Ablative shielding

Overview

Trainees will learn about how heat transfers and how heat tiles and ablative systems protect space craft. In the activity, trainees will attempt to create an ablative heat shield to protect.

Objective

Describe how heat tiles protect the orbiter. Create a thermal protection system that uses these concepts to protect and egg. Define ablation, convection, conduction and radiation.

Materials

For the briefing:

- Projector
- PowerPoint

For shield testing:

- Pre-fabricated test stand
- Propane tanks (2)
- Propane igniter
- Eggs (1 per sub-team)
- Flame resistant mat (Optional)
- Safety cones
- Safety glasses
- Safety gloves
- Fire extinguisher
- Infrared Thermometer

Shield construction materials:

- Data / scoring sheets
- Cotton balls
- Large steel
- Uncooked lasagna noodles
- Spackle
- Cork
- Sponges
- Steel wool (No soap added)
- Acrylic yarn
- Aluminum foil
- Aluminum mesh
- Copper mesh
- Cotton yarn
- Felt
- Paper (4” x 4”)

Introduction

The trainees may already know that the shuttle and other spacecraft travel at 17,500 mph (or 28,000 kmph). When the spacecraft reenters, it uses the air to help it slow down. This heats the air immediately around the orbiter to temperatures of in excess of 3000 °F (1649 °C), hot enough to melt steel.

On the orbiter thermal protection is provided by tiles – about 24,000 and NOMEX blankets. The tiles come in three colors – each one withstanding differing amounts of heat. White tiles can withstand heat up to about 1,200ºF (650ºC), black tiles up to 2 300 F (1 260 °C) and gray tiles up to about 3,600 °F (1,649 °C). Location of tiles is determined by the amount of heat an area receives upon re-entry. White blankets made of coated Nomex felt reusable surface insulation are used on the upper payload bay doors, portions of the mid-fuselage and aft fuselage sides, portions of the upper wing surface and a portion of the OMS/RCS pods and is protective up to temperatures of 700 °F (371 °C). The shuttle TPS is reusable, and the tiles are like marshmallows made of glass—10 % silica (sand) and 90 % air—a marshmallow is essentially a ball of sugar puffed up with air—the TPS tiles are similar, microscopic air pockets make the glass block lighter than Styrofoam but highly resistant to heat.

The principal task of the heat shield that forms the outer structure is to protect the crew from the fiery heat of reentry—heat so intense that it melts most metals. The ablative material makes up the shield is a phenolic epoxy resin, a type of reinforced plastic. This material turns white hot, chars, and then flakes away, taking the heat with it. The heat is absorbed and shed by the shield and does not penetrate to the capsule interior.

The command module enters the atmosphere with its base down; this is covered by the thickest part of the heat shield. The heat shield varies in thickness from ½ to 2¾ inches thick (1.3-7 cm) and weighs about 3,000 pounds (1,360 kg).

Ablative Budget Sheet

Shield Survival Time = _____

Requirements:

1. Only the provided items may be used to build your ablative shield.
2. No going over the **100 Credit** budget!
3. Your shield should be no thicker than the width of a standard pencil.

Budget: 100 Credits				
Supplies	**Amount Per Purchase**	**Price Per Item**	**Quantity Used**	**Total Cost**
Egg-stronaut	1	Free	1	0
Cotton Balls	5	30		
Large Steel	3” x 3”	30		
Pasta (Uncooked Lasagna)		30		
Gypsum	1 Tablespoon	30		
Cork		15		
Sponges		15		
Steel Wool	1 piece (Pre-Cut)	15		
Copper sheet		60		
Aluminum Foil	1 piece	5		
Aluminum Net	1 piece	20		
Copper Mesh		5		
Fiberglass net		10		
Felt		5		
Paper		5		
			Ablative Shield Credits Used:	

Ablative Score Sheet

Criteria	Result Ranges Points	Points Earned
Survival Points	No charring & no cooking = 200 Points Some charring, but not cooked inside = 100 Points Charred & cooked inside = 0 Points	
Unused Credits	100 - _____ = (Budget) - (Credits Used)	
	TOTAL =	

Conduction

The transfer of energy between objects that are in contact. Metals are good conductors of heat.The best conductors of heat include silver, gold, copper, aluminum and iron.

Examples: warming a pot on a stove or melting ice by holding it

Convection

The transfer of energy between an object and its environment, due to fluid motion. Usually the dominant form of heat transfer in liquid and gases The best convectors of heat include air, water, oils.

Examples: toaster or central heating

Radiation

Takes place in form of electromagnetic waves. Radiant energy (like from a radiator) is how energy from the sun warms the Earth despite the 93 million miles of the vacuum of space that lie in between.