SURFACE VEHICLE INFORMATION REPORT

J810™ MAR2025

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Superseding J810 MAR1996

(R) Classification of Common Imperfections in Sheet Steel

RATIONALE

The surface imperfections identified in this document should be used as a general guide to help identify common surface imperfections that can exist with flat rolled steels.

Identifying the specific surface imperfection and its root cause should be discussed with the steel supplier.

These surface imperfections may be normal for the products produced and are not indications the steel is out of specification or cause for rejection.

This document has been revised to update the pictures and descriptions.

1. SCOPE

Common or obvious surface imperfections are normally visible to the naked eye before or after fabrication or processing.

Illustrations and definitions of these imperfections are contained in this SAE Information Report. The identifying names are those commonly used throughout the steel industry. The imperfections identified include the major and most often encountered imperfections known to exist at this time. These imperfections are variable in appearance and severity. Extreme conditions have been selected in some instances in order to obtain suitable photographs.

Photographs are courtesy of the American Iron and Steel Institute, Kaiser Aluminum, U.S. Steel, Nucor Steel, Samuel Steel, Steel Dynamics, Worthington Steel, and companies no longer in existence: LTV Steel, National Steel, and The Budd Company.

2. REFERENCES

There are no referenced publications specified herein.

3. COMMON IMPERFECTIONS

See Table 1.

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Table 1 - Common imperfections encountered in sheet steel

Imperfection	Origin: Steelmaking	Origin: Rolling	Origin: Processing	Origin: Coating	Figure No.
Anneal Border			X		40
Anode Scratch				X	69
Bare Spots				X	70
Blisters				X	71
Bright Spots				X	72
Burr			X		41
Carbon Stain			X		42
Caster Cracks	X				1
Centerline Cracks	X				2
Chatter Marks		X			11
Chipped Slitter Knife			X		43
Coil Breaks			X		44
Coil Welds			X		45
Collapsed ID (Inside Diameter)			X		46
Dents			X		47
Drag Board Marks			X		48
Dross Build-Up				X	73
Dross Stringers				X	74
Edge Breaks		X			12
Entrapped Mold Powder	X				3
Flaking				X	75
Fluting		X			13
Fold Over		X			14
Friction Digs			X		49
Ghost Lines	X				4
Handling Damage			X		50
Holes	X				5
Lamination	X				6
Lamination: Edge Lamination	X				7
Lamination: Pipe Lamination	X				8
Lightning Bolt		X			15
Line Stop				X	76
Loose Winding		X			16
Lost Slit Edge			X		51
Lüders Lines			X		52
Non-Alloyed Surface				X	77
Onion Skin			X		53
Orange Peel			X		54
Oscillation			X		55
Oxide Edges		X			17
Oxide Flakes				X	78
Passivation Stain			X		56

Imperfection	Origin: Steelmaking	Origin: Rolling	Origin: Processing	Origin: Coating	Figure No.
Pickle Stain			X		57
Pick-Up		X			18
Pinchers		X			19
Pits		X			20
Plugged Die Line				X	79
Ragged Edge	X				9
Reel Breaks		X			21
Ridge		X			22
Roll Marks		X			23
Rust			X		58
Sag				X	80
Scale: Primary Scale		X			24
Scale: Rolled-In Scale		X			25
Scale: Silicon Streaks		X			26
Scale: Streak Scale		X			27
Scale: Worn Roll Scale		X			28
Scratch		X			29
Scratch: Healed-Over Scratch		X			30
Seams		X			31
Separator Disk Damage			X		59
Shape: Full Center		X			38
Shape: Buckles		X			32
Shape: Camber		X			33
Shape: Cross-Bow		X			34
Shape: Crown		X			35
Shape: Edge Build-Up		X			36
Shape: Edge Wave		X			37
Slit Edge Beading			X		60
Slivers	X				10
Solution Stain		X			39
Solution Stain			X		61
Solution Starve			X		62
Speckled Rust			X		63
Stagger Sheet			X		64
Sticker Breaks			X		65
Strain			X		66
Telescoping			X		67
Unpickled Edge			X		68
White Rust/Water Stains				X	81
Wiper Streaks				X	82

4. STEELMAKING IMPERFECTIONS

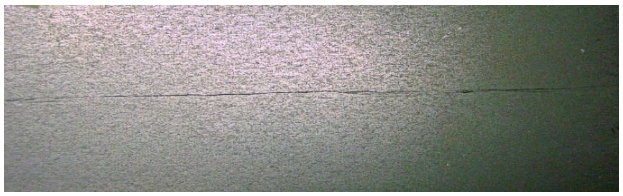
See Table 2 and Figures 1 to 10.

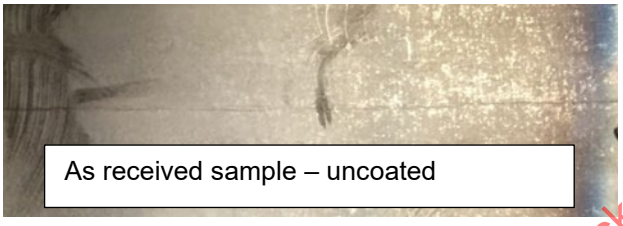
Table 2 - Common imperfections encountered in sheet steel related to steelmaking

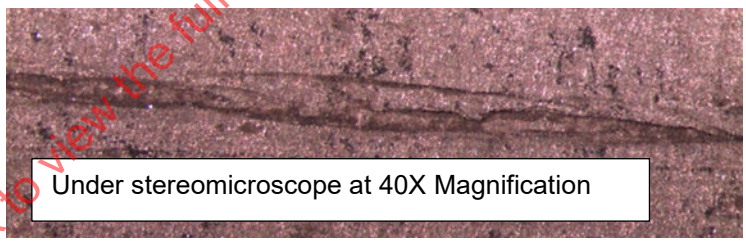
Steelmaking Imperfections	Similar Imperfections	Figure
Caster Cracks	Caster Fold; Seam; Longitudinal Crack	1
Centerline Cracks	Pipe Lamination; Center Lamination; Radial Crack	2
Entrapped Mold Powder	Laminations	3
Ghost Lines	Surface Scratches; Striations; Chatter Lines	4
Holes	Perforations; Edge Holes	5
Lamination	Sliver; Skin Lamination; Edge Lamination; Heavy Lamination; Pipe Lamination; Subsurface Lamination	6
Lamination: Edge Lamination	Rough Edges; Slab Cracks	7
Lamination: Pipe Lamination	Center Lamination; Blister Lamination; Radial Crack	8
Ragged Edge	Damaged Edge; Sawtooth Edge; Cracked Edge; Serrated Edge; Chipped Slitter Knife	9
Slivers	Scab; Seam; Skin Lamination; Lamination	10

4.1 Caster Cracks

Description:	Caster cracks are formed as a tear in the surface as the slab solidifies. They look like a deep scratch in the surface of the strip. They run in the rolling direction and may be continuous or fade and reappear throughout a coil.
Cause:	Caster cracks are caused by uneven cooling across the width of the slab as it solidifies and are influenced by chemistry and caster practices relative to mold flux, cooling rates, and/or mold taper.
Product Affected:	All products.
Similar Imperfection:	Caster Fold; Seam; Longitudinal Crack.







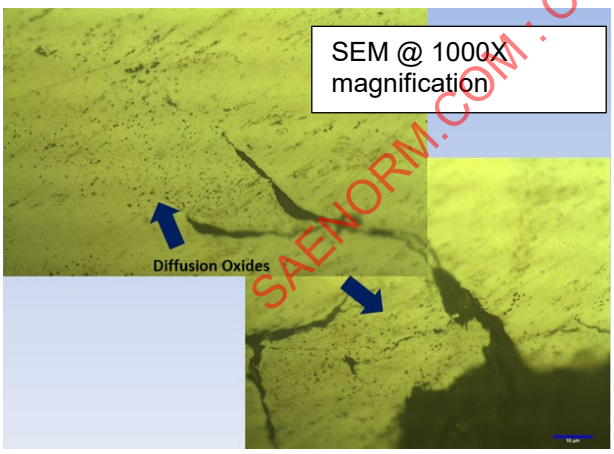
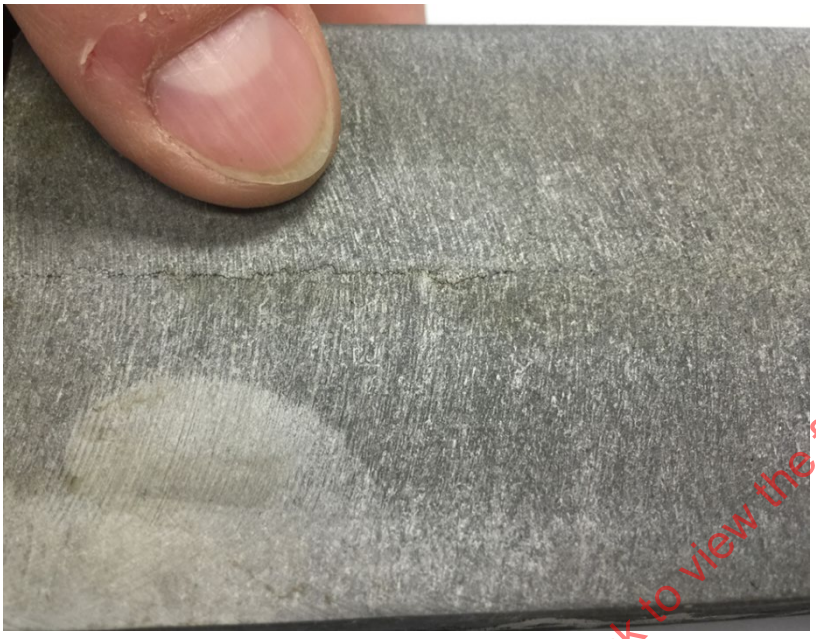


Figure 1

4.2 Centerline Cracks

Description:	An opening along the centerline of the as-cast slab that is oxidized during cooling and does not close on subsequent rolling. This subsurface tear may be continuous or interrupted. This defect may be exposed during shearing, cutting, or punching of the strip.
Cause:	Centerline cracking originates with the normal shrinkage of the steel at the center of the slab as it solidifies relative to the subsequent deformation of the strand during casting and can be caused by segregation, poor cooling condition during casting, and misalignment of caster segments.
Product Affected:	All products.
Similar Imperfection:	Pipe Lamination; Center Lamination; Radial Crack.



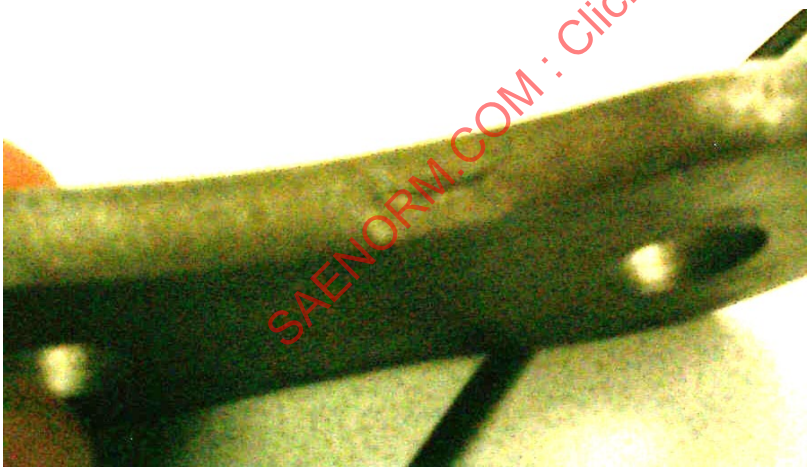


Figure 2

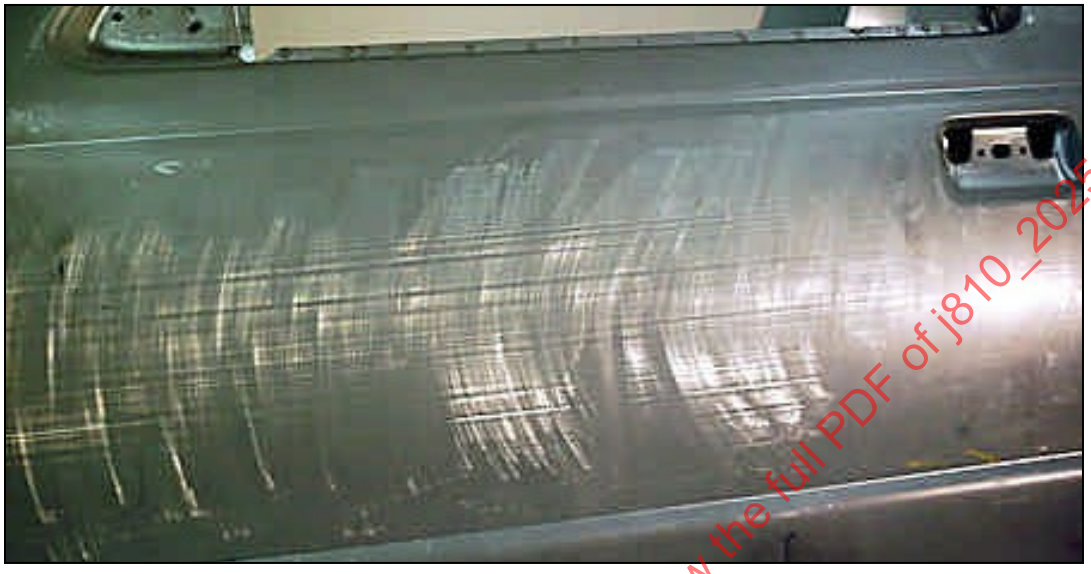
4.3 Entrapped Mold Powder

Description:	Mold powder is used to lubricate the sides of the caster mold so that the steel solidifies and slides freely out of the bottom of the mold. The powder is specially designed to burn off, but occasionally, it will get entrapped in the steel and create a defect.
Cause:	Entrapment during turbulent liquid metal flow during casting.
Product Affected:	All products.
Similar Imperfection:	None.

Figure 3

4.4 Ghost Lines

Description:	Ghost lines typically are not visible until after the sheet is stamped into a formed panel, although stoning brings out the ghost lines in unformed sheet steel. Ghost lines run parallel to the rolling direction.
Cause:	Ghost lines are caused by improper caster alignment and deoxidation practices. Ghost lines can also be caused by rolled-in alumina or phosphorus segregation.
Product Affected:	All products.
Similar Imperfection:	Surface Scratches; Striations; Chatter Lines (except chatter is perpendicular to the rolling direction).



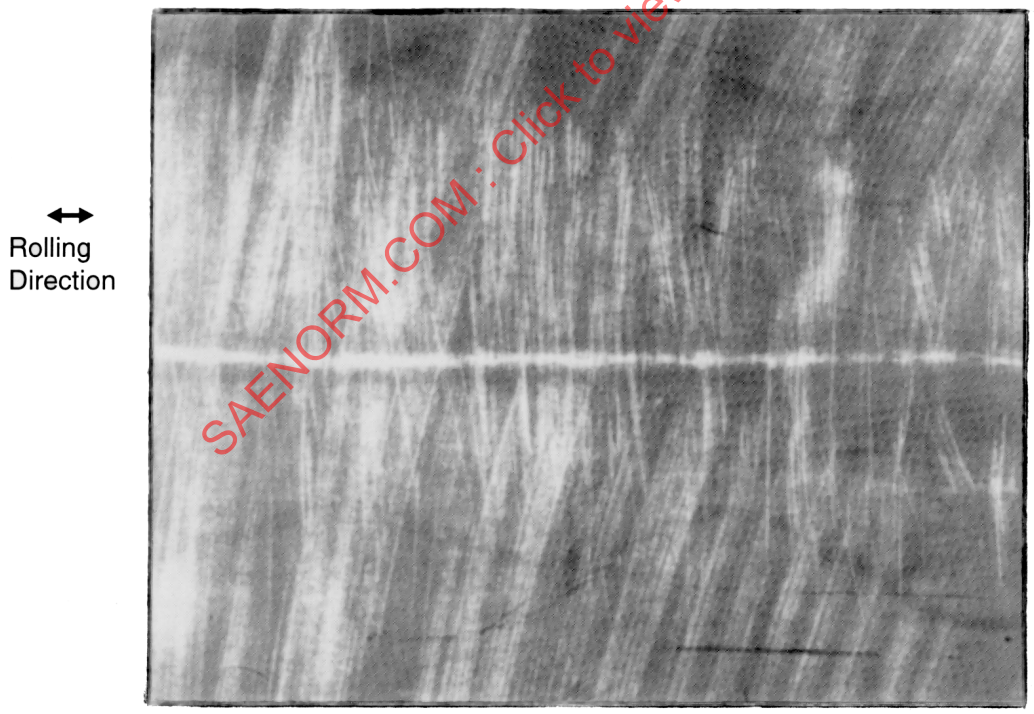


Figure 4

4.5 Holes

Description:	Holes are voids in the sheet.
Cause:	Holes result from the presence of laminations, pipe laminations, inclusions, scabs, or rolled-in foreign material which open during rolling.
Product Affected:	All products.
Similar Imperfection:	Perforations; Edge Holes.

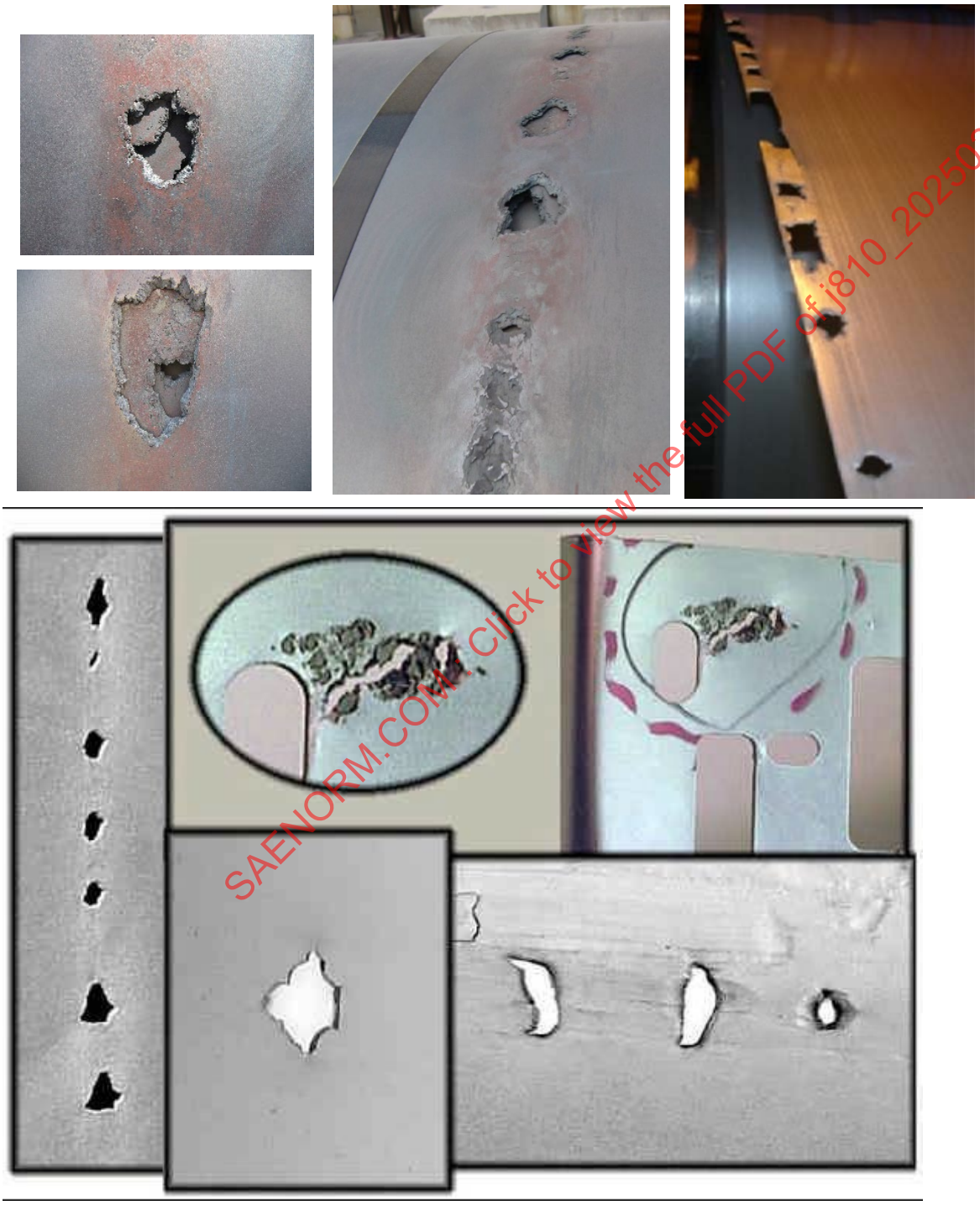


Figure 5

4.6 Lamination

Description:	Lamination is a subsurface separation which usually results in a visible surface rupture.
Cause:	Lamination is usually caused by the presence of nonmetallic inclusions or entrapped steelmaking refractory or other contaminant often resulting in delamination or fractures during forming or stamping.
Product Affected:	All products.
Similar Imperfection:	Sliver; Skin Lamination; Edge Lamination; Heavy Lamination; Pipe Lamination; Subsurface Lamination.

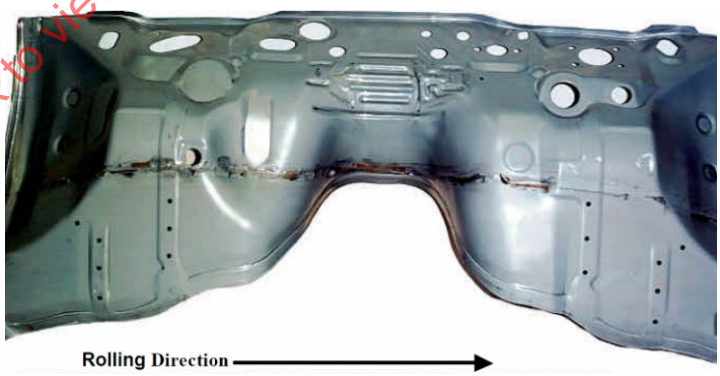


Figure 6

4.7 Lamination: Edge Lamination

Description:	Edge laminations are tears in the steel, particularly at the edges where the slab is colder.
Cause:	Edge laminations are microsegregations on grain boundaries causing them to slide instead of pancaking during deformation at certain temperatures depending on the steel composition.
Product Affected:	All products containing the original hot mill edge.
Similar Imperfection:	Rough Edges; Slab Cracks.

Figure 7

4.8 Lamination: Pipe Lamination

Description:	Pipe lamination is an internal imperfection running parallel to the rolling direction. It appears as a separation midway between the surfaces.
Cause:	Pipe lamination results from centerline segregation and the presence of oxide inclusions.
Product Affected:	All products.
Similar imperfection:	Center Lamination; Blister Lamination; Radial Crack.

