APPENDIX D

HAZARD ANALYSIS

QUEST
CONSULTANTS INC.®

December 6, 2006

Ms. Debra Bright Stevens
Environmental Audit, Inc.
1000-A Ortega Way
Placentia, California 92670-7125

Dear Ms. Stevens:

Quest Consultants Inc. has performed a series of release and vapor dispersion calculations in an effort to quantify the consequences following a release from an existing anhydrous ammonia storage tank and the associated ammonia vapor lines (one existing and one proposed) leading to Selective Catalytic Reduction (SCR) units (one existing, one proposed) in Paramount's refinery in Paramount, California. The releases were designed to simulate what would happen if a pipe fails and releases either anhydrous ammonia (NH_3) liquid or ammonia vapor to the environment.

Site-Specific Information

Several of the parameters defined in the analysis are listed in Table 1.

Table 1
Pipe and Pipeline Data

Parameters	Current NH_3 Storage Tank	Existing NH_3 Vapor Line to SCR	Proposed NH_3 Vapor Line to SCR
Pipe internal diameter	1.5-inch	0.957-inch	0.957-inch
Material composition	Anhydrous ammonia liquid	Anhydrous ammonia vapor	Anhydrous ammonia vapor
Temperature	75°F	82°F	82°F
Pressure	142 psia	155 psia	50 psia
Normal flow rate	3.46 lb/hr	1.73 lb/hr	1.73 lb/hr
Approximate length of pipe	0 ft	870 ft	1530 ft

Atmospheric Conditions

Wind speed = 1.5 m/s and 5 m/s
Relative humidity = 70%
Air temperature = 75°F
Atmospheric stability = Pasquill-Gifford F (extremely stable) and Pasquill-Gifford D (neutral)

[Atmospheric stability is classified by the letters A through F. In general, the most unstable atmosphere is characterized by stability class A. Stability A would correspond to an atmospheric condition where there is strong solar radiation and moderate winds. This combination of radiation and winds allows for rapid fluctuations in the air and thus greater mixing of the released gas with time. Stability D is characterized by fully overcast or partial cloud cover during both daytime and nighttime. The atmospheric turbulence is not as great during D conditions as during A conditions; thus, the gas will not mix as quickly with the surrounding atmosphere. Stability F corresponds to the most "stable" atmospheric conditions. Stability F generally occurs during the early morning hours before sunrise (thus, no solar radiation) and under low winds. The combination of low winds and lack of solar heating allows for the atmosphere to appear calm or still and thus restricts the ability to actively mix with the released gas.]

Toxic Gas Hazards

Release/dispersion calculations were made in order to determine the extent of downwind travel of the ammonia gas resulting from a jet release of anhydrous ammonia liquid (an aerosol cloud released from the storage tank) or the ammonia vapor release case (a release from the vapor lines). Dispersion calculations were performed until a specific ammonia concentration was reached in the downwind direction. The ammonia gas concentration chosen for evaluation was:

ERPG-2 for Ammonia = 150 ppm

Emergency Response Planning Guideline (ERPG) Level 2. The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their ability to take protective action.

Consequence Analysis

When performing site-specific consequence analysis studies, the ability to accurately model the release, dilution, and dispersion of gases and aerosols is important if an accurate assessment of potential exposure is to be attained. For this reason, Quest uses a modeling package, CANARY by Quest®, that contains a set of complex models that calculate release conditions, initial dilution of the vapor (dependent upon the release characteristics), and the subsequent dispersion of the vapor introduced into the atmosphere. The models contain algorithms that account for thermodynamics, mixture behavior, transient release rates, gas cloud density relative to air, initial velocity of the released gas, and heat transfer effects from the surrounding atmosphere and the substrate. The release and dispersion models contained in the QuestFOCUS package (the predecessor to CANARY by Quest) were reviewed in a United States Environmental Protection Agency (EPA) sponsored study[1] and an American Petroleum Institute (API) study[2]. In both studies, the QuestFOCUS software was evaluated on technical merit (appropriateness of models for specific applications) and on model predictions for specific releases. One conclusion drawn by both studies was that the dispersion software tended to over-predict the extent of the gas cloud travel, thus resulting in too large a cloud when compared to the test data (i.e., a conservative approach).

A study prepared for the Minerals Management Service[3] reviewed models for use in modeling routine and accidental releases of flammable and toxic gases. CANARY by Quest received the highest possible ranking in the science and credibility areas. In addition, the report recommends CANARY by Quest for use when evaluating toxic and flammable gas releases. The specific models contained in the CANARY by Quest software package have also been extensively reviewed.

Ammonia Releases Analyzed

Three physical releases were evaluated in this study. A short description of each is provided below.

Release 1 - Rupture of liquid line between the anhydrous ammonia storage tank and the vaporizer. In this scenario, the 1.5-inch (I.D.) schedule 80 line leaving the liquid space of the 1,000-gallon anhydrous ammonia storage tank is ruptured. The ruptured pipe is assumed to be oriented parallel to the ground (worst case). The release continues until the tank is empty. The anhydrous ammonia is stored as a liquefied gas and partially flashes to vapor upon release. The resulting vapor/liquid mist, called an aerosol, is denser-than-air and slumps to the ground. This "heavy gas" disperses downwind while the liquid ammonia drops vaporize in the cloud.

