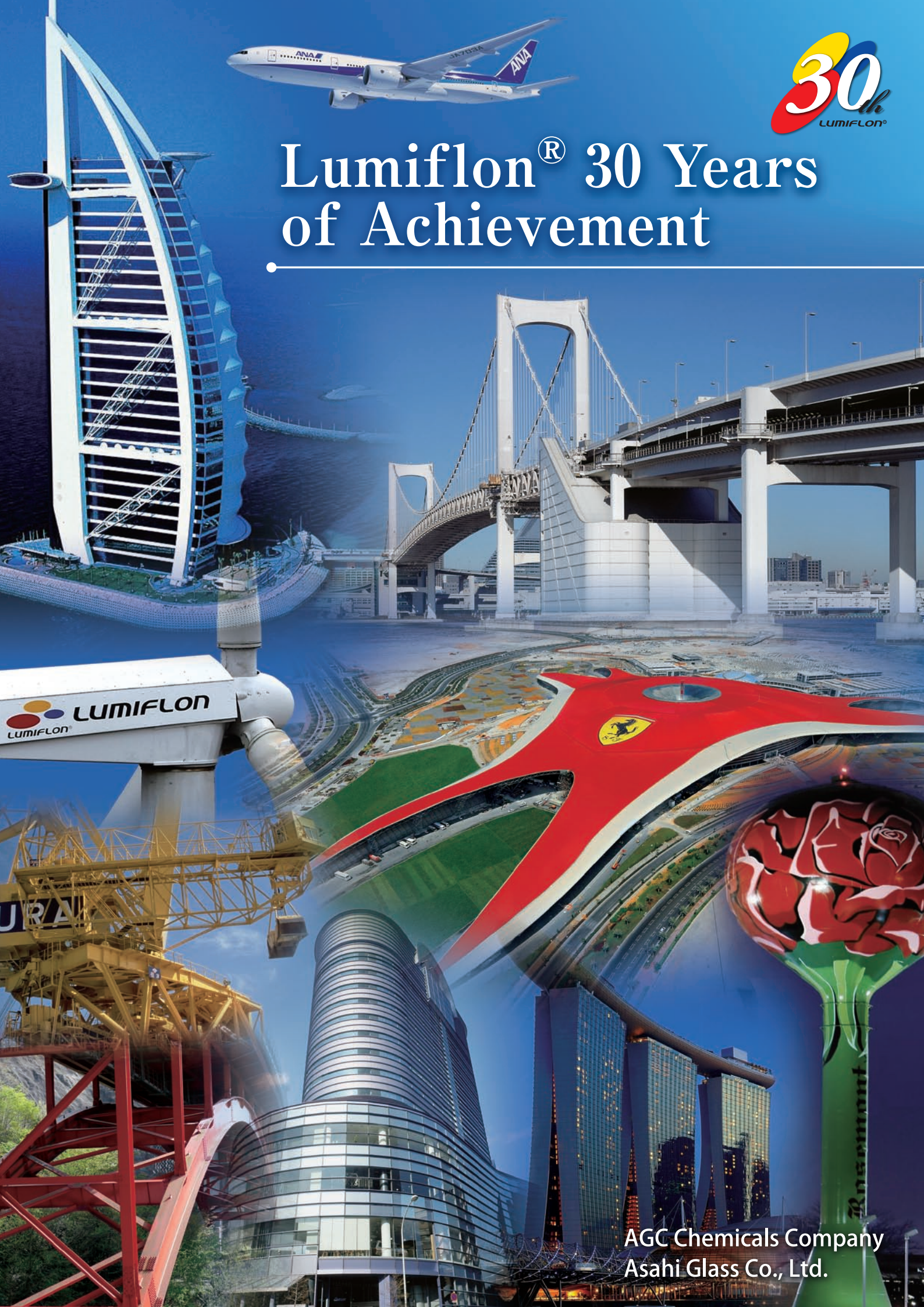


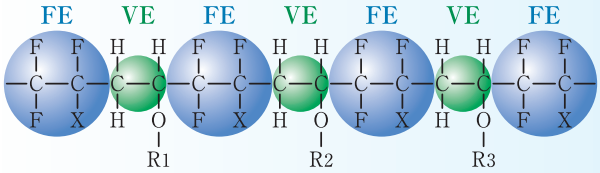
Lumiflon® 30 Years of Achievement

AGC Chemicals Company
Asahi Glass Co., Ltd.

