



"Material Challenges Facing the Automotive and Steel Industries from Globalization"

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The Global Automotive Industry

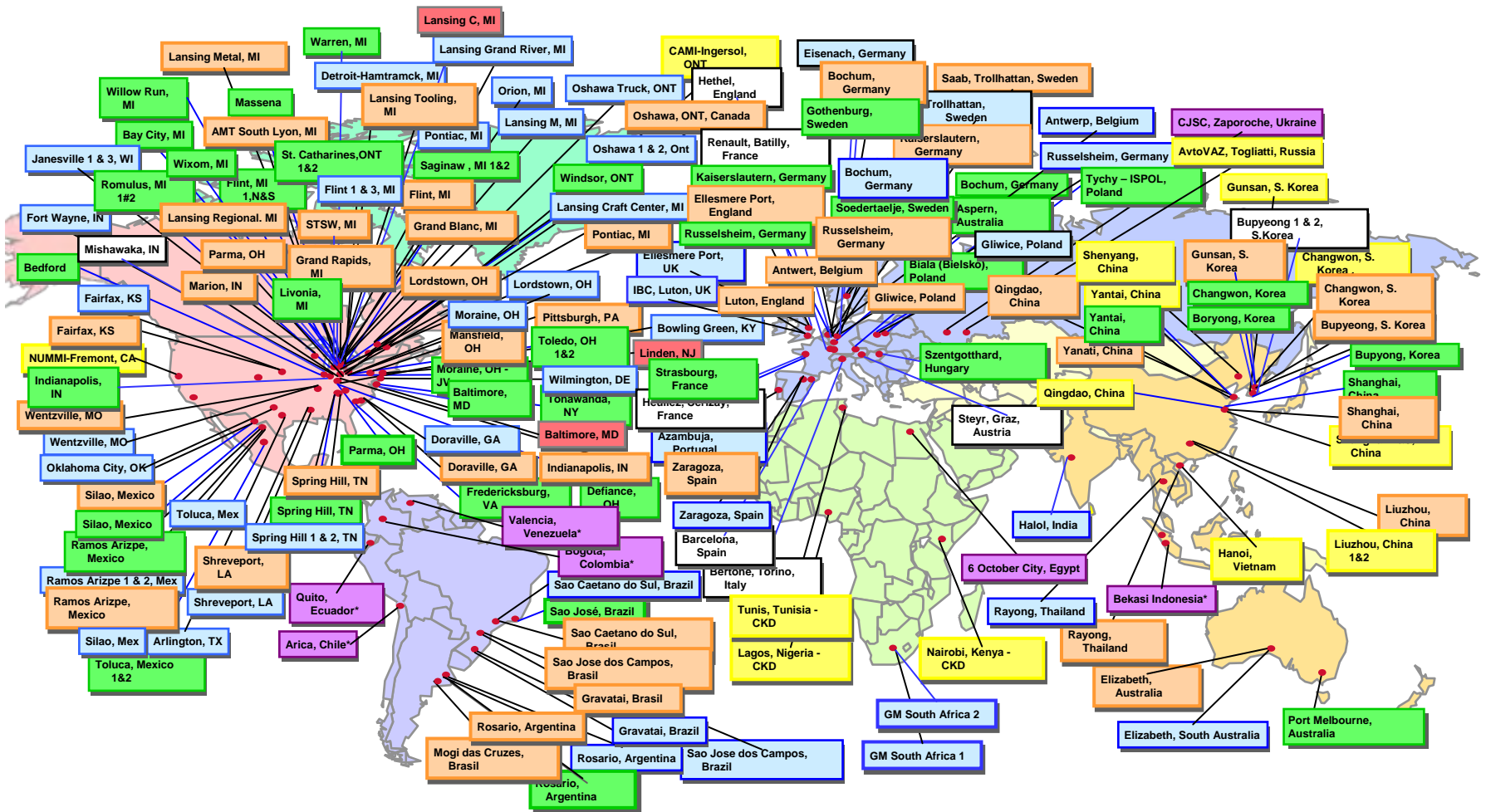
Globalization

- Producing very large “Global Powerhouses”
- Leveraging global resources to improve efficiency
- Global sharing of products





GM's Global Footprint



- Assembly Locations in Over 32 Countries
- Annual Volume of 9.1 Million Vehicles
- Products Sold in 170 Countries



The Global Automotive Industry

Enablers for Resource Leveraging

- 
- A light gray world map is visible in the background, centered behind the text.
- Common vehicle development process
 - Common engineering process
 - Common manufacturing process





The Global Automotive Industry

Primary Building Blocks for Commonization

- Common materials and specifications provide a global “language” for requirements
- Enabler for common engineering and manufacturing processes





The Global Automotive Industry

Global Specifications - Benefits

- Reduce development, manufacturing and validation costs
- Assist in moving into developing markets
- Improved productivity
- Improved quality
- Enabler for global architectures



Complex Material Landscape

SAE/ASTM - High Strength Steel

- Focus on **Yield** Strength
- YS-Steps: **Not Systematic**
- Test Direction: **Longitudinal**
- Tensile Test Length: **50 mm**

EN/SEW - High Strength Steel

- Focus on **Yield** Strength
- YS-Steps: **40 MPa**
- Test Direction: **Transverse**
- Tensile Test Length: **80 mm**

EMS.ME - High Strength Steel

- Focus on **Yield** Strength
- YS-Steps: **40 MPa**
- Test Direction: **Transverse**
- Tensile Test Length: **50 mm**

JFS/JIS - High Strength Steel

- Focus on **Tensile** Strength
- TS-Steps: **Not Systematic**
- Test Direction: **Transverse**
- Tensile Test Length: **50 mm (JIS)**



