# SUNBESTA-ZV

## ETFE Multilayer Tube Solutions for the Automotive Industry

Your Dreams, Our Challenge

# Requirements for Fuel Lines

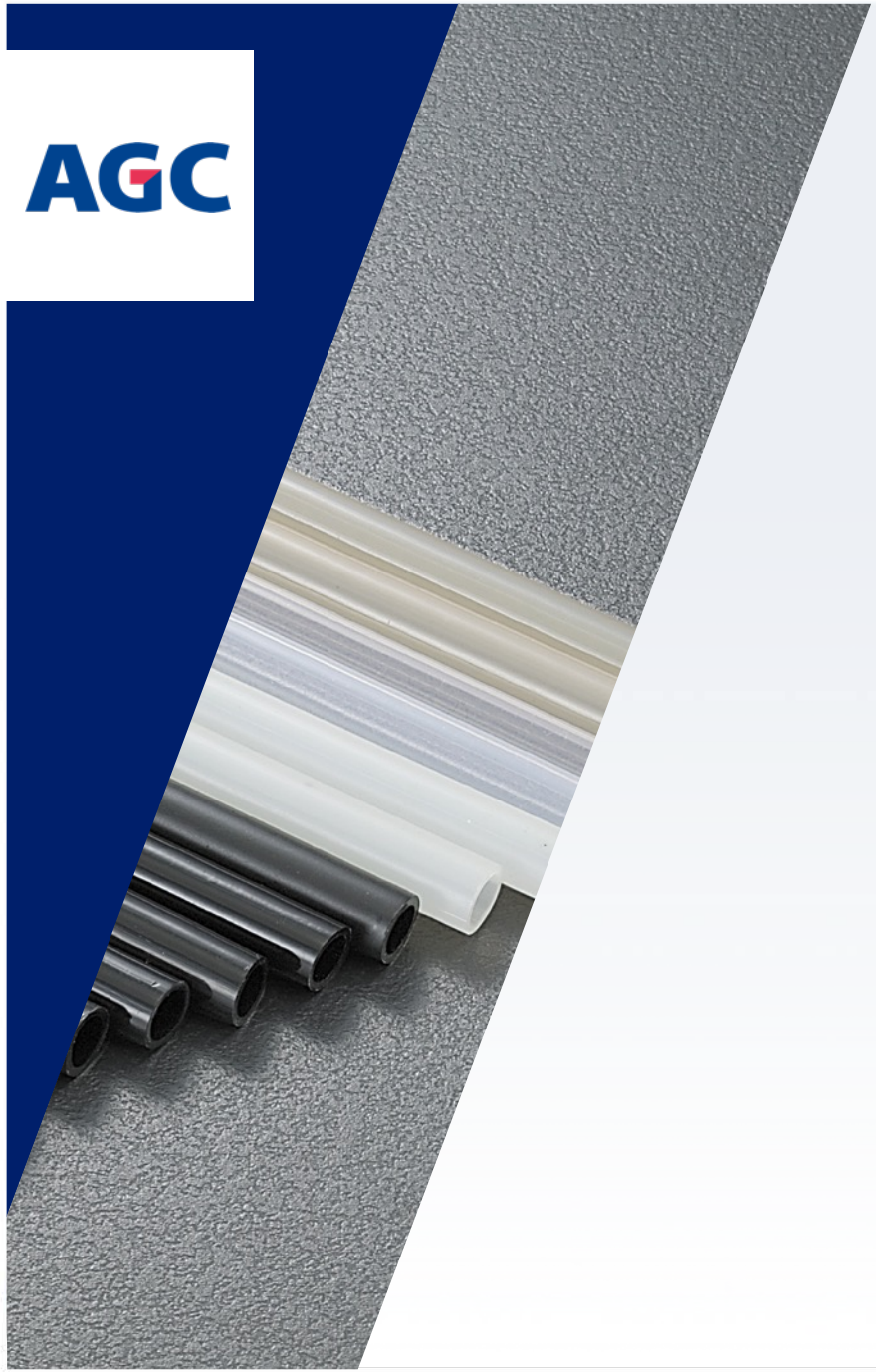
- Mechanical properties *(burst pressure, cold impact resistance, tensile elongation, etc.)*
- Long-term durability *(15 years, 150,000 miles)*
- Fuel and chemical resistance
  - CE5, CE10, CM15, CE22, CM30, CE85, E100
  - Biofuels *(bioalcohol, biodiesel; RME, SME, etc.)*
  - Auto-oxidized fuels *(aggressive fuels with high peroxide number)*
- Low permeation *(Euro4, Euro5, Euro6, LEV II, PZEV, LEV III)*
- Conductive *(USA , Japan)*
- Processability, thermoforming *(straight, corrugated)*
- Cost reduction

