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Institute for Research in Construction

Fire Suppression Performance of Manually Applied CAF and Other Water Based System

Andrew Kim and George Crampton

Fire Suppression Research and Applications – A Technical Working Conference (SUPDET2012)

Outline

- Introduction
- Experimental set-up
- Test Results
- Discussion
- Conclusion

Introduction

- Fire services currently use
  - Water hose stream or
  - Foam system with air-aspirated nozzle
    - poor foam quality
    - reduced discharge momentum
- Recently, several new mobile fire suppression systems
  - Compressed-air-foam (CAF) system
  - Medium Pressure Water system
  - High Pressure Water system
  - High Expansion Foam System

Mobile CAF System

- New type of fire suppression system
- Injects compressed air and foam concentrate into water stream in the mixing chamber
- Water/Foam/Air mixture flows in the pipe, producing good quality foam with high discharge momentum

Medium Pressure Water System

- Similar to current water system but discharge at higher pressure
- 550 psig (37 bar)
- Relatively new system

High Pressure Water System

- Similar to current water system but discharge at very high pressure
- 1450 psi (99 bar)
- Relatively new system

High Expansion Foam System

- Produces foam with high expansion ratio
- Expansion ratio of 250:1
- Questionable whether it can be used for manual fire suppression tactics

New Mobile System

- New type of fire suppression systems
- Some are gaining popularity among fire services
- No study done to systematically evaluate its fire suppression effectiveness
- Necessary to compare the fire suppression effectiveness of these new manual systems with traditional fire suppression system
  - fully developed compartment fires
  - fire control effectiveness
  - amount of water consumption

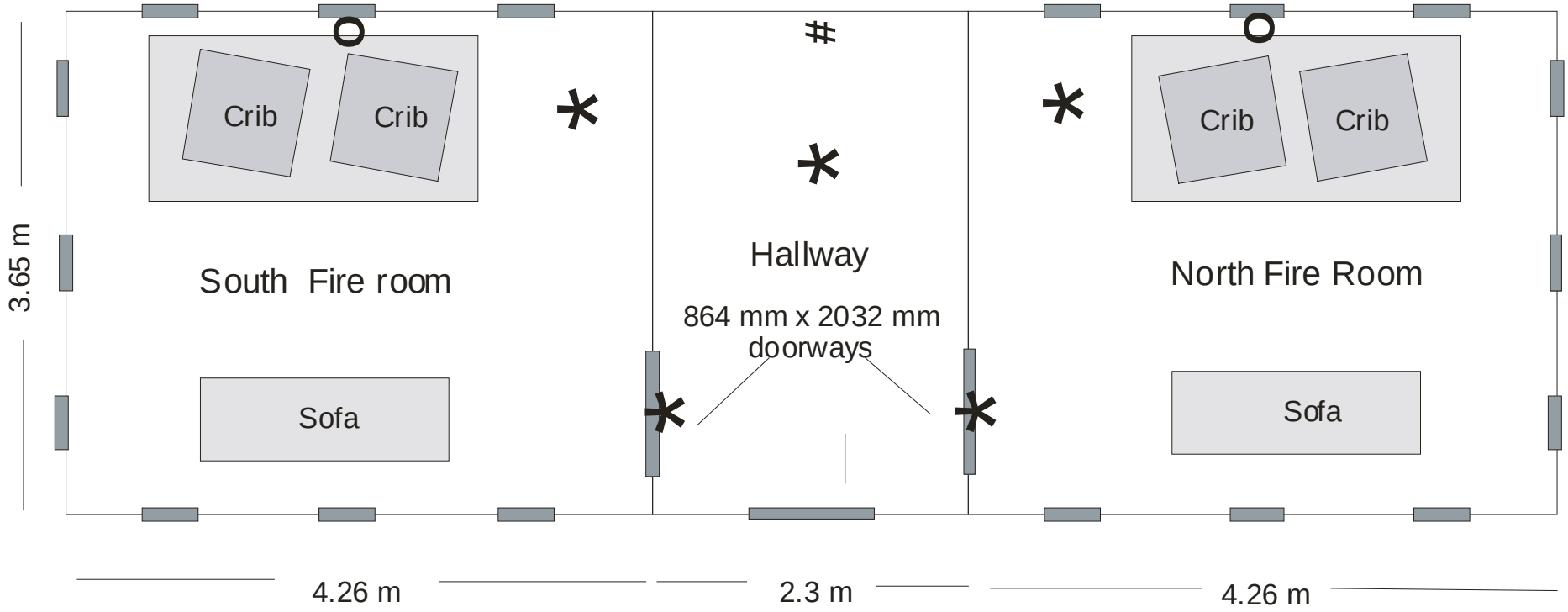
Objective of the Project

- Evaluate fire suppression performances of these new manual systems, and compare its performance with that of current fire suppression system
- Full-scale tests
  - fully developed compartment fires
  - suppress manually by same fire fighter
  - compare fire control effectiveness
  - amount of water consumption

Experimental Set-Up

- Test compartment
  - 4.3 m by 3.7 m and 2.4 m high
  - 0.86 m by 2 m door opening
  - a corridor (hallway) outside of the door opening
- Several ventilation openings
  - nine 0.23 m x 0.41 m openings on lower walls
  - simulated window opening of 0.41 m by 0.48 m
- Fire load
  - two wood cribs (48 pc of 38 x 90 x 800 mm pine studs)
  - simulated wooden bench
  - OSB board on the lower half of walls and floor

Test Compartment



Fire Load

Instrumentation

- Thermocouple trees
  - 24-gauge type K thermocouples
  - five T/C in each tree 0.5 m apart from ceiling
  - fire room and hallway
- Heat flux meter
  - in the fire room near the centre of the back wall
- Gas sampling
  - in the hallway
  - smoke obscuration, O_2, CO and CO_2
- Video cameras
  - two for visual records