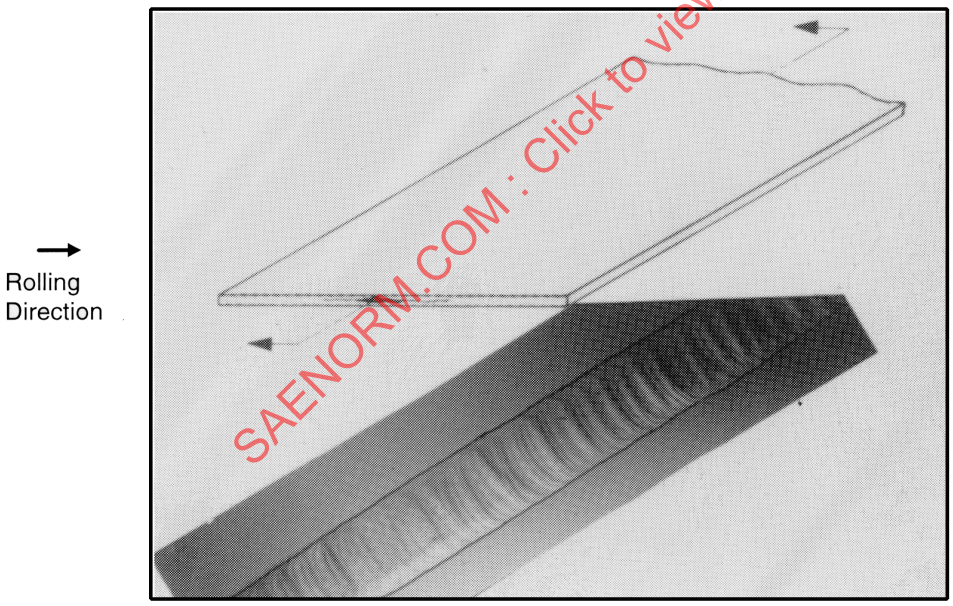
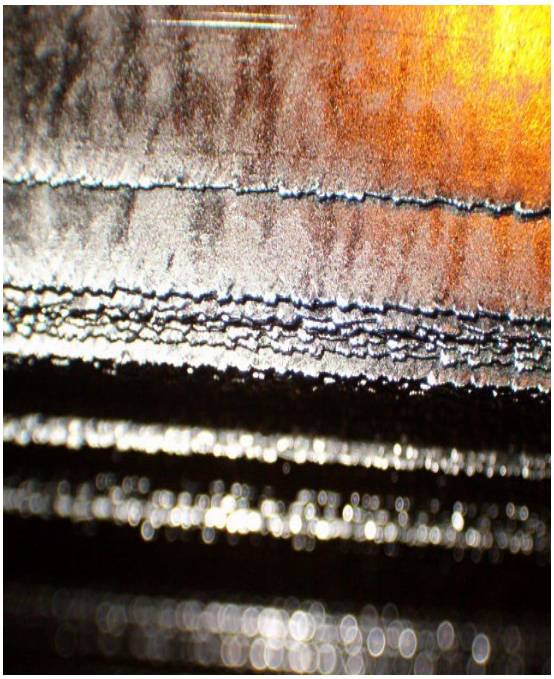


Figure 8

4.9 Ragged Edge

Description:	Appears as a rough, broken-away mill edge or as splitting on the coil edge. Cracks generally run perpendicular to the rolling direction. Ragged edge is a serrated edge that has been work hardened and subsequently fractured or deformed during the rolling operation.
Cause:	Ragged edges can be caused by: - Bad heating practices - Poor slitting or edge trimming - Damage during annealing
Product Affected:	All products.
Similar Imperfection:	Damaged Edge; Sawtooth Edge; Cracked Edge; Serrated Edge; Chipped Slitter Knife.



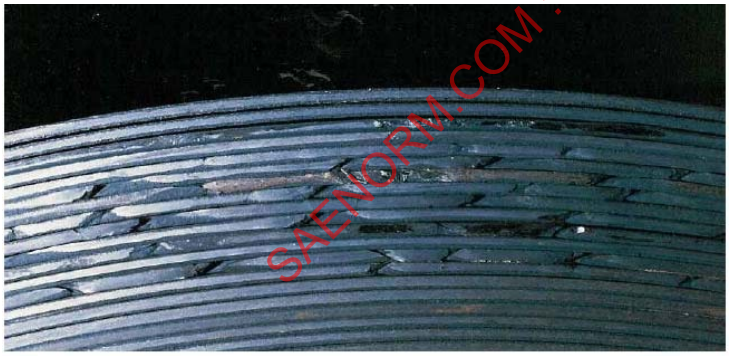


Figure 9

4.10 Slivers

Description:	Jagged tapered slivers of metal attached at one end. Usually an isolated defect. Slivers are small open surface laminations which are the result of any subsurface inclusion or steelmaking refractory entrapped in the liquid steel which comes to the surface during the rolling process.
Cause:	Slivers can be generated mechanically, or caused by: - Improper casting conditions - Improper composition (over oxidized, high sulfur) - Inadequate slab conditioning - Improper heating (overheating) - Tearing of corners in early stages of rolling - Entrapped mold flux - Transverse corner crack in slab
Product Affected:	Hot rolled.
Similar Imperfection:	Scab; Seam; Skin Lamination; Lamination.

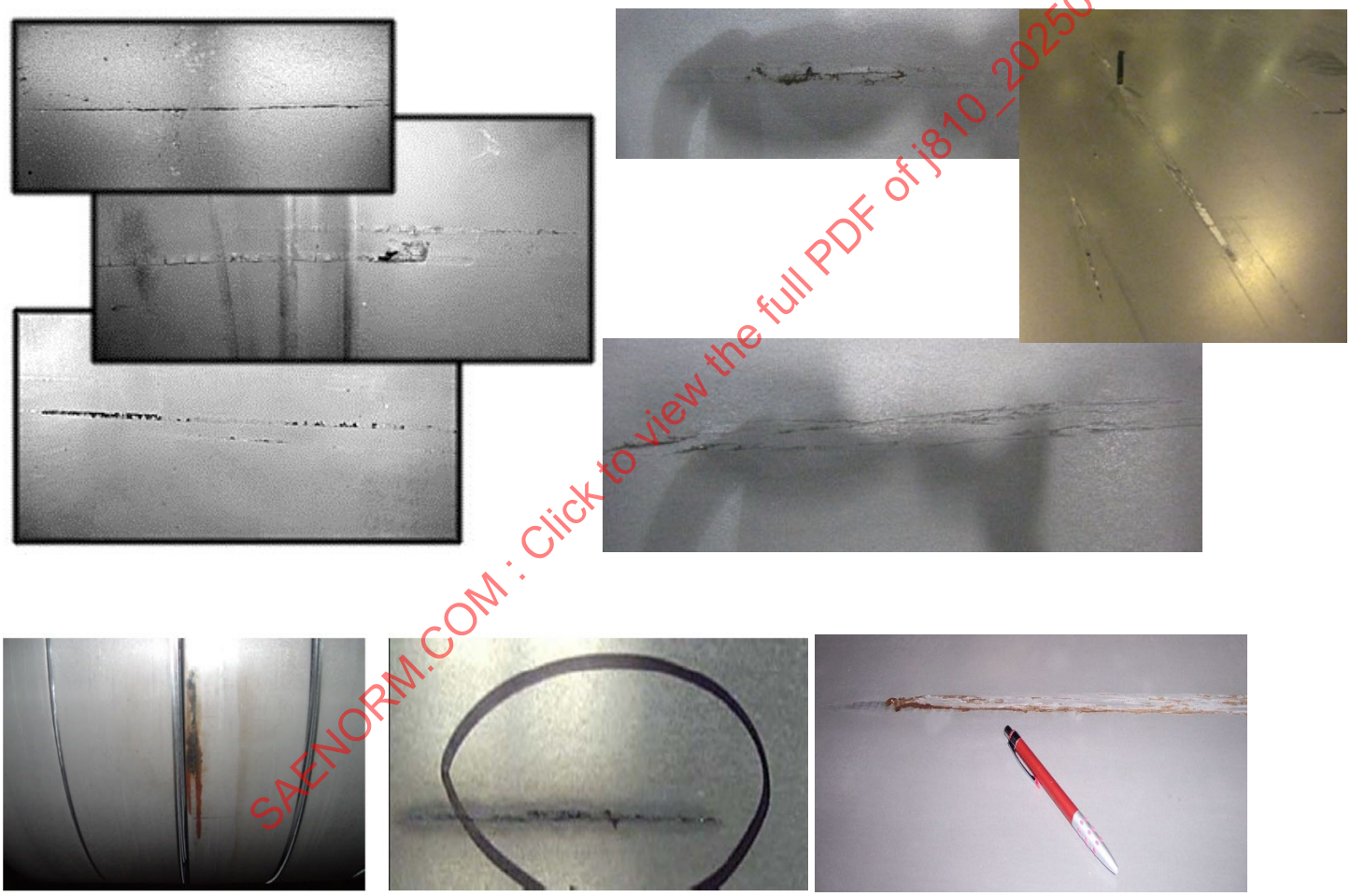


Figure 10

5. ROLLING IMPERFECTIONS

See Table 3 and Figures 11 to 39.

Table 3 - Common imperfections encountered in sheet steel related to rolling

Rolling Imperfections	Similar Imperfections	Figure
Chatter Marks	Chatter	11
Edge Breaks	Lüders Lines; Yield Point Elongation (YPE); Edge Strain; Stretcher Marks; Sticker Breaks	12
Fluting	Reel Kink; Coil Breaks; Lüders Lines	13
Fold Over	Whip Marks; Crimp; Flopper; Creases	14
Lightning Bolt	Skin Lamination; Furnace Tear	15
Loose Winding	Soft Coils; Telescoping; Clocksprung Coil	16
Oxide Edges	Anneal Blue; Annealing Burn	17
Pick-Up	Roll Pick-Up; Punch Roll Pick-Up; Pits	18
Pinchers	Feathering; Cross Hatch; Pinch Marks; Stickers; Sticker Breaks; Floppers	19
Pits	Pick-Up; Rolled-In Dirt; Rolled-In Scale; Corrosion Pits; Scale Pits; Grease Pits; Slug Pits; Scale Pits	20
Reel Breaks	Breaks; Mandrel Breaks; Reel Kink; Latch Marks; Lap Marks	21
Ridge	Build-Up; Burnish Mark; Crease	22
Roll Marks	Bruise; Mill Mark; Repeat Mark; Pick-Up; Dents; Pits	23
Scale: Primary Scale	Furnace Scale; Fleck Scale; Spot Scale; Secondary Scale	24
Scale: Rolled-In Scale	Fleck Scale; Spot Scale; Pepper Scale; Primary Scale; Peeled Roll Scale; Worn Mill Scale	25
Scale: Silicon Streaks	Tiger Stripes	26
Scale: Streak Scale	Black Streak; Pits; Rolled–In Dirt	27
Scale: Worn Roll Scale	Pepper Scale; Streak Scale	28
Scratch	Healed-Over Scratch; Friction Digs	29
Scratch: Healed-Over Scratch	Rolled-Over Scratch; Scratch	30
Seams	Welds; Fold-Over; Creases	31
Shape: Buckles	Edge Wave; Oil Canning; Ridge Buckle; Center Buckle; Full Center	32
Shape: Camber	Hook Ends; Snake	33
Shape: Cross-Bow	Coil Set; Off-Flatness; Hog Back; Canoe	34
Shape: Crown	Heavy Gauge/Light Gauge; Feathered Edge; Wedge	35
Shape: Edge Build-Up	Flared Edge; Pie Crust Edge; Spooling	36
Shape: Edge Wave	Wavy Edge; Pie-Crust Edge; Rippled Edge	37
Shape: Full Center	Oil Can; Edge Wave; Center Buckle	38
Solution Stain	Cold Rolled Detergent Stain; Pickle Stain; Annealing Stain; Emulsion Stain	39

5.1 Chatter Marks

Description:	Chatter is an intermittent surface distortion, perpendicular to the rolling direction (across the width). They may or may not be perceptible to the touch. They may appear as alternate bright and dull streaks. They can be highlighted by stoning.
Cause:	Chatter marks can be caused by: - Vibration during rolling - Vibration during leveling - Vibration of tools used to grind rolls - Lubricant failure causing fluctuation in the coefficient of friction between the roll face and the sheet surface - Improper tension between stands during rolling
Product Affected:	All products.
Similar Imperfection:	Chatter.

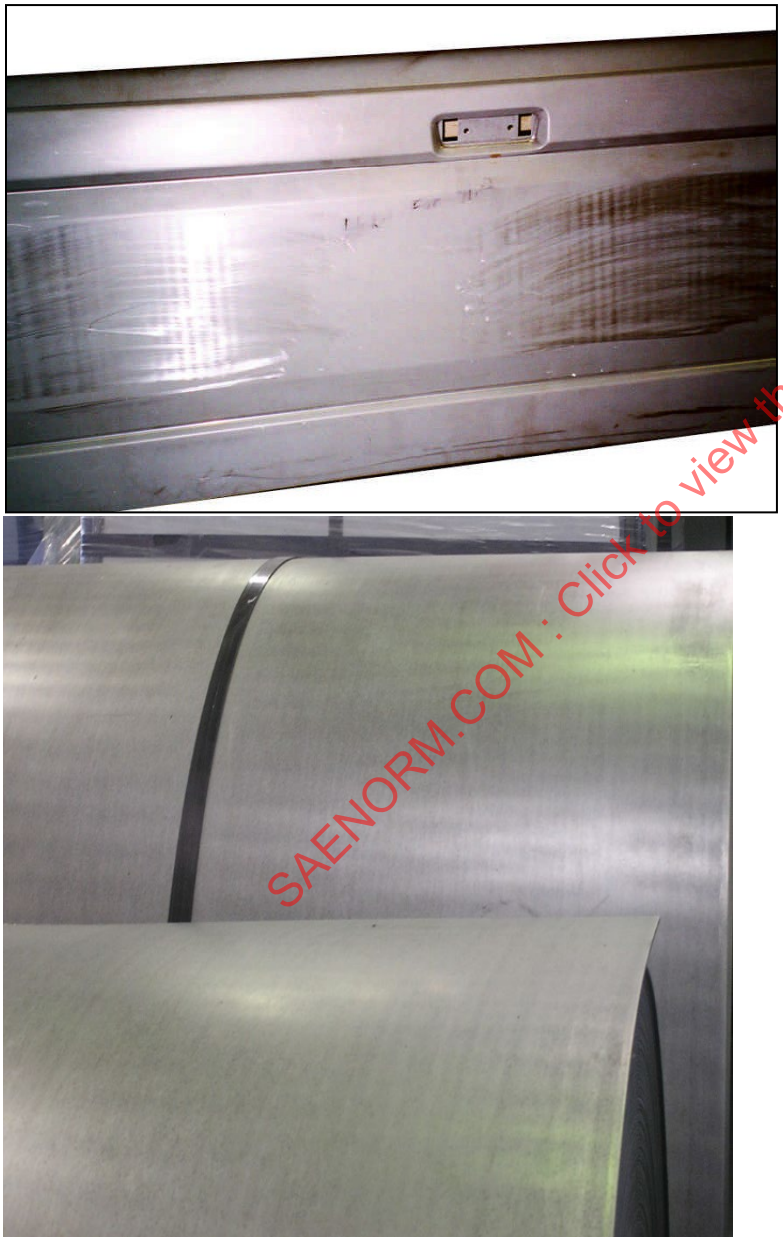


Figure 11

5.2 Edge Breaks

Description:	Edge breaks are short creases which extend in from the edge of the sheet and appear as “branch like” transverse stretch lines that originate at the edge of the material. Edge breaks usually appear on both top and bottom surfaces.
Cause:	Edge breaks are caused by insufficient tempering and yield point elongation. Edge breaks occur in steel when the edges are substantially thinner than the rest of the sheet and do not receive sufficient temper reduction to minimize or eliminate yield point elongation.
Product Affected:	All products.
Similar Imperfection:	Lüders Lines; Yield Point Elongation (YPE); Edge Strain; Stretcher Marks; Sticker Breaks.

Figure 12

5.3 Fluting

Description:	Appearance will be similar to a reel kink. Severity can vary by material grade and application.
Cause:	Fluting typically occurs during roll forming to small diameters or stretching during stamping resulting from the presence of yield point elongation (YPE).
Product Affected:	Roll formed products.
Similar Imperfection:	Reel Kink; Coil Breaks; Lüders Lines.

Figure 13

5.4 Fold Over

Description:	Fold over appears as random surface folds or whip-like marks.
Cause:	Fold over is caused by poor shape or tension control during rolling.
Product Affected:	All products.
Similar Imperfection:	Whip Marks; Crimp; Flopper; Creases.

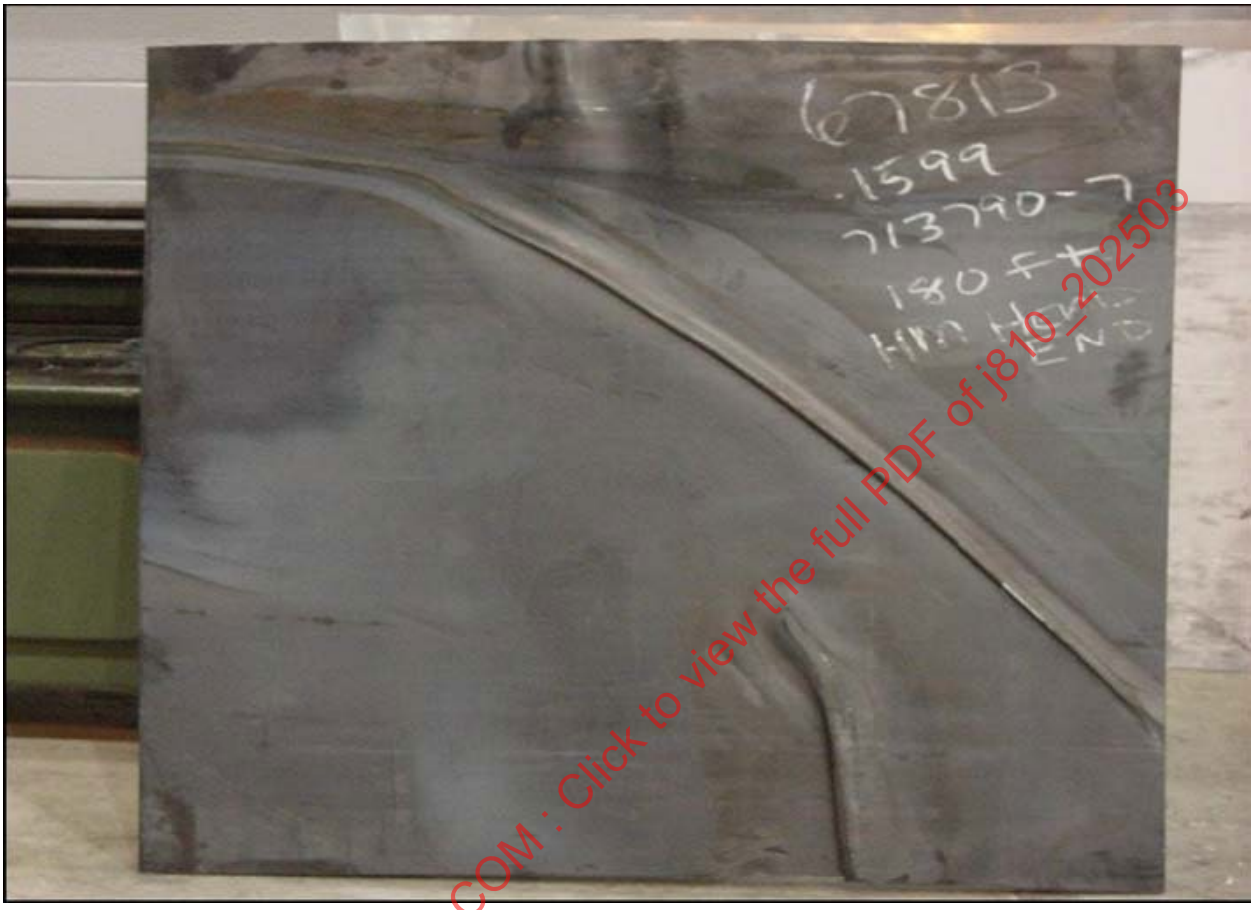


Figure 14

5.5 Lightning Bolt

Description:	Lightning bolts are breaks or tears in the surface of the strip and are located on the bottom surface at the hot strip mill.
Cause:	Lightning bolts are caused by: - Wear and deterioration of skids in a reheat furnace - A surface rupture in the hot mill reheat furnace - Slab conveyor condition - Slab handling procedures
Product Affected:	All products.
Similar Imperfection:	Skin Lamination; Furnace Tear.

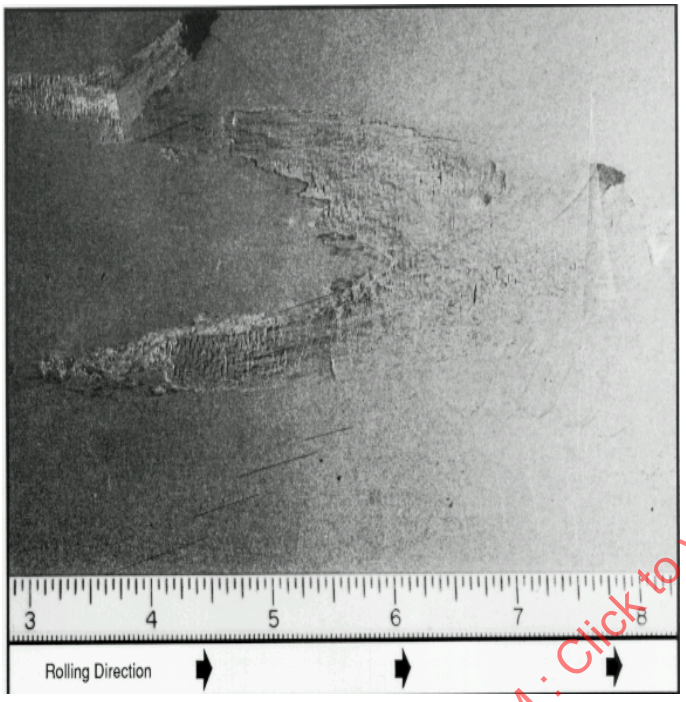


Figure 15

5.6 Loose Winding

Description:	Loose laps typically near the ID (inside diameter) of a coil.
Cause:	Insufficient tension during winding.
Product Affected:	All products.
Similar Imperfection:	Soft Coils; Telescoping; Clocksprung Coil.

Figure 16

5.7 Oxide Edges

Description:	Oxide edges are discolored edges on hot band coils and appear as a wavy pattern located near an edge. Oxide edges can be multiple shades of blue, gray, and black.
Cause:	Different types of scale forming from the edge leading to discoloration. Additionally, heat from the surrounding coils leads to various scale formation.
Product Affected:	Hot rolled steel.
Similar Imperfection:	Anneal Blue; Annealing Burn.

Figure 17

5.8 Pick-Up

Description:	Pick-up is a series of repetitive depressions, dents, or scratches on a sheet.
Cause:	Pick-up is caused when metallic or nonmetallic debris adhere to work rolls or other rolls. These particles could be the base metal or the galvanized coating if it occurs at that stage of processing. Pinch roll pick-up, also called stickers, occurs when metal sticks to the hot mill coiler pinch roll and leaves a repeating impression on the strip.
Product Affected:	All products.
Similar Imperfection:	Roll Pick-Up; Punch Roll Pick-Up; Pits.