Development of Lumiflon®

The world's first solvent-soluble fluoropolymer for coatings was developed 37 years ago, and it is still being used with the same structure. This fluoropolymer for coatings was commercialized in 1982 as "Lumiflon®" by Asahi Glass. Chemically Lumiflon® is a fluoroethylene-vinyl ether alternating copolymer (see Figure 1).

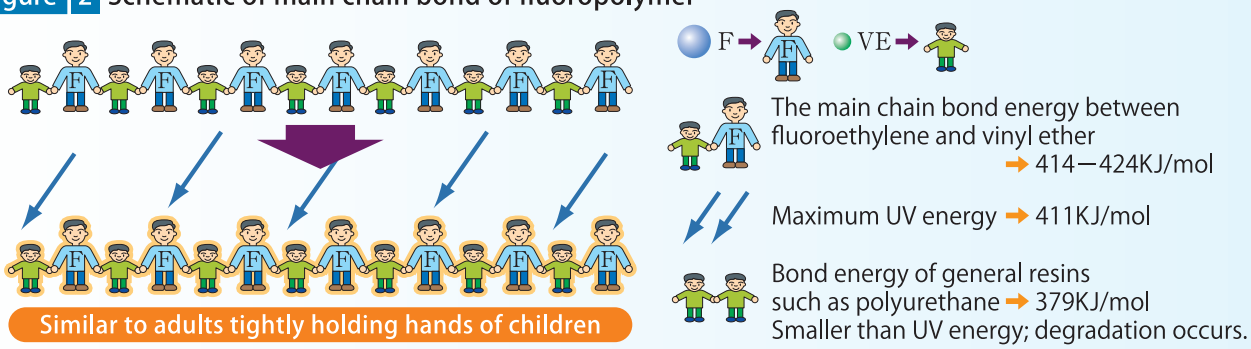
Figure 1 Fluoropolymer for coatings, Lumiflon® Structure of fluoroethylene (FE) and vinyl ether (VE)



This amorphous resin is soluble in general organic solvents, has high transparency, can be cured by cross-linking sites, and creates tough coating films from room temperature to 250℃. The alternating copolymer structure gives high durability and excellent chemical resistance.

The energy of the alternative main chain bond between fluoroethylene and vinyl ether is higher than the maximum UV energy of sunlight, and so in principle, it does not degrade. In contrast, other resins such as polyurethane break down and deteriorate due to their low bond energy (see Figure 2).

Figure 2 Schematic of main chain bond of fluoropolymer



Data on Weatherability and Life Cycle Costs

The high weatherability not only leads to long-lasting beautiful coatings but also drastically reduces Life Cycle Cost because repainting time decreases compared to conventional coatings. Simultaneously, it decreases the volatility of solvents, thus reducing VOC and conserving resources (see Figures 3 and 4).

