O T T A W A November 17th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1747.

Impact Properties of C.D.P. Track Pins.

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Abstract

This investigation deals with the impact properties of C.D.P. track pins as affected by (1) location of cut from the ingot, (2) austenitic grain size, and (3) heat treatment. Variation in heat treatment, between different producers, is shown to be the most significant factor.

Origin of Material and Object of Investigation:

On September 14th, 1944, Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Toronto, Ontario, requested (Requisition No. 841, Report No. 22C, Test 31) that an investigation be undertaken to check the performance of SAE 9255 C.D.P. track pins with respect to metal from top and bottom cuts of the ingot. The steel was produced and selected from various locations in the ingot by Atlas Steels Limited, Welland, Ontario.

One lot of 18 pins (Lot No. 1179) was heat-treated by this company and similar lots, of 18 pins each, were sent

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

for heat treatment to (a) Cockshutt Plow Company Limited, Brantford, Ontario, (Lot No. 1180), and (b) Steel Company of Canada, Swansea Works, Toronto 3, Ontario, (Lot No. 1181). It was agreed that following heat treatment all three lots would be submitted to these Laboratories for impact testing, also that specimens would be cut from each pin after quenching and submitted for the purpose of determining the austenitic grain size.

Locations in the ingot from which the rod was rolled are not known but are indicated throughout this report by the numbering system used by Atlas Steels Limited.

Chemical Analysis:

The chemical analyses of the two heats from which the pins were taken are as follows:

	Heat No. E2601*	Heat No. E2683*	Heat No. E2601-T1-A**	Heat No. E2601-T1-C**	Heat No. E2683-T1-S**
	- Per Cent -				
Carbon -	0.56	0.58	0.56	0.56	0.57
Manganese -	0.80	0.82	0.82	0.79	0.86
Silicon -	2.03	2.06	2.11	2.11	2.12
Phosphorus -	0.016	0.016	0.015	0.015	0.023
Sulphur -	0.018	0.019	0.012	0.017	0.017

* Analyses supplied by Atlas Steels Limited.

** Check analyses on one pin from each lot.

Heat Treatment:

The heat treatment given each lot of pins was reported as follows:

Atlas Steels Limited -

Pins heated in cast iron chips, providing a dry neutral atmosphere, at 1625° F. for ¾ hour; quenched in Houghton's #2 oil at 70° F; drawn at 900° F. for 1 hour.

(Continued on next page)

(Heat Treatment, cont'd) -

Cockshutt Plow Company Limited -

Pins heated in double chloride salt bath, deoxidized with boric acid, 18½ minutes at 1625° F.; quenched in oil at 104° F.; drawn at 890° F. for 1½ hours.

Steel Company of Canada -

Pins heated in furnace of the following approximate atmosphere: CO, 25 per cent; CO_2, 2.8 per cent; O_2, nil.

Quenching temperature, 1650°-1700° F.

Drawing temperature, 890° F. for 1½ hours.

Quenching medium, oil at 135° F.

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Austenitic Grain Size:

The austenitic grain size was determined by drawing the "as quenched" specimens submitted by the different heat treaters, at 600° F. for 30 minutes, and then etching suitably polished specimens with Vilella's reagent. The results are shown in Tables II and III.

Impact Test:

Impact tests were carried out on the standard drop impact testing machine. Twelve blows of 400 foot-pounds was the maximum number given to any pin. Results are shown in Tables I, II and III.

(Tables I, II and III follow, on Pages 4 and 5.)

TABLE I. - LOT HEAT-TREATED BY ATLAS STEELS LIMITED.

Heat and Pin Nos.	Drop Impact Test, 400-ft-lb. blows	Austenitic Grain Size	HARDNESS, ROCKWELL 'C' Surface	HARDNESS, ROCKWELL 'C' Core
E2601-T1-A-1	Broke, 5	AS QUENCHED SPECIMENS NOT SUBMITTED.	44-47	44-47
-2	" , 9		44-45	
-3	" , 10		44-45	
E2601-B1-A-1	Broke, 6		44-47	44-47
-2	" , 11		43-46	
-3	Passed, 12		44-45	
E2601-T4-A-1	Broke, 7		43-44	46-47
-2	" , 8		45-47	
-3	" , 6		42-43	
E2601-B4-A-1	Passed, 12		42-44	45-45
-2	Broke, 8		44-45	
-3	Broke, 7		44-47	
E2683-T1-A-1	Broke, 8		42-43	46-47
-2	" , 11		43-45	
-3	" , 7		42-45	
E2683-B4-A-1	Broke, 10		43-44	44-47
-2	Passed, 12		45-47	
-3	Broke, 10		43-45	

All hardness values are as submitted by respective heat treaters.

