United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: ● Original 1-44
Amendment

Contract Number: EP-C-09-027

Contract Period
Base:
Option Period No. 1

SF Site Name:

Title of Work Assignment: Laboratory Research on the Efficacy of Chlorine Dioxide for the Remediation of Mold Contaminated Buildings

Suggested Source: Arcadis

Specify Section & Paragraph of Contract SOW:

Purpose: ● Work Assignment Initiation
Work Assignment Amendment
Work Plan Approval
Work Assignment Close-Out
Incremental Funding

Period of Performance
From: 07/13/2010 To: 03/31/2010

Comments: Continuation of WA 0-4 from base period

QA Category (check one)
I Enforcement
II Standard Setting
● III Technology Development
IV Proof of Concept
N/A

Note: To report additional accounting and appropriations data use EPA Form 1900-69A.

SFO 22 (Max 2) Superfund | | Non-Superfund

Accounting and Appropriations Data

	DCN (Max 6)	Budget/FYs (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount	Sites/Project (Max 8)	Cost Org/Code (Max 7)
1									
2									
3									
4									
5									

Authorized Work Assignment Ceiling

Contract Period:		Cost/Fee	LOE
Previously Approved	New		0
This Action			0
Total			0

Work Plan / Cost Estimate Approvals

Contractor WP Dated: Cost/Fee: LOE:

Cumulative Approved: Cost/Fee: LOE:

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Contractor Acknowledgement of Receipt and Approval of Workplan (Signature and Title) | Date

STATEMENT OF WORK

LABORATORY RESEARCH ON THE EFFICACY OF CHLORINE DIOXIDE FOR THE REMEDIATION OF CONTAMINATED BUILDINGS
(APPCD ON-SITE CONTRACT EP-C-09-027)

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I. TITLE

Laboratory and Field Research on the Efficacy of Chlorine Dioxide for the Remediation of Contaminated Buildings

II. PERIOD OF PERFORMANCE

The period of performance for the work under this work assignment shall be July 13 16 March 31, 2011. 2010

III. SUMMARY OF OBJECTIVES

The goal of this research is to evaluate the efficacy of chlorine dioxide for inactivating a variety of viable mold and mold spores, and neutralizing allergens and mycotoxins found in mold-contaminated structures.

An underlying objective of the effort is to compare the efficacy of chlorine dioxide fumigation to conventional remediation methods by measuring the presence of viable mold vegetative cells and spores and/or detectable mycotoxins before and after remediation using both methods.

IV. RELEVANCE

The Air Pollution Prevention and Control Division (APPCD) has an active indoor air research program that includes characterization of mold species and evaluation of remediation approaches. The Division also actively supports the Office of Radiation and Indoor Air (ORIA) and the Office of Pesticide Programs (OPP), both of which have expressed strong support for this type of research. OPP is responsible for review of data leading to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) registration of antimicrobials, including the Section 24(c) Special Local Needs (SLN) registrations of chlorine dioxide for mold remediation. The data from this research will be considered during the review of any future applications for registration of chlorine dioxide for this purpose. ORIA is responsible for providing guidance on the appropriate techniques for remediation of mold in structures and can consider the products of this research when the guidance is revised.

V. BACKGROUND

The aftermath of Hurricane Katrina has resulted in widespread mold contamination in many different types of structures. The type of contamination ranges from heavy infestation on walls and ceilings (which have sustained heavy wetting from flooding and/or roof leaks) to the strong residual odor of mold in buildings which may have been subject to conventional mold remediation practices. Several companies use chlorine dioxide fumigation as a mold remediation technique for buildings. Observations of chlorine dioxide fumigations of contaminated buildings strongly indicate that it is a highly efficacious method for the remediation of mold contamination. The indications are that the chlorine dioxide gas is highly penetrating and effective in reaching spaces throughout the structure. The available data from one study shows that chlorine dioxide fumigation substantially reduced viable spores in air, on surfaces, and in core samples. These data were used as the basis for the issuance of a FIFRA Section 24(c) State SLN registration in Louisiana, Mississippi, and Texas. However, the Federal Emergency Management Agency (FEMA) and ORIA have raised concerns about the potential for residual

allergenic molds, fungal materials, and mycotoxins that might possibly remain in any residual materials after fumigation of the structure. In addition, there are concerns that viable fungal material could remain inside walls, behind vinyl wallpaper, and inside porous materials.

