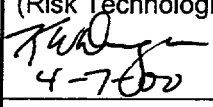
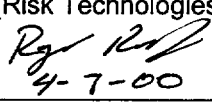
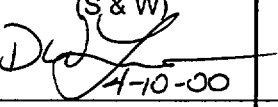


STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION TITLE PAGE

CLIENT & PROJECT Private Fuel Storage L. L. C./Private Fuel Storage Facility				PAGE 1 OF 6	
CALCULATION TITLE Radiant Heat Flux Calculations for Canister Transfer Building Heavy Haul Vehicle Tire Fire				QA CATEGORY I	
CALCULATION IDENTIFICATION NUMBER					
J.O. OR W.O. NO.	DIVISION & GROUP	CURRENT CALC. NO.	OPTIONAL TASK CODE	OPTIONAL WORK PACKAGE NO.	
05996.02	Mechanical	P-007	NA	NA	
APPROVALS - SIGNATURE & DATE			REV. NO. OR NEW CALC. NO.	SUPERSEDES CALC. NO. OR REV. NO.	CONFIRMATION REQUIRED (X) YES NO
PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)			
K. Dungan (Risk Technologies)  4-7-00	R. Rudy (Risk Technologies)  4-7-00	D. Lewis (S & W)  4-10-00	0	NA	X
DISTRIBUTION					
GROUP	NAME & LOCATION	COPY SENT (X)	GROUP	NAME & LOCATION	COPY SENT (X)
RECORDS MGT. FILES (OR FIRE FILE IF NONE)	JOB BOOK R4.2 FIRE FILE	ORIG. x			

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER				PAGE <u>2</u>
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.02	P	007	--	

RECORD OF REVISIONS

Revision 0 - Original Issue

CALCULATION SUMMARY

J.O./W.O./CALCULATION NO.

0599601-P-007

REVISION

0

PAGE 3

CLIENT / PROJECT

Private Fuel Storage L.L.C.

QA CATEGORY / CODE CLASS

QA Category I

SUBJECT / TITLE

Radiant Heat Flux Calculations for Canister Transfer Building Heavy Haul Vehicle Tire Fire

OBJECTIVE OF CALCULATION

The objective of this calculation is to determine the peak radiant heat flux that would be given off by a set of burning tires to see what affect it would have on the spent fuel shipping cask and tires on an adjacent axle. The calculation will determine:

1. The radiant heat flux from the flame of 8 burning tires.
2. The affect of the heat flux on the shipping cask.
3. The affect of the heat flux on an adjacent axle of tires.

CALCULATION METHOD / ASSUMPTIONS

Method: The calculation will utilize typical radiant heat transfer formulas to determine the radiant heat flux of the burning tires.

Assumptions:

1. From Ref. 1 (a typical heavy haul trailer), use trailer tire size 255/70R x 22.5 16PR Radials. These tires are 10 in. wide x 36.5 in. high. Therefore, a double axle set of dual tires will be approximately 1m high x 1 m wide x 3 m long.
2. Use heat release rate of 1500 kW/m² for burning tires. This is conservative based on similar fuels listed in Table 5-5.2(a) of Reference 3.
3. Assume closest set of axles on trailer to shipping cask burn to calculate part 2. From Ref. 1, scale 12 ft (3.7 m) from closest axle to nearest edge of shipping cask.
4. From Ref. 1, distance between sets of axle tires is 12 ft (3.7m).

SOURCES OF DATA / EQUATIONS

1. Trail King Drawing No. 962620, TK300 Trailer System, 5/24/96.
2. Society of Fire Protection Engineers Handbook, NFPA, 2nd edition.
3. NFPA 204, Guide for Smoke and Heat Venting, 1991.

CONCLUSIONS

The results show that the peak radiant heat flux given off by the burning tires of 10.7 kW/m² to the shipping cask is less than the radiant heat flux from the fire for which the cask is qualified in accordance with 10 CFR 71, which yields 68 kW/m².

The results also show that the peak radiant heat flux given off by the burning tires of 8 kW/m² to the adjacent set of axle tires is less than the minimum flux necessary to ignite vulcanized rubber (Similar materials shown in Section 3/Chapter 4 of Reference 2 as ethylene/propylene rubber power cables as 20-23 kW/m² and for chloroprene rubber conveyor belts as 20 kW/m²).

