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FEATURES AND MECHANISMS OF THE CORROSION OF STEELS WITH BOILING—ETC(U)
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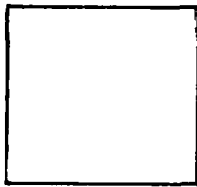


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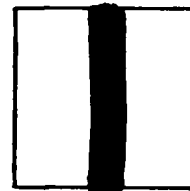
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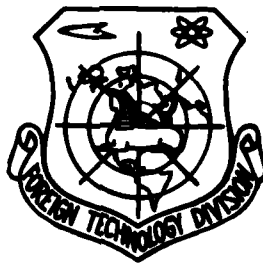
FOREIGN TECHNOLOGY DIVISION



FEATURES AND MECHANISMS OF THE CORROSION OF STEELS
WITH BOILING AND CONDENSATION OF N_2O_4

by

A. M. Sukhotin, N. Ya. Lantratova, et al.



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EDITED TRANSLATION

FTD-ID(RS)T-1907-79

4 December 1979

MICROFICHE NR: FTD-79-C-001564

CSP73279346

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English pages: 11

Source: Izvestiya Akademii Nauk BSSR, Seriya
Fizika-Energeticheskikh Nauk, Nr. 2, 1973,
pp. 127-131

Country of Origin: USSR

Translated by: John A. Miller

Requester: FTD/TQTA

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	<i>А а</i>	A, a	Р р	<i>Р р</i>	R, r
Б б	<i>Б б</i>	B, b	С с	<i>С с</i>	S, s
В в	<i>В в</i>	V, v	Т т	<i>Т т</i>	T, t
Г г	<i>Г г</i>	G, g	У у	<i>У у</i>	U, u
Д д	<i>Д д</i>	D, d	Ф ф	<i>Ф ф</i>	F, f
Е е	<i>Е е</i>	Ye, ye; E, e*	Х х	<i>Х х</i>	Kh, kh
Ж ж	<i>Ж ж</i>	Zh, zh	Ц ц	<i>Ц ц</i>	Ts, ts
З э	<i>З э</i>	Z, z	Ч ч	<i>Ч ч</i>	Ch, ch
И и	<i>И и</i>	I, i	Ш ш	<i>Ш ш</i>	Sh, sh
Й й	<i>Й й</i>	Y, y	Щ щ	<i>Щ щ</i>	Shch, shch
К к	<i>К к</i>	K, k	Ъ ъ	<i>Ъ ъ</i>	"
Л л	<i>Л л</i>	L, l	Ы ы	<i>Ы ы</i>	Y, y
М м	<i>М м</i>	M, m	Ь ь	<i>Ь ь</i>	'
Н н	<i>Н н</i>	N, n	Э э	<i>Э э</i>	E, e
О о	<i>О о</i>	O, o	Ю ю	<i>Ю ю</i>	Yu, yu
П п	<i>П п</i>	P, p	Я я	<i>Я я</i>	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ë in Russian, transliterate as yë or ë.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh
cos	cos	ch	cosh	arc ch	cosh
tg	tan	th	tanh	arc th	tanh
ctg	cot	cth	coth	arc cth	coth
sec	sec	sch	sech	arc sch	sech
cosec	csc	csch	csch	arc csch	csch

Russian English

rot curl
lg log

1907

FEATURES AND MECHANISMS OF THE CORROSION OF STEELS WITH BOILING AND
CONDENSATION OF N_2O_4

A. M. Sukhotin, N. Ya. Lantratova, S. A. Laterner, V. A. Matushkin,
R. Ye. Polyakova, and G. A. Sergeyeva

As already noted [1-5] a large number of stainless steels have high corrosion resistance in N_2O_4 coolant in the range of temperatures 350-700°C, under both static and flow conditions. The surfaces of these materials are, upon contact with nitric oxides, coated with dense oxide films, and a slight increase in weight is observed.

At 100°C under static conditions corrosion of stainless steels occurs with a weight loss, from 0.003 to 0.0005 g/m²·h.

However, under flow conditions in the boiling and condensation region there is observed a 10-fold increase in the rate of corrosion of stainless steels. Table 1 gives the results of tests with

specimens of steels for corrosion in the boiling and condensation region.

