FIRE AND SECURITY CONSULTING SERVICES

17 McKenna Court
NOOSAVILLE
QUEENSLAND, 4566
AUSTRALIA

Phone: +61 (0)7 5455 5148, Mobile: 0409 399 190, Email: rafoster@bigpond.net.au

http://fscs-techtalk.com

CORRELATION OF REAL FIRES, FIRE TESTS AND MODELLING – V2

Fire and Security Consulting Services is frequently asked if fire modeling has ever been substantiated in real fires and / or fire tests.

The answer is a definite YES and all modeling programmes, especially those in the CFAST [1] and BranzFire [2] databases are based on data which includes real fires and/or fire tests.

Note that in the following, text underlined thus xxxxxxxxxx leads to the referenced web site or document cited.

Whilst researching latest released FSCS paper "*Smoke and Heat Vents in High Rise Residential Buildings*", the selection of the design fire was naturally selected as a type of house furnishing, and the NIST "love seat" was used.

At that time the existence of video evidence from prior to 2000 was overlooked because, as cited in that paper, more recent residential fire tests were in available. However, the more recent tests were couched to convince Regulatory Authorities to legislate for sprinkler systems in homes and did not contain much technical data.

FSCS has now searched its fire archives and found the comparison of sprinklered and unsprinklered fire tests from NIST [3] US National Institute of Standards and Technology [National Institute of Standards and Technology's web site] in 1996. The importance of this is that the NIST test data from those tests can be used to correlate the model used in the FSCS paper addressing the *smoke and heat vent* paper.

Domestic Furnishing Fire Tests

As discussed in several FSCS papers including *"Developing Design Fires for Alternative Solutions – V4* " NIST carried out a series of free-burn tests using typical home furnishings. These tests were carried out at the Building Fire Research Laboratory (BFRL) [4] [http://www.nist.gov/building-and-fire-research-portal.cfm] furniture cone calorimeter.

For those readers not au-fait with what cone calorimeters are, they are used to gather data from the free burning of samples in a controlled environment where all the products of combustion can be collected and analysed. Figure 1 below shows an ISO 9705 "small" cone calorimeter in Europe. FM Global and other test stations have large scale calorimeters which can accommodate multi-megawatt fires of large furniture or rack storage of materials.

Figure 1 -Typical ISO 9705 Small Calorimeter

Data collected includes heat released, temperatures, and species such as CO, CO_2 and HCN against a specified time frame which organisations such as NIST use in the development of zone and CFD models.

The results those tests are available on the NIST web site and the one of interest in this paper is the "love seat" test as described in Figure 3 below.

