

Duplex Systems: Paint/Powder Coatings Over Hot-Dip Galvanizing (HDG)

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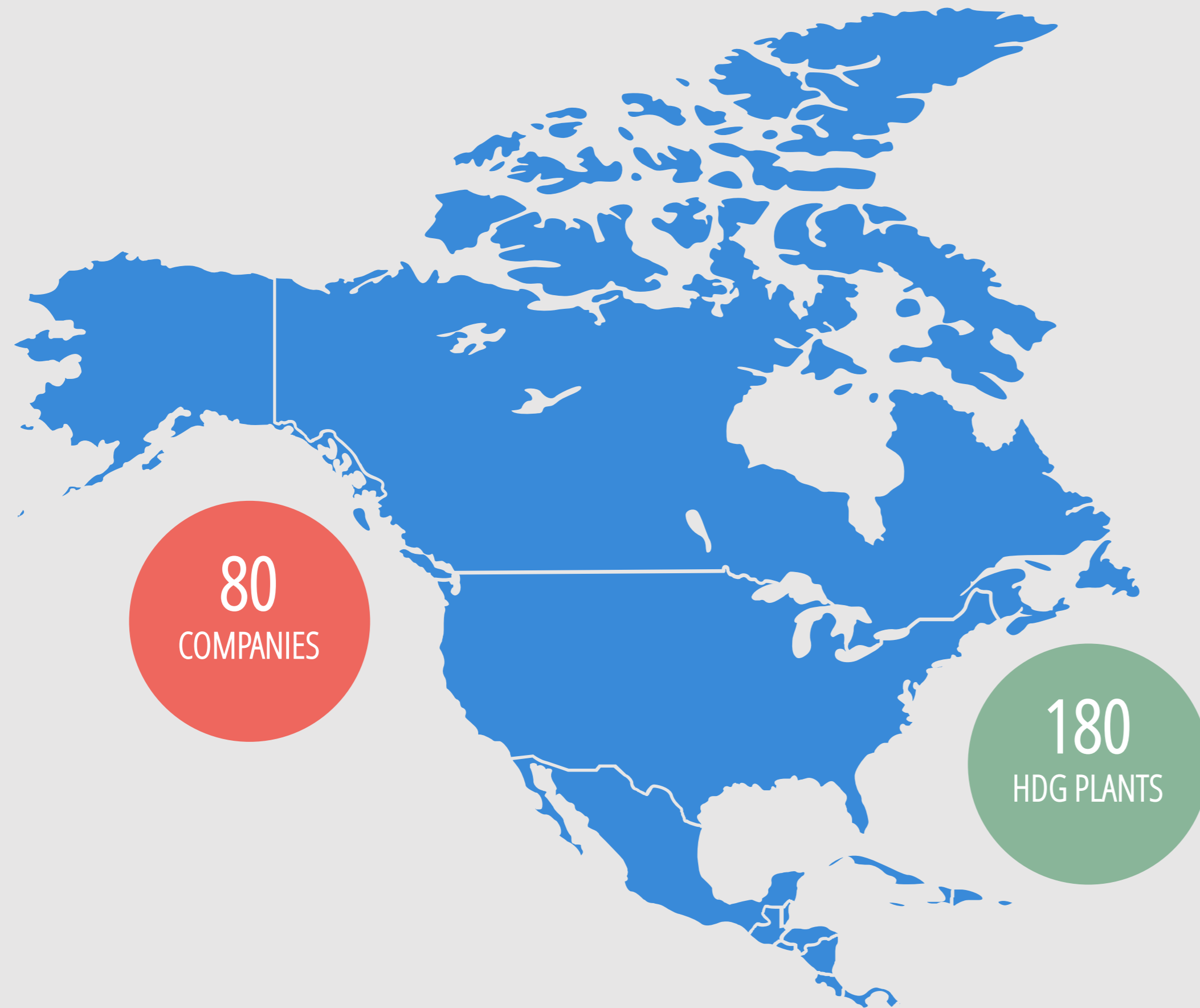
AGA/SSSBA 6-Part Webinar Series
Steel Bridges – Beyond the Textbook
June 23, 2026

John Krzywicki | American Galvanizers Association



About the American Galvanizers Association (AGA)

Non-profit trade organization established in 1933



Technical

The AGA provides technical support on the performance, design, inspection and specification of HDG steel

Marketing

The AGA provides its members with sales & marketing support and serves as the unified voice of the industry

Specifiers

The AGA is a free resource to North American specifiers and provides guidance on specifying HDG steel



Why Specify Duplex Systems?

- Painting/Powder coating galvanized steel
 - Aesthetic preference
 - Branding/matching
 - Safety/identification
 - Repair existing structures
- Synergistic Effect
 - Paint/powder + HDG provide 1.5x – 2x sum of the systems alone
 - Extends maintenance cycle of paint

MAS BUILDING & 2 LOWELL BRIDGES BY THE RIVERWALK

Lowell, MA | 2021



galvanizeit.org

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PANTHER CREEK BRIDGE

Klamath, CA | 2024

130 tons – Box-section arch ribs,
floor beams, cable hanger
assemblies, traffic railing,
pedestrian railing, fasteners,
anchor rods





**NOISETTE CREEK
PEDESTRIAN BRIDGE**

North Charleston, SC | 2022



2 tons – Curved cable railing system.

The posts are made of solid steel,
HDG, and powder-coated

Communication is Critical

Roles & Responsibilities for Surface Preparation

Specifier

Inform all parties the article is to be duplexed

Mutually agree with all parties on responsibility for surface smoothing after HDG

Galvanizer

Refrain from HDG post treatments (i.e. quenching)

Mutually agree with all parties on responsibility for surface smoothing

Liquid Coating Applicator

Cleaning, Profiling, and potential Outgassing

Mutually agree with all parties on responsibility for surface smoothing

Surface Preparation is Critical

- Poor preparation of the HDG surface is primary cause for Duplex System failure.
 - Miscommunication about responsibilities for surface prep
 - HDG repair products or filler materials incompatible with primer
 - Incorrect identification of initial condition
 - Insufficient smoothing
 - Insufficient cleaning
 - Insufficient roughening



