PVC – Polyvinyl Chloride

Legacy SeaPerch Resource www.seaperch.org

What is PVC?

PVC, Polyvinyl Chloride, is a thermoplastic polymer, a material that can be heated to it's melting point, then formed into a shape and allowed to cool to a brittle but rock solid material at room temperature. The manufacturing of PVC relies on this transformation from molten plastic to hard plastic to create a variety of shapes that can withstand a multitude of environmental stresses.

These stresses include:

- Heat (up to 60º C or 140º F)
- Pressure
- Collisions
- Acidic material
- Physical deformation

This specific set of material properties allows PVC to:

- Bend slightly under stress before it breaks
- Resist corrosion from acids
- Resist fracture when dropped
- Hold a lot of pressure before bursting
- Work in a variety of temperatures

With this diverse set of material properties, PVC is an ideal material to hold and move in water and act as a structural member. If you want more information on material properties of PVC, check out Lenntech's PVC webpage.

Why PVC?

Although there are thousands of materials in the world, it is essential to choose the best match of material properties for the application and design criteria.

In the case of plumbing, the criteria are that the material must:

- Be able to hold pressurized hot water
- Withstand the environment of a construction site
- Not contaminate drinking water
- Resist damage from being dropped
- Low cost

In the case of a structural material, the properties of interest are:

- Cost effectiveness
- Rigidity (resistance to bending)
- Availability
- Resistance to dropping or impact
- Safe handling
- Waterproofing

Although there are many materials that meet most or all of these requirements (like steel), PVC meets all of the requirements and is the least expensive. As a result, the industry standard for plumbing for many years has been PVC. Many other low cost, low force structures use PVC as well.

How is PVC made?

PVC is made of salt and oil. Salt provides chlorine when energy is added to the salt crystal (sodium chloride). The energy breaks the internal bonds and releases the chlorine from the salt.

Oil is heated and cooled rapidly and repeatedly, which break oil's large molecules of hydrocarbons into smaller molecules, some of which are known as ethylene (small forms of hydrocarbons). These ethylene molecules are filtered out using pressure and distillation.

Once these two molecules are extracted and contained, they are mixed together in high temperature baths resulting in a new molecule known as ethylene dichloride, which at high temperatures becomes vinyl chloride. This vinyl chloride is then polymerized (forced to bond with more of the same molecule) to create polyvinyl chloride.

PVC is not the final step. Depending on what material properties are needed, materials are added during the heating stage to get a more flexible material, a different colored material, a less flammable material, or a more impact resistant material. As a result, it is possible to design a plastic that is an exact match to any design criteria.

Why is PVC used for SeaPerch?

In order to find the perfect material to use to make an underwater vehicle or SeaPerch, the requirements for building a small underwater vehicle must be determined. Some of those requirements are: resistance to water, rigid, strong, inexpensive, easily available, diversity of connections, easy to work with, and can be used in small applications.

The next step is to evaluate possible materials. What materials are used in ships, submarines, and other marine applications? Possible materials include metals, wood, resin, fiberglass, and plastics. A basic evaluations of these materials follows:

1) Metal – Metal is is rigid, can carry large loads, and has a diversity of shapes/sizes. However, it is expensive, difficult to cut, heavy, and rusts in water. Aluminum doesn't rust and is lightweight but it is expensive and more difficult to work with.
2) Wood – Wood is easily available and can carry large loads, but doesn't work well in small applications without a lot of work.

3) Resin – Resins are characterised by their very good electrical properties and chemical resistance, good strength and low absorption of moisture; however, they are not easy to obtain or work with.
4) Fiberglass – Fiberglass is lightweight and strong and can be molded into a variety of shapes; however, it must be molded which makes it not easy to work with.
5) Plastic – Plastic is generally low cost, easy to manufacture, durable, strong for its weight, electrically and thermally insulative, and resistant to shock, corrosion, chemicals, and water. When PVC is considered, it is easy to obtain in many shapes, sizes and connection options in most home improvement stores, easy to cut and work with, and can be used in small applications.

When evaluating the properties of different materials, it becomes apparent that PVC is an ideal material for SeaPerch.

Vocabulary

Fiberglass: A reinforced plastic material composed of glass fibers embedded in a resin matrix.

Polymer: A substance or material consisting of very large molecules, or macromolecules, composed of many repeating subunits.

Resin: A solid or highly viscous substance of plant or synthetic origin that is typically convertible into a polymer. Resins are usually mixtures of organic compounds and are widely used in building as adhesives, coatings or as a construction material when a strong bond is required

Plastic: A synthetic material made from a wide range of organic polymers such as polyethylene, PVC, nylon, etc., that can be molded into shape while soft and then set into a rigid or slightly elastic form.

Test Your Knowledge

1. Evaluate glass as a potential material to use for building an underwater vehicle. List the positive aspects as well as the negative aspects.

POSITIVES	NEGATIVES

Resources:

Videos:
The PVC Production Process Explained: https://www.youtube.com/watch?v=PvlrXifViVM

Articles:
British Plastics Federation - PVC: https://www.bpf.co.uk/plastipedia/polymers/pvc.aspx