



SURFACE VEHICLE INFORMATION REPORT

J810™

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(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		86



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.

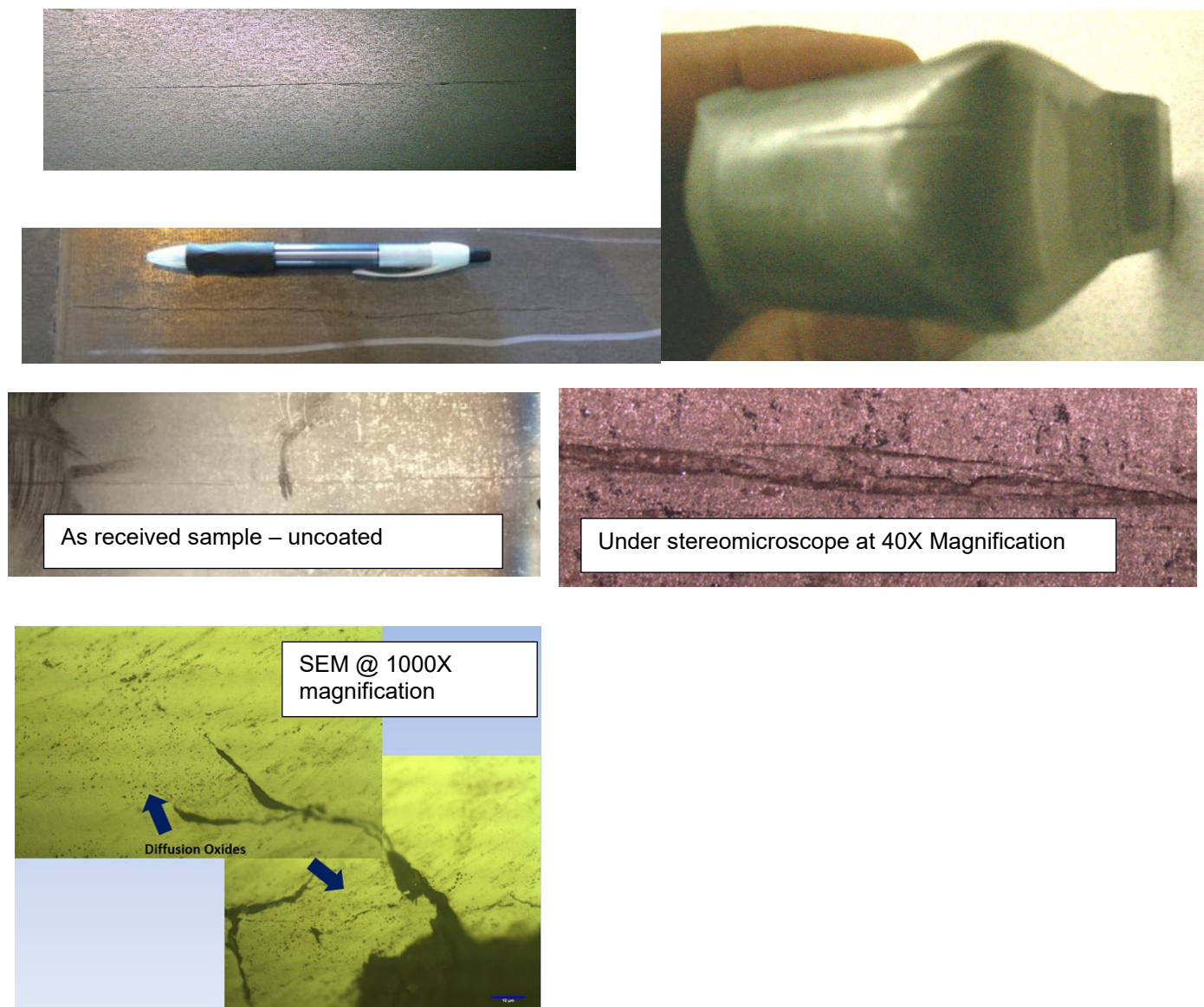


Figure 1

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

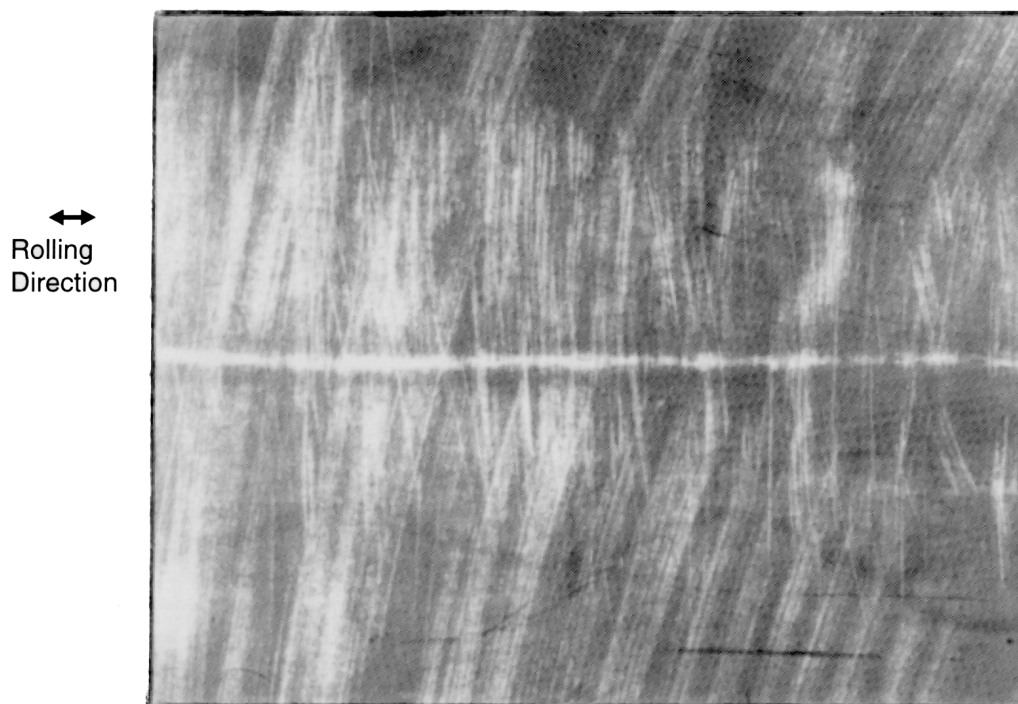
4.3 Entrapped Mold Powder

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.

