REPORTS NO. 344/50 -1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11.

MONEL METAL REPORTS

By

Peter R. Kosting
Chemical Engineer

1937

INDEXED

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Report No. 344/50-1

February 5, 1937

Cracks in Monel Metal Plate for Spindles,
1965-7, Ex. O. 509-211, Spec. WXS-11-1,
55,000 Yield Strength

Conclusions Surfaces adjacent to scarfed edges should be ground before welding. A light cut should be taken off total surfaces to remove all cracks when machining to blue print dimensions.
The yield strength of the plate will now probably run 25,000-30,000 psi.

Investigation Only a cursory examination was made based mainly on facts made available by Mr. Maguire, Mr. Pillsbury and Mr. Healy.

Flaws Longitudinal cracks, perhaps 1/64" and less deep, developed on convex surface, increasing in extent toward the long scarfed edges of the plate.

Cause Probably due to friction between die and plate in forming operation.

Cure Probably the cracks may be prevented in future by lubricating the die.

Note

Some 60% of the surface area will have 1/4" metal removed during machining operations, another 20% will have 1/8" metal removed. The remainder will probably have a light cut taken off when trueing up for machining. All cracks will certainly be removed on 80% area and care should be taken to remove cracks from the other 20% area. If cracks are removed from area to be welded, it is not believed that welding stresses will enlarge the other cracks in this soft material. This should be checked when welding the first few pieces.

The service stresses are low and the annealed metal is expected to be sufficiently strong.

Requested: Major Rehm and Mr. Maguire.

P. R. Kosting
Chemical Engineer.

mrm

Report No. 344/50-2

February 12, 1937

LONGITUDINAL CRACKS IN MONEL METAL CYLINDERS

Dwg. No.- C-8122A - Recuperator Cylinder A #56

X. O. - 571-186 also 771-186

Conclusions - Flaws are due to inclusions inherent in this particular heat of metals and not due to our processing.

Recommend - Rejection of other cylinders with surface appearance similar to this.

Material - Recuperator cylinder A #56 was made from Monel Metal. Upon machining, small longitudinal cracks 1/4" long were occasionally opened up. The next cut would remove these cracks. On this cylinder and on some others, long fine longitudinal hairline cracks or marks were detected. Cylinder #56, which was the first tested, leaked badly under hydraulic pressure.

Tests - Scrap rings from end of cylinders were flattened under pressure and the area where bending occurred, examined. Flake-like cracks with a whitish wall were found.

Requested - Major Guion.

Peter R. Kosting
Peter R. Kosting

emg

Report No. 344/50-3

March 2, 1937

Internal Stresses in Cold Rolled Monel

Re: Cold Rolled Monel going out of shape when machined

Ex. O. 509-657, P. O. 2809 - Item 3, Piece No. 196645-5

Navy Inspector File No. 2542

Material: Copper Nickel Alloy, Spec. QQ-C-541-Class A

(1) Upon light machining, 10 ft. length of 1/2 x 1-1/8" stock sprung out of line. Although the machining operation was not observed, judging from the setup and the cuts taken, it is not believed that machining and local overheating induced internal strains.

(2) Material contained internal strains when received, contrary to requirements of specification.

(3) Unless stress relieved, difficulty with further machining is to be expected. Material should be stress relieved at 300°C, 5 hours, furnace cooled.

(4) International Nickel Co. should be informed that their stress relief annealing is not sufficient.

(5) Recorder stress strain diagrams should be used in acceptance work in order that internal strains may be detected.

prk

Peter R. Kosting

Peter R. Kosting,
Chemical Engineer.

Requested by Major Rehm

Report No. 344/50-4
Watertown Arsenal

March 16, 1937

THE EFFECT OF HEAT TREATMENT UPON MONEL METAL MACHINED WITH HIGH "S" CUTTING OIL

Object

To determine if any "S" diffused into the metal.

Conclusions

Sulfur penetrated the grain boundaries, but affected only a layer 2 to 3 grains deep, or 0.0002".

