SSAB

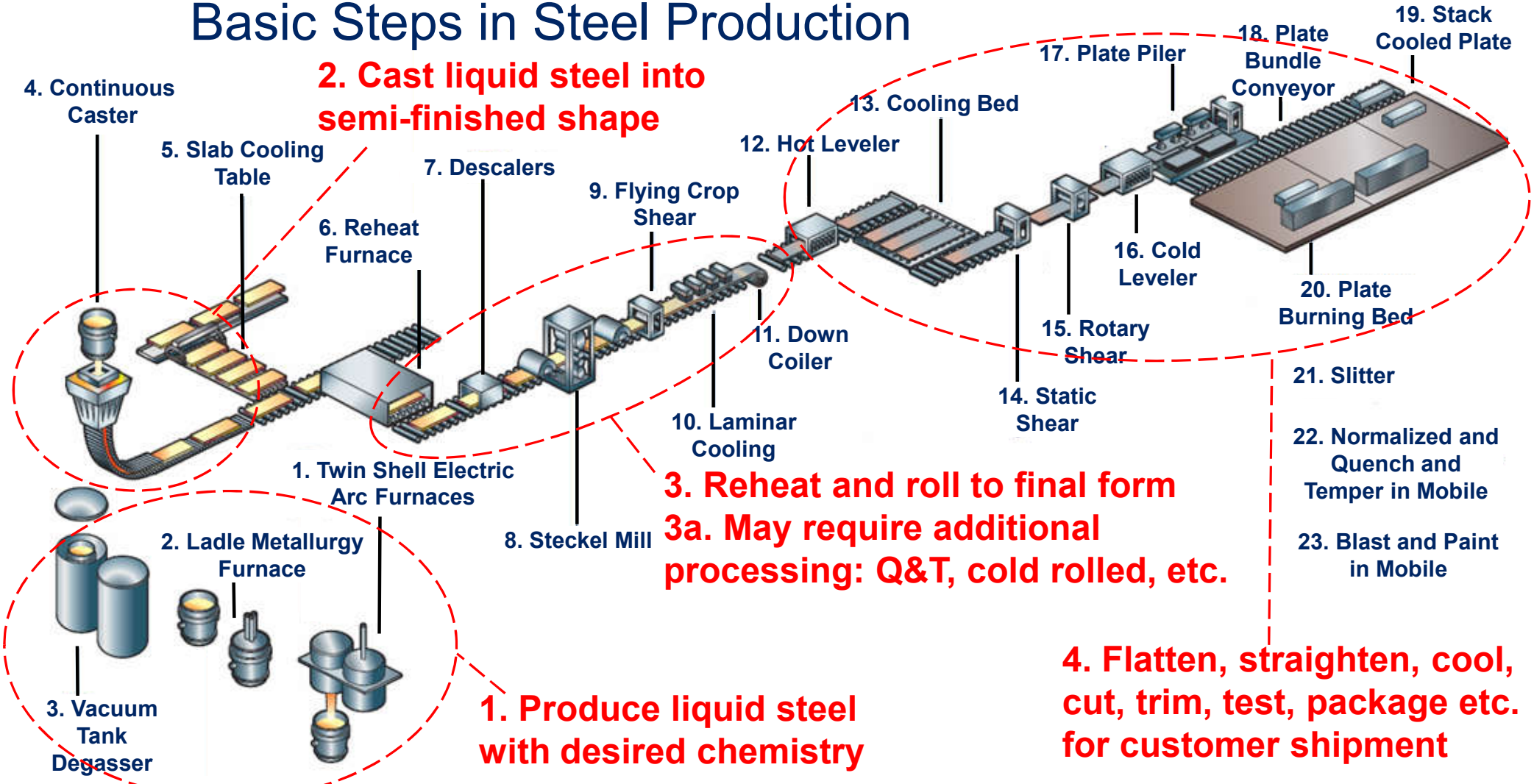
Steelmaking and Bridge Plate Capabilities
MN DOT - ACEC | NSBA Steel Bridge Forum

Oct. 26, 2021 – David Stoddard, SSAB Americas

Outline

- Introduction to Steel Production
  - Comparison between Integrated and Electric Arc Furnace Mills
- American Plate and Structural Steel Mills
- Determination of Bridge Plate Capabilities
  - SSAB Americas Bridge Plate Capabilities
- From Inquiry to Shipment – How a Bridge Plate Order Happens

Basic Steps in Steel Production

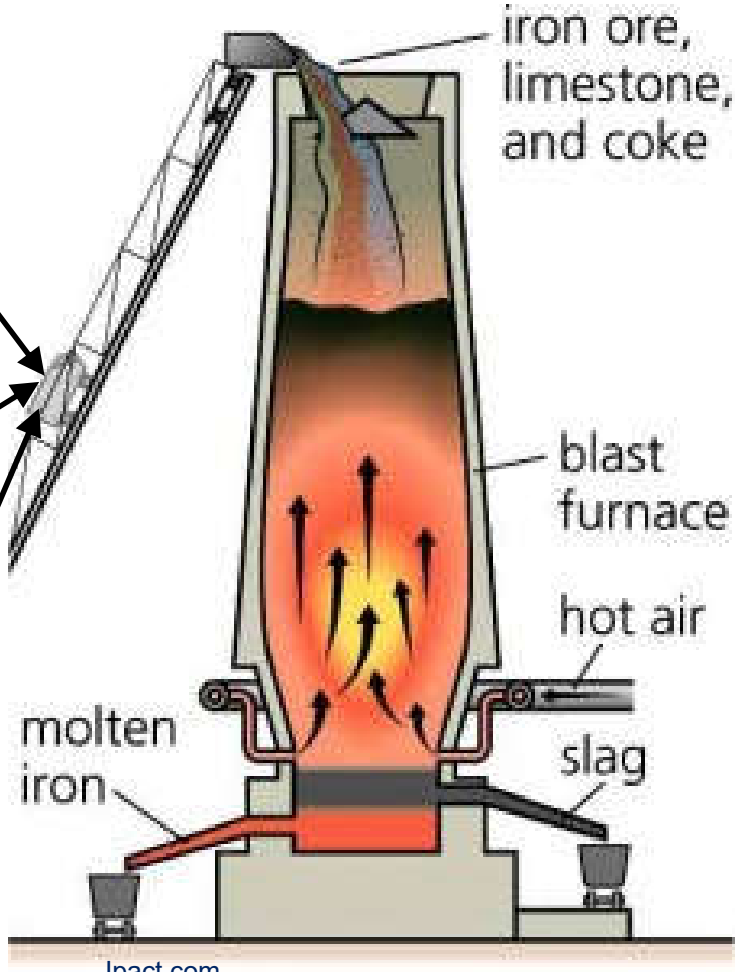


Blast Furnace Process – Convert iron ore into pig iron

Iron ore pellets

Limestone

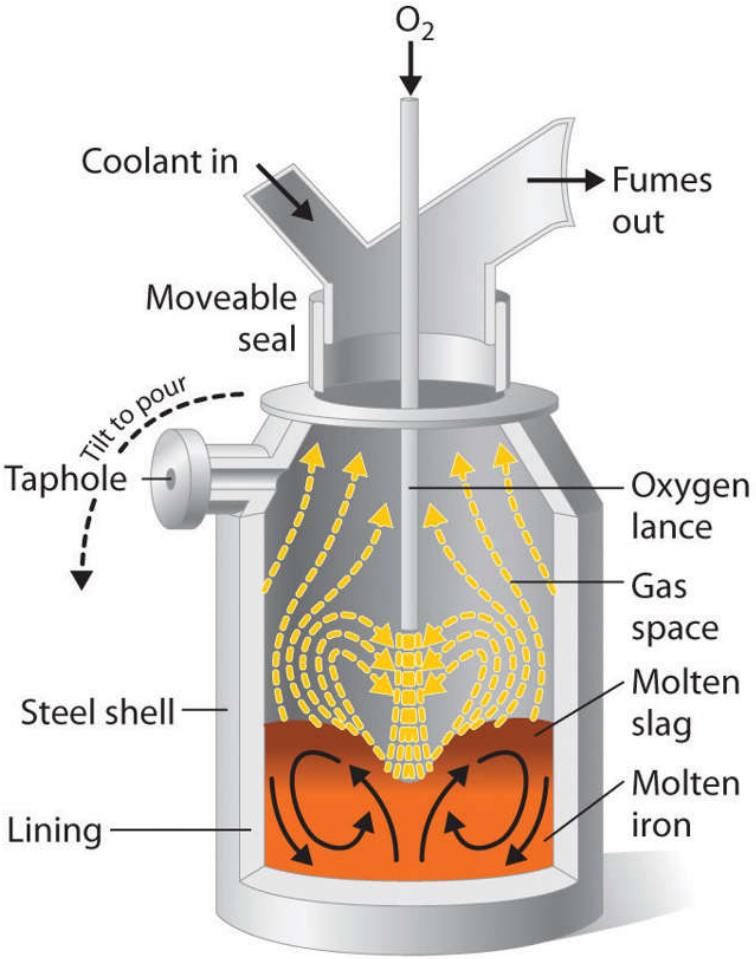
Coke (C)



