SERIAL NO. SSC-89

Seventh

PROGRESS REPORT

(Project SR-110)

on

EFFECT OF ACCELERATED COOLING AFTER HOT ROLLING ON THE NOTCHED-BAR PROPERTIES OF SHIP PLATE STEEL

by

R. H. FRAZIER, F. W. BOULGER and C. H. LORIG
Battelle Memorial Institute

Transmitted through

NATIONAL RESEARCH COUNCIL'S
COMMITTEE ON SHIP STEEL

Advisory to

SHIP STRUCTURE COMMITTEE

Division of Engineering and Industrial Research
National Academy of Sciences - National Research Council
Washington, D. C.

July 1, 1955

SERIAL NO. SSC-89
BuShips Project NS-011-078

SHIP STRUCTURE COMMITTEE

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ADDRESS CORRESPONDENCE TO:

SECRETARY
SHIP STRUCTURE COMMITTEE
U. S. COAST GUARD HEADQUARTERS
WASHINGTON 25, D. C.

July 1, 1955

Dear Sir:

As part of its research program related to the improvement of hull structures of ships, the Ship Structure Committee is sponsoring an investigation of the influence of deoxidation and composition on properties of semikilled steel ship plate at the Battelle Memorial Institute. Herewith is a copy of the Seventh Progress Report, SSC-89, of the investigation entitled "Effect of Accelerated Cooling after Hot-Rolling on the Notched-Bar Properties of Ship-Plate Steel" by R. H. Frazier, F. W. Boulger and C. H. Lorig.

The project is being conducted with the advisory assistance of the Committee on Ship Steel of the National Academy of Sciences-National Research Council.

Any questions, comments, criticism or other matters pertaining to the report should be addressed to the Secretary, Ship Structure Committee.

This report is being distributed to those individuals and agencies associated with and interested in the work of the Ship Structure Committee.

Yours sincerely,

K. K. COWART
Rear Admiral, U. S. Coast Guard
Chairman, Ship Structure Committee

SEVENTH
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Battelle Memorial Institute

under

Department of the Navy
Bureau of Ships NObs-53239
BuShips Project No. NS-011-078

for

SHIP STRUCTURE COMMITTEE

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EFFECT OF ACCELERATED COOLING AFTER HOT-ROLLING ON THE NOTCHED-BAR PROPERTIES OF SHIP PLATE STEEL*

INTRODUCTION

The notched-bar properties of ship plate steels reheated to temperatures above 1500 F are affected by the rate at which they cool to room temperature. Previous work at Battelle(1) showed that cooling in an air blast produced better properties than slower cooling rates. This suggested that faster cooling from the hot-rolling operation might improve the properties of ship plate steels. Work at Inland Steel Company(2) indicated that changing the rate of cooling between 1100 and 125 F does not significantly affect the properties of semikilled steels. It appeared, therefore, that cooling rates at temperatures above 1100 F were of greatest interest.

With this background the effect of accelerated cooling from the final rolling pass was investigated. Two open-hearth steels of conventional ship plate composition were used for the experiments. The plates were time-quenched as they left the rolling mill at 1850 F. The quenching periods were kept short in order to develop a microstructure of ferrite and pearlite in the final plate. The plates were cooled to room temperature in air after the time-quenching treatment. Keyhole Charpy and tear tests were made on samples from plates cooled from the final rolling pass at four different rates.

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*Ed. Note: Attention is directed to the fact that the Bethlehem Steel Company may have filed an application for patents on a process for improving the notch toughness of ship plate steel by accelerated cooling from the finishing pass in the hot-rolling operation.

EXPERIMENTAL WORK

Cooling Rates. Before planning the experimental work, it seemed desirable to estimate the cooling rates produced by quenching and air cooling 3/4-in. plates. For this purpose a thermocouple was welded in the bottom of a hole drilled to the center of a 6- by 12-by 3/4-in. plate, as shown in Fig. 1. Temperature measurements by this method gave the cooling curves shown in Fig. 2. Water quenching gave an average rate of 20 F per second, compared with 0.7 F per second for air cooling in the range from 1850 to 1300 F.

The broken lines in Fig. 2 show cooling rates estimated for three interrupted quenches. Subsequently, stock for the investigation was produced by immersing hot-rolled plates for 6, 10, and 25 seconds in water and then cooling in still air.

Materials and Heat Treatments. Two semikilled steels were used in the study. These steels were made in a commercial open-hearth furnace and cast into large commercial sized molds. The ingots were rolled to 1 3/4-in. thick plate in a commercial rolling mill. Sections of the plate from one ingot were received at Battelle. The chemical compositions of the steels are shown in Table 1. Steel W-1 would meet the ABS Class A specification had it been rolled to plates 1/2 in. thick and lighter. The other steel could have been rolled to plates over 1/2 in. to 1 in. thick, inclusive, to meet the ABS Class B specification.

