The Release of Cadmium Due to Corrosion From Anthropogenic Sources

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UNECE Workshop on Release of Heavy Metals

Due to Corrosion of Materials

Munich, Germany **12-14 May 2003**

Sources of Cadmium Releases

- **Natural**
  - **Forest Fires, Volcanoes, Soil Erosion**
- **Anthropogenic**
  - **Intentional Additions in Products**
  - **Impurities in Other Materials**

Intentional Uses of Cadmium

Product	%Cd	% of Market	Cd Forms
NiCd Batteries	7-25	78	Cd,$Cd(OH)_2$
Cd Pigments	≅ 1	12	Cd(Zn)S(Se)
Cd Coatings	≅ 0.2	8	Cd, Cd-Ti, Cd-Sn
Cd Stabilizers	≅ 1	1.5	Cd Laurate, Cd Stearate
Cd Alloys et al	1-20	0.5	Cu-Cd, Ag-CdO

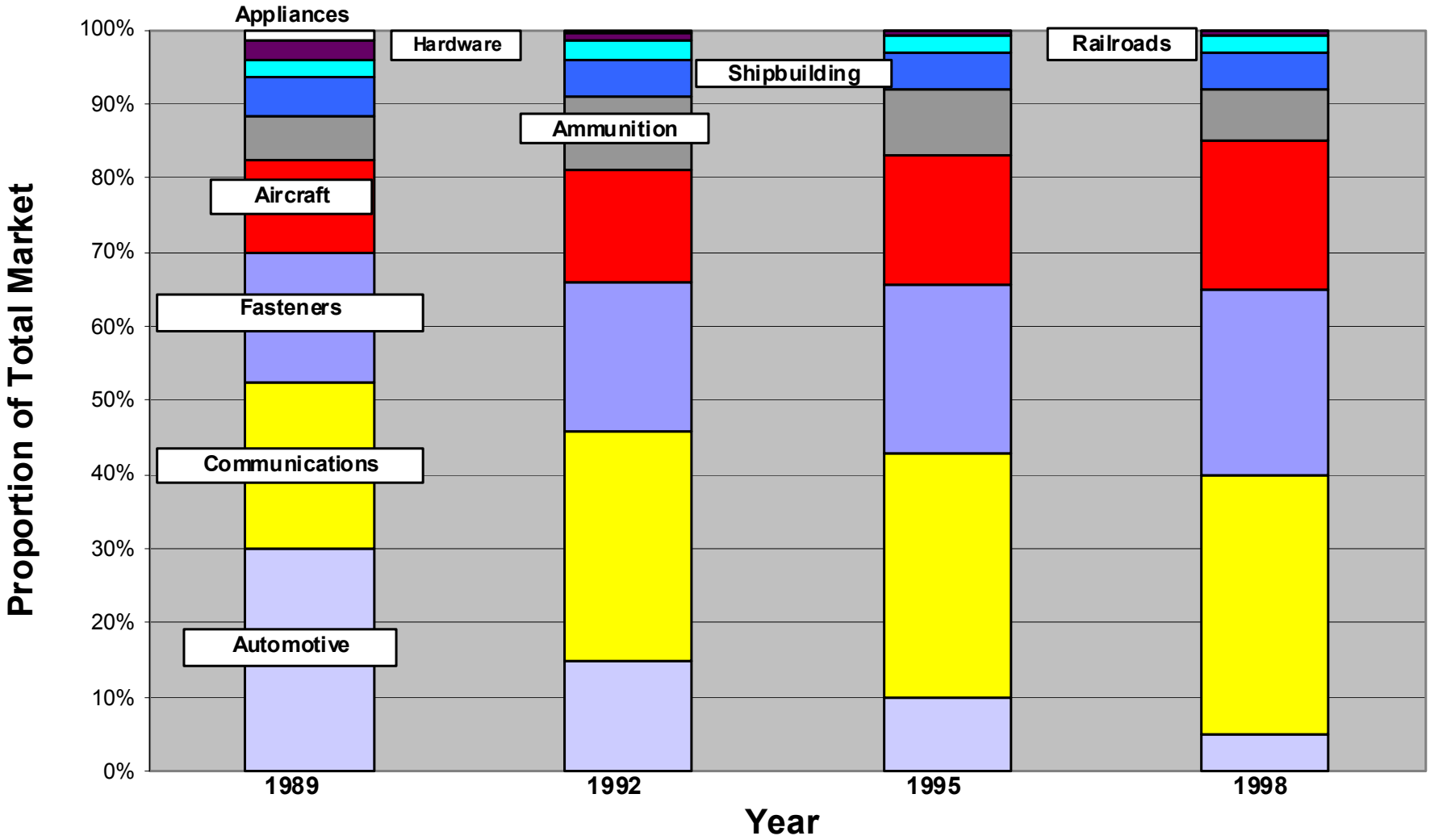
Cadmium Impurity Levels in Other Products

