Crane rail joint failures have been reduced to zero over a 2-year period following the adoption of a flash butt welding practice.

# Economics of crane runway rerailing

**Charles A. Totten**, General Foreman—Central Crane Repair, Heating and Air Conditioning and General Repair, Burns Harbor Div., Bethlehem Steel Corp., Chesterton, Ind.

MOST steel mills have similarly designed crane runways and perform crane runway rerailing on a regular basis. Different maintenance organizations, even inside the same company, have different criteria for rail replacement, preferences for rail joining and techniques for rail replacement. There is no accepted industry-wide practice or standard for crane runway rail replacement. Much of this diversity is attributed to the wide range of locally understood mechanical needs or requirements of the crane runway. Variations are also due to the existing work practice paradigms of the local production and maintenance organizations.

Bethlehem's Burns Harbor Div. has extensive experience with crane rail maintenance under conditions of high plant production with a relatively large number of long-span, electrical overhead traveling cranes designed in accordance with AISE Technical Report No. 6. They operate at high speeds and high duty cycles. The 230 cranes with their 70 runways and 20 miles of rails are an integral part of the production process, production equipment and maintenance. They are critical to the demanding flow of material. Rail maintenance time on crane runways has always been at a premium and, at the same time, the condition of the runway rail is expected to be smooth, safe and not a source of crane operator apprehension or complaints. Successfully achieving all of the operating and maintenance parameters are typical requirements of all maintenance organizations in the steel industry.

## Requirements of rerailing

Runway rail replacement is an expensive program. It is no longer sufficient for any organization, large or small, to simply lay in new rail and only consider initial installation costs without consideration of function, duty cycle, maintenance and the reason for rail replacement. Optimizing rail life must be part of the rerailing program. Conditions that should be factored into the program include:

- Impact on cranes, operations and building structures.
- Effects on product quality and customer service.
- Interaction with crane operator's environment.

Failure to consider all of the relevant factors can lead to disastrous consequences: expensive, unscheduled maintenance downtime on the runway rail; increased repairs to cranes; and structural repair costs to the building. Also, high maintenance labor costs, damaged product on the floor, product rework, customer shipment mixups, reject claims, safety complaints from the crane operators, and even dropped loads and equipment damage are factors directly related to runway rerailing decisions.

The principal problem associated with crane rails, which is frequently overlooked, is joint deterioration. This condition is recognized in AISE Technical Report No. 6, *Specification for Electrical Overhead Traveling Cranes for Steel Mill Service*. In the Commentary—Structural section of the document it states: "Poorly made or worn joints increase the impact effect both on the crane runway girders and on the crane and create an increasing tendency toward fatigue failure and other maintenance problems."

The conclusion reached from extensive experience with the four available joint types is that the selection of the joint method to use in rerailing is the most important decision to be made. The four rail joint types available today are:

- Bolted joint, nearly 200 years old dating back to 1797.
- Thermit joint, approximately 100 years old from 1898.
- Manual welded joint, 60 years old from the 1930's.
- Flash butt weld for No. 175 crane rail. A relatively new, 9-year old technique from 1986. (The flash butt weld has been used for railroad rails since 1950, 45 years ago.)