Ipact.com

Pig Iron 5% C
Most Steel < 0.4% C)

Basic Oxygen Furnace (BOF) – Convert pig iron into steel



Refine liquid pig iron (5% C) into steel (0.02 – 0.40% C) using O_2 to remove carbon:

- $C + O_2 \rightarrow CO_2$
- $C + ½\ O_2 \rightarrow CO$

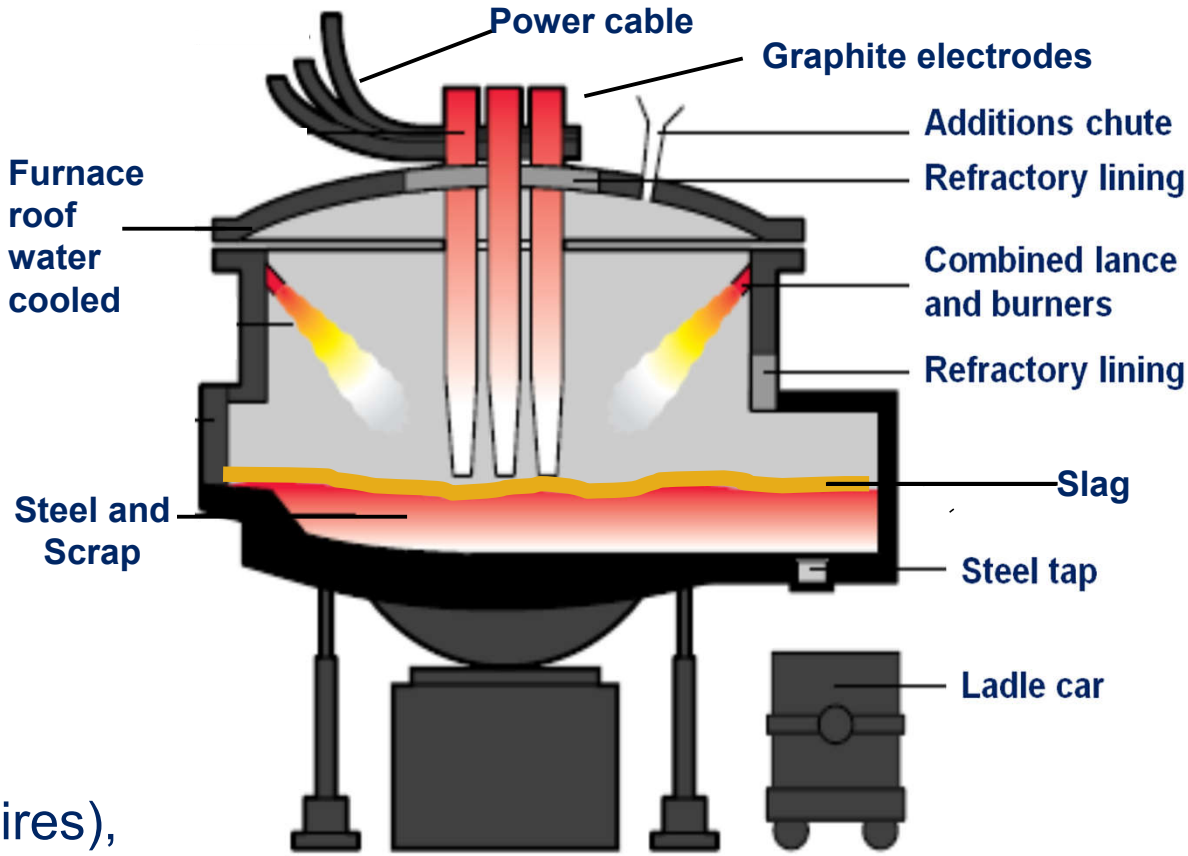
Also add steel scrap (25%), Flux (Lime) and Alloys

- **BF-BOF steelmaking accounts for 5.5% of world CO_2 emissions**
- **Cement production accounts for 5 – 7%**
- **SSAB - HYBRIT (2026) use C free electricity and H to reduce iron ore to steel**

Electric Arc Furnace (EAF) – Melt steel scrap to liquid

EAF Charge Based on Density and Residual Element Content

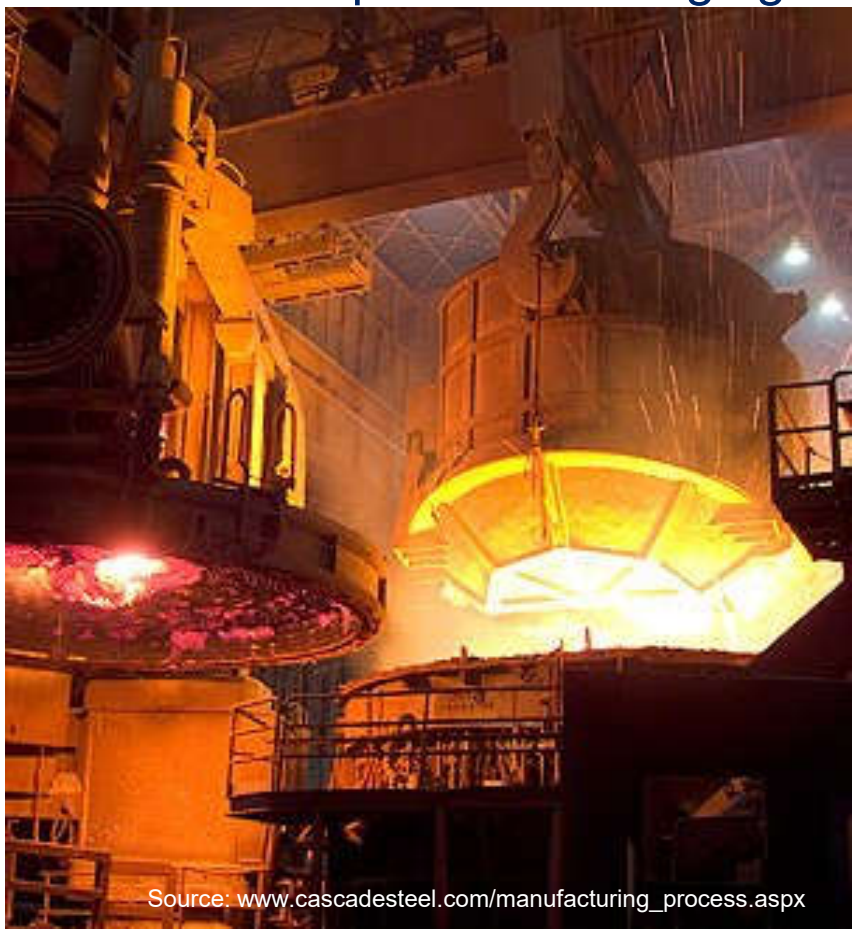
	Cu	Cr	Ni	Mo
Pig Iron	0.01	0.04	0.05	0.01
Shredded	0.25	0.09	0.09	0.02
#1, #2 Heavy	0.40	0.13	0.13	0.03
Turnings	0.30	0.33	0.33	0.11