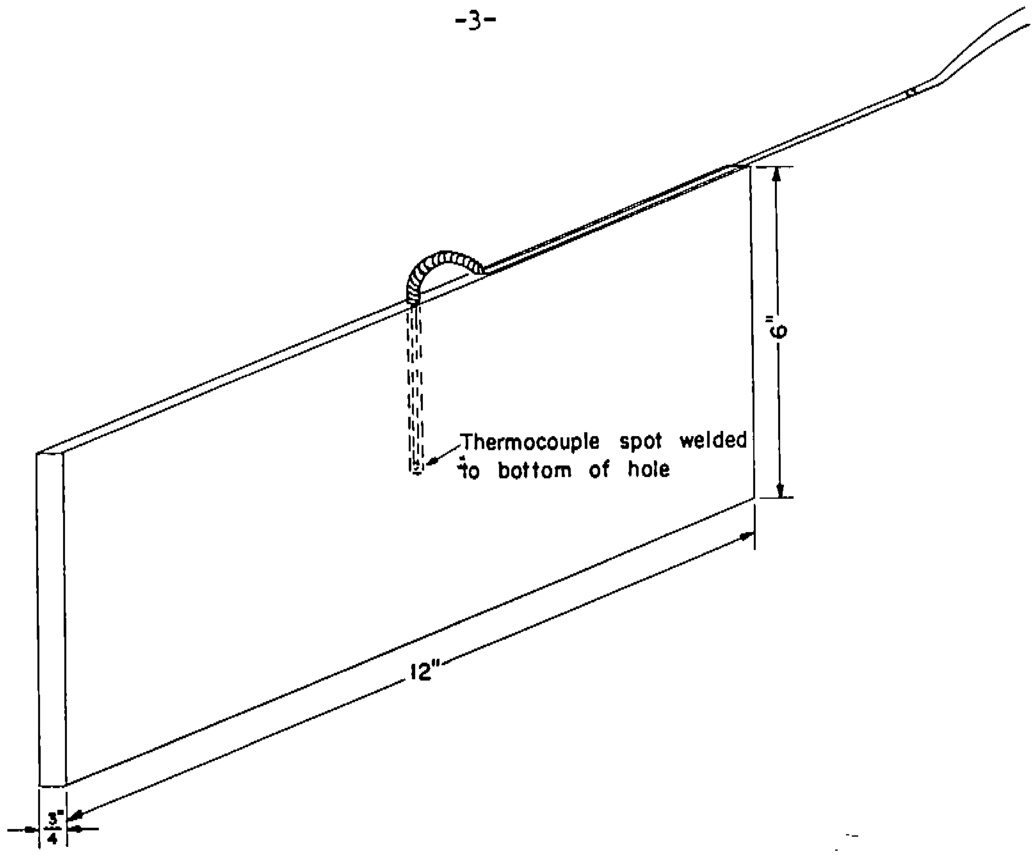


FIGURE 1. TEST PLATE FOR COOLING-RATE DETERMINATION

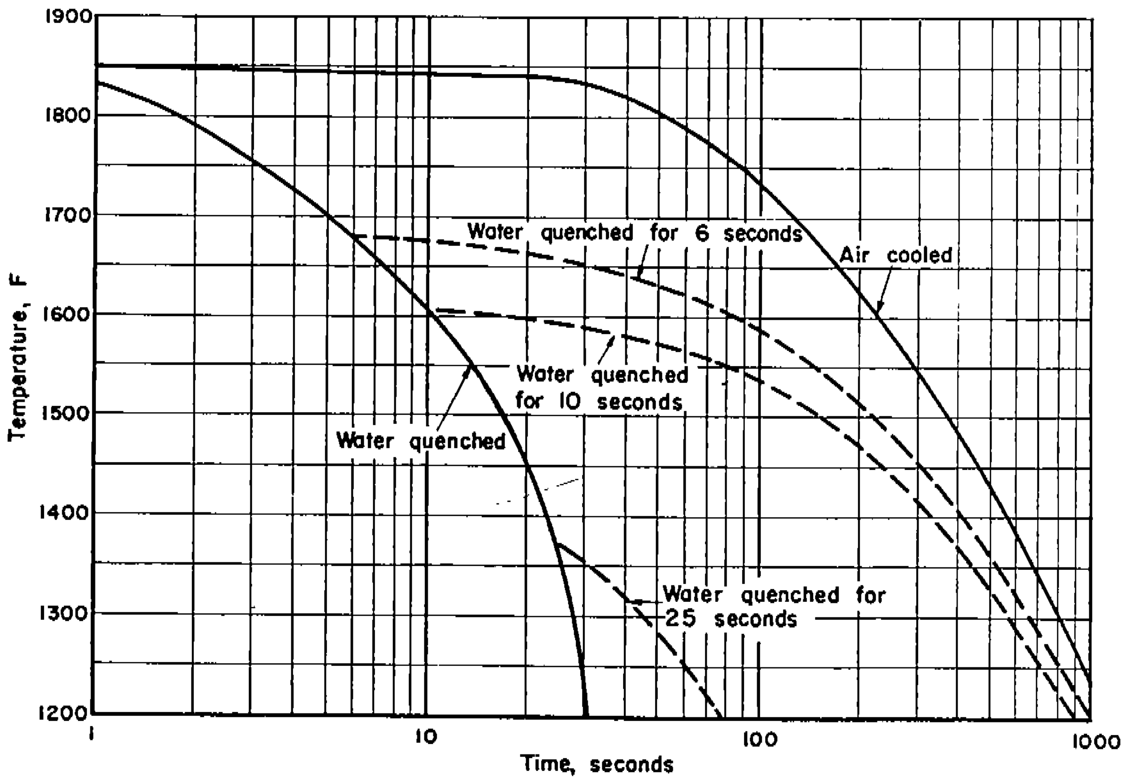


FIGURE 2. COOLING CURVES FOR WATER-QUENCHED AND AIR-COOLED $\frac{3}{4}$-INCH STEEL PLATES

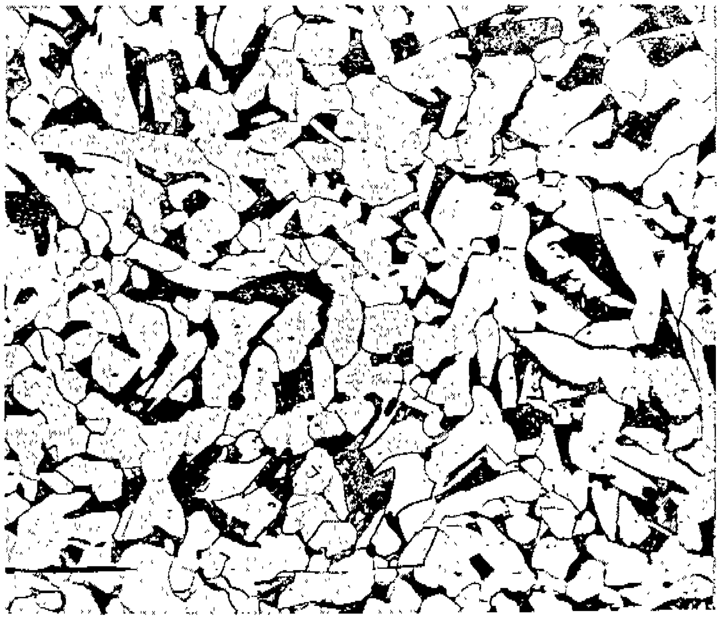
TABLE 1. CHEMICAL COMPOSITION OF EXPERIMENTAL OPEN-HEARTH STEELS

Heat Number	Battelle-Assigned Heat Number	Composition, per cent				
		Carbon	Manganese	Silicon	Phosphorus	Sulfur
64C623	W-1	0.23	0.52	0.09	0.013	0.037
67C658	W-5	0.23	0.78	0.09	0.012	0.025

Note: No aluminum was added to either steel.

The sections of 1 3/4-in. plate were heated to 2250 F and rolled to 0.9-in. gage, using reduction of approximately 1/6 in. per pass. In order to insure a uniform finishing temperature, the 0.9-in. sections were immediately recharged in a furnace held at 1850 F. After 30 minutes in the furnace at 1850 F, the plates were reduced to 3/4 in. in one pass. Following this final pass, one plate from each steel was placed on edge on a brick floor, with a brick separating each plate, and allowed to air cool. Another plate from each steel was immersed immediately in a water bath. After six seconds the plate was removed from the water bath and air cooled to room temperature. A third plate from each steel was quenched for 10 seconds, and a fourth plate was quenched for 25 seconds. The estimated cooling curves for each plate are given in Fig. 2.

Microstructure. Fig. 3 shows photomicrographs of the structures of air-cooled steel plates used in this study. The



180X

Steel W-1

180X

Steel W-5

