TEST REPORT: EVOLUTION OF COMBUSTION BYPRODUCTS FROM GASEOUS FIRE SUPPRESSION AGENTS

Contract FA8075-14-D-0014

DS TAT 2T10

TAT # 16-1258

Report:
28 September 2018

(Cover dates 2010-28 Sep 2018)

Operated by:

Alion Science & Technology Corporation
GCSS
12601 Fair Lakes Cir
Fairfax, VA 22033

REPORT DOCUMENTATION PAGE

Form Approved

1. REPORT DATE *(DD-MM-YYYY)*
28/9/2018

2. REPORT TYPE
Test Report

3. DATES COVERED *(From - To)*
2010 - 28/9/2018

4. TITLE AND SUBTITLE
Test Report - Evolution of Combustion Byproducts from Gaseous Fire Suppression Agents

5a. CONTRACT NUMBER
FA8075-14-D-0014 DO# 2T10

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
Dr. Steven Hodges, TARDEC Fire Protection Team, Alion Science and Technology
Mike Chapman, Warfighter Directorate, US Army Aberdeen Test Center

5d. PROJECT NUMBER
N/A

5e. TASK NUMBER
Delivery Order #2T10 (1258)

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Defense Systems
Alion Science & Technology Corporation
12601 Fair Lakes Cir
Fairfax, VA 22033

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army TARDEC
6501 E. 11 Mile Road
Warren, MI 48397

LEATHERS.EDWIN.W.JR.1094292057
Digitally signed by LEATHERS.EDWIN.W.JR.1094292057
Date: 2018.10.18 13:28:23 -04'00'

10. SPONSOR/MONITOR'S ACRONYM(S)
TARDEC

11. SPONSORING/MONITORING AGENCY REPORT NUMBER
N/A

12. DISTRIBUTION AVAILABILITY STATEMENT

DISTRIBUTION STATEMENT A: Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Task 3.3.2 Provide subject matter expertise in the area of fire prevention, detection, and suppression and for other damage prevention and damage reduction systems. (**Deliverable 4.8:** Ground Vehicle Survivability Technologies and Demonstrators Reports).

An interesting observation made during a study of potential fire suppression agents with lower GWP than those currently used, was that the byproducts from FK-5-1-12 evolved quite differently than those from Halon 1301 or HFC227-BC. Continuous sampling gas phase Fourier Transform Infrared (FTIR) spectrometers were used to analyze the combustion byproducts from each trial in near real time. Using this technique allows for the accurate measurement of multiple analytes, including COF2 and HF.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF: U			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
					Mr. Joel King
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**	SAR	7	**19b. TELEPONE NUMBER** (*Include area code*)
U	U	U			(586) 282-6032

TEST REPORT: EVOLUTION OF COMBUSTION BYPRODUCTS FROM GASEOUS FIRE SUPPRESSION AGENTS

Steven E. Hodges, Ph.D.
TARDEC Fire Protection Team
Alion Science & Technology
2979 La Combadura Road
Santa Barbara, CA 93105
805-455-5777

Michael Chapman, Physical Scientist
Field Sampling and Analysis Branch, Building 363
Applied Science Test Division, TEDT-AT-WFA
Warfighter Directorate
US Army Aberdeen Test Center
400 Colleran Road
APG, MD 21005-5059
410-278-0538

EXTENDED ABSTRACT

An interesting observation made during a study of potential fire suppression agents with lower GWP than those currently used, was that the byproducts from FK-5-1-12 evolved quite differently than those from Halon 1301 or HFC227-BC.[1] Continuous sampling gas phase Fourier Transform Infrared (FTIR) spectrometers were used to analyze the combustion byproducts from each trial in near real time. Using this technique allows for the accurate measurement of multiple analytes, including COF_2 and HF. Since the relative toxicity of these compounds are quite different, the ability to quantify each of these compounds is necessary for an adequate determination of injury or incapacitation due to inhalation of these toxic gases.[2]

