THE WATERPROOFING PLASTOMERIC COMPOUND INTENDED AS A "POLYMER-BITUMEN" ALLOY

History, properties and function performed on the composite structure of the waterproofing membrane of modern design.

(Abstract from the paper prepared by NOVAGLASS for the XI\textsuperscript{o} IWA Congress Florence 2000.)

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**PRESENTATION:**

People operating in the waterproofing sector is well aware of the role performed by the waterproofing compound in the bitumen-polymer membrane.

Today, there are basically two types of waterproofing compounds:

- plastomeric, with polyolefinic polymeric base;
- elastomeric, with polymeric base with thermoplastic styrene rubbers.

The plastomeric waterproofing compounds taken into consideration in present work can assume semi-elastic properties when during the modification of the bitumen polyolefinic components having semi-elastic behaviour are used; hence the possibility to define compounds and/or membranes as plasto-elastomeric.

The history of the modification of the bitumen and the properties of the different types of waterproofing compounds are reported in Table A.

Further on, making use mainly of graphic diagrams, the following concepts are proposed:

Table B: most representative characteristics of a plastomeric waterproofing compounds, highlighting elastic behaviour, thermo-sensitivity and rheological behaviour.

Table C: diagram of modification with polypropylene of distilled bitumen.
Table D: parameters of control in the production of waterproofing compounds.
Table E: characteristics of traditional polyolefinic modifiers.
Table F: modifying capacity of traditional polymers on the bitumen.
Table G: diagram of bitumen/polymer compound processing
Table H: ageing effect on plastomeric waterproofing compounds

**History and purpose of the work:**

Many efforts were made in the research to improve the proprieties of the bitumen: especially the thermal susceptibility and the ageing properties. Only in the mid sixties, in Italy it was discovered that the atactic polypropylene, available as by product of the isotactic polypropylene invented by Prof. G. NATTA, was able to bestow to the bitumen required properties.

Such date represents the beginning of a new generation of membranes, defined as PLASTOMERIC from the polymer used in the modification of the bitumen, having characteristics clearly higher than the ones of the previous membranes made with oxidised bitumen with filler.

Later on, also the thermo-plastic styrene-butadiene-styrene rubbers were found suitable for the modification of the bitumen, giving birth in this way to the waterproofing compound and the membranes defined as ELASTOMERIC.

In the next research and manufacturing activities, substantial and progressive improvements were made too on the reinforcements and on the superficial finishing of the membranes.

In the particular case of the PLASTOMERIC waterproofing compounds there was an interesting development which allowed the use of functionalised polyolefins as polymers complementary to the traditional polypropylenes.

During the last years even the polyolefins produced with the new systems of metallocenic catalysis demonstrated their ability to confer to the waterproofing compound high plastomeric and elastomeric properties with high yield.
The load/deformation curves reported in the following diagram show the modifying ability expressed by the polymers currently available.

**Bitumen/Polymer Compound with 85/15 ratio having inverted structure (continuous polymeric phase and dispersed bitumen according to class 2 of Internal NG Norm 6/96 - Method A)**

**VB type Bitumen:**
- R. & B. ASTM-D36 = 41 °C
- Penetration ASTM-D5 = 193 dmm
- Composition - saturated = 11 %
  - aromatics = 56 %
  - resins = 20 %
  - asphaltenes = 13 %

**Polymer:** variable

![Graph 1](image)

1. 50/50 APP HOMOPOLYMER/COPOYMER Mixtures
2. APP
3. HETEROPHASIC COPOYMER EPR/APP 70/30 (mechanically/chemically processed)
4. OLEFINIC COPOLYMER from METALLICALLY catalyze (ethylene base)

Purpose of the work is to make available the knowledge developed by industrially manufacturing the finished membrane, by co-operating in the designing and realisation of waterproofing systems and by monitoring their behaviour during use.

Our reference will be the plastomeric membrane (APP) because it is the one on which we have more knowledge especially under the aspect of the processability and applicability.
The polymer-bitumen compound as polymeric alloy
Polymeric alloys originated from the inadequacy of the single polymers to satisfy requirements of higher performance in the same way the bitumen-polymer mixtures originated from the inadequacy of the properties of the bitumen to satisfy the requirements of the waterproofing sector.

Both alloys are obtained by physical mixing at high temperature. They present a morphologic structure where one of the components assumes the continuous phase conferring the characteristics to the system, while the other component remains dispersed in discontinuous form.

In common the two alloys present the thermo-plasticity, even if expressed within different ranges of temperature. The comparison in terms of mechanical properties situates the polymeric alloys at well superior levels in respect to the polymer - bitumen alloys, but this fact is justified by the different application requirements: replacement of wood, metals or similar materials in the first case, production of waterproofing sheets in the latter.

Role and functionality of the waterproofing compound in the plastomeric membrane
When associated to the reinforcement, the waterproofing compound concurs to increase the mechanical characteristics thanks to the well known synergies; furthermore, it transfers to the finished product thermoplastic and rheological properties.