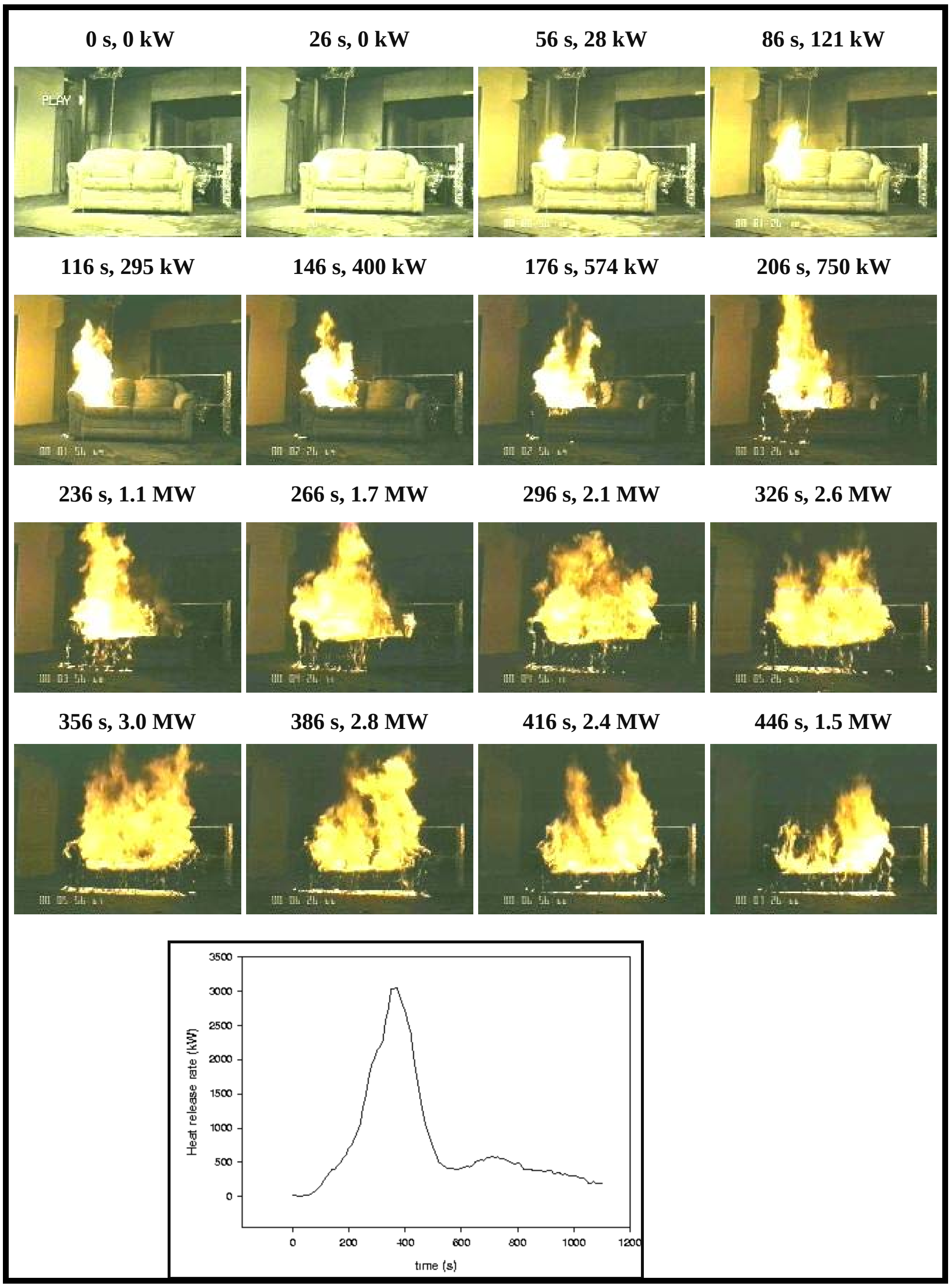


Figure 3 – Free-burn "Love Seat" Fire

Residential Fire Sprinkler Tests

When the BFRL commissioned NIST to investigate the effectiveness of residential sprinkler systems, they used the furnishings as described in the previously cited NIST test.

The test was a comparison of a "living room" fire, with and without residential (domestic) sprinklers which had recently been released to the market with design criteria in NFPA 13D [4] for domestic (up to two storey single occupancy dwellings and NFPA 13R [5] residential systems (up to 4 storeys in height).

Two rooms, each 3.7m x 2.4m high, were built in the Large Fire Research Facility at NIST. Both of the "living rooms" were furnished with a sofa, love seat, end table, lamp and carpeting. Room A had a smoke detector installed and Room B had both a smoke detector and a residential sprinkler system. A match was used to ignite the sofa. The fires in both rooms continued to grow. Figure 4 below shows, in time lapse photography, pictures at various periods in the fire development.

Key times in the test were:-

1. Within 40 seconds after ignition, the smoke detectors in each room activated.
2. At 85 seconds the residential sprinkler activated in Room B, and as a result of the water spray from the sprinkler, the fire is suppressed and safe conditions are maintained.
3. The fire in Room A continues to grow with flash over in Room A at 195 seconds after ignition, with temperatures exceeding 600°C.

Figure 4 below shows selected images from the videos taken during the tests. Note that this figure and the videos can be downloaded from the NIST web site http://www.fire.nist.gov/fire/sprink/, however for convenience both the sprinkled and non sprinklered videos are on the FSCS web site http://fscs-techtalk.com although the file size will be lager and with different controls.

FSCS recommends that you first download the videos, save them to an appropriate folder, then open and view the videos using the Apple programme QuickTime. If you do not have that programme, QuickTime 7 can be freely downloaded at www.apple.com/au/quicktime .

If you use other programmes such as Windows Media Player you may not be able to adjust the screen size, and more importantly, be able to pause and view frame by frame.

