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PROCESS - PLATING - CRACK FREE CHROMIUM, CF-500, PHYSICAL AND CHEMICAL PROPERTIES, EVALUATION OF

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TEST NO. 1	F-8914		REPORT	FGT-2732
MODEL 1	3-58A		DATE 2	7 March 1961
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		TITLE		
	PROCESS - PLA	TING - CRACK-FREE CHI	TOMIUM, CF-50	<u>, 00</u>
	PHYSICAL AND	CHEMICAU PROPERTIES,	EVALUATION	<u>DF</u>
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		CONTRACT NUMBER	•	
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	The tests desc	ribed in this report	were conduct	ed
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PROCESS - PLATING - CRACK-FREE CHROMIUM. CF-500, PHYSICAL AND CHEMICAL PROPERTIES. EVALUATION OF

PURPOSE:

Conventional chromium electroplates as applied to meet Specification QQ-C-320 has no salt spray test requirements. This is because conventional chromium plate, sometimes called engineering chromium or industrial hard chromium contains, microcracks. These microcracks allow corrosive media to penetrate the plating to basis metal causing corrosion. Because the electroplate and basis metal are dissimilar metals the steel basis metal used in most applications becomes anodic with an increased corrosion rate.

Crack-free 500 (CF-500) chromium is a new development by Metal and Thermit Corporation reported to contain certain stress relief additives which allows chromium to be electrodeposited in a crack free condition. The CF-500 is also reported to be softer, more ductile and more adherent. The purpose of this test is to determine the properties of CF-500 chromium.

SUMMARY:

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Crack-free 500 chromium and conventional chromium plated 4130 and Thermold A steel, a H-11 type steel similar to Vascojet 1000, test specimens were plated and compared in various tests. The tests were (1) crack detection, (2) visual observations, (3) adhesion, (4) hardness, (5) salt spray accelerated corrosion tests, (5) sustained load tests and (7) effects of various bakeout conditions on hydrogen content in plated Thermold A steel.

The two types of chromium were comparable in appearance and adhesion but CF-500 chromium was slightly harder and considerably more corrosion resistant in salt, spray tests. It was also determined that increasing the hydrogen relief bake-out conditions produced adequate sustained load strength of CF-500 chromium plated high heat treat steel. Hydrogen analysis test results on specimens with one or more unplated edges showed the hydrogen content was reduced by increasing the bake-out time and temperature. Adequate hydrogen embrittlement relief was obtained by baking at 500°F for 23 hours.

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		Knoop Indenter	1 1 1	Bridgeport, Conn.
	E.	Tukon hardness teater with	hardness tests of	Wilson Mechanical
	D.	Balt spray test cabinet type C-Al	porosity (salt spray) tests	Industrial Pump & Filter Mfg. Co., Chicago, Ill.
x	c.	Bausch & Lomb sterioscopic microscope	visual examination of specimens	W. H. Curtin Co. P.O. Box 5304 Dallas, Texas
	в.	electroplating test fixture XJ- 91602	anodic cleaning, pickling and plating of speci- mens	manufactured by tooling department
	Α.	vapor degreaser	preplate cleaning of all basis metal	manufactured by Dept. 36
III.	Equ	1pment:	Т Т е	
	c:	100 pounds of Oakite 190	anodic electro- cleaner prior to plating	Oakite Products, In 52 H. Rector St. New York 6, N. Y.
	в.	100 pounds of Chromic Acid Flake	ingredient for 53 oz/gal conven- tional chromium plating solution	Mutual Chromium Che Baltimore, Md.
•	A.	125 pounds of Crack-free 500 Chromium	ingredient for Crack-free 500 chromium plating	Metal & Thermit Cor Rahway, N. J.
'II.	Mat	erials:		
	H.	3 pieces Thermold A steel .055" x .25" x 6"	basis metal speci- men. for hydrogen pick-up determina- tions	Universal-Cyclops Steel Company Titusville and Bridgeville, Pa.
·	ġ.	44 pieces of Thermold A steel .055" x 1.25" x 8"	basis metal for notched tensile and sustained load test specimens.	Universal-Cyclops Steel Company Titusville and Bridgeville, Pa.