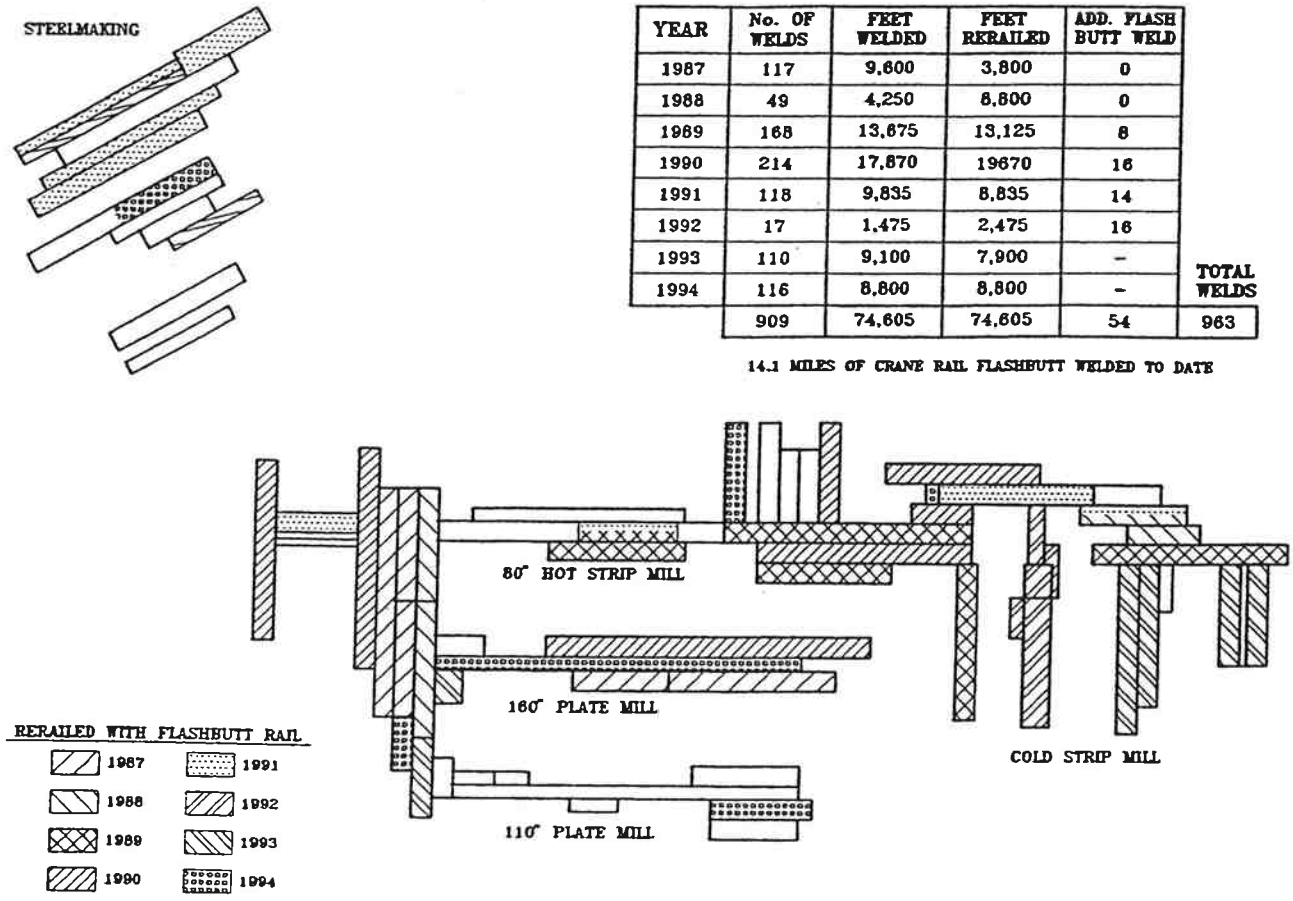
**Burns Harbor experience** — Burns Harbor has used the flash butt weld joint since 1987 in rerailing 39 runways, replacing more than 14 of the 20 miles of No. 175 crane rail in the plant (Fig. 1). All new facilities since 1987 were also erected with the flash butt welded runway rail. A total of 909 flash butt weld joints have been made without any failures. Most of the rerailed runways are 117 ft-0 in. spans and have multiple cranes. The cranes, typically, have eight wheels, 24 or 27 in. dia, double A-4 bridge drive arrangements, and run at 400 to 450 fpm with individual wheel loads in the 65,000 to 75,000-lb range. Some cranes have wheel loads in excess of 120,000 lb. Approximately 71% of the rerailed runways were 1000 ft in length, having up to 13 welds/side: 23% were 1300 to 1700 ft long, with 16 to 21 welds/side; and two runways were 2500 ft long, with 30 and 31 welds/side. Replacement rail sections were 78 ft-0 in. long before welding. Currently, the condition of the remaining runways do not warrant rerailing.