TABLE II. - LOT HEAT-TREATED BY COCKSHUTT PLOW CO. LIMITED.

Heat and Pin Nos.	Drop Impact Test, 400-ft-lb. blows	Austenitic Grain Size	HARDNESS, ROCKWELL 'C' Surface	HARDNESS, ROCKWELL 'C' Core
E2601-T1-C-1	Passed, 12	6	40-42	44-45
-2	" , 12	5-6	41-44	43-45
-3	" , 12	6	41-44	45-46
E2601-B1-C-1	Broke, 11	5-6	41-44	44-45
-2	Passed, 12	5-6	43-44	46-47
-3	" , 12	6	41-42	46-47
E2601-T4-C-1	Passed, 12	6	41-43	45-47
-2	" , 12	6	41-43	44-46
-3	" , 12	6	42	45-46
E2601-B4-C-1	Passed, 12	6	36-40	42-44
-2	Broke, 11	6	39-42	44-45
-3	Passed, 12	6	39-41	43-45
E2683-T1-C-1	Passed, 12	6-7	43-44	45-47
-2	Broke, 11	6-7	43-45	46-47
-3	Passed, 12	7	44-46	45-46
E2683-B4-C-1	Passed, 12	6-7	44-46	46-48
-2	" , 12	6-7	43-44	46-48
-3	" , 12	6-7	43-45	45-47

TABLE III. - LOT HEAT-TREATED BY STEEL COMPANY OF CANADA (SWANSEA WORKS).

Heat and Pin Nos.	Drop Impact Test, 400-ft-lb. blows	Austenitic Grain Size	HARDNESS, ROCKWELL 'C' Surface	Core
E2601-T1-S-1	Broke, 7	5-6		
-2	" , 6	5-6		
-3	" , 4	5-6		
E2601-B1-S-1	Broke, 4	5-6		
-2	" , 5	5-6		
-3	" , 5	5-6		
E2601-T4-S-1	Broke, 4	5-6		
-2	" , 4	5-6		
-3	" , 5	5-6		
E2601-B4-S-1	" , 5	6		
-2	" , 5	5-6		
-3	" , 7	6		
E2683-T1-S-1	Broke, 4	6-7		
2	" , 6	6-7		
3	" , 6	6-7		
E2683-B4-S-1	Broke, 5	6-7		
-2	" , 5	6-7		
-3	" , 4	6-7		

ROCKWELL 'C' 43-47 ON BOTH SURFACE AND CORE.

Microscopic Examination:

Microscopic examination of specimens from all groups failed to show any significant variation with respect to type and distribution of inclusion content. Moreover, the type and distribution of non-metallic inclusions were essentially the same as observed in many previous heats of SAE 9255 steel for C.D.P. track pins.

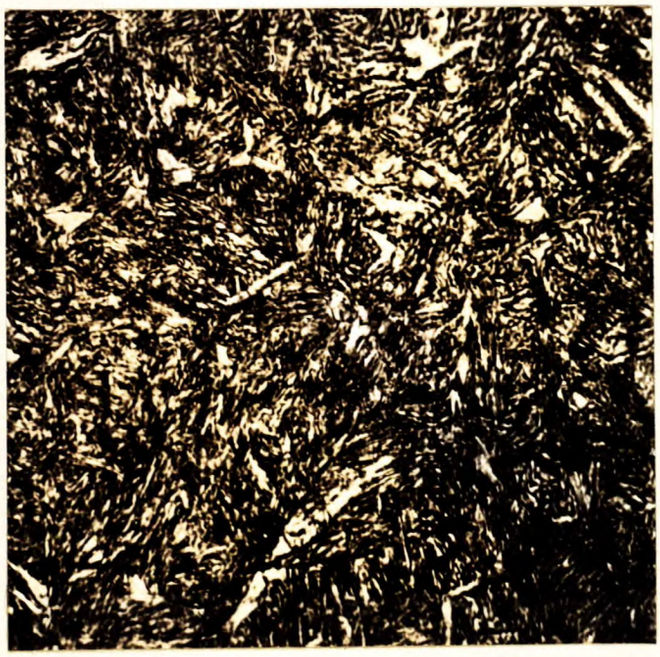
The cross-sections of pins from all lots showed uniformly tempered martensite. Photomicrographs illustrating the microstructures resulting from the three different heat treatments are shown in Figures 1, 2 and 3.

Examination of the surface of pins from each lot

(Microscopic Examination, cont'd) -

did not disclose either partial decarburization or cementite.

