What is Steel?

Steel is a material containing pure iron (Fe) combined with other elements such as carbon (C), manganese (Mn), silicon (Si), titanium (Ti), aluminum (Al), etc. in order to develop special properties.

Steel is…

- Often confused with pure iron…however, there is significant difference between iron and steel
- More practical for commercial use
- Due to combinations of additives (elements such as carbon, manganese, etc.), attributes of steel include toughness, abrasion resistance, formability and strength
- Typically less expensive to produce

Why Steel?

Steel has become the material of choice by modern society due to various reasons.

Most importantly…

- Cost - pound for pound, steel is the most inexpensive metal for many consumer products (cars, appliances, etc.)
- End-Use Applications - steel is very versatile…it can be tailored to meet a wide range of product requirements
- Sustainable
- Durable

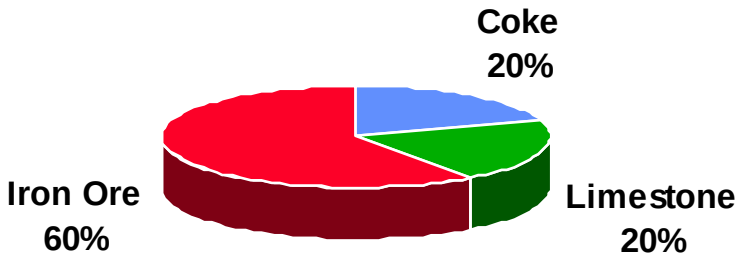
How is Steel Produced?

There are three (3) primary components of Pig Iron…

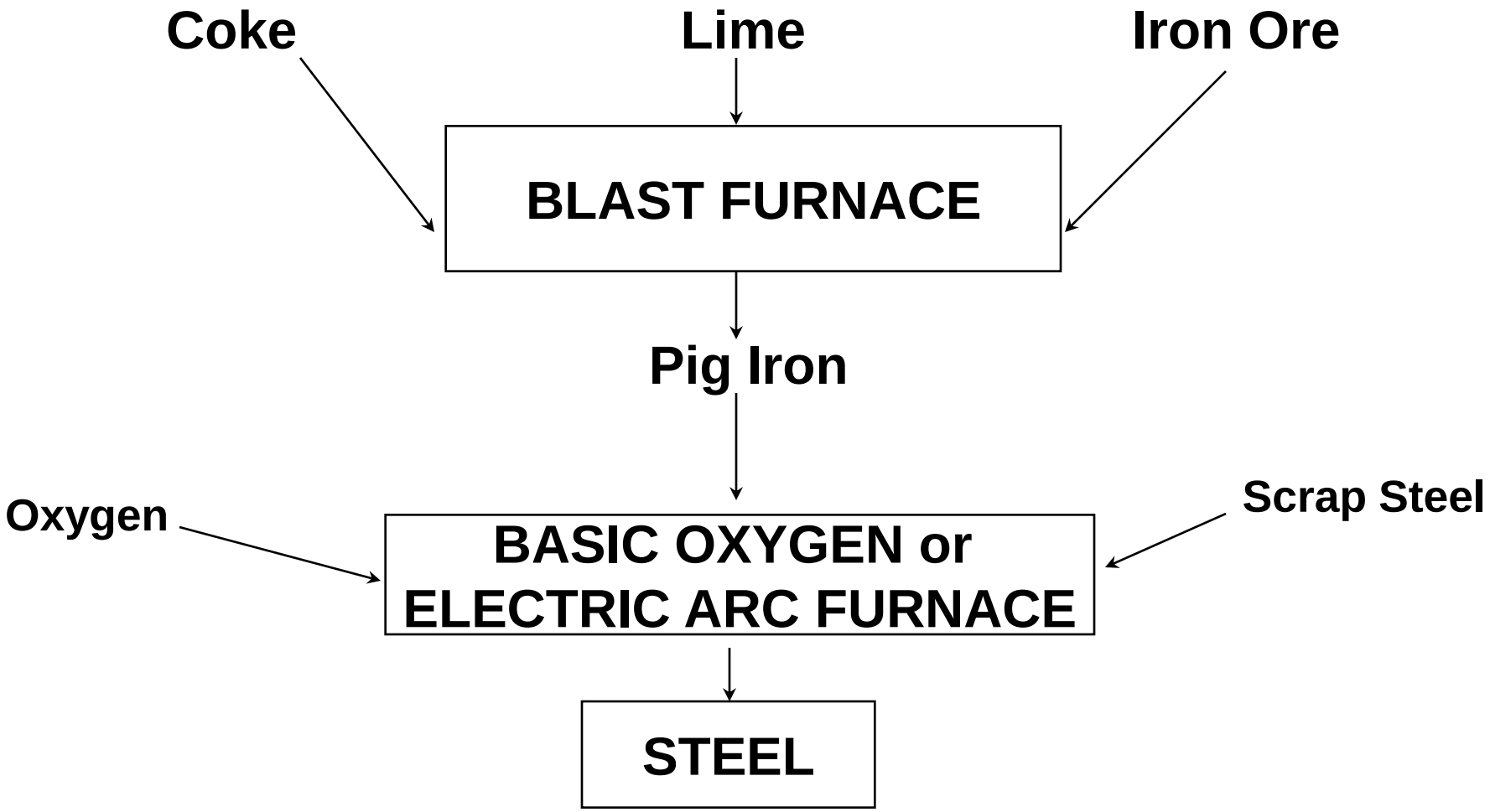
1. Iron Ore = Primary source of iron.
2. Limestone = Flux used to remove impurities
3. Coal (Coke) = A fuel and reducing agent

