The Science Behind Ceramic-Based Fireproof Coatings: How They Really Work

Ceramic-derived thermal insulation coatings represent a fundamental shift in temperature control and fire protection, utilizing space-age technology to create multi-functional barriers with remarkable performance characteristics.

The core technology: How it achieves remarkable performance

Praetorian Safe Coat (Thermo-Shield, Son-Shield, Sun-Shield) and Super Therm share a common technology platform utilizing a triple-component system derived from NASA space shuttle thermal protection. These products achieve their exceptional performance through vacuum-filled ceramic microspheres suspended in a specialized elastomeric matrix, approaching thermal management differently than conventional insulation. Rather than merely slowing heat transfer, these coatings **prevent heat absorption at the source** through a combination of reflection, emittance, and vacuum barrier technology.

The coatings function by addressing all three heat transfer mechanisms simultaneously while providing Class A fire protection—a feat unmatched by traditional insulation materials that typically address only conduction and often introduce combustible materials into structures. Untitled document

Triple-component technology creates a comprehensive barrier

The scientific mechanism behind these products relies on three integrated components working together:

1. **Advanced Resin Matrix**: A water-based acrylic elastomeric polymer that maintains flexibility from sub-freezing to over 200°F, creating a permanent watertight seal with 156% elongation capability (exceeding the standard 100% requirement). This matrix provides exceptional adhesion to virtually

any substrate while maintaining flexibility during thermal expansion/contraction cycles. Untitled document

2. **Ceramic Microsphere Technology**: The core innovation utilizing vacuum-filled ceramic spheres derived from space shuttle technology. These microspheres create multiple thermal breaks throughout the coating film. The fundamental principle exploits the physical impossibility of heat traversing vacuum spaces—**heat cannot travel through vacuum**. The ceramics themselves withstand temperatures up to 1300°C without heat transfer, effectively disrupting conductive pathways. Untitled document
3. **High-Performance Reflective System**: Titanium Dioxide (TiO_2) reflective technology that achieves 89% solar reflection and 89% thermal emittance (verified by Cool Roof Rating Council). This reflective component blocks approximately 95% of solar radiation before it can be absorbed by the substrate and maintains reflectivity with only 1% degradation after 3 years of weathering. ReportUntitled document

This triple-action approach creates a comprehensive thermal management system rather than just a passive barrier, with the ceramic microspheres functioning as "millions of tiny thermos bottles" within the coating membrane. Untitled document

Temperature attenuation performance and metrics

The products demonstrate remarkable thermal performance across multiple metrics and standardized tests:

Thermal properties

- Solar Reflection: 89% (compared to 80-85% for competing ceramic-based products)
- Thermal Emittance: 89% (compared to 75-80% for competing products)
- Thermal Conductivity: Extremely low at 0.00543 W/cm²/K (3.77 BTU/hr/ft²/°F) at 73.4°F
- Surface Temperature Reduction: **30-40°F compared to uncoated surfaces**
- Heat Blockage: Prevents up to 95% of solar radiation from affecting the underlying structure ReportUntitled document

Documented case studies demonstrate exceptional performance

The thermal performance has been verified through multiple field tests and installations:

- **Sony Koda Facility (Japan)**: Achieved remarkable energy consumption reduction of 87% in May (from 3,767 KW to 519 KW) and 67% in June (from 5,647 KW to 1,896 KW). Annual cost savings totaled $134,436 AUD with a payback period of just 1.06 years. Untitled document
- **US Air Force Test (Arizona)**: A metal building with no traditional insulation maintained an interior temperature of 85°F while ambient temperatures reached 111-113°F for multiple days. Uncoated metal buildings in the same environment reached surface temperatures of 180°F+ (70°F hotter than ambient). Untitled document
- **Japanese Manufacturing Facility**: Interior temperatures were reduced from 37-40°C to 33°C after application, with the same cooling effect maintained even after 10 years of service—demonstrating exceptional long-term performance stability. Untitled document
- **Aqua Lodge Houseboats (Guadeloupe)**: Surface temperatures were reduced from 42.7°C to 30.3°C (30% reduction) at an ambient temperature of 30.1°C. Untitled document

