Painting Continuously Galvanized Steel

SKY Korroosiokoulutuspäivät 18.-19.4.2024, Otaniemi

Sanna Järn, SSAB Europe

A stronger, lighter and more sustainable world

This is SSAB

1878
Founding year

8.8 million tonnes
annual steelmaking capacity

15,000
Employees

119 SEK BILLION
Revenue 2023

HQ in Stockholm, Sweden

16.5 SEK BILLION
Operating result 2023

SSAB Special Steels
SSAB Europe
SSAB Americas
Ruukki Construction
Tibnor

Divisions and subsidiaries

CO_2
emissions from own operations
largely eliminated around 2030

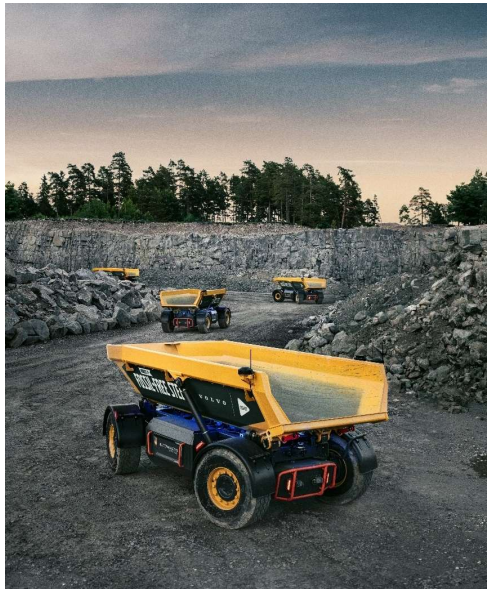

Luleå, Sweden
SSAB Europe
Blast furnace-based steel production
Raahe, Finland
SSAB Europe
Blast furnace-based steel production, heavy plate and strip products
Montpelier, Iowa, USA
SSAB Americas
Scrap-based steel production in electric arc furnace, heavy plate
Borlänge, Sweden
SSAB Europe
Strip products
Hämeenlinna, Finland
SSAB Europe
Strip and tubular products
Mobile, Alabama, USA
SSAB Special Steels
Scrap-based steel production in electric arc furnace, heavy plate
Oxelösund, Sweden
SSAB Special Steels
Blast furnace-based steel production, heavy plate

First in fossil-free steel

2017
HYBRIT – Joint venture between LKAB, Vattenfall and SSAB formed

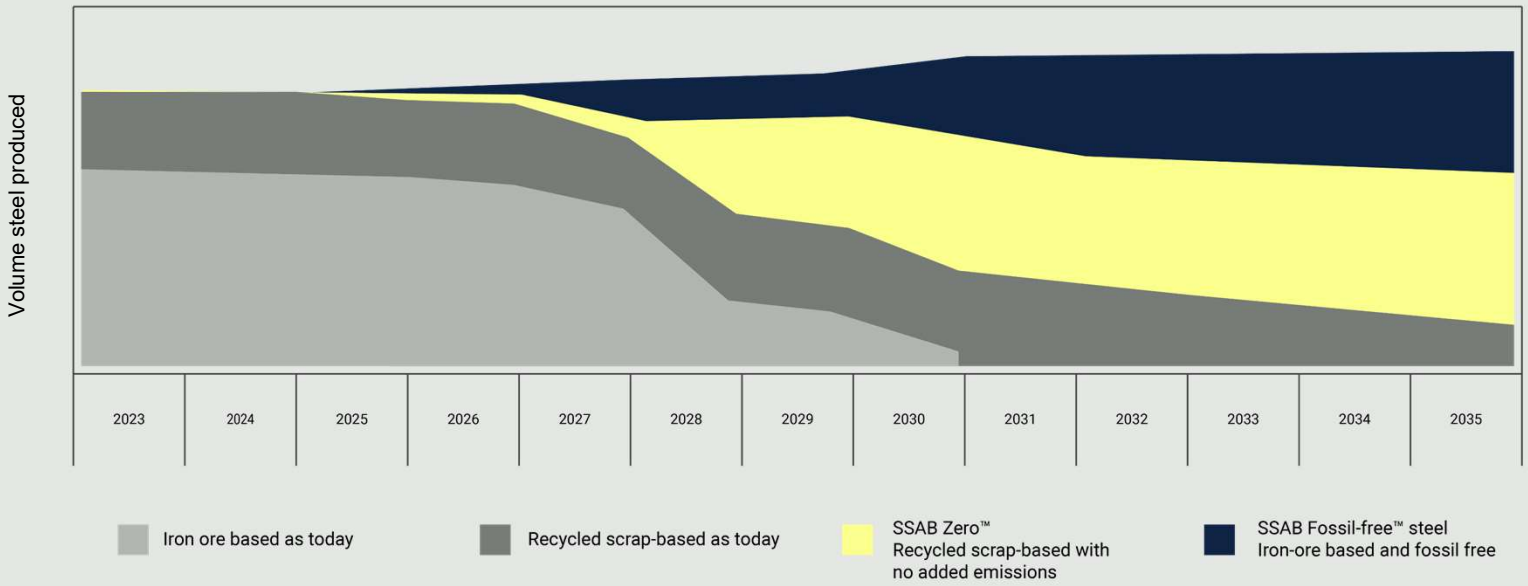
2020
World-unique pilot plant started operation in Luleå

