
SAUKVILLE MELTING PROCESS OVERVIEW
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How Charter Steel Saukville Melting Division produces steel billets for the rolling mill.
An overview of the process

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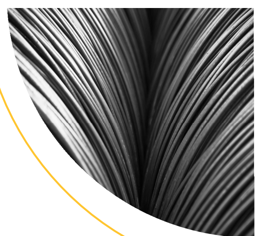
Introduction & Outline



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Charter Steel Saukville Melting (CSSM)

Basic information

First heat produced on September 13, 1991

2024 Good Tons produced: 528,191

Operating schedule: 24/7 with a scheduled weekly down day from 4-12 hours typically

Employees work a 5-2-2-5 base schedule, 12 hour shifts

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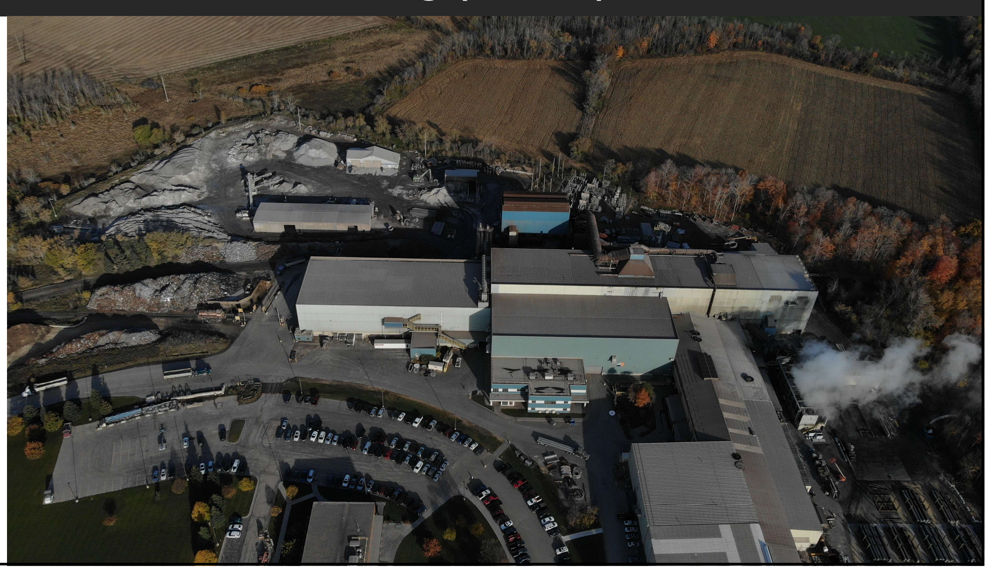

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Charter Steel Cleveland Melting (CSCM)

Basic information

First heat produced on June 15, 2006

2024 Good Tons produced: 507,487

Operating schedule similar to Saukville

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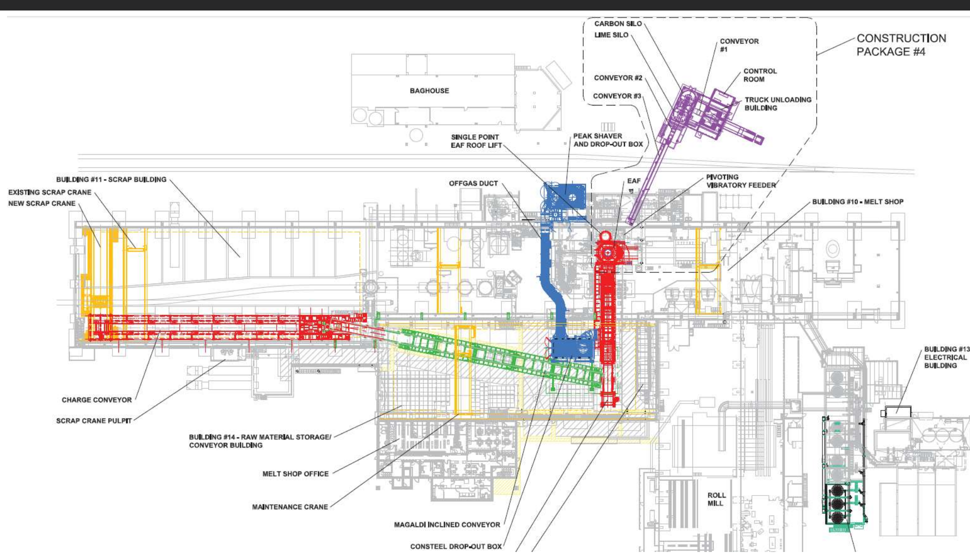
Saukville Melt Shop Layout



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Process Outline

- Scrap Building
- Primary Melting/Refining
- Ladle Refining
- Casting
- Billet Inspection/Handling

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Scrap / Iron Units

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CHARTER STEEL

Arriving Scrap

By truck and rail

About 85% of our scrap arrives by truck, 15% by rail

All arriving scrap must go through radiation detectors. These are backed up by hand-held units and other redundant systems.