# Trend of MLT System

- Wide variety of fuels is being used
- Lower emission requirements
- Cost efficiency
- Oligomer-free and conductive material for inner layer
- Wide range of MLT systems for fuel lines has been proposed:
  - PA11/PA12 and PBT, PBN, PVDF, ETFE, EFEP, EVOH, PPS MLT systems
- Layer construction of MLT has grown more complicated

# Advanced Multilayer Tube System

- AGC, KURARAY and UBE jointly developed 3-layer tube system:
  - High level of low permeation against a variety of fuels
  - Low-oligomer washout
  - Reasonable cost
- **Outer layer:** Modified PA12 with excellent cold impact resistance and long-term heat resistance
- **Middle layer:** Modified PA9T with excellent hydrocarbon barrier properties and good chemical and hydrolysis resistance
- **Inner layer:** Modified ETFE with excellent alcohol barrier properties, resistance to fuel (including aggressive oxidized fuels and high alcohol based fuel), chemicals and hydrolysis, and adhesive properties



# SUNBESTA-ZV Tube Construction

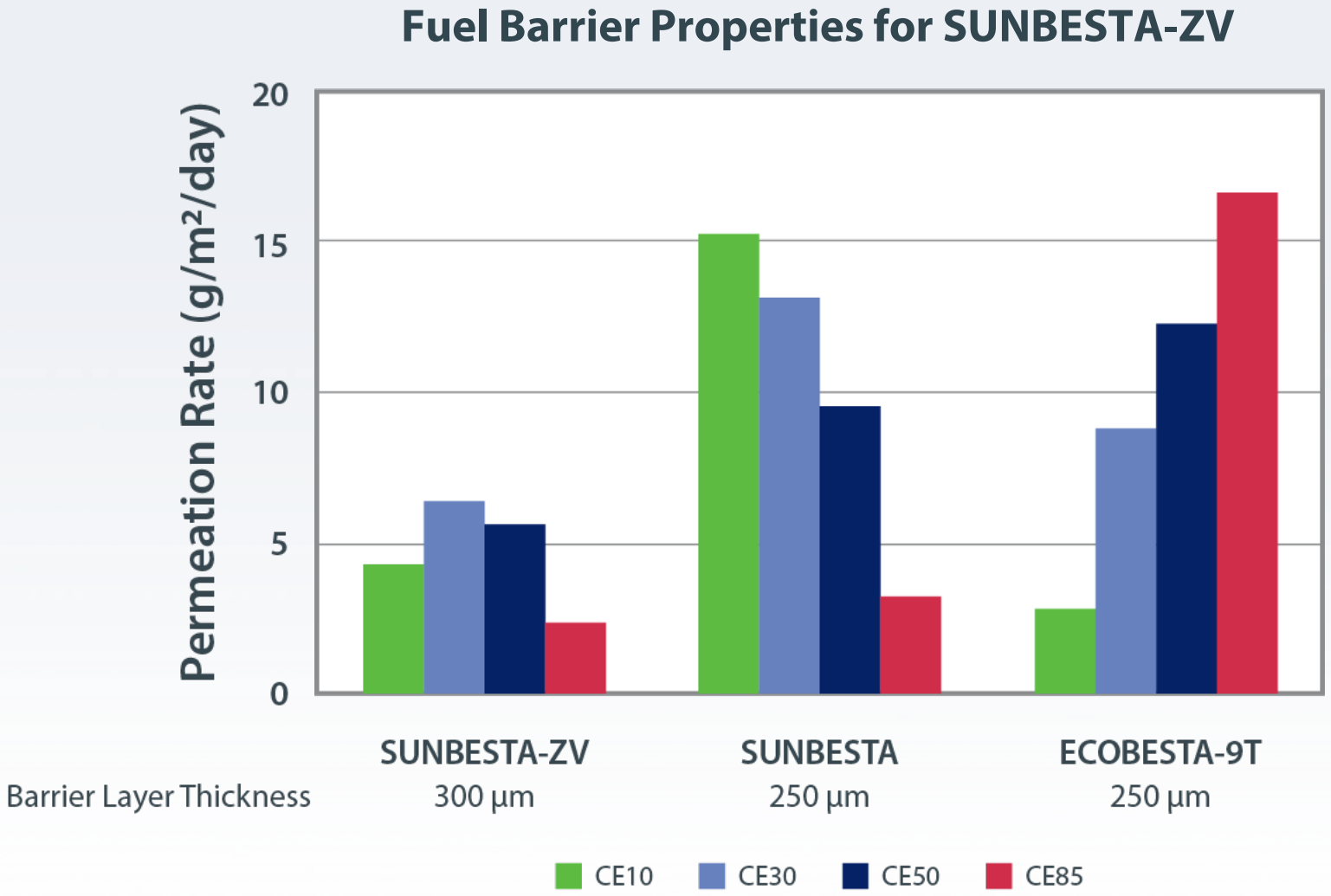
**AH-ETFE / PA9T / PA12**

*OD/ID = 8.0 mm/6.0 mm*
*Thickness: Inner/Middle/Outer = 150/150/700 µm*

## Standard Material:

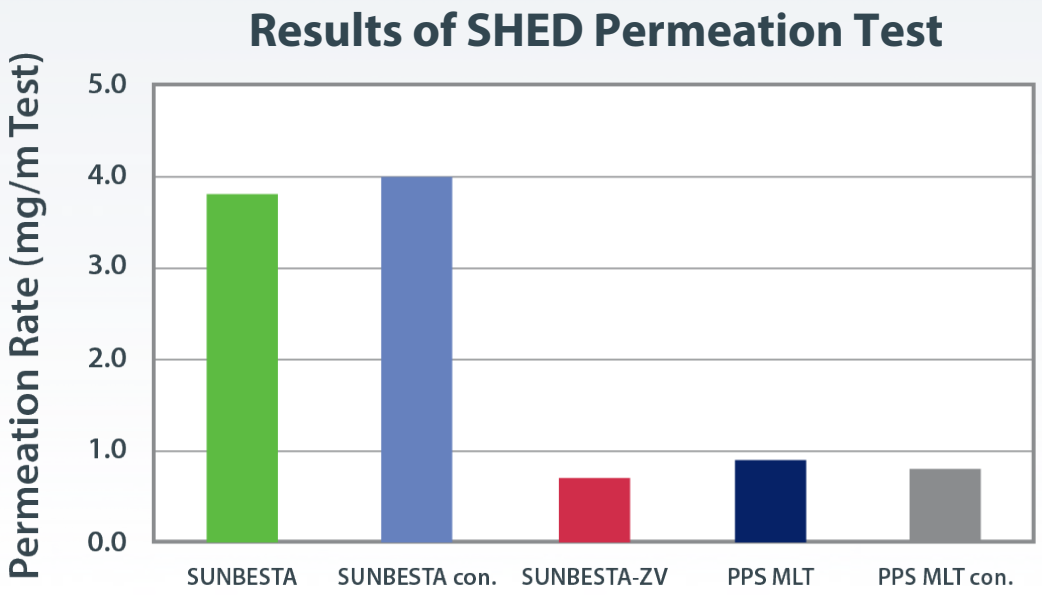
- Outer layer: PA12 UBESTA® 3030JI series
- Middle layer: PA9T GENESTAR™ N1001D-U series
- Inner layer: ETFE Fluon® AH series

