

**Appendix K**  
**Hazardous Materials Technical Analysis**



**APPENDIX K**  
**HAZARDOUS MATERIALS TECHNICAL ANALYSIS**  
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## 1.0 INTRODUCTION

Hazardous materials are often a necessary part of industrial operations. Hazardous materials present potential risks based upon their specific chemical properties and characteristics. A hazard risk analysis evaluates a system or unit using hazardous chemicals by examining the process, the hazardous properties of substances involved with the process, the potential deviations that may affect the process, the potential consequences of a worst-case release scenario, and the appropriate controls and mitigations. Accordingly, this analysis was performed for the Project to address such potential risks.

Various hazardous materials will be used in connection with operation of the Project. This appendix addresses anhydrous ammonia (ammonia), hydrogen, acid gas (45 percent hydrogen sulfide, 55 percent carbon dioxide [CO<sub>2</sub>]), methanol, and synthesis gas [syngas] (which contains water, carbon monoxide, CO<sub>2</sub>, hydrogen, hydrogen sulfide, nitrogen, argon, and trace amounts of ammonia and carbonyl sulfide).

## 2.0 APPLICABLE REGULATORY REQUIREMENTS

The Project will comply with applicable laws, ordinances, regulations, and standards (LORS) pertaining to the storage and use of hazardous materials. The hazardous materials evaluated in this appendix (ammonia, hydrogen, acid gas [hydrogen sulfide] and syngas) are regulated hazardous materials under the California Accidental Release Prevention (CalARP) program, the federal Clean Air Act (CAA) Risk Management Program (RMP), and the Occupational Safety and Health Administration (OSHA) Process Safety Management (PSM). Additionally, although methanol is not regulated under CalARP, RMP, and PSM, it is regulated as a hazardous material under various federal and state regulations, and is therefore evaluated here.

The CalARP, RMP, and PSM programs set regulatory thresholds for the aforementioned hazardous materials, with the exception of methanol. The use or storage of any of these substances in excess of their specific regulatory thresholds triggers specific CalARP, RMP, and PSM program requirements. The specific threshold requirements and regulatory program applicability for the hazardous materials analyzed are provided in Table K-1, Regulatory Program Applicability.

The following sections provide the analysis that was performed for each of these five hazardous materials.

## 3.0 OFF-SITE CONSEQUENCE ANALYSIS

Off-site consequence analysis (OCA) modeling was performed to address the potential off-site impacts from a worst-case release scenario for each substance. The OCA modeling was used to determine if an accidental chemical release would remain within the Project Site or the Controlled Area, or extend off-site.

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**Table K-1  
Regulatory Program Applicability**

Hazardous Chemical	Federal RMP Threshold (pounds)	State CalARP Threshold (pounds)	Federal PSM Threshold (pounds)	Regulatory Program Applicability
Anhydrous Ammonia	10,000 <sup>(1)</sup>	500	10,000	Project will store 3.8 million gallons of anhydrous ammonia (approximately 10,733 short tons of ammonia) for turbine emissions control (Selective Catalytic Reduction), production of a urea and ammonium nitrate (UAN) solution used as a fertilizer, and for wholesale to commercial users. The ammonia will be subject to state CalARP program requirements and federal RMP program requirements. The ammonia will also be subject to federal PSM program requirements.
Hydrogen	10,000	10,000		The Project will store 30,000 scf (approximately 150.8 pounds) of hydrogen for electrical generator cooling. The hydrogen will not be subject to either state CalARP or federal RMP program enforcement because it does not exceed the minimum threshold levels. Hydrogen is not listed in the PSM regulations.
Syngas (Hydrogen, Hydrogen Sulfide, Methane, Carbon Monoxide, CO <sub>2</sub> , Ammonia)	Hydrogen 10,000 Hydrogen Sulfide 10,000 Methane 20,000 Ammonia 10,000 Carbon Monoxide N/A CO <sub>2</sub> N/A	Hydrogen 10,000 Hydrogen Sulfide 500 Methane 10,000 Ammonia 500 Carbon Monoxide N/A CO <sub>2</sub> N/A	Hydrogen Sulfide 1,500 Anhydrous Ammonia 10,000	The Project will generate syngas in the gasification block of the facility. The syngas will not be subject to either state CalARP, federal RMP, or federal PSM program requirements ( <i>see Note<sup>(2)</sup></i> ).
Acid Gas (Hydrogen Sulfide, CO <sub>2</sub> )	Hydrogen Sulfide 10,000 CO <sub>2</sub> N/A	Hydrogen Sulfide 500 CO <sub>2</sub> N/A	Hydrogen Sulfide 1,500	The Project will generate acid gas from the Acid Gas Removal unit of the facility. The quantities of acid gas (hydrogen sulfide) do not trigger regulatory requirements under the state CalARP, federal RMP, or federal PSM program requirements ( <i>see Note<sup>(3)</sup></i> ).
Methanol	N/A	N/A		The Project Site will have approximately 300,000 gallons of methanol on site for use in the Acid Gas Removal unit. Methanol will be stored within a large aboveground storage tank. Another approximately 250,000 gallons will be contained within process equipment and piping. Methanol is not regulated under the state CalARP, federal RMP, or federal PSM program enforcement. However, methanol is regulated under 29 CFR § 1910, 40 CFR §§ 116, 117, 355, 372, 302.

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**Table K-1  
Regulatory Program Applicability**

Hazardous Chemical	Federal RMP Threshold (pounds)	State CalARP Threshold (pounds)	Federal PSM Threshold (pounds)	Regulatory Program Applicability
Nitric Acid	15,000 (conc. 80% or greater)	1,000	500 (94.5% by weight or greater)	The Project will store a maximum of 120 tons of nitric acid (60% by weight) in a storage tank. Since the concentration of nitric acid is under the concentration specified by the federal RMP and federal PSM thresholds, the nitric acid will not be subject to federal RMP and PSM program enforcement. However, since CalARP regulations do not specify a minimum concentration, nitric acid will be subject to CalARP RMP program enforcement.

**Notes:**

- (1) Federal RMP requirements apply only to aqueous ammonia solutions that are of a concentration of 20 percent or greater by weight.
- (2) Only hydrogen, hydrogen sulfide, ammonia, and methane in the syngas mixture are regulated chemicals under federal RMP or state CalARP regulations. Carbon monoxide is a hazardous substance, but is not regulated by either the federal RMP or state CalARP regulations. CO<sub>2</sub> is not a regulated hazardous substance. The quantities of regulated substances in syngas do not trigger regulatory requirements for the following two reasons: 1) syngas is not stored on site but consumed within the operation as it is produced, and therefore is not a stationary source; and 2) quantities are below regulatory thresholds.
- (3) Acid gas is composed of approximately 55 percent CO<sub>2</sub> and 45 percent hydrogen sulfide. CO<sub>2</sub> is not a regulated hazardous substance. Hydrogen sulfide is a regulated substance under federal RMP or state CalARP regulations; however, the Project will not be subject to these regulations for the two following reasons: a) hydrogen sulfide is not stored on site but converted to elemental sulfur within the operation as it is produced, and therefore is not a stationary source; and b) quantities are below regulatory thresholds.

- CalARP = California Accidental Release Prevention
- CFR = Code of Federal Regulations
- lbs. = pounds
- N/A = not applicable
- RMP = Risk Management Plan
- scf = standard cubic foot

The Project Site consists of the 453-acre area directly used for the IGCC electrical generation, low-carbon nitrogen-based products manufacture. The Controlled Area consists of an additional 653 acres of land, which surround the Project Site on the south, west, and north. Both the Project Site and Controlled Area are lands that will be owned by HECA. Therefore, HECA has control of all activities and development that may occur in either land. Territory extending beyond both the Project Site and Controlled Area boundaries is considered to be off site in this analysis.

The OCA models provide an examination of separate hazards: (1) the dispersion of the substances in the form of a vapor cloud; (2) the ignition of the released substance; and/or (3) pool fire. The modeling assumptions for a worst-case release scenario are that the total contents from the largest inventory (e.g., tank or pipe) are accidentally vented.

For dispersion modeling, the calculations also assumed the worst-case atmospheric conditions during such a release, when applicable. These conditions provide conservative results, because these extreme and unlikely climatic conditions maximize the vaporization to create the vapor cloud and minimize its dispersion. The specific atmospheric parameters under which a worst-case release scenario is examined are provided by the California Code of Regulations (CCR) Title 19 § 2750.2, and consist of the following:

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- Temperature – The highest temperature—115 degrees Fahrenheit (°F)—is recorded for the area in the past 3 years. High temperatures are used because increased temperatures accelerate the vaporization rate of substances upon release.
- Average Humidity – 50 percent atmospheric humidity is used when performing the worst-case scenario evaluation. An average humidity of 50 percent is found during months providing the highest temperatures for the area. This level of humidity provides low interference for chemical dispersion, but is still taken into consideration to provide conservative results.
- Wind Speed – A 1.5-meter-per-second (m/s) wind speed is used when performing the worst-case scenario evaluation (equivalent to 4.92 feet per second [ft/s]). A low wind speed prevents the quick dispersion of vapor clouds.
- Atmospheric Stability – An atmospheric stability level of F is applied for the worst-case scenario OCA.<sup>1</sup> The Level F atmospheric stability provides the most stable atmospheric environment where the tendency of the atmosphere is to resist or enhance vertical motion and/or turbulence—this also contributes to minimum dissipation of the vapor cloud.

