

## **DF-200: An Enhanced Formulation for Decontamination and Mitigation of CBW Agents, Biological Pathogens, and Toxic Industrial Chemicals**

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Sandia National Laboratories has developed, tested and commercialized an aqueous-based decontamination technology (DF-200) that can rapidly neutralize chemical and biological warfare (CBW) agents, many toxic industrial chemicals, and other biological pathogens. The formulation:

- is effective for neutralizing both chemical and biological agents which has been demonstrated in live agent testing at approved military facilities such as the Edgewood Chemical and Biological Center and the Dugway Proving Ground;
- is environmentally benign (i.e., non-toxic, non-corrosive, and biodegradable);
- works on a number of anticipated material surfaces;
- can be incorporated into a variety of high quality delivery systems (foam, liquid, fog) that satisfy a wide variety of operational objectives.

DF-200 was developed through funding provided by the U.S. Department of Energy's and National Nuclear Security Administration's Chemical and Biological National Security Program (CBNP). This technology is an enhancement of the initial Sandia decon technology (DF-100) that was used to help remediate Congressional Office Buildings and other contaminated facilities in 2001. The U.S. military has recently purchased emergency supplies of DF-200 from Sandia's licensee, EnviroFoam Technologies of Huntsville Alabama for use in Operation Iraqi Freedom.

The Sandia-developed technology is effective for both CW and BW warfare agents including in emergency response situations where the actual agent may not be known. It is also effective for many toxic industrial chemical threats. Successful "live-agent" effectiveness tests have been performed by the Edgewood Chemical and Biological Center (ECBC), the Illinois Institute of Technology Research Institute (IITRI), and the Southwest Research Institute (SWRI). The formulation has also been extensively tested by the DOD in support of Operation Iraqi Freedom.

Biological kill tests were conducted at IITRI in Chicago, Illinois. Results of tests utilizing DF-200 against anthrax spores are shown below. Similar results were achieved for *Yersinia pestis* which are also shown below (minimum contact time tested was 15 minutes).

<b><i>B. anthracis</i> AMES-RIID</b>	<b>Average CFU/ml</b>	<b>Log Reduction</b>	<b>% Reduction</b>
Control	1.21E+07	0	0.00
15 min contact	No Growth	7	100±.00004
30 min contact	No Growth	7	100±.00004
60 min contact	No Growth	7	100±.00004

**Figure 1: Kill rates for *B. anthracis* AMES-RIID spores in a solution of DF-200.**

<b><i>B. anthracis</i> ANR-1</b>	<b>Average CFU/ml</b>	<b>Log Reduction</b>	<b>% Reduction</b>
Control	6.42E+07	0	0.00
15 min contact	No Growth	7	100±.00004
30 min contact	No Growth	7	100±.00004
60 min contact	No Growth	7	100±.00004

**Figure 2: Kill rates for *B. anthracis* ANR-1 spores in a solution of DF-200.**

<i>Y. pestis</i> (ATCC 11953)	Average CFU/ml	Log Reduction	% Reduction
Control	1.33E+07	0	0.00
15 min contact	No Growth	7	100±.00004
30 min contact	No Growth	7	100±.00004
60 min contact	No Growth	7	100±.00004

**Figure 3: Kill rates for *Y. pestis* (plague bacterium) cells in a solution of DF-200.**

Sandia also participated in field trials sponsored by SBCCOM at the Dugway Proving Ground to test the effectiveness of the foam for the kill of *Bacillus globigii* spores (an anthrax simulant). **This testing utilized Sandia's original decon formulation (DF-100).** Phase I testing at Dugway involved the deployment of the DF-100 formulation onto a series of 16" x 16" test panels consisting of a variety of materials that might be found in a typical office building. Based on the results of the Phase I test, Sandia was invited to participate in Phase II testing. In Phase II, the DF-100 formulation was deployed in an 8' x 8' x 8' room that was constructed with a variety of building materials. The room was contaminated by *B. globigii* spores by a simulated explosion. DF-100 was deployed as foam through an Intelagard, Inc Macaw backpack foam system and allowed to dry on the surface (approximately 1-2 hours). Sampling was conducted by Dugway personnel approximately 20 hours after deployment of the DF-100 foam. Results from Phase II are shown below. No surviving spores were found on any surface. Equal or better results would be expected with DF-200 since it has increased efficacy against biological pathogens as compared to DF-100.