Truck drivers are directed where to dump

Railcars are moved by our own personnel and unloaded by crane

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CHARTER STEEL

Busheling

Key scrap type

Trimmings from sheet stamping operations, etc.

Busheling is relatively low in metallic residuals (Cu, etc.)

Density low compared to other scrap types

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Bundles

Pressed scrap

Some busheling-type scrap gets pressed into bundles

This increases the density and improves handling/yield

CSSM uses 2 foot x 2 foot x 2 foot bundles, typically. They are usually charged in the bucket.

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Rail Scrap

Wheels and cut rail

Provide more density to mix

Fairly consistent chemistry

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Auto Shred

Recycled cars

Scrap suppliers run stripped, compacted automobiles through shredder that separates ferrous material from others

In spite of separation, some copper wires, etc. remain

Ideal density for a continuously-fed scrap charge, like we have in Saukville

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CHARTER STEEL

Shredded Clips

Similar to auto shred

Another type of shredded scrap

Old appliances, slitter scrap, etc.

Ideal density for continuous scrap feed

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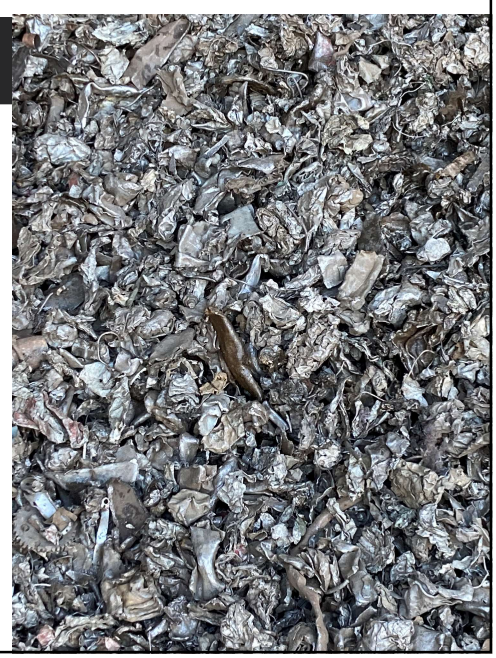

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CHARTER STEEL

Alloy Scrap

Segregating valuable scrap

Scrap and revert material known to have alloy content

Reduces need for other alloy additions

Typically used for 86XX and similar grades (nickel, chromium, and molybdenum ranges)

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CHARTER STEEL

Pig Iron

"Clean" iron units

Iron from blast furnaces that is poured off into "pigs"

Provides carbon (typically 4%) – foaming aid

Little to no metallic residuals – dilution

Takes extra energy to melt – density

Higher metallic percentage than other "clean" iron units such as hot briquetted iron (HBI)

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CHARTER STEEL

Loading Scrap

ROS (Remote Operating System)

The scrap crane operator uses the 34-ton scrap crane (primarily) to load scrap in buckets and on the charge conveyor per the scrap recipe

Operator has many camera views as well as the main furnace screen

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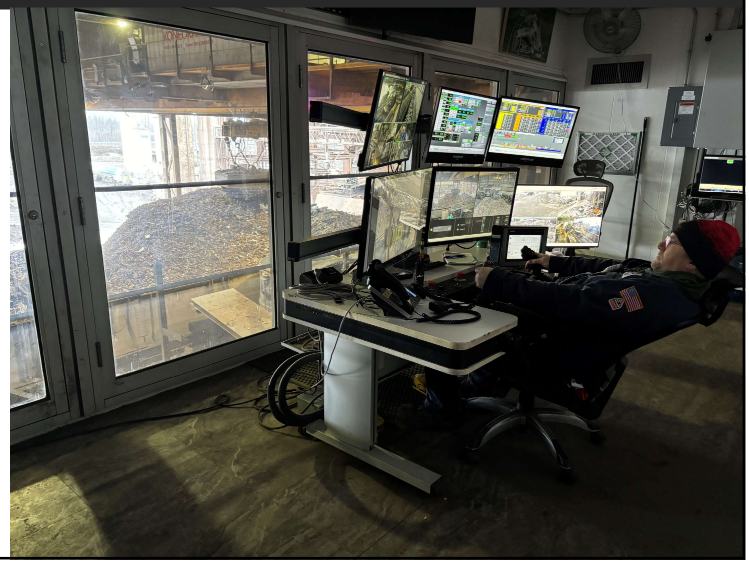

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CHARTER STEEL

Charge Buckets / Conveyor

Start of scrap charge

A 60-65,000 lb bucket is prepared to start each heat

Remaining scrap is loaded onto the charge conveyor

Slip/stick style conveyor to move the scrap forward

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Incline Conveyor

Through raw material warehouse

The incline (13°) conveyor moves the scrap up and drops it onto the preheat conveyor