2021
World's first fossil-free steel rolled and delivered to Volvo Group



2022
Pilot shipments to strategic customers – 500 tonnes delivered

Targeting a fully sustainable steel portfolio



Illustrative only

Content

1. Different galvanized coatings and surfaces
2. Painting galvanized surface
3. Questions?

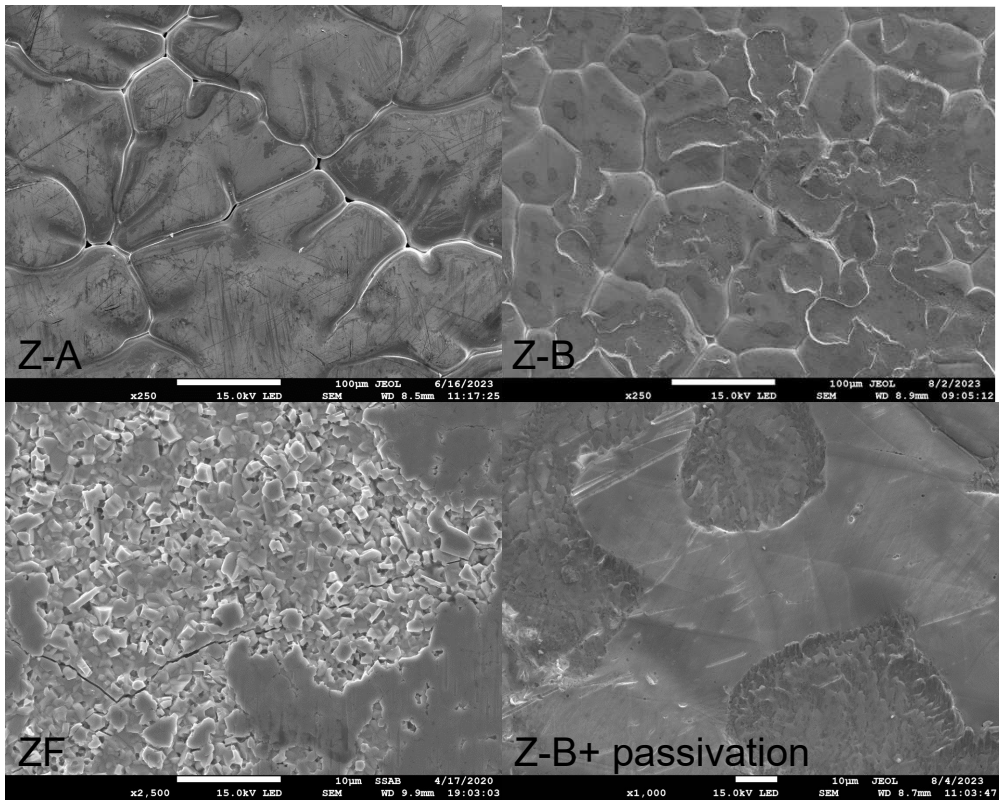
Different galvanized coatings and surfaces

Various zinc-coatings and surfaces

- Different galvanized coatings
  - Batch galvanized coatings (35 – 300 μm)
  - Continuously galvanized coatings (7 – 32 μm)
    - Galvanized coating (0,4%Al)
    - Galvannealed (10 % Fe, 6 – 10 μm)
    - Galfan (5 % Al, 7 – 23 μm)
    - Aluzinc (55 % Al, 13 – 25 μm)
    - Zinc magnesium coating (Al ~ 1-3 %, Mg ~ 1-3.5 %, 7 - 23 μm)
  - Electro galvanized (3 - 7μm)

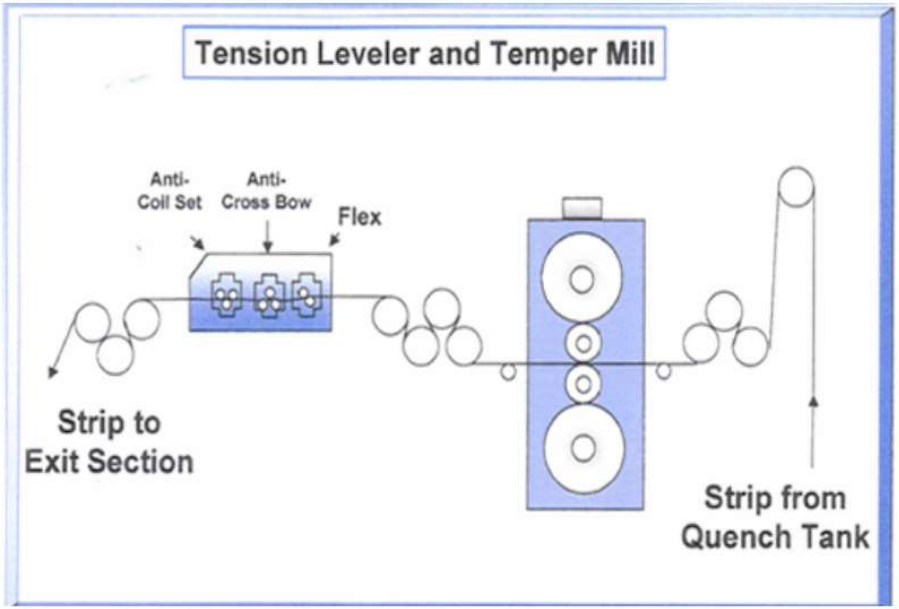
… with different surface treatments on galvanizing line

  - Skin passed
  - Passivated (inorganic <50 nm and organic ~ 1μm)
  - Oiled
  - Zinc phosphated



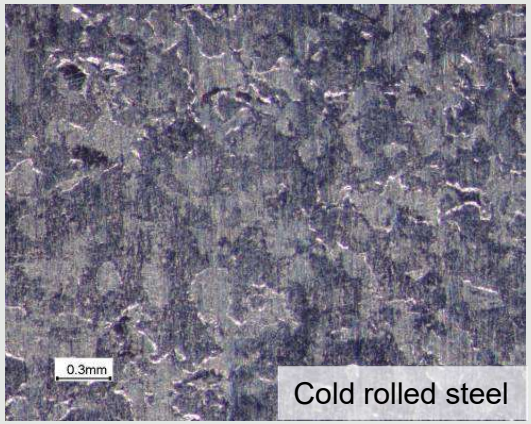
Skin pass rolling of galvanizing line

- Zinc-coated sheet is customary temper rolled (skin-passed) and/or tension levelled after coating to reduce yield point elongation and improve strip shape
- Temper roll surface is textured to:
  - roughen the surface of the zinc coating so that lubricative oils can be trapped to the depressions of the surface
  - break up the thermal oxide film resulting from hot-dip coating and improve the chemical reactivity of the surface in the following chemical treatments