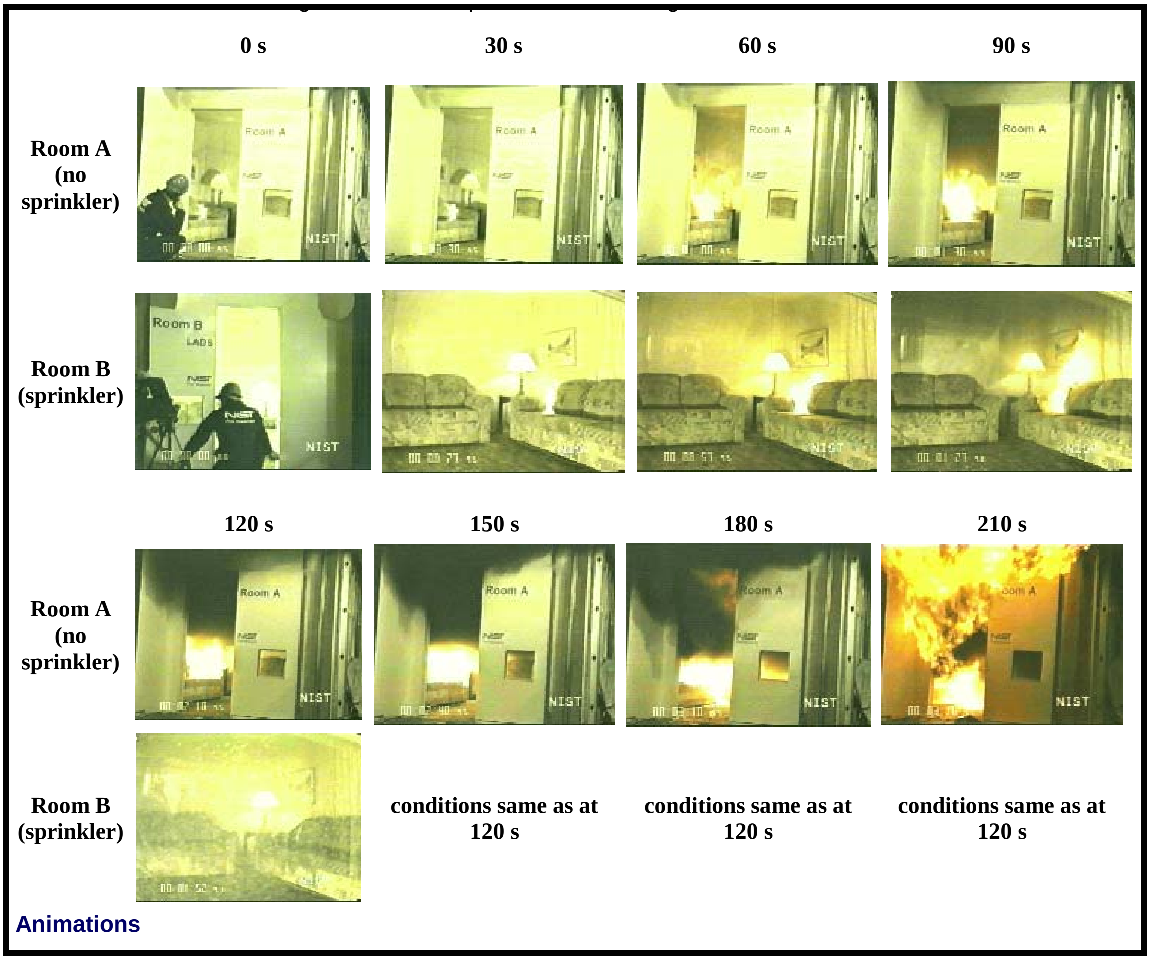


Figure 4 – Selected Test Images

Test	QuickTime	mpeg
Fire with sprinkler	**sprink.mov (1.2 mb)**	**sprink.mpg (820 kb)**
Fire without sprinkler	**nosprink.mov (1.2 mb)**	**nosprink.mpg (930 kb)**

Figure 5 – Video Availability from NIST

Correlation

As discussed, the HRR data generated in the BranzFire model in the FSCS paper "*Smoke and Heat Vents in High Rise Residential Buildings*" was used to demonstrate the effectiveness of automatic smoke and heat vents and sprinklers in residential occupancies in high rise buildings – see **Note** below.

Note that the FSCS paper "*Fire Spread from Openings in Sprinkler Protected Buildings*" was used to demonstrate the efficacy of residential sprinklers and referenced the September 9th, 2006 live fire exercises by the Redmond and the Woodinville Fire Departments in the USA.

Comparing the Model and Video

To assist in this process Figure 6 below is the HRR graph from the FSCS paper "*Smoke and Heat Vents in High Rise Residential Buildings"* where all the unnecessary (for this comparison) data has been omitted. The remaining free burn and sprinkler HRR data remains.

