

# GEOMEMBRANE WELDING PROCEDURES AND IMPERVIOUSNESS ASSESSMENT

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**Abstract:** *This paper presents the main geomembrane welding procedures used in the sealing systems. The causes leading to inefficacious welding of sheets are studied and the procedures currently used for welds are presented. The paper also includes the advantages and downsides of each procedure, by the type of geomembrane and by the technology used for these works. In addition, the article outlines the assessment methods for welds executed on sites (for quality control goals).*

**Key words:** *geomembrane, welding, sealing*

## 1. Introduction

Geomembranes were initially used for sealing channels or reservoirs with low pressures (water column of 5-10 m). Global concerns related to environment protection and to effective waste disposal facilities led to the design of high quality seals, meant to prevent soil pollution and the contamination of groundwater supply sources. Geomembranes must meet strict requirements related to the following: resistance to aggressive chemical agents, long-term life (100 years), and resistance to environmental factors. For these reasons, such products have diversified significantly and they have evolved in terms of technical characteristics.

## 2. Imperviousness of Geomembranes

Geomembranes are made of polymers which, from a structural viewpoint, may be classified into crystalline (organization

degree between 30% and 90%) or amorphous [1]. The structure of polymers comprises a set of holes that do not take the form of a network of pores specific to classic porous materials, but is represents a structural element that depends upon molecular mass, polymerization type, cooling type, and verification interval. Because of their structure, within the geomembrane there is an ongoing process of fluid penetration and circulation through the free volume, (assimilated to an osmotic type of process). Diffusion is a phenomenon that occurs within complex systems due to differences in temperature, pressure, and concentration. The permeability of geomembranes generally increases by the temperature – in case of PVC membranes, a temperature increase from 25 °C to 35 °C was proved to augment permeability by around 20%. The presence of pores and microcracks – due to fabrication flaws – entails a significant increase in the permeability of

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geomembranes. The degradation of polymers over time – as effect of ageing process influenced by the action of UV radiations, temperature variations, and biological factors – leads to a reduction of the imperviousness of these products [2], [3].

### 3. Geomembrane Welding

Sealing systems made of geomembrane sheets involves seaming them because the width of these products is relatively small (10.5 m) and their length is about 30-40 m. These limits in size are justified by transportation and application motivations. Furthermore, the surfaces to seal have various shapes; sometimes clines and corners are required upon changing direction or level. The application process includes the execution of working joints, of junctions with various constructions, and of certain welds [4]. When applying the sheets, damage may be produced due to tearing or ruptures; such damage also requires repairs involving welds.

These welds represent vulnerability points in terms of sealing, because the geomembrane roll is highly impermeable. When installed correctly, at least theoretically there should not be any points or surfaces that are not perfectly sealed [5]. All welds necessary must be executed on site where, though all measures are taken for an effective execution of works, technological dysfunctions leading to imperfect sealing works may still arise.

Such situations may be due to:

- unfavourable weather conditions (unavoidable, for that matter);
- lack of qualification or attention of the personnel executing the works;
- insufficient monitoring of the quality of works;
- flaws in the functioning of welding machines.

Moreover, it must be taken into account

that it is impossible to assess right away the imperviousness of welds. Such assessments involve the application of both destructive tests (that actually fail to provide absolute information in this sense) and non-destructive tests (hard to apply).

### 4. Geomembrane Welding Procedures

Geomembrane welding procedures depend on product nature, on technology available, and on the corresponding machinery, on the level of prescribed sealing, and on the conditions recorded on site [6]. Generally, the technological process of welds involves the use of thermal or chemical energy that reorganizes temporarily the polymeric structure of the geomembranes that come in contact with each other. After applying a previously determined pressure and after waiting for a while, the two materials join on a microstructural level, thus creating a new surface.

The result of this operation is assessed initially in terms of mechanical resistance of the weld: ideally, it should preserve the characteristics of the basic products. Technological process usually requires aid materials, represented by either polymers or other chemical substances.

The technological procedures used in factories for making rolls with standard dimensions require the use of 40 kHz ultrasounds or of alternative dielectric currents. On site, two types of procedures based on thermal processes or on chemical dissolution processes may be used.