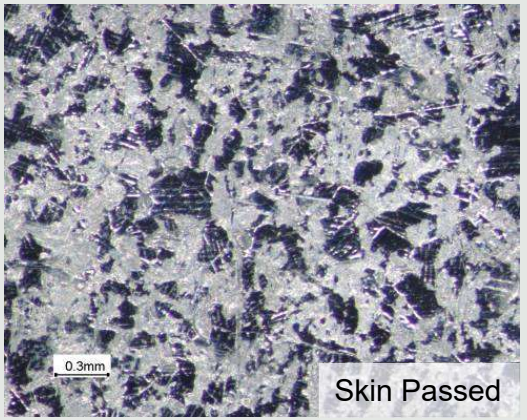
Source: Galv Info Center

Steel sheet surfaces

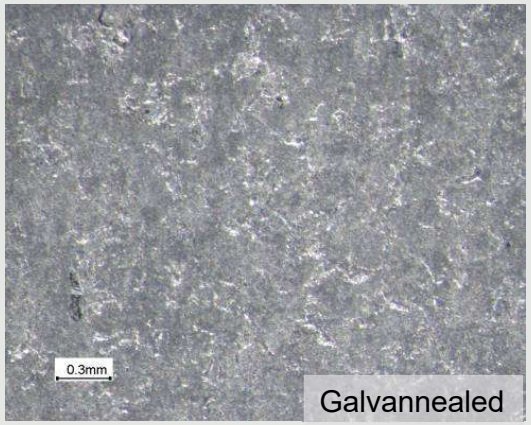


Cold rolled steel

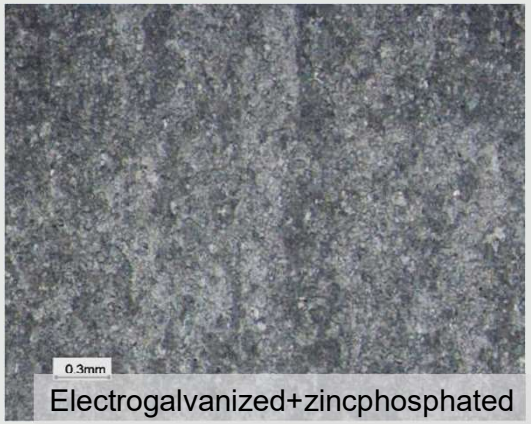
Non skin passed zinc-coating



Skin Passed

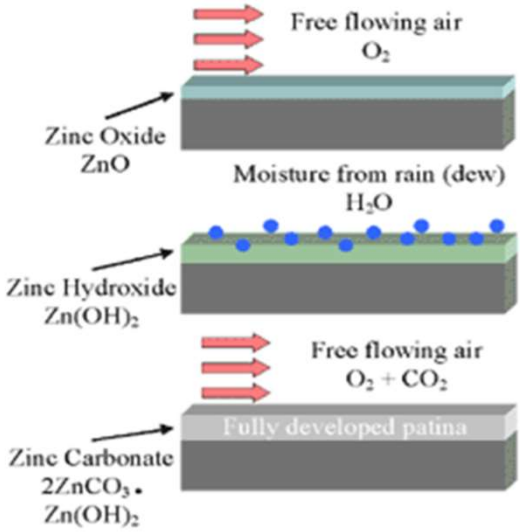


Galvannealed



Electrogalvanized+zincphosphated

Formation of zinc patina

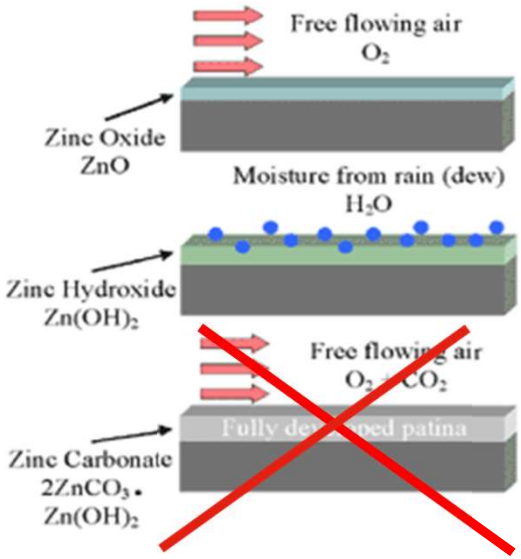


Formation cycle of the zinc patina. This cycle can take from 3 - 24 months to complete depending on the atmospheric conditions.

Source: www.galvanizeit.org

1. Formation of zinc oxide
2. Formation of zinc hydroxide = white rust
3. Formation of zinc carbonate

Formation of white rust



Formation cycle of the zinc patina. This cycle can take from 3 - 24 months to complete depending on the atmospheric conditions.

Source: www.galvanizeit.org

1. Formation of zinc oxide
2. Formation of zinc hydroxide = white rust
3. Zinc surface is wet + free flowing air is blocked by tightly stacked sheets and coil windings -> A protective zinc carbonate film never gets a chance to form
4. The layer of white rust is loosely attached to the surface and doesn't protect against the proceeding corrosion. Corrosion continues as long as there is moisture in surface.

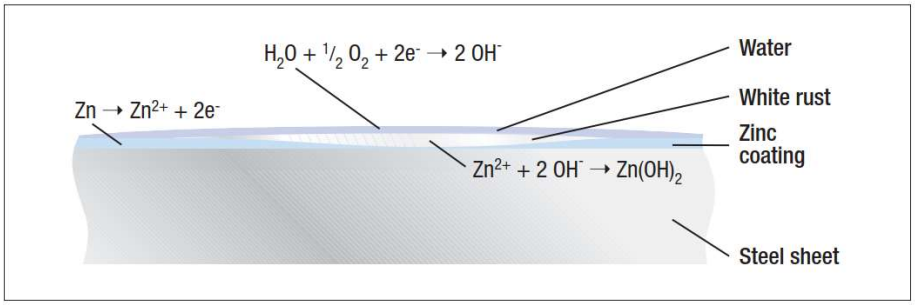


Fig. 1: Formation of white rust due to direct exposure of zinc coating to water

Source: Stahl-infromation Zentrum MB-130E

White Rust

- Storage stain is a corrosion product that is typically white, but which can also take the form of a grey or black deposit on the surface
- Since the most common form of discoloration is white, storage stain is often called white rust


