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O T T A W A August 13th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1478.

Examination of Low-Chromium and High-Chromium SAE 3115 Universal Carrier Pins.

(I.B.U.K. & C. (Detroit) Req. No. 40677)

(Copy No. 18.)

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:

On July 23rd, 1943, at the request of Captain V. J. Sharkey of the Inspection Board of the United Kingdom and Canada, Detroit, Michigan, the Campbell, Wyant and Cannon Foundry Company, Muskegon, Michigan, submitted forty-eight SAE 3115 Universal Carrier pins for examination. The pins were received in four bundles, tagged as follows:

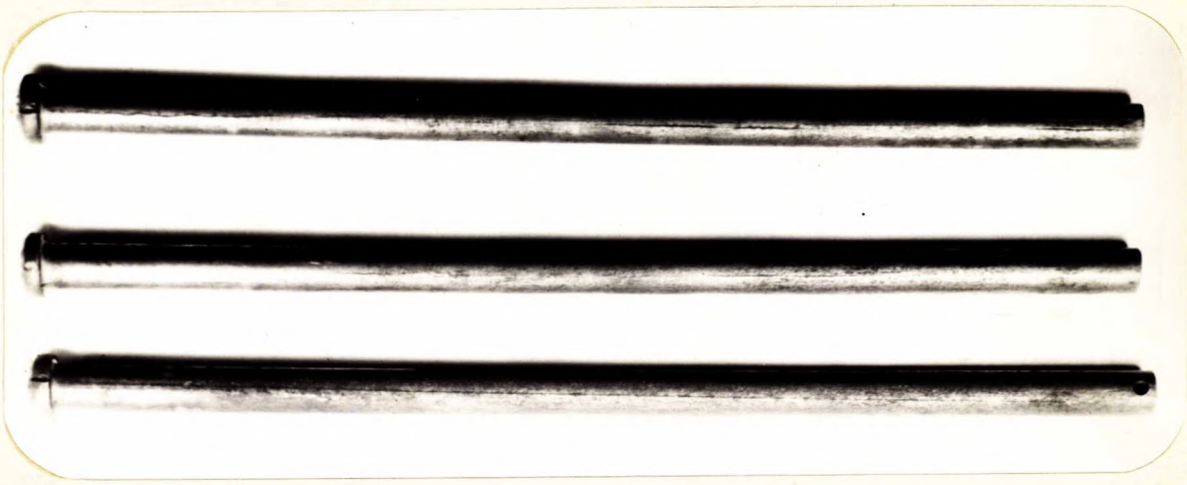
12 pins. High chromium, not heat-treated.
12 pins. Low chromium, not heat-treated.
12 pins. High chromium, heat-treated.
12 pins. Low chromium, heat-treated.

It was reported by Captain Sharkey, after a visit to the plant, that there were cracks in the pin heads which indicated seams for the length of the pins. It was further reported that the seams penetrated below the case of the pins and in many instances right into the core of the pins. It was requested that the pins be subjected to a thorough examination to determine whether or not they are serviceable.

Macro-Examination:

Examination of the pins showed cracks in the heads some of which were of the nature of chisel marks. Seams extended from the cracks over the whole length of the pins. On sectioning some of the pins transversely, these seams were seen to penetrate into the case of the pins and in some cases right through the case and well into the core. Figure 1 shows these seams on the surface of three pins. The pins have been magnafluxed to show them up more clearly.

Figure 1.



MAGNAFLUXED PINS, SHOWING SEAMS.

Chemical Analysis:

A chemical analysis was made on drillings taken from the core of one of the pins. The results found and the specification limits appear below:

	AS FOUND		Specification SAE 3115	
	Low Chromium	High Chromium	Old	Modified
	- Per cent -			
Carbon -	0.13	0.14	0.10-0.20	0.10-0.20
Manganese -	0.51	0.43	0.30-0.60	0.30-0.60
Silicon -	0.24	0.20	0.15 min.	0.15 min.
Phosphorus -	0.020	0.011	0.040 max.	0.040 max.
Sulphur -	0.031	0.022	0.050 max.	0.050 max.
Nickel -	1.01	1.29	1.00-1.50	1.00-1.50
Chromium -	0.24	0.48	0.45-0.75	0.30 max.

