

## **S**pray **A**ppplied **F**ire **R**esistive **M**aterials

Onshore and Offshore



# W.R. Grace Inc. & Co. at a glance

- Founded in 1854
- Headquarter in Cambridge – U.S.A.
- 2010 Worldwide Sales — \$ 2.7 billion
- Listed on the New York Stock Exchange
- +6000 employees worldwide
- [www.graceconstruction.com](http://www.graceconstruction.com)



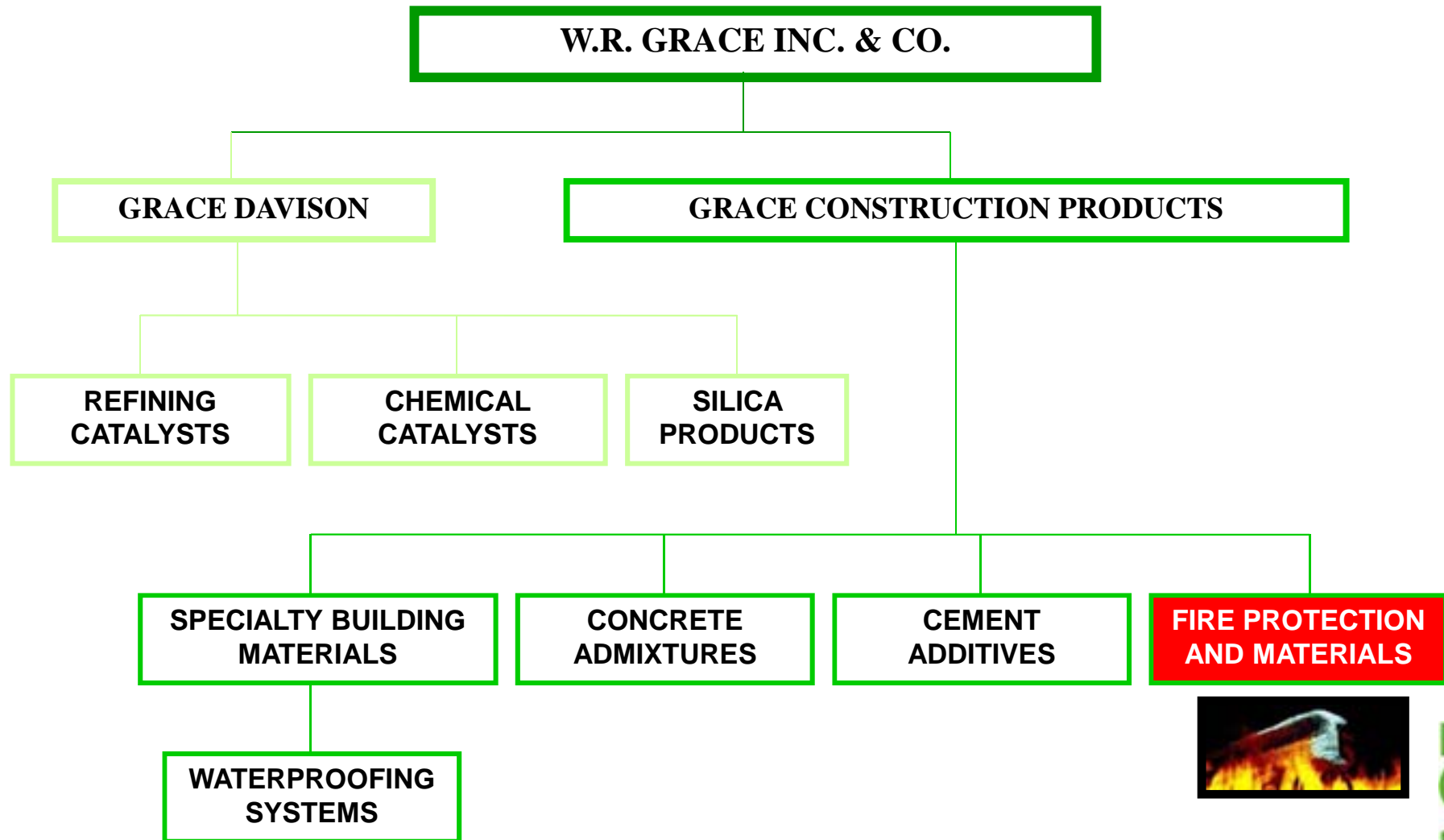
# Grace worldwide presence



Offices: ●

Fireproofing production facilities: ●

# Grace business units



GRACE

# Grace Global Market Positions in 2010

- **World #1 in Cellulosic Structural Fireproofing**
- **Hydrocarbon Structural Fireproofing:**
  - **#1 in ME; #2 in EU; #3 in the USA**
- **World #1 in Fluid Cracking Catalysts**
- **World #1 in Resid Hydroprocessing Catalysts**
- **World #1 in Independent Polyethylene Catalysts**
- **World #1 in Micronized Silica Gel**
- **World #1 in Can Sealants**
- **World #1 in Cement Additives**
- **World #2 in Concrete Admixtures**