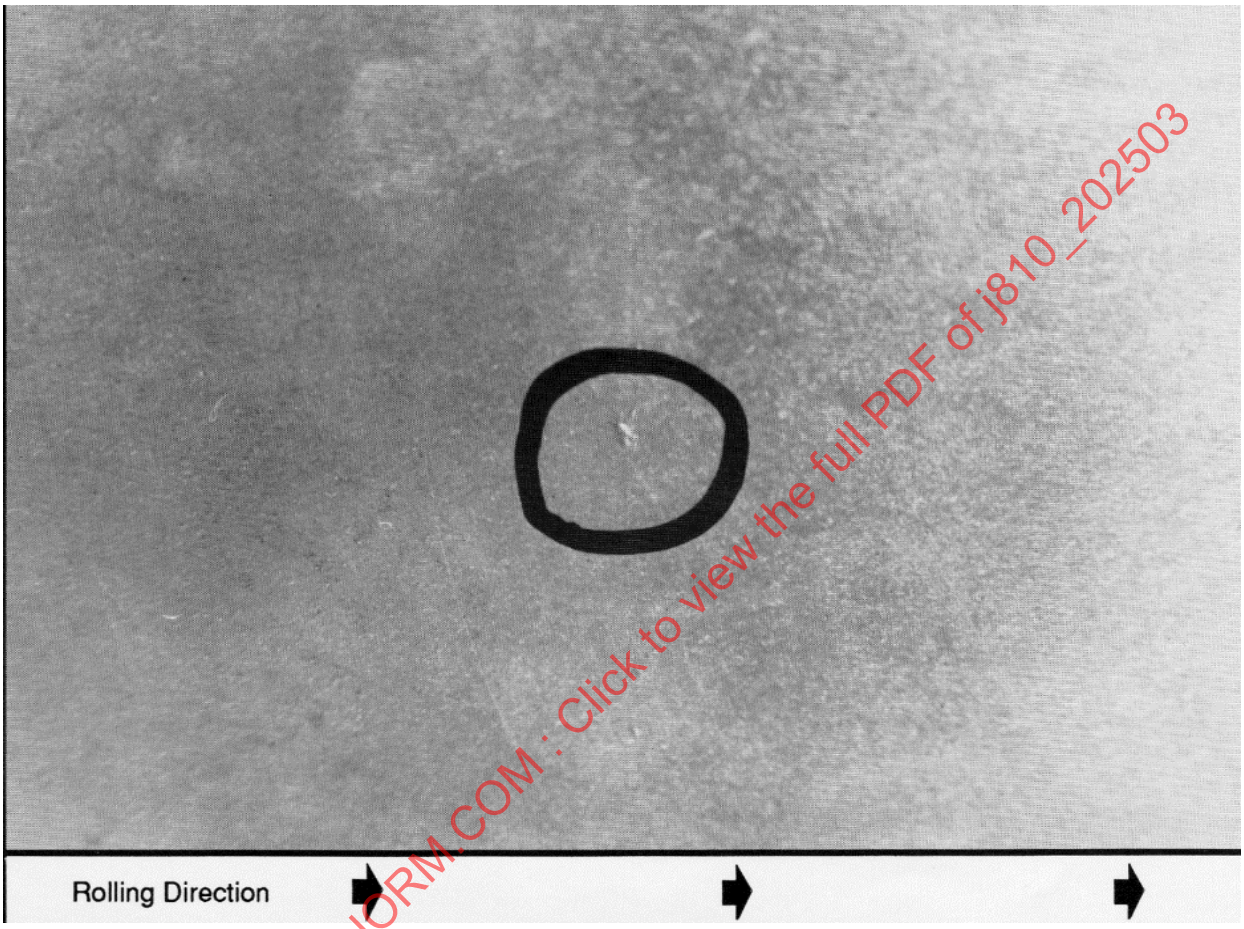


Figure 18

5.9 Pinchers

Description:	Pinchers occur during rolling. They can be observed with the naked eye and usually run diagonal to the direction of rolling. Pinchers may occur locally or across the width of the sheet. The strip may slip sideways after it leaves the last mill stand and is more prone to occur at lighter gauges and on strips with camber. This sideways slip may produce an area of pinched up metal at the downcoiler. Floppers are a type of pincher, usually from an edge wave that bunches up in a roll bite. Stickers are different than pinchers. Pinchers are more mechanical, occurring when metal bunches up in roll bite. Stickers have a heat component. Pinch marks are sometimes described using the term “pinchers.” Pinch marks are caused by roll marks left behind when a tail end pinches or rips going through the last mill stand. These pinch marks are usually very large repeating areas of discolored steel but can rarely be felt.
Cause:	Pinchers are caused when the profile of the incoming strip does not coincide with that of the “roll gap” during temper rolling to produce, for example, a wavy strip.
Product Affected:	Cold rolled.
Similar Imperfection:	Feathering; Cross Hatch; Pinch Marks; Stickers; Sticker Breaks; Floppers.

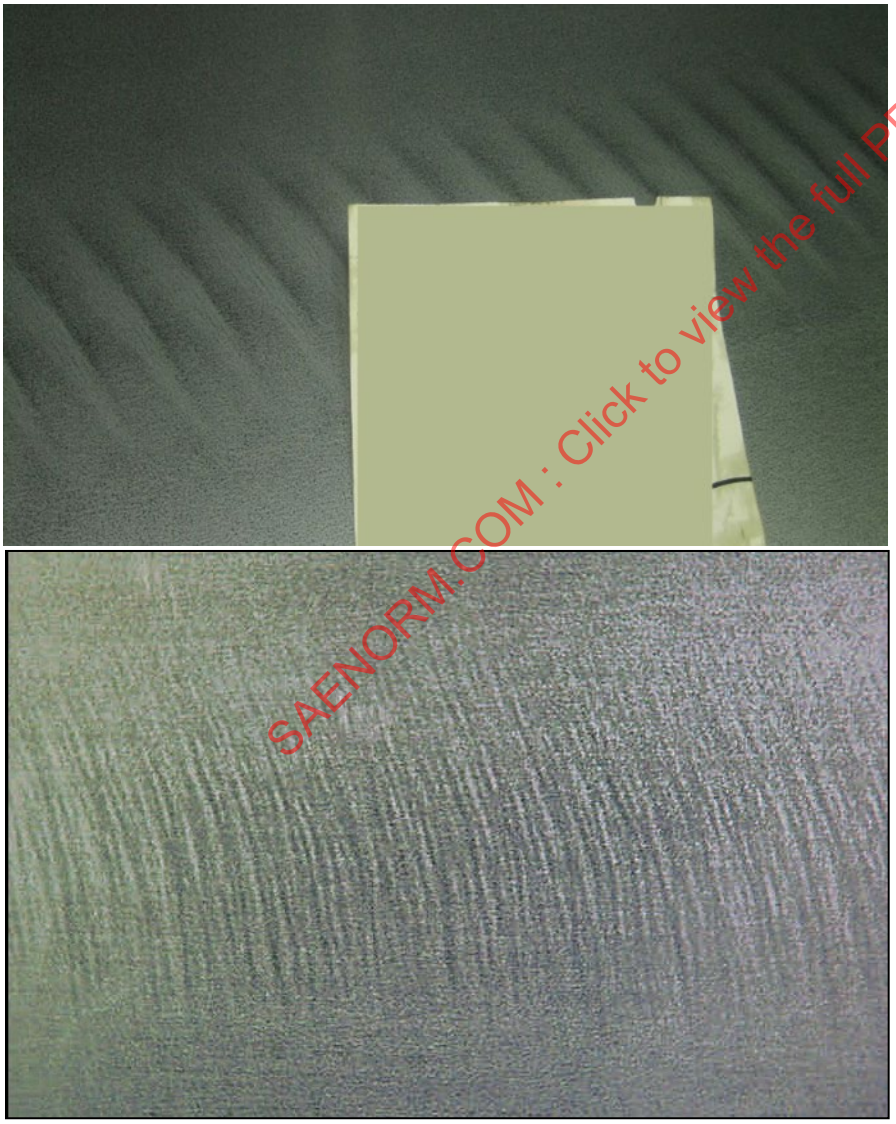


Figure 19

5.10 Pits

Description:	Pits are small cavities in the surface of the steel characterized by randomly distributed indentations.
Cause:	Pits can be caused by: - Debris on temper mill rolls - Foreign particles or metal flakes rolled into and subsequently fall out of the steel coil surface - Rolled-in scale which has been removed by pickling Pits can form when coils have been set on rocks or debris which then are pressed into the surface.
Product Affected	All products.
Similar Imperfection:	Pick-Up; Rolled-In Dirt; Rolled-In Scale; Corrosion Pits; Scale Pits; Grease Pits; Slug Pits; Scale Pits.

Figure 20

5.11 Reel Breaks

Description:	Reel breaks are transverse breaks or ridges on successive inner laps of a coil. A hump occurs at the latch point of the recoiler. A subsequent kink is formed as each lap is wound over the hump. Reel breaks typically affects the full width of the coil. During subsequent unwinding, the distance between kinks will decrease in distance but increase in severity closer to the ID (inside diameter) of the coil.
Cause:	Reel breaks are caused by excessive tension during rolling or improper feeding of the head end into the mandrel. Reel breaks can also be caused by misalignment of reel segments.
Product Affected:	All products.
Similar Imperfection:	Breaks; Mandrel Breaks; Reel Kink; Latch Marks; Lap Marks.

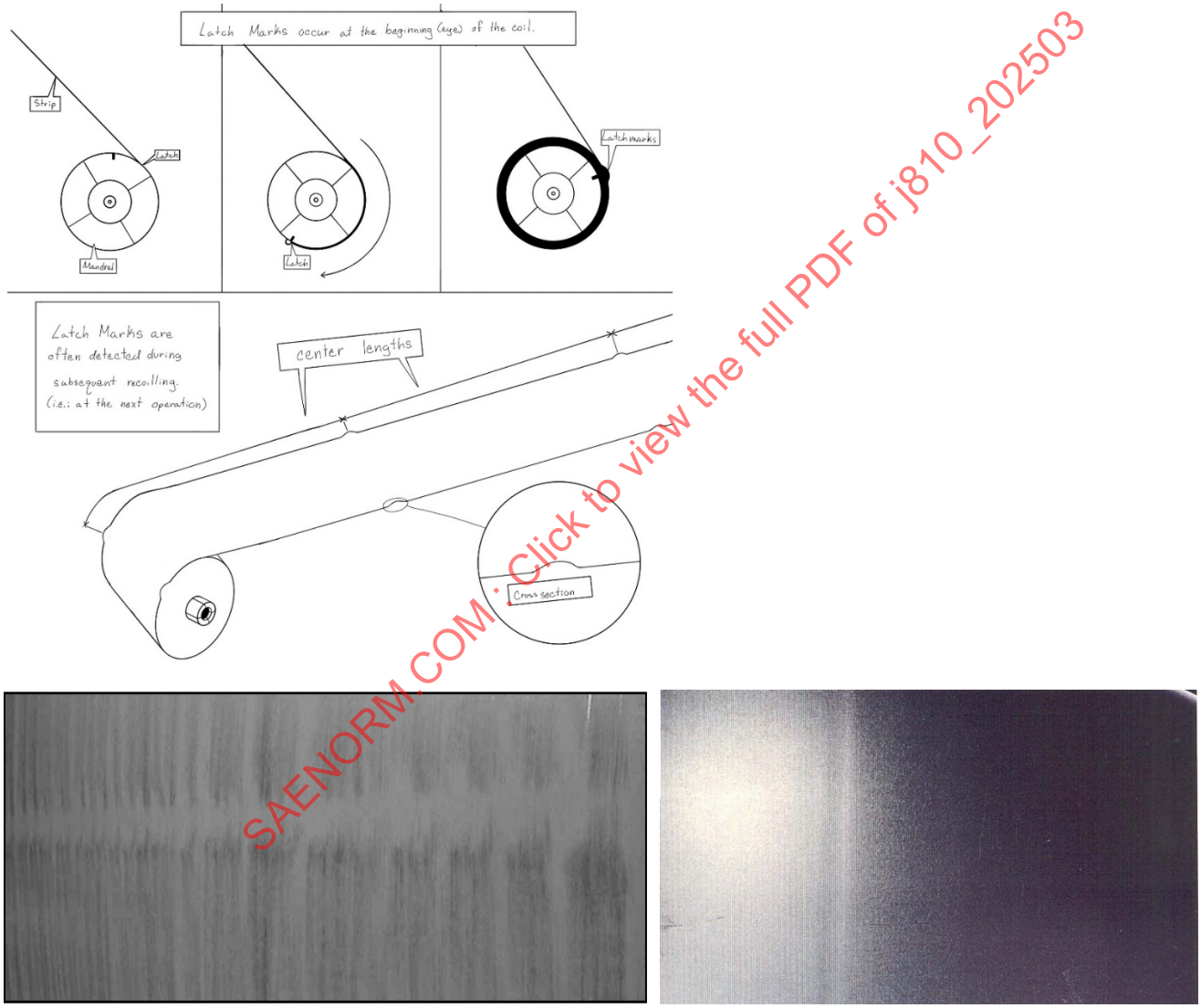


Figure 21

5.12 Ridge

Description:	A ridge is a localized linear difference in the strip contour or thickness that runs parallel to the rolling direction.
Cause:	Ridges can be caused by localized excess coating or strip thickness. Ridges can also be caused by improper work roll cooling during hot rolling.
Product Affected:	All products.
Similar Imperfection:	Build-Up; Burnish Mark; Crease.

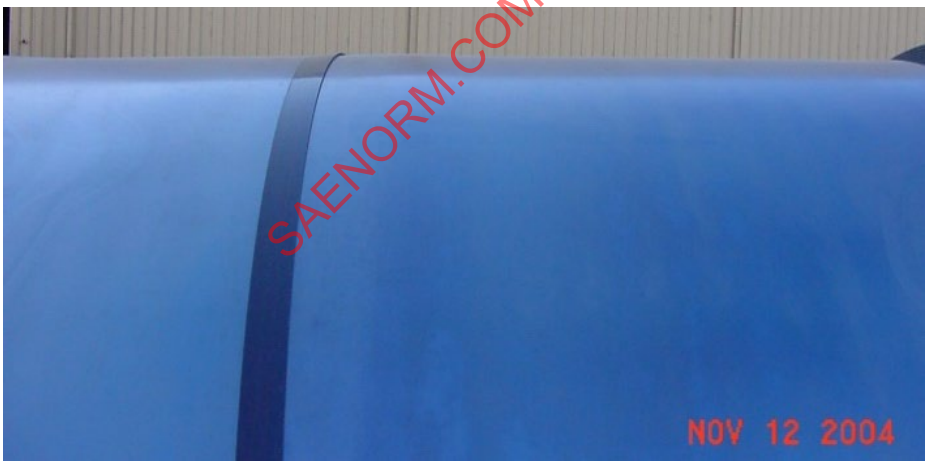


Figure 22

5.13 Roll Marks

Description:	Roll marks appear as indentations in the material surface and are usually irregularly shaped. Roll marks repeat at regular intervals, with the repeat distance matching the circumference of the roll that caused the imperfection (distance may be elongated by subsequent rolling).
Cause:	Roll marks are caused by damaged roll(s) or debris on roll(s).
Product Affected:	All products.
Similar Imperfection:	Bruise; Mill Mark; Repeat Mark; Pick-Up; Dents; Pits.

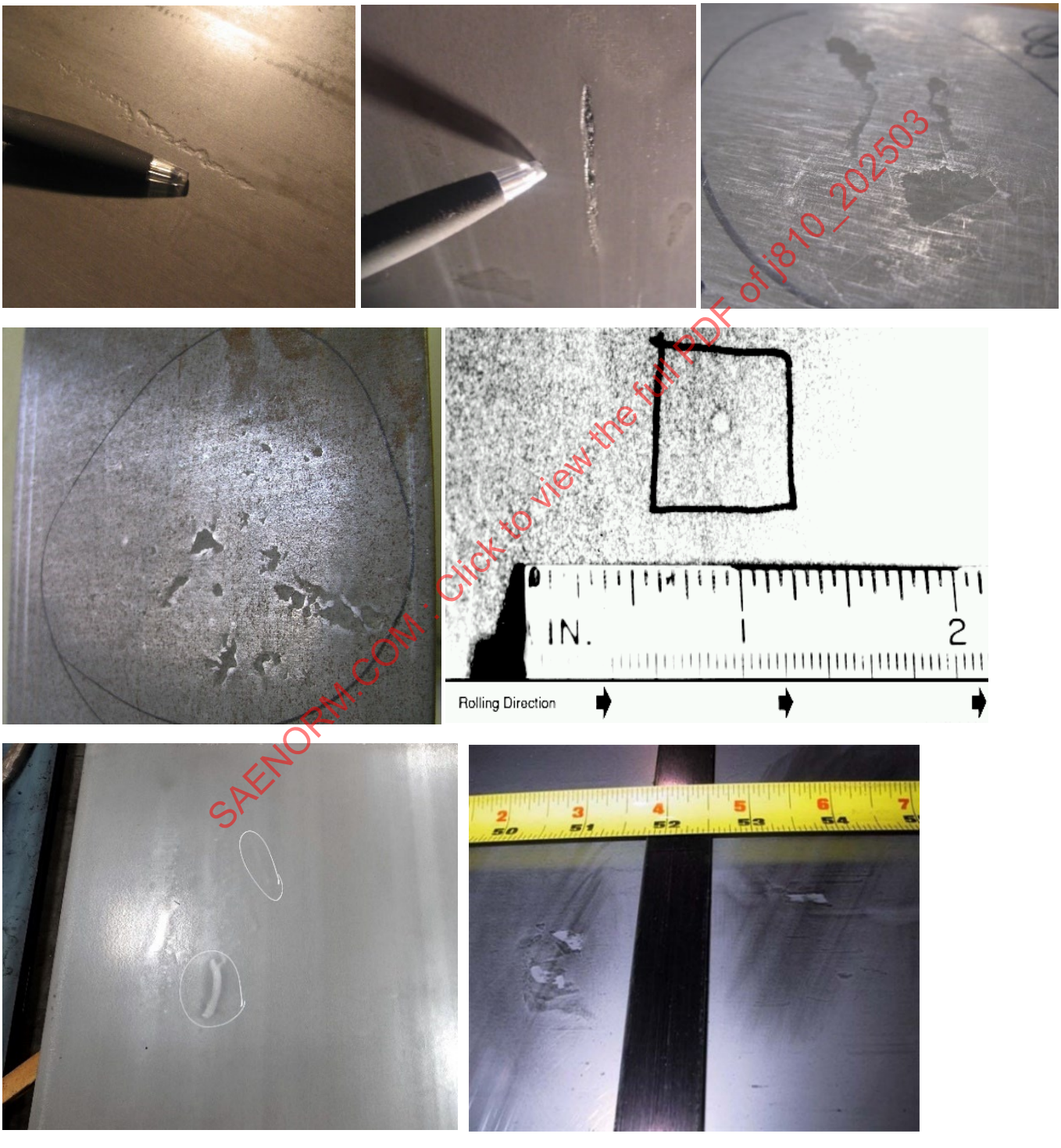


Figure 23

5.14 Scale: Primary Scale

Description:	Primary scale forms on the slab in the reheat or tunnel furnace by reaction between the surface of the steel with combustion gasses that include excess air, water vapor, and carbon dioxide. If this primary scale is not removed by the descaling process prior to hot rolling, it becomes pressed into the surface of the steel and leaves an impression that often contains residual portions of this scale after pickling.
Cause:	Primary scale can be caused by extended time in the reheat or tunnel furnace and abnormally thick scale layers not easily removed prior to rolling through the roughing mill or finishing mill.
Product Affected:	Hot rolled.
Similar Imperfection:	Furnace Scale; Fleck Scale; Spot Scale; Secondary Scale.

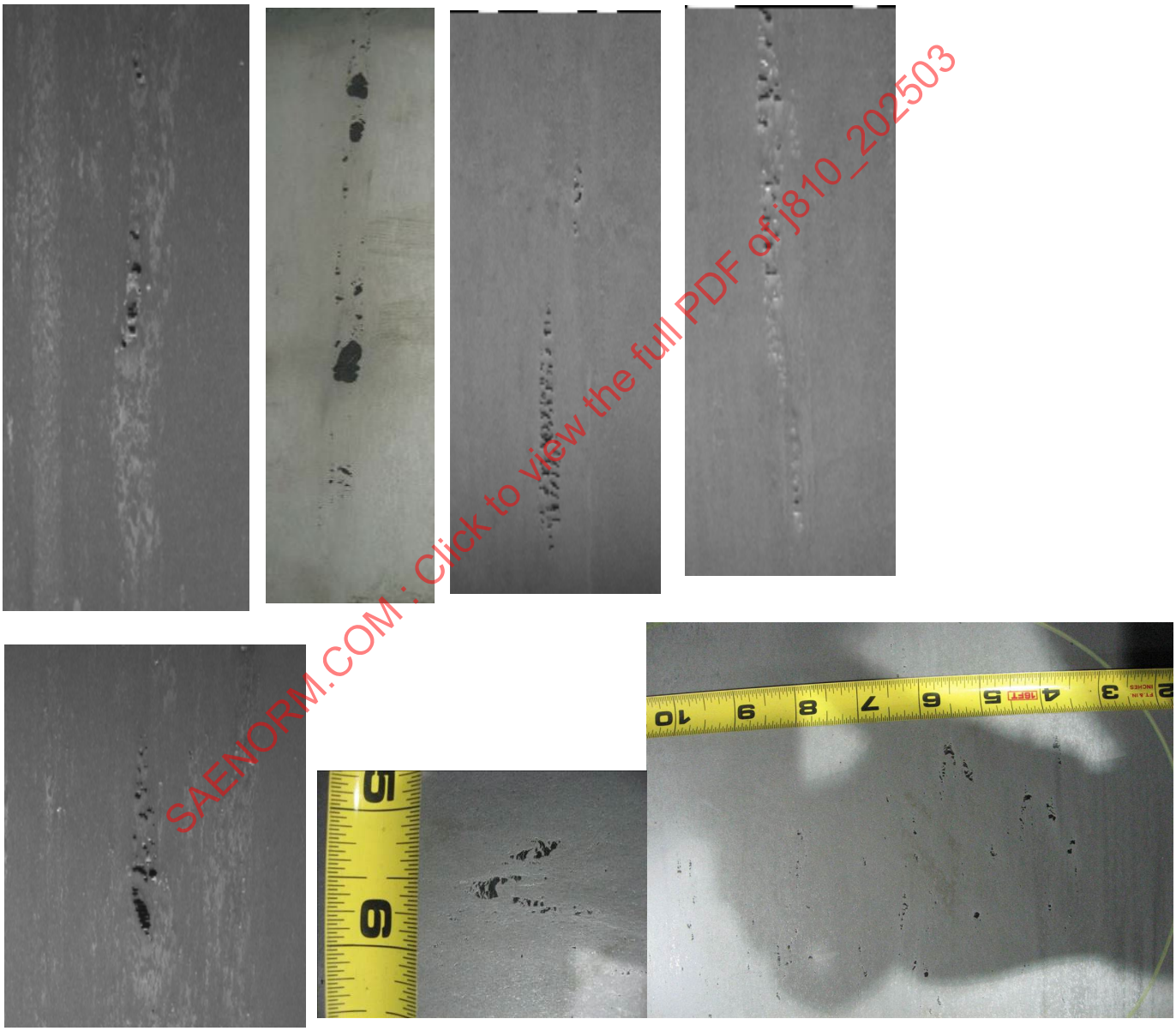


Figure 24

5.15 Scale: Rolled-In Scale

Description:	Rolled-in scale appears as dark streaks or spots in the rolling direction which are small particles loosely attached or embedded in the surface of the metal. May be elongated in the rolling direction. May appear as pit marks if the scale has been pickled out. When a slab reaches the hot strip mill, the surface scale must be completely removed prior to rolling. Reasons for incomplete removal of scale include a clogged water-jet nozzle, a chunk of scale ricocheting through the nozzles (rebound scale), or tight adherence to the steel. Scale is mechanically harder but more brittle than base metal, so when it is rolled into the steel, it leaves a deep impression and breaks apart as it is elongated.
Cause:	Rolled-in scale results when scale that has accumulated on the work roll surface is partially rolled into the surface of the sheet. This condition can cause holes in certain products. The scale sometimes forms in pits and is rolled into the steel and is often described as “pepper” scale. Sometimes, the effect is an elongated streak of black scale similar to primary scale, but much lighter and thinner. Rolled-in scale can also result from insufficient pickling of deeply pitted surfaces during hot rolling.
Product Affected:	All products.
Similar Imperfection:	Fleck Scale; Spot Scale; Pepper Scale; Primary Scale; Peeled Roll Scale; Worn Mill Scale.

Figure 25

5.16 Scale: Silicon Streaks

Description:	Silicon streaks appear as closely packed tapered streaks lightly impressed or imprinted in the surface. The color is usually slightly darker than the pickled strip.
Cause:	Silicon streaks are caused by the formation of a difficult to remove silicon-rich scale, called fayalite, which becomes elongated during hot rolling.
Product Affected:	Hot rolled, cold rolled.
Similar Imperfection:	Tiger Stripes.

