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DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA

Ottawa, February 27, 1947.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2187.

Examination of Fractured Weld in a 35-15 Stainless Steel Retort.

(Copy No. 6.)

Bureau of Mines

Mineral Dressing and
Metallurgy Division

Physical Metallurgy
Research Laboratories

CANADA

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OF
MINES AND RESOURCES

Mines and Geology Branch

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Introduction:

On January 7, 1947, Mr. L. G. Brewer, Mechanical Superintendent, Dominion Magnesium Limited, Haley, Ontario, submitted a section of a magnesium retort for examination. The section consisted of a barrel extension piece and part of a condenser section. The weld joining the barrel extension section to the barrel proper had broken completely through along the centre line of the weld. In his covering letter, Mr. Brewer requested an examination with a view to determining the cause of failure. He also volunteered to furnish the operating history of the retort if this would facilitate the examination.

On January 10, 1947, the service history of the retort, and information on the welding procedure used, was

(Introduction, cont'd) -

requested. On January 15, 1947, a telephone call from Mr. Brewer revealed that the service history of the retort could not be located. The welding procedure used was that recommended by these Laboratories and which has proven satisfactory in the past. Mr. Brewer further stated that the section of the barrel used as an extension piece had previously been taken from an old barrel and that it had been subjected to the carbide precipitation temperature zone. It was not known whether the weld that failed had also been exposed to carbide precipitation conditions.

Object of Investigation:

To determine the cause of weld failure.

PROCEDURE:

(1) Visual Examination -

The section submitted was wire-brushed and given a careful visual examination. No visual cracks were detected other than that which failed. The section as-received is shown in Figure 1. Figure 2 is a photograph showing the fibrous nature of the fracture.

Figure 1.

RETORT SECTION AS-RECEIVED.

Barrel extension piece upward to show weld fracture.

(Procedure, cont'd) -

Figure 2.

FRACTURED WELD SURFACE.

Note fibrous nature of the fracture.

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(2) Macroscopic Examination -

A sample was cut at the fractured area and etched in aqua regia to show the cross-section of the weld. A small crack can be noticed at the toe of the weld (see Figure 3). Such incipient cracks were found to be relatively infrequent in this section. The crack which caused failure passed directly through the centre of the weld.

Figure 3.

X2, etched in aqua regia.

MACROSTRUCTURE OF WELD CROSS-SECTION.

Note small crack at toe of the weld (top centre of photograph).

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(Procedure, cont'd) -

(3) Microscopic Examination -

A sample for metallographic examination was electrolytically polished and etched in a NaCN solution. This etching solution darkens carbides without attacking austenite or grain boundaries. Figures 4 to 8 are photomicrographs showing the characteristics of the weld and parent metal and the nature of the crack.

Figure 4.

X500, electrolytic NaCN etch.

TERMINATION OF A CRACK IN THE WELD.

Note intergranular type of fracture.

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(Procedure, cont'd) -

Figure 5.

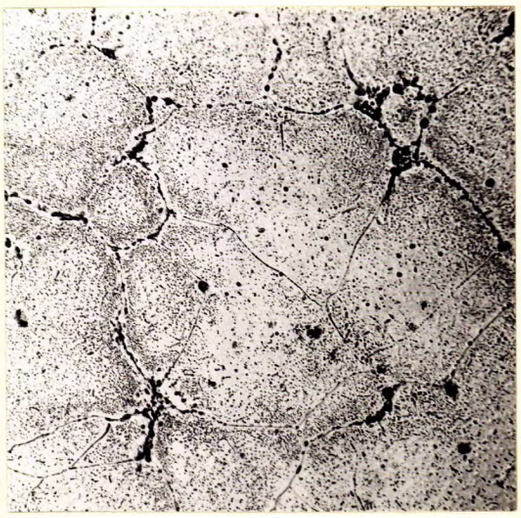
X100, electrolytic NaCN etch.

MICROSTRUCTURE OF WELD METAL.

Note distribution of carbides in austenite.

-

Figure 6.



X100, electrolytic NaCN etch.

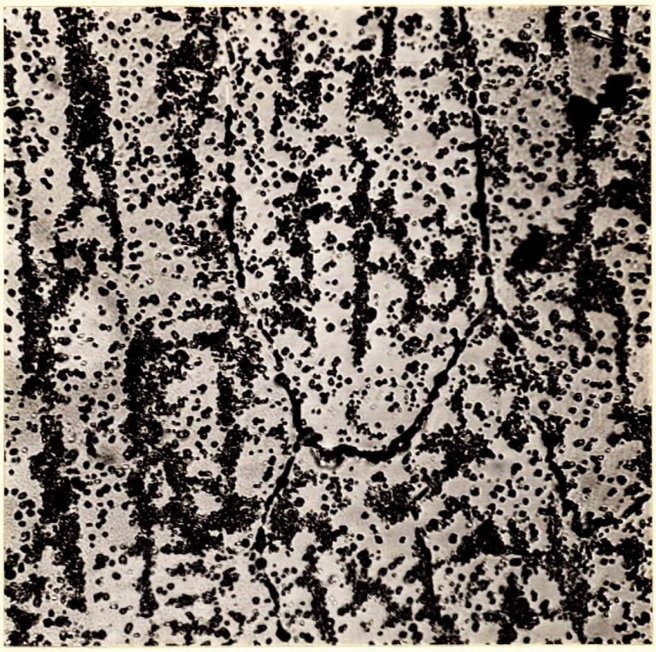
MICROSTRUCTURE OF PARENT METAL.