2.5 tons of raw material and a nearly equal amount of air is required to produce 1 ton of pig iron.

Manufacture of Blast Furnace Pig Iron



Steelmaking



Conversion to Slab Product

After final adjustments have been made to the chemistry of the product, the molten metal is converted into a slab product for subsequent rolling operations.

Steps…

1. Molten steel is poured into ingot molds
2. After the ingot has solidified, the mold is stripped from the ingot
3. The solid ingots are reheated within a soaking pit and then rolled into a useable slab

Hot Rolling Process

The Hot Rolling process is the conversion of steel slab into coiled sheet of finite dimensions (thickness and width)...

- Slabs are reheated to a temperature exceeding 2300º F
- Reheated slabs pass through a scale breaker/roughing mill
- Slab continues through additional roughing mills where a substantial portion of the thickness is reduced
- Slab is passed through a finishing mill where final thickness and surface quality are achieved
- Cooling rate of the strip is controlled to approximately 1600º F exiting the finishing mill
- Strip is quenched to 1100º F to control the microstructure (grain), mechanical properties and formation of scale (oxide)
- Strip is coiled at end of the line at temperature near 1100º F

Hot Rolling Process

During hot rolling, the grains of the steel are flattened and elongated. Due to the high temperatures, the grains are able to reform into a round shape again.

Finishing and coiling temperatures must be controlled.

Potential adverse affects on steel sheet if temperature is not controlled:

- Unsatisfactory base metal mechanical properties
- Rolled in scale (contamination) on the base metal surface

Hot Band

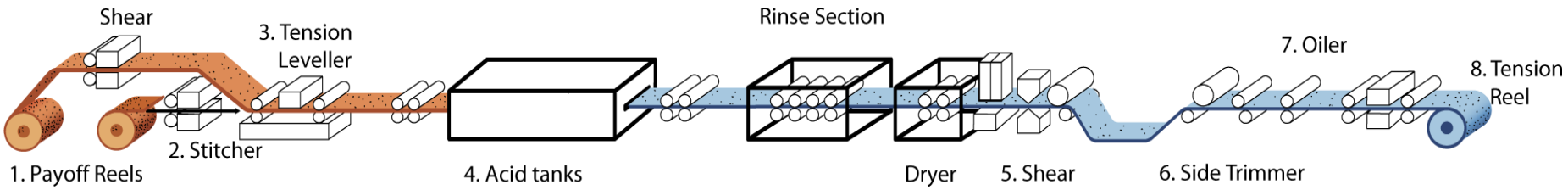
Steel Pickling Process

Pickling is the first step of the cold rolling process

Primary Functions of Pickling:

- Eliminate Hot Mill oxide from the surface
- Trim the edges for improved width tolerances
- Fulfill the inspection requirements (i.e. surface, thickness) of finished Hot Rolled Pickle and Oil product
- Prepare the strip for further processing (cold reduction) by winding and oiling

Steel Pickling Process



1) The hot rolled coil enters the pickle line on one of two payoff reels.

2) The end of one coil is joined with the beginning of the next coil at the stitcher. Connecting the end of one coil with the beginning of another allows for continuous operation of the pickle line.