Figure 3 Fluoropolymer's weatherability

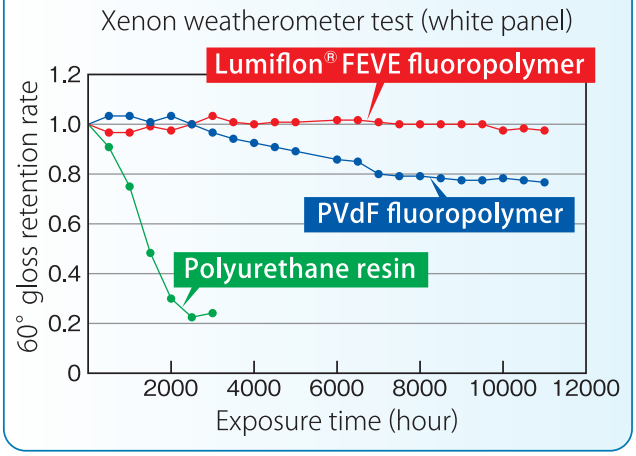
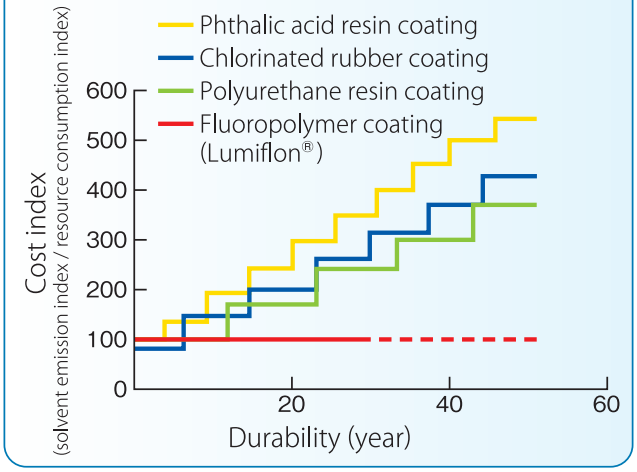


Figure 4 Fluoropolymer's life cycle costs



List of Awards for Lumiflon®

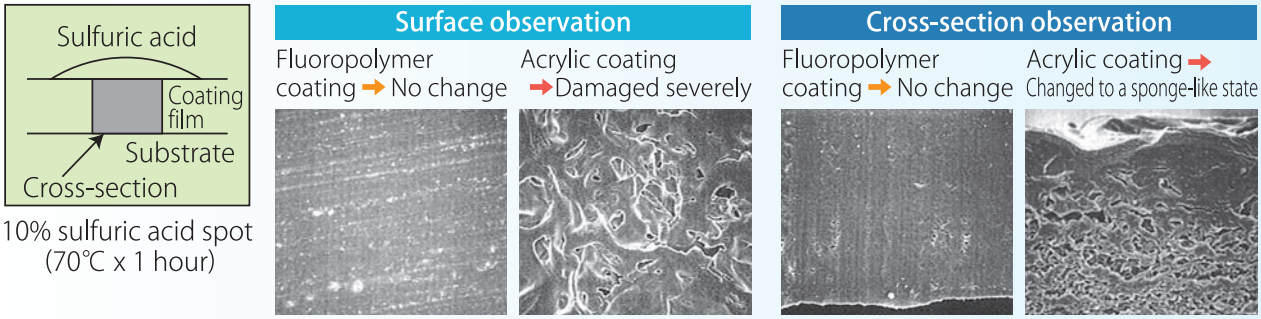
- 1983 : Nikkan Kogyo Shimbun's Best 10 New Products Award
- 1983 : Nikkei Inc.'s Nikkei Product Award
- 1984 : The Chemical Society of Japan's Chemical Technology Award
- 1985 : Ichimura Award for Achievement
- 1989 : Japan Chemical Industry Association's Technology Award

Basic Data

❶ Resistance to acid rain 10% sulfuric acid spot

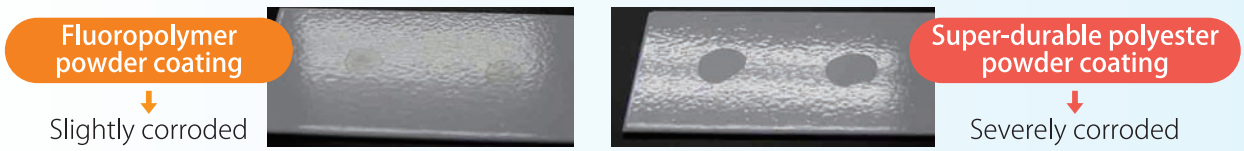
Figure 5 shows photos of cross-sections of coatings spotted with 10% sulfuric acid and heated at 70℃ for 1 hour. Fluoropolymer and acrylic resin coatings with melamine hardener are compared. The acrylic coating has deteriorated to a sponge-like state, whereas there is no visible change in the fluoropolymer coating.