# Different fire curves and fire scenarios

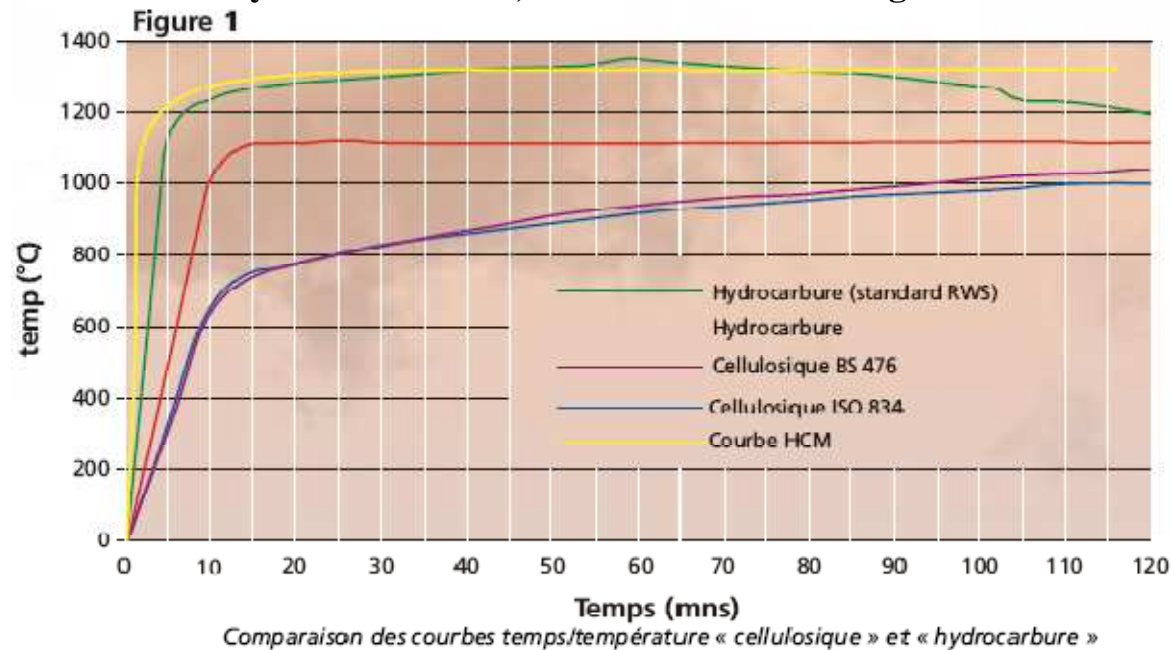


Commercial or  
cellulosic fire



Petrochemical or hydrocarbon fire

Every fire is different, Grace offers a full range of materials



Tunnels

# Fireproofing standards

Mostly adopted international hydrocarbon fireproofing standards :

- **UL 1709** (globally accepted and most well-known hydrocarbon fire test)
- **BS 476 Part 21 Appendix D** (fairly known hft mainly in the UK, Australia and India)
- **ASTM E-1529** (hydrocarbon fire test fairly known mainly in the USA)
- **API RP 2218** (fireproofing guideline globally accepted)
- **OTI HSE 95634** (jet fire test – globally accepted)
- **Factory Mutual** (LPG structural protection & hose stream test – globally accepted)
- **DNV** (mainly accepted in the offshore industry)
- **Lloyd's Register** (mainly accepted in the offshore industry)

# Typical areas that need fire protection

- Structural elements (beams and columns)
- Storage tanks (especially LPG)
- Divisional protections (underdecks and bulkheads)
- Concrete structures (to avoid spalling)
- Vessels skirts
- Pressure vessels supports
- ... others





# The Monokote family in the world

## – **MONOKOTE Z-146 PC**

- High Density, insulating inorganic coating (40 pcf - 640 Kg/m<sup>3</sup>)

## – **MONOKOTE Z-156 PC**

- Ultra High Density, insulating inorganic coating (50 pcf - 800 Kg/m<sup>3</sup>)

Developed to meet the harsh conditions found in  
Petrochemical Processing and Refinery Facilities



# The Monokote family in the Middle East

- **AVIKOTE AV650 (same as Z-146 PC)**
  - High Density, insulating inorganic coating (40 pcf - 640 Kg/m<sup>3</sup>)
- **AVIKOTE AV800 (same as Z-156 PC)**
  - Ultra High Density, insulating inorganic coating (50 pcf - 800 Kg/m<sup>3</sup>)



