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CALCULATION NOTES THAT SUPPORT ACCIDENT SCENARIO AND CONSEQUENCE OF THE IN-TANK FUEL FIRE/DEFLAGERATION.

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Abstract: The purpose of this calculation note is to provide the basis for In-Tank Fuel Fire/Deflageration consequence for the Tank Farm Safety Analysis Report (FSAR). Tank Fuel Fire/Deflageration scenario is developed and details and description of the analysis methods are provided.

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Calculation Notes that Support Accident Scenario and Consequence Determination for Vehicle Fuel Fire Calculations

**Ralph Crowe
Nuclear Analysis and Characterization**

Purpose

Diesel and gasoline powered vehicles routinely enter the tank farms in support of surveillance, sampling, maintenance and construction activities. A hazards analysis identified the potential of these vehicles to be involved in an accident resulting in fuel from a ruptured vehicle tank spilling into a waste storage tank and igniting. Several possible scenarios can be considered in assessing the results of fuel spills from vehicles. A distinction is made between a pool fire where the vehicle fuel burns on the surface of the waste and a headspace deflagration where head space volume reaches the lower flammability limit (LFL) from the vaporized fuel and then is ignited.

This analysis identifies the consequences for both a pool fire on the surface of the waste and a deflagration in the headspace by showing these accidents are bounded by the Organic Solvent Fire Accident (Cowley 1996) and SST and DST Flammable Gas Deflagration Accidents (Van Vleet 1996).

Scenario Development

The following paragraphs develop the scenario for a vehicle fuel fire in single shell tanks (SSTs), double shell tank (DSTs), double-shell tank annulus, and miscellaneous other tanks including the double-contained receiver tanks (DCRTs), 200-series single shell tanks, catch tanks and MISFs.

The In-Tank Fuel Fire/Deflagration accident is initiated by an errant vehicle or truck (external event) that shears off one or more tank risers. The vehicle fuel tank is ruptured and its contents released. A portion of the fuel enters the waste tank through the damaged riser and/or through cracks in the cover blocks above the pump pit. Some of the vehicle fuel vaporizes or is aerosolized as the fuel drains to the tank. The remaining portion of the fuel pools on the waste surface. The fuel spill has the potential to cause a fire or deflagration in the head space of the tank and could challenge the active or passive ventilation systems. A deflagration could also damage the structural integrity of the tank with the potential for collapse of the tank dome. The uncontrolled release of gases, aerosols, and particulate of radioactive and hazardous material from the tank head space, ventilation system and the tank waste would result.

Unmitigated Accidents

Vehicle fuel pool fire in waste tank - The spilled vehicle fuel enters the waste tank but the vehicle fuel is not immediately ignited. The fuel pools on the surface of the waste and vaporizes. However, the fuel is ignited before the lower flammability limit is reached in the head space. The fuel burns as a pool fire. This scenario is bounded by the Organic Solvent Fire accident (Cowley 1996) based in terms of amount of fuel burned.

Vehicle fuel deflagration in the headspace - A portion of the spilled fuel enters the waste tank and is not immediately ignited. The fuel pools on the surface of the waste and begins to vaporize. The lower flammability limit is reached and the vaporized fuel ignites in the head space. This scenario is bounded by the Flammable Gas Deflagrations (Van Vleet 1996) based on the peak pressure of the burn.

Mitigated Accident

The following controls have been selected to prevent this accident from occurring, thereby protecting the offsite public, onsite and facility worker.

- Vehicle fuel tank protection required within the tank farm boundary
- Physical barriers around tank farm above ground structures outside the tank farm boundary; only vehicles with fuel tank protection access inside the barrier.