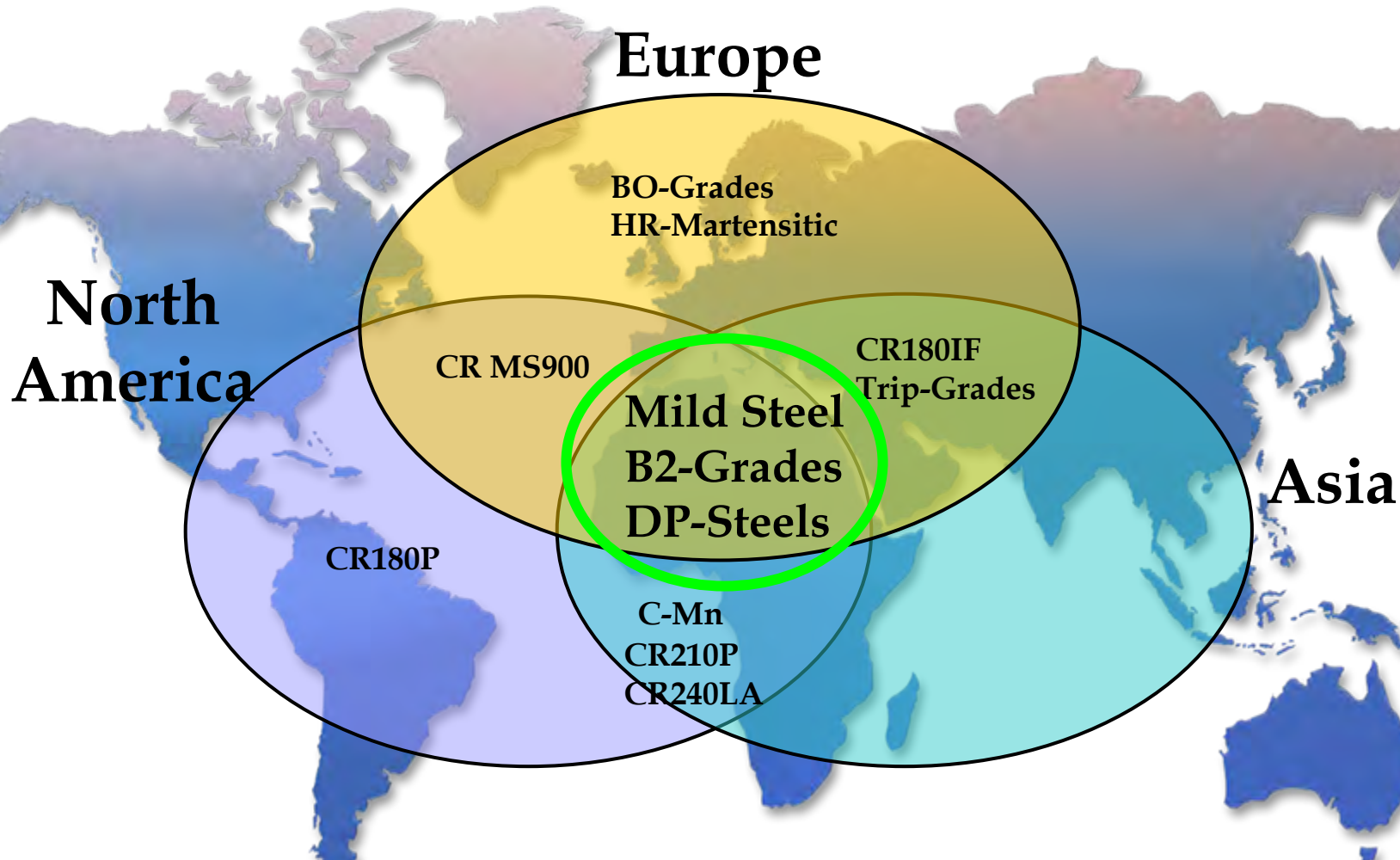
Challenges

- Global availability of materials
- Grade/material commonization
- Supplier capability differences
- Variability in materials
 - Chemistry
 - Microstructure
 - Mechanical Properties
 - Performance





Global Grade Strategy



FOCUS: Guarantee Global Availability of Material



Global Specifications

Global Material Specifications are the Common Engineering Language

	WORLDWIDE ENGINEERING STANDARDS	Material Specification Metals	GMWZ
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Low Carbon Sheet Steel

	WORLDWIDE ENGINEERING STANDARDS	Material Specification Metals	GMW3032
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High Strength Sheet Steel, 180 MPa through 550 MPa Yield Strengths

	WORLDWIDE ENGINEERING STANDARDS	Material Specification Metals	GMW3399
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Multi Phase and Ultra High Strength Sheet Steel

1 Scope
This specification covers continuous cast, hot rolled or cold rolled sheet steel with specified tensile strengths from 390 MPa through 1500 MPa. Typical applications include body panels, body structure members, chassis components and bumpers.

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1.1 Material Description. The type of coating and its mass and finish are specified by suffixes added to the basic specification number. The first two letters FC will designate an electrogalvanized coating. The coating mass for each side is designated by a minimum value in g/m². Only coating masses of 47 g/m², 60 g/m² or 70 g/m² for pure zinc, and 32 g/m² for zinc-nickel alloy should be used unless materials engineering is consulted. Other coating masses shall follow the same designation method. For one side coated coils, or sheets/blanks the uncoated side should be free of coating. A residue of 40 mg/m² maximum is permissible. The letter N designates a pure zinc coating. The letter Z designates a zinc-nickel alloy coating. The first set of digits along with the letter designation specifies the coating parameters of the unexposed side. The remaining designation specifies E (exposed), or U (unexposed) to depict surface finish.

surface coatings (metallic hot dipping, electrolytic plating, hot spray painting, organic coatings and/or other coatings). This specification does not apply to steel for case hardening and cold reduced, work hardened strips. Additional requirements or agreements have to be specified by local business units. [e.g., North America (NA), Europe (E), Latin America (LA), and Asia Pacific (AP)].

1.2 Material Identification. The GMW base metal specification number defines the material designation, steel product type, grade, and finish type. The steel product type is "CR" for cold rolled products, or "HR" for hot rolled products. For

	WORLDWIDE ENGINEERING STANDARDS	Material Specification Metals	GMW2296
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Hot Dip Zinc Coatings For Sheet Steel

	WORLDWIDE ENGINEERING STANDARDS	Material Specification Metals	GMW8
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Electrogalvanized Coatings for Sheet Steel

	WORLDWIDE ENGINEERING STANDARDS	Material Specification Metals	GMW11
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1 Scope
This standard covers the requirements for both one and two side pure zinc and zinc nickel alloy electrogalvanized coatings. These coatings are applied to a sheet steel substrate utilizing an electroplating process. The sheet steel substrate may be either cold or hot rolled low carbon, high-strength, dual phase steel, transformation induced plasticity (TRIP) steel, or ultra high strength steel. Additional requirements or agreements shall be specified by the local business units (e.g., NA, E, LA, AP). The letter N designates a pure zinc coating. The letter Z designates a zinc-nickel alloy coating. The first set of digits along with the letter designation specifies the coating parameters of the unexposed side. The remaining designation specifies E (exposed), or U (unexposed) to depict surface finish.