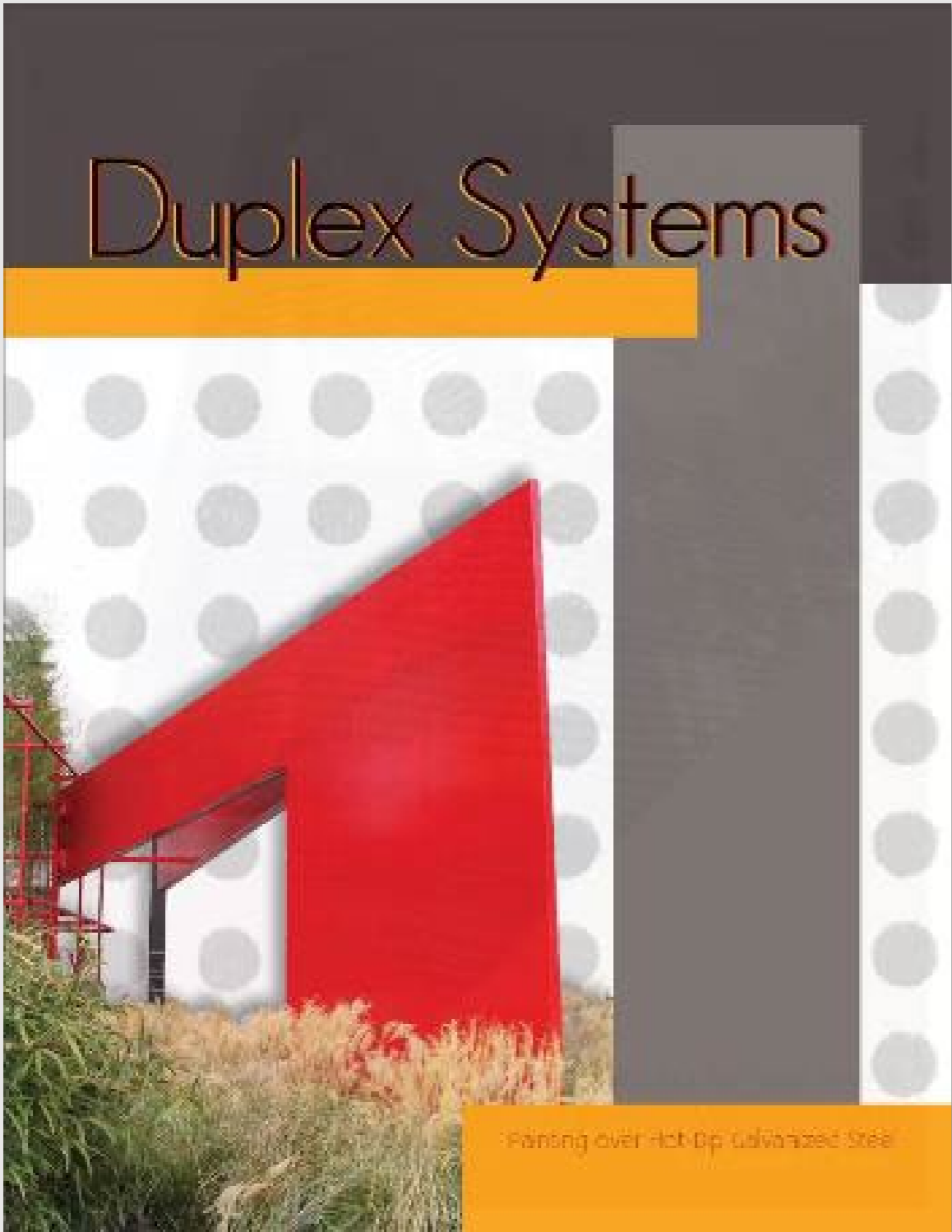


Brush-Off Blasting (most common)

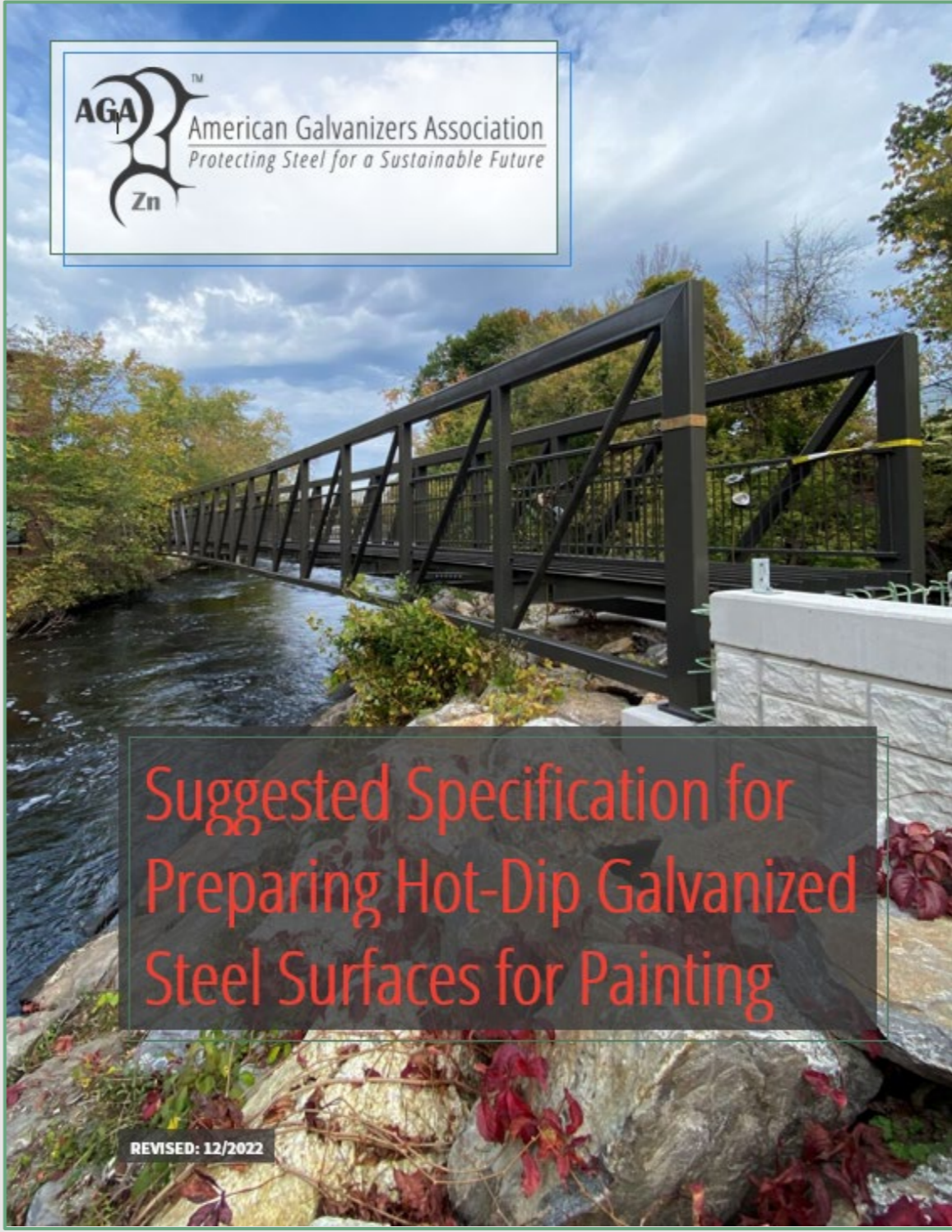
- SSPC-SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals
 - Sweep angle 30 to 60 degrees
 - Lower pressures and softer/finer abrasives
 - 0.75 mils minimum profile height
 - Look for change in appearance (not as pronounced on some coatings)

