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CF Industries, Inc.
Bartow Operations
P. O. Box 1480
Bartow, Florida 33831

863-533-8040
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November 3, 2009

Certified Mail 7009 1410 0000 2724 0021

Carol L. Kemker, Acting Director
Air, Pesticides & Toxics Management Section
U.S. Environmental Protection Agency Region IV
Sam Nunn Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8960

RECEIVED
NOV 06 2009
BUREAU OF AIR REGULATION

RE: CF Industries, Inc.
Bartow Phosphate Complex
Phosphogypsum Stack
Request for Approval of Alternative Compliance Method
NESHAP 40 CFR 61 Subpart R

Dear Ms. Kemker:

Please find enclosed a Request for Approval of Alternative Method of Demonstrating Compliance being submitted by CF Industries, Inc. (CFI), to the U.S. Environmental Protection Agency Region IV (EPA) for approval under 40 CFR 61 Subpart A for the above-referenced phosphogypsum stack at CFI's Bartow Phosphate Complex.

Specifically, as allowed under 40 CFR 61.13, CFI is requesting through the attached application that EPA approve an alternative method of determining compliance with the radon-222 flux standard applicable to inactive phosphogypsum stacks as set forth in 40 CFR 61.202. The EPA Method 115 testing referenced in 40 CFR 61.203 is outdated, no longer available in the industry, and not economically practical. As detailed in the attached application, CFI has covered most of the phosphogypsum stack at the Bartow Phosphate Complex with a liner as well as several inches of soil and vegetation, which lowers radon levels, and CFI is proposing to use an alternative method to demonstrate that the radon-222 flux levels from the stack are below the standard of 20 pCi/ m^2s.

CFI sincerely appreciates you and your staff's attention to this matter and consideration of the enclosed application. If you or your staff have questions or need further information to complete your review of the requested approval, please do not hesitate to contact me at (863) 534-5488.

Sincerely,

John M. Doran
Manager

Copies sent electronically and by U.S. Mail to:

Doug Neeley, Chief, Air Toxics & Monitoring Branch, EPA Region IV, neeley.doug@epa.gov
Rick Button, EPA Region IV, button.rick@epa.gov
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Request for Approval of Alternative Method of Demonstrating Compliance

CF Industries, Inc. – Bartow Phosphate Complex
Phosphogypsum Stack
November 3, 2009

1. Introduction

CF Industries, Inc. (CFI) owns a phosphogypsum stack in Bartow, Florida, at the Bartow Phosphate Complex. This stack is no longer receiving additional amounts of phosphogypsum. Process waste water associated with the stack and the prior production of phosphoric acid at the site continues to be managed. The federal NESHAP rules (National Emissions Standards for Hazardous Air Pollutants) under 40 CFR 61 Subpart R provide that inactive stacks are to be tested for radon-222 flux in accordance with EPA Method 115 to ensure that radon-222 flux levels are below the applicable standard of 20 pCi/m^2s. [40 CFR 61.203] CFI wishes to demonstrate that radon-222 flux levels associated with its Bartow gypsum stack are below these levels.

EPA Method 115 is no longer used in the industry and is therefore not an available means for determining radon-222 flux levels from the stack. Therefore, CFI respectfully requests, pursuant to 40 CFR 61.13(h)(1)(ii), that the U.S. Environmental Protection Agency (EPA) approve the use of an alternative method of determining the radon-222 flux levels from the stack and demonstrating the stack's compliance with the radon-222 flux emission standard, as set forth in Attachment A, Protocol for Measurement of Radon-222 Flux Levels from CFI's Phosphogypsum Stack at the Bartow Phosphate Complex. CFI developed this Protocol using long-standing EPA guidance and Method 115 where possible. See "Indoor Radon and Radon Decay Product Measurement Device Protocols," U.S. EPA Office of Air and Radiation. EPA 402-R-92-004 (July 1992).

2. Reason for Request

EPA "Method 115" (set forth in 40 CFR 61, Appendix B) for the collection of radon is no longer used in the industry, is not an available method, and would not be economically feasible to recreate (even if possible). Based on CFI's investigation, there are no active laboratories offering analysis of activated charcoal canisters or that conduct Method 115 tests to determine radon-222 flux levels from phosphogypsum stacks.