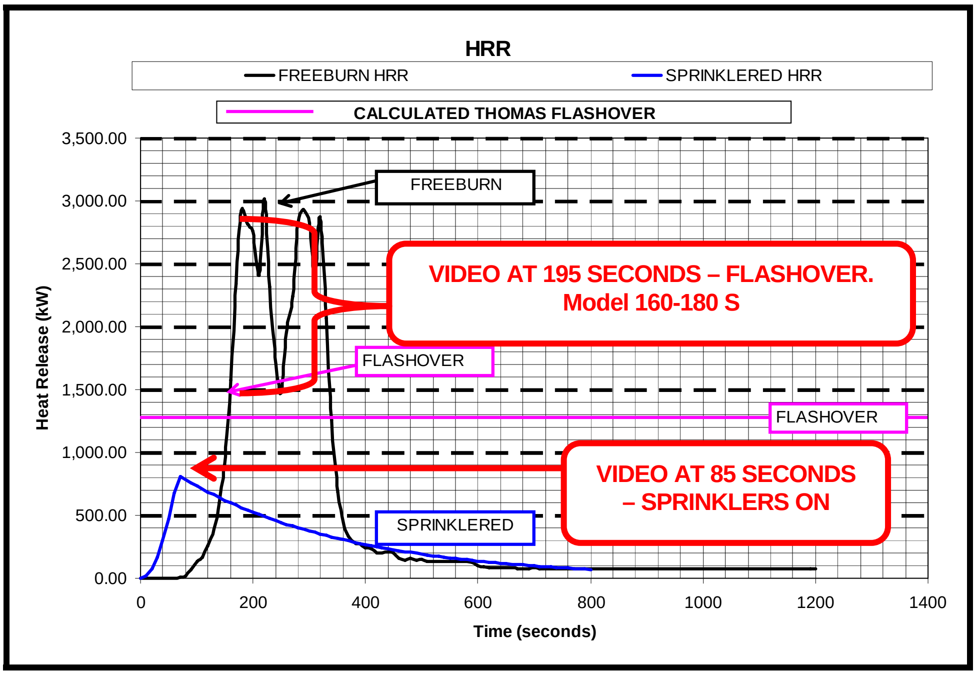


Figure 6

Now it will advantageous to have this figure and the QuickTime video on the same screen as shown in Figure 7 below.

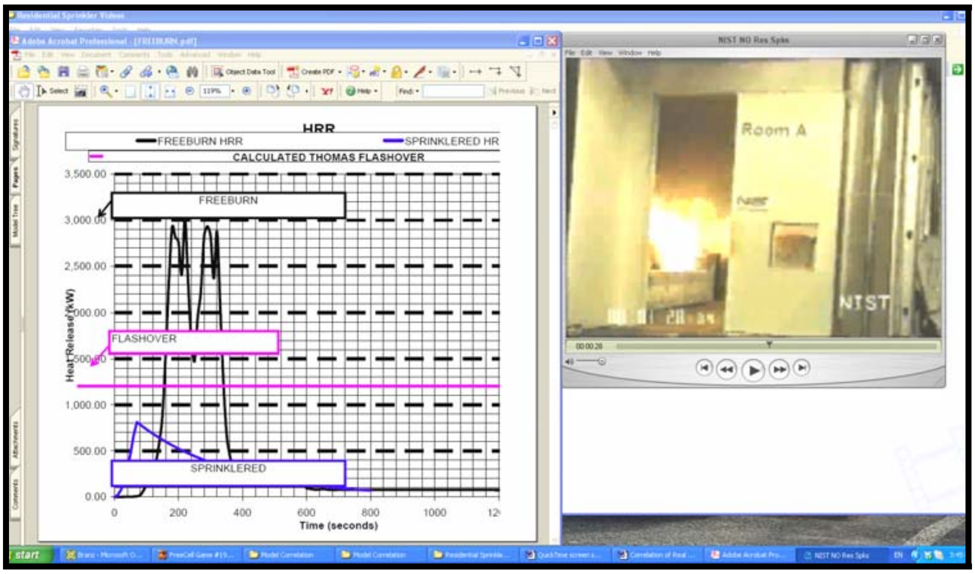
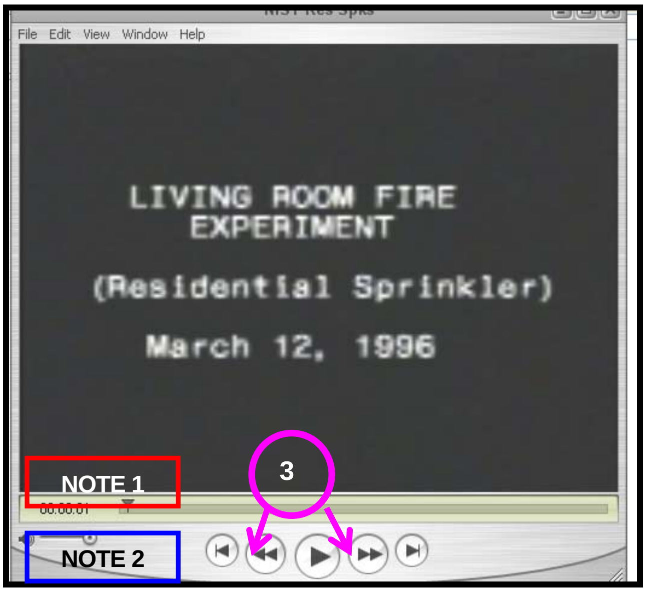