CAF System

- NRC CAF system
- Variable foam concentrate and air input
- Variable flow rate

CAF System Nozzles

- Special smooth bore nozzles

12.5 GPM nozzle

25 GPM nozzle

Medium Pressure Water System

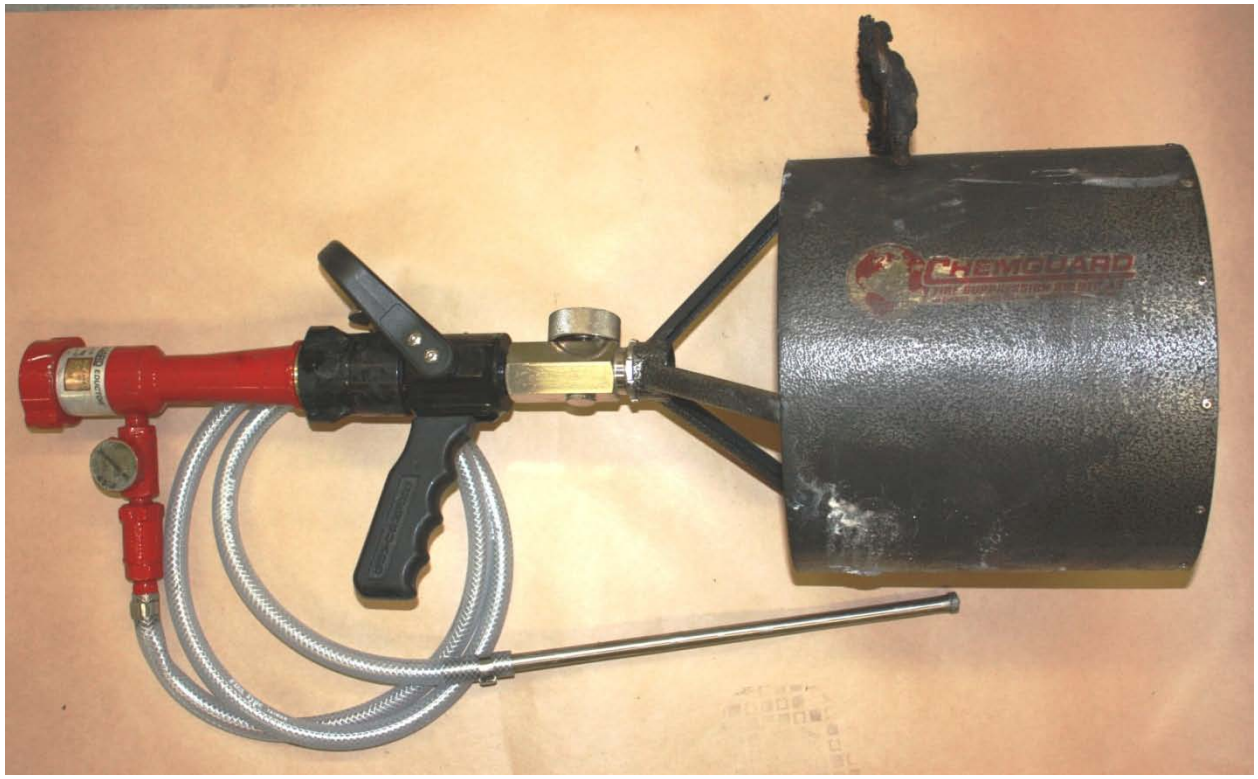
- Rosenbauer truck mounted system
  - 550 psi with flow rate of 43 GPM

Ultra High Pressure Water System

- Trailer mounted system supplied by HMA
  - 1450 psi with flow rate of 17.5 GPM

High Expansion Foam System

- Nozzle was Chemguard VARI-X-III with settings for low, medium and high expansions
- Coupled with Chemguard 25 GPM eductor at 2% foam concentration
- Expansion set at 250:1 with 750 CFM delivery rate



Foam Concentrate

- Hi-Combat Class A foam concentrate
  - designed for use in Class A/B foam systems
  - can also be used in CAF systems
  - typically used at 0.3% - 1.0%
  - for CAF system, 0.1% - 0.5% recommended
- For High Expansion Foam System, Hi-Ex Synthetic foam concentrate was used at 2%

Experimental Procedure

- Same procedure used to minimize variables
  - same fire load
  - same ignition method
  - same fire fighter
  - same fire development time
- Test Procedure
  - ignition of cribs (4 pans, 150 ml methyl hydrate)
  - flashover at approx. 3 min
  - 2 min beyond flashover for deep seated wood crib fire and intense fire in the compartment
  - suppression attempt by fire fighter
  - time for knock down noted (water consumption)
  - time for extinguishment of all fires in the compartment noted (water consumption)