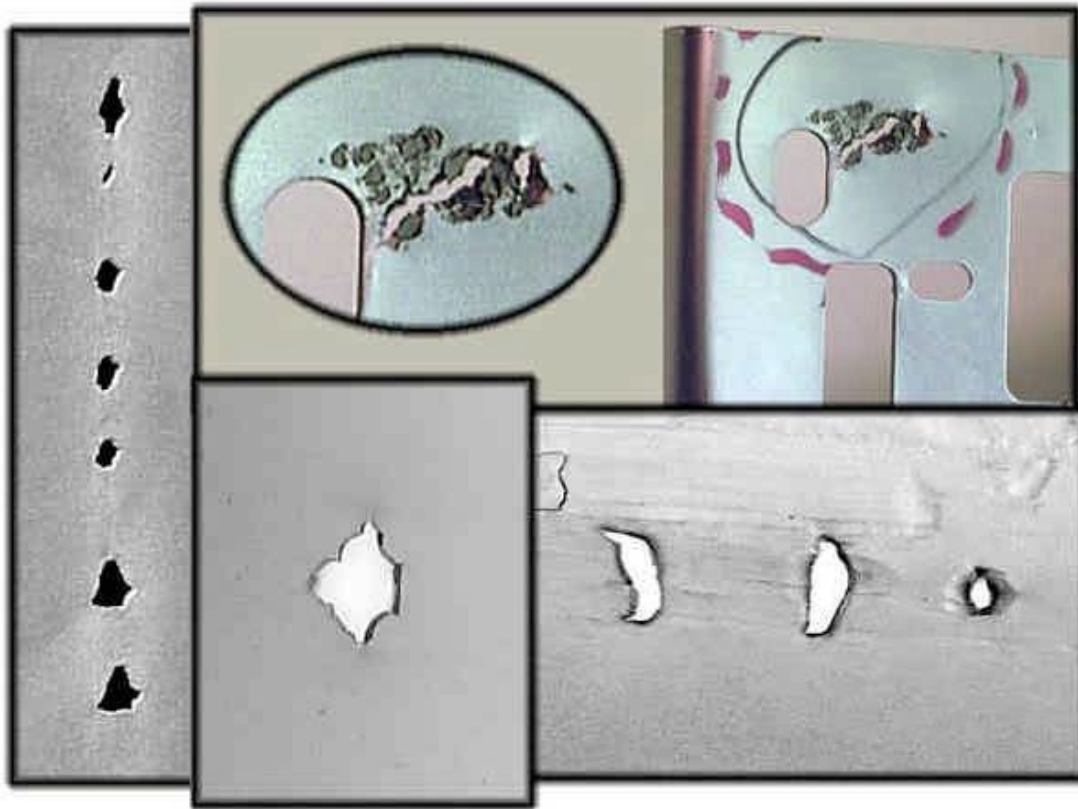
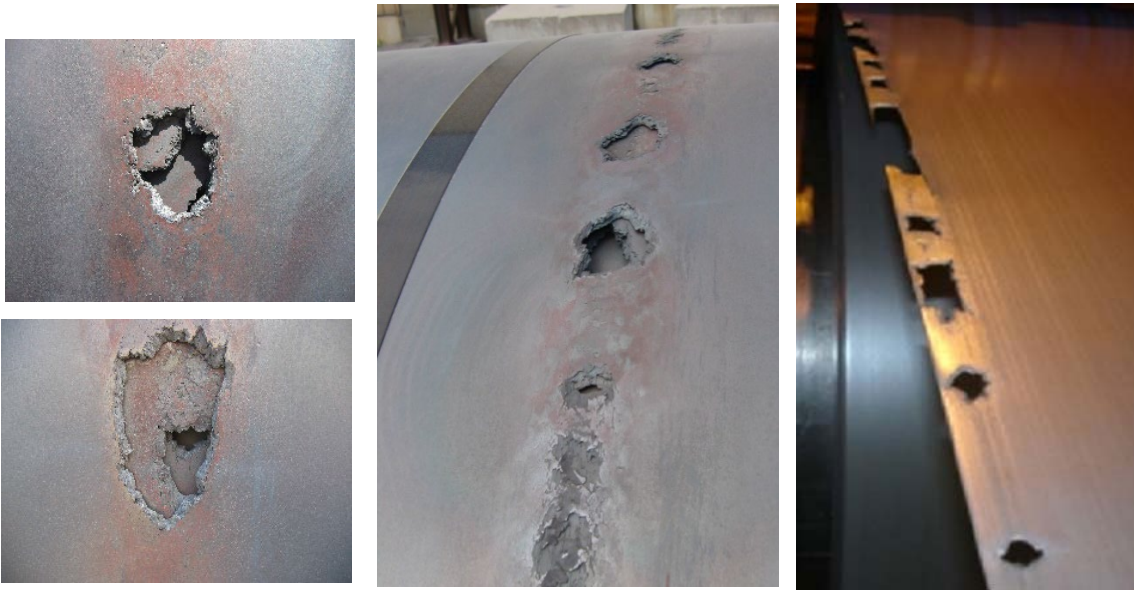


Figure 5

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.

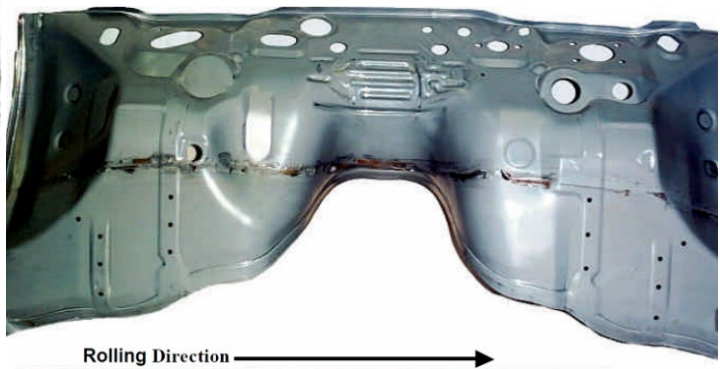
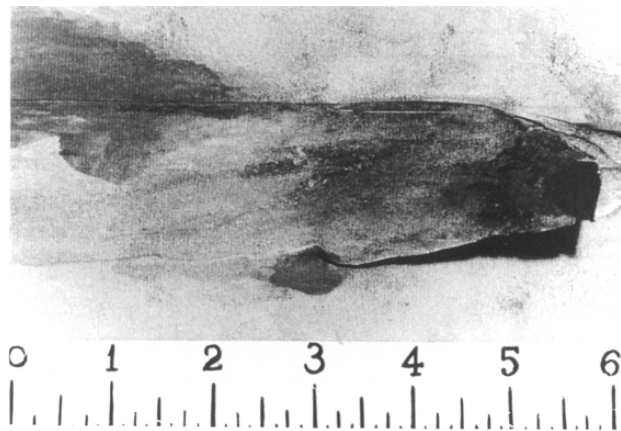