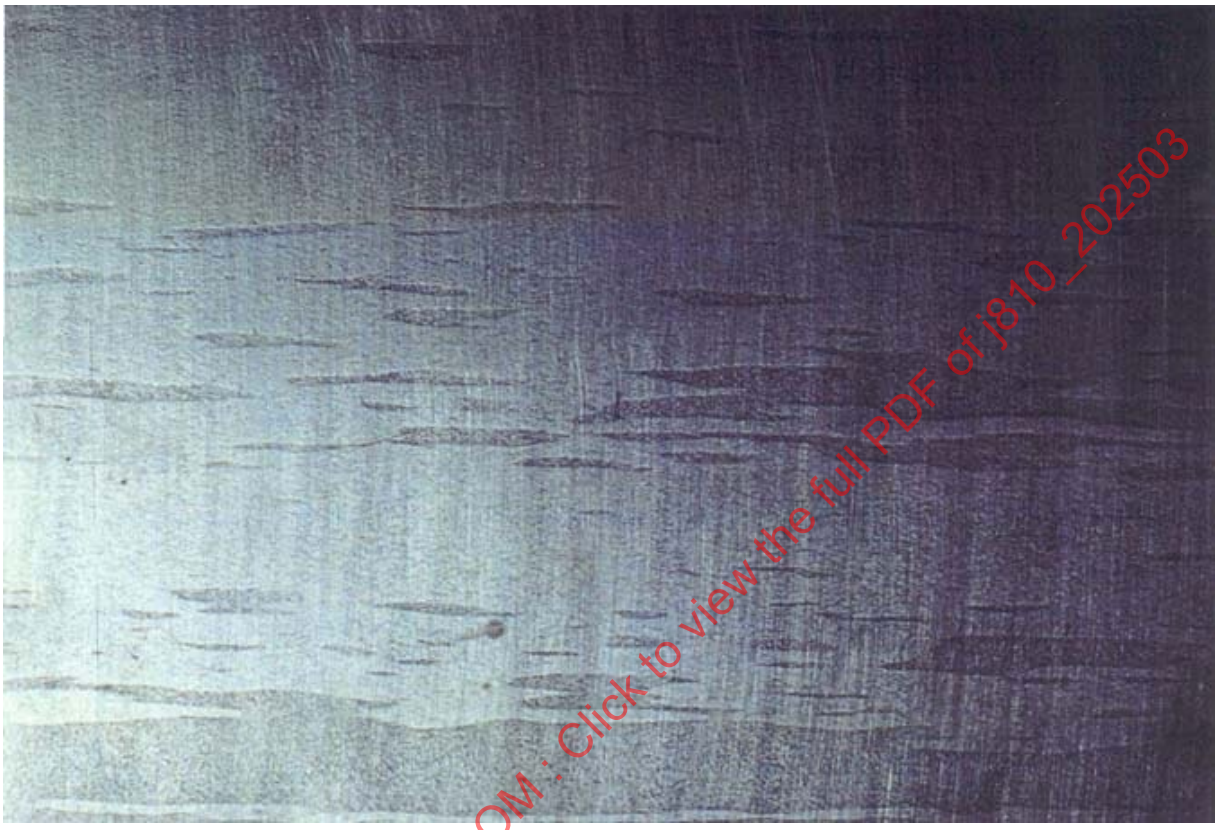


Figure 26

5.17 Scale: Streak Scale

Description:	Streak scale appears as dark streaks in the rolling direction.
Cause:	Streak scale results when scale is partially rolled into the surface of the sheet.
Product Affected:	All products.
Similar Imperfection:	Black Streak; Pits; Rolled–In Dirt.

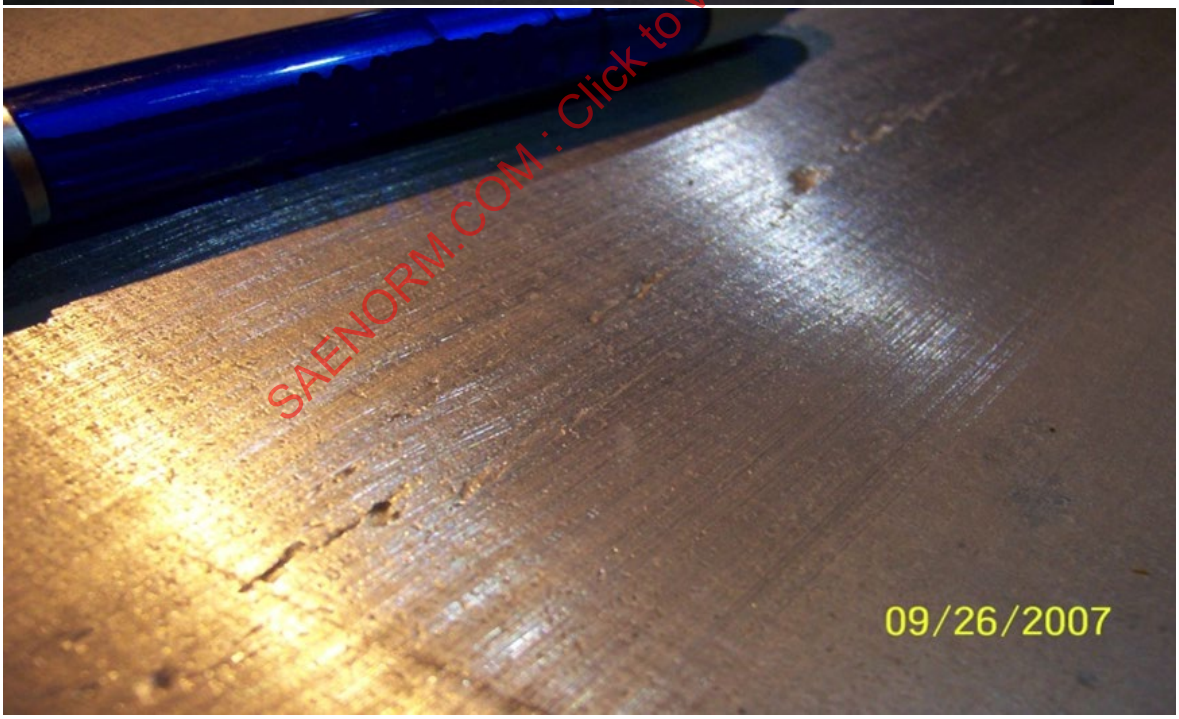


Figure 27

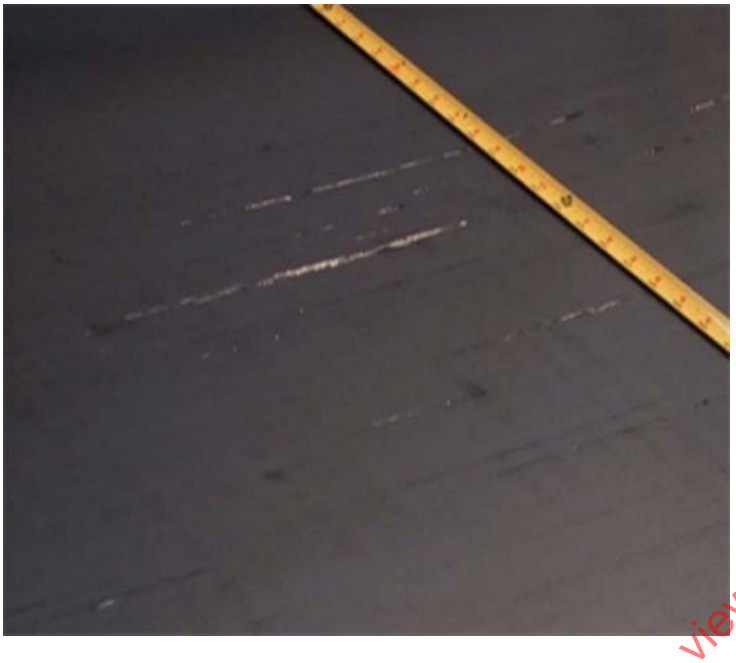
5.18 Scale: Worn Roll Scale

Description:	Worn roll scale looks like patches or streaks of pits. Sometimes, black scale is present in the pits.
Cause:	Worn roll scale is produced when scale (oxidized steel) forms in the rough area left behind when peeled hot strip mill work rolls scour the surface of the steel during rolling. The scale usually grows in the earlier mill stands where a combination of high temperature, heavy workload, and time between stands is ideal for scale growth.
Product Affected:	All products.
Similar Imperfection:	Pepper Scale; Streak Scale.

Figure 28

5.19 Scratch

Description:	Scratches appear as a linear scoring of the material surface and can be continuous or intermittent.
Cause:	Scratches are typically caused by an object rubbing against the material surface. Scratches can come from a variety of sources.
Product Affected:	All products.
Similar Imperfection:	Healed-Over Scratch; Friction Digs.



Galvanized scratches (left); Galvanized scratches under 50X magnification (right)

Figure 29

5.20 Scratch: Healed-Over Scratch

Description:	A healed-over scratch is one that has been rolled hot or cold that may open during rolling or forming.
Cause:	A healed-over scratch is one that originated in one mill operation and is partially or completely masked in subsequent rolling.
Product Affected:	All products.
Similar Imperfection:	Rolled-Over Scratch; Scratch.

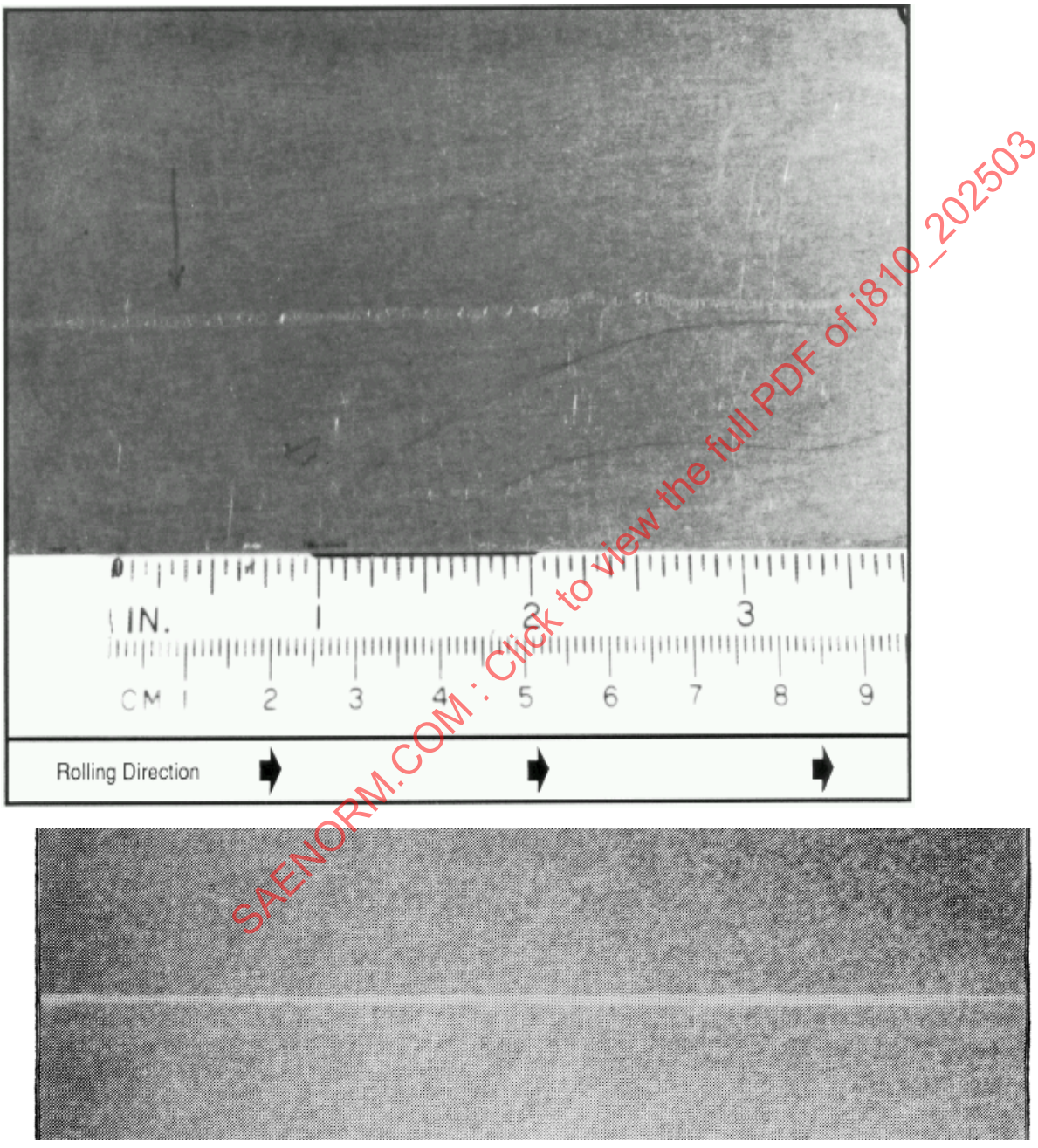


Figure 30

5.21 Seams

Description:	Seams may appear as a shiny or gray line across the width of the material. The gauge of the material will usually be heavier at the weld point.
Cause:	Two sections of coil being joined together.
Product Affected:	All products.
Similar Imperfection:	Welds; Fold-Over; Creases.

Figure 31

5.22 Shape: Buckles

Description:	Buckles are a series of waves transverse to the direction of rolling and vary in frequency and can be located along the centerline of the sheet or off center. The imperfection is called center buckle when it is located in the middle of the sheet, or side buckle (also called quarter buckle), when it is located near, but off-center.
Cause:	Buckles are caused by hardness variations of hot rolled sheet due to uneven cooling of the steel or mill rolls, build-up, or poor rolling practice.
Product Affected:	All products.
Similar Imperfection:	Edge Wave; Oil Canning; Ridge Buckle; Center Buckle; Full Center.

Figure 32

5.23 Shape: Camber

Description:	Camber is the deviation of the edge of a sheet from a straight line. It is measured as the greatest deviation of the concave edge of the sheet from a straight line.
Cause:	Camber is the result of improper slitting or is caused when the mill is off-level when the sheet is rolled. Camber can also be caused by edge wave and center buckle.
Product Affected:	All products.
Similar Imperfection:	Hook Ends; Snake.

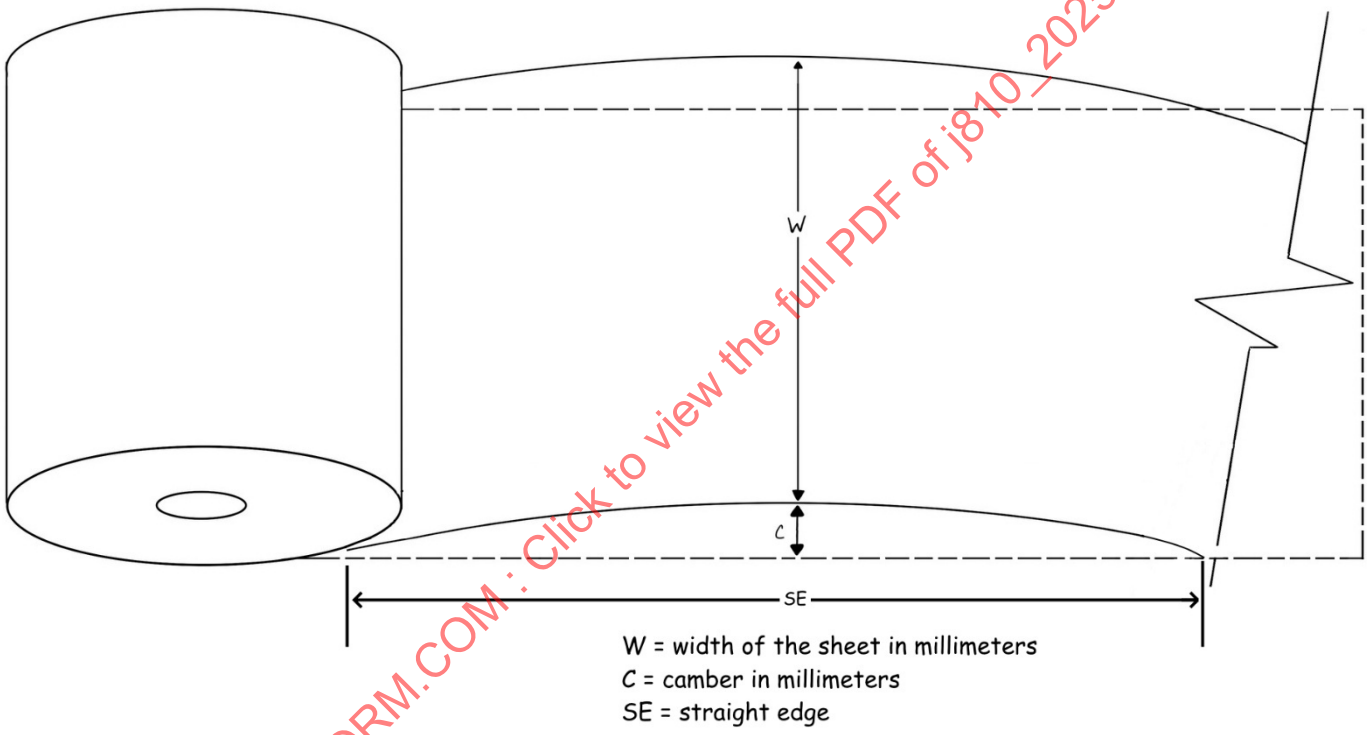


Figure 33

5.24 Shape: Cross-Bow

Description:	A concave curvature with the center of the width being the high point and the edge being the low point. Reverse cross-bow is where the curvature condition is in the opposite direction to cross-bow.
Cause:	Cross-bow is typically found with steel sheet supplied in coil form resulting from coil set. Cross-bow can be caused by improper rolling and tension control and can be minimized with proper post-flattening or leveling operations.
Product Affected:	All products.
Similar Imperfection:	Coil Set; Off-Flatness; Hog Back; Canoe.

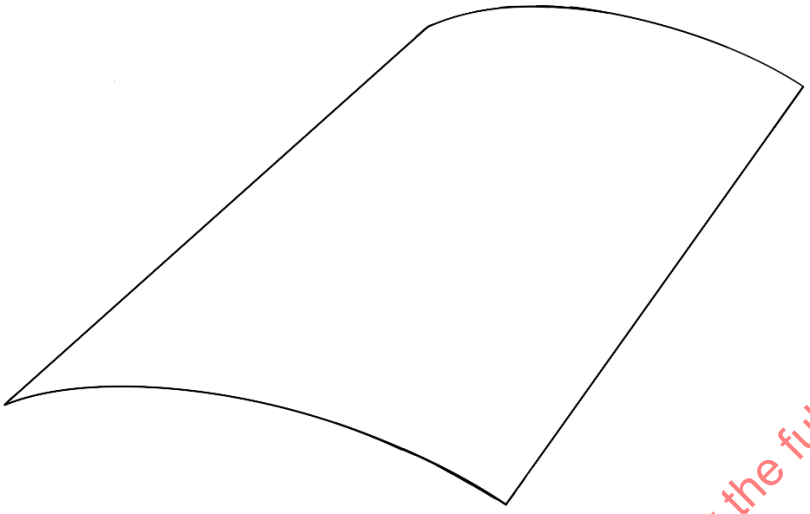
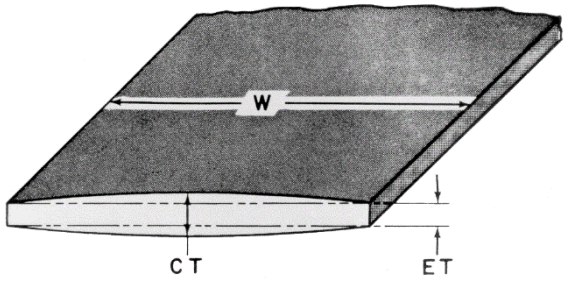


Figure 34

5.25 Shape: Crown

Description:	Crown is a typical condition that exists with flat rolled products where the thickness at the centerline is greater than the thickness at a defined distance from the edge. Crown is inherent on all products.
Cause:	Crown is controlled by rolling practice.
Product Affected:	All products.
Similar Imperfection:	Heavy Gauge/Light Gauge; Feathered Edge; Wedge.



W = WIDTH OF SHEET
ET = EDGE THICKNESS OF THE SHEET
CT = CENTER THICKNESS OF THE SHEET

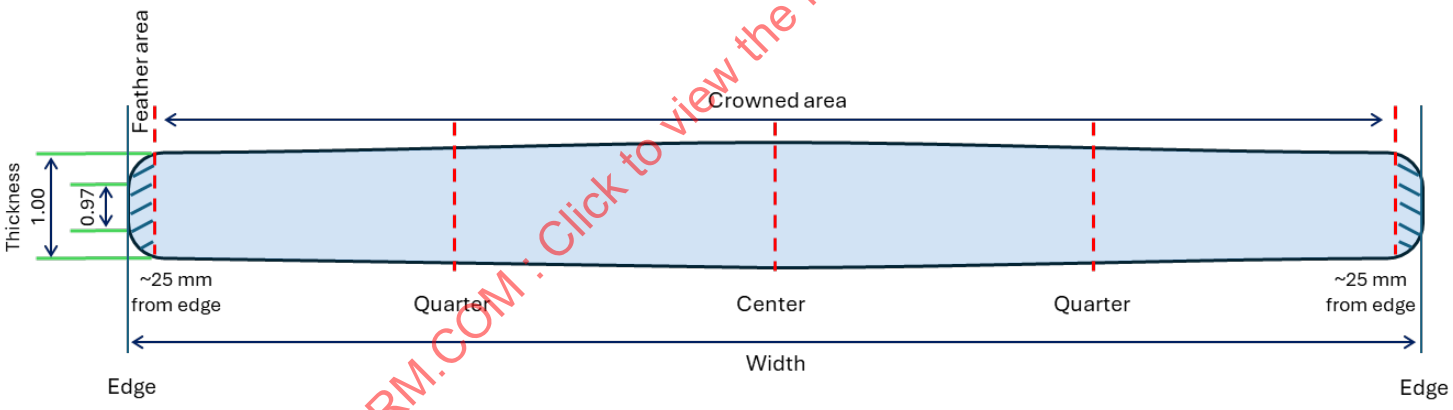


Figure 35

5.26 Shape: Edge Build-Up

Description:	Edge build-up appears as an up turned edge, usually on one side of the coil, but can affect both. Occurs during coiling when one edge flares up, giving the coil a trumpet shape.
Cause:	Edge build-up can be caused by: - Long edge - Rippled edge - Heavy coating on the edge - Material rubbing on separator disk during slitting - Excessive burr
Product Affected:	All products.
Similar Imperfection:	Flared Edge; Pie Crust Edge; Spooling.