VI. SCOPE

This work will involve laboratory chamber studies and field sampling to determine the effectiveness of chlorine dioxide gas for inactivating viable fungi vegetative cells and spores, and neutralizing allergens and mycotoxins from a variety of mold species found in structures. During the field study, the effectiveness of chlorine dioxide fumigation to mitigate the concern of entombed mold and fungal material will be addressed to the extent reasonable and feasible.

The purpose of the lab study is to quantify the reduction in viable mold spores, mycotoxins, and allergenic mold (allergens) for use in EPA/OPP's consideration of chlorine dioxide for registration or further exemptions under FIFRA. For this effort, a quantifiable reduction of at least four logs of viable mold spores is currently required. Controlled, laboratory experiments are required to provide the necessary information to show the effectiveness of the fumigant against specific target molds and associated mycotoxins and allergens. Coupon preparation and analysis is not included as part of the scope of this work assignment and will be provided by Research Triangle Institute (RTI).

The purpose of the field tests is to measure the effectiveness of the practical application of the chlorine dioxide fumigation technology to actual mold contamination in the field. Although quantification (e.g., quantifiable reduction in target species) will be attempted, such application is difficult under non-homogenous circumstances as typically found in the field. The standard in the field is to remediate the source of moisture causing the mold growth and removal of visible mold. The objective will be to document the effectiveness through post-fumigation sampling. Pre-fumigation sampling will be done to document the contamination of the facility prior to fumigation.

VII. TECHNICAL APPROACH

This project consists of laboratory research on the efficacy of chlorine dioxide for mold remediation in contaminated structures. This is a continuation of an existing work assignment; as such the Quality Assurance Project Plan (QAPP) has already been developed. An amendment will be required to add the additional tests described in this SOW.

The systematic laboratory research on the efficacy of chlorine dioxide on a variety of mold species as a function of concentration-time (CT) values, material, and mold, mycotoxin, or allergen species. Preparation of the coupons, inoculation, and analysis are outside the scope of this project and will be provided under another contract. The contractor shall be responsible for receipt of the prepared coupons, fumigation, and return of the coupons to the contractor responsible for preparation and analysis.

VIII. TASKS

The tasks for this work are broken down into two phases, as mention in the previous section. These tasks are discussed in detail in this section.

This project shall involve the use a fumigation chamber and prototype, lab-scale, Sabre ClO_2 generation system to investigate the inactivation of mold vegetative cells and spores, and neutralization of allergens and mycotoxins, on materials as a function of fumigation parameters. For this phase, the inoculated coupons and analysis shall be done by an external contractor (RTI) and provided to the APPCD onsite contractor for the completion of work detailed specifically in Tasks 1-4.

The coupons shall be transferred from RTI to the contractor for each fumigation trial in Tyvek envelopes. The coupons shall be maintained in these envelopes and handled according to pre-defined sterile practices, as to be detailed in the approved QAPP. After fumigation (Task 1), the enveloped coupons will be transferred back to RTI for analysis. For reference, the analytical methods to be used in this laboratory study will be adapted from Task 1 and will likely include, in priority order: quantitative viability (CFUs), Vectashield™ staining for qualitative DNA assessment, allergenic mold, and mycotoxins.

The laboratory study shall include at least four materials fabricated into approximately 1 inch by 1 inch coupons. The materials shall likely include Latex-painted gypsum wallboard, wallpapered wallboard, unpainted pine wood, and ceiling tile. At least two mold species (*Chaetomium globosum, Aspergillus versicolor*) and at least one allergen (*Alternaria*) shall be included in the study.