Learn More: Duplex Systems

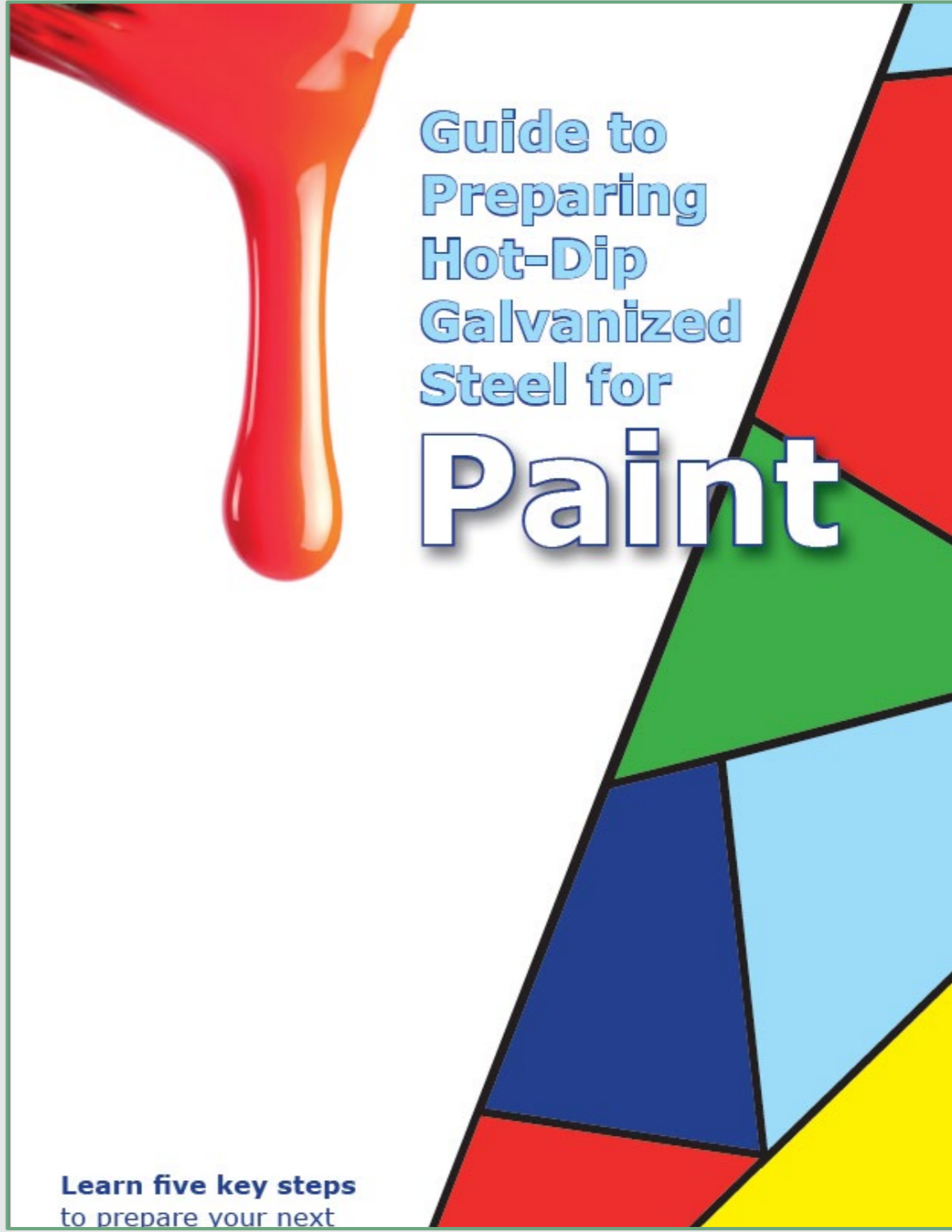
Painting & Powder Coating over HDG Steel Resources



 **Download (PDF)**



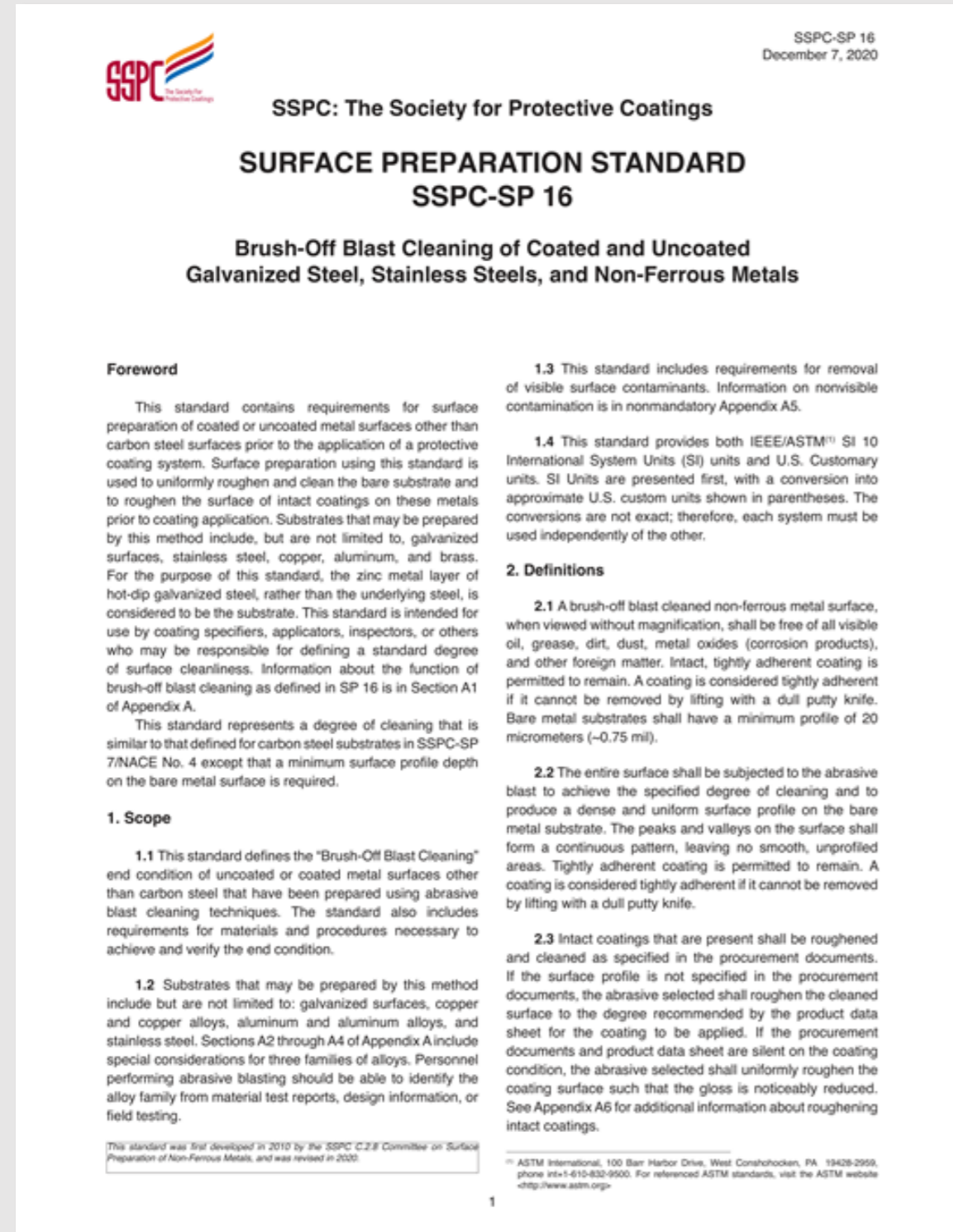
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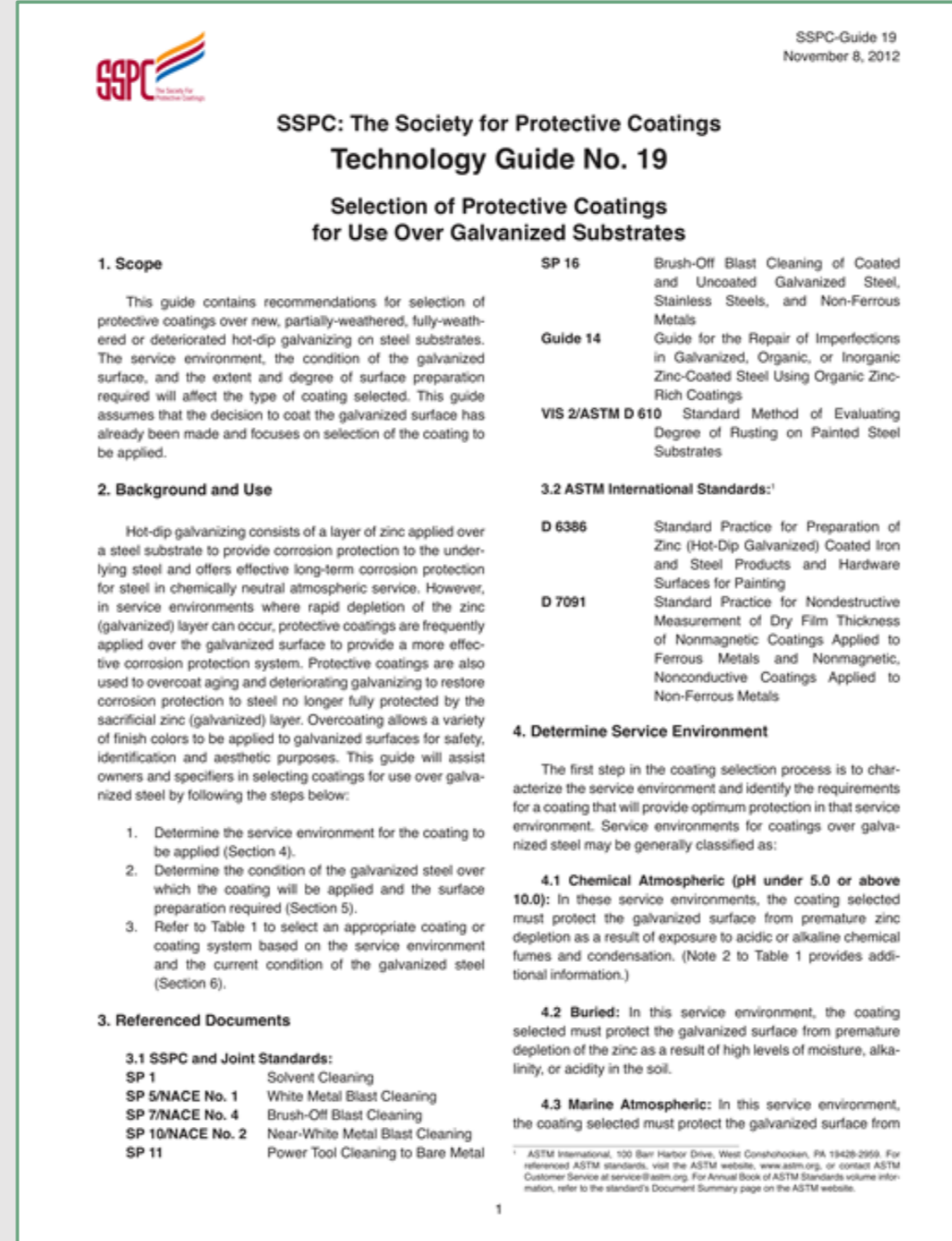
 **Watch Video (YouTube)**

