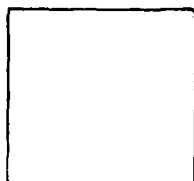


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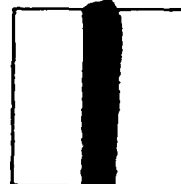
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Waterbury, Connecticut

D. K. CRAMPTON
DIRECTOR OF RESEARCH
B. H. MCGAR
ASST. DIRECTOR OF RESEARCH



August 28, 1936.

G. F. Jenks,
Col., Ord. Dept.,
War Department,
Watertown Arsenal,
Watertown, Mass.

Dear Colonel Jenks:-

We have your letter of August 21st and the copy of report No. 342/223 covering comparison of aluminum, silicon and beryllium tin bronzes on which you ask for comment.

As Olympic bronze which is mentioned by name in this report is our own particular type of silicon bronze, we are naturally much interested in results of the tests given in this report. Naturally we are much disappointed in the rather poor showing of this material in comparison with the others tested. After studying carefully into conditions of preparation and testing, we believe the test values probably are somewhat misleading.

The alloy is used in the condition as sand cast in which condition it shows properties not at all comparable to those found in the wrought materials in which condition they are usually produced. Further, the conditions of casting, particularly the temperature of pouring of the metal, have a profound effect on the physical properties. Apparently the particular bar had been cast at a rather high temperature resulting in a very coarse, weak structure. Very much better properties would probably have been found had a lower pouring temperature been used.

Further, it is noted that while the bar was made approximately 1-1/2" in diameter, the tensile test specimen had been turned to 0.505" diameter so that a small proportion of the whole original section was tested and unfortunately that portion, which was probably the poorest and perhaps the least sound.

It is hoped that the logic of the above comments will be accepted and the values reported not be taken as typical of what this material should show.

Very truly yours,

CHASE BRASS & COPPER CO.

D. K. Crampton.
RW

D. K. Crampton

Research Director.

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Report No. 342/223
Watertown Arsenal

July 22, 1936

Comparison of Al, Si, Be, and Sn Bronzes

Object

To compare properties and corrosion resistance of special aluminum (Ampco 18), special silicon (Olympic) beryllium and tin bronzes.

Reference

X.O. 624-A2

Conclusions

The order of decreasing tensiles strengths observed was beryllium bronze, ampco 18, tin bronze, olympic bronze. The order of decreasing corrosion resistance to synthetic sea salt spray was ampco 18, beryllium bronze, tin bronze, olympic bronze.

When coupled with monel metal and CRS1 (18/8 stainless alloy) in synthetic sea water, negligible galvanic currents were observed.

Aluminum bronzes appear to be a suitable substitute for tin (Phosphor) bronze which is harder and probably more corrosion resistant. Beryllium bronzes are harder and of equal corrosion resistance and probably more expensive. The sample of olympic bronze was probably poorly processed,

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Introduction

Engineers desired a bronze which was harder than tin (phosphor) bronze for certain uses. The corrosion resistance had to be equal to that of tin bronze. Ampco metal was chosen for test. Olympic bronze was on hand and parallel tests were carried out with it.

Material

The analyses of the material tested are given on table I.

Tensile Properties

The results of tension and impact tests are given on table II.

Corrosion Resistance

Behavior in synthetic sea salt spray is recorded in table III.

The behavior wherein galvanic contact with monel and 18/8 stainless alloy - CRS1 - in synthetic sea water is recorded in table IV. The test method was that reported in W.A. 780/1 and consisted of shorting the couples and periodically inserting a milliammeter in the circuit.

Discussion

Ampco metal, a product of Ampco Metal Inc., Milwaukee, Wisconsin, is a copper aluminum iron alloy, containing

from 9% Al, 3% Fe to 13% Al 4% Fe according to the grade.

The physical properties claimed for grade 18 are:

Tensile Strength	77,000/85,000#/sq.in.
Yield Point	37,000/42,000 "
Elongation	10-14%
Reduction in Area	6-10%
BHN ₃₀₀₀	167-179
100 ^R _B	85-87

These compare favorably with observed properties.

Local experience with similar castings indicates same order of magnitude of properties are readily obtainable. By increasing the alloy content strength is obtained at a sacrifice in ductility. The various grades available in Ampco are listed in the appendix.

The beryllium copper alloy was received in the soft condition from Ampco Metals Inc. (100^R_B 54, BHN 89). It was then hardened by heating to 570°F (300°C) for 2 hours and furnace cooling. The hardness was raised to 150^R_C 36 - BHN 340/360.

The olympic bronze did not have as high physical properties as expected. The test bar was cut from a cast 1-1/2" round rod. The metal appeared coarse. It is evident that the observed properties are not representative and the sample was improperly processed.

Respectfully submitted,

P R Kosting
P. R. Kosting,
Chemical Engineer.