Input Data

Gasoline Properties (Lange 1961)

$$LFL := 1.4\%$$

$$UFL := 6\%$$

gasoline has a specific gravity of 0.75

$$\rho_{H_2O} := 1000 \frac{\text{kg}}{\text{m}^3}$$

$$\rho_{\text{liquid}} := 0.75 \cdot \rho_{H_2O}$$

$$\rho_{\text{liquid}} = 750 \frac{\text{kg}}{\text{m}^3}$$

gasoline vapor is 3-4 times heavier than air

$$\rho_{\text{air}} := 1.2 \frac{\text{kg}}{\text{m}^3}$$

$$\rho_{\text{gas}} := 3 \cdot \rho_{\text{air}}$$

$$\rho_{\text{gas}} = 3.6 \frac{\text{kg}}{\text{m}^3}$$

Gallons of gasoline per cubic meter of head space to reach the LFL

$$f_{LFL} := LFL \cdot \frac{\rho_{\text{gas}}}{\rho_{\text{liquid}}}$$

$$f_{UFL} := UFL \cdot \frac{\rho_{\text{gas}}}{\rho_{\text{liquid}}}$$

$$f_{LFL} = 6.72 \cdot 10^{-5}$$

$$f_{UFL} = 2.88 \cdot 10^{-4}$$

Tank Capacity by tank type and farm (Hopkins, 1995)

SST, 530,000 gallon capacity; Dish bottom; 114,400 ft³ empty - B, BX, C, T, U tanks
 SST, 758,000 gallon capacity; Dish bottom; 140,600 ft³ empty - BY, S, TX, TY tanks.
 SST, 1,000,000 gallon capacity; Dish bottom; 170,620 ft³ empty - SX tanks.
 SST, 1,000,000 gallon capacity; Flat bottom; 168,949 ft³ empty - A, AX tanks.
 DST's 1,160,000 gallon capacity; Flat bottom; 187,376 ft³ empty - AN, AP, AW, SY, AY, AZ tanks.

Tank Farm	Tank Radius (ft)	Tank Capacity (gals)	Operating Volume (ft ³)	Total Type	Bottom Height (in)	Capacity Volume (Gals)	(Gal/in)
b	37.5	530,000	114,400	dished	0	12,500	2,754
bx	37.5	530,000	114,400	dished	0	12,500	2,754
c	37.5	530,000	114,400	dished	0	12,500	2,754
t	37.5	530,000	114,400	dished	0	12,500	2,754
u	37.5	530,000	114,400	dished	0	12,500	2,754
by	37.5	758,000	140,600	dished	12	12,500	2,754
s	37.5	758,000	140,600	dished	12	12,500	2,754
tx	37.5	758,000	140,600	dished	12	12,500	2,754
ty	37.5	758,000	140,600	dished	12	12,500	2,754
sx	37.5	1,000,000	170,620	dished	12	18,500	2,754
a	37.5	1,000,000	168,949	flat	0	0	2,754
ax	37.5	1,000,000	168,949	flat	0	0	2,754
an	37.5	1,160,000	188,490	flat	0	0	2,754
ap	37.5	1,160,000	188,490	flat	0	0	2,754
aw	37.5	1,160,000	188,490	flat	0	0	2,754
sy	37.5	1,160,000	188,490	flat	0	0	2,754
ay	37.5	1,000,000	188,490	flat	0	0	2,754
az	37.5	1,000,000	188,490	flat	0	0	2,754
b2	10	55,000	8,168	dished	6	590	196
c2	10	55,000	8,168	dished	6	590	196
t2	10	55,000	8,168	dished	6	590	196
u2	10	55,000	8,168	dished	6	590	196

Calculations for Pool Fire -

The amount of diesel or gasoline fuel is limited to 60 gallons for the vehicle fuel pool fire in waste tank (see attached IVF). This accident is directly comparable to the organic solvent fire in the waste tank (Cowley 1996). The organic solvent fire, which is based on dodecane, is oxygen limited. The stoichiometry of burning either dodecane or diesel fuel should be nearly the same (see attached memo). Therefore, both the dodecane and diesel fires are expected to self extinguish when the oxygen concentration is approximately 13 mole percent.

The largest pressure transient and greatest consequences for the organic pool accident involved a fire that burned 146 kgs of solvent before the fire self extinguished. This fire was based on a pool surface of 210 m². Using a specific gravity of 0.75 for diesel fuel and a density of 1000 kg/m³ for water, 146 kgs of solvent is equivalent to 51 gallons of diesel fuel. However, the pool surface of the fuel burn would be less since 60 gallons of fuel would have a depth of only 0.1 cm if spread out over 210 m².

$$\frac{146 \text{ kg}}{0.75 \cdot 1000 \frac{\text{kg}}{\text{m}^3}} = 51.4 \cdot \text{gal}$$

$$\frac{60 \text{ gal}}{210 \text{ m}^2} = 0.108 \text{ cm}$$

Calculations for Deflagration -

The peak pressure from a gasoline burn is equivalent to a hydrogen burn. The following discussion supporting this argument is condensed from the Closed Vessel Deflagration description of the reference (NFPA 1988).