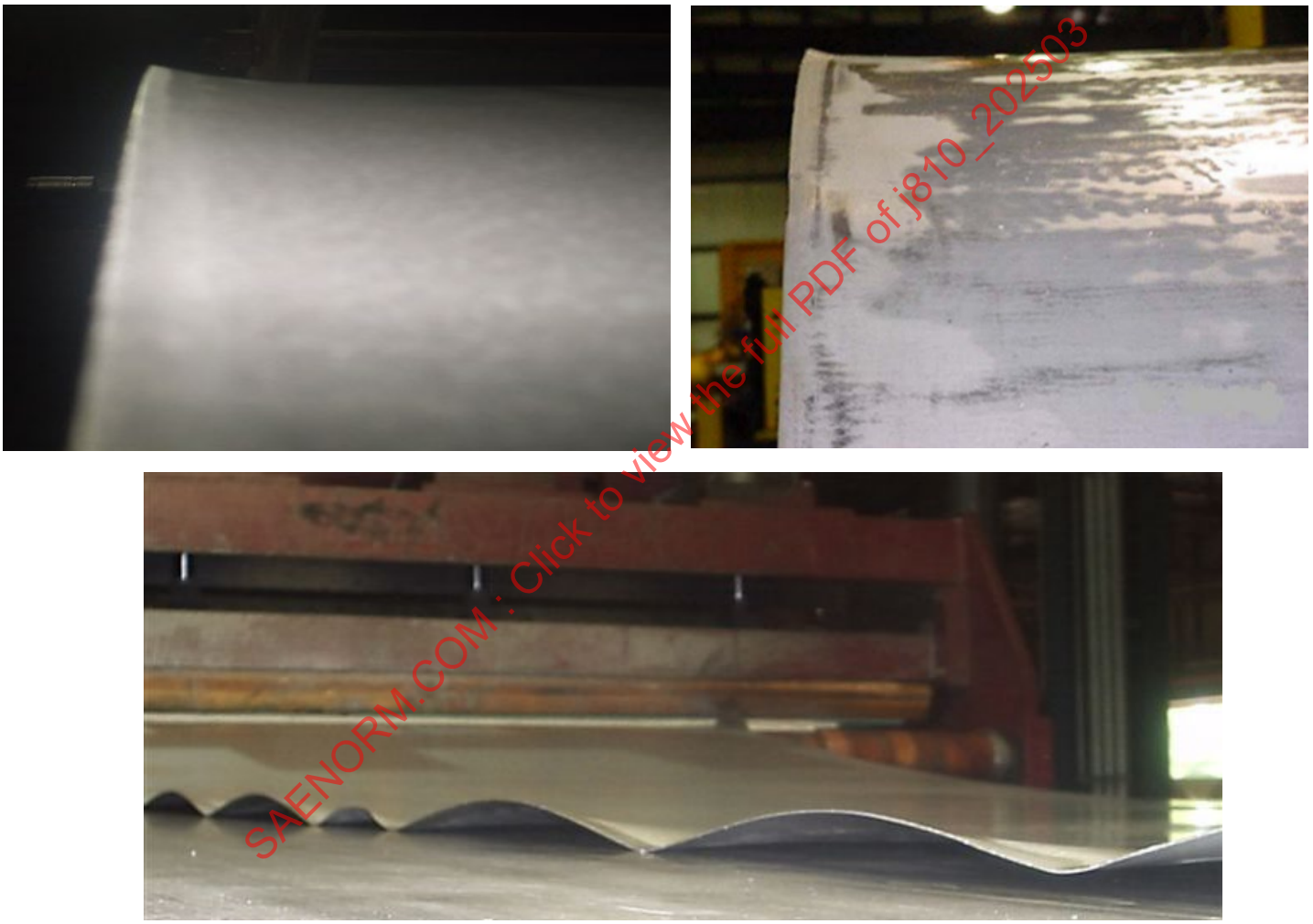


Figure 36

5.27 Shape: Edge Wave

Description:	Edge wave appears as a rise and fall of the edge on one or both sides of the strip.
Cause:	Edge wave occurs when the material along the edge of the strip is longer than the center. Edge wave can be caused by worn work rolls and uneven coolant flow during rolling.
Product Affected:	All products.
Similar Imperfection:	Wavy Edge; Pie-Crust Edge; Rippled Edge (if there is a short peak-to-peak distance).

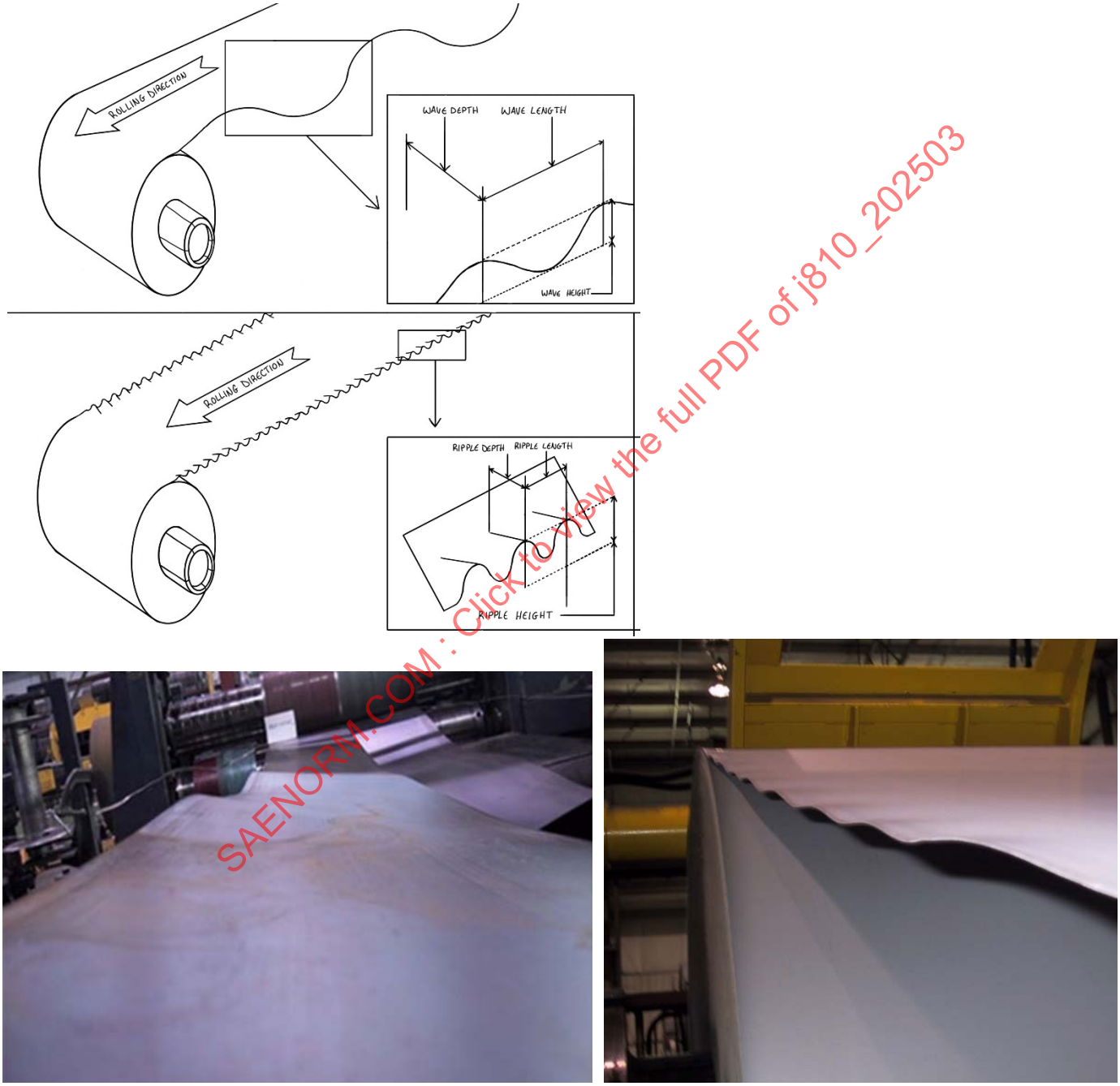
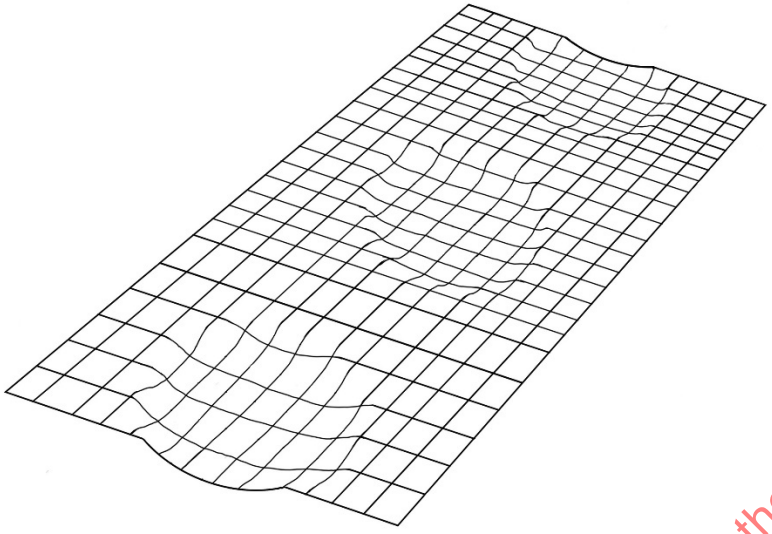


Figure 37

5.28 Shape: Full Center

Description:	Appears as trapped buckles near the center of the master coil width. When slit, the center mults will be longer in length
Cause:	Occurs when the center of the strip receives more roll force than the rest from either too much roll crown, roll wear, inadequate roll bending, or too much crown or ridge in the incoming material. May also be caused by uneven coolant flow during rolling.
Product Affected:	All products.
Similar Imperfection:	Oil Can; Edge Wave; Center Buckle.



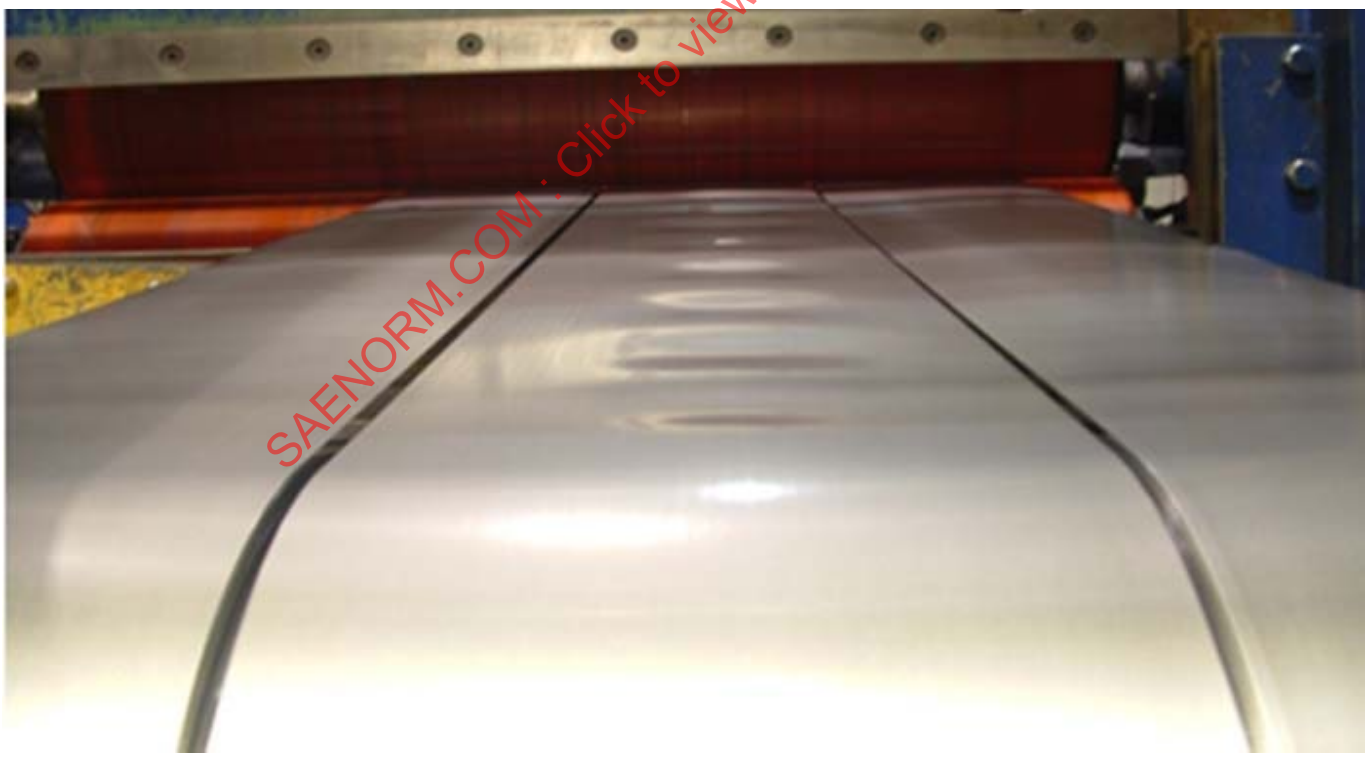


Figure 38

5.29 Solution Stain

Description:	An unsightly black stain that has poor paintability.
Cause:	Poor rinsing in cold rolling mill/poor bath maintenance. Poor blow off when rolling with solution.
Product Affected:	Cold rolled steels.
Similar Imperfection:	Cold Rolled Detergent Stain; Pickle Stain; Annealing Stain; Emulsion Stain.

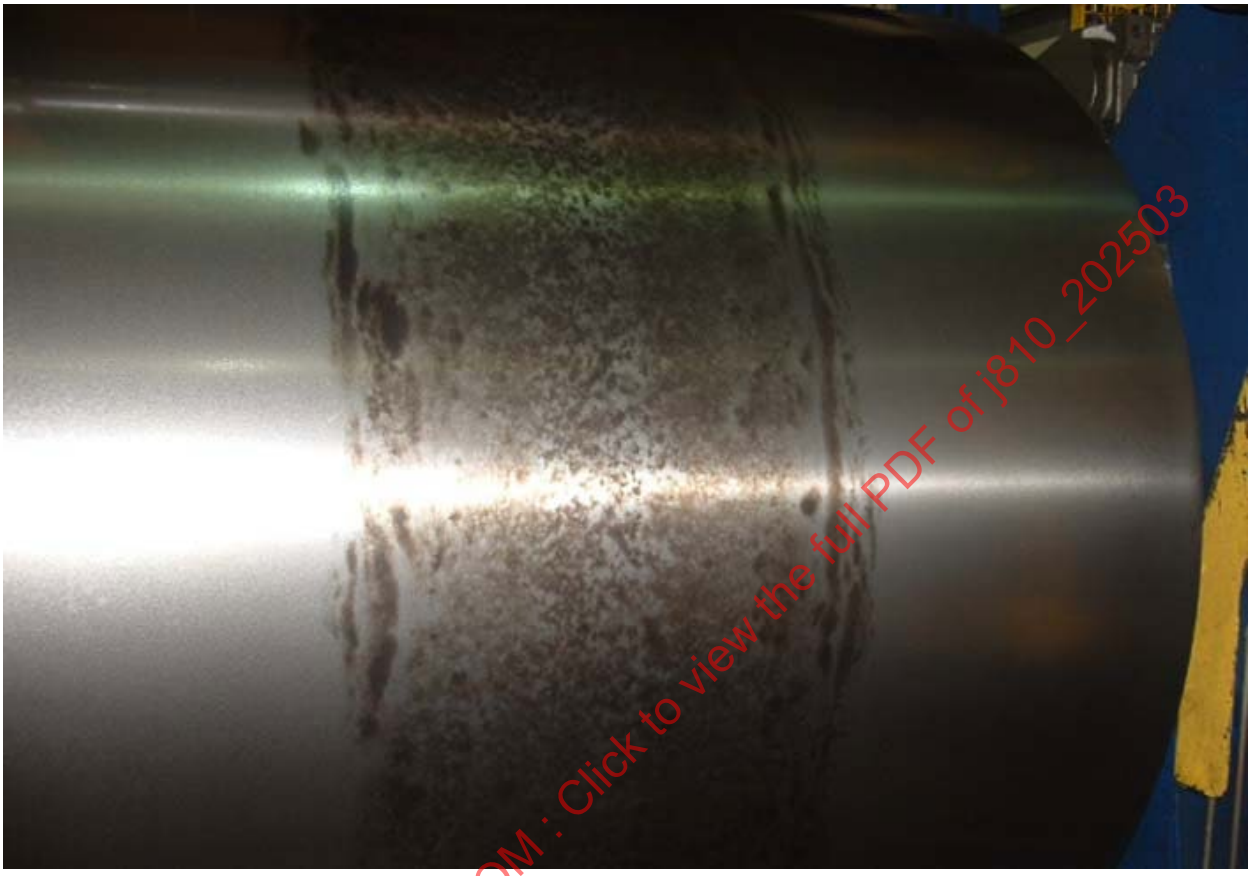


Figure 39

6. PROCESSING IMPERFECTIONS

See Table 4 and Figures 40 to 68.

Table 4 - Common imperfections encountered in sheet steel related to processing

Processing Imperfections	Similar Imperfections	Figure
Anneal Border	Oxidized Surface; Straw Color; Anneal Stain; Blue Steel; Carbon Edge	40
Burr	None	41
Carbon Stain	Snake Edge; Solution Stain; Carbon Border; Carbon Smut	42
Chipped Slitter Knife	Poor Slit; Knick; Burr Edge	43
Coil Breaks	Sticker Breaks; Fluting; Break Marks: Lüders Lines	44
Coil Welds	Weld Fusion Marks; Seam; Creases	45
Collapsed ID (Inside Diameter)	Egg Shaped ID; Flat Coil; Collapsed Coil; Soft Coil; Loose Winding; Out-of-Round Eye	46
Dents	Roll Marks; Impressions; Punch Marks; Indents	47
Drag Board Marks	Scratches; Drag Board Scuff	48
Friction Digs	Galls; Gouges; Scratches	49
Handling Damage	Chain Damage; Coil Damage; Crane Damage; Floor Damage; Dropped Coil	50
Lost Slit Edge	Insufficient Trim of Mill Edge	51
Lüders Lines	Stretcher Strains; Lüders Strain; Yield Point Elongation	52
Onion Skin	None	53
Orange Peel	Alligator Skin; Grains; Blown Grains; Enlarged Grains	54
Oscillation	Telescoping; Staggered Wind	55
Passivation Stain	Chemical Treatment Stains; Chromate Stains	56
Pickle Stain	Rust; Water Stain; Rinse Stain; Pickle Rinse Stain	57
Rust	Speckled Rust; Water Stain; Red Rust	58
Separator Disk Damage	Knife Nicks; Edge Wave; Separator Damage	59
Slit Edge Beading	Poor Slit Edge; Sawtooth Edge; Uneven Slit Cut; Double-Break Condition	60
Solution Stain	Carry-Over; Cold Rolled Detergent Stain; Pickle Stain; Annealing Stain; Emulsion Stain	61
Solution Starve	Insufficient Oil; Work Roll Chrome Peel; Wet Temper Dry Streaks	62
Speckled Rust	Lineal Rust; Pinpoint Rust; Rust Patches; Salt and Pepper Rust	63
Stagger Sheet	Stagger-Stacked	64
Sticker Breaks	Coil Breaks; Edge Breaks; Stickers; Pinch Marks; Pick-Up	65
Strain	Lüders Lines; Stretcher Marks; Yield Point Elongation (YPE)	66
Telescoping	Oscillation; Stagger Wind; Hyphened Coil	67
Unpickled Edge	Underpickled; Black Edges	68

6.1 Anneal Border

Description:	Anneal border is a thin, tightly adhering oxidized layer which extends in from the edge of the coil or sheet. The color may range from straw yellow to blue and can be removed by pickling or re-deoxidizing.
Cause:	Anneal border is caused by air coming into contact with hot steel via leaks in the anneal furnace cover or by removing the anneal furnace cover at too high a temperature.
Product Affected:	Cold rolled.
Similar Imperfection:	Oxidized Surface; Straw Color; Anneal Stain; Blue Steel; Carbon Edge.

Figure 40

6.2 Burr

Description:	A burr is a sharp raised area at the edge of the material resulting from trimming, shearing, or slitting and may be continuous or intermittent.
Cause:	Poor clearance on slitter knives or shear blade. May also be caused by dull or damaged knives and blades.
Product Affected:	All products mechanically slit, sheared, or trimmed.
Similar Imperfection:	None.

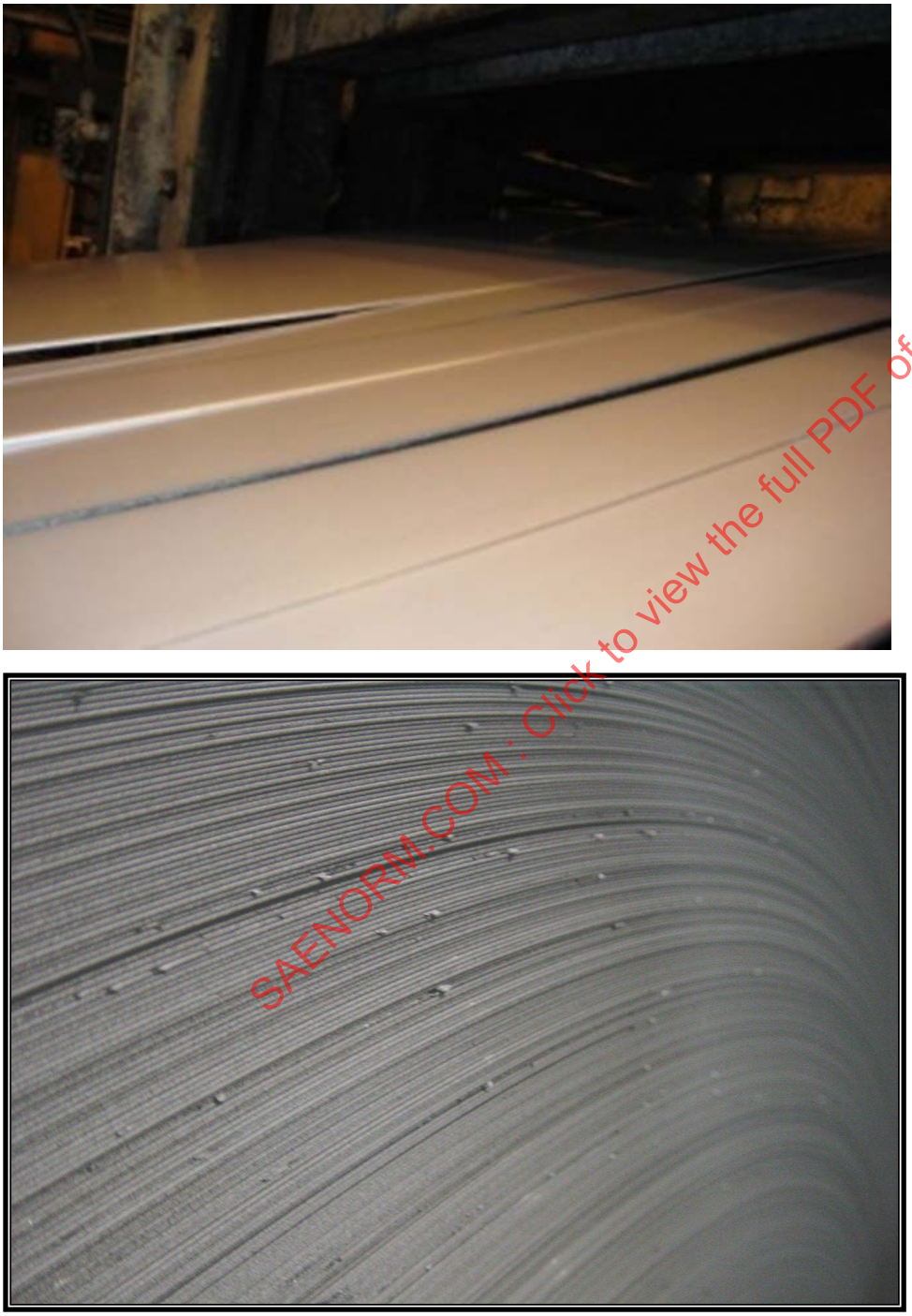


Figure 41

6.3 Carbon Stain

Description:	Carbon stain appears as smutty black or gray stains.
Cause:	Carbon stain is the result of residual rolling oils reduced in the annealing process.
Product Affected:	Cold rolled.
Similar Imperfection:	Snake Edge; Solution Stain; Carbon Border; Carbon Smut.

Figure 42

6.4 Chipped Slitter Knife

Description:	This condition will appear as a periodic variance in the slit edge. The distance of the variance will correlate to the distance between knife defects or, if only one knife, the circumference of the knife. Severity can range from a light blemish to a heavy burr.
Cause:	This condition is the result of a chipped slitter knife.
Product Affected:	Slit products.
Similar Imperfection:	Poor Slit; Knick; Burr Edge.