Fire Growth and Suppression

Ignition of wood cribs

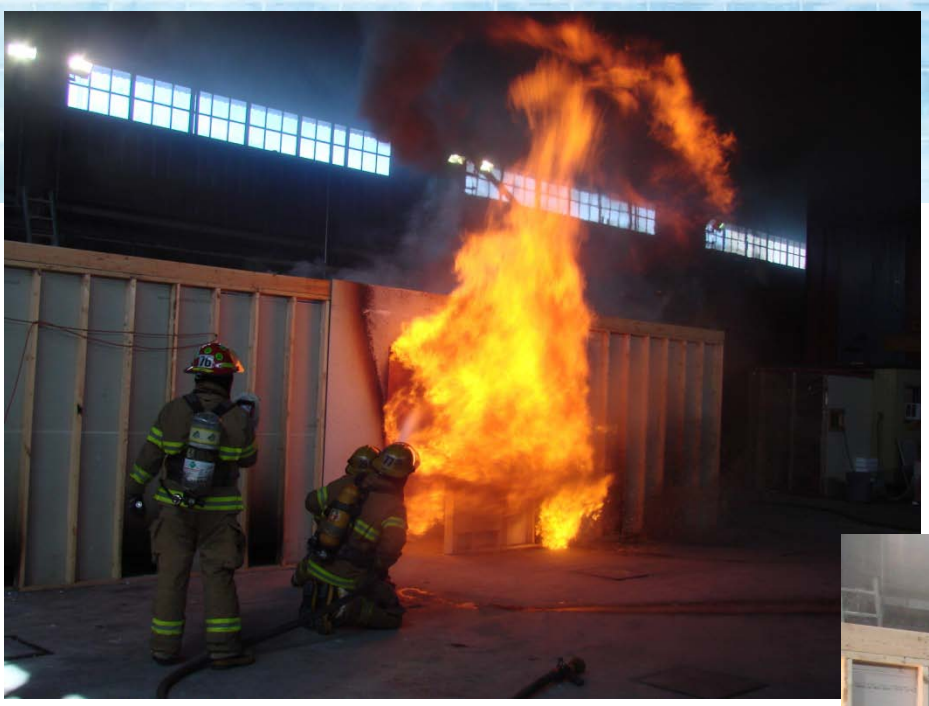
2 min after ignition

3 min after ignition (Flashover)

4 min

4 min 40 s

4 min 55 s



5 min after ignition (Fire attack starts)

5 min 20 s

5 min 30 s

5 min 50 s

Test Results

- Flow rates of 12.5 GPM (47.3 L/min) and 25 GPM (94.6 L/min) were used
- For quantitative comparison, following instrumentations were used

  - T/C tree in the test compartment and hallway
  - heat flux meter in the test room
  - smoke obscuration in the hallway
  - gas concentrations in the hallway

- Most useful data;

  - temperature in the test room
  - amount of water used for control

Summary of Results

Test #	Description	Water Flow Rate	Knock-down Time	Water Used for Knock-down	Fire ext. time	Total Water Consumption
4	CAF	25 GPM (94.6 L/min)	10 s	13.8 L	54 s	63.9 L
9	Water only	25 GPM (94.6 L/min)	24 s	39 L	144 s	66.2 L
2	Foam-solution	25 GPM (94.6 L/min)	20 s	32 L	134 s	67.3 L
7	CAF	12.5 GPM (47.3 L/min)	34 s	25 L	232 s	87.4 L
5	Water only	12.5 GPM (47.3 L/min)	74 s	60 L	300 s	128.6 L
8	Foam-solution	12.5 GPM (47.3 L/min)	58 s	46 L	162 s	93 L
10	MPW	43 GPM (162.8 L/min)	16 s	39.5 L	148 s	71.9 L
11	MPW (0.3% foam-solution)	43 GPM (162.8 L/min)	13 s	18.2 L	110 s	64.6 L
13	HPW	17.4 GPM (65.9 L/min)	18 s	20.6 L	216 s	42.4 L
14	HPW (0.3% foam-solution)	17.4 GPM (65.9 L/min)	19 s	24.6 L	246 s	41.2 L
15	High Exp. Foam	21 GPM (79.5 L/min)	110 s	147.2 L	205 s	182.4 L

Test Results

- CAF is more effective in suppressing compartment fire than water or foam-solution
  - suppression time less than ½
  - water consumption for suppression about 1/3
  - extinguishment time less than ½
  - water consumption for extinguishment slightly less