3. Source Information

A. Identification and Location:

CF Industries, Inc.
Bartow Phosphate Complex
2501 Bonnie Mine Road
Bartow, Polk County, FL 33830
U.S. EPA Region IV

B. Contact Information:
John Doran, Manager
CF Industries, Inc.
2501 Bonnie Mine Road
Bartow, FL 33830
(863) 534-5488

C. Source Description:
The Bartow Phosphate Complex was historically operated as a phosphate fertilizer manufacturing plant but is currently under closure. The facility formerly manufactured sulfuric acid, phosphoric acid, and granulated ammonium phosphate fertilizers. Currently the only activities at the facility involve permanent closure and long-term post-closure care.

D. Compliance Status:
The radon-222 flux levels from the phosphogypsum stack are expected to be well below the applicable emission standard of 20 pCi/ m^2s, established under 40 CFR 61.202.

4. Process Information
A. Pollutant Emitted: Radon-222 flux

B. Process Description: Phosphogypsum stack

C. Amount of Pollutant: Less than 20 pCi/ m^2s of radon-222 flux

D. Control Devices: No further phosphogypsum is being added to the stack and the stack is compacting. A high density polyethylene (HDPE) liner has been installed over most of the gypsum surfaces and a soil covering has also been added over that liner and most of the unlined gypsum as described further below. All of these control factors significantly minimize radon-222 flux levels emanating from the stack.

5. Additional Information to Support Request
A. History of Radon-222 NESHAP Standards for Phosphogypsum Stacks
On March 7, 1989, EPA proposed four different standards for phosphogypsum stacks, including the 20 pCi/ m^2s, which is the current standard, as well as three lower emission levels. EPA stated that a 20 pCi/ m^2s standard "represents current emissions, which will protect public health with an ample margin of safety." EPA proposed this NESHAP "to prevent emissions from increasing." EPA stated that if this limit was selected, "it is expected that all stacks will be in compliance with the standard." If the lower levels suggested by EPA had been adopted, EPA stated that "the stacks will most likely not be in compliance unless they cover the stack with dirt, or something else, to reduce the radon flux off the stack." 54 Fed. Reg. 9612. Later that year, on December 15, 1989, EPA issued the final rule, establishing the radon-222 flux standard for phosphogypsum stacks at 20 pCi/ m^2s, specifically finding that this standard would be sufficient to ensure the continued safety of the public with an ample margin of safety. EPA stated that "[t]his numerical standard simply ensures maintenance of the status quo as EPA believes all

existing phosphogypsum stacks meet these requirements without the need for additional control technology." 54 Fed. Reg. 51654. These rules are found at 40 CFR 61 Subpart R.

B. Radon Studies

The EPA and the Florida Institute of Phosphate Research (FIPR), an independent state research agency, have studied radon-222 emissions from phosphogypsum stacks.[1] These studies involved both active and inactive phosphogypsum stacks. Inactive phosphogypsum stacks had a variety of covering combinations including no covering, vegetation only, three inches of soil covering with vegetation, and six inches of soil covering with vegetation. EPA and FIPR have independently established radon-222 reduction up to seventy-five percent (75%) by covering the exposed gypsum with soil and vegetation.

C. Discussion of Radon Properties

Radon is a noble gas and is essentially inert. It will not react with other elements to form complex compounds. Unlike other gases, radon-222 is radioactive and has a half-life of 3.8 days. A half-life is that period of time it would take half the population of the radon-222 atoms to decays into polonium-218.[2] Looking at it another way, the half-life is that period of time where the probability of the radon-222 atom decaying into polonium-218 is fifty percent (50%). It is this property of decay that allows radon to be measured. Originally, activated charcoal was used that would capture the polonium-218 as the radon-222 decayed. An analysis of the polonium-218 and its decay products provided a surrogate for the relative radon concentration in the air at the time of sampling.

