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A COMPREHENSIVE GENERIC CQA PLAN FOR HDPE GEOMEMBRANES

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ABSTRACT

A generic construction quality assurance (CQA) plan for HDPE liners (for landfills, wastewater treatment plants, canals, etc.) has been prepared that, unlike those typically prepared by geotechnical and civil engineers, incorporates decades of materials science, polymer engineering, geomembrane field CQA, HDPE liner and pipe failure analysis, and liner leak location survey experience. Analysis of field performance problems clearly identifies installation practices that need careful attention. The contents of this CQA plan are outlined together with those items that need adding to make the plan project specific.

1 INTRODUCTION

The inevitable initial materials-based performance problems of HDPE geomembranes became apparent in the mid-1980s [(1)] and have now essentially been resolved. The growing problem is a lack of geomembrane performance characteristics knowledge by the third generation of designer, installer, and CQA personnel relatively new to the geosynthetics field. It has been proven that the performance of knowledgeable on-site quality assurance during the installation of a geomembrane liner can result in the earlier availability of the facility and in a geomembrane with fewer leak defects [(2)]. This implies the existence of a comprehensive CQA Plan. Unfortunately, most of those writing CQA Plans do not have polymer materials engineering/science backgrounds nor do they understand the causes of failures, thus they cannot incorporate in a CQA Plan many of the requirements necessary to assure the long term performance of a geomembrane liner.

The conventional CQA Plan describes the methodologies used for the installation and testing of the geomembrane and the actions required in the event of nonconformance. However, an effective CQA Plan should also be carefully integrated with the project specifications and the QC programs of the geomembrane manufacturer and installer. But, it should be noted that the CQA Plan is only part of a total Quality Assurance program (including CQA) that should start at the design stage and continue until after the protective soil layer or first layer of waste has been placed.

A more philosophically-advanced, performance-based, CQA Plan would describe the installed characteristics of the geomembrane and its seams but would not describe how such characteristics are obtained. It would likely require that such geomembranes be electrically surveyed for the locations of leaks after the protective soil layer has been placed. However, our industry is not yet ready for this approach.

This paper describes the components of a practical comprehensive generic CQA Plan that has been developed for HDPE geomembranes, the reasons for the inclusions of specific items, and considerations to be given for those few items to be added for each specific project. This plan provides guidance on the specifications, installation, procedures, test methods, and nonconformance activities that contribute to the cost-effective installation of a durable HDPE geomembrane lining system. This Plan incorporates 20 years of plastics research and development experience, more than 15 years of geomembrane research, on-site CQA, seam testing, and failure analysis expertise, and 11 years of electrical leak location surveys.

2 BACKGROUND

The typical geomembrane-lined facility is designed by a geotechnical or civil engineer with very little formal knowledge of the performance of polymeric materials. Quite often they have little experience with geomembrane lining systems. The design engineer also prepares the CQA Plan which often only is presented to CQA firms with a request for proposal to perform CQA about 3 weeks before liner installation commences. Thus the acknowledged experts in CQA, those who perform on-site CQA, have very little opportunity to contribute to the basic quality of the lining system and the appropriateness of the CQA Plan. And the general expectation of regulators and some owners is that if CQA is performed this will guarantee the quality of the lining system whether or not it is badly designed. This is a misconception. The intent of CQA is to ensure that what was designed is built. Thus, if the design is bad, CQA assures that a bad design is installed. Under such a circumstance the CQA firm may be wise to refuse to work on such a project. Under normal circumstances, a responsible CQA firm will proactively contribute to improving the quality of the lining system, but within the constraints of the design, the budget, and the schedule.

Because of a lack of polymer knowledge CQA Plans do not generally mobilize the full resources of qualified and experienced CQA personnel, nor do they usually integrate the Project Specifications and drawings with the QC program of the installer. Often, conflicting overlaps occur or, even worse, there are gaps where no guidance is given in critical areas. For instance, while specifications are usually given for individual seam peel and shear tests, quite often no guidance is given on how many of the five peel and five shear specimens must meet specifications for the seam sample to be accepted.

Few of those preparing CQA plans have been involved with the investigation of liner failures and thus are not intimately aware of those factors that need most careful monitoring during liner installation. And if the CQA personnel are not experienced, there may be a tendency to be overcontrolling, thereby frustrating the installer, resulting in an installation of lesser quality than if the installer was left to its own devices.