Recommendations

The use of high sulfur cutting oil with monel must be considered a special procedure and not a general one, and in every case where the metal is heat treated, all surfaces must be machined before being put into service.

Metal

Material supplied by Major Rehm from end of cylinder machined with S/V Sultran cutting oil #2 which is high in S and which tarnished the surface. Cylinder was stress relief annealed at 575°C for 5 hours and rough machined except for very extreme edges.

Study

A sample, 1/2 x 3/4 x full thickness, was copper plated, polished and etched with HAc + HNO_3 + H_2O:: 30:30:40. Machined surfaces were satisfactory. Edge with tarnish still in place showed S penetration along grain boundary for 2 to 3 grains, as shown in Fig. 1.

A sample, 3/4" x full thickness x 5", was bent double, free bend, with no cracking.

Tarnish removable by scrubbing in cyanide.

The S in the cutting oil forms sulfides upon the metal surface. Upon heat treatment this S diffuses into the Monel Metal along grain boundaries. In the area affected, ductility will be markedly lowered.

Requested by: Major Rehm, Ex.O. C-12

Respectfully submitted,

Peter R. Kosting

Peter R. Kosting
Chemical Engineer

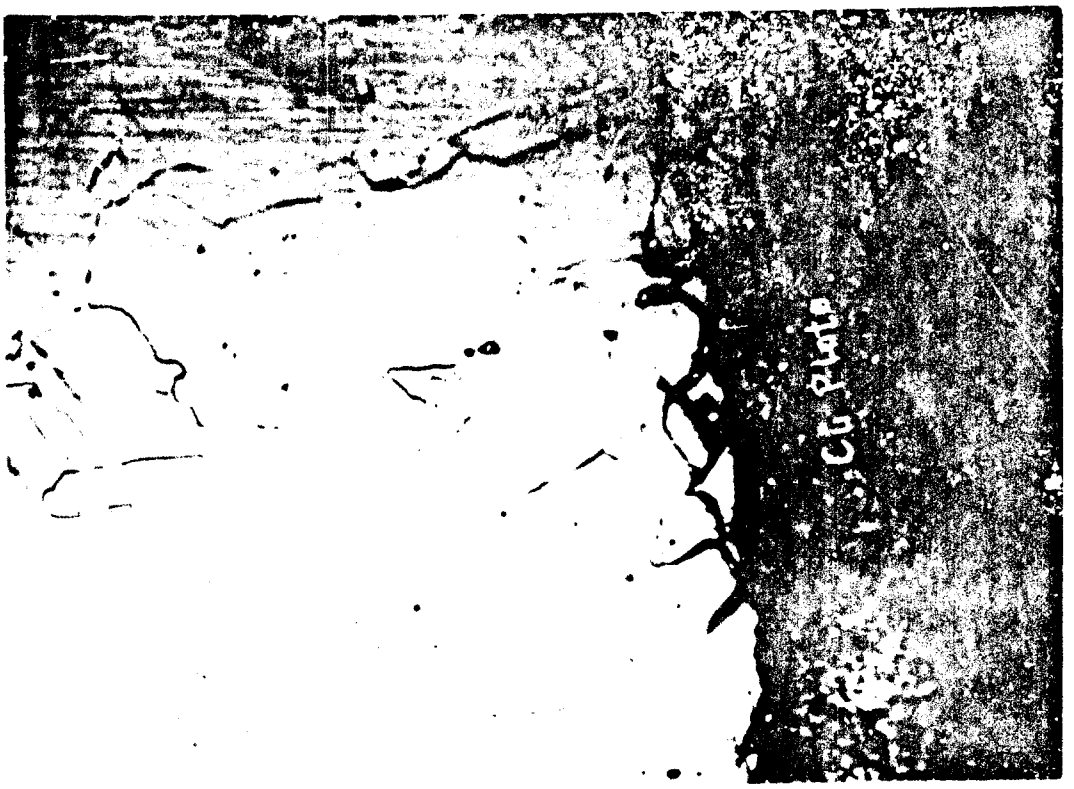

Fig. 1

ME577 X500 Etched HAc + HNO_3 + H_2O::30:30:40
Sulfur diffused along grain boundary from surface which is copper plated.

