Specification and Selected Materials

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2.2.1 Overview

The Sphere Space Station (Earth ONE) is an innovative space station designed specifically for operation in Low Earth Orbit (LEO). This document describes the material selection and specifications for various structural components and functional units of the station. Based on the unique requirements of space deployment, special materials and composites have been chosen to withstand extreme environmental conditions and operational demands.

2.2.2 Introduction

In the demanding environment of low Earth orbit, every material must endure intense stresses, including: - **Fire resistance** for exposure to high thermal loads. - **Acid and chemical resistance** to ensure long-term durability even in chemically stressed areas. - **Biological resistance** to protect against mold, microbes, and biological contamination. - **Rapid decompression and temperature fluctuation resistance**, as temperatures in LEO can range from -150°C to 120°C.

2.2.3 Material Requirements and Specifications

To meet the needs of the space station, the following silicon-based and additional materials have been selected as primary components:

2.2.3.1 Silicon Carbide (SiC)

- **Properties**: Extremely hard, chemically resistant, and fireproof; withstands temperatures above 1000°C.

- **Advantages in space**: Resistant to thermal shocks and radiation exposure, ideal for highly stressed structural components.
- **Disadvantages**: Brittle; requires composite techniques for elasticity.

2.2.3.2 Silane-based Polyimide Compounds

- **Properties**: Chemically stable, elastic, and heat resistant.
- **Advantages in space**: Withstands extremely low temperatures, exhibits low outgassing, and is resistant to biological influences.

2.2.3.3 Silicon-based Elastomers

- **Properties**: High elasticity and temperature resistance; good resistance to chemical and biological effects.
- **Advantages in space**: Excellent for shock absorption and vibration resistance in a vacuum environment.

2.2.3.4 Silica Aerogels

- **Properties**: Lightweight, heat resistant, and extremely insulating.
- **Advantages in space**: Provides strong thermal insulation and radiation resistance; however, brittle, so best used as a coating.

2.2.4 Structural Components and Material Selection

Materials are chosen specifically according to the application area and mechanical load to achieve an optimal balance between strength and weight.

2.2.4.1 Load-Bearing Structures

- **Recommended materials**: Silicon carbide (SiC) as the main structural material, supplemented by silicon elastomers for vibration damping.
- **Advantages**: High structural stability, resistant to rotational dynamics and vibrations.

2.2.4.2 Hull Components and Heat Exchangers

- **Recommended materials**: Silane-modified polyimides and heat-resistant ceramics for outer hull sections; steel for pressurized water pipes.
- **Advantages**: Chemical stability, high heat resistance, and pressure tolerance, ideal for heat exchanger applications.

2.2.4.3 Radial Bulkheads Along the Axis of Rotation

- **Recommended materials**: Combination of SiC and carbon-fiber-reinforced polymers.
- **Advantages**: Provides protection against mechanical loads and fire hazards; low weight and high strength.

2.2.4.4 Tangential Constructions

- **Recommended materials**: Silicon-based elastomers and lightweight carbon polymers.
- **Advantages**: Flexibility and vibration damping to absorb rotational loads.

2.2.4.5 Cabin and Laboratory Constructions

- **Recommended materials**: Silane-based polyimides, coated silica aerogels for thermal insulation, steel and carbon polymers for structural components.
- **Advantages**: Protection against temperature fluctuations and high biological resistance.

2.2.4.6 Spatial Constructions (Shops, Workshops)

- **Recommended materials**: Silicon elastomers and carbon polymers as base structure.
- **Advantages**: Adaptable, lightweight, yet sturdy enough for various spatial uses.

2.2.5 Specific Materials for Special Applications

2.2.5.1 Steel, Carbon Polymers, and Ceramics

- **Areas of use**: Steel for highly stressed internal structures (e.g., pipes in the heat exchanger), carbon polymers for lightweight structural applications, and ceramics as thermal barriers in high-temperature areas.
- **Function**: Targeted placement of these materials optimizes weight while ensuring the necessary resistance and stability.

2.2.6 Appendix A: Window Specification and Material Selection of LEO-based Earth ONE Station

High-Performance Composite Window for Space Applications: Material and Specification Overview

A.1 Introduction

The selection of materials for the windows of the Earth ONE station demands an extraordinary level of durability. These windows are subject to extreme temperature fluctuations, rapid decompression, impacts from micrometeorites, and high levels of UV and cosmic radiation. The proposed composite window uses a multi-layered construction designed to withstand these conditions, ensuring optical clarity and maximum protection.

A.2 Window Requirements in Low Earth Orbit (LEO)

- **Temperature Range**: -150°C to +120°C, requiring resistance to extreme thermal cycling.
- **Pressure Fluctuations**: Resilience to rapid decompression without failure.
- **Impact Resistance**: Resistance to micrometeorite impacts at velocities of up to 15 km/s.
- **Radiation Shielding**: UV and cosmic radiation protection to prevent damage over extended periods.

A.3 Layered Material Structure

A.3.1 Outer Layer: Aluminum Oxide (Sapphire) or Aluminum Oxynitride (ALON)

- **Properties**: Hardness, UV resistance, and protection against high-velocity impacts.
- **Thickness**: 5 cm, providing optimal micrometeorite resistance.

A.3.2 Middle Layer(s): Fused Silica (Quartz Glass) and Polycarbonate

- **Fused Silica**: Thermal stability and UV shielding.
- **Polycarbonate**: Shock absorption and impact resistance.
- **Total Thickness**: 10 cm for fused silica and 5 cm for polycarbonate.

A.3.3 Inner Layer: Borosilicate or Cerium-doped Glass

- **Properties**: Additional radiation protection and optical clarity preservation.
- **Thickness**: 3 cm.

A.4 Total Thickness and Weight

- **Overall Thickness**: Approximately 20–30 cm for optimal protection.
- **Weight per Square Meter**: Approximately 530–550 kg/m², significantly heavier than conventional bulletproof glass but offering substantially greater resistance to space-specific hazards.

A.5 Comparison to Bulletproof Automotive Glass

In contrast to high-end bulletproof glass, which is optimized for low-velocity impacts and ambient temperatures, this space-grade composite window structure withstands high-energy impacts, thermal extremes, and radiation exposure, ensuring robust and reliable performance for the Earth ONE station.

2.2.7 Conclusion

The specified materials and configurations of the Earth ONE station enable unparalleled resilience against the harshest conditions of the low Earth orbit environment. By tailoring each component's material properties to its functional demands, the Earth ONE station is engineered for optimal performance, durability, and safety.

2.2.8 Sources

No external sources used.