Other Inputs: Carbon (recycled tires), Lime, **Electricity (focus on C free)**

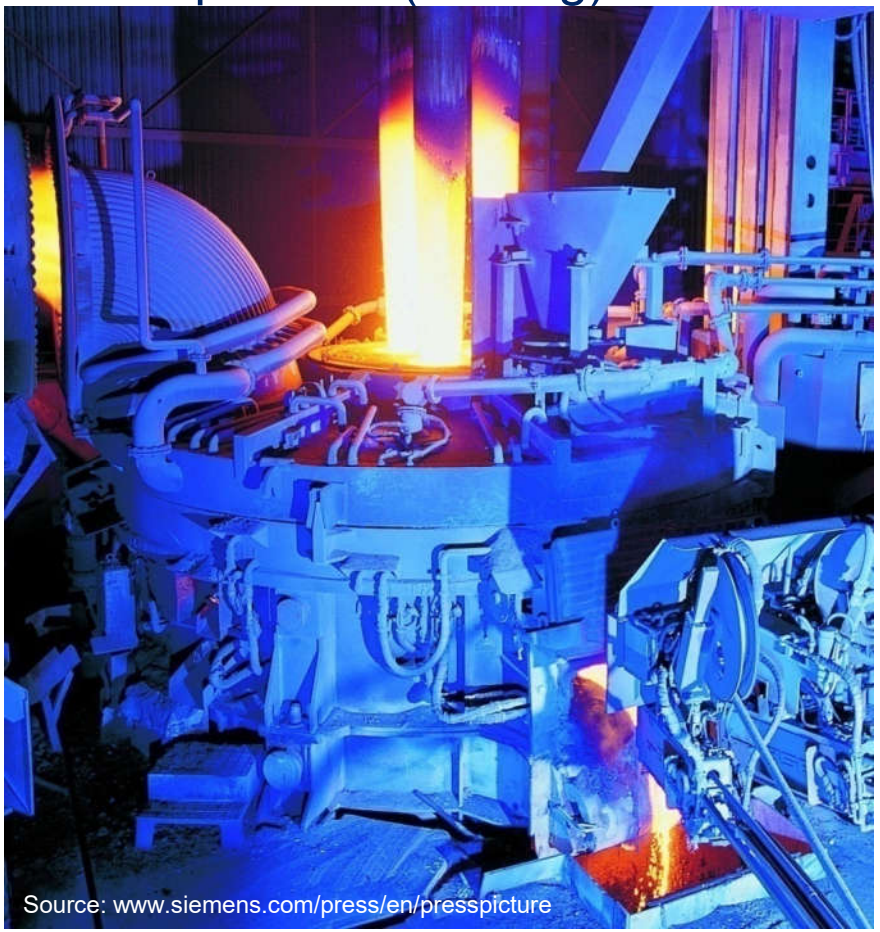
Electric Arc Furnace

Scrap Bucket Charging



Source: www.cascadesteel.com/manufacturing_process.aspx

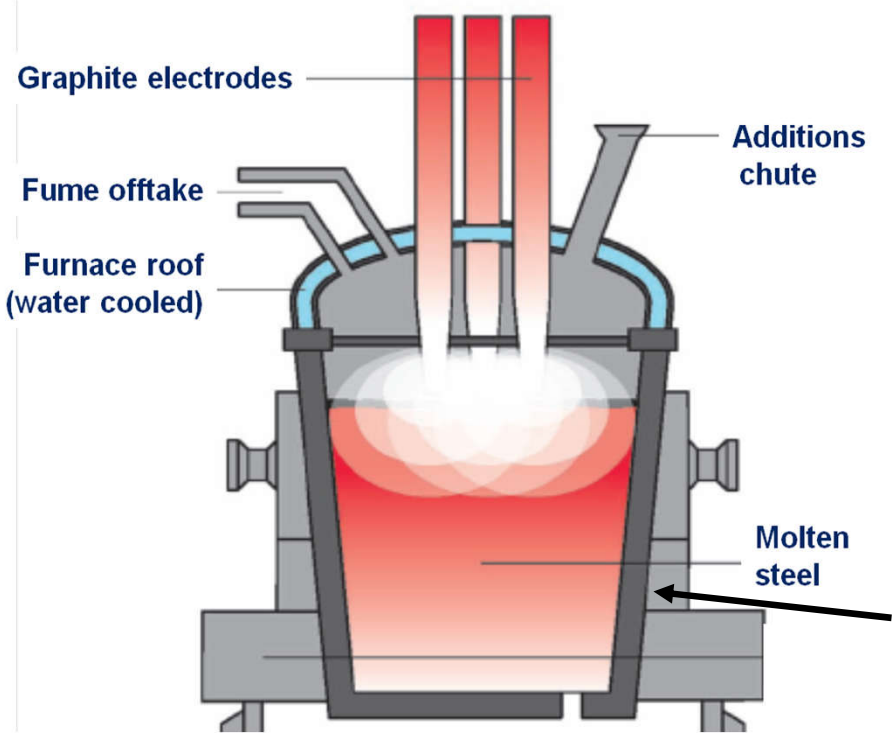
In Operation (Melting)



Source: www.siemens.com/press/en/presspicture

Steel refining to obtain final composition

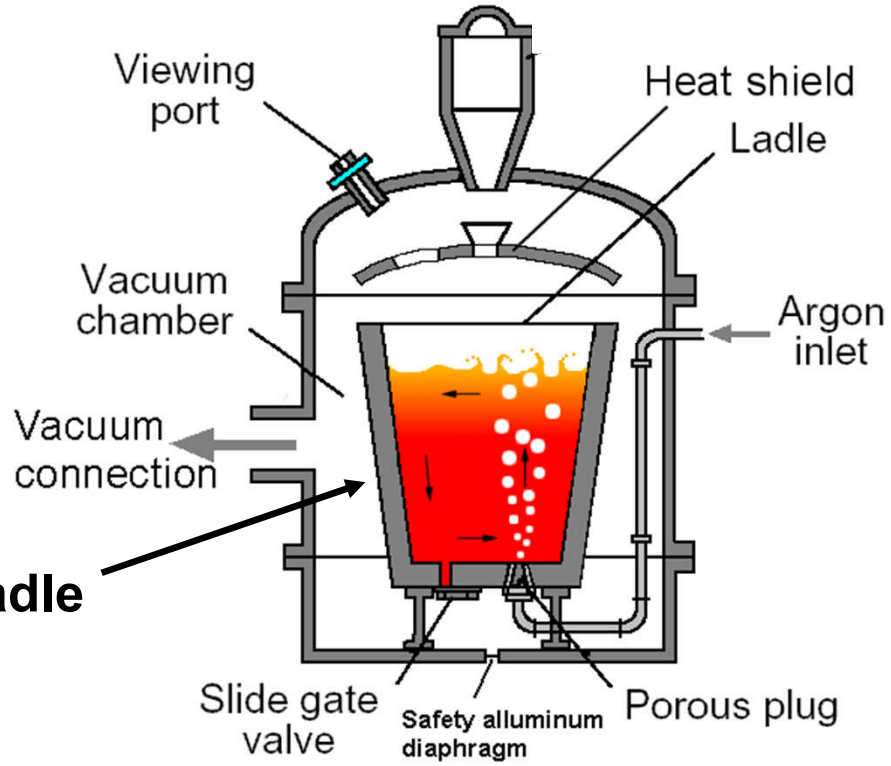
Ladle Metallurgy Furnace



Make alloy additions and remove sulfur to obtain final chemistry

Source: www.coruseducation.com

Vacuum Tank Degasser



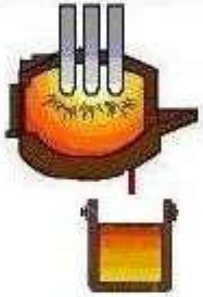
Remove Hydrogen and control nitrogen

Comparison of Steelmaking Routes

Recycled Steel Scrap

Blend various types based on residuals

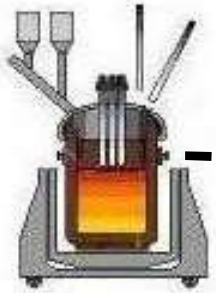
Electric Arc Furnace



Melt scrap to molten steel. Remove impurities (P). Add alloys at tapping.

Scrap and EAF

Ladle Metallurgy Furnace



Make final alloy additions, remove S, control temperature

Vacuum Tank Degasser (optional)

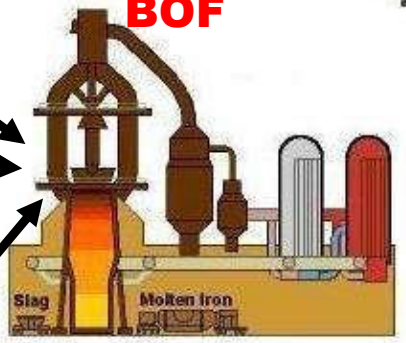
Remove dissolved gases (N and H)

Blast Furnace and BOF

Iron Ore

Coke

Limestone



Blast Furnace
Produces molten pig iron from iron ore

Recycled Steel

Basic Oxygen Furnace

Produces molten steel from pig iron (removes C). Initial alloy addition.