Conservative estimates of the associated pressure rise in a closed vessel can be made from flame temperature calculations as follows. The ratio of the peak pressure to initial pressure can be calculated from the ideal gas equations at the end of the combustion and prior to ignition.

$$\frac{P_m}{P_0} = \frac{M_0}{M_b} \cdot \frac{T_b}{T_0}$$

where:

- P_m = maximum pressure at completion of burn
- P_0 = initial pressure
- M_0 = molecular weight of gas-air mixture
- M_b = molecular weight of combustion products
- T_b = temperature of burned gas
- T_0 = initial temperature

Assuming the deflagration occurs sufficiently fast to neglect heat dissipation, the value of T_b should correspond to the adiabatic flame temperature of the gas-air mixture. Adiabatic constant-pressure temperatures are shown in the attached figure (Figure 2.5.4 from NFPA 1988) for a number of fuel-air mixtures. The temperatures shown in the figure are in the range of 2100 K to 2400 K for most of the hydrocarbon gases-air mixtures. The adiabatic constant-volume temperatures are generally about 10% higher than the corresponding constant-pressure temperatures.

The molecular weights needed for the above equation are approximately the same prior to and following the combustion for many of the gas-air mixtures. An exception is hydrogen where the molecular weight of the combustion products is less than the initial gas-air mixture by about 15% for a stoichiometric mix. For non-stoichiometric mixes, this difference becomes less.

Therefore, the use of the equation would indicate peak/initial pressure ratios of 7 to 8 range for both hydrogen and the heavier hydrocarbons initially at 300 K. Use of the constant-volume adiabatic flame temperature and accurate calculations of mixture molecular weights would probably produce pressure ratios about 10 percent higher for many of the mixtures.

The burning velocity, S_u , is the flame propagation velocity relative to the unburned gas. The burning velocity for hydrogen is about 8 times the velocity of the heavier hydrocarbons. This means that the rate of pressure rise for a hydrogen burn would be greater than for a gasoline burn (NFPA 1998).

Quantity of Gasoline Required to Reach the LFL in Various Tanks

The lower flammable limit (LFL) can be reached in a full DST (416 inches) with 17.5 gallons of fuel. The annulus of the DST reaches the LFL at 10.7 gallons.

DSTs - (AN, AP, AW, SY, AY, AZ farms)

Estimated 17.5 gallons of gasoline to reach the LFL in full DST.	$DST_radius := 37.5 \text{ ft}$	$area := \pi DST_radius^2$	$area = 410.4 \cdot m^2$
	$empty := 187976 \cdot ft^3$		$empty = 5323 \cdot m^3$
	$max_height := 416 \text{ in}$		$max_height = 10.6 \cdot m$
	$head_space := empty - (max_height \cdot area)$		$head_space = 986.088 \cdot m^3$
	$head_space \cdot f_{LFL} = 17.5 \cdot gal$	$head_space \cdot f_{UFL} = 75.0 \cdot gal$	

DST Annulus (AN, AP, AW, SY, AY, AZ farms)

Width of annulus estimated to be approximately 2.5 ft with a height of 420 in.

Estimated 10.7 gallons of gasoline to reach the LFL in the DST annulus.

$$annulus := \left[\left[(37.5 \text{ ft} + 2.5 \text{ ft})^2 - (37.5 \text{ ft})^2 \right] \cdot \pi \right] \cdot 420 \text{ in}$$

$$annulus = 603.26 \cdot m^3$$

$$annulus \cdot f_{LFL} = 10.7 \cdot gal$$

$$annulus \cdot f_{UFL} = 45.9 \cdot gal$$

SSTs - (A, B, BX, BY, C, S, SX, T, TX, TY, U Farms)

Since transfers to a SST is not allowed, the existing waste volume in each SST will not increase. Based on published waste volumes (Hanlon, 1995), the quantity of fuel required to reach the LFL was calculated for each SST in the following manner as done below for A-101. The results are given in table 2.