Industry Resources for Duplex Systems

Painting & Powder Coating over HDG Steel Resources



 AMPP / SSPC-SP 16



 AMPP / SSPC Guide 19



 ASTM D6386 (Paint)

 ASTM D7803 (Powder)

Hybrid Zinc Coatings: Hot-Dip Galvanizing (HDG) & Thermal Spray Zinc (TSZ)

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Hybrid Zinc Coatings Overview

→ Hybrid (HDG + TSZ) Zinc Coatings

→ Superior corrosion protection for steel fabrications leveraging a combination of zinc application methods

→ Hot-Dip Galvanizing (HDG)

→ Immersion in molten zinc to form durable zinc-iron alloy layers that protect steel from corrosion effectively.

→ Thermal Spray Zinc (TSZ)

→ Spray-applied zinc with strong mechanical bond to blasted steel surfaces, ideal for components unsuitable for HDG.





Benefits

- Leverage strengths of each coating: achieve a long-lasting metallic zinc coating beyond constraints of a single coating process
 - Durable corrosion protection (barrier, cathodic, patina)
 - Complete coverage
 - Natural finish blends with surroundings
 - Initial aesthetic variation fades
- Avoid unnecessary cost premiums
- Project history available

Hot-Dip Galvanizing (HDG)

→ Coating Process Overview

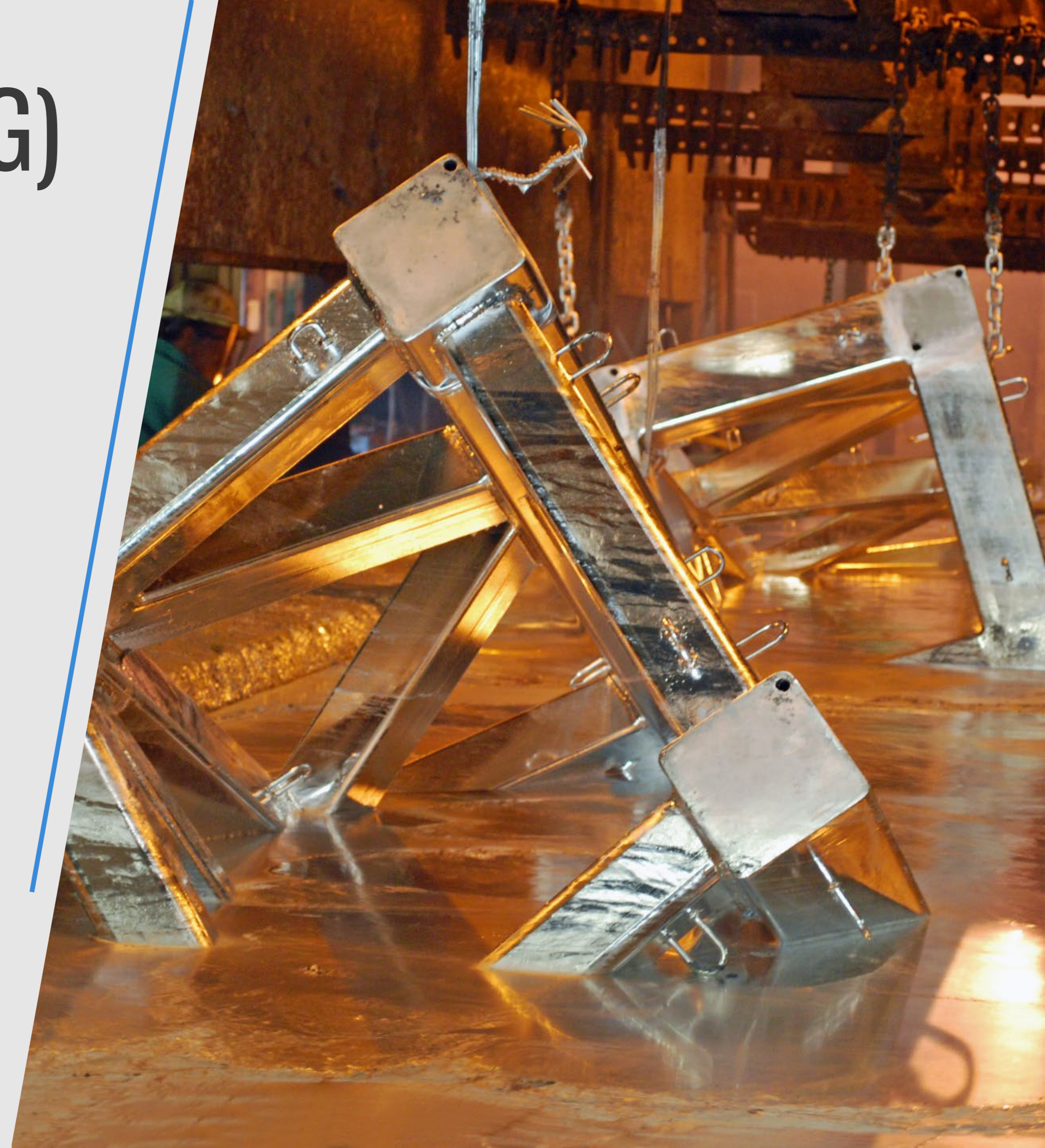
- Immersion in molten zinc forming metallurgical zinc-iron alloy layers
- Size limited by the dimensions of the galvanizing kettle