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Globalization - Impact on Steel Industry

Basic Structure of GMW's

- Test direction selected as the lowest strength direction

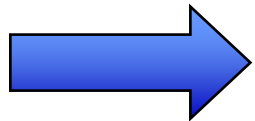
Base Material	Test Direction
GMW 2: Mild Steel	Long. & Transverse Direction
GMW 3032: High Strength Steel	Longitudinal Direction
GMW 3399: Multiphase Steel	Longitudinal Direction

- YS and TS specified for all Advanced HSS's

Result: CR 590T/340Y DP (Common name: CR DP600)

Strategy

- Common part design
 - One part number valid world wide
- One material specification for each part number
 - Same material used worldwide
- Single validation of a product
 - Basic product will be validated once
- Common manufacturing process
 - One engineering package for all regions.



Requirement: Common materials in each region



Globalization - Impact on Steel Industry

Benefit

- Increase engineering and manufacturing efficiency
- Leverage global engineering and manufacturing resources
- Reduced product validation
- Reduced engineering costs
- Eliminate redundant development work
- Increased speed to market
- Maximize opportunities of global purchasing





Global Grade Strategy

Catalog of Globally Available Materials

Product Engineering Grade	GMW Grade ⁽¹⁾		Coating ^(4,5)			
	Manufacturing Engineering Grade	Common Name	Bare	EG (5)	HD/GA	Exposed
CR	CR1		x	x	x	.....
	CR2		x	x	x	.....
	CR3		x	x	x	x
	CR4		x	x	x	x
CR5	CR5		x	x	x	x
	HR1		x	.....	x	.....
	HR2		x	.....	x	.....
CR180 E	HR3		x	.....	x	.....
	see table below		x	x	x	x
	CR180B2	CR180B2	x	x	x	x
CR210B2	CR210B2		x	x	x	x
	CR240B2	CR240B2	x	x	x	x
	CR270B2	CR270B2	x	x	x	x
	CR180IF	CR180IF or CR180P	x	x	x	.....
CR210IF	CR210IF	CR210IF or CR210P	x	x	x	.....
	CR240IF	CR240IF or CR240P	x	x	x	.....
	CR240IF/P		x	x	x	.....
CR240LA	CR240LA	CR240LA	x	x	x	.....
	CR270LA	CR270LA	x	x	x	.....
	CR300LA	CR300LA	x	x	x	.....
	CR340LA	CR340LA	x	x	x	.....
	CR380LA	CR380LA	x	x	x	.....
HR270LA	CR420LA	CR420LA	x	x	x	.....
	HR270LA	HR270LA	x	.....	x	.....
	HR340LA	HR340LA	x	.....	x	.....
	HR420LA	HR420LA	x	.....	x	.....
270LA ⁽³⁾	HR550LA	HR550LA	x	.....	x	.....
	CR or HR270LA		x	x	x	.....
	300LA ⁽³⁾	CR or HR300LA	x	x	x	.....
	340LA ⁽³⁾	CR or HR340LA	x	x	x	.....
	380LA ⁽³⁾	CR or HR380LA	x	x	x	.....
CR490T/290Y DP	420LA ⁽³⁾	CR or HR420LA	x	x	x	.....
	CR490T/290Y DP	CR490T/290Y DP	x	x	x	.....
	CR590T/340Y DP	CR590T/340Y DP	x	x	x	.....
	CR780T/420Y DP	CR780T/420Y DP	x	x	x	.....
CR980T/650Y DP	CR980T/650Y DP	CR980T/650Y DP	x	x	x	.....
	CR980T/650Y DP	CR980T/650Y DP	x	x	x	.....
	CR980T/650Y DP	CR980T/650Y DP	x	x	x	.....
CR900T/700Y MS	CR900T/700Y MS	CR DP1000 High Yield	x	x	.....	.....
	HR 1200T/1030Y MS ⁽²⁾	CR MS900	x	x	.....	.....
HS1300T/850Y MS	HR 1200T/1030Y MS	HR MS1200	x	x	.....	.....
	HS1300T/850Y MS	GMW14400 - PHS*	x	.....	TBD	.....