Steel Ladle holds 1 Heat

A heat is the smallest unit of a grade chemistry

Ladle transports Heat to Caster

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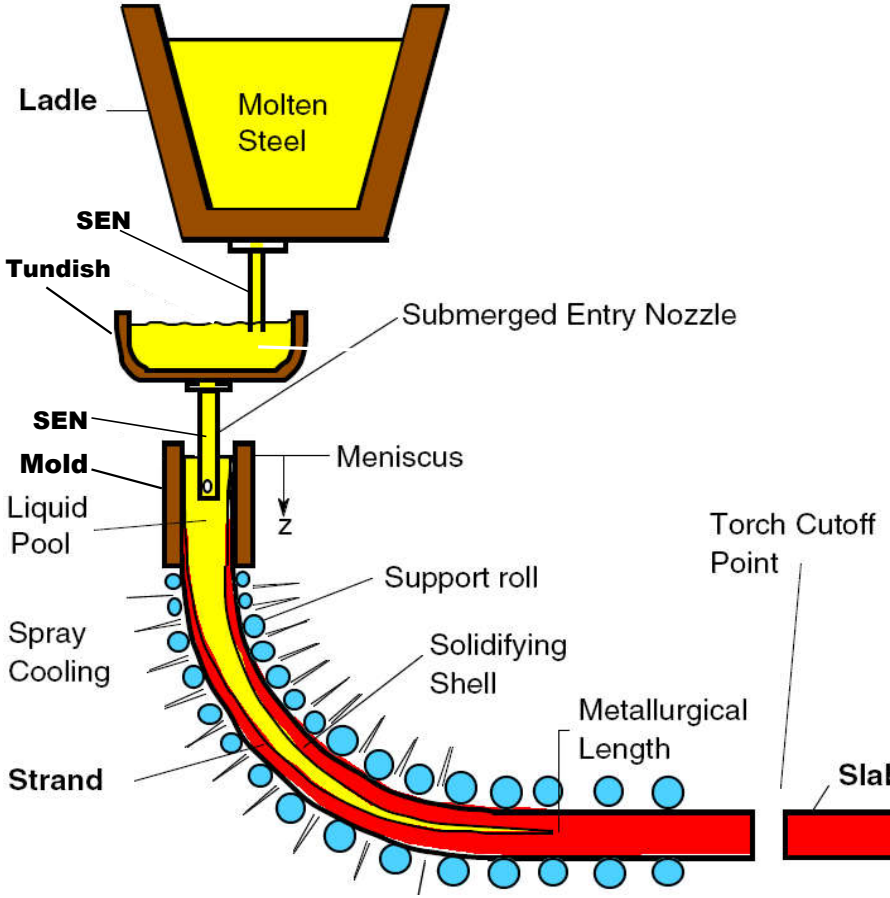
Continuous Casting - Molten Heats are cast into solid steel slabs



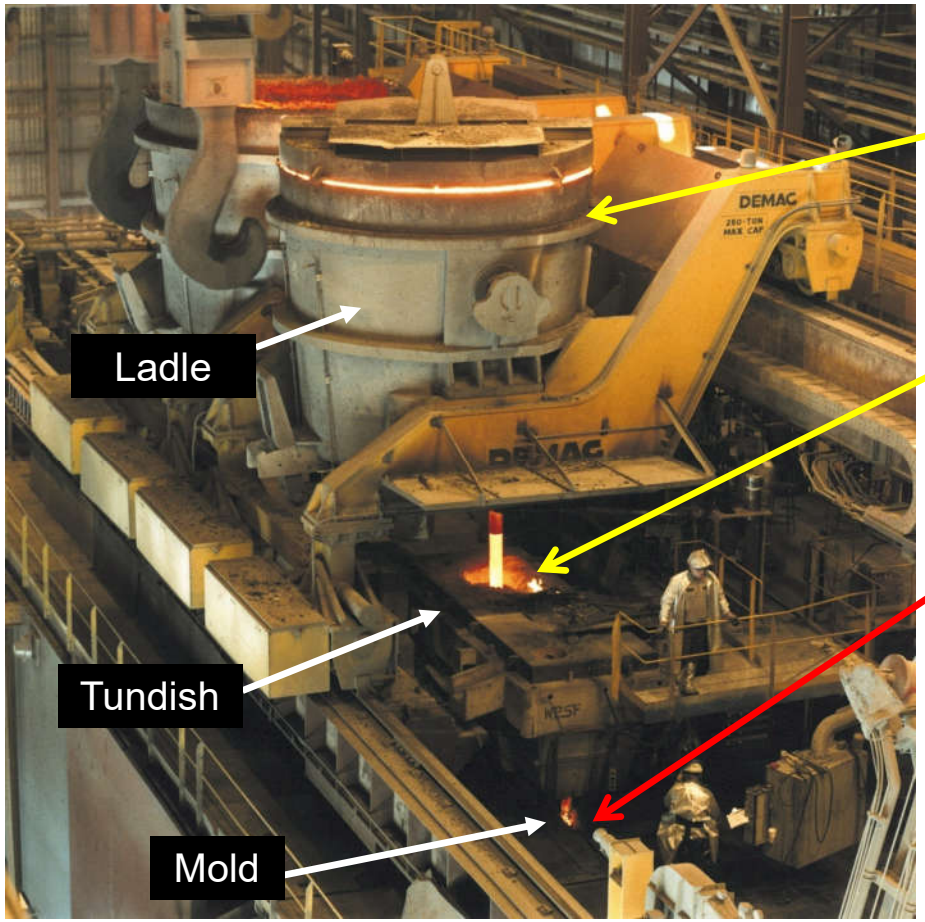
Mold sets slab thickness and width:

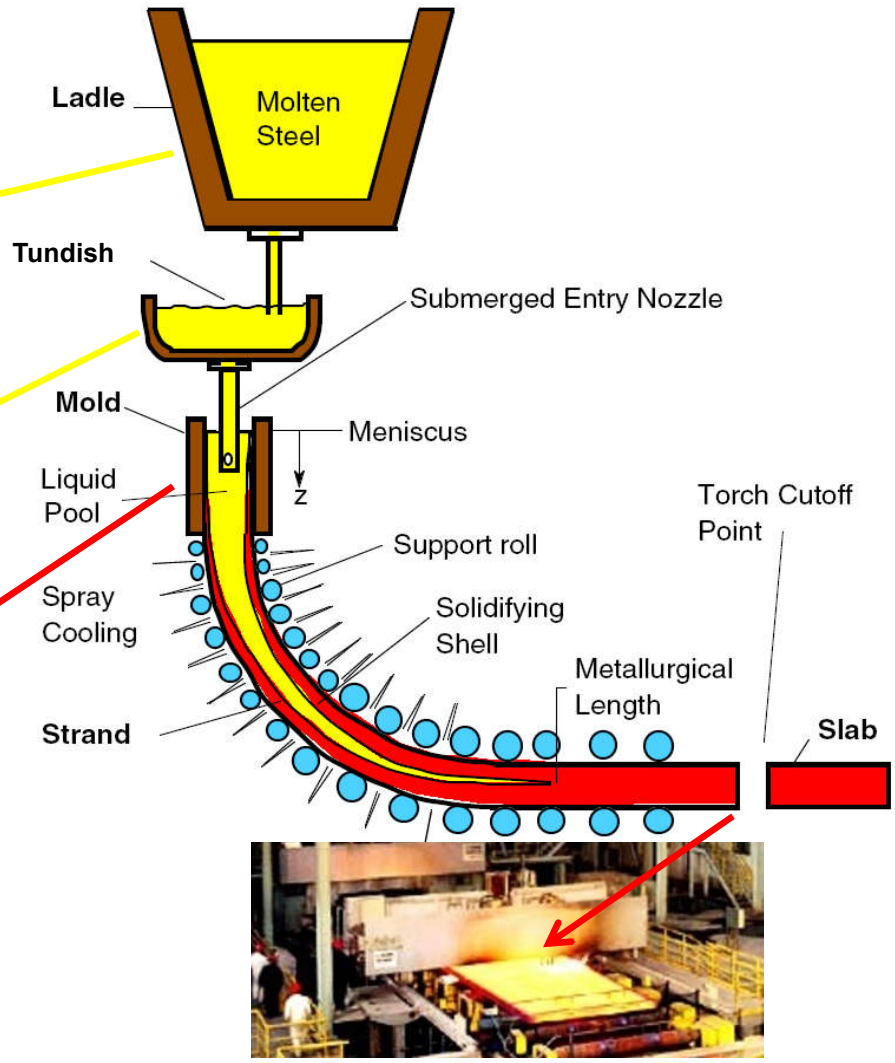
- All slabs are the same thickness
- Slab widths vary from 40 to 124 in.
- Tundish maintains steel flow to mold while changing ladles
- Must stop caster for width and significant grade/chemistry changes
- Cast Sequence is a series of heats cast together without stopping the caster

cut Slabs: typically 5 -7 per Heat

B. G. Thomas, Encyclopedia of Advanced Materials, Vol. 2, 2001, p. 8

Continuous Slab Casting



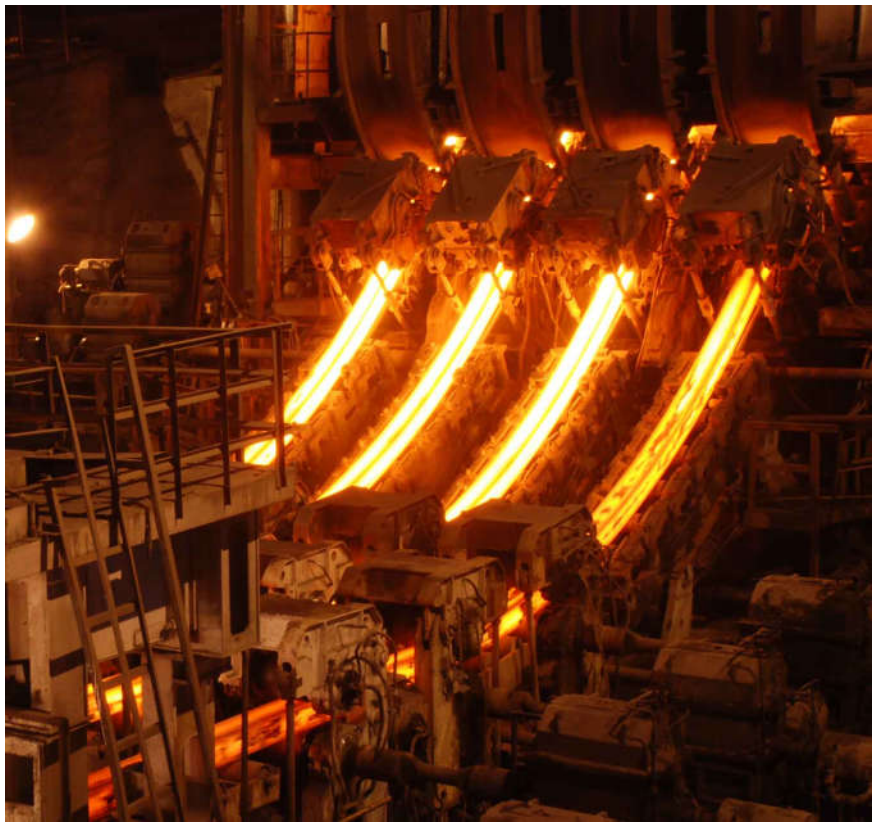


B. G. Thomas, Encyclopedia of Advanced Materials, Vol. 2, 2001, p. 8

Other Steel Casting - Near Net Shape Casting of Beam Blanks

Primetals Technologies (primetals.com)