Belt-type conveyor

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CHARTER STEEL

Preheat Conveyor

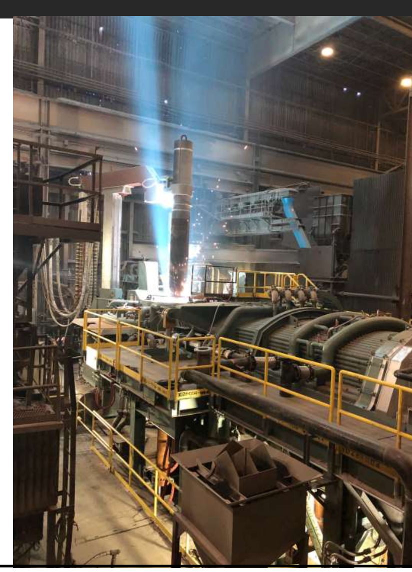
Preheating the scrap

Slip/stick style conveyor to move the scrap forward

The preheat conveyor uses off-gas from furnace to preheat the scrap to approximately 600°- 800° F

Experimented with air jet turbulators to further mix the gases through the scrap

Hoods/ducts are a combination of refractory-lined and water-cooled to control off-gas temperature



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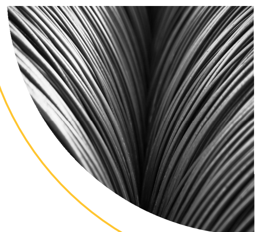
CHARTER STEEL

DC Furnace



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Furnace Process

Specific energy is key

Heel (50+ tons) remains in furnace

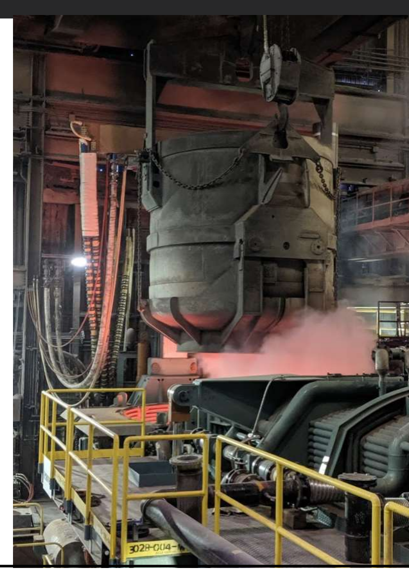
A smaller amount (7 – 10 tons, typical) is fed from the conveyor into the bath to help control bath temperature and volatility

The roof is opened and the bucket charge is dropped. Roof is closed and arcing begins.

Bucket step / Use of burners, then switching to carbon and HS oxygen

Consteel step / Resume scrap feed while continuing injection

Refining step / Continue injection to refine the heat



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CHARTER STEEL

Powering the Electric Arc Furnace (EAF)

Electric energy to melt

Saukville site is fed with 138 kV line, stepped down to 26.4 kV (for furnace) at our north substation

The furnace is powered by dual transformer/rectifiers

Operating power is 62 MW (620 V, 100* kA)

Direct current (DC): single electrode with pin bottom anode (40 pins are thermocoupled so we can monitor)

*Currently testing 105 kA

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Top Feed System

Slag formation

Carbon (anthracite) and dolomitic lime are top fed through the roof of the furnace to build slag and control its composition

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Inside the Furnace

Brick, panels, injectors

Bottom of furnace lined with refractory brick

Top of furnace uses water-cooled panels

Injectors angled downward from panels to treat the steel scrap/bath

- As natural gas burners
- For chemical reactions/energy

Also have one lime injector (hi-cal/dolo)

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CHARTER STEEL

Auto Sampler

Safe sampling of heat in furnace

Thermocouple probes for temperature (disposed)

Sampler tubes to collect “lollipop” samples to be sent by pneumatic tube to the lab for chemistry

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Chemistry Testing

CSSM Lab

Sample ("duckbill") is ground and the thicker part is run on an optical emission spectrometer (OES) for most elements

Photo is staged – door would normally be closed

A 1 gram punching is taken from the thin part to run on a Leco (combustion analysis) machine for nitrogen (these machines also test oxygen when needed)

Chemistry is sent back through the computer system to operators to verify chemistry is acceptable and to calculate alloy additions

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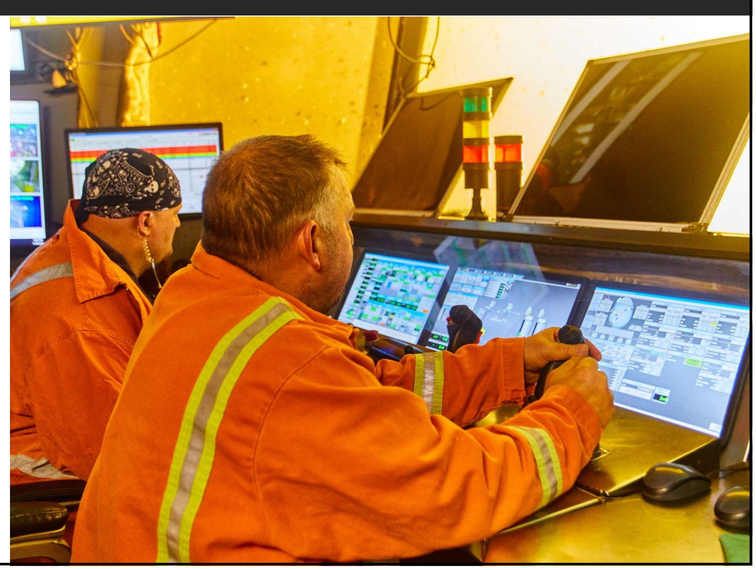
CHARTER STEEL