Report No. 344/50-5

Watertown Arsenal March 25, 1937

MONEL SLIDE S2

1. Monel Metal Slide S2, X.O. 509-398, upon finish milling was found to be warped, the apron having moved up 0.009" (0.005"?) in 0.008", and having buckled, allowing the distance between two shoulders to change 0.002".

2. This slide was stress relieved 575°C, 6 hours, furnace cooled after welding and before rough machining.

3. No difficulty was experienced with slide S1.

4. In finish planing, one of the surfaces on inside of apron was not completed due to tool not cutting.

5. It is not believed that sufficient evidence has been obtained to indicate that the stress relief operation is not sufficient.

6. The desirability of giving a second stress relief

anneal after rough machining should be considered if slide S[illegible] gives difficulty due to warping.

7. Requested by Mr. Fowler.

Respectfully submitted,

Peter R. Koning

Peter R. Koning,
Chemical Engineer.

Report No. 344/50-6
Watertown Arsenal

April 1, 1937

12" M.C. M1918 RECUPERATOR CYLINDERS

Ex. O. 860-A1

(1) Four recuperators were received, partially dismounted with no fluid, gaskets or packing in place, and marked Mount 1º, 39, 59, 83.

(2) The condition of some of the surfaces indicated that not all traces of the glycerine solution had been removed. It has been reported before that to minimize corrosion of the pitting type it is necessary not to permit thin films of alkaline glycerine solution to remain on metal surfaces. Such surfaces must be kept totally immersed or totally free of the glycerine solution.

(3) Glands were badly battered and showed slight etched areas where flax and leather are used for packings.

(4) Piston rod and nut were most seriously affected by corrosion. Galvanic corrosion due to close proximity of bronze pieces was most pronounced. In general, such galvanic effects extended only approximately 3/8 in. from the bronze, but in one or two instances such galvanic effects appeared to extend as much as 2 1/2 in. along the steel from the bronze. This corrosion observed indicates

that the glycerine solution had been allowed to become acid for quite a long time sometime during the life of the recuperator.

Elimination of the dissimilar metals would not eliminate all the corrosion but would retard the break-down of the glycerine solution.

(5) Bronze liners were slightly etched at areas under the packing materials.

(6) Air cylinders in all recuperators were pitted but not as severely as others now in service. A considerable amount of debris was found in the cylinders, including caked iron rust and iron chips.

(7) Exterior surfaces showed evidence of neglect, especially Mount 59.

(8) Rounded particles of sand, graphite flakes, solder particles, caked rust and iron chips were among the debris recovered.

(9) Table I lists the condition of these recuperators in convenient form. It supplements the detailed report of the inspector.

(10) Correspondence W.A. 472.81/6771, O.O. 473.82/2645, A.P.G. 473.82/150, 2nd Ind. 3/11/37, gives the known history of the mechanisms as follows:

12" Mortar Carriages M1918 #19, 39, 59, 83 were

TABLE I

CONDITION OF FOUR RECUPERATORS 12" M.C. M1918

Mt. No.	Steel Piston Rod	Bronze Sleeve	Bronze Liner	Flax Packing Areas on Sleeve	Flax Packing Areas on Plunger	Leather Packing Areas	Miscellaneous
19	Pitting, group, 0.006" deep Entire length affected, especially severe in area within 8" of bronze sleeve, and extending 2 1/2" on circumference.	Minor dents along entire area. Etched at packing areas.	Etched under packing. Laterial ridges 10" from end.	Etched deeply.	Serious etching, pits running circumferentially. Dented.	Slight etching.	Bronze glands stained and slightly etched. Bronze plunger stained on end and badly etched on side.
59	Pitting, group, 0.005" deep at junction of bronze sleeve. Deep grooves running along 4" from sleeve, longitudinally. 0.003" deep, covering 20 sq.in. Within 15" of bronze plunger are pits 0.015" deep. Deep pits, 0.1" adjacent to plunger.	No apparent defects. Piston rod nut badly pitted within 2" of flanged end & running circumferentially	Etched under packing.	-	Slight etching.	-	Bronze glands slightly stained. Bronze plunger slightly etched on side & deeply stained with green at external end; pitted.