Source: Stahl-infromation Zentrum MB114

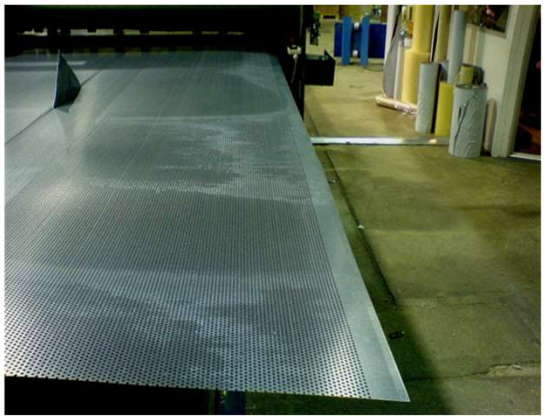


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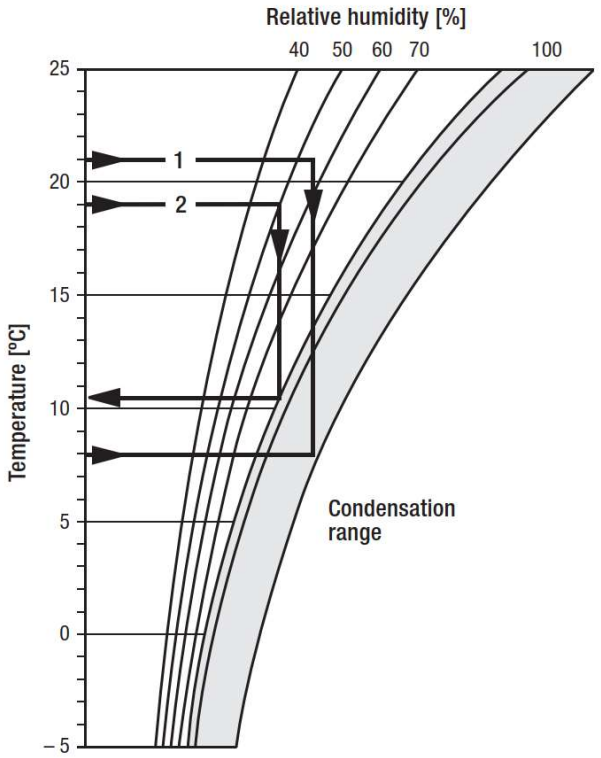
Diagram for determining the condensation risk



Condition example 1:

Temperature of sheet stack: +8 °C
Storage room temperature: +21 °C
Relative humidity in storage room: 55%

Interpretation:

From the point where an imaginary horizontal line through +21 °C intersects the 55% curve, proceed vertically downwards to the horizontal line passing through +8 °C. The condensation range is intersected.

A condensation risk exists.
Material placed in storage in a cold state must not be unpacked until temperature equalization has taken place.

Condition example 2:

Storage room temperature: +19 °C
Relative air humidity in storage room: 50%

Interpretation:

From the point where an imaginary horizontal line through +19 °C intersects the 50% curve, proceed vertically downwards to the boundary of the condensation range.
The level of the tangential point indicates the minimum acceptable steel temperature (+10.5 °C)

There is no risk of moisture condensing if the steel temperature exceeds a value of approx. +10 °C.

Source: Stahl-infromation Zentrum MB-130E

Temporary corrosion protection of galvanised products during storage and transportation

- Common methods of protecting the surface against moisture are oiling and chemical passivation
- If the application requires painting in the manufacturer's plant, rust inhibitive oil is usually the best solution
- Passivation treatments are more effective in corrosion prevention and are mostly used in the products which are not painted
- It is also possible to order a product with both passivation and oil

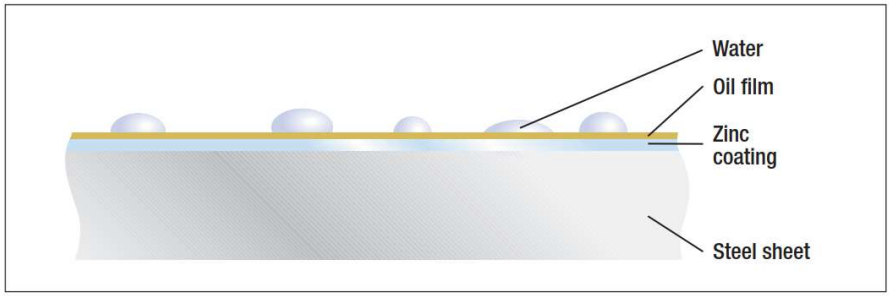


Fig. 2: Protection based on application of an oil film

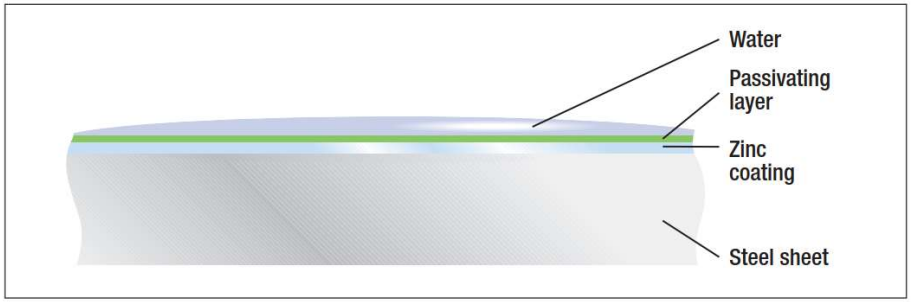


Fig. 3: Barrier effect of the passivating layer

Source: Stahl-infromation Zentrum MB-130E

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Protective oil

- Electrostatically applied protective oils in galvanizing line are typically:
  - mineral oils with corrosion inhibitors
  - pre-lube type oils containing waxes
- Zinc-coated products can be delivered as ”dry” = without any temporal protection, but only with customers responsibility
- SSAB has over 20 years experience on customers buying their galvanized raw material for painted product as dry without any problems
- If galvanized sheet steel is delivered as dry, extra care should be obeyed on trasportation and storage
  - big temperature variation and hig air humidity favor water condensation between coil wraps and ease storage stain fromation


Source: Stahl-infromation Zentrum MB114

Passivation

- If passivated, majority of zinc-coateed products produced in Europe are passivated with Cr^{3+} systems or totally Cr-free systems
- There are different types of passivation products on market and different galvanized steel suppliers use different chemicals on their lines -> different paintability

Painting galvanized surface

General rules on processing galvanized surface before painting

- It is very important that galvanized surface is clean and dry before painting:
  - Loose dirt is removed e.g. brushed with nylon brush etc.
  - Grease and oil are removed by wiping detergent and/or alkalic cleaning
  - All residues of cleaning medias are rinsed off
  - No painting before surface is totally dry
  - Surface wettability is verified before painting (no drop formation when surface is wet)