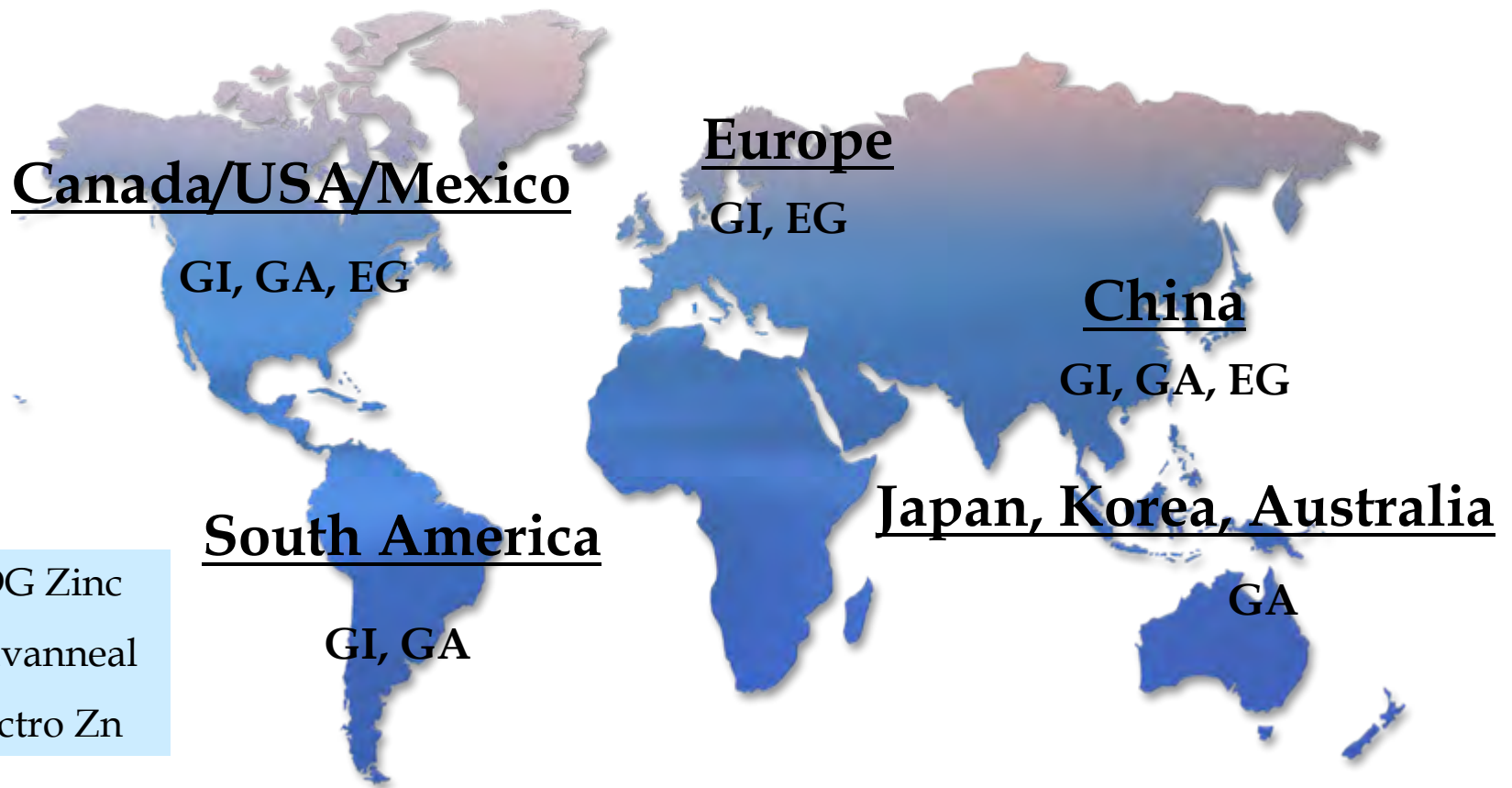
Global Availability

Technological Competitiveness



Global Coating Strategy

Overview of Common Coatings by Region

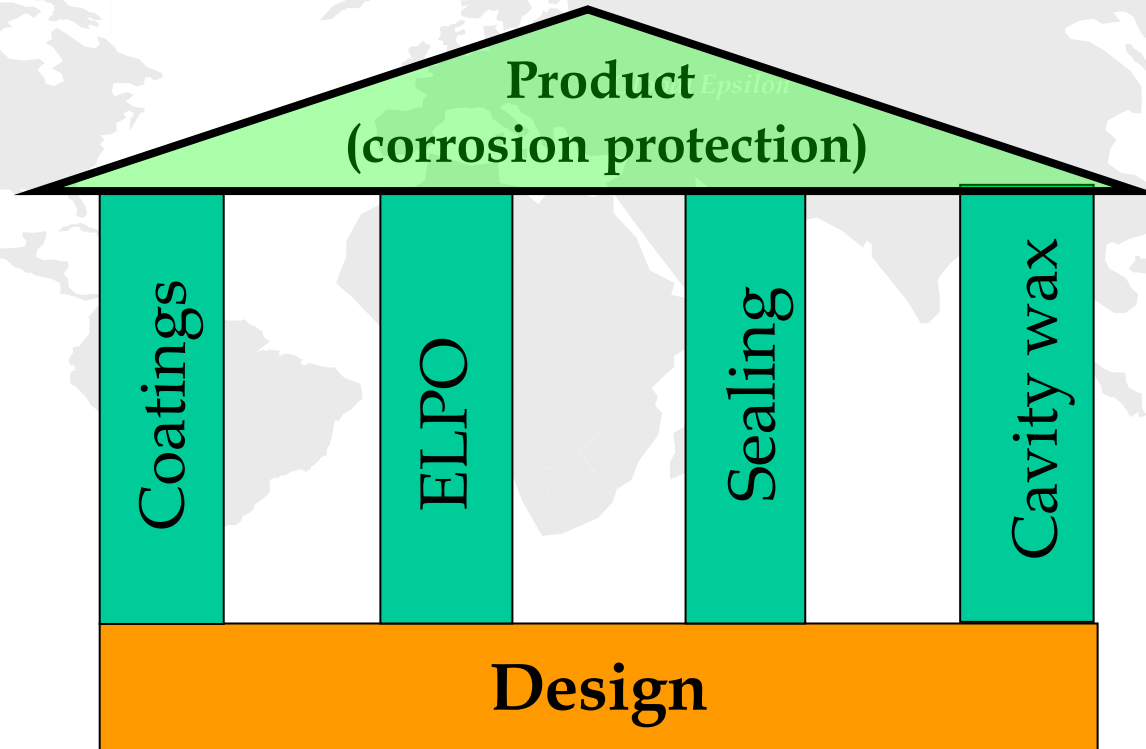


GI: HDG Zinc
GA: Galvanneal
EG: Electro Zn



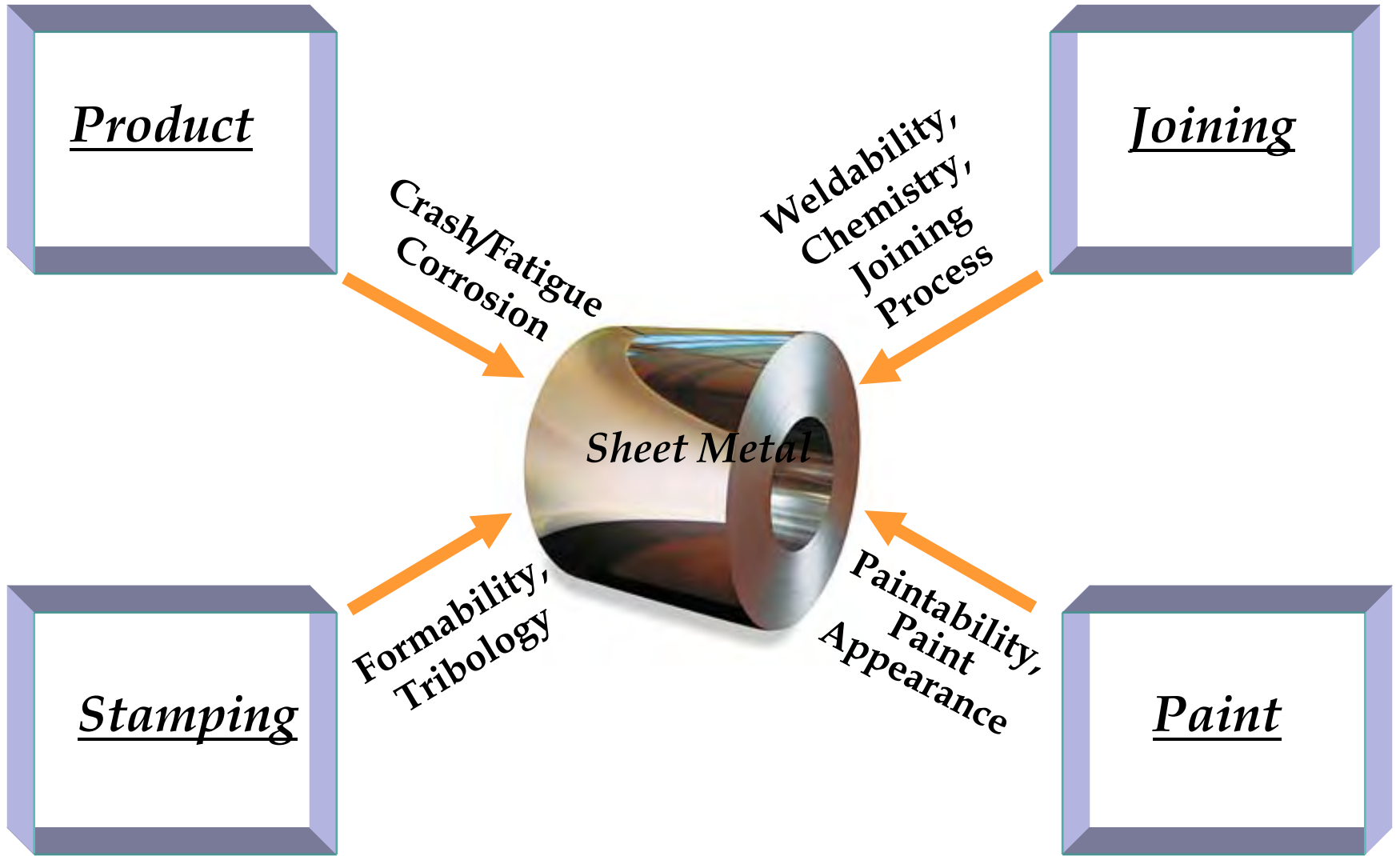
Global Coating Strategy

Coatings: One of the 4 Pillars of Vehicle Corrosion Protection





Sheet Metal Attributes





Status

Implementation of Common Strategy

Common

In Process

- Global Standards (GMW's)

