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DETERMINATION OF WATER REMOVABILITY
OF RUST PREVENTIVE COMPOUNDS

EVALUATION REPORT

NETL PROJECT A-331
SRO07-08-C4
SUBTASK 0614

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by
J. A. MC KELVEY

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NAVAL BOILER AND TURBINE LABORATORY
PHILADELPHIA NAVAL SHIPYARD
PHILADELPHIA 12, PENNA.

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APPROVAL INFORMATION

Submitted by:

S. Greenberg
S. Greenberg
Head, Chemistry Branch

J. W. Murdock
J. W. Murdock
Associate Technical Director
for Applied Physics

Approved by:

P. W. Johnson, Jr.
P. W. Johnson, Jr.,
Commander, USN
Acting Director

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Table 4 - Effect of "dynamic" steam (15 psig) on rust preventive removal

SUMMARY PAGE

The Problem

To determine whether Grade 3 corrosion preventive compounds can be successfully removed by either hot water (170-180 F) or low pressure (15 psig) steam. These compounds are used to protect metal surfaces during prolonged storage periods under normal atmospheric conditions. Removal by hot water and/or low pressure steam is desirable since much of the equipment preserved by these compounds cannot be cleaned using regular "boil-out" procedures.

Findings

None of the preservative evaluated were completely removed by either hot water or low pressure steam (dynamic or static). Dynamic low pressure steam was the most effective means of removal; hot water was slightly less effective; static steam was the least effective. Preservatives with the highest percent removal were "Cosmoline 1091," uncut, 2 coats and "MS 3763," cutback 3:1 preservative to solvent ratio, using dynamic (15 psig) steam; "Tectyl 5-11M," uncut, 2 coats, employing hot water; again "Cosmoline 1091," uncut, 2 coats using static steam (Autoclave, 15 psig). Preservatives with the lowest percent removal were "Cosmoline 1046" uncut, 1 coat, using dynamic steam; "Gulf No Rust D," uncut, 1 coat, employing hot water; "Cosmoline 1091" cutback 1:1 preservative to solvent ratio using static steam (Autoclave, 15psig). Evaluating preservative removability on the more realistic "weight per unit area of preservative remaining on tube surfaces" showed that, generally, "Tectyl 5-11M" and "Tectyl 8/8" were the preservatives with the least amounts remaining after the various treatments. In most cases "Gulf No rust D" and "NOKOROLE" had the largest amounts remaining.

on the weight per unit area basis. Inadequate corrosion protection was afforded by three compounds that had been solvent cutback at a 1:1 ratio since corrosion was found under the "preserved" surface of the tubes. The three compounds were as follows: "WS-3673," "Cosmoline 1091" and "Nox-Rust 208."

Recommendations

It is recommended that:

a. None of the preservatives evaluated be accepted if complete removal of the Grade 3 compounds by hot water or low pressure steam is required.

b. If less than complete removal is acceptable, "Tectyl 5-111A" and "Tectyl 848" were in most cases the best preservatives evaluated based on weight per unit area of compound remaining on tube surfaces after hot water or low pressure steam treatment.

NBTL PROJECT A-331

ADMINISTRATIVE INFORMATION

The project dealing with rust preventive compound removability by hot water or low pressure steam was authorized by BUSHIPS letter R007-08-04 Ser. 634A-127 of 22 June 1960.

The cost of the project was charged to Allotment 10176/16/RD1&E. The Navy Index Number is S-R 007-08-04. Subtask 0614.

REPORT OF INVESTIGATION

Introduction

The original specifications for rust preventive compounds MIL-C-972 (SHIPS) and 32-c-16 required that residual films of Grade 3 solvent cutback rust preventive compounds be removed by hot water (170 F). However, service difficulty was experienced in completely removing the preservatives from boiler watersides. Apparently, prolonged storage had increased the resistance of the compounds to removal by hot water. Since even minute amounts of these preservatives remaining on boiler tube waterside surfaces are a potential means for hot spots to develop, boiler tube failures could occur. Therefore, complete removal of these compounds from boiler watersides is required. Accordingly, a boiling out procedure to satisfy these conditions was developed and has been incorporated in