# Fuel Permeation Rate



# Permeation Rate in Comparison with Various MLTs

| MLT System | Type | Outer Layer | Middle Layer | Inner Layer | Innermost Layer |
|---|---|---|---|---|---|
| SUNBESTA | Nonconductive | PA12 (800 µm) | – | – | ETFE (200 µm) |
| SUNBESTA | Conductive | PA12 (800 µm) | – | – | Con. – ETFE (200 µm) |
| SUNBESTA-ZV | Conductive | PA12 (800 µm) | PA9T (100 µm) | - | Con. – ETFE (100 µm) |
| PPS MLT | Nonconductive | PA11 (600 µm) | Modified – PPS (100 µm) | - | PPS (300 µm) |
| PPS MLT conductive | Conductive | PA11 (600 µm) | Modified – PPS (100 µm) | PPS (150 µm) | Con. – PPS (150 µm) |




SHED Method
(Fuel: CARB DBL Indolene+ETOH10%)

Tube Dimension
OD/ID: 8.0 mm/6.0 mm
Length: 1 m

# Typical Tube Properties

| | | | Units | SUNBESTA-ZV |
|---|---|---|---|---|
| | | Line Speed | m/min | 10 |
| **Material** | | Outer Layer | | UBESTA 3030JI26L |
| | | Middle Layer | | Genestar N1001D U83/020 |
| | | Inner Layer | | Fluon AH3000L |
| **Distance (Target)** | | Outer Diameter | mm | 8.00 |
| | | Wall Thickness (Total) | | 1.00 |
| | | Wall Thickness (Each Layer) | | 0.15/0.15/0.70 |
| **Burst Pressure** | | Burst Test | MPa | 9.4 |
| | | Burst Test (Hoop Stress) | | 32 |
| **Flexibility** | | Stiffness | N | 28 |
| | | Minimum Bend Radius | mm | 20 |
| **Heat Resistance** | V.W. | Impact after 150 °C for 200 hrs | b/t | 0/10 |
| **Cold Impact** | V.W. | -40 °C for 22 hrs | | 0/10 |
| | DIN | (No Treatment) -60 °C | | 0/10 |
| **Layer Adhesive** | SAE | Peel Strength (180°) | N/cm | 27 |
| **Tensile Test*** | SAE | Tensile Strength | N | 1039 |
| | | Elongation between Marks/Grips | % | 283/340 |

**Tensile Speed: 50 mm/min  Distance between Marks/Grips: 50 mm/100 mm*

# Burst Properties: SAE J2260

| Section | Item | Detail | Unit | SUNBESTA-ZV | Specification (SAE J2260) |
|---|---|---|---|---|---|
| Material | | Outer Layer | | UBESTA 3030JI26L | |
| | | Middle Layer | | GENESTAR N1001D U83/02 | |
| | | Inner Layer | | Fluon AH3000L | |
| Dimension (Target) | | Outer Diameter | mm | 8.00 | |
| | | Wall Thickness (Total) | | 1.00 | |
| | | Wall Thickness (Each Layer) | | 0.15/0.15/0.70 | |
| 7.1 | Room Temperature Burst Test | At 23 °C | MPa | 7.1 | More than 3 times of design value or 75% of initial value |
| 7.2 | High Temperature Burst Test | At 115 °C for 2 hrs | | 2.6 | |
| 7.4 | After Kinking | At 23 °C | | 7.0 | |
| 7.5 | After Cold Impact Test | At 23 °C | | 7.0 | No crack & more than 75% of initial value |
| 7.6 | After Fuel Exposure | CE10 at 60 °C for 5000 hrs | b/t MPa | 0/5 7.0 | |
| | | CE10 at 60 °C for 1000 hrs | | 0/5 6.5 | |
| 7.7 | After Methanol Resistance | CM15 at 60 °C for 1000 hrs | | 0/5 6.3 | |
| 7.8 | After Auto-Oxidized Gasoline | At 40 °C for 1000 hrs | | 0/5 6.2 | |
| 7.14 | After Heat Aging | At 90 °C for 1000 hrs | | 0/5 11.5 | |
| | After Heat Aging | At 90 °C for 1000 hrs then at 115 °C for 48 hrs | | 0/5 12.0 | |
| | After Heat Aging and Cold Impact | At 90 °C for 1000 hrs then at 115 °C for 48 hrs then cold impact text | | 0/5 11.9 | |