D. Ensuring Radon Levels Below 20 pCi/m^{2}s

Before becoming an airborne hazard, radon-222 must travel through the phosphogypsum in the stack and then through any overlying material, such as soil, before it decays within the half-life of 3.8 days. The density of the material results in many collisions of the radon atom as it travels through material. Each collision can "change the radon travel direction" that may not allow the radon-222 to escape into the atmosphere before decaying back into a solid (polonium-218).[3]

The thickness of the material also complicates the emissions of radon-222 from the phosphogypsum stack. The farther the distance to the outer perimeter, the less likely a radon-222 atom escapes the phosphogypsum stack before decaying to polonium-218.

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[1] *Radon Flux Measurements on Gardinier and Royster Phosphogypsum Piles Near Tampa and Mulberry, Florida*, EPA 520/5-85-029 (January 1986); *A Long-Term Study of Radon and Airborne Particulates at Phosphogypsum Stacks in Central Florida*, EPA 520/5-88-021 (October 1988); *Establishing Vegetation Cover on Phosphogypsum in Florida*, FIPR Pub. No. 01-086-116 (December 1995).

[2] http://www.epa.gov/rpdweb00/radionuclides/radon.html.

[3] Tomozo Sasaki, "*Radon Emanation Phenomena: A Probabilistic Basis to Estimate Radon Emanation Coefficients Based on Its Zigzag Travel*", Journal of Nuclear Science and Technology, Vol. 45, No. 9, p. 932–941 (2008).

Regardless of the size of a phosphogypsum stack, only radon-222 emitted within a few inches of the surface can become an airborne hazard. The underlying radon-222 will not travel through the phosphogypsum stack matrix before decaying into polonium-218.

(1) EPA Testing

In 1985, the EPA performed a four-day study on two phosphogypsum stacks. EPA 520/5-85-029 (January 1986). One phosphogypsum stack was still active and had an average radon flux of 19.9 ± 9.2 pCi/m^2s for dry areas and 10.3 ± 28.1 pCi/m^2s for wet areas. The second phosphogypsum stack had both an active and inactive section. The active section had an average radon flux of 16.7 ± 7.8 (pCi/m^2s) and the inactive section, covered with a dry phosphogypsum layer, had an average radon flux of 4.5 ± 5.8 (pCi/m^2s). These results indicated an inactive site, with only a dry phosphogypsum layer on top, reduced the radon flux by seventy-five percent (75%).

Subsequently, in 1988, the EPA expanded the first test and performed a yearlong study of radon flux at four active and one inactive central Florida phosphogypsum stacks. EPA 520/5-88-021 (October 1988). These phosphogypsum stacks were exposed to the environment without attenuation from a layer of soil. The EPA measured an average radon flux of 20.5 ± 6.25 pCi/m^2s with a range from 5 to 58 pCi/m^2s.

The closed phosphogypsum stack had been inactive for twenty years and had developed a patchy vegetation cover with no soil placement over the phosphogypsum material. The radon flux averaged 4.4 ± 1.5 pCi/m^2s with a range from 1.7 to 7.4 pCi/m^2s. Id. This indicated a seventy-nine percent (79%) reduction in radon-222 emissions compared to the active phosphogypsum stack.

(2) FIPR Testing

In 1995, FIPR performed a study on the attenuation of radon emissions with the addition of soil and grass over the phosphogypsum. FIPR Pub. No. 01-086-116 (December 1995). The radon flux of a phosphogypsum stack without any attenuating layer averaged 24.50 pCi/m^2s. Id. at page 41. With the addition of six inches of soil or overburden, the radon flux was reduced to 5.4 pCi/m^2s, a reduction in radon emissions of over seventy-five percent (75%). Id.

The FIPR results are comparable to EPA data. Data from the 1995 FIPR study and 1985 and 1988 EPA studies reveal that radon-222 emissions from inactive phosphogypsum stacks are well below 20 pCi/m^2s. Averaging the radon-222 flux from the three inactive phosphogypsum stacks analyzed in these studies provides a working value of 4.8 pCi/m^2s for inactive phosphogypsum stacks.

(3) CFI Phosphogypsum Stack Closure

CFI installed an HDPE liner over the graded gypsum surfaces of the Bartow phosphogypsum stack and capped these and other areas with soil and grass. Table 1 lists the areas covered and the method of coverage. Figure 1 shows the phosphogypsum stack as it currently appears and Figure 2 shows the areas listed in Table 1. Each cover system is color-coded for quick reference.