REVIEWER (S) COMMENTS

PREPARER

K. Dungan

DATE

4-7-00

REVIEWER / CHECKER

R. Rudy

DATE

4-7-00

INDEPENDENT REVIEWER

D. Lewis

DATE

4-10-00

Description:

8 - 255/70R 22.5 16PR Radial tires per axle
(10" wide, 36.5" high)

Separation: 12' (3.7m) from tire to next double axle
12' (3.7m) from closest tire to cask edge

Burning characteristics:

Assume heat release rate of 1500 kW/m² floor area
for tires, 1m high, 1m wide, 3m long

$$Q_T = (3 \times 1) 1500 = 4500 \text{ kW}$$

Radiative fraction $\chi_r \leq .35$ so maximum radiative heat
release

$$Q_R = \chi Q_T = .35 \times 4500 = 1575 \text{ kW}$$

Flame emissive flux:

$$E = Q_R / A_f, \quad A_f = \text{flame area envelope} = H_f \times P_f$$

H_f = flame height

P_f = flame perimeter = 3 + 1 + 3 + 1 = 8m

Flame Height (per Heskestad eq 6-1 NFPA 204)

$$H_f = -1.02 D + .235 Q_T^{2/5}$$

$$= -1.02(3m) + .235 (4500)^{2/5} = 3.74 \text{ m}$$

			Radiant Heat Flux Calc.				CLIENT Stone & Webster	
							PROJECT PFSF	
							TASK TIRE FIRE	
							1 ISSUED BY	
PREPARED	KWD	4-5					DATE 4-5-00	
CHECKED	RR	4-6					NUMBER	
APPROVED							1 of 3	
REVISIONS BY	2		3	4	5	6		
DATE								

$$A_f = 3.74\text{m} \times 8\text{m} = 30\text{m}^2$$

$$E = Q_R / A_f = \frac{1575}{30} = 52.5\text{ kW/m}^2$$

Exposure calculations:

$$\dot{q}_r = F_{12} E, \quad F_{12} = \text{view factor}$$

Case 1 Tire fire exposing shipping cask.

At closest point cask will be 3.7m from edge of flame;
greatest point flux will be on portion of cask centered
on flame.

$$F_{12} = \frac{2}{\pi} \left[\frac{X}{\sqrt{1+Y^2}} \tan^{-1} \frac{Y}{\sqrt{1+X^2}} + \frac{Y}{\sqrt{1+Y^2}} \tan^{-1} \frac{X}{\sqrt{1+Y^2}} \right]$$

$$X = \frac{1}{2} \text{ Flame height} / \text{distance to target} = \frac{1.87}{3.7} = .5054$$

$$Y = \frac{1}{2} \text{ flame width} / \text{distance to target} = \frac{1.5}{3.7} = .4054$$

$$F_{12} = \frac{2}{\pi} \left[\frac{.5054}{\sqrt{1+.5054^2}} \tan^{-1} \frac{.4054}{\sqrt{1+.5054^2}} + \frac{.4054}{\sqrt{1+.4054^2}} \tan^{-1} \frac{.5054}{\sqrt{1+.4054^2}} \right]$$

$$= \frac{2}{\pi} [.1567 + .1646] = .2045$$

$$\dot{q}_r = 52.2 \times .2045 = 10.7\text{ kW/m}^2 \text{ peak}$$

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CHECKED			RR				1 ISSUED BY
APPROVED							DATE 4-5-00
REVISIONS BY	2	3	4	5	6	NUMBER	
DATE						2 of 3	

Case 2 Tire fire exposing adjacent axle

At closest point tire edge will be 3.7m from edge of flame, tire will be at base of flame, worst case is center base.

$$F_{12} = \frac{1}{\pi} \left[\frac{X}{\sqrt{1+Y^2}} \tan^{-1} \frac{Y}{\sqrt{1+Y^2}} + \frac{Y}{\sqrt{1+Y^2}} \tan^{-1} \frac{X}{\sqrt{1+Y^2}} \right]$$

$$X = \text{flame height} / \text{separation distance} = \frac{3.74}{3.7} = 1.011$$

$$Y = \frac{1}{2} \text{flame width} / \text{separation distance} = \frac{1.5}{3.7} = .4054$$

$$F_{12} = \frac{1}{\pi} \left[\frac{1.011}{\sqrt{1+1.011^2}} \tan^{-1} \frac{.4054}{\sqrt{1+1.011^2}} + \frac{.4054}{\sqrt{1+.4054^2}} \tan^{-1} \frac{1.011}{\sqrt{1+.4054^2}} \right]$$

$$= \frac{1}{\pi} [.1975 + .283] = .153$$

$$\ddot{q}_{b_r} = 52.2 \times .153 = 8 \text{ kW/m}^2 \text{ peak}$$

							CLIENT Stone & Webster
	BY	DATE					PROJECT JF SF
PREPARED	KWD	4-5					TASK TIRE FIRE
CHECKED	RR	4-6					1 ISSUED BY
APPROVED							DATE 4-5-00
REVISIONS BY	2		3	4	5	6	NUMBER
DATE							3 of 3