TABLE I (Cont'd)

CONDITION OF FOUR RECUPERATORS 12" M.C. M1918

Mt. No.	Steel Piston Rod	Bronze Sleeve	Bronze Liner	Flax Packing Areas on Sleeve	Flax Packing Areas on Plunger	Leather Packing Areas	Miscellaneous
39	Pitting, group, 0.020" deep, starting at bronze sleeve & extending along entire length covering 1/2 the available area	Badly etched in middle	Etched under packing	Etched deeply	Etched deeply	-	Bronze plunger badly etched on sides, stained green on external end.
83	Pits 1/8" deep covering area of 20sq.in. adjacent to bronze sleeve; 2 sq.in. of pits 1/8" deep adjacent to bronze plunger. Pits 0.1 to 0.2" deep along entire length of shaft. Nut pitted on flanged end.	Stained: dezincified areas at end and middle.	Etched under packing.	Extensive staining and pitting	Extensive staining and pitting	Slight staining	Glands slightly stained.

manufactured by Morgan Engineering Company.

They were received at Aberdeen Proving Ground, 1931, from Fort Eustis with recoil and counter-recoil cylinders drained and packings removed. There has been no occasion since then to refill cylinders. Metal parts were slushed, etc., and prepared for open storage upon receipt at Aberdeen Proving Ground and no record was made of condition at that time.

These records indicate that the corrosion was old and that these conditions are no test of newer specifications for materials going into the mechanism.

(11) Air cylinders should be cleaned and either slushed or parkerized and painted. Slushing compound should be very heavy, applied very hot in a very thin film.

(12) New air cylinders for new recuperators should be protected against corrosion, either by electroplating zinc or parkerizing.

(13) The following taken from Ex. Order 860-A2, prepared by Mr. Healy, indicates the extent of repair work.

"1. The four (4) steel cylinders (12-17-52) will be cleaned of all rust and scale (no machining) both inside and out. The inside of the air chambers will be slushed with heavy compound at a temperature high enough to melt the compound, and rolling the cylinder until cold. Use 2-1/2 lbs. per cylinder.

2. The four (4) cylinder bronze liners will be bored and lapped longitudinally to a diameter of not to exceed 6.35 to clean out all scoring and pitting. Use lap on hand shown on drawing B-11-22286.

3. Make 20 studs, 54G, (12-17-54) and assemble as follows:

5 in cylinder #19
8 in cylinder #39
5 in cylinder #59
2 in cylinder #83

4. Turn and lap 4 plungers (12-17-53) to 6.27 dia; fill in nicks by brazing or hard solder after turning and before lapping.

5. Glands (53F1) 12-17-53 - use "as is".

6. Stuffing box (53C1) 12-17-53 - use "as is".

7. Reducing rings (53L) and (53M) 12-17-53 - use "as is".

8. Provide new (4 each, drawing 12-17-53)
Gasket 53K4
Packing 53H4
Garlock Rings .375 sq.

9. Make new (4 each) Gland, large, (54D) drawing 12-17-54. The 6.312 diameter hole to be made to suit the plunger.

10. Make new (4 each) Stuffing Box (large) (54C) drawing 12-17-54. The 6.295 diameter to be made to suit the plunger.

11. Make new (4 each) Packings (54K2); sets of Garlock rings 54E1, 12-17-54.

12. Make new 4 - recup. piston rods (55B3) - drawing 12-17-5

13. The 4 pistons 56A, drawing 12-17-56 will have .125 removed from the packing shoulder to remove all pitting; change .875 to .75. The packing retainer (56B1) will have .937 increased to 1.062.

