Fire Modeling

At the request of the Region III inspectors, an Office of Nuclear Reactor Regulation (NRR) fire protection engineer performed an analysis of the radiation protection office area to evaluate the potentially hazardous conditions (increased temperature and smoke layer level) that could be caused by a fire and assess the associated damage potential in the fire area.

The staff concluded that hot gas layer temperature in the radiation protection office could reach in excess of 1,006 °F (540 °C) in 9 minutes. The staff's analysis was based on computer fire modeling of the radiation protection office using CFAST (**C**onsolidated Model of **F**ire Growth **a**nd **S**moke **T**ransport). CFAST was developed by the Building and Fire Research Laboratory (BFRL) at the National Institute of Standards and Technology (NIST) for fire modeling steady and unsteady state burning rates in multiple compartment configurations (multiple room capability, up to 15 rooms can be modeled) (Jones *et al.,* 2000).

The primary combustibles in the radiation protection office are open bookshelves with paper materials, offices chairs, tables, computers, open plastic recycle bin, and plastic trash can. Actual fire growth curves from testing have shown that the many common combustibles (e.g., cotton, polyester, mail bags, pallets stack) tend to be greater than the t^2 medium fire growth (Nelson, 1987). The t^2 relationship has proven to be useful and has been adopted into the National Fire Protection Association NFPA 72 to categorize fires for detector spacing requirements and into NFPA 92B for design of smoke control system. For the purpose of this analysis a t^2 medium fire growth rate for these fires was assumed for fire modeling.

The main ignition sources in radiation protection office include coffee makers, toaster, pizza oven, freezer, microwaves, and printer. The electrical failure of one of the ignition source is postulated in this analysis to ignite the combustibles in the radiation protection office.

Based on this information, the inspectors concluded that a fire in the radiation protection office area could adversely affect the post-fire safe-shutdown cable trays in the cable spreading area above due to heat being conducted and radiated through the metal decking.

