OAK RIDGE NATIONAL LABORATORY LIBRARIES
3 4456 0548220 6

CENTRAL RESEARCH LIBRARY
DOCUMENT COLLECTION

ORNL-3787
UC-4 – Chemistry
TID-4500 (37th ed.)

EVALUATION OF HASTELLOY F AND OTHER CORROSION-RESISTANT STRUCTURAL MATERIALS FOR A CONTINUOUS CENTRIFUGE IN A MULTIPURPOSE FUEL-RECOVERY PLANT

W. E. Clark
L. Rice
D. N. Hess

OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

Printed in USA. Price $1.00. Available from the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, *U.S. Department of Commerce, Springfield, Virginia*

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

ORNL-3787

Contract No. W-7405-eng-26

CHEMICAL TECHNOLOGY DIVISION

Chemical Development Section B

and

REACTOR CHEMISTRY DIVISION

EVALUATION OF HASTELLOY F AND OTHER CORROSION-RESISTANT STRUCTURAL MATERIALS FOR A CONTINUOUS CENTRIFUGE IN A MULTIPURPOSE FUEL-RECOVERY PLANT

W. E. Clark L. Rice D. N. Hess

APRIL 1965

Oak Ridge National Laboratory
Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

OAK RIDGE NATIONAL LABORATORY LIBRARIES

3 4456 0548220 6

CONTENTS

	Page
Abstract	1
1. Introduction	1
2. Experimental	2
3. Results	3
4. Conclusions and Recommendations	9
5. Acknowledgment	11
6. References	12

ABSTRACT

Hastelloy F was found suitable as a material of construction for a centrifuge to be used for clarifying solutions generated in various nuclear head-end processing schemes. The maximum corrosion rate was $\leq$0.7 mil/month in all solutions tested.

Test solutions were of the following types: stainless steel dissolved in 4 M H_2SO_4 (from the Sulfex process), stainless steel dissolved in 5 M HNO_3--2 M HCl (from the Darex process), Zircaloy-2 dissolved in 6 M NH_4F--1 M HNO_3 (from the Zirflex process), UO_2-ThO_2 dissolved in 13 M HNO_3--0.04 M NaF--0.04 M $Al(NO_3)_3$ (from the Thorex process) and UO_2 dissolved in 10 M HNO_3--0.01 M Zr--0.05 M NaF (core dissolvent from the Zirflex process). Test temperature was 35°C. Candidate materials besides Hastelloy F included Carpenter 20SCb stainless steel, Hastelloy C, titanium-45A, and a vacuum-melted, low-carbon variation of Ni-o-nel. Hastelloy F was the only one of these materials which was satisfactorily resistant to all of the test solutions.

---

1. INTRODUCTION

Many plans for the chemical recovery of fissile or fertile material from spent fuel elements are based on the concept of a multipurpose facility. In such a facility the commoner types of fuel were to be converted into aqueous nitrate solutions which were then to be used as feed for a solvent extraction process, such as the Purex process.

The head-end steps were adapted to the type of fuel to be prepared for solvent extraction. One proposed multipurpose plant would have used 4 M H_2SO_4 (Sulfex process[1]) and NH_4F-NH_4NO_3 (Zirflex process[2]) to remove stainless steel and Zircaloy cladding, respectively, from ceramic (e.g., UO_2 or UO_2-ThO_2) fuel cores. The fuel cores were then to be dissolved in 10 M HNO_3 (for UO_2) or in 13 M HNO_3--0.04 M NaF--0.04 M $Al(NO_3)_3$ (for UO_2-ThO_2; Thorex process[3]). Fuel elements consisting of UO_2—stainless-steel cermets clad with stainless steel and certain other fuel types not susceptible to chemical decladding were to be completely dissolved in mixed HNO_3-HCl (Darex process[4]).

The material of construction for the dissolver vessels varied according to the nature of the reagents and the products of the reaction. The Sulfex and Zirflex two-step decladding processes were to be conducted in a Ni-o-nel dissolver.[5] The dissolver used in the Darex (HNO_3-HCl) process was to be of titanium.[5,6] An alternative to the Sulfex decladding process for stainless-steel-clad UO_2-ThO_2 cores was the Darex-Thorex process,[7] in which the cladding was to be removed by dissolving it in 5 M HNO_3--2 M HCl, with the core being subsequently dissolved in 13 M HNO_3--0.04 M NaF.* This process would be contained in the titanium dissolver.

