World's Largest Lagoon Liner

1,400,000 sq. metres

350 acres - Installed in 7 months!

World's Largest Lagoon Liner

Considered to be the World's largest lagoon lining, more than 1.4 million square metres (350 acres) of continuous polypropylene geomembrane lining was recently installed on a project in Kazakhstan.

A giant lagoon facility in Kazakhstan, of some 1,400,000 square metres (350 acres), designed to contain process liquid waste for an oil company, was lined in 7 months site work. This remarkable fast track programme was achieved by British company, Geosynthetic Technology Ltd, (GT) which was appointed to manage all aspects of the lining project.


(Fig 1)

GT, based in Colchester England, has more than 40 years experience of Geomembrane Engineering and specialises in high quality lining project management on an international basis. In preparation for the fast track plan, considerable time was spent by GT on project planning particularly in:

- The evaluation and testing of various geomembrane lining materials
- reviewing manufacturing resources
- international transport logistics
- training and certifying unskilled labour
- geomembrane installation planning
- quality assurance procedures

GT Chairman, John Alexander, said that the original planning by the oil company client foresaw the lining being installed in phases over a three-year period. The harsh winters from November to March meant that lining installation work was only possible from April to October. Based upon the clients past experience of lining works by other companies working on the same site, this indicated a three year installation programme for the 1.4million square metre (350 acre) project.


(Fig 2)

GT commenced the installation in August 2010 (Fig 2) with the objective of testing their rapid installation plan over about 10% of the total lagoon design area. GT literally 'hit the ground running'. Everything worked perfectly and, despite very hot weather, (up to 38°C) the trial area was completed ahead of schedule. The client noted the rapid progress and authorised the whole of the remaining area to be installed on the same fast track basis from April to October during 2011. In fact, despite severe dust storms and occasional flooding, the work was completed by the end of August 2011. Every seam was tested and all quality procedures completed. GT Chairman, John Alexander said, "I have been working in Geomembrane Engineering for nearly 40 years and have never seen a geomembrane installation more professionally performed. The pace was breathtaking!".

Geomembrane Material Evaluation

The key design requirements, which had to be considered in the selection of a suitable geomembrane material, are set out in the table (Fig 3). In the final review, two materials were considered and compared in detail; High Density Polyethylene (HDPE) and Polypropylene (PP-Ex). Although HDPE has been widely used for geomembrane lining for many years, it is known to have serious limitations, particularly in relation to its very slow seam welding speed as well as its stiffness and poor thermal properties - all of which could be exacerbated by the design requirements.

Comparative Review – HDPE v PP-Ex *(Fig 3)*

Fast welding speed was crucial with 240km (160 miles) of liner seams to be undertaken. PP-Ex can be seam welded up to 5 times faster than HDPE.

Geomembrane must remain thermally stable and weldable across an ambient temperature range of 0°C + 40°C (black sheet temperature up to 70°C) HDPE thermal expansion is 2 times PP-Ex which combined with its stiffness, can lead to the HDPE sheet buckling and induce severe stress on seams following cooling and contraction from day to night. HDPE installation often necessitates night working in hot climates. PP-Ex remains flat and weldable at high ambient temperature. (Fig 4)

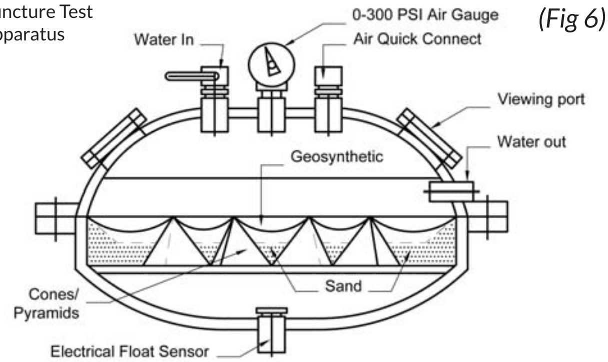
Liner flexibility was considered essential for safe deployment in windy conditions on the exposed site. Flexible PP-Ex flops over whereas HDPE stiffness acts like a sail and sometimes cannot be restrained by any number of men! (Fig 5)

Extreme low winter temperature performance down to -50°C was important. HDPE seams can be susceptible to brittleness and cracking failure at - 40°C. PP-Ex remains flexible.