**Extrusion fillet welding** includes the use of a polymer electrode along the edge of the overlap of two geomembrane sheets to be welded. The procedure used in Romania for welding HDPE geomembranes includes the following instructions:

- use an aid material with the same composition as the geomembrane, applied by extrusion at temperatures between 200-

280 °C, depending on membrane thickness;

- the welding is executed using a portable extruder that melts the polyethylene electrode (4-5 mm in diameter);

- membranes to be welded are previously overlapped on a 10-15 cm width;

- the welding process will be executed at temperatures above 5 °C and air humidity below 80%;

- this procedure is used for membranes with thickness of 0.75-3 mm.

The procedure is used for welding corners and for applying patches in damages areas or in areas where coupons were extracted. For the rest, this type of welding is modest in terms of efficiency.

**Extrusion flat welding** uses a band (not an electrode) inserted between the two sides of the welding. **Hot wedge welding** is also used for HDPE geomembranes. In this case, the following instructions are stated:

- hot wedge welding is done by seaming 15-20 cm of the overlapping lower and upper membranes;

- membranes are pre-heated using hot air jet; at the same time, two separate tracks of the dual hot wedge pass over the geomembranes, and then a squeeze roller system melts the layers immediately behind the wedge;

- the hot wedge is heated to a temperature of 300-400 °C, depending on geomembrane thickness and on the temperature of the environment;

- the device is portable and it comprises two separate tracks of dual hot wedge and a hot air preheating system;

- it is easy to use, because it advances automatically, by self-propulsion, once the two sheets are introduced.

This procedure is indicated for field seaming on great lengths, because of its high efficiency, (1 m /min). It does not require any aid material. An operator determines its parameters, and then he just monitors the device, without any further

interventions.

**Solvent welding** uses a solvent applied by brushing on the two surfaces, which must be pressed firmly for a few seconds. The solvent partially dissolves the geomembranes on a depth of 0.1-0.3 mm, thus forming a heavy-bodied paste that solidifies. The downside is that too much solvent may damage considerably the product (a thin film of solvent is to be used).

**Soak solvent welding** – 8-12% of the geomembrane material is dipped into the solvent.

**Adhesive solvent welding** uses an adhesive after the dissipation of solvent; hence, the adhesive is a second element of the system.

**Contact adhesive bonding.** In this case, the adhesive is applied on the two surfaces using a brush or a roller. After applying the right amount of adhesive, geomembranes are firmly pressed together. The adhesive forms an intermediate layer between the two geomembrane sheets.

For all types of welds, it is necessary to respect certain generic guidelines:

- the meteorological conditions during the execution of such procedures. In order to observe the required execution rhythm, one may use temporarily closed spaces within the working area. Special attention must be paid to heat-involving procedures and to seaming stress-relief, taking into account that a two sudden contact with low temperature may determine the weld to crack.

- the two layers to weld must be cleaned thoroughly.

- before beginning the welding per se, overlapping smoothness must be checked;

- the work speed must meet all the guidelines regarding temperature, pressure, and the amount of aid material;

- minimum overlapping width is 10 cm and it may reach 20 cm in case of geomembranes used for sealing systems in

standing water bodies (tanks, wastewater disposal facilities) and 25-30 cm for channels or surfaces with running water (in this case, the welding direction respects the downstream overlapping).

#### 4. Imperviousness Assessment

Imperviousness assessment phases include the following:

- a) trial welds;
- b) testing welded coupons;
- c) testing the entire welded system.

##### a) Trial welds

The purpose of trial welds is to determine whether, under the concrete circumstances on site, proper welds can be obtained. The factors that may influence welding quality are: the existence of skilled personnel, the technology and the machines used.

These trials are executed twice a day: in the morning, at the beginning of working hours, and in the afternoon (upon resuming work). Furthermore, these trials are to be performed when climatic conditions change suddenly or when new elements occur in terms of equipment or personnel.

Geomembranes to weld must measure at least 0.5 m in width and 1-2 m in length and they must be overlapped according to the procedure used.

As for welding procedures involves heat, trial weld can be performed within a few hours, following the normal cooling of the coupon. As for procedures using solvents, the trial must be performed after a longer interval, of a few days, depending on the technical instructions of the bonding agent.

Such a trial is destructive and it includes shear test and peel tests, using a field tensiometer.

##### b) Testing welded coupons

This involves sampling coupons from the welding performed within the sealing

process per se. In this case, sensitive points emerge on the geomembrane - covered surface, where system continuity must be subsequently restored, (in quite difficult conditions). In this situation, it is important to respect regulations regarding sampling frequency and coupon size. It is recommended to sample 6 coupons per 1 km of welded material, either evenly distributed or randomly selected, (the size of coupons ranges from 30 to 100 cm). Such tests represent destructive procedures and they are meant to assess welding resistance and tearing pattern.