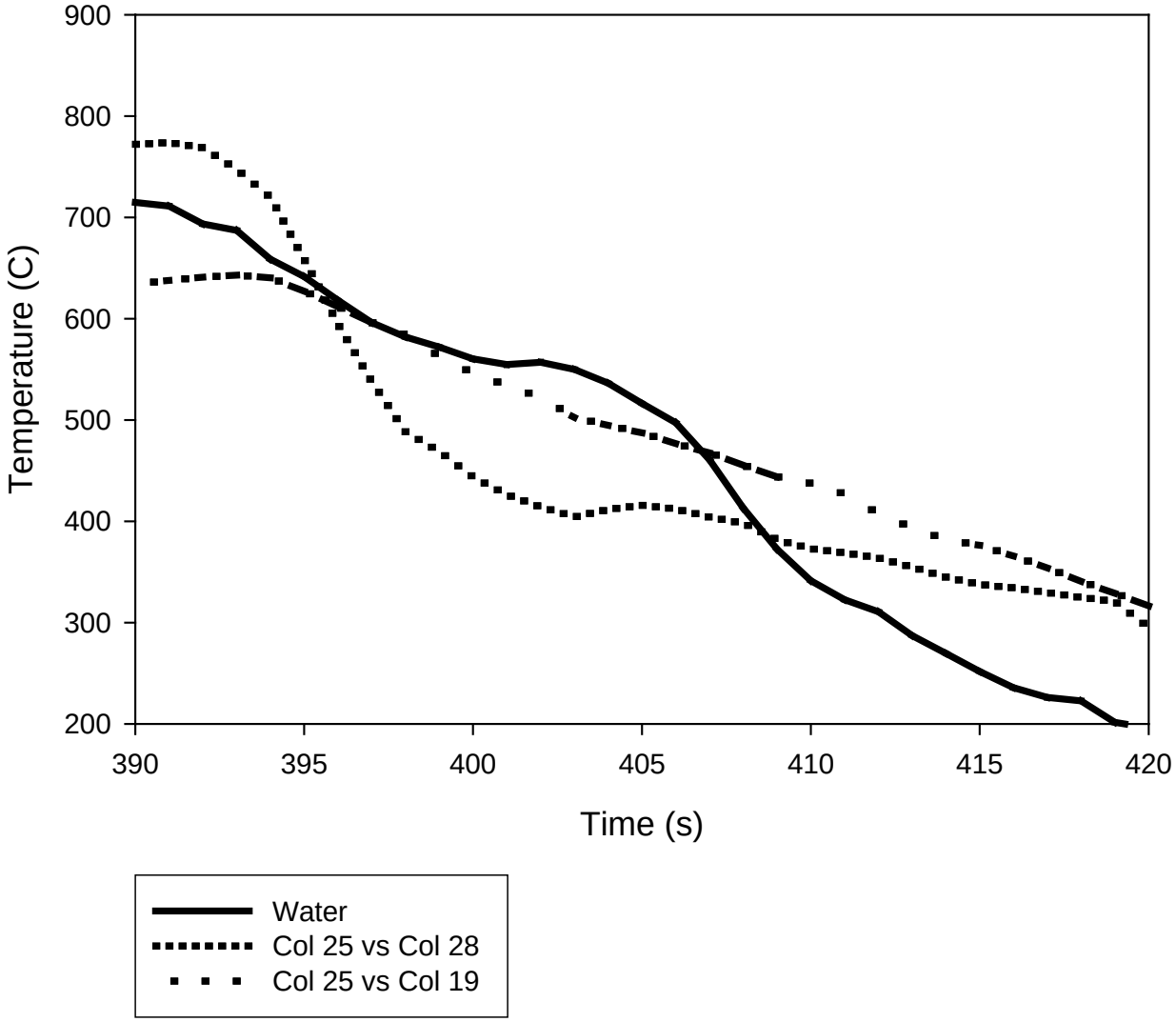
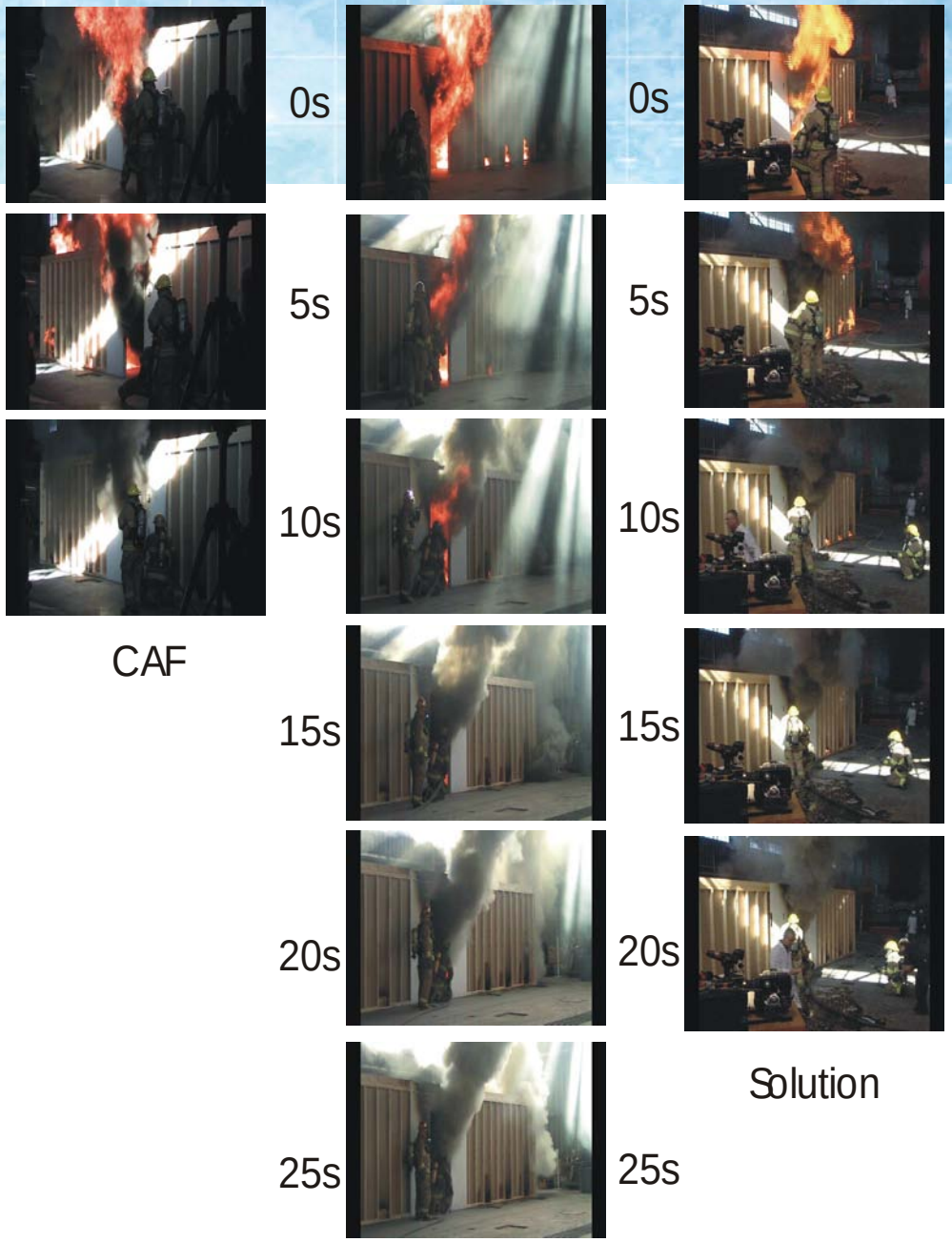


