

STUDY ON THE FACTORS PROMOTING THE OCCURRENCE OF FISH-BONING ON HDG STEEL AND HOW TO PREVENT ITS FORMATION

Éric Michaud
2026-10-08

AGA Tech Forum / Denver, CO

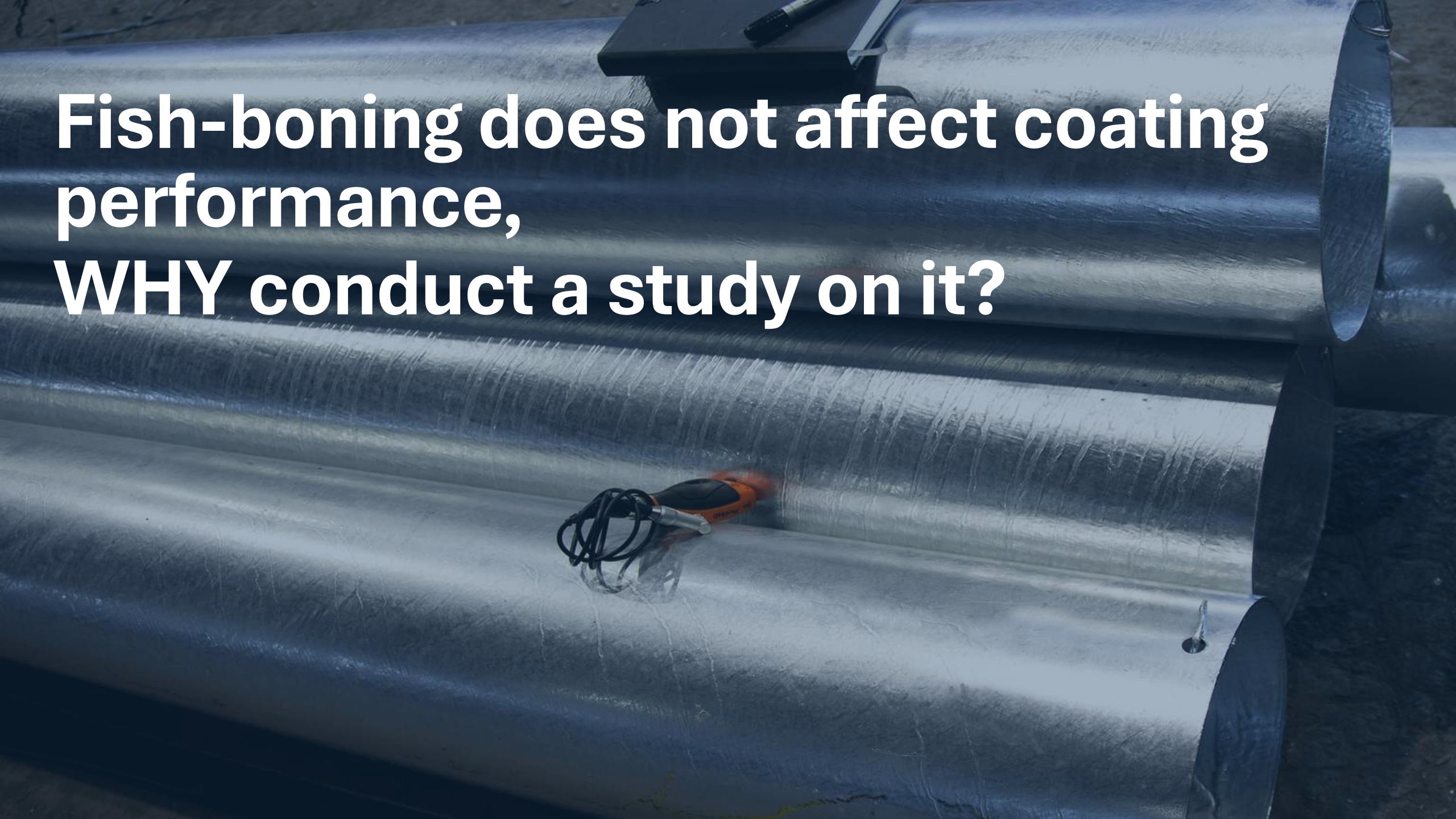




FBI

FISH BONYING INVESTIGATION

**Fish-boning does not affect coating performance,
WHY conduct a study on it?**



Because of the

ASCS



Asymptomatic Soup Can Syndrome

ASCS

If we were in a courtroom and I were a lawyer:

I would say that over the next 30 minutes, we are going to demonstrate that main suspect in the fish-boning case is innocent.

Differences in steel composition were not the cause of the "fish-boning" phenomenon in the three cases presented in this study.

30

Summer 2024

Quebec City plant manager called me:

“Hi Eric, ... in the last few months we have had **problems with** some **tubes** of a customer. We have tried various things, but the problem persists.

We believe this is because of the steel quality this customer is using.

Could you help us with this? ”



The problem with Problems
its that they never come alone!

Few days later

Montreal plant manager sent an e-mail:

“Hi Eric, we’re doing a **Duplex system AESS** job for an architectural project with the Metropolitan transportation agency.

There is **fish-boning on all the tubes**.
The inspection firm rejected them all.

Could you help us with this? ”



August 2024

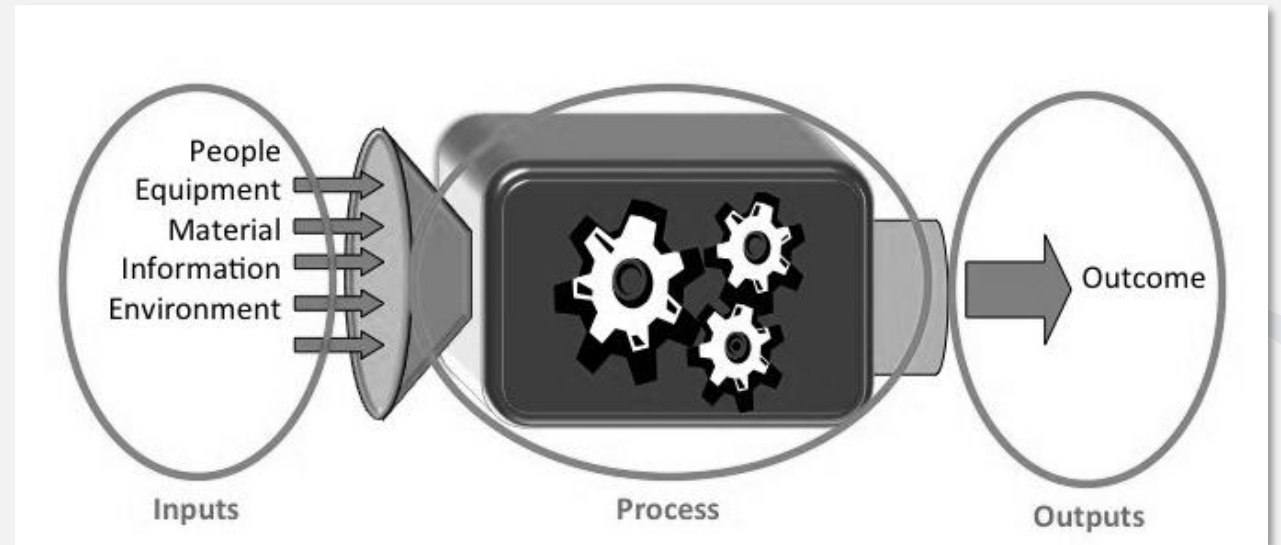
Hamilton plant: Text Message
“Fish-boning on corrugated plates”



**Our Fish-boning project has been conducted as a
Six-Sigma project: DMAIC** (Define, Measure, Analyze, Improve, Control)
Tools: C&E Matrix, DOE, Fish Bone Analysis

$$Y = f(X) + \varepsilon$$

When you know all the variables of an equation as well as their interactions, then you can predict the result.



The project:

Objectives:

Investigate the factors involved in the formation of fish boning from the steel source to the end of the galvanizing process and establish the optimal parameters to prevent future cases of fish-boning.

Project leader:

Éric Michaud, Technical director

Resources:

Internal resources: Plant galvanizers, Plant manager, General manager

External resources: AGA, GA, LDV, Montreal University Polytechnique lab, Clients, and other relevant resources

Literature review



F-0

Fish Boning

Fish boning is an irregular pattern over the entire surface of the steel part. This is caused by differences in the surface chemistry of a large diameter steel piece and variations in the reaction rate between the iron in the steel and the molten zinc. These reaction differences cause the thickness of the galvanized coating to vary in sharply defined zones across the surface. Fish boning (Figure 34) has no effect on the corrosion protection provided by the zinc coating and is not cause for rejection of the hot-dip galvanized part.

Source: AGA web site



Figure 34: Fish Boning

The scientific literature addressing the phenomenon of fish-boning is not extensive. Only a few documents discuss it.



Source: Industrial Galvanizers Australian Galvanizing Division

Fishbone striations on large diameter pipes arise from surface stresses in the steel causing different zinc-steel reaction rates on the pipe surface.

AI

What causes fish-boning in hot-dip galvanizing?

Fish-boning in hot-dip galvanizing is generally associated with an uneven galvanizing reaction, **often caused by the chemical composition of the steel** and/or the preparation and dipping conditions.