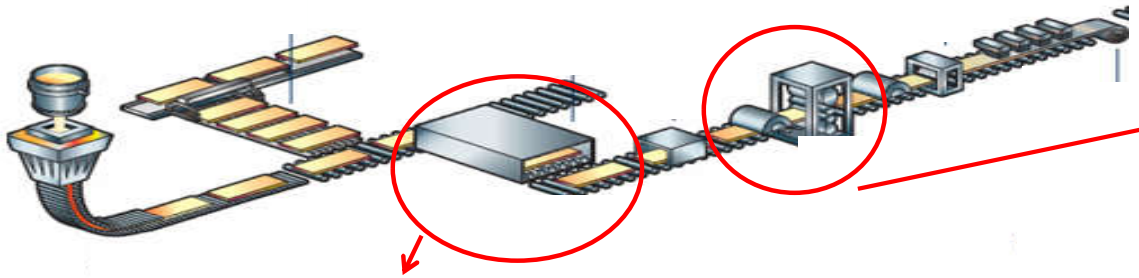
Other Steel Casting – Blooms and Billets



vizagsteel.com

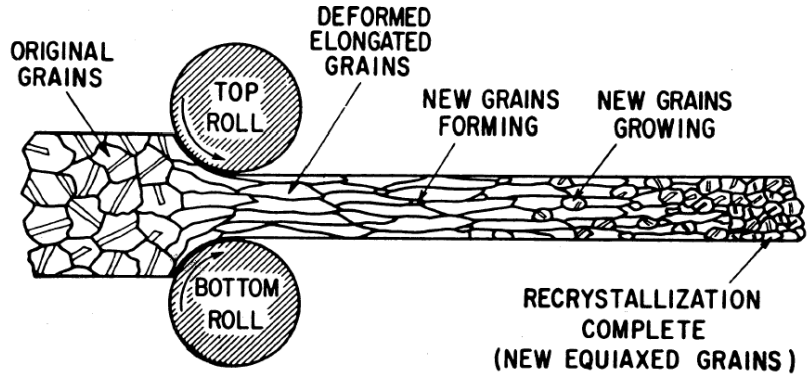
sms-group.com)

Reheating and Rolling



Reheat Furnace: heat slab to proper rolling temperature 2100 – 2350°F

Rolling Mill: reduce the slab to the ordered thickness and develop the specified properties during rolling and cooling

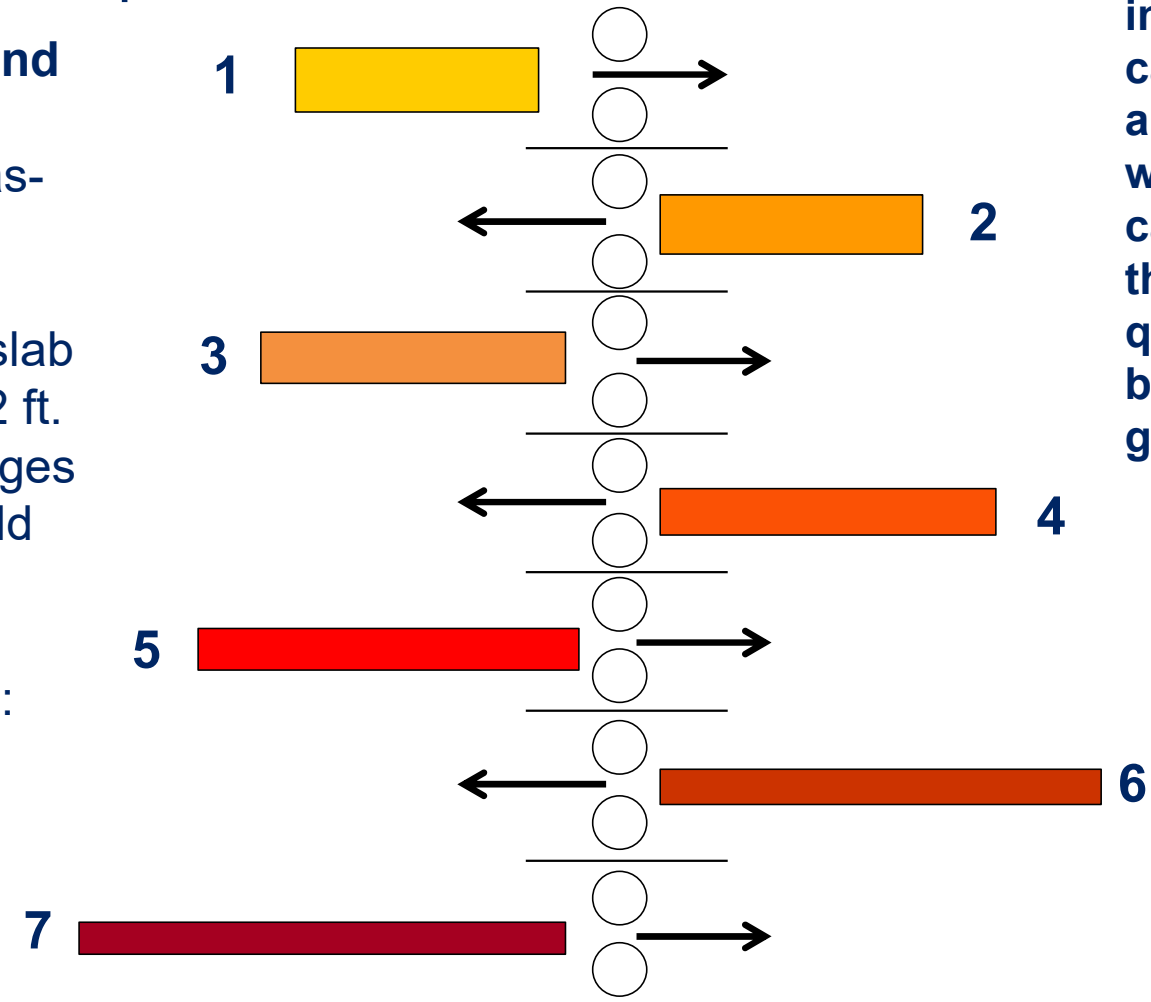


Rolling slabs into plates

Schematic of **single stand reversing rolling mill** reduction of 6” slab to as-rolled 3” plate

In this example a 36 ft. slab would be rolled into a 72 ft. plate. At the thinner gauges much longer plates would be rolled from the same slab, which would take additional rolling passes:

