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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1802.

Examination of Rivetted C.D.P. Track Pins and Washers.

(Copy No. 10.)

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Origin of Material and Object of Investigation:

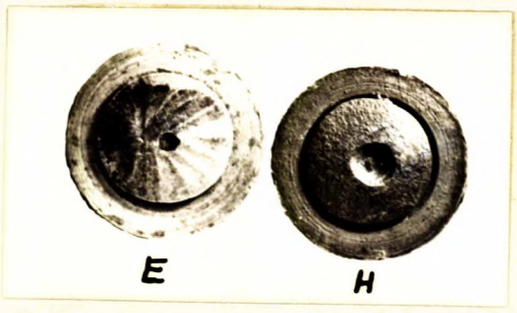
A number of samples of rivetted C.D.P. track pins were submitted for examination on February 17, 1945, by the Inspection Board of United Kingdom and Canada. The covering Analysis Requisition O.T. 4332 (Reference No. 12/4/44) was received on February 22, together with a letter (File No. 4/10/D/Ram/9) from Mr. E. V. Adams, Inspecting Officer (Tanks), for Director of Tanks and M.T., Inspection Board of United Kingdom and Canada, Ottawa, which stated that the pins represent samples from production track assembled by the Hull Iron and Steel Foundries Limited, Hull, Quebec, and Electric Steels Limited, Three Rivers, Quebec. Recent field test samples of these two track assemblies disclosed ten breakages of rivetted washers on track assembled at Electric Steels to two breakages of rivetted washers on Hull track. The pins and washers had been submitted to both manufacturers from the same sources.

It was requested that an investigation be carried out to determine the reason for the higher rate of breakage in Electric Steels washers. It is understood that the Electric Steels rivetting is completely mechanical, whereas at Hull an air hammer is operated by hand. Some of the Hull pins submitted had been in service.

Macro-Examination:

Figure 1 illustrates the rivetted surface of the pins representative of both firms. The Electric Steels operation evidently flattens the pin tip much more than the Hull process. Figures 2 and 3 show this more clearly on the cut section of the peened tips. The letters H and E in the pictures stand for Hull Iron and Steel Foundries and Electric Steels respectively.

Figure 1.

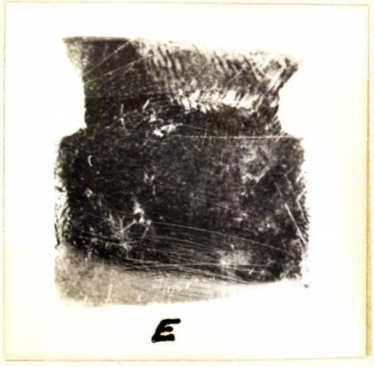


RIVETTED TIPS OF BOTH TYPES OF PINS.

Figure 2.

Note slightly larger diameter of Electric Steels tip.

Figure 3.



Note flatness of Electric Steels tip.

X-Ray Diffraction Studies on Pin Tips:

The sections from the tips shown in Figure 3 were polished and electrically etched. These specimens were then subjected to X-ray diffraction, using the back reflection method. The specimens were arranged so that the same spot (approximately) was being X-rayed on each. These tests did not establish proof of greater deformation on either one of the tips.

Magnaflux Examination:

Several pins of each type were magnafluxed circularly, using 1000 to 1200 amperes of current. No cracks were observed on any of the rivetted tips.

Hardness Tests:

Hardness readings were taken across the surface of sections shown in Figure 3, using the Tukon hardness tester and a 500-gram load. Two pins taken from each firm were tested. Table I lists the results obtained.

TABLE I. - HARDNESS RESULTS.

Distance from the peened surface, in inches	Electric Steels Limited		Hull I. & S. Foundries	
	Pin A	Pin B	Pin A	Pin B
	(Knoop Hardness Numbers)			
0.004 -	292	385	325	358
0.008 -	304	385	320	348
0.012 -	292	368	324	348
0.016 -	289	358	320	368
0.020 -	289	363	324	379
0.024 -	292	348	334	358
0.028 -	292	385	334	358
0.032 -	308	368	325	385
0.036 -	300	363	-	363

Strain Measurements on Washers:

In an effort to determine whether peening the pin had imparted stresses to the washers, SR-4 electrical strain gauges were employed to determine the stresses in both types of pins. Type A-7 gauges were cemented on the outer radius of the washer, with the gauge length in the circumferential direction.

Initial gauge readings were taken, using a SR-4 strain recorder. The pins were then placed in a lathe and the peened material cut away, releasing the washer. Table II shows the stresses which were present in the washers. The peening of the pin forced the washer to deform elastically, and removal of the peened material resulted in a relief of this deformation.

TABLE II.

Washer	Type of Service	Stress, p.s.i.	Vickers pyramid hardness
Electric Steel No. 1	Not in field service.	+ 4,500	178
" " " 3	" " " "	+ 9,600	179
Hull Steel No. 2	After field service.	+14,700	164
" " " 4	" " "	+ 9,300	173
" " " 5	Not in service.	+ 6,000	177

It was then desired to ascertain whether these same washers had been plastically deformed due to peening of the pin. Therefore, each washer was split 180° from the gauge and at right angles to the gauge length of the strain gauge. This would measure any bending moment stress present. The readings for each gauge were recorded and the stresses are listed in Table III.