FIGURE 3 PHOTOMICROGRAPHS OF LONGITUDINAL CROSS SECTIONS OF AIR-COOLED 3/4-IN. PLATES FROM STEELS W-1 AND W-5 air-cooled material had a ferrite-pearlite microstructure closely resembling that of a hot-rolled mild carbon steel plate. Steel W-5 shows somewhat more banding of the pearlitic areas due probably to its higher manganese content.

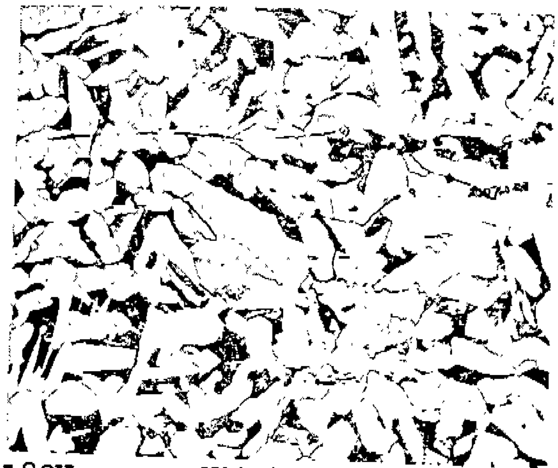
The microstructure of the quenched plates was different at the surface than at the center. Typical microstructures from near the surface and at the center of the plate from both steels quenched for various times are shown in Fig. 4 and 5.

The microstructure in the surface layer of the W-1 steel plate quenched for six seconds consists of unresolved finely divided carbides in a matrix of ferrite. Some patches of pearlite were also observed. After longer times in the quenching bath, the microstructure in the surface layer consisted of bainite with some tempered martensite. The longer quenching time produced more tempered martensite. The microstructure at the center of the W-1 steel plate quenched for six seconds is very similar to that for the air-cooled plate. Longer quenching times produced bainite in the center of what were the original austenitic grains. The bainite is outlined by free ferrite.

Plates of Steel W-5, quenched for six seconds, had a ferrite-pearlite microstructure throughout the plate thickness. The ferrite grains and the pearlite patches were much smaller near the surface than at the center of the plate. The microstructure of the W-5 steel plates quenched for 10 and 25 seconds was bainite