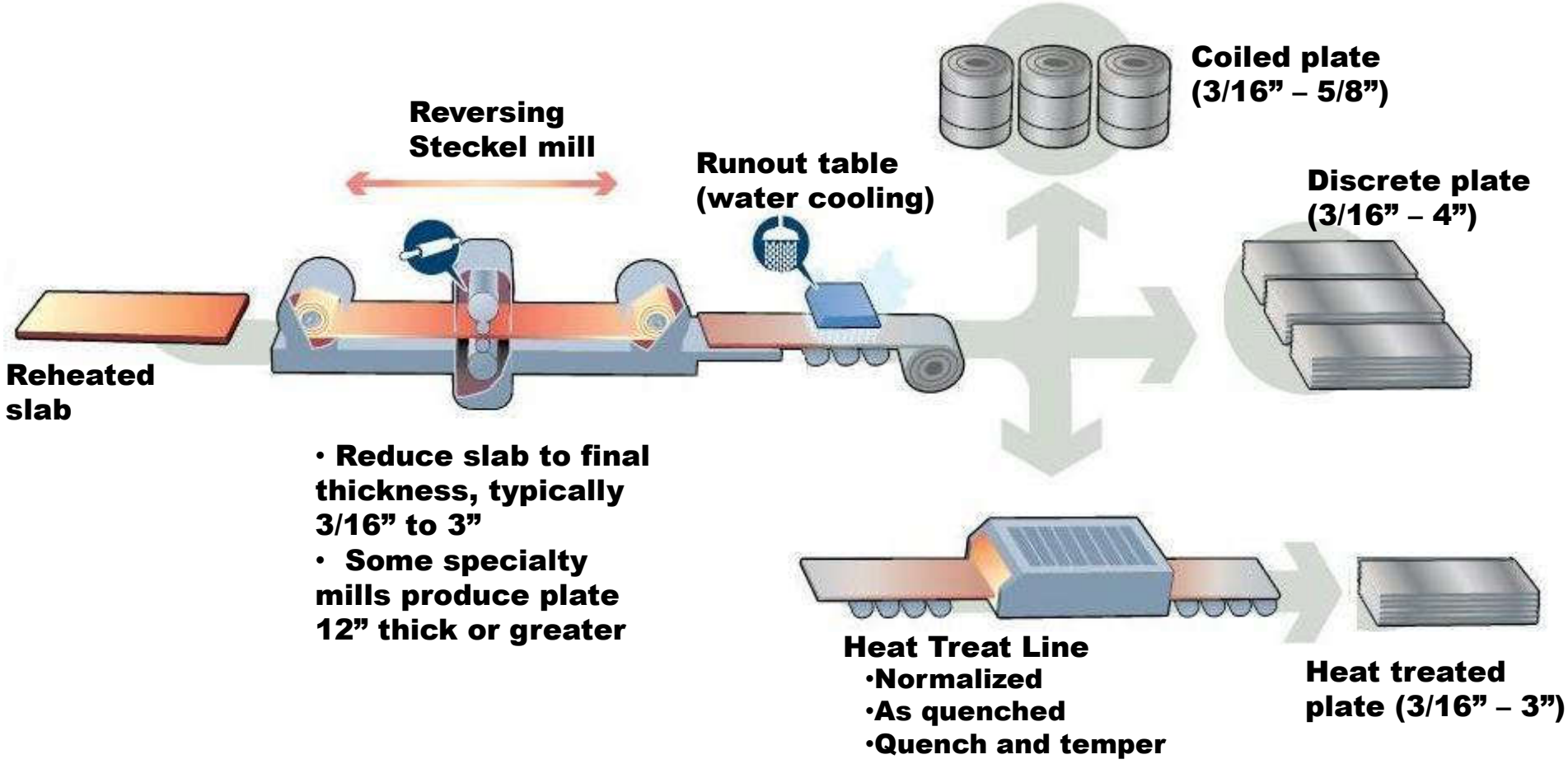
2” – 108 ft.
1” – 216 ft.
½” – 432 ft.
¼” - 864 ft.
$^{3}/_{16}$” - 1152 ft.



Note: an individual slab can be rolled to any thickness within the mills capability and is the smallest quantity that can be rolled to a given gauge