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٠,٠.	F.	Research Metall graph	lo- examination of specimens for microcracks	Bausche & Lomb Co., Rochester, N. Y.
	G.	60,000 pound Baldwin univer- sal test machin with microforme extensioneter an MA_1 atress str regorder	tensile tests	Baldwin Lima Hamilto Company Waltham, Mass.
	Н.	12,000 pound Aroweld creep- rupture machine	sustained load tests	Arcweld Mfg. Company Grove City, Pa.
	I.	375-1000°F draf oven	t application of various bake=out conditions	Blue M. Electric Co. Blue Island, Ill.
	J.	vaduum hydroger determinator	n ahalysis of spec mens for hydroge content	1- National Research Co n Newton Highland 61, Mass.
	ĸ.	out-off saw	cutting specimen after sustained load tests	 Precision Scientific Company Chicago, Ill.
PRO I.	App fre All deg cle 3 m ano at in 6 mat	RES: to basis metal spe stened with meth reased in trichl aned in Oakite 1 inutes. Thermol de first in the 6 volts and then t for chromium p 5 normal hydrochl ely; two minutes	ares for conventional cest finishes to 4130 ecimens were wiped wit byl ethyl ketone. The core thylene. Specime 90, (6, 05/gal), 160-1 d A steel specimens w chromium plating solu a quickly switched, ove blate. Specimens of 4 foric acid at room tem just prior to plating	chromium and Crack- and Thermoid A steel. h cheesecloth y were then vapor ns were anodic 80°F at 6 volts for ere made the tion for one minute r to cathodic arrange- 130 steel were pickled perature for approxi-
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		The	convent1	onal chro	mium bat	th used w	as made up	of 53
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	· · ·	while	the pla	ating cur	rent was	s 2 amps/	square incl	1. Crack-
		free	500 chr	omium pla uctions s	ting was	3 perform	ed accordin	lg to
		Venu		ao atoma ta	J LOXIO			
·		A. !	The conc	entration	of CF-	500 mater	1al was 44	oz/gal
		4	anu the	operating	ramher.	ILUIG WAD		
		B.	Plating	current d	ensity w	vas 2 amp	s/square in	ndh.
		C. '	The new :	solution	was dumr	nied with	copper cat	thode at
	-		5 volts	for 4 hou	rs.			•
		D. (Ordinary	chromium	plating	r anodés	of tin-lead	i allov
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		Α. `	Visual I	nspection	2	r		r =-
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		i	Specimen	s were be	nt repea	tedly th	rough an ar	igle of
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			from the failure.	Dasis me Plate t	tal Was hickness	arbitrar 1 van 2 m	ily conside ils.	med a
			1					
		C.	Porosity		٦	: •		
		i	Specimen	s were ex	posed to	20% dal	t spray as	described
			in Feder	al Test M	ethod St	andard 1	51, Method	811, until
			appearan	ce of rus	t was co	nsidered	a failure.	
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The tests were conducted on a 3 mil plating applied to 4130 steel. Specimens were sawed, mounted and tested in a position perpendicular to saw direction so that indenter impinged only into the chromium.

E. Crack Detection

A specimen of 4130 steel was plated with conventional chromium while another was plated with Crack-free.500 chromium. Both were plated with .002" thickness chromium. The specimens were then examined on a metallograph at various magnifications; however, a magnification of 250 X was best suited for crack , detection.

F. Sustained Load Tests

In order to arrive at a 90% ultimate load for actual sustained load tests standard sheet tensile specimens, taken in the longitudinal direction, were fabricated according to drawing FTJ-10940-8. Standard notched sheet tensile specimens, also taken in the longitudinal direction, were fabricated as shown in drawing FTJ-10940-20.* After fabrication specimens were heat treated as follows:

- 1. Preheat to 1450°F hold for 30 minutes (argon atmosphere)
- 2. Heat to 1850°F hold for 1 hour (argon atmosphere)
 - 3.4 Air cool
 - "4., Double temper at 1025°F for 2 hours (argon atmosphere).

The tensile tests for both notched and unnotched specimens were conducted in a 60,000 pound Baldwin universal test machine. A microformer extensometer and a MA-1 stress-strain recorder were used to obtain the yield strength by the 0.25 offset method on the unnotched specimens. Ninety percent of the average notched tensile specimen value was used as load for sustained load, tests.

Specimens for sustained load were additional notched tensile specimens, fabricated, heat treated, sanded, polished, plated and baked as shown in Table IV. Sustained load tests were run on an Arcweld 12,000 pound creep-rupture machine until failure or completion of 1000 hour test.

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*See Supplemental Sheet S-1

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After sustained load tests the notched area was removed with an alundum water cooled cut off saw. The areas removed were $.055" \ge 0.25" \ge 0.25"$. Specimens were then thoroughly cleaned in acetone, dried and analyzed in the vacuum hydrogen analyzer. A few additional specimens were examined on the outer edge as shown in Table IV.

0. Hydrogen pick-up determinations *.

Three strips approximately 6" long x 1/4" wide of .055" Thermold A material were sheared out of sheet stock. One strip was used as unplated control, one strip was plated with .002" conventional chromium and the remaining strip was plated with .002" of Crack-free 500 chromium. The strips were identified and sheared into pieces 1/4" x 1/4" x .040". Specimens were baked out as groups at various conditions of time and temperature shown in Table V. Hydrogen content of specimens after various treatments was determined on a N.R.C. vacuum hydrogen determinator according to procedures described in FZM-1776, procedure 3.560.

RESULTS:

Figure 1 is a photomicrograph at 250 X magnification of Crackfree-500 chromium and conventional chromium. Table I presents data for visual observations, adhesion and hardness tests. Salt bpray test data are shown in Table II while Table III and IV contain results of tensile, sustained load and hydrogen content of sustained load tests. Effects of various bake-out conditions on hydrogen content are shown in Table V.