(Continued on next page)

(Strain Measurements on Washers, cont'd) -

TABLE III.

Washer	Type of Service	Amount and Direction of Stress at Outer Surface of Washer When Split Open, p.s.i.
Electric Steel No. 1	Not in service.	+15,900
" " " 3	" " "	+22,800
Hull Steel No. 2	In service.	- 1,800
" " " 4	" "	+17,400
" " " 5	Not in service.	+ 1,800

Pull Tests:

Pull tests on the Amsler tensile testing machine were made on pins rivetted by each company. The results were:

Pin No.	Electric Steels Limited	Hull I. & S. Foundries
1	22,600 pounds	20,850 pounds
2	23,000 "	19,500 "
3	22,600 "	24,400 "

Discussion:

It is suggested that this report be read in conjunction with that submitted by Ordnance Proving Ground, Ottawa, on Project D.V.A. 6-390-1 and also a letter written from England on January 16, 1945, by Lt.-Col. C. Hunt.

The Electric Steels method of rivetting flattens the tip of the pin more than the Hull process. Although no cracks were observed on magnafluxing the pin tips submitted, it is conceivable that some pins may be cracked during the peening operation. Should a batch of pins be encountered which have somewhat harder tips it is felt that the more severe flattening, as produced by the Electric Steels method, would result in more cracking of the tips. A severely cracked

(Discussion, cont'd) -

pin tip which breaks would cause the washer to fall off in service. It is interesting to note that the pin tips after rivetting vary in hardness from 292 to 385 Knoop hardness number (this is approximately 270-360 Vickers). The washers ranged in hardness from 164 to 179 Vickers. The X-ray diffraction tests gave no indication of whether one type of pin was more severely deformed (below the surface) than the other type. The pull tests indicated more uniformity in the Electric Steels pins. This could be expected from a mechanically operated process, provided that the pin tips are of relatively uniform hardness

By examining the results shown in Tables II and III, the following general conclusions may be advanced on the basis of the few washers and pins examined:

If the peening action had been so great that it caused plastic deformation of the washer, the measurements shown in Table I would not reveal it, since only the elastic deformation would be measured. All washers with the exception of Hull Steel No. 2 showed low elastic deformations. The higher stress of the Hull Steel No. 2 may be accounted for by the fact that in service the washer could have been forced more tightly up the wedge formed by the peened end of the pin. It must be also pointed out that it was possible to measure strain in only one direction and that the principal strain may not have been measured. Furthermore, the gauges, being small, may not have been oriented in the same direction and thus some error must be allowed for. However, the elastic strains measured are sufficient to show that elastic deformation is occurring due to peening of the pin.

If the peening had been excessive and the washers had been stretched beyond their yield point, then as the

(Discussion, cont'd) -

peened end of the pin was machined away residual stress would remain in those washers which had yielded (because yielding would have been local in the inner radius). This residual stress was measured by slitting the washer and releasing the bending moment stress. This method is a rough way of determining stress (Sachs' boring method would have been more accurate, but is a lengthy procedure). However, it was considered to be a sufficiently accurate method for determining the amount of plastic deformation which had taken place.

Hull Steel No. 4, which was in service, also showed that plastic deformation had occurred in the washer but, assuming that Hull Steel No. 5 is representative of other washers, it may be concluded that deformation occurred in service and was not due to peening.

It would be difficult to say positively that the plastic deformation of the washer, due to peening, could be the cause of failure of Electric Steels washers. However, the results show that the peening of Electric Steels pins was greater than the peening of Hull Steel pins, and this peening appears to be excessive. It should be unnecessary to peen the pin to such an extent as to cause deformation of the washer, since it appears that additional deformation of the washer occurs in service.

By means of electric strain gauges it should be possible to determine the severity of peening by attaching gauges to the washer before the pin is peened and watching the change in dimensions of the washer during this operation.

CONCLUSIONS:

1. The pin tip is flattened more severely by the Electric Steels method of rivetting. This may cause cracking if the tip is hard.

2. Magnaflux examination showed no cracks on the rivetted pin head.

3. The Tukon hardness tests indicate that the hardness of the rivetted tips varies from 270 to 360 V.P.N. (approximately).

4. Pull tests show greater uniformity for the Electric Steels method of rivetting.

5. On the basis of the few pins and washers examined it is concluded that failures of Electric Steels pins and washers are due to overpeening and the deformations of the pin and washer weaken them sufficiently so that they are unable to withstand the load of the link. More extensive and more accurate stress measurements would provide more conclusive results.

6. Since failures are being encountered in both Hull and Electric Steels pins and washers, it is felt that the peening operation is critical. Design and laboratory work should be extended to devise a more suitable type of fastening.

Recommendations:

Unfortunately, pins from Electric Steels Limited which had been in service were not furnished for examination. It is suggested that for a complete, accurate investigation at least twenty pins and washers from each supplier should be submitted, ten of these twenty to have seen service and the other ten to be as produced.

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SLG:HLL:GHB.