As seen in Table 1, the corrosion of steel Kh18N10T in the region of boiling occurs with a weight loss that varies within the limits $-(0.03-0.045)$ g/m²·h. In the condensation region the values of the corrosion rate are lower, $-(0.005-0.02)$ g/m²·h.

Figure 1 shows the corrosion rate of steels Kh18N10T and EI847 vs temperature distribution over the installation.

The tests were conducted on an installation for studying the corrosion stability of materials in a flow of nitrogen tetroxide, to some extent simulating the operation of an AES [nuclear power plant] circuit.

The temperature distribution over the installation corresponds approximately to that of the working circuit of an AES.

Along the ordinate in Fig. 1 is plotted the corrosion rate, g/m²·h, and along the abscissa - the temperature with functioning of the installation. As can be seen from the figure, maximum corrosion occurs in the boiling zone; in this temperature region (100-130°C) a weight loss is observed, whereas with an increase in the temperature

to approximately 200°C the weight loss is replaced by a significant increase in weight.

In the 350-500°C temperature range the rate of corrosion of stainless steels is insignificant, and increases anew only in the condensation region. In the boiling zone there is observed a significant difference in corrosion stability of steels Kh18N10T and EI847.

The corrosion rate of steel Kh18N10T is 0.045 g/m²·h, while that of steel EI847 is (0.4-0.6) g/m²·h, which is greater by at least a factor of 10. In the condensation region this difference is less, while in the high-temperature region the corrosion rates of both steels are approximately the same.

The assumption was made that the reason for the increased corrosion rate in the boiling and condensation region is the local increase in nitric-acid content. Since nitric acid is the least volatile component of the mixture, in the boiling and condensation region its content in the liquid phase can be noticeably higher than in the initial nitrogen tetroxide.

To check the validity of this assumption we conducted a series of experiments on the study of the corrosion of materials under

static conditions in nitrogen tetroxide containing varying quantities of water or HNO_3 at 130-170°C and a pressure of 40-80 atm.

As can be seen from Table 2, with an increase in water content in N_2O_4 , the corrosion rate of steel Kh18N10T at 150°C increases, whereas at 20 and 50°C the addition of such quantities of water led to a significant decrease in the corrosion rate. This confirms the correctness of our assumption.

Since the absolute values of the corrosion rate of steel Kh18N10T in N_2O_4 containing 0.7% H_2O are close to the corrosion rate of this steel in the boiling region under flow conditions, it was possible to consider that to some extent we were able, under static conditions, to reproduce the conditions occurring in the working circuit during boiling.

Figure 2 gives the comparative characteristics of the corrosion resistance of various brands of steels under static conditions at 150°C, 50 atm (tech) in N_2O_4 containing 0.7 wt.% H_2O . Similar data are given in Fig. 3 for the boiling region under N_2O_4 flow conditions.

As can be seen, steels EI654 and EI696M containing up to 3% Ti have somewhat better corrosion resistance as compared with steel

Kh18N10T.

Steel EI612 containing more Ni has lower resistance. Steels containing Mo, Ni, and Mn have even lower resistance.

Thus, under conditions of boiling and condensation, unlike in the high-temperature region, the corrosion resistance of steel is a function of its composition. Even small quantities of elements unstable in N_2O_4 significantly lower the corrosion resistance of materials.

Increased corrosion of stainless steels can also be observed in those parts of the installation where there is possible, as a result of periodic shutdowns, condensation of the coolant and its subsequent evaporation during heating. When conducting corrosion tests under static conditions we observed increased corrosion in the narrow gap of the upper part of the thermocouple recess and in the lower feed pipe. The rate of corrosion reached from 1 to 3.5 mm/year.

The temperature region of 180-350°C is interesting. Under static conditions at 350°C a slight weight gain is observed. Under coolant flow conditions, however, this weight gain reaches a significant magnitude. The surfaces of the specimens are coated with dark, dense, sometimes slightly rough, films. After removal of the films the

change in weight of the specimens was insignificant. The corrosion rate in this region, calculated from the weight loss, is shown in Fig. 1, curve 2.