Except for Area 1 & 2 in Figure 2 (Lined Stormwater Reservoir), all areas covered with HDPE are also covered with twenty-four (24) inches of soil and vegetation, well above the six inches of coverage in the FIPR test that resulted in a seventy-five percent (75%) reduction in radon emissions. Area 1 & 2 is being maintained for storm water collection for severe storms such as hurricanes. HDPE is a common impermeable liner for gas and water pipes and also is used for radon mitigation systems. CFI has placed twenty-four inches of soil over the HDPE liner to protect the liner and provide additional radon flux shielding. Vegetation was then planted to stabilize the soil.

The phosphogypsum stack covers approximately 652.4 acres as listed in Table 1. Approximately 574.8 acres of phosphogypsum stack are covered with HDPE. This represents over eighty-eight percent (88%) coverage of the phosphogypsum stack with material that inhibits radon-222 migration. Therefore, the area of the phosphogypsum stack that can emit radon-222 has been reduced from 652.8 acres to 77.6 acres as viewed from above. The slopes of the stack have a 2.5:1 ratio or approximately 22 degrees of slope, increasing the surface area of the slopes by fewer than eight percent (7.7%). These figures are included in Table 1.

Of the 77.6 acres that have no liner, 16.1 acres have 24 inches of soil and a vegetation covering. Using results from the FIPR study of the effect of a six-inch layer of soil with vegetation, radon-222 flux would be reduced by 75% to 5.4 pCi/m^{2}s. FIPR Pub. No. 01-086-116 (December 1995). With 24 inches of soil, radon-222 emissions should be reduced even more and, therefore, these covered stacks should emit radon in amounts well below the 20 pCi/m^{2}s standard.

The remaining 61.5 acres of the stack are covered by gypsum and grass. An EPA study indicated that a closed phosphogypsum stack with no soil and patchy vegetation had an average radon flux of 4.4 ± 1.5 pCi/m^{2}s with a range from 1.7 to 7.4 pCi/m^{2}s. EPA 520/5-88-021 (October 1988).

Averaging the expected radon emissions from the data from the EPA and FIPR reports with the reported coverage of the phosphogypsum stack, a weighted average of radon-222 emissions over the entire phosphogypsum stack would be below 1 pCi/m^{2}s. This should establish that the Bartow phosphogypsum stack, as a whole, would emit radon-222 well below the 20 pCi/m^{2}s threshold that EPA has established.

E. 40 CFR 61 Part R EPA "Method 115" Radon-222 Testing Method

Based on the analysis presented above, a defensible technical basis exists to support a waiver of radon flux monitoring. Nonetheless, CFI wishes to pursue analytical verification of the anticipated radon levels pursuant to 40 CFR 61 Subpart R. The procedures outlined in EPA "Method 115" call for activated charcoal canisters to be deployed on the phosphogypsum stack. The radionuclides are captured on the activated charcoal, which is sent to a certified laboratory for analysis. An investigation by CFI has indicated there are limited manufacturers of the activated charcoal and no laboratories available that actively perform analysis on the charcoal. The cost of establishing a laboratory to perform the analysis outweighs the reasonableness of the testing requirement.

An equivalent alternative exists for radon-222 testing. Alpha track devices are still readily available for purchase and analysis and have been successfully used by EPA for indoor radon-222 studies and can be used outdoors. CFI developed a protocol for use of the alpha track devices to confirm compliance with the 20 pCi/m2s standard. See Attachment A, "Protocol for Measurement of Radon 222 Flux Levels from CFI's Phosphogypsum Stack at the Bartow Phosphate Complex." CFI believes this protocol can be used to adequately demonstrate radon flux rates across the stack in conformance with the intent of 40 CFR 61 Subpart R.