- Surface Finish

- Material Strategy

- Strain Rate Properties

- Grade Strategy

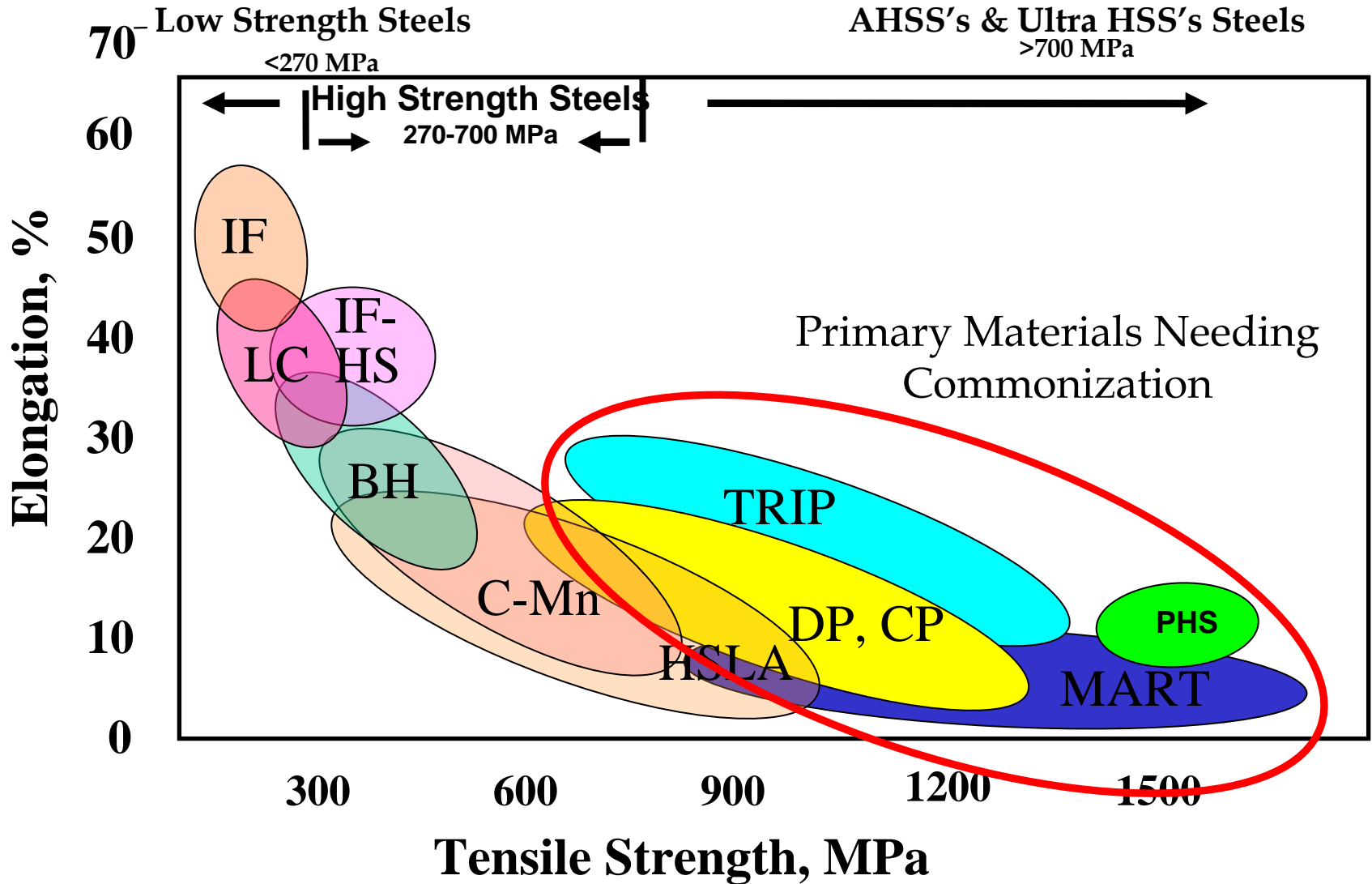
- Lubrication

- Coating Strategy

- Carbon Equivalent



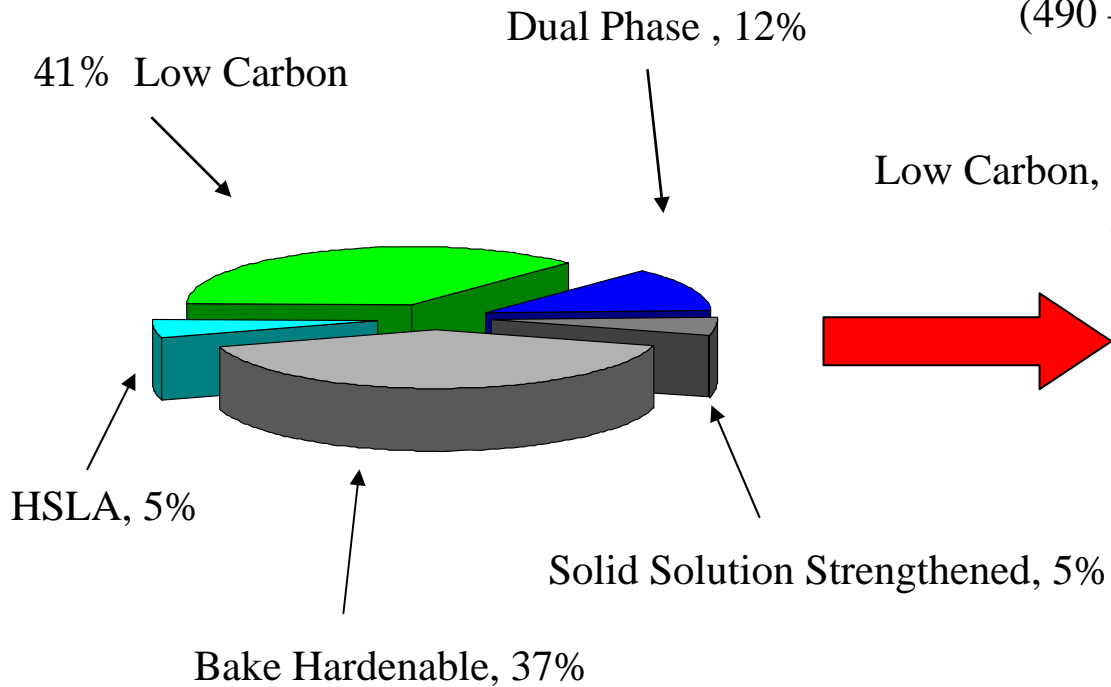
Automotive Steel Strength/Ductility Ladder



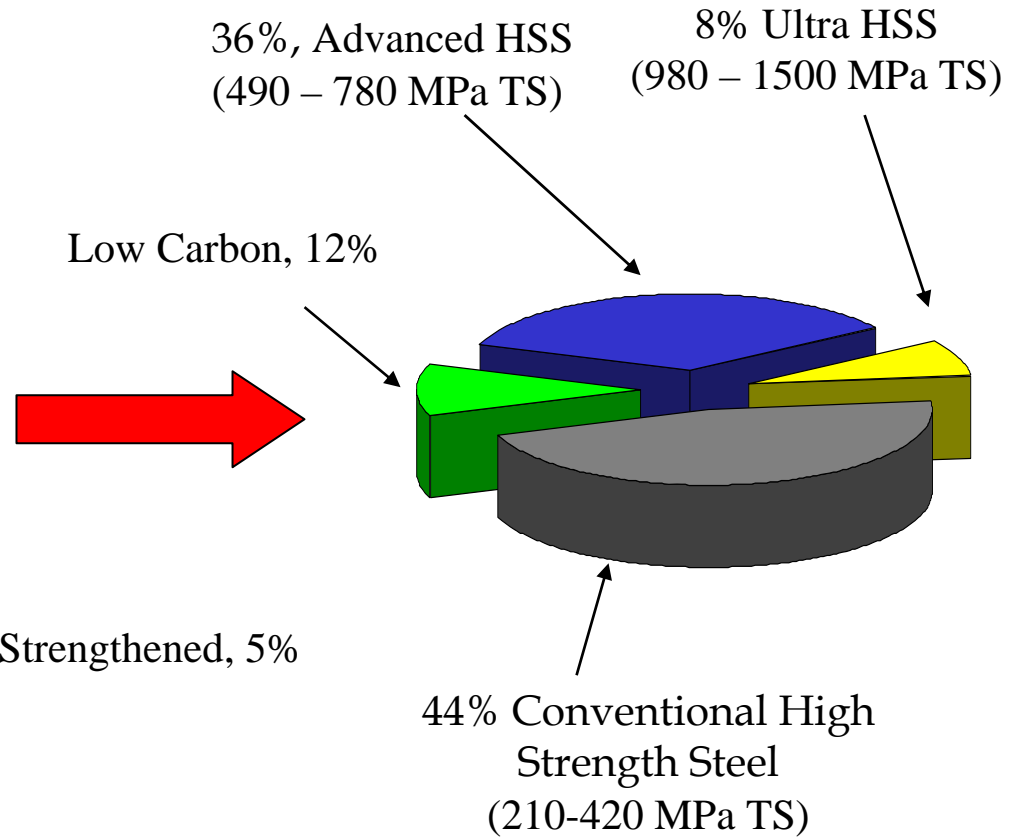


Steel Usage Changing

2004 Vehicle



2012 Vehicle



* Body Structures Only



Dual Phase 980 Example

Mechanical Properties

Grade Version	Coating Type	Tensile Strength, MPa, min	Yield Strength, MPa, min	Total Elongation, % (typical)	Hole Expansion Grade
A	Bare/EG	980	550	~ 11	No
B	Bare/EG	980	650	~ 13	No
C	Bare/EG	980	800	~ 9	Yes
D	GI/GA	980	600	~ 14	No



