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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1502.

Examination of Universal Carrier Track Pins
at Room Temperature and -50° F.

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(Copy No. 23.)

Abstract.

This report discusses the properties of SAE 3115 and SAE 2115 cased pins and homogeneous SAE 9255 pins, quenched-and-drawn and austempered. These pins are at present undergoing field tests at Windsor, Ontario. Impact tests were made at -50° F. to compare the quality of the various types of pins at sub-zero temperatures.

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

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA October 1st, 1943.

REPORT

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ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1502.

Examination of Universal Carrier Track Pins
at Room Temperature and -50° F.

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Origin of Material and Object of Investigation:

In compliance with Requisitions Nos. 467, 704 and 705, dated respectively May 26th, August 26th, and August 27th, 1943, issued by Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Toronto, Ontario, covering A.E.D.B. Lots Nos. 611, 612, 613, 614 and 648, an investigation was carried out on 48 universal carrier track pins which had been submitted to these Laboratories at various times since January of this year, to determine whether these pins comply with Specification O.A. 214. Tests were also made at -50° F. to see if low temperatures had any effect on the pin properties.

Four types of pin were received (these are

(Origin of Material and Object of Investigation, cont'd) -

representative of the pins at present undergoing field tests at Windsor, Ontario), namely:

(a) Twelve SAE 9255 austempered pins. Received on January 18th, 1943. Heat-treated at O.D.M.L.

(b) Twelve SAE 9255 quenched-and-drawn pins. Received on January 18th, 1943. Heat-treated at O.D.M.L.

(c) Twelve SAE 3115 cased pins. Received on January 18th, 1943. Heat-treated at Chapman Valve Company.

(d) Twelve SAE 2115 cased pins. Received on Sept. 3rd, 1943. Heat-treated at Canadian Acme Screw and Gear Company.

Chemical Analysis:

Drillings were taken from the centre of the pin for chemical analysis. The same heat of SAE 9255 steel was used for both the quenched-and-drawn and the austempered homogeneous pins.

Austempered and Q.-and-D. Pins, O.D.M.L. -

		As Found	Specification, SAE 9255 Steel.
		- Per cent -	
Carbon	-	0.52	0.50-0.60
Manganese	-	0.76	0.60-0.90
Silicon	-	2.02	1.80-2.20

Chapman Valve Pin. -

		As Found	Specification, SAE 3115 Steel
		- Per cent -	
Carbon	-	0.19	0.13-0.18
Manganese	-	0.56	0.40-0.60
Phosphorus	-	0.009	0.040 max.
Chromium	-	0.72	0.55-0.75
Nickel	-	1.24	1.10-1.40

Canadian Acme Pin. -

		As Found	Specification, SAE 2115 Steel
		- Per cent -	
Carbon	-	0.13	0.10-0.20
Manganese	-	0.41	0.30-0.60
Chromium	-	0.09	-
Nickel	-	1.60	1.25-1.75

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HEAT TREATMENT:

HOMOGENEOUS PINS -

(a) Quenched and Drawn.

Pins were heated in a Vapocarb furnace at 1625° F. for 45 minutes, then quenched in oil (110-120° F.). They were then drawn to 45-51 Rockwell 'C' hardness.

(b) Austempered.

The pins were heated in the Vapocarb for 45 minutes at 1625° F., then plunged into 47 per cent $NaNO_2$ and 53 per cent KNO_3, in which they were held at 500° F. for 45 minutes.

CASED PINS -

Canadian Acme Pins.

These pins are cyanided, using Houghton's "Pearliton", for two hours at 1600-1625° F., then water-quenched individually in a quenching press.

Chapman Valve Pins.

The Chapmanizing process is used for case hardening. Anhydrous ammonia is dissociated, then forced into a fused cyanide bath. The pins are left in this activated cyanide bath for 2½ hours at 1600° F. and oil quenched.

Bend Tests:

Bend tests were carried out, using the standard bend test machine for the cased pins and the Amsler Universal testing machine for the homogeneous type. All conditions are the same in both types of machine except for the steady application of load in the latter type.

(Continued on next page)

(Bend Tests, cont'd) -

TABLE I. - BEND TEST RESULTS.

Steel	Treatment	Surface Hardness	Core Hardness	Load, in pounds	Bend Deflection, in inches
SAE 9255	Quenched and drawn	46-49 R.'C'	47.5	2500	2.00(unbroken).
"	"	47-50	49	2575	2.00(unbroken).
"	Austempered	53-55	55	2450	0.850(broken).
"	"	52-54	54	2900	1.109(broken).
SAE 3115	Chapmanized	83-84 R.'A'	32.5 R.'C'	-	0.325(case cracked).
"	"	83-84 R.'A'	40.5 R.'C'	-	0.31(case cracked).
SAE 2115	Cyanided	83-84 R.'A'	24 R.'C'	-	0.23(case cracked).
"	"	84.5-85.5 R.'A'	24 R.'C'	-	0.23(case cracked).

