APPENDIX II-F

HAZARD IMPACT CALCULATIONS

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The consequence modeling for the postulated pool fire scenarios was based on methodology contained in the U.S. EPA document *Risk Management Program Guidance for Off-Site Consequence Analysis* (EPA, 1999), equation D-25. The EPA equation for estimating the distance to a heat radiation level that could cause second degree burns from a 40-second exposure from pool fires of flammable liquids with boiling points above ambient temperature is:

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

Where:

X	=	distance to the 5,000 watt per square meter endpoint (m)
H_C	=	heat of combustion of the flammable liquid (joules/kg)
H_V	=	heat of vaporization of the flammable liquid (joules/kg)
A	=	pool area (m^2)
C_P	=	liquid heat capacity (joules/kg-ºK)
T_B	=	liquid boiling temperature of the liquid (ºK)
T_A	=	ambient temperature (ºK)
0.0001	=	Constant
5000	=	5,000 watts per square meter

This equation is based on the implicit assumptions that the fraction heat of combustion radiated is 0.4 and that the atmospheric transmissivity to thermal radiation is 1.0. (EPA, 1999, Eqn. D-25)

The consequence modeling for the postulated vapor cloud explosion was based on methodology contained in the U.S. EPA document *Risk Management Program Guidance for Off-Site Consequence Analysis* (EPA, 1999). The EPA equation for estimating the distance to an overpressure of 1.0 psi from a vapor cloud explosion following a catastrophic release of a flammable liquid from a storage tank is:

$$D = 17 \times \left(0.1 \times W_f \times \frac{HC_f}{HC_{TNT}} \right)^{1/3}$$

Where:

D	=	distance to the 5,000 watt per square meter endpoint (m)
HC_f	=	heat of combustion of the flammable liquid (joules/kg)
HC_{TNT}	=	heat of combustion of trinitrotoluene (TNT) (joules/kg)
W_f	=	weight of flammable substance (kg) (see below)
17	=	constant for damages associated with 1.0 psi overpressures
0.1	=	constant reflecting 10 percent of mass participating in explosion (explosion efficiency)

This equation is based on the implicit assumptions that the explosion efficiency is 10 percent. (EPA, 1999, Eqn. C-1).

The quantity of flammable substance released as vapor from a liquid pool (W_f) is computed from methodology contained in the U.S. EPA document *Risk Management Program Guidance for Off-Site Consequence Analysis* (EPA, 1999), equation D-1.

$$QR = \frac{0.284 \times U^{0.78} \times MW^{2/3} \times A \times VP}{82.05 \times T}$$

Where:

QR	=	evaporation rate (lbs/min)
U	=	wind speed (m/s)
MW	=	flammable substance molecular weight
A	=	surface area of pool formed within the diked berm (sq ft)
VP	=	flammable substance vapor pressure (mm Hg)
T	=	temperature of released flammable substance (°K)
0.284	=	constant
82.05	=	constant

Shell Products Company Carson Distribution Facility 2/16/2012
E10 Hazards Analysis

Chemical Physical Parameters

Input	Chemical	Hc (joules/kg)	Hv (joules/kg)	Cp (joules/kg-K)	Tb (K)	Density (lb/gal)	Flash Fraction Factor	Reference
1	Gasoline	47,800,000	300,513	2,198	399	5.89	-	1
2	Ethanol	29,700,000	866,265	2,407	351	6.60	-	2
3	Diesel	48,100,000	275,218	2,183	447	7	-	1

References

1 Petroleum Refining, J. Gary and G Handwerk, Marcel Dekker, Inc, 1975; Vapor pressure based on 7.0 RVP and nomograph from EPA AP-42 Table 7.1-55 10/06 for 75F

2 Perry's Chemical Engineering Handbook.; Vapor pressure from Wikepedia, verified at http://www.s-ohe.com/Ethanol_cal.html

Scenario Definitions

Scenario	Description	Event Type	Chemical	Quantity (bbl)	Quantity (gal)	Quantity (lbs)	Quantity kg)
1	New Gasoline Tank	Pool Fire	Gasoline	158,000		39,086,040	17,729,428
2	Converted Ethanol Tank	Pool Fire	Ethanol	158,000		43,797,600	19,866,591
3	Loading Rack Spill	Pool Fire	Ethanol	200		55,440	25,148
4	Existing Diesel Tank	Pool Fire	Diesel	115,168		35,117,027	15,929,083

Confined Spill Surface Area.