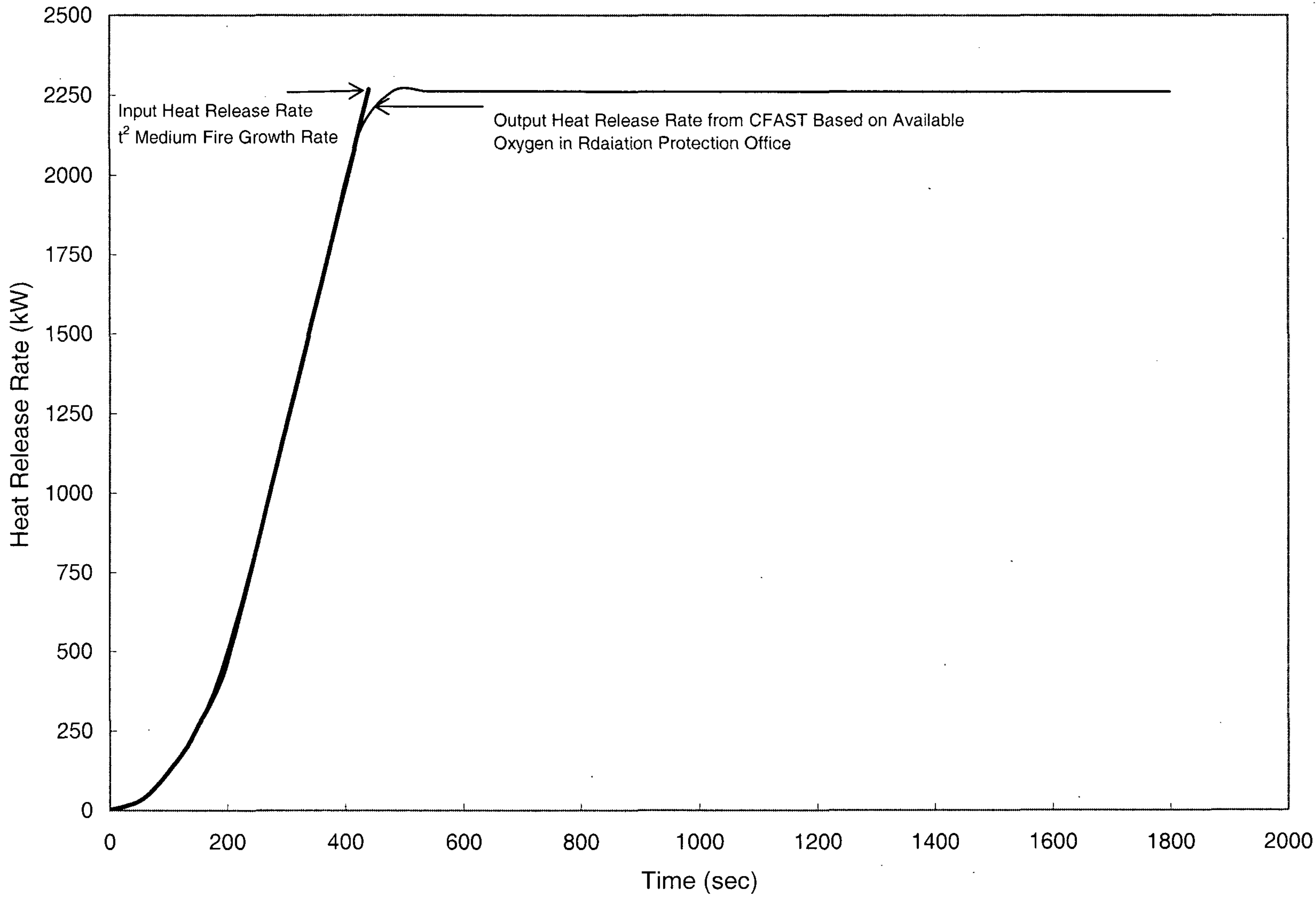
References

Jones, W. W., Forney, G. P., Peacock, R. D., and Reneke, P. A., "A Technical Reference for CFAST: An Engineering Tool for Estimating Fire and Smoke Transport," NIST TN 1431, U.S. Department of Commerce, National Institute of Standards and Technology (NIST), Building and Fire Research Laboratory (BFRL), Gaithersburg, Maryland, January 2000.

Nelson, H.E., "An Engineering Analysis of the Early Stages of Fire Development: The Fire at the Dupont Plaza Hotel and Casino on December 31, 1986," NBSIR 87-3560, U.S. Department of Commerce, National Bureau of Standards (NBS), Gaithersburg, Maryland, May 1987.

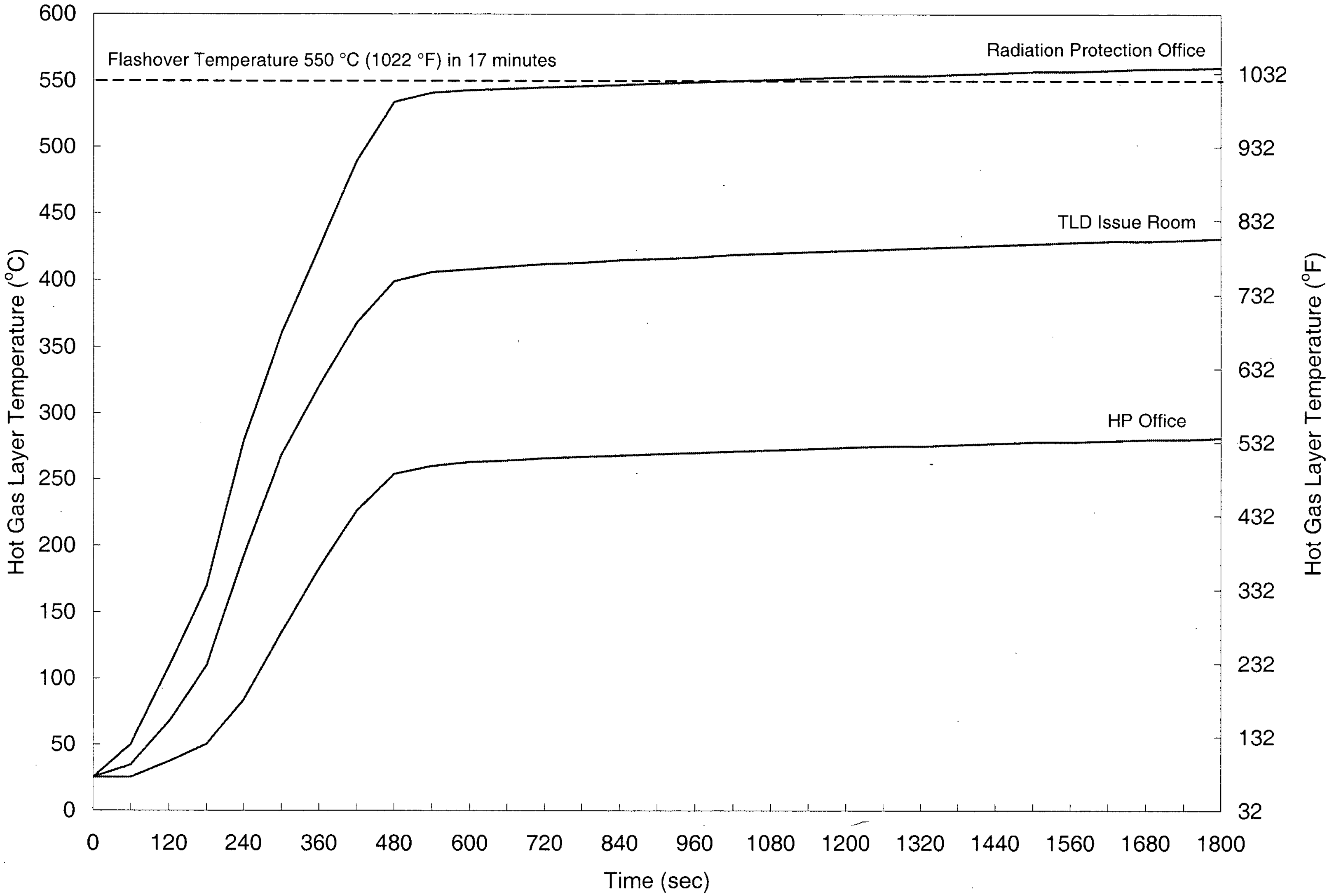
NFPA 72, "National Fire Alarm Code," 1999 Edition, National Fire Protection Association, Quincy, Massachusetts.