Impact Tests:

Impact tests were carried out at room temperature and at -50° F., using the standard impact machine. The low-temperature tests were made on pins which were held in a solution of acetone and dry ice at -50° F. ± 5° for ½ hour prior to testing. Pins have to withstand a 45-foot-pound blow without failing.

TABLE II. - IMPACT RESULTS.

Steel	Treatment	Surface Hardness	Case Hardness	Temperature	Remarks
SAE 9255	Q. and D.	51 R.'C'	-	-50° F.	Passed.
"	"	51-52 R.'C'	-	-50° F.	Passed.
"	"	49-50 R.'C'	-	-50° F.	Passed.
"	"	50-51 R.'C'	-	-50° F.	Passed.
"	"	49	48 R.'C'	Room	Passed.
"	"	47-48	47	Room	Passed.
"	"	48-50	48	Room	Passed.
"	"	45-47	47	Room	Passed.
"	Austempered	53-54	52-53	-50° F.	Passed.
"	"	53-54	-	-50° F.	Passed.
"	"	53-54	51-52	-50° F.	Passed.
"	"	53-54	51-52	-50° F.	Passed.
"	"	54-56	54	Room	Passed.
"	"	53-55 R.'C'	56 R.'C'	Room	Passed.
"	"	52-54 R.'C'	55 R.'C'	Room	Passed.
"	"	53-54 R.'C'	53 R.'C'	Room	Passed.
SAE 3115	Chapmanized	83-84 R.'A'	279 V.P.N.	-50° F.	Failed.
"	"	83-84 R.'A'	307 V.P.N.	-50° F.	Failed.
"	"	84 R.'A'	330 V.P.N.	-50° F.	Passed.
"	"	84 R.'A'	371 V.P.N.	-50° F.	Failed.
"	"	81-82	230 V.P.N.	Room	Passed.
"	"	83-86	311 V.P.N.	Room	Passed.
"	"	83-84	358 V.P.N.	Room	Passed.
SAE 2115	Cyanided	83-84	274 V.P.N.	-50° F.	Passed.
"	"	83	258 V.P.N.	-50° F.	Passed.
"	"	84.5-85.5	247 V.P.N.	-50° F.	Passed.
"	"	85	235 V.P.N.	50° F.	Passed.
"	"	84.5	264	Room	Passed.
"	"	-	-	Room	Passed.
"	"	-	-	Room	Passed.

Case Depths:

The case depths of the Chapman Valve pins ranged from 0.012-0.021 inch (6 pins tested).

The case depths of the Canadian Acme pins ranged from 0.012-0.20 inch (4 pins tested).

Depth-Hardness Survey:

A depth-hardness survey was made on the face of a transverse section cut from each type of pin. Table III lists the results obtained.

TABLE III. - DEPTH HARDNESS RESULTS.

Vickers Hardness Numbers; 10-Kilogram Weight.

Type of Steel	Treatment	At depths in inches from the surface									
		Surface	0.005	0.010	0.015	0.020	0.030	0.040	0.050	0.10	0.20
SAE 9255	Quenched and drawn	535	524	513	511	510	506	500	494	483	477
SAE 9255	Austempered	607	307	606	606	606	605	605	605	592	575
SAE 3115	Chapmanized	815	710	612	570	528	445	365	365	369	358
SAE 2115	Cyanided	857	771	690	586	480	270	247	234	247	262

Grain Size:

The McQuaid-Ehn grain sizes of the pins were:

(1) SAE 3115 Chapman Valve, 4-5;
(2) SAE 2115 Canadian Acme, 4; and
(3) SAE 9255 Austempered and Quenched-and-Drawn, 4-5.

Grain size determination on the SAE 9255 pin was carried out by regular McQuaid-Ehn treatment at 1700° F. for 8 hours in a carburizing medium. However, it was cooled from 1700° to 1200° for a period of 8 hours. Grain size was determined by the precipitation of ferrite at the austenitic grain boundaries. It was found to be 4 to 5.

Microscopic Examination:

Transverse sections were cut from one pin of each type and examined under the microscope. The etching reagent was 2 per cent nital. Figures 1 and 2, at X1000 magnification, are of the quenched-and-drawn and austempered SAE 9255 pins respectively. The core and case structures of the SAE 3115 and SAE 2115 pins are shown in Figures 3 to 6, all taken at X500 magnification.

Figure 1.

X1000, nital etch.
TEMPERED MARTENSITE.

Figure 2.

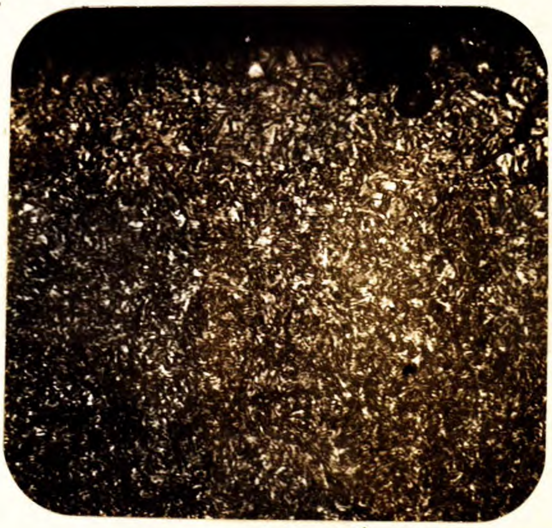
X1000, nital etch.
ISOTHERMAL TRANSFORMATION PRODUCT--BAINITE.