F. Conclusion

CFI has exceeded the requirements for radon-222 emission control from the Bartow phosphogypsum stack. CFI has covered approximately 88.1 percent of the phosphogypsum stack with HDPE liner and twenty-four (24) inches of soil and vegetation. The remaining areas were covered with soil and vegetation or vegetation alone. Using the FIPR and EPA studies discussed above, radon levels from the 77.6 acres of unlined phosphogypsum stack would emit less than an average of 5.4 pCi/m^2s. With the remainder of the phosphogypsum stack covered by the HDPE liner, the weighted average of radon-222 emissions over the entire phosphogypsum stack would be below 1 pCi/m^2s.

Additionally, EPA Method 115 for testing radon, referenced in 40 CFR 61 Subpart R, requires technology and analysis that are no longer available. CFI requests that it be allowed to use the alternative methodology, as described in the attached Protocol, to demonstrate that the radon-222 flux levels from the Bartow phosphogypsum stack are below the standard of 20 pCi/m^2s established under 40 CFR 61.202.

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Figure 1. Aerial View of the Bartow Phosphogypsum Stack.

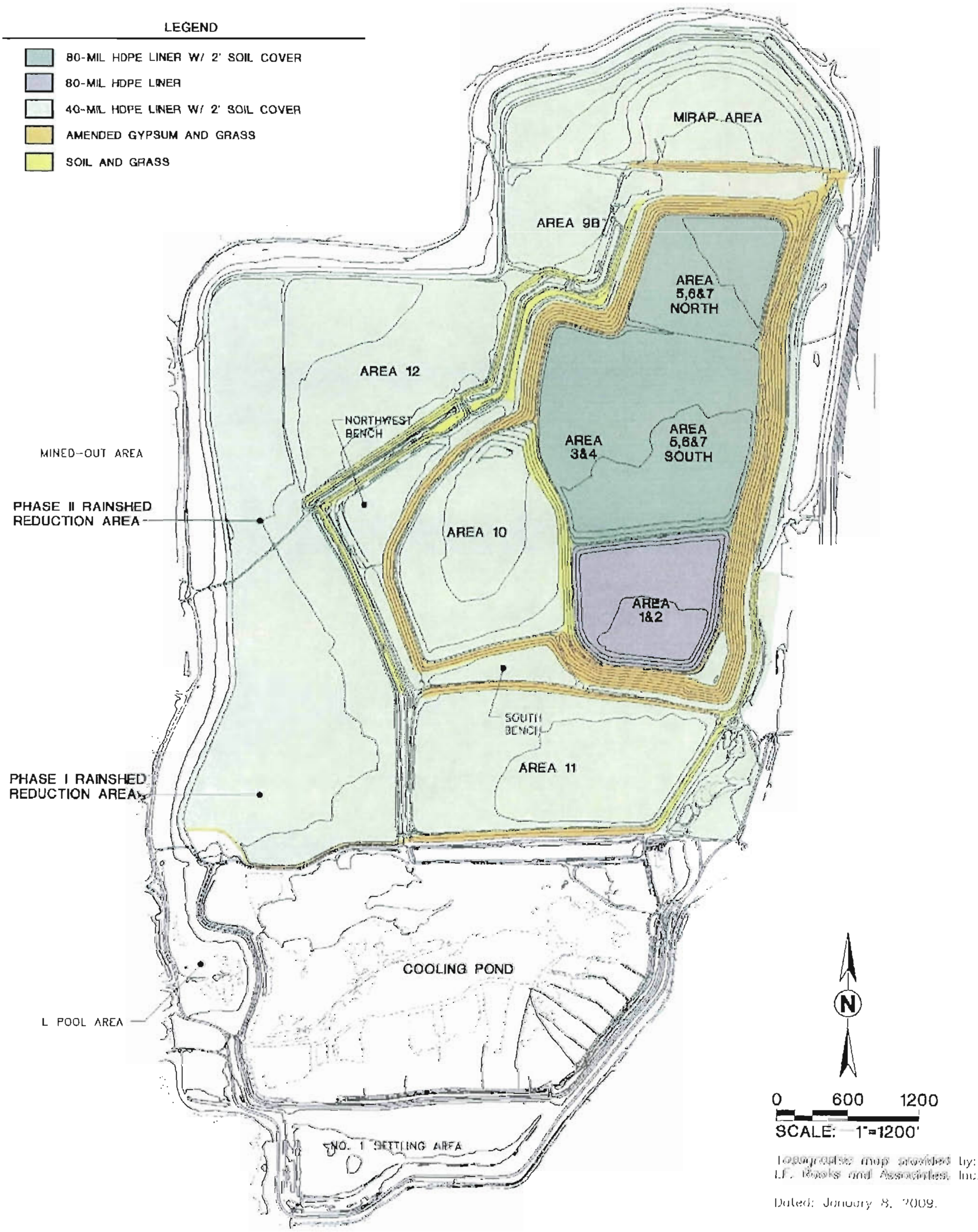

Figure 2. Cover Materials on Bartow Phosphogypsum Stack

Table 1. Bartow Phosphogypsum Stack

	Acreage Closed	Liner (Acres)	Soil and Grass (Acres)	Gypsum and Grass (Acres)
GYPSUM STACK AREAS				
40-mil HDPE, 24 inches soil and grass	366.6	366.6	-	-
80-mil HDPE, 24 inches soil and grass	95.0	95.0	-	-
80-mil HDPE, no soil	30.0	30.0	-	-
CHANNELS, SLOPE SWALES AND ROADS				
40-mil HDPE, 24 inches soil and grass	83.2	83.2	-	-
Soil and grass	12.1	-	12.1	-
SLOPES				
Amended gypsum and grass	61.5	-	-	61.5
Soil and grass	4.0	-	4.0	-
Total	652.4	574.8	16.1	61.5
Percent Coverage	100.0	88.1	2.5	9.4

Attachment A

Protocol for Measurement of Radon-222 Flux Levels from CFI's Phosphogypsum Stack at the Bartow Phosphate Complex

CF Industries, Inc. (CFI) developed the following site-specific Protocol for measurement of radon-222 flux levels from the phosphogypsum stack at the Bartow Phosphate Complex. CFI developed this Protocol using both the 1992 U.S. Environmental Protection Agency (EPA) protocol for the measurement of indoor radon concentrations ("Indoor Radon and Radon Decay Product Measurement Device Protocols," found at http://www.epa.gov/radon/pubs/devprot1.html) and EPA's Method 115. Where appropriate, however, and as recommended by the EPA Protocol, CFI developed its site-specific procedures to accurately measure the radon-222 flux from the Bartow stack.

1. Method