SURFACE	CONTAMINATED (Surface average in CFU/SQ. IN.)	DECONTAMINATED (Surface average in CFU/SQ. IN.)
Floor (painted concrete)	7.67E+07	0.00E+00
Floor (tile)	1.31E+07	0.00E+00
Floor (carpet)	1.23E+07	0.00E+00
Floor (wood)	7.30E+06	0.00E+00
Window (glass)	5.32E+04	0.00E+00
Painted wall below window	8.16E+04	0.00E+00
Left hand wall panels	4.70E+04	0.00E+00
Wall (stucco)	2.80E+05	0.00E+00
Painted wall above carpet	4.56E+04	0.00E+00
Carpeted wall	1.08E+06	0.00E+00
Door	3.13E+04	0.00E+00
Ceiling	8.49E+02	0.00E+00

**Figure 4: *Bacillus globigii* spore kill in Dugway field tests with DF-100 (Phase II results)**

## Summary of Biological Kill Test Results (Kinetic Testing)

Microorganism	Formulation	Kill Effectiveness (%)				Test Facility
		10 min	15 min	30 min	60 min	
<i>Bacillus anthracis</i> spores	DF-100A (pH 8)	-	-	99.99999	99.99999	IITRI
<i>Bacillus anthracis</i> spores	DF-100A (pH 9.2)	-	-	-	-	IITRI
<i>Bacillus globigii</i> spores	DF-100A (pH 8)	-	-	99.99	99.99999	Sandia
<i>Bacillus globigii</i> spores	DF-100A (pH 9.2)	-	-	-	99.99	Sandia
<i>Erwinia herbicola</i>	DF-100A (pH 8)		99.99999	-	-	Sandia
<i>E. Coli</i>	DF-100A (pH 8)		99.99999	-	-	Sandia
MS2 Bacteriophage (smallpox simulant)	DF-100A (pH 8)	-	-	-	99.999	Sandia
Citrus Canker	DF-100A (pH 8)	-	-	-	99.9999	Sandia
FMD Virus*	DF-100A (pH 8) diluted by a factor of 6					USDA Plum Island
<i>Candida bombicola</i>	DF-100A (pH 8)	-	99.99999	-	-	Sandia

\* Results not yet received

Equal or better results would be expected with DF-200 since it has increased efficacy against biological pathogens as compared to DF-100.

Live agent tests on three CW agents (soman, VX, and mustard) were conducted at ECBC. Results for kinetic testing of DF-200 on CW agents are shown in Figure 5. DF-200 has also been tested against several toxic industrial chemicals (TICs) utilizing LDRD (Laboratory Directed Research and Development) funding at Sandia. Results of these tests are summarized in Figure 6. Note that the results for malathion, butyl isocyanate, sodium cyanide, and carbon disulfide were obtained by analyzing for the unreacted chemical in foam solution while the results for phosgene was obtained by analyzing for the chemical in the headspace above a foam solution.

Decon Formulation	HD			GD			VX		
	10 Min	30 Min	60 Min	10 Min	30 Min	60 Min	10 Min	30 Min	60 Min
DF-200	97	100	100	100	100	100	99	100	100

**Figure 5: Decontamination of chemical agents by DF-200.**

TIC	% Decontaminated		
	1 minute	15 minutes	60 minutes
Malathion (liquid)	89	95	Below Detection
Hydrogen Cyanide (gas)	>99	>99	>99
Sodium Cyanide (solid)	93	98	>99
Butyl Isocyanate (liquid)	99	Below Detection	Below Detection
Carbon Disulfide (liquid)	>99	>99	Below Detection
Phosgene (gas)	98	>99	>99

Figure 6: Summary of TIC neutralization testing.