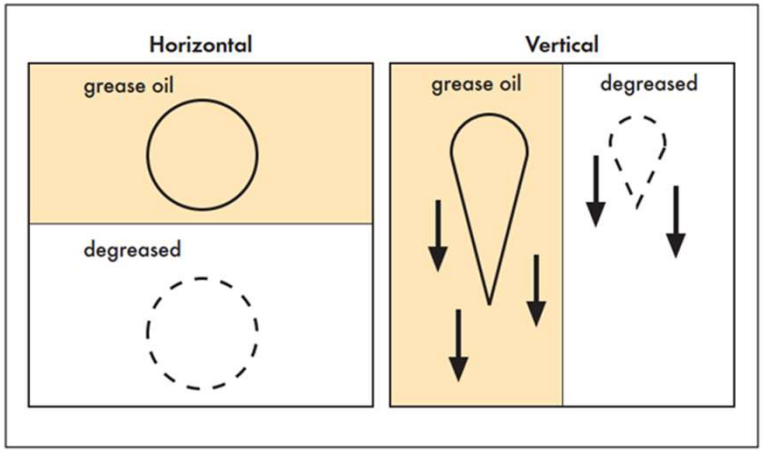


Figure 4: Practical test for judging of galvanized steel surfaces. One droplet of a 1% solution of Fettrot BB (Bayer) in ethyl alcohol on metal surface. Wait 30 - 60 seconds. Form and extension of red ring indicate presence of oil or grease, as well as effective degreasing (dotted lines).

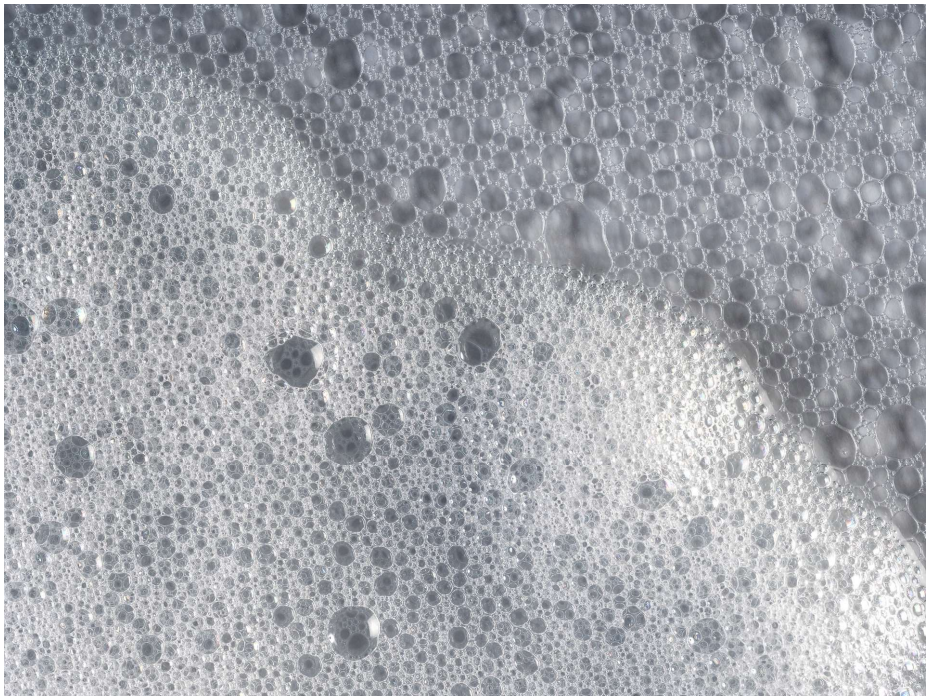
Source: Hot Dip Galvanizing Today, 2005 Vol2, 4

Mechanical cleaning of galvanized surface

- Objects made of batch galvainized and continuously galvanized sheets require different pretreatment:
  - batch galvanized are usually abrasive blast cleaned
  - continuously hot dip galvanized are usually cleaned with detergents and chemically pre treated
- Abrasive blast cleaning is too heavy treatment for continuosly hot dip galvanized coatings
  - SSAB don’t recommend mechanical pretreatment for line zinc-coated sheet material in any case, because thin zinc-coating is destroyed and corrosion protection ability is weakened remarkably!

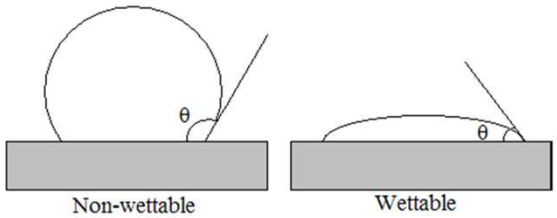
Chemical cleaning of galvanized surface

- Different cleaning medias can be used for galvanized surfaces:
  - mild alkalic cleaning with detergent and water
  - aromatic or alifatic solvents
  - acid or alkalic water solutions
  - water soluble solvents
- Most used method on field painting is wiping with solvent
- Mild alkalic cleaning is the most used method in shop paiting
- Efective rinsing after cleaning has to be ensured to be able to get rid ofl cleaning media residues from the surface



