TPO Waterproofing Systems
using Novel Plastomers and Elastomers

Stefan Ultsch – DOW Europe GmbH

• Global Waterproofing Markets
• Applications, Requirements, and Trends
• Norms and Testing
• VERSIFY™ Plastomers and Elastomers
• VERSIFY™ use in Waterproofing Systems
European and North American Single-Ply Roofing

Europe = 340 mio m²/a

North America = 320 mio m²/a
Global Waterproofing Markets

European Olefinic Waterproofing Estimate

- Geomembranes and Tunnel liners
- Single-ply Roofing
- Temporary Use
- Relining
- Geonets
- Tarps, Pitched Roof, Vapor Barriers
- Drainage and Water Retention
- Waterproofing Tapes and Perimeter Sealants

Total = 160 k tons/a
Waterproofing Applications

Unballasted (Naked) Roof
Waterproofing Applications

Unballasted Roof, Mechanically Fixed

- Fabric reinforced TPO roofing membrane
- Heat weld
- Mechanical fixation
- No separation layer
- Thermal Insulation
- Vapor barrier
- Installation aid
- Base construction
Waterproofing Applications

Adhered Roof

Fleece backed reinforced TPO roofing membrane

Fleece backing

Adhesive

Thermal Insulation

Adhesive

Bitumen

Concrete

Plywood/OCB...

Refurbishment

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777-02401-1010
Waterproofing Applications

Ballasted Roof
Waterproofing Applications

Green Roof
Waterproofing Applications

Ballasted Roof (TPO)

- Ballast (pebbles, stone chipping)
- Separation layer
- TPO, fleece reinforced roofing membrane
- No separation layer
- Thermal Insulation
- Bituminous vapor barrier
- Concrete
Waterproofing Applications

Reversed Roof
Waterproofing Applications

Reversed Roof

- Substructure
- Thermal Insulation (STYROFOAM™ XPS)
- Fleece layer (ROOFMATE™ MK)
- Stone chipping
- Filter/fleece layer
- Adhered or loose laid waterproofing
- Paving

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Waterproofing Applications

Civil B&C Waterproofing

- Liquid roofing
- Façade sealants
- Expansion joints
- Wet room sealants
- Insulation bonding
- Pitched roof
- Acrylics adhered roof
- Bitumen bonding
- PUR adhered refurbishment
- Subsoil waterproofing
Waterproofing Applications

Water Management
Waterproofing Applications

Tunnel Liners
Waterproofing Applications

Modern Architecture
Waterproofing Trends

- Converging but Growing Industries
- Price Driven Markets

- Broad Variety of Applications and Products
- 60 % Refurbishment, 40 % New Buildings
- Diversification: Roofing, Waterproofing, Water-Management, Tunnel liners

- Service and Quality Requirements are high
- Norms and Standards are manifold
- National Preferences

- TPO share is increasing at the expense of Bitumen, EPDM, PVC, Exotics

- Smart Accessories, Ease of Installation
- Environmental Friendly
- System Solutions
- One-Stop Shops
## Roofing Application Requirements

<table>
<thead>
<tr>
<th>Property Requirements</th>
<th>North America</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions</strong></td>
<td>40 – 60 mils (1 – 1.5 mm) 12 ft width</td>
<td>1.2 - 1.8 mm 2 m width</td>
</tr>
<tr>
<td><strong>Materials</strong></td>
<td>EPDM, Bitumen, TPO</td>
<td>Bitumen, PVC</td>
</tr>
<tr>
<td></td>
<td>PVC = high quality</td>
<td>PVC = low quality</td>
</tr>
<tr>
<td></td>
<td>TPO = Future</td>
<td>TPO = On the rise</td>
</tr>
<tr>
<td></td>
<td>EPDM = losing share</td>
<td></td>
</tr>
<tr>
<td><strong>Property Requirements</strong></td>
<td>Higher stiffness</td>
<td>Higher flexibility</td>
</tr>
<tr>
<td></td>
<td>Mostly naked roofs</td>
<td>Many different roof types</td>
</tr>
<tr>
<td></td>
<td>Mostly for mechanical fixing</td>
<td>Mechanical, adhered, ballasted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extensive refurbishment</td>
</tr>
<tr>
<td></td>
<td>White color, Energy Star</td>
<td>Al(OH)₃, MgOH₂ flame retardant for TPO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Greyish…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 to 15 year warranties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 year longevity</td>
</tr>
</tbody>
</table>
# Roofing Standards: TPO