Estimated 20.9 gallons of gasoline to reach LFL in tank 241-A-101

$$\text{empty_volume} := 168949 \cdot \text{ft}^3$$

$$\text{waste_volume} := 953 \cdot \text{kgal}$$

$$\text{empty_volume} = 4.784 \cdot 10^3 \cdot \text{m}^3$$

$$\text{waste_volume} = 3.607 \cdot 10^3 \cdot \text{m}^3$$

$$(\text{empty_volume} - \text{waste_volume}) \cdot f_{\text{LFL}} = 20.9 \cdot \text{gal}$$

$$(\text{empty_volume} - \text{waste_volume}) \cdot f_{\text{UFL}} = 89.518 \cdot \text{gal}$$

There are 110 SST tanks identified where the head space could reach the LFL with 60 gallons of diesel or gasoline fuel. None of these 110 tanks have vapor space temperatures that exceed the flashpoint of diesel fuel. The flash point of Grade 2D-A, general purpose automotive diesel fuel is 125 F (Lange 1961). Only the six tanks in the SX farm (241-SX-101 through 241-SX-106) on active ventilation could potentially exceed the flashpoint temperature and reach the LFL with 60 gallons of diesel fuel if ventilation were lost for some sufficient length of time.

DCRTs, 200-series single shell tanks, and catch tanks could all reach the LFL with less than 25 gallons of gasoline, i.e., 20 foot diameter single shell tanks.

$$\text{SST200} := 55000 \cdot \text{gal}$$

Estimated 3.7 gallons of gasoline to reach the LFL in an empty 20 ft diameter single shell tanks (Farms B,C,T & U). A full tank would require even less fuel.

$$\text{SST200} \cdot f_{\text{LFL}} = 3.7 \cdot \text{gal}$$

$$\text{SST200} \cdot f_{\text{UFL}} = 15.8 \cdot \text{gal}$$

References

Cowley, W. L., 1996, *Consequences of Postulated Solvent Fires in Hanford Site Tanks*, WHC-SD-WM-CN-032, Westinghouse Hanford Company, Richland, Washington.

Hopkins, J. D., 1995, *Methodology For Flammable Gas Evaluations*, WHC-SD-WM-TI-724, Westinghouse Hanford Company, Richland, Washington.

Lange, 1961, *Handbook of Chemistry*, McGraw-Hill Book Company, Inc., New York, New York.

NFPA, 1988, *The SFPE Handbook of Fire Protection Engineering*, National Fire Protection Association, Quincy, Massachusetts.

Van Vleet, R. J., 1996, *Flammable Gas Deflagration Consequence Calculations for the Tank Waste Remediation Systems Basis for Interim Operation*, WHC-SD-WM-CN-055, Westinghouse Hanford Company, Richland, Washington.

Note

This report was written in MathCad Plus 6.0 Professional Edition (Mftsoft 1995). The following constants and/or equations were used as a part of the calculation.