Task 1: Set-up of Fumigation System

EPA shall provide a ClO_2 gas generation system for use in this work. The system is expected to generate ClO_2 in air by stripping from an aqueous ClO_2 solution. The contractor shall use this system, as provided by EPA, to complete this task. The generation system shall be plumbed to a fumigation chamber and the entire system shall be automated to control temperature (ambient to 40 °C, +/-2 °C), ClO_2 concentration (50 – 4000 ppmv, +/-10%), relative humidity (30 - 90%, +/-4%), and air exchange rate within the chamber. The chamber shall be able to accommodate at least 60 coupons, of the dimension specified above, maintained in individual Tyvek envelopes. The ideal chamber and testing approach would be able to accommodate up to 180 coupons for one fumigation cycle. Homogeneity of the gas temperature, RH, and ClO_2 concentration throughout the chamber shall be verified prior to use of the chamber for the completion of the test matrix. The fumigation system design shall support the removal of coupons from the chamber during the fumigation without affecting the chamber conditions (i.e., temperature, RH, and ClO_2 concentration remain within target specifications). All parameters shall be measured in real-time; in addition, the ClO_2 concentration shall also be measured using the modified SM-4500 E method currently in practice in the NHSRC's Decontamination Technologies Research Lab (DTRL). The fumigation set-up shall be contained and operated in the DTRL space located in H-222 or H-224 of the EPA RTP Campus. The ClO_2 generation system, and necessary automation components, shall be contained on a cart for easy transportation of the system. The entire mobile system shall occupy a footprint that maintains the space required for appropriate access to all equipment in the lab.

The fumigation system shall be able to maintain the conditions detailed in the test matrix. Shakedown of the system shall include documentation of the control of the process parameters throughout a complete cycle (e.g., humidification, charging, and dosing [CT clock]).

Task 2: Quality Assurance Project Plan (QAPP) for the Laboratory Research Effort

An amendment to the existing QAPP shall be submitted for approval as part of this effort.

Task 3: Fumigation Tests

The general test method for the fumigation tests is as follows: (1) place the appropriate coupons for the trial in the chamber and seal the chamber airlock; (2) establish the target temperature and RH for the trial; (3) charge the chamber with ClO_2 to achieve the target concentration; (4) maintain the target concentration, temperature, and RH for the specified time (note: time zero is defined as the time at which the target concentration was achieved in the chamber); (5) aerate the chamber for a defined length of time and until a safe ClO_2 concentration is achieved in the chamber; and (6) open the chamber and remove the coupons, placing them in the appropriate sample packaging containers per the approved QAPP. Coupons may also be removed, through the airlock (without affecting the chamber conditions) at intermittent time points in the fumigation cycle.

The preliminary test matrix for this work is shown in Table 1 for this SOW. The test matrix may be changed by the EPA Work Assignment Manager (WAM) based upon results obtained during the testing; however, the overall level of effort required for completion of the tasks specified in this Statement of Work (SOW) as currently written shall be maintained.

The matrix shows the information relevant to the completion of this task. Specifically, this information includes the test number, materials, contamination (mold species, mycotoxin, or allergenic mold), and total number of coupons (N) of a particular material/contamination required for a particular treatment, treatment conditions, and time of exposure to the target conditions.

For all chamber studies, the target temperature and RH shall be 24 °C (+/-2 °C) and varying RH (+/- 4%), as detailed in Table 1. A target chamber ClO_2 concentration of 750 ppmv, 3000 ppmv, and 4000 ppmv (+/- 10%) shall be required for these tests. The target concentrations may be changed by the EPA WAM prior to or during the completion of the test matrix within the concentration ranges defined for the fumigation system in Task 1.

Real-time data for temperature, RH, and ClO_2 concentration within the chamber shall be logged throughout the fumigation cycles for all trials. The ClO_2 concentration in the chamber shall be confirmed at defined intervals throughout the fumigation cycle by titration according to the modified SM-4500 E approach currently in practice in the DTRL. The intervals will be specified in the approved QAPP and shall be expected to occur at no shorter than every 20 minutes.