Figure 5 Coating film spotted with acid Comparison between fluoropolymer Lumiflon® and acrylic resin



❷ Chemical resistance test 3% sulfuric acid spot (compared to the conventional powder coating)

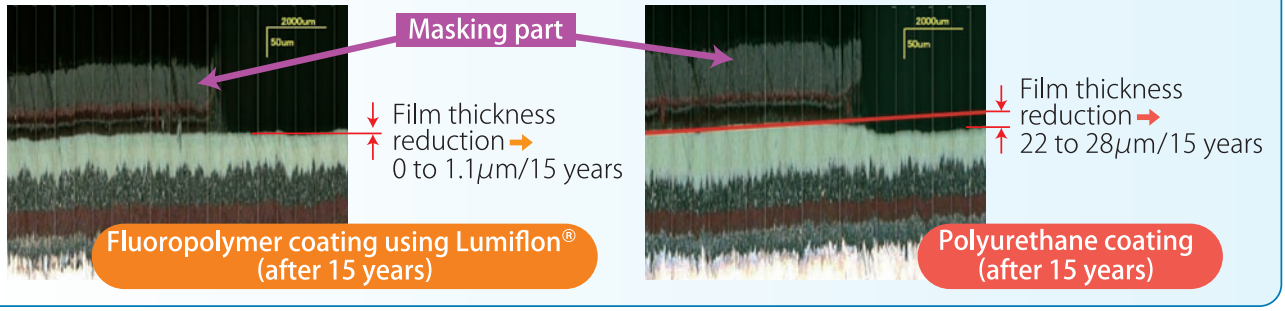
Figure 6 Coating spotted with acid Comparison between fluoropolymer powder coating using Lumiflon® and super-durable polyester powder coating



❸ Degree of coating thickness reduction (15-year exposure: comparison with polyurethane resin on the rooftop of Chugoku Technical and Engineering Office in Hiroshima)

In the fluoropolymer coating using Lumiflon®, little wear was observed over the 15-year period. In contrast, wear of 2μm per year was observed in the polyurethane coating (see Figure 7).

Figure 7 Degree of coating thickness reduction seen in cross-sections of the coatings (horizontal scale 1/20)



Follow-up Research Conducted with Government Agencies

Tokiwa Bridge

Previously, it had been painted with a chlorinated rubber paint, but after 8 years, it was repainted with Lumiflon® fluoropolymer paint and has remained in good condition for 25 years since.

Daiichi Mukaiyama Bridge

New bridge. Zinc-rich paint was used as a primer to prevent corrosion. It remains in good condition after 25 years. Phthalic acid resin coating, which was applied at the same time, was repainted after 16 years.

Nikko River Bridge

New bridge. Zinc-rich paint was used as a primer to prevent corrosion. The original appearance remains after 20 years.

Actual Achievements

Civil Engineering

Important standards : Honshu-Shikoku Bridge Authority's Coating Standards (1990), Handbook for Steel Highway Bridge Coating (1990), JISK-5659 (1998), Nagoya Expressway Public Corporation's Design Standards (2002), standards of various former public corporations related to highways, etc. (1992-2002), New Handbook on Painting and Corrosion Prevention of Steel Highway Bridges (2005)

Akashi-Kaikyo Bridge

Coating completed in 1998.
Main towers, main cables, hanger ropes, and all other exterior surfaces are coated with fluoropolymer paint.

The Honshu-Shikoku Bridge Authority specified the use of fluoropolymer paint as the standard coating for new bridges as well as for repainting, beginning in 1990.

Rainbow Bridge's main towers

Coating completed in 1993.
As an expressway bridge in the Tokyo Bay area, it adopted fluoropolymer coating early on.

Kiyosu Bridge

Coating completed in 2005.
Since repainting was done at the site, mild solvent-based paints were used as both modified epoxy resin paint for the under/middle-coats and fluoropolymer paint for the topcoat.