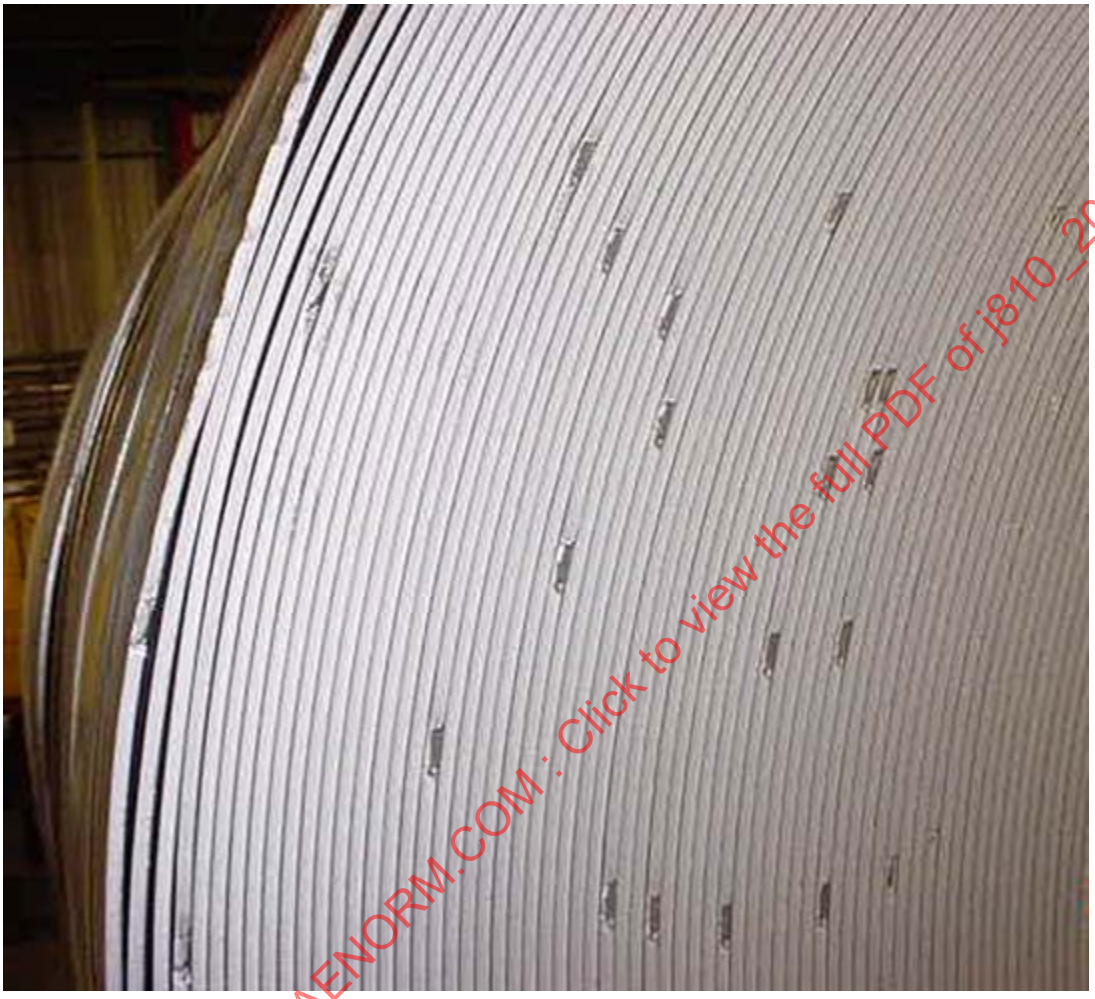


Figure 43

6.5 Coil Breaks

Description:	Coil breaks are creases or ridges which appear as parallel lines transverse to the rolling direction and may extend across the sheet width.
Cause:	Coil breaks are formed during coiling or uncoiling when the extension exceeds the elastic limit of the steel and yield point elongation is present.
Product Affected:	All products.
Similar Imperfection:	Sticker Breaks; Fluting; Break Marks: Lüders Lines.

Coil Break on Hot Band (left); Coil Break on finished product (right)

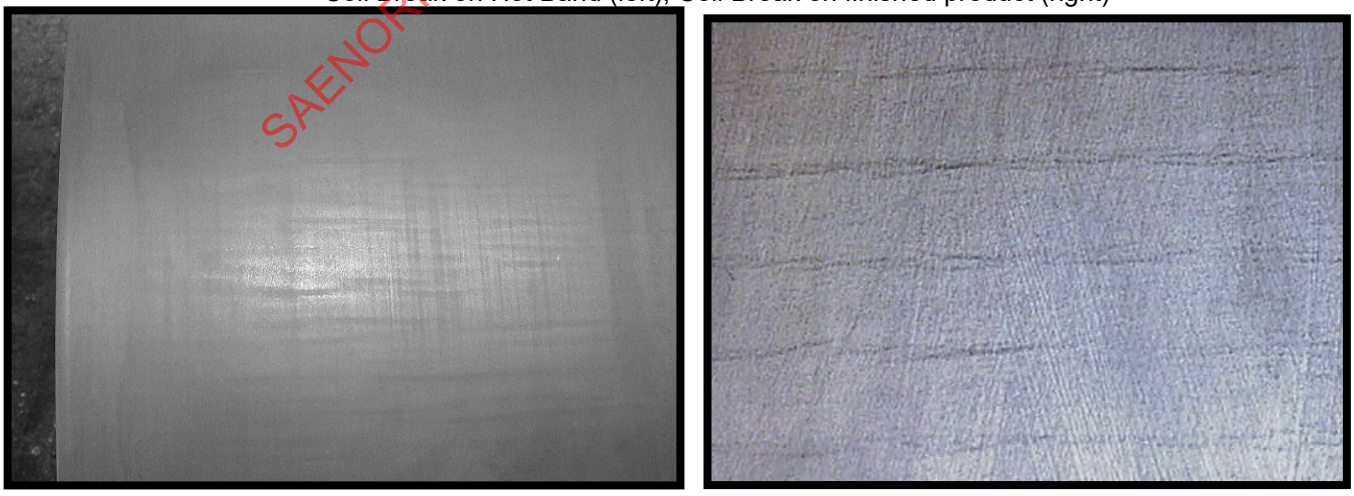
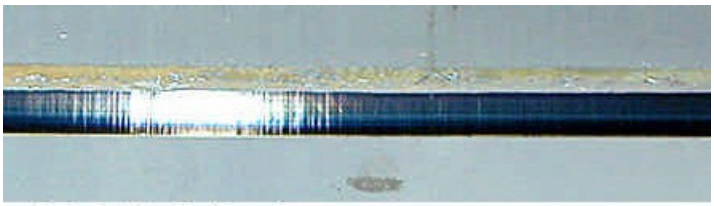


Figure 44

6.6 Coil Welds

Description:	A coil weld is the area where two coils have been joined together to go through pickling, rolling, or coating lines for continuous processing.
Cause:	Two coils are joined or fused together by heat. Cold reduced butt weld or lap welds should be undetectable in the cold rolled or coated stage.
Product Affected:	All products.
Similar Imperfection:	Weld Fusion Marks; Seam; Creases.



Pickle Weld (Butt)

EGL Weld (Butt)

HDG Weld (Lap)

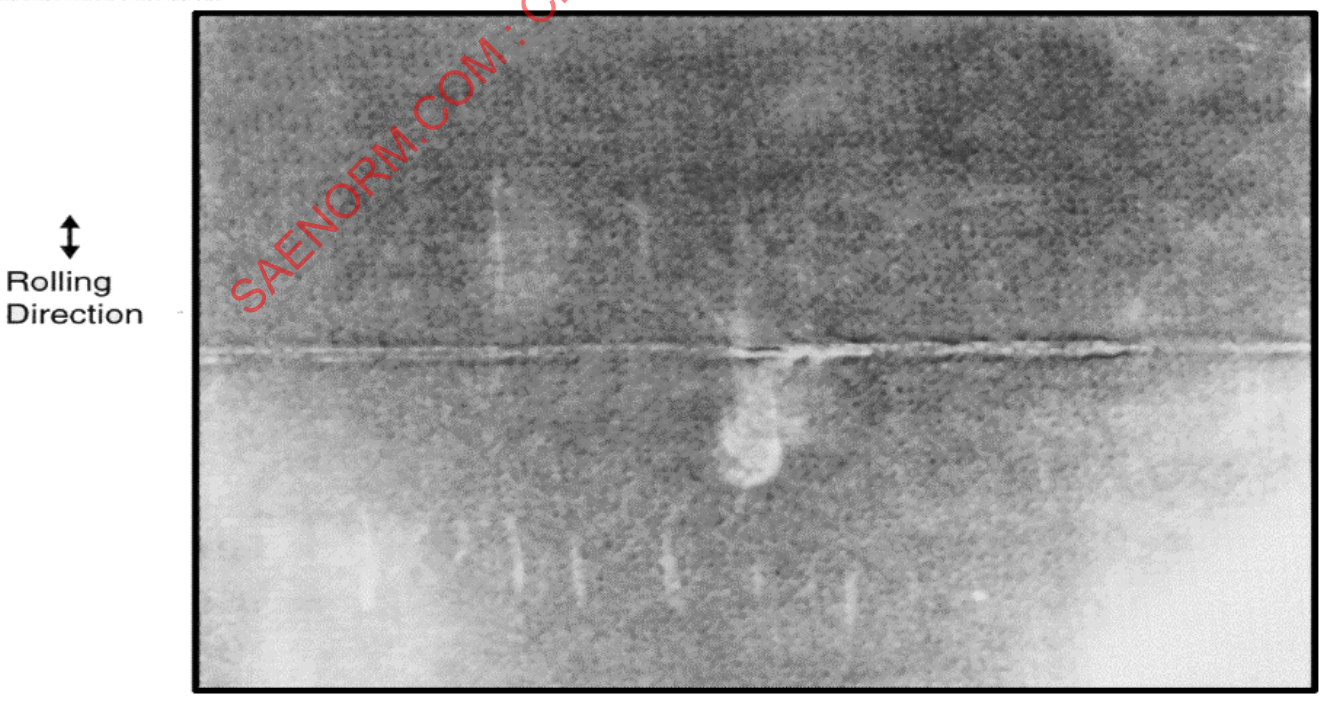


Figure 45

6.7 Collapsed ID (Inside Diameter)

Description:	A collapsed ID (inside diameter) is oblong instead of round. Severity can range from minor to almost flat.
Cause:	A collapsed ID can be caused by improper coiling or storage practices.
Product Affected:	All products.
Similar Imperfection:	Egg Shaped ID; Flat Coil; Collapsed Coil; Soft Coil; Loose Winding; Out-of-Round Eye.

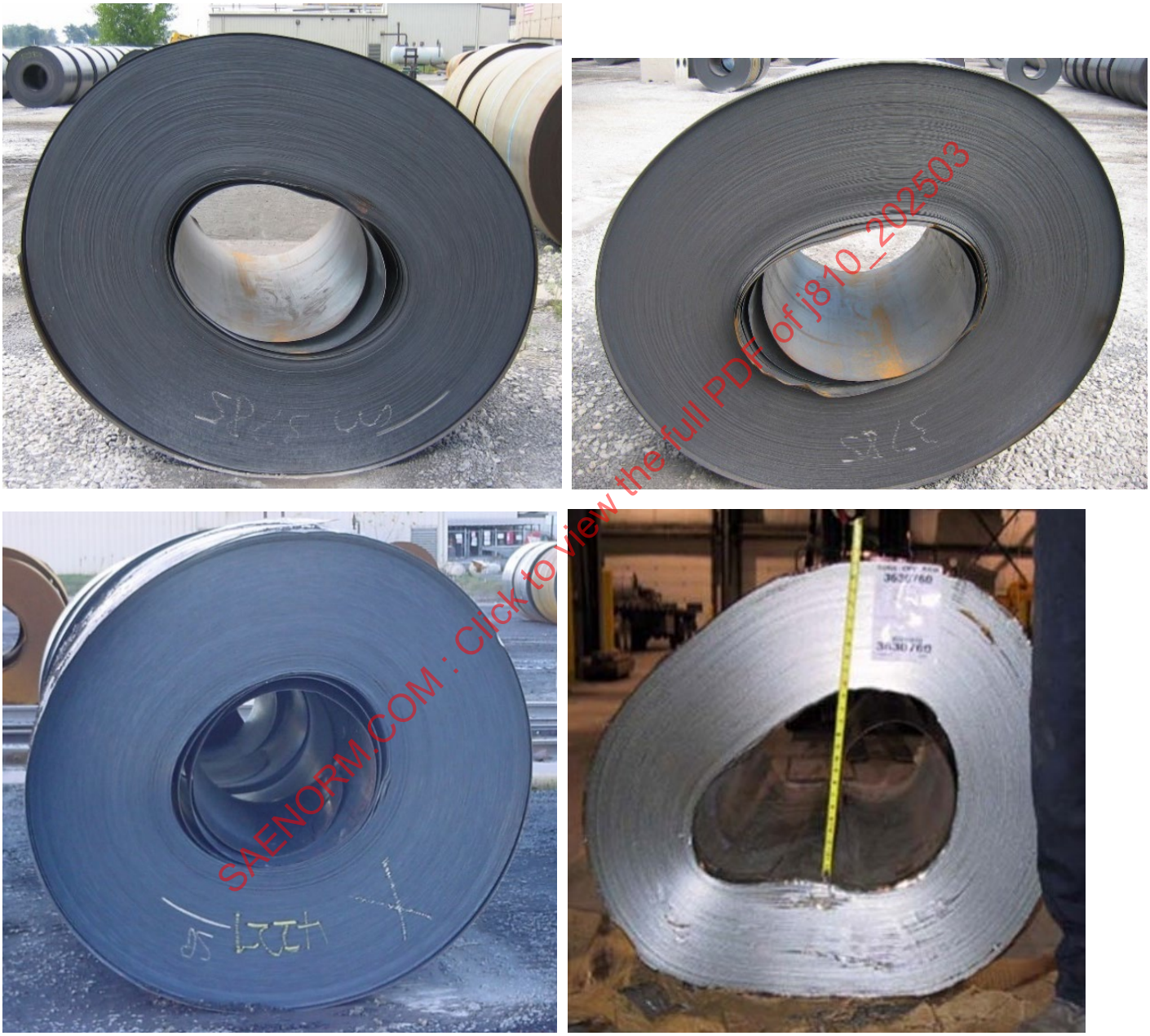


Figure 46

6.8 Dents

Description:	Dents are repetitive impressions in the sheet surface that will have an embossed area that usually is visible as an expression on the opposite side.
Cause:	Dents are caused when debris on a roll is mechanically pressed into the surface of the sheet. Common causes are foreign objects between the coil laps, coil sitting on strap clip, and ID (inside diameter) damage from a mandrel.
Product Affected:	All products.
Similar Imperfection:	Roll Marks; Impressions; Punch Marks; Indents.

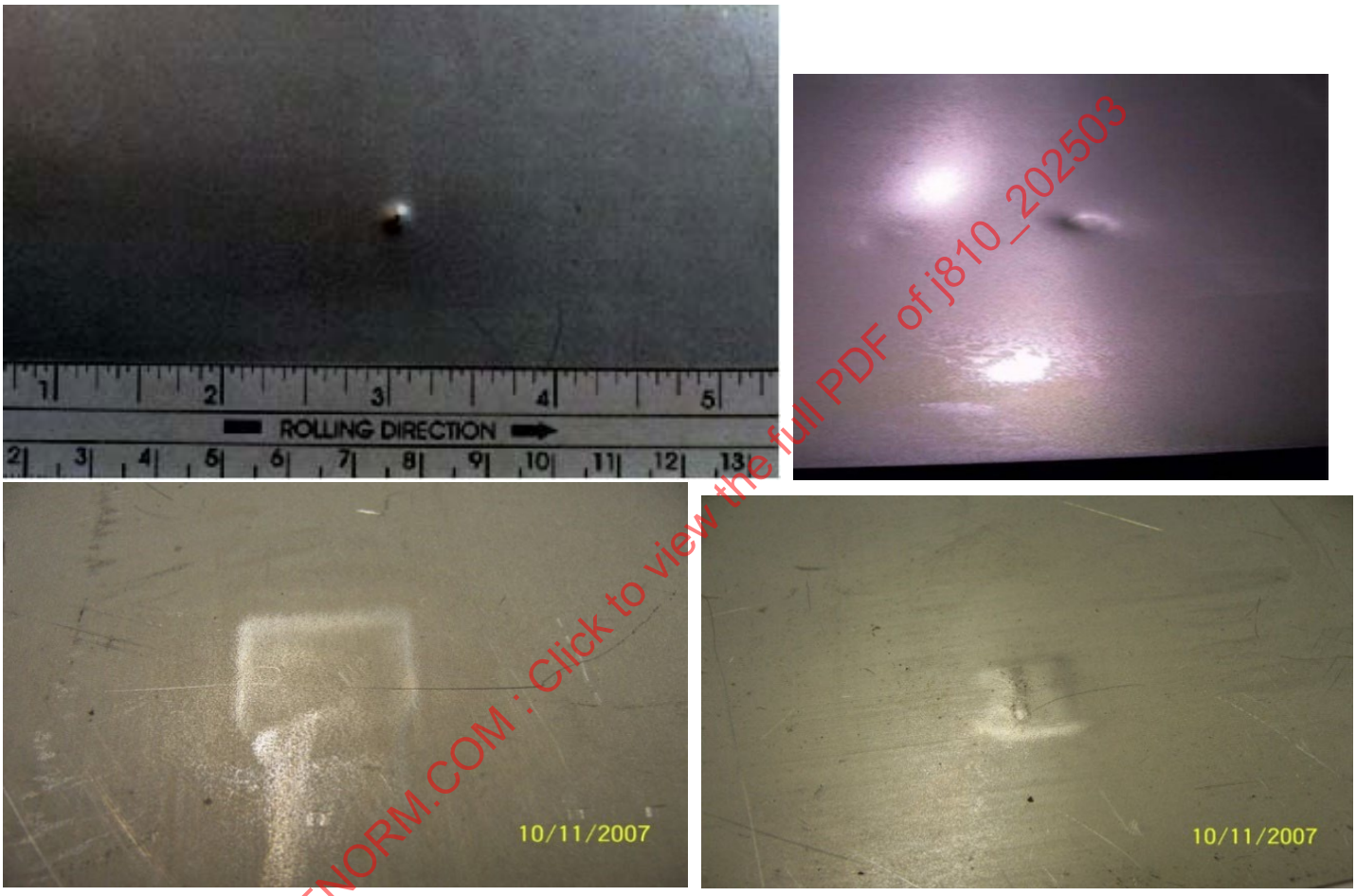


Figure 47

6.9 Drag Board Marks

Description:	Drag board marks appear as fine shiny longitudinal lines on the strip surface and may affect both top and bottom surfaces. Severity can range from a light shiny scuff mark to a distinct linear scratch that can be felt.
Cause:	Drag board marks are caused by either excess pressure or foreign material on the nip pad or other areas where a drag board may be applied. Drag board marks are a processing defect.
Product Affected:	All products.
Similar Imperfection:	Scratches; Drag Board Scuff.

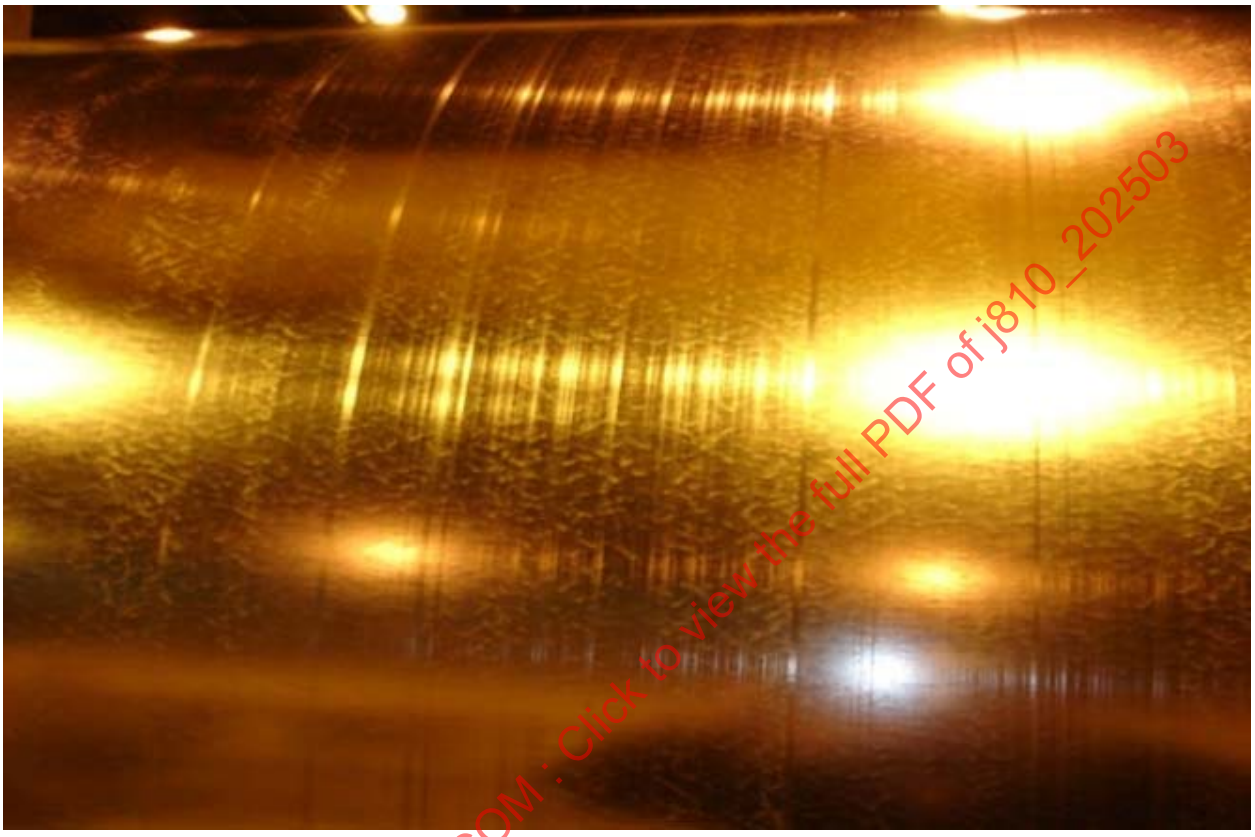


Figure 48

6.10 Friction Digs

Description:	Friction digs are short gouges running in the longitudinal, transverse, or slightly angled direction. Friction digs are usually found on mating surfaces with metal buildup at one end of the dig.
Cause:	Friction digs are caused by slippage of adjacent laps of a coil during uncoiling and coiling or in transit if a coil is inadequately wound.
Product Affected:	All products.
Similar Imperfection:	Galls; Gouges; Scratches.