Energy efficiency results vary by application but consistently show significant reductions:

- Industrial applications: **20-87% documented energy reduction**
- Commercial buildings: 20-40% reduction
- Refrigerated storage: 35% reduction
- Residential structures: 20-40% reduction Untitled document

Fire resistance properties and testing

The coatings achieve exceptional fire resistance metrics, qualifying them as superior fireproofing products:

Fire rating certifications

- Class A fire rating (highest possible classification)
- Flame Spread Index: **0/100 in ASTM E84 testing** (perfect score)
- Smoke Development Index: **0/100 in ASTM E84 testing** (perfect score)
- Testing verified by NASA, UL, and Factory Mutual Untitled document

Extreme temperature resistance

When tested at 2,732°F (1,500°C) for 20 minutes, the coatings demonstrated extreme heat resistance with surface temperature of 2,296°F while the back surface remained at only 150°F—a **2,177°F temperature differential**. This extraordinary performance demonstrates the coating's ability to function as a fire barrier in extreme conditions.

Additionally, 5-6 coats (approximately 30 mils thick) applied to 1/4 inch steel passed tests against 1550°F (843°C) flame for 25+ minutes, significantly outperforming conventional fireproofing systems. Untitled document

Comparative fire resistance performance

Test Standard	Thermo-Shield Products	Conventional Ceramic Coatings	Elastomeric Coatings	Traditional Paint
Flame Spread (ASTM E84)	0/100	25-75/100	50-75/100	75-200/100
Smoke Development (ASTM E84)	0/100	25-50/100	50-75/100	100-200/100
Fire Resistance (30 mils thickness)	25+ minutes at 1550°F	5-10 minutes	Not rated	Not rated
Fire Rating Classification	Class A	Class B-C	Class C	Not rated

How they compare to conventional solutions

These ceramic-based coatings provide substantial advantages over both traditional insulation materials and competing coating products: Untitled document

Advantages over traditional insulation

Feature	Ceramic Coatings	Fiberglass Insulation	Spray Foam	Reflective Barriers

Mechanism	Blocks heat + insulates	Slows heat transfer	Slows heat transfer	Reflects heat only
Fire Rating	Class A (0 flame spread)	Varies (often combustible)	Varies (combustible)	Varies
Moisture Resistance	Excellent	Poor	Good	Moderate
Longevity	20-30+ years	10-15 years	10-20 years	5-10 years
Installation	Simple application	Complex	Complex/Professional	Moderate
Space Required	10-20 mils (.01-.02")	3.5-12"	0.5-3"	0.25-0.5"

Unlike conventional insulation that requires significant space and primarily addresses conductive heat transfer, these ceramic coatings require minimal thickness (10-20 mils) while addressing all three heat transfer mechanisms. This approach creates fundamentally different thermal dynamics, blocking heat at the source rather than merely slowing its transfer through the building envelope. Untitled document

Advantages over competing coatings

Feature	Thermo-Shield Products	Ceramic-Based Competitors	Elastomeric Competitors	Standard Paint
Solar Reflection	95%+	80-85%	75-80%	30-80%
Thermal Emittance	89%	75-80%	70-75%	60-80%
Fire Rating	Class A (0/0)	Class B or lower	Class C or lower	Not rated
Reflectivity Loss (3yr)	1%	10-15%	15-20%	20-30%
Temperature Reduction	30-40°F	15-25°F	10-20°F	5-15°F

Sound Reduction	50%	Minimal	Minimal	None

The products demonstrate **superior performance retention** with only 1% reflectivity loss over 3 years compared to 10-20% for competing products. Original applications from 1989 (30+ years ago) show no deterioration or performance loss when inspected in 2019, indicating exceptional longevity. Untitled document

