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O T T A W A November 15th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1744.

Examination of Steel Oxygen Cylinder.

(Copy No. 10)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Request and Object of Investigation:

On November 6th, 1944, Mr. C. C. Stibbard, Director of Operation, The Board of Transport Commissioners for Canada, Ottawa, Ontario, submitted an oxygen cylinder, No. K11140, for examination, to determine whether it conformed to the amended Specification 3A of the Railway Association of Canada.

Macro-Examination:

The tube was sawn in half longitudinally, as shown in Figure 1. The ends of the cylinder were found to have been formed by spinning. Examination after a macroscopic etch and under the microscope disclosed no evidence of a weld in the tube; hence, the cylinder is assumed to have been spun from seamless tubing. The tube has been drawn through a finish die after the hot forming operation, as shown by the die scratches in Figure 1. Any evidence of cold work has been removed by subsequent heat treatment.

The point of closure at the bottom was etched, and found to be leak-proof. The internal surface of the bottom was ragged, as shown in Figure 1.

Wall Thickness:

The minimum wall thickness was found to be 0.163 inch. The thickness of the spun bottom at the points of contact between the cylinder and the floor was 0.241 inch.

Chemical Analysis:

The steel was found to have the following chemical analysis:

		Per Cent
Carbon	-	0.24
Manganese	-	0.54
Silicon	-	0.18
Phosphorus	-	0.008
Sulphur	-	0.033
Other alloys	-	None.

Mechanical Tests:

The steel was found to have the following mechanical properties:

(Continued on next page)

(Mechanical Tests, cont'd) -

Yield point, p.s.i.(0.2% proof stress)	-	54,000
Ultimate strength, p.s.i.	-	83,500
Elongation, per cent in 2 inches	-	27.0
Reduction of area, per cent	-	59.5

Microstructure:

A photomicrograph of the steel is shown in Figure 2. It is the usual normalized structure for this type of steel.

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Discussion:

The cylinder was formed by a spinning operation. As no evidence of a weld was found after the macro-etching, it is assumed that it was spun from seamless tubing.

After the forming operation the tubing has been drawn through a finishing die, but the evidence of cold work has been removed by heat treatment.

The steel has a uniform normalized structure.

A comparison of this steel with the amended Specification 3A of the Railway Association of Canada reveals the following:

(1) The steel conforms to the chemical specification, which calls for a maximum of 0.55 per cent carbon, 0.045 per cent phosphorus, and 0.050 per cent sulphur. (Paragraph 5).

(2) The material was free from seams, cracks, laminations, or other serious defects. (Paragraph 7).

(3) The steel was uniformly and properly heat treated. (Paragraph 10).

(4) The steel possessed an elongation of 27 per cent in 2 inches, and the yield strength was 65 per cent of the ultimate strength. This conforms to Paragraph 16(b), which calls for a minimum elongation of 20 per cent and a yield point not

(Discussion, cont'd) -

greater than 70 per cent of the ultimate strength. The flattening test was not conducted.

(5) The point of closure at the bottom was ragged, as shown in Figure 1. The thickness of the bottom at the points of contact with the ground was 1.48 times that of the minimum wall thickness. These conditions do not conform to Supplement 8, Paragraph 8, which states:

> "Manufacture.--By best appliances and methods; dirt and scale to be removed as necessary to afford proper inspection; no defect acceptable that is likely to weaken the finished cylinder appreciably; reasonably smooth and uniform surface finish required. The internal surface of bottoms of spun cylinders must be free from fissures or other defects, and if not originally free from such defects should be machined or otherwise treated to eliminate these defects. The thickness of the spun bottoms is, under no condition, to be less than two times the minimum wall thickness of the cylindrical shell; such bottom thicknesses to be measured within an area bounded by a line representing the points of contact between the cylinder and floor when the cylinder is in a vertical position."

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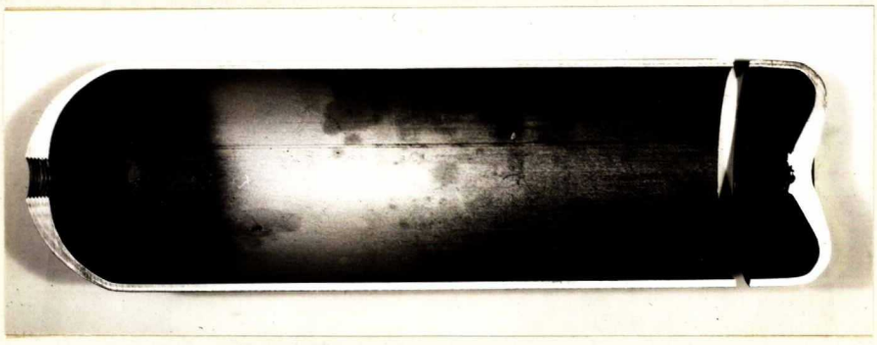
Figure 1.



OXYGEN CYLINDER, SAWN IN
HALF LONGITUDINALLY.

Note ragged internal surface at bottom.

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Figure 2.

X500, nital etch.

UNIFORM NORMALIZED STRUCTURE, TYPICAL
FOR THIS GRADE OF STEEL.

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