Product Category	Cadmium Levels, ppm
Phosphate Fertilizers	3 - 90
Fossil Fuels	0.1 – 1.5
Cement	2.0 – 2.5
Iron and Steel	0.1 – 5.5
Nonferrous Metals	1 - 50

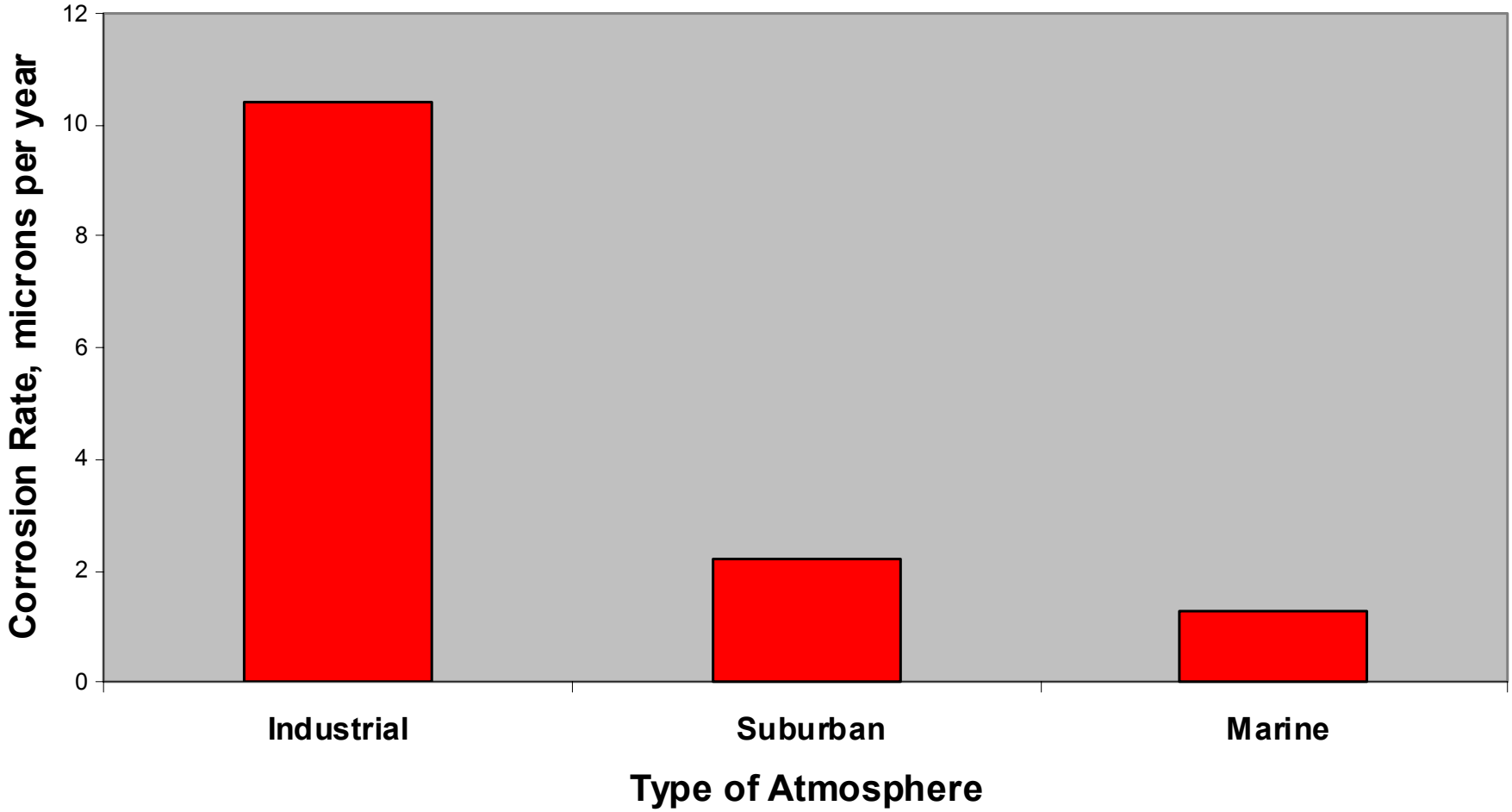
Properties of Cadmium Coatings

- Electrochemically Active Sacrificial Coating
- Good Corrosion in Alkaline and Marine
- Poor Corrosion in Low pH or Industrial
- Thin, Adherent Corrosion Film
- Low Coefficient of Friction
- High Electrical Conductivity
- Good Soldering Characteristics
- Prevents Fe/Al Bimetallic Corrosion