TABLE I

Report No. 342/298

Sample from Dr. Kosting, Ex. O. 624-A2

Mark	A 3" dia.	B 3" dia.	C 1" dia.	D 1-1/2" dia.	E 3" dia.
Tin	Nil	Nil	Nil	Nil	3.625
Copper	97.20	85.50	85.65	94.00	95.95
Nickel	.35	.17	.18	Nil	Nil
Manganese	Nil	.015	.02	Nil	Nil
Phosphorus	.006	Trace	Nil	Nil	.345
Iron	.24	4.06	3.60	.18	.06
Aluminum	Nil	10.26	10.55	.10	Trace
Lead	Nil	Nil	Nil	Nil	Nil
Zinc	Nil	Nil	Nil	.97	Nil
Silicon	-	-	-	4.75	-
Beryllium	2.20	-	-	-	-

A - Be Bronze Cent. Casting - Ampco Product
 B - Al " " Ampco Grade 18
 C - Al " " " "
 D - Si " " Olymnic Bronze
 E - Sn " Rod

A. Sloan,
Chemist.

TABLE II

Report No. 342/483

STUDY OF BRONZES

Tensile Properties

June 18, 1936

Specimen Mark	Dia. inches	Y.S. 0.00% set #/sq. in.	Y.S. C. % set #/sq. in.	T.S.	Elong. %	Red. of Area %	Break	Fracture
A1	.113	114,000	---	136,500	2.5	3.2	middle third	Irregular pitted dendritic "
A2		X	X	136,000	2.5	1.5	"	" "
B1	.113	X	X	78,000	10.0	13.5	at gage mark	90° finely pitted
B2		X	X	83,000	10.0	3.3	"	" "
C	.357	curved	curved	84,600	9.3	7.6	at gage mark	90° finely pitted, segre- gated checks on stem
D	.505	curved	curved	28,750	4.5	8.8	outer third	Irregular 90°, pitted, segre- gated coarsely dendritic cracks on stem
E1	.113	X	X	54,500	32.5	76.3	middle third	(Partial cup, pitted, checks & cracks on stem near break.
E2	.113	48,000	54,000	55,000	25.0	59.3		

Report No. 342/483 (cont.)

A = Be copper centrifugal casting - Ampco product
 B = Aluminum Bronze centrifugal casting - Ampco product Grade 18
 C = Aluminum Bronze Sand Casting - Ampco product Grade 18
 D = Si Bronze Sand Casting - Olympic Bronze
 E = Sn Bronze Rod
 X = not observed

Impact-tensile notched Charpy

Specimen No.	Ft. Lbs.	Fracture
C1	9.2	Irregular break, spongy, pitted, segregated.
D1	27.6	Irregular break, coarsely pitted, segregated, coarsely dendritic.
D2	21.1	Irregular break, coarsely pitted, segregated, coarsely dendritic.
E	18.1	Pitted, coarse.

D. E. Driscoll

Rockwell B Hardness

A	B	C	D	E
115	90	88-1/2	65	76

100^RB

TABLE III

STUDY OF BRONZES

Synthetic Sea Salt Spray Resistance

Metal	Spec. No.	Wgt. Ave.	Gain or Loss		Time Exposed Hrs.	Surface Finish	Appearance
			Mg.	Mn.			
A	1-2-3	-1.5	-2.2	-1.6	147	00 emery	Bluish, uniform attack
		-1.5	-2.2	-0.6	184	Corroded	" 90% uniform
	4-5-6	-1.9	-2.3	-1.7	213	00 emery	" uniform
		-2.4	-2.7	-2.3	184	Corroded	" 90% uniform
		-2.0	-2.7	-0.6	184	Corroded Rating	
B	1-2-3	-0.1	-0.3	-0.0	147	00 emery	Irregular spotting, rough
		-0.1	-0.3	+0.1	184	Corroded	" Mottled 60% rough
	4-5-6	+0.8	+0.3	+1.0	213	00 emery	Irregular spotting, rough
		+0.2	-0.2	+0.7	184	Corroded	" Mottled 60% rough
		+0.1	-0.3	+0.7	184	Corroded Rating	
C	1 & 2	-0.3	-0.3	-0.3	147	00 emery	Irregular spotting, rough
		+0.3	+0.3	+0.2	184	Corroded	" Mottled 60% rough
	3 & 4	+0.4	+0.4	+0.3	213	00 emery	Irregular spotting, rough
		+0.9	+1.1	+0.6	184	Corroded	" Mottled 60% rough
		+0.6	+1.1	+0.2	184	Corroded Rating	
D	1-2-3	+32.0	+51.0	+22.0	147	00 emery	Irregular encrustations
		-5.6	-9.3	-0.8	184	Corroded	" "
	4-5-6	+58.0	+85.0	+34.0	213	00 emery	" "
		-40.0	-62.0	-23.0	184	Corroded	" "
		-23.0	-62.0	-0.8	184	Corroded Rating	