Figure 6

4.7 Lamination: Edge Lamination

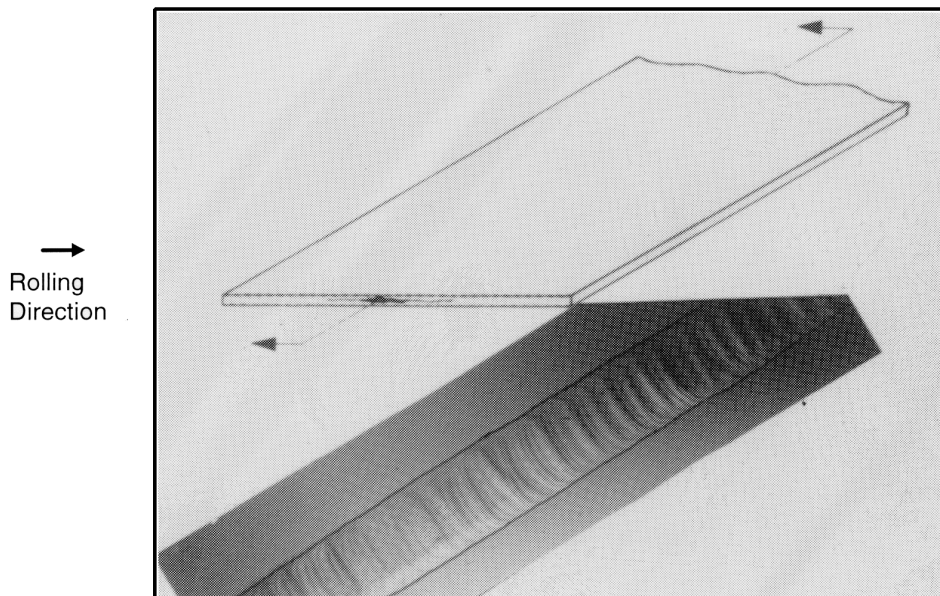
Description:	Edge laminations are tears in the steel, particularly at the edges where the slab is colder.
Cause:	Edge laminations are microsegregations on grain boundaries causing them to slide instead of pancaking during deformation at certain temperatures depending on the steel composition.
Product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



Figure 7

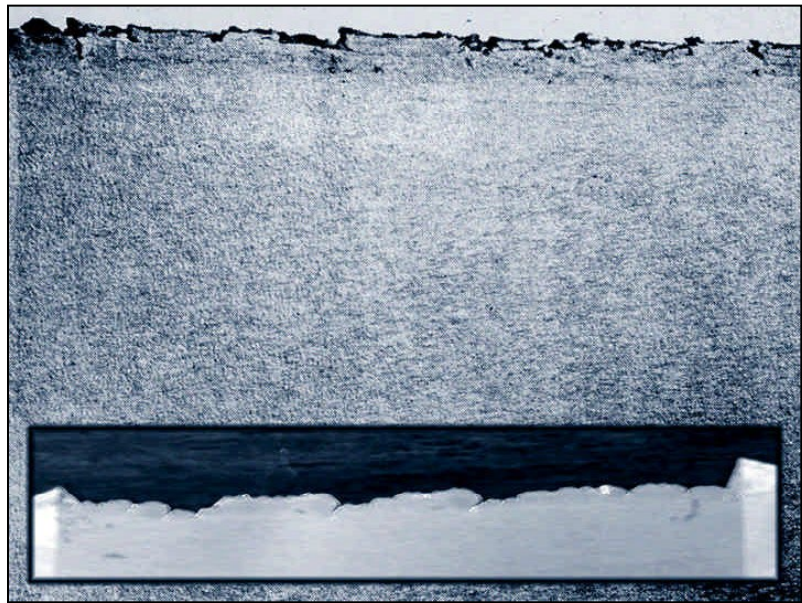
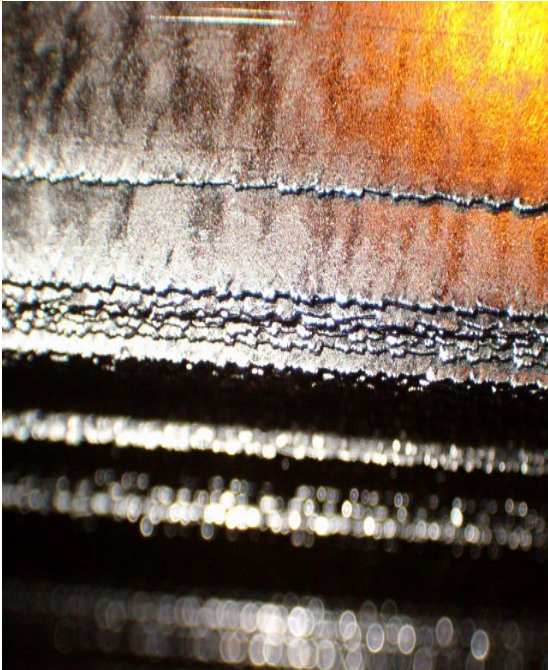
4.8 Lamination: Pipe Lamination

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.