3) The band passes through the tension leveller which flattens the strip and mechanically breaks up surface defects.

4) The band of steel is run through a series of acid tanks to remove rust and other impurities. Rubber rollers between the tanks act as squeegees to remove as much acid and contaminant as possible. After the acid bath, the band is rinsed in hot water to remove the last of the acid.

5) The band then runs through a shear, which cuts out the stitch that connected the two coils at the beginning of the pickle line. The band must be separated after it is cleaned so each individual coil can be re-coiled.

6) The sides of the band are trimmed to the customer's specified width.

7) The band can be coated with oil.

8) The tension reel re-coils the steel so it's ready for the next step.

Cold Reduction Process

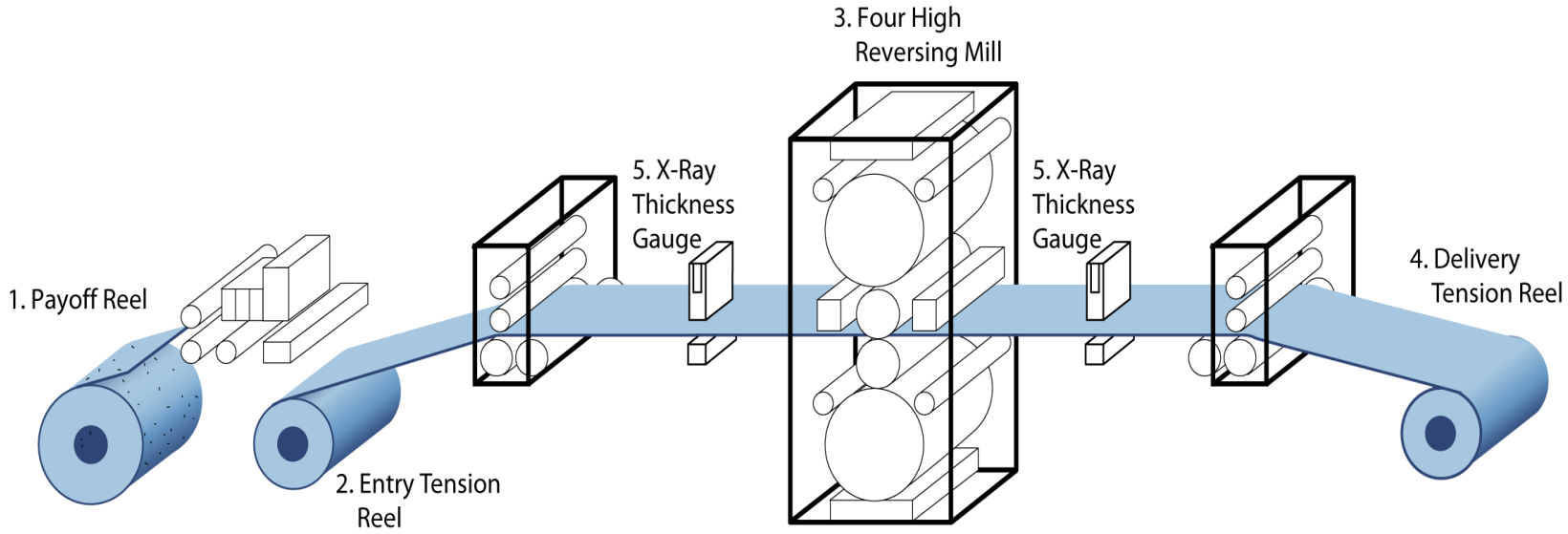
Primary functions:

- To reduce the strip to ordered thickness
- To apply a surface texture to the strip
- To roll the strip to a suitable shape

In the cold rolling process, the grain of the steel is elongated similar to in the hot rolling process

- Grain does not re-crystalize on its own since the strip is not hot enough
- Resulting cold reduced strip is comparatively hard with poor ductility
- Steel must be restored to a soft, ductile state (re-crystalized) in a subsequent operation

Cold Reduction Process



1) A coil fresh from the pickle line sits in waiting for the cold rolling process.

2) The coil being processed starts at the entry tension reel, where it is uncoiled and passed forward through the reversing mill.

3) A four-high set of rolls applies pressure to the steel in order to make it thinner, while maintaining its shape and width. The number of passes depends upon the customer's specification for coated-product thickness.

4) As it passes forward through the rolls, the steel is re-coiled onto the delivery tension reel. From there it goes back through the rolls in reverse, making it even thinner.