NFPA 92B, "Guide for Smoke Management Systems in Malls, Atria, and Large Areas," 2000 Edition. National Fire Protection Association, Quincy, Massachusetts.



Input and Ouput Heat Release Rate for CFAST Fire Model, Fire in Radiation Protecion Office

0	0	0	0
60	42.192	60	42.2
120	168.768	120	169
150	263.7	180	387
200	468.8	240	769
440	2268.992	300	1218
		360	1667
		420	2115
		480	2262
		540	2262
		600	2262
		660	2262
		720	2262
		780	2262
		840	2261
		900	2261
		960	2261
		1020	2261
		1080	2261
		1140	2261
		1200	2261
		1260	2261
		1320	2261
		1380	2261
		1440	2261
		1500	2261
		1560	2261
		1620	2261
		1680	2261
		1740	2261
		1800	2261



Temperature Rise in Radiation Protection Office, TLD Issue Room, and HP Office, Fire in Radiation Protection Office

0	25	25	25	77
60	50	34.4	25	77
120	109	67.2	37	98.6
180	170	110	50.3	122.54
240	279	192	83.7	182.66
300	361	269	135	275
360	424	321	183	361.4
420	489	368	226	438.8
480	534	399	254	489.2
540	541	406	260	500
600	543	408	263	505.4
660	544	410	264	507.2
720	545	412	266	510.8
780	546	413	267	512.6
840	547	415	268	514.4
900	548	416	269	516.2
960	549	417	270	518
1020	550	419	271	519.8
1080	551	420	272	521.6
1140	552	421	273	523.4
1200	553	422	274	525.2
1260	554	423	275	527
1320	554	424	275	527
1380	555	425	276	528.8
1440	556	426	277	530.6
1500	557	427	278	532.4
1560	557	428	278	532.4
1620	558	429	279	534.2
1680	559	429	280	536
1740	559	430	280	536
1800	560	431	281	537.8