The U.S. Environmental Agency (USEPA) approved ALOHA<sup>®</sup> software version 5.4.1 for use in examining the impacts from a hypothetical accidental spill. ALOHA<sup>®</sup> is a Gaussian plume model that incorporates continuous source and meteorological parameters.

For vapor cloud explosion calculations, USEPA's RMP OCA guidance was used. The Endpoint selected by the USEPA as a significance criterion is an overpressure of 1.0 pound per square inch (psi) for vapor cloud explosion. An overpressure of 1.0 psi may cause partial demolition of houses and shattering of glass windows. Blast impacts are also of concern wherever flammable materials and ignition sources are present, or where processes operate under high temperatures and pressures.

The potential impact distance from a worst-case release scenario for a vapor cloud explosion was determined through the following equation:

$$X = 0.0081 \left( 0.1 W_f \frac{H_{Cf}}{H_{CTNT}} \right)^{1/3} \quad \text{(Equation K-1)}$$

where:

X	=	distance to overpressure of 1 psi (miles)
W <sub>f</sub>	=	weight of flammable substance (pounds)
H <sub>Cf</sub>	=	heat of combustion of flammable substance (kilojoules/kilogram [kJ/kg])
H <sub>CTNT</sub>	=	heat of combustion of trinitrotoluene (4,680 kJ/kg)

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<sup>1</sup> Level F atmospheric stability: provides the most stable atmospheric environment where the tendency of the atmosphere is to resist or enhance vertical motion and/or turbulence—this also contributes to minimum dissipation of the vapor cloud.

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In some cases (e.g., hydrogen), the RMP\*Comp software developed by the USEPA and the National Oceanic and Atmospheric Administration (NOAA) was used as an additional tool to determine the 1 psi overpressure impact distance.

For pool fire scenarios, the analysis was conducted in accordance with the appropriate regulatory guidance as follows: the modeling basis for a pool fire estimates the distance from the center of a pool fire to the heat radiation Endpoint (defined as 5 kilowatts per square meter [kW/m<sup>2</sup>]). The worst-case release that is assumed for the model is as follows: the entire contents of the vessel are released, forming a pool of fire of approximately 1 inch in liquid thickness.

The following equation was used to estimate the possible impact distance from the pool fire:

$$X = H_c \sqrt{\frac{0.0001 A}{5000 \pi (H_v + C_p (T_B - T_A))}} \quad \text{(Equation K-2)}$$

where:

X	=	distance to the 5-kilowatt-per-square-meter Endpoint (meters)
H <sub>C</sub>	=	heat of combustion of the flammable liquid (joules/kg)
H <sub>V</sub>	=	heat of vaporization of the flammable liquid (joules/kg)
A	=	pool area (meters squared [m <sup>2</sup> ])
C <sub>P</sub>	=	liquid heat capacity (joules/kg -°Kelvin [K])
T <sub>B</sub>	=	boiling temperature of the liquid (°K)
T <sub>A</sub>	=	ambient temperature (°K)

Models considering the ignition of a material (such as hydrogen, syngas, methanol, and acid gas) examine the impact from a vapor cloud explosion of the flammable material, or the heat or radiation derived from the ignition of the material. As stated above, the OCA for these scenarios uses the maximum quantity of the materials and the specific combustion characteristics of the material to conservatively assess the potential impact distance from either an explosion or a pool of fire.

The following sections provide the specific modeling criteria, programs, and procedures applied for each of the materials.

### 3.1 Modeling Parameters

#### 3.1.1 Anhydrous Ammonia

The Project will store approximately 3.8 million gallons of anhydrous ammonia (approximately 10,733 short tons). The design for the anhydrous ammonia storage system is state-of-the art and provides maximum protection against the accidental release of ammonia. The storage system uses two vertical cylindrical steel tanks each housed in its own unique second vessel with double integrity, elevated above ground on a concrete pedestal, and each having a storage capacity of

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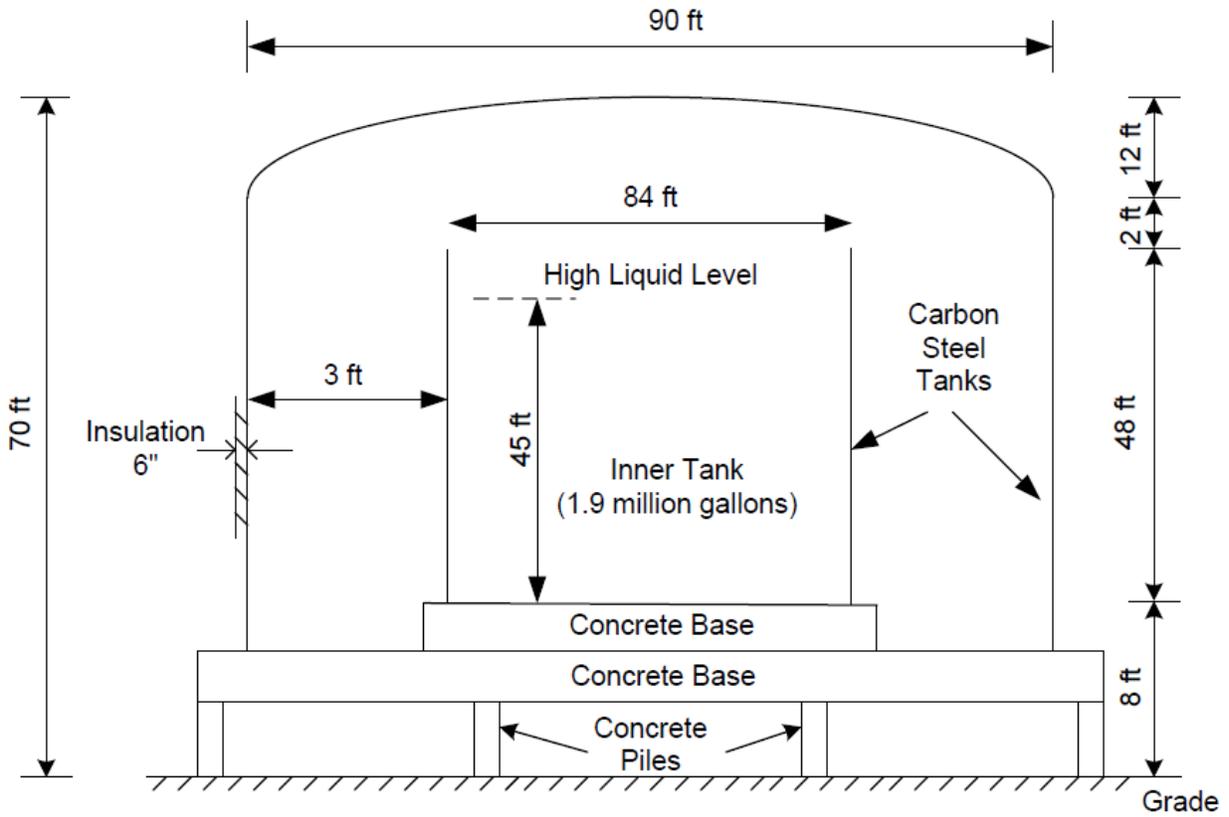
5,367 tons, which is equivalent to 1.9 million gallons. The storage system incorporates an inner tank approximately 84 feet in diameter, containing refrigerated liquid ammonia with a 3-foot interstitial space between the inner tank and outer sidewall. The inner tank will be constructed out of steel, in accordance with API 620 (Appendix R). The outer sidewall will also be constructed out of steel and will contain insulation and aluminum cladding. Sensors will be installed in the interstitial space to detect liquid ammonia leaks. The top of the tank will be a dome with a suspended deck insulated by mineral wool. Between the suspended deck and the top roof, the presence of ammonia vapor acts as an insulating media. The tanks will be elevated on a concrete pedestal with a concrete base. Siporex (light-weight concrete with high thermal insulation) blocks, foam glass, and layers of sand will serve as insulating layers between the pedestal and the vessel. The concrete pedestal prevents ice formation in the ground under the foundation. The ammonia storage system will be surrounded on all sides by a 4-foot-high reinforced-concrete barrier wall. A worst-case release of ammonia will be contained in the secondary housing, and released only through the pressure-relief valves. A scenario that assumes the simultaneous failure of both the primary tank and the secondary housing is not likely. The ammonia storage system is shown on Figures A and B.