# Cold Impact Properties: SAE J2260

| Section | Item | Detail | Unit | SUNBESTA-ZV | Specification (SAE J2260) |
|---|---|---|---|---|---|
| Material | | Outer Layer | | UBESTA 3030JI26L | |
| | | Middle Layer | | GENESTAR N1001D U83/02 | |
| | | Inner Layer | | Fluon AH3000L | |
| Dimension (Target) | | Outer Diameter | mm | 8.00 | |
| | | Wall Thickness (Total) | | 1.00 | |
| | | Wall Thickness (Each Layer) | | 0.15/0.15/0.70 | |
| 7.5 | Initial Value | At -40 °C for 4 hrs | b/t | 0/10 | No Crack |
| 7.6 | After Fuel Exposure | CE10 at 60 °C for 1000 hrs | | 0/5 | |
| | | CE10 at 60 °C for 5000 hrs | | 0/5 | |
| 7.7 | After Methanol Resistance | CM15 at 60 °C for 1000 hrs | | 0/5 | |
| 7.8 | After Auto-Oxidized Gasoline | At 40 °C for 1000 hrs | | 0/5 | |
| 7.12 | After Zinc Chloride Resistance | Immersion in 50% $ZnCl_2$ solution at 23 °C for 200 hrs then dried at 23 °C for 24 hrs | | 0/5 | |