# Features of Grace fireproofing products

- RWS, UL 1709, FM, Jet-fire\* tested and approved products
- Lloyds Register approved for offshore installations
- Over 50 years of experience in fire protection, extensive track record
- The only products containing a special corrosion inhibitor
- Long term durability and excellent in-place “real” performances
- Explosion tested with 227 Kg (500 lb) of TNT placed 19 meters (20 yd) away
- Easy to trowel, to spray and to cast
- Application by Grace certified companies
- Worldwide technical service and presence

\* 2 hrs according to HSE OTI 95634 with 2 tons of propane; >2 bar pressure; 45 m/sec velocity (49 yd/sec); 0.3 Lt/sec (10,6 ounce/sec) flow rate

# Benefits of Grace fireproofing products

- Based on Bauxite (not poor aggregates like sand and vermiculite)
- Lightweight, about 65-75% lighter than regular concrete
- UL certified for exterior exposure under thaw/freeze cycles, rain, wind
- Superior bonding and mechanical characteristics
- Lower overall costs if compared to similar products
- Stock availability and speed of delivery anywhere in the world
- Low thermal conductivity
- Up to 25 mm (1 in) thickness per coat
- High yield rates
- Tested for cryogenic conditions

# Benefits of Grace fireproofing products

- Non flammable and non combustible
- Asbestos, chlorides and sulphides free
- Suitable for upgrading regular concrete fire resistance
- No smoke and no gas generation during a fire
- Ready to use products – just add potable water
- Endothermic insulating coating with subliming characteristics



# Liquid Nitrogen Test (LNG facilities)

A steel plate coated with 25 mm (1 in) of Monokote Z-146 PC has been submerged for 60 minutes into a liquid nitrogen bath at a temperature of  $-198^{\circ}\text{C}$  ( $-324^{\circ}\text{F}$ ).

After 60 minutes the sample has been removed from the liquid nitrogen bath and allowed to return to ambient temperature.

The sample was tested for bond strength according to ASTM E-736.



## RESULTS:

Bond strength values showed no significant difference between a sample submerged into liquid nitrogen and a sample not been submerged.

No degradation of material has been observed.