→ Full Coverage

- Immersion process ensures consistent coating on all surfaces (corners, edges, and complex geometries)

→ Durability

- Superior abrasion resistance, no curing time, and maintenance-free longevity





Thermal Spray Zinc (TSZ)

→ Coating Process Overview

→ Spray-applied to blast-cleaned steel surfaces, forming a mechanical bond.

→ Coating Thickness (No Limit)

→ Typically applied in multiple passes to achieve a total thickness of 4 - 20 mils

→ Low viscosity sealers are applied to address coating porosity

→ Advantages and Flexibility (Shop or Field)

→ Versatile for large and accessible surfaces

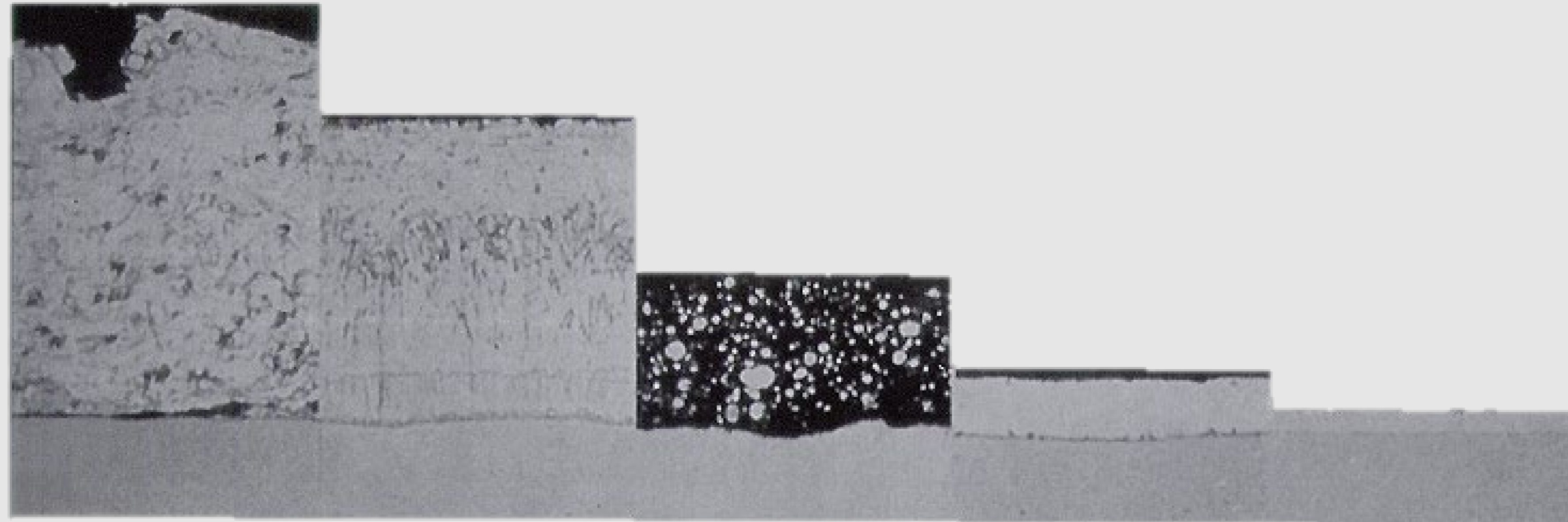
→ Suitable when HDG is impractical

→ Operational Considerations

→ Requires skilled operators and environmental controls, especially for field applications

Zinc Coatings

Common zinc coating thickness and density



Thermal Spray Zinc (TSZ)

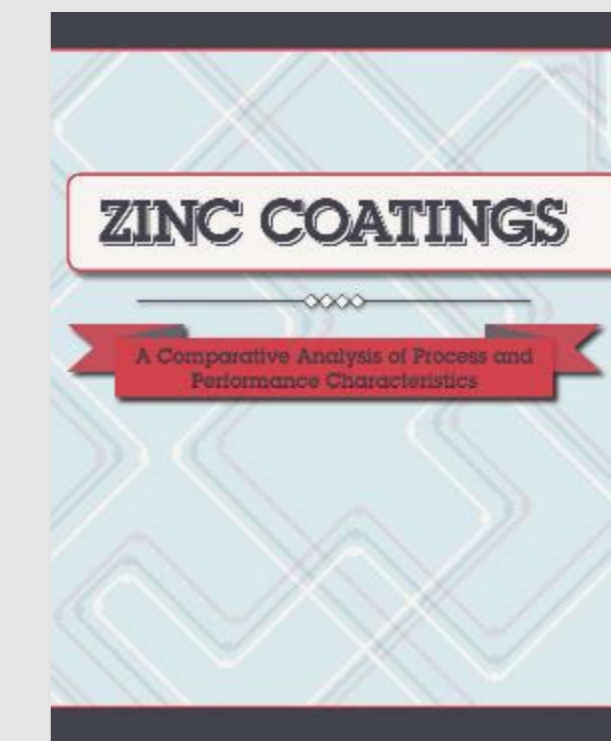
Hot-Dip Galvanized (HDG)