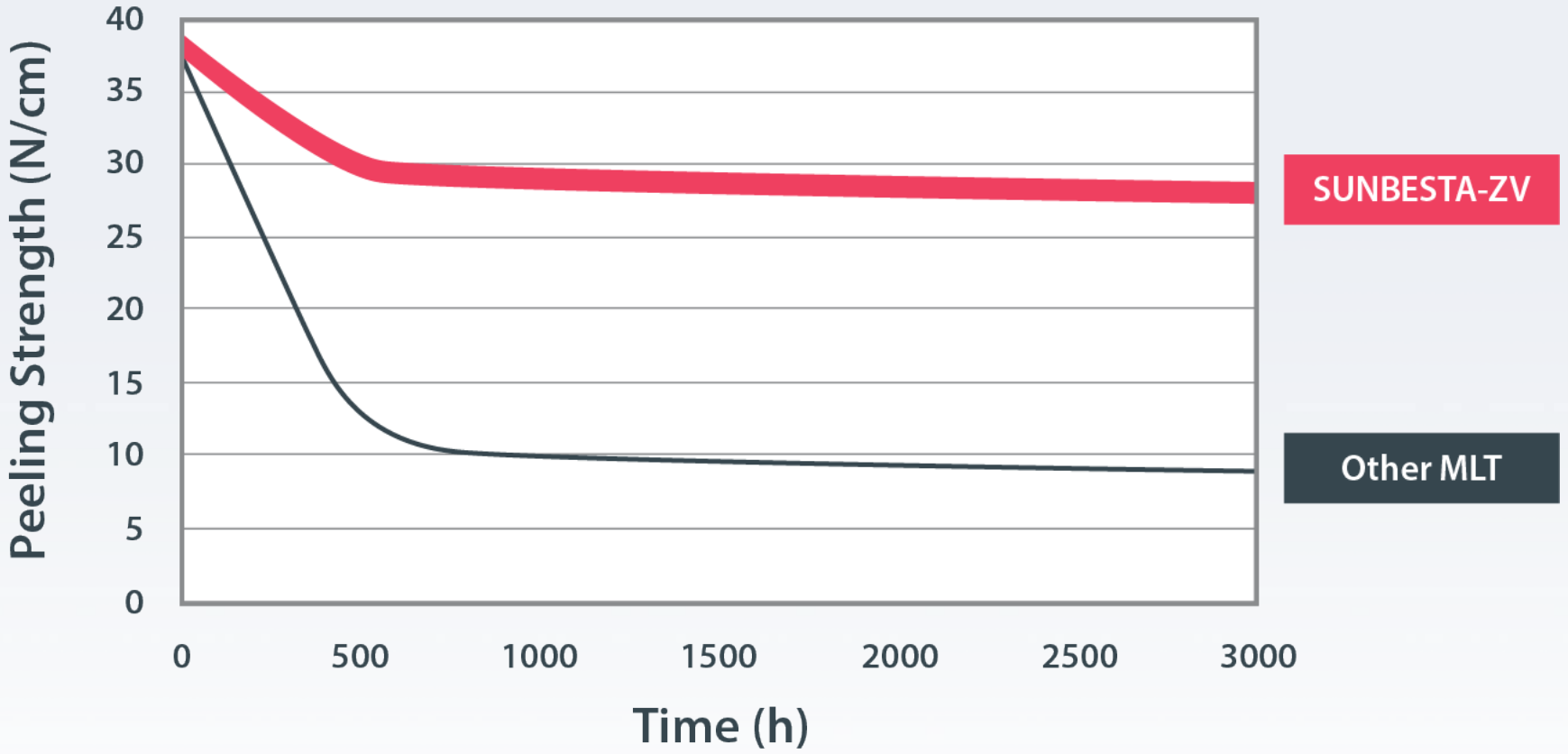
# Layer Adhesion: SAE J2260

| Section | Item | Detail | Unit | SUNBESTA-ZV | Specification (SAE J2260) |
|---|---|---|---|---|---|
| **Material** | | **Outer Layer** | | **UBESTA 3030JI26L** | |
| | | **Middle Layer** | | **GENESTAR N1001D U83/02** | |
| | | **Inner Layer** | | **Fluon AH3000L** | |
| Dimension (Target) | | Outer Diameter | mm | 8.00 | |
| | | Wall Thickness (Total) | | 1.00 | |
| | | Wall Thickness (Each Layer) | | 0.15/0.15/0.70 | |
| 7.6 | After Fuel Exposure | CE10 at 60 °C for 5000 hrs | – | No Delamination | |
| | | CE10 at 60 °C for 1000 hrs | | | |
| 7.7 | After Methanol Resistance | CM15 at 60 °C for 1000 hrs | | | |
| 7.8 | After Auto-Oxidized Gasoline | At 40 °C for 1000 hrs | | | |
| 7.13 | Initial Value | At 23 °C | | | |

# Electrical Resistance: SAE J2260

| Section | Item | Detail | Unit | SUNBESTA-ZV | |
|---|---|---|---|---|---|
| **Material** | | **Outer Layer** | | **UBESTA 3030JI26L** | **Specification (SAE J2260)** |
| | | **Middle Layer** | | **GENESTAR N1001D U83/02** | |
| | | **Inner Layer** | | **Fluon AH3000L** | |
| Dimension (Target) | | Outer Diameter | mm | 8.00 | |
| | | Wall Thickness (Total) | | 1.00 | |
| | | Wall Thickness (Each Layer) | | 0.15/0.15/0.70 | |
| 7.9 | Initial Value | At 23 °C | ohm/sq | $6.0 \times 10^3$ | Less than $10^6$ ohm/sq |
| 7.4 | After Kinking | At 23 °C | | $9.0 \times 10^3$ | |
| 7.5 | After Cold Impact | At 23 °C | | $6.0 \times 10^3$ | |
| 7.6 | After Fuel Exposure | Fuel C at 60 °C for 1000 hrs | | $8.0 \times 10^3$ | |

# Layer Adhesion Performance




Peeling strength measured after filling with CE10 at 60 °C
Test specimens prepared by Spiral strip, Peeling speed: 50 mm/min

