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O T T A W A July 22nd, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1457.

Investigation of Low-Chromium SAE 3115 Steel for Universal Carrier Track Pins.

(Copy No. 23.)

Bureau of Mines
Division of Metallic
Minerals
-
Ore Dressing
and Metallurgical
Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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Origin of Material and Object of Investigation:

The Inspection Board of the United Kingdom and Canada were informed by the Allied Products Corporation, of Detroit, Michigan, that their sub-contractor, the Commercial Steel Treating Corporation, was encountering difficulty in producing a pin which would pass Specification O.A. 214 from SAEt3115 steel having 0.30 per cent chromium maximum. Accordingly, Lieut.-Col. A. V. Golding, for Inspector General, Inspection Board of United Kingdom and Canada, Ottawa, Ontario, in May, 1943, requested that bar stock be submitted to these Laboratories to determine whether a heat treatment could be found which would confer the required properties. The bar stock was received on May 21st.

This report embodies (a) the work done on this bar stock, and (b) test results on pins treated by the Commercial Steel Treating Corporation.

Chemical Analysis:

Drillings were taken for chemical analysis. The results obtained and the specification limits are shown below:

	As Found	Specification, SAE 3115, Modified
	- Per cent -	
Carbon -	0.18	0.10-0.20
Manganese -	0.54	0.30-0.60
Silicon -	0.24	0.15 min.
Phosphorus -	0.020	0.040 max.
Sulphur -	0.023	0.050 max.
Nickel -	1.27	1.00-1.50
Chromium -	0.26	0.30 max.

Physical Tests:

A tensile bar, 0.252 inch in diameter, was machined from the bar stock and tested. The results follow:

Ultimate tensile strength, p.s.i. -	95,200
0.1 per cent proof stress, p.s.i. -	72,400
Elongation, per cent for 1 inch gauge length -	17.
Reduction of area, per cent -	52.
Rockwell 'B' hardness -	73 to 75

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HEAT TREATMENTS AND TESTS:

Table I shows the heat treatments tried and the results obtained on the treated material.

(Table I follows, comprising Pages 3 and 4. Text continues on Page 5.)

TABLE I.

Number of Pins	HEAT TREATMENT RECEIVED	Drop Impact Test	Bend Deflection at 1st Crack, in.	Surface Hardness, Rockwell 'C'	Core Hardness, Rockwell 'C'	Case Depth, in.
2	2½ hours in cyanide at 1600°F., water quench. Reheat to 1425°F. for 10 minutes, water quench.	Failed.	0.27	60-61	33	0.016
2	2½ hours in cyanide at 1600°F., water quench. Draw at 300°F. for 40 minutes.	Passed.	0.24	57-58	44	0.16
2	2½ hours in cyanide at 1600°F., cool in air. Reheat to 1425°F. for 10 minutes, water quench.	Failed.	0.23	59-61.5	34	0.18
2	1¾ hours in cyanide at 1600°F., air cooled. Reheated to 1400°F. for 10 minutes, water quenched.	Failed.	0.22	55-60 (599-690 V.P.N.)	20	--
1	2½ hours in cyanide at 1600°F., oil quenched (115°F.).	Passed.	--	52-54	25	0.018
2	1¾ hours in cyanide at 1600°F., oil quenched. Reheated at 1400°F. for 10 minutes, water quench.	Passed.	0.24	50-60 (514-690 V.P.N.)	13-16.5 (197-209 V.P.N.)	--
1	2½ hours in cyanide at 1600°F., oil quench. Reheat to 1425°F. for 10 minutes, water quench.		0.34	61-61.5	45	0.018

(Continued on next page)

TABLE I (continued)

Number of Pins	HEAT TREATMENT RECEIVED	Drop Impact Test	Bend Deflection at 1st Crack, in.	Surface Hardness, Rockwell 'C'	Core Hardness, Rockwell 'C'	Case Depth, in.
2	2½ hours in cyanide at 1550°F., water quench. Reheat to 1400°F. for 10 minutes, water quench.	Passed.	0.275	53-55.5	29	0.014
2	2 hours in cyanide at 1650°F., water quench. Reheat to 1400°F. for 10 minutes, water quench.	Failed.	0.30	62	29	0.018
2	2 hours in cyanide at 1600°F., oil quench. Reheat to 1400°F. for 10 minutes, water quench.	Passed.	0.26	59-63	24	0.018
2	2½ hours at 1550°F. in cyanide, water quench. Rea at at 1400°F. for 10 minutes, water quench.	Passed.	0.29	52-54	19	0.019
2	2½ hours in cyanide at 1600°F., water quench. Reheat to 1400°F. for 10 minutes, water quench.	Failed.	0.31	62-65.5	21	0.019

(Heat treatments and tests, cont'd) -

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(Heat Treatments and Tests, cont'd) -

On July 7th, 1943, the Commercial Steel Treating Corporation, Detroit, Michigan, submitted several pins which had been heat-treated at their plant. Table II, below, indicates the treatments and our test results on these pins.