The most likely scenario using a gun fired from the perimeter of the facility will, at the most, impact the outer tank. Based on the "Army Ammunition Data Sheets Small Caliber Ammunition FSC 1305," a 0.30-Caliber armor piercing (AP) M2 round with a muzzle velocity of 2,715 feet per second will have a penetration when "fired at 7/8-inch thick homogenous armor plate at 100 yards, will be not less than 0.42 inch." The closest distance from the ammonia system centerline to the earthen berm is approximately 1,599 feet. The closest distance from the centerline to the fence line is approximately 2,253 feet, with apparent obstructions to line of sight. Such a round fired from the fence line at the ammonia system will lose significant muzzle velocity and will have subsequently less penetration, and is unlikely to puncture the secondary housing. An armor piercing M2 round is also not commonly used for hunting, and is relatively expensive, so it is unlikely a rifle will be chambered with such a round.

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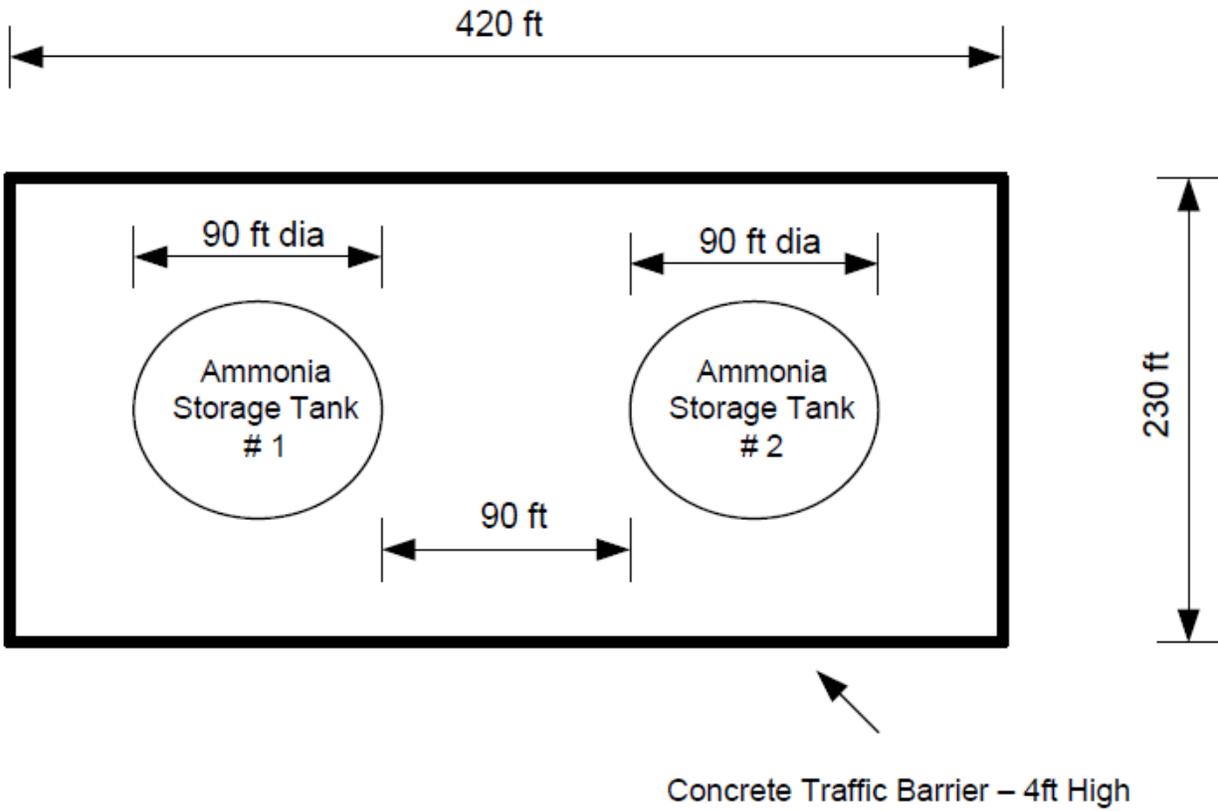
**Figure A**  
Ammonia Storage Tank Estimated Dimensions



A

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**Figure B**  
Ammonia Storage System Tank Layout



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Ammonia will be used as a reducing agent used for control of nitrogen dioxide (NO<sub>2</sub>) emissions from the combustion turbine generators (CTGs), used as a component in manufacturing of fertilizer, and will also be sold off site. Ammonia is a potentially toxic chemical that will vaporize upon release into a vapor cloud.

Due to its hazardous characteristics, ammonia is regulated by state and federal regulations. As presented in Section 5.12, Hazardous Materials Handling, of this Application for Certification (AFC) Amendment, the use and/or storage of ammonia is regulated by the federal CAA RMP, federal PSM, and the CalARP program. The regulations are found in the Code of Federal Regulations (CFR) Title 40 Part 68, CFR Title 29 Part 1910, California Health and Safety Code §§ 25531 to 25543.3, and CCR Title 19, §§ 2735.1 to 2785.1. The aforementioned regulations governing the use and storage of ammonia require facilities using the substance in quantities exceeding the imposed threshold to develop and implement an RMP and a PSM. As indicated in Section 5.12 of the AFC Amendment, a CalARP RMP is required and will be submitted to the Kern County Environmental Health and Safety Department.

A component of the RMP involves the evaluation of potential off-site consequences derived from the accidental worst-case release of ammonia. Following the regulatory guidance for OCAs, an OCA was conducted for a worst-case accidental release under worst-case atmospheric conditions for the Project Site. Under the scenario, all 3.8 million gallons of ammonia are assumed to flow instantaneously into the interstitial space between the inner tank and outer sidewall. Because the outer sidewall is exposed to the environment, it will be nearer to ambient temperature. Due to the temperature gradient between the liquid ammonia and outer sidewall, heat will transfer to the ammonia and the liquid ammonia will begin to vaporize until temperature differences approach thermal equilibrium. The vaporization of ammonia will cause an increase in pressure which will be released through a relief valve located at the top of the vessel. Ammonia will be at atmospheric pressure, with the relief valve set at approximately 2 psig. The design of the tank provides the maximum safety against the release of ammonia. When in a worst-case release scenario, the amount of ammonia vented will be limited. The model examines the results of the subsequent dispersion over a 1-hour period. In order to determine the total rate of ammonia venting, the following cases were considered:

- **Case 1: Heat Ingress** – The transfer of heat from hot ambient air (external to the tank) to cold, saturated, stored ammonia leading to ammonia vaporization proportional to the heat flow.
  - The ambient air temperature is based on the extreme high case of 115°F.
  - Liquid ammonia is stored at 0.44 psig and -28°F.
  - The vapor ammonia in the tank annular region will be well mixed by natural convection, and therefore the bulk vapor temperature will be the same as the saturated liquid (-28°F). The heat transfer calculation then considers the heat ingress by the following path: bulk air -> insulation -> steel tank wall -> bulk vapor ammonia.

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- The heat flow was calculated using both convective (film) and conductive (bulk) heat transfer resistances in the steady-state heat transfer equation, leading to an ammonia vaporization rate of *3.0 lb/min per tank*. In the case of the refrigeration package failing, both storage tanks will vent simultaneously.
- The maximum vaporization of ammonia for Case 1 is **6.0 lb/min**.
- **Case 2: Fill Rate Displacement** – the rate of ammonia vapor displaced by the inflow of the liquid ammonia at design rate produced in the Ammonia Synthesis Plant.
  - Normal out-breathing is a result of the maximum inflow of liquid into the tank and subsequent vapor displacement caused by such inflow. The maximum inflow is based on the design rate of ammonia production in the Ammonia Synthesis Plant, 2,087 STPD.
  - The calculated volume of ammonia vapor displaced for Case 2 is **3.6 lb/min**.
- **Case 3: Non-Release For Inner Tank Rupture Calculation** – Built-up pressure from ammonia release does not exceed the ammonia storage tank design pressure of 2.5 psig.
  - Stored liquid ammonia is contained within the inner walls of the storage tank, and maintains a constant temperature with the vapor space ammonia. The heat flow was calculated using the overall heat transfer equation. Subsequently, intermediate temperatures were calculated along the temperature gradient from the bulk air to the bulk ammonia vapor. The resulting temperature inside of the outer wall of the storage tank is -17.2°F.
  - Assuming the inner wall of the storage tank ruptured, resulting in the liquid volume being contained within the outer wall of the storage tank, the heat released into the ammonia liquid by cooling the steel wall from -17.2°F to -28°F is calculated. The resulting vaporized ammonia leads to a molar flow rate increase of approximately 30 lb-mol.
  - The resulting pressure is approximately 2 psig, which is contained within the 2.5 psig designed storage tank. Therefore, no ammonia is released for Case 3.
- **Case 4: Secondary Cooling** – The rate of ammonia vaporized from the cooling of the steel wall driven by the heat flux tangential to the vessel wall (from the top of the dome to the bottom of the tank wall and into the bulk liquid).
  - The storage wall below the liquid is assumed to have cooled instantly to -28°F.
  - Using the conductive heat transfer equation, the heat flow calculated results in an ammonia vaporization rate of *1 lb/hr*.