Ready to Tap

Reaching the end…

A heat is ready to tap from the furnace when

- The chemistry (somewhat generic) is verified as acceptable
- The free oxygen content of the furnace is above 500 ppm (C ~0.10%)
- The aim tap temperature is achieved (typically 3050° F)
- Ladle is in place, etc.



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CHARTER STEEL

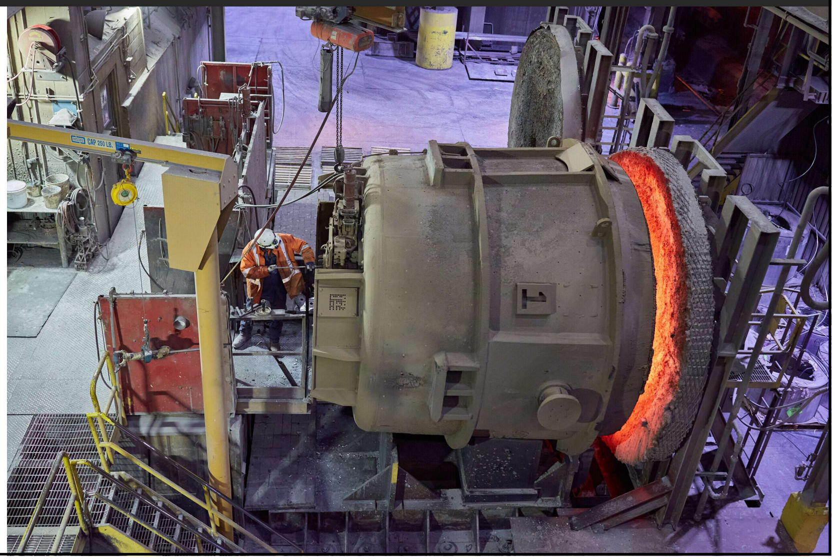
Ladles - Prep

Ready to tap steel into

Ladles are kept heated to around 1600° F to prevent heat loss and thermal shock to the brick

Nozzles and gates are maintained between heats

When ready, nozzle well is sanded to protect the gate plates



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Tap Additions…

…to the 100 tons in the ladle

Carbon from hopper (as needed)

Alloy from hopper for supersacks of other alloys (as needed)

Bulk alloy bins (ferrosilicon, silicomanganese, ferromanganese, ferrochromium, nickel) and other alloys in bags/drums loaded into car

Furnace gas Eccentric Bottom Tapping (EBT); synthetic slag added from hopper

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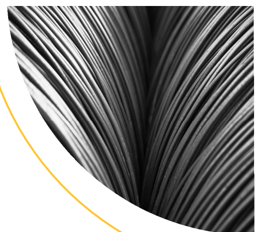
Vacuum Arc Degasser (VAD)



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CHARTER STEEL

Synthetic Slag

A lot more than dirt/dust

Argon stirring (using porous plug in the ladle) mixes steel and slag to aid in melting and consistency

The pre-mixed bag of synthetic slag contains hi-cal lime, dolomitic lime, silica sand, and fluorspar (for fluidity) to achieve a targeted ladle slag chemistry

The slag performs several key functions including insulation, sulfur removal, inclusion absorption, and coating the ladle brick

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CHARTER STEEL

VAD Process

Refining the heat

Additional heating is done due to temperature losses at tap / alloy additions

Chemistry sample to measure bulk addition

Trim chemistry and degas

Chemistry sample to measure trim addition

Boron heats require an in-process exit from the chamber for titanium (cored wire) addition

