
<td>Wrap-Up Discussion Checklist</td>
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