5) Thickness gauges measure the thickness of the steel with each pass through the rolls.

6) Once the proper thickness is achieved, the steel is again coiled onto one of the tension reels. From there it is ready to move to the coating line.

Cold Reduction Process

Advantages of a Cold Rolled Sheet product vs. a Hot Rolled product:

- Decreased strip thickness can be achieved.
- Improved surface characteristics (i.e., texture, shape).
- Improved formability can be achieved (upon subsequent heat treatment)

Cold reduced steel sheet is quite versatile and can be processed further to develop the following products:

- Batch and Preannealed Products
  - Cold Rolled products
  - Tin Mill Products (tin or chrome plated)
  - Electrogalvanized Steel
- Inline Annealed Products:
  - Hot-Dip Galvanized products (Regular or Galvanneal)
  - Hot-Dip ZINCALUME sheet

Hot Dip Galvanized Process

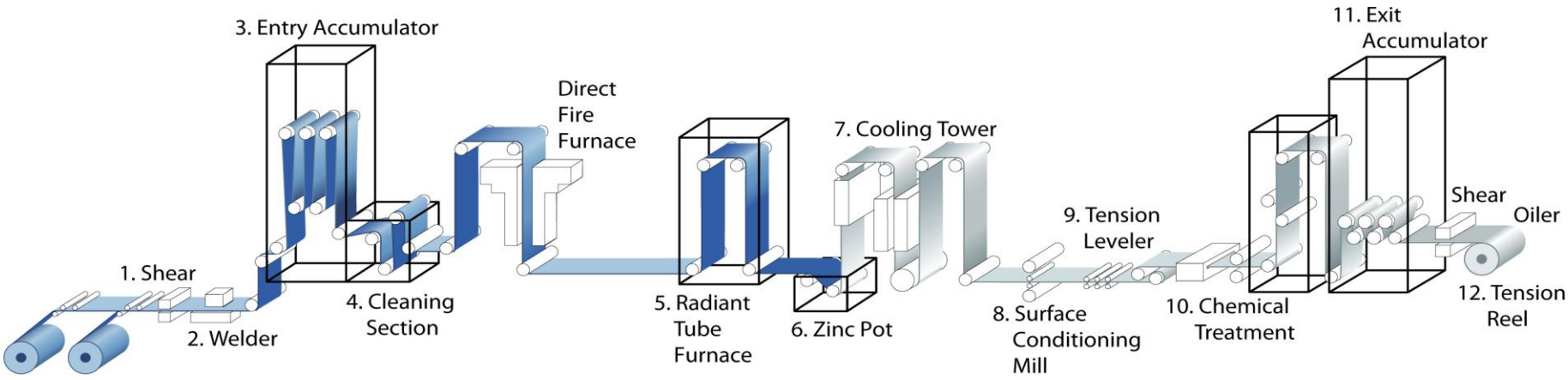
Hot Dip Galvanized products are produced via...

- **The Sendzimir Type Process:**
  - Full hard cold reduced steel enters the process
  - The strip is annealed in line and dipped into a molten bath

- **The Molten Bath:**
  - Can be comprised of virtually 100% zinc
  - Can be comprised of alternative metallics

- **The Coated Strip:**
  - Can be cooled to achieve a bright spangled surface
  - Can be reheated inline to cause coating to alloy and create a dull surface
  - Can be skin passed to achieve a smooth, spangle-free surface

Hot Dip Galvanized Process



1) The coil is delivered from the cold rolling mill to one of two payoff reels on the coating line. The ends of each coil are sheared. The new ends must be welded together to create a continuous band of steel.

2) The tail of one coil and the head of the next are welded together using an electric seam welder.

3) The steel enters the first accumulator tower.

4) The steel is cleaned, rinsed and dried.

5) The cold steel band enters the furnace. The purpose of the furnace is to do one final cleaning of the surface, and to heat the steel to develop the proper mechanical properties.

6) The steel goes straight from the furnace into the coating pot. After it is coated, the steel passes through the pair of "air knives," where a high-pressure blast of air strips off the excess coating. The air knives work in conjunction with a computer-controlled gauge to create the customer's specified coating thickness.

7) The steel runs through a cooling tower so that the strip is almost back to room temperature.

8) At the customer's request, the steel can be run through a surface-conditioning mill to create a smooth surface for painting.

9) The tension leveler stretches the steel while passing over a series of rollers to provide superior flatness.