After analyzing all cases, the total maximum simultaneous ammonia venting rate is *9.6 lb/min*.

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The analysis also assumes the worst-case climate conditions consisting of an ambient temperature of 115°F (the highest average temperature within the Project area), a 50 percent average humidity, a 1.5 m/s wind speed (i.e., 4.9 ft/s), and a level F atmospheric stability.

During the hypothetical worst-case release scenario, the ammonia is assumed to evaporate in the form of gas via laminar mass transfer. The ALOHA<sup>®</sup> model examined the effects of the designated wind speed and atmospheric turbulence force that move the released molecules as gas through the air. The examination of the affecting atmospheric parameters allow for an evaluation of the total area impacted.

Three levels of concern were used to evaluate the potential impacts associated with the hypothetical worst-case aqueous ammonia release:

- CEC Significance Level – The CEC Significance Level is 75 ppmv and constitutes the odor threshold of ammonia.
- Emergency Response Planning Guideline Level 2 (ERPG-2) – The ERPG-2 Level, developed by the American Industrial Hygiene Association (AIHA) is 150 ppmv. It is the maximum concentration in air where a 1-hour exposure will not result in irreversible or other serious health effects.
- USEPA/CalARP Toxic Endpoint (the “Endpoint”) – The CalARP for ammonia concentration, based on USEPA 40 CFR 68, is 200 ppmv (0.14 milligrams per liter [mg/L]) averaged over 1 hour. The Endpoint concentration is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual’s ability to take protective action.

The anhydrous ammonia modeling results are presented in Section 3.2 of this appendix, titled Results of Modeling.

### 3.1.2 Hydrogen

The unique properties of hydrogen—low density, high specific heat, and thermal conductivity—make it an ideal coolant for electricity generators. Hydrogen is also now being widely used as a coolant for power plants. In a hydrogen-cooled generator, the hydrogen gas is circulated in a closed loop within the generator to remove heat from its active parts; then it is cooled by gas-to-water heat exchangers that are part of the stator frame. The Project will use a hydrogen-cooled generator and store 30,000 standard cubic feet (scf) of compressed hydrogen gas in a pressurized multi-tube trailer as make-up for the loss within the generator.

Although hydrogen gas is not toxic, it is a highly flammable material. The potential risks posed by a hydrogen leak are mainly fire and explosion. Due to its low ignition energy, the potential impact of a hydrogen-oxygen fire is usually localized. A hydrogen release may also pose an explosion risk, which is generally localized with small-source volumes.

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To determine the behavior of hydrogen under a worst-case release scenario, we have examined its properties, along with the historical data, to evaluate the potential impacts in this section. Although the storage amount of hydrogen at the Project Site is far below the federal or state regulatory threshold, a worst-case OCA evaluation was performed in order to assess the potential consequences of a worst-case release scenario, and the need for appropriate controls and mitigations. The examination was performed following instruction from USEPA's RMP OCA guidance (April 1999) document (USEPA RMP OCA guidance). In addition, the USEPA-approved RMP\*Comp software for hazardous chemical release modeling was also used to confirm the results. These results are presented in Section 3.3, Modeling Outputs.

The purpose of the modeling was to estimate the consequences from potential releases of hydrogen gas from the storage vessel. Due to the chemical properties of hydrogen (i.e., ignitability and reactivity) and historical data (obtained from public databases of hydrogen incidents throughout a variety of industries), the hazard caused by explosion is considered to be the most significant potential impact for an accidental hydrogen release. The USEPA vapor cloud explosion method was used for the evaluation (see Equation K-1 in Section 3.0).

The OCA modeling performed for the worst-case release scenario was based on USEPA's RMP criteria as follows:

The contents of the entire hydrogen tube trailer (30,000 scf) are accidentally vented. For vapor cloud explosions, the total quantity of hydrogen is assumed to form a vapor cloud. (Note: vapor cloud explosions generally are considered unlikely events). The entire cloud is assumed to be within the flammability limits, and the cloud is assumed to explode. Ten percent of the flammable vapor in the cloud is assumed to participate in the explosion. The impact is measured as the distance to the 1 psi overpressure level. This is determined using Equation K-1 (from USEPA's RMP OCA guidance). According to USEPA's RMP OCA guidance Exhibit C-1,  $H_c$  for hydrogen is 119,950 kJ/kg. Other input parameters used in Equation K-1 are provided in Table K-2, Hydrogen Modeling Input Parameters.

**Table K-2**  
**Hydrogen Modeling Input Parameters**

Chemical	Storage Type	Volume (scf)	Weight (lbs)	$H_c$ (kJ/kg)	Density (lb/ft <sup>3</sup> )
Hydrogen	Compressed gas	30,000	159	119,950	0.0053

Notes:

scf = standard cubic foot (volume is measured under standard condition 59°F, 1 atm)

kJ/kg = kilojoules per kilogram

lbs/ft<sup>3</sup> = pounds per cubic feet

The weight of the flammable substances, in this case hydrogen, is calculated using the equation below:

$$W_h = V\rho \quad \text{(Equation K-3)}$$

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where:

$W_h$	=	weight of hydrogen (lbs)
$V$	=	volume of hydrogen (ft <sup>3</sup> )
$\rho$	=	density of hydrogen gas (lb/ft <sup>3</sup> )

Because the amount of hydrogen to be stored on site is 30,000 scf, and the density of hydrogen gas at 60°F, 1 atmosphere (atm) is 0.0053 lb/ft<sup>3</sup>,

$$W_h = 30,000 \text{ ft}^3 \times 0.0053 \text{ lb/ft}^3 = 159 \text{ lbs}$$

The hydrogen modeling results are presented in Section 3.2 of this appendix.

### 3.1.3 Acid Gas (45 percent Hydrogen Sulfide)

The Rectisol<sup>®</sup> process will remove acid gas to significantly reduce sulfur dioxide emissions. Acid gas is removed from shifted syngas to produce low-sulfur hydrogen-rich fuel for low-carbon electrical generation. The acid gas will consist of an approximately 45 percent hydrogen sulfide and 55 percent CO<sub>2</sub> mixture. Of the two substances, hydrogen sulfide presents a greater potential hazard due to its toxic and flammable characteristics.

Hydrogen sulfide is classified as a regulated hazardous substance by federal CAA § 112(r) RMP regulations and by CalARP regulations. The regulatory threshold for hydrogen sulfide is 10,000 pounds under CAA RMP regulations, and 500 pounds under CalARP regulations. The toxicity concentration level set by the CAA RMP/CalARP for hydrogen sulfide is 32 parts per million (ppm) (0.042 mg/L). However, the quantities of hydrogen sulfide do not trigger regulatory requirements under CalARP and the federal CAA RMP for worst-case modeling because (1) hydrogen sulfide is not stored on site, but converted to elemental sulfur within the operation as it is produced—thus, there is no stationary source; and (2) quantities are below regulatory thresholds. Nonetheless, the Project performed an OCA for the worst-case release scenario to investigate the potential impact from the explosion and toxicity of a hydrogen sulfide vapor cloud.

The worst-case release scenario for hydrogen sulfide was studied using the USEPA-approved ALOHA<sup>®</sup> 5.4.1 air dispersion modeling program and with worst-case atmospheric and environmental conditions as provided by CalARP regulations. Worst-case atmospheric conditions under which the hypothetical release was examined were set as follows: wind speed of 1.5 meters per second; an F atmospheric stability level (most stable); atmospheric temperature of 115°F; and atmospheric humidity of 50 percent. These conditions are default settings on the RMP\*Comp modeling program per regulatory protocols established by CalARP.

The ALOHA<sup>®</sup> 5.4.1 model requires calculation of the weight of the regulated chemical. The model assumes the total quantity of hydrogen sulfide released is identical to the volume of hydrogen sulfide found within the piping system. In order to obtain the weight of the hydrogen sulfide found in the acid gas mixture, the ideal gas law was applied for the hydrogen sulfide component of the total acid gas within the transfer piping system (i.e., 45 percent of total pipe volume). The HECA acid gas handling system was analyzed to determine the maximum

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potential volume of hydrogen sulfide within the acid gas. The maximum volume of hydrogen sulfide within this system is equivalent to 305 cubic feet. It is on this basis that the total mass of the system was calculated.