Specifically, Halon 1301 (Figures 1 and 2) and HFC227-BC (Figures 3 and 4) generally produced lower levels of carbonyl fluoride (COF_2) initially which then decayed into hydrogen fluoride (HF), whereas FK-5-1-12 produced high levels of HF and COF_2 simultaneously (Figures 5 and 6). Adding BC dry chemical to the FK-5-1-12 discharge nozzle improved performance, but did not change the temporal trend, and the levels of byproduct remained above acceptable limits (Figure 7). The result was that the dose of acid and carbonyl byproducts from FK-5-1-12, neat or with dry chemical, were consistently well above the US Army casualty criteria limit of 746 ppm-min (5-minute dose), while byproducts from HFC227-BC and Halon 1301, used with normal design concentrations, were well below the limit. Even when HFC227-BC was applied at less than 1/3 of the HFC-227ea class B minimum design concentration of 8.7% (Figure 3), the byproduct levels were much lower than obtained in any tests using FK-5-1-12 (Figures 5 – 7).

Overall, this result suggests that chemicals, such as FK-5-1-12, that are designed to be more reactive, thus yielding shorter atmospheric lifetimes and therefore lower GWPs, generate much higher byproduct levels during the fire suppression process than more stable, and thus likely higher GWP, compounds.

1. Hodges, S. E. and McCormick, S. J., “Fire Extinguishing Agents for Protection of Occupied Spaces in Military Ground Vehicles,” Suppression & Detection Symposium (SUPDET), National Fire Protection Association (NFPA), 2010. http://www.dtic.mil/dtic/tr/fulltext/u2/a517470.pdf

2. ATC Chemistry test report no. 2009-CC-359.

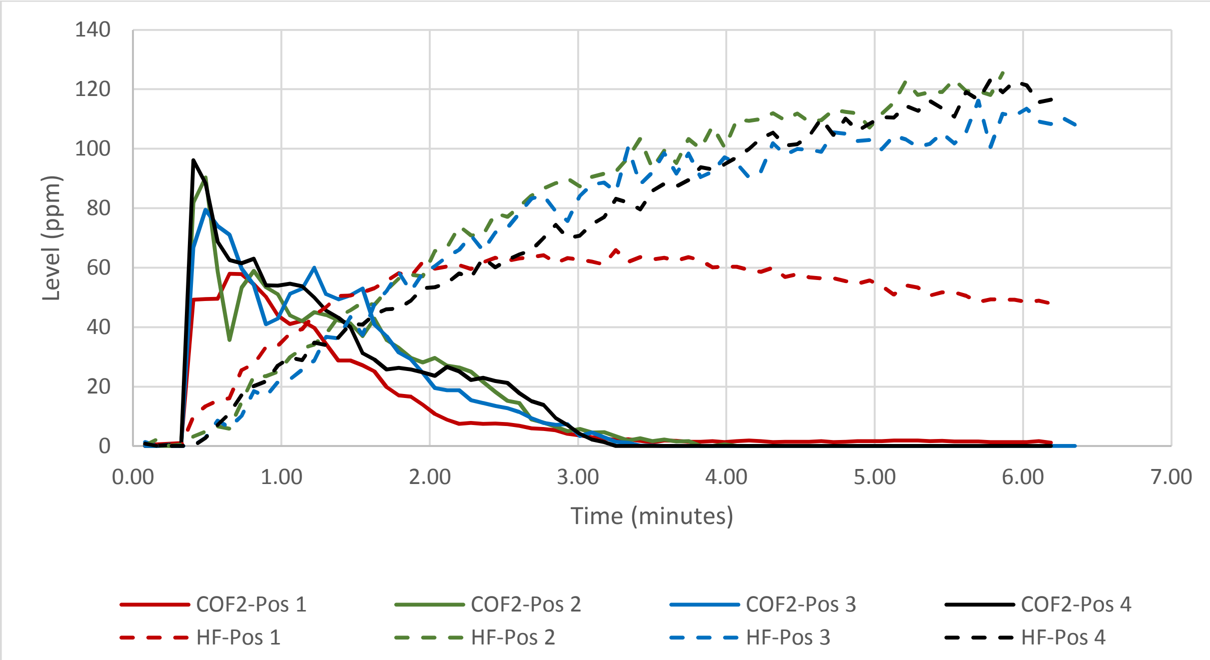

Figure 1. Byproduct levels for Halon 1301: 3.25%, fire out 155 ms, 5-min average dose 439 ppm-min (2009-CC-359_KH5)

