SOUTH CAROLINA ELECTRIC & GAS

SCANA®
POWER FOR LIVING

DOCUMENTATION OF LINER TYPE

FOR THE

WATEREE STATION FGD POND

RICHLAND COUNTY, SOUTH CAROLINA

OCTOBER 2016

SOUTH CAROLINA GARRETT AND MOORE, INC. No. C3371 CERTIFICATE OF AUTHORIZATION

GARRETT & MOORE
Engineering for the Power and Waste Industries

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10/12/16

1 OVERVIEW

The EPA Administrator, Gina McCarthy, signed the Disposal of Coal Combustion Residuals from Electric Utilities final rule on December 19, 2014, and it was published in the Federal Register (FR) on April 17, 2015. The regulations provide a comprehensive set of requirements for the safe disposal of coal combustion residuals (CCRs), commonly known as coal ash, from coal-fired power plants. The rule will be administered as part of the Resource Conservation and Recovery Act [RCRA, 42 United States Code (U.S.C.) §6901 et seq.], using the Subtitle D approach.

South Carolina Electric & Gas (SCE&G) is subject to the CCR Rule. Based on SCE&G's review of the rule, the **two forebays** of the **Flue Gas Desulfurization (FGD) Pond at SCE&G Wateree Station** has been determined to be an existing CCR surface impoundment subject to the CCR rule requirements.

2 PURPOSE

The purpose of this document is to document that the Wateree Station FGD Pond was constructed with a liner system that meets CCR rule §257.71 - *Liner design criteria for existing CCR surface impoundments.*

3 APPLICABLE REGULATIONS

CCR rule §257.71 - *Liner design criteria for existing CCR surface impoundments* states the following:

> (a)(1) No later than October 17, 2016, the owner or operator of an existing CCR surface impoundment must document whether or not such unit was constructed with any one of the following:
>
> > (i) A liner consisting of a minimum of two feet of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec;
> >
> > (ii) A composite liner that meets the requirements of **§ 257.70(b)**; or
> >
> > (iii) An alternative composite liner that meets the requirements of **§ 257.70(c)**.
>
> (2) The hydraulic conductivity of the compacted soil must be determined using recognized and generally accepted methods.
>
> (3) An existing CCR surface impoundment is considered to be an existing unlined CCR surface impoundment if either:
>
> > (i) The owner or operator of the CCR unit determines that the CCR unit is not constructed with a liner that meets the requirements of paragraphs (a)(1)(i), (ii), or (iii) of this section; or
> >
> > (ii) The owner or operator of the CCR unit fails to document whether the CCR unit was constructed with a liner that meets the requirements of paragraphs (a)(1)(i), (ii), or (iii)

of this section. (4) All existing unlined CCR surface impoundments are subject to the requirements of § 257.101(a).

CCR rule **§ 257.70 (b)** states:

A composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil geomembrane liner (GM), and the lower component consisting of at least a two foot layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} centimeters per second (cm/ sec). GM components consisting of high density polyethylene (HDPE) must be at least 60-mil thick. The GM or upper liner component must be installed in direct and uniform contact with the compacted soil or lower liner component. The composite liner must be:

(1) Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the CCR or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

(2) Constructed of materials that provide appropriate shear resistance of the upper and lower component interface to prevent sliding of the upper component including on slopes;

(3) Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

(4) Installed to cover all surrounding earth likely to be in contact with the CCR or leachate.

CCR Rule **§ 257.70 (c)** states:

If the owner or operator elects to install an alternative composite liner, all of the following requirements must be met:

(1) An alternative composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil GM, and a lower component, that is not a geomembrane, with a liquid flow rate no greater than the liquid flow rate of two feet of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec. GM components consisting of high density polyethylene (HDPE) must be at least 60-mil thick. If the lower component of the alternative liner is compacted soil, the GM must be installed in direct and uniform contact with the compacted soil.