Dual Phase 980 Example

Chemistry

Grade Version	Carbon	Mn	Si	Others	CE
A	> .12	> 2.0	~ 1.0 - 1.2	Mo, Cr, B, etc	0.28 - 0.33
B	> .12	> 2.0	~ 1.0 - 1.2	Mo, Cr, B, etc	0.28 - 0.33
C	< 0.10	>> 2.0	< 1.0	Mo, Cr, B, etc	0.20 - 0.25
D	0.10 - 0.13	>2	< 1.0	Mo, Cr, B, etc	0.24 - 0.28

$$CE = C + Mn/20 + Si/30 + 4S + 2P$$



Joining

Pre-Requisites for Global Body Shop

- Common welding performance for “same” grades
- Common manufacturing processing windows

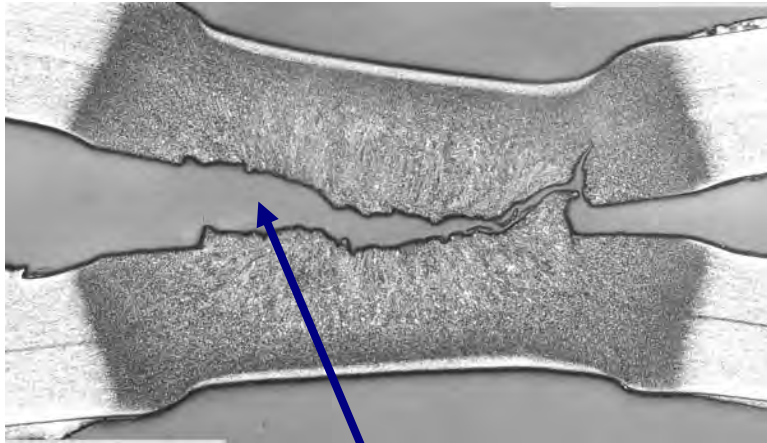
Material Requirements

- Similar welding parameters for the same grades in all regions
 - Steel industry support of global grades
 - Strive for similar performance and processing of those grades