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CHARTER STEEL

Inside the VAD

Finkl-Mohr Degasser

Box-type degasser in which the ladle and car move into the chamber

Swing tracks / door

Chamber has two ladle positions: VAD/VOD

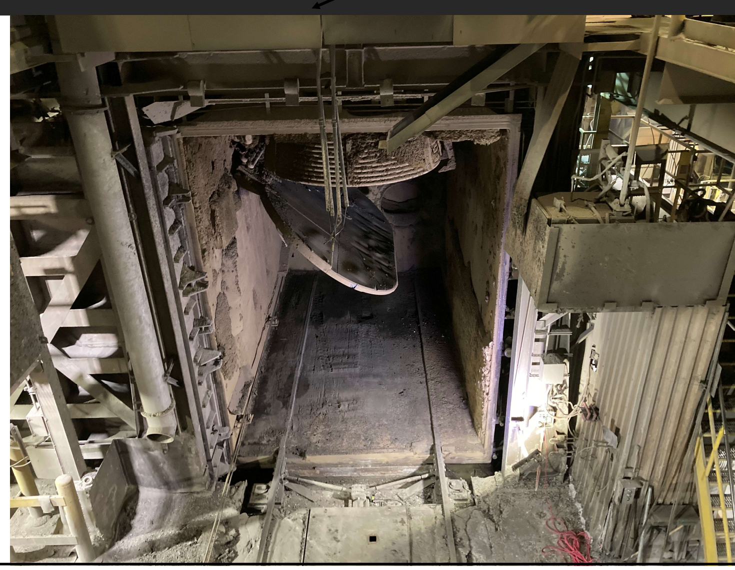
Ladle continues to stir with argon

AC electrodes to reheat

Vacuum to < 200 Torr

Safety wall for cleaning/maintenance

Carbon Storage Bin



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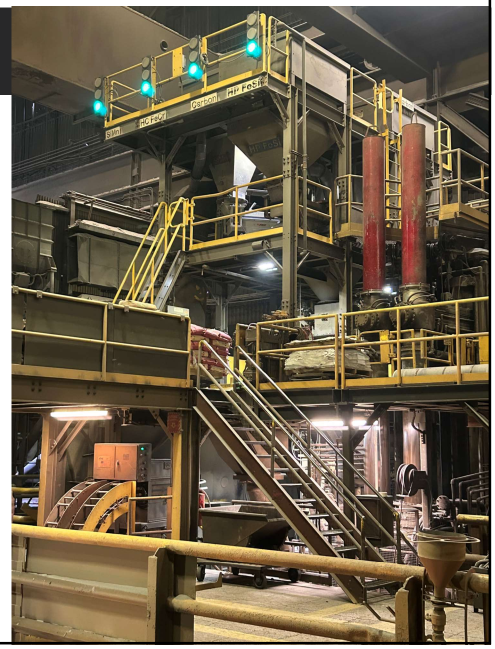
VAD Auto Alloy Addition System



Reducing Manual Additions

Four most common trim alloy additions at the VAD are now added with this system:

Carbon, Ferrosilicon, Silicomanganese, Ferrochromium

Weigh hopper loads automatically, sends to surge hopper

Other alloys (typically in 50 lb bags) added through separate surge hopper

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CHARTER STEEL

Exiting the VAD

Finishing the heat

Final carbon, sulfur, boron wire trim additions

Temperature using the west temp pole

Reduce stir to a gentle “rinse”

When ready, craneman picks up ladle and checks with vision system for hot spots, then proceeds to the caster tower

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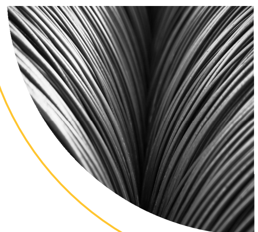
Continuous Caster



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Caster Process

Semi-finished steel

- Ladle opened, steel fills tundish
- Strands started, speed established
- Four-strand billet caster, casting on a 26’ radius
- Section size: 5.5” x 5.5”
- Cut to ~ 44’ length

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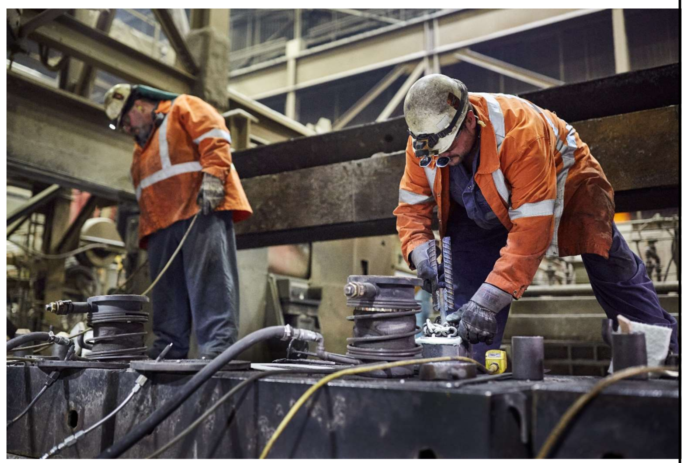
CHARTER STEEL

Caster Turnaround

Between casts

After the last cast has finished, operators will clean the molds, dress the dummy bar heads, verify aluminum wire targeting, and set the shrouds.