Zinc-Rich Paint

Continuously Galvanized Sheet

Electroplated

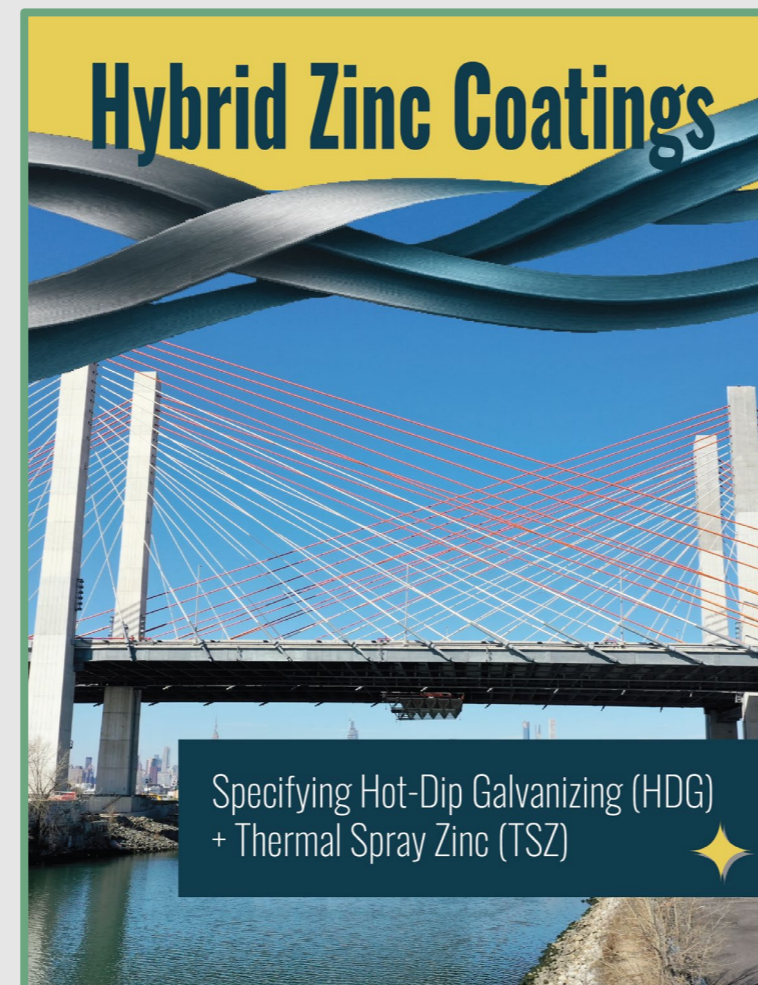
Thickness Required to meet 1 oz of zinc/ft ² of surface	
Thermal Spray Zinc (TSZ)	1.9 mils (48µm)
Hot-Dip Galvanized, Galvanized Sheet, Electroplated	1.7 mils (43µm)
Zinc-Rich Paint	3-6 mils (75-150µm)



 [Zinc Coatings \(PDF\)](#)

Hybrid Strategy for Long Spans

- Hybrid zinc coating systems (HDG + TSZ metallizing) for mixed-size projects
 - TSZ large, accessible steel articles / HDG steel articles that fit in kettle
 - Maximize cost efficiency
 - Leverage superior protection of zinc coatings
- Galvanize smaller components (cross frames, splice plates, etc.)



Hybrid Zinc Coatings
(HDG + TSZ) Guide (PDF)

galvanizeit.org

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WYE TRUSS BRIDGE

Riverside, IA | 2025



KOSCIUSZKO BRIDGE

New York, NY

TSZ specified for girders, floor beams, and other items too large for HDG. HDG specified for anchor assemblies and anchor stay tubes.



CANAM I-95 OVERPASS

Norwalk, Connecticut | 2024

TSZ specified for plate girders totaling 165 ft. HDG specified for cross frames and utility supports. Completion achieved in 4 months.

Estimating HDG & TSZ Performance in Atmospheric Environments

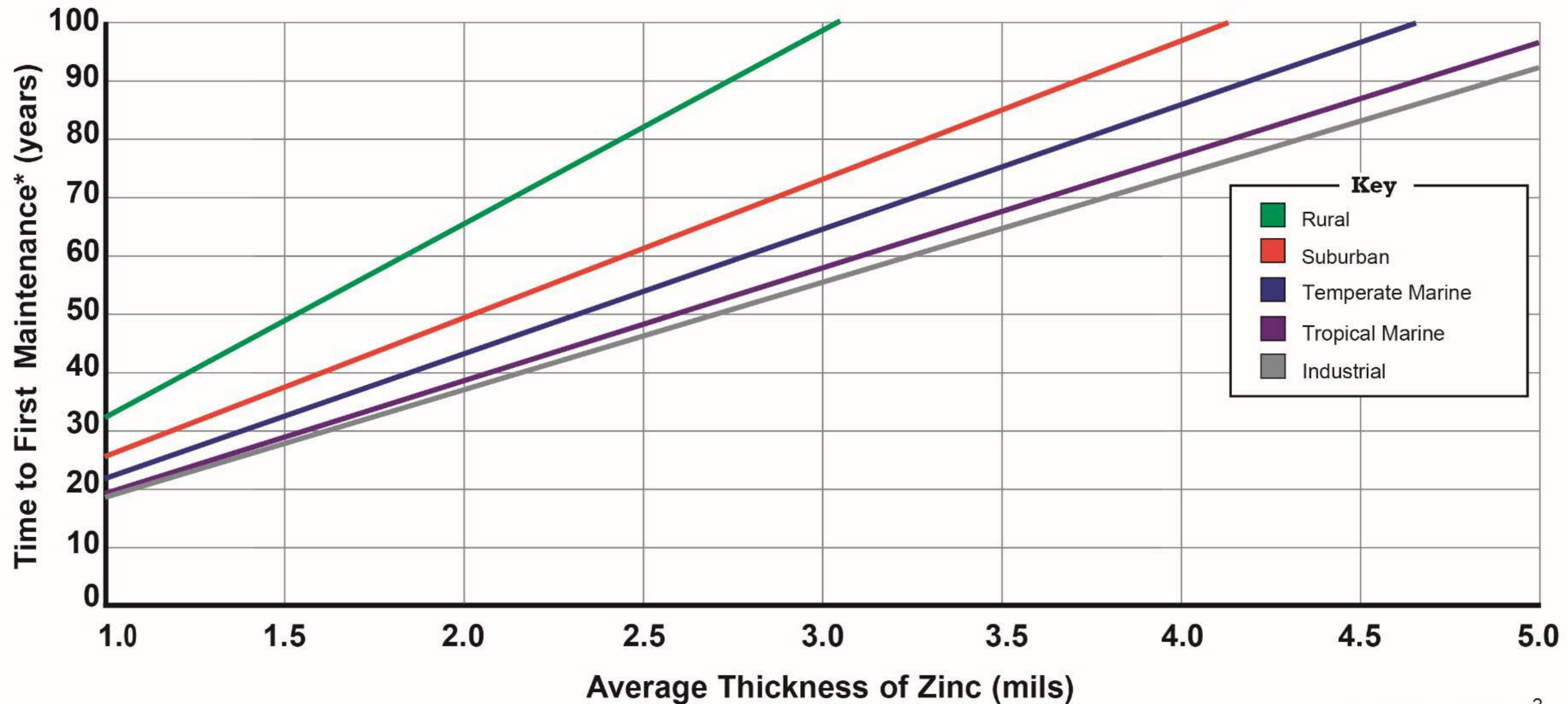
- Corrosion rate dependent on:
 - Temperature, relative humidity, rainfall, airborne salinity, sulfur dioxide concentration, sheltering condition
- Time to First Maintenance Chart
- Zinc Coating Life Predictor (ZCLP)
 - [Users Guide w/ Links to Collect Local Data](#)
- Adjustments for TSZ porosity overcome by increased coating thickness
- Accelerated tests (e.g. neutral salt spray) not appropriate for metallic zinc coatings and do not reflect real world performance



Try the Zinc Coating Life Predictor
(Web App)

Time to First Maintenance

Defined as the time to 5% rusting of the steel surface



*Time to first maintenance is defined as the time to 5% rusting of the substrate steel surface.