A continuous centrifuge was also required, preferably one resistant to corrosion by all the solutions produced by the several processes. Since some fines are produced by cracking or spalling of the fuel cores during irradiation or during the decladding process, it would be necessary to recover such suspended fines from the decladding solutions before these were sent to waste storage. Also, it would be necessary to remove suspended solids of any type from the core solutions before sending them on to the feed adjustment and solvent extraction operations.

The purpose of this report is to summarize the results of corrosion tests on candidate materials of construction for this multipurpose centrifuge. Although the proposed processing plant has since been dropped from consideration, the corrosion data obtained in this study (October 1960-May 1961) and the fact that Hastelloy F is very resistant to several aggressive solutions, may be of value to other programs.

2. EXPERIMENTAL

Welded specimens of candidate materials were exposed to the test solutions, to the air-solution interface, and to the vapors above the stirred solutions. Duplicate exposures were made in every case. The solutions had the compositions expected for spent dissolvents from the processes under study, after making allowance for cross-contamination

*Addition of $Al(NO_3)_3$ to complex the fluoride is not necessary if a titanium container is used (refs 5 and 8).

of solutions in the case of the two-step dissolution processes (Table 1). A test temperature of 35°C was regarded as being the most likely one for these spent dissolvents. The specimens were normally removed each week for examination and weighing.

Materials tested included Carpenter 20SCb stainless steel, LCNA,* Hastelloy C, Hastelloy F, and titanium 45A (Table 2). The selection was based primarily on prior experience with these alloys in various fuel-processing media. All the metals were exposed in all media, although a few (e.g., titanium in NH_4F) were not expected to be satisfactory.

3. RESULTS

All the metals were satisfactorily resistant to the Sulfex decladding solution. Cumulative corrosion rates for 672 hr of exposure were less than 0.1 mil/month in every case (Table 3).

For the solution resulting from the Zirflex decladding process, rates were lower than those for the Sulfex process for all metals tested except titanium. The calculated cumulative rate for titanium during 672 hr of exposure in this solution was about 6 mils/month (Table 4). The solution was unstable with respect to the dissolved zirconium, part of which precipitated during the test period. Therefore, solutions were renewed weekly, using freshly prepared solution so that all components, including the zirconium precipitate, would be present in the test vessel.

Titanium, as expected, was the most resistant to spent Darex dissolvent. However, Hastelloy F was also quite resistant, with a maximum overall corrosion rate of 0.05 mil/month for 674 hr of exposure (Table 5). Hastelloy C was also satisfactory, with a rate of 0.36 mil/month. Both LCNA and Carpenter 20SCb showed very erratic behavior when exposed in vapor and interface positions. Rates for these two alloys varied from a small fraction of a mil to 80 mils/month for 168 to 336 hr of exposure, indicating the existence of an active-passive condition in the vapor phase.

---

*A specially produced, vacuum-melted, low carbon alloy corresponding closely in composition to the International Nickel Company trademarked alloy, Ni-o-nel.

Table 1. Compositions of Test Solutions

Solution Designation	Preparation of Solution	Nominal Compositions,[a] moles/liter											
		H^+	NH^{4+}	Stainless Steel[b]	Zr^{4+}	Th^{4+}	UO_2^{2+}	Na^+	Al^{3+}	NO_3^-	SO_4^{2-}	Cl^-	F^-
Sulfex	Dissolve 30 g of type 304L stainless steel in 1 liter of 4 M H_2SO_4--0.001 M NaF	4	---	0.53	---	---	---	0.001	---	---	4	---	0.001
Zirflex	Dissolve 25 g of Zr in 1 liter of 6 M NH_4F--1 M NH_4NO_3	~0	5.5	---	0.37	---	---	---	---	~0.1	---	---	6
Darex	Dissolve 45 g of 304L and 5 g of 302B stainless steels in 1 liter of 5 M HNO_3--2 M HCl	2.4	---	0.88	---	---	---	---	---	4.6	---	1.9	---
UO_2 core[c]	Dissolve 453 g UO_2 in 1 liter of 10 M HNO_3 containing 0.01 M Zr and 0.05 M NaF	~8	---	---	0.01	---	1.0-1.9	0.05	---	9.4-9.8	---	---	0.05
Thorex	Dissolve 275 g of 96% ThO_2--4% UO_2 in 13 M HNO_3--0.04 M NaF--0.04 M $Al(NO_3)_3$	8.5	---	---	---	1.0	0.04	---	0.04	12.7	---	---	0.04

[a]Based on calculations from published flowsheets plus occasional analyses.