The ideal gas law was used to determine the total amount of moles found for hydrogen sulfide in the acid gas piping system (see equation that follows).

$$PV = nRT$$

$$n = PV/RT$$

$$\text{Weight of Gas} = n \times \text{Molecular Weight of H}_2\text{S (34 lb/lb-mol)}$$

A process pressure of 30 pounds per square inch absolute (psia) and process temperature of 120°F were selected for the equation based on operational conditions that will be found at the Project. Additionally, the Ideal Gas Constant (R), which is equivalent to 10.73 cubic feet·psia/lb-mol°R, was also applied to the equation. After calculating the moles of hydrogen sulfide, the weight of hydrogen sulfide in the piping system (50 pounds) was calculated by multiplying the molecular weight of hydrogen sulfide with the moles. The total weight for the hydrogen sulfide gas for the acid gas piping system is shown below:

System Capacity (actual cubic feet)	H <sub>2</sub> S Volume (actual cubic feet)	Moles of H <sub>2</sub> S (lb-mol)	Weight of H <sub>2</sub> S (lbs)
677	305	1.47	50

The quantities shown in the table above correspond to a maximum pipe length of 864 feet, which was used in the ALOHA<sup>®</sup> 5.4.1 modeling program, under worst-case scenario conditions, to determine the distance to the Endpoint from the complete release of the pipe contents. ALOHA<sup>®</sup> 5.4.1 was used to determine the distance to the Endpoint concentration of 32 ppm (0.042 mg/L), as required by CAA § 112 (r) RMP and CalARP regulations. A 10-minute time of release was also selected for the scenario, following CAA § 112 (r) RMP and CalARP regulatory requirements.

Although not regulated as a flammable substance, hydrogen sulfide may present a hazard of producing a flammable vapor cloud upon an accidental release. In order to determine the most significant potential impact that could be developed from a worst-case release scenario for a flammable hydrogen sulfide vapor cloud, USEPA's RMP OCA guidance document was used for determining the distance to 1 psi overpressure for vapor cloud explosions. The pipeline diameter was the key input parameter for the vapor cloud explosion analysis.

Equation K-1 was then used to calculate the potential impact distance as a result of the worst-case vapor cloud explosion. Results of the hydrogen sulfide modeling are presented in Section 3.2 of this appendix.

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### 3.1.4 Syngas

The feedstock will be gasified to produce syngas, which will be processed and purified to produce a hydrogen-rich fuel. This hydrogen-rich fuel will be used to fuel the combustion turbine for low-carbon baseload power generation.

Wet-syngas consists primarily of water, carbon monoxide, CO<sub>2</sub>, hydrogen, hydrogen sulfide, nitrogen, and argon, with trace amounts of ammonia and carbonyl sulfide. The approximate quantity of the relevant hazardous compounds for the syngas stream is presented in the Table K-3.

**Table K-3**  
**Relevant Hazardous Compounds**

Component	Quantity in Wet-Syngas (lbs) <sup>(3)</sup>
H <sub>2</sub> <sup>(1)</sup>	216
CO <sup>(2)</sup>	4,185
CH <sub>4</sub> <sup>(1)</sup>	1
H <sub>2</sub> S <sup>(1)</sup>	181
NH <sub>3</sub> <sup>(1)</sup>	15

Note:

1. H<sub>2</sub>, CH<sub>4</sub>, H<sub>2</sub>S, and NH<sub>3</sub> are all regulated chemicals. However, the mass proportion of each chemical within the syngas is such that the chemicals fall below regulated quantities. Regulated quantity for H<sub>2</sub> > 10,000 pounds, CH<sub>4</sub> >10,000 lbs, H<sub>2</sub>S > 500 pounds, and NH<sub>3</sub> > 500 pounds, based on CalARP regulations. Because the quantity of the syngas is below the regulated levels, syngas is not considered a regulated substance.
2. Carbon monoxide is a hazardous substance with both toxic and ignitable characteristics.
3. The quantity (by weight) of each component is based on the weight found within the Gasifier System.
4. Additional syngas components have not been included in the table.

Carbon monoxide, hydrogen, hydrogen sulfide, ammonia, and methane are considered to be hazardous substances found in syngas. Of these substances, only hydrogen, hydrogen sulfide, ammonia, and methane are regulated chemicals under federal and state regulations. Hydrogen and methane are regulated as flammable substances; ammonia and hydrogen sulfide are regulated for toxicity (see 40 CFR 68.130 and 19 CCR 2770.5). However, the quantities of these constituents in the syngas do not trigger regulatory requirements under CalARP and the federal CAA RMP for worst-case modeling because (1) syngas is not stored on site, but consumed within the operation as it is produced; thus, there is not considered to be a stationary source; and (2) quantities are below regulatory thresholds.

Nonetheless, the Project performed an OCA for the worst-case release scenario to investigate the potential impact from the explosion, combustion, and toxicity levels of a syngas vapor cloud.

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The Project considered the release from a source point that would provide a worst-case release scenario. The worst-case syngas release source can be attributed to the gasification section of the Project, because it is this zone that will potentially store the highest concentrations of hazardous materials in syngas at any given time. The gasification section includes the gasifier vessel quenched zone, syngas scrubber vessel, and the connecting pipeline for all of the equipment (the largest quantity that can be released is from the Gasifier System).

In order to evaluate the worst-case release scenario for a syngas vapor cloud explosion, a catastrophic release of the syngas from equipment and process piping at the site was assumed based on the volume of the gasifier and downstream equipment up to the closest isolation valve, and the maximum concentrations of each flammable component found in the syngas mixture. Flammable substances including hydrogen, carbon monoxide, and hydrogen sulfide were considered in the modeling calculations. Methane and ammonia were excluded from the calculations, because syngas contains trace amounts of these substances that would not provide a significant contributing factor to trace the vapor cloud explosion impact.

The syngas vapor cloud explosion evaluation was conducted following USEPA's RMP OCA guidance document (see Equation K-1 in Section 3.0). The purpose of the modeling was to estimate the consequences from a hypothetical worst-case release of syngas at the Project Site. To calculate the heat of combustion of the syngas, the following equation was used:

$$H_{\text{Syngas}} = \frac{W_{\text{H}_2}}{W_{\text{CO}+\text{H}_2+\text{H}_2\text{S}}} \times HC_{\text{H}_2} + \frac{W_{\text{CO}}}{W_{\text{CO}+\text{H}_2+\text{H}_2\text{S}}} \times HC_{\text{CO}} + \frac{W_{\text{H}_2\text{S}}}{W_{\text{CO}+\text{H}_2+\text{H}_2\text{S}}} \times HC_{\text{H}_2\text{S}} \quad \text{(Equation K-4)}$$

where:

$W_{\text{H}_2}$	=	weight of H <sub>2</sub> (lbs)
$W_{\text{CO}}$	=	weight of CO (lbs)
$W_{\text{H}_2\text{S}}$	=	weight of H <sub>2</sub> S (lbs)
$H_{\text{H}_2}$	=	heat of combustion of H <sub>2</sub> (joules/kg)
$H_{\text{CO}}$	=	heat of combustion of CO (joules/kg)
$H_{\text{H}_2\text{S}}$	=	heat of combustion of H <sub>2</sub> S (joules/kg)
$H_{\text{syngas}}$	=	heat of combustion of syngas (joules/kg)

Results provided from the vapor cloud explosion analysis performed tend to be conservative, because they exclusively account for the hydrogen, carbon monoxide, and hydrogen sulfide in the syngas. These three compounds only account for approximately one-third of the syngas components. The remaining syngas components are mainly composed of non-flammable substances (e.g., H<sub>2</sub>O), which may reduce the potential for combustion of the syngas. However, in order to assess the worst-case scenario, non-flammable substances were excluded from the modeling. Results derived from the application of Equation K-1, for the potential impact distance as a result of the worst-case vapor cloud explosion, are presented in Section 3.2 of this appendix.

In order to evaluate the potential impact from a toxic vapor cloud generated from the release of the syngas, the distance to the Endpoint for ammonia, hydrogen sulfide, and CO<sub>2</sub> was

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evaluated. Each hazardous substance was evaluated individually based on the specific quantity found in the syngas.

Ammonia and hydrogen sulfide are regulated hazardous substances. Each substance composes only a small portion of the syngas. However, because both compounds are considered hazardous regulated materials and have been classified as toxic, the impact distance generated from the release of these materials was evaluated through the ALOHA<sup>®</sup> modeling program. The concentrations of concern modeled for ammonia and hydrogen sulfide were set at 0.14 mg/L and 0.042 mg/L, respectively, as provided by CalARP and federal CAA § 112(r) RMP regulations.

Unlike ammonia and hydrogen sulfide, carbon monoxide is not classified as a regulated hazardous substance by federal CAA § 112(r) RMP regulations or by CalARP regulations. However, carbon monoxide is a hazardous material with toxic characteristics. In order to evaluate the potential health hazards that could be attributed to the carbon monoxide component of the syngas, an OCA was conducted. Table K-4 below provides some regulatory concentration level thresholds that have been established for carbon monoxide.