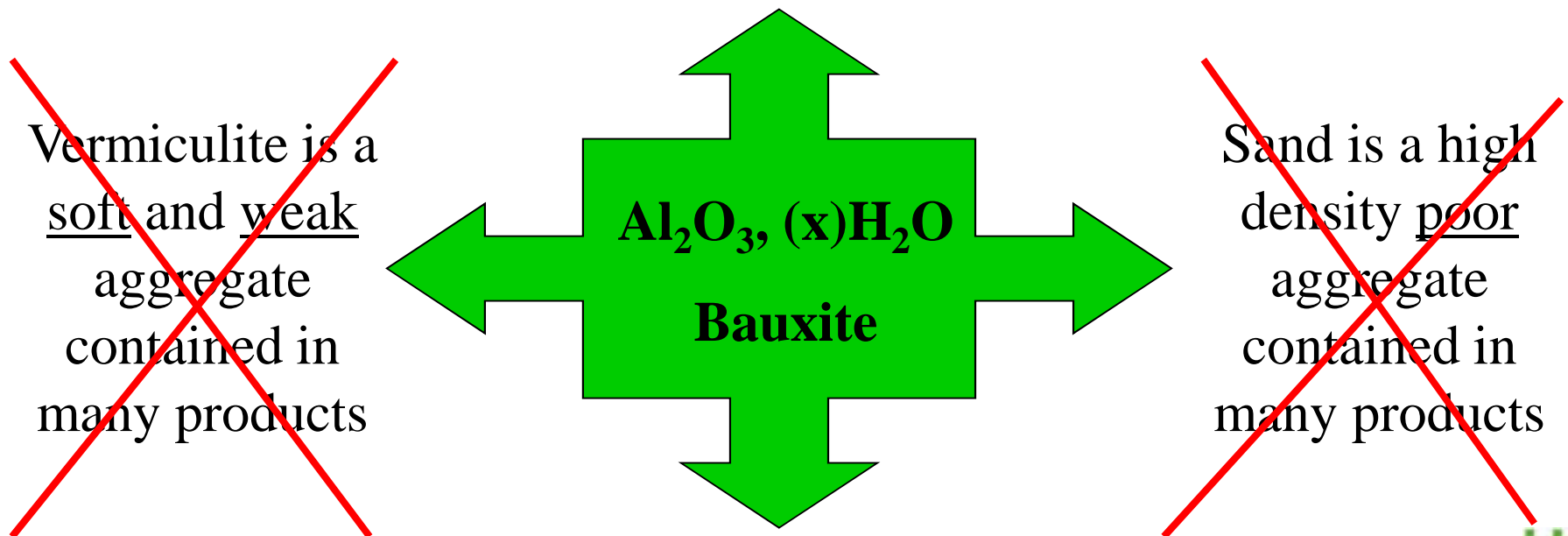
# UL - exterior ambient exposure test

- **Accelerated Aging**
  - In a circulating air oven at 80°C for 135 days
- **High Humidity**
  - 35°C and 100% relative humidity for 180 days
- **Salt Spray Exposure**
  - Salt spray (fog) testing in accordance with the methods described in ASTM B 117-97 for 90 days
- **Cycling Effects of Freeze/Thaw**
  - Simulated rainfall of 18 mm/h for 72 h (extremely heavy rainfall)
  - Followed by a temperature of -43°C to -37°C for 24 h
  - Followed by a temperature of +57°C to +62 °C for 72 h
  - This cycle is repeated 12 times, so the entire test lasts 84 days
- **Industrial Atmosphere Exposure**
  - Gas contains 1% SO<sub>2</sub> (sulfur dioxide) and 1% CO<sub>2</sub> (carbon dioxide)
  - 30 days



# What makes Monokote Z products different ?

**Monokote includes a high density aggregate which contains water that is chemically released during a fire**



**Monokote is free from Vermiculite and Sand.**

# Hardness makes a great difference

Mohs' scale is used to measure the hardness of minerals

1- Talc

2- Gypsum

3- Calcite

4- Fluorite

5- Apatite

6- Orthoclase

7- Quartz

8- Topaz

9- Corundum (used for blasting metal)

10- Diamond

Vermiculite – 1,5 Mohs

**Bauxite is 500% harder than Vermiculite**

Bauxite – 9 Mohs

Soft - Scratched with a finger nail

Semi hard - Scored by a metal cutting tool

Hard - Not scored by a metal cutting tool