A new, preheated tundish is brought into place



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Ladle at Caster

Preparing to cast

Ladle is set in tower with crane

Hydraulic, argon, air hooked up

Ladle shroud / gasket attached using manipulator

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CHARTER STEEL

Tundish

Directing steel to the strands

Tundishes sprayed, dried off-line

When ready, tundish is preheated

Ladle stream targeted within center pad to limit turbulence

Cones around nozzles to gain height before opening

Tundish powder added when level reached

Typically cast with ~ 11 tons in tundish

Design has been *extensively* water modeled

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CHARTER STEEL

Tundish to Mold

Protecting the steam

Bellows-style shrouds between tundish and molds protect the steel stream coming through the metering nozzles

Automatic gates to shut off strand when finished casting

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Inside the Mold

Critical point in process

Mold level control

Oil lubrication

Oscillation (hydraulic)

EMS (dual coil)

Aluminum wire feed

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Copper Mold Tube

Heart of the casting machine

The copper mold tube is a highly engineered part of the caster, critical to product quality

Parameters that have been developed over the years include:

- type of copper
- coating on inside
- taper
- thickness, corner radius
- added machining to adjust cooling

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CHARTER STEEL

Starting the Process

Dummy bar – not what you think

Dummy bars are run up into the mold and the heads are dressed. They are then set in the mold to needed depth.

At start of cast, steel freezes to dummy bar head and the bar withdraws the strand from the mold.

After passing through the lower part of the caster, the tangent rolls engage and take over the strand withdrawal.

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CHARTER STEEL

Torches

Cutting the strand

Oxy-acetylene torches cut the crops at the start and end of each cast, as well as the individual billets.

The billets pass through a high-pressure descaler before reaching stops and getting moved onto cooling bed.

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CHARTER STEEL

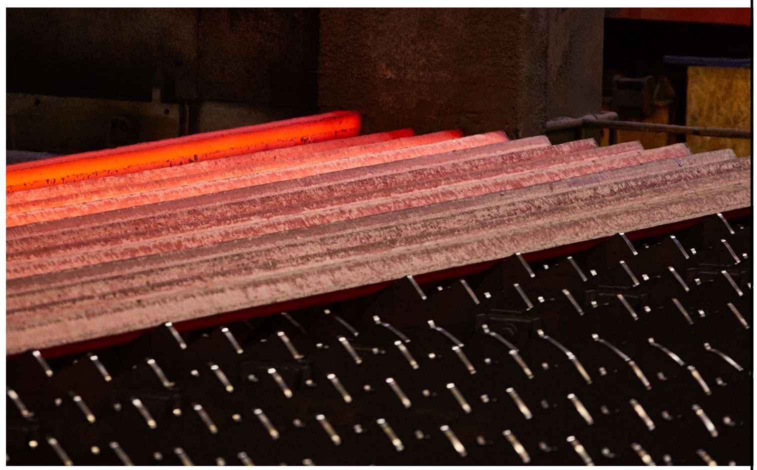
Cooling Bed

Keeping things straight

The rakes of the cooling bed move in order to rotate billets 90° each time

Billets continue to cool

Even cooling helps keeps them straight



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CHARTER STEEL

Sequence Casting

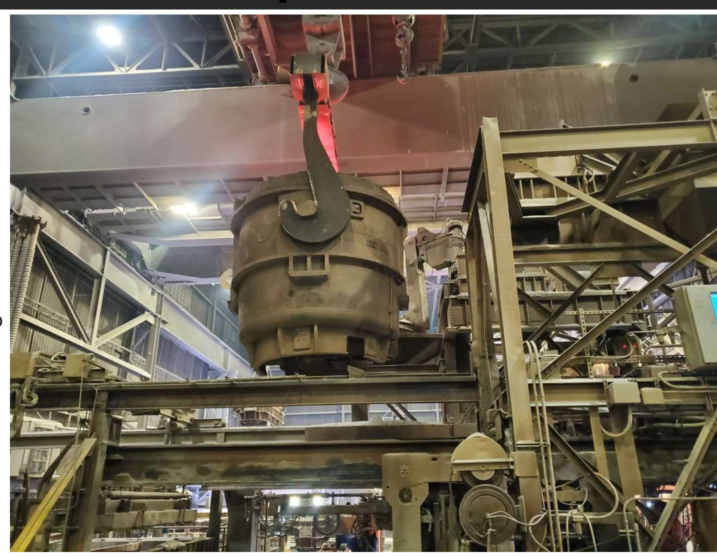
Carbon Storage Bin

Multiple heats through the same tundish, etc.

CSSM caster does not have a turret; must remove one heat and bring next one in

Tundish must begin to refill before minimum weight is reached

Only like / very similar grades are sequenced to avoid long intermix billets that get scrapped



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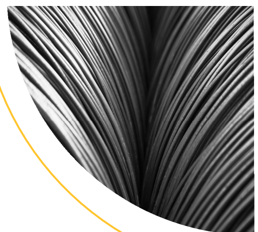
Billet Handling / Inspection