Burns Harbor experience is summarized in Table I for comparative purposes.

**Joint assembly time** — The assembly time per joint shown in Table I illustrates the greater speed (efficiency) of the flash butt weld method, 3 min, compared with 10 to 12 hr for the longest method, the manual weld joint.

**Joint cost** — In Table I all labor costs are calculated at a $40/hr shop rate. The $430 cost for the bolted joint is based on $110 for materials (bolts, nuts, washers and splice bars): the balance is for labor including operating the hydraulic crane to lift the rail to the runway. The bolted joint connections usually required a 4-person crew.

The manual weld joint cost of $2000 consists of $80 for materials (primarily welding rods), with labor cost representing the balance. This type of weld is usually performed by a 3-person crew, one person being the welder. This joint procedure is typically used for rail joint repairs in the field.




| YEAR | No. OF WELDS | FEET WELDED | FEET RERAILED | ADD. FLASH BUTT WELD | |
|---|---|---|---|---|---|
| 1987 | 117 | 9,600 | 3,800 | 0 | |
| 1988 | 49 | 4,250 | 8,800 | 0 | |
| 1989 | 168 | 13,675 | 13,125 | 8 | |
| 1990 | 214 | 17,870 | 19670 | 16 | |
| 1991 | 118 | 9,835 | 8,835 | 14 | |
| 1992 | 17 | 1,475 | 2,475 | 16 | |
| 1993 | 110 | 9,100 | 7,900 | – | TOTAL WELDS |
| 1994 | 116 | 8,800 | 8,800 | – | |
| | 909 | 74,605 | 74,605 | 54 | 963 |

14.1 MILES OF CRANE RAIL FLASHBUTT WELDED TO DATE

Fig. 1 — Plant crane runway rerailing (Dec. 1994).

Material cost for the $620 thermit weld is $300. It is based on a 1-shot thermit weld kit and grinding stones for the removal of the weld mushroom after the process is completed. A 2-person crew is typically involved in this process.

The cost of the flash butt weld, $633, includes a service charge per weld by the contractor who provides the specialized equipment to perform the weld on the runway. The contractor also performs the finish grinding operation and nondestructive testing of the joint. This type of weld also includes a $108 plant labor cost based on the average cycle time between welds of 20 min/weld with an 8-person crew or a total of 2.7 man-hr/weld.

The overall installation cost of the preferred flash butt weld joint, that includes the joint cost, is appreciably lower than the average cost for any other type of rail joint.

**Failures** — The primary consideration when selecting the type of rail joint is the predicted failures. Experience from 15 years of plant-wide rail work and detailed record-keeping shows that each joint type has its inherent characteristics. One conclusion reached is that bolted joints should not be considered for steel mill crane runway service because 95% fail within a 2-year period. This failure rate is unacceptably high in today's reliability-required environment.

The failure rate for a manually welded joint is lower, 16% over a 2-year period. This means that additional weld repairs will be required from joint breakage and from battering out conditions.

The thermit welded joint has a breakage failure rate of 8%. This rate was documented over a 3-year period, 1985-1987, when approximately 250 thermit joints were made plantwide, and this type was the preferred joint.

Currently, the flash butt weld joint is the most reliable and durable with a 0% failure rate.

**TABLE I Rail joint statistics**

| Joint type | Assembly time/joint | Cost/ joint, $ | Failures in 2-year period, % | Maintenance cost/joint (1st year), $ | Rerail man-hr/ linear ft |
|---|---|---|---|---|---|
| Bolted | 2 hr | 430 | 95 | 1000 | 1.5 |
| Manual welded | 10-12 hr | 2000 | 16 | 750 | 2.0 |
| Thermit | 4 hr | 620 | 8 | 240 | 1.7 |
| Flash butt | 3 min | 633 | 0 | 0 | 0.5 |

**Maintenance cost** — Maintenance cost per joint is based on failure rates and subsequent repair labor hours on the runway.