Figure 1 Average room temperature for 25 GPM tests (Test # 2, 9 and 12)


0s
0s
5s
5s
10s
10s
15s
15s
20s
20s
25s
25s
CAF
Water
Solution

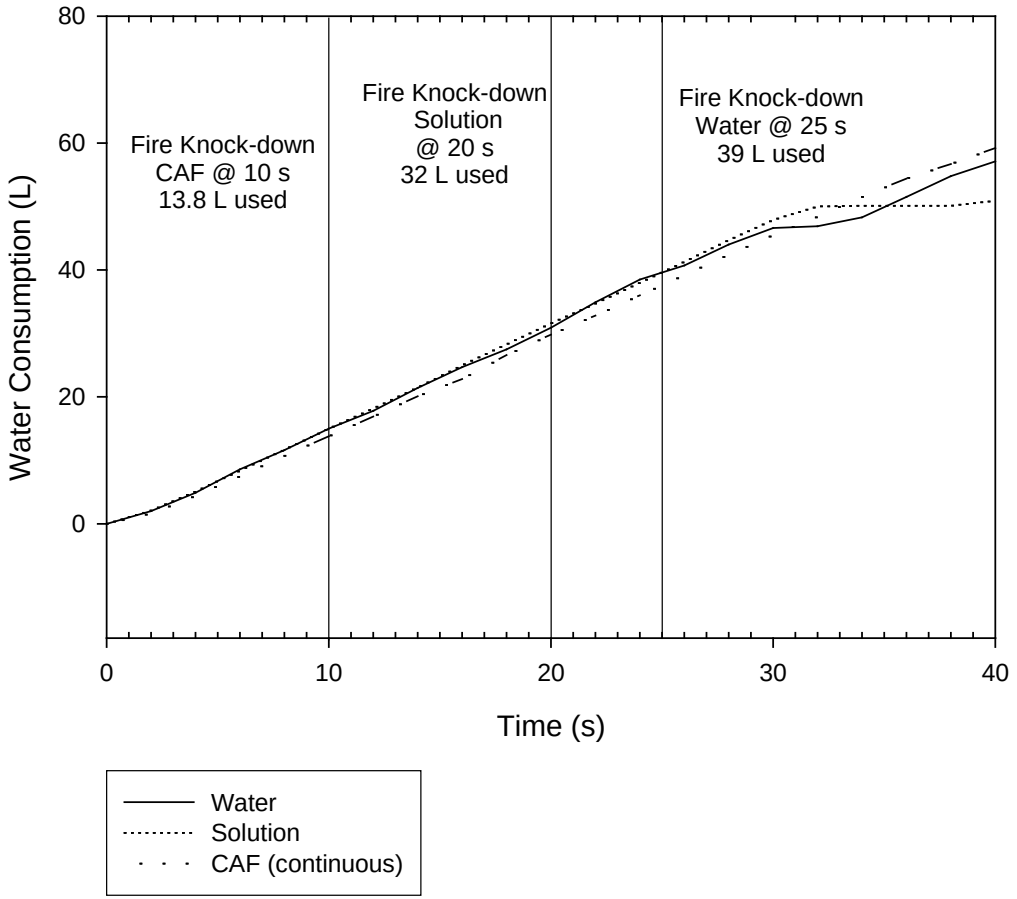


Figure 2 Water Consumption 25 GPM tests (Test # 2, 4 and 9)