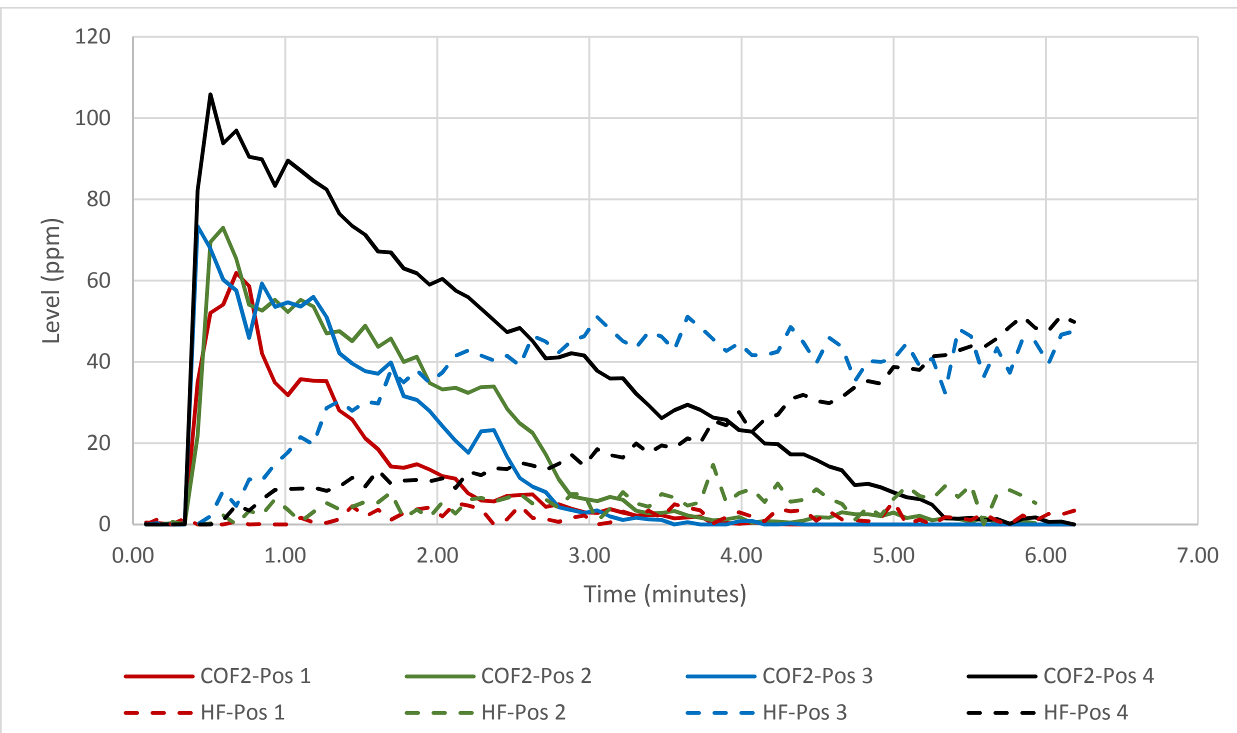

Figure 2. Byproduct levels for Halon 1301: 4.77%, fire out 190 ms, 5-min average dose <233 ppm-min (2009-CC-359_KH3)

