

Variance Request

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Consulting Engineers

Mr. Randall Hicks, PG
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Albuquerque, New Mexico 87104

March 31, 2015

RE: Technical Memorandum
LLDPE as Alternative Primary Liner System
Devon Energy / Hackberry Modular Impoundment

Dear Mr. Hicks:

At your request, I have investigated the suitability of application for two 30 mil LLDPE non-reinforced geomembranes as an alternative Primary liner in the Devon Energy /Hackberry Modular Impoundment. I have reviewed your C-147 Supplemental Information Report, Modular Tank Drawing, Design and Construction Plan as well as applicable correspondence. In consideration of the Primary lining system application (modular impoundment), size of the impoundment and depth, design details for modular tanks as well as estimated length of up to two years of service time, it is my professional opinion that two 30 mil LLDPE geomembranes will provide the requisite barrier against processed water loss. The two 30 mil LLDPE liners will function equal to or better than 60 mil HDPE, 30 mil PVC or 45 mil LLDPE as a primary liner system. The following are discussion points that will exhibit the attributes for using two 30 mil LLDPE geomembranes as the primary lining system:

The nature and formulation of LLDPE resin is very similar to HDPE. The major difference is that LLDPE is lower density, lower crystallinity (more flexible and less chemical resistant). However LLDPE will resist aging and degradation and remain intact for many years in exposed conditions. Although the lifetime of LLDPE in covered conditions (i.e., secondary liner) will be somewhat reduced with respect to HDPE, a secondary liner of LLDPE will outlast an exposed HDPE liner. In fact, according to the Geosynthetic Research Institute (GRI) study on lifetime prediction (GRI Paper No. 6), the half life of HDPE (GRI GM 13) exposed is > 36 years and the half-life of LLDPE (GRI GM 17) exposed is approximately 36 years (the Devon Energy Modular Impoundment life span is expected to be only 2 years maximum). It is understood that in order to ensure compliance of materials, 60 mil HDPE must meet or exceed GRI GM 13. Likewise, the primary or secondary liner must meet or exceed GRI GM 17 for non-reinforced LLDPE. Adhering to the minimum requirements of the GRI Specifications, two 30 mil LLDPE geomembranes when used as a primary liner system in the Devon Modular Impoundment will be equally as protective as a 60 mil HDPE liner.

Flexibility Requirements. 30 mil LLDPE geomembranes are less stiff and far more flexible than HDPE or 45 mil reinforced LLDPE and in this regard are preferred for installations in vertical wall tanks such as the Devon Modular Impoundment. LLDPE

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provides a very flexible sheet that enables it to be fabricated into large panels, folded for shipping and installed on vertical walls transitioned to flat bottom. LLDPE will conform to the tank dimensions under hydrostatic loading.

Thermal Fusion Seaming Requirements. Thermal seaming and QC seam test requirements for geomembranes are product specific and usually prescribed by the sheet manufacturer. Both dual wedge and single wedge thermal fusion welding is commonly used on LLDPE and QC testing by air channel (ASTM D 5820) or High Pressure Air Lance (ASTM D 4437) is fully acceptable and recognized as industry standards. In this regard, there should be no exception or recommended practice for seaming and QC testing in the OCD rules. This would be fully covered in comprehensive specifications for both the Primary and Secondary geomembranes that would be reviewed by OCD.

Potential for Leakage through the Primary Liners. Leakage through geomembrane liners is directly a function of the height of liquid head above any hole or imperfection. The drainage media provides immediate drainage to a low point or outside the Modular Impoundment and thus no hydrostatic head or driving gradient is available to push leakage water through a hole. In this regard, secondary geomembrane materials can be (and usually are) much less robust in both thickness and polymer type.

Leakage through any Primary geomembrane is driven by size of hole and depth and will be detected by the increase of waste water in the drainage system and the volume being pumped out of the secondary containment. In this regard and for this variance, the Primary consists of 2 layers of 30 mil LLDPE geomembrane which will out perform a single layer of HDPE or LLDPE for potential leakage. Thus, if a leak occurs through the top layer, it will be effectively contained by the second layer. If required, location of holes in the Primary can be found by Electrical Leak Location Survey (ELLS) using a towed electrode (ASTM D 7007). Holes found can then be repaired and thus water seepage into the Secondary will be kept to a minimum. Dependent on OCR requirements for Action Leakage Rate (ALR), the leakage volumes may only be monitored. For example, a typical ALR is < 20 gpad whereas a rapid and large leak (RLL) may be > 100 gpad. Most states specify maximum ALR values for waste water impoundments usually in the range of 100 to 500 gpad. However, New Mexico does not specify any ALR for waste water impoundments (GRI Paper No. 15).

HDPE can not be prefabricated into large panels and thus 30 mil LLDPE offers the following for Primary Liner Modular Containment:

- Prefabrication in factory controlled conditions into very large panels (up to 35,000 sf) results in ease of installation, less or no thermal fusion field seams and less on site QC and CQA.
- Large prefabricated panels of 30 mil LLDPE will provide better control of thermal fusion welding in a factory environment that will improve the liner system integrity for the long term.

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- The LLDPE geomembrane provides superior flexibility, lay flat characteristics and conformability which allows for more intimate contact with the underlying drainage media and tank walls.
- Two layers of the 30 mil LLDPE provide redundancy. Additionally, the bottom layer provides protection for the top layer during installation as well reduction in leakage due to pinholes (no driving head on the second 30 mil liner)
- Ease of installation of large prefabricated custom size panels results in a greater reduction of installation time and associated installation and QC costs.
- The LLDPE geomembrane is easily repaired using the same thermal fusion bonding method without the need for special surface grinding/preparation for extrusion welding used in repair of HDPE geomembranes.

In summary, it is my professional opinion that the double 30 mil LLDPE geomembranes will provide a Primary liner system that is equal to or better than a single 60 mil HDPE, 30 mil PVC or 45 mil reinforced LLDPE liner and will provide the requisite protection of fresh water, public health and the environment for many years and especially for the estimated two year life of the Devon Energy / Hackberry Modular Impoundment.

If you have any questions on the above technical memorandum or require further information, give me a call at 303-679-0285 or email geosynthetics@msn.com

Sincerely Yours,

RK Frobel

Ronald K. Frobel, MSCE, PE

References:

C-147 Supplemental Information
Devon Energy Modular Impoundment
Prepared by Hicks Consultants and Rockwater Energy Solutions

Title 19, Chapter 15, Part 34 NMAC (2015 Revision)

Geosynthetic Research Institute (GRI) Published Standards and Papers 2013

ASTM Standards 2013

Attachments:

R. K. Frobel C. V.