

ENGINEERING RESEARCH INSTITUTE
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Final Report
METALLOGRAPHIC EXAMINATION
OF
CONVERTER CORE SAMPLES

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Project 2390
PENNSYLVANIA SALT MANUFACTURING COMPANY
WYANDOTTE, MICHIGAN

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ABSTRACT

This is the sixth report presenting the findings of metallographic examinations of core samples from the No. 2 unit converter of the Pennsylvania Salt Manufacturing Company of Wyandotte, Michigan. Previous reports were made as follows:

<u>Project</u>	<u>Date</u>
M406-7	August 1946
M774	July 1948
M849	November 1949
M906	October 1950
M954	May 1952

OBJECT

The primary interest has been in core samples from the sponsor's processing units to determine the safe economic life of equipment.

INTRODUCTION

The previous reports, listed in the abstract, which (with the exception of that of October, 1950 [M906]) were made on core samples from the outer vessel only, showed that in as far as the core samples were representative of the metal of the outer vessel they had undergone no readily measurable decarburization or embrittlement. A core sample from the inner vessel was submitted in 1950. This was the first sample removed from the inner vessel following the installation of the converter in 1942. Examination of this sample showed the metal of the inner vessel, as represented by the core section, to be completely decarburized and badly embrittled. Replacement of the inner vessel, using a chromium molybdenum steel similar to that used for the outer vessel in place of the carbon or carbon silicon steel previously used, was recommended.

Replacement of the inner vessel was made in February, 1952. The steel used was, however, the carbon or carbon silicon steel, ASTM A212-39 or A212-49T, rather than the chromium molybdenum type.

The core samples, covered by this report, were submitted by the Pennsylvania Salt Manufacturing Company in accordance with the letter of Mr. O. T. Aepli, dated May 10, 1955. The core sample from the outer vessel was roughly $3/8$ inch in diameter and 1 inch long. It was removed from the inner face of the converter at about 5 feet below the No. 14 stud. The sample from the inner vessel was removed from the outer face and about 8 feet up from the bottom. The inner core sample was roughly about $1/4$ inch in diameter and $5/8$ inch long, but had broken into two pieces during the drilling and removal.

Operating conditions for the converter were, as stated in previous reports, 100 to 140 atmospheres pressure at 400 to 450°C and with three parts hydrogen and one part nitrogen.

The results of the examination of the core samples were previously reported by letter to Mr. O. T. Aepli, dated May 19, 1955.

FINDINGS

The two core samples were sectioned longitudinally. One half of each was prepared for metallographic examination and the other half was retained for the impact or bending test.

Examination of the polished but unetched sections of the outer vessel core sample showed the metal to be free of any definite indication of intercrystalline cracking or embrittlement. Examination of the etched sections showed a uniform pearlite ferrite microstructure extending from the inner end of the core sample to the outer face and with no evidence of readily recognizable decarburization or intercrystalline cracking. Figure 1 shows the microstructure at and adjacent to the outer surface; Fig. 2, about 1 inch from the surface; and Fig. 3, midway between the outer surface and the fracture end.

Figure 4, at 750 magnifications and cutting through the outer surface of the metal, shows the pearlite grains to have undergone little or no carbide depletion, or no readily recognizable decarburization.

Examination of the polished but unetched core section from the inner vessel showed the presence of minute fissures or cracks throughout the length of the core sample. A typical section is shown in Fig. 5. Examination of the polished and etched sections showed complete decarburization for the core sample and again the presence of the intergranular fissures or cracks. Typical microsections for the etched core sample are shown in Figs. 6, 7, and 8. It is probable that most of the fissures or intercrystalline cracks were formed in the drilling and removal of the core sample.

The results of the bending or impact tests confirmed the results of the metallographic examination. Following the removal of burrs and rough edges from remaining halves of the core samples, they were supported at one end in a vise and subjected to light blows with a hammer. Using a 1-pound peen hammer, the section from the outer vessel was bent through an angle of 60 degrees without any indication of cracking. Due to the limited length of the inner-vessel sample, a tack hammer was used in place of the peen hammer. The inner-vessel core section fractured without deformation on the first blow (the hammer head moved through a distance of not over 3 inches), indicating that the impact resistance of the core sample approached zero foot pounds.

CONCLUSIONS

Insofar as the core samples (submitted in accordance with the letter of Mr. O. T. Aeppli, dated May 10, 1955) are representative of the metal of the outer and inner vessels of the No. 2 converter, the following conclusions may be drawn:

1. The metal of the outer vessel of the No. 2 converter has shown no recognizable decarburization or embrittlement during the period of operation, from 1942 to the time of removal of the core sample examined for this report.