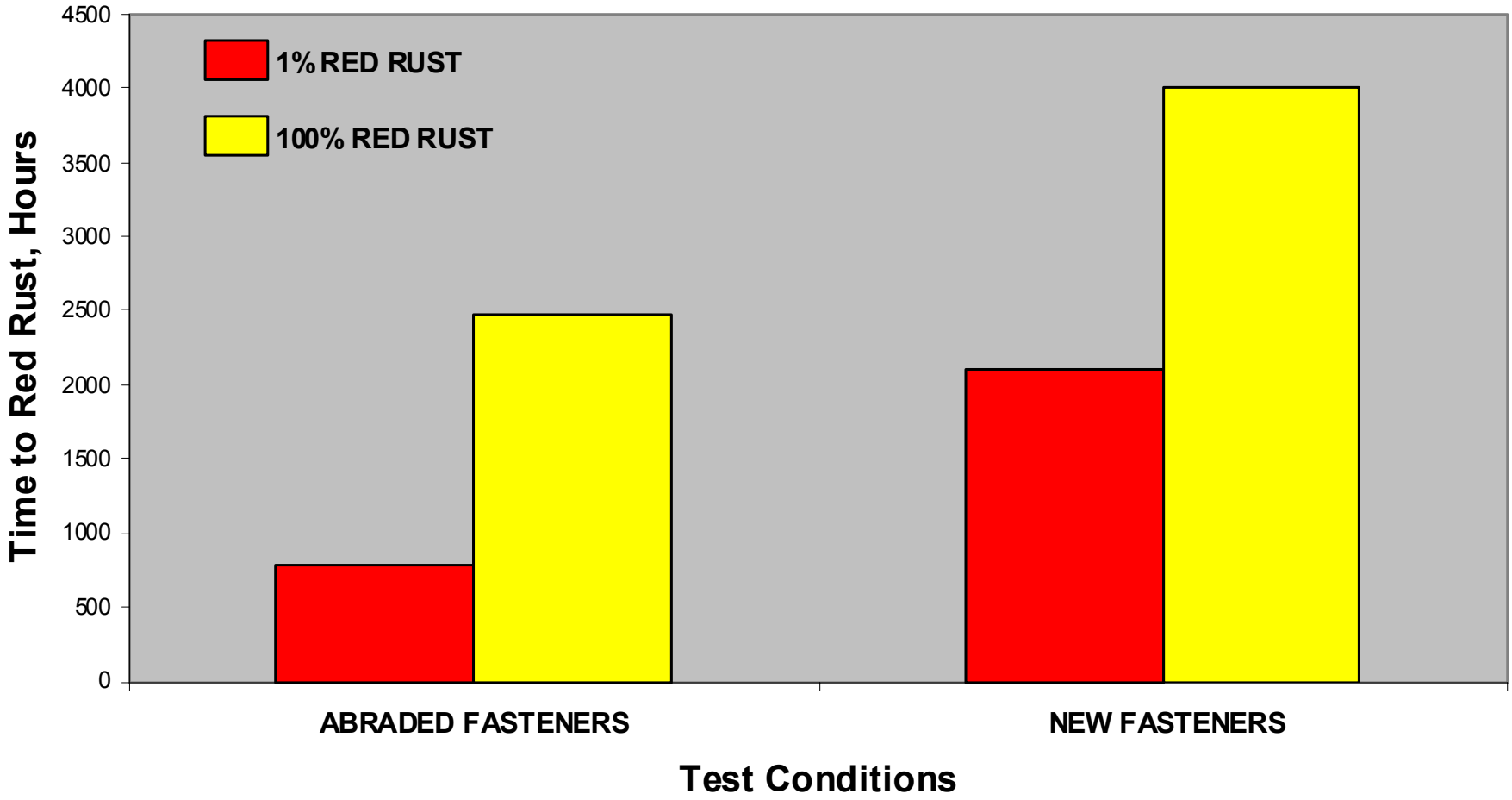
USA Cadmium Coatings Market



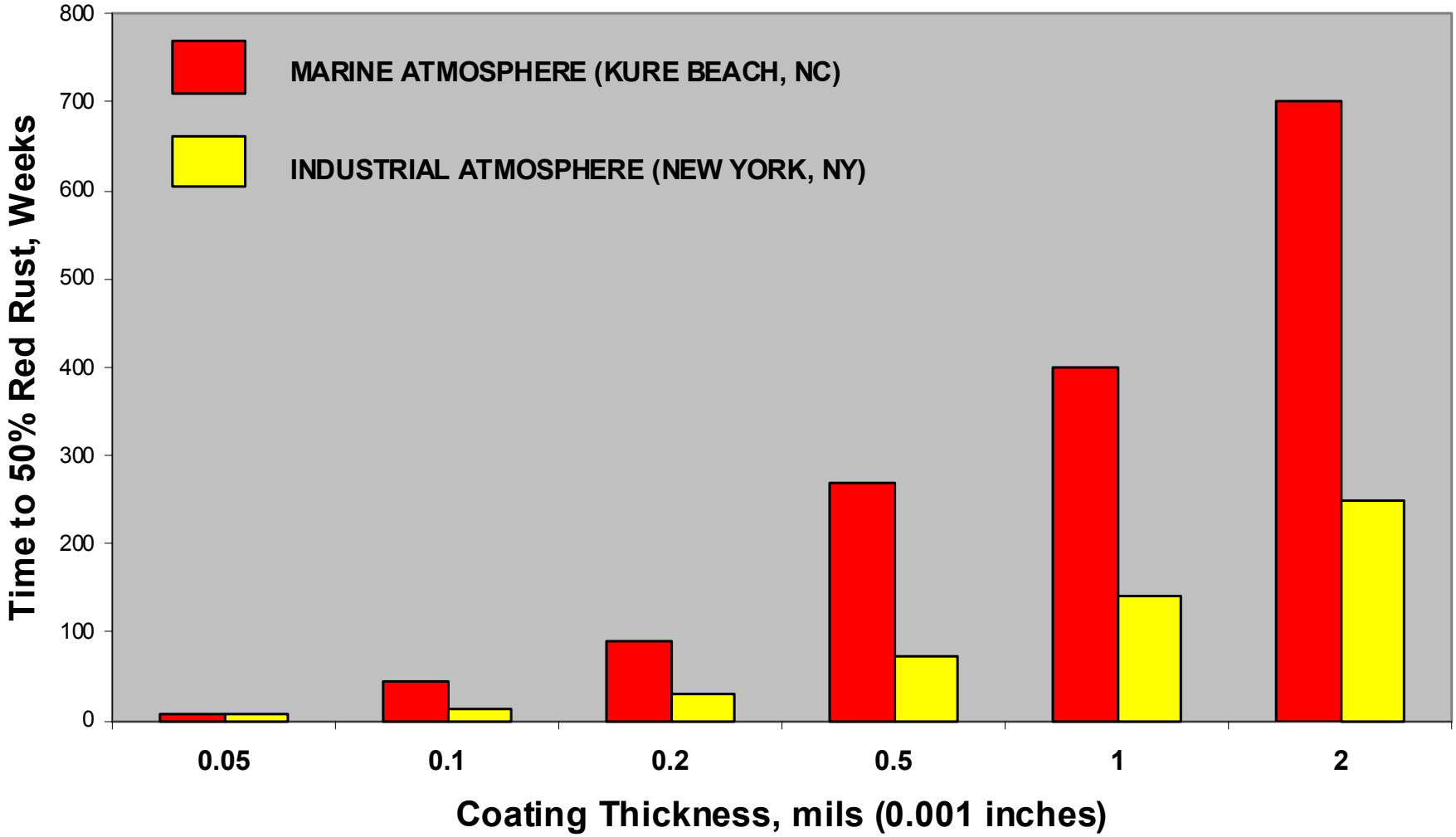
Corrosion Rates of Cadmium Coatings
(Meyer 1986)



U.S. Army 5% Salt Spray Corrosion Tests on Cadmium Coated and Chromated Fasteners