1 mil = 25.4µm = 0.56oz/ft²



Other Factors To Consider

- Size, Handling, and Application Constraints
- Risk of Distortion in HDG
- Dissimilar Metals
- Slip Critical Connections
 - Bridge (0.45)
- Coating Repair Materials
- Aesthetics
 - Harmonized appearance as zinc patina develops



Industry Resources

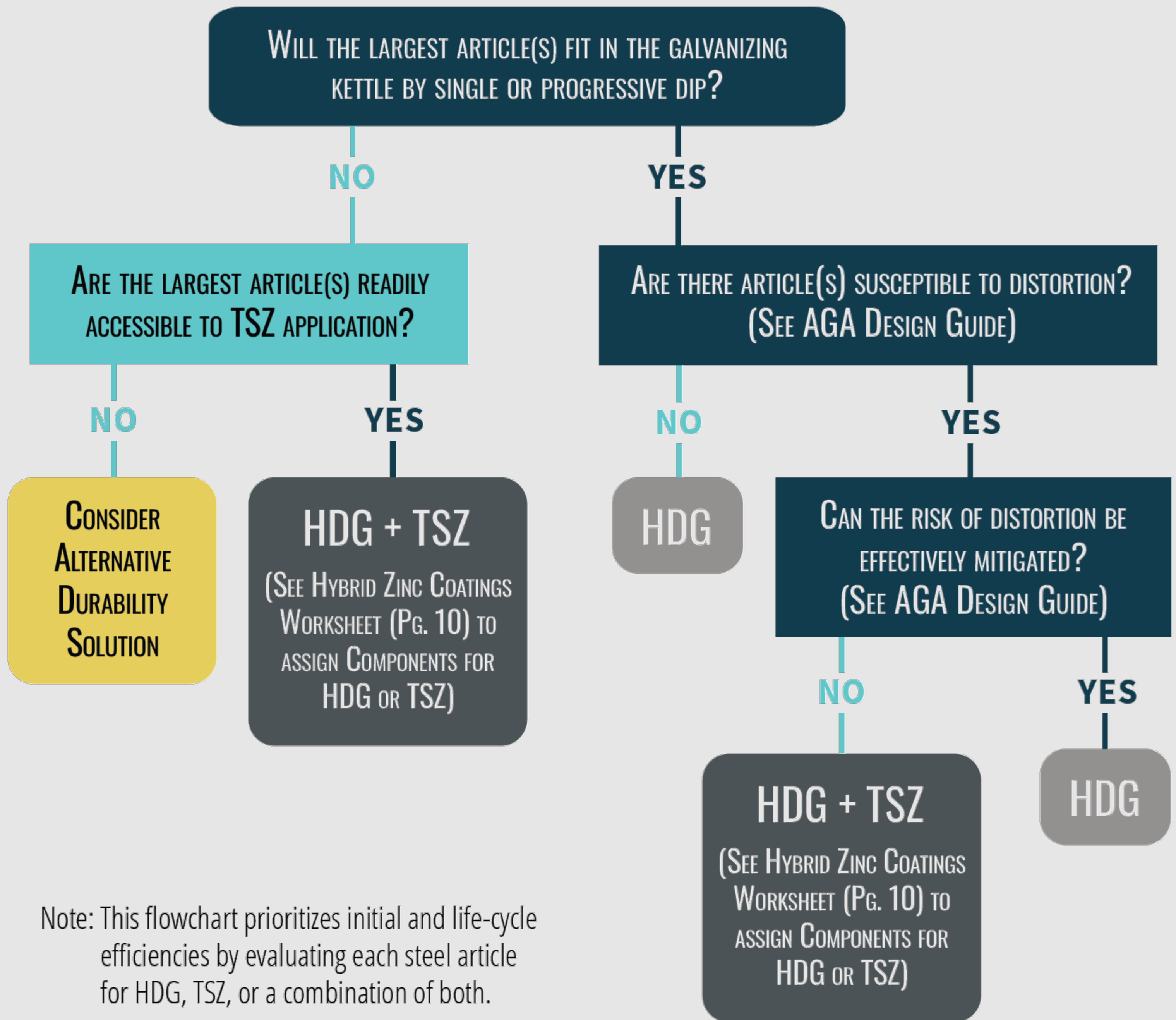
- AGA Publication: *Hybrid Zinc Coatings*
Guidance on evaluating larger or more complex fabrications
 - Guidance for evaluating maximum dimensions for hot-dip galvanizing
- AGA Article: *Determining & Overcoming the Size Limitations of Hot-Dip Galvanizing*



Free publication on AGA website

Hybrid Zinc Coatings

Specifying Hot-Dip Galvanizing (HDG)
+ Thermal Spray Zinc (TSZ) ✨




Note: This flowchart prioritizes initial and life-cycle efficiencies by evaluating each steel article for HDG, TSZ, or a combination of both.

Hybrid Zinc Coatings Worksheet

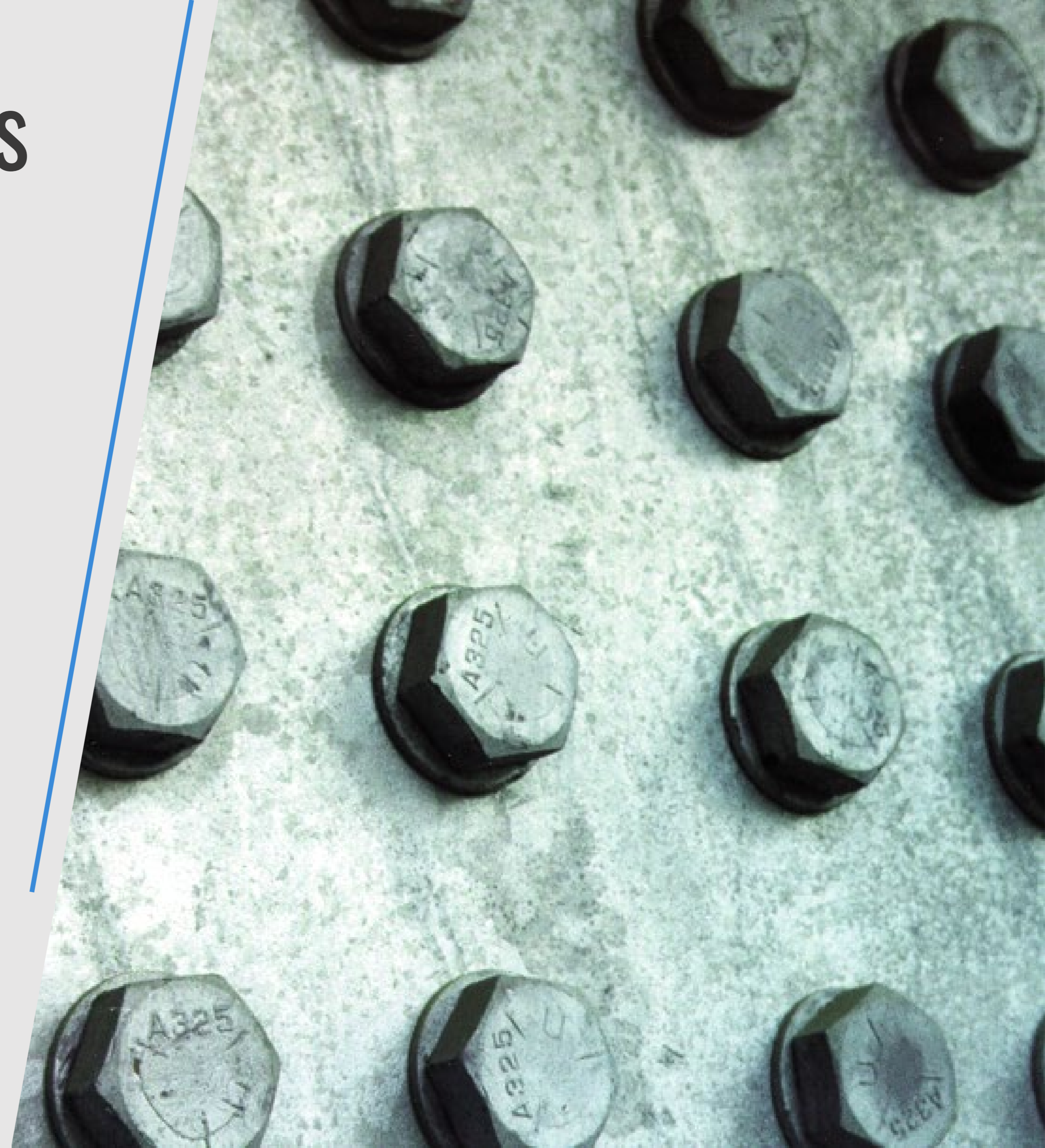
The following worksheet is designed to be used in conjunction with the flow chart (page 9). This worksheet can also be downloaded as a standalone, single-page, fillable form with flowchart from the AGA website: [insert link]

