

CRANE RAIL WELDING AND RAIL STEELS

Rail Steels

Crane rail steels are formulated to give high wear resistance together with a suitable tensile strength. The strength ranges from 550N/mm² to 1100N/mm² but are typically in the range 600 to 900N/mm². These correspond to hardness of 185 to 280 Vickers Hardness Number HV. For heavier duty applications, the higher grades tend to be used. Steel producers use both tensile strength and hardness in their quality control checking of rails. However, they typically specify rails by tensile strength. The rail user requires the hardness of the rail and is normally less worried by tensile strength, other than as a means of proving the correct grade is in use.

Stresses in Crane Rails

There are four frequently encountered mounting systems for crane rails which influence the stress they must carry.

- *continuous rail on continuous steel support*
- *continuous rail on continuous elastomeric pad on continuous steel support.*
- *discontinuously rail supported on individual steel soleplates.*
- *discontinuously rail supported on elastomeric pad on individual soleplates.*

When rail is placed on a continuous steel support the support offers some very limited flexibility. However, the bending stresses in the rail will be low in comparison with the rails ability to carry stress. When the rail is placed on an elastomeric pad, it will bend below the wheel load. The extent of this bending has been studied and calculated in a number of research projects. The conclusions from these are that the bending stress in the rail is not of significance in relation to the strength of the rail

unless the pad is very soft. The Gantrail pad is designed to allow limited bending of the rail but its stiffness is controlled by the fluted top surface and the steel reinforcement.

It is not normal to consider the bending stresses in a rail for the cases where the rail is continuously supported. It is not practical or necessary to carry out such calculations in all cases. As has been stated, the rail strength is chosen to give the required hardness and not to achieve bending or tensile strength.

Rail Welding Methods

Rails steels have carbon contents which are very much higher than steels used for any other engineering purposes. Thus the welding techniques and consumables have developed to meet these needs. Two techniques are commonly used:

- *Puddle Arc (sometimes called Enclosed Arc)*
- *Thermit*

Two further methods are sometimes used, however, these are not commonly available or practical for site welding, thus they are briefly described here but thereafter not mentioned.

Flash butt welding. Commonly used for railway rail welding in steel mills before shipment. It requires thousands of amps current and hence heavy equipment. The rail ends are heated in light contact and when hot are forged together.

The Bethlehem process. Bethlehem Steel in the USA developed a rail welding procedure which is similar to conventional butt welding with a V preparation. It uses manual metal arc welding. It is not thought to be economical now.

The Puddle Arc or Enclosed Arc Method

Puddle Arc Welding was developed by Philips Welding, probably in the 1950's. The method was developed as a means for joining any large cross section steel items together. The welding of crane rails became a particular application which is now a specialist area. In the method the two rail ends to be joined are cut square and placed about 15mm apart. The base of the

rail at the gap has a copper strip placed beneath it and a mild steel strip of 3mm by 15mm section is placed on the copper. This strip prevents the arc of the welding process striking on the copper. Copper contamination of the weld metals could cause cracking. The strip is fully melted in the welding process and becomes alloyed with the weld metal. Thus the composition of the strip is not important, providing it does not contain significant impurities.

The welding process uses large diameter electrodes (5 or 6mm) and a high current. The process is to strike the arc on the rail ends and to melt the electrode and rail into a puddle of weld metal which is covered with liquid slag derived from the coating on the electrode. As the steel of the rail and characteristics of the flux are both very different from other welding processes, special electrodes have been developed for this process. While it is possible to use some conventional low hydrogen electrodes for puddle arc welding, it is strongly discouraged. The gap between the rail ends is filled in two stages normally. The foot of the rail is first welded. This is done run by run with the slag being chipped off after each run. Following this the remainder of the weld is completed. To prevent the puddle of weld metal and flux from flowing away from the weld, copper mould pieces are placed either side of the weld. The welding is continued to above the head of the rail and then it is ground back to form the final running surface for the crane wheel.

The precise procedure for puddle arc welding rails needs to be specified on the basis of the rail steel and the application details. The rail ends must be placed at a small angle to each other, (in the vertical plane). This is to allow for distortion due to shrinkage of the weld metal. The ends of the rails must be pre-heated to a temperature dependant on the carbon content of the steel. Some electrodes are not suitable for some carbon contents. See the Gantrail specifications. The completed weld may need to be cooled under controlled conditions, ie. insulated with a thermal blanket, depending on rail steel composition.

Puddle arc welds are never perfect. It is normal to entrain some slag and to have a limited degree of lack of fusion or undercut at the bottom. This cannot be inspected easily. It is wise to agree the quality control standards for production welds before work starts. The agreed standard should be based on trial welds or past experience.

Thermit Welding

In thermit welding a refractory mould is placed around the two square cut rails ends. The gap between the rail ends is about 15mm. The rail is preheated to a temperature dependant on the chemical composition of the rail and the precise welding process. A crucible containing a combustible powder, iron and alloying elements is placed above the mould. The powder is ignited and when it attains the correct temperature, it melts a plug and flows into the mould. The cooling and post weld heat treatment of the rail are chosen dependant on the rail material and the application.

Comparison of Thermit and Puddle Arc

Both the thermit and puddle arc processes are suitable methods for welding most grades of crane rails. The choice of method is normally dependant on local factors. Puddle arc is cheaper on its use of consumables. Thermit welding is quicker per joint. As there are normally two men to a thermit welding team, the manpower requirements of the two processes are similar. Thus overall puddle arc is cheaper. In some cases, thermit welding is considered to be potentially too dangerous to be undertaken above ground level. Puddle Arc is the most economical process for a small number of welds.

The weld metal quality of thermit welds is of high integrity compared with puddle arc welds. However, the performance of the two systems are both adequate as the fracture resistance of puddle arc weld metals is higher than that of thermit.

Rail Head Hardening

There are a number of situations when it can be beneficial to harden the head of the rail. The puddle arc process can tend to leave a soft spot at the rail head in the weld metal and adjacent to it. The design of container crane boom hinges and rail expansion joints results in the rail being split. This can mean that the crane or trolley wheel load is carried on half the rail head width. In these cases, the rail head can be hardened by using a welding process. The material of the head is removed by grinding down to 10, 15 or 20mm. Ideally, the cut is tapered or stepped and spread over 200 to 400mm of rail. The rail head is then built up with a work hardening welding electrode. This is soft when welded so that it can be ground to the correct profile. After a few passages of crane wheel, it develops the hardness and wear resistance required.