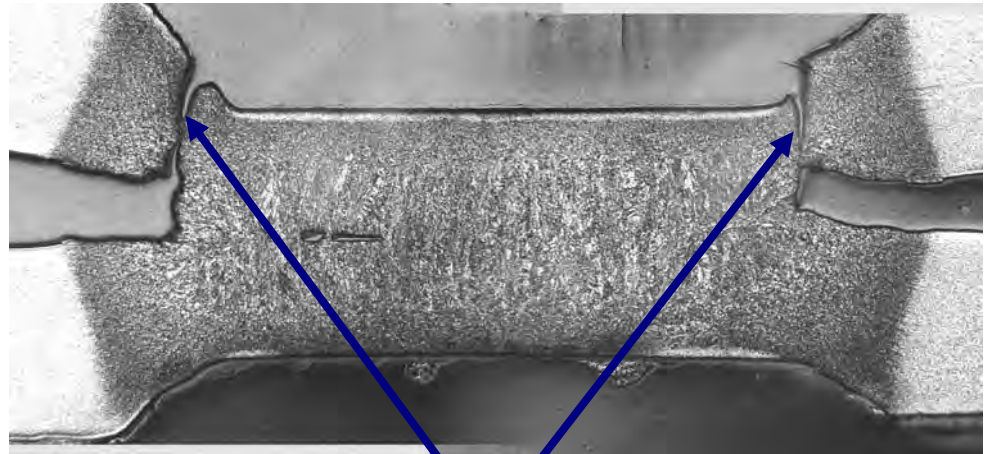
Joining

High Carbon Equivalents Increase Likelihood of Interfacial Fractures



Interfacial Fracture

CE ~ 0.28



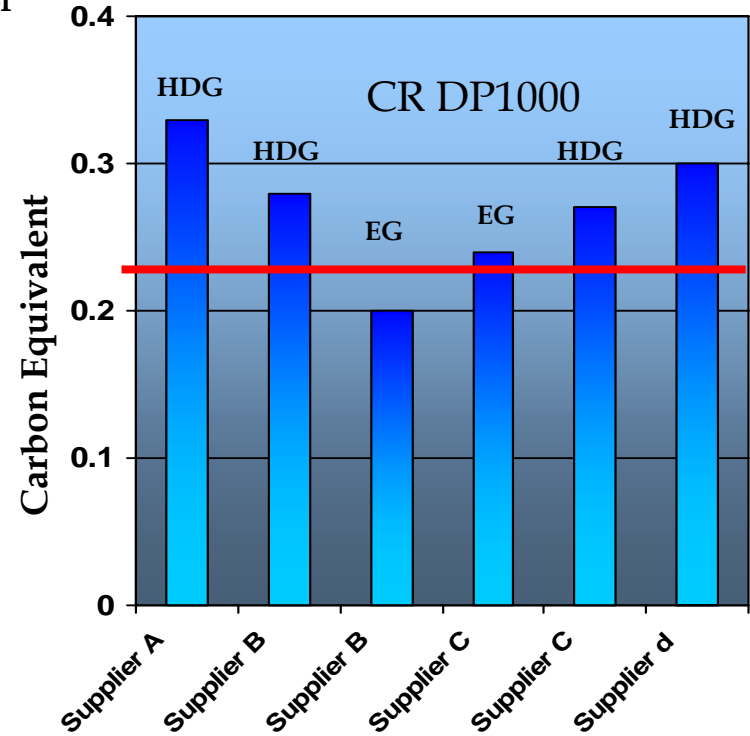
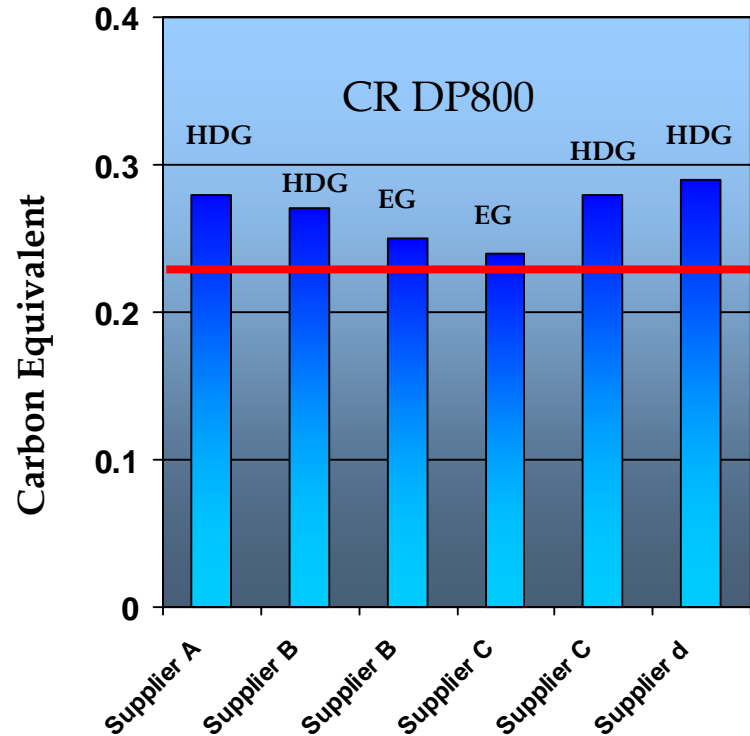
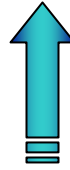
Button Pull-out