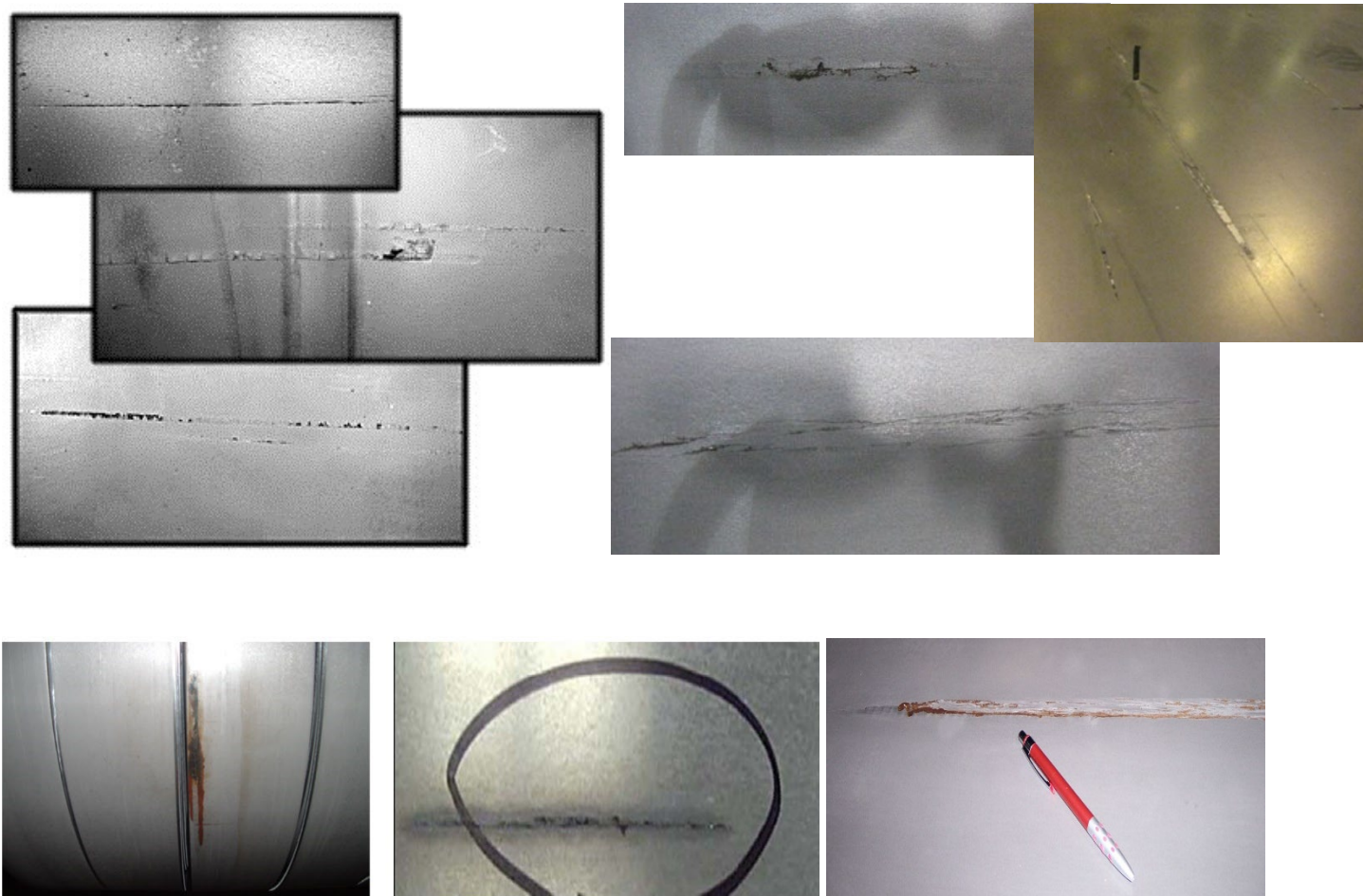


Figure 10

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.

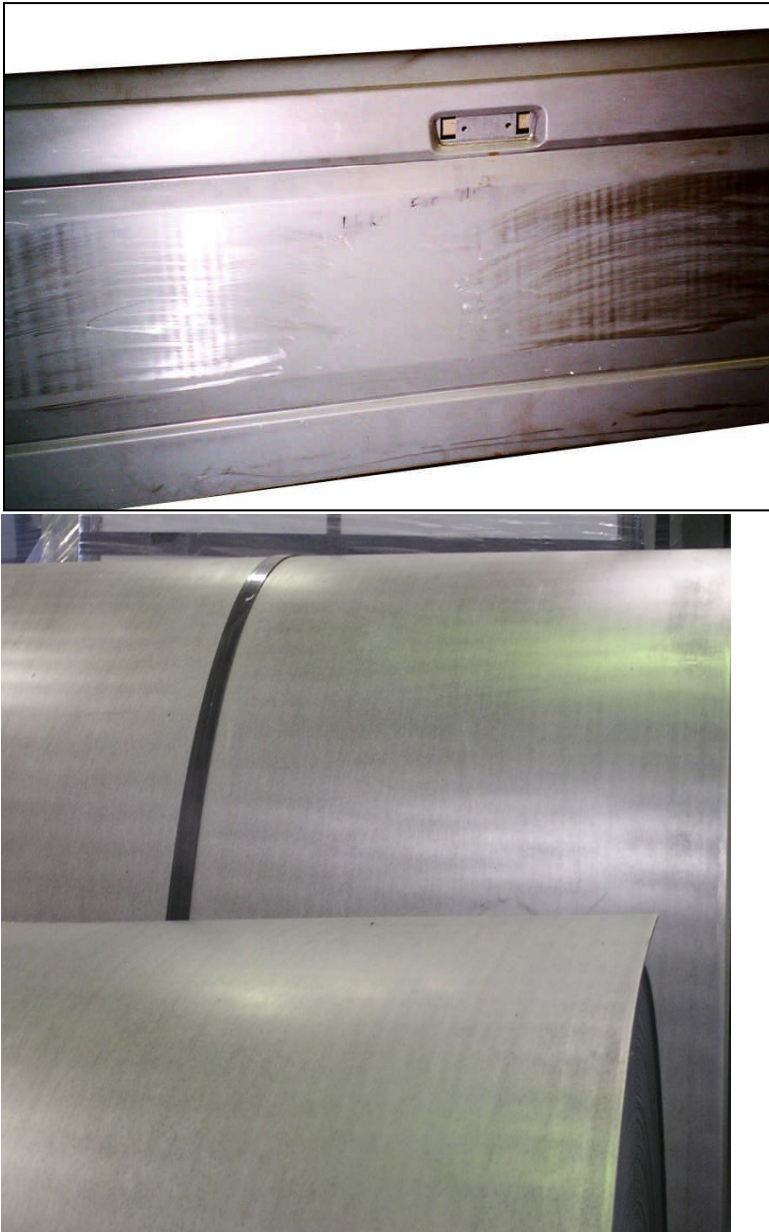


Figure 11

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

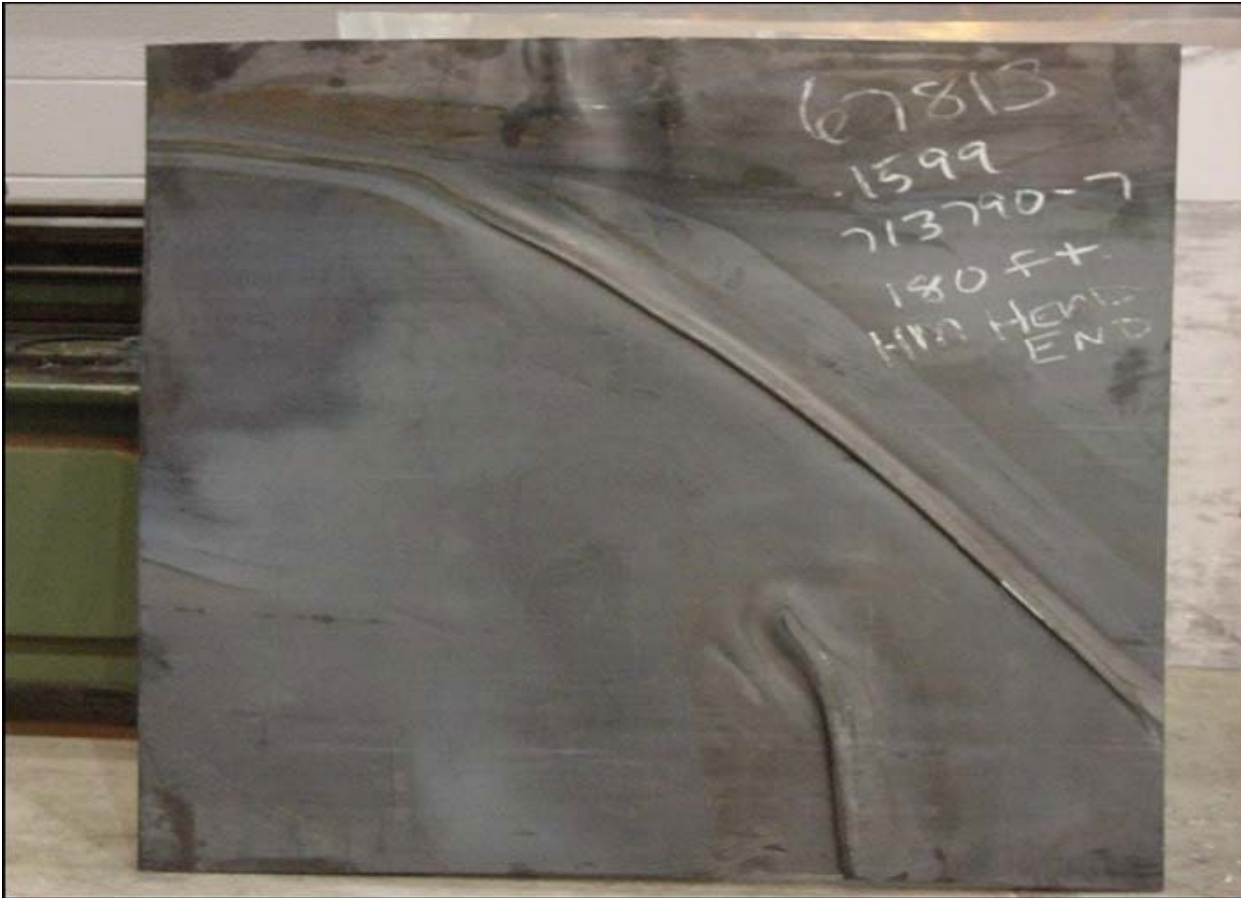
Description:	Appearance will be similar to a reel kink. Severity can vary by material grade and application.
Cause:	Fluting typically occurs during roll forming to small diameters or stretching during stamping resulting from the presence of yield point elongation (YPE).
Product Affected:	Roll formed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