10) Any steel that is not destined for the paint line receives a chemical treatment that provides interim protection against staining during storage.

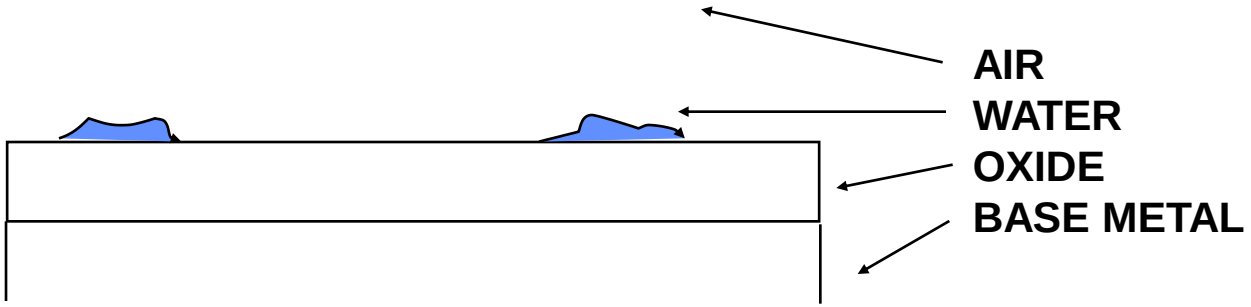
11) The steel enters the exit accumulator, waiting to be coiled again.

12) The steel is re-coiled onto the tension reel and sent for painting or packaging.

Hot Dip Galvanizing Process

Why does steel have to be coated?

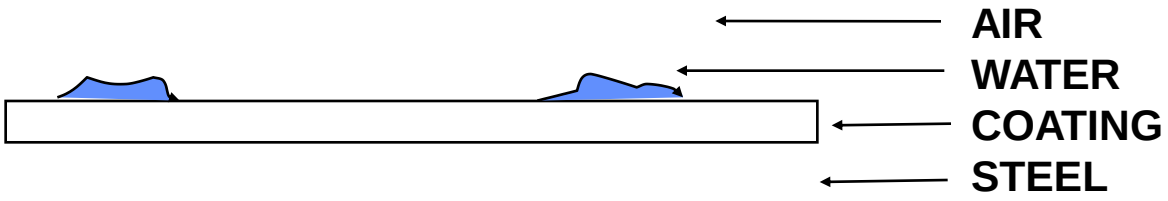
- All metals corrode
- Metals will combine with oxygen from the *air* where *moisture* is present
- Some metals (Zinc, Aluminum, Copper, Stainless steel) are *corrosion resistant* because they form a *protective oxide* which prevents *further* corrosion.



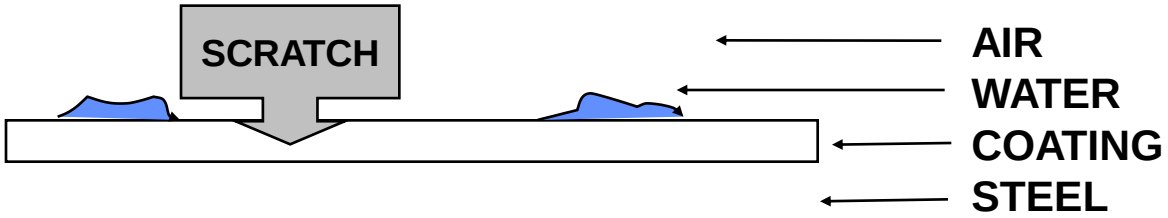
Hot Dip Galvanizing Process

Barrier Coatings

- These provide a mechanical barrier between steel and the atmosphere



- These *will not work* if there is a break in the coating



Advantages of Metallic-Coated Steel

Corrosion Resistance	- Unparalleled corrosion protection for steel. - Zinc coating provides exceptional protection to cut edges
Formability	- Exhibits an excellent combination of coating adherence and base steel ductility = zinc coating will not crack or peel during deep drawing and bending
Weldability	- Suitable for wide range of welding processes - electric arc welding, brazing and the various methods of resistance welding - single spot projection , indirect spot , multiple projection , seam and stud welding (TruZinc may also be hot soldered)
Appearance	- Resistant to normal marks more than zero spangled coated steel (electrogalvanized) - The sheet is readily paintable