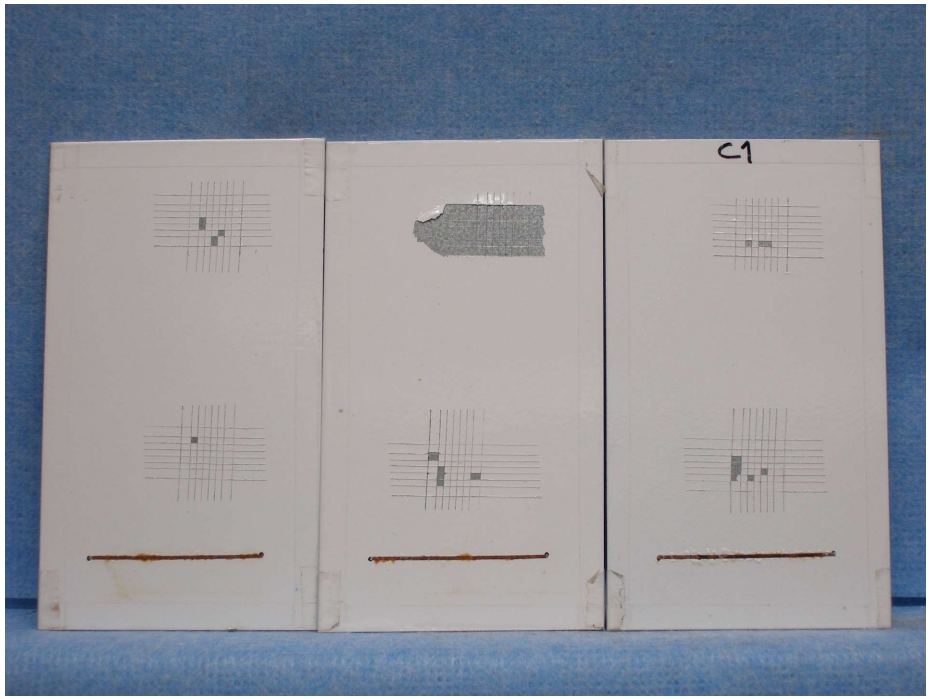
Cleaning oiled surface

- Decisive for the effectiveness of the removability of lubricants are:
  - The chemical composition and concentration of the cleaning agent
  - The mechanical aids by spraying, immersion, brushing and ultrasonic during the cleaning process
  - The duration of cleaning
  - The temperature of the cleaning solution

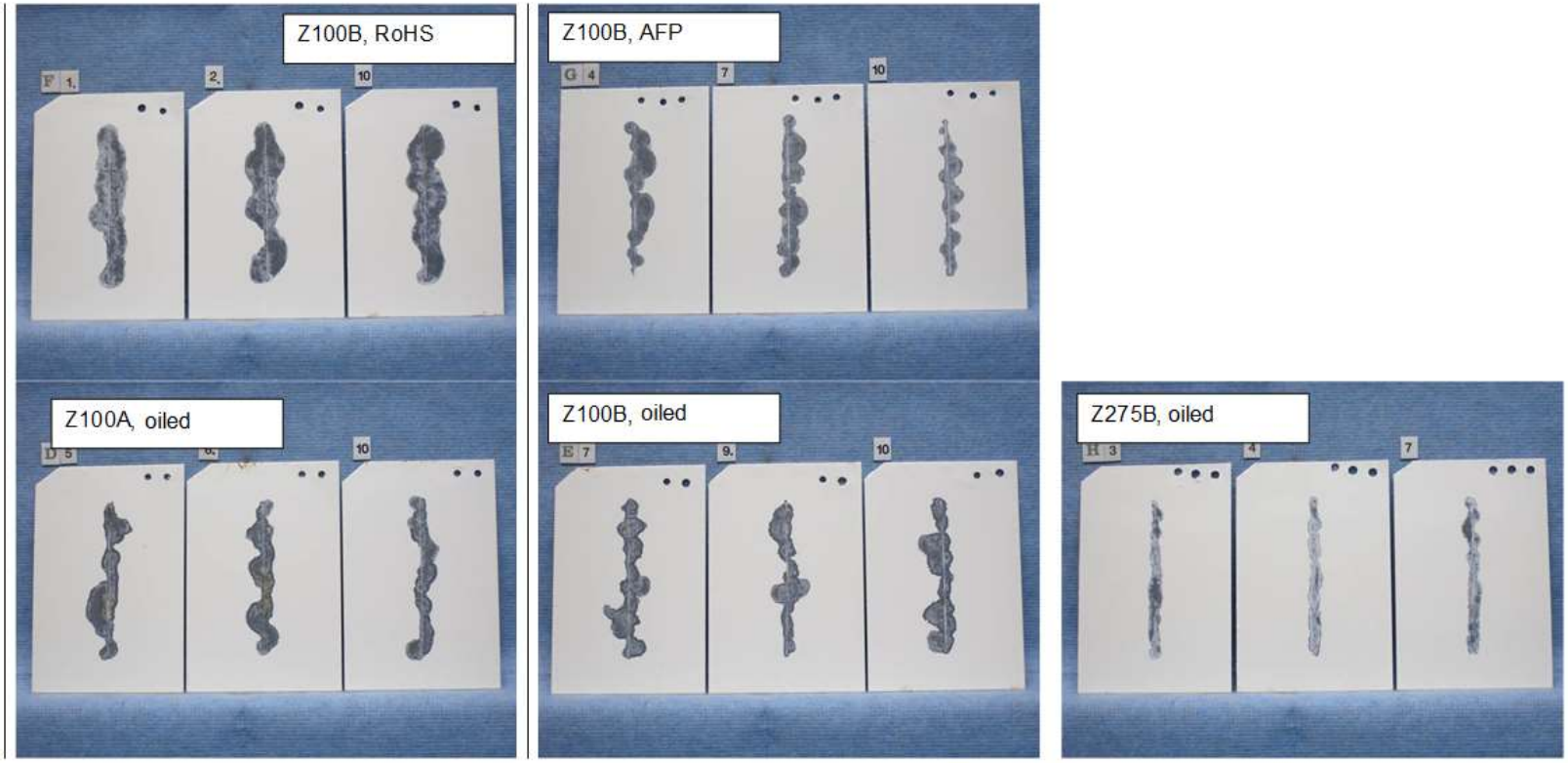


Processing chemically passivated flat products

- It is very difficult or even impossible to get paint pretreatment work well on most of passivated surface, so it's not recommended to use passivated material for painted products
- In general, the process capability of chemically passivated product with surface-sensitive downstream operations (phosphating, painting and adhesive bonding) processes should be studied beforehand
- If it is found that chemical passivation is incompatible with a given downstream process, it is recommended to use oiled material



Zinc with different temporary protection chemicals, SST 732h, Bonderite NT1 + Powder paint 60µm