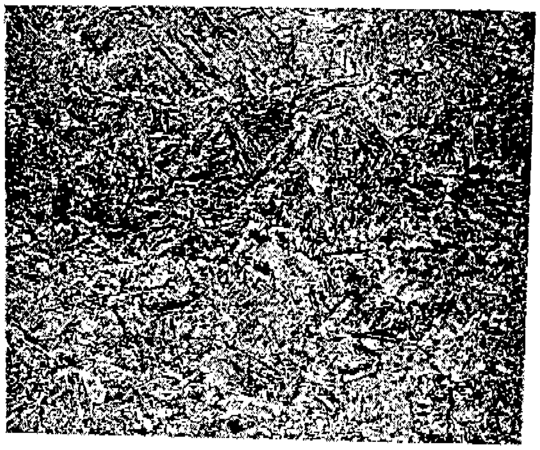
Surface of Plate — Center of Plate

180X Picral Etch



180X Nital Etch

Water Quenched for 6 Seconds



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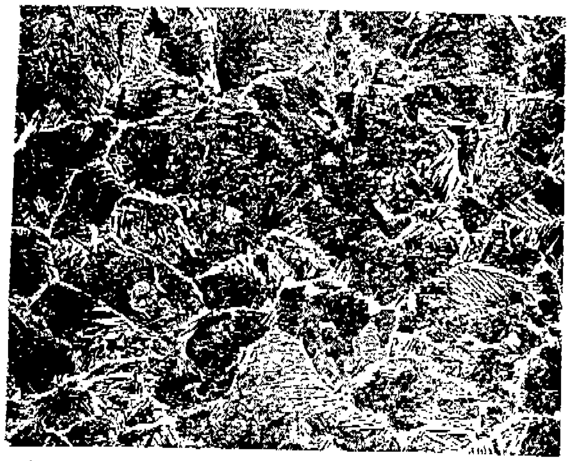
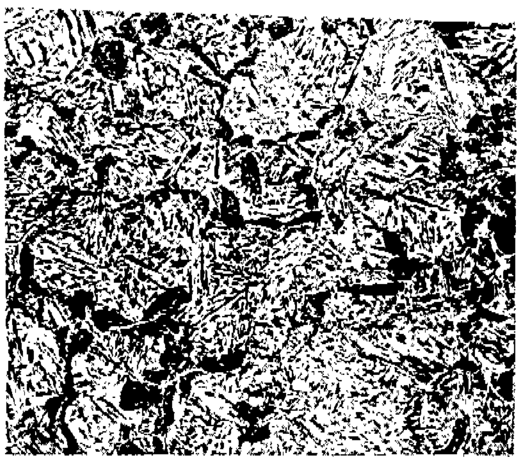


180X Picral Etch

Water Quenched for 10 Seconds



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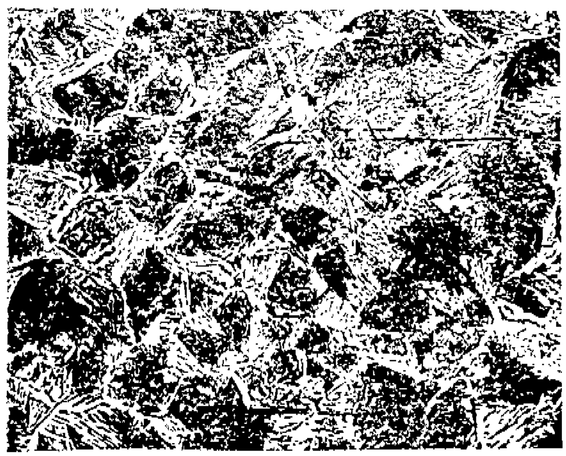
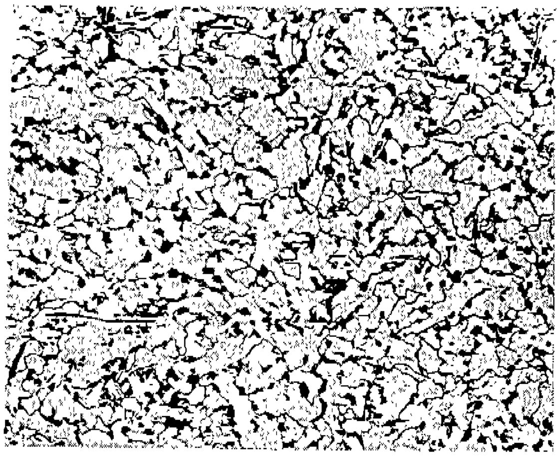


180X Picral Etch

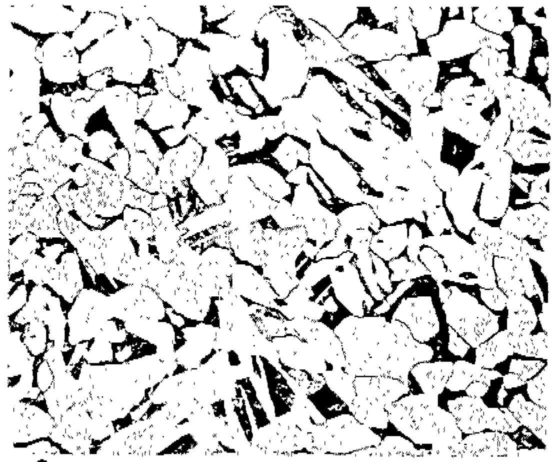
Water Quenched for 25 Seconds

FIGURE 4 MICROSTRUCTURE OF THE LOW-MANGANESE W-1 STEEL PLATE WATER-QUENCHED FOR VARIOUS TIME INTERVALS AND THEN AIR-COOLED TO ROOM TEMPERATURE

Edge of Plate | Center of Plate

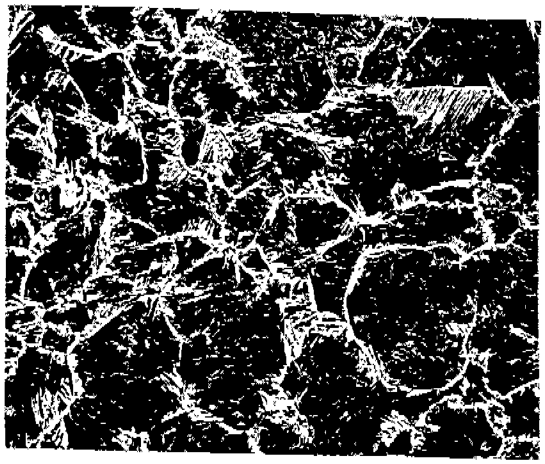


180X Nital Etch

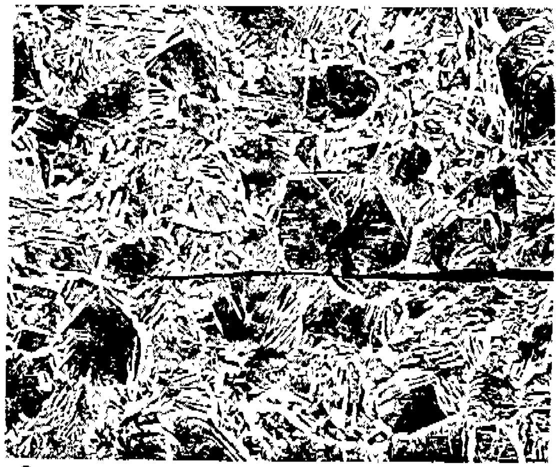


180X Nital Etch

Water Quenched for 6 Seconds



180X Picral Etch



180X Picral Etch

Water Quenched for 10 Seconds

180X Picral Etch

180X Picral Etch

Water Quenched for 25 Seconds

FIGURE 5 MICROSTRUCTURE OF THE HIGHER MANGANESE W-5 STEEL PLATE WATER-QUENCHED FOR VARIOUS TIME INTERVALS AND THEN AIR-COOLED TO ROOM TEMPERATURE surrounded by free ferrite, with the ferrite outlining what were originally the austenitic grains. More free ferrite grains existed in the center of these plates than near the surface.