# Other differences

## Melting points:

**Bauxite: 2050 °C (3722 °F)**

**Vermiculite: 1350 °C (2462 °F)**

## Most typical uses:

**Bauxite: refractory materials**

**Vermiculite: horticultural market (95%)**

## Abrasion:

**Bauxite: low**

**Vermiculite: very high**

## Water/moisture absorption:

**Bauxite: lower**

**Vermiculite: Higher**

Fireproofing materials should have the lowest possible water/moisture absorption. Vermiculite based fireproofing contain as much as 30-40% vermiculite, leading to high water uptakes.



# Bauxite Vs. Vermiculite

Manufacturer:	Product formulation based on:
W. R. Grace Monokote Z series	Bauxite
Carboline Pyrocrete's range	Vermiculite
Cafco-Promat-Isolatek Fendolite MII	Vermiculite

# Vermiculite drawbacks

- Extremely soft and weak
- Highly hygroscopic (attracting water and moisture)
- More prone to cracks generation and CUI/CUF issues
- Particles may contain certain levels of asbestos
- Particles cause severe eye irritation and coughing

**MONOKOTE DOES NOT CONTAIN VERMICULITE**

# Why is the corrosion inhibitor relevant ?

Galvanized wire mesh condition after just 5 years



Competitor's product without corrosion inhibitor

Monokote Z-series with corrosion inhibitor

21

GRACE

# Why is the corrosion inhibitor relevant ?

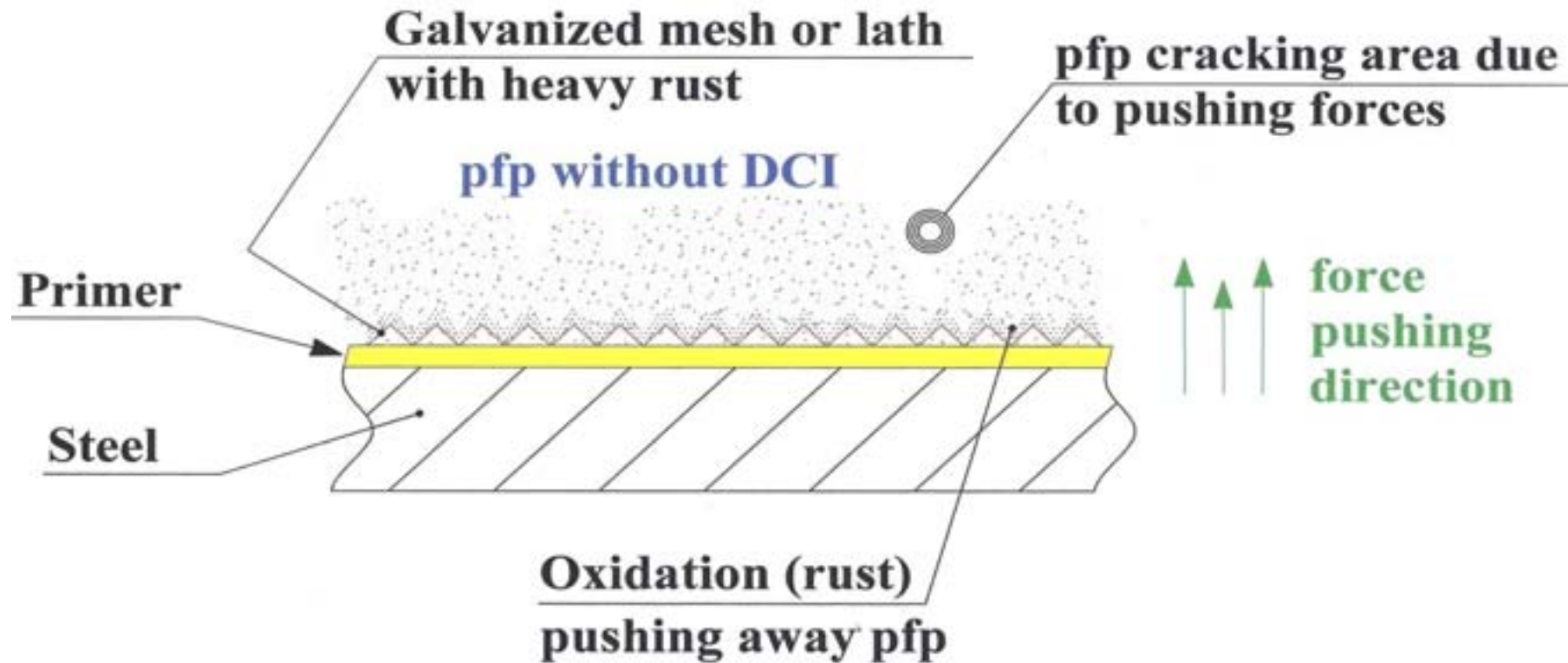
One of the main purposes of using a metal mesh is to hold in place the fireproofing product during a fire and/or during an explosion.