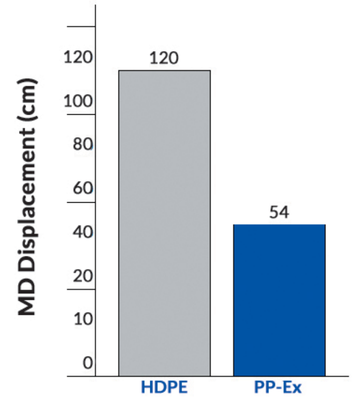
Liner resistance to incoming effluent at 85°C was examined. PP-Ex has much higher temperature resistance than HDPE, which softens and expands causing stress around effluent pipe liner fixings.

Liner to have outstanding puncture resistance The Test Method ASTM D5514 (Fig 6) which simulates field service by pressurising the liner over steel cones, revealed that PP-Ex has 4 times the puncture resistance of HDPE, enabling thinner (lower cost) PP-Ex sheet to be used. (Fig 7)

Puncture Test Apparatus *(Fig 6)*

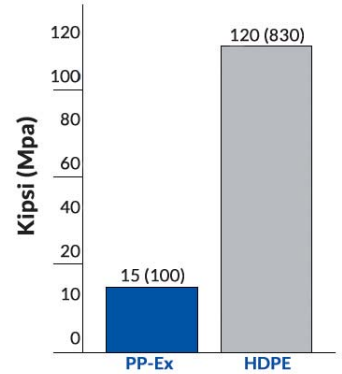


Geomembrane Displacement Due To A Typical Temperature Change. *(Fig 4)*

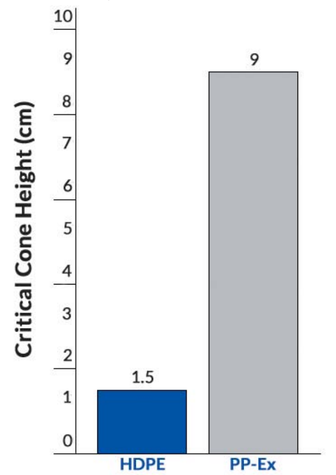


MD displacement per 100m length of geomembrane when exposed to a 50°C temperature change (20°C - 70°C)

Relative Stiffness of PP-Ex and HDPE *(Fig 5)*



Large Scale Point Stress (Truncated Cone) *(Fig 7)*



Cost Benefit

The Geomembrane Material Evaluation clearly indicated that key factors such as maintaining programme in hot weather conditions and / or moderate winds, distinctly favoured PP-Ex over HDPE. Moreover, using PP-Ex would eliminate the need for night working throughout summer months. On a 1,400,000 square metre (350 acre) project employing several people in a 'fast track' liner installation, these factors had major cost implications. In addition, whilst on a same gauge thickness basis, PP-Ex sheet material costs more than HDPE, the much higher puncture resistance of PP-Ex enabled PP-Ex 1.00mm (40mil) gauge (for the lagoon bases) and PP-Ex 1.5mm gauge (60mil) (for the lagoon embankments) to be proposed.

HDPE would need to be at least 2mm (80mil) gauge to be equivalent on this basis and, as such, the basic material - cost advantage of HDPE over PP-Ex is insignificant in the final cost calculations. Overall, taking into account other beneficial factors including much faster welding speeds; installation programme reliability; and fewer quality and rectification problems the total cost benefit of using PP-Ex on the project as opposed to HDPE was calculated to be considerable. This, together with the clear technical limitations of HDPE, led to HDPE being expressly banned from use on the project by the client's Engineers.

Manufacturing Quality Assurance

A "right first time" failsafe approach was taken by Geosynthetic Technology Limited (GT) to manufacturing quality. The distance of more than 2000 miles from the liner manufacturing plant to the job site, and the tight installation programme, could not tolerate manufacturing faults on delivered materials.

Raw material tests certificates were provided and checked for each batch of polymer used and rolls of sheet manufactured from each polymer batch were allocated a unique reference number. Every roll was tested at the production plant for compliance with particular contract specification basic physical properties.

A sample of each thickness from every batch was selected at random by GT and submitted to an Independent Laboratory for repeat conformance testing of basic physical properties. GT also arranged for various Reference Tests, such as surface friction, multi-axial elongation, and coefficient of thermal expansion to be conducted in an Independent Laboratory in the USA, using specially developed apparatus. The results of all testing were incorporated into a Quality Assurance Report for the client to archive. (Fig 8)

(Fig 8)

Freight

The two most important factors considered for container freight were size of the rolls, to enable best use of container volume and the method of loading/unloading without damage occurring.