Atmospheric Corrosion of Cadmium

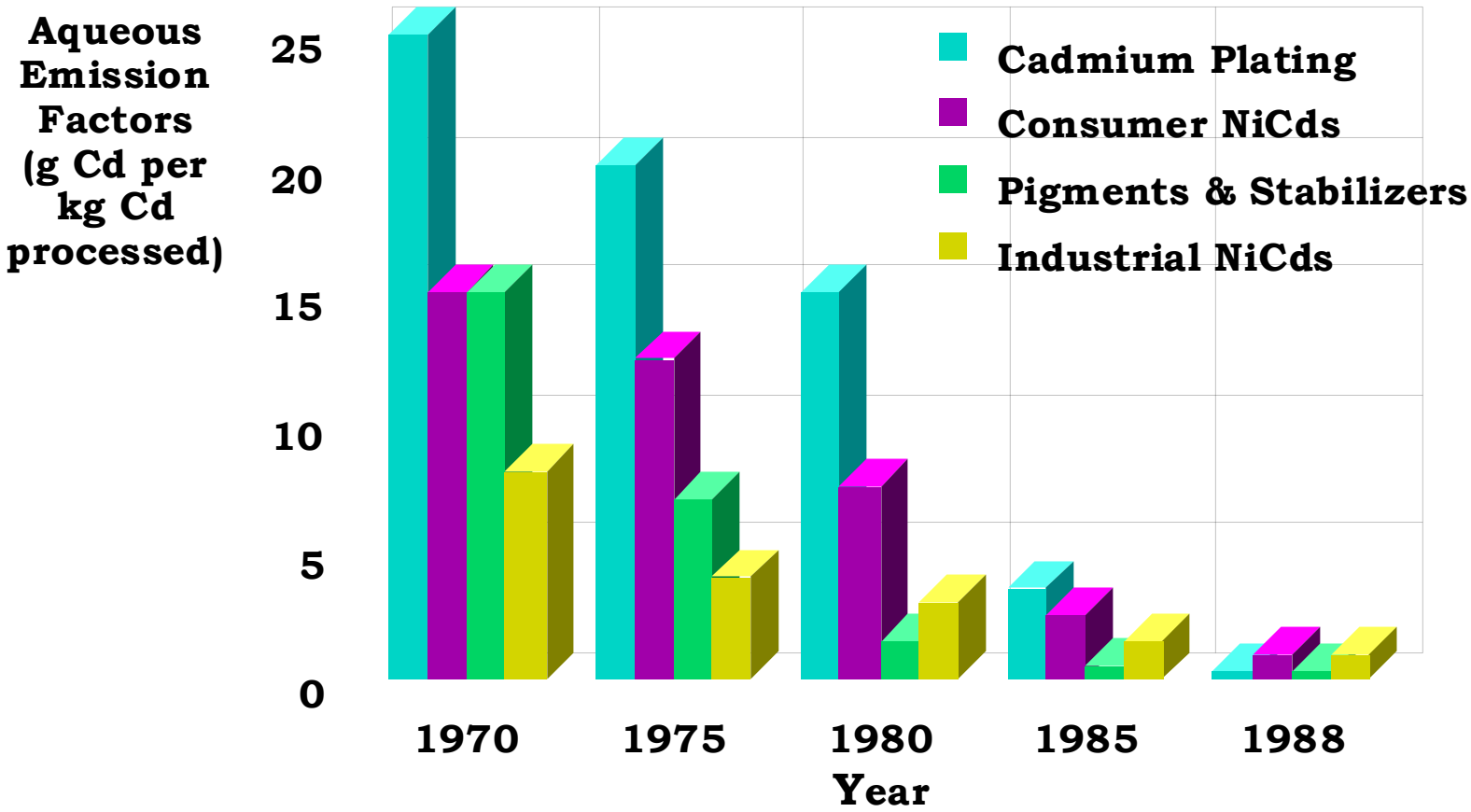


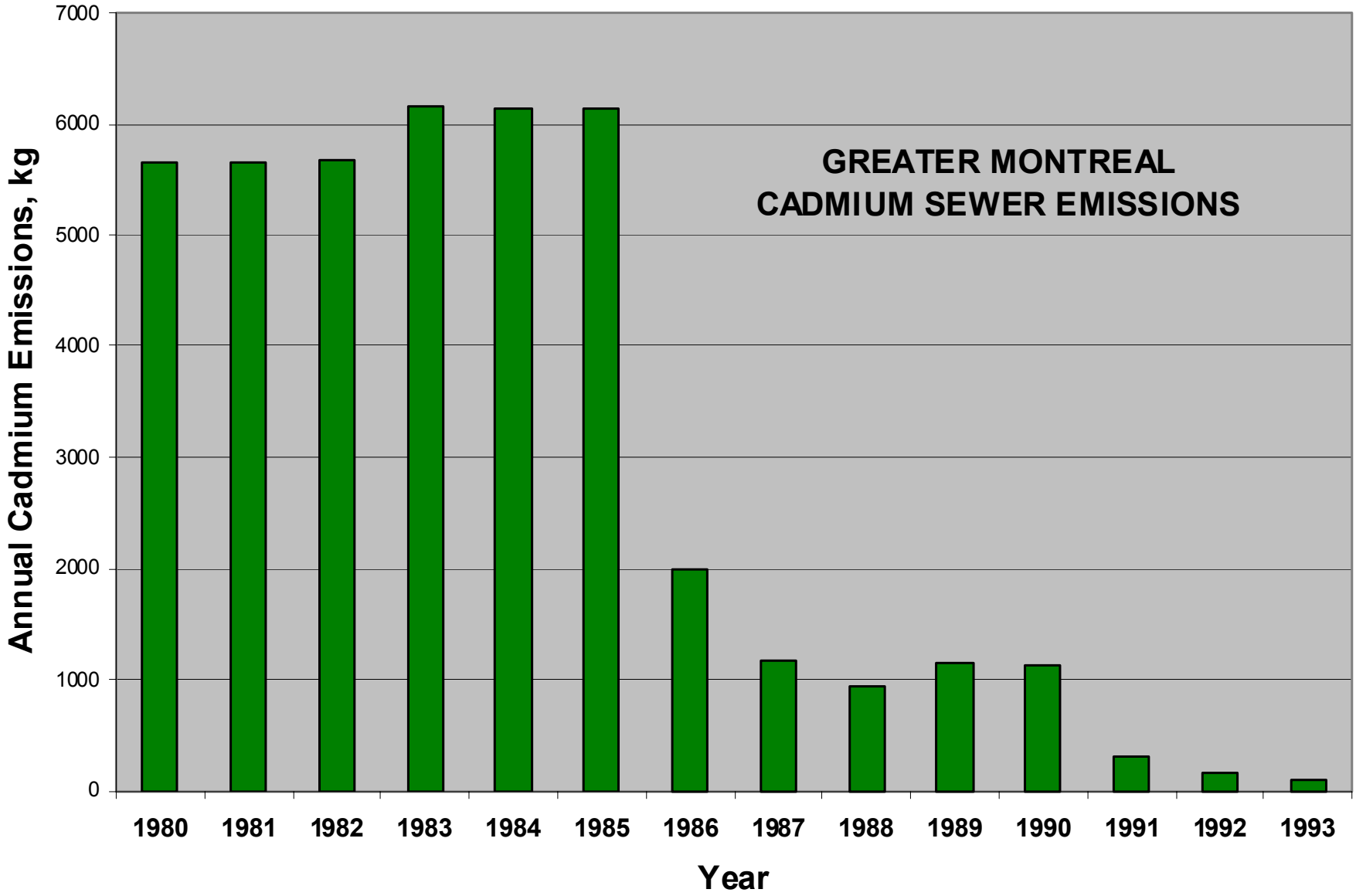
Summary of Corrosion Rate Data (μm/year)

Study	Industrial	Suburban	Marine
Meyer	10.4	2.2	1.3
Carter	25.0	-	5.0
Shreir	33.3	-	5.3
Farrara	-	-	10.7 – 17.7
Sample	4.3 - 5.3	-	1.23 – 1.89

Summary of Corrosion Weight Loss Data ($mg/cm^2/year$)

Study	Industrial	Suburban	Marine
Meyer	9.05	1.91	1.13
Carter	21.75	-	4.35
Shreir	28.97	-	4.57
Farrara	-	-	9.3 – 15.4
Sample	3.77 – 4.61	-	1.1 – 1.6