Tokyo Gate Bridge

Coating completed in 2012.
- Anti-corrosion primer : Zinc-rich paint 75μm
- Undercoat : Epoxy resin paint 120μm
- Middle coat : Paint for fluoropolymer topcoat (basically epoxy resin paint) 30μm
- Topcoat : Fluoropolymer paint 25μm

A recently opened bridge that crosses Tokyo Bay. It is also popular for its unique shape which looks like a dinosaur.

Architecture

Important standards : Architectural Institute's JASS18 (1989), JISK-5658 (1992), Ministry of Land, Infrastructure, Transport and Tourism's Standard Specifications for Construction (1998)

Marunouchi Building

Location : Marunouchi, Chiyoda-ku, Tokyo
Coating completed in 2001.
Substrate : Concrete / Aluminum sashes
Technique : Baking / Drying at ambient temperature

This building in front of Tokyo Station was rebuilt as a state-of-the-art building while retaining its historical atmosphere.

Landmark Tower

Location : Minatomirai, Yokohama
Coating completed in 1993.
Substrate : Aluminum sashes
Technique : Baking

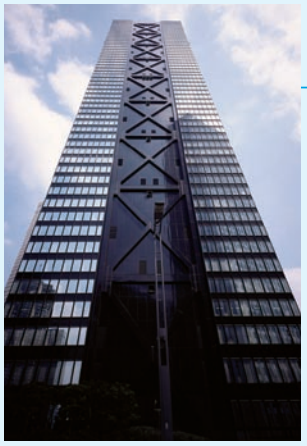
Queen's Square

Location : Minatomirai, Yokohama
Coating completed in 1997.
Substrate : Aluminum curtain walls
Technique : Baking

Carrot Tower

Location : Sangenjaya, Setagaya-ku, Tokyo
Coating completed in 1996.
Substrate : Concrete
Technique : Drying at ambient temperature

Carrot Tower and Tokyo International Forum used a coating which resists dirt accumulation for the first time in Japan.



Shinjuku Mitsui Building

Location : Nishi-shinjuku, Shinjuku-ku, Tokyo
Coating completed in 1989.
Substrate : Aluminum electrolytic color panels
Technique : Drying at ambient temperature

TOKYO SKYTREE®

Location : Oshiage, Sumida-ku, Tokyo
Building started in 2008 and completed in 2012.
Operators : TOBU RAILWAY CO., LTD.
TOBU TOWER SKYTREE CO., LTD.

- Anti-corrosion primer : Zinc-rich paint 75μm
- Undercoat : Epoxy resin paint 120μm
- Middle / topcoat : Thick-coating fluoropolymer paint 55μm

At the time of coating

Toyota Amlux Building

Coating completed in 1990.
Substrate : Aluminum
Specifications : Metallic blue
No clear coating

Even after 21 years, there has been no color change. With a deep blue appearance and clear colors, it maintains its elegant, gorgeous, and beautiful appearance as a showroom.

After 21 years (2011)

At the time of coating

Annex Building of the National Diet Library

Coating completed in 1986.
Substrate : Concrete
Specifications : Grainy texture
Design pattern finish

Even after 25 years, there has been no degradation, and the building retains its dignified appearance.

After 25 years (2011)

At the time of coating

Yushima Seido

Coating completed in 1989.
Substrate : Concrete
Specifications : Black, semi-gloss

Even after 22 years, the dark, heavy, and dignified atmosphere remains unchanged.

After 22 years (2011)

At the time of coating

South Building of Nagoya Isen
(former HAL Nagoya)

Coating completed in 1985.
Substrate : Concrete
Specifications : Black

Even after 26 years, the coating remains in good condition.

