O T T A W A December 3rd, 1940.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 935.

Report on Embrittlement of Superstructure Members for Military Trucks (Galvanized Pipe).

BUREAU OF MINES
DIVISION OF METALLIC MINERALS
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CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Origin of Problem:

The office of the D.C.I.A.(G), Department of National Defence, 479 Bank Street, Ottawa, Ontario, reported that pipe frames used for supporting canvas covers on military trucks were failing due to brittleness. Examiners reported that the pipes fractured on being thrown

to the ground while unloading. A report was requested which would explain the cause of this condition and recommend a solution.

Macro-Examination:

The samples of pipe as received showed a crystalline fracture. The pipe had been flattened and a square hole punched through it.

It appeared that the brittleness existed only at the flattened and punched section. Bending tests on the undeformed pipe showed it to be quite ductile and plastic. The strength at the punched section was far less than the reduction of cross-section would produce, therefore some other factor must be responsible for this condition.

Physical Tests:

In order to find out the effect of mechanical work on the pipe, the following experiments were undertaken:

Bending -

A piece of the pipe was held vertical in a vise and pounded with a heavy hammer. The pipe bent through an angle of 30 degrees with no sign of failure.

Flattening Centre of 3-Foot Section -

The centre of a 3-foot section of pipe was flattened for a distance of 4½ inches. Immediately, this was placed in a vise and hammered. It bent through an angle of 30 degrees satisfactorily. Another piece similarly treated but left for two days, cracked at the first blow. The crack occurred at the end of the flattened section.

(Continued on next page)

(Physical Tests, cont'd) -

Flattening a 2½-Inch Collar -

A piece 2½ inches long was flattened under a load of 20,000 pounds. After two days an attempt was made to open up the flattened section by driving a cold chisel into the centre of the flattened hole. The pipe split into two flat pieces. Another piece was flattened and then annealed at 975° F. for one hour. This piece deformed and could not be split as readily as the untreated piece. Annealing destroys the zinc coating, therefore it cannot be performed on galvanized pipe.

Zinc Coating:

The flattening operation causes the zinc coating to flake off; this exposes the iron pipe to the forces of corrosion.

Conclusions:

The piece of pipe submitted was tough enough as received to bend considerably. After cold working, by flattening, it became quite brittle. Brittleness was eliminated by annealing, but the zinc was oxidized.

The supplier of this product must

either

(1) Select pipe which does not become brittle after cold work,

or

(2) Reduce the amount of cold work performed upon the pipe;

also

(3) Repair damage to zinc coating done by flattening operation.

Figure 1.

Crystalline fracture.
Pipe as received.
(Actual size).

Figure 2.

Flattened and punched section.
Pipe as received.
(Actual size).

DISCUSSION:

Galvanized structural members are subject occasionally to brittleness around punched holes.(1) Drilled holes do not affect the metal surrounding them. The severe cold working of the punching operation appears to intensify the notch effect severely. This effect becomes more pronounced as the thickness of punched metal is increased.

Presumably cold work aids in precipitating, segregating, or orienting submicroscopic particles which cause embrittlement, so that their effect is at a maximum. Apparently the mutually acting effects of phosphorus, nitrogen, carbon, and oxygen are necessary to cause embrittlement.

The aging of steel after cold work is a well-known phenomenon.(2) Age-hardening which may cause embrittlement is supposed to be caused by the precipitation of carbides, nitrides, and oxides. The relative importance of large and small inclusions has not been definitely established,(3) but there are undoubtedly many more invisible inclusions than there are visible ones.

Particles finer than 0.001 centimetre diameter exist as a suspension or emulsion in the metal.(4)

Age hardening or precipitation hardening is observed in low carbon steels.(5) It is found that a

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(1) Epstein on Embrittlement. (Proc. A.S.M. '32).
(2) Deoxidation of Mild Steels. (Daniloff, Trans. A.S.M. '36).
(3) Work Sensitivity. (Case, Met. Prog., Nov. '37).
(4) Inclusions in Iron. (Wohrman, A.S.S.T. Vol. XIV, '28).
(5) Modern Steels. (A.S.M. Publication).

(Discussion, cont'd) -

sheet which will make a certain difficult stamping without undue breakage if it is delivered and worked promptly, may crack badly in the dies if work is delayed until a month after rolling.

The embrittlement of the galvanized pipe appears to be similar to age hardening produced by cold work. In order to eliminate this trouble certain recommendations are made.

Recommendations:

Reduction of Cold Work -

Completely flattening the pipe weakens and embrittles it. Punching also embrittles the pipe. A better procedure would be to flatten the pipe leaving a space at least equal to the thickness of the pipe wall. This reduces the amount of cold work at the bend. The hole should be drilled and broached.

Selecting Pipe by Work Sensitivity Test -

Since different lots of pipe vary in their response to cold work it is suggested that the purchaser of the pipe set up a practical testing procedure to evaluate this property. The samples after being formed should be set aside for 48 hours and then distorted by hammer blows. Brittle material can be sorted out by this test.

Corrosion-Resistant Coating -

Flattening the pipe makes the zinc coating peel off. Therefore, it would seem advisable to use ungalvanized pipe and galvanize after forming. This would ensure that

(Recommendations, cont'd) -

a continuous zinc coating was obtained and also the heat of galvanizing would have a beneficial effect on the work brittleness. An alternative procedure would be to use ungalvanized pipe, anneal after cold working, and paint with aluminium paint.

Square Hole -

The square hole gives the section greater "notch brittleness" than a round hole. If possible, the design should be changed to include a round hole at this point.

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