The Korean Society for Railway

Railway Seminar in Kyungju University

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„RAIL WELDING“

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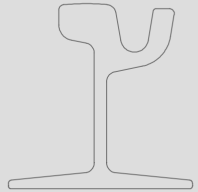
Rail welding at TKW

- Rail types,switch details and materials
- Methods used in turnout construction
  - Flash butt welding - RA
  - Flux cored welding – MF
- New development
  - Electron beam welding - EB

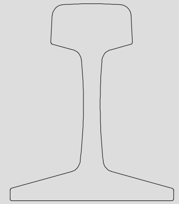
Rail types - profiles

The rails used in turnout construction are

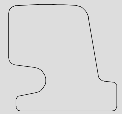
•Grooved rails (e.g. Ri 60 N, Ri 59 N)



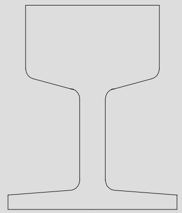
•Flat bottom rails (e.g. UIC 60, S54)



•Switch blade or tongue rail profiles (e.g. Zu1-60, Fz36)



•plus various engineering profiles such as D180/105 or VkRi 60

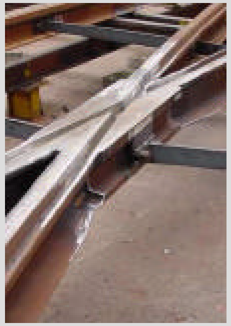


Rail types – switch details

From these rail types the different construction units of a switch are manufactured:

Deflecting device

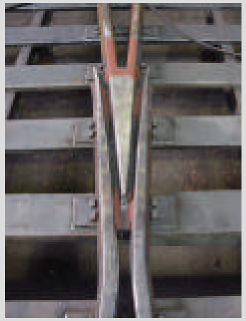
Switch for underground light rail



Crossing, grooved rail

Deflecting device

Switch for Railway



Crossing, flat bottom rail

Rail types - materials

The profiles are made from different steel grades depending on train speed, axle load and train sequence. These are generally carbon steels governed by UIC 860 V.

The table below shows the chemical composition and mechanical properties of such steels.

Grade	Chemical composition				Mech. properties	
	C %	Si %	Mn %	P + S %	Tensile strength N/mm²	Elongation at fracture %
700	0.4-0.6	0.05-0.35	0.8-1.25	<0.05	>680	>14
900 A	0.6-0.8	0.1-0.5	0.8-1.3	<0.04	>880	>10
900 B	0.5-0.75	0.1-0.5	1.3-1.7	<0.04	>880	>10
1100	0.6-0.8	<0.9	0.8-1.3	<0.03	>1080	>9

Rail steels – particular requirements

Due to their high carbon (<0.6%) and manganese (<0.8%) contents, rail materials are susceptible
to critical hardening which can result in stress cracking under load.

Problem ⇩

Heating, e.g. during welding, causes a change in the material's microstructure. Cooling too quickly then results in the formation of martensite. This martensitic microstructure is characterized by high hardness and low toughness.

Solution ⇩

Martensite formation can only be prevented by keeping below the critical max. cooling rate. This is achieved through heat control during the entire welding process. This includes preheating, possible intermediate heating and post-heating as well as corresponding temperature monitoring.

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Flash butt welding – RA – principle

Flash butt welding is a form of resistance welding. The ends of the workpieces to be joined are heated by electric current. The electricity is introduced to the two workpiece ends from a transformer via clamping jaws. The circuit is closed by the abutting ends.
Welding takes place by moving the workpieces together. It is important that the workpieces to be welded have the same profile.

The images below show the Siemens 120/1000 flash butt welder currently used in our Bochum plant.

Welding the switch blade profile Fz36 to standard profile Ri 60 with transitional profiling

Flash butt welding – RA – welding sequence

Facing: Surface irregularities are removed. The workpiece ends are moved together slowly until current flows at the points of contact. The high current density causes the projecting material to heat up, melt and then vaporize.

Preheating: The workpiece ends are reversed together at high speed until contact is made. Closing the circuit allows the electric current to flow and the high current density causes the parallel faces to heat up, though not yet to the stage of coalescence and flashing. After a time, the abutting surfaces are uniformly heated.