14. Provide new packing 56F7 and 56H2, drawing 12-17-56.

15. The nuts (56D2) - use "as is". "

Respectfully submitted,

Peter R. Kosting

Peter R. Kosting,
Chemical Engineer.

Report No. 344/60-7

Letter from International Nickel Company, 12/22/37

WA 470.1/3968

The International Nickel Company, Inc.

EXECUTIVE OFFICES: 67 WALL STREET

O. B. J. FRASER
SUPERINTENDENT OF
TECHNICAL SERVICE
MILL PRODUCTS

New York, December 22nd, 1936.

F. L. LaQue

War Department
Watertown Arsenal
Watertown, Mass.

3445-1

Att. Dr. P. R. Kosting

Dear Dr. Kosting:-

Following his recent visit with you, our Mr. C. A. Crawford has asked me to write you concerning two questions that you brought up in your discussion with him.

The first has to do with the removal of oxide coating from hot rolled Monel plates prior to painting, and it is our opinion that such removal is not necessary, since the presence of an oxide coating on Monel does not impair its resistance to sea water corrosion, nor would there be any accelerated corrosion at exposed breaks in such an oxide coating. Consequently, so far as corrosion is concerned, there would be no need of removing oxide coatings by sand blasting prior to painting.

In regard to the corrosion behavior of welds made with 130-x rod when exposed to sea water, it has been our finding that Monel of the composition represented by 130-x weld metal is equal to Monel plate in resistance to corrosion and pitting by sea water. Furthermore, some tests in active electrolytes have shown that there is no accelerated corrosion of either 130-x weld metal or the Monel adjacent to it in welded specimens.

I hope that these notes will clear up all questions on these points.

190-191

Yours very truly,

Technical Service
Development & Research Division

FLL:WAS

Report No. 344/50-8

Letter from International Nickel Company 4/26/37

WA 470.1/4093

The International Nickel Company, Inc.

EXECUTIVE OFFICES: 67 WALL STREET

DEVELOPMENT AND RESEARCH
A. J. WADHAMS, VICE PRESIDENT
MANAGER
T. H. WICKENDEN
ASSISTANT MANAGER

New York,

C. A. Crawford

April 26, 1937

The Commanding Officer
War Department
Watertown Arsenal
Watertown, Mass.

Attention: Major James L. Guion

Dear Sir:

This is in reply to your letter of April 14th asking us for a description of the bone-ash test for detecting cracks. The mill has given us a description of the test, as they apply it, as follows:

This test consists of warming the material to be inspected either by immersion in a warm oil bath or by other methods and slushing with a light grade oil.

The oil is allowed time to penetrate the cracks, usually five to ten minutes, and is then wiped off very carefully until the surface is clean.

The material is then painted with a light coat of bone-ash suspended in alcohol. The alcohol quickly evaporates leaving an even white coat which may become stained by oil seeping out of the seams or cracks thus indicating their location.

The defective areas indicated can then be examined to determine their extent by use of shop microscope, etching, filing, etc.

We hope this information will be useful to you.

Very truly yours,

C. A. Crawford

CAC:LR

Development & Research Division

Report No. 344/50-9

Letter from International Nickel Company 6/17/37

WA 470.1/4093

The International Nickel Company, Inc.

EXECUTIVE OFFICES: 67 WALL STREET

O. B. J. FRASER
SUPERINTENDENT OF
TECHNICAL SERVICE
MILL PRODUCTS

New York,

June 17th, 1937.

IN YOUR REPLY PLEASE REFER TO
DEVELOPMENT AND RESEARCH DIVISION
ATTN F. L. LaQue

War Department
Watertown Arsenal
Watertown, Mass.