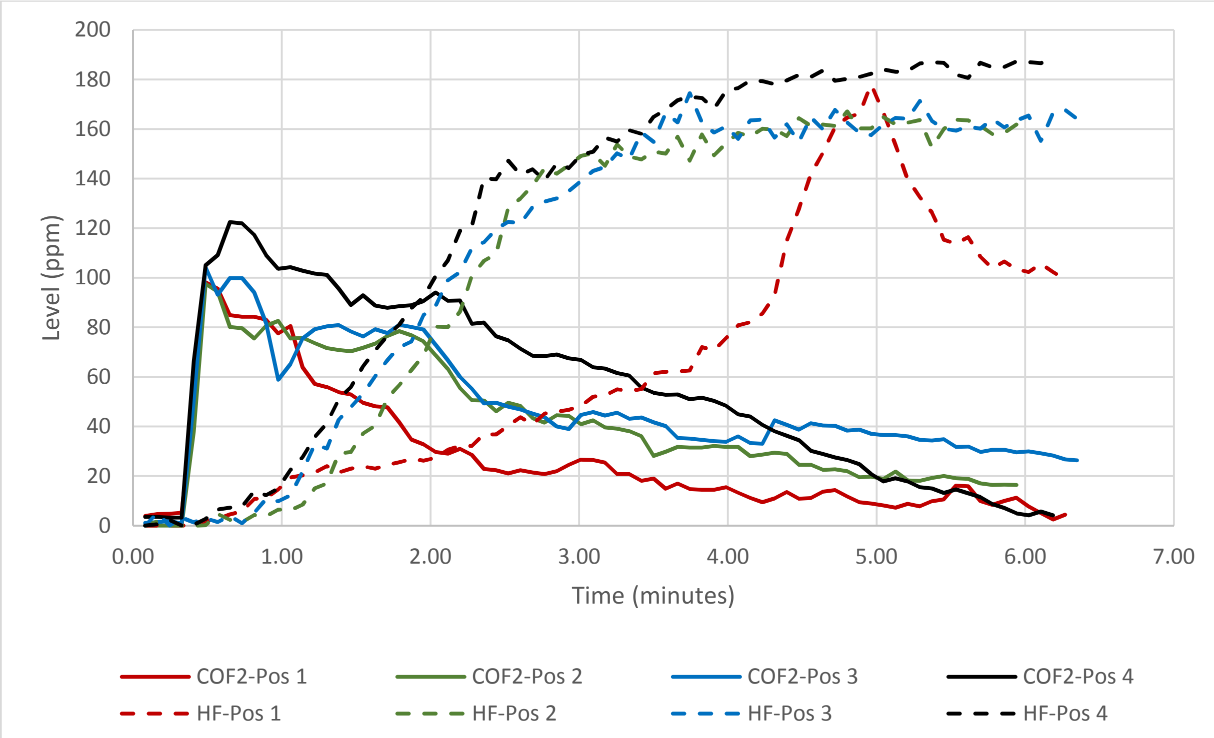

Figure 3. Byproduct levels for HFC227-BC: 2.50% HFC-227ea + 5% w/w BC, fire out 184 ms, 5-min average dose 1,070 ppm-min (2009-CC-359_KFMBC3)