## NORTH AMERICA

**ASTM D6878 - 03**  
*TPO Roofing*

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall sheet Thickness</td>
<td>D 751</td>
<td>&gt; 1 mm</td>
</tr>
<tr>
<td>Effective Thickness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass per Unit Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coating over Fabric or Scrim (Weathering Side)</td>
<td>D 751</td>
<td>&gt; 0.305</td>
</tr>
<tr>
<td>Breaking Strength</td>
<td>D 751</td>
<td>976 N</td>
</tr>
<tr>
<td>Elongation at Reinforcement Break</td>
<td>D 751</td>
<td>&gt; 15 %</td>
</tr>
<tr>
<td>Elongation at Break</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tearing Strength</td>
<td>D 751</td>
<td>&gt; 245 N</td>
</tr>
<tr>
<td>Resistance to Static Loading</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## EUROPE

**EN 13956 04/2007**  
*Flexible Sheet for Waterproofing*

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Requirement</th>
<th>Common</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall sheet Thickness</td>
<td>EN 1849-2</td>
<td>MDV -5/+10</td>
<td>&gt; 1.2</td>
</tr>
<tr>
<td>Effective Thickness</td>
<td>EN 1849-2</td>
<td>&gt; 80 g/m²</td>
<td>&gt; 1200 g/mm²</td>
</tr>
<tr>
<td>Mass per Unit Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coating over Fabric or Scrim (Weathering Side)</td>
<td>EN 12311-2</td>
<td>&gt; MLV</td>
<td>&gt; 7 Mpa</td>
</tr>
<tr>
<td>Breaking Strength</td>
<td>EN 12310-2</td>
<td>&gt; MLV</td>
<td></td>
</tr>
<tr>
<td>Elongation at Reinforcement Break</td>
<td>EN ISO 527-</td>
<td>&gt; MLV</td>
<td>&gt; 500 % (Polymer)</td>
</tr>
<tr>
<td>Elongation at Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tearing Strength</td>
<td>EN 12730</td>
<td>&gt; MLV</td>
<td></td>
</tr>
</tbody>
</table>
## Roofing Standards: TPO

### Property

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Requirement</th>
<th>Test</th>
<th>Requirement</th>
<th>Common</th>
</tr>
</thead>
<tbody>
<tr>
<td>Britleness point</td>
<td>D 2137,</td>
<td>&lt; - 40 °C</td>
<td>EN 495-5</td>
<td>&gt; MLV</td>
<td>-30 °C, no cracks</td>
</tr>
<tr>
<td>Foldability at Low Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ozone resistance (rubber only)</td>
<td>D 1149</td>
<td>no cracks</td>
<td>EN 1844</td>
<td>no cracks, pass</td>
<td></td>
</tr>
<tr>
<td>Heat Aging</td>
<td>D 573, 116 °C</td>
<td>&gt; 90 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retained Break Elongation</td>
<td></td>
<td>&gt; 90 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retained Elongation at</td>
<td></td>
<td>&gt; 60 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tear Strength</td>
<td></td>
<td>+/-1 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change of mass</td>
<td></td>
<td>+/-1 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear Dimensional Change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Tightness</td>
<td>D 471,</td>
<td>&lt; +/-3 mass%</td>
<td>EN 1928, B</td>
<td>Pass at 10 kPA (.1)</td>
<td></td>
</tr>
<tr>
<td>Water Absorption / Exposure</td>
<td></td>
<td></td>
<td>EN 1847</td>
<td>BE &gt; 200 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Change BE &lt; 25 %</td>
<td></td>
</tr>
<tr>
<td>Factory Seam Strength</td>
<td>D 751, 25 mm</td>
<td>&gt; 290 N</td>
<td>EN 12316-2</td>
<td>Peel resist. &gt; MLV</td>
<td>Welding Window</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EN 12317-2</td>
<td>Shear Resist. &gt; MLV</td>
<td></td>
</tr>
</tbody>
</table>

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# Roofing Standards: TPO

**ASTM D6878 - 03**  
TPO Roofing Flexible Sheet for Waterproofing

## Property | Test | Requirement | Test | Requirement | Common
--- | --- | --- | --- | --- | ---
Weather Resistance | G 155 | No cracks  
BS ret > 90 %  
EB ret > 90 % | EN 1297 | > 1000 h  
> 1000 h | > 3000 h ballasted  
> 5000 h naked roofs  
≤ 3 % Change of Mass

