# Bituminous Membrane Cap of a Radioactive Waste Landfill - Quality Program

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ABSTRACT: A stringent quality control plan was established for the permanent geomembrane-based capping system to be built over the low and medium activity, short-lived (300 years) radioactive waste landfill repository at the *Manche Centre de Stockage* in France. Since minimum containment integrity was stipulated as 300 years, the quality control plan covered all stages of design, selection and manufacture of the bituminous geomembrane, transport and storage of the rolls, field fabrication, hot air welding and 100% ultrasound inspection of all seams.

## 1 PURPOSE

The use of geomembranes has been steadily growing over the last twenty years and the more critical projects now call for a quality plan covering the whole sequence from membrane system design, materials and product control, and field supervision.

An example of this new need is the bituminous membrane cap for the low and medium activity, short-lived radioactive waste landfill repository at the *Centre de la Manche* near La Hague, operated by the French national radioactive waste control authority ANDRA.

## 2 CAP DESIGN

### 2.1. Objectives

The most fundamental requirement for safe radioactive waste disposal is that human lives and the environment in general must be protected to within official limits against dangerous leakage. With this in mind, the basic design criteria for the repository were isolating the waste from the effects of weather, biological attack and uncontrolled human activity. The most important component in achieving this aim is the multilayer cap design. Containment must be ensured over the whole of the 300-year institutional control period.

### 2.2. Membrane System

The membrane system design criteria for meeting the stated safety requirements include watertightness (mean seepage rate of only a few litres per square metre per year), durability (integrity maintained for 300 years), deformability (to allow for landfill settlement), and repairability. The repository operator ANDRA and the Consulting Engineers Coyne & Bellier, responsible for project management up to the construction plan stage, decided that polymers would not meet this specification and that clay would be subject to drying problems. The selection of a bituminous membrane was influenced by French and US studies indicating a maximum 300-year biodegradability of 1.5mm per face. This remarkable finding is supported by boat and canal linings several thousand years old still found in good condition in Mesopotamia, asphalt deposits still in place in Trinidad since the Miocene, and pure bitumen seams in Utah, known commercially as gibsonite.

### 2.3. Cap Description

The complete cap membrane system consists of the following parts, seen from bottom to top:

- > Coarse aggregate base course, 0.5m to 0.7m thick, laid to the required falls (a series of flat vees), and providing a semi-pervious buffer bed between the waste canisters and the cap. Each vee slope was 50m long from top to bottom, equal to one geomembrane roll length to avoid transverse field welds.
- > Fine sand drain, 0.2m thick, providing a yielding bed against membrane puncture, and in the event of such damage, collecting any infiltrating water for measurement.
- > Bitumen impregnated geotextile-based geomembrane approximately 0.0056m thick.
- > Sand drain, 0.30m thick, between the geomembrane and the overlying biological barrier, to collect seepage penetrating this barrier.
- > Biological barrier of coarse compacted aggregate not less than 0.95m thick at top and 1.45m at bottom.
- > 0.20m topsoil, grassed to intercept and evaporate rainfall.

## 3 GEOMEMBRANE MANUFACTURING QUALITY CONTROL

Repository cap design and construction involved ANDRA imposing a quality control programme on the contractor and all his subcontractors.

The quality control plan relevant to geomembrane manufacture was as follows. All materials (needle-punched polyester, glass fibre mat, bitumen, sand and filler) were inspected and tested on delivery.

During the manufacturing process, samples from each roll were tested in the works laboratory and by an independent outside laboratory. The tests covered weight per unit area (specification 5.89 km/m² min, 6.81 kg/m² max), thickness (0.005m min, 0.0055m mean), tensile strength (20 kN/m min, 24 kN/m mean lengthwise, 17 kN/m min, 20 kN/m mean crosswise), elongation at failure (40% min), cold bending properties (2°C min) and static puncture strength (no puncture with 40kg weight on 10mm dia. die after 24 hours). Completed rolls were marked with their identification codes and stored in the works.

## 4 GEOMEMBRANE TRANSPORT QUALITY CONTROL

Tests by the French atomic energy authority CEA in Grenoble have shown the importance of membrane thickness for good strength and watertightness, and so special means were designed to prevent the rolls being left standing on a flat surface, which would have compressed the layers.

With this in view, the rolls were wound on special cylindrical overlength bobbins whose ends took the weight at all times - in the manufacturing plant, during delivery to the storage depot, and when being laid.

## 5 SITE PREPARATORY WORK: APPROVED LABOUR AND EQUIPMENT

In addition to quality control manuals, formal procedures were specified for dealing with special points such as interfaces with concrete.

A panel layout plan was also prepared at this time.

The geomembrane panels were laid so that the overlaps were made in the direction of water flow. In this way, they tend to shed water, in the manner of tiling.

Specific site equipment such as ultrasound testers and self-propelled seaming machines were subject to approval. For example, the performance of the seaming machine was compared with the work of an approved skilled seamer.

All workmen including seamers and seam testers had to be qualified and approved for the job.

## 6 SITE INSPECTION AND TESTING

EFISYS, a subsidiary of *Electricité de France*, was responsible for the site inspection and testing during construction of the cap. The first item inspected was the sand bedding for the geomembrane after it had been watered, graded and checked by the earthmoving contractor.

The geomembrane had to be laid downslope according to the layout plan. Each panel was unrolled by a crane-mounted hydraulic machine with remote forward and reverse controls. Each panel was laid parallel to the previous panel, with a 20cm overlap, and its identification number promptly noted on the record drawings.

The seams were made by a self-propelled hot air welding machine. A data logger kept a continuous record of weld air temperature, machine speed and total distance covered.

All seams were fully tested by ultrasound apparatus. Its accuracy was checked several times each day, especially after interruptions to the work, with a device consisting of bronze disks of precisely known areas within a test seam to simulate air bubbles. The same

device is also used in the seamer approval procedure.

Seams were inspected by qualified inspectors sweeping the ultrasonic head from side to side along the whole width of the seam with a 20% overlap between passes. This represents an overlap of 20cm, so that any flaw larger than 1.5cm is detected.

The seam quality criterion requires that there shall be no seepage path from the edge of a weld longer than 12cm in any direction. Detected flaws were noted on the layout drawing.

## 7 SEAM REPAIRS

Substandard seams were made good by welding a 60cm-wide strip of geomembrane material over the suspect area. The new seams were also tested in the manner specified.

Statistics have demonstrated that all repaired areas at the Manche radioactive waste repository were fault-free. In the first year's work (1992), repair strips accounted for 49 $m^2$ of material, i.e. less than 0.15% of total geomembrane area, or 1% of the total seam area.

## 8 CONCLUSION

The plan prepared by the contractor and approved by the Engineer and ANDRA made it possible to test with the greatest stringency each of the steps from design of the bituminous geomembrane containment system up to final acceptance of the job.

This quality control plan will be the best assurance of the 300-year integrity stipulated for this exceptional project, which will evidently be an example for very many important jobs of this kind in the future.

It was found that the testing of the seams promptly after they had been made had a very beneficial effect on the quality of subsequent workmanship.

## REFERENCE

Ph. Convert, J.P. Coquille, R. Herment (1993) Couverture par une géomembrane bitumineuse d'un stockage de déchets radioactifs de faible et moyenne activité à vie courte - 5th Eurobitume Congress - Stockholm 1993 p. 422-426

General view of the bituminous geomembrane capping on the radioactive waste landfill

View of the self-propelled seaming machine