# Typical Processing Conditions: Conductive Straight Tube

| | Material | Grade | Unit | Cylinder | | | | | | Co-Extrusion Die | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | C1 | C2 | C3 | C4 | Head | Adaptor | D1 | D2 | D3 |
| Outer Layer | PA12 | UBESTA 3030JI26L | °C | 230 | 235 | 240 | 245 | 250 | 265 | 310 | 310 | 310 |
| | | | °F | 446 | 455 | 464 | 473 | 482 | 509 | 590 | 590 | 590 |
| Middle Layer | PA9T | GENESTAR N1001D U83/02 | °C | 280 | 290 | 300 | – | 300 | 300 | – | – | – |
| | | | °F | 536 | 554 | 572 | – | 572 | 572 | – | – | – |
| Inner Layer | Conductive ETFE | Fluon AH3000L | °C | 280 | 300 | 320 | – | 320 | 320 | – | – | – |
| | | | °F | 536 | 572 | 608 | – | 608 | 608 | – | – | – |

# UBESTA 3030JI26L Properties

| Properties | | Standard | Units | UBESTA 3030JI26L |
|---|---|---|---|---|
| MFR (250 °C, 5000 g) | | ISO 1133 | g/10 min | 1.00 |
| Density | | ISO 1188-3 | $g/cm^3$ | 1.00 |
| Melting Point | | ISO 11357-3 | °C | 176 |
| Tensile Strength at Yield | | ISO 527-1,2 | MPa | 29 |
| Tensile Strain at Yield | | ISO 527-1,2 | % | 19 |
| Elongation at Break | | ISO 527-1,2 | % | > 200 |
| Flexural Strength | | ISO 178 | MPa | 23 |
| Flexural Modulus | | ISO 178 | MPa | 500 |
| Impact Strength (Charpy Notched) | 23 °C | ISO 179/1eA | $kJ/m^2$ | 115 P |
| | -40 °C | | | 15 C |
| Shore Hardness | | ISO 868 | – | 67 |
| DTUL (1.8 MPa) | | ISO 75-2 | °C | 42 |
| Permeation Rate (CE10, 60 °C) | | JIS Z 0208 | $g \cdot mm/m^2 \cdot day$ | 120 |

# GENESTAR N1001D U83/020 Properties

| Properties | | Standard | Units | GENESTAR N1001D U83/020 |
|---|---|---|---|---|
| MFR (320 °C, 5000 g) | | ISO 1133 | g/10 min | 3.00 |
| Density | | ISO 1183-3 | $g/cm^3$ | 1.09 |
| Melting Point | | ISO 11357-3 | °C | 265 |
| Tensile Strength at Yield | | ISO 527-1,2 | MPa | 64 |
| Tensile Strain at Yield | | ISO 527-1,2 | % | – |
| Elongation at Break | | ISO 527-1,2 | % | 20 |
| Flexural Strength | | ISO 178 | MPa | 82 |
| Flexural Modulus | | ISO 178 | GPa | 1.8 |
| Impact Strength (Charpy Notched) | 23 °C | ISO 179/1eA | $kJ/m^2$ | 97 |
| | -40 °C | | | 17 |
| DTUL (1.8 MPa) | | ISO 75-2 | °C | 114 |
| Permeation Rate (CE10, 40 °C) | | JIS Z 0208 | $g \cdot mm/m^2 \cdot day$ | 0.35 |

# Fluon AH2000 and AH3000L Properties

| Properties | | Standard | Units | Fluon ETFE AH2000 (Nonconductive) | Fluon ETFE AH3000L (Conductive) |
|---|---|---|---|---|---|
| MFR (297 °C, 49N) | | ASTM D3159 | g/10 min | 25 | 6.5 |
| Specific Gravity | | ASTM D792 | – | 1.76 | 1.78 |
| Melting Point | | DSC | °C | 240 | 240 |
| Tensile Strength at Break | | ASTM D638 | MPa | 49 | 38 |
| Elongation at Break | | ASTM D638 | % | 420 | 400 |
| Flexural Modulus | | ASTM D790 | MPa | 790 | 1240 |
| Izod Impact Strength | 23 °C | ASTM D256 | J/m | N/B | N/B |
| Permeation Rate (CE10, 60 °C) | | JIS Z0208 | g • mm/m$^2$ • day | 2.6 | 2.0 |
| Surface Resistivity | | AGC Method | ohm/sq | – | $2.0 \times 10^3$ |

# AGC Chemicals Americas, Inc.

www.agcchem.com

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