Scenario	Description	Tank Vol (bbl)	Tank Vol (Gal)	Tank Volume (cu ft)	Containment Area (sq ft)	Containment Depth (ft)	Area (sq m)
1	New Gasoline Tank	158,000	6,636,000	887,166	104,000	8	9,662
2	Converted Ethanol Tank	158,000	6,636,000	887,166	104,000	8	9,662
3	Loading Rack Spill	200	8,400	1,123	104,000	8	9,662
4	Existing Diesel Tank	115,168	4,837,056	646,665	79,104	8	7,349

Unconfined Spill Surface Area. Liquid spreads to a depth of 1 cm depth (0.0328 feet).

Scenario	Description	Tank Vol (bbl)	Tank Vol (Gal)	Tank Volume (cu ft)	Containment Area (sq ft)	Containment Depth (ft)	Area (sq m)
3	Loading Rack Spill	200	8,400	1,123	34,229	0.03	3,174

Pool Fire. Boiling point above ambient temperature. Distance is to energy flux of 5,000 W/m^2

Scenario	Description	Chemical	Size (bbl)	Hc (J/kg)	Hv (J/kg)	Cp (j/kgK)	Tb (K)	A (m**2)	x (m)
1	New Gasoline Tank	Gasoline	158,000	4.78E+07	3.01E+05	2.20E+03	399	9,662	520
2	Converted Ethanol Tank	Ethanol	158,000	2.97E+07	8.66E+05	2.41E+03	351	9,662	230
3	Loading Rack Spill	Ethanol	200	2.97E+07	8.66E+05	2.41E+03	351	9,662	230
4	Existing Diesel Tank	Diesel	115,168	4.81E+07	2.75E+05	2.18E+03	447	7,349	420

EPA RMP Off-Site Consequence Analysis Guideline (5/24/96), Equation D-25. Air Temperature assumed to be 25°C (298°K).

All impact distances rounded to the nearest 10 meters.

Evaporative Emission Rate from Pool Surface

Scenario	Description	Chemical	Surface Area (ft^2)	Wind Speed (m/s)	Elapsed Time (min)	Vapor Pressure (mm Hg)	Temperature for Vapor Pressure (°C)	Molecular Weight	Emission Rate (lbs/min)	Emission Rate (lbs)
1	New Gasoline Tank	Gasoline	104,000	1.5	10.0	240	24	108	9,061	90,605
2	Converted Ethanol Tank	Ethanol	104,000	1.5	10.0	56	24	40	1,090	10,900
3	Loading Rack Spill	Ethanol	3,200	1.5	10.0	56	24	40	34	335
4	Existing Diesel Tank	Diesel	79,104	1.5	10.0	0	24	200	17	173

Vapor Explosion. Distance to overpressure of 1 psi.

Scenario	Description	Chemical	Emission Rate (lbs)	Qs [Wt (kg)]	Hc (KJoules/kg)	x (m)
1	New Gasoline Tank	Gasoline	90,605	41,099	4.78E+04	590
2	Converted Ethanol Tank	Ethanol	10,900	4,944	2.97E+04	250
3	Loading Rack Spill	Ethanol	335	152	2.97E+04	80
4	Existing Diesel Tank	Diesel	173	79	4.81E+04	70

Source of Equation. EPA RMP Off-Site Consequence Analysis Guideline (5/24/96), Equation C-1

All impact distances rounded to the nearest 10 meters. Assumes 10% of cloud mass participates in vapor explosion.