After 26 years (2011)

Transportation

Aircraft

Train

Ship

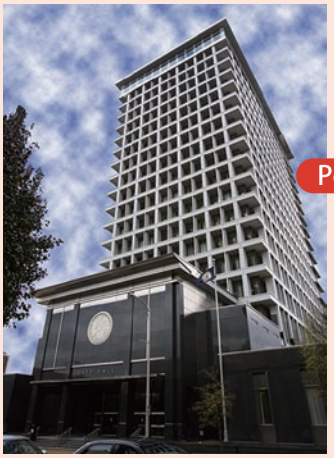
Resins for the future (water-borne, powder)

Emulsion grade

Okayama Castle (17 years after coating)

Dispersion grade

Tank



Powder grade

Left : **Richmond City Hall** (U.S.) Akzo Nobel Powder Coatings, Interpon D3000
Right : **Benelong Point, Sydny Harbour** (Australia) Dulux Powder Coatings, Fluoroset FP

Actual achievements overseas

Burj Al Arab Hotel (Dubai)
ALPOLIC®, manufactured by Mitsubishi Plastic

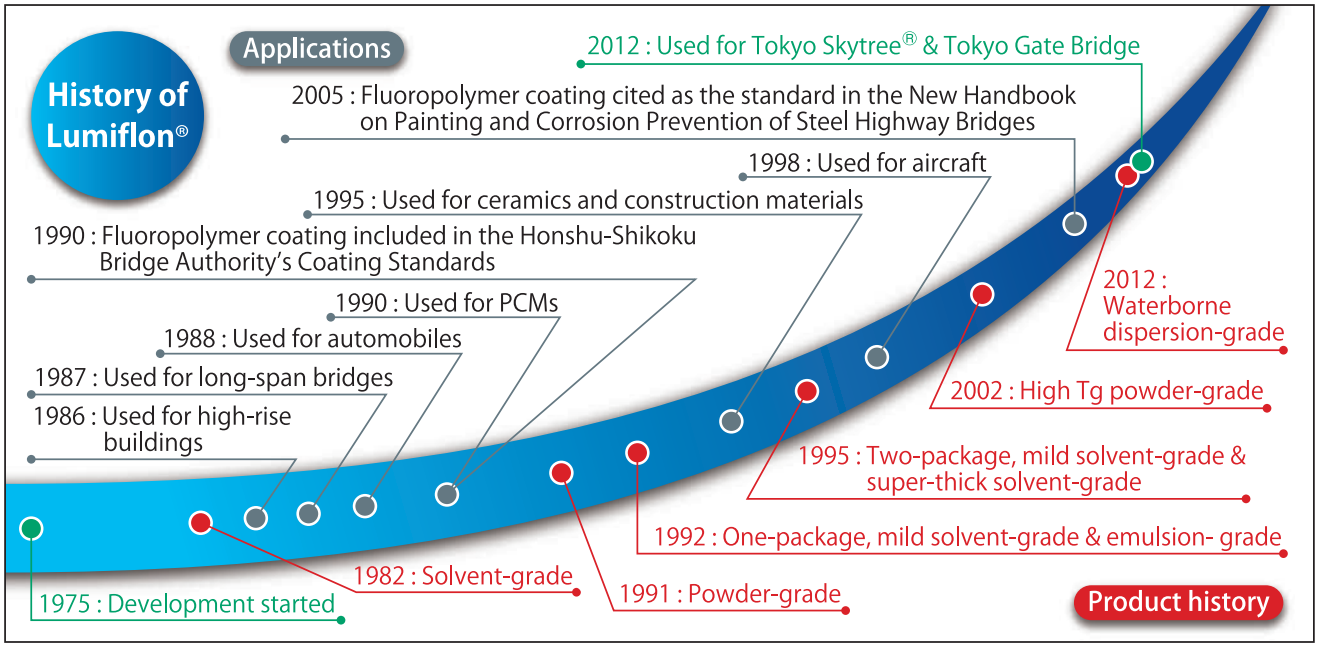
Water tank
(U.S.)

Yeongjong Grand Bridge
(South Korea)

Ferrari World (Abu Dhabi)

Marina Bay Sands (Singapore)
ALPOLIC®, manufactured by Mitsubishi Plastic

National Australia Bank
(Australia)



These achievements would not have been possible without the support of many people. We deeply appreciate it and look forward to your continuous support.

AGC Chemicals Company
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