[b]Listed thus for convenience. Both 304 and 302 are "18-8" stainless types, i.e., Fe ≅78-80, Cr = 17-19%, Ni = 8-10%, with minor amounts of Mn, C, Si, etc.

[c]Some of the uranium hydrolyzed from this solution to form a precipitate. See Table 8 for some solution analyses.

Table 2. Nominal Composition of Candidate Materials

Alloy	Co	Cr	Ni	Fe	Mn	Mo	Cu	Si	W	C	Nb	Ti	N	H
Carpenter 20SCb stainless steel	---	20.0	29.0	43.6	0.75	2.0	3.0	1.0	---	---	0.7	---	---	---
LCNA[a]	---	21	40	31	0.6	3	1.75	0.4	---	0.005	---	(20xC)	---	---
Hastelloy C	2.5 max.	15.5	54.6	5.5	1.0	16.0	---	1.0	3.8	0.08	---	---	---	---
Hastelloy F	2.5 max.	22.0	45.0	21.0	1.55	6.0	---	1.0	1.0	0.05 max.	---	---	---	---
Titanium-45A	---	---	---	0.25	---	---	---	---	---	0.08 max.	---	Bal.	0.05 max.	0.015 max.

[a]A specially produced vacuum-melted alloy closely approximating the International Nickel trademarked alloy, Ni-o-nel.

Table 3. Corrosion of Various Alloys at 35°C in a Solution Derived from the Sulfex Decladding Process

Alloy[b]	Test Period (hr)	Cumulative Corrosion Rate (mils/month) V	I	S
Carpenter-20SCb	168	0.03, 0.05	0.05, 0.05	0.05, 0.07
	336	0.01, 0.02	0.02, 0.02	0.02, 0.03
	504	0.01, 0.02	0.02, 0.01	0.02, 0.02
	672	0.01, 0.01	0.01, 0.01	0.01, 0.02
LCNA	168	c c	0.22, 0.21	0.28, 0.31
	336	c c	0.11, 0.11	0.14, 0.17
	504	c c	0.07, 0.07	0.09, 0.11
	672	0.01, c	0.05, 0.05	0.07, 0.08
Hastelloy C	168	0.01, 0.01	0.06, 0.06	0.08, 0.08
	336	0.01, 0.01	0.05, 0.05	0.06, 0.07
	504	0.01, 0.01	0.05, 0.05	0.07, 0.07
	672	0.01, 0.01	0.05, 0.05	0.06, 0.06
Hastelloy F	168	0.01, 0.01	0.01, 0.01	0.01, 0.02
	336	c c	0.01, 0.01	0.01, 0.01
	504	0.01, 0.01	0.01, 0.01	0.01, 0.01
	672	0.01, 0.01	0.01, 0.01	0.01, 0.01
Titanium-45A	168	0.01, c	c, 0.01	c c
	336	c c	0.01, 0.01	0.01, 0.01
	504	0.01, c	0.02, 0.01	0.02, 0.03
	672	0.01, c	0.02, 0.03	0.04, 0.03

[a]Solution prepared by dissolving 30 g of type 304 stainless steel in 1 liter of 4.0 M H_2SO_4--0.001 M NaF.

[b]Alloy compositions listed in Table 2.

[c]Indicates small weight gain.

This conclusion was confirmed by repeating the exposure. It seems likely that the existence of this active-passive state depends on the aeration of the vapor-phase and interface-phase specimens; if contact with air is prevented by condensing vapor, the metal will assume an active potential. Whatever the explanation, LCNA and Carpenter 20SCb are not as resistant to the spent Darex dissolvent as the Hastelloys and titanium. None of the alloys corroded excessively in simulated, spent, Thorex dissolvent. Cumulative rates for 672 hr of exposure varied from 0.01 mil/month for titanium to 0.33 mil/month for Hastelloy C (Table 6).