After completion of each trial, the coupons shall be promptly transferred to RTI for the appropriate analyses. Electronic files for each fumigation cycle that document all process parameters as a function of time through each trial shall be maintained on the DTRL share drive in an appropriate sub-folder of the share. A single MS Excel file for each trial documenting the trial conditions (e.g., coupon types and number, contamination type, target conditions) and process parameters as a function of time (i.e., ClO_2 concentration [on-line and via titration], temperature, and RH) shall be generated from the raw data files. These files shall be appropriately annotated to clearly specify the data being reported. A single Excel file for each trial is preferred.

Task 4. Documentation.

The results will be summarized in monthly reports as the tasks are completed or partially completed. At the EPA discretion, mold/allergen/mycotoxin results from the testing may be made available for the contractor to prepare a comprehensive final report.

IX. DELIVERABLE SCHEDULE

Deliverables include an amendment to the existing QAPP as required for sampling at additional sites, and monthly progress reports. The contractor shall comply with all requirements as delineated on the "Quality Assurance Planning Requirements Form (QARF)" included with this work assignment and the QA requirement as defined in Attachment #1 to the SOW. Additional information related to QA requirements can be found at: http://www.epa.gov/quality/qs-docs/r5-final.pdf.

X. REPORTING REQUIREMENTS

- The Contractor shall prepare Quality Control data reports of all facility-specific data. Each Quality Control report shall be in a format suitable for EPA/NHSRC publication and shall discuss how well various measurements described in the QA plan were met.

- The monthly invoice reports for this work assignment shall provide a detailed description of any equipment or expendables that have been purchased by the contractor for use on the projects discussed herein.

- All compiled data files for each trial, generated as discussed in Section VIII shall be provided in electronic format in MS Excel. The files shall be of consistent format, with proper annotation to readily identify the data incorporated in the worksheets.

- A draft and final report for Phase 1 shall be submitted to the EPA WAM. The final report shall incorporate changes specified by the EPA WAM, peer reviewers, and EPA Quality Assurance Review. The draft and final shall be submitted in electronically to the EPA WAM in MS Word format. The report shall be sufficient for incorporation into a comprehensive report covering Phase 1 and Phase 2 of the testing.

Report

Table 1 Test Matrix for Laboratory Studies

Test ID	Materials	Contamination	Anticipated Treatment	Time Points	Analysis	Total Coupons	Sum
Run 1	L, W, WW, C	*Aspergillus fumigatus*	none (pos.control)	0	V(6), A(6)	48	
	L, W, WW, C	none (blank)	ClO2 (neg cont)	1.5, 3	V(1), A(1)	16	
	L, W, WW, C	*Aspergillus fumigatus*	750 ppmv ClO2	1.5, 3	V(6), A(6)	96	160
Run 2	L, W, WW, C	*Chaetomium*	none (pos.control)	0	V(6)	24	
	L, W, WW, C	none (blank)	ClO2 (neg cont)	3, 6	V(1)	8	
	L, W, WW, C	*Chaetomium*	3000 ppmv ClO2 45% RH	3, 6	V(6)	48	80
Run 3	L, W, WW, C	*Chaetomium*	none (pos.control)	0	V(6)	24	
	L, W, WW, C	none (blank)	ClO2 (neg cont)	3, 6	V(1)	8	
	L, W, WW, C	*Chaetomium*	4000 ppmv ClO2 45% RH	3, 6	V(6)	48	80

Notes: Materials: L = Latex-painted wallboard; W = unpainted pine wood; C = ceiling tile; WW = wallpapered wallboard (grown at 100% RH as before, but dry by the time they were treated)
Analysis: V = viability; A = antigen
Numbers in parentheses represent the number of replicate coupons per analysis type (for material/contaminant)
Treatment: fumigation at the specified concentration of ClO2, at specified RH, for specified time

Total # of runs : 3