##### c) Testing the entire welded system

The advantage of testing the entire system is the fact that it involves non-destructive procedures.

For double continuous welds, the test is easy: introducing compressed air in the channel between two welds, using a pressure of up to 200 kPa. Air leaks are easy to detect, as well as areas prone to tearing.

Another method uses compressed air with a pressure of 350 kPa through a connector nipple measuring 5 mm in diameter. Compressed air is applied beneath the upper welding edge, in order to detect areas that have not been seamed. Upon detecting such an area, the air passes through it and it creates a lump. The method is applied successfully for sealing using geomembrane that are less than 1 mm thick.

Another procedure consists in manually pressing a bevelled punch on the welded area. An experienced inspector can detect areas that have not been seamed because they feel softer. The procedure is quick, but not very accurate, as it can only detect major flaws.

Another method uses a vacuum pumping device, made of a circular box with 0.5 m in diameter, with transparent top. It is applied along the seamed surface, after

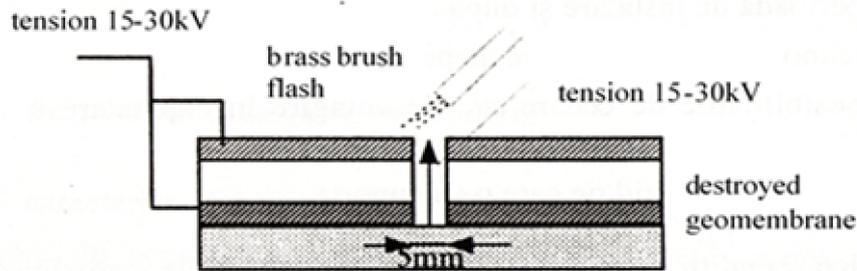


Fig. 1. *Detection system of the defects*

wetting it with a foaming agent. A vacuum air penetrates from under the seaming (from the vacuum, if the seam is not flawless the side that has contact with the field) and soap bubbles emit from the seam. The method is useful for geomembranes thicker than 1 mm.

One may also use ultrasound or electric methods; in the latter, a copper wire is placed in the centre of the seam area prior to welding, with a current of 15-30 kV passing through it (Fig. 1).

A modern method for assessing welds and for monitoring the work following its execution is to design an array of sensors applied beneath the geomembrane. They are connected to a computer through electric wires. To assess the seaming, a source of power is placed on top of the

of 20 kPa is created inside. During geomembrane. The system of sensors measures the intensity of the electric power. If the system is not impervious, abnormal values of intensity will be recorded. The calculating program used allows analysing the data through three-dimensional charts, thus permitting to pinpoint flaws with high precision.

There are also geomembrane with a conductive lower layer. The conductive layer is charged by induction, while the non-conductive side is tested is a brush electrode; thus, any potential perforation sets a spark discharge that is visible and audible [7], [8],[9],[10], [11], [12], [13], [14], [15] (Fig. 2).

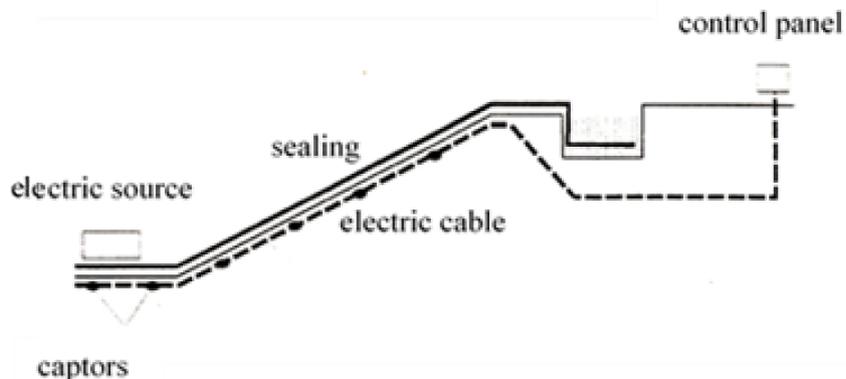


Fig. 2. *Control of the sealings with captors network*

## 5. Conclusions

The increasing large-scale use of such categories of products in Romania has also stirred the interest of the specialists in the field. A special attention has been given to welding methods and to weld testing procedures (to assess their quality). The beneficiaries of such works are directly interested in the technical performances of geomembranes, and their imposed exploitation timeframe must equal the one of the construction

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