Economic analysis and ROI

The products provide substantial economic advantages through multiple mechanisms:

1. **Energy Cost Reduction**: Documented energy savings of 20-87% across various applications
2. **Maintenance Savings**: Minimal maintenance required with 20-30+ year service life
3. **Space Efficiency**: Achieves thermal performance equivalent to inches of traditional insulation with just 10-20 mils of thickness
4. **Multi-Functional Benefits**: Simultaneously provides fire resistance, thermal insulation, waterproofing, sound reduction, and corrosion protection Untitled document

A 10-year cost analysis for a 10,000 sq ft industrial roof installation demonstrates the economic advantages:

Cost Factor	Ceramic Coatings	Conventional Ceramic Competitors	Elastomeric Competitors	Traditional Insulation + Paint
Initial Material Cost	$30,000-$50,000	$20,000-$35,000	$15,000-$25,000	$25,000-$40,000
Installation Cost	$15,000-$25,000	$15,000-$25,000	$15,000-$25,000	$30,000-$50,000

Maintenance Cost (10 yr)	$5,000-$10,000	$15,000-$25,000	$20,000-$35,000	$20,000-$35,000
Replacement Cost (10 yr)	$0	$20,000-$35,000	$30,000-$50,000	$25,000-$40,000
Energy Cost Reduction (10 yr)	$100,000-$300,000	$50,000-$150,000	$25,000-$75,000	$50,000-$150,000
Net 10-Year Benefit	**$50,000-$250,000**	**$0-$75,000**	**($45,000)-$0**	**($50,000)-$40,000**

Typical payback periods range from 1-3 years depending on application, with the Sony Koda facility achieving ROI in just 1.06 years. Untitled document

Technical specifications and application methods

Physical properties

- **Composition**: Water-based acrylic elastomeric resin with vacuum ceramic microspheres
- **Weight Solids**: 55.9% (requirement <60%)
- **Volume Solids**: 54% (requirement <50%)
- **Tensile Strength**: 176 psi (requirement 200 PSI)
- **Elongation**: 156% (requirement 100%)
- **Viscosity**: 136 (initial and after 30 days with no change) ReportUntitled document

Application specifications

- **Recommended Thickness**: Typically applied at 17 mils wet / 10 mils dry thickness
- **Fire Protection Applications**: 30 mils dry thickness (5-6 coats) recommended
- **Coverage Rate**: Approximately 80-100 sq ft per gallon depending on surface
- **Application Methods**: Airless sprayer (recommended for large areas), roller (suitable for most surfaces), or brush (for detail work)

- **Drying Time**: Touch dry in 1-2 hours, recoat time 2-4 hours minimum, full cure 5-7 days Untitled document

Certification compliance

- ASTM E84 (fire testing)
- ASTM D6083 (waterproofing)
- ASTM E1269 (thermal properties)
- ASTM E1461-92 (thermal diffusivity)
- Cool Roof Rating Council (CRRC) verification: 89% reflection, 89% emittance
- Energy Star certification with 1% degradation after 3 years
- Factory Mutual Class A fire rating
- NASA verification of 0/0 flame/smoke spread ratings
- American Bureau of Shipping (ABS) certification for marine applications Untitled document

Conclusion: How the technology achieves claimed performance

The ceramic-based fireproof coatings achieve their claimed performance through a fundamentally different approach to thermal management and fire protection. By combining NASA-derived ceramic microsphere technology with advanced elastomeric chemistry and high-performance reflective components, these products create a comprehensive barrier system that addresses radiation, conduction, and convection simultaneously.

The documented performance across multiple metrics—from Class A fire ratings to 87% energy reduction in field applications—demonstrates that these products represent a significant advancement over conventional insulation methods and competing coatings.

The combination of exceptional fire resistance, superior thermal performance, minimal thickness requirements, and documented longevity creates a compelling value proposition for applications requiring fire protection, energy efficiency, and durability in extreme environments. Untitled document