Hardness. The average hardnesses of the air-cooled plates were 69 and 71 Rockwell B for Steels W-1 and W-5, respectively. These plates had uniform hardnesses from one surface to the other and from edge to edge, whereas the water-quenched plates were not of uniform hardness. In the latter the surfaces and edges showed a higher hardness than the center. The average hardnesses at the center and surfaces of the various plates from the two steels are shown in Table 2. The hardness of the water-quenched plates

TABLE 2. AVERAGE HARDNESS OF EXPERIMENTAL 3/4-IN. STEEL PLATE

Type of Cooling From Last Hot-Rolling Pass	Hardness, Rockwell B	
	Center	Edges and Surfaces
	Steel W-1	
As rolled	69	69
Quenched for 6 seconds	70	95
Quenched for 10 seconds	88	105
Quenched for 25 seconds	88	105
	Steel W-5	
As rolled	71	71
Quenched for 6 seconds	67	90
Quenched for 10 seconds	78	95
Quenched for 25 seconds	88	100

decreased gradually from the surface toward the center, with the hardness gradient extending inward about 3/16 in. from both surfaces. The edge hardening, on the other hand, extended somewhat more than one inch before the hardness reached that of the center. The tear tests were taken so that the notches cut through this hardened edge. The harder surfaces were present in all specimens of the water-quenched steel, since they represent the full thickness of the plate.

The Charpy specimens were taken from the center of the plate so that some of the hardened surface area of the water-quenched steel specimens was removed. However, the surface hardness of some thirty specimens from these steels averaged 96 Rockwell B, while six of the thirty had surface hardnesses over 100 Rockwell B. This higher hardness of the six specimens probably influenced their Charpy values but not the shape of the average Charpy value curves of the steels. The Charpy specimens with hard surfaces represented only about one-fifth of the bars tested.

Keyhole Charpy Tests. Four keyhole Charpy specimens from each plate were broken at each 10 F interval throughout the ductile-brittle transition range. Smooth curves were drawn through the averages of the results at each temperature. From these curves the temperatures at the 12 and 20 ft-lb energy levels were determined as criteria for the transition. All specimens were parallel to the rolling direction and notched perpendicular to plate surface.

The keyhole Charpy transition curves and individual test values for the two air-cooled steels are shown in Fig. 6. The temperatures at the 12 ft-lb level for Steels W-1 and W-5 are -10 and -23 F, respectively. When the 20 ft-lb criterion is used, the transition temperatures are +6 and -11 F for air-cooled plates from the Steels W-1 and W-5, respectively. The transition temperatures measured by the same criteria for the water-quenched plates are given in Table 3. The average energy values of duplicate specimens tested at +80 F are also shown for comparison. The transition temperature at the 12 ft-lb level was lowered by increasing the quenching time. In the case of Steel W-1, the transition temperature at the 20 ft-lb energy level did not change in a consistent manner with the time at quench. This seemed to result from the fact that quenching for different lengths of time profoundly altered the character of the keyhole Charpy transition curve as shown in Fig. 7.

TABLE 3. SUMMARY OF KEYHOLE CHARPY DATA FOR PLATES TIME-QUENCHED FROM THE LAST HOT-ROLLING PASS

Steel		Transition Temperature, F 12 Ft-lb	 20 Ft-lb	Impact Value at 80 F Ft-lb
W-1	Air-cooled	-10	+6	34.5
	Quenched for 6 seconds	-30	-25	42.0
	Quenched for 10 seconds	-36	-15	44.0
	Quenched for 25 seconds	-45	-6	25.5
W-5	Air-cooled	-23	-11	37.0
	Quenched for 6 seconds	-26	-14	31.5
	Quenched for 10 seconds	-31	-20	31.5
	Quenched for 25 seconds	-35	-26	37.0