Table 4. Corrosion of Various Alloys at 35°C in a Solution Derived from the Zirflex Decladding Process

Alloy[b]	Test Period (hr)	Cumulative Corrosion Rate (mils/month)		
		V	I	S
Carpenter-20SCb	168	0.01, 0.01	0.02, 0.01	0.02, 0.01
	336	c c	0.01, 0.01	0.01, 0.01
	504	c, 0.01	0.01, 0.01	0.03, 0.03
LCNA	168	c c	c c	0.01, 0.01
	336	c c	c c	c, 0.01
	504	c c	c c	c, 0.01
Titanium-45A	234	0.03, 0.04	7.49, 7.35	15.4, 14.9
	504	0.01, 0.01	3.85, 3.67	7.51, 7.23
	672	0.01, 0.01	3.17, 2.96	6.06, 5.86
Hastelloy C	168	0.01, c	0.03, 0.02	0.03, 0.03
	504	0.01, 0.01	0.01, 0.01	0.01, 0.01
	672	0.01, 0.01	0.01, 0.01	0.01, 0.01
Hastelloy F	234	0.01, 0.02	0.07, 0.08	0.08, 0.09
	402	0.01, 0.01	0.04, 0.04	0.04, 0.05
	504	0.01, 0.01	0.03, 0.03	0.03, 0.04
	672	0.01, 0.01	0.03, 0.03	0.03, 0.03

[a]Solution prepared by dissolving 25 g of zirconium in 1 liter of 6.0 M NH_4F--0.01 M NH_4NO_3.

[b]See Table 2 for alloy compositions.

[c]Indicates small weight gain.

A thermally cold solution prepared by dissolving UO_2 in either pure HNO_3 or in HNO_3 contaminated with small amounts of H_2SO_4 presents no corrosion problem. A dissolver solution contaminated with fluoride (i.e., from the Zirflex decladding process) was, therefore, the only core solution other than Thorex to be tested. Alloy LCNA, Carpenter 20SCb, and Hastelloy F were all reasonably resistant to this environment; average cumulative rates for 840 hr of exposure were 0.24, 0.47, and 0.68 mil/month, respectively (Table 7). Both Hastelloy C and titanium were attacked at excessive rates at the interface and in the solution; tests on these materials were, therefore, terminated after 336 hr.

Table 5. Corrosion of Various Alloys at 35°C in a Spent Darex Dissolvent[a]

Alloy[b]	Cumulative Corrosion Rate (mils/month)											
	168 hr			336 hr			506 hr			674 hr		
	V	I	S	V	I	S	V	I	S	V	I	S
Titanium-45A	0	0	0.01	0.01	0	0	0.0	0.0	0.0	0.0	0.0	0.0
	c	0	0.02	0	0	0.01	0.0	0.0	0.1	0.0	0.0	0.01
Hastelloy C	0.28	0.35	0.50	0.22	0.26	0.43	0.18	0.33	0.39	0.15	0.20	0.36
	0.23	0.25	0.39	0.19	0.21	0.34	0.15	0.17	0.32	0.13	0.15	0.31
Hastelloy F	0.05	0.08	0.10	0.04	0.07	0.09	0.03	0.06	0.07	0.03	0.05	0.05
	0.04	0.08	0.10	0.04	0.07	0.09	0.03	0.05	0.07	0.02	0.04	0.05
LCNA	0.03	0.13	0.06	52.0	7.40	0.03[d]	--	--	--	--	--	--
	0.02	0.06	0.05	51.0	7.50	0.03	--	--	--	--	--	--
Carpenter 20SCb	2.70	0.34	0.12	80.2	32.1	0.06[d]	--	--	--	--	--	--
	0.19	0.20	0.12	79.9	22.8	0.06	--	--	--	--	--	--
Repeat Tests												
LCNA	0.06	56.0	0.54[d]	--	--	--	--	--	--	--	--	--
	55.8	57.3	0.24	--	--	--	--	--	--	--	--	--
Carpenter 20SCb	2.85	6.71	0.15[d]	--	--	--	--	--	--	--	--	--
	0.21	1.24	0.14	--	--	--	--	--	--	--	--	--

[a]Solution prepared by dissolving 45 g of type 304 stainless steel and 5 g of type 302B stainless steel in 1 liter of 5.0 M HNO_3--2.0 M HCl.

[b]Alloy compositions listed in Table 2.

[c]Indicates slight weight gain.