The consensus in the industry seems to be that:

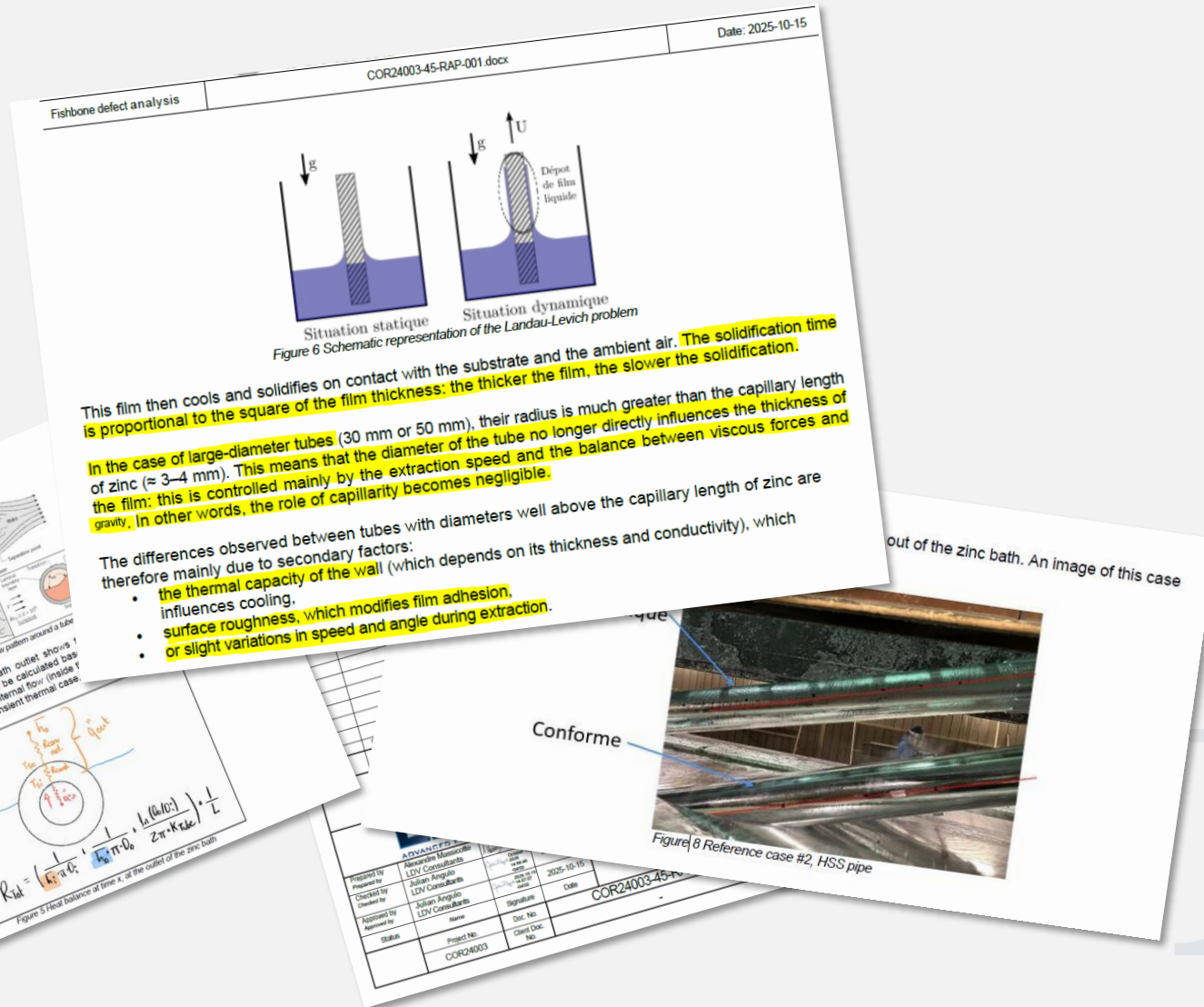
The phenomenon is generally observed on large diameter tubes and is thought to be caused by differences in steel composition.

The Fish-Bone Failure Analysis

Review of literature and engineering regarding fluid flow.

The suspected factors:

- Steel composition
- Surface finish
- Geometry of the parts
- Extraction angle
- Extraction rate
- Thermal gradient



The Montreal fish-boning case

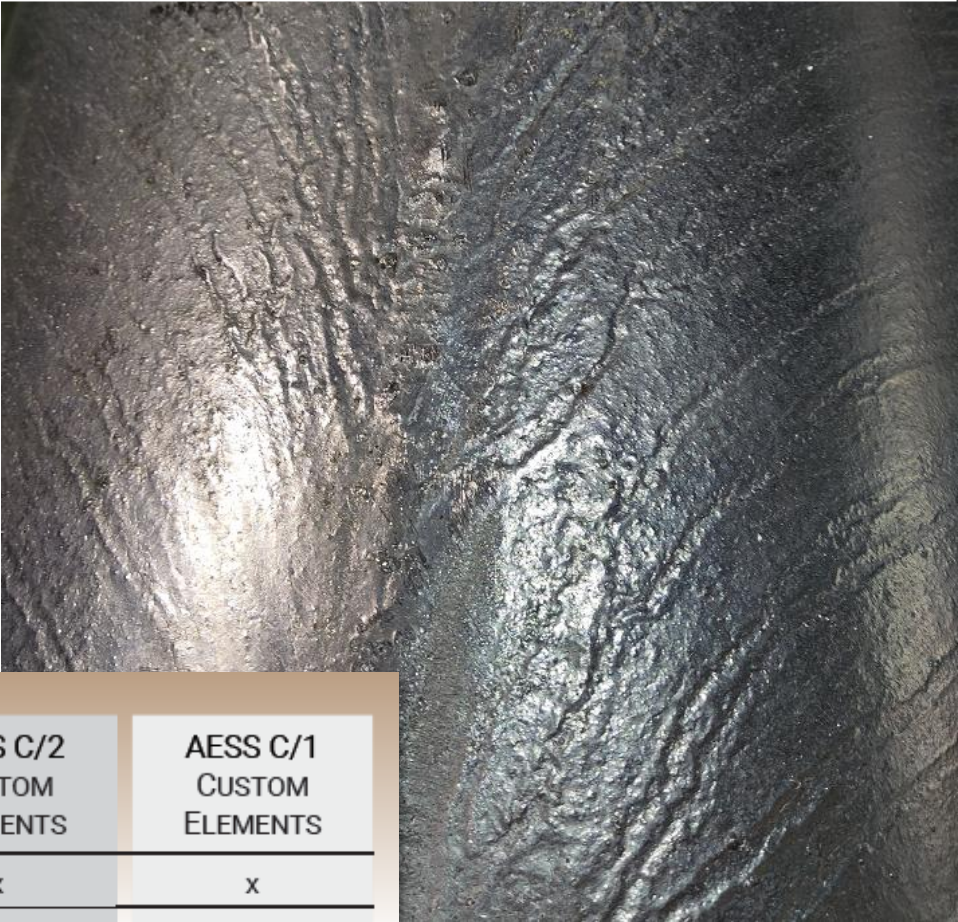
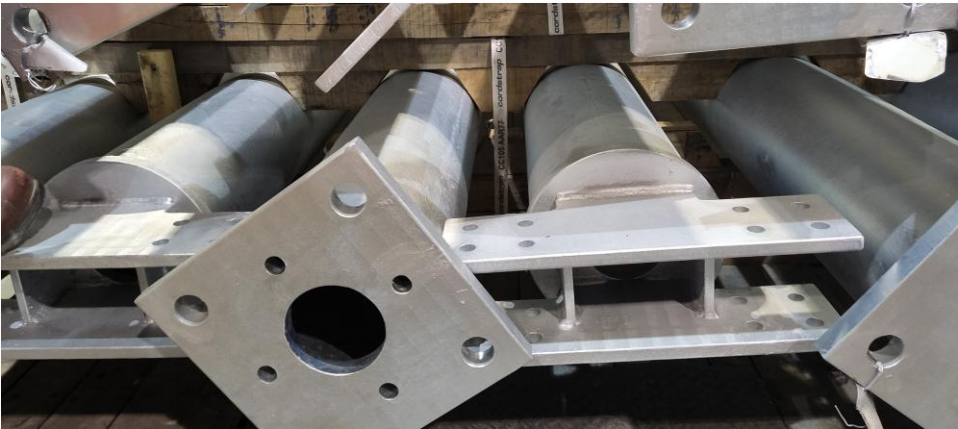
An Architectural project for a train station.

As per AESS guide, tubes have been **sandblasted** (SPC-SP6) prior to galvanizing.



COMMERCIAL BLAST CLEANING BEFORE HDG

The specification of commercial blast cleaning (SSPC-SP 6/NACE No. 3) is primarily specified to roughen the steel surface before HDG and not to provide a specific degree of cleaning. This practice is necessary to achieve the elevated aesthetic quality expected for each AESS category because it promotes a more uniform initial appearance among variations in steel surface chemistry, minimizes the formation of excessively thick HDG coatings, and minimizes the formation of brittle coatings prone to delamination.



MODIFIED AESS CATEGORY MATRIX FOR HDG		AESS C/4 CUSTOM ELEMENTS	AESS C/3 CUSTOM ELEMENTS	AESS C/2 CUSTOM ELEMENTS	AESS C/1 CUSTOM ELEMENTS
I.D	CATEGORY CHARACTERISTICS				
1.1	Surface preparation to SSPC-SP 6	x	x	x	x

The Montreal fish-boning case



Close up of "fishboning" on abrasive blasted and hot-dip galvanised pipes.

Fishboning in Hot-Dip Galvanising – Why Those Tear-Shaped Zinc Marks Appear



Galvatech (Pty) Ltd.

Galvatech (Pty) Ltd.

Corrosion Protection Specialists

Published Jun 15, 2026

Follow

One of the questions we occasionally receive from fabricators and engineers concerns a surface appearance commonly referred to as **fishboning**.

The appearance is most often seen on abrasive blasted steel and can be particularly noticeable on round pipes or tubular sections. It presents as a series of tear-shaped or run-like marks in the galvanised coating, leading some people to wonder whether the coating is defective.

In reality, fishboning is generally a normal characteristic of the hot-dip galvanising process and is usually only cosmetic in nature.

What Causes Fishboning?

During hot-dip galvanising, steel is immersed in molten zinc at approximately 450°C. As the steel is withdrawn from the bath, excess zinc drains back into the kettle while the remaining coating begins to cool and solidify.

Fishboning occurs when small amounts of molten zinc continue to flow across the steel surface as solidification takes place. The movement of the zinc creates characteristic tear-shaped patterns that become visible once the coating has fully cooled.