The CQA Plan has been developed on the assumption that the Project Specifications do not adequately cover the specification, installation, testing, and completion of a lining system that will provide the required service. Consequently, to assure that an adequate lining system is installed, it is also assumed that the CQA Program will be implemented prior to the selection of a geomembrane manufacturer, a geomembrane installer, a CQA contractor, and an independent testing laboratory, since all of these parties must be suitably experienced and knowledgeable for the resultant lining system to be successful.

Thus, in several respects, this Plan initially assumes some of the responsibilities of the liner design engineer. However, it must be recognized that the design engineer is ultimately the party responsible for the successful performance of the lining system, and it will be the designer's responsibility to adopt the appropriate items from this CQA Plan and to incorporate them into the Project Specifications so that the next generation of CQA Plans can simply be a description of actions that will be taken, the results that are expected, and the actions in the event of noncompliance. Therefore, this detailed CQA Plan should be considered a transitionary document to facilitate the development of the industry.

3 THE CQA PLAN

The CQA Plan is written to suit any HDPE geomembrane installation since, in many applications geomembrane deployment, seaming, seam testing, and nondestructive testing methods are common to most installations. Where project specific information is required, guidance is given on the information that should be provided. The major sections of the CQA Plan are as follows:

3.1 Introduction

This section identifies the project, the basic regulatory documents on which the lining system is based, and the specific project documents (Project Specifications, drawings, manufacturer and installer QC Programs) used in the project. The CQA Plan should integrate all these documents to minimize overlaps and to eliminate gaps.

3.2 Definitions

Quality Control (QC) and Construction Quality Assurance (CQA) are defined and are simply explained in relation to the Construction Project. QC is work performed by one party on its own work. QA is work performed by a third party on work performed by others. Thus, an installer, who will be doing his own QC work to satisfy himself and his client, the General Contractor, cannot be assigned the responsibility of doing "CQA" for the owner or designer, since there is a direct conflict between the two functions.

3.3 Parties to CQA

In this section the individual parties to the project are defined and their official representatives are named. The parties are typically; the Owner, the Operator (usually the Owner), the Project Manager, the Project Engineer (Designer), the General Contractor, the Earthwork Contractor (usually also the General Contractor), the geomembrane Resin Supplier, the geomembrane Manufacturer, the Transporter, the site Land Surveyor, the Installer, the CQA Consultant, and the Independent Testing Laboratory.

The qualifications and experience of the Manufacturer, Installer, CQA Firm, and Independent Laboratory, are then defined. Clearly, these criteria will, to a large extent, be dependent on the resources that are locally available. However, equally clearly, the less experienced are the local resources the more important is the CQA function. It is essential that not only should the experience of the various companies be defined, so should the experience of the individuals assigned to the specific project.

Next, the duties of the CQA personnel (Project Manager, Site Superintendent, and Monitors) are described, so that all parties working in the field will know what is expected of them. It is, of course, required that no field work be performed on the liner unless a CQA representative is on site. And, ideally, there will be a CQA representative monitoring each major installation and testing function.

3.4 Communications

An organization chart is presented that shows the flow of communications. While there can be informal communications between CQA personnel and the Installer, formal communications will pass through the Project Manager. The CQA contractor will not make **unilateral** decisions, but will make reasoned presentations to the Project Manager for the latter's ultimate decision.

3.5 References

A listing is presented of all documents referred to in the CQA Plan. This will include ASTM, ISO, CEN, NSF, DIN, and other standards organizations as appropriate.

3.6 Project Control Meetings

The requirements, attendees, topics, and preparation and disposition of minutes of the required series of meetings are outlined in this section. Meetings include:

- Resolution Meeting, held well before site work commences, to discuss questions on the design, drawings, specifications, CQA Plan, installation procedures, and sampling and testing procedures, to minimize delays and conflicts during the installation work
- Preconstruction Meeting, immediately before site work commences, to fine tune the adjustments to the documents and procedures made as a result of the Resolution Meeting, to discuss specific work plans, and to perform a site walkover.
- Progress Meetings, held daily or weekly during the project to review progress and plan future work.
- Action Decision Meetings, to define problems, identify their cause, propose resolutions, and to identify an agreed course of action/implementation.

3.7 Geomembrane Manufacturing, Transportation, and Storage

This section includes a general description of the resin that shall be used to make geomembrane for the project (density, melt index, stress rupture resistance, recycled polymer limits), and that there should only be one resin type used. It requires that QC certificates for the resin and geomembrane shall be provided before any material is shipped from the manufacturing plant. This seems a logical requirement but is not often achieved.

If a plant audit and conformance testing at the plant are required their conditions are described. If plant QC testing is observed the need for conformance testing may be considerably reduced. It is far better to perform conformance testing before material reaches the site than after it reaches the site. Invariably material must go straight on the ground when it reaches the site, so there can be a tendency to use inferior material if nonconformance is found only when material reaches the site. When plant audits are performed, the proprietary nature of some processes must be respected.