(2) The owner or operator must obtain certification from a qualified professional engineer that the liquid flow rate through the lower component of the alternative composite liner is no greater than the liquid flow rate through two feet of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/sec. The hydraulic conductivity for the two feet of compacted soil used in the comparison shall be no greater than 1×10^{-7} cm/sec. The hydraulic conductivity of

any alternative to the two feet of compacted soil must be determined using recognized and generally accepted methods. The liquid flow rate comparison must be made using Equation 1 of this section, which is derived from Darcy's Law for gravity flow through porous media.

(Eq. 1) $QA=q=k\ (h/t+1)$

Where, Q = flow rate (cm^3/s); A = surface area of the liner (cm^2);

q = flow rate per unit area ($cm^3/s/\ cm^2$);

k = liner's hydraulic conductivity (cm/s);

h = hydraulic head above the liner (cm);

t = thickness of the liner (cm).

4 FGD POND

Wateree Station is coal-fired electric generation plant located along the Wateree River near Eastover, Richland County, South Carolina. The FGD Pond is used to manage wastewater generated from the flue gas desulfurization scrubber system. The FGD pond was constructed in accordance with construction permit (permit 19263-IW) issued from the South Carolina Department of Health and Environmental Control (SCDHEC) on December 7, 2009, and placed into operation in accordance with an operation approval issued by DHEC on April 10, 2010. Effluent discharge for the FGD Pond is regulated under NPDES Permit #SC0002038.

The liner system for the two FGD Pond forebays (1.1 and 1.15-acres) is comprised of the following materials, from top to bottom:

- 60-mil HDPE Geomembrane Liner (GM)
- Geosynthetic Clay Liner (GCL)
- Min. 18"-thick Compacted Soil Liner (CSL)

Review of the liner system indicates that the existing liner system does not conform with the requirements of regulation §257.71 (a)(1), (i) and (ii) as the compacted soil liner component of the composite liner system is not a minimum 24" thick, as required by the regulation. Therefore, an alternate composite liner demonstration is necessary to demonstrate existing liner system meets the requirements of **§ 257.70(c)** and therefore complies with **§257.71**.

5 ALTERNATE COMPOSITE LINER DEMONSTRATION

§ 257.70 (c)(1) requires that an alternative composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil GM, and a lower component, that is not a geomembrane, with a liquid flow rate no greater than the liquid flow rate of two feet of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec. GM components consisting of high density polyethylene (HDPE) must be at least 60-mil thick.

§ 257.70 (c)(2) requires the owner or operator must obtain certification from a qualified professional engineer that the liquid flow rate through the lower component of the alternative composite liner is no greater than the liquid flow rate through two feet of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/sec. The hydraulic conductivity for the two feet of compacted soil used in the comparison shall be no greater than 1×10^{-7} cm/sec. The hydraulic conductivity of any alternative to the two feet of compacted soil must be determined using recognized and generally accepted methods. The liquid flow rate comparison must be made using Equation 1 of this section, which is derived from Darcy's Law for gravity flow through porous media.

With regards to § 257.70 (c)(1), the FGD Pond's existing composite liner system includes a 60-mil HDPE geomembrane liner (GM). Therefore, the GM upper component of the existing pond's liner system meets upper GM component required by the CCR rule.

With regards to § 257.70 (c)(1) and (2), the FGD Pond's existing composite liner system include a lower component comprised of the combination of a geosynthetic clay liner (GCL) underlain by a minimum 18" thick low permeable compacted soil liner (CSL).

As required by§ 257.70 (c)(2), Darcy's Law is used demonstrate that the liquid flow rate of the lower component of the pond's composite liner system meet or exceeds the liquid flow rate of a 24" thick compacted soil liner with a hydraulic conductivity 1×10^{-7} cm/sec. A spreadsheet comparing the two lower unit components is attached.

The results of the Darcy's Law calculation indicates that the following liquid flow rates:

- 24" thick compacted soil liner w/ hydraulic conductivity 1×10^{-7} cm/sec = 4.0×10^{-7} $cm^3/s/cm^2$
- FGD Pond's existing system (GCL underlain by a minimum 18" thick CSL) = 3.9×10^{-7} $cm^3/s/cm^2$

Based on the above results, the liquid flow rate through the lower component of the existing pond's alternate composite liner system is less than the liquid flow rate through two feet of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/sec. Therefore, the lower component of the pond's alternative composite liner system meets the requirements.

