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BENEFITS OF INDEPENDENT CONSTRUCTION QUALITY CONTROL (CQC) IN GEOMEMBRANE INSTALLATIONS

Historically, geomembrane installations are designed as containment systems that must conform to strict environmental guidelines as set out by the EPA and local government bodies. Similarly, they must follow a design philosophy that meets and exceeds the requirements of the principal to ensure serviceability into the future. Whether counteracting the devastating effects of environmental contamination or ensuring that water supply is facilitated without significant loss, the growing need for geomembrane installations in countless applications is clear. With an ever increasing need for resources, appropriately designed and installed containment systems for various purposes are required to be compliant with design parameters and meet service demand. However, the requirements of geomembrane installations are becoming increasingly stringent due to the extreme costs associated with systemic failure. Therefore, the primary objective for the designer is to achieve the best installation whilst minimising issues that may occur and hence the associated liability (Menoff et al, 1990).

With the current rapid rate of technological advances in the geomembrane industry, there is no simple solution for designing an installation given the multitude of new products, methods of testing, installation requirements and material suitability. Expert understanding of the industry and recent technological developments is paramount to ensure that installations are completed utilising the latest innovations whilst remaining relevant for their intended purpose. Independent Construction Quality Control (CQC) is the assessment of a contractor's performance by the facility owner/operator's third party specialist representative (Menoff et al, 1990). It is recommended that this specialist be an experienced and responsible party that is fully informed about installation procedures, and is involved in decisions associated with detailed design (Thiel, 2013). The CQC representative must address all aspects from manufacturing through to installation (Menoff et al, 1990).

CQC involves a structure of activities that gives the principal and relevant government bodies assurance of all construction being completed as specified by the design. This involves audits, evaluations, inspections and verification of the completed workmanship and specific materials that are required to ascertain and document the quality (Koerner et al 1993). A properly executed CQC program can identify deficiencies that may occur in the CQA process (Koerner et al, 1993).

Geotest is currently the largest CQC Company operating in Australasia, specialising in providing assurance for all purpose geomembrane installations. It is noted that CQC is widely recognised as an essential factor in complete quality management (Koerner et al, 1993). With the large amount of technologies, installation methods and testing regimes currently available, Geotest is in a unique position where it is familiar with all facets of the geomembrane industry.

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By employing Geotest alongside a contracting company, the Construction Quality Assurance procedures completed by the installer are monitored. Although CQA and independent CQC are separate undertakings, they are inherently similar in nature and in an efficient construction project will complement one another (Koerner et al, 1993).

Geotest has provided independent services on all types of installations completed by every major lining company in Australia. However, Geotest is not affiliated with lining or geomembrane manufacturing companies meaning that its services are fully independent. In addition, Geotest has been the Australasian pioneer in reviewing new technology and products in the geomembrane industry. As a result, there is no other company with the amount of experience and knowledge comparatively in the nation. Geotest specialises in niche testing regimes and has proven results time and time again.

By employing personnel with extensive experience in the geomembrane industry, Geotest can give full confidence that a project is completed without delays or doubt in the installation quality. Given that geomembrane is notoriously difficult to install with huge variability in materials and required techniques, the devastating consequences of a failure are minimised and confidence is upheld for a project. There is much variability in geosynthetic properties due to manufacturing processes or as a result of damage incurred in the installation processes (Touze-Foltz et al, 2008). CQC confirms that the installation was completed according to the design philosophy and relevant technical specification (Menoff et al, 1990).

Current standard specification values, such as those presented in GRI-GM13 tend to suggest minimum property values for geomembrane materials that are at the low end of what is achievable when compared to manufacturer's current published values (Erickson et al, 2008). This demonstrates that expert knowledge is required to determine the appropriate minimum technical values for each individual project as these standards are becoming superseded with performance requirements increasing.

Although the implementation of CQC may increase the budget for a projects completion, it is low when compared to the possible cost of corrective actions, subsequent remediation and potential environmental contamination as a result of a defective installation (Menoff et al, 1990). A defective installation may result in premature closure of the facility, create operational problems and present asset value loss (Menoff et al, 1990). CQC provides certification of the installation by provision of technical and legal documentation and gives confidence that it has been completed with the largest degree of integrity to minimise the aforementioned problems (Menoff et al, 1990). CQC puts pressure on the geomembrane contractor to complete the required work within specification, giving confidence that the installation has been completed correctly and as per the design philosophy (Darilek et al. 2001).