**Table K-4**  
**Regulatory Concentration Level Thresholds**

Regulatory Enforcement	Concentrations
NIOSH REL (ceiling @ 10 minutes)	35 ppm
OSHA PEL (ceiling)	35 ppm
OSHA PEL (maximum peak @ 10 minutes)	50 ppm
ACGIH TLV TWA	25 ppm
IDLH	1,200 ppm
LCLO (human @ 30 minutes)	4,000 ppm

Notes:

<sup>1</sup> NIOSH REL (ceiling @ 10 minutes)

<sup>2</sup> OSHA PEL (ceiling)

<sup>3</sup> OSHA PEL (maximum peak @ 10 minutes)

<sup>4</sup> ACGIH TLV TWA

<sup>5</sup> IDLH

<sup>6</sup> LCLO (human @ 30 minutes)

National Institute for Occupational Safety and Health Recommended Exposure Limit.  
Occupational Safety and Health Administration Permissible Exposure Limit  
Occupational Safety and Health Administration Permissible Exposure Limit  
American Conference of Governmental Industrial Hygienists Threshold Limit Value Time-Weighted Average  
Immediately Dangerous to Life and Health  
Lethal Concentration Low

The vapor cloud dispersion that may occur from the accidental worst-case release scenario for syngas was examined using the USEPA-approved ALOHA<sup>®</sup> 5.4.1 air dispersion modeling program. The concentrations of IDLH and the Lethal Concentration Law (LCLO) were used as Endpoints to estimate the potential maximum impact that could occur. The program was used to examine hypothetical scenarios under which the entire volume of the pipe would be vented under worst-case scenario conditions as provided by CalARP regulations. Worst-case climate conditions were assumed as follows: wind speed of 1.5 meters per second (i.e., 4.9 ft/s), an F atmospheric stability level (most stable), an atmospheric temperature 115°F, and an atmospheric humidity of 50 percent, per regulatory protocols established by CalARP.

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### 3.1.5 Methanol

The Project will use methanol in the process unit, which will be stored in a single 300,000-gallon AST with secondary containment. An additional 250,000 gallons of methanol will also be contained in process vessels, equipment, and piping of the of AGR unit. This process inventory is geographically remote from the 300,000-gallon AST, and a pump and isolation valve are placed on the piping between the storage tank and the AGR unit isolating the AST and AGR unit. The 300,000-gallon AST is considered as the major hazardous source because it contains the largest amount of methanol at the Project Site, and is normally isolated from the process inventory of 250,000 gallons.

Methanol is considered to be a hazardous substance due to its flammable and moderately toxic chemical properties. Methanol is listed in the following federal regulations:

- 29 CFR 1910.1200 (OSHA)
- 40 CFR 116 and 40 CFR 117 (USEPA)
- 40 CFR 355, Appendices A and B (USEPA)
- 40 CFR 372 (Superfund Amendments and Reauthorization Act [SARA] Title III)
- 40 CFR 302 (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA])

Although it is a listed hazardous substance, federal regulations do not require an OCA for the storage of methanol. Additionally, methanol is not regulated under applicable state regulations. Nonetheless, an OCA was conducted to evaluate the potential impact area associated with a worst-case methanol release at the Project Site. Because methanol is a flammable substance, the most severe potential consequence from an accidental worst-case release could be a vapor cloud explosion. The second potential consequence from an accidental worst-case release of methanol would be a pool fire. These two potential worst-case release scenarios were evaluated for the methanol as described in the following paragraphs.

The first worst-case scenario modeled was the formation of a methanol vapor cloud. The hypothetical release assumes a situation where the entire contents of the methanol storage tank (300,000 gallons) are vented. In accordance with regulatory guidance, the methanol was assumed to be released over a 10-minute period, and to form a vapor cloud where 10 percent of the flammable vapor explodes. An analysis was undertaken using Equation K-1 to determine the potential impact distance of a pressure wave for a vapor cloud explosion. For Equation K-1, the weight of methanol,  $W_f$ , was calculated to be approximately 1,980,000 pounds and the heat of combustion,  $H_{Cf}$ , was identified to be 22,700,000 joules/kg.

The second worst-case scenario analyzed was a methanol pool fire, in accordance with the appropriate regulatory guidance. The modeling basis for a pool fire estimates the distance from the center of a pool fire to the heat radiation Endpoint as 5 kilowatts per square meter ( $\text{kW}/\text{m}^2$ ). The worst-case release assumed for the model is as follows: the entire content of one methanol storage tank (300,000 gallons) is released, forming a pool of fire of approximately 1 inch in liquid thickness.

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Equation K-2 in Section 3.0 was used to estimate the possible impact distance from the pool fire. The input parameters for Equation K-2 in the methanol pool fire case are as follows:

$H_C$	=	heat of combustion of methanol (joules/kg) = 22,700,000 joules/kg
$H_V$	=	heat of vaporization of methanol (joules/kg) = 1,100,000 joules/kg
$A$	=	pool area ( $m^2$ ) = 44,592 $m^2$ = 479,984 square feet
$C_P$	=	liquid heat capacity (joules/kg $^\circ K$ ) = 2,482 joules/kg $^\circ K$
$T_B$	=	boiling temperature of the liquid ( $^\circ K$ ) = 337.8 $^\circ K$
$T_A$	=	ambient temperature ( $^\circ K$ ) = 320 $^\circ K$

Neither of the scenarios described above account for the safety systems that will be present at the Project Site, including: nitrogen blanketing of the tanks' vapor space, automatic fire detection and fire suppressant foam system in the storage tank and surrounding berm area, and fire water system for the Project Site. These safety systems will significantly reduce the likelihood of this event and the possibility of ignition. However, the results of the model presented in Section 3.2 do not take into account any of these safety measures.

### Nitric Acid

Nitric Acid will be used at the Project in a maximum quantity of 120 tons at a 60 percent concentration. The nitric acid will be stored in an above-ground tank in the process equipment in the unit. Nitric acid is an intermediate product used to produce UAN solution.

## 3.2 Results of Modeling

The following sections provide modeling outputs, calculations, and results of the OCAs conducted for the aqueous ammonia, hydrogen, acid gas, syngas, and methanol at the Project Site.

### 3.2.1 Anhydrous Ammonia

The dispersion analysis does not account for prevailing wind direction, and therefore assumes that there is an equal probability of the ammonia vapor cloud dispersing in any direction. Thus, the model results in Figure L-1, Aqueous Ammonia Area of Potential Impact from Worst-Case Scenario, show a circle of equal predicted ammonia concentration around the source for the greatest area of impact. The radius of the circle represents the distance to the 200 ppm (0.14 mg/L) Endpoint concentration threshold provided by CalARP regulations.

The distance from the storage equipment to the nearest Project Site boundary is approximately 0.1 mile. The predicted Endpoint is well within the Project Site boundaries. The CEC Significance Level of 75 ppm, the CalARP regulatory threshold concentrations of 200 ppm (0.14 mg/L) and the ERPG-2 200 ppm concentrations reached a distance of zero miles. Ground-level concentrations of ammonia do not exceed any levels of concern at any time during a worst-case release scenario. No off-site impact is expected to occur from a worst-case release scenario.

As additional protection measures for ammonia spills, the Project has also equipped the ammonia AST with automated controls and an alarm system with an emergency beacon and horn. The

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Project will provide employee training, enforce safe operation procedures, enforce the separate storage of incompatible chemicals, and provide scheduled inspection of equipment. Materials will be handled in accordance with all applicable LORS. Based on the above, the potential impacts of the use and storage of ammonia at the Project Site are less than significant.

### 3.2.2 Hydrogen

USEPA's RMP\*Comp model results (presented in Section 3.3, Modeling Outputs) show that the approximate distance reached by a 1 psi overpressure wave resulting from a worst-case release scenario would be 317 feet (0.06 mile). The potential impact from the vapor cloud explosion resulting from a worst-case 30,000 scf release of hydrogen does not extend outside of the Project Site boundaries.

As an added examination measure, an analysis of the vapor cloud explosion area of impact was also performed following instruction from USEPA's RMP OCA guidance document. Equation K-1 was applied to determine the approximate distance that would be reached by a hydrogen vapor cloud explosion. The equation was applied in the manner below (equation provided by the USEPA RMP OCA guidance):

$$X=0.0081\left(0.1\times 159\text{lbs}\times\frac{119,950\text{ kJ/kg}}{4,680\text{ kJ/kg}}\right)^{1/3}=0.06\text{ mile}\approx 317\text{ feet}$$

Results from vapor cloud explosion computations reflected those obtained through the RMP\*Comp modeling program. Both modeling practices showed a total distance of impact of 317 feet (0.06 mile).

The OCA analysis result shows that even for the worst-case release scenario for hydrogen, the potential impact will be restricted within an area of a 317-foot-radius (0.06 mile) from the center of the storage tube trailer, which will remain within the Project Site boundary. The hydrogen multi-tube trailer is approximately 1,200 feet (0.23 mile) from the Project Site boundary. Any explosion or combustion of a worst-case release scenario for hydrogen at the Project Site would not have any negative impacts off site and would be contained within the Project Site boundaries. Based on the above, the potential impacts of the use and storage of hydrogen at the Project Site are less than significant.