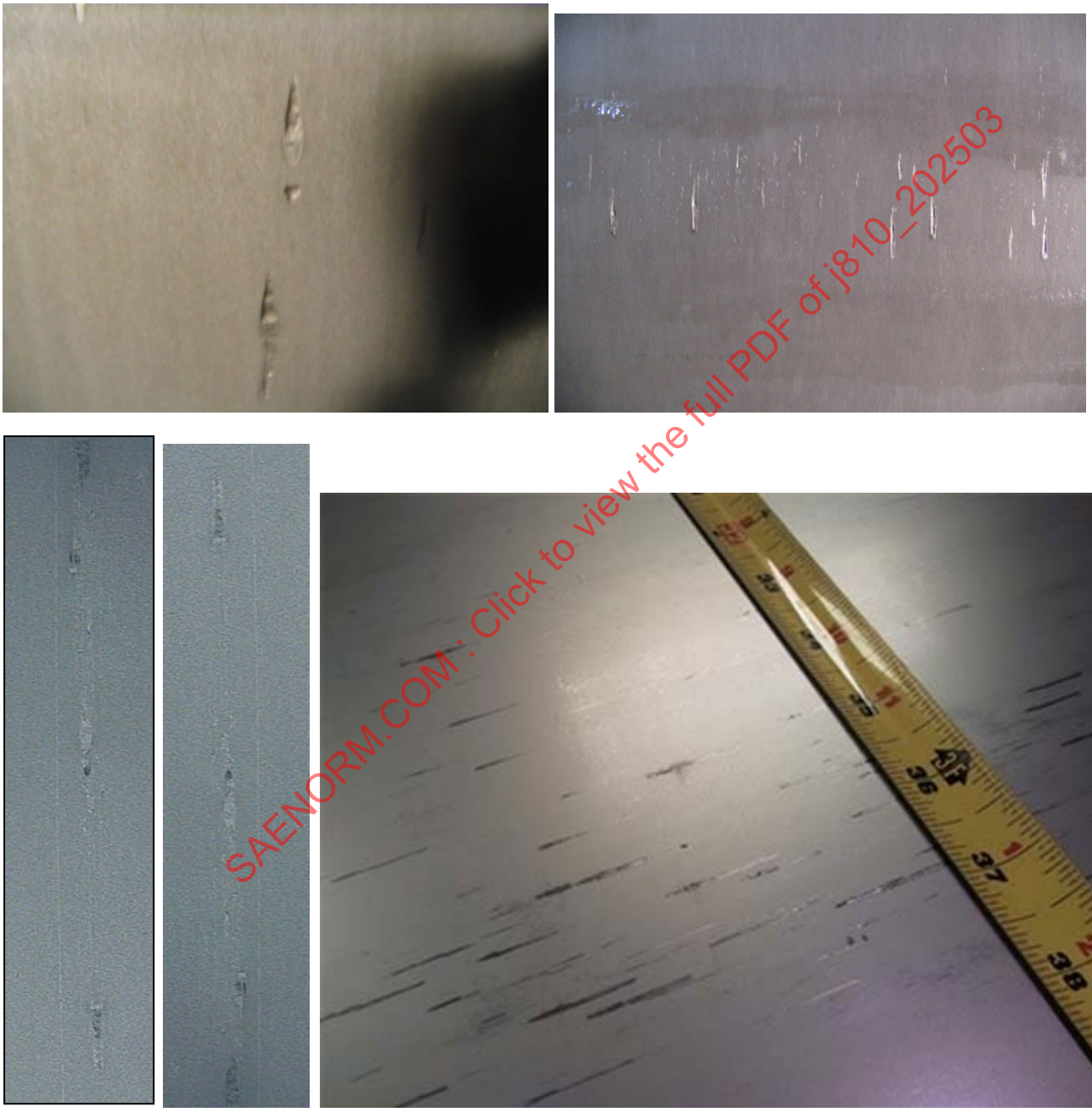


Figure 49

6.11 Handling Damage

Description:	Localized mechanically induced tear, dent, scrape, or gouge.
Cause:	Storage and/or transportation practices.
Product Affected:	All products.
Similar Imperfection:	Chain Damage; Coil Damage; Crane Damage; Floor Damage; Dropped Coil.

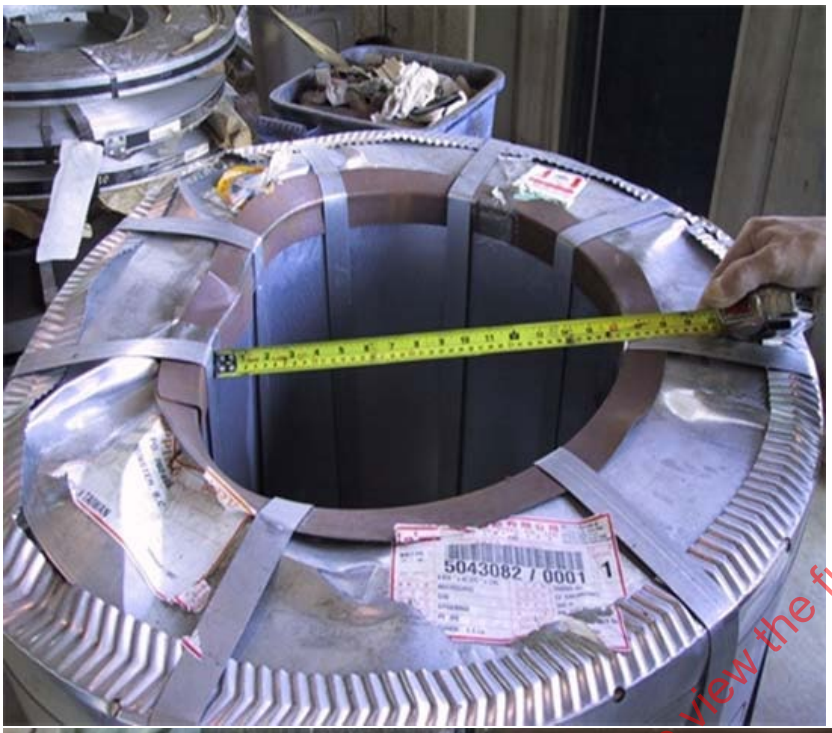


Figure 50

6.12 Lost Slit Edge

Description:	A lost slit edge appears as a duller rounded edge when compared to the brighter slit edge and can be of brief duration or for significant portions of the coil.
Cause:	The width of the master coil is insufficient to accommodate the width(s) of the slit coils(s) to be taken from it.
Product Affected:	Slit products.
Similar Imperfection:	Insufficient Trim of Mill Edge.

Figure 51

6.13 Lüders Lines

Description:	Lüders lines occur during forming and cause an uneven, undulating surface.
Cause:	Lüders lines are associated with yield point elongation. Just after the yield point is exceeded, nonuniform plastic deformation occurs. With increased stretching, these zones multiply and intersect each other until the entire surface is covered.
Product Affected:	All products.
Similar Imperfection:	Stretcher Strains; Lüders Strain; Yield Point Elongation.

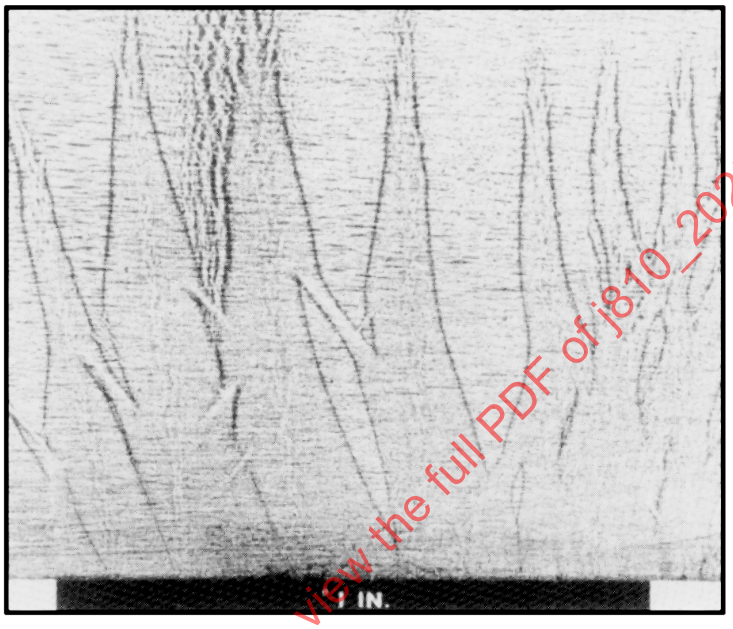


Figure 52

6.14 Onion Skin

Description:	Onion skin is a flaky layer of tightly adhering oxidized steel that can be produced with non-optimized run-out table cooling after hot rolling or during the annealing process of black (not pickled) coils. Formation during annealing is caused when the oxygen present in the furnace atmosphere combines with the carbon present in the steel while the coil is being heated. This condition only affects the surface of the steel but can sometimes be difficult to remove during pickling, even with rotating brushes. Onion skin is most common in alloy steels (e.g., SAE J404 Grade 4140 and SAE J404 Grade 6150).
Cause:	During annealing, onion skin results from the oxygen present in the furnace atmosphere combining with the carbon present in the steel while the coil is being heated. This condition only affects the surface of the steel but can sometimes be difficult to remove during pickling.
Product Affected:	Hot rolled.
Similar Imperfection:	None.

Figure 53

6.15 Orange Peel

Description:	Orange peel is a rough surface in the form of a pebbly-grained pattern produced during a forming or drawing operation when the metal has a very coarse grain size and is stressed beyond its elastic limit.
Cause:	Coarse grain structure occurs because of secondary recrystallization after deformation when annealing at high temperatures.
Product Affected:	Cold rolled.
Similar Imperfection:	Alligator Skin; Grains; Blown Grains; Enlarged Grains.

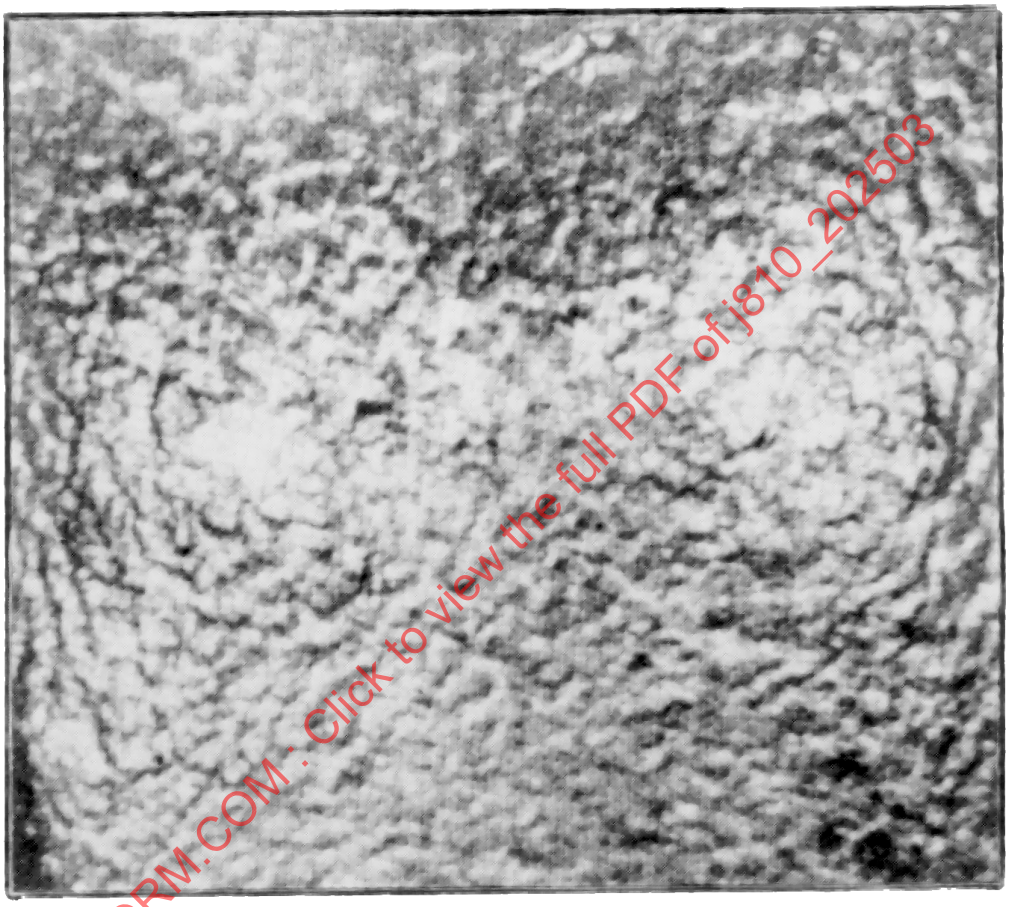


Figure 54

6.16 Oscillation

Description:	Oscillation is characterized by unevenly wound wraps resulting in an intermittent telescoping condition throughout the coil.
Cause:	Oscillation is caused by temporary loss of tension during coiling. A simple, repetitive oscillation pattern may be done intentionally by some operators. If intentional, it is referred to as staggered edges.
Product Affected:	All products.
Similar Imperfection:	Telescoping; Staggered Wind.

Figure 55

6.17 Passivation Stain

Description:	A passivation stain appears as spots streaks or patches that are greenish or orange in color. The stains typically affect top and bottom surfaces and may affect the entire width or appear as streaks or drips anywhere along the strip in the rolling direction. Chromate stain is a specific type of passivation stain involving a chromate conversion coating.
Cause:	Passivation/chromate stain can be caused by: - Insufficient wiping - Worn squeegee rolls - Inappropriate temperature - Inappropriate concentration
Product Affected:	Coated products, galvanized.
Similar Imperfection:	Chemical Treatment Stains; Chromate Stains.

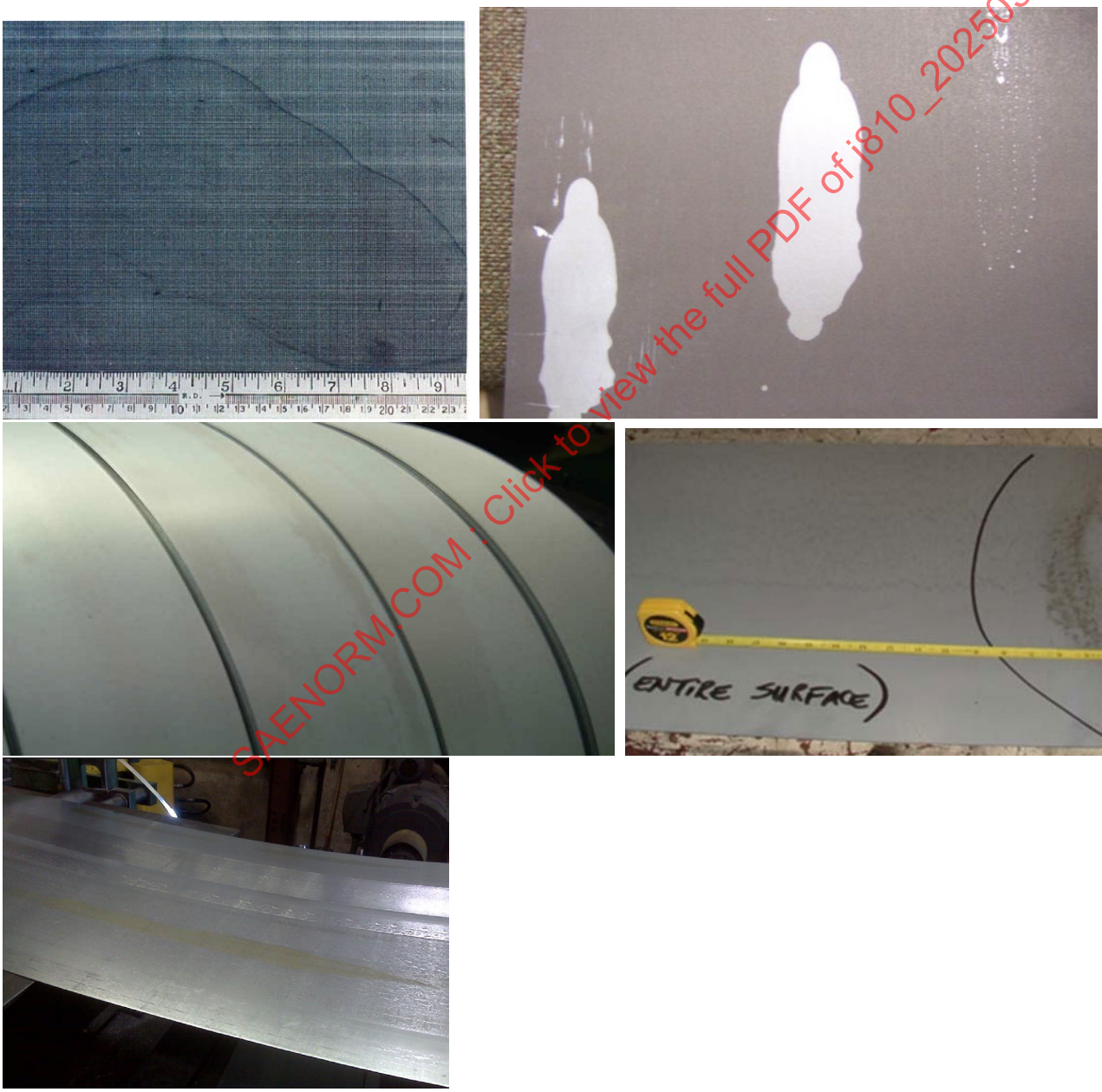


Figure 56

6.18 Pickle Stain

Description:	Pickle stain is light to dark orange and may be isolated to edges or go across the surface of the strip.
Cause:	Pickle stain can be caused by poor acid rinsing practices and line stops during the pickling process.
Product Affected:	Pickled hot roll.
Similar Imperfection:	Rust; Water Stain; Rinse Stain; Pickle Rinse Stain.

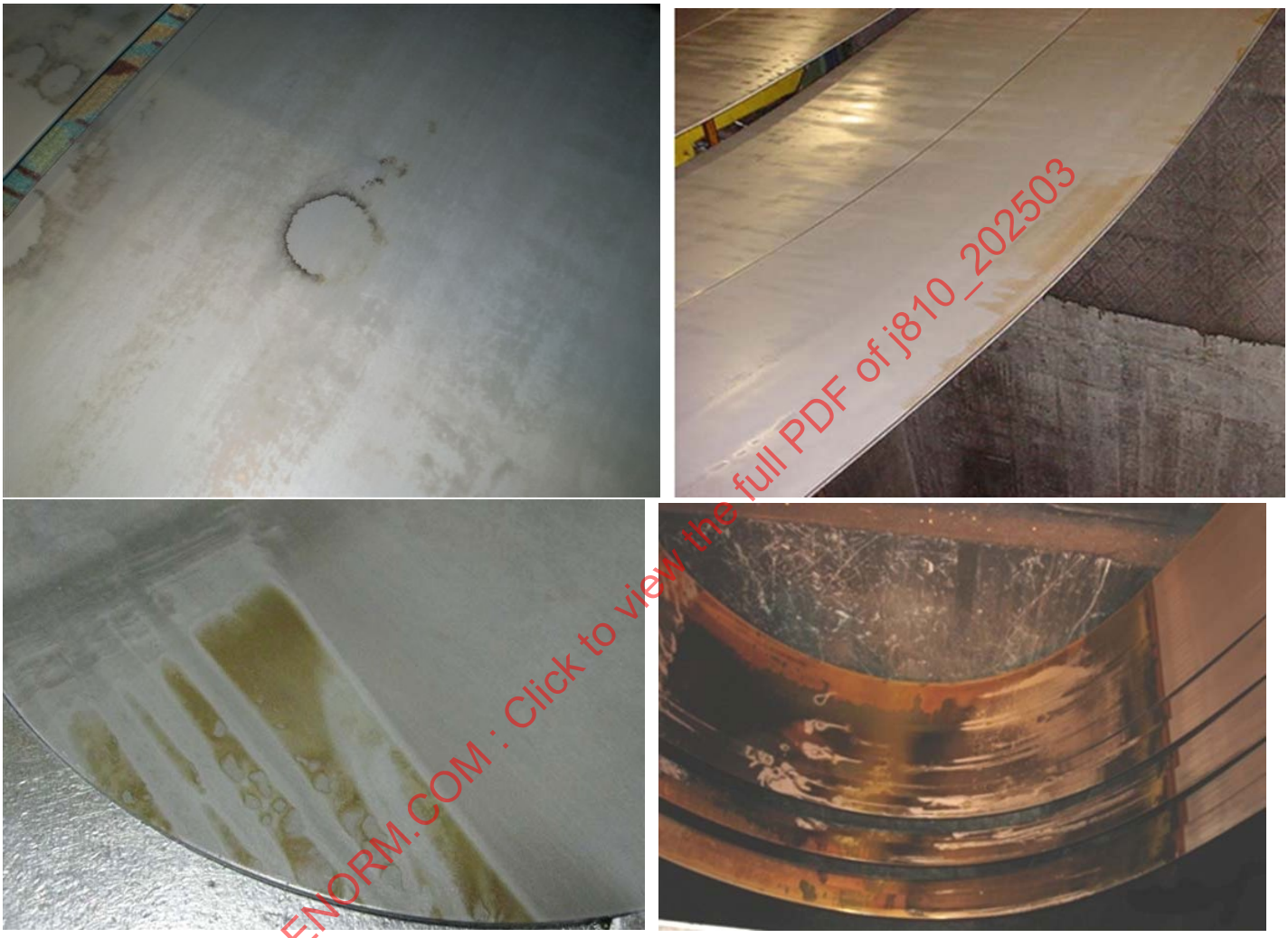


Figure 57

6.19 Rust

Description:	Rust is an oxide that forms on the surface of the sheet.
Cause:	Rust is caused when steel comes in contact with moisture.
Product Affected:	Hot rolled and cold rolled uncoated products.
Similar Imperfection:	Speckled Rust; Water Stain; Red Rust.

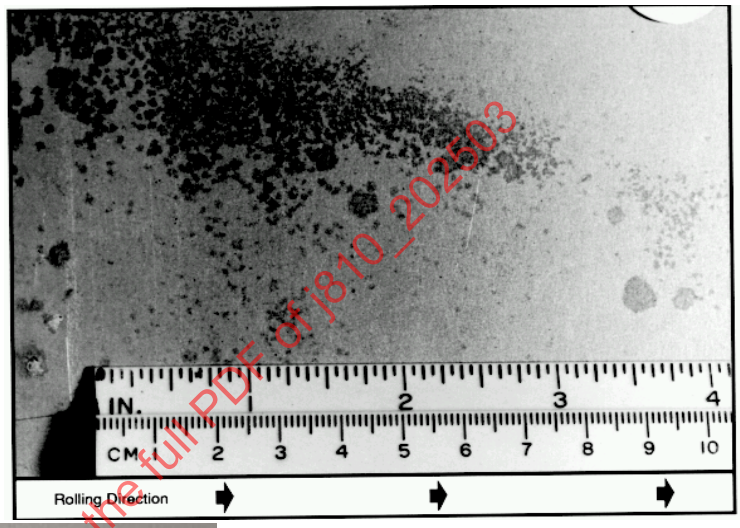


Figure 58

6.20 Separator Disk Damage

Description:	Separator disk damage typically appears as crescent shaped markings on the coil sidewall. In severe cases, it will appear as an abrasion with small filings on the sidewall.
Cause:	Separator disk damage is caused by a damaged separator disk in the trimming or slitting operation.
Product Affected:	Slit products.
Similar Imperfection:	Knife Nicks; Edge Wave; Separator Damage.

Figure 59

6.21 Slit Edge Beading

Description:	Slit edge beading appears as a rough slit edge where the material is not broken off evenly in the break portion of the cut.
Cause:	Poor slitter knife clearance.
Product Affected:	Slit products.
Similar Imperfection:	Poor Slit Edge; Sawtooth Edge; Uneven Slit Cut; Double-Break Condition.

Figure 60

6.22 Solution Stain

Description:	Solution stain can vary in severity from light gray to brown or black discoloration of the steel surface and can result in poor paintability.
Cause:	Solution stain is caused by inadequate blow-off of the rolling solution used during tandem or temper mill rolling which results in a wet strip before oiling. The residue subsequently stains or etches the strip's surface.
Product Affected:	Cold rolled.
Similar Imperfection:	Carry-Over; Cold Rolled Detergent Stain; Pickle Stain; Annealing Stain; Emulsion Stain.