It was determined that rolls of 1.00mm (40mil) gauge in a sheet size of 5.8m (19ft) x 200m (656ft), and rolls of 1.5m (60mil) in a sheet size of 5.8m (19ft) x 135m (443ft) would enable 16 rolls to be packed per container in each case, a symmetrical 4 x 4 formation, without risk of crushing or becoming loose during the 2000 mile journey. (Fig 10)

A purpose made 'spike' was bolted to a forklift truck. The spike was inserted through the central core of the rolls for loading/unloading. (Fig 11). Each roll was fitted with slings to facilitate site lifting by excavators. (Fig 9)

(Fig 9)

(Fig 10)

(Fig 11)

Geomembrane Installation

Prior to start up, an inventory of specialist equipment, welding machines, spare parts, lifting frames and quality control equipment was assembled by GT and shipped out to the job site. An air-conditioned site laboratory and workshop was established. GT calculated it would be necessary to operate with 3 welding crews each day on 12 hour shifts, 7 days a week, for continuous sessions of 30 days on / 30 days off per rotation crew, in order to achieve the output target.

It was foreseen by GT that it would be necessary for at least one of their skilled and experienced Senior Technicians to be on site on a rotation basis throughout the entire works. To facilitate a smooth start up and communication, two Kazakhstan personnel were selected who travelled to GT's Head Office near Colchester in England, where they underwent intensive training including much site work in all weathers for some three months. Training included learning job-specific English words: weld; deploy; quality control etc. At the completion of training, they were issued with Certificates of Competence in Welding signed by GT's Chairman, John Alexander, a professionally qualified Chartered Engineer.

The availability of the trained Kazakhstan personnel (Fig 12) under the management and organisation of the GT Technician enabled GT to make an efficient start and within days of commencement, output of 20,000m^2 (215280 ft^2) per day was being consistently achieved when weather conditions permitted (Fig 13).


(Fig 12)


(Fig 13)

Over the 7 month installation period, the work crews (Fig 14) experienced two flash floods, numerous dust storms (Fig 15), frosty mornings and high temparatures exceeding 40°C. On many days no installation was possible, which made it even more imperative to achieve high output during good weather to accomplish the overall programme.


(Fig 14)


(Fig 15)

Installation Quality Control

Every seam was tested qualitatively by an air pressure method. Each seam weld actually comprised two parallel welds with a gap between them. The end of the seam run, (up to 200m in length), is clamped, and air is pumped in to the weld gap to inflate it to a predetermined pressure, which is read from a gauge. If this pressure is maintained for a specified time, the seam is verified as airtight. In the event of a drop in pressure, the leaking air is easily located by sound, and the leak can be patched by welding. (Fig 16)

At the start of each shift or change of welding machine setting, a sample seam tab is submitted to the site laboratory for destructive testing. It is pulled to destruction on a Tensiometer and the values for strength and elongation at break are noted. The mode of failure of the seam is also examined. Detailed records are maintained and the location of all rolls and seams are noted on an As Built drawing. The site based quality control function was performed by an English-speaking person to ensure nothing became "lost in translation"! (Fig 17)


(Fig 16)

(Fig 17)

Overview

"This Geomembrane Lining Project was groundbreaking in many respects" says John Alexander, GT's Chairman, seen shaking hands with the President of the Kazakhstan Main Contractors (Fig 18).


(Fig 18)

"Its shear scale of 1,400,000 square metres (350 acres) is awesome and is, by any standards, the largest lagoon lining ever undertaken anywhere in the world. The speed of liner installation together with the high quality standards maintained throughout the work has set new standards in geomembrane engineering".

This project clearly demonstrated the value of employing the Project Management Services of a company highly experienced in Geomembrane Engineering but independent of liner manufacturer's influence. "Liner material manufacturers promote their particular liner material on a, 'one size fits all basis' with strong influence on lowest price per square metre" says John Alexander. "They are generally not qualified (or concerned) to consider the much more important cost benefit factors or to involve themselves fully in the client's design and operating requirements for the facility concerned. These are the key benefits that GT brings to bear on lining projects and which make our projects so successful".

Geosynthetic Technology Limited

Worldwide Geomembrane Engineering

About Geosynthetic Technology Ltd. (GT)

GT has more than 40 years experience in geomembrane engineering and provides its services internationally. It has carried out installations in more than 30 countries on 5 continents including: most of Europe; Middle East; USA; Canada; Australia; and China. Some 9 billion people saw an example of GT's work on television in 2004, being the artificial lake inside the stadium at the opening ceremony of the Athens Olympics.

GT welcomes enquiries on any aspect of geomembrane engineering where the opportunity to participate in projects involving linings is at any stage of development. GT's advice is provided free of charge and without obligation.

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