(Microscopic Examination, cont'd) -

Figure 3.

X500, nital etch.
SAE 3115 CORE.
Note ferrite and finely lamellar carbides.

Figure 4.



X500, nital etch.
SAE 3115 CASE.
Tempered martensite.

Figure 5.

X500, nital etch.

SAE 2115 CORE.
Note fine dispersion of ferrite.

Figure 6.

X500, nital etch.

SAE 2115 CASE.
Tempered martensite.

Discussion:

The chemical analyses of the three steels conform to their respective specified limits except the carbon in the SAE 3115 steel, which is 0.01 per cent higher. It should be pointed out, however, that manufacturers of track pins are endeavouring to get a modified SAE 3115 steel of 0.25-0.45 per cent chromium and 0.15-0.20 carbon.

The bend tests indicated that the homogeneous type of pin has more ductility than the cased pin. In the past, experience has shown that cased pins will only take loads up to 1,500 pounds before they break completely. The homogeneous pins, both the quenched-and-drawn and austempered, take loads well over 2,000 pounds prior to failing. The specification for cased pins required a bend of 0.25 inch without cracking the case. The SAE 3115 pin passed this but the SAE 2115 failed by a small amount, 0.02 inch. It is possible that the harder core in the 3115 pins gave better support to the case, with resultant better bends.

No low-temperature bend tests were carried out, due to previous findings (O.D.M.L. Investigation No. 1197, April 2nd, 1942) which showed that at -50° F. little, if any, change occurred in cased pins of both SAE 3115 and SAE 2115 types.

It is a well-known fact that the impact strength of a steel is the property most sensitive to temperature change. All types of pins passed the room temperature impact. At low temperatures, three out of four Chapman Valve pins failed. These latter pins differed from the cased SAE 2115 pins in the heat treatment employed and also in the chromium content. Very recently it has been reported (not published) that oil-quenching steels do not have as good impact values at low

(Discussion, cont'd) -

temperatures as have the same steels which have been water-quenched. It is not known, at the present time, whether chromium of itself has any deleterious effect on low-temperature impact strength.

The grain size required by specification is 6-8 (5 is permissible). Both the SAE 2115 and SAE 3115 pins were somewhat coarser.

The microscopic examination showed tempered martensite for the oil-hardened SAE 9255 homogeneous pin. The austempered pin has the bainite structure usually associated with an isothermal transformation of this type.

The SAE 2115 and 3115 pins both have tempered martensite cases. The structure of the SAE 3115 pin appears to be finer than that of the 2115 pin. Photomicrographs of the cores illustrate the difference between the structures produced by oil quenching and by water quenching. The latter gives the more refined structure and a better dispersion of ferrite. It would be interesting to determine whether a double oil quench would give low-temperature impacts superior to those from a single oil quench. The double quench should give a much finer core structure as compared with that of the water-quenched pin.

Pins fail mainly in fatigue. In the absence of a suitable fatigue machine, impact and bend tests are used to indicate quality. It has been shown by field test results that there appears to be a correlation between these tests and actual service. A pin having good bend and impact properties gives good results in the field.

CONCLUSIONS:

1. The steels conform to the specified analysis except for 0.01 per cent carbon above the upper limit for the SAE 3115 pins. This is, however, within the range in which manufacturers are endeavouring to purchase the steel, namely, 0.15-0.20 per cent carbon.

2. The homogeneous pins have better ductility than the cased pins. It takes well over 2,000 pounds to break them, as compared to 1,500 pounds for the cased pin.

3. The SAE 2115 pins failed the 0.25-inch specified bend test by a slight margin, bending 0.23 inch.

4. All pins passed the room temperature impact requirement of 45 foot-pounds.

5. Of the SAE 3115 pins, three out of four pins tested failed the minus 50° F. drop impact test.

6. The core structure produced by water quenching has a greater dispersion of the ferrite than that produced by oil quenching. This might explain the poor low-temperature impact strength obtained with the latter type of pin.

7. The quenched-and-drawn SAE 9255 pins have a tempered martensitic structure.

8. The austempered pins have a bainite structure.

9. The McQuaid-Ehn grain size of the SAE 3115 pin is 4-5, that of the SAE 2115 pin is 4, and that of the SAE 9255 pin is 4-5.

10. The cased pins have a proper depth of case.

11. Fatigue is the principal cause for failure in pins. In field tests, however, it has been shown that good results are obtained with pins that have good bend and impact properties.

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SLG:GHB.