This section presents a set of HDPE geomembrane specifications in the event that the Project Specifications are inadequate. Clearly the final version of the CQA Plan should integrate these specifications with the Project Specifications to eliminate all conflicts.

3.8 Conformance Testing

The requirements of plant or field conformance test sampling and testing are defined in this section. Conformance testing should not be viewed as another opportunity to repeat QC testing - the frequency of testing and the numbers of tests should be considerably reduced. The conformance tests of most significance are thickness, density, carbon content and dispersion, uniaxial break strength and elongation, and single point notched constant tensile load stress rupture break time. It is most important to describe what constitutes a failure of a conformance test and what will be the resulting actions, so that all will know and there will be no confusion and extensive deliberations that waste time during the project.

3.9 Geomembrane Installation

In this section the required earthwork surface finish and condition of the anchor trenches are described, together with the documents that must be provided and approved before any liner can be laid. The most important of these is a document that confirms that the Manufacturer and Installer have read, understood, and can and will comply with all project document requirements.

This section then covers the conditions under which the geomembrane can be deployed, how it shall be deployed, panel/roll numbering, requirements for compensation wrinkles or flatness, and what the CQA team will be monitoring. Note that when temperatures are mentioned for deployment or seaming

conditions, the only temperature of significance is the actual geomembrane temperature. The ambient temperature, and the temperature 50 cm or 2 in. above the geomembrane, as specified by many engineers, have no practical significance.

Unacceptable damage to, and defects in, the geomembrane are described together with actions that shall be taken if such damage/defects are observed.

3.10 Field Seaming

The panel layout (used only as a guide), seaming equipment, seam orientation, geomembrane surface preparation, weather conditions, temporary bonding, trial seaming, production seaming, nondestructive testing, and destructive testing procedures are described together with requirements and actions in the event of noncompliance.

Trial seams are required each four hours and at any time the geomembrane temperature changes by more than 25°C. Seam specifications do not need to include shear and peel strengths but must include shear elongation and peel separation [3]. The former is most important to ensure that the welding process has not reduced the ductility of the geomembrane adjacent to the seam. Not only should seam peel and shear test quantities be provided, so also should the number of allowable failures out of the 10 specimens tested for overall acceptance or rejection of the seam sample.

3.11 Defects and Repairs

The nature of flaws and the types of repairs are described. All penetrating holes, even pinholes, are required to be patched rather than extrusion beaded. Seams shall not be reseamed, to minimize overheating and casement reductions in stress cracking resistance.

3.12 Soils in Contact With Geosynthetics

This section describes covering the geomembrane to ensure that the liner is not damaged in the final stages. Electrical liner integrity surveys have shown [4] that the majority of liner damage is caused during placement of the cover layer. Nondestructive testing should include an electrical integrity survey after a minimum of 300 mm of soil/stone have been placed on the geomembrane. At this stage the liner can still easily be repaired, but the likelihood of additional damage is virtually nil.

3.13 Responsibility For The Geomembrane

This section describes the time at which the geomembrane will be handed over from the Installer to the Owner.

3.14 Documentation

The intent of documentation is to provide the records required by the permitting agency and to provide full traceability of men, machines, weather, and material, in the event that problems occur in service. Thus the full extent and location of any potential problem can be determined. A set of CQA records/logs might include:

- Manufacturer/Installer Compliance Agreement
- Daily personnel attendance list
- Material inventory
- Conformance testing
- Subgrade acceptance
- Material deployment

- Trial seaming
- Production seaming
- Repairs
- Nondestructive testing
- Destructive Testing
- Laboratory testing
- Problems and solutions
- Soil cover placement
- Daily report
- Weekly report summary

The contents of the final CQA Report are also described together with requirements for the Record Drawings. The Record Drawings shall show:

- The locations of all geomembrane seams and the types of seams
- Geomembrane panel and roll numbers, and geomembrane type
- Locations and numbers of all repairs and the types of repairs
- Toes of slopes
- Crests of slopes
- Locations of anchor trenches
- Locations and numbers of destructive sample tests sites
- Construction details that differ from as-designed details

4 SUMMARY

A generic CQA Plan developed for the installation of HDPE Geomembranes lining systems has been outlined that provides polymer based technical support for geotechnical and civil engineers designing lining systems for many different applications. In addition to the general outlines presented in this paper, the CQA Plan includes guidance for information that must be entered into the Plan to make it project specific.

5 REFERENCES

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