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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1431.

Examination of Welded Oxygen Cylinders.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals

Ore Dressing
and Metallurgical
Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA June 21st, 1943.

REPORT

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ORE DRESSING AND METALLURGICAL LABORATORIES.

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Examination of Welded Oxygen Cylinders.

Source of Material and Object of Investigation:

On June 8th, 1943, Mr. H. H. Scotland, Inspector of Materials, Inspection Board of United Kingdom and Canada, 70 Lyon Street, Ottawa, Ontario, sent in four welded steel cylinders for examination (Analysis Requisition O.T. 1231).

In a letter accompanying the cylinders it was stated that they had been fabricated by welding from SAE T-1340 seamless steel tubing by Kincaid Manufacturing Company of New Jersey, U.S.A., and that after welding the cylinders had been annealed at 1500° F. The working pressure was stated to be 1,800 p.s.i. and it was claimed that these cylinders had been submitted to a hydrostatic pressure of 5,000 p.s.i.

It was requested that a full metallurgical examination be carried out on the weld and parent metal of one of these cylinders in order to determine, if possible, their suitability for use as oxygen cylinders. For purposes of identification the cylinders were marked Nos. 1, 2, 3 and 4.

X-Ray Examination:

The work of X-raying the welds of these cylinders was referred to the National Research Council, Ottawa. They made the following comments:

"The top and bottom welds of oxygen tanks were radiographed, using radium suspended in the centre of the tank opposite the weld.

The radiographs indicate serious lack of fusion in the penetration zone in every case, slightly less serious in the bottom welds of Tanks 2 and 3. Undercut is also shown in every case, less pronounced in the top weld of Tank 3.

There is considerable porosity scattered throughout the welds. Films on Tank 3, top weld, exhibit excessive porosity. Linear porosity, as in film C, Tank 1, bottom weld, occurs in several welds.

Slag inclusions occur frequently."

The nature of the defects indicated in the X-ray films is illustrated in Figure 1.

Figure 1.

PRINT OF X-RAY FILM, SHOWING LACK OF FUSION
IN THE WELD OF CYLINDER NO. 1.

Macroscopic Examination:

Figure 2 is a photograph of one of the welded cylinders. The bottom and top sections of the cylinder were assembled by welding. The valves on the tops of the cylinders were provided with a safety arrangement and also a threaded tee gas outlet. The latter was threaded with a standard right-hand thread, 14 threads to the inch, and the outside diameter measured 29/32 inch. This dimension was found to be approximately 1/16 inch larger than a similar fitting on a Linde Air Products Company oxygen cylinder.

Figure 2.

GAS CYLINDER.
(Approximately 1/16th size).

A section of the weld was cut from Cylinder No. 1 and given a macro-etch in a solution of 5 per cent HCl and 1 per cent picric acid in alcohol. Figure 3 is a photograph showing the macro-etched structure of a cross-section of the weld and parent metals. The weld metal consisted of four layers, and from the nature of the weld it would appear to have been produced by gas welding. It may be seen that alignment is quite bad and penetration is only about 50 per cent.

(Continued on next page)

(Macroscopic Examination, cont'd) -

Figure 3.

CROSS-SECTION OF WELD AND PARENT METAL.

(Approximately 2/3 size).

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Chemical Analysis:

Drillings taken from the parent and weld metals were analysed.

		Specified (1942) SAE T-1340	FOUND Parent Metal	FOUND Weld Metal
Carbon	-	0.38 to 0.43	0.36	0.13
Manganese	-	1.60 to 1.90	1.41	0.51
Phosphorus	-	0.04	ND	ND
Sulphur	-	0.04	ND	ND
Silicon	-	0.20 to 0.35	ND	ND
Chromium	-	-	0.03	ND
Molybdenum	-	-	None detected	ND
Nickel	-	-	" "	ND

ND - not determined.

Bend Test:

A weld bend test specimen from Cylinder No. 1 broke under a load of 2,500 pounds. Figure 3 shows the fracture of this specimen. It will be observed that the weld metal covers only approximately one-half of the cross-section.