Thus the weight gain in this case is caused primarily by deposition, on the surfaces of the steel, of corrosion products entrained by the flow of coolant from the boiling region. Such a picture is observed only for this temperature region.

We observed an analogous picture on one of the sections of the testing unit. When studying the corrosion resistance of materials in a flow, we cut from the stand a section of pipe which was critically analyzed at 300-350°C for 4000 h and subjected to jet impact.

When studying the microstructure we found that on the wall of the pipe subjected to jet impact there was a thick film whose thickness gradually decreased. In addition, there was erosion destruction of the metal. The opposite wall of the pipe remained visibly unchanged.

To trace the distribution of the deposits, small glass tubes were placed together with metal specimens in various parts of the installation for corrosion testing in N_2O_4 flow. On these tubes in the temperature range of 50-130°C we observed a slight oily deposit;

in the temperature region of 200-300°C, however, a thick dark film formed. The glass tubes in the 400-500°C region remained clean.

Studies conducted by us previously showed that complex salts form during the corrosion of stainless steel in liquid N_2O_4 . These salts, getting into the high-temperature region and being thermally unstable, are converted into oxides which apparently are deposited on the metal in the form of comparatively dense thick films.

This process can be facilitated by the fact that one of the basic products of the corrosion of steels, viz., nitrosonium tetranitroferrate, is volatile.

Leningrad Institute of Applied Chemistry

Received 10 January 1973

REFERENCES

1. Сухотин А. М., Ландратова Н. Я., Герасимова В. А. Вестн АН БССР, сер. физ.-энерг. наук, № 2, 1968.
2. Сухотин А. М., Ландратова Н. Я., Матушкин В. А., Полякова Р. Е., Латернер С. А. Диссоциирующие газы как теплоносители и рабочие тела энергетических установок. Минск, 1971, стр. 122.
3. Сухотин А. М., Ландратова Н. Я. Вестн АН БССР, сер. физ.-энерг. наук, № 2, 1971.
4. Коррозия и защита химической аппаратуры. Справочное руководство под редакцией доктора хим. наук проф. А. М. Сухотина, т. 3. Л., 1970, стр. 209.
5. Сухотин А. М., Ландратова Н. Я. Коррозия конструкционных материалов в среде N_2O_4 , глава книги «Термодинамические и переносные свойства химически реагирующих газовых систем», ч. II, под редакцией академика АН БССР А. К. Красина и доктора техн. наук В. Б. Нестеренко, Минск, 1971.

Table 1. Corrosion resistance of structural materials under conditions of N_2O_4 coolant flow ($V = 10-30$ m/s; $P = 20-25$ atm (tech); $\tau = 360$ h).

1 Температура, °C	2 Скорость коррозии, г/м ² ·час		3 Примечание
	4 Kh18N10T	5 ЭИ847	
30—40	—0,001	—0,002	
100	—0,045	—0,420	кипение 6
250—300	—0,017	—0,011	
550	—0,006	—0,001	
100	—0,020	—0,045	конденсация 7
130—150	—0,040	—0,60	
190—220	0,040	—0,036	кипение 6
300—340	0,030	—0,020	
500—510	0,001	—0,001	
180—200	—0,005	—	
45	—0,001	—	
105	—0,031	—0,410	кипение 6
245	0,021	—0,028	
120—160	—0,001	—0,008	
100	—0,006	—0,017	конденсация 7

Key: 1 - Temperature, °C; 2 - Corrosion rate, g/m²·h; 3 - Remarks; 4 - Kh18N10T; 5 - EI847; 6 - boiling; 7 - condensation.

Table 2. Corrosion rate of steel Kh18N10T vs H₂O and HNO₃ content in N₂O₄ (τ = 360 h).

1 Содержание примесей в N ₂ O ₄ , вес. %		2 Температура, °C	3 Давление, ат	4 Скорость коррозии, г/м ² ·час	
H ₂ O	HNO ₃			5 жидкая фаза	6 газовая фаза
Исходная 7 0,11—0,15 0,32 0,66—0,7	N ₂ O ₄	145—160	86—40	0,002—0,009	0,001—0,013
		135—155	78—32	0,005—0,008	0,008—0,017
		145—150	76—52	0,038	0,009
		130—170	77—38	0,022—0,099	0,010—0,068
		150—155	65—52	0,260	0,127
	5,28				

Key: 1 - Content of impurities in N₂O₄, wt. %; 2 - Temperature, °C; 3 - Pressure, atm(tech); 4 - Corrosion rate, g/m²·h; 5 - liquid phase; 6 - gaseous phase; 7 - Starting.