$$\text{kgal} = 1000 \cdot \text{gal}$$

Table 2 - Single Shell Tank Lower Flammability Limit Calculations

Tank	Tank Capacity gal	Empty Volume ft ³	Waste Volume kgal	Vapor space m ³	LFL gal	Average Vapor Space Temp F
A-101	1,000,000	168,949	953	1,177	20.9	99
A-102	1,000,000	168,949	41	4,629	82.2	90
A-103	1,000,000	168,949	370	3,384	60.1	86
A-104	1,000,000	168,949	28	4,678	83.0	193
A-106	1,000,000	168,949	125	4,311	76.5	106
AX-101	1,000,000	168,949	748	1,953	34.7	90
AX-102	1,000,000	168,949	39	4,636	82.3	76
AX-103	1,000,000	168,949	112	4,360	77.4	90
AX-104	1,000,000	168,949	7	4,758	84.5	94
B-101	500,000	114,400	113	2,812	49.9	92
B-102	500,000	114,400	32	3,118	55.4	64
B-103	500,000	114,400	59	3,016	53.5	62
B-104	500,000	114,400	371	1,835	32.6	63
B-105	500,000	114,400	306	2,081	36.9	63
B-106	500,000	114,400	117	2,797	49.6	62
B-107	500,000	114,400	165	2,615	46.4	62
B-108	500,000	114,400	94	2,884	51.2	62
B-109	500,000	114,400	127	2,759	49.0	61
B-110	500,000	114,400	246	2,308	41.0	68
B-111	500,000	114,400	237	2,342	41.6	86
B-112	500,000	114,400	33	3,115	55.3	63
BX-101	500,000	114,400	42	3,080	54.7	64
BX-102	500,000	114,400	96	2,876	51.1	65
BX-103	500,000	114,400	66	2,990	53.1	77
BX-104	500,000	114,400	99	2,865	50.9	87
BX-105	500,000	114,400	51	3,046	54.1	66
BX-106	500,000	114,400	31	3,122	55.4	63
BX-107	500,000	114,400	345	1,933	34.3	72
BX-108	500,000	114,400	26	3,141	55.8	65
BX-109	500,000	114,400	193	2,509	44.5	75
BX-110	500,000	114,400	198	2,490	44.2	63
BX-111	500,000	114,400	211	2,441	43.3	65
BX-112	500,000	114,400	165	2,615	46.4	65

Table 2 - continued

Tank	Tank Capacity gal	Empty Volume ft ³	Waste Volume kgal	Vapor space m ³	LFL gal	Average Vapor Space Temp F
BY-101	750,000	140,600	387	2,516	44.7	66
BY-102	750,000	140,600	341	2,691	47.8	76
BY-103	750,000	140,600	400	2,467	43.8	70
BY-104	750,000	140,600	406	2,444	43.4	79
BY-105	750,000	140,600	503	2,077	36.9	78
BY-106	750,000	140,600	642	1,551	27.5	81
BY-107	750,000	140,600	266	2,974	52.8	79
BY-108	750,000	140,600	228	3,118	55.4	80
BY-109*	750,000	140,600	423	2,380	42.3	60
BY-110	750,000	140,600	398	2,475	43.9	74
BY-111	750,000	140,600	459	2,244	39.8	70
BY-112	750,000	140,600	291	2,880	51.1	72
C-101	500,000	114,400	88	2,906	51.6	85
C-102	500,000	114,400	423	1,638	29.1	90
C-103	500,000	114,400	195	2,501	44.4	105
C-104	500,000	114,400	295	2,123	37.7	86
C-105	500,000	114,400	150	2,672	47.4	83
C-106	500,000	114,400	229	2,373	42.1	80
C-107	500,000	114,400	275	2,198	39.0	109
C-108	500,000	114,400	66	2,990	53.1	73
C-109	500,000	114,400	62	3,005	53.3	76
C-110	500,000	114,400	187	2,532	44.9	65
C-111	500,000	114,400	57	3,024	53.7	74
C-112	500,000	114,400	104	2,846	50.5	77
S-101	750,000	140,600	427	2,365	42.0	91
S-102	750,000	140,600	549	1,903	33.8	77
S-103	750,000	140,600	248	3,043	54.0	71
S-104	750,000	140,600	294	2,868	50.9	84
S-105	750,000	140,600	456	2,255	40.0	66
S-106	750,000	140,600	543	1,926	34.2	66
S-107	750,000	140,600	368	2,588	45.9	80
S-108	750,000	140,600	604	1,695	30.1	67
S-109	750,000	140,600	568	1,831	32.5	76
S-110	750,000	140,600	390	2,505	44.5	76
S-111	750,000	140,600	596	1,725	30.6	72
S-112	750,000	140,600	637	1,570	27.9	67