NRR Primarily CFAST Fire Modeling Results								
Kewaunee Nuclear Plant								
Fire in Radition Protection Office								
t^2 Medium Fire Growth Rate								
Door at Location 56 is Open								
SI System					**English System**			
	Rad Pro Office	TLD Issue RM	HP Office			Rad Pro Office	TLD Issue RM	HP Office
Time (sec)	Hot Gas Layer	Hot Gas Layer	Hot Gas Layer		Time (sec)	Hot Gas Layer	Hot Gas Layer	Hot Gas Layer
(sec)	Temp **(°C)**	Temp **(°C)**	Temp **(°C)**		(min)	Temp **(°F)**	Temp **(°F)**	Temp **(°F)**
0	25	25	25		0	77	77	77
60	50	34.6	25		1	122	94.28	77
120	109	67.7	37.9		2	228.2	153.86	100.22
180	170	109	49.8		3	338	228.2	121.64
240	279	192	83.4		4	534.2	377.6	182.12
300	361	269	135		5	681.8	516.2	275
360	424	321	183		6	795.2	609.8	361.4
420	489	368	226		7	912.2	694.4	438.8
480	534	399	254		8	993.2	750.2	489.2
540	**541**	406	260		**9**	**1005.8**	762.8	500
600	543	408	263		10	1009.4	766.4	505.4
660	544	410	264		11	1011.2	770	507.2
720	545	412	266		12	1013	773.6	510.8
780	546	413	267		13	1014.8	775.4	512.6
840	547	415	268		14	1016.6	779	514.4
900	548	416	269		15	1018.4	780.8	516.2
960	549	417	270		16	1020.2	782.6	518
1020	**550**	419	271		**17**	**1022**	786.2	519.8
1080	551	420	272		18	1023.8	788	521.6
1140	552	421	273		19	1025.6	789.8	523.4
1200	553	422	274		20	1027.4	791.6	525.2
1260	554	423	275		21	1029.2	793.4	527
1320	554	424	275		22	1029.2	795.2	527
1380	555	425	276		23	1031	797	528.8
1440	556	426	277		24	1032.8	798.8	530.6
1500	557	427	278		25	1034.6	800.6	532.4
1560	557	428	278		26	1034.6	802.4	532.4
1620	558	429	279		27	1036.4	804.2	534.2
1680	559	429	280		28	1038.2	804.2	536
1740	559	430	280		29	1038.2	806	536
1800	560	431	281		30	1040	807.8	537.8

```
VERSN  3  Kewanuee Nuclear Plant-Fire in Rad Protection Office-t2 Medium Fire Growth
Rate
TIMES 1800  60  60  60   0.0
TAMB  298. 101300. 0.0
EAMB  298. 101300. 0.0
HI/F   0.00  0.00  0.00
WIDTH  5.18  5.18  3.96
DEPTH  8.30  5.25  2.43
HEIGH  2.43  2.43  2.43
HVENT  1  2  1  3.35  2.13  0.0  0.0  0.0  0.0  0.0  0.0
HVENT  1  4  2  0.91  2.13  0.0  0.0  0.0  0.0  0.0  0.0
HVENT  2  3  1  0.91  2.13  0.0  0.0  0.0  0.0  0.0  0.0
HVENT  2  4  2  1.82  2.43  1.52 0.0  0.0  0.0  0.0  0.0
CVENT  1  4  2  0.91  2.13  1.0  1.0  1.0  1.0  1.0  1.0
CEILI  CONCRETE CONCRETE CONCRETE
WALLS  CONCRETE CONCRETE CONCRETE
FLOOR  CONCRETE CONCRETE CONCRETE
CHEMI 16. 10. 10.  20000000.  298.  388. 0.2
LFBO  1
LFBT  2
FPOS  1.0  1.0  0.0
FTIME 60.0  120.0  150.0  200.0  440.0
FHIGH 0.5  0.5  0.5  0.5  0.5
FAREA 0.5  0.5  0.5  0.5  0.5
FQDOT 0.0  42192.0  168768.0  263700.0  468800.0  2268992.0
CJET OFF
CO   0.03  0.03  0.03  0.03  0.03
OD   0.08  0.08  0.08  0.08  0.08
HCR  0.13  0.13  0.13  0.13  0.13
STPMAX  1.00
DUMPR KNP3.Hi
DEVICE 1
WINDOW   0  0. -100. 1280. 1024. 1100.
GRAPH 1  170.  300.   0. 625.   820.  10.  5  TIME CELSIUS
GRAPH 2  765.  300.   0. 1220.  820.  10.  5  TIME FIRE_SIZE (kW)
LABEL 1  970.  960.   0. 1231.  1005. 10.  15 00:00:00    0.   0.
LABEL 2  690.  960.   0. 987.   1005. 10.  13 TIME_ [SEC] 0.   0.
TEMPERA  0  0  0  0  1   1 U
HEAT     0  0  0  0  2   1 U
```