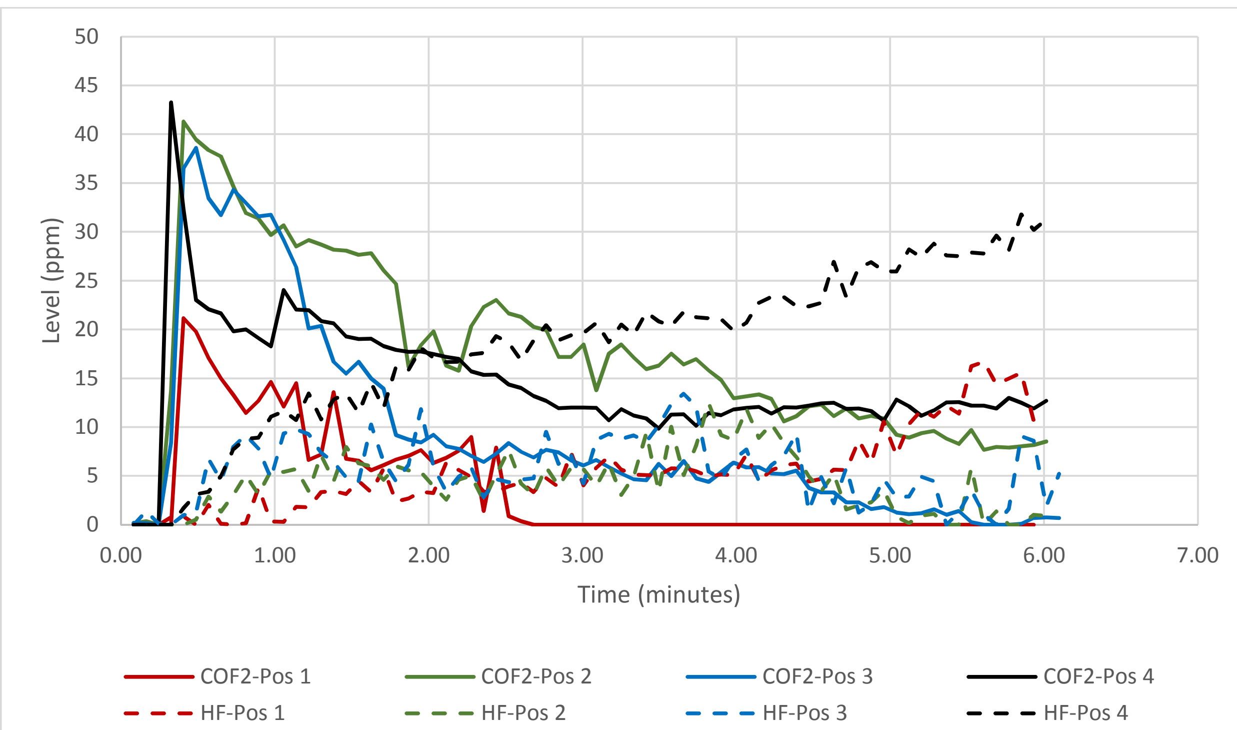

Figure 4. Byproduct levels for HFC227-BC: 4.88% HFC-227ea + 5% w/w BC, fire out 148 ms, 5-min average dose <125 ppm-min (2009-CC-359_KFMBC2)

