

JAN 18 1968

# NATIONAL BUREAU OF STANDARDS REPORT

9669

EFFECT OF REFRIGERATION ON CHARPY V-NOTCH  
IMPACT PROPERTIES OF TYPE 431 STAINLESS STEEL

By

I. J. Feinberg  
Engineering Metallurgy Section

To

Materials Division  
Naval Air Systems Command  
Department of the Navy



U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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## Effect of Refrigeration on Charpy V-Notch Impact Properties of Type 431 Stainless Steel

Section 1 of NBS Report No. 9614, "Effect of Some Hardening Variables On the Mechanical Properties of Type 431 Stainless Steel" gives Charpy V-notch impact values for material refrigerated and not refrigerated during heat treatment. These values showed that a marked reduction in the notch toughness of specimens tested at both room temperature and at  $-40^{\circ}$  F resulted from inclusion of refrigeration in the heat treatment sequence. The reduction was so great as to warrant testing of additional specimens for verification of the results reported in NBS 9614.

Table 1 contains the results of both the original tests and supplementary tests. The supplementary tests confirm that the inclusion of refrigeration in the heat treating sequence for type 431 stainless steel results in a sharp reduction in the notch impact strength of this material. It is noteworthy that an overnight delay in applying the refrigeration treatment after quenching produces less of a loss in impact strength than does an immediate application of the refrigeration treatment.

Refrigeration is introduced into type 431 heat treating cycles to reduce retained austenite contents in the material. This reduction has been considered necessary to minimize the possibility of deleterious effects from dimensional changes (expansion) occurring in the transformation of austenite to martensite resulting from working in service. Since refrigeration severely reduces notch impact strength of 431 at both room temperature and at  $-40^{\circ}$  F it appears that any advantage this treatment would impart would be nullified if part geometry included notches and/or the parts were subjected to impact loading and is, therefore, not recommended for such material.

When hardened 431 is aged at room temperature, prior to sub-cooling intended to transform retained austenite to martensite, the retained austenite becomes stabilized and resists sub-zero transformation. This accounts for the appreciably higher room temperature and  $-40^{\circ}$  F notch impact properties of 431 refrigerated after an overnight delay as compared with the impact properties of the same material refrigerated immediately after the oil quench. Accordingly, if refrigeration is deemed necessary in the 431 heat treating cycle it should be employed as soon as possible after quenching and before tempering.

Table 1, Mil H 6875D, contains no reference to immediate sub-cooling after quenching. It is recommended that it be reworded to specify immediate refrigeration for material requiring maximum austenite transformation.





Table 1. Charpy V-notch Impact Properties of Type 431 Stainless Steel; Stress Relieved 1/2 Hour at 1200° F, Austenitized 1/2 Hour in Air at 1900° F, Quenched in Oil at 100-105° F and Refrigerated for 2 Hours at -140° F as Noted. Tempered Twice at 550° F for 2 Hours Specimens Ground to Finished Dimensions After Heat Treatment.

Charpy V-Notch, Ft. Lbs.

Results given in NBS  
Report No. 9614,  
Dated Oct. 6, 1967

Results of Supplementary  
Tests, Dated Dec. 16, 1967

Heat Treatment	Specimen No.	R.T.	-40° F	Specimen No.	R.T.	Specimen No.	-40° F
Stress relieve Austenitize in air Quench in oil Refrigerate immediately Double temper	C-1	35.0		J-1	31.5	J-2	10.25
	C-2	34.0		J-3	34.0	J-4	8.0
	C-3	-	11.0	J-5	32.5	J-6	7.5
	C-4	-	7.5				
	Avg.	34.5	9.25	Avg.	32.7	Avg.	8.6
Stress relieve Austenitize in air Quench in oil Refrigerate after overnight delay Double temper				J-13	35.0	J-14	13.0
				J-15	36.0	J-16	7.25
				J-17	35.0	J-18	15.0
				Avg.	35.3	Avg.	11.75
Stress relieve Austenitize in air Quench in oil Double temper	D-1	46.0		J-7	45.5	J-8	31.0
	D-2	47.0		J-9	43.0	J-10	31.0
	D-3	-	37.0	J-11	43.25	J-12	28.75
	D-4	-	37.5				
	Avg.	46.5	37.25	Avg.	43.9	Avg.	30.25