Att. Dr. P. R. Kosting

Dear Dr. Kosting:-

You may recall that last December we had some correspondence concerning the effect of oxide on the resistance of Monel to corrosion by sea water. Previously we had discussed this same subject early in 1936 and I wrote you at that time on January 25th. Since then I have exposed a plate of Monel covered with an oxide similar to that found on hot rolled plate that has not been pickled, to flowing sea water at the plant of the Ethyl Dow Chemical Company, Wilmington, North Carolina, for a period of 388 days. Examination of the specimen at the end of that period showed a rate of corrosion as measured by weight loss of only 0.3 milligrams per square decimeter per day, 0.00005" per year, and there was no evidence of pitting or other local attack anywhere on the surface of the specimen, even though the oxide was broken in a few places. This rate of corrosion may be compared with a rate of corrosion of unoxidized Monel of 1.7 milligrams per square decimeter per day during the same period of exposure.

It would appear from these data that the oxide present on hot rolled Monel tends to decrease corrosion rather than to accelerate it, and it was also interesting to note that there was no accelerated attack at breaks in the oxide scale. The behavior of the oxidized Monel in this test confirms our previous experience with Monel in sea water, and supports my statement that the presence of the oxide on hot rolled Monel would not be detrimental to the behavior of the material in sea water.

Yours very truly,

F. L. LaQue
Technical Service
Development & Research Division

FLL:WAS

Report No. 344/50-10

Letter from International Nickel Company

6/22/37

The International Nickel Company, Inc.

EXECUTIVE OFFICES: 67 WALL STREET

DEVELOPMENT AND RESEARCH
A. J. WADHAMS, VICE PRESIDENT
MANAGER
T. H. WICKENDEN
ASSISTANT MANAGER

New York

C. A. Crawford

June 22, 1937

3,44/E-10

The Commanding Officer
War Department
Watertown Arsenal
Watertown, Mass.

Attention: Dr. P. R. Kosting

Dear Sir:

This is in reply to your letter of June 4th and confirming our conversation in your office on June 16th regarding the free machining quality copper nickel alloy. I advised you on the 16th that there was practically nothing to add to the information which I gave you in my letter of March 8th. We would suggest that you disregard comments in the news release which conflict with statements made in my letter of March 8th.

As I told you, Grade "R" Monel as supplied to the trade in general is all of the Grade I composition (sulfur up to .02% max.). The second grade for automatic machine work in rounds 1/8 to 1/2" incl. carries sulfur up to .045%. For specification purposes, we think the limits adopted by the Navy are proper (.025 to .060% S).

Very truly yours,

C. A. Crawford

Development & Research Division

CAC:LR

Report No. 344/50-11
Watertown Arsenal

December 10, 1937

A NOTE ON WARPING OF MONEL METAL CYLINDERS

While discussing, in Seacoast Office, warping of Monel metal cylinders due to machining after first stress-relief anneal at 1065°F, held 5 hours, furnace cooled, it was suggested that a ring, 1" approximately, be cut off, "mic'd", ring cut open and again "mic'd". Internal strains, if present, would cause ring to close or to open. The following shows the dimensions of both ends of the ring section before and after slitting.

Inside Diameter, Inches

	Plain End		End Near Threads	
O'clock	After Splitting	Before Splitting	After Splitting	Before Splitting
12 - 6	4.749	4.7485	4.7493	4.7485
1^{30}-7^{30}	4.749	4.749	4.7478	4.7478
3 - 9	4.7505	4.7505	4.7505	4.750
4^{30}-10^{30}	4.7505	4.750	4.751	4.7515

The maximum change noted was 0.0008 inches.

Using Hatfield and Therkell's formula for calculating stresses that cause a ring to spring open when slit, a change of 0.005" in radius of a ring 4.750/2" in radius corresponds to a stress of only 336 p.s.i. when thickness of ring is 0.350 in.

The Monel metal cylinder could therefore be considered free of internal stresses after the stress-relief anneal.

Respectfully submitted,

Peter R. Kosting

Peter R. Kosting,
Chemical Engineer.