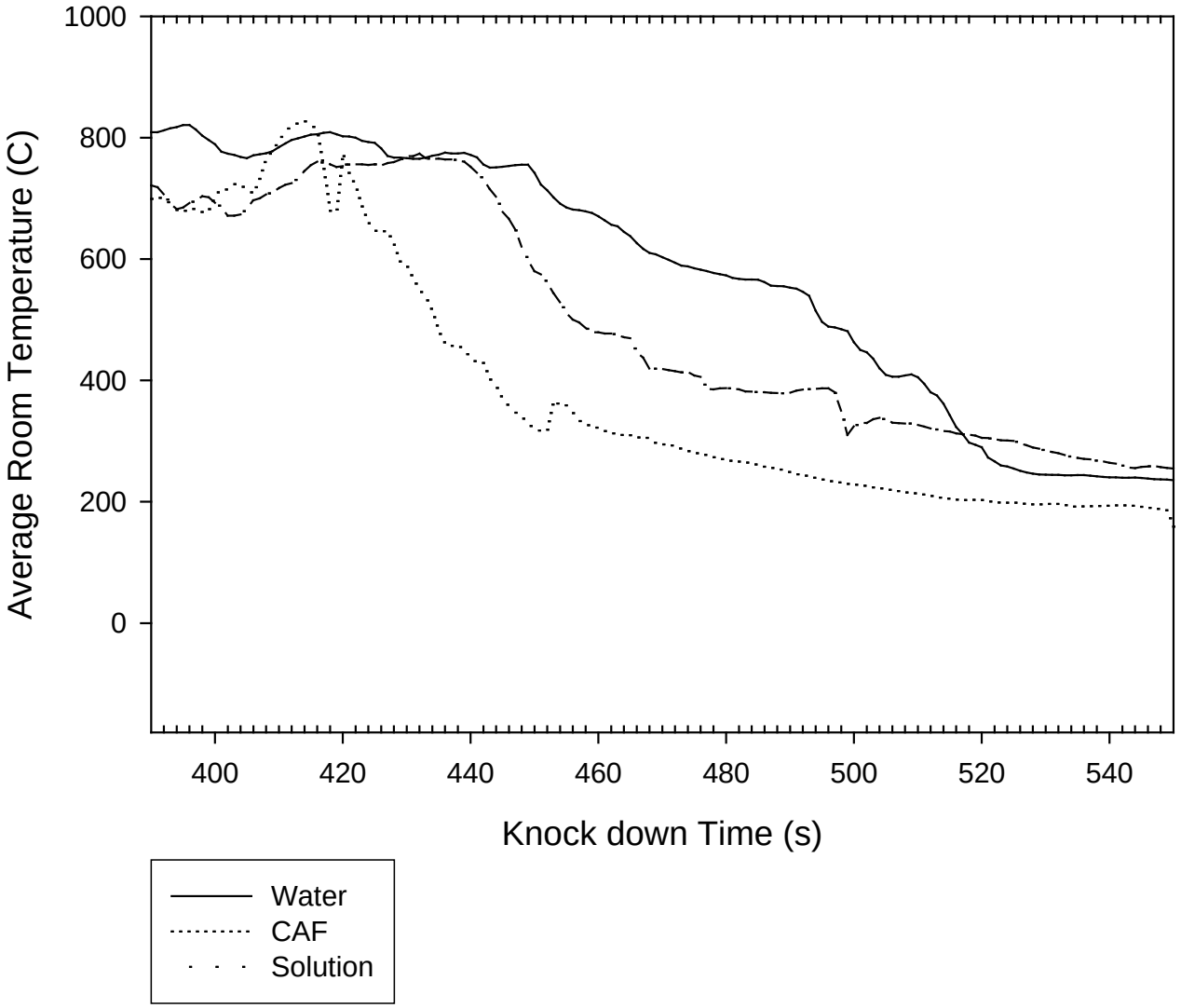


Figure 3 Average room temperature for 12.5 GPM tests (Test # 5, 7 and 8)

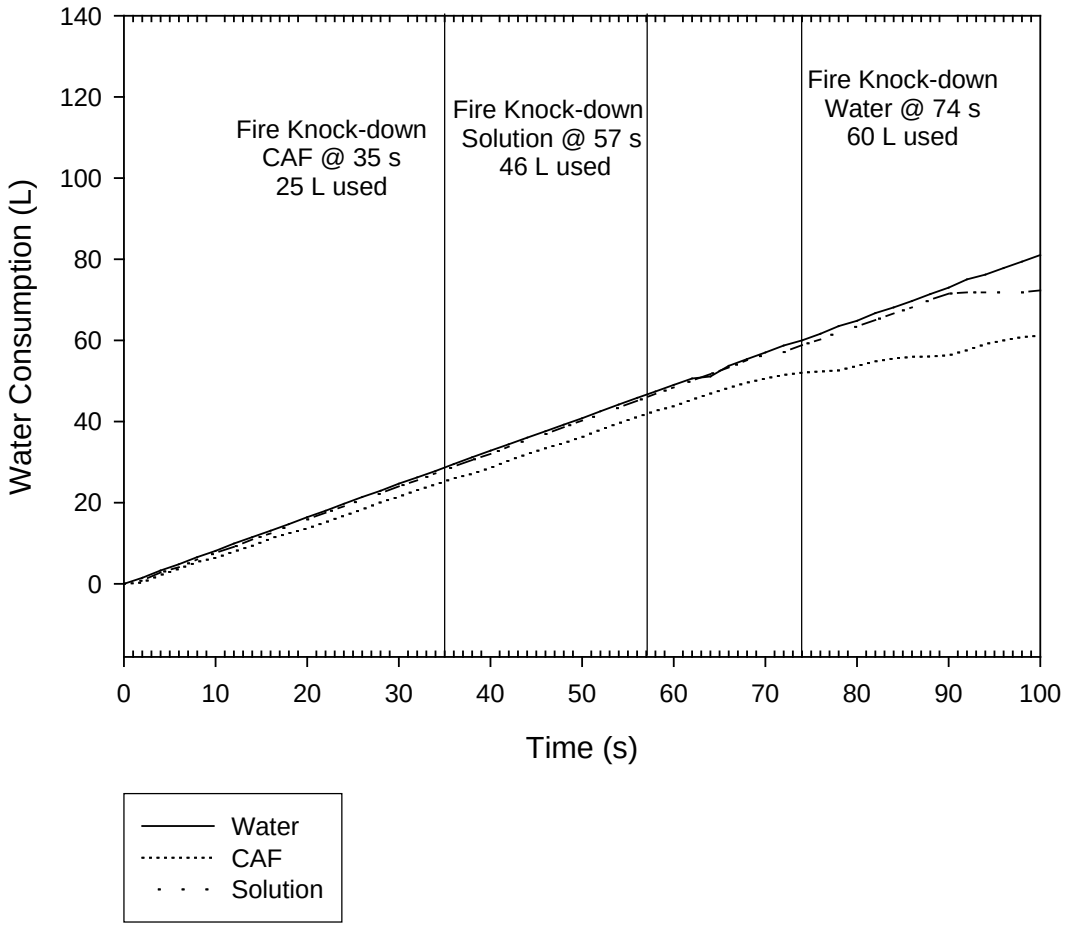


Figure 4 Water Consumption 12.5 GPM tests (Test # 5, 7 and 8)