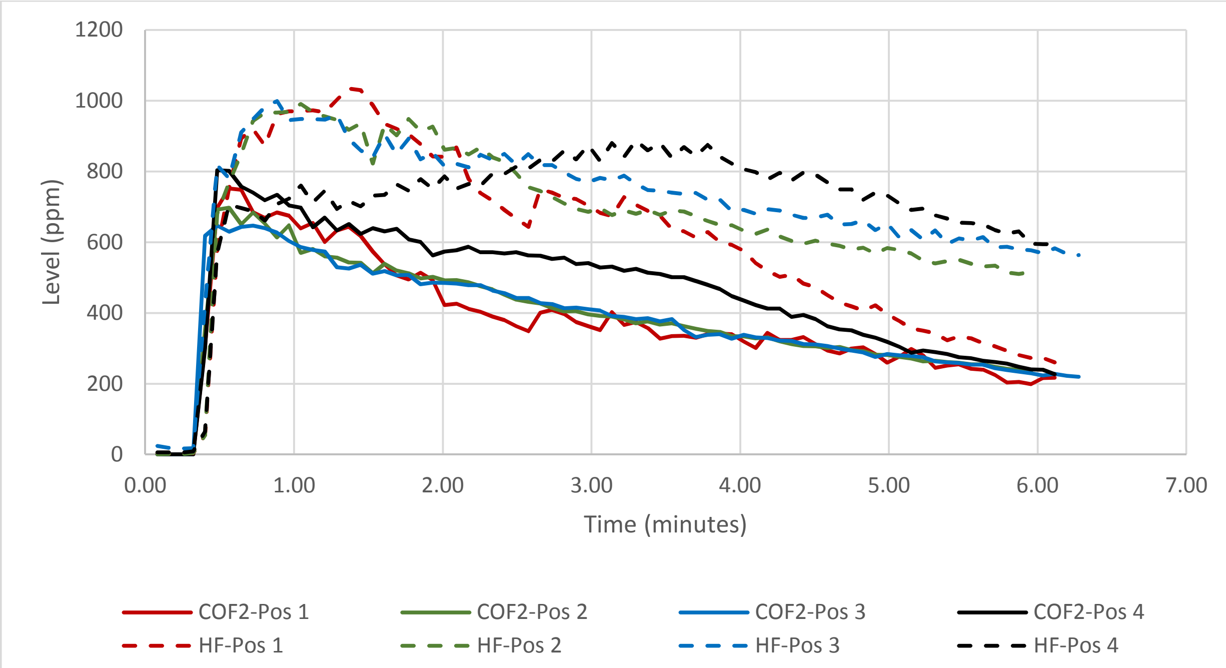

Figure 5. Byproduct levels for FK-1-5-12: 5.90%, fire out 199 ms, 5-min average dose 8,100 ppm-min (2009-CC-359_KNOV1)