Figure 1.



X1000, etched in 2 per cent nital.

TYPICAL MICROSTRUCTURE OF C.D.P. TRACK PIN HEAT-TREATED BY ATLAS STEELS LIMITED.

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Figure 2.

X1000, etched in 2 per cent nital.

TYPICAL MICROSTRUCTURE OF C.D.P. TRACK PIN HEAT-TREATED BY COCKSHUTT PLOW CO. LIMITED.

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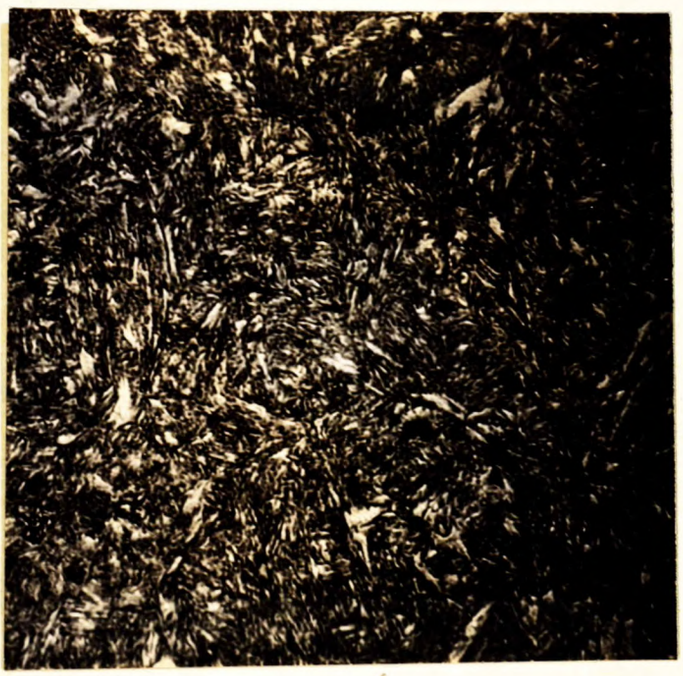
(Microscopic Examination, cont'd) -

Figure 3.



X1000, etched in 2 per cent nital.

TYPICAL MICROSTRUCTURE OF PIN HEAT-TREATED BY STEEL COMPANY OF CANADA LIMITED.

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Discussion:

The influence of three possible variables on the impact properties of C.D.P. track pins has been investigated. These variables are:

1. Location in the ingot from which the rod has been rolled.
2. Austenitic grain size.
3. Final heat treatment.

Results have shown that, while some variation in the impact properties exists within each heat-treated lot, there appears to be no definite relationship between impact strength and location of cut from the ingot, or austenitic grain size, or core hardness.

Quite evident, however, is the variation in impact properties between the three lots of different heat treatments:

(Discussion, cont'd) -

(a) of pins austenitized in a double chloride salt bath by the Cockshutt Plow Company, 100 per cent passed seven 400-ft-lb. blows; (b) of the pins heat-treated in dry iron chips by Atlas Steels Limited, 67 per cent passed seven 400-ft-lb. blows; and (c) of the pins heat-treated in a gas atmosphere by Steel Company of Canada, none withstood seven 400-ft-lb. blows.*

Microscopic examination has not shown any difference in microstructure which would explain the variation in heat treatment affecting the impact strength. It is possible that these variations in impact strength are caused by variation (not microscopically evident) in the degree of carbide solution at the austenitizing temperature, or by residual stresses incurred in quenching and relieved to a varying degree during tempering. Also, a period of delay between quenching and tempering increases the internal stress.

Hardness values indicate some partial decarburization on the pins heat-treated by the Cockshutt Plow Company and the Atlas Steels Limited but none on the pins heat-treated by the Steel Company of Canada. It is considered significant that the groups partially decarburized had higher impact strength. This relationship has been observed consistently during investigation of many types of track pin.

In general, it may be stated that although the possibility of low impact strength due to large austenitic grain size or segregation cannot be neglected, heat treatment appears to be the dominating factor affecting the impact properties of the C.D.P. track pins.

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* The value of seven 400-ft-lb. blows is an arbitrary figure chosen to best indicate the variation in impact results and is not meant to suggest any quantitative value. All pins tested passed the three 400-ft-lb. blows required by specification.

CONCLUSIONS:

1. All pins tested met specifications.

2. Variations of impact strength, within each heat-treated group, could not be correlated with grain size or with location of cut from ingot.

3. The greatest variation of impact properties was between lots of different heat treatment.

4. Variation in heat treatment appears to be the dominating factor influencing the impact properties of C.D.P. track pins.

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