Table 2 - continued

Tank	Tank Capacity	Empty Volume	Waste Volume	Vapor space	LFL	Average Vapor Space Temp
	gal	ft ³	kgal	m ³	gal	F
SX-101	1,000,000	170,620	458	3,098	55.0	91
SX-102	1,000,000	170,620	543	2,776	49.3	91
SX-103	1,000,000	170,620	652	2,363	42.0	116
SX-104	1,000,000	170,620	614	2,507	44.5	85
SX-105	1,000,000	170,620	583	2,625	46.6	86
SX-106	1,000,000	170,620	538	2,795	49.6	82
SX-107	1,000,000	170,620	104	4,438	78.8	121
SX-107	1,000,000	170,620	104	4,438	78.8	113
SX-108	1,000,000	170,620	115	4,396	78.0	134
SX-108	1,000,000	170,620	115	4,396	78.0	132
SX-109	1,000,000	170,620	250	3,885	69.0	124
SX-110	1,000,000	170,620	62	4,597	81.6	115
SX-111	1,000,000	170,620	125	4,358	77.4	124
SX-112	1,000,000	170,620	92	4,483	79.6	122
SX-113	1,000,000	170,620	26	4,733	84.0	74
SX-114	1,000,000	170,620	181	4,146	73.6	135
SX-115	1,000,000	170,620	12	4,786	85.0	
T-101	500,000	114,400	102	2,853	50.7	68
T-102	500,000	114,400	32	3,118	55.4	71
T-102	500,000	114,400	32	3,118	55.4	71
T-103	500,000	114,400	27	3,137	55.7	59
T-104	500,000	114,400	445	1,555	27.6	65
T-104	500,000	114,400	445	1,555	27.6	59
T-105	500,000	114,400	98	2,868	50.9	76
T-105	500,000	114,400	98	2,868	50.9	74
T-106	500,000	114,400	21	3,160	56.1	59
T-107	500,000	114,400	180	2,558	45.4	63
T-108	500,000	114,400	44	3,073	54.6	63
T-109	500,000	114,400	58	3,020	53.6	75
T-109	500,000	114,400	58	3,020	53.6	62
T-110	500,000	114,400	379	1,805	32.0	59
T-111	500,000	114,400	458	1,506	26.7	58
T-112	500,000	114,400	67	2,986	53.0	59

Table 2 - continued

Tank	Tank Capacity gal	Empty Volume ft ³	Waste Volume kgal	Vapor space m ³	LFL gal	Average Vapor Space Temp F
TX-101	750,000	140,600	87	3,652	64.8	
TX-102	750,000	140,600	113	3,554	63.1	
TX-103	750,000	140,600	157	3,387	60.1	58
TX-104	750,000	140,600	65	3,735	66.3	60
TX-105	750,000	140,600	609	1,676	29.8	73
TX-106	750,000	140,600	453	2,267	40.2	59
TX-107	750,000	140,600	36	3,845	68.3	59
TX-108	750,000	140,600	134	3,474	61.7	60
TX-109	750,000	140,600	384	2,528	44.9	62
TX-110	750,000	140,600	462	2,232	39.6	81
TX-111	750,000	140,600	370	2,581	45.8	72
TX-112	750,000	140,600	649	1,525	27.1	80
TX-113	750,000	140,600	607	1,684	29.9	70
TX-114	750,000	140,600	535	1,956	34.7	
TX-115	750,000	140,600	640	1,559	27.7	70
TX-116	750,000	140,600	631	1,593	28.3	
TX-117	750,000	140,600	626	1,612	28.6	
TX-118	750,000	140,600	347	2,668	47.4	69
TY-101	750,000	140,600	118	3,535	62.7	65
TY-102	750,000	140,600	64	3,739	66.4	68
TY-102	750,000	140,600	64	3,739	66.4	64
TY-103	750,000	140,600	162	3,368	59.8	66
TY-104	750,000	140,600	46	3,807	67.6	64
TY-105	750,000	140,600	231	3,107	55.2	66
TY-106	750,000	140,600	17	3,917	69.5	60
U-101	500,000	114,400	25	3,145	55.8	67
U-102	500,000	114,400	374	1,824	32.4	71
U-103	500,000	114,400	468	1,468	26.1	73
U-104	500,000	114,400	122	2,778	49.3	
U-105	500,000	114,400	418	1,657	29.4	73
U-106	500,000	114,400	226	2,384	42.3	71
U-107	500,000	114,400	406	1,703	30.2	70
U-108	500,000	114,400	468	1,468	26.1	73
U-109	500,000	114,400	463	1,487	26.4	71
U-110	500,000	114,400	186	2,535	45.0	68
U-111	500,000	114,400	329	1,994	35.4	70
U-112	500,000	114,400	49	3,054	54.2	61