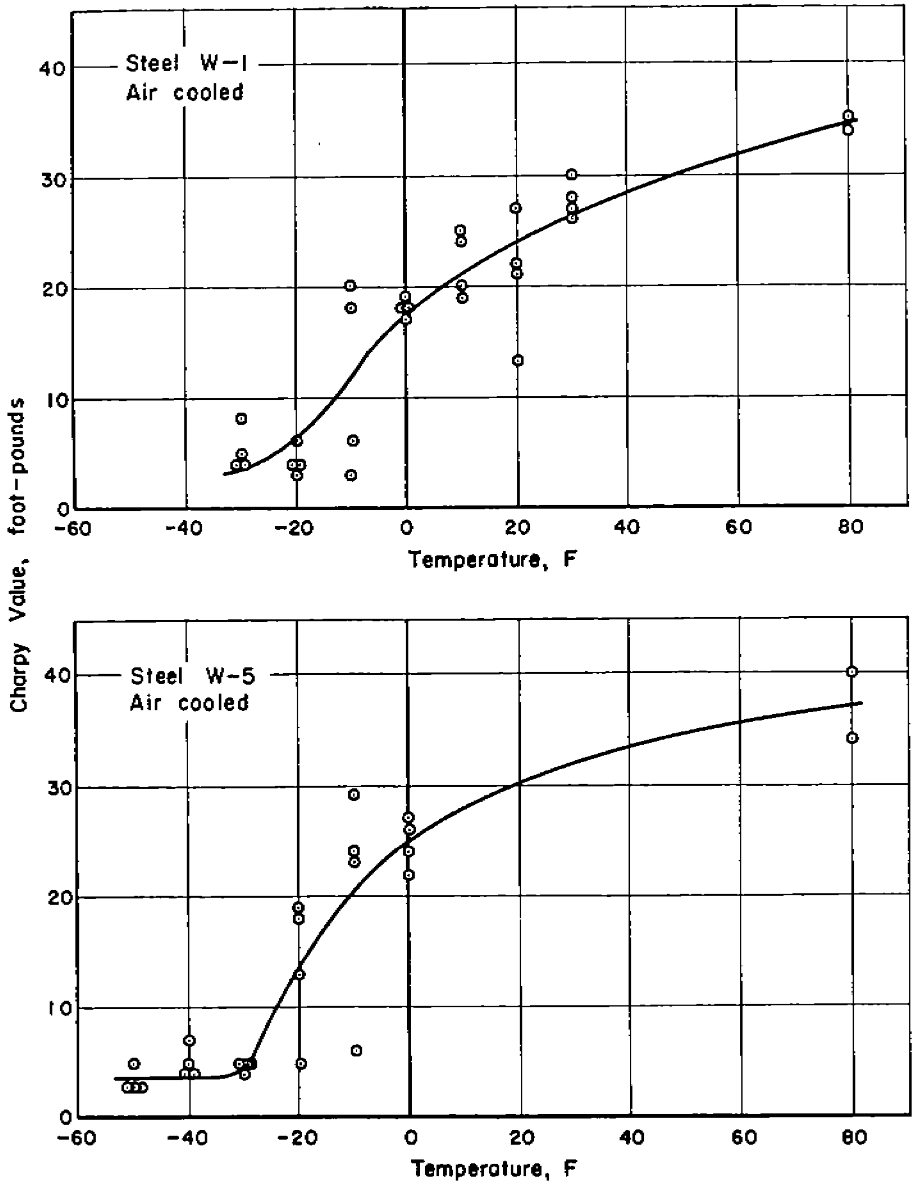


FIGURE 6. KEYHOLE CHARPY TRANSITION CURVES FOR STEELS W-1 AND W-5 AIR COOLED FROM 1850 F

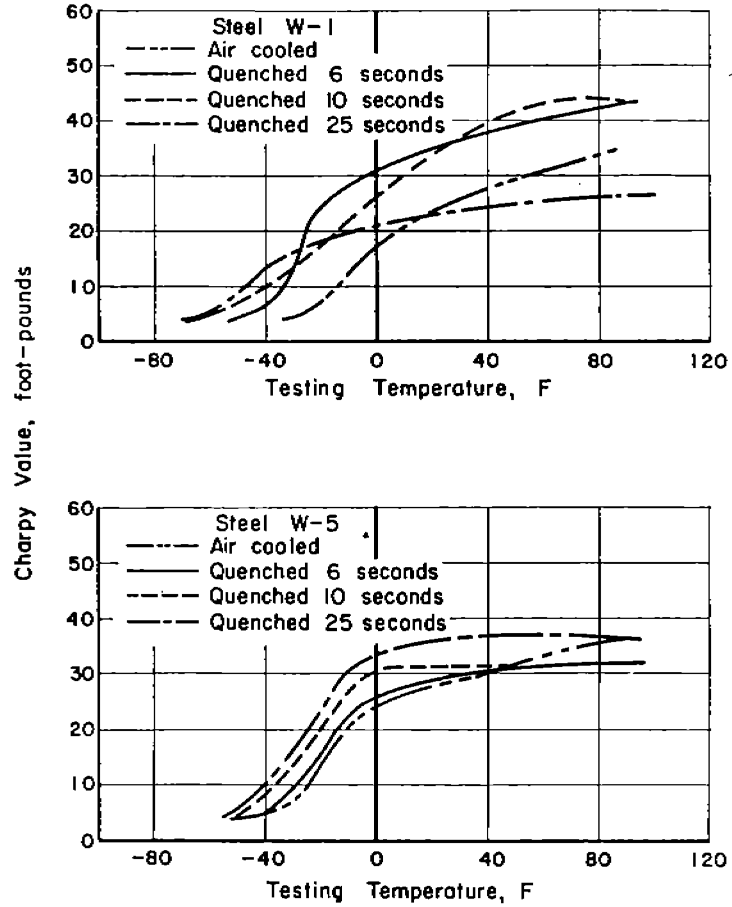


FIGURE 7. EFFECT OF INTERRUPTED WATER QUENCHING ON KEYHOLE CHARPY TRANSITION CURVES FOR STEELS W-1 AND W-5

One important observation was that the transition temperatures for the quenched plates were always lower than those for the air-cooled plates.

The keyhole notch Charpy properties of 3/4-in. semikilled steel plate were, therefore, improved by time-quenching in water for time intervals of 25 seconds or less.

Influence of Quenching on Tear Test Properties. Sixteen tear tests were also made on stock from plates representing each condition. These specimens were broken at various temperatures to determine the transition temperatures. For this purpose the transition temperature was defined as the highest temperature where at least one specimen was brittle. No more than four specimens were tested at one temperature. Brittle specimens were those with fractures indicating that more than half of the cross section failed by cleavage rather than shear. This criterion for defining the transition temperature has been used by many investigators and was used in this investigation in order to conserve stock. The information obtained in each test is shown in Table A-4 of the Appendix. The tear test data are summarized in Table 4.