This effect is often more noticeable on:

- Abrasive blasted steel surfaces

- Round pipes and hollow sections
- Edges and corners
- Areas where zinc drainage is influenced by the withdrawal angle

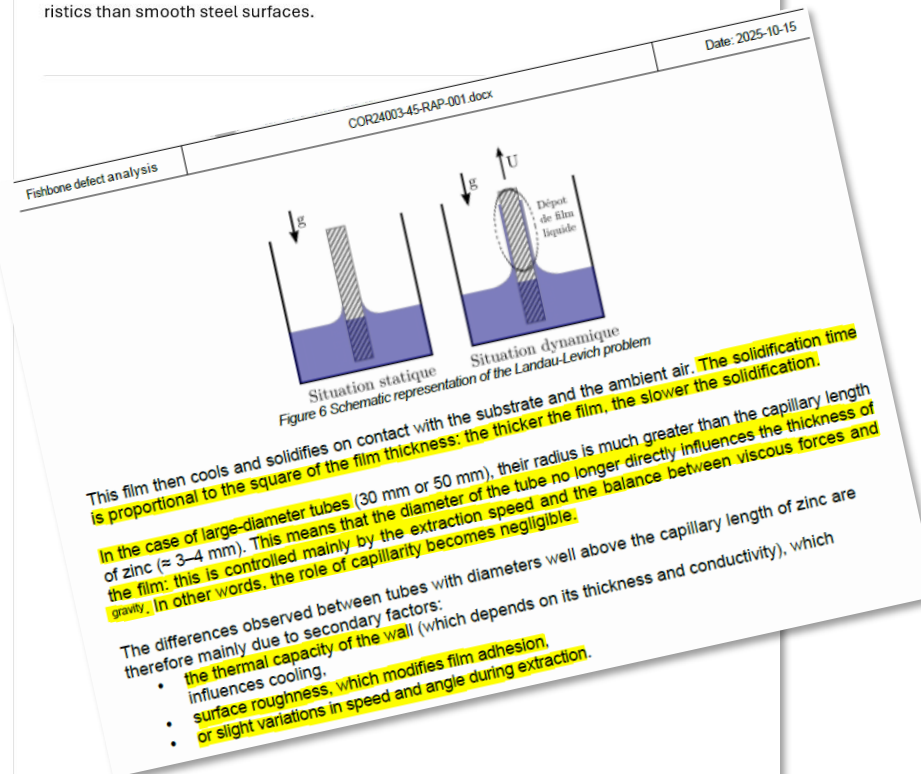
Because the coating is still in a semi-molten state as it leaves the zinc bath, gravity, surface tension and drainage behaviour all influence the final appearance of the coating.

Why Is It More Visible on Abrasive Blasted Steel?

Abrasive blasted steel produces a rougher surface profile than untreated steel.

This roughened profile promotes the formation of thicker galvanised coatings and can make natural zinc flow patterns more visible. As the molten zinc drains and solidifies, the underlying surface texture can accentuate the appearance of fishboning.

For this reason, abrasive blasted steel often displays more pronounced coating characteristics than smooth steel surfaces.



The engineers in charge of the project believed they were doing the right thing by recommending sandblasting of the surfaces prior to galvanizing.

However, it was actually this sandblasting that caused the fish-boning problem to appear.

Evolution of our understanding of the fish-boning problem

Beginning of the fish-boning Project

Montreal case: **Sandblasting has been identified as a factor promoting fish-boning.**

Similar tubes non sandblasted have been galvanized successfully.

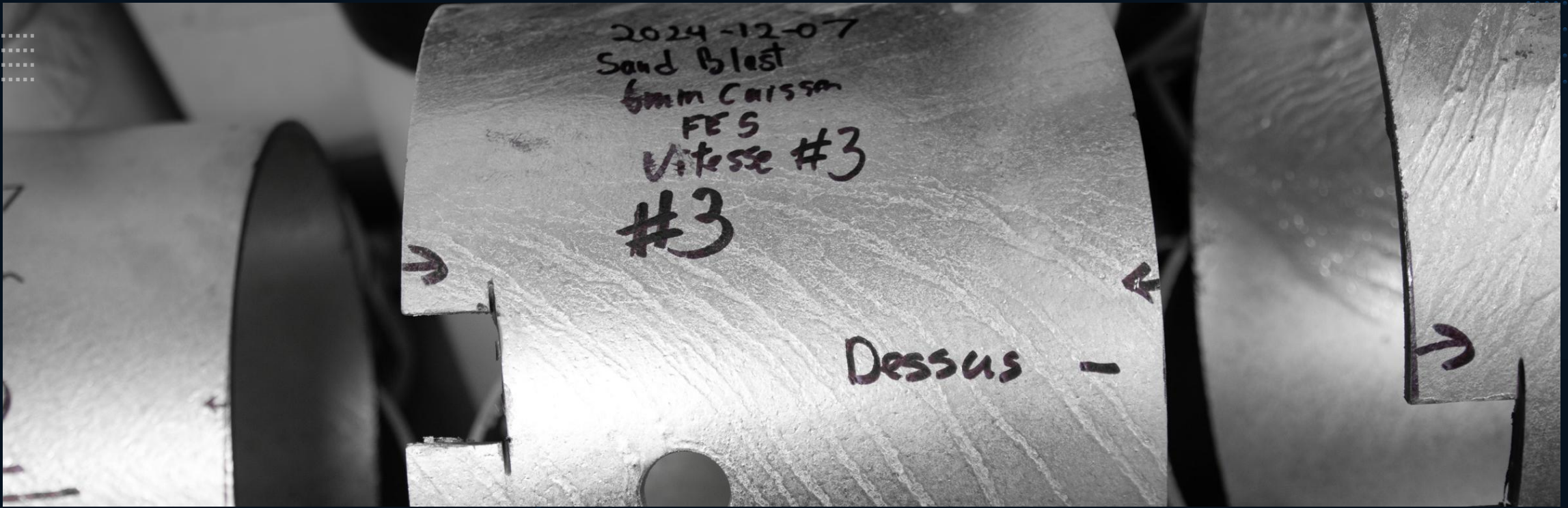
A note should be added to AESS guide to address the risk of fish-boning on some particular parts.

Quebec and Hamilton cases: **The parts from Quebec and Hamilton were not sandblasted**, but signs of fish-boning still appeared during galvanizing.

Other parameters and variables therefore also contribute to the occurrence of fish-boning.



2024-08 2024-10



Quebec fish-boning case:

Hamilton fish-boning case is similar to Quebec's one.

- Twelve days of tests in 2 plants (From 2024 to 2026)
- More than 100 dips
- 12 hours of video

We had a meeting with the customer

“Mr. Customer, fish-boning doesn’t affect the coating performance. Tubes should be accepted; we have documents to support this.”



The customer – “You galvanize a lot of these tubes for us. Most of them have uniform coating only few of them have the fish-boning problem. How come?”



“The final user do not want to have tubes with fish-boning in its project.”



“There must be some uncontrolled parameters in your process?”



What are the variation in the galvanizing process?

- Operators: **Day** shift versus **Evening** and **Night** shifts
- Pickling time
- Zinc stripping
- Acid concentration
- Flux, pH, concentration
- Kettle temperature
- Time in the kettle
- Extraction rate
- Alloys

$$Y = f(X)$$

How we found the variation in our process?

We conducted a survey with kettle operators

Kettle extraction rate:

61 to 258 cm/min

depending on the operator

Questionnaire sur la galvanisation des poteaux de lignes de transmissions

L'objectif de ce questionnaire est de recueillir le maximum d'information sur les paramètres de galvanisation utilisés lors de la galvanisation des tubes de JL Leclerc et Captel



Figure 1: Exemple de poteaux de JL Leclerc

- 1- Quart de travail et/ou nom du trempoir: SOIR D.P
- 2- Quel temps de cuisson utilisez-vous pour les tubes: 30 à 35 minutes
- 3- Pendant la cuisson, faites-vous un mouvement alternatif de haut en bas avec la balancette: NON
- 4- Quel est la vitesse utilisée pour l'extraction du matériel (vitesse de remonté): 3
- 5- Est-ce que de l'air comprimé est utilisé par les assistants trempoirs pendant l'extraction: NON
- 6- Appliquez-vous une inclinaison à la balancette lors de l'extraction: NON
- 7- Est-ce qu'il y a des arrêt de remonté lors de l'extraction: NON

Observations et commentaires:
VITESSE DE REMONTÉ FAIT DÉPENDRE LE
PRÉCISÉMENT DE PRÉCISER LE GESTE PLUS RAPIDE QUE
LES

Questionnaire sur la galvanisation des poteaux de lignes de transmissions

Balmall 24

L'objectif de ce questionnaire est de recueillir le maximum d'information sur les paramètres de galvanisation utilisés lors de la galvanisation des tubes de JL Leclerc et Captel



Figure 1: Exemple de poteaux de JL Leclerc

- 1- Quart de travail et/ou nom du trempoir: S. DUBÉ
- 2- Quel temps de cuisson utilisez-vous pour les tubes: 20 min
- 3- Pendant la cuisson, faites-vous un mouvement alternatif de haut en bas avec la balancette: NON
- 4- Quel est la vitesse utilisée pour l'extraction du matériel (vitesse de remonté): 4 à 5
- 5- Est-ce que de l'air comprimé est utilisé par les assistants trempoirs pendant l'extraction: NON
- 6- Appliquez-vous une inclinaison à la balancette lors de l'extraction: NON
- 7- Est-ce qu'il y a des arrêt de remonté lors de l'extraction: NON

Observations et commentaires:
avant sortir à partir 5 min

Questionnaire sur la galvanisation des poteaux de lignes de transmissions

L'objectif de ce questionnaire est de recueillir le maximum d'information sur les paramètres de galvanisation utilisés lors de la galvanisation des tubes de JL Leclerc et Captel