Information Validation Form

Tracking # VEHFUEL-001

Name of Originator	Organization or Team	Date
J. M. Grigsby	ISB/FSAR	3/15/96
<p>Statement of Problem - The candidate accident "Vehicle Fuel Spill/Fire" involves a "run-away vehicle or truck that shears off one or more risers and ruptures the fuel tank. The resulting fire from the fuel spill has the potential to cause a fire or explosion in the headspace of the tank....". In order to perform bounding/representative unmitigated accident cases, the following data is requested.</p> <ol style="list-style-type: none"> 1. The maximum amount of gasoline contained in the vehicles that are allowed in the tank farms. The bounding assumption is that all of this fuel can enter a SST or DST or DST annulus and be ignited. 2. The maximum amount of diesel fuel contained in the vehicles that are allowed in the tank farms. The bounding assumption is that all of this fuel can enter a SST, a DST or DST annulus and be ignited. 3. Please specify the minimum ventilation flow rate in a DST and DST annulus. This ventilation may or may not prevent a fuel vapor cloud from forming as it evaporates from the pool created by the fuel spilled into the tank. Best judgement is that unless the flowrate is quite high (hundreds of CFM), there is little chance of showing that a vapor cloud could not form above the fuel pool. I.e., if minimum flow rate is in the 20 - 50 CFM range, don't spend much time being more accurate. 4. Please specify the maximum temperature that you desire DSTs to be limited to. If it is above 55 - 70°C, don't spend much time on this one either as we will need to assume that the fuels will be well above their flashpoints (diesel has a flashpoint of 40 - 55°C) 5. Please verify that a vehicle accident and spill <u>can not</u> cause fuel to enter DCRTs, catch tanks, or MISFs. If this can not be verified, we will assume that fuel can enter these tanks. Therefore, please specify the maximum temperatures for these tanks. Again, if it is above 55 - 70°C, just so state and the exact maximum is not that important. 		
Alternatives		Consequences to Alternatives
Decision Reached		Basis for Decision
Date Requested: 3/15/96	Sent To: Tim Bohan	Date Requested By: 3/22/96

Response #1 60 gallons is a good bounding number for diesel and gasoline fuel. The maximum temperature for DSTs should be limited to less than 200 deg. F. Assume fuel can enter the DCRTs. Assume less than 200 deg. F for DCRTs also, since the waste ~~will~~ is not intended to be stored in DCRTs, we can assume the DST temp. is bounding. The design flow rates for the DSTs are as follows: AW Primary 1000 SCFM, AW Annulus 4800 SCFM, AN Primary 600 SCFM, AN Annulus 6125 SCFM, SY Primary 1000 CFM, SY Annulus 1000 CFM. The AY and AZ farms use the same ventilation system, as such the Primary operates 800 - 1000 cfm, the stacked was measured at 3200 - 4000 cfm. The AY annulus ventilation systems (two separate ones) normally operate at 800 cfm; there maximum flow rate is approximately 3500 cfm. The AZ annulus ventilation pulls approximately 1600 cfm through each annuli.

Response #2

Attachments (List)

References (List)

Responder #1 Name and Signature

Responder #2 Name and Signature

Lankford Ruffin *L.R.* 5-7-96

POC:

Filed:

Routed:

Further Action Required (i.e., RML, Senior Management Attention, etc.)

**Westinghouse
Hanford Company**
**Internal
Memo**

From: TWRS FAR Engineering
 Phone: 376-4567 A3-37
 Date: August 8, 1996
 Subject: CONSEQUENCES OF BURNING 60 GALLONS OF DIESEL FUEL

To: R. D. Crowe H0-32
 D. S. Leach A3-34
 A. K. Postma G&P Consultants

cc: S. M. Stahl A3-37
 W. L. Cowley A3-37

You asked if burning 60 gallons of diesel fuel in an underground storage tank would be bounded by the consequences that are analyzed in the organic solvent fire accident. I discussed the question with Arlin Postma of G&P consultants, and we decided that our accident analyses would be bounding for your diesel fire.