In most cases time-quenching the hot-rolled plates in water lowered the transition temperature determined by tear tests. The maximum improvements amounted to 30 F for Steel W-1 and 40 F for Steel W-5. In general, increasing the length of the quenching time lowered the transition temperature. The exception to this statement

TABLE 4. SUMMARY OF TEAR TEST DATA

Treatment	Maximum Load*, pounds	Energy to Start Fracture** ft-lb	Energy to Propagate Fracture** ft-lb	Transition Temperature‡, F
Steel W-1 (0.52 Per Cent Manganese)				
Air-cooled	38,490	708	667	90
Quenched for 6 seconds	42,600	879	1021	80
Quenched for 10 seconds	60,620	775	767	60
Quenched for 25 seconds	56,480	417	525	130
Steel W-5 (0.78 Per Cent Manganese)				
Air-cooled	39,940	825	638	60
Quenched for 6 seconds	38,790	650	642	
Quenched for 10 seconds	51,690	507	716	50
Quenched for 25 seconds	51,030	666	708	20

*Average of all tests made.
**Average of tests made 10 F above transition temperature.
‡Transition temperature is defined as the highest temperature where one or more specimens out of four showed more than 50 per cent cleavage type of fracture.

is the plate of W-1 which was quenched in water for 25 seconds before air-cooling. This plate had a higher transition temperature than the plates which had been quenched for shorter times or air-cooled from the last hot-rolling pass. The transition temperature for the plate of W-5 which had been quenched for 6 seconds could not be determined because of a shortage of material.

SUMMARY

The results of this work may be summarized as follows:

(1) Water quenching 3/4-in. plates for six seconds did not raise the hardness in the center of the plate. Longer quenching times increased the center hardness, an indication that the ultimate strength of the plate was increased. The hardness at the edge of all plates quenched was approximately 95 R_B, with the higher carbon steel having the highest surface hardness.

(2) The microstructure of the center of plates, quenched for periods longer than six seconds, was no longer typical of as-rolled steel but, instead, tended to show ferrite outlining the original austenite grain areas. The centers of the quenched plates also showed some Widmanstätten structures.

(3) The transition temperature, when the 12 ft-lb keyhole notch Charpy criterion was used, was lowered by quenching the plates from the last hot-rolling pass. Longer quenching times gave lower transition temperatures. The higher manganese Steel W-5 appeared to be more adaptable to quenching than Steel W-1, since the shape of the keyhole Charpy transition curves for Steel W-5 was not altered by quenching.

(4) In general, increasing the length of the quenching time lowered the tear test transition temperature. An exception was the plate of Steel W-1 which was quenched in water for 25 seconds before being air-cooled. This plate had a higher transition temperature than the plates which had been quenched for shorter times or air-cooled from the last hot-rolling pass.

REFERENCES

1. Frazier, R. H., Boulger, F. W., and Lorig, C. H. "The Influence of Heat Treatment on the Notched-Bar Properties of Semikilled Steel Plate," Third Progress Report, Ship Structure Committee Report, Serial No. SSC-71, March 15, 1954.

2. Mair, L. "Effect of Cooling Rate on Transition Temperature," Inland Steel Company's Final Report to Subcommittee on Project SR-110, June 11, 1952.

APPENDIX

TABLE A-1. KEYHOLE CHARPY TEST DATA FOR AIR-COOLED STEELS

Steel Number	Testing Temperature, F	Charpy Value, ft-lb				
		Test 1	Test 2	Test 3	Test 4	Average
8W 1	-30	4	5	4	8	5.3
	-20	4	4	3	6	4.3
	-10	18	6	3	20	11.5
	0	18	19	17	18	18.0
	10	19	24	25	20	22.0
	20	22	27	21	13	20.8
	30	27	26	28	30	27.8
	80	35	34			34.5
8W 5	-50	3	5	3	3	3.5
	-40	7	5	4	4	5.0
	-30	5	5	4	5	4.8
	-20	19	5	18	13	13.8
	-10	6	24	29	23	20.5
	0	22	26	24	27	24.8
	80	40	34			37.0

TABLE A-2. TEAR TEST DATA FOR AIR-COOLED STEELS

Testing Temperature, F	Maximum Load, Pounds	Energy, ft-lb To Start Fracture	Energy, ft-lb To Propagate Fracture	Per Cent Shear in Fracture
		Steel 8W 1		
50	41,650	961	334	30
50	41,150	950	117	3
50	41,200	961	142	5
50	41,900	961	508	60
60	37,350	790	125	5
60	38,050	833	167	16
60	37,700	842	492	55
60	37,950	750	75	5
70	40,700	875	700	90
70	39,850	790	750	100
70	38,700	891	450	53
70	38,650	775	83	18
80	37,500	808	508	68
80	37,500	700	665	89
80	37,150	790	665	88
80	38,100	750	100	30
90	39,750	824	725	100
90	40,350	891	665	95
90	36,200	734	675	83
90	37,500	725	200	33
100	36,400	757	700	98
100	37,150	725	633	83
100	35,200	707	650	90
100	36,000	642	684	95
		Steel 8W 5		
40	41,200	833	590	68
40	41,150	876	675	90
40	41,150	833	665	91
40	40,850	833	500	52

TABLE A-2. (Continued)

Testing Temperature, F	Maximum Load, Pounds	Energy, ft-lb To Start Fracture	To Propagate Fracture	Per Cent Shear in Fracture
		Steel 8W 5		
50	35,550	715	616	99
50	36,200	750	600	95
50	37,700	790	625	90
50	41,350	860	725	92
60	40,250	833	700	83
60	40,900	860	658	83
60	40,850	885	690	90
60	42,050	925	316	30
70	39,200	-	-	86
70	39,800	784	715	88
70	39,600	790	675	96
70	41,200	900	675	87