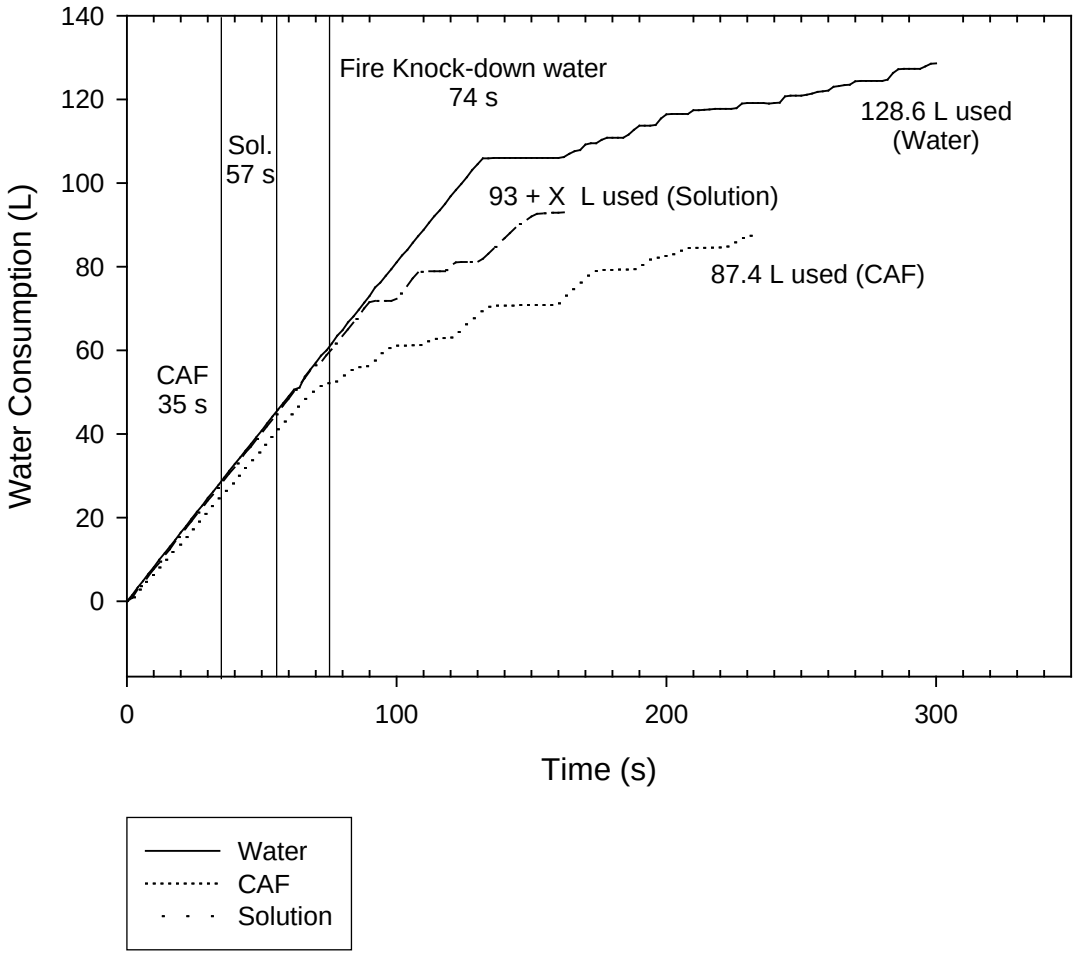


Figure 5 Total Water Consumed for 12.5 GPM tests (Test # 5, 7 and 8)

Test Results

- MPW system is difficult to compare with others

  - fixed flow rate (43 GPM)

  - effectiveness similar to water hose-stream

  - when 0.3% foam concentrate was used, MPW system performance was improved substantially

Test Results

- UHP system was very effective in suppressing the compartment fire

  - knocking-down big flames quickly with small amount of water

  - UHP system with 17.4 GPM performed better than hose-stream with 12.5 and 25 GPM