Physical Characteristics of Individual Steel Articles			
The following questions relate to the size, shape, configuration, and application of each steel article to assess whether HDG, TSZ, or a combination of both would be the best fit to maximize your project's cost efficiency.			
Questions	Answers		Notes
1	What are the dimensions of the largest article?	___ L ___ W ___ H	Ideally, all steel articles are designed to fit in the galvanizing kettle in a single dip (immersion). Components larger than the kettle may be candidates for progressive dipping (see Q4). A TSZ coating is ideal for larger components that cannot fit in the kettle in a single dip and cannot be progressively dipped.
1a	What is the largest length steel article?	___ L	
1b	What is the largest width steel article?	___ W	
1c	What is the largest depth (height) steel article?	___ H	
2	What is the size of the galvanizing kettle?	___ L ___ W ___ H	Typical kettle sizes range from 30-60' L x 5-8' W x 6-12' D (9-18 m L, 1.5-2.4 m W, 1.8-3.6 m D). The average galvanizing kettle size in North America is 40' L x 6' W x 8' D (12 m L x 1.8 m W x 2.4 m D). Kettle sizes for all AGA member galvanizers can be found on the AGA website: galvanizeit.org/galvanizers .
3	Are all dimensions listed in Q1 < Q2?	___ Yes ___ No	If YES, HDG is an ideal and cost efficient coating for all steel articles (Skip Q3a). If NO, Q4 will determine whether progressive dipping can be considered. It is important to verify this with the galvanizer to ensure the material handling capabilities of the galvanizer.
3a	Are the steel articles candidates for progressive dipping? (see Notes)	___ Yes ___ No	Articles up to 90' in length have been successfully hot-dip galvanized by employing a progressive dip process (dependent on kettle size). The AGA has developed simple reference charts to determine if this is possible (galvanizeit.org/PDcharts) and a more comprehensive progressive dip calculator (galvanizeit.org/PDcalculator). See also: galvanizeit.org/knowledgebase/article/determining-overcoming-the-size-limitations-of-hot-dip-galvanizing
4	Is the structure susceptible to distortion? (see Notes)	___ Yes ___ No	Some fabricated structures and assemblies may distort at the galvanizing temperature as a result of relieving stresses induced during steel production and in subsequent fabricating operations. The following AGA Knowledgebase article highlights particular fabrications that are susceptible and design/fabrication techniques to mitigate distortion/warpage risk: galvanizeit.org/knowledgebase/article/warpage-and-distortion .
5	Does the steel design include tight recessed areas? (nooks, crannies, threads for connections)	___ Yes ___ No	Tight recessed areas and other steel components can be difficult to blast clean or spray with the thermal spray gun. These components are ideally hot-dip galvanized depending on answers to Q1-Q4. See "Accessibility" for more information.
6	Is the article readily accessible for TSZ application?	___ Yes ___ No	Large, flat, uniform surfaces which are readily accessible are ideal for TSZ. Meanwhile, some design factors can make other items difficult to blast clean or spray with the thermal gun (i.e. large, flat surfaces and not hollow fabrications, small parts with many edges, etc.). See "Accessibility" for more information.
7	Does the project require surfaces with increased abrasion resistance?	___ Yes ___ No	If areas traditionally vulnerable during shipping, handling, and installation require increased durability and abrasion resistance, galvanizing is the preferred coating. Piles, posts, walkways and other components to be driven into the ground also benefit from galvanizing's superior abrasion resistance.
Schedule Impacts Considerations			
The following questions relate to factors that may influence the project schedule. If accelerated timelines and/or hard deadlines are required it is important to consider the following factors when choosing to hot-dip galvanize, apply thermal-spray zinc, or use a hybrid coating solution utilizing both coating systems.			
Questions	Answers		Notes
8	When is the steel required to be delivered to the job site? (i.e. accelerated timeline?, hard deadlines?)	Project Delivery Date: ___ Galvanizer Meet Delivery: ___ TSZ Applicator Meet Delivery: ___ ___ Yes / No ___ Yes / No	Applying multiple coatings will increase the project timeline. It is important to verify with the coating facilities directly that they can accommodate the required project schedule.
9	Does the fabricator offer in-house TSZ?	___ Yes ___ No	If the steel fabricator offers in-house TSZ capabilities this can shorten the project delivery schedule by limiting transportation between coating facilities.
10	If the project includes slip-critical connections, which are acceptable for design?	___ Class A/C ___ Class B ___ Class D	HDG and TSZ have different established friction properties as listed within RCSC and AASHTO specifications. Use of mixed connections or Class D may require project-specific testing prior to erection.

 **Download Flowchart / Worksheet (only)**

Slip Critical Connections

- Consistently achieves $\mu = 0.45$ minimum in independent testing.
- Bridges (AASHTO LRFD BDS)
 - Included in Class D definition:
 - *Blast-cleaned surfaces with Class D coatings, or a mixed faying surface utilizing an unsealed pure zinc or 85/15 zinc/aluminum thermal-sprayed coating with a thickness less than or equal to 16 mils mating with a HDG surface.*





Conclusions

- Complementary Coating Strengths
- Selection Tools Available for Efficiency in Specification
- Overall System Compatibility
- Proven Practical Benefits
 - Enhanced durability
 - Reduced initial cost



QUESTIONS?

GALVANIZEIT.ORG



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