TABLE A-3. KEYHOLE CHARPY DATA FOR STEELS QUENCHED IN WATER AND THEN AIR-COOLED

Steel Number	Testing Temperature, F	Charpy Value, ft-lb				
		Test 1	Test 2	Test 3	Test 4	Average
		Quenched for Six Seconds				
A8W1	-50	3	3	3	5	3.5
	-40	9	4	10	4	6.8
	-30	5	28	5	6	11.0
	-20	27	30	25	21	25.8
	-10	27	29	25	26	26.8
	0	29	29			29.0
	80	39	45			42.0
A8W5	-40	6	4	5	6	5.3
	-30	8	5	14	22	
		19	12			13.3
	-20	12	20	7	8	11.8
	-10	21	15	21	26	20.8
	0	28	26	27	27	27.0
	80	30	33			31.5
		Quenched for Ten Seconds				
B8W1	-60	5	10	3	3	5.3
	-50	7	4	15	4	7.5
	-40	28	21	3	5	14.3
	-20	26	26	4	25	20.3
	-10	33	24	6	29	23.0
	0	9	28	29	7	18.3
	10	28	28	32	35	30.3
	80	45	43			44.0
B8W5	-50	4	3	5	3	3.8
	-40	5	14	6	4	7.3
	-30	4	5	5	28	
		26	31			16.5
	-20	6	30	6	32	18.0
	-10	9	32	31	31	25.8
	0	33	29	33	30	31.3
	80	32	31			31.5

TABLE A-3. (Continued)

Steel Number	Testing Temperature, F	Charpy Value, ft-lb Test 1	Test 2	Test 3	Test 4	Average
		Quenched for Twenty-Five Seconds				
C8W1	-60	9	4	5	3	5.3
	-50	22	11	6	20	14.8
	-40	6	14	9	11	10.0
	-20	15	20	11	27	18.3
	-10	10	29	27	20	21.5
	0	18	30	26	8	20.5
	10	13	14	20	25	18.0
	20	17	14	18		16.0
	80	24	27			25.5
C8W5	-50	4	4	5	4	4.3
	-40	5	7	4	26	10.5
	-30	6	23	14	6	12.3
	-20	12	24	33	27	24.0
	-10	30	29	33	32	31.0
	0	32	36			34.0
	80	36	38			37.0

TABLE A-4. TEAR TEST DATA FOR STEELS QUENCHED IN WATER AND THEN AIR-COOLED

Steel Number	Testing Temperature, F	Maximum Load, Pounds	Energy, ft-lb: To Start Fracture	Energy, ft-lb: To Propagate Fracture	Per Cent Shear in Fracture
		Quenched for Six Seconds			
A8W 1	40	44,600	900	133	3
		41,500	915	208	16
	50	45,200	918	768	75
		44,400	833	400	32
	60	40,200	800	500	55
		43,200	766	133	15
	70	41,800	961	133	18
		44,000	935	734	90
	80	40,700	875	734	100
		43,600	958	92	23
		45,300	885	885	100
		41,250	915	690	82
	90	42,000	824	800	97
		41,550	915	891	98
		41,450	815	860	99
		40,800	961	1533	97
A8W 5	-30	39,350	808	117	7
	-20	38,000	584	590	59
		37,150	600	690	63
		37,400	665	633	73
		42,000	766	133	5
	-10	39,200	842	383	30
		42,000	725	600	83
		38,550	750	725	80
		38,200	690	575	77
	0	39,450	650	642	80
	10	37,350	684	642	80
	20	40,600	633	766	90
	30	36,500	665	658	94
	40	38,700	600	642	85
	50	37,450	534	633	93
		Quenched for Ten Seconds			
B8W 1	30	64,200	866	67	5
		65,000	800	100	6
		69,400	1100	133	1

TABLE A-4. (Continued)

Steel Number	Testing Temperature, F	Maximum Load, Pounds	Energy, ft-lb To Start Fracture	Energy, ft-lb To Propagate Fracture	Per Cent Shear in Fracture
		Quenched for Ten Seconds (Continued)			
B8W1	40	61,600	1000	534	63
		61,800	665	133	5
	50	49,500	707	750	95
		61,600	900	167	11
	60	58,400	900	67	15
		60,200	800	700	93
		67,000	800	133	8
		63,200	900	234	19
	70	51,400	700	700	90
		60,000	766	766	97
		57,800	766	800	88
		58,200	866	800	100
B8W5	30	44,800	800	734	100
		54,400	633	400	45
		59,600	665	67	3
		54,400	565	33	3
	40	57,200	565	100	15
		54,200	500	633	97
		50,400	734	367	13
		57,200	600	133	4
	50	51,600	766	665	100
		47,500	1020	775	100
		51,000	600	734	100
		53,400	466	433	44
	60	49,000	665	665	99
		46,600	665	800	100
		50,800	433	665	100
		46,000	665	734	100
		Quenched for Twenty-Five Seconds			
C8W1	50	59,200	600	300	15
	60	63,800	565	67	0
	70	69,200	534	133	0
	80	53,800	400	67	1
	100	56,400	433	133	0
	110	53,600	633	67	2
		59,800	900	700	100

TABLE A-4. (Continued)

Steel Number	Testing Temperature, F	Maximum Load, Pounds	Energy, ft-lb To Start Fracture	Energy, ft-lb To Propagate Fracture	Per Cent Shear in Fracture
		Quenched for Twenty-Five Seconds (Continued)			
C8W 1	120	60,600	935	300	88
		54,800	400	167	18
	130	58,400	600	133	1
		49,800	400	334	63
	140	51,000	367	534	100
		54,000	534	534	100
		52,200	367	466	100
		50,600	400	565	100
C8W 5	0	54,000	665	266	12
		53,000	833	766	90
	10	50,600	700	665	95
		53,400	565	800	100
		52,400	734	300	27
		52,200	665	334	21
	20	48,400	665	935	100
		51,400	565	766	98
		48,800	766	734	99
		52,400	565	466	39
	30	49,600	665	700	100
		48,200	665	766	100
		51,800	633	734	83
		52,000	700	633	100
	50	51,000	334	633	100
	60	47,200	658	707	100