DISCUSSION:

Upon examination of Figure 1 it is evident that Crack-free 500 chromium can be deposited in the crack-free state. Table I data shows the two materials to be comparable except in hardness with Crack-free 500 chromium being somewhat harder. Salt spray test, data from Table II is conclusive that Crack-free 500 is considerably more resistant to corrosion. For instance .003" conventional chromium failed 48 hours salt spray while the same thickness Crack-free 500 chromium passed 250 hours without any basis steel corrosion. This is also further proof that the Crack-free 500 is crack-free.



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	Sustaine	d load te	st data 1	n Table T	/ shows f	inst that	375°F
,	for 23 h	ours bake	-out of C	rack-free	-500 is n	ot suffici	ent
	hydrogen	relief a	ince all	anecimens	failed t	he 1000 ho	ur
	test. W	1th more	bake out.	for inst	ance 500°	F for 2 ho	urs.
	adequate	sustaine	d load st	rength way	obtaine	d. Data f	or
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	publishe	d data wh	ich indica	ates 375°	7 for 23	hours is a	n
	adequate	bake-out	condition	n. This (lata ther	efore is g	ood
	control	data. It	is also d	obvious, (generally	speaking,	that
	the anal	yzed hydr	ogen conte	ent is le	ss at mor	e elevated	con-
1	ditions	of temper	ature and	time, So	ome diffi	oulties we	re
	encounte	red in th	e hydrogei	n determin	nation te	sts. Duri	ng
	cut-off	operation	s with the	alundum	wheel vi	.Bible oxid	ation
	occurred	on the s	pecimens (even thou	sh they w	ere cut un	der
	water.	For this	reason it	was deci	led to co	nduct addi	tional
	tests fo	r hydroge	n determi	nations W	Ltn empha	1518 on ell	minat-
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	plated a	ng small	specimens	were the	n sneared	OIT IOT V	Brious
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	4.	Adequate	hydrogen	embrittle	ement rel	ief can be	
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		and remp	erature, to	5 300°F I	or 23 nou	ur s .	
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PAGE_ REPORT NO FGT 2.732 O N V A I R 858 A MODEL A DIVISION OF GENERAL DYNAMICS CORPORATION 3-27-61 DATE___ (FORT WORTH) FIGURE 1 CONVENTIONAL CHROMIUM . ODZ' THER 250X CRACK-FREE ED CHECMINA . OLZ THER ZSUK

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10 PAGE. 1.4 Π FGT-2732 REPORT NO. B-58A MODEL A DIVISION OF GEI 3-27-61 DATE (FORT WORTH) TABLE I TEST RESULTS I. VISUAL OBSERVATIONS TYPE OF PLATING SURFACE APPEARANCE PITS BLISTERS EDGE BUICD-UP CO. VENTIONAL CHROMINA NOVE SLIGHT NONE SMOOTH, GREY, MATTE 11 11 11 11 CRACK-FREE 500 II. ADNESION -- (4x MAGNINGATION) - BEND TEST CONVENTIMAL CHROMIUM RACK-FREE 500 PASS PASS III. HARDHESS - TUKON HARDHESS TESTER USING KNOOP INDENTER CONVENTIONAL CHROMIUM CRACK-FREE , 500 KNOOP ROCKWELL C * ROCKWELLC KNOOP 889 . 70+ 247 67.6 847 67.6 1039 70 + 889 936 .70+ 70+ 847 889 676 70+ 985 . 70+ 770 63.5 593 53,5 936 70+ 939 65.3+ AV4. 206 69. 1 * SCALE CONVERSION FROM KNOOP DETERMINATION 3 UTILITY REPORT SHEET Department 6 FWP 1072-8-54

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· · ·	EFFECTS TAST	TABLE OF 250 How METHON STR	E <u>II</u> e Sait Saray Exassure per Federa NORED 151 METHOD 811
•	BISIS METAL C TYPE OF PLATING	1130 THICKNESS, INCHES	FRILURE DEFINED AS IST AMERICAN CF RUST RESULTS OF SALT SPRAY TESTS
	CONVENTIONAL CHROMIUM 53 03/GAL	0.0005	PASSED 250 HOURS (I SACAMEN)
·	- //	0,001	3 OF 6 FRILED AT SHOURS, / FRILED 24, IFAILE 72, / PASS 250 Hours
·	"	0.002	ZOFG FAILED Z& HOURS, 3 FARED 48 HOURS AN QUE FAILED AT 96 HEURS
		0.003	3 OF 6 FAILED 24 Hoves, 3 FAILED 48 Hoves
	CR:25-FREE' 500	0.0005	FAILED 216 Hours, ONE SPECMEN
×	"	0,001	3 OF 3 FAKED AT 104 HOURS
		0.002	3 OF 3 PASSED 250 Hours
		0.003	2. OF 2 PASSED 250 Hours

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