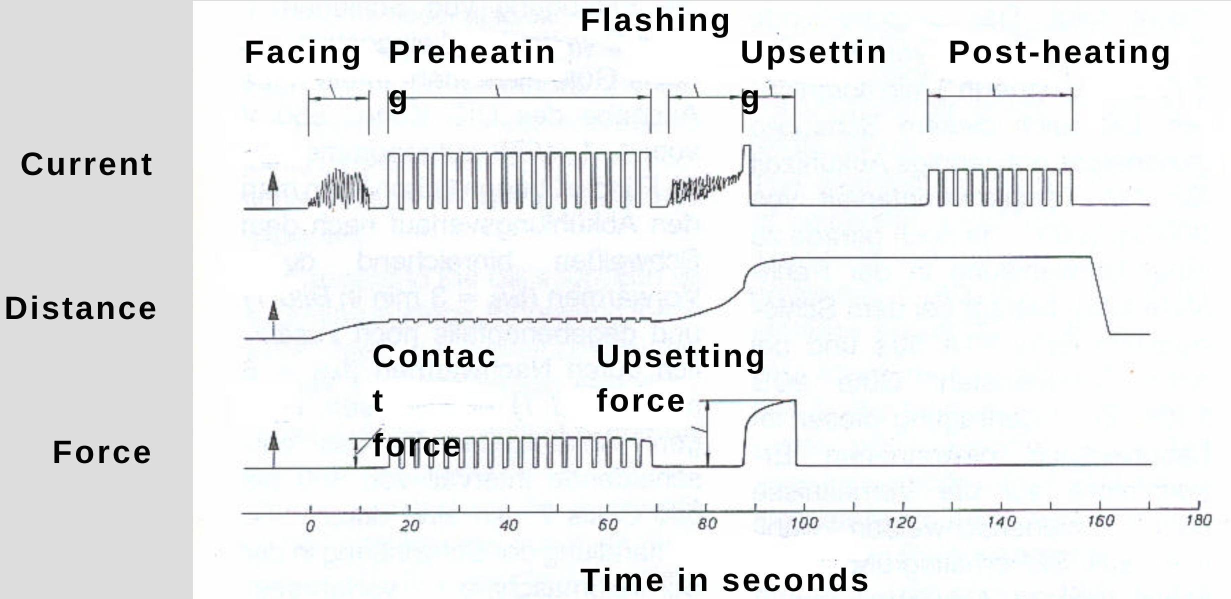
Flashing: The abutting ends are moved together slowly. The material melts and vaporizes. The metallic vapor forms a shield gas atmosphere which keeps air out of the joint and thus prevents oxidation. Other undesired inclusions are removed by the expulsion of material.

Upsetting: Upsetting force is then applied by moving the abutting faces together at velocities of up to 100 mm/s. The plasticized metal is expelled from the weld gap. The flash formed is later machined off. The upsetting force required depends on the cross section and the yield strength of the materials being welded.

Post-heating: Post-heating prevents the weld from cooling too quickly and the creation of a martensitic microstructure. ($t > t_{8/5\ krit}$).

Flash butt welding – RA – analysis and process control

The key process parameters are registered in a welding diagram.



Quality assurance measures:

- Analysis of **welding diagrams**
- PT or MT **surface crack inspection** plus **ultrasonic inspections**.
- **Regular destructive bending fracture tests are performed on specimen welds**.

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Flux cored welding – MF - principle and setup

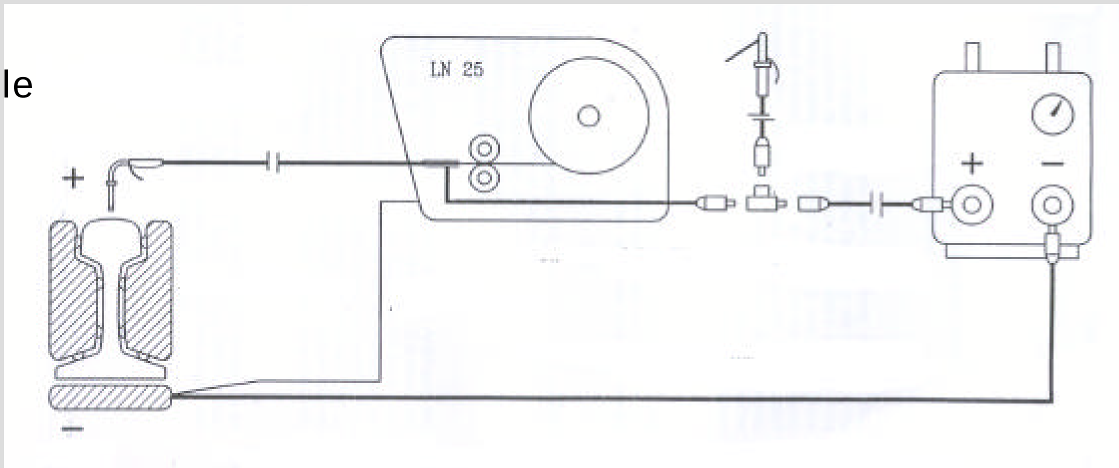
The MF method is an arc welding process. A flux cored wire electrode is continuously fed to the welding process from a wire feeder. The electrode contains slag- and shield gas-forming components which protect the weld pool from undesired external influences.