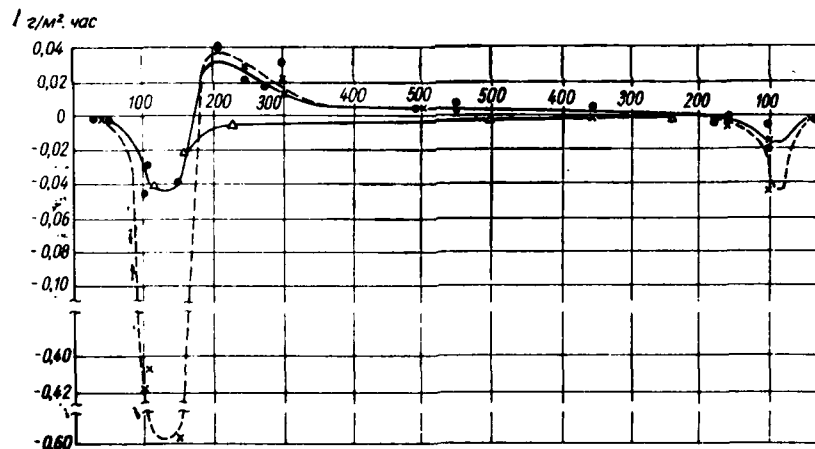


Fig. 1. Corrosion rate of steels Kh18N10T and EI847 in various temperature regions of the installation: solid lines - Kh18N10T; dashed lines - EI847.

Key: 1 - g/m²·h.

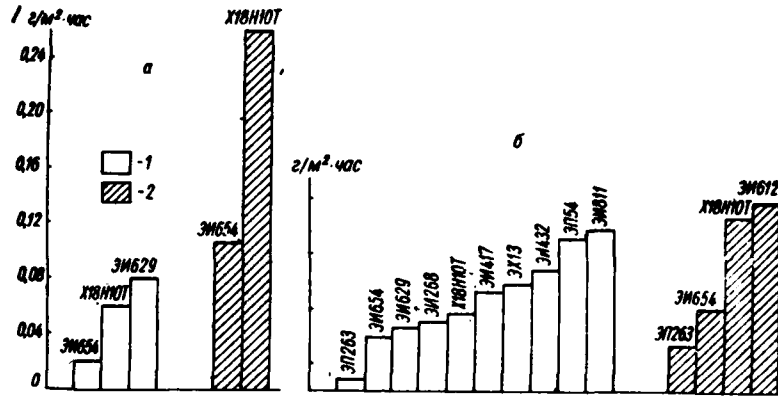


Fig. 2. Corrosion rate of structural materials in N₂O₄, with additions of H₂O or HNO₃ under static conditions (t = 150 ± 10°C, τ = 360 h): a - liquid phase, b - gaseous phase; 1 - N₂O₄ + 0.7 wt. % H₂O; 2 - N₂O₄ + 5% HNO₃.

Key: 1 - g/m²·h.

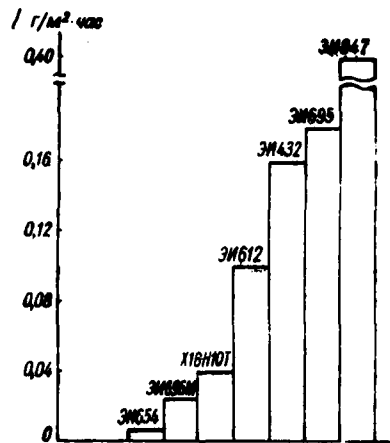


Fig. 3. Corrosion resistance of structural materials in flow of N₂O₄ in the boiling region (V = 10-30 m/s, P = 20-25 atm (tech), τ = 360

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h).

Key: 1 - $\text{g/m}^2 \cdot \text{h}$.

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