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Inside Billet Yard

Primary Billet Storage

Approximately 20,000 tons of inside billet storage

Billets moved using chains

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CHARTER STEEL

Outside Billet Yard

Additonal Billet Storage

Approximately 30,000 tons of additional billet storage

Billets moved in/out with a transfer car

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CHARTER STEEL

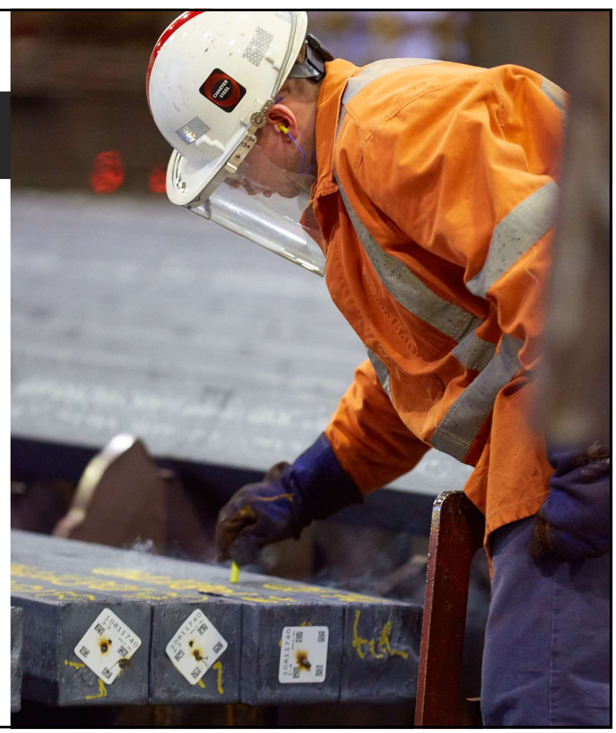
Billet Identification

Importance of traceability

Billets dropped off of the walking bed are identified with heat number as well as individual strand and billet number. Thus, each billet is uniquely identified (these are linked to coil number when rolled).

The numbers are written with a lumber crayon, and then a bar-coded tag is welded on.

Should any uncertainty arise about the identification of a billet, it gets scrapped.



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CHARTER STEEL

Heat Chemistry

Certification values

The three samples taken from the tundish are used to provide the certified chemistry for the heat.

As CSSM adds aluminum in the mold, the final aluminum value for the heat must come from samples from the cast.

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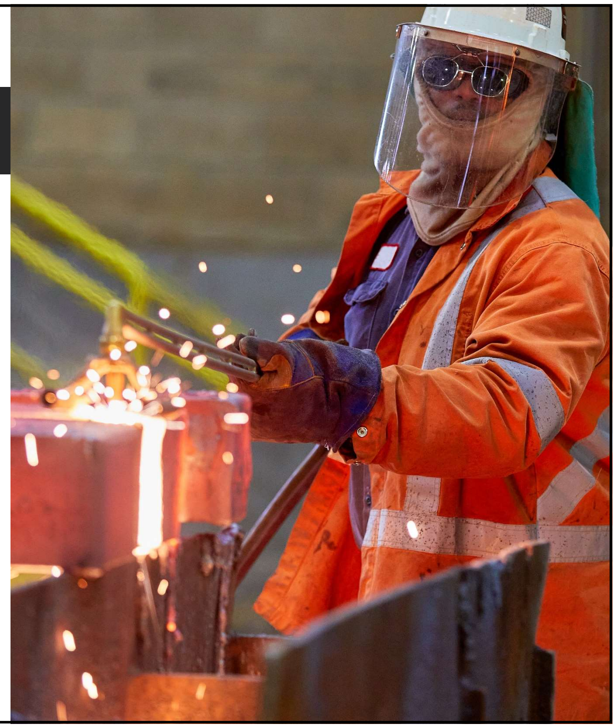

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Billet Inspection

Targeted inspection of surface

Depending upon steel grade, quality level, and the caster quality model, billets are selected for inspection.

Billets are inspected visually for cracks, pinholes, “reox,” casting laps, and other anomalies.

Cracks are rejected

Others are ground out by hand

Data also provides some feedback to our process

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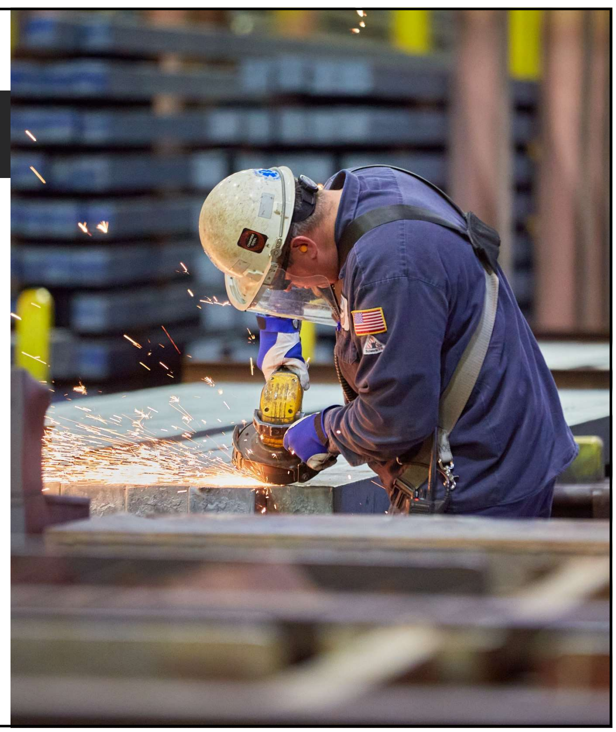