Figure 1: Exemple de poteaux de JL Leclerc

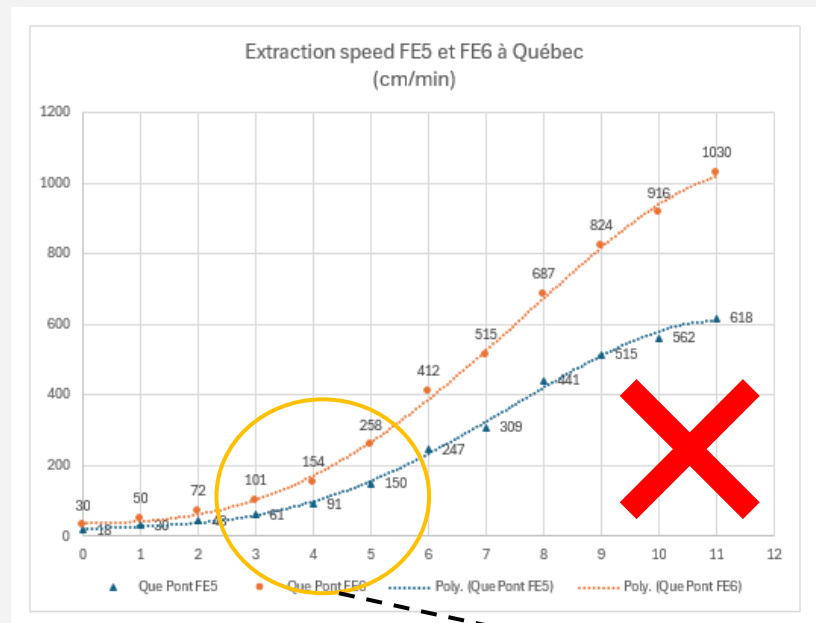
- 1- Quart de travail et/ou nom du trempoir: AP SOIR CLÉMENT LECLERC
- 2- Quel temps de cuisson utilisez-vous pour les tubes: 8
- 3- Pendant la cuisson, faites-vous un mouvement alternatif de haut en bas avec la balancette: NON
- 4- Quel est la vitesse utilisée pour l'extraction du matériel (vitesse de remonté): CA DÉPEND DU PAYS (4) VITESSE
- 5- Est-ce que de l'air comprimé est utilisé par les assistants trempoirs pendant l'extraction: NON
- 6- Appliquez-vous une inclinaison à la balancette lors de l'extraction: OUI
- 7- Est-ce qu'il y a des arrêt de remonté lors de l'extraction: NON

Observations et commentaires:
avant sortir à partir 5 min

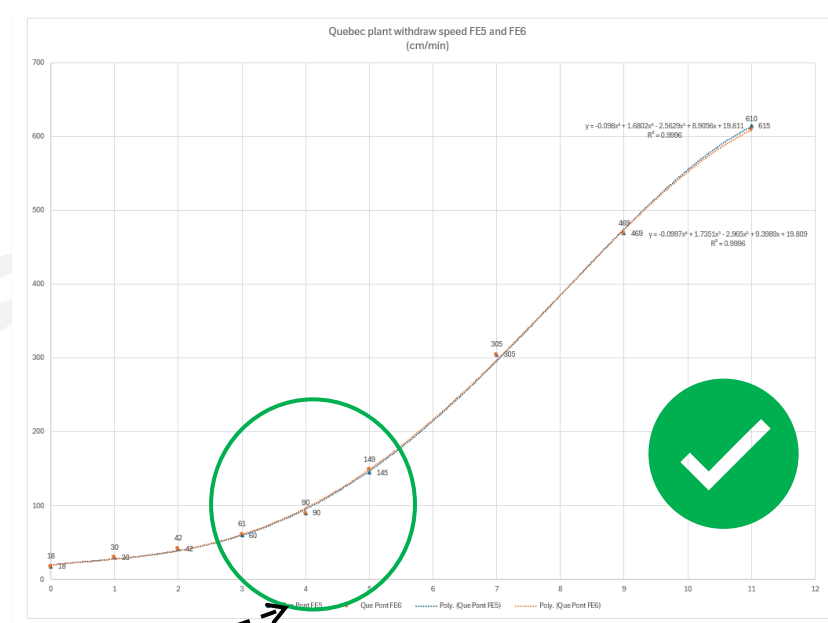
How we found the variation in our process?

We looked at the extraction speed of the monorail crains (2 sets) used at the kettle.

FE5 and FE6 **before** calibration



FE5 and FE6 **after** calibration



Quebec fish-boning case:

Variables and constants

Variables studied

- Extraction speed 18 to 150 cm/minutes (7 to 59 in/min)
- Tube angle: 2° to 90 °
- Enclosure doors opening
- Level of agitation: Movement versus Still during cooking
- Cooking (dwell) time 4 to 8 minutes
- Effect of zinc stripping (delay between stripping and re-galvanizing)

Fixed parameters

- Kettle temperature: Constant 443°C $\pm$ 1°C (829 °F)
- Alloys: Constant (Bi, Ni, Al, SGH Zn) Pb less than 0,0030%

Quebec fish-boning case: Material

- Purchase of two 40' long by 13" diameter tubes
 - One cut in 10 feet sections
 - One kept as is for tests representing real conditions
- The customer also provided similar tubes for the experimentations

Atlas Tube Canada
200 Clark St.
Harrow Ontario Canada
N0R 1G0
Tel: 519-738-3541
Fax: 519-738-3537

Atlas Tube

A DIVISION OF ZEKELMAN INDUSTRIES

REF. B/L: 81214231
Date: 04/12/2024
Customer: 97

Sold To
Leroux Steel - Boucherville
Division of Russel Metals
1331 Graham Bell
BOUCHERVILLE QC J4B 6A1

MATERIAL TEST REPORT

Shipped To
Captel Inc
9395, Boul. Parent
TROIS-RIVIERES QC 69A 5E1
CANADA

Material: 12.750x250x40"0"0"0"(2x1)VS1LSTC-5AY70-VMaterial No: R12750250Made in: Canada

Sales Order: 2014644Purchase Order: 094053952Melted and Poured in: Canada

Heat No C Mn P S Si Al Cu Cb Mo Ni Cr V Ti B N CaCust Material#: 12922

7164650.0600.8100.0080.0050.0170.0460.0480.0700.0060.0210.2000.0020.0020.00020.00500.0002CE: 0.24

Bundle No Pcs Yield Tensile Eln. 2inCertificationASTM A500-23 MOD 70

M2017616632076691 Psi080748 Psi23.0 %

CHARPY Test Results

Ft. lbsTest TempSample SizeDirect ionAbsorbed Energy1 FT-LBSAbsorbed Energy2 FT-LBSAvg FT-LBSShear Area1 %Shear Area2 %Shear Area3 %Avg %

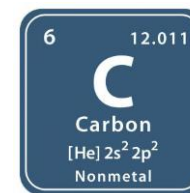
7-20C10x3.3 mmL414942606060

Heat MILLMill LocationMethodRecycled ContentPost ConsumerPre-Consumer (Post Industrial)% HarvestedWithin Miles of Location

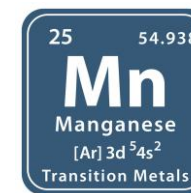
716465STELCONanticoke, ONBOF36.90%19.80%14.40%100%1000

Material Note:

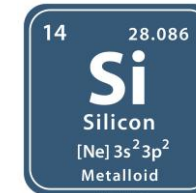
Sales Or. Note:



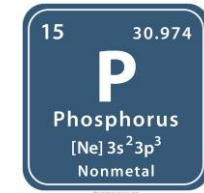
0,060 %



0,810 %



0,017 %



0,008 %

Steel composition validated
by lab analysis



Quebec fish-boning case:

Documentation and test preparation

Test #1

Planning the test matrix: 3 variables, 2 levels

$2^3= 8$ combinations

Variable	Level 1	Level 2
Cooking time	4 min	8 min
Extraction speed	30 cm/min	150 cm/min
Zinc stripped in HCl	Galv (No strip)	Stripped and regalvanized

Racking angle constant $20 \pm 2^\circ$

Date : 2024-11-14

Personnel impliqué : Éric Michaud, Martin Paquet, Yann Lacasse

Durée : 4h

Définition d'une matrice de tests pour deux facteurs variant de deux niveaux pour des tubes de première galvanisation et les mêmes tubes dézincés et regalvaniser par la suite.

Essai	Galvanisation	Temps de cuisson	Vitesse
1	1 ^{er}	4 min	Lent vitesse 1
2	1 ^{er}	4 min	Rapide vitesse 5
3	1 ^{er}	8 min	Lent vitesse 1
4	1 ^{er}	8 min	Rapide vitesse 5
5	Après dézinc	4 min	Lent vitesse 1
6	Après dézinc	4 min	Rapide vitesse 5
7	Après dézinc	8 min	Lent vitesse 1
8	Après dézinc	8 min	Rapide vitesse 5

Angle d'accrochage : $20^\circ \pm 2^\circ$

Pont de galvanisation : FE5

Documentation



Date : 2024-11-14

Personnel impliqué : Éric Michaud, Martin Paquet, Yann Lacasse

Durée : 4h

Définition d'une matrice de tests pour deux facteurs variables : première galvanisation et les mêmes tubes dézingués et

Essai	Galvanisation	Temps de
1	1 ^{er}	4 min
2	1 ^{er}	4 min
3	1 ^{er}	8 min
4	1 ^{er}	8 min
5	Après dézinc	4 min
6	Après dézinc	4 min
7	Après dézinc	8 min
8	Après dézinc	8 min

Angle d'accrochage : $20^\circ \pm 2^\circ$

Pont de galvanisation : FE5



Angle measurement

Date : 2024-11-23
Personnel impliqué : Éric Michaud, David Naud, André Poirier, Martin Paquet

Durée : 8h

Test en usine avec des tubes de JL Leders selon le protocole élaboré le 2024-11-14