TABLE II.

Pin No.	Heat Treatment Received	Impact	Bend deflection, in inches	Case hardness, R. 'A'	Core hardness, R. 'C'	Case depth, in.
1.	1600° F. cyanide; air cooled. Reheated to 1425° F.; water quenched.	Failed.	0.340	83-85	27-28	0.012
2.	Chapmanized 1575° F., oil quenched.	Passed.	0.26	83-84	17-18	0.016
3.	Cyanided 1600° F.; oil quenched. Reheated to 1400-1425° F.; water quenched.	Passed.	0.24	81-82	25-26	0.018

Microscopic Examination:

Transverse sections were cut from each of the above pins, polished, and then etched in nital. Figures 1, 3, and 5 are photomicrographs, taken at X500, of the cores of Pins Nos. 1, 2, and 3. Figures 2, 4, and 6 are photomicrographs of the cases, taken at X1000.

(Continued on next page)

(Microscopic Examination, cont'd) -

Figure 1.

X500, nital etch.
CORE, PIN NO. 1.
Note presence of coarse ferrite.

-

Figure 2.

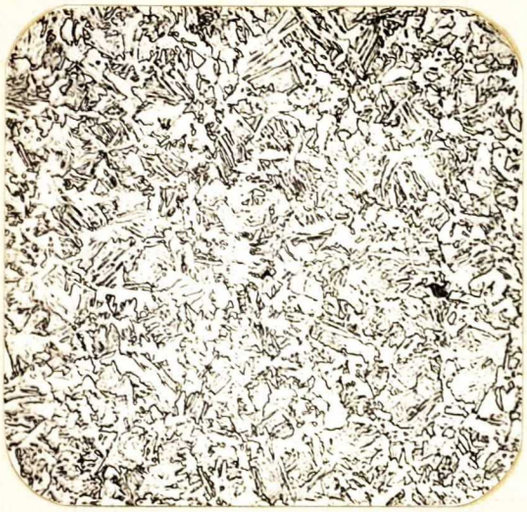
X1000, nital etch.
CASE, PIN NO. 1.

-

HEAT TREATMENT: Cyanided 1600° F., air cooled; reheated to 1425° F., water quenched.

(Microscopic Examination, cont'd) -

Figure 3.



X500, nital etch.
CORE, PIN NO. 2.

-

Figure 4.

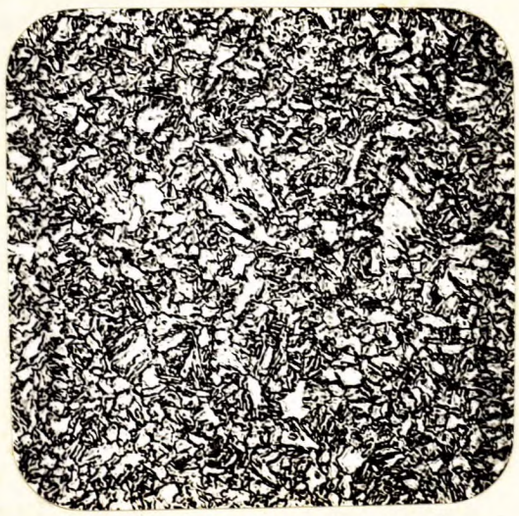
X1000, nital etch.
CASE, PIN NO. 2.
Note coarser structure than in Figures 2 and 6.

-

HEAT TREATMENT: Chapmanized 1575° F., oil quenched.