### 3.2.3 Acid Gas (45 percent Hydrogen Sulfide)

An OCA for the worst-case release of acid gas from the process pipeline between the AGR and SRU was examined. The process pipeline is located approximately 1,050 feet (0.2 mile) from the Project Site boundary, and approximately 2,100 feet (0.4 mile) from the Controlled Area boundary. The acid gas system volume is approximately 677 actual cubic feet, which is equivalent to 864 feet of 12-inch-diameter pipe.

The ideal gas law ( $PV = nRT$ ) was used to determine the total amount of moles found in the hydrogen sulfide in the acid gas process system. The results were then used to determine the

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approximate weight of the hydrogen sulfide gas in the process pipeline. The total weight for the hydrogen sulfide gas from the pipeline is shown below:

System Capacity (cubic feet)	H <sub>2</sub> S Volume (cubic feet)	Moles of H <sub>2</sub> S (lb-mol)	Weight of H <sub>2</sub> S (pounds)
677	305	1.47	50

The weight shown above was input into the ALOHA® 5.4.1 modeling program, under worst-case climate conditions to determine the distance to the Endpoint from the complete release of the pipe contents. The Endpoint concentration for hydrogen sulfide is equivalent to a concentration of 32 ppm (0.042 mg/L), as required by CAA §112 (r) RMP and CalARP regulations. A 10-minute time of release was also selected for the scenario, following CAA § 112 (r) RMP and CalARP regulatory requirements. The distance to the Endpoint generated by an accidental release of hydrogen sulfide from the acid gas is shown below:

Distance to Endpoint (miles)
0.37

Results from the ALOHA® 5.4.1 modeling program presented a distance to the Endpoint of 1,974 feet (0.37 mile). The potential impacts from a vapor cloud under the worst-case release scenario will remain within the Controlled Area.

As previously mentioned, in addition to conducting a vapor cloud OCA, the acid gas was also examined for the impacts from a vapor cloud explosion. The same volumetric amount was taken into consideration, and the same weight of hydrogen sulfide. By applying weight and heat of combustion parameters to Equation K-1, the 1 psi overpressure wave impact derived from the acid gas was determined to reach a distance of 108 feet.

Equation K-1 was applied in the manner shown below (equation provided by the USEPA RMP OCA guidance):

$$X = 0.0081 \left( 0.1 \times 50 \text{ lbs} \times \frac{15,240 \text{ kJ/kg}}{4,680 \text{ kJ/kg}} \right)^{1/3} = 0.02 \text{ mile} \approx 108 \text{ feet}$$

The 108-foot distance reached by the vapor cloud explosion from the acid gas worst-case scenario will remain well within the Project Site boundary. As such, the use of acid gas at the Project Site will not have any impacts to the surrounding community and will not present a significant hazard by the Project. Based on the above, the potential impacts from the use of acid gas at the Project Site are less than significant.

### 3.2.4 Syngas

Equations K-1 and K-4 (provided by the USEPA RMP OCA guidance) were applied to determine the approximate distance that would be reached by a syngas vapor cloud explosion. As an initial step, Equation K-4 was applied to determine the combined heat of combustion of

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flammable syngas components. These flammable materials and their respective heats of combustion are provided in Table K-5.

**Table K-5**  
**Flammable Materials**

Target Syngas Composition	Total Mass (pounds)	Heat of Combustion (kJ/kg)
Hydrogen (H <sub>2</sub> )	216	119,950
Carbon monoxide (CO)	4,185	10,111
Hydrogen sulfide (H <sub>2</sub> S)	181	15,240

The total heat of combustion for syngas was determined in the manner shown below.

$$H_{\text{syngas}} = \frac{216\text{lbs}}{4,582\text{lbs}} \times 119,950 \text{ kJ/kg} + \frac{4,185\text{lbs}}{4,582\text{lbs}} \times 10,111 \text{ kJ/kg} + \frac{181\text{lbs}}{4,582\text{lbs}} \times 15,240 \text{ kJ/kg} = 15,492 \text{ kJ/kg}$$

Following the determination of heat of combustion for syngas, Equation K-1 was used to estimate the approximate distance that would be reached by a syngas vapor cloud explosion.

$$X = 0.0081 \left( 0.1 \times 4,582 \text{ lbs} \times \frac{15,492 \text{ kJ/kg}}{4,680 \text{ kJ/kg}} \right)^{1/3} = 0.09 \text{ mile} \approx 491 \text{ feet}$$

The maximum potential impact distance was calculated to be 0.09 mile. The Project Site boundary is approximately 0.23 mile from the Gasifier System (i.e., potential source of syngas release). Based on the above calculations, the syngas would not present an off-site hazard from a vapor cloud explosion. In addition, the impact area may be further reduced by the large concentration of water and CO<sub>2</sub> (>50 percent by weight) present within the syngas.

The ALOHA<sup>®</sup> 5.4.1 model was applied to estimate the potential impact of the toxic chemical components of the syngas from a worst-case scenario release of a syngas vapor cloud. The distance to the Endpoints was examined for ammonia and hydrogen sulfide using the RMP/CalARP criteria. Concentrations examined for carbon monoxide were based on IDLH and LCLO because RMP and CalARP do not regulate carbon monoxide.

The worst-case release scenario also modeled the specific characteristics of the source, including the minimum release height of 70 feet above grade. The height of the equipment was also considered to determine the potential impact at ground level. Input parameters and results obtained from the modeling are provided in Table K-6.

**Table K-6**  
**Input Parameters and Results**

Syngas Component	Concentration of Concern	Basis of Concentration	Elevation of Release Source	Distance to Concentration of Concern
Ammonia	200 ppm (0.14 mg/L)	CalARP/RMP	70 feet	Not Exceeded
Hydrogen Sulfide	32 ppm (0.042 mg/L)	CalARP/RMP	70 feet	Not Exceeded
Carbon Monoxide	1200 ppm	IDLH	70 feet	Not Exceeded
	4000 ppm	LCLO	70 feet	Not Exceeded

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Based on the modeling results shown in Table K-6, the concentration of concern will not be reached or exceeded at ground level. Therefore, according to the worst-case scenario modeling, potential impacts from the generation and use of syngas at the site will be less than significant.

### 3.2.5 Methanol

The methanol storage area is approximately 0.11 mile from the Project Site boundary and 0.4 mile from the Controlled Area boundary. As discussed in the Section 3.1, Modeling Parameters, two worst-case scenarios were modeled for methanol: (1) pool fire; and (2) vapor cloud explosion. Modeling indicated that a potential methanol pool fire resulting from the worst-case complete release of a single tank may reach a distance of 1,215 feet (0.23 mile) from the center of the methanol pool. The modeling showed that the potential impact distance from a worst-case methanol vapor cloud explosion after a complete release may reach a distance of approximately 4,224 feet (0.8 mile) from the location of the tank.

Results from the worst-case release scenario modeling demonstrated that impact from the methanol pool fire scenario will be maintained within the boundary of the Controlled Area, and the potential impact from the methanol vapor cloud explosion may extend just beyond the Controlled Area. The immediate vicinity surrounding the Project Site and the Controlled Area is composed of rural, agriculturally developed land and undeveloped native terrain. As such, the potential off-site impact modeled for a worst-case methanol vapor cloud explosion will not affect sensitive receptors. Therefore, potential impacts from the use and storage of methanol at the Project Site will be less than significant.

As discussed in Section 3.1, the modeling assumes a highly unlikely event and worst-case conditions. These assumptions do not take into account any safety measures that will be employed for the Project. For example, safety measures in the Project Site will include nitrogen blanketing of the tank vapor space, automatic fire detection, a fire suppressant foam system surrounding the methanol storage tank and within the berm area, and a fire water system. The implementation of these safety measures will significantly reduce the likelihood of a pool fire and/or vapor cloud explosion. The potential impacts from the use and storage of methanol on the Project Site will be less than significant.

## 3.3 Modeling Outputs

### 3.3.1 Anhydrous Ammonia

Outputs from the ALOHA<sup>®</sup> 5.4.1 dispersion model obtained from the evaluation of the worst-case release scenario for anhydrous ammonia are provided below.

Text Summary  
ALOHA<sup>®</sup> 5.4.1



#### SITE DATA:

Location: BAKERSFIELD, CALIFORNIA

Building Air Exchanges Per Hour: 0.60 (unsheltered single storied)

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Time: April 9, 2012 1502 hours PDT (using computer's clock)

### CHEMICAL DATA:

Chemical Name: AMMONIA                      Molecular Weight: 17.03 g/mol  
AEGL-1 (60 min): 30 ppm   AEGL-2 (60 min): 160 ppm   AEGL-3 (60 min): 1100 ppm  
IDLH: 300 ppm   LEL: 150000 ppm   UEL: 280000 ppm  
Ambient Boiling Point: -28.7° F  
Vapor Pressure at Ambient Temperature: greater than 1 atm  
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

### ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1.5 meters/second from ESE at 3 meters  
Ground Roughness: open country              Cloud Cover: 5 tenths  
Air Temperature: 115° F  
Stability Class: F (user override)  
No Inversion Height                      Relative Humidity: 50%

### SOURCE STRENGTH:

Direct Source: 9.6 pounds/min              Source Height: 60 feet  
Release Duration: 60 minutes  
Release Rate: 9.6 pounds/min  
Total Amount Released: 576 pounds  
Note: This chemical may flash boil and/or result in two phase flow.  
Use both dispersion modules to investigate its potential behavior.