[d]Test discontinued after this exposure.

Table 6. Corrosion of Candidate Alloys in Spent Thorex Dissolvent[a] at 35°C

Alloy[b]	Test Period (hr)	Cumulative Corrosion Rate (mils/month)		
		V	I	S
Carpenter 20SCb	168	0.05, 0.06	0.06, 0.07	0.07, 0.07
	336	0.03, 0.04	0.05, 0.04	0.05, 0.05
	672	0.02, 0.03	0.03, 0.03	0.03, 0.03
LCNA	168	0.02, 0.02	0.03, 0.03	0.04, 0.05
	336	0.02, 0.02	0.03, 0.02	0.03, 0.03
	672	0.01, 0.01	0.02, 0.01	0.03, 0.02
Titanium	168	0.02, 0.01	c c	c c
	336	0.01, 0.01	<0.01, <0.01	<0.01, 0.01
	672	0.01, 0.01	0.01, 0.01	0.01, 0.01
Hastelloy C	168	0.31, 0.30	0.36, 0.40	0.53, 0.49
	336	0.24, 0.24	0.28, 0.32	0.42, 0.39
	672	0.19, 0.20	0.23, 0.28	0.33, 0.31
Hastelloy F	168	0.06, 0.05	0.06, 0.06	0.05, 0.06
	336	0.04, 0.04	0.04, 0.05	0.04, 0.04
	672	0.03, 0.03	0.03, 0.03	0.03, 0.03

[a]Solution prepared by dissolving 275 g of 96% ThO_2--4% UO_2 pellets in 1 liter of 13.0 M HNO_3--0.04 M $Al(NO_3)_3$--0.04 M NaF.

[b]Alloy compositions listed in Table 2.

[c]Indicates small weight gain.

A second exposure of titanium in this solution gave rates for vapor-phase corrosion and corrosion at the interface which were only about half as large as those obtained for the first exposure. Although titanium had already been eliminated from consideration by the excessive rate observed for the Zirflex decladding solution, a few scoping tests were made to define, if possible, the effect of minor changes in the composition of the solution.

The results (Table 8) indicate the sensitivity of the titanium corrosion to the F/Zr ratio, even in the presence of complexing agents such as aluminum and iron. In these complexed solutions, pitting of the titanium was observed, although the corrosion calculated as an overall rate was low. This is in agreement with the results obtained in Thorex dis-

Table 7. Corrosion of Various Alloys in a UO_2 Core Solution[a] at 35°C

Alloy[b]	Test Period (hr)	Cumulative Corrosion Rate (mils/month) V	I	S
Carpenter 20SCb	168	0.45, 0.45	0.59, 0.60	0.69, 0.62
	336	0.37, 0.35	0.46, 0.47	0.53, 0.49
	504	0.31, 0.31	0.44, 0.43	0.48, 0.45
	840	0.30, 0.30	0.43, 0.43	0.48, 0.45
LCNA	168	0.43, 0.42	0.49, 0.52	0.54, 0.44
	336	0.32, 0.30	0.33, 0.36	0.38, 0.32
	504	0.26, 0.26	0.28, 0.30	0.32, 0.27
	840	0.22, 0.20	0.22, 0.24	0.25, 0.23
Hastelloy F	168	0.37, 0.37	0.53, 0.54	0.54, 0.55
	336	0.30, 0.31	0.48, 0.47	0.49, 0.50
	504	0.28, 0.29	0.50, 0.49	0.51, 0.53
	840	0.30, 0.32	0.62, 0.61	0.66, 0.69
Titanium 45A	168	1.10, 1.20	10.3, 10.2	10.7, 10.9
	336[c]	1.20, 1.20	10.4, 10.7	10.8, 11.1
Hastelloy C	168	1.2, 1.1	4.0, 3.8	3.9, 3.8
	336[c]	1.3, 1.4	5.1, 5.0	5.2, 5.0

[a]Solution prepared by dissolving 453 g of UO_2 in 1 liter of 10.0 M HNO_3--0.01 M in Zr^{4+}, and 0.05 M in NaF.

[b]Alloy compositions listed in Table 2.

[d]These tests were terminated after 336 hr because of the severe attack on the interface and solution specimens.

solver tests.[5,8] Further tests are needed to properly evaluate this effect. The corrosion of Hastelloy F was not greatly affected by these changes in solution composition.