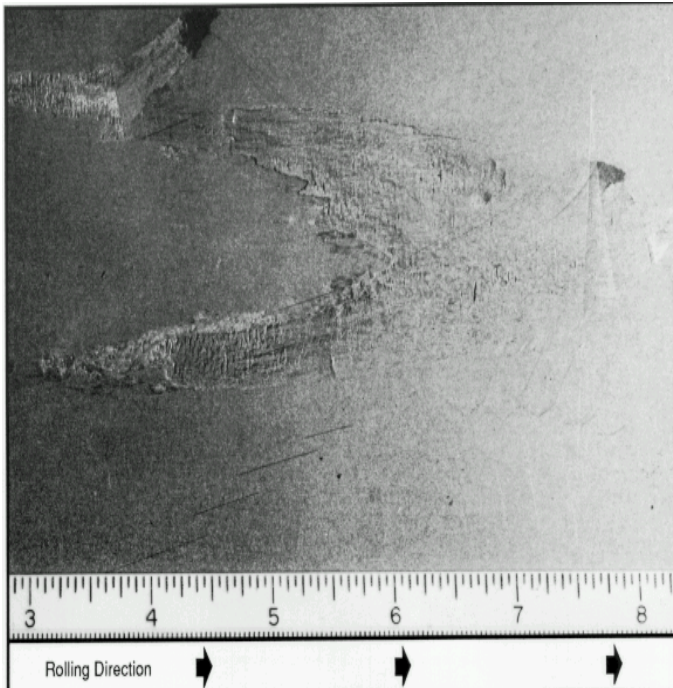


Figure 15

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.

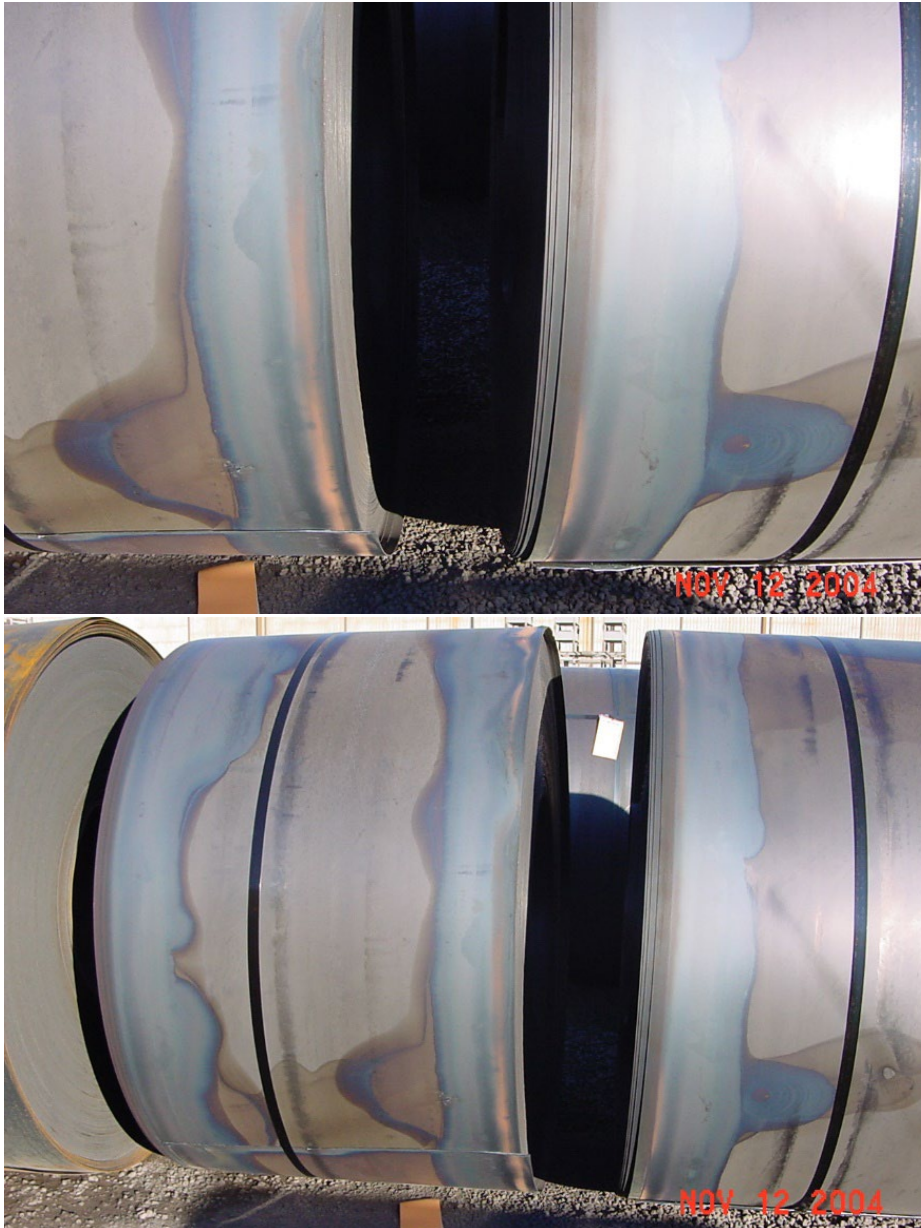
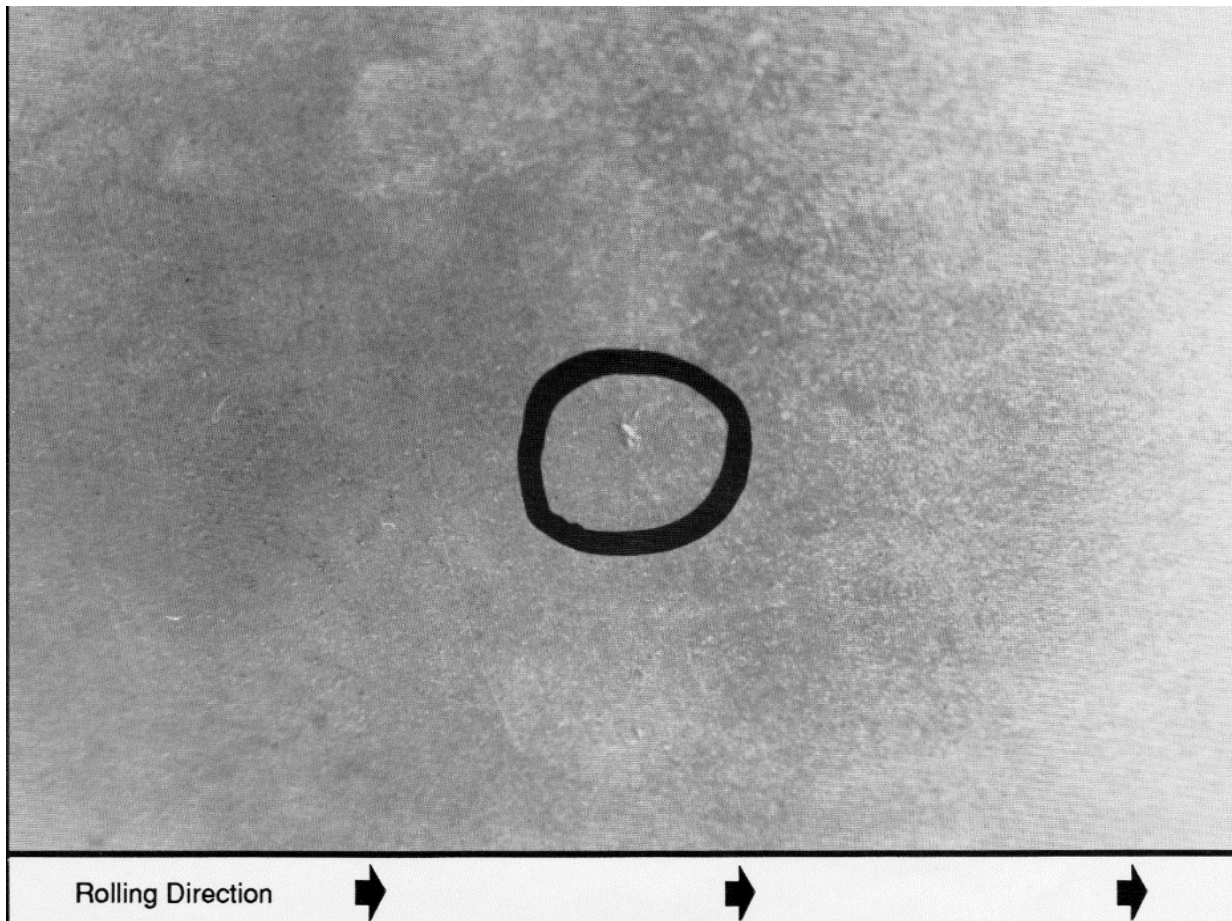