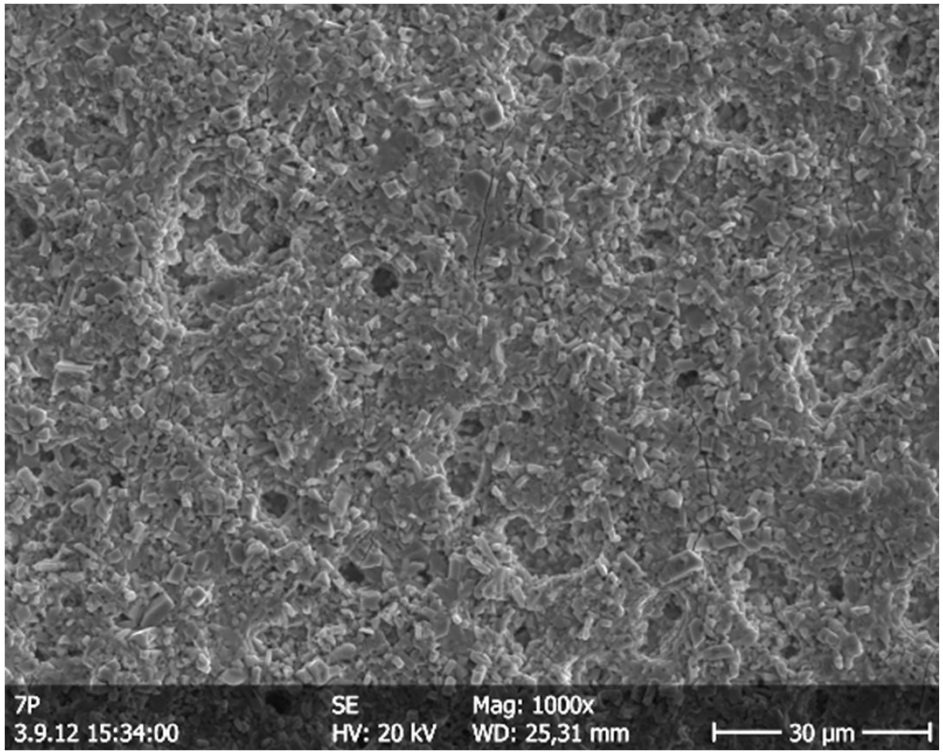
Example of shop paint process

Pretreament

- Galvanized coatings are usually chemically pretreated before painting
  - Pretreatment ensures good paint adhesion to zinc-coated surface
- Good paint adhesion to rough Galvannealed surface can be achieved without any chemical pretreatment before painting
  - Pretreatment is not mandatory, but improves corrosion properties of painted galvannealed surfaces too

Galvannealed

- Rough matt gray surface
- Surface is full of microscopic pores, where paint penetrates ensuring good paint adhesion to the galvannealed surface



Traditional pretreatmens

- Metallic objects are coated with phosphates by dipping, spraying or brushing
- Cleaning and phosphating can be done in same bath in **iron phosphate treatment.** Typical process steps:
  - cleaning & iron phosphating
  - rinsing (1 or 2 steps)
  - drying
- Cleaning should be done before phosphating in **zinc phosphate treatment.** Typical process steps**:**
  - cleaning
  - rinsing (1 or 2 steps)
  - zinc phosphating
  - rinsing with deionized water
  - drying

- Zinc phosphate process:
  - has more process steps
  - is more expensive
  - more complicated

  than iron phosphate process.
- Traditional pretreatments have heavier environmental burden with phosphates and aggressive bath chemistry causing heavy metal containing sediments :

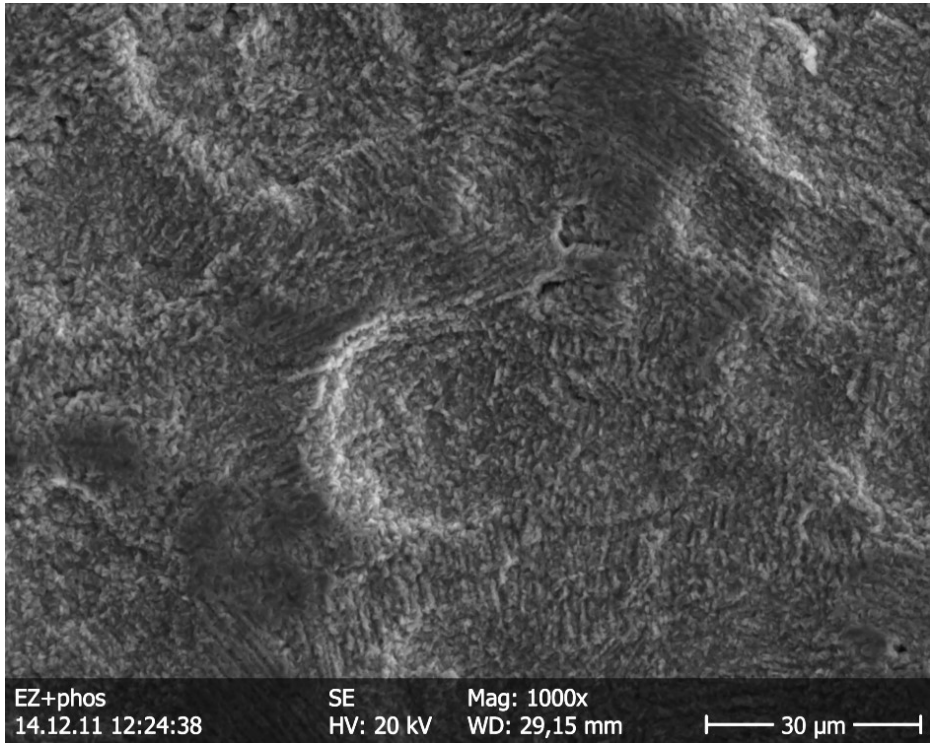
  → Requirements for environmental permits

  → Need for heavier waste treatment

  → Higher costs

Phosphates

- Thickness 1 - 10 μm
- Rough and porous surface improves mechanical adherence of the paint to the phosphated surface
- Insulating phosphate layer prevents corrosion reactions on paint/zinc boundary



New Pretreatments

- New pretreatments have many benefits compared to traditional pretreatmens, e.g.:
  - better corrosion protection
  - lower costs
    - less processing steps
    - lower bath temperatures
  - lower environmental burden:
    - no phosphates
    - No heavy metal containing sediments