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REQUIREMENTS OF AN EXPERIENCED CONSTRUCTION QUALITY CONTROL (CQC) PROVIDER

Simply providing a specification and design philosophy to a contracting company is no longer enough to guarantee the correct installation of a geomembrane containment system.
Given the high stakes nature of systemic failure in an installation, confidence that the construction has been completed correctly is a mandatory requirement to satisfy concerns from stakeholders such as environmental agencies and principals. Third party CQC allows mitigation of risk from the principal to reduce ultimate liability. Third party CQC monitors an installer to evaluate whether there has been compliance with the design philosophy of the project (Touze-Foltz, 2008).
An experienced third party CQC provider will provide a full package of CQC services, using rigorous processes to ensure that installations are completed in accordance with strict environmental guidelines and site specific technical specifications.

The following processes are needed from a CQC provider to ensure installation quality:

- Demonstration of a complete understanding of factory fabrication processes, onsite installation issues, welding techniques and mandatory certifications required by personnel.
- Performing a full review of contractor work method statements (WMS) and Inspection and Test Plans (ITPs) to ensure that the intended procedures adhere to standards set in the technical specification and industry standards including GRI-GM 13, 19 and IAGI.
- Completion of a full analysis of all materials proposed to be used by the contractor, selecting samples for independent testing, reviewing manufacturer's information and warranty, keeping records of when and where each is used with full traceability, conducting inspections to assess handling, storage and damage of materials, useability requirements and quarantining of materials not conforming to specification.
- Attending scheduled meetings outlining progress, planned activities, issues requiring resolution, revision to proposed works. Provide full expert technical support on installation issues, RFI's, TQ's and NCR's that may be encountered during the installation process. This ensures immediate resolution with problems and that the project is completed without delay.
- Maintain a real time digital database of all field information that is updated as installation occurs. This includes trial welds from field seaming and their conformance to GRI-GM 19 and ASTM D6392, progress tracking of installation and comparison to planned completion time, destructive test selection, defect identification and logging of all repairs.
- Providing an extensive photo history that gives assurance to the principal that the specification and design philosophy has been followed for the project.
- Be experienced in completing inspections of subgrade, GCL lining systems, geomembrane and geotextile. This gives confidence to all parties that hold points throughout the project have been complied to and that the installation has been correctly implemented.
- Maintain a presence and monitoring in the field at all times, minimising installation issues that occur, completing inspections of finished areas for defects and providing a final sign off of lot areas. Review documentation of all installed materials and contractor QA submittals. Report damage and

deviations from methods statements or technical specification including non-conformances. Monitor progress against schedules and report performances against targets. Provide daily reports of all works conducted.

- Provide independent destructive test selection and location recording for every 150 metres of welded field seam ensuring that a representative sample is taken of installation quality.
- Provision of a final executive summary of the project on completion. This outlines the conformance to the Construction Quality Assurance Plan, the approved manufacturer MQA, deployment completion, conformance to relevant ASTM or GRI standards and other issues encountered during the project.

IMPLEMENTATION OF CQA BY THE CONTRACTOR ON A PROJECT ALONG WITH ELECTRICAL LEAK INTEGRITY SURVEYING

The following statistics were collected during a ten year period and extracted from a previous publication: Lessons Learned from 10 years of Leak Surveys on Geomembranes (Forget B. 2005a, Forget B. et al. 2005b). The study of 89 projects covering 2,652,000 m^2 in 8 different countries highlights the importance of installation contractors employing a rigorous CQA program during geomembrane installation. Analysis of the data illustrates there to be fewer voids detected in each project with a CQA system implemented and leak detection survey in comparison to the absence of both.

The CQA system allows a preventive control of leaks and reduces incidences of damage and non-conformance by the contractor when completed correctly. Therefore, competent Quality Assurance when combined with leak detection ensures the integrity of a project.

Table 1 - Results from Study (Forget et al. 2005)

Activity	Exposed HDPE **Geomembranes (Water Puddle)**		**Covered HDPE Geomembranes (Dipole)**	
	With CQA	Without CQA	With CQA and geoelectrical leak survey (water puddle) before covering	Without CQA nor geoelectrical leak survey (water puddle) before covering
Geomembrane Thickness	**Number of leaks per hectare (prospected area m^2) –quantity of site prospected**			
2.0 mm	**3.2** (362 460) – 32	No data	**0.2** (170 190) - 16	**15.6** (50 600) - 3
1.5 mm	**5.1** (66 880) - 4	No data	No data	**24.7** (10 500) - 3
1.0 mm	**20.5** (17 070) - 2	**31.5** (313 770) - 6	No data	No data

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GEOTEST RESULTS CQC IN ADDITION TO CQA

The table following below is generated from a selection of installations Geotest has electrical leak tested that have been completed with third party CQC. These statistics demonstrate that third party CQC significantly reduces the amount of voids found post installation with electrical leak integrity surveys by up to 14 times in comparison to without CQC. This further reinforces that independent third party CQC completed by Geotest gives the utmost confidence about the quality and compliance of an installation and increases the standard of work completed by a contractor/installer.