Note distribution of carbides in austenite.

-

(Procedure, cont'd) -

Figure 7.



X500, electrolytic NaCN etch.

MICROSTRUCTURE OF WELD METAL
- SAME AS FIGURE 5.

Note the coalesced nature of the carbides.

-

Figure 8.

X500, electrolytic NaCN etch.

MICROSTRUCTURE OF PARENT
METAL - SAME AS FIGURE 6.

Note the coalesced nature of the carbides.

-

(Procedure, cont'd) -

(4) Chemical Analysis -

Samples of both the weld metal and the parent metal (barrel extension piece) were submitted for chemical analysis of the significant elements. The results are listed below:

		Weld Metal	Barrel Material
		- Per Cent -	
Carbon	-	0.11	0.16
Nickel	-	37.53	38.43
Chromium	-	16.66	17.77

Discussion:

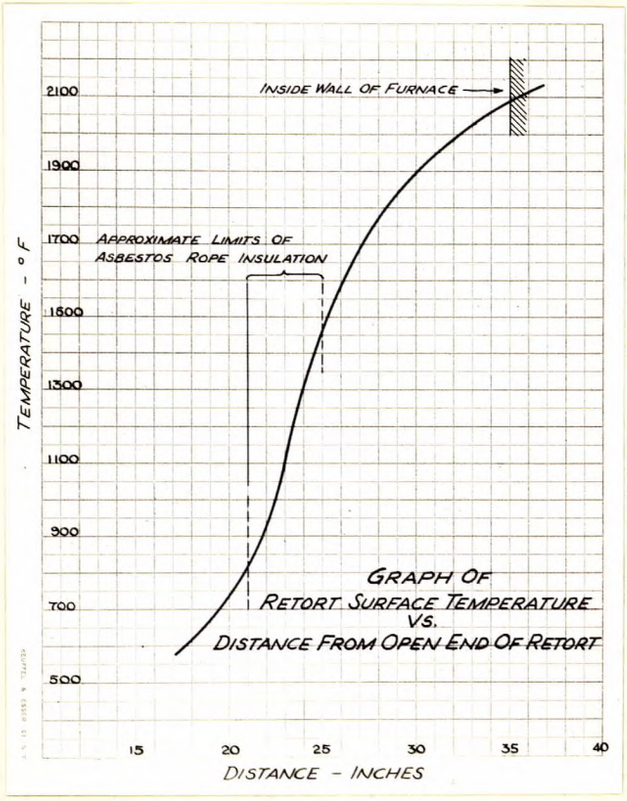
The chemical analysis of both the weld metal and the adjacent barrel material revealed no irregularities of the significant elements which would contribute to failure. The results were satisfactory for the material in question.

Microscopic examination (Figures 5 to 8) revealed massive carbides within the grains and along the grain boundaries. While data on the service conditions are not at hand to confirm the fact, the size and distribution of the carbides would indicate that the weld zone had been held for prolonged periods within the carbide precipitation temperature range of 800 to 1600° F. Referring to Figure 9 below, it can be seen that the weld area in service must have been between 21 inches and 26 inches from the open end of the retort, a critical location. These linear measurements are true only if the insulation conditions of the furnace are similar to those investigated during the summer of 1945, the time the data used in the graph were compiled.

(Figure 9 follows,)
(on Page 8.)

(Discussion, cont'd) -

Figure 9.



GRAPH* OF RETORT SURFACE TEMPERATURE VS DISTANCE FROM OPEN END OF RETORT.

-

A previous investigation of similar failures in 35-15 Ni-Cr retorts* outlines the damaging effects of this temperature range on the structural stability of the weld metal. Corrosion resistance and weld ductility are consequently impaired. Figure 4 is a photomicrograph showing the intergranular path of fracture of a weld crack. In accordance with the "chromium depletion" theory, corrosion proceeds most rapidly at the grain boundaries, thus initiating "notch" effects and finally resulting in intergranular failure.

The type of failure herein reported is considered to be similar to those already investigated.

Conclusions:

1. The results of the chemical analysis were

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* Investigation No. 1924, "Metallurgical Examination of Cracked Welds in 35% Ni-15% Cr Steel Retorts for the Production of Magnesium," Bureau of Mines, Ottawa, Ontario, August 28, 1945.

(Conclusions, cont'd) -

satisfactory for both the weld metal and the adjacent barrel material.

2. The size and distribution of the carbides present would indicate that the weld zone had been at a service temperature within the carbide precipitation range of 800 to 1600° F. at some time in the course of service.

Recommendation:

That the results of Investigation Report No. 1924 be adhered to, i.e., that the location of the welds be such that in service they fall either below or above the limits of the carbide precipitation temperature zone.

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