CE ~ 0.20



Joining

Increasing
Likelihood of
Interfacial
Fractures



Carbon Equivalent: Variability between suppliers

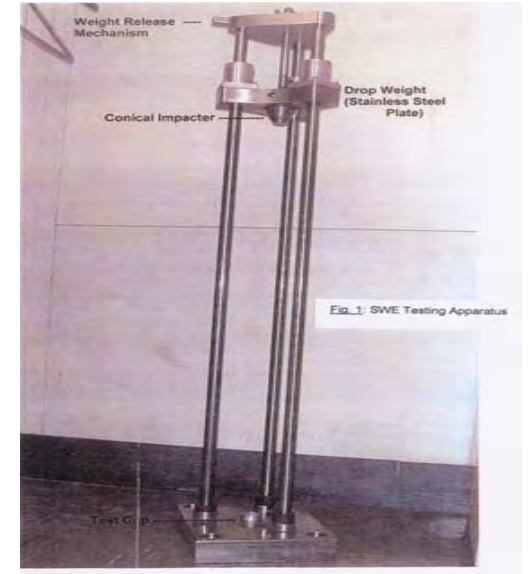
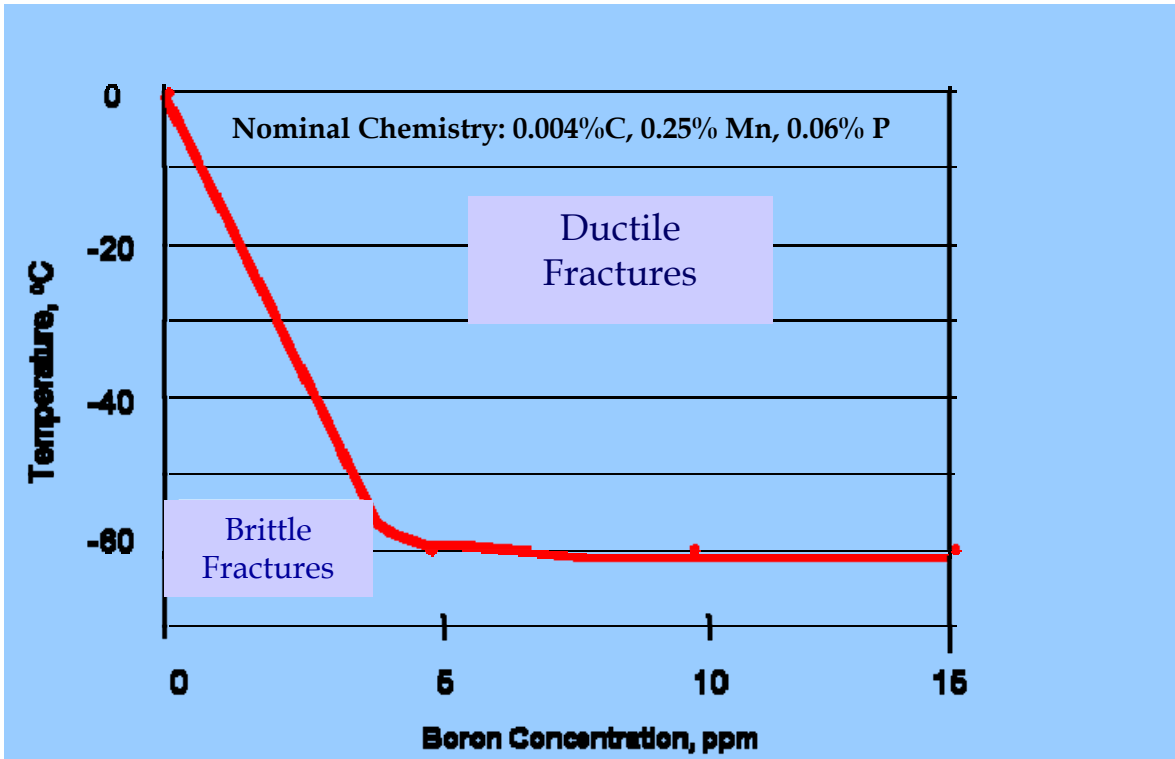
$$CE = C + Mn/20 + Si/30 + 4S + 2P$$

HDG - Hot Dip Galvanized, EG - Electrogalvanized



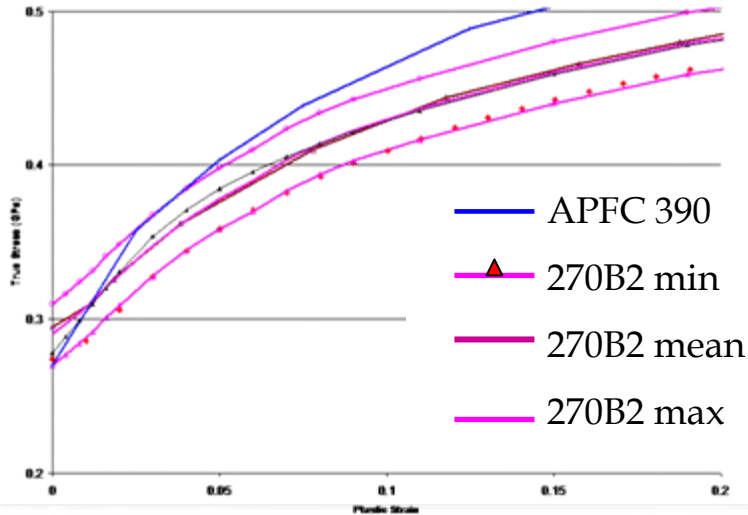
Product Performance

Effect of boron on DBTT of ULC phosphorus bearing steels

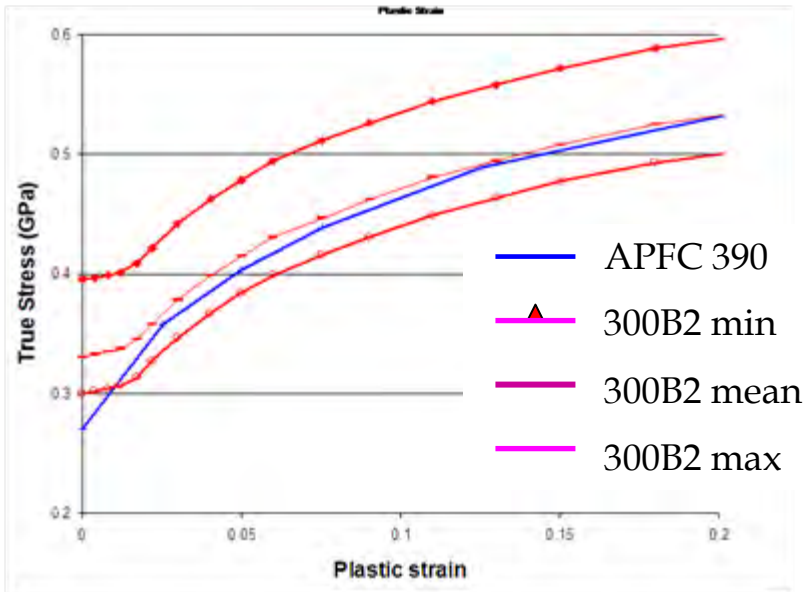




Product Performance



GMW3032M-ST-S CR270B2 is not a good match for APFC 390



GMW3032M-ST-S CR300LA is a good match for APFC 390





Global Qualification Process

- Steel companies and grades will be approved globally and not regionally
- Grades approved by “Global Ferrous Materials and Sheet Metal Team” will be considered acceptable for use in other regions

Level I: Global Engineering Requirements

Level II: Regional Manufacturing Requirements

Level III: Supplier Qualified to Level 1 and Level 2 in all regions

Conclusion

- Globalization of the steel and automotive industries is following similar paths
- The challenges for both industries are large, but the benefits are also large
- Commonization of material grades, to the extent possible, is critical to the continued globalization of our industries
- Continued cooperation and increased focus will accelerate these changes and benefit everyone