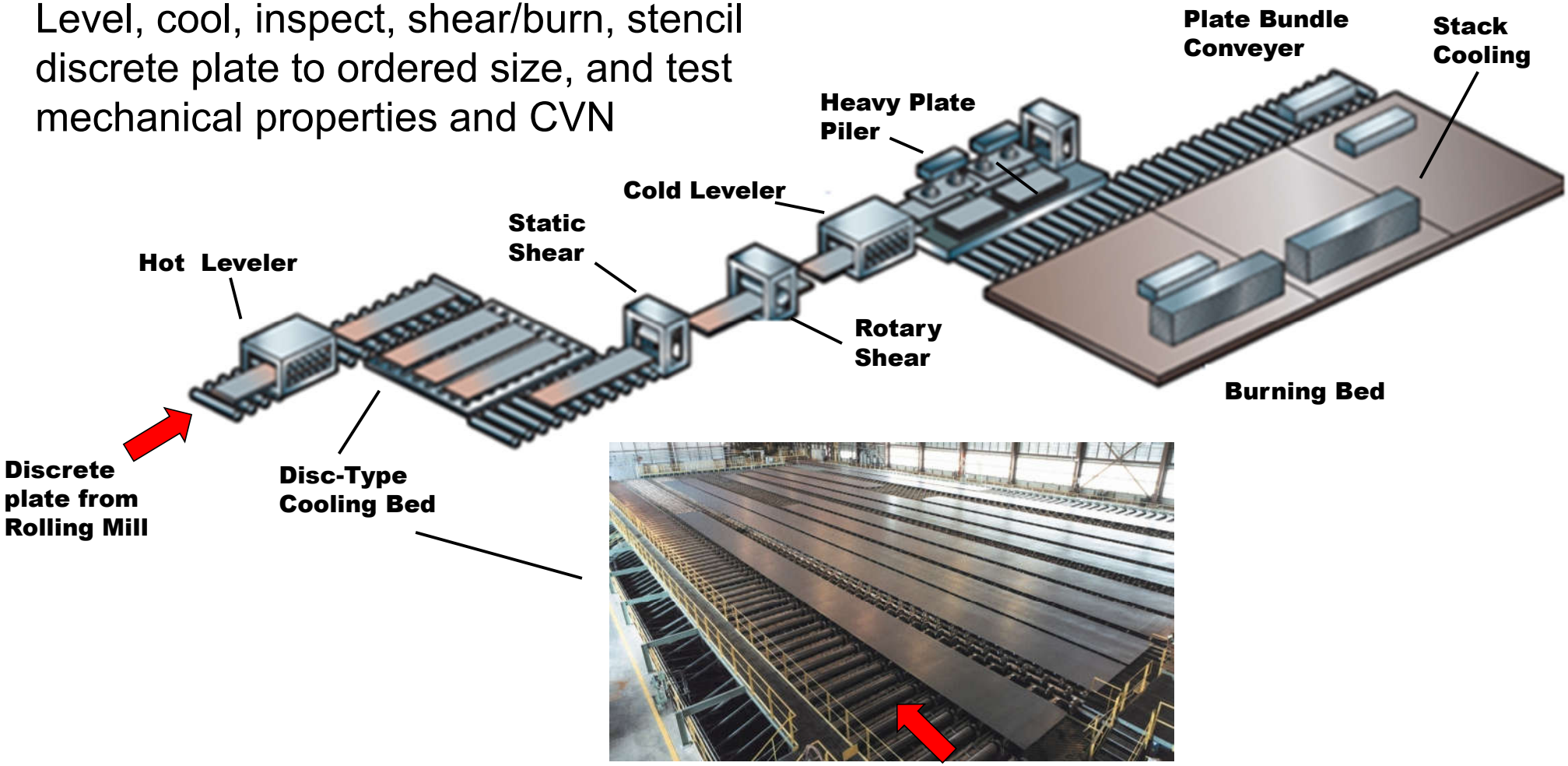
Plate Hot Rolling Mill

Reduce the 6 - 10 in. slab to the ordered thickness, develop required properties

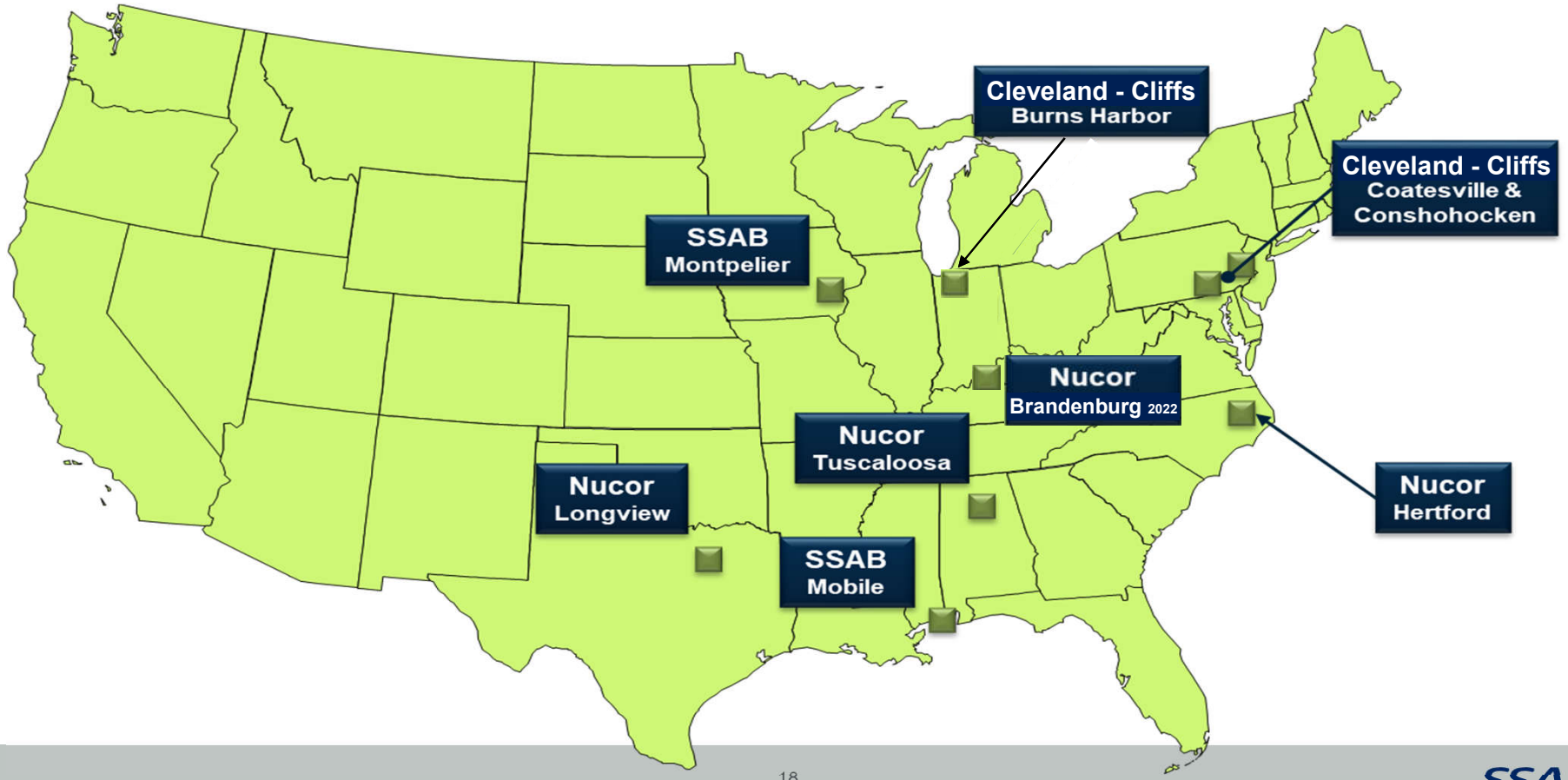


Finishing and Shipping

Level, cool, inspect, shear/burn, stencil discrete plate to ordered size, and test mechanical properties and CVN



Structural Plate Availability



Structural Shape Availability

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SSAB – Americas Plate Production Mills

- Scrap-based Electric Arc Furnace (EAF)
- Capacity of 1.25 million tons
- Capable of casting slabs from 60-120/123” wide for immediate in-line rolling into discrete plate
- Steel scrap can be converted to finished plate in a matter of hours

Montpelier, IA (1997)

Mobile, AL (2001)

Determination of Plate Dimensional Capabilities

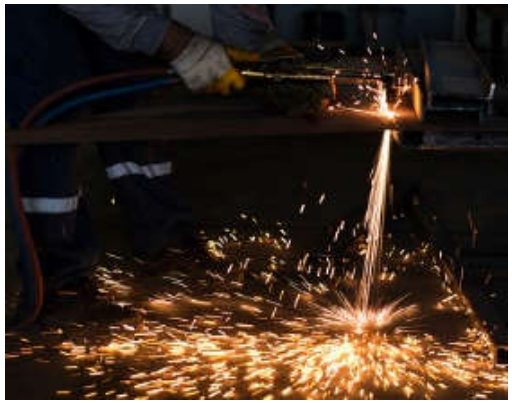
Physical mill limitations

- Width range - set by caster and rolling mill
- Length – set by shipping bay length
- Weight – set by shipping crane capacity
- Thickness – set by slab thickness and reduction ratio
  - Minimum of 2:1
- Heat treated plate may have additional dimensional / weight restrictions

https://www.chinacranemanufacturer.com/

Sampling and end cut loss

- If plate can be sheared inline – no sample loss
- Thicker plate must be torch cut off-line, lose 24” for 1 sample, 36” for 2 samples



https://media.istockphoto.com

Metallurgical limits to meet properties

SSAB ASTM A709 Bridge Plate Capabilities

A709-36, 50, 50W, HPS-50W

- 3/16 – 3” non-fracture critical
- 3/16 – 2” fracture critical (anticipate increasing thickness to 3”)
- Lengths up to 102 ft.
- Width: Montpelier 72” to 120”, Mobile 72” – 123”
- Max weight 73,000 lbs.

A709 HPS-70W

- 11/16 – 2” non-fracture critical & fracture critical
- Lengths up to 100 ft. (11/16 – 1.25”)
- Lengths up to 92 ft. (1.25” – 2.0”)

Ordered Plate Width (in.)

Maximum Plate Length (in.) / Ordered Plate Thickness (in.)	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
3/8"	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224	1224
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2-1/2"	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1187	1173	1159	1146	1133	1120	1107	1095	1083	1071	1060	1049	1037	1027	1016	1006	995	985	976	966	957	947	938	929	921	912	904	895	887	879	871	864	856	849	841	834
2-5/8"	1200	1200	1200	1200	1200	1200	1200	1200	1200	1187	1172	1157	1143	1130	1116	1103	1090	1078	1066	1054	1042	1030	1019	1008	997	987	977	966	957	947	937	928	919	910	901	892	884	876	867	859	852	844	836	829	821	814	807	800	793
2-3/4"	1200	1200	1200	1200	1200	1192	1176	1161	1146	1132	1117	1104	1090	1077	1064	1052	1040	1028	1016	1005	993	982	972	961	951	941	931	921	912	903	894	885	876	867	859	851	843	835	827	819	812	804	797	790	783	776	769	763	756
2-7/8"	1200	1200	1186	1170	1154	1139	1124	1109	1095	1081	1068	1055	1042	1029	1017	1005	993	982	971	960	949	939	928	918	909	899	890	880	871	862	854	845	837	829	821	813	805	797	790	783	775	768	761	755	748	741	735	728	722
3"	1168	1151	1135	1120	1105	1090	1076	1062	1049	1035	1022	1010	997	985	974	962	951	940	929	919	909	899	889	879	870	861	852	843	834	826	817	809	801	793	785	778	770	763	756	749	742	735	729	722	716	709	703	697	691

Ordered Plate Width (in.)