(Microscopic Examination, cont'd) -

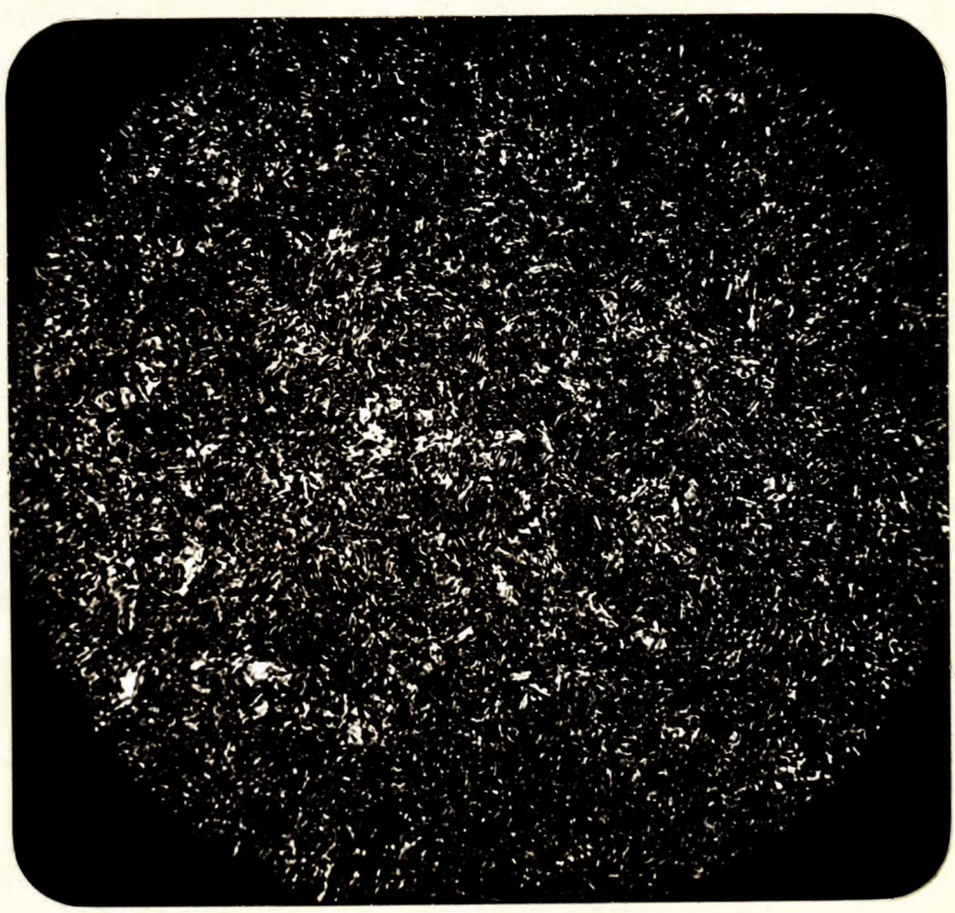
Figure 5.



X500, nital etch.
CORE, PIN NO. 3.

-

Figure 6.



X1000, nital etch.
CASE, PIN NO. 3.

-

HEAT TREATMENT: Cyanided 1600° F., oil quenched; reheated to 1400-1425° F., water quenched.

DISCUSSION:

The chemical analysis of the bar stock conforms to SAE 3115 modified as required by Specification O.A. 214.

Any treatment using a water quench would necessitate the use of a quenching fixture, as otherwise severe warpage would be encountered. It was felt that oil-quenching should be used if at all possible.

Figure 1, which gives the core structure of the pin that was air cooled, and then reheated and water quenched, shows the presence of coarse grains of ferrite produced by the normalizing treatment. This type of pin failed the impact and passed the other requirements. A finer core structure, such as would be produced had the pin been oil quenched instead of normalized in the first heat treatment, should produce a pin which would have better resistance to impact.

The case (Figure 4) of the single-oil-quenched pin has a somewhat coarser structure than those of Pins Nos. 1 and 3, which have had a grain-refinement reheat treatment. The double-quenched pin, No. 3, has a more finely divided core structure than either of the other pins.

Commercial Steel Treating Corporation produced 160,000 pins using a single oil quench. They found that the pins failed the impact test when the surface hardness was over the required 80 Rockwell 'A' minimum. Examination of these pins indicated that the case depth was 0.015-0.020 inch. Accordingly, one series of pins was heat treated at 1580° F., single oil quenched, and another series was double oil quenched from, first, 1660° F., then 1450° F. The case depth aimed for was 0.012-0.015. All these pins (40 of each type) passed the specification, except for core hardness, which was low in some of the pins. The difference between the results of the single-quenched pins and of the double-

(DISCUSSION, cont'd) -

quenched pins was not sufficiently great to warrant the time-consuming double quench. Information Memorandum No. 59, July 13th, 1943, discusses these results.

Conclusions:

1. The following treatment gave the best laboratory results:

Two hours in cyanide at 1600° F., oil quench; reheat for 10 minutes at 1400° F., water quench.

2. A finely divided core structure is desirable, as it is more resistant to impact.

3. In production, a single oil quench from 1580° F. Chapmanizing temperature produced a pin which passed the physicals if the case depth was held toward the lower limit of the specification range. The core hardness does not always meet the specified 24-32 Rockwell 'C'.

RECOMMENDATIONS:

1. The heat treatment recommended is:

Chapmanize at 1580° F. to obtain a case depth of 0.012-0.015 inch, then oil quench.

2. In production, a certain leeway in hardness inspection should be granted, as the core minimum of 24 Rockwell 'C' cannot always be met using this type of steel.

3. The pins must pass all the physical tests outlined in Specification O.A. 214, in order to ensure satisfactory service.

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