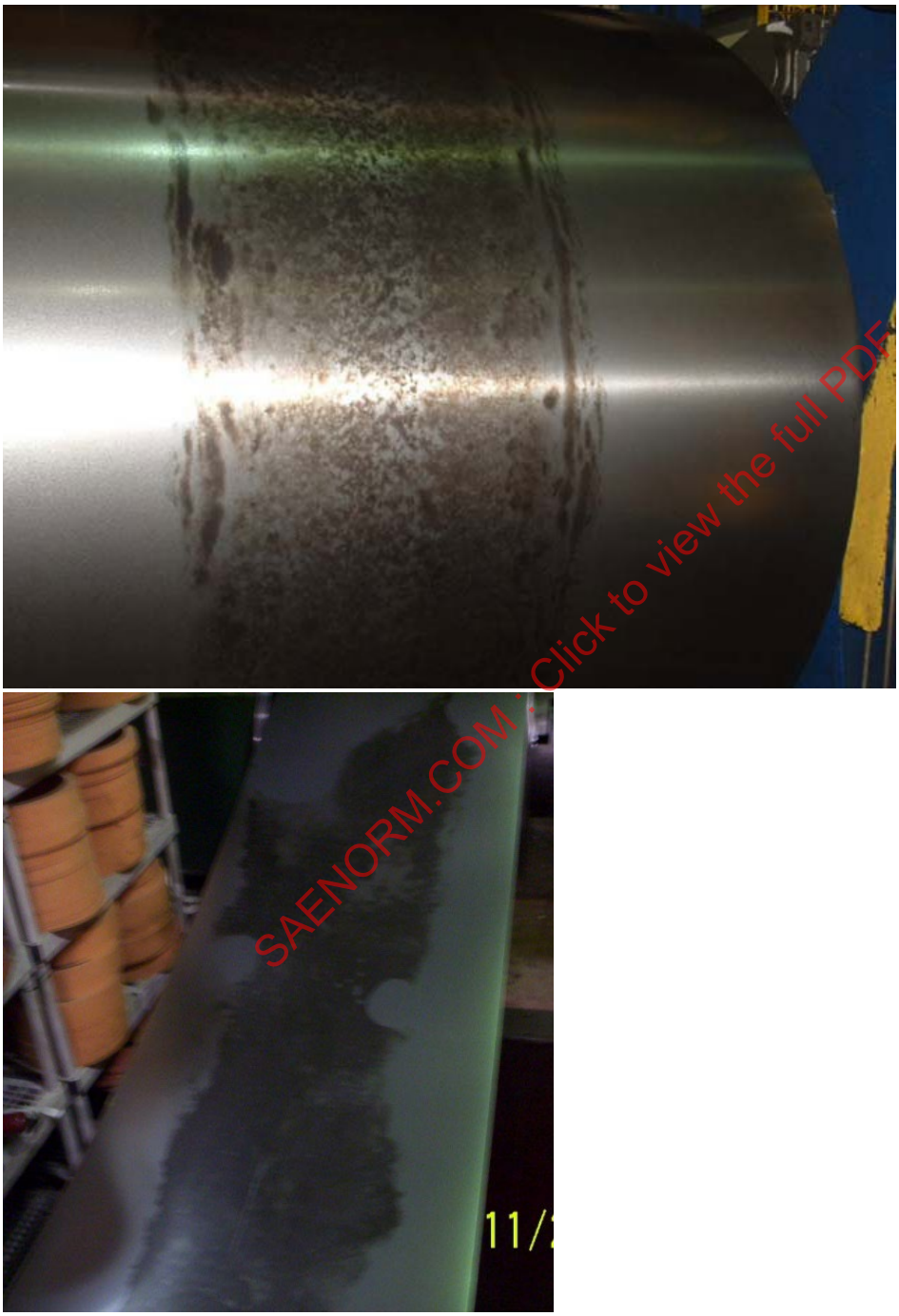


Figure 61

6.23 Solution Starve

Description:	Solution starve will appear as a difference in surface texture and may also cause poor shape in the area affected. Solution starve may be followed by pick-up or roll marks because of damage to the rolls involved.
Cause:	Solution starve is caused by insufficient flooding ahead of the roll bite in a reducing mill. Steel comes in direct contact with rolls, and the friction causes galling as the two surfaces stick, then friction weld together, and then tear apart.
Product Affected:	Cold rolled.
Similar Imperfection:	Insufficient Oil; Work Roll Chrome Peel; Wet Temper Dry Streaks.

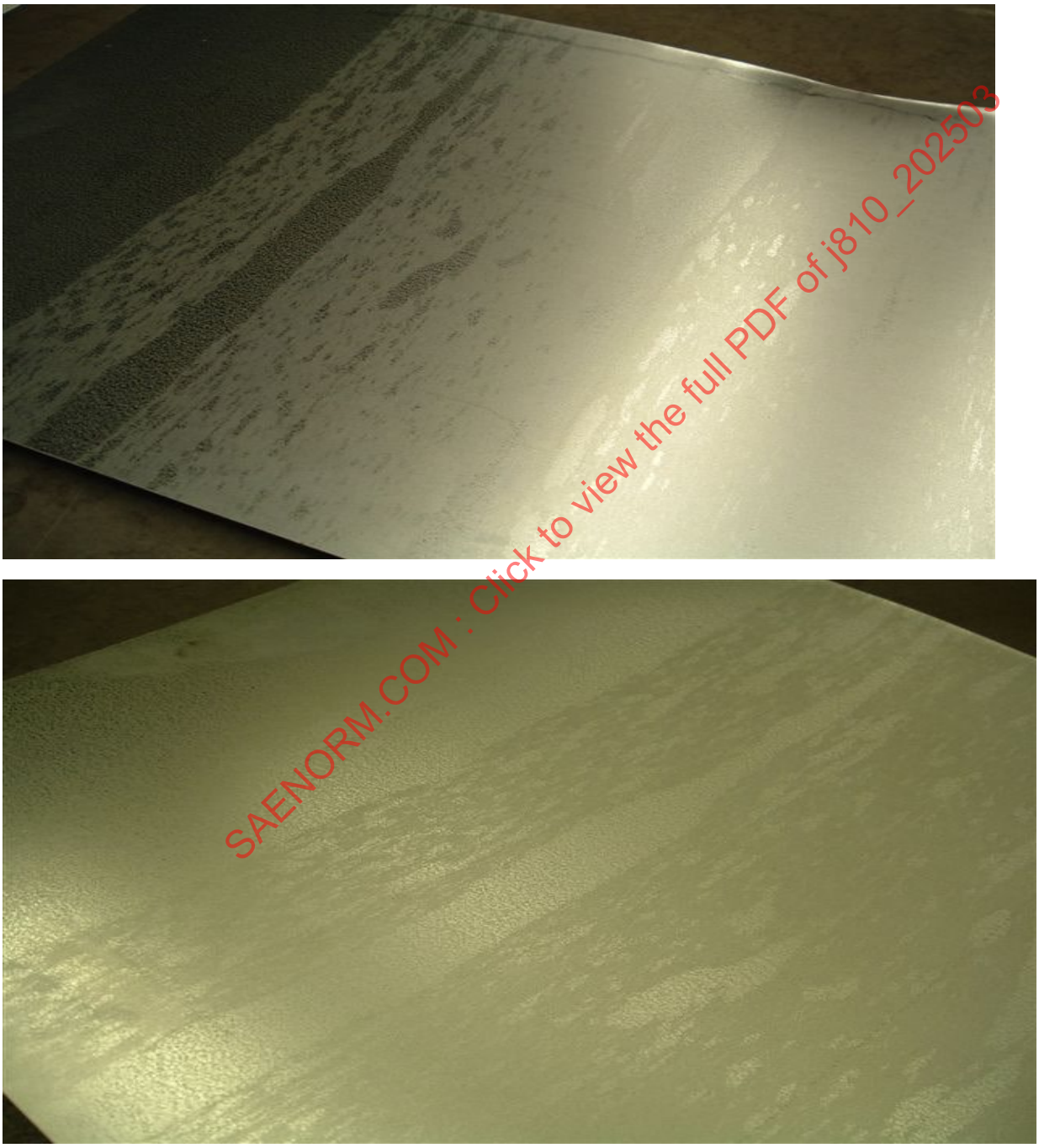
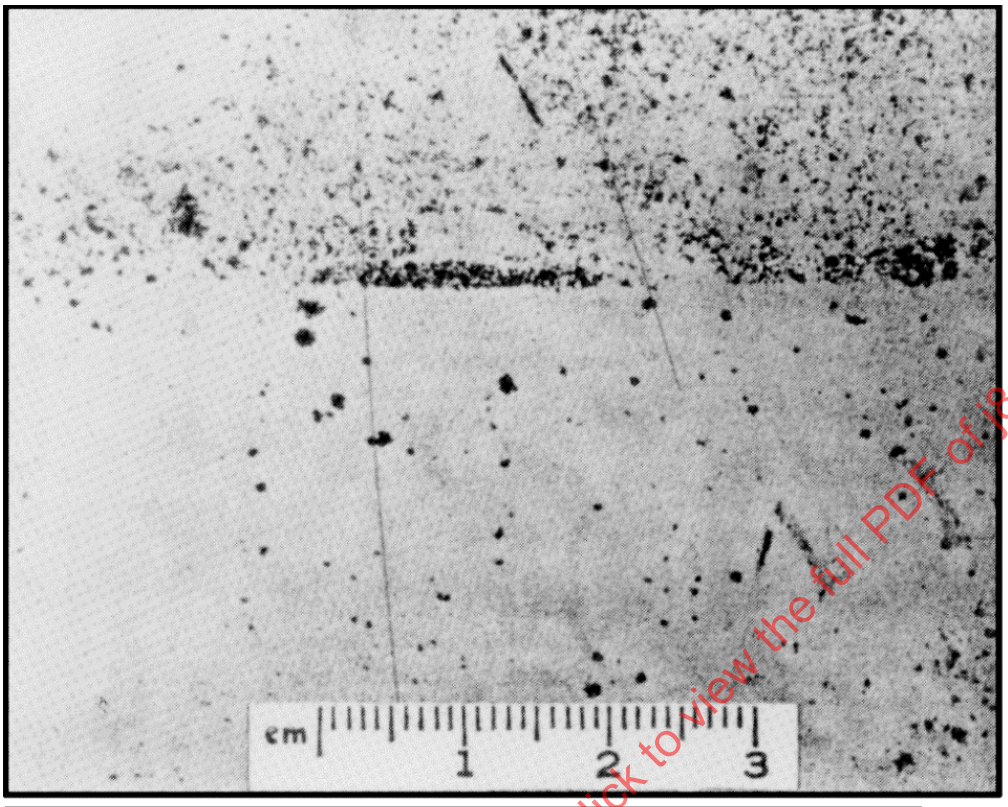


Figure 62

6.24 Speckled Rust

Description:	Speckled rust appears as round dark specks randomly distributed on the coil surface.
Cause:	Speckled rust is caused by high humidity or moisture spray.
Product Affected:	Hot rolled, cold rolled.
Similar Imperfection:	Lineal Rust; Pinpoint Rust; Rust Patches; Salt and Pepper Rust.



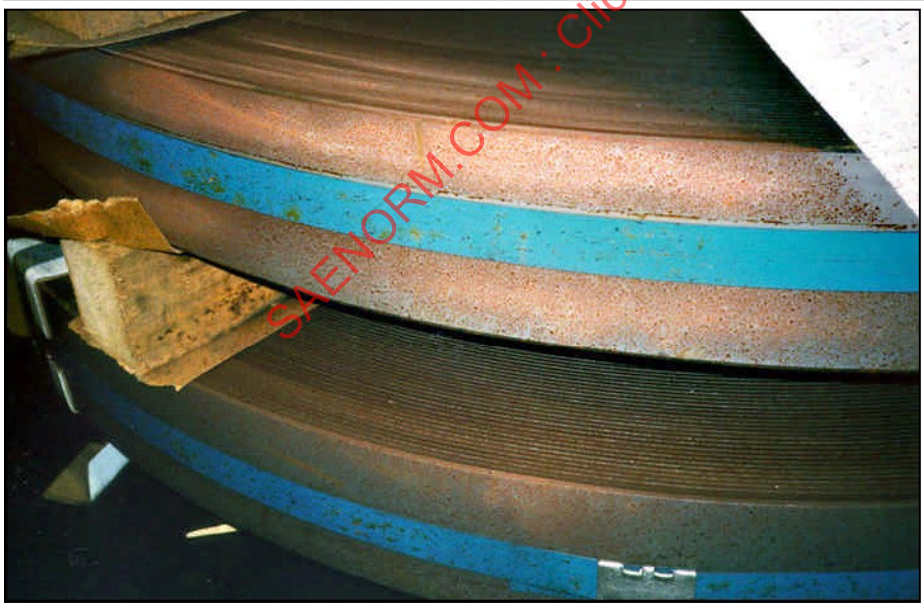


Figure 63

6.25 Stagger Sheet

Description:	Walls of the sheet or blank stacks are not straight.
Cause:	Poor placement of stacker skirts or end stops.
Product Affected:	All blanked or cut-to-length products.
Similar Imperfection:	Stagger-Stacked.

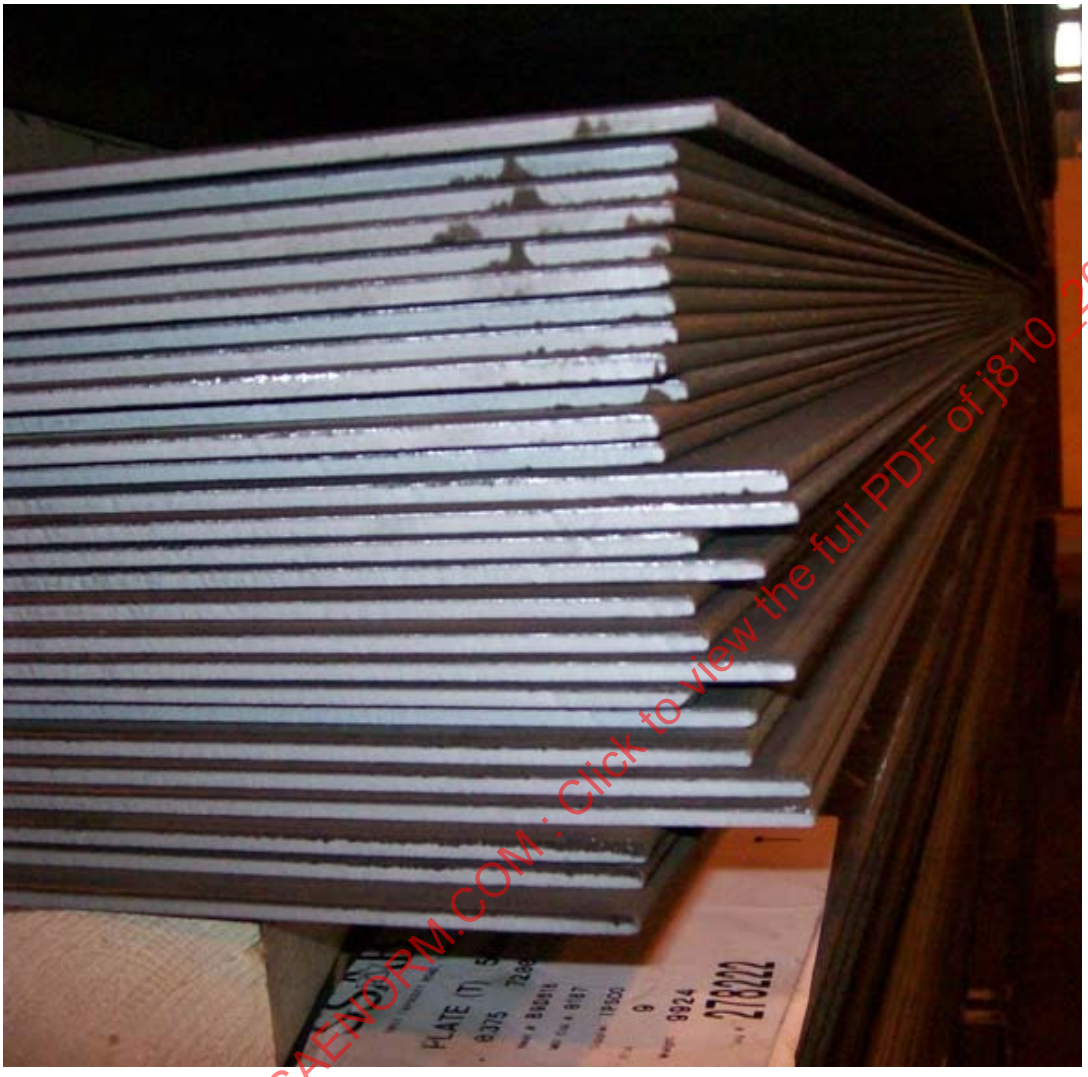


Figure 64

6.26 Sticker Breaks

Description:	Sticker breaks are creases or ridges which appear as crescent shaped lines running transverse to the rolling direction and usually near the middle of the sheet.
Cause:	Sticker breaks are formed as a result of coil laps sticking together during uncoiling which causes a raised area that is subsequently rolled during temper or skin passing because of: - Coils being too tightly wound prior to annealing - Surface too smooth - Annealing temperature too high - Damaged coils (bumped) prior to annealing
Product Affected:	Cold rolled.
Similar Imperfection:	Coil Breaks; Edge Breaks; Stickers; Pinch Marks; Pick-Up.

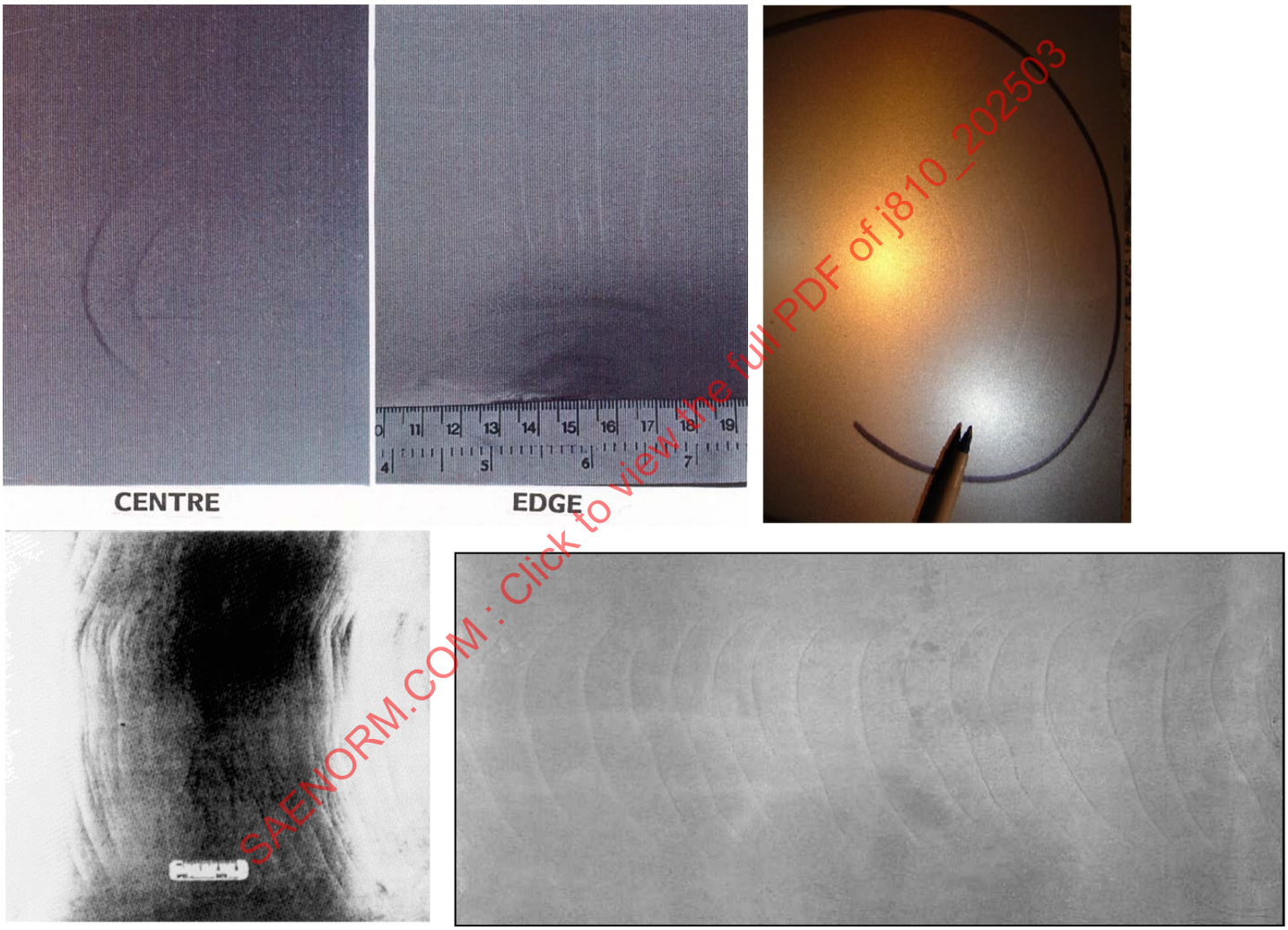
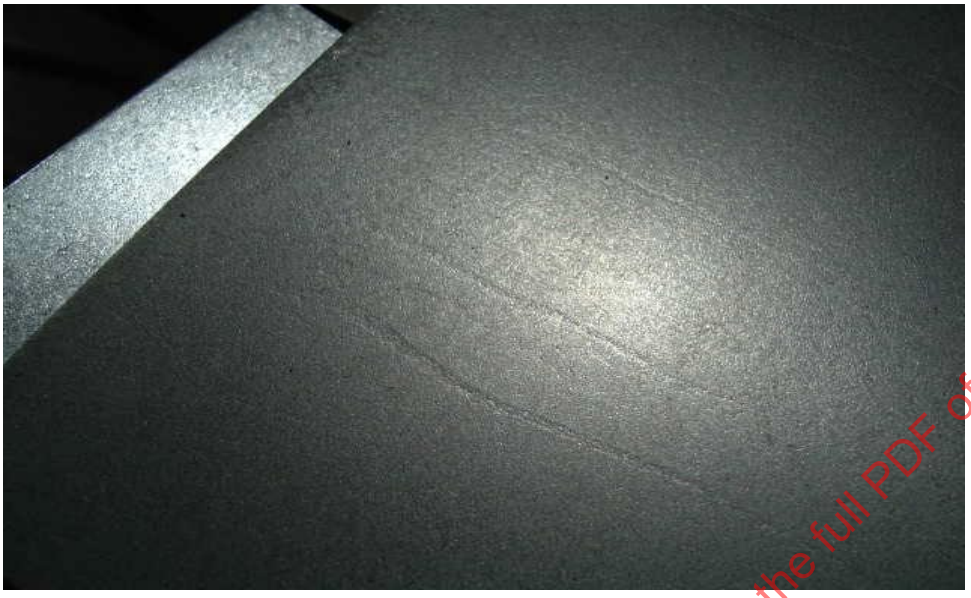


Figure 65

6.27 Strain

Description:	Strain appears as an irregular surface pattern or ridges and valleys.
Cause:	Strain is a result of yield point elongation during stretcher leveling or forming operations.
Product Affected:	All products.
Similar Imperfection:	Lüders Lines; Stretcher Marks; Yield Point Elongation (YPE).



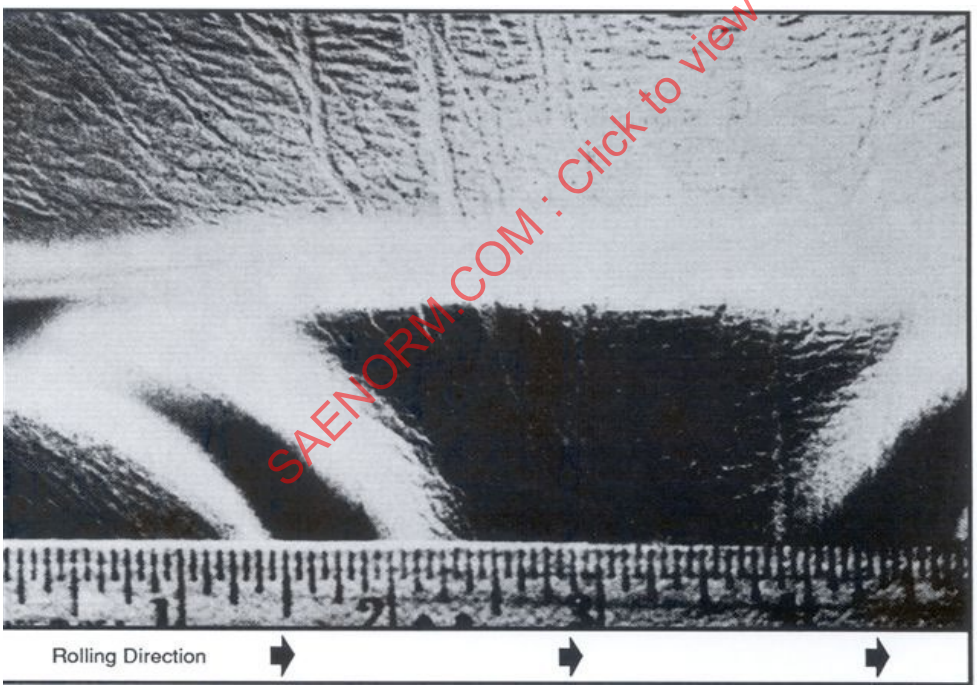


Figure 66