Physical Properties:

Tensile bars, 0.252 inch in diameter, machined from the cores of pins not heat-treated and pins heat-treated, were tested. The results follow:

Test Bar	Ultimate strength, p.s.i.	0.2% proof stress, p.s.i.	Elongation, % for 1-in. gauge length.	Reduction of area, per cent.	Hardness, Rockwell "B"
High Chromium, not heat-treated.	84,400	68,000	22	60	84-85
High Chromium, heat-treated.	126,000	81,000	22	56	98-99
Low Chromium, not heat-treated.	91,600	87,000	15	58	87-90.5
Low Chromium, heat-treated.	109,200	57,500	21	52	88-90.5

Case Depth:

The case depth was measured on eight pins of each of the low-chromium and high-chromium types, by cutting a transverse section from the pin, etching it in nital, and measuring, with the Brinell microscope, the case depth from the surface to the first point of colour change. The depth of case on the low-chromium pins was from 0.017 to 0.019 inch and on the high-chromium pins, from 0.015 to 0.019 inch.

Depth-Hardness Relationship:

Hardness readings were taken across the faces of polished transverse sections, using the Vickers hardness machine and the 10-kilogram load. Table I lists the results obtained at various distances from the surface.

(Table I follows on Page 4)

Table I.

PIN NO.	VICKERS HARDNESS NUMBERS (10-Kilogram Weight) At depths in inches from the surface.							
	At Surface	0.005	0.01	0.02	0.04	0.06	0.08	0.10	0.20
Low Cr No. 1	824	807	792	540	265	235	233	233	237
Low Cr No. 3	824	745	657	490	255	241	245	250	255
High Cr No. 4	824	805	782	610	270	262	262	267	269
High Cr No. 7	803	815	824	550	285	288	282	270	266

Core Hardness After an Oil Quench from 1580° F.:

Two pins of each of the high-chromium and low-chromium types were heated in a Vapocarb furnace in a neutral atmosphere at 1580° F. for 30 minutes and quenched in oil at 110° F. to 120° F. A transverse section was cut from each pin and the core hardness found, using the Vickers machine and the 10-kilogram load. The results appear below:

Pin.	V.P.N.
Low Chromium	
(a)	259
(b)	219
High Chromium	
(a)	309
(b)	299

Grain Size:

The McQuaid-Ehn grain size of both types of steel was found to be 8-7.

Bend Tests:

Bend tests were carried out on heat-treated pins of each type, using the standard bend test machine, the pin

(Bend Tests, cont'd) -

resting on 8-inch centres, and using a 12-inch-radius block. The deflection at the first crack in the case was noted. Table II includes the results of the bend tests, also the surface and core hardnesses and the case depths.

Table II.

PIN NO.	Surface Hardness, Rockwell 'A'	Core Hardness, V.P.N.	Case Depth, inches	Deflection at First Crack, inches
Low Chromium				
1	82.5-84	247	0.017	0.31
2	83.5-84	241	0.019	0.21
3	83-84	255	0.019	0.24
4	83-84.5	240	0.017	0.36
High Chromium				
1	81-83	263	0.019	0.51
2	82-82.5	251	0.015	0.31
3	81-84	281	0.017	0.32
4	83-84	269	0.019	0.46

Drop Impact Tests:

Drop impact tests were carried out on pins of each type. All pins passed the test, being subjected to an impact of 45 foot-pounds. Table III records the surface and core hardnesses and the case depths of the pins tested.

Table III.

PIN NO.	Surface Hardness, Rockwell 'A'	Core Hardness, V.P.N.	Case Depth, inches
Low Chromium			
1	81-84	222	0.017
2	83-84	230	0.019
3	81-84	235	0.019
4	83-84	216	0.019
High Chromium			
1	81.5-83	265	0.017
2	82-83	283	0.017
3	82-83	266	0.015
4	82-83	271	0.019

Micro-Examination:

Transverse sections were cut from pins of each type, polished, etched in nital, and examined under the microscope. Figures 2 and 3 show typical cores of the low- and high-chromium pins respectively. Figure 4 shows a typical case structure.