  - when 0.3% foam concentrate was used, UHP system performance was the same

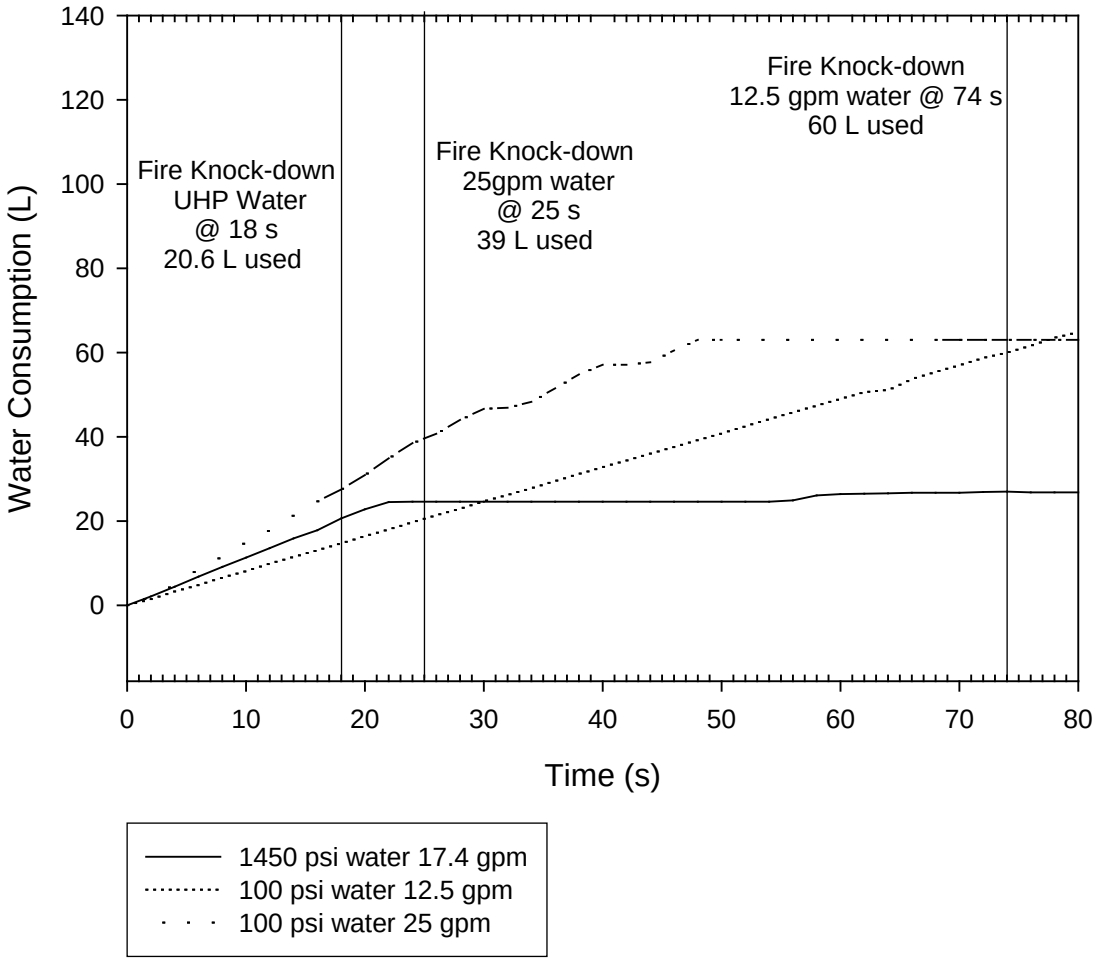


Figure 6 Water Consumption curve for UHP and water only tests (Test #5, 9 and 13)

Test Results

- HEF system was not effective in suppressing the compartment fire
  - no discharge momentum
  - it has to be put through an opening
  - difficulty in suppressing compartment fire
  - 110 s to control the fire with 147 L of water
  - 205 s to extinguish the compartment fire

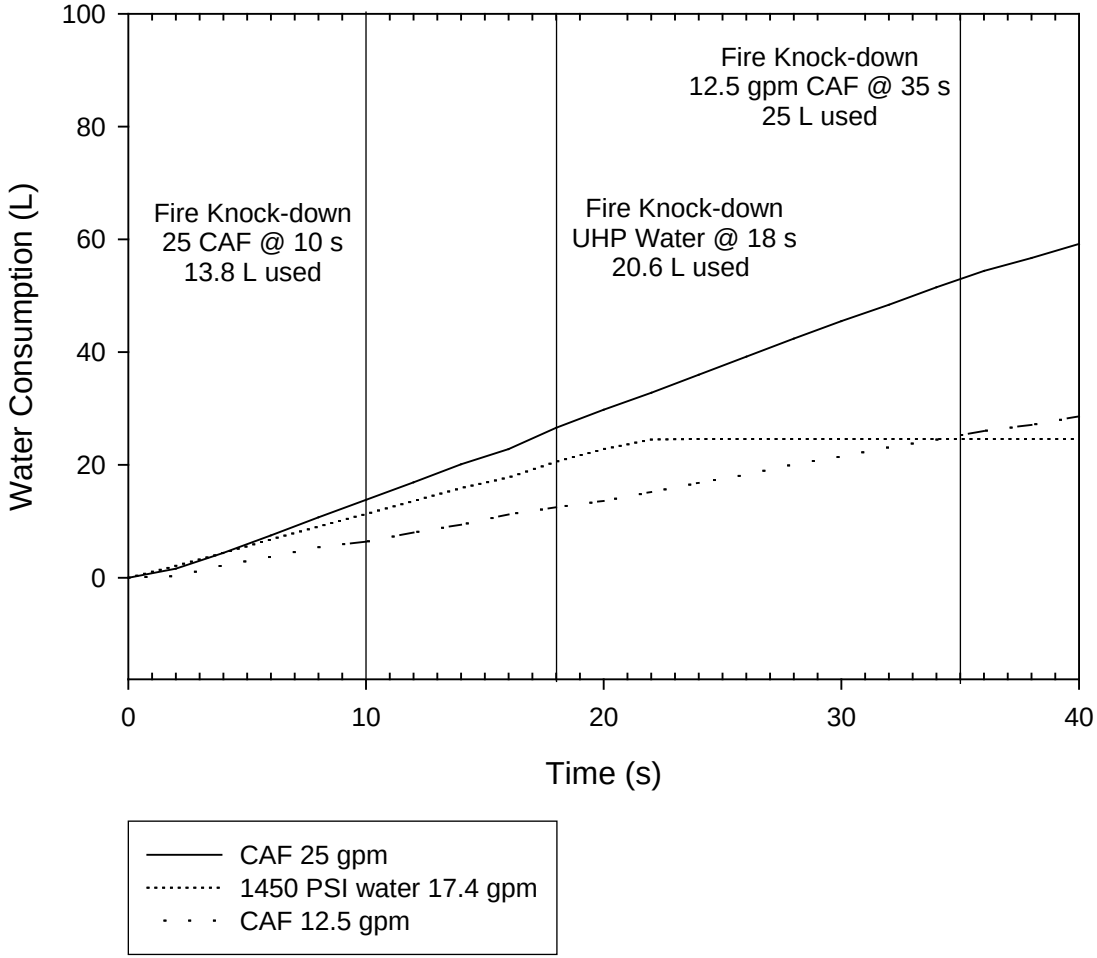


Figure 7 Water Consumption curves for UHP and CAF systems

Conclusion

- Project to evaluate several mobile systems in suppressing fully developed compartment fire
- Using foam-solution slightly more effective than using water alone
- CAF and UHP system performed better
- Used manual fire fighting, thus human factor was involved, and difficult to get the same results in repeat test
- Effectiveness of the system depends on fire fighting technique
- CAF system requires some training for it to be used effectively

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