Polymers for Subsea Lunch & Learn
Energy, Marine, Offshore

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About Nylacast
Engineering today for a brighter tomorrow.

- Established in 1967.
- Over 220 state of the art manufacturing machines.
- Over 530 members of staff worldwide.
- 5 Strategic worldwide locations including 3 manufacturing sites.
- Winners of three British Engineering Excellence Awards.
- Capacity to produce over 2,000 tonnes of Nylon per annum.
- Supplying key industries worldwide: Automotive, Construction, Offshore, Oil & Gas, Defence, Food & Drink, Packaging, Pharmaceutical, Marine.
- Award winning Engineering Training Academy.
- Inward investment into:
  - Lean Manufacturing
  - JIT / Kanban
  - Manufacturing Skill Base

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Marine Applications
What is a polymer?

Example of the Polyamide 6 process

Heat the monomer, add catalyst & activator

Opened up rings of monomer join together in very long slender polymers. In the case of PA this gives particularly high tensile strength and impact toughness.
The Polymer Triangle

PI - Polyimide
PAI - Polyamide-imides
PES - Polyethersulfone
PC - Polycarbonate
PMMA - Acrylic
PS - Polystyrene
PVC – Polyvinyl Chloride
ABS - Acrylonitrile butadiene styrene
Some common polymers:

- **PEEK** - Polyetheretherketone
- **PTFE** - Polytetrafluoroethylene
- **PA** – Polyamide (Nylon)
- **POM** - Polyoxymethylene (Acetal)
- **PP** – Polypropylene
- **PE** – Polyethylene
  - Low, high and ultra-high density

(Polyurethanes are another large group mostly used for non-structural applications so not covered here)
Subsea Polymers

Disclaimer

The following are generic and typical figures.

Properties of polymers are highly dependent on the specific raw materials, the manufacture process and the test method. For critical applications always request specific manufacturer material test data.
## Subsea Polymers

Relative properties at a glance

<table>
<thead>
<tr>
<th></th>
<th>Strength</th>
<th>Temp</th>
<th>Impact resistance</th>
<th>Friction</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEEK</td>
<td>High</td>
<td>High</td>
<td>Med</td>
<td>Med</td>
<td>$$$$</td>
</tr>
<tr>
<td>PTFE</td>
<td>v Low</td>
<td>High</td>
<td>n/a</td>
<td>V Low</td>
<td>$$$</td>
</tr>
<tr>
<td>PA 6</td>
<td>High</td>
<td>Med</td>
<td>Med</td>
<td>V Low*</td>
<td>$$</td>
</tr>
<tr>
<td>POM-C</td>
<td>Med</td>
<td>Med</td>
<td>Med</td>
<td>Med</td>
<td>$$</td>
</tr>
<tr>
<td>PP</td>
<td>Low</td>
<td>Med</td>
<td>Med</td>
<td>Med</td>
<td>$</td>
</tr>
<tr>
<td>HDPE</td>
<td>Low</td>
<td>Med</td>
<td>High</td>
<td>Med</td>
<td>$</td>
</tr>
</tbody>
</table>

* PA 6 Lubricated formulation
The ultimate performance polymer

- High strength – 116MPa tensile
- Machines well
- High temperature resistance 260 deg C
- High chemical resistance
- High radiation resistance

But
- Expensive
- Not available >150mm dia
The low friction polymer

- Very low friction
- High temperature resistance: 260 deg C
- High chemical resistance

But

- Low strength 22Mpa
- Soft and easily flows under load
- Frequently used as a dry lubricant within other materials
POM-C - Polyacetal

Characterised by a highly rigid crystalline structure. Copolymer (Acetal) version is most used. The homopolymer version (Delrin™) has higher strength.

- Good tensile strength 67 Mpa
- Good machinability – will take a very fine finish
- High dimensional stability
- Practically unaffected by water
- Medium resistance to impact
- Dimension constraints on homopolymer version

Delrin is a DuPont trademark
PE - Polyethylenes

Low and medium density (PE) – food and packaging use
High density (HDPE) – engineering applications
Ultra high molecular weight (UHMW-PE) – premium

- Low tensile strength 25 Mpa
- Low hardness
- High impact resistance (HPDE)
- Exceptional resilience (UHMW-PE)
- Low dimensional stability – it will creep under high load
- Can be welded
- Unaffected by water
- Low cost

PE plugs

HDPE Rollers (with Nylube inserts).

UHMW-PE Mooring ropes
PP - Polypropylene

PP is a low density material similar to PE but notably lower density.

- Low tensile strength 30 Mpa
- Excellent impact resistance
- Positively buoyant in seawater
- Good dimensional stability – will machine well
- Unaffected by water
- Low cost

ROV side panels

Hand ropes

[Image of a ROV side panel]

[Image of hand ropes]
PA – Polyamide

A versatile material combining strength, toughness and stability. Many versions – PA 6 specifically here.