Corroded meshes cannot hold in place the fireproofing during a hydrocarbon fire because they have lost most of their original thickness through oxidation.

Consequently during a fire the fireproofing may be easily detached from the substrate leading to its temperature increase and structural collapse.

# Why is the corrosion inhibitor relevant ?



Monokote has been formulated with a unique and special Corrosion Inhibitor (DCI) capable of neutralizing high levels of chloride ion concentrations existing in potable waters



# Key features in fireproofing materials

## **LOOK FOR THESE KEY FEATURES WHEN SELECTING YOUR PASSIVE FIRE PROTECTION**

High bond strength (= stronger cohesion and long term performance)

High hardness (= better impact resistance)

Low thermal conductivity (= lower heat transmission)

Corrosion inhibitor (= better corrosion protection)

High yield rates (= less material consumption)

High thickness per coat (= higher production rate)

Fully tested products (= maximum performance)

# Physical properties

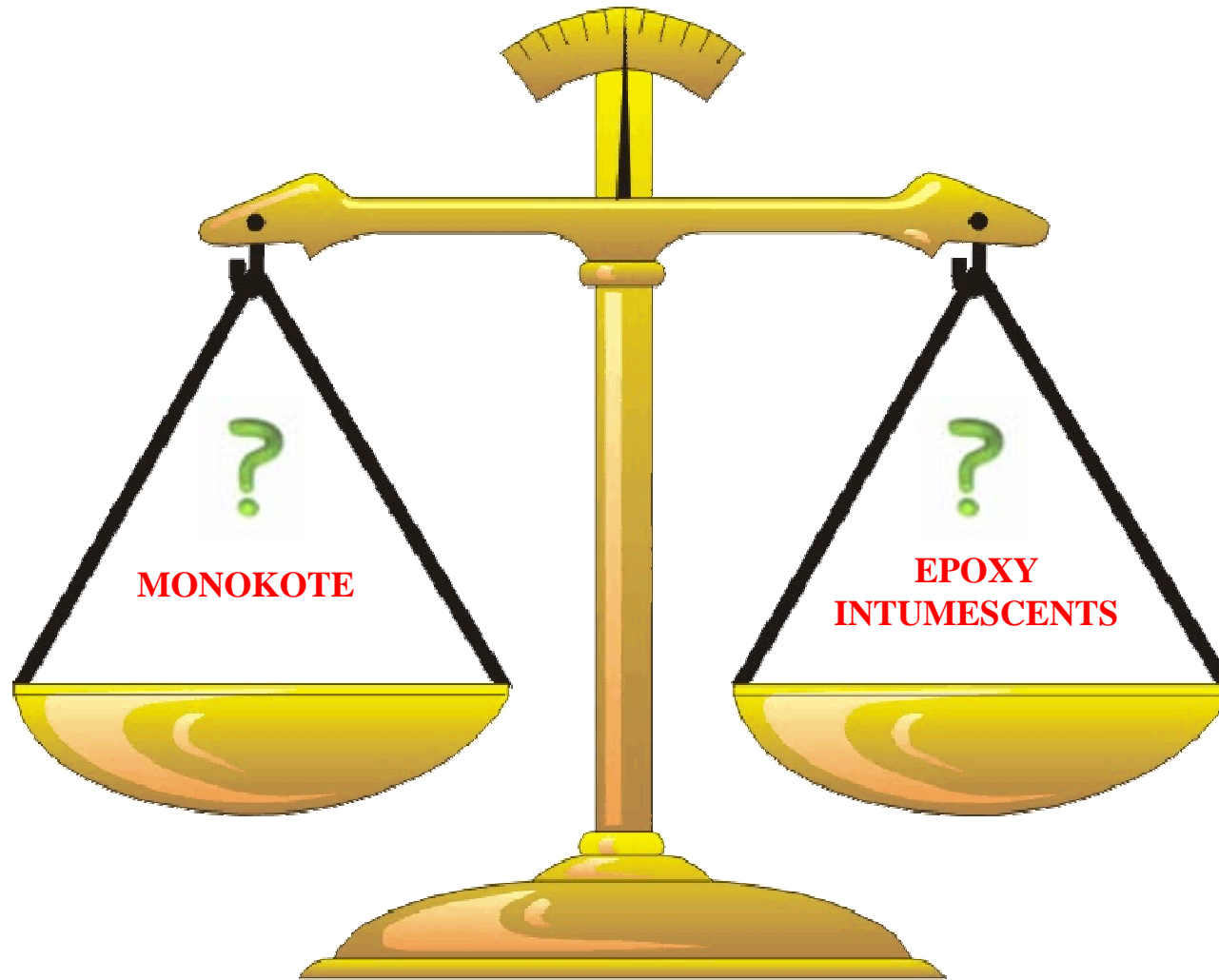
	PROPERTIES	
Product commercial name	Monokote Z-146 PC	Monokote Z-156 PC
Type	High density	Ultra high density
Minimum density when dry and in place	640 Kg/m3 (40 pcf)	800 Kg/m3 (50 pcf)
Bond Strength, recommended values	4.9 Kg/cm2 (10,000 psf )	4.9 Kg/cm2 (10,000 psf)
Bond Strength, independent laboratory test	8,8 Kg/cm2 (17,967 psf)	>13 Kg/cm2 (>26,536 psf)
Shore D hardness, recommended values	40	40
Shore D hardness, independent laboratory test	49	91
Compressive strength at 10% deformation, recommended values	35 Kg/cm2 (500 psi)	60 Kg/cm2 (850 psi)
Compressive strength at 10% deformation, independent laboratory test	38 Kg/cm2 (541 psi)	74 Kg/cm2 (1,059 psi)
Corrosion Inhibitor	YES	
Type of aggregate	Bauxite (hard aggregate)	
Yield rate per bag (theoretical)	39 m2 at 1 mm (16.7 bf)	31 m2 at 1 mm (13.3 bf)

# Thickness Vs. fire rating

Thickness of Monokote depends upon:



- Fire rating (up to 4 hours)
- Standard adopted (UL 1709, BS 476, LLOYDS, etc.)
- Section factor of the element (massivity)
- Critical temperature (usually 538°C or 1000 °F)

# Monokote vs. epoxy intumescent



*Sorry, we  
cannot specify  
Monokote  
because at same  
fire rating it is  
much heavier  
than epoxy  
intumescent !!*

# Monokote vs. epoxy intumescent

	CEMENT BASED	EPOXY INTUMESCENT	KEY DIFFERENCES
Product commercial name	Monokote Z-146 PC	Several	-
UL 1709 - avg. 2 hours fire rating	28,5 mm (1 1/8")	15 mm (10/16")	-
Density	640 Kg/m3 (40)	1200 Kg/m3 (75 pcf)	Intumescent over 87% higher density than Monokote
 Average weight per square meter applied at given thicknesses	18,5 Kg (40.8 lb)	18 Kg (39.7 lb)	Intumescent only 3% less weight per m2 than Monokote
Average waste during application (i.e. H section)	7%	25%	Intumescent waste 57% higher than Monokote
Average cost of product	1 €/Kg (0.66 \$/lb)	13 €/Kg (8,75 \$/lb)	Intumescent cost 1200% more than Monokote
 Average product cost per square meter considering waste + mesh	€ 20 (29,67 \$)	€ 295 (437.6 \$)	Intumescent cost per m2 1375% more than Monokote



# Monokote vs. epoxy intumescent

Features	Monokote	Epoxy Intumescent
Product, application & labor cost	lower	higher
Sound absorption properties	yes	no
Ease of maintenance	easy	complicated
Maximum hydrocarbon fire resistance	4 hours	3 hours for most
Maximum jet-fire resistance	2 hours	30-45 minutes
Hardness Shore D	up to 90	up to 55
Maximum RH% allowed during application and curing	90%	70-75%
Compatibility with existing primer	yes, most likely	no, in most cases
Primer applied at specified thickness range	no	yes (3-5 mils)
Concerns about primer maximum over-coating window	no if proper lath is used	yes, always
Smoke and gas generation during a fire	no	yes (HCL, CO, NH3)
Application in closed spaces	yes	no
Minimum ambient temperature during application and curing	5°C (40 °F)	10°C (50 °F)
Primer approval	generally not required	yes, always mandatory
Maximum thickness per coat	25 mm (1")	7 mm (1/4")
Application over hot dip galvanized steel without tie-coat	yes	no
Fire performance over CHS	high	low
Application in shop with on-site erection	yes	yes
Degradation over time	no	yes, due to the epoxy nature
Thermal conductivity	lower	higher