- **Resistance to Impact**
- **Resistance to hail**
- **Resistance to chaulk milk, acidic solutions, break elongation, change of break**

- **Reaction to Fire (for naked roofs)**
  - **Flame retardancy**
- **Root resistance (green)**
- **Bitumen Contact (where)**

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Tunnel Liner/Geomembrane Standards

• International Standards
• Similar requirements and tests as roofing standards
  • Some specialized tests & approvals required
    • Environmental, drinking water approvals
    • Special joint technology
    • Specific water pressure
    • Perforation testing
    • Flexibility

Specialty Plastics & Elastomers from DOW are the starting point for your waterproofing solutions
VERSIFY™ Plastomers and Elastomers

Commodity PE & PP (with Conventional Catalyst)

Specialty PE & PP (with Metallocene & Post-Metallocene Catalyst)

Propylene based Plastomers/Elastomers

HDPE
LLDPE
ULDPE
Et Elastomers

EPDM

Modulus

100% C₂

Comonomer Content

100% C₃
VERSIFY™ Plastomers & Elastomers

- Based on INSITE® catalyst technology
- Propylene/Ethylene copolymer

- No reactor blends, no reactor cascades, no vis-breaking
- Tailored, narrow molecular weight structure
- No oligomers, no low-molecular weight fraction

- Excellent and lasting heat welding
- Excellent filler acceptance and properties
VERSIFY™ Plastomers and Elastomers

- **Injection Molding/Extrusion Coating**
  - VERSIFY™ 4000
  - VERSIFY™ 4200

- **Film Sealants**
  - VERSIFY™ 3000
  - VERSIFY™ 3200

- **General Purpose**
  - VERSIFY™ 3300
  - VERSIFY™ 3401

- **Extrusion Grades**
  - VERSIFY™ 2000
  - VERSIFY™ 2200

- **Soft Compounds**
  - DE 4301.01

- **Impact Modification**

MFR @ 230°C

Density

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# VERSIFY™ Plastomers and Elastomers

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>MFR</th>
<th>Density (g/cc)</th>
<th>Shore A</th>
<th>Flex Modulus (MPa)</th>
<th>Typical Applications</th>
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</thead>
<tbody>
<tr>
<td>VERSIFY 2000</td>
<td>2</td>
<td>0.888</td>
<td>96</td>
<td>370</td>
<td>Food and Specialty Films, Blown Films</td>
</tr>
<tr>
<td>VERSIFY 2200</td>
<td>2</td>
<td>0.876</td>
<td>95</td>
<td>96</td>
<td>Food and Specialty Films, Blown Films</td>
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<tr>
<td>VERSIFY 2300</td>
<td>2</td>
<td>0.866</td>
<td>88</td>
<td>32</td>
<td>TPE, Calandering and Extrusion</td>
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<tr>
<td>VERSIFY 2400</td>
<td>2</td>
<td>0.858</td>
<td>66</td>
<td>11</td>
<td>TPE, Calandering and Extrusion</td>
</tr>
<tr>
<td>VERSIFY 3000</td>
<td>8</td>
<td>0.888</td>
<td>97</td>
<td>370</td>
<td>General Purpose, BOPP Sealant, Cast Films</td>
</tr>
<tr>
<td>VERSIFY 3200</td>
<td>8</td>
<td>0.876</td>
<td>94</td>
<td>100</td>
<td>General Purpose, BOPP Sealant, Cast Films</td>
</tr>
<tr>
<td>VERSIFY 3300</td>
<td>8</td>
<td>0.866</td>
<td>86</td>
<td>35</td>
<td>General Purpose, Elastic films, Cast Film</td>
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<tr>
<td>VERSIFY 3401</td>
<td>8</td>
<td>0.864</td>
<td>70</td>
<td>11</td>
<td>Impact Modification,TPE/TPO, Cast Film</td>
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<tr>
<td>VERSIFY 4000</td>
<td>25</td>
<td>0.888</td>
<td>97</td>
<td>390</td>
<td>Injection Molding</td>
</tr>
<tr>
<td>VERSIFY 4200</td>
<td>25</td>
<td>0.876</td>
<td>95</td>
<td>110</td>
<td>Extrusion coating, Injection Molding</td>
</tr>
<tr>
<td>DE 4301.01</td>
<td>25</td>
<td>0.8665</td>
<td>86</td>
<td>35</td>
<td>Injection Molding</td>
</tr>
</tbody>
</table>
VERSIFY™-based TPO Membranes