Alpha Track Detectors (ATD) will be used to measure the radon-flux from the Bartow phosphogypsum stack. An ATD consists of a small piece of plastic or film enclosed in a container with a filter-covered opening or similar design for excluding radon decay products. Radon diffuses into the container and alpha particles emitted by the radon and its decay products strike the detector and produce submicroscopic damage tracks. At the end of the measurement period, the detectors are returned to an approved laboratory. ATD detectors function as true integrators and measure the average concentration over the exposure period.

A group of ATDs will be deployed as soon as possible after delivery from the supplier. If the storage time exceeds more than a few months, the background exposures from a sample of the stored detectors will be assessed to determine if they are different from the background of detectors that are not stored for long periods. The supplier's instructions regarding storage and background determination will be followed.

The sampling period begins when the protective cover or bag is removed. The edge of the bag will be cut carefully, or the cover removed, so that it can be reused to reseal the detector at the end of the exposure period. The detector and the radon-proof container will be inspected to make sure that they are intact and have not been physically damaged in shipment or handling.

[Source: EPA Protocol, Sections 2.2.3. and 2.2.7.2.]

3. Measurement Criteria

A. Number of Data Points

Based on the Wilcoxon Rank Sum (WRS), 25 ATDs will be used to measure radon-222 flux from the stack. The WRS is a statistical test used to determine compliance with the release criterion when the radionuclide of concern is present in background. The WRS will determine the number of survey points to accurately quantify a site for license termination. The same concept of using the WRS to determine the number of samples to confidently release a site can apply to determining compliance of radon-222 emissions from a phosphogypsum stack.

The WRS calculates the number of data points by using Type I decision error, Type II decision error, shift and relative shift.

Type I Decision Errors. Type I decision errors (α) are referred to as a false positive error. This condition exists when a sample exceeds the established criterion but overall the site still meets EPA guidelines. This value reflects the amount of evidence required to ensure the site still falls within EPA standards given the occasional sample falling outside the guidelines. This value will be low to restrict the use of an elevated sample.