- High strength – 83MPa tensile
- Dimensionally stable (when cast)
- Impact resistant
- Good temperature resistance 100 deg C
- High chemical resistance
- The default sheath material for flexible pipelines

- In the cast version, it is particularly suitable for process modification and additives to create specific grades for bearings, creep, wear, temperature and many others

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No! – the material name is just the start.

- Polymerisation is a process. The result depends on both the quality of the raw materials, the specific catalysts and the process control (mixing, time, heat, curing and ageing)
- Cast polymers have the polymerisation direct in the mould. This gives maximum possible strength.
- Extruded and injected polymers generally use pre-made pellet stock. The polymers lose strength each time they are melted and have greater tendency to residual stress - may “spring” when cut. (Especially large tubes and bars)
- For critical applications, always ask for specific material test figures and batch control.
Moisture Absorption

Many polymers are light materials with relatively open structures. In most cases, any water absorbed will sit in cavities and does not react.

However PA 6 has a known sensitivity to water absorption. Water will weakly react with the polymer.

In Nylacast tests a PA 6 block in seawater for 3 years gained 0.5% weight after 3 years. This indicates absorption is a surface effect only.
Polymer bearings

All polymers have natural bearing properties. Smooth metal will slide on contact.

For true bearing applications, there are many specialised polymer formulations. Many are combined products, often using PTFE in a matrix of structural material. Many suppliers on the market, especially for small diameters.

PA 6 with lubricant addition is particular good for large bearings, pads and rollers. The PA gives a robust structure to take the load while the additives reduce the friction.

Design notes:
• Bearing bushes need a true interference fit
• The interference will transfer to reduce the shaft ID
• Always use a true clearance shaft fit
• (refer to manufacturer guidelines)
PA 6 Custom formulations

Brief Overview

PA 6 is particularly suitable for custom formulations. The following are some examples:

<table>
<thead>
<tr>
<th>Custom Formulation</th>
<th>Description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA 6 Natural</td>
<td>Unmodified grade of cast nylon 6</td>
<td>Structures</td>
</tr>
<tr>
<td>Nylube</td>
<td>Cast Nylon with Oil and Wax additives</td>
<td>Bearings</td>
</tr>
<tr>
<td>Oilon</td>
<td>Cast Nylon with Oil fill</td>
<td>Bearings</td>
</tr>
<tr>
<td>Aquanyl</td>
<td>Copolymer with Nylon 12 Laurinlactam</td>
<td>Subsea</td>
</tr>
<tr>
<td>H S Blue</td>
<td>Heat Stabilised grade of Cast Nylon</td>
<td>Improved heat range</td>
</tr>
<tr>
<td>Moly</td>
<td>Cast Nylon with Molybdenum (MoS₂)</td>
<td>Wear (sheaves etc)</td>
</tr>
<tr>
<td>CF110</td>
<td>Ultimate PA 6 for creep resistance</td>
<td>Creep</td>
</tr>
<tr>
<td>CF160</td>
<td>Heat Stabilised nylon</td>
<td>HPHT downhole</td>
</tr>
<tr>
<td>CF306</td>
<td>30% glass filled</td>
<td>Surface Hardness</td>
</tr>
<tr>
<td>Nylastat</td>
<td>ATEX approved material with low friction</td>
<td>Conductive anti-static</td>
</tr>
</tbody>
</table>
Application examples

Energy, Marine, Offshore

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Sheaves & Segmented Sheaves

- Low weight (1/7 of steel)
- Corrosion free
- Less maintenance
- Extended rope life
- Enhanced performance
- ATEX Option
- Large diameter (examples to 3m)
- High loads capacity (examples to 180T)
Rollers

- Low Friction
- Bearing grade materials
- Complete assembly
- ATEX Option

- Diablo
- Guide
- Vertical / Side
- Composite
- Snub
Winch Spooling Shells

- Low mass (1/7 of steel)
- Easy to install / change
- Multiple wraps
- Range of sizes <300 to >1200

- TMS / LARS
- Umbilical
- Hydrographic Survey
- Winch

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ENGINEERED PRODUCTS

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Shrouds

- Neutral buoyancy
- Easy handling subsea
- Low maintenance
- Good thermal performance

- PLETs
- SPOOLs
Riser components

- High visibility
- Corrosion free
- Neutrally buoyant
- Diver or ROV installable
Centralisers (PiP)

- More than 500,000 in service
- Good thermal resistance
- Creep resistant
- Grip enhanced inner surface

- J / S-Lay / Reeled
- HPHT
- Bundle
- ETH
Distributed buoyancy module clamps (DBM)

- CF110
- Creep Resistant
- Low Moisture uptake
- Life > 25 years

- Flexible risers
- Subsea clamps of all types
ROV buckets & handles

- Corrosion free
- Less maintenance
- No CP required
- High visibility
- >4kNm (ISO Class 4 bucket)

- Christmas Trees
- Valves
- Tooling
- Connectors

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J Tube seals

- Bespoke design
- Incorporating seals
- Bend restrictor elements
- Offshore wind farms
- Cables
- Umbilical's