Release 2 - Rupture of the existing ammonia vapor line leading to the existing SCR unit. In this scenario, the ammonia vapor line (0.957-inch I.D.) leading from the vapor space of the existing ammonia storage tank to the existing SCR unit is ruptured. The ammonia line is equipped with a pressure control valve (located near the SCR unit) that maintains the downstream pressure to 20 psig. The worst case release results when a failure in the line between the ammonia storage tank and the pressure control valve occurs and releases ammonia from the vapor space of the ammonia storage tank. The ammonia vapor initially exits the ammonia storage tank at a temperature around 82°F and a pressure of around 155 psia. The pressure will drop as the system empties, resulting in a transient, decaying release rate. When released, the ammonia vapor will be lighter-than-air (buoyant) and may slowly rise upward.

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[1] *Evaluation of Dense Gas Dispersion Models.* Prepared for the U.S. Environmental Protection Agency by TRC Environmental Consultants Inc., East Hartford, Connecticut, 06108, EPA Contract No. 68-02-4399, May, 1991.

[2] *Hazard Response Modeling Uncertainty (A Quantitative Method)*; *Volume II, Evaluation of Commonly-Used Hazardous Gas Dispersion Models*, S. R. Hanna, D. G. Strimaitis, and J. C. Chang, Study cosponsored by the Air Force Engineering and Services Center, Tyndall Air Force Base, Florida, and the American Petroleum Institute, and performed by Sigma Research Corporation, Westford, Massachusetts, September 1991.

[3] *A Critical Review of Four Types of Air Quality Models Pertinent to MMS Regulatory and Environmental Assessment Missions*, Joseph C. Chang, Mark E. Fernau, Joseph S. Scire, and David G. Strimaitis. Mineral Management Service, Gulf of Mexico OCS Region, U.S. Department of the Interior, New Orleans, November, 1998.

Release 3 - Rupture of the proposed ammonia vapor line leading to the proposed SCR unit. In this scenario, the new ammonia vapor line (0.957-inch I.D.) connected to the existing vapor line out of the ammonia storage tank and leading to the proposed SCR unit is ruptured. The new ammonia line is equipped with a pressure control valve, followed with an excess flow valve (both located near the existing vapor line). This system limits the maximum flow of ammonia through the system to just below 0.0285 lb/s (a higher rate would cause the excess flow valve to close). Thus, the worst case release results when a failure occurs in the line downstream of the pressure control valve and excess flow valve, with a release rate just below 0.0285 lb/sec.

Ammonia Dispersion Results

CANARY by Quest was used to model the momentum jet releases resulting from failures of pipes carrying anhydrous ammonia as a liquid and as a vapor. The results of these calculations are presented in Table 2.

Table 2
Ammonia Vapor Dispersion Results

Release Scenario	Wind Speed (m\s)	Stability Class	Ammonia Concentration ERPG-2 (ppm)	Distance to ERPG-2 (ft)
Existing anhydrous ammonia storage tank liquid line rupture	1.5	F	150	2945
	5.0	D	150	2265
Existing ammonia vapor line to existing SCR rupture	1.5	F	150	610
	5.0	D	150	135
Proposed ammonia vapor line to proposed SCR rupture	1.5	F	150	340
	5.0	D	150	60

Conclusions

Table 2 presents the maximum downwind distance of each ammonia hazard zone for each release considered in this study. As can be seen from Table 2, the impact distances (as measured by the ERPG-2 level for ammonia) are far larger for the liquid releases than for the ammonia vapor releases. This is not unexpected since the liquefied gas release rate from the storage tank is far larger than the maximum release rate out of the ammonia vapor lines.

If a circle with a radius of 2,945 feet is drawn around the anhydrous ammonia tank, it would represent the vulnerability zone for the ERPG-2 level (150 ppm) for ammonia. This circular area represents the maximum area that could be exposed, not all at one time, if the liquid line leaving the ammonia tank were to rupture. When the vulnerability zones for the two ammonia vapor releases are plotted (radii of ~ 600 and 350 feet), it is found that both ammonia vapor lines vulnerability zones lie completely within the vulnerability zone for the ammonia storage tank. Thus, neither the existing nor proposed ammonia vapor line pose a greater potential impact to the surrounding area than that posed by the existing ammonia storage tank.

I believe this covers the analysis requested. If you have any questions, please give us a call.

Sincerely,

John B. Cornwell.
Principal Engineer

nsm

ESTIMATED INCREASE IN ANHYDROUS AMMONIA USE
PARAMOUNT PETROLEUM REFINERY

1. The existing ammonia usage at the Refinery is about 270 gallon/month = 3,240 gallons/year.

2. Proposed new SCR in H-601 is predicted to be 1.73 lbs/hour assuming 40 ppm NOx inlet concentration and 5 ppm NOx outlet concentration at the maximum permit duty of 85 mmBtu/hr. Therefore: (1.73 lb/hr)/(37.48 lb/CF liquid)*(7.48 gal/CF)*(24 hr/day)*(30 days/month) = 248.6 or about 250 gal/month

3. Proposed modified Reformer heater SCR usage is predicted to be 4.43 lbs/hour assuming about 75 ppm NOx inlet concentration and 5 ppm NOx outlet concentration at the maximum permit duty of 162.1 mmBtu/hr. Therefore: (4.43 lb/hr)/(37.48 lb/CF liquid)*(7.48 gal/CF)*(24 hr/day)*(30 days/month) = 636.6 gal/month or about 640 gal/month.

4. Total Refinery usage of anhydrous ammonia would be 890 gal/month (250 + 640)

5. Difference between proposed project and existing refinery ammonia use = 890 – 270 = 620 gal/month (890-270) or about 7,440 gallons per month.

6. The chemical supplier who provides the anhydrous ammonia transports the anhydrous ammonia in trucks sized at a maximum fill capacity of 3,300 gallons. Since the Paramount tank is 1,000 gallons, the total increase in truck trips is then 7,440/1,000 = 7.4 trucks per year.