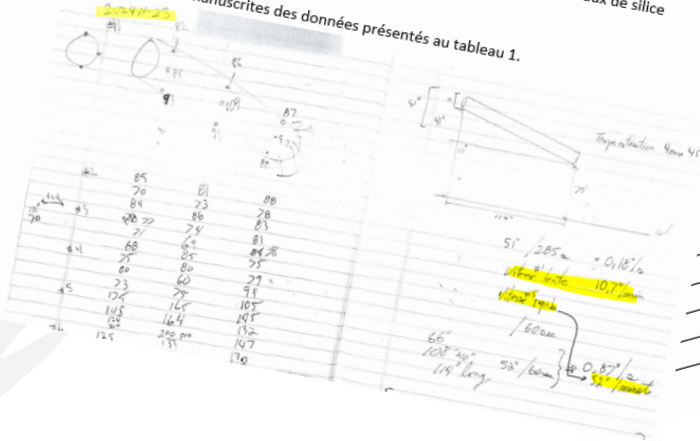
Balancette #	Test #	Galvanisation	Temps de cuisson (min)	Vitesse d'extraction (# de vitesse)	Observations	Angle d'accrochage (°)	Pont de galvanisation
10	1	1 ^{re}	8	Lent 1	Pas de fishboning	18.5	FE5
18	2	1 ^{re}	4	Lent 1	Pas de fishboning	21.45	FE5
7	3	1 ^{re}	4	Rapide 5	Pas de fishboning	19.35	FE5
29	4	1 ^{re}	8	Rapide 5	Présence de fishboning	18.5	FE5
10	5	2 ^e galv (après dézinc)	8	Lent 1	Pas de fishboning très bons résultats	21.45	
18	6	2 ^e galv (après dézinc)	8	Lent 1	Pas de fishboning très bons résultats	19.35	
7	7	2 ^e galv (après dézinc)	4	Lent 1	Présence de fishboning	21	
29	8	2 ^e galv (après dézinc)	4	Rapide 5	Présence de fishboning	20	

Estimation de la vitesse vertical #1 : 30 cm/min
Estimation de la vitesse galvanisation 443°C
Température de galvanisation 443°C

Observations :

- La vitesse d'extraction lente ou rapide ne semble pas favoriser la formation de fishboning lors de la première galvanisation et ce peu importe le temps de cuisson (4 ou 8 minutes). Ce qui corrobore les observations faites par l'équipe de production.
- Le fishboning se produit lors de la seconde galvanisation et sa présence n'est observé seulement sur les tubes dont la vitesse d'extraction était rapide (vitesse 5). Les tubes extraits lentement (vitesse 1) ne présentent pas de signe de fishboning. La variation du temps de cuisson (4 ou 8 minutes) ne semble pas favoriser la formation de fishboning.
- Tous les tubes du tableau 1 ci-dessous on remarque que les tubes après dézinc (essais 5 à 8) ont des épaisseurs de revêtements supérieures à ceux des tubes issus de la première galvanisation.
- Les épaisseurs le long du tube n'augmentent pas significativement entre le haut du tube et ce qui suggère qu'ils sont composés d'acier calé à l'aluminium et que le taux de silice est bas.

Schéma 1 : Notes manuscrites des données présentées au tableau 1.



Les épaisseurs correspondantes aux tests

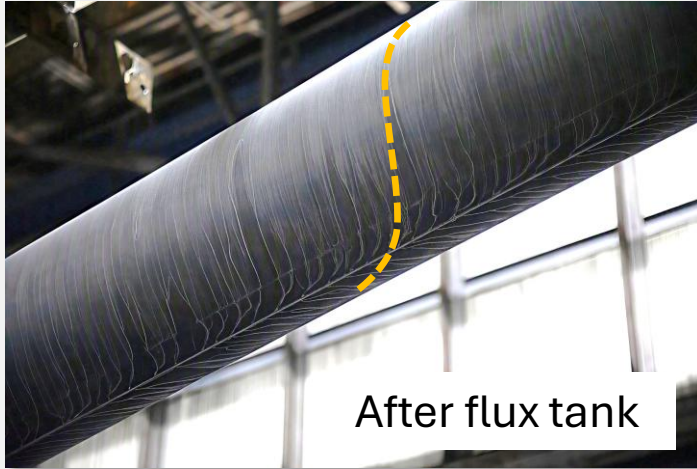
Épaisseur du revêtement de zinc (µm)		Bas du tube
Haut du tube	Milieu	
	86	87
	109	92
	99	88
	81	78
	73	83
	86	81
	74	78
	69	75
	85	79
	80	94
	60	105
	75	145
	80	132
	73	165
	175	164
	145	200
	124	133
	135	148
	150	114
	160	120
	122	97
	109	89
	90	141-300
	200	120
	100	100
	92	76



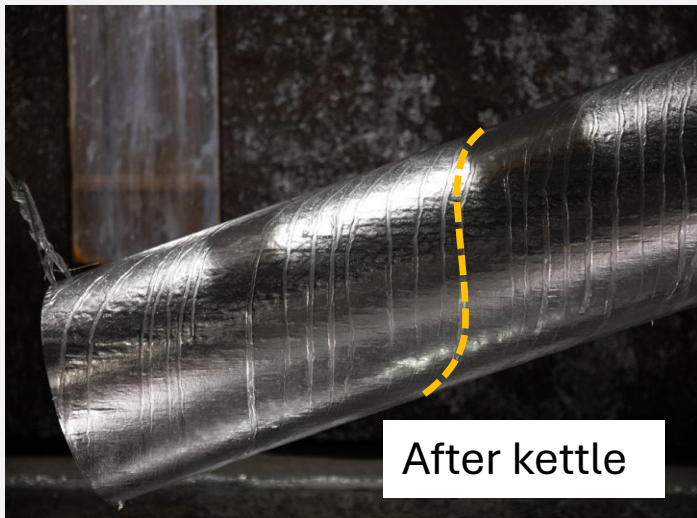
Quebec fish-boning case: Observations



Quebec fish-boning case: Observations

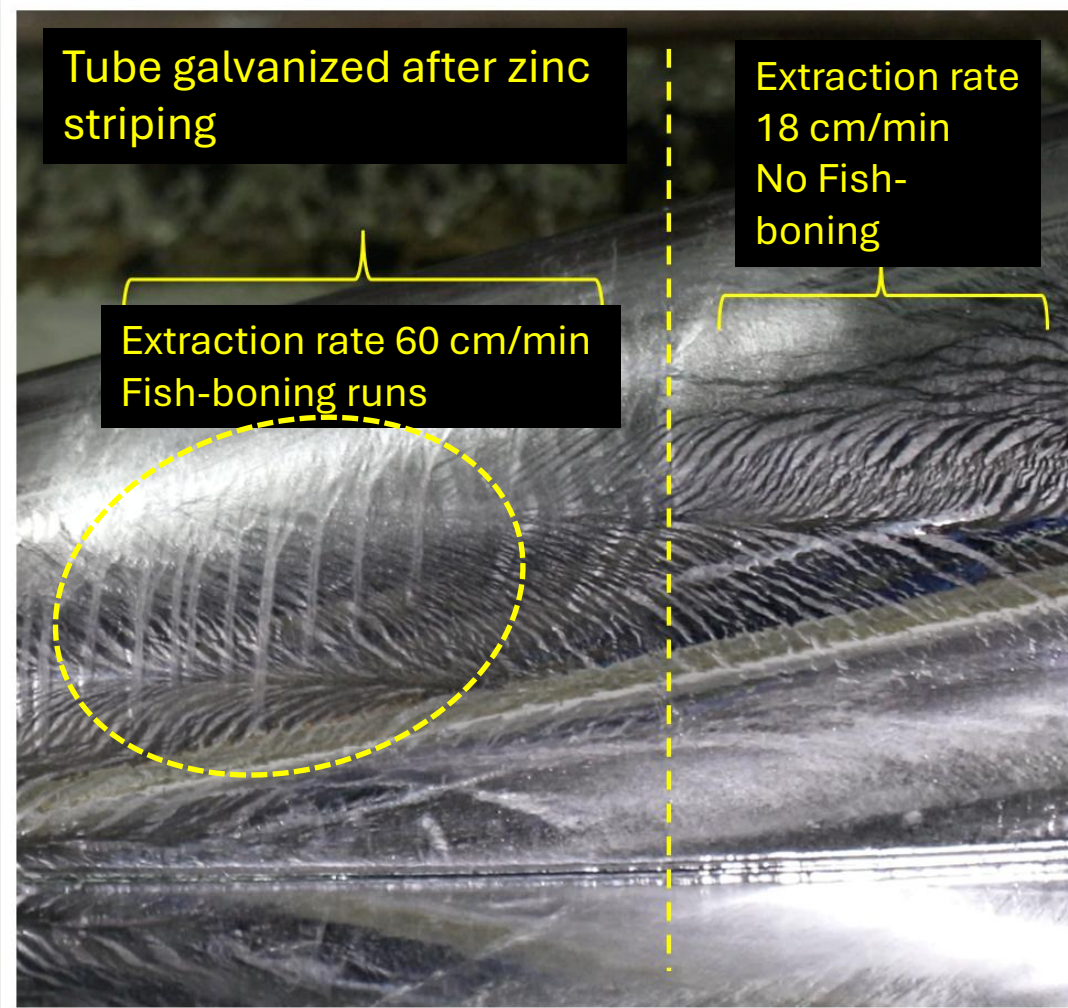


Similarities in the liquid flow pattern observed on the tube as it exits the flux tank and the galvanizing kettle.



It suggest that the fish-boning problem could be attributed to a disruption in the zinc flow rather than to differences in steel composition.

