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Failure Analysis Case Study

Failure Analysis of a Brass Pipes due to Stress Corrosion

Keywords: Pipe, Cracking, Stress Corrosion

Material: Brass

Introduction

Five lengths of brass pipe were submitted for testing and analyses. A cause of failure analysis was conducted on one of the lengths, "NYCHA No. 1", which had a longitudinal crack. It was reported that "NYCHA No. 1" had leaked after only a few months service in a domestic water service line. The other four lengths were samples from different lines in the system. . Visual examination, Chemical, mechanical and metallographic analyses was performed on the submitted pipe sections to look for root cause of the failure.

Visual Examination

''NYCHA NO. 1'' samp1e had a five inch long crack which was interrupted at its center, showed in fig 1. Both segments of the crack had winded. The other four lengths were free of any crack or other surface imperfections. The dimensions conform to the requirements for regular pipe sizes as shown

Fig 1 Crack on ''NYCHA NO.1''

Specimen No.	Outside Diameter/inch	Wall thickness/inch
NYCHA No.1	0.839/0.840	0.103/0.106
Required:	0.835/0.845	0.101/0.113

Chemical Analysis

Chemical Analysis was conducted on 5 submitted pipes. The results of all five samples conform to the requirements for copper alloy No.C23000 pipe per ASTM B43-85.

NYCHA No.	1	2	3	4	5	ASTM B 43-85
Copper	84.43	85.21	85.43	84.36	84.89	84.0/86.0
Antimony	0.02	0.01	<0.01	0.04	0.01	---
Lead	0.02	0.01	0.02	<0.01	0.02	0.05 Max
Iron	0.04	0.02	0.03	0.01	0.03	0.05 Max
Nickel	0.01	0.01	0.01	0.01	0.01	---
Phosphorus	<0.01	<0.01	<0.01	<0.01	<0.01	---
Zinc	15.48	14.74	14.51	15.58	15.04	Remainder

Mechanical Test

Four of the submitted lengths (Nos. 2, 3, 4 and 5) were subjected to a hydrostatic pressure teat of 1,000 psi for ten minutes. There was no evidence of leakage from any of the four lengths. Sample No. 1 was submitted with a longitudinal crack which precluded hydrostatic testing.

Each of the five lengths of pipe was immersed for 30 minutes in a standard mercurous nitrate solution per ASTM B 154-82, wiped free of excess mercury and examined for cracks.

NYCHA sample Nos, 1 (1/2 inch N.P.S.), 3 (1/2 inch N.P.S. and 4 (3/4 Inch N.P.S) developed cracks. Figure 2 shows the cracks on NYCHA sample No.3. NYCHA sample Nos.2(1-1/4 inch N.P.S.) and 5 (1 inch N.P.S.) did not develop any cracks and conform to the requirements of ASTM B 154-82

Fig 2 Cracking shows after mercurous nitrate test on NYCHA No.3

Microscopic Examination

Transverse and longitudinal samples from both the No. 1 and No.3 pipes were mounted for metallographic examination. The crack widened further during cutting showing a high circumferential tensile residual stresses. In Fig 3, both pipes (Nos.1 and 3) were in as-drawn (o1d worked) condition which would be expected to contain residual stress. The fracture path in the No.1 and 3 pipe(after mercurous nitrate testing) was found to be intergranular and branched which is typical of stress corrosion cracking, showed in fig 4. Fig 5 shows the fracture to be intergranular and branced under SEM. The pipe is not in the annealed condition with complete recrystallization as required by ASTM B43-85.

Fig 3 Microstructure of No.1 pipe x200

Fig 4 Intergranular cracking of No.1 pipe x200

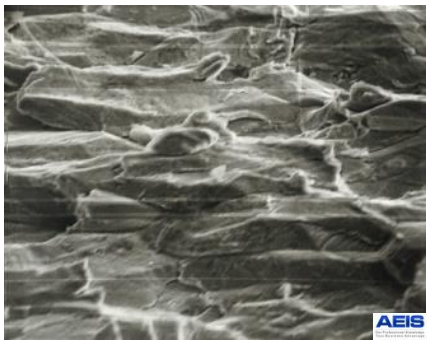

Fig 5 SEM of fracture surface on NYCHA No.1 X750

Discussion

There is no doubt that the mechanism of failure in the subjeçt pipe is stress corrosion cracking. This is borne out by the fracture path which is intergranular and branched. The first requirement of SCC is stress which has been proven from cold drawn residual stress as showed in mercurous nitrates test and microscopic examination.

The second requirement for stress—corroion cracking to occur is the presence of a specific corrosiveIn the case of brasses the most common cause of such failures is ammonia or ammonia compounds (amides). Household ammonia is widely found in kitchens and bathrooms.

Conclusion

The cause of the cracks found in NYCHA NO.1 pipe is due to the presence of high residual stresses in the pipe. Furthermore, the pipe is not in the annealed condition as required by ASTM B43-85. Annealing is a heat treatment that removes residual stresses that occur during manufacturing of the pipe.