(Continued on next page)

(Bend Test, cont'd) -

Figure 3.

FRACTURE OF BEND TEST SPECIMEN.

(Approximately ½ size).

Hardness Tests:

Vickers hardness determinations were carried out on the weld and parent metals, using a 10-kilogram load. The following results were obtained:

		Weld Metal	Parent Metal
Vickers hardness number	-	155	191

There were no brittle zones observed in the parent metal adjacent to the weld.

Microscopic Examination:

A cross-sectional specimen of the weld and parent metal was prepared for microscopic examination. The steel was first examined under the microscope in the unetched condition. Figure 4 shows a porous section of the unetched metal. The steel was then etched in a solution of 2 per cent nitric acid

(Microscopic Examination, cont'd) -

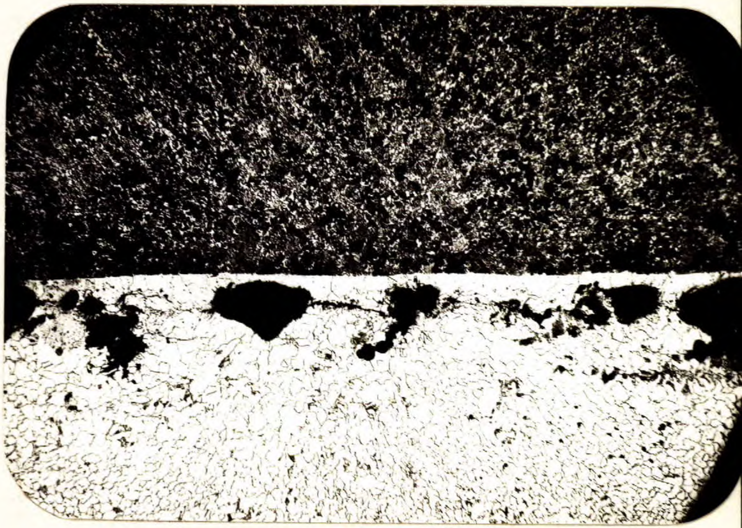
in alcohol and re-examined. It was found that the porosity shown in Figure 4 occurred in the weld metal. This is illustrated in Figure 5. Figure 6 shows the structure of a sound portion of the weld metal.

Figure 4.

X100, unetched.

POROUS METAL.

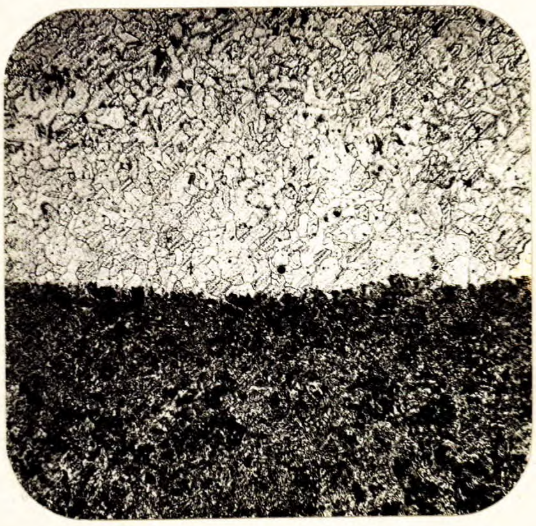
Figure 5.



X100, etched in 2 per cent nital.

SAME AS FIGURE 4, SHOWING POROUS WELD METAL.

Figure 6.



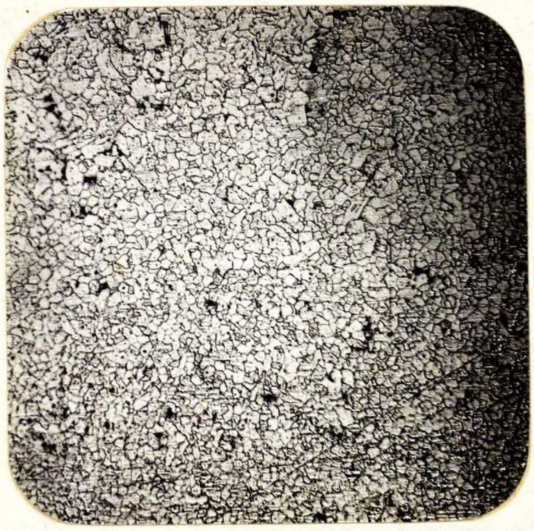
X100, etched in 2 per cent nital.