# Monokote vs. epoxy subliming

- Sublimation requires a phase change from a solid state into a gas, absorbing large amounts of energy in the form of heat
- One of the main characteristics of sublimation is that it is an endothermic process
- When Monokote is exposed to fire it enters an endothermic process similar to sublimation because the binder absorbs heat as the chemical water is converted from its crystal structure into a vapor gas
- Unlike epoxy subliming/intumescent products which are totally sacrificial because they are physically consumed as they absorb heat (leaving less protection to the steel over time), Monokote undergoes the endothermic process retaining most of its original thickness, and therefore providing better and longer protection to the steel during a fire through its tough insulating coating.

# Surface finishing

- The most typical application requires a smooth surface finish. The finish facilitates subsequent cleaning, is easily paintable and provides a 'concrete like' appearance. Top-coating with acrylic, epoxy and polyurethane paints according to specific requirements.
- Texture can be attained by adjusting the nozzle orifice size, air pressure, and product density. These adjustments will give different degrees of finished texture.

Smooth



Textured

Smooth

# Typical onshore protective system

A typical protective system resistant to corrosion and fire depends very much upon the environmental corrosion class as specified by ISO 12944-2. Every case should be evaluated specifically, nevertheless a typical example could be:

- One coat of zinc rich epoxy or zinc phosphate primer
- One coat of high build epoxy coating (optional)
- Monokote Z series
- A topcoat in any RAL color, such as acrylic, epoxy or a polyurethane coating (topcoat is optional)

# Typical offshore protective system

A typical protective system resistant to corrosion and fire depends very much upon the environmental corrosion class as specified by ISO 12944-2. Every case should be evaluated specifically, nevertheless an example could be:

- One coat of zinc rich epoxy or zinc rich silicate primer\*
- One coat of high build epoxy coating or epoxy tie-coat\*
- Monokote Z series
- A topcoat in any RAL color, such as epoxy or polyurethane

# A look at Corrosion Under Insulation

Carbon steel is more prone to CUI when operating at temperatures between  $-4^{\circ}\text{C}$  ( $25^{\circ}\text{F}$ ) up to  $150^{\circ}\text{C}$  ( $300^{\circ}\text{F}$ ). More specifically CUI is also called CUF (Corrosion Under Fireproofing)

CUI starts when water, moisture or other electrolytes penetrate into the anticorrosive primer down to the substrate

The continuous wet/humid condensation processes taking place beneath the primer will dramatically increase the corrosion rate of the substrate