2. The metal of the inner vessel has undergone complete decarburization during the period from February, 1952, to the time of the removal of the core sample examined for this report.

3. The metal of the inner vessel is in a highly embrittled condition and shows an impact or shock resistance approaching zero foot pounds. The drilling and removal operation for the core sample undoubtedly contributed to the presence of the minute fissures or intercrystalline cracks. Their occurrence, however, is in itself a definite indicator of an embrittled condition for the metal.

4. The fact that the inner face of the outer vessel and the outer face of the inner vessel operate under the same temperature, pressure, and atmospheric conditions, and the carbon steel of the inner vessel becomes completely decarburized and highly embrittled in a period of two years or perhaps less while the chromium molybdenum steel remains unchanged in microstructure and retains its shock or impact resistance, largely unchanged over a period of ten years or more, clearly indicates that the carbon steel is not a suitable material for the intended service. (The use of the chromium molybdenum type of steel for the inner vessel was recommended in 1950.)

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100X

Fig. 1

Etch Nital

100X

Fig. 2

Etch Nital

Figs. 1, 2, and 3. Longitudinal sections of outer vessel: (1) cutting the core sample inner face of the outer vessel, (2) cutting the fracture roughly 1 inch from surface, and (3) midway between the outer surface to the fracture end. Microstructure is uniform pearlite ferrite with no evidence of decarburization or intercrystalline cracking.

100X

Fig. 3

Etch Nital



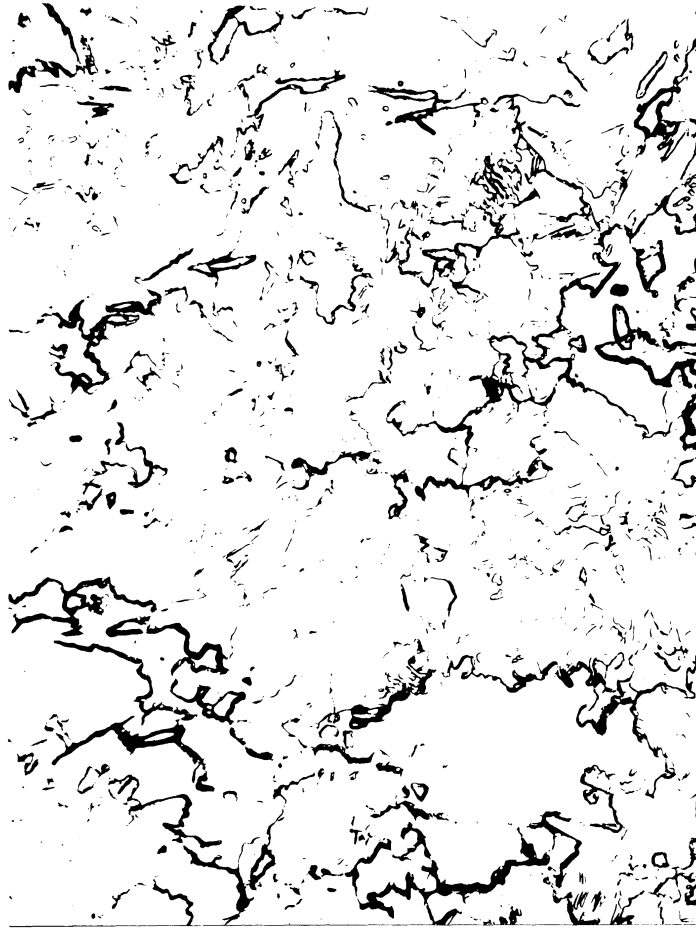
750X

Etch Nital

Fig. 4. Longitudinal section cutting through inner surface of outer vessel; pearlite grains at or adjacent to surface show no significant depletion of carbides or readily recognizable decarburization.

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Fig. 5. Unetched longitudinal section of inner-vessel core sample showing minute fissures or intercrystalline cracks.



250X

Etch Nital

Fig. 6. Longitudinal section of inner-vessel core sample, approximately 0.01 inch from the surface, showing complete decarburization and presence of intergranular fissures or cracks.

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100X

Fig. 7

Etch Nital

250X

Fig. 8

Etch Nital

Figs. 7 and 8. Longitudinal sections cutting through fracture approximately $5/8$ inch from surface, showing complete decarburization and presence of intergranular fissures or cracks.