Figure 17

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.

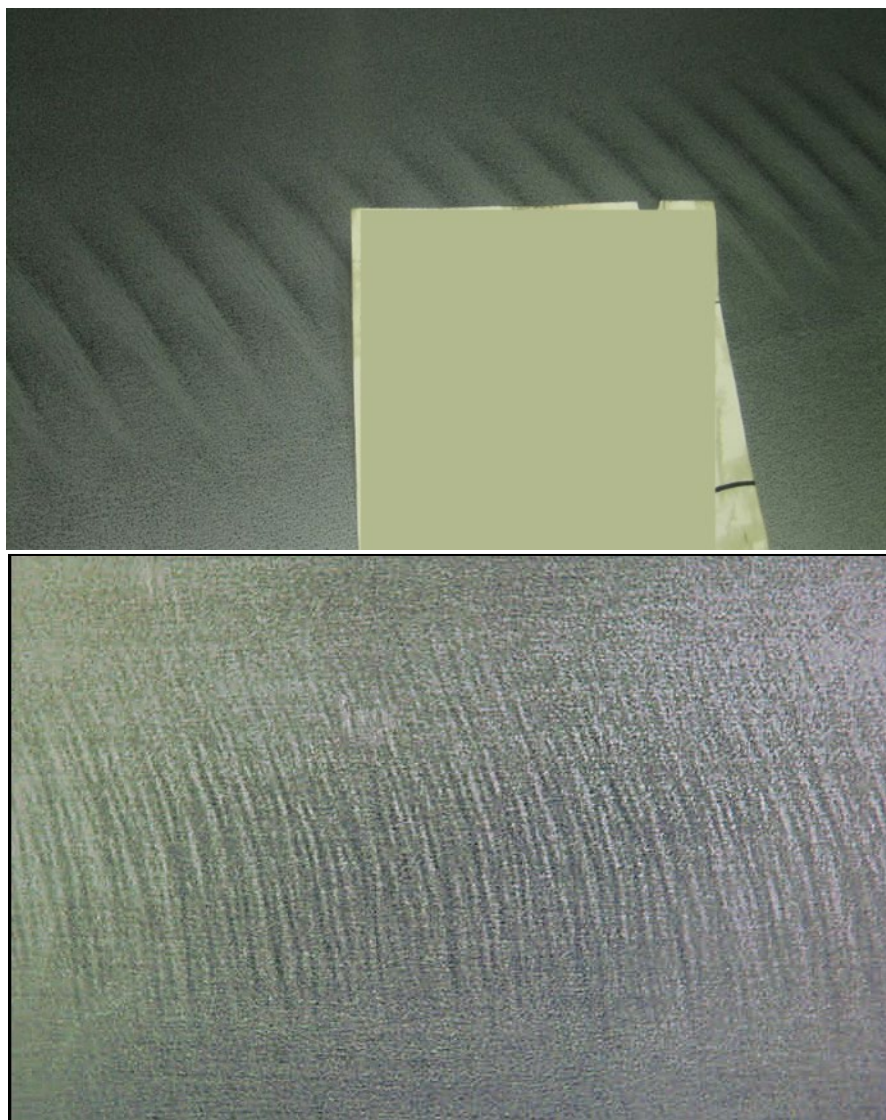
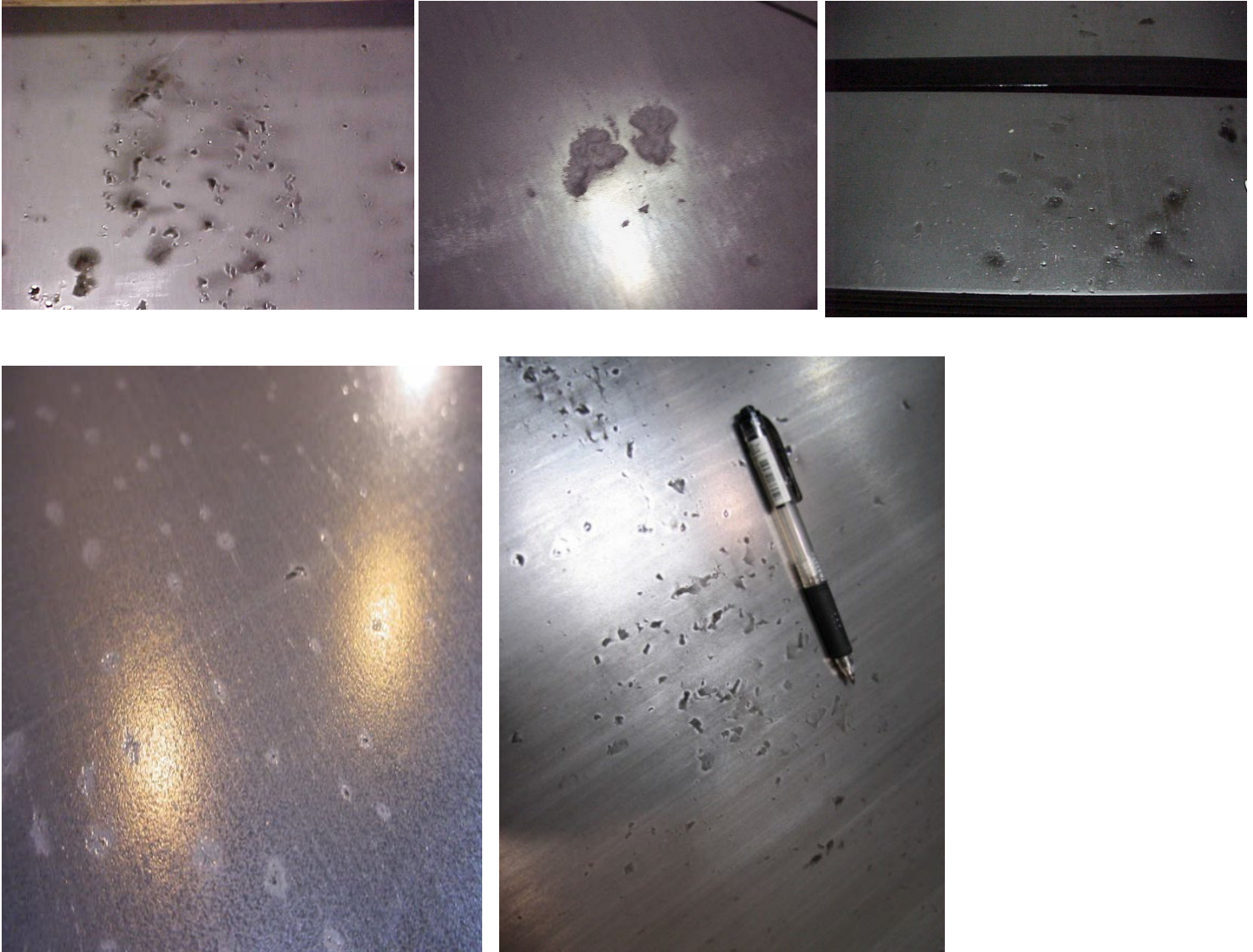


Figure 19

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.

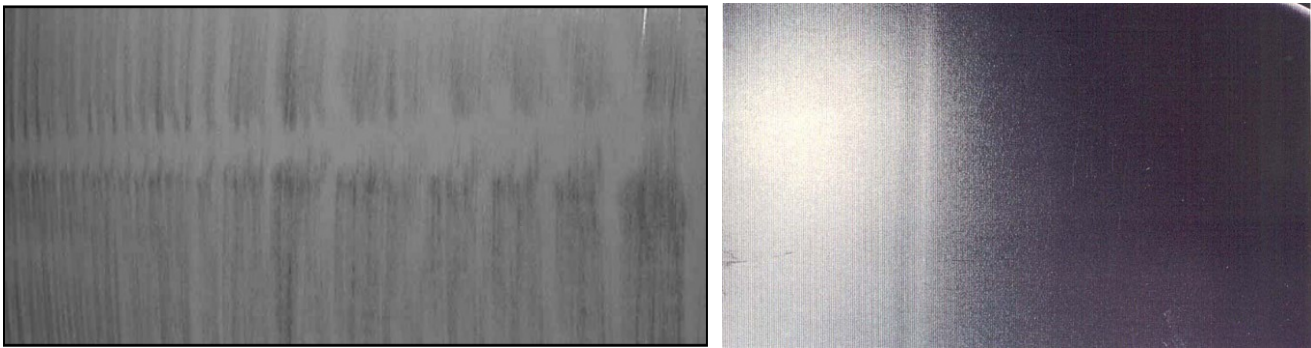
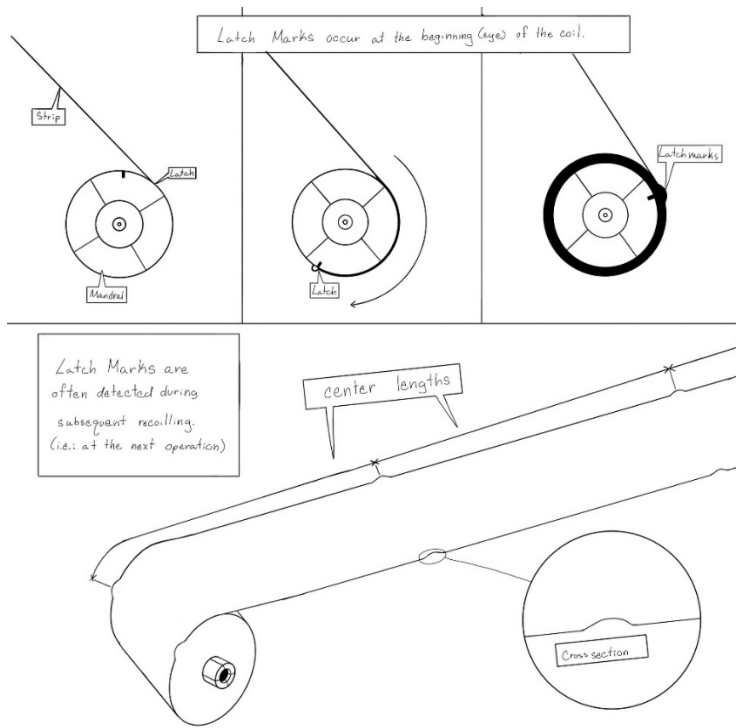


Figure 21

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.