TABLE III (Cont'd)

Synthetic Sea Salt Spray Resistance

Metal	Spec. No.	Wgt. Ave.	Gain or Loss		Time Exposed Hrs.	Surface Finish	Appearance
			Mg.	Mn.			
E	1-2-3	-3.5	-4.3	-2.7	147	00 emery	Coppery
		-4.1	-6.3	-1.2	184	Corroded	Bluish 80% uniform smooth
	4-5-6	-3.3	-3.7	-3.0	213	00 emery	Coppery
		-3.3	-3.4	-3.1	184	Corroded	Bluish 80% uniform smooth
		-2.7	-6.3	-1.2	184	Corroded Rating	

Rating

Surface Finish : #00 emery
 Time, hrs. : 148
 Material-poor : E A C B I
 Wt. Loss "g. : -2.7 -2.0 +0.1 +0.6 : -3.5 -1.5 -0.3 -0.1 +3.2

Surface Finish : #00 emery
 Time, hrs. : 213
 Material-poor : E A C B I
 Wt. Loss "g. : -3.3 -1.9 +0.4 +0.8 +5.0

Aluminum Bronze may be considered slightly more corrosion resistant to synthetic sea salt spray than 3 1/2% tin bronzes and other bronzes with 96% copper or better in them. Silicon bronze is definitely inferior to tin bronze. Plumb bob specimen used, 1" high 0.55" cone, 0.25" body 0.10" recess, 0.10" base, 0.625" dia. of body.

Observers - W. Galvin and W. R. Gruzdis.

A = Pe Copper C.C.
 B = Al Bronze C.C.

C = Al Bronze Sand Casting
 I = Si

E = Sn Bronze Rod

TABLE IV
STUDY OF BRONZES

Galvanic Behavior in Synthetic Sea Water

Bronze	A	A	B	D	E
Spec #	2	3	2	1	1
Electrode Monel Metal #	6	2	5	1	4
Time, hrs.	Current m amps/sq.in.				
0	.0025	-.0040	-.0030	+.0050	+.0060
1	-.0004	-.0018	-.0038	-.0012	+.0002
96	-.0030	-.0022	-.0050	-.0021	-.0020
Anode	A	A	B	D	E
Wt. Loss Electrode Monel	0	0	0.6	0.7	0.1
in					
Mg Bronze	10.1	2.0	13.8	11.9	3.5

Bronze	A	B	D	E
Spec. #	1	1	3	2
Electrode CRS #1 (18/8)#	3	8	6	9
Time, hrs.	Current m amps/sq.in.			
0	-.0040	-.0060	+.0170	-.0015
1	-.0018	-.0023	-.0015	-.0018
96	-.0010	-.0018	-.0016	-.0020
Anode	A	B	D	E
Wt. Loss Electrode CRS #1	0	0	.5	.1
in				
Mg Bronze	1.7	.5	10.3	10.6

Bronze	A	B	D
Spec. #	6	3	2
Electrode Bronze E #	1	1	3
Time, hrs.	Current m amps/sq.in.		
0	-.0150	-.0300	-.0080
1	-.0002	-.0300	-.0120
96	-.0010	-.0120	-.0040
Anode	A	B	D
Wt. Loss Electrode E	.7	3.4	1.7
in			
Mg Bronze	5.4	1.3	5.6

The order of magnitude of current that flowed is negligible except in case where tin bronze was coupled with Aluminum Bronze. Data is inconsistent.

Observer - M. B. Gruzdis

A = Be Copper C.C.

B = Al Bronze C.C.

C = Al Bronze Sand Casting

D = Si Bronze Sand Casting

E = Sn Bronze Rod

APPENDIX

TABLE I

GRADES OF AMPCO METAL

Metal Grade	%		Tensile Strength 1000 psi	Yield Point 1000 psi	Elong. %	Red. in Area %	BHN ₃₀₀₀	Rockwell	Applications
	Al %	Fe %							
Ampco 12	8.6	2.9	55/65	22/27	22/27	22/27	115/121	65/67 B	Bushings, light load - high speed: machine parts.
16	10.2	3.3	70/80	32/37	18/22	16/20	137/143	78/80 B	General bushing & bearing work, machine parts, pump parts.
18	11.3	3.7	77/85	37/42	10/14	6/10	167/179	85/87 B	Heavy duty bearings & gears, acid equipment.
20	12.4	4.1	83/90	40/43	4/6		229/241	19/21 C	Cams, rollers, guide bush- ings, striking plates.
21	13.0	4.1	88/95	42/44	3-5		285/302	32/34 C	Forming dies, slides.
22	13.4	4.4	93/100	42/45	1-4		321/341	36/38 C	Forming dies for stain- less steels.