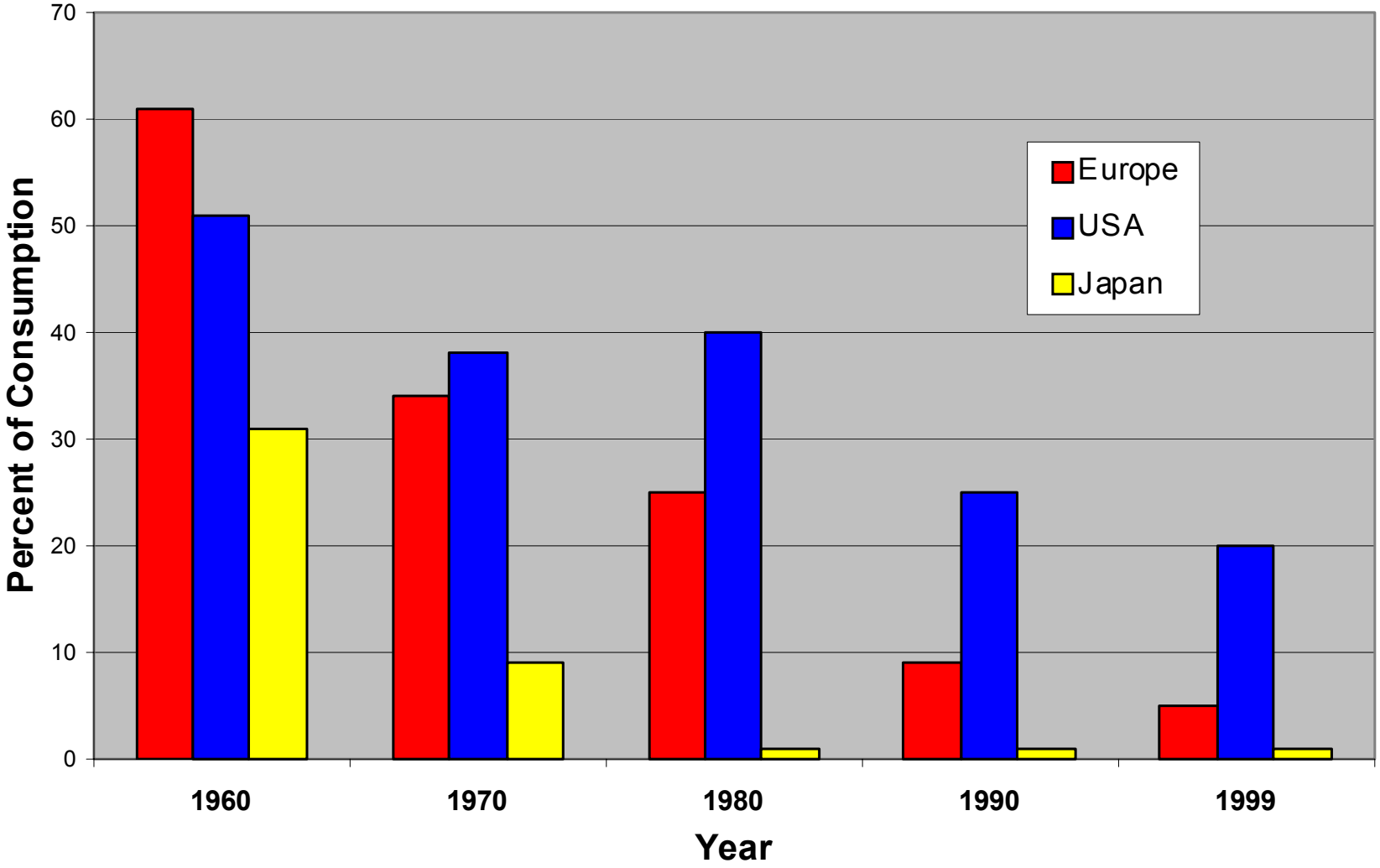

Aqueous Emission Factors (g Cd per kg Cd processed)
25
20
15
10
5
0
Cadmium Plating
Consumer NiCds
Pigments & Stabilizers
Industrial NiCds
1970
1975
1980
1985
1988
Year


GREATER MONTREAL
CADMIUM SEWER EMISSIONS
Annual Cadmium Emissions, kg
7000
6000
5000
4000
3000
2000
1000
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
Year