Bolted joints batter out at the ends. Bethlehem's approach has been to make a weld repair back to a smooth surface. Weld repairs, however, have been found to be only temporary and frequently require additional repairs.

Manual and thermit joints have similar fracture occurrences and both batter or dip out. During the same life cycle, battering is deeper and longer in the manual weld joint than the thermit joint.

The maintenance cost associated with a flash butt joint is zero because of the absence of any failure due to a broken or battered out joint. The superior batter resistance is

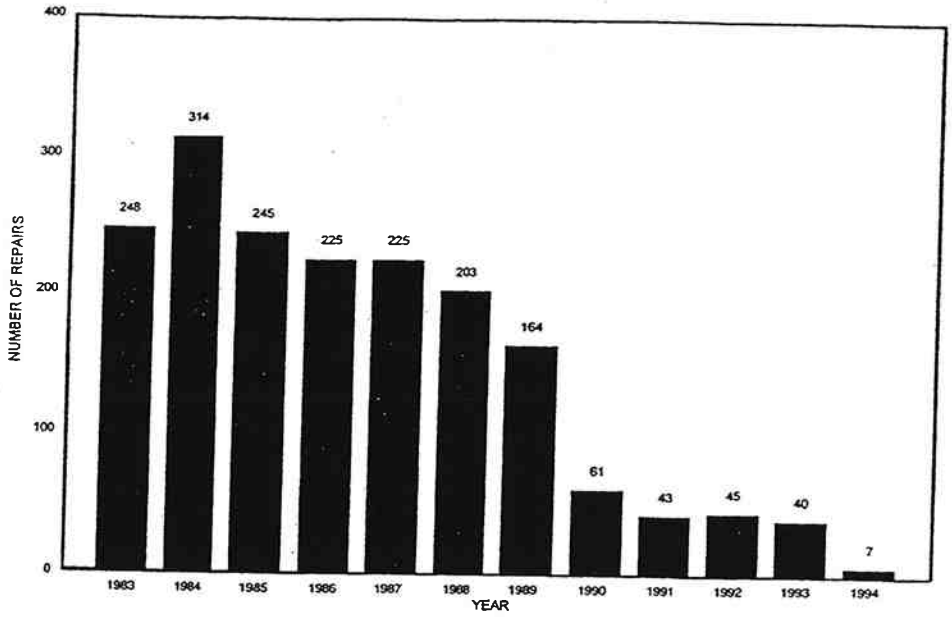



**Fig. 2** — Crane rail joint repair welds.

due to a considerably smaller heat affected zone, inherent in the process. The superior qualities of a flash butt weld joint are apparent from a review of Table I.

**Rerailing man-hours** — The flash butt welding process has resulted in a labor saving paradigm shift where it is most important—the cost of the rerailing process. The man-hours shown in Table I are the total man-hours/linear foot of rail during a replacement project. It includes loading and transporting rail from storage, welding sections together on the runway and positioning new rail along side the rail in service (usually during a short outage before the actual replacement). It also includes removing the old rail followed by the installation of the new rail in its place, and finally reinstalling all rail clips. Since the flash butt joint has been established and its superiority proven, no other type joint has been selected for use. Crane runway rail joint repair welds have been reduced to an insignificant level (Fig. 2).

## Summary

Selection of the method for joining crane rails at Burns Harbor has become an easy decision based on the described criteria. The flash butt weld joint is the most durable and reliable joint in service coupled with long-term service life and low maintenance labor costs. It avoids many fatigue related and impact caused problems. Installation costs are low because of the efficiency in rail handling, rail positioning and short welding time. Joint cost is moderate. The flash butt weld joint eliminates 90% of the rail maintenance problems. ▲