4. CONCLUSIONS AND RECOMMENDATIONS

Hastelloy F is the only one of the candidate materials considered satisfactorily resistant to all environments studied. The maximum rate was never greater than 0.7 mil/month in any solution tested. The considerable amount of corrosion testing that has been done on this alloy in the HNO_3-HCl and HNO_3-HF systems,[9] which are also the most aggressive of those studied, adds an extra margin of confidence to the results obtained in this study.

Table 8. The Effect of Changes in Composition[a] of a UO_2 Dissolver Solution on the Corrosion of Titanium 45A and Hastelloy F

Solution Designation and Compositional Variables	Alloy[b]		Cumulative Corrosion Rate (mils/month) (Ave. of 2 Specimens) at Exposure Times (hr) Indicated						
			168	240	336	408	508	528	700
No. 1. No F^-, 0.01 M Zr	Ti-45A	V	--	<0.01	--	<0.1	--	<0.1	--
		I	--	c	--	c	--	0	--
		S	--	<0.01	--	<0.01	--	<0.03	--
No. 2. 0.01 M Zr; F/Zr ratio = 7.1	Ti-45A	V	0.14	--	--	--	--	--	--
		I	2.14	--	--	--	--	--	--
		S	2.61	--	--	--	--	--	--
No. 3. 2×10^{-4} M Zr; F/Zr ratio = 200	Ti-45A	V	--	--	--	--	0.94	--	0.88
		I	--	--	--	--	5.55	--	5.25
		S	--	--	--	--	8.65	--	8.30
	Hastelloy F	V	--	--	--	--	0.15	--	0.13
		I	--	--	--	--	0.20	--	0.18
		S	--	--	--	--	0.25	--	0.21
No. 4. 6×10^{-4} M Zr; 0.07 M Al^{3+}; F/Zr ratio = 100-150[a]	Ti-45A	V	0.69	--	0.63	--	--	0.54	0.57
		I	2.84	--	2.67	--	--	2.48	2.40
		S	3.52	--	3.48	--	--	3.42	3.30
	Hastelloy F	V	0.12	--	0.10	--	--	0.08	0.07
		I	0.15	--	0.12	--	--	0.10	0.08
		S	0.15	--	0.11	--	--	0.09	0.08
No. 5. 0.01 M Zr; 0.07 M Fe^{3+}; F/Zr ratio = 6.3	Ti-45A	V	--	0.10	--	0.09	--	0.07	--
		I	--	0.94	--	0.85	--	0.78	--
		S	--	1.00	--	0.99	--	0.95	--

[a]Solution compositions (M):

		Free Acid	U	Zr	F	NO_3^-	Al	Fe	~F/Zr
No. 1.	Initial	8.8	1.34	0.01	N.A.	N.A.	--	--	0
No. 2.	Final	Not Anal.	N.A.	0.01	0.071	N.A.	--	--	7.1
No. 3.	Initial	7.7	1.04	2×10^{-4}	0.04	9.7	--	--	200
No. 4.	Initial	7.3	1.17	6×10^{-4}	0.09	9.4	N.A.	--	150
	Final	7.6	N.A.	6×10^{-4}	0.06	9.8	0.07	--	100
No. 5.	Final	Not Anal.	N.A.	0.01	0.063	N.A.	--	0.06	6.3

[b]Alloy compositions listed in Table 2.

[c]Very slight weight gain.

Any further study aimed at selecting materials of construction for multipurpose equipment such as that described here should consider not only newly developed alloys such as Carpenter 20SCb (3), HAPO 20 (ref 10), and Corronel 230, but also specially prepared heats of commercial alloys such as the vacuum-melted, low-carbon variation of Hastelloy F investigated by Maness.[9] Similar low-carbon variations of the high-cobalt alloys (e.g., Haynes 25, Haynes 21, S-816) would probably have good resistance to all the solutions considered in the study except the Sulfex dissolver solution.

Simulated fission products should also be included in solutions used in any future tests. Fission-product concentrations of zirconium, niobium, and the lanthanides should be effective complexing agents for the fluoride in the UO_2 core solution, thus decreasing its corrosivity. Fission-product ruthenium would probably act as a corrosion accelerator on ferrous and nickel alloys[11] and as an inhibitor on titanium.

