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EXAMINATION OF FOUR SAMPLES OF BASIC OXYGEN (LD) PROCESS, SILICON-KILLED, AS-ROLLED PLATE

by

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SUMMARY

Four samples of plate from a single heat of silicon-killed basic oxygen process (LD) steel were submitted for determination of low temperature impact properties. The material was in the as-rolled condition. The 15 ft-lb Charpy V-notch transition temperatures were -45°F for the $\frac{3}{4}$ inch thick plate, -19°F for the 7/8 inch, -29°F for the 1 inch and -18°F for the $1\frac{1}{2}$" inch. The microstructures were normal and deep etching showed the material to be reasonably clean and sound. The chemistry conformed to the reported ladle analysis of the heat within the expected variation for such material. The oxygen content was determined by vacuum fusion.

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(5 tables, 2 illus.)

INTRODUCTION

On 23 July, 1958, under file "LAB" 55/4652 a request was made by the Department of Research and Development of the Canadian National Railways, 1801 Le Ber Street, Montreal, Quebec, to determine the low temperature impact properties of four samples of basic oxygen process (LD), as-rolled, silicon-killed steel. The samples were all from the same Dominion Steel and Foundries heat, 19748, and were in four different thicknesses. For ease of reference the samples are hereinafter referred to as indicated below in Table 1.

Table 1

Sample Identification

Thickness	Designation
$\frac{3}{4}$"	LD 1
7/8"	LD 2
1"	LD 3
$1\frac{1}{2}$"	LD 4

The ladle analysis of the heat was also given and is shown in Table 5.

The impact (Charpy V-notch) and the tensile properties were reported by letter on 23 September 1958. These results together with the results of chemical and vacuum fusion gas analyses, macroetch examination and microexamination are embodied in this report.

MECHANICAL PROPERTIES

The plate samples were first etched to determine the rolling direction. Both tensile and impact test bars were prepared in the longitudinal direction. Standard .505" dia x 2" gauge length tensile test bars were utilized. Standard Charpy V-notch bars were prepared with the notch perpendicular to the plate surface. The

tensile test results are shown in Table 2 and the Charpy impact test results are given in Table 3. The 15 ft-lb transition temperatures are shown in Table 4. The transition temperatures were determined from graphs of energy absorbed vs temperature.

Table 2

Tensile Test Results

Code	Plate Thickness	Tensile Strength Yield kpsi	Tensile Strength Ultimate kpsi	% Elong. in 2 in.	% Reduction in area
LD 1-1	$\frac{3}{4}$ in.	44.7	65.2	38.0	68.2
LD 1-2	"	42.7	64.4	39.5	65.0
LD 2-1	7/8 in.	40.9	65.0	39.0	66.5
LD 2-2	"	43.8	65.2	37.5	64.8
LD 3-1	1 in.	41.7	63.9	38.0	66.3
LD 3-2	"	40.0	63.5	39.0	68.5
LD 4-1	$1\frac{1}{2}$ in.	39.8	62.6	40.0	67.2
LD 4-2	"	36.9	62.2	39.5	67.5

(Standard .505 inch diameter tensile test bars were used)

Table 3

Charpy V-Notch Impact Test Results

Plate	Energy Absorbed in Foot Pounds -80°F	-40°F	0°F	32°F	73°F	140°F	212°F
LD 1	4	16.5	44	59.5	127.5	129.5	137.5
LD 2	3.5	8	27.5	66	95	111	116.5
LD 3	3	10.5	37.5	54.5	97	115	114.5
LD 4	3.5	7	9.5	32.5	88.5	128	126

(Values shown are the average of two tests at each temperature)

Table 4

Plate	15 ft.lb Transition temperature - °F
LD 1	-45
LD 2	-19
LD 3	-29
LD 4	-18

ANALYSIS

Results of chemical and vacuum fusion analyses are shown in Table 5 together with the reported ladle analysis of the heat. The value for oxygen was determined by vacuum fusion, the remainder by chemical analysis.