When assuming the thermoplastic properties, the membrane becomes susceptible from the functional point of view of both the temperature and the speed of deformation. The rigidity of the product as expression of the performance properties, depends always on the temperature and on the deformation time according to the following relationship:

\[ R (t \times T^n) = S/d \]

In order to correctly interpret the influence of the variables time and temperature on the behaviour of the waterproofing compound and consequently of the membrane, it is proper to show the load/deformation diagram of the compound with different times and conditions of temperature.
PLASTOMERIC COMPOUND WITH
-10°C COLD FLEXIBILITY
Variation of mechanical characteristics changing temperature
and speed of deformation

Graph. 2
TEMPERATURE VARIATION

Graph. 3
SPEED VARIATION
### TYPICAL CHARACTERISTICS OF BITUMEN/POLYPROPYLENE POLYMERS WATERPROOFING MASS

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>STANDARD</th>
<th>UNIT</th>
<th>VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength (max)</td>
<td>Reference of EN 12311/1</td>
<td>N/mm²</td>
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<tr>
<td>Ultimate Elongation</td>
<td>%</td>
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<tr>
<td>Sensitivity to Heat</td>
<td>IK-LNG No 3/67</td>
<td>POINTS</td>
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<tr>
<td>Brookfield Viscosity</td>
<td>ASTM D. 2619</td>
<td>CPs (mPa s)</td>
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<td>Softening Point (RBD)</td>
<td>ASTM D. 36-76</td>
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<td>Density at 23°C</td>
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<td>g/cm³</td>
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<tr>
<td>Cold Flexibility</td>
<td>pr EN 12311/1</td>
<td>°C</td>
<td>-40</td>
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<tr>
<td>Cold Flexibility AFTER 28 g/80°C</td>
<td>pr EN 12311/1</td>
<td>°C</td>
<td>-5</td>
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<tr>
<td>Performance in H₂O</td>
<td>UNI 8302/22</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>G.U.V. Aging Test</td>
<td>ASTM G59-77</td>
<td>Super II test</td>
<td></td>
</tr>
<tr>
<td>Thermal Conductivity (λ)</td>
<td>Kcal/m²°C</td>
<td></td>
<td>&gt; 0.12</td>
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<tr>
<td>Dielectric Constant (k)</td>
<td>ASTM D. 150</td>
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<td>K at 1000Hz = 2.5</td>
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PARAMETERS OF CONTROL IN THE PRODUCTION OF PLASTOMERIC WATERPROOFING COMPOUND

- Temperature (°C)
- Mechanical action (%)
- Mechanical stress (%)
- Compound viscosity (CP)

Raw materials addition sequence: 1, 2, 3, 4

Time (h)

Phase inversion
### CHARACTERISTICS OF BITUMEN MODIFYING POLYMERS

<table>
<thead>
<tr>
<th>POLYMER TYPE</th>
<th>POLYPROPYLENE</th>
<th>EPDM</th>
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<td>APP</td>
<td>IPP</td>
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<td>COPOLYMERS</td>
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#### CHARACTERISTICS

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<tr>
<th>Characteristics</th>
<th>Standard</th>
<th>Reference (Pt.10)</th>
<th>Reference (EN 12311/1)</th>
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<th>Brookfield Viscosity 190 °C</th>
<th>Softening Point (F &amp; B)</th>
<th>Cold Flexibility</th>
<th>Aging Due to Atmospheric Agents (12-month exposure)</th>
<th>Resistance to Acid-Base Solutions (12-month exposure)</th>
<th>Dispersibility in Bitumen B-500</th>
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<tr>
<td>Tensile Strength</td>
<td>kg/cm²</td>
<td>%</td>
<td>% Ultimate Elongation</td>
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<td>2,000-5,000</td>
<td>&gt;180</td>
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<td>Good</td>
<td>Good</td>
<td>Very Good</td>
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<td>Ultimate Elongation</td>
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<td>% Ultimate Elongation</td>
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<td>900-300</td>
<td>&gt;150</td>
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<td></td>
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<tr>
<td>Brookfield Viscosity 190 °C</td>
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<td>Good</td>
<td>Very Good</td>
<td>Very Good</td>
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<td>Good</td>
<td>Satisfactory</td>
<td>Satisfactory</td>
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</table>
BITUMEN/POLYPROPYLENE POLYMERS COMPOUNDING PROCESS DIAGRAM

Original Characteristics of Components

Characteristics of Components during Transformation Phase

Compound Characteristics

Brookfield Viscosity c.p.s. (mPa.s) (ASTM - 2669)

Temperature °C

Structure as seen under Microscope (scale x 240)

Bitumen in continuous phase

Polymer in non continuous phase

Swollen polymer with low characteristics

Bitumen with improved characteristics due to loss of molecular weight components

NG CLASS = >5

NG CLASS = 4-5

NG CLASS = 1-2
EFFECT OF AGEING ON BEHAVIOUR PROPERTIES OF WATERPROOFING PLASTOMERIC COMPOUNDS HAVING -10 °C COLD FLEXIBILITY

Table H

Range of temperature for use of new waterproofing compound

Range of temperature for use of aged waterproofing compound

Glass phase

Beginning of viscous phase

Temperatures of handling and application

Temperature of use

TEMPERATURE °C

SHORE HARDNESS on points

Range of temperature for use of new waterproofing compound

Aged waterproofing compound (30 days in oven at 80°C)

New waterproofing compound