Figure 7 – Both data on same screen

Open the QuickTime movie by downloading the **NIST No Res Sprinklers** from the FSCS web site or directly from NIST.

Set up the QuickTime video as Figure 8 below with the size set to "double" being the best resolution and noting that:-

1. The time in minutes and seconds on the picture should be used.
2. The timesacle on the slider control is to be ignored, as is the slider
3. Start the video using the play **(>)** button. You can then use the pause button (II) or stop button ((▮) as per any normal video device
4. With the video paused, use the "**>>**"fast forward" or **<<** "fast back" controls to advance or rewind the video in approximately one second intervals, noting the time on the screen.



1. Read time on screen

2. Not on timeframe bar

3. Frame forward and back controls

Figure 8 – QuickTime controls

5. Compare the timeframes in the computer model HRR graph with the timescale on the video. To assist with the comparison, this paper includes the following comparisons.

Non Sprinklered Video – Compare to black graph

No Sprinklers - Title

Furnishings

No Sprinklers - Title

13 Seconds – Sofa fire starts

1 minute 40 seconds
Smoke hot layer clearly visible

2 minutes 30 seconds

3 minutes 0 seconds

3 minutes 15 Seconds (195 seconds)
Flashover

3 minutes 36 seconds - water stream applied to upper layer

Sprinklered Video – Compare to green graph

With sprinklers – Title

0 minutes 30 seconds, flaming fire

1 minute 0 seconds. Well developed fire

1 minute 0 seconds outside

1 minute 25 seconds (85 seconds)
Sprinkler operated

1 minute 30 seconds
Largely suppressed

2 minutes 0 seconds. Fire out – blurred image is water on camera lens. Note the table lamp still on!

Conclusion

FSCS is of the opinion that correlation between fire models and fire tests has been shown to have an excellent fit.

1. The correlation of flashpoint in the free burn model at between 160 and 180 seconds is a good fit being on average ~14% more conservative than the fire test flashover at 195 seconds.
2. The correlation of sprinkler operation model at 80 seconds is a good fit being ~ 6% faster than the test fire being 85 seconds. It is noted that the test fire achieved rapid suppression whilst the model was more conservative.

FSCS is comfortable with this satisfactory correlation because, as discussed, the model developers have not only used the available mathematical computations and research available, but much of the NIST data has been used as an input to the models.

Accordingly FSCS is of the opinion that subject to careful design fire selection, that the various model results can be used with a high degree of confidences.

FSCS however, cautions that as fire scenarios get bigger than those that can be measured in cone calorimeters, i.e. =/>20MW, that results from models should have conservative safety factors added.

FSCS recommends that Fire Engineers should use design fires from sources such as:-

1. The current **Society of Fire Safety** (SFS) "*Practice Note on Design Fires"; or*
2. The **FSCS** paper *"Developing Design Fires for Alternative Solutions – V4* ".

Both having been developed by appropriately qualified and experienced Fire Engineers.

References

[1] *CFAST, National Institute of Standards and Technology, 1995; and NIST, 1997. "A User's Guide for FAST: Engineering Tools for Estimating Fire Growth and Smoke Transport", http://fire.nist.gov/bfrlpubs or http://www.bfrl.nist.gov*

[2] *BranzFire Fire models http://www.branz.co.nz*

[3] *NBSIR 83-2787 – Fire Performance of Furnishings As measured in the NBS Furniture Caloririmeter. - U.S. DEPARTMENT OF COMMERCE, National Bureau of Standards*

[4] *NFPA 13D, Domestic Sprinkler Systems, National Fire Protection Association, USA.*

[5] *NFPA 13R [45] Residential Sprinkler Systems, National Fire Protection Association, USA.*

Prepared by:

Richard A Foster Dip Mech Eng; Dip Mar Eng; MSFPE

Fire Safety Engineer

Principal – Fire and Security Consulting Services

Version 1 – January 2014