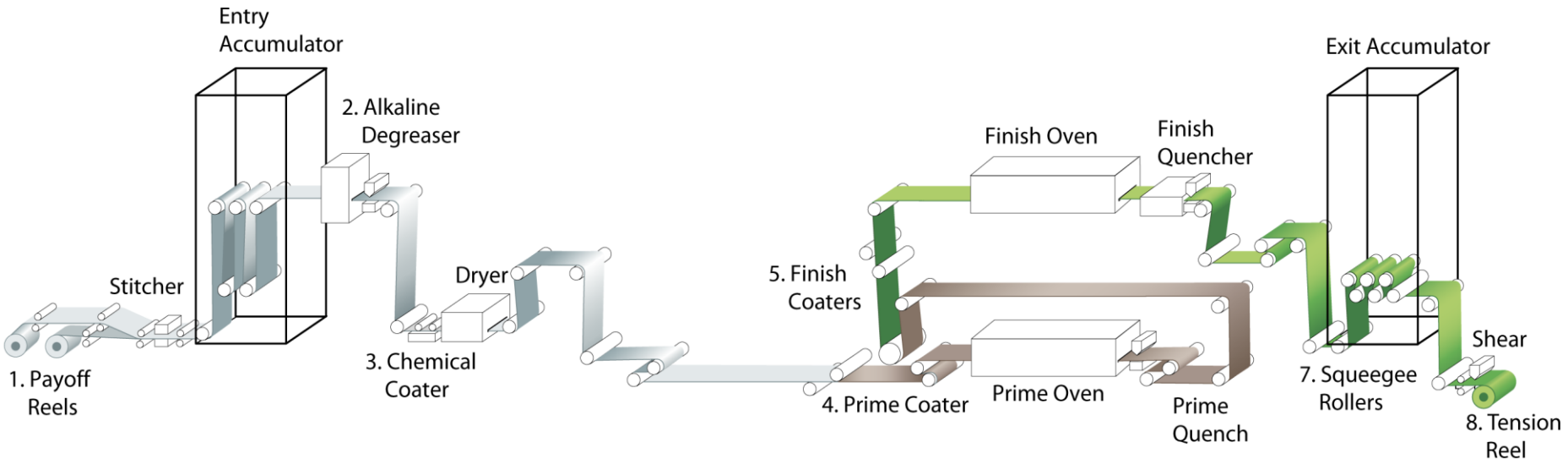
Coil Coating (Paint) Process

If the end-use application calls for a pre-painted product, the metallic-coated coil proceeds to the coil paint line for additional processing.

Benefits of pre-painted coil include…

- Weatherability - Resistance to moisture, sunlight & temperature changes.
- Flexibility - Able to be formed without cracking.
- Appearance - Available in various gloss ranges.
- Color - Maximum color retention, wide variety of colors available.
- Application - Applies easily on the line resulting in the desired finish.
- Cure - Dries completely within the specified dwell time and temperature.

Coil Coating (Paint) Process



1) The coil is fed into the process from one of two payoff reels. The stitcher joins the two ends together, and the steel enters the first accumulator tower.

2) The steel is cleaned, rinsed and dried.

3) The chemical coater applies a roll-on pre-treatment, the initial coating under the paint systems. A drying oven cures the pre-treatment.

4) Rollers apply a prime coat to both sides of the steel band. That coat is then cured in the prime oven. The steel comes out of the prime oven and travels back through a water quench and squeegee rolls to the finish coaters.

5) The finish coaters apply the final coat of paint, which is then cured by the finish oven.

6) The painted steel moves from the finish oven into the water quench, where water cools it to room temperature.

7) Rollers squeegee off the excess water, then the steel goes into the exit accumulator.

8) From the exit accumulator, the painted steel is re-coiled on the tension reel and sent for packaging

Quality Assurance

Coil Metallurgical Testing Attributes…

- Strip Thickness
- Strip Hardness
- Strip Formability
- Strip Fluting Characteristics
- Coating Mass
- Coating Adhesion
- Mechanical Properties
- Coating Composition
- Strip Passivation Integrity
- And MORE!!

Metallic-Coated & Pre-Painted Steel Applications

- **Lightweight framing**
- **Internal & external painted applications**
- **Residential house framing**
- **Door frames**
- **Electrical cabinets**
- **General manufacturing operations**
- **Cool-room panels**
- **Heating , ventilation and air conditioning ducting**
- **Structural decking**
- **Purlins**
- **Animal containment buildings (with a soil and/or cement interface)**
- **Building structures (with a soil and / or cement interface)**
- **And MORE!!**