SOUND WELD METAL.

(Microscopic Examination, cont'd) -

Figures 7 and 8, photomicrographs at X100 magnification, show the fine-grained structure of the weld and parent metals respectively, after an etch in 2 per cent nital. These structures consist of ferrite (the white etching constituent) and pearlite (the dark etching material). The coarse nature of the pearlite is illustrated in Figure 9, a photomicrograph at X1000 magnification.

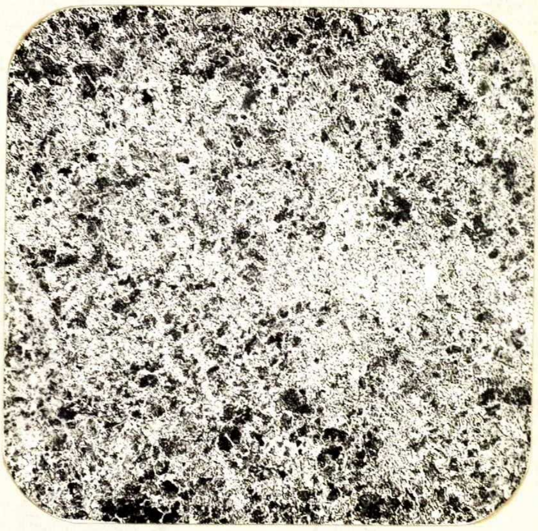
Figure 7.



X100, etched in 2 per cent nital.

WELD METAL.

Figure 8.



X100, etched in 2 per cent nital.

PARENT METAL.

Figure 9.

X1000, etched in 2 per cent nital.

PARENT METAL.

Discussion of Results:

The steel of the cylinder examined had a chemical composition similar to that of an SAE T-1340 steel. The weld metal was a plain low-carbon steel. From the nature of the weld it would appear to have been produced by gas welding.

The X-ray films of the welds of the four cylinders examined indicated lack of fusion in all the welds and, in addition, the weld metal was porous and contained slag inclusions. The lack of fusion and also the porous condition observed in X-ray films were confirmed by the macro- and micro-examination of a section of the weld. Such defects would seriously lower the impact properties of the welds.

A hardness survey showed that there were no brittle zones adjacent to the weld metal. The low hardness values obtained indicated that the steel was in the annealed condition. This latter fact was confirmed by a microscopic examination (see Figure 9).

The oversize dimensions of the threaded outlet tees on the valves supplied with these cylinders would prohibit their use either in filling or in service, unless a special oxygen hose coupling were supplied. An alternative to this would be to obtain new valves with tees threaded to fit Canadian standard oxygen hose couplings.

According to British Standard Specification No. 400, cylinders used for storage of permanent gases such as hydrogen, oxygen, nitrogen, etc., must be free from welds.

Specifications which permit the manufacture of oxygen cylinders by welding seamless steel tubing of SAE T-1340 composition, are unknown to this Bureau. However, even if such a specification existed, the lack of alignment and fusion, together with the porous nature of the welds, would eliminate any possibility of allowing these cylinders to be used for the storage of

(Discussion of Results, cont'd) -

oxygen gas. The fact that these cylinders were stated to have withstood a hydrostatic pressure of 5,000 p.s.i. cannot be considered as a basis of their strength under impact. Therefore, since gas cylinders may be subjected to fairly high impact stresses in service, the use of these cylinders is quite dangerous and definitely should not be considered.

CONCLUSIONS:

1. The cylinders examined were fabricated by gas welding of SAE T-1340 seamless steel tubing.

2. They were given an annealing heat treatment after welding.

3. The welds were all found to be defective, some being extremely bad.

4. Welding of steel cylinders for storing oxygen gas is definitely prohibited by British Standard Specification No. 400.

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