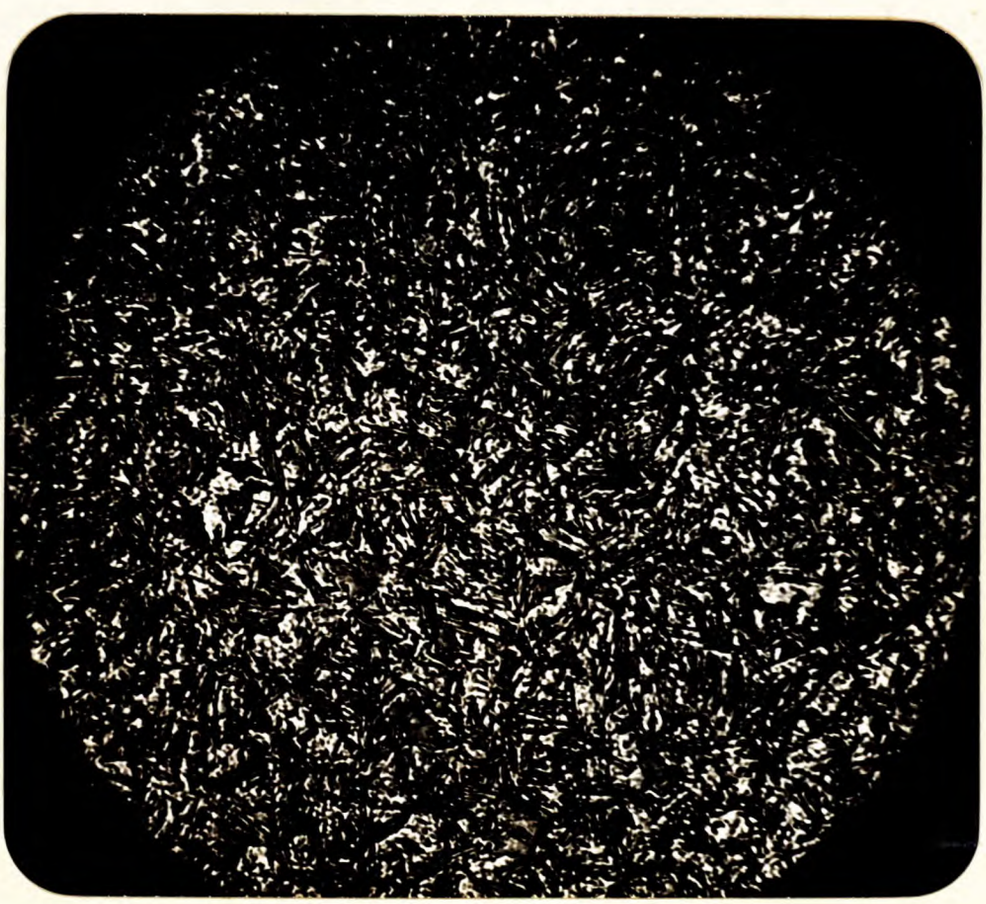
Figure 2.

X500, nital etch.
TYPICAL CORE OF LOW-CHROMIUM PIN.
Note massive ferrite.

Figure 3.

X500, nital etch.
TYPICAL CORE OF HIGH-CHROMIUM PIN.

Figure 4.



X1000, nital etch.
TYPICAL CASE.

DISCUSSION:

The chemical analysis of the low chromium bar stock conforms to SAE 3115 modified as required by Specification O.A. 214, and that of the high-chromium bar stock conforms to the old SAE 3115 specification. Chromium content in the higher range of the limits, of course, ensures a higher hardenability and a consequent higher core hardness.

Satisfactory case depth has been obtained.

The core hardness obtained on the low-chromium pins is below that required by Specification O.A. 214.* That of the high-chromium pins is satisfactory. This was also found on pins oil-quenched from 1580° F. in these Laboratories. Satisfactory surface hardness has been obtained.

Two of the low-chromium pins failed to take the specified 0.25-inch deflection before the case cracked. All the high-chromium pins took very satisfactory deflections before cracking.

All pins tested passed the impact test.

The cores of the low-chromium pins, contained more massive ferrite than those of the high-chromium pins, as shown in Figures 2 and 3. This is also shown in the core hardnesses, the high-chromium pins having harder cores than the low-chromium ones.

The seams present on the pins under examination would not be expected to have much effect on the properties determined in the test work described above. Very possibly, however, they might seriously lower the fatigue strength. Field tests indicate that failure is almost invariably produced by the action of alternating stress, so a lowering of fatigue strength would be a serious defect.

However, these Laboratories are not at the present time

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* Core hardness limits, 24-32 Rockwell 'C' (250-297 V.P.N., converted). Optional in U. S. A.

(Discussion, cont'd) -

equipped to test track pins under alternating stresses; therefore, it was not possible to determine what effect the seams would have on fatigue life and (through inference) service behaviour.

CONCLUSIONS:

1. The chemical analyses correspond to the old and modified specification limits for SAE 3115 steel.

2. The low-chromium pins had marginal bend-test properties, while the high chromium pins all passed the bend test requirements.

3. The pins all passed the impact test requirements.

4. The case depth obtained was satisfactory in all cases.

5. The core hardness of the low-chromium pins was below that required by Specification O.A. 214, while that of the high-chromium pins was satisfactory.

6. All pins had satisfactory surface hardness.

7. The pins are substandard, due to the presence of longitudinal seams on the surface. The effect of these seams on the service life of the pins cannot be determined without carrying out some sort of fatigue test but it is considered that the effect may well be serious.

RECOMMENDATION:

It is recommended that the pins be subjected to fatigue tests to determine their service life.

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