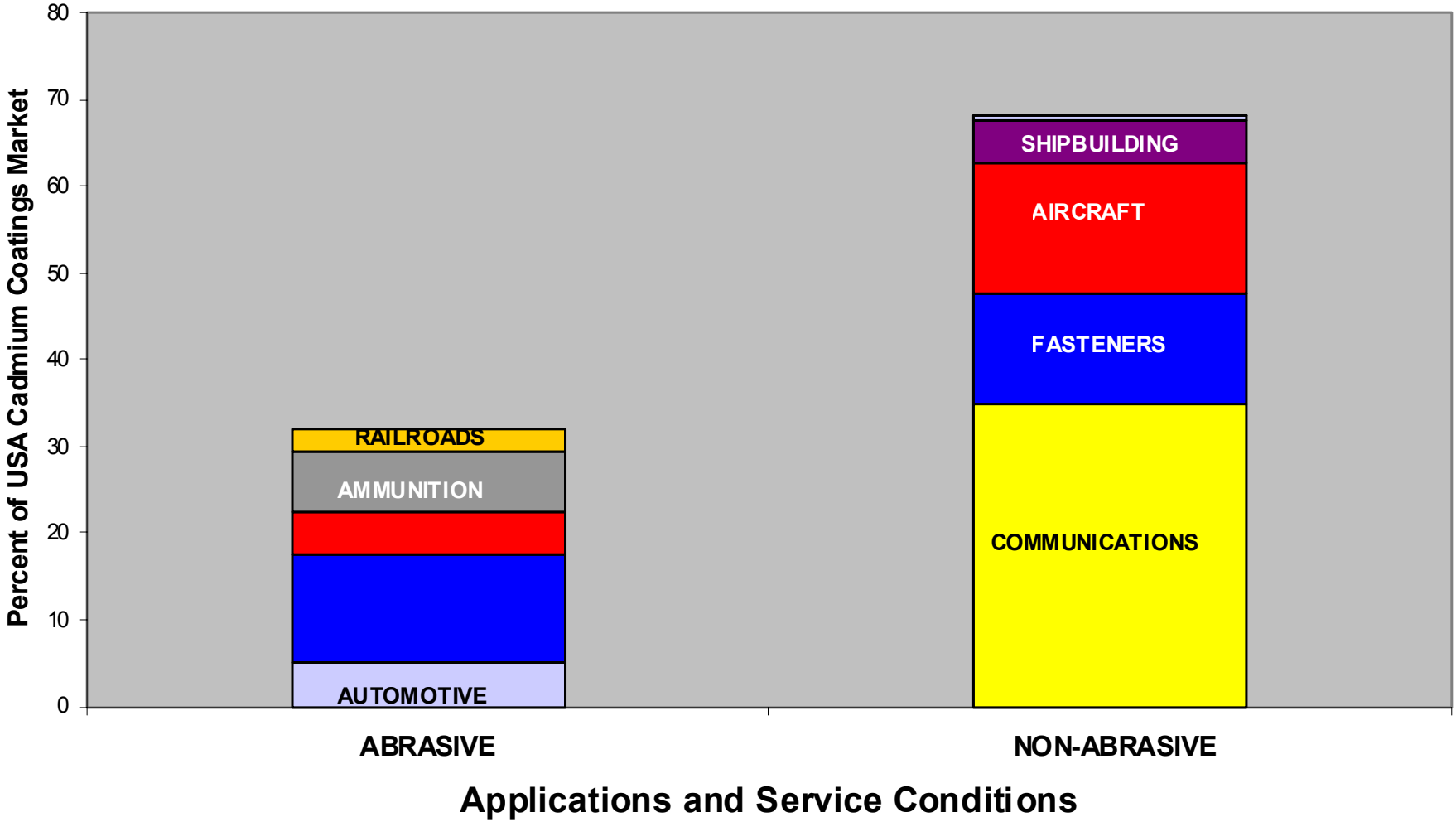
Cadmium Coatings Emissions Based on Applications

- Morrow 1996: 50% of coating lost during its normal service life of 10-25 years
- WS Atkins 1998: 25% of coating lost based on abrasive vs. non-abrasive applications
- Corden & Floyd 2001: 25% of coating lost but should be greater near airports
- Importance of Different Cadmium Coatings Usage in Different Geographical Areas

Geographical Cadmium Coating Markets, 1960 - 1999



Applications and Service Conditions for 1998 USA Cadmium Coatings Market



Cadmium Corrosion Emissions vs. Total Cadmium Emissions

- Van Assche 1998: All Cadmium Products Account for 2% of Total Human Exposure to Cadmium
- EU Risk Assessment 2003: Cadmium Plating Accounts for 0.05% of Total Cadmium Emissions
- U.S. EPA 1993: All Cadmium Products Account for 1.1% of Cadmium Air Emissions
- ERL 1990: Production & Use of Cadmium Coatings Accounts for 1% - 2% of Cadmium Emissions

Cadmium Corrosion Emissions From Other Sources

- Cadmium-Containing Alloys
  - Cu-Cd, Ag-CdO, Bi-Pb-Sn-Cd, Ag-Cu-Zn-Cd
  - <0.5% of Total Cadmium Consumption
  - Not Normally Exposed to Atmospheric Service
- Impurities in Other Metals
  - Very Low Impurity Levels, 1 – 50 ppm
  - Zn More Electrochemically Active Than Cd
- Insignificant (<<2%) Contribution to Cd Emissions

Summary

- Cadmium Coatings Have Excellent Corrosion Resistance in Alkaline and Marine Atmospheres
- They Have Poor Corrosion Resistance in Industrial and Acidic Atmospheres and Are Not Used There
- Cadmium Coatings Used Where Good Friction and Conductivity Properties are Also Required
- Cadmium Emissions From Corrosion of Cadmium Products are <2% of Total Cadmium Emissions
- Cd Corrosion Emissions from Other Products <<2%