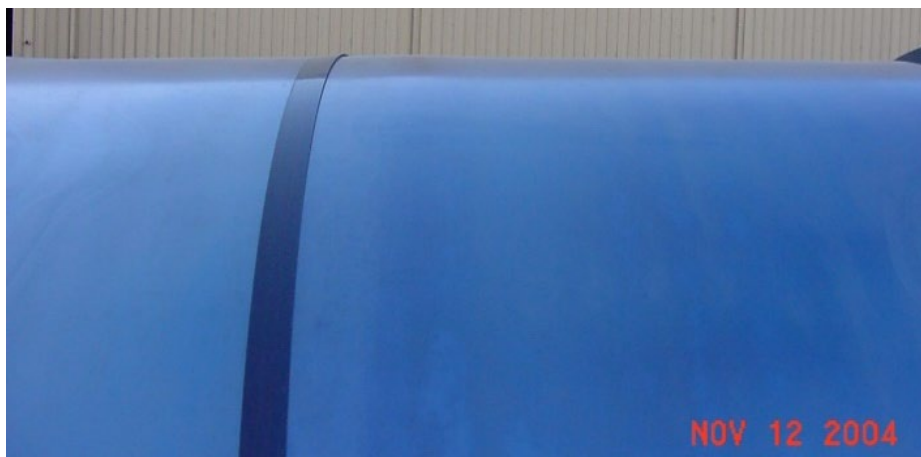
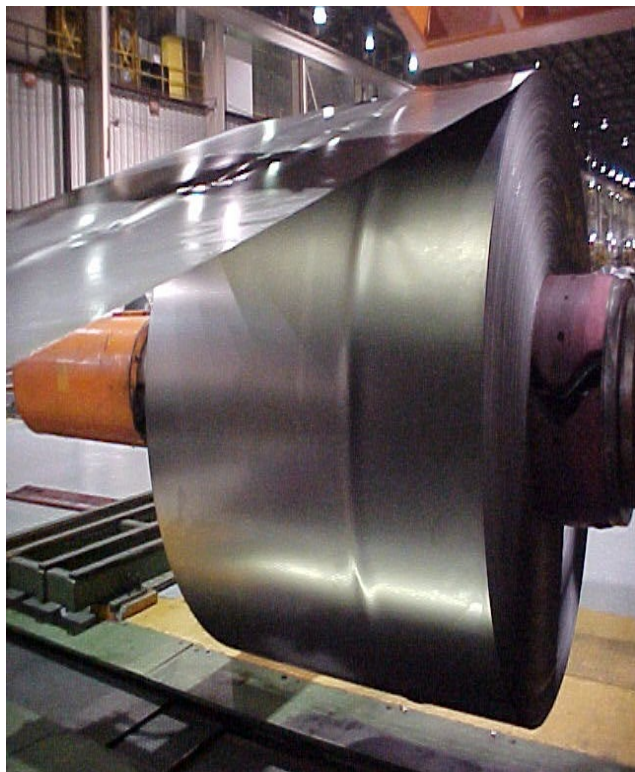


Figure 22

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.

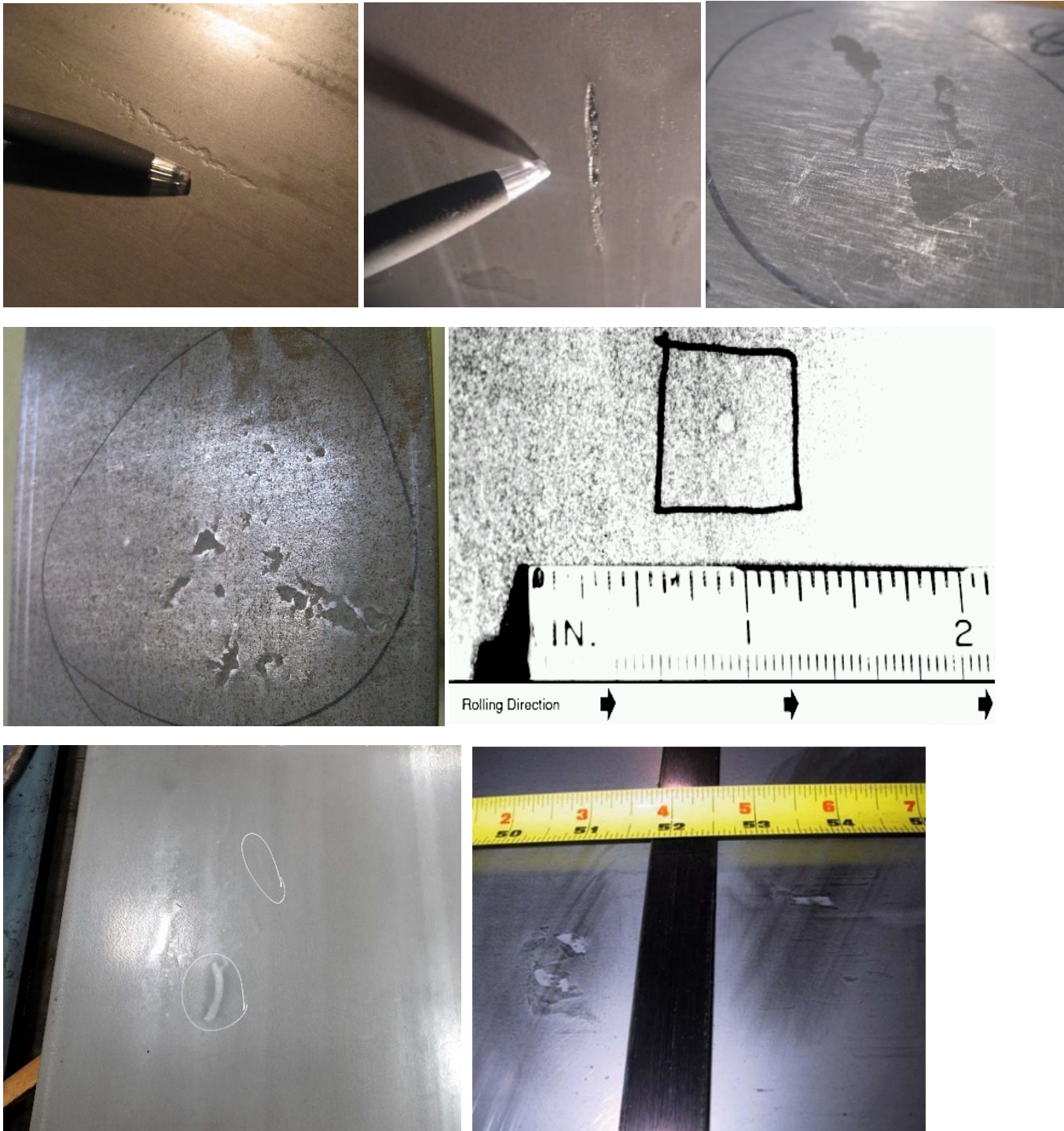


Figure 23