It is also noteworthy to add that a geomembrane leak location survey was performed on the installed 60-mil HDPE geomembrane liner to verify the geomembrane liner was free of holes, which is above and beyond the requirements of the CCR rules and provides another level of protection to ensure the integrity of the pond's liner system.

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JOB NAME	**SCE&G Wateree Station FGD Pond**
SUBJECT	**Composite Liner Lower Component Flow Rate**

Purpose Estimate the rate of flow through the lower component of the composite liner using Darcy's Law

$$\frac{Q}{A} = q = k\left(\frac{h}{t} + 1\right)$$

Where, Q = flow rate (cm^3/s); A = surface area of the liner (cm^2); q = flow rate per unit area ($cm^3/s/cm^2$); k = liner's hydraulic conductivity (cm/s); h = hydraulic head above the liner (cm); t = thickness of the liner (cm).

Base scenario - 24" thick Compacted Soil Liner with hydraulic conductivity of $1x10^{-7}$ cm/sec

Where:

1.0E-07	k	liner's hydraulic conductivity (cm/sec)
182.88	h	hydraulic head above the liner (cm) (*normal pool water depth*)
60.96	t	thickness of the liner (cm)
4.0E-07	q	flow rate per unit area ($cm^3/s/cm^2$)

Alternate Liner - GCL underlain by 18" thick CSL.

The GCL is comprised of Bentomat ST, which is a reinforced GCL consisting of a layer of sodium bentonite between a woven and a nonwoven geotextiles, which are needlepunched together. Whereas the manufacturer warrants a maximum permeability of 5x10-9 cm/s, studies (Thiel et al., 2001) indicate a recommended design value of 2x10-9 cm/s given the effective compressive stress for the GCL in the subject pond application assuming hydration of the GCL through absorption of moisture contained within the underlying CSL.

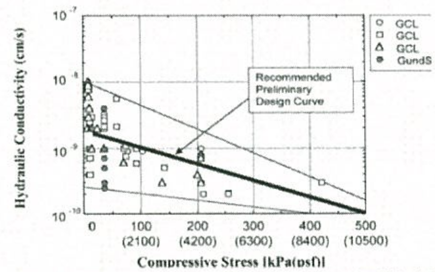

Figure 2. Hydraulic Conductivity as a Function of Effective Confining Stress. (from Thiel et al., 2

The CSL was installed in 3 approximate 6-inch-thick lifts. To calculate a composite permeability for the 18-inch liner, the maximum (fastest) permeability for each of the three lifts were determined, with the mean of these three values yielding a composite value for the entire liner. Permeability test results performed on undisturbed tube samples of the soil liner performed as part of the QA/QC program during construction of the CSL were used in the analysis. Based on the analysis, a composite mean value of 2.2 x 10-7 cm/s was calculated for the CSL component of the lower liner.

To use Darcy's Law for the combination GCL/CSL, it is first necessary to develop "effective" hydraulic conductivities and thicknessess for the composite system using the equations below:

$$k_{effective} = \frac{t_1 + t_2}{\frac{t_1}{k_1} + \frac{t_2}{k_2}} \qquad t_{effective} = t_1 + t_2$$

2.0E-09	k_1	GCL hydraulic conductivity (cm/sec)
2.2E-07	k_2	CSL hydraulic conductivity (cm/sec)
0.75	t_1	thickness of the GCL (cm)
45.72	t_2	thickness of the CSL (cm)
8.0E-08	k_{eff}	effective hydraulic conductivity forthe combo GCL/CSL (cm/sec)
46.47	t_{eff}	effective thickness of the combo GCL/CSL (cm)

Where:

8.0E-08	k	liner's effectivehydraulic conductivity (cm/sec)
182.88	h	hydraulic head above the liner (cm) (*normal pool water depth*)
46.47	t	effective thickness of the liner (cm)
3.9E-07	q	flow rate per unit area ($cm^3/s/cm^2$)