Type II Decision Errors. Type II decision errors (β) are referred to as the false negative error. This condition exists when a sample meets the established criterion but overall the site does not meet EPA guidelines. This value can be larger than the Type I decision error since a false negative will not affect the end results.

The Multi-Agency Radiation Survey & Site Investigation Manual (MARSSIM) recommends that the Type I and Type II decision error rates be treated simultaneously and in a balanced manner. For this protocol the recommended default value of 0.05 will be used for α and β. This means there is a five percent chance of a stack with high radon-222 emissions being overlooked. Likewise, there is a five percent chance of a stack with low radon-222 emissions not being released. Decreasing the decision errors increases the number of samples required. Phosphogypsum stacks have generally had radon-222 emissions below the EPA guidelines indicating excessive restrictions on testing would not be warranted.

Decision Error Percentiles. The Type I and Type II decision errors (α and β) were used to determine the decision error percentiles ($Z_{1-\alpha}$ and $Z_{1-\beta}$). This is a correlation provided in the MARSSIM manual and restated in Table 1 below.

Table 1. Decision Error Percentiles

A or β	$Z_{1-\alpha}$ or $Z_{1-\beta}$
0.005	2.576
0.01	2.326
0.015	2.241
0.025	1.96
0.05	1.645
0.10	1.282
0.15	1.036
0.20	0.942
0.25	0.674
0.30	0.524

Derived Concentration Guideline Level (DCGL). MARSSIM defines a "gray region" where the consequences of decision errors are relatively minor. The upper bound of this region is defined as the Derived Concentration Guideline Level (DCGL) and is a radionuclide-specific concentration corresponding to the release criterion. MARSSIM specifically defines a $DCGL_W$ for an average concentration of a radionuclide over a large area. The EPA, in 40 CFR 61.202, established 20 pCi/m^{2}s as the criterion for radon-222 emissions from phosphogypsum stacks.

Lower Bound of the Gray Region (LBGR). MARSSIM defines the Lower Bound of the Gray Region (LBGR) as a site-specific variable that is initially selected to equal one half the $DCGL_W$. With a $DCGL_W$ of 20 pCi/m^{2}s, the LBGR would be 10 pCi/m^{2}s.

Relative Shift. The relative shift (Δ/σ) determines the probability that a random measurement (P_r) from the survey exceeds a random measurement from the background by less than the DCG L_W when the survey was equal to the LBGR above background. The relative shift is the ratio of the shift to the standard deviation of the measured values and is an expression of the resolution of the measurements.

To calculate the shift, MARSSIM recommends setting the LBGR to one-half the DCGL. The width of the gray region would be equal to the difference between the DCGL and LBGR. Since the DCGL is 20 pCi/m^{2}s and the LBGR is one-half that value, the difference between the DCGL and LBGR would be 10 pCi/m^{2}s. This value represents the shift.

To calculate the relative shift, the standard deviations of radon-222 results are required. The EPA provided radon-222 emission information in their study "A Long-Term Study of Radon and Airborne Particulates at Phosphogypsum Stacks in Central Florida," EPA 520/5-88-021, October 1988. The following table of results is provided from the EPA report.

Stack Location	Radon Flux ± Standard Deviation (pCi/m^{2}s)
Gardinier	**20 ± 4**
W.R. Grace	**16 ± 6**
Royster	**21 ± 3**
Conserv	**25 ± 12**
Estech	**4.4 ± 1.5**

Averaging the standard deviations provided above, the relative shift would be (10 pCi/m^{2}s) / (5.3 pCi/m^{2}s) = 1.9.

NUREG-1575 is the Nuclear Regulatory Commission (NRC) enactment of MARSSIM. Using Table 5.1 of NUREG-1575 (EPA 402-R-97-016) the P_r value for a relative shift of 1.9 would be 0.910413.