We specifically looked at the case of a large pool fire in an SST which gives the maximum radiological consequences and produces the largest pressure transient. This is case g in our spreadsheet. The configuration is a pool 210 square meters in area on the top of the waste surface. The tank has an active ventilation system. The mass of solvent burned is 146 kg's. The only vent path is through the HEPA filter on the ventilation system.

Our model assumes that the solvent is 84% NPH and 16% TBP. To model the properties of NPH, we used dodecane. Since the model assumes 84% NPH, the properties we used for the model are nearly identical to pure dodecane. We believe that the properties of dodecane are a good representation for diesel oil. Therefore we think it is reasonable to assume that our model, which is based on dodecane, is also a good model for diesel fuel.

The stoichiometry of burning dodecane and diesel should be nearly the same in terms of moles of oxygen consumed. Therefore we expect both the dodecane and diesel fires to self extinguish when the oxygen concentration in the air is approximately 13 mole percent.

Our model uses a flame spread velocity of 10 cm/sec. This value comes from tests of unconfined pools of jet fuel. The rate at which jet fuel (essentially kerosene) burns is a good approximation of the rate at which diesel oil burns.

Our case g self extinguishes after 146 kg's of solvent are burned. Using 0.75 for the SpG of diesel oil and 8.34 lbs/gal for the density of water, the 146 kgs of solvent would be equivalent to 51.3 gallons of diesel fuel. The maximum amount of diesel oil that would burn before self extinguishment is 51.3 gallons. The consequences of burning the diesel oil are bounded by the consequences of burning 146 kg's of solvent. Similar

R. D. Crowe
Page 2
August 8, 1996

reasoning also demonstrates that your 60 gallons of diesel fuel is bounded for SSTs and DCRTs by our accident analyses.

W. L. Cowley
Senior Principle Engineer
TWRS SAR Engineering

WLC

Fig. 2-5.4. The adiabatic constant-pressure explosion temperatures for a number of fuel-air mixtures. Initial conditions: $T = 298.15 \text{ K}$, $P = 101.325 \text{ kPa}$. The vertical bars represent stoichiometric mixtures. The species H_2 and CO share the same bar.¹³

CHECKLIST FOR PEER REVIEW

Document Reviewed:

Scope of Review:

Yes No NA

- ☐ ☐ ☒ * Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
- ☒ ☐ ☐ Problem completely defined.
- ☒ ☐ ☐ Accident scenarios developed in a clear and logical manner.
- ☒ ☐ ☐ Necessary assumptions explicitly stated and supported.
- ☐ ☐ ☒ Computer codes and data files documented.
- ☒ ☐ ☐ Data used in calculations explicitly stated in document.
- ☒ ☐ ☐ Data checked for consistency with original source information as applicable.
- ☒ ☐ ☐ Mathematical derivations checked including dimensional consistency of results.
- ☒ ☐ ☐ Models appropriate and used within range of validity or use outside range of established validity justified.
- ☒ ☐ ☐ Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
- ☐ ☐ ☒ Software input correct and consistent with document reviewed.
- ☐ ☐ ☒ Software output consistent with input and with results reported in document reviewed.
- ☒ ☐ ☐ Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
- ☐ ☐ ☒ Safety margins consistent with good engineering practices.
- ☒ ☐ ☐ Conclusions consistent with analytical results and applicable limits.
- ☒ ☐ ☐ Results and conclusions address all points required in the problem statement.
- ☐ ☐ ☒ Format consistent with appropriate NRC Regulatory Guide or other standards
- ☐ ☒ * Review calculations, comments, and/or notes are attached.
- ☒ ☐ ☐ Document approved.

Scott Finrock
 Reviewer (Printed Name and Signature)

9/5/96
 Date

* Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	R. D. Crowe	Date 09/05/96
Project Title/Work Order		EDT No. 618485
Calculation Notes That Support Accident Scenario and Consequence Determination of the In-Tank Fuel Fire/Deflagration.		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
E. R. Bruschi	A2-34	X			
C. Carro	A2-34	X			
R. D. Crowe (3)	H0-32	X			
S. H. Finfrock	H0-32	X			
D. S. Leach	A3-34	X			
A. E. Waltar	H0-32	X			
TWRS S & L Project Files (2)	A2-26	X			
Central Files (original +2)	A3-88	X			