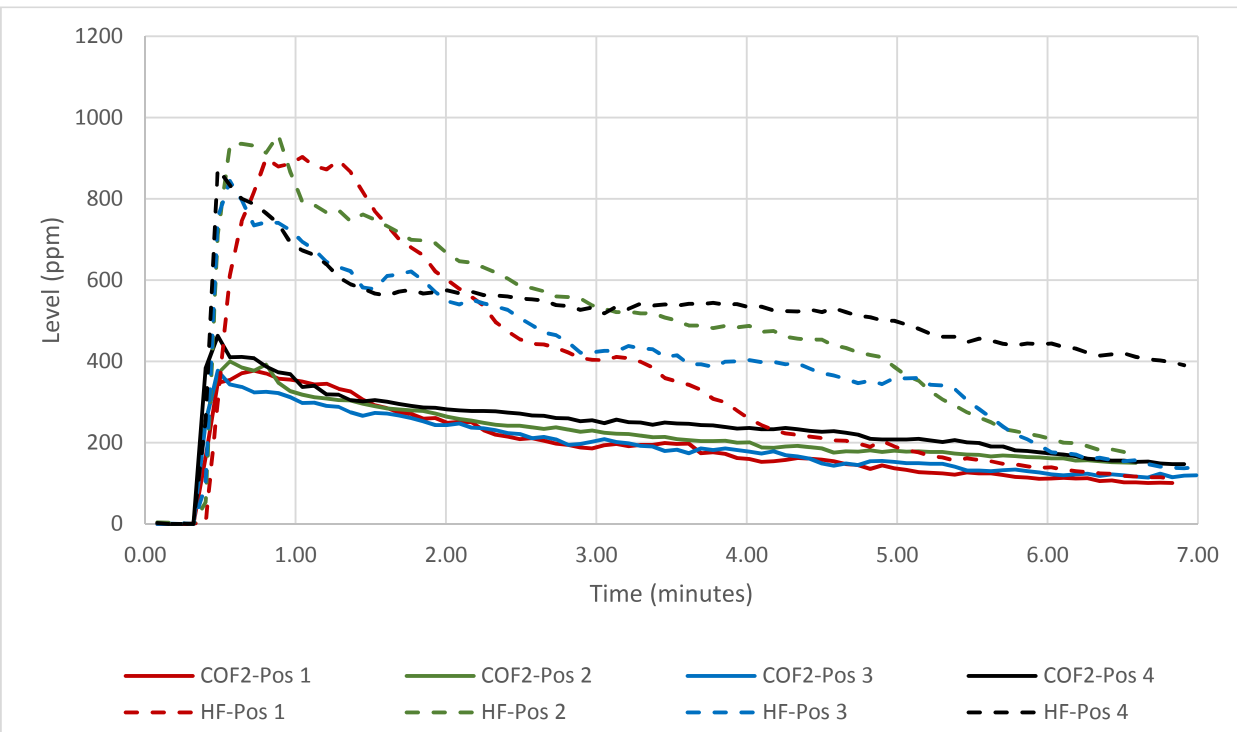

Figure 6. Byproduct levels for FK-1-5-12: 9.31%, fire out 141 ms, 5-min average dose 4,959 ppm-min (2009-CC-359_KNOV2)

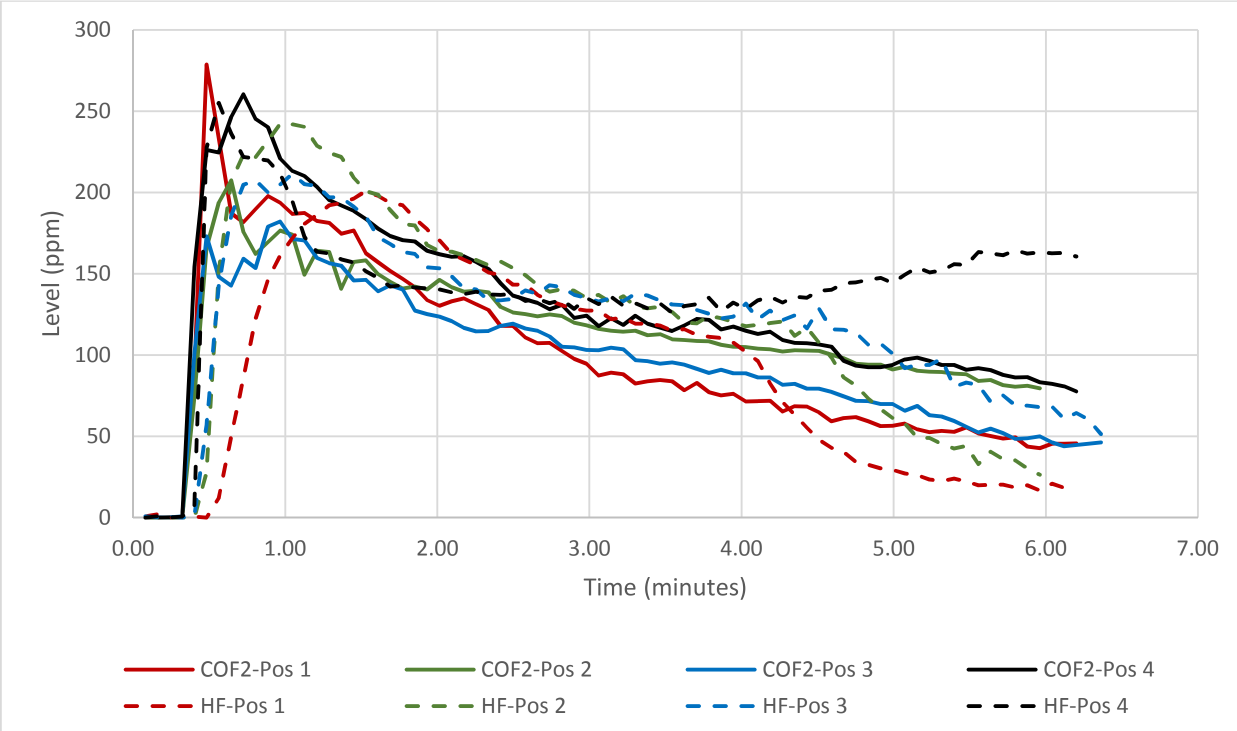

Figure 7. Byproduct levels for FK-1-5-12 with 5%w/w BC: 9.32%, fire out 168 ms, 5-min average dose 1,900 ppm-min (2009-CC-359_KNVBC2)