The number of survey points to obtain a ninety-five percent confidence level using the WRS test would be:

$$N = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{3\left(P_r - 0.5\right)^2}$$

$Z_{1-\alpha} = Z_{1-\beta} = 1.645$
$P_r = 0.910413$

Using the values provided above, a total of 21 survey points would confidently determine if a phosphogypsum stack has radon-222 emissions below 20 pCi/m^2s. Many factors contribute to the variability of ATD results, including differences in the detector response within and between batches of plastic, non-uniform plate-out of decay products inside the detector holder, differences in the number of background tracks, and variations in etching conditions. Since the variability in ATD results decreases with the number of net tracks counted, counting more tracks over a larger area of the detector, particularly at low exposures, will reduce the uncertainty of the result. MARSSIM recommends the number of data points be increased by twenty percent to account for reasonable amount of uncertainty in the parameters. The number of data points to provide confidence that the stack will meet EPA guidelines would be 25.

[Source: WRS Analysis]

B. Sampling Location Selection

CFI will identify appropriate regions of the stack to be sampled and will place ATD sampling devices in each of those identified regions.

C. Measurement Period

The radon collector will placed on the surface of the stack area to be measured and allowed to collect radon for a minimum period of 24 hours. The surface of the phosphogypsum will not be penetrated by the lip of the radon collector; rather, the collector will be carefully positioned on a flat surface with soil or phosphogypsum used to seal the edge. The alpha emissions tracks collected on the ATD will be measured at an approved laboratory.

[Source: EPA Method 115, Sections 3.1.6]

D. Measurement Conditions

The following restrictions are placed on making radon flux measurements:

(1) Measurements will not be initiated within 24 hours of a rainfall.

(2) If a rainfall occurs during the 24-hour measurement period, the measurement will be considered invalid if the seal around the lip of the collector has washed away or if the collector is surrounded by water.

(3) Measurements will not be performed if the ambient temperature is below 35 °F or if the ground is frozen.

[Source: EPA Method 115, Sections 3.1.4]

4. Retrieval of Detectors

At the end of the measurement period, the detector will be inspected for damage or deviation from the conditions recorded at the time of deployment. Any changes will be recorded. The time and date of removal will be recorded. The detector will then be resealed following the instructions provided by the supplier. After retrieval, the detectors will be stored in a low radon environment and returned as soon as possible to the analytical laboratory for processing.

[Source: EPA Protocol, Section 2.2.8.]

5. Documentation and Quality Assurance

A. Reporting.

The results of individual flux measurements, the approximate locations on the stack, and the mean radon flux for each region and the mean radon flux for the total stack will be included in the emission test report. Any condition or unusual event that occurred during the measurements that could significantly affect the results will be reported.

B. Quality Assurance Procedures for Measuring Radon-222 Flux

(1) Sampling Procedures

Records of field activities and laboratory measurements shall be maintained. The following information shall be recorded for each ATD measurement:

(a) Site

(b) Location of Phosphogypsum Stack

(c) Sample location

(d) Sample ID number

(e) Date and time on

(f) Date and time off

(g) Observations of meteorological conditions and comments

Records will include all applicable information associated with determining the sample measurement, calculations, observations, and comments.

(2) Sample Custody

Custodial control of all ATDs exposed in the field will be maintained in accordance with EPA chain-of-custody field procedures. A control record will document all custody changes that occur between the field and laboratory personnel.

6. Calculations

The mean radon flux for each region of the phosphogypsum stack and for the total stack will be calculated and reported as follows:

A. The mean radon flux for each region of the stack will be calculated by summing all individual flux measurements for the region and dividing by the total number of flux measurements for the region.

$$J = \frac{\left[\dfrac{R_i}{t_i \ X \ a_i}\right]}{i}$$

J = Mean radon flux for a region (pCi/m^2s)

R_i = Radon captured on ADT (pCi)

t_i = Elapsed time measuring radon flux (sec)

a_i = Area of container holding ADT (m^2)

B. The mean radon flux for the total phosphogypsum stack will be calculated as follows:

$$J_s = \frac{J_1A_1 + J_2A_2 + \cdots J_iA_i}{A_t}$$

Where:

J_s=Mean flux for the total stack (pCi/m^2-s)

J_i=Mean flux measured in region i (pCi/m^2-s)

A_i=Area of region i (m^2)

A_t=Total area of the stack

[Source: EPA Method 115, Section 3.1.7.]