5. ACKNOWLEDGMENT

The authors wish to express their indebtedness to B. L. Johnson, who assisted with the laboratory work.

6. REFERENCES

1. J. R. Flanary, W. E. Clark, J. H. Goode, and A. H. Kibbey, Development of the Sulfex Process for Decladding Stainless Steel-Clad Power Reactor Fuel Elements with Sulfuric Acid, ORNL-2461 (Mar. 13, 1959); see also L. M. Ferris and A. H. Kibbey, ORNL-2714.

2. J. L. Swanson, Dejacketing of Zircaloy-Clad Fuel Elements with Ammonium Fluoride Solutions: Interim Progress Report, HW-49633 (Apr. 15, 1957); see also L. M. Ferris, ORNL-2558; T. A. Gens, ORNL-2905; T. A. Gens and F. G. Baird, ORNL-2713; F. G. Kitts, ORNL-3465.

3. A. T. Gresky, Reactor Sci. Technol. 4 (2), pp 43-57, TID-2013 (June 1954); see also A. T. Gresky, ORNL-1367, -1431, -1518, and -1610; W. D. Bond, ORNL-2519.

4. F. G. Kitts and W. E. Clark, Darex Process: Processing of Stainless Steel-Containing Reactor Fuels with Dilute Aqua Regia, ORNL-2712 (May 23, 1962).

5. C. L. Peterson, P. D. Miller, J. D. Jackson, and F. W. Fink, Construction Materials for Various Head-End Processes for the Aqueous Reprocessing of Spent Fuel Elements, BMI-1375 (Aug. 28, 1959).

6. C. L. Peterson, P. D. Miller, E. L. White, and W. E. Clark, Ind. Eng. Chem. 51, 32-7 (1959); see also C. L. Peterson, et al., BMI-1242.

7. L. M. Ferris and A. H. Kibbey, Sulfex-Thorex and Darex-Thorex Processes for the Dissolution of Consolidated Edison Power Reactor Fuel: Laboratory Development, ORNL-2934 (Oct. 26, 1960); see also L. M. Ferris, ORNL-2822.

8. L. Rice and E. S. Snavely, ORNL, unpublished results, 1959-1961.

9. R. F. Maness, Power Reactor Fuels Reprocessing. Progr. Rept. on Corrosion Studies, HW-61662 (Aug. 26, 1959).

10. R. E. Burns, R. F. Maness, D. C. Drennan, and C. L. Peterson, Ind. Eng. Chem. Prod. Research and Development 2, 163-7 (1963); see also C. L. Peterson, et al., BMI-1459; R. F. Maness, HW-68426.

11. R. S. Greeley, ORNL, unpublished results.

ORNL-3787
UC-4 – Chemistry
TID-4500 (37th ed.)

INTERNAL DISTRIBUTION

1. Biology Library
2-4. Central Research Library
5. Reactor Division Library
6-7. ORNL – Y-12 Technical Library Document Reference Section
8-50. Laboratory Records Department
51. Laboratory Records, ORNL R.C.
52. R. E. Blanco
53. E. J. Breeding
54-55. W. E. Clark
56. F. L. Culler
57. J. L. English
58. D. E. Ferguson
59. D. N. Hess
60. C. E. Larson
61. H. G. MacPherson
62. E. C. Miller
63. R. L. Pilloton
64. L. Rice
65. M. J. Skinner
66. W. C. Thurber
67. A. M. Weinberg
68. P. H. Emmett (consultant)
69. J. J. Katz (consultant)
70. C. W. J. Wende (consultant)
71. C. E. Winters (consultant)

EXTERNAL DISTRIBUTION

72. E. L. Anderson, Atomic Energy Commission, Washington
73. O. T. Roth, Atomic Energy Commission, Washington
74. H. Schneider, Atomic Energy Commission, Washington
75. S. A. Lawroski, Argonne National Laboratory
76. R. C. Vogel, Argonne National Laboratory
77. R. E. Burns, Pacific Northwest Laboratory
78. A. M. Platt, Pacific Northwest Laboratory
79. M. T. Walling, Pacific Northwest Laboratory
80. C. H. Ice, Du Pont Company, Aiken
81. Research and Development Division, AEC, ORO
82-680. Given distribution as shown in TID-4500 (37th ed.) under Chemistry category (75 copies – CFSTI)