Table 2 – Geotest statistics for tested installations with and without CQC.

	No. of installations	**Voids**	**Area (m^2)**	**Voids per Hectare**
Contractor **Without** CQA	12	403	536,600	7.51
Contractor **With** CQC	13	57	1,040,000	**0.55**

TESTING CAPABILITIES

Geotest are the leaders in Electrical Leak Location Surveying of installations in Australasia. Testing methods that Geotest can supply are dependent on project specific circumstances, however can be combined or adapted to suit needs.
Current testing methods that Geotest are able to provide are compliant with the following ASTM standards for the testing of Geomembranes.

- Dipole Method - Soil Covered Geomembranes ASTM D7007
- Dipole Method – Water Covered Geomembrane ASTM D7007
- Water Puddle Method ASTM D7002
- Water Lance Method ASTM D7703
- Conductive-Backed Geomembrane Spark Testing Method ASTM D7240
- Arc Testing Method ASTM D7953

Geotest also specialise in assisting with specification, location and orientation of design elements required for testing, required electrical isolation, Optimum Moisture Content (OMC) for subgrade and GCL, site specific testing requirements and the provision of material for testing such as conductive liner.

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SUMMARY

Liner installations have many components required to be successful, and without any of these there is a risk of failure and/or compromise of the service life. These include;

- **Good design and specification.**
- **Correct selection of materials both in resistance and performance.**
- **Choice of competent installation company with appropriate CQA measures.**
- **Use of an experienced CQC provider to monitor and prevent problems in the installation, ultimately managing the overall risk.**
- **Completion of Electrical Leak Detection over the entire installation to ensure integrity.**
- **Ongoing monitoring and maintenance of the installation**

Only with this combination of processes can there be the optimum outcome for the installation, with confidence that it has been completed to specification and in line with the intended design philosophy.

Geotest's services are extremely cost effective and flexible in meeting our client's needs on a job specific basis. We have extensive experience in providing CQC solutions that ensure the project is completed within specification and environmental requirements.
Geotest has a proven track record with an increase in installation quality on all projects involved in, providing a full package of CQC services to give confidence in works completed by the contractor. Geotest is engaged by large institutions and companies as they recognise geomembrane installations are a specialist area that requires expert, up to date knowledge to address concerns. Geotest has the familiarity and experience to effectively identify problems in polymers and installations to ultimately reduce the risk profile to the client.

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REFERENCES

Darilek, G.T. & Laine, D.L., 2001. Costs and benefits of geomembrane liner installation CQA. Geosynthetics 2001 Conference Proceedings.

Erickson, R., Thiel, R., and Peters, J., March 2008. The Ongoing Quality Issues Regarding Polyethylene Geomembrane Material Manufacturing & Installation, IFAI, GeoAmericas conference, Cancun, Mexico.

Forget, B., Rollin, A.L. & Jacquelin, T., 2005. Lessons learned from 10 years of leak detection surveys on geomembranes. Proceedings of the 10th International Waste Management and Landfill Symposium, 3-7 October 2005, S. Margherita di Pula, Cagliari, Sardinia, Italy.

Koerner, R. M. & Daniel, D.E., 1993. Manufacturing and construction quality control and quality assurance of geosynthetics. Proceedings GRI-6, MQC/MQA and CQC/CQA of Geosynthetics, 1-14.

Steven D. Menoff, Anthony W. Eith, 1990, Quality assurance as a means to minimize long-term liability, Geotextiles and Geomembranes, Volume 9, Issues 4–6, Pages 461-465, ISSN 0266-1144, http://dx.doi.org/10.1016/0266-1144(90)90037-D. (http://www.sciencedirect.com/science/article/pii/026611449090037D)

Thiel, R., April 2013. A 25-Year Perspective on Waste Containment Liner and Cover System Designs with Geosynthetics, Proceedings of the 25th Annual GRI Conference, Geosynthetics 2013 Conference, in coordination with IFA, Long Beach, CA.

Touze-Foltz, N., Lupo, J. and Barroso, M., 2008. Geoenvironmental applications of geosynthetics. Keynote lecture, EuroGeo4, 98p.