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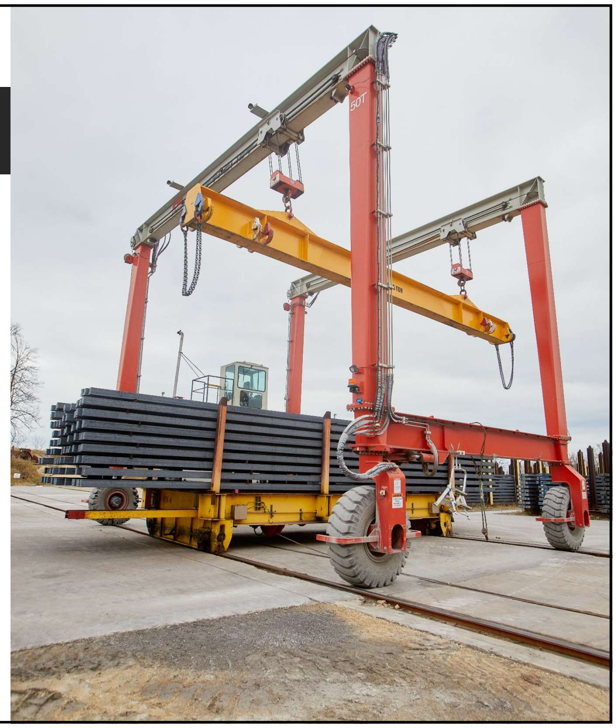
Moving Billets Outside

Mobile gantry crane

If billets are to be moved outside, they are loaded on a transfer car that travels between the inside and outside billet yards.

A rubber-tired gantry crane then lifts the billets and takes them to the outside storage racks.



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Loading the Skid Bed

Start of Rolling

Billet Haulers retrieve billets from yard per rolling schedule and bring them to the skid bed to be charged into the reheat furnace.

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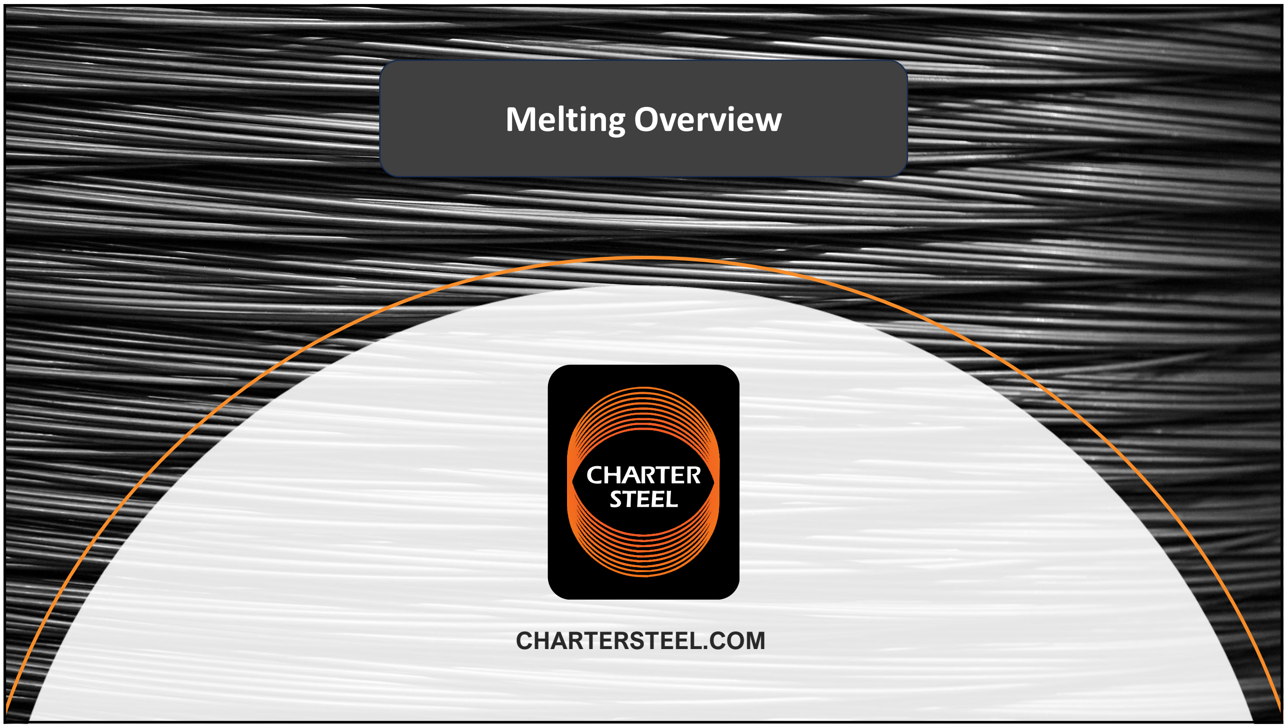

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