This method is used for all carbon steel rail profiles up to grade 900 (Tensile strength 880 N/mm^2)
The complete system for rail welding comprises:

manual welding torch, wire-guide with ceramic nozzle

Wire feeder with spool and drive rolls

Current source as rectifier with constant voltage characteristic

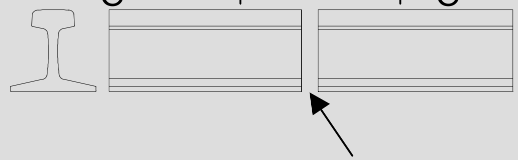


Flux-cored welding – MF - welding sequence

•The rail ends are cut by saw or torch in preparation for welding.

•The rails are aligned to 2-3 mm crown using a 1 m straightedge.

•The gap is set to 15-18 mm.

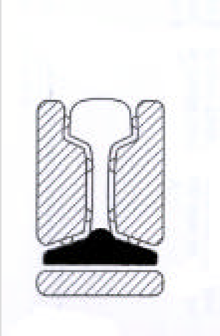


•The rail ends are each preheated to 100-150°C over a length of 100 mm and to approx. 100°C over a length of 500 mm.

•A copper plate is placed below the foot of the rail to back up the weld pool.

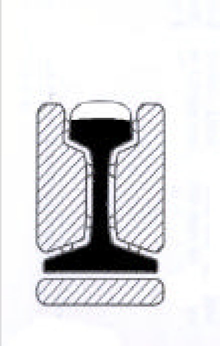
•The foot of the rail is welded in one pass. The seam is reinforced in the middle to guarantee slag runoff.

Flux-cored welding – MF - welding sequence



•Copper shoes are attached to the web to back up the weld pool. The shoes are
shaped to permit the slag to run off freely.

•Intermediate heating is provided if the temp. falls below 250° C.



•The web and ~2/3 of the head are welded. The seam is reinforced in the middle.

•The final 1/3 mm of the rail head are welded using a wear-resistant surfacing electrode.

•After removal of the copper shoes and the slag, cover passes are welded onto the rail foot.

Welding fillers used: NS 3 M, self-shielding flux cored electrode

SH 300 blue K, surfacing electrode

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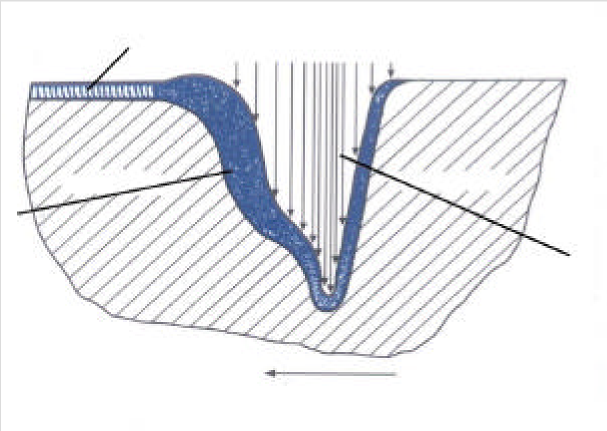
Electron beam welding - principle

The principle of electron beam welding is to create electrons through emission which are then accelerated by high voltage and subsequently focused via a magnetic lens. These bundled and accelerated electrons strike the workpiece to be welded and partially vaporize the material.

This creates a vapor cavity which bores its way into the workpiece and flows around the molten material, thus forming the weld. To avoid electron deflection, the process must take place in a vacuum.

solidified weld bead



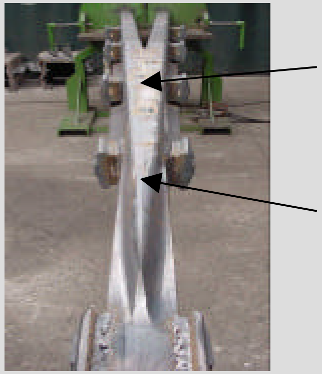
molten material, covering

vapor cavity

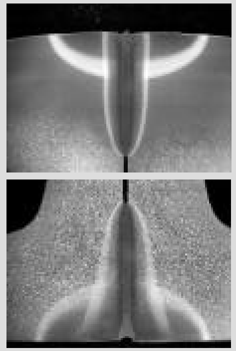
workpiece travel

Electron beam welding – application in turnout construction

In turnout construction, electron beam welding can be used as an alternative for cross-point manufacture.
Some flat-bottomed cross-points are manufactured using a combination of conventional welding methods. For this, two machined rails are welded together lengthways by manual electric welding.
The cross-point tip is then flash butt welded to this rail pair.



Electron beam welding can be used to substitute these steps. The rails are simply welded lengthways at the head and the foot.



Further technological properties:

•Seam depth max. 25mm, Welding speed ~8 mm/sec

•Narrow heat-affected zone for low distortion (<1 mm over 1900mm length),

•Automated process minimizes sources of error

Additionel development – monoblock deflecting devise

New on this design:

- The switch housing is manufactured from one monoblock part.
  Thus a high rigidity of the construction unit is reached

- The tongue rail is clamped.
  Thus the tongue rail is fast exchangeable and available in different Materials such as manganese or carbon steel