Actual Plate Weight (tons) / Ordered Plate Thickness (in.)	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
3/8"	4.7	4.8	4.8	4.9	4.9	5.0	5.1	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	5.7	5.8	5.9	5.9	6.0	6.1	6.1	6.2	6.2	6.3	6.4	6.4	6.5	6.6	6.6	6.7	6.8	6.8	6.9	7.0	7.0	7.1	7.2	7.2	7.3	7.4	7.4	7.5	7.5	7.6	7.7	7.7	7.8
7/16"	5.5	5.5	5.6	5.7	5.8	5.8	5.9	6.0	6.1	6.2	6.2	6.3	6.4	6.5	6.5	6.6	6.7	6.8	6.8	6.9	7.0	7.1	7.1	7.2	7.3	7.4	7.4	7.5	7.6	7.7	7.7	7.8	7.9	8.0	8.0	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.7	8.8	8.9	9.0	9.0	9.1
1/2"	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.2	10.3	10.4
9/16"	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7
5/8"	7.8	7.9	8.0	8.1	8.2	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0
11/16"	8.6	8.7	8.8	8.9	9.1	9.2	9.3	9.4	9.5	9.7	9.8	9.9	10.0	10.1	10.3	10.4	10.5	10.6	10.7	10.9	11.0	11.1	11.2	11.3	11.5	11.6	11.7	11.8	11.9	12.1	12.2	12.3	12.4	12.5	12.6	12.8	12.9	13.0	13.1	13.2	13.4	13.5	13.6	13.7	13.8	14.0	14.1	14.2	14.3
3/4"	9.4	9.5	9.6	9.8	9.9	10.0	10.2	10.3	10.4	10.5	10.7	10.8	10.9	11.1	11.2	11.3	11.5	11.6	11.7	11.8	12.0	12.1	12.2	12.4	12.5	12.6	12.8	12.9	13.0	13.1	13.3	13.4	13.5	13.7	13.8	13.9	14.1	14.2	14.3	14.4	14.6	14.7	14.8	15.0	15.1	15.2	15.4	15.5	15.6
13/16"	10.2	10.3	10.4	10.6	10.7	10.9	11.0	11.1	11.3	11.4	11.6	11.7	11.8	12.0	12.1	12.3	12.4	12.6	12.7	12.8	13.0	13.1	13.3	13.4	13.5	13.7	13.8	14.0	14.1	14.2	14.4	14.5	14.7	14.8	14.9	15.1	15.2	15.4	15.5	15.7	15.8	15.9	16.1	16.2	16.4	16.5	16.6	16.8	16.9
7/8"	10.9	11.1	11.2	11.4	11.5	11.7	11.8	12.0	12.1	12.3	12.5	12.6	12.8	12.9	13.1	13.2	13.4	13.5	13.7	13.8	14.0	14.1	14.3	14.4	14.6	14.7	14.9	15.0	15.2	15.3	15.5	15.6	15.8	15.9	16.1	16.2	16.4	16.6	16.7	16.9	17.0	17.2	17.3	17.5	17.6	17.8	17.9	18.1	18.2
1"	12.5	12.7	12.8	13.0	13.2	13.4	13.5	13.7	13.9	14.1	14.2	14.4	14.6	14.8	14.9	15.1	15.3	15.4	15.6	15.8	16.0	16.1	16.3	16.5	16.7	16.8	17.0	17.2	17.4	17.5	17.7	17.9	18.1	18.2	18.4	18.6	18.7	18.9	19.1	19.3	19.4	19.6	19.8	20.0	20.1	20.3	20.5	20.7	20.8
1-1/8"	14.1	14.3	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.5	18.7	18.9	19.1	19.3	19.5	19.7	19.9	20.1	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7	21.9	22.1	22.3	22.5	22.6	22.8	23.0	23.2	23.4
1-1/4"	15.6	15.8	16.1	16.3	16.5	16.7	16.9	17.1	17.4	17.6	17.8	18.0	18.2	18.4	18.7	18.9	19.1	19.3	19.5	19.7	20.0	20.2	20.4	20.6	20.8	21.0	21.3	21.5	21.7	21.9	22.1	22.3	22.6	22.8	23.0	23.2	23.4	23.6	23.9	24.1	24.3	24.5	24.7	24.9	25.2	25.4	25.6	25.8	26.0
1-3/8"	17.2	17.4	17.7	17.9	18.1	18.4	18.6	18.9	19.1	19.3	19.6	19.8	20.0	20.3	20.5	20.8	21.0	21.2	21.5	21.7	22.0	22.2	22.4	22.7	22.9	23.1	23.4	23.6	23.9	24.1	24.3	24.6	24.8	25.1	25.3	25.5	25.8	26.0	26.3	26.5	26.7	27.0	27.2	27.4	27.7	27.9	28.2	28.4	28.6
1-1/2"	18.7	19.0	19.3	19.5	19.8	20.0	20.3	20.6	20.8	21.1	21.3	21.6	21.9	22.1	22.4	22.6	22.9	23.2	23.4	23.7	24.0	24.2	24.5	24.7	25.0	25.3	25.5	25.8	26.0	26.3	26.6	26.8	27.1	27.3	27.6	27.9	28.1	28.4	28.6	28.9	29.2	29.4	29.7	29.9	30.2	30.5	30.7	31.0	31.2
1-5/8"	20.3	20.6	20.9	21.2	21.4	21.7	22.0	22.3	22.6	22.8	23.1	23.4	23.7	24.0	24.3	24.5	24.8	25.1	25.4	25.7	25.9	26.2	26.5	26.8	27.1	27.4	27.6	27.9	28.2	28.5	28.8	29.1	29.3	29.6	29.9	30.2	30.5	30.7	31.0	31.3	31.6	31.9	32.2	32.4	32.7	33.0	33.3	33.6	33.8
1-3/4"	21.9	22.2	22.5	22.8	23.1	23.4	23.7	24.0	24.3	24.6	24.9	25.2	25.5	25.8	26.1	26.4	26.7	27.0	27.3	27.6	27.9	28.2	28.6	28.9	29.2	29.5	29.8	30.1	30.4	30.7	31.0	31.3	31.6	31.9	32.2	32.5	32.8	33.1	33.4	33.7	34.0	34.3	34.6	34.9	35.2	35.5	35.8	36.1	36.4
1-7/8"	23.4	23.8	24.1	24.4	24.7	25.1	25.4	25.7	26.0	26.4	26.7	27.0	27.3	27.7	28.0	28.3	28.6	29.0	29.3	29.6	29.9	30.3	30.6	30.9	31.2	31.6	31.9	32.2	32.5	32.9	33.2	33.5	33.8	34.2	34.5	34.8	35.1	34.8	35.1	35.4	35.7	35.8	35.8	35.8	35.8	35.8	35.7	35.7	35.7
2"	25.0	25.3	25.7	26.0	26.4	26.7	27.1	27.4	27.8	28.1	28.5	28.8	29.2	29.5	29.9	30.2	30.5	30.9	31.2	31.6	31.9	32.3	32.6	33.0	33.3	33.7	34.0	34.4	34.7	35.1	35.4	35.8	36.1	36.4	36.5	36.5	36.5	35.8	35.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7
2-1/8"	26.0	26.4	26.8	27.1	27.5	27.8	28.2	28.6	28.9	29.3	29.7	30.0	30.4	30.7	31.1	31.5	31.8	32.2	32.5	32.9	33.3	33.6	34.0	34.4	34.7	35.1	35.4	35.8	35.8	35.8	35.8	35.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.6	35.6	35.6
2-1/4"	27.6	27.9	28.3	28.7	29.1	29.5	29.9	30.2	30.6	31.0	31.4	31.8	32.2	32.5	32.9	33.3	33.7	34.1	34.5	34.8	35.2	35.6	35.8	35.8	35.8	35.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6
2-3/8"	29.1	29.5	29.9	30.3	30.7	31.1	31.5	31.9	32.3	32.7	33.1	33.5	33.9	34.4	34.8	35.2	35.6	35.8	35.8	35.8	35.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.5	35.5	35.5
2-1/2"	30.6	31.1	31.5	31.9	32.3	32.8	33.2	33.6	34.0	34.5	34.9	35.3	35.7	35.8	35.8	35.8	35.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5
2-5/8"	32.2	32.6	33.1	33.5	33.9	34.4	34.8	35.3	35.7	35.8	35.8	35.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.4	35.4	35.4
2-3/4"	33.7	34.2	34.6	35.1	35.6	35.8	35.8	35.8	35.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4
2-7/8"	35.2	35.7	35.8	35.8	35.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.3	35.3	35.3
3"	35.8	35.8	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.6	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3

Plate length and weight limits:

(white box) Maximum plate length 1224 in., maximum plate weight 73,000 lbs, end crops and sample can be sheared inline.

(grey box) Maximum plate length 1200 in., maximum plate weight (73,000 lbs - 24 in. of product loss), end crops and samples may/must be torch cut off line.

The Bill of Materials (BOM), Inquiry, and Quote

1. Bridge Fabricators rationalize the flanges, webs, splice plates, stiffeners, cross frames and other bridge components into B.O.M. to send to mills.
   a. Fabricator adds width allowances for kerf and mill camber (3 – 4”)
   b. B.O.M. can vary by fabricator

2. Mill determines capability to produce (grade, thickness, length, etc.)

3. Mill rationalizes B.O.M into heats, slabs, and plates to be produced. This may be different than the original B.O.M. (Ex: offering 96” wide for 93” wide)

Example: Mill technical review of bridge inquiry

- Inquiry for A709-50T2 585 tons
- Rationalize inquired widths to “more producible” widths
- Determine percentage over inquired weight

item	pcs	width	gauge	ft	in	length	tons	Steel Mill’s offered width	Steel Mill’s offered width tons
1	12	74	0.625	90	8	1088	85.6	74	85.6
2	12	74	0.625	94	0	1128	88.7	74	88.7
3	24	74	0.625	64	4	772	121.5	74	121.5
4	2	98	0.75	90	8	1088	22.7	108	25.0
6	2	98	1	90	8	1088	30.2	108	33.3
7	6	90	1.75	94	0	1128	151.1	90	151.1
8	3	74	0.75	85	6	1026	24.2	74	24.2
9	3	74	0.75	43	0	516	12.2	74	12.2
10	3	74	1	85	6	1026	32.3	74	32.3
11	3	74	1	43	0	516	16.2	74	16.2

584.7 tons 590.1 tons

0.92% over weight

From Inquiry to Shipment – How a Bridge Order Happens

4. Sales develops pricing based on current market, consist of base price (A36) plus adders for grades, testing, dimensions, etc.

5. Offer for B.O.M. (rationalized) with pricing and current lead time summited to customer.
   a. Lead time a function of market, current mill capacity, etc.

6. Customer accepts offer, becomes an order.

Inquiry to Shipment – How a Bridge Order Happens (cont'd)

7. Mill puts order into melting/casting schedule to maximize efficiency

   a. Based on chemistry. A709-50/50W have multiple chemistries depending on product thickness.

   b. Based on width. Caster has limited or no ability to change width on the fly. 120", 96", and 72" will all be cast at different times (sequences).

8. Mill puts order into rolling schedule to maximize efficiency.

https://www.bloombergquint.com/business

   a. Based on thickness, grade and width.

   b. After rolling plates are cut to order, sampled and tested.

Inquiry to Shipment – How a Bridge Order Happens (cont'd)

9. Plates are shipped to customer via rail or truck.
    a. Rail more efficient, larger, longer loads.
    b. Truck faster.

10. Aim: on time delivery (88%).
    a. All orders delivered with in 4 weeks of aim.

Want to learn More?

- Mill Tours (post COVID)
- Steelmaking Seminars/Webinars
- Provide PDHs
- Contact:
  - David Stoddard
    David.Stoddard@ssab.com
  - Tony Peterson
    Peterson@aisc.org