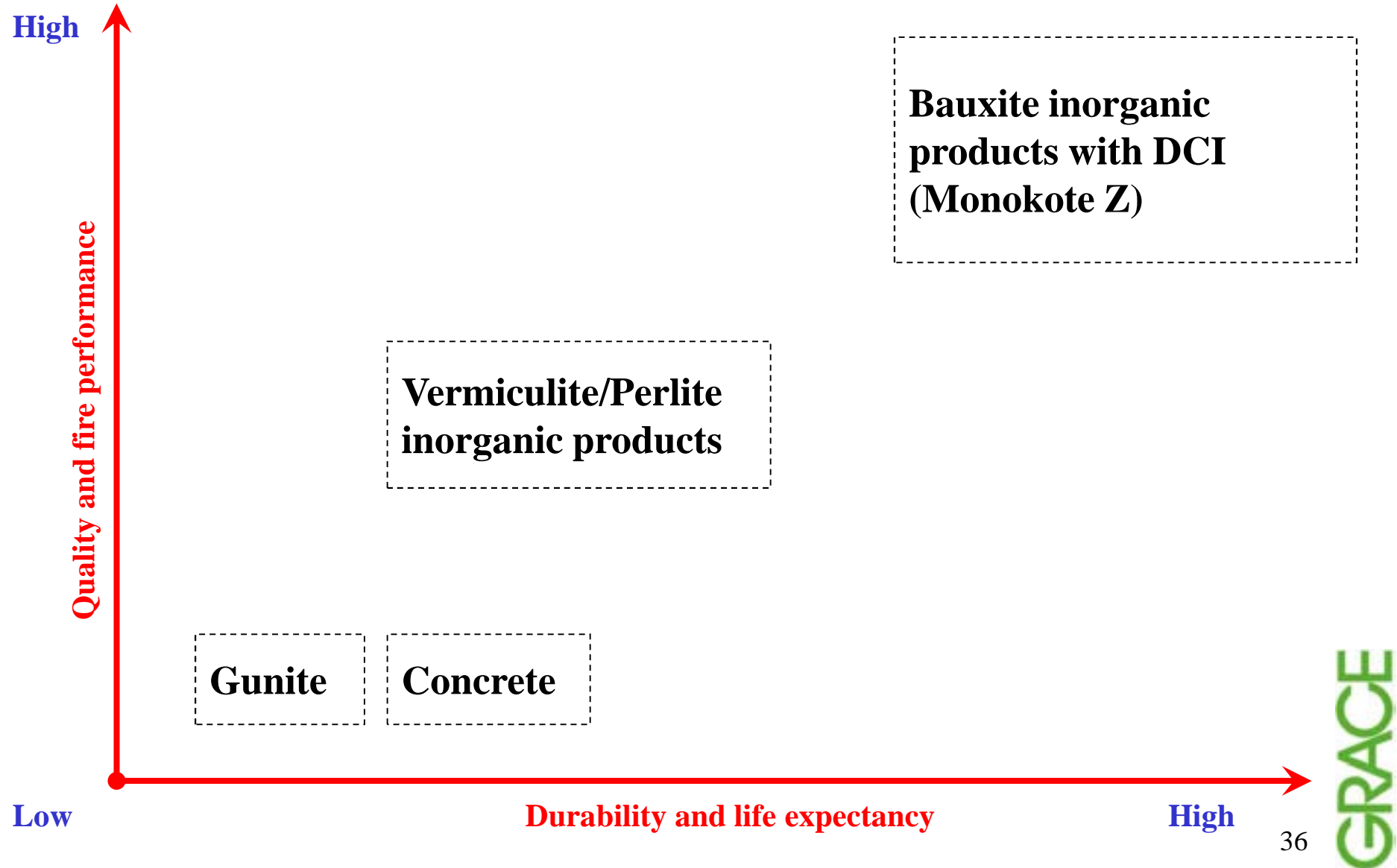
# How to face CUI over carbon steel

CUI on carbon steel can be limited, and in most cases even solved, by specifying a proper anti-corrosive system

When CUI is suspected to take place, the use of zinc rich silicate primers should be avoided if possible, or alternatively they should be protected with an epoxy tie-coat because these products show very critical performances in wet/humid confined conditions

Last but not least, a good quality application along with a good maintenance program are the best tools to keep the integrity of the total protective system. More details on CUI/CUF prevention can be found on NACE RP 0198-98 standard

# Durability of inorganic products



# 4 easy steps for application

1



**MONOKOTE**

2



**WATER**

**MIXING**

3



**PLASTERING  
MACHINE**

**APPLICATION**

4

**GRACE**

# Benefits of using Monokote Z series

For the Engineering Company	For the PFP Contractor
Fully tested products with proven in-place reliability	High yield rates (less material consumption)
Production facilities with top quality manufacturing control	Ease of application even in high-rise installations (lower labor cost and high production rate)
Highest life expectancy	Products far less abrasive than vermiculite based products (longer life for equipments)
New generation products that can also be used instead of epoxy intumescent	High thickness per coat (higher productivity)
Global products availability and technical assistance	Stock availability
Excellent physical properties of Monokote Z series. New generation products	Speed of deliveries
You will have qualified professionals helping you defining pfp specifications	Competitive prices
Grace balanced business and financial stability	Regular training offered by Grace
Choosing Grace systems means getting maximum performance and cost-savings	Lower overall costs when compared to any other fireproofing system
Choosing Grace means getting a complete service rather than just products	Single source supplier (paints, lath, fixing devices)

## .... just a few references

Repsol	Kuwait Oil	Sasol
Lukoil	Avon Chemicals	World Trade Center
Agip (ENI)	Mobil Aimcor	UN buildings
Esso	Qatar Gas	Enagas
Shell	Emirates Gas	Fluor
Hyundai	QP Refinery	Saipem (ENI)
LG	Gasco, Foster Wheeler	OPF Shakalin
Samsung	Laffan Refinery	Infineum
Abu Dhabi Gas	Texaco	... and others
Q-Chem	Aramco	

# Grace Construction Products Contacts

## Ing. Giuseppe de Luca

Sales Development Manager - Fireproofing EMEA

**Grace Construction Products**

*SSPC Certified P/C Specialist – Frosio Certified Coatings Inspector Level III*

W. R. Grace Italiana S.p.A.

Via Trento, 7

20017 Passirana di Rho (Milano) - Italy

**T** +39 02 93537517   **M** +39 340 8386570

**F** +39 010 9642549

**E** [giuseppe.deluca@grace.com](mailto:giuseppe.deluca@grace.com)

**W** [www.grace.com](http://www.grace.com)

GRACE

GRACE