### THREAT ZONE:

Model Run: Gaussian

Red: LOC is not exceeded— (75 ppm)

Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Orange: LOC is not exceeded— (150 ppm = ERPG-2)

Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Yellow: LOC is not exceeded—(200 ppm)

Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

### 3.3.2 Hydrogen

Given the same hydrogen amount, a potential impact distance calculated by USEPA RMP\*Comp software is also shown below (the result below is directly imported the USEPA RMP\*Comp software):

### **RMP Modeling Result**

RMP\*Comp Ver. 1.07  
Results of Consequence Analysis  
Chemical: Hydrogen  
CAS #: 1333-74-0  
Category: Flammable Gas  
Scenario: Worst-case  
Quantity Released: 153.7 pounds  
Release Type: Vapor Cloud Explosion  
Estimated Distance to 1 psi overpressure: .06 mile (.10 kilometer)

-----Assumptions About This Scenario-----  
Wind Speed: 1.5 meters/second (3.4 miles/hour)  
Stability Class: F  
Air Temperature: 77 degrees F (25 degrees C)  
-----

### **3.3.3 Acid Gas (45 percent Hydrogen Sulfide)**

Outputs from the ALOHA<sup>®</sup> 5.4.1 dispersion model obtained from the evaluation of the worst-case release scenario for acid gas are provided below.

Text Summary  
ALOHA<sup>®</sup> 5.4.1



#### **SITE DATA:**

Location: HECA Project Site, California  
Building Air Exchanges Per Hour: 0.60 (unsheltered single storied)  
Time: April 14, 2009 1021 hours PDT (using computer's clock)

#### **CHEMICAL DATA:**

Chemical Name: HYDROGEN SULFIDE  
Molecular Weight: 34.08 g/mol  
ERPG-1: 0.1 ppm  
ERPG-2: 30 ppm  
ERPG-3: 100 ppm  
IDLH: 100 ppm  
LEL: 43,000 ppm  
UEL: 455000 ppm  
Ambient Boiling Point: -76.8° F  
Vapor Pressure at Ambient Temperature: greater than 1 atm  
Ambient Saturation Concentration: 1,000,000 ppm or 100.0 percent

#### **ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)**

Wind: 1.5 meters/second from east at 3 meters

## APPENDIX K

# HAZARDOUS MATERIALS TECHNICAL ANALYSIS

---

Ground Roughness: open country  
Cloud Cover: 0 tenths  
Air Temperature: 115° F  
Stability Class: F (user override)  
No Inversion Height  
Relative Humidity: 50 percent

### SOURCE STRENGTH:

Direct Source: 5 pounds/min  
Source Height: 0  
Release Duration: 10 minutes  
Release Rate: 5 pounds/min  
Total Amount Released: 50.0 pounds

Note: This chemical may flash boil and/or result in two phase flow.

### THREAT ZONE: (GAUSSIAN SELECTED)

Model Run: Gaussian  
Red: 658 yards — (0.042 mg/liter)

### 3.3.4 Syngas

Outputs from the ALOHA<sup>®</sup> 5.4.1 dispersion model obtained from the evaluation of the worst-case release scenario for syngas are provided below.

Text Summary  
ALOHA<sup>®</sup> 5.4.1



#### 3.3.4.1 Carbon Monoxide

### SITE DATA:

Location: HECA Project Site, California  
Building Air Exchanges Per Hour: 0.60 (unsheltered single storied)  
Time: March 26, 2009 0848 hours PDT (using computer's clock)

### CHEMICAL DATA:

Chemical Name: CARBON MONOXIDE  
Molecular Weight: 28.01 g/mol  
ERPG-1: 200 ppm  
ERPG-2: 350 ppm  
ERPG-3: 500 ppm  
IDLH: 1,200 ppm  
LEL: 125,000 ppm  
UEL: 740,000 ppm  
Ambient Boiling Point: -313.0° F  
Vapor Pressure at Ambient Temperature: greater than 1 atm  
Ambient Saturation Concentration: 1,000,000 ppm or 100.0 percent

## APPENDIX K

# HAZARDOUS MATERIALS TECHNICAL ANALYSIS

---

### ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1.5 meters/second from east at 3 meters  
Ground Roughness: open country  
Cloud Cover: 5 tenths  
Air Temperature: 115° F  
Stability Class: F (user override)  
No Inversion Height  
Relative Humidity: 50 percent

### SOURCE STRENGTH:

Direct Source: 4,185 pounds  
Source Height: 70 feet  
Release Duration: 1 minute  
Release Rate: 69.7 pounds/sec  
Total Amount Released: 4,185 pounds  
Note: This chemical may flash boil and/or result in two-phase flow.  
Use both dispersion modules to investigate its potential behavior.

### THREAT ZONE:

Model Run: Gaussian  
Red: LOC is not exceeded — (1,200 ppm = IDLH)  
Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.  
Orange: LOC is not exceeded — (4,000 ppm)  
Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

### 3.3.4.2 *Ammonia*

#### SITE DATA:

Location: HECA Project Site, California  
Building Air Exchanges Per Hour: 0.60 (unsheltered single storied)  
Time: March 26, 2009 0848 hours PDT (using computer's clock)

#### CHEMICAL DATA:

Chemical Name: AMMONIA  
Molecular Weight: 17.03 g/mol  
ERPG-1: 25 ppm  
ERPG-2: 150 ppm  
ERPG-3: 750 ppm  
IDLH: 300 ppm  
LEL: 160,000 ppm  
UEL: 250,000 ppm  
Ambient Boiling Point: -28.7° F  
Vapor Pressure at Ambient Temperature: greater than 1 atm  
Ambient Saturation Concentration: 1,000,000 ppm or 100.0 percent

### ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1.5 meters/second from east at 3 meters

## APPENDIX K

# HAZARDOUS MATERIALS TECHNICAL ANALYSIS

---

Ground Roughness: open country  
Cloud Cover: 5 tenths  
Air Temperature: 115° F  
Stability Class: F (user override)  
No Inversion Height  
Relative Humidity: 50 percent

### SOURCE STRENGTH:

Direct Source: 15 pounds  
Source Height: 70 feet  
Release Duration: 1 minute  
Release Rate: 0.25 pound/sec  
Total Amount Released: 15.0 pounds

Note: This chemical may flash boil and/or result in two-phase flow.  
Use both dispersion modules to investigate its potential behavior.

### THREAT ZONE:

Model Run: Gaussian

Red: LOC is not exceeded — (0.14 mg/liter)

Note: Threat zone was not drawn because the ground-level concentrations never exceed the LOC.

Orange: LOC is not exceeded — (300 ppm = IDLH)

Note: Threat zone was not drawn because the ground-level concentrations never exceed the LOC.

Yellow: LOC is not exceeded — (2,000 ppm)

Note: Threat zone was not drawn because the ground-level concentrations never exceed the LOC.

### 3.3.4.3 *Hydrogen Sulfide*

#### SITE DATA:

Location: HECA Project Site, California  
Building Air Exchanges Per Hour: 0.60 (unsheltered single storied)  
Time: March 26, 2009 0848 hours PDT (using computer's clock)

#### CHEMICAL DATA:

Chemical Name: HYDROGEN SULFIDE  
Molecular Weight: 34.08 g/mol  
ERPG-1: 0.1 ppm  
ERPG-2: 30 ppm  
ERPG-3: 100 ppm  
IDLH: 100 ppm  
LEL: 43,000 ppm  
UEL: 455,000 ppm  
Ambient Boiling Point: -77.0° F  
Vapor Pressure at Ambient Temperature: greater than 1 atm  
Ambient Saturation Concentration: 1,000,000 ppm or 100.0 percent

#### ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1.5 meters/second from east at 3 meters

## APPENDIX K

### HAZARDOUS MATERIALS TECHNICAL ANALYSIS

---

Ground Roughness: open country  
Cloud Cover: 5 tenths  
Air Temperature: 115° F  
Stability Class: F (user override)  
No Inversion Height  
Relative Humidity: 50 percent

#### SOURCE STRENGTH:

Direct Source: 181 pounds  
Source Height: 70 feet  
Release Duration: 1 minute  
Release Rate: 3.02 pounds/sec  
Total Amount Released: 181 pounds

Note: This chemical may flash boil and/or result in two-phase flow.

#### THREAT ZONE: (GAUSSIAN SELECTED)

Model Run: Gaussian  
Red: LOC is not exceeded — (0.042 mg/liter)

Note: Threat zone was not drawn because the ground-level concentrations never exceed the LOC.