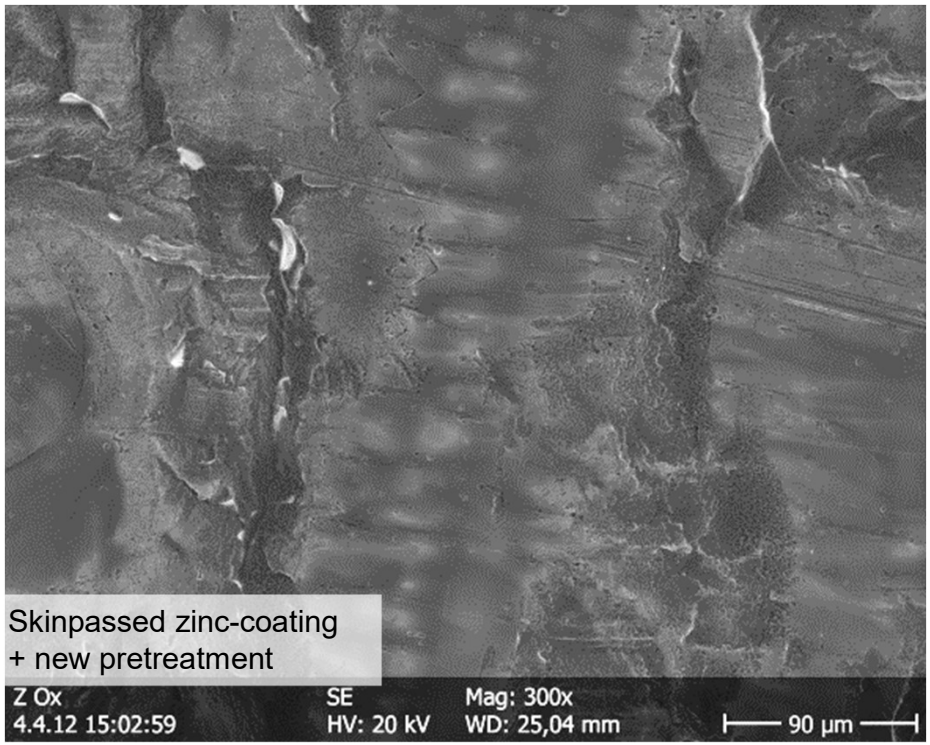
  ->New pretreatments are replacing traditional pretreatments

- Henkel pretreatment system is based on fluorozirconates :
  - **Bonderite CC40** replacing iron phosphate system
  - **Bonderite NT1** replacing zinc phosphate or iron phosphate
  - **Bonderite Tec Tails** replacing zinc phosphate system

- BASF-Chemetall has organosilane based system:
  - **Oxsilan** replacing zinc phosphate and iron phosphate systems

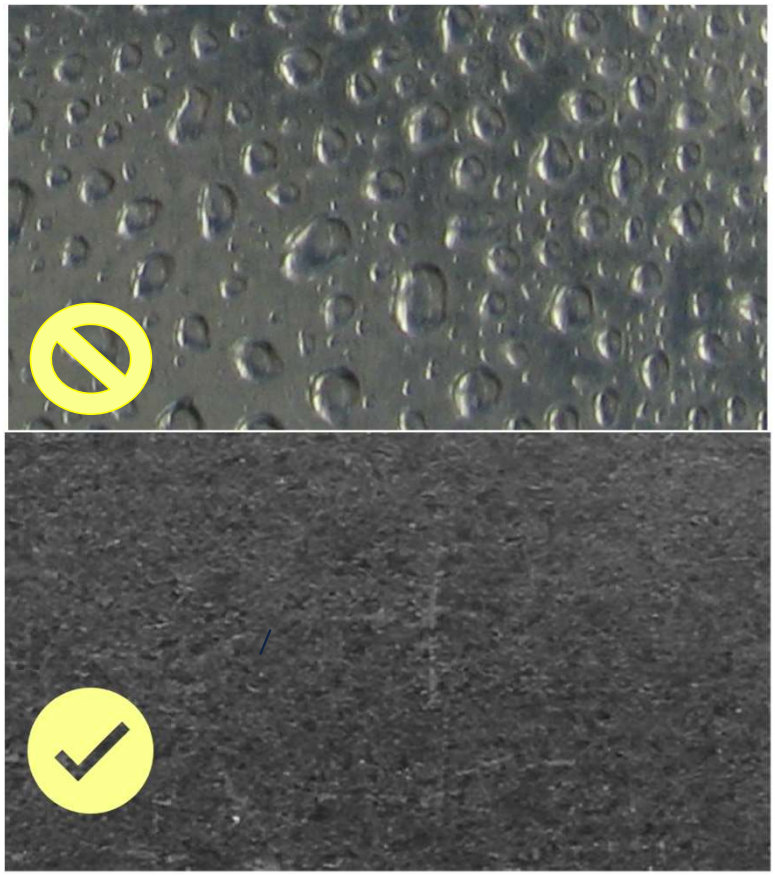
New Pretreatments

- Thickness 30-100 nm
- Microscopically rough surface helps in paint mechanical and chemical adhesion to the zinc surface



Painting

- When cleaning and pretreatment has been done with care and zinc surface is wettable (no water droplets on wet surface), painting can be done without problems with wet paint or powder paint systems



Pretreatment and paint suppliers have best knowledge on paint systems suitable for galvanized sufraces

- Before choice of pretreatment-paint system it should be discussed with both pretreatment chemical and paint suppliers
- Paint supplier need to know:
  - Planned service life
  - Weather condition and atmosphere:
    - Acidity
    - Coastal salts
    - Industrial emissions etc.
  - Wetness, duration of dry and wet periods,
  - UV radiation
  - Customers expectations and requirements on outlook
    - Paint blistering
    - Paint chalking
    - Rust caused by edge corrosion

ISO 12944 Classification	Impact	Interior	Exterior
C1	Very low	Heated buildings with clean air, such as offices, shops, schools, hotels, etc.	None
C2	Low	Buildings not heated, where condensation may occur, such as warehouses and sports centers.	Atmosphere with low pollution, such as in the countryside.
C3	Middle	Buildings for production, with high atmospheric humidity and some degree of air pollution, such as food manufacturers, breweries, dairies and laundries.	Urban and industrial areas, moderate sulfur dioxide pollution. Coastal areas with low salt content.
C4	High	Chemical manufacturers, swimming pools and ship and boat yards located by the sea.	Industrial and coastal areas with moderate salt impact.
C5-1	Very high (Industrial)	Buildings or areas with almost permanent condensation and with high pollution.	Industrial areas with high humidity and aggressive atmosphere.
C5-M	Very high (Marine)	Buildings or areas with almost permanent condensation and with high pollution.	Coast and offshore areas with high salt content.

Thank you!