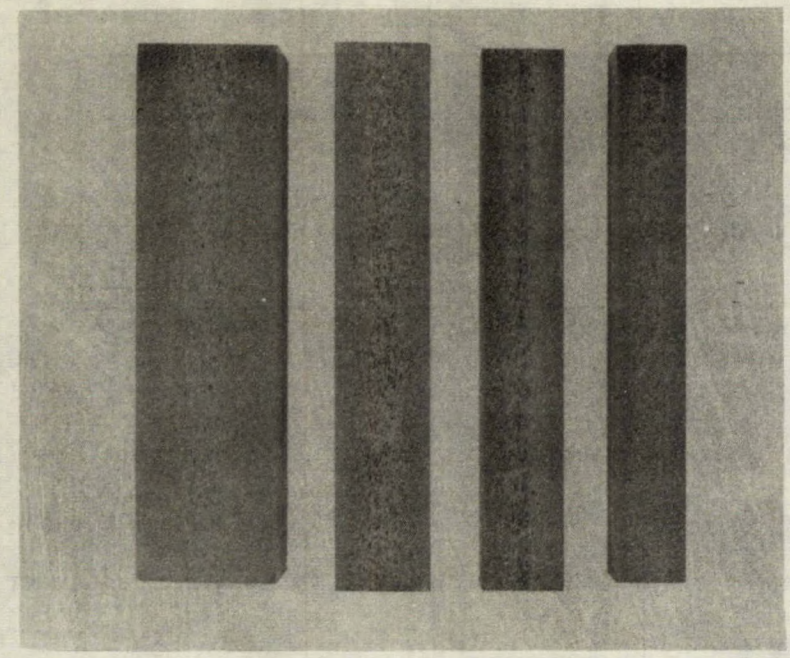
Table 5

Analysis

Sample	Percent of Element				
	LD1	LD2	LD3	LD4	Ladle
Element					
Carbon	.17	.16	.17	.19	.16
Manganese	.74	.74	.78	.80	.71
Silicon	.19	.16	.20	.19	.17
Sulfur	.017	.024	.021	.021	.016
Phosphorous	.017	.015	.015	.016	.022
Nitrogen	.006	.004	.006	.005	-
Oxygen	.0007	.001	.001	.001	-

MACRO ETCH

Portions of each sample were etched in hot 1:1 HCl and water. The material appeared reasonably sound (Fig. 1).



(Approx. ½ full size)

Fig. 1. - Transverse sections deep-etched in hot 1:1 HCl and water.

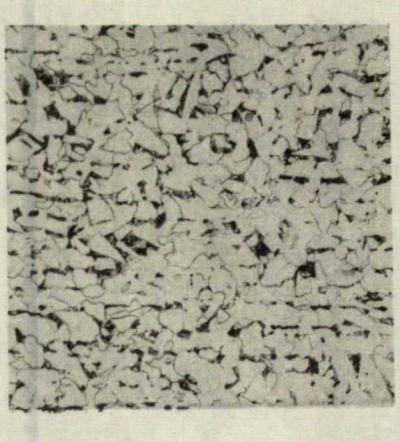
MICROEXAMINATION

Longitudinal and transverse sections of all samples were examined. The non-metallic inclusions showed no abnormalities in type, number or distribution. The steel was reasonably clean. The microstructures, (Fig. 2), are normal for as-rolled mild steel. They show approximately the variation in ferrite grain size and pearlite patch size that would be expected over the range of plate thickness.

DISCUSSION

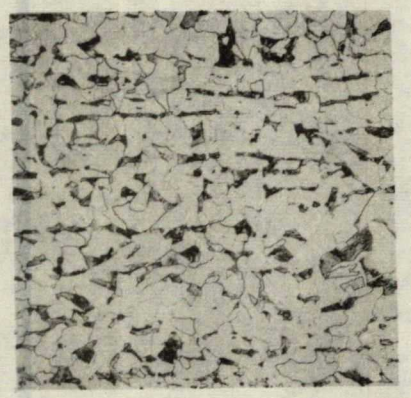
The only point which appears to require any comment is that the usual progression of increasing transition temperature with increasing plate thickness is not quite adhered to in that the 7/8 inch thick LD2 had a higher transition temperature than the 1 inch LD3. However, a variation of only 10°F in the transition temperature of mild steel, even killed mild steel, is well within the variation

expected with this class of material in the as-rolled condition. Hence it is considered the anomaly in the transition temperatures of LD2 and LD3 is more apparent than real.



LD1

LD2



LD3

LD4

(X100, etched in 2% Nital)

Fig. 2. - Longitudinal Sections.