VERSIFY™ Plastomers and Elastomers versus PVC

• No plasticizer migration, no separation layers
• Compatible with hot bitumen
• Lower density provides weight advantages

• Improved heat resistance
• Improved cold temperature impact
• Excellent root resistance

• Metal-free stabilizers, no biocides
• Advantages for drinking water applications
• No irritating fumes in heat welding
VERSIFY™-based TPO Membranes

• VERSIFY™ Plastomers and Elastomers versus Bitumen
  • One layer, installation cost savings
  • No open torch required, no toxic fumes
  • Easy to color
  • Excellent root resistance, no biocides
  • No environmental issues

• VERSIFY™ Plastomers and Elastomers versus EPDM
  • No extender migration
  • Heat weld possibility, no pre-confectioning
  • Ease of installation
  • Excellent root resistance
VERSIFY™-based TPO Membranes

VERSIFY™ Plastomers and Elastomers versus standard TPOs

- Broad heat welding window
- Long-term heat seal strength - No migration of Oligomers
- No pre-cleaning with solvent
- Long-term stable adhesion to fabrics

- Temperature resistance and flexibility – design freedom
- Transparent / clarity
- Excellent filler acceptance, compatibility and morphology
- Excellent processing properties, higher production rates
VERSIFY™-based TPO Membranes

Processing

Comparative Trials on Co-rotating Twin Screw Extruders

<table>
<thead>
<tr>
<th></th>
<th>Standard TPO</th>
<th>Copolymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 wt% flame retardant</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>50 wt% flame retardant</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

+ Less die pressure = Potential for Faster Extrusion
+ Lower Mass Temperature = Faster Extrusion, less Stress on Flame Retardant
+ Excellent Appearance
+ Adjustable Flexibility
+ Excellent Scrim Adhesion
Lab-Scale Direct Extrusion Line

Courtesy of BERSTORFF, Hanover Germany

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FR-TPO In-Line Compounding

Diagram with courtesy of BERSTORFF, Hanover Germany
VERSIFY™-based TPO Membranes

Starting formulations

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>GRADE</th>
<th>AMOUNT (phr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELASTOMER</td>
<td>VERSIFY 2300, VERSIFY 2400</td>
<td>80 - 60</td>
</tr>
<tr>
<td>POLYPROPYLENE</td>
<td>PP HOMOPOLYMER</td>
<td>20 - 40</td>
</tr>
<tr>
<td>STABILIZER BATCH COLORANT</td>
<td>VARIOUS, PROCESSING, THERMAL, UV</td>
<td>1 - 1.5</td>
</tr>
<tr>
<td></td>
<td>VARIOUS, WEATHERING RESISTANT</td>
<td>2 - 4</td>
</tr>
</tbody>
</table>

Often as pre-batch for ease of handling

Up to 15% recycle can be fed into the lower membrane layer
VERSIFY™-based TPO Membranes

Starting formulations

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>GRADE</th>
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<td>POLYPROPYLENE</td>
<td>PP HOMOPOLYMER</td>
<td>20 - 40</td>
</tr>
<tr>
<td>FLAME RETARDANT</td>
<td>MAGNESIUM OR ALUMINUM</td>
<td>60 - 80</td>
</tr>
<tr>
<td>STABILIZER BATCH</td>
<td>VARIOUS, PROCESSING, THERMAL, UV</td>
<td>1 - 1.5</td>
</tr>
<tr>
<td>COLORANT</td>
<td>VARIOUS, WEATHERING RESISTANT</td>
<td>2 - 4</td>
</tr>
</tbody>
</table>

Often as pre-batch for ease of handling

Up to 15% recycle can be fed into the lower membrane layer
Summary

• Global Waterproofing Markets require different Solutions

• TPO Waterproofing is growing substantially

TPO membranes provide improved properties

• Excellent heat-weld performance – broad window, long-term stability
• Design freedom – low-temperature flexibility, good fabric adhesion
• Processing advantages – high filler acceptance, processability

Let us assist you in solving your Waterproofing Needs

Please visit us: http://www.dow.com/versify/index.htm