Kettle extraction rate

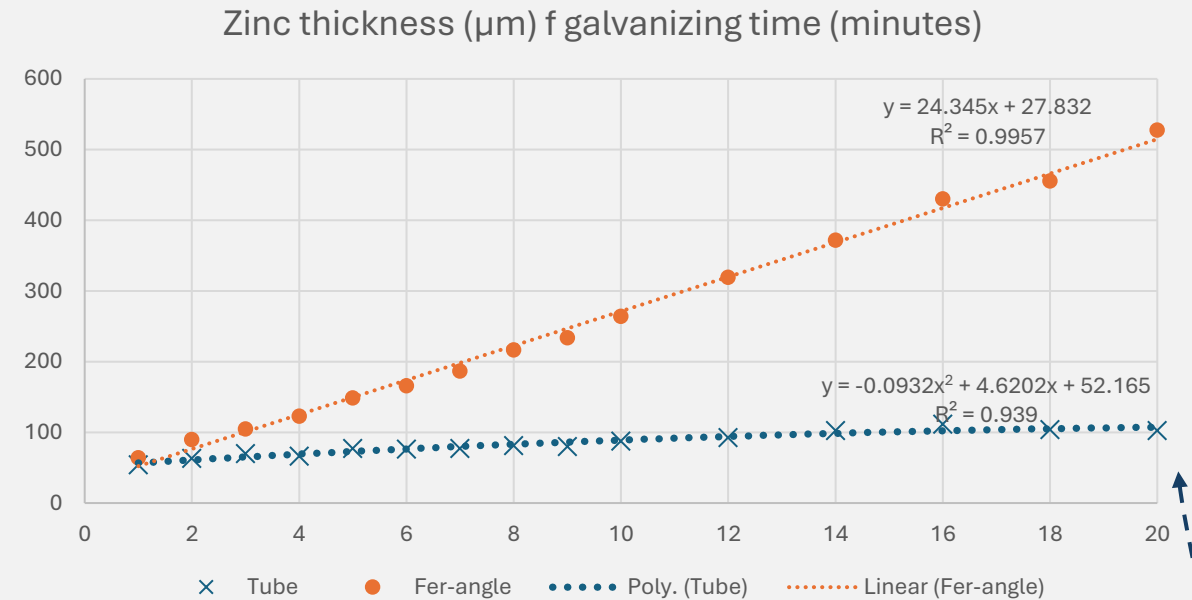
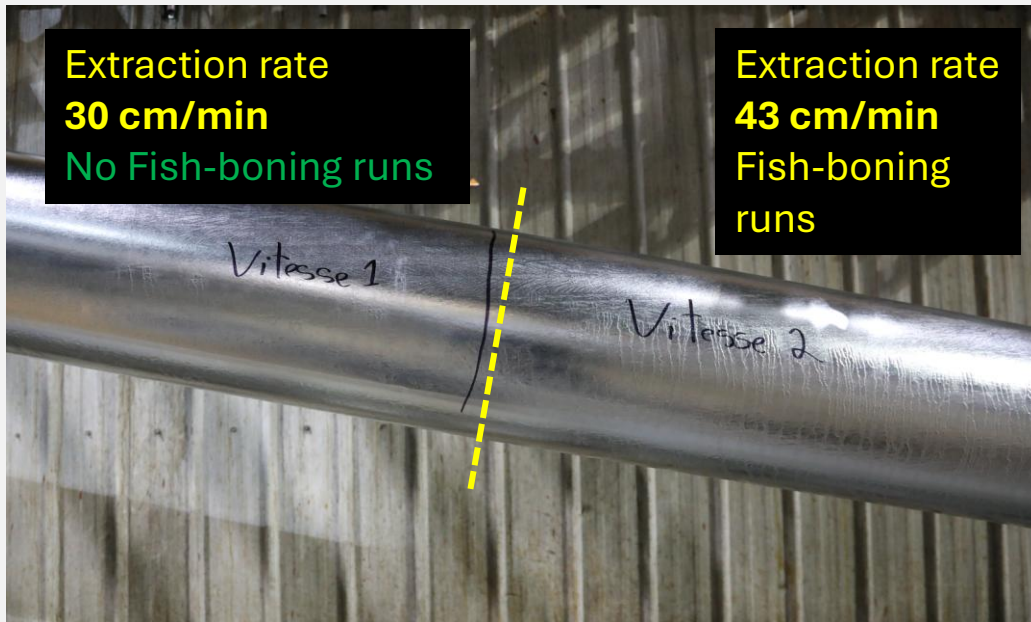


On the initial galvanization of tubes, kettle extraction rate from 60 to 150 cm/min (24 to 60 inches/min) is not an issue.

No fish-boning is observed when using these parameters.

Once a tube has been stripped, the kettle extraction rate should be as low as possible. **Best results were achieved with a rate in the range of 18 to 30 cm/min (7 to 11 inches/min)**

Kettle extraction rate



Slow extraction rates mean longer time in the kettle.

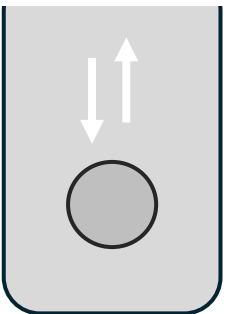
Not to worry!

These tubes are mostly made of aluminum killed steel. The reaction of low silicon steel with zinc in the kettle doesn't generate thick or brittle coating even after a long dwell time in the kettle.

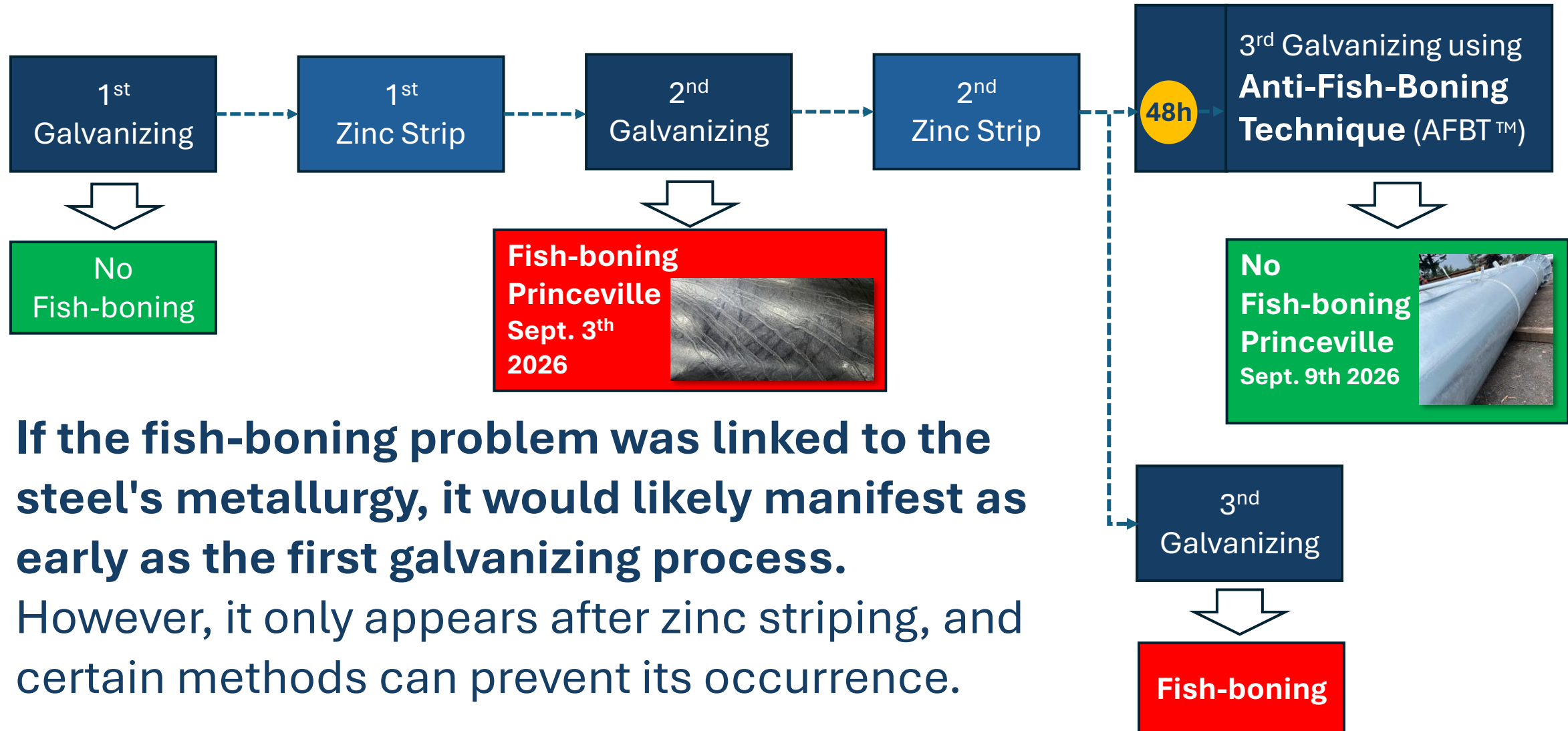
Agitation in kettle



Based on observations, fish-boning resembles a gel on the tube surface. Gentle agitation during dwell time helps to wash this gel away. It seems to glide along the tube wall (see picture above).



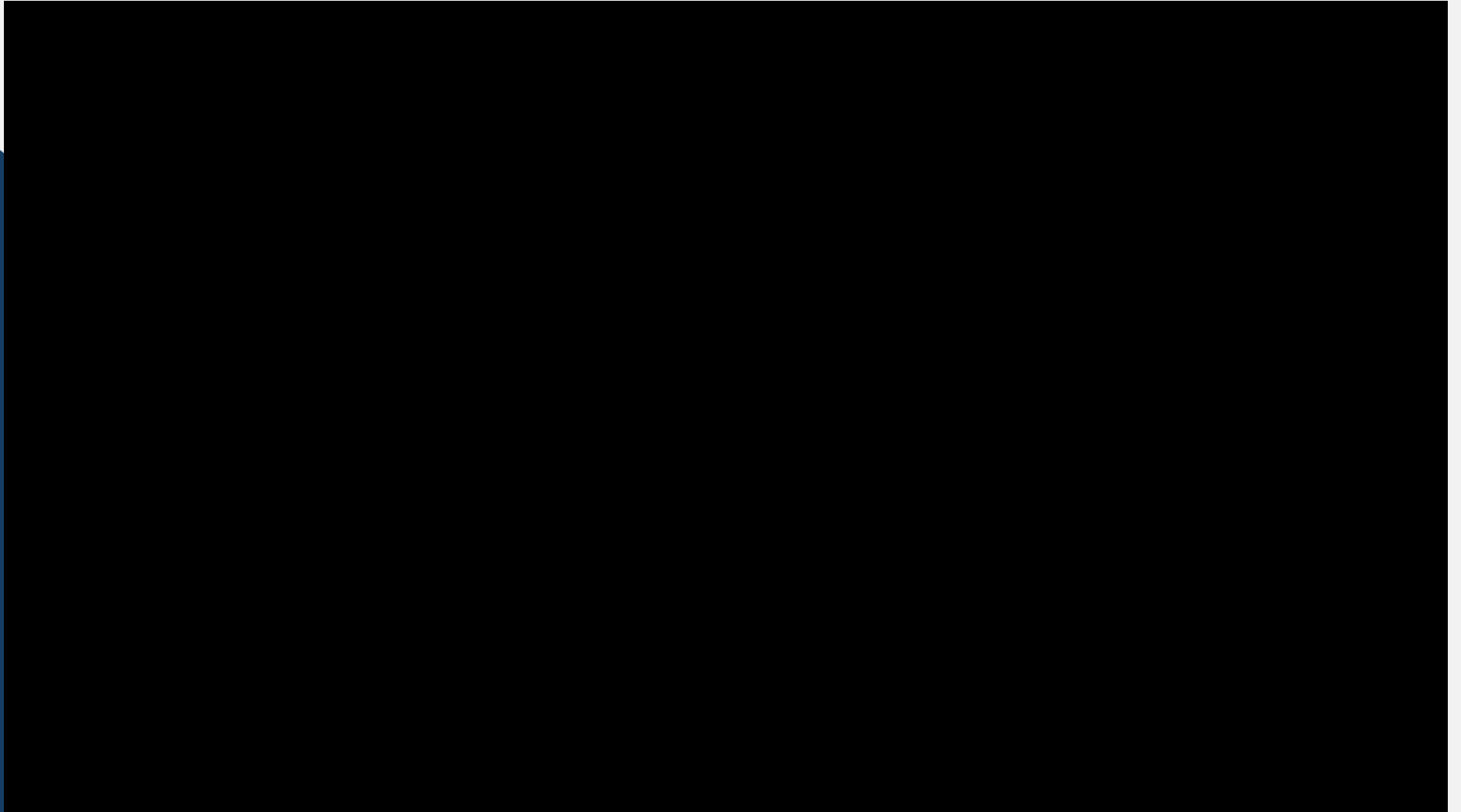
Quebec fish-boning case: Observations



If the fish-boning problem was linked to the steel's metallurgy, it would likely manifest as early as the first galvanizing process.

However, it only appears after zinc striping, and certain methods can prevent its occurrence.

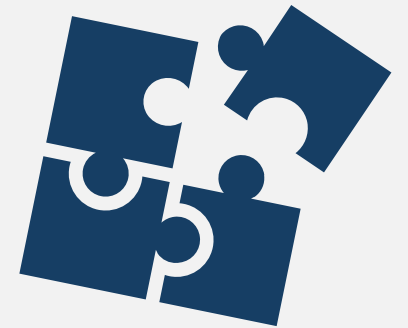
A few dips in action



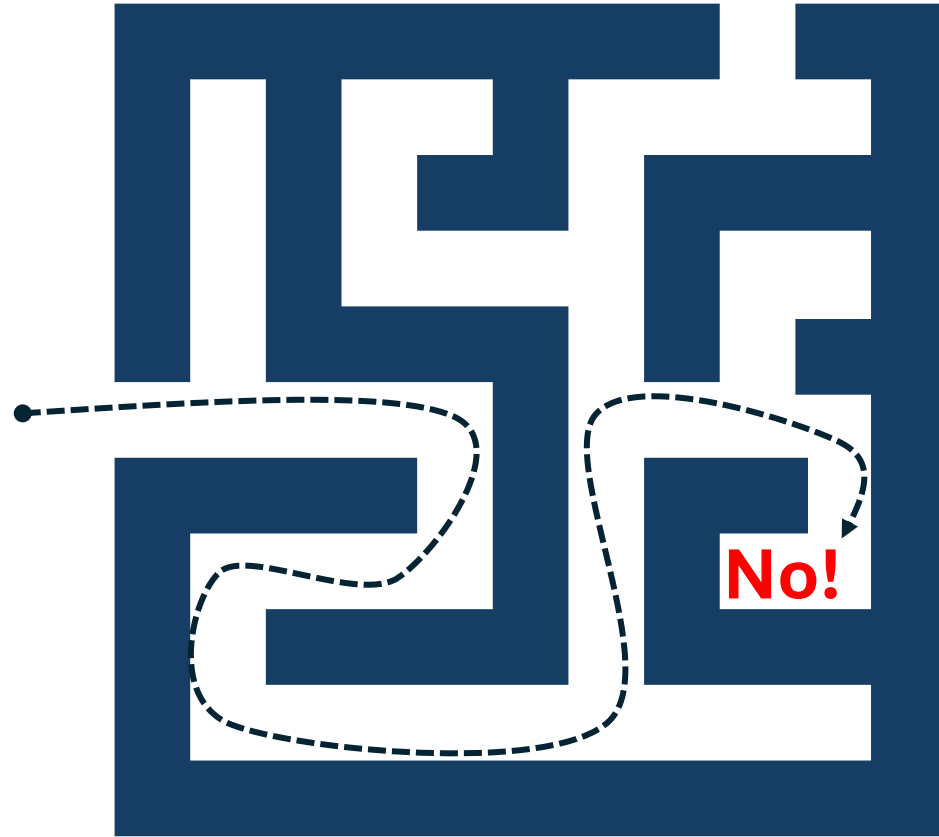
Fish-boning:

Is it caused by **differences in steel composition** or is it caused by a **disturbance of the fluid flow induce by the zinc striping process?**

Could the disturbance be amplified by the shape and size of the object?



**Does zinc striping
change steel
surface like
sandblasting
does?**



Evolution of our understanding of the fish-boning problem

Quebec and Hamilton cases:

Fish-boning appears only after zinc stripping. It mostly appears on tubular shapes but can also be seen on large structures.

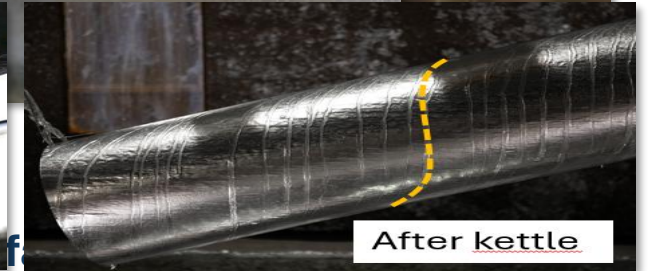
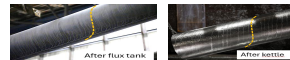
Depending on the kettle **extraction rate**, you can get the **same tube**.

The **Fish-boning pattern** and the **flux**

Once stripped, the tubes galvanized a second time. And **this time without fish-boning**

A 48 hours break between zinc stripping and galvanization helps reduce fish-boning formation.

Up and down agitation in the kettle helps reduce fish-boning.



Montreal case:

Beginning of the fish-boning Project

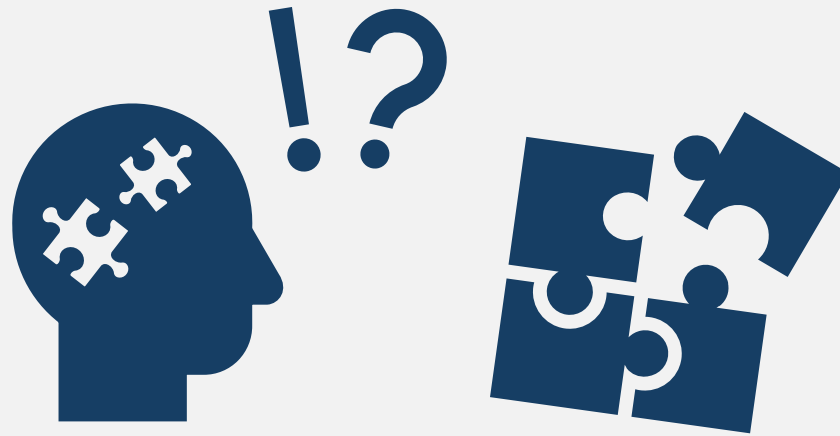
2024-08 2024-10 2025-03

Parameters to avoid fish-boning on zinc stripped large parts

$$Y = f(X) + \varepsilon$$

- **48 hours break after zinc stripping** before regalvanizing.
- **Angle during kettle extraction** is important (Racking the part with a low angle allows a larger amplitude during agitation.) Then the angle is created with the crain.
- **Up and down agitation** during cooking
- Kettle **extraction rate 18 to 30 cm/minute**
- Cooking time 4-8 minutes

May 2025



It works...

But we don't know WHY and HOW it works!

Why does the 48h break after zinc strip helps?



June 2026

**A possible explanation
emerged during a
discussion with French
galvanizers in Istanbul at the
EGGA conference**



The fish-boning problem is likely caused by **hydrogen absorbed during pickling that is RELEASED** from the steel during galvanizing.



Steel pickling compared to zinc stripping



[Video File] Unavailable in PDF form

Pickling

Zinc Stripping



- **Zinc:** $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$
- **Iron:** $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$
- **Reduction:** $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$

Why does zinc react faster?

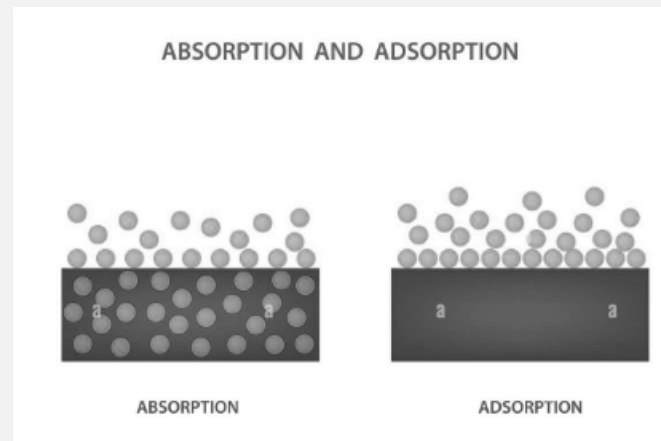
Zinc has a greater tendency to oxidize than iron. In other words, zinc atoms give up their electrons to H^+ ions relatively easily.

This can be seen from the standard reduction potentials:

Couple	Standard reduction potential
Zn^{2+}/Zn	-0.76 V
Fe^{2+}/Fe	-0.44 V
H^+/H_2	0.00 V

H₂ desorption occurs over time.

This is the reason why adding a **48h delay between zinc stripping and regalvanizing helps** avoid fish-boning formation.



How Hydrogen Leaves (Desorption)

Spontaneous release: Over time, hydrogen naturally escapes (desorbs) back out into the air or surrounding environment.

Accelerating factors: Desorption happens faster in warm temperatures or when the steel is exposed to water rather than dry air.

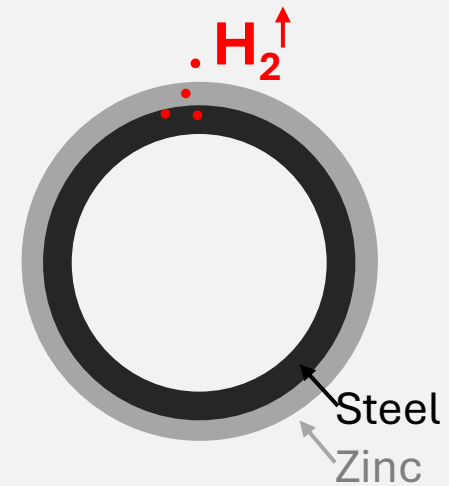
Baking out: Manufacturers use a controlled heating process (called a hydrogen bake) to force trapped hydrogen out of high-strength steel parts after plating and prevent damage.

(AI source)

As seen on the video, Zn stripping generates much more $\text{H}_{2(g)}$ than the usual steel pickling process.

The hypothesis is that hydrogen gas generated during stripping is absorbed by steel and release while in the kettle.

The presence of this gas at the steel to liquid zinc interface modifies the flow properties of liquid zinc and contribute to the fish-boning appearance.



Considering absorbed hydrogen is released during galvanizing, then some traces of it should be found in the zinc coating?

H_2



Like the mosquito trapped in amber in Jurassic Park movie.



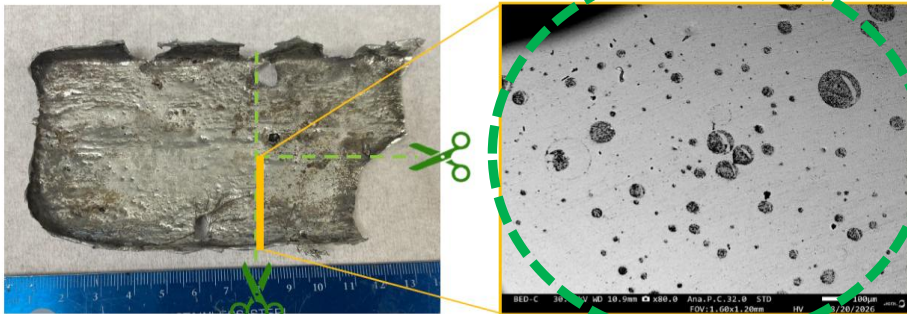
Fortunately, during the experimentation, a sample of viscous zinc flowing along a tube was collected.



The presence of bubbles in the sample indicates the possible presence of gas in the molten zinc at the time of its solidification. ✓

Which reinforces the hypothesis of H_2 desorption in the kettle is modifying the flow of liquid zinc on the galvanized part and is responsible of fish-boning on tubes.

Images de référence de la section transversale

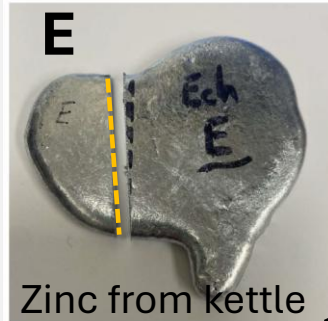


L'échantillon a été coupé et poli afin de caractériser sa section transversale.

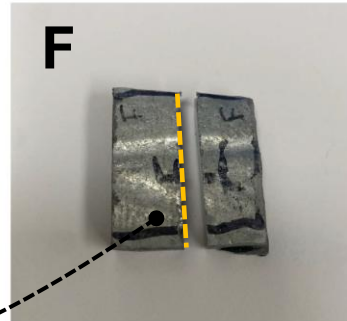
Validation of H₂ hypothesis on a second tube : Septembre 2026



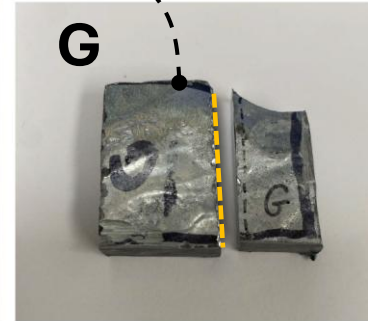
Photographies des pièces



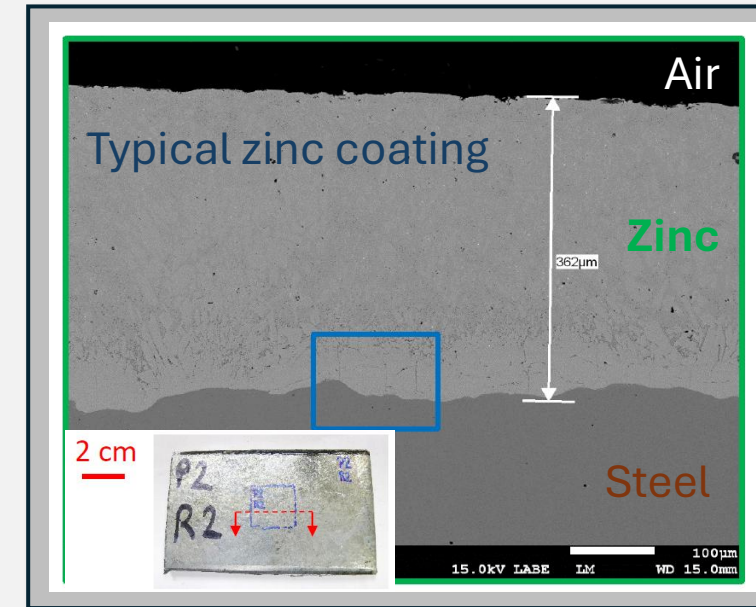
Échantillon E



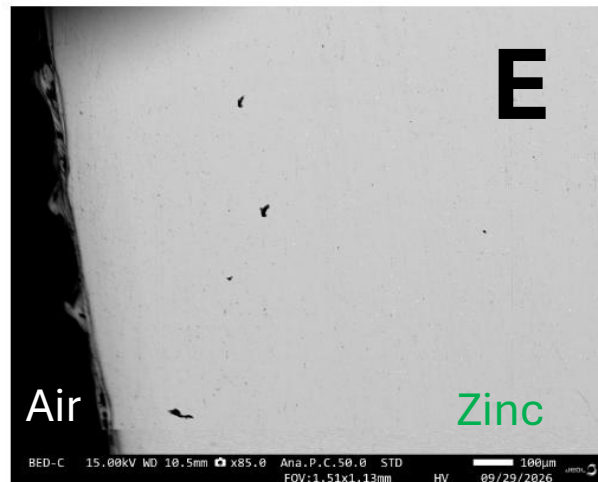
Échantillon F



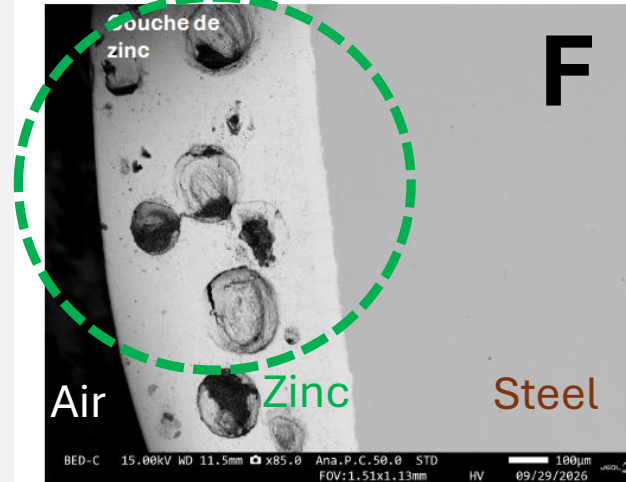
Échantillon G



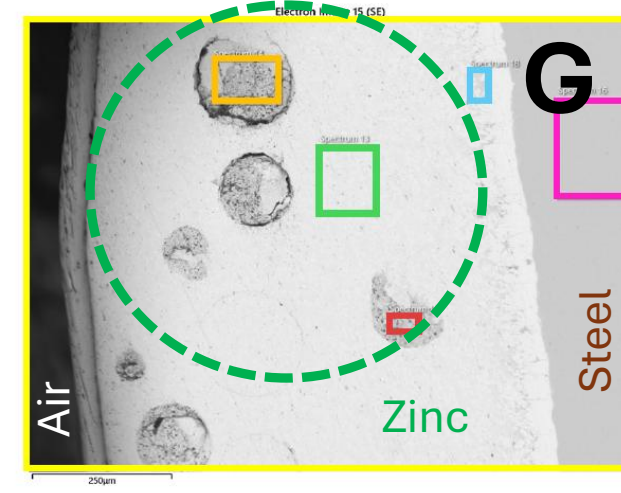
Micrographies MEB – Échantillon E



Micrographies MEB – Échantillon F



Micrographies MEB-EDS – Échantillon G



H₂

What's next

Based on observations made during this work, the following could be considered:

- In cases studied steel composition was not the reason for having fish-boning on HDG parts.
- Updating the AESS guide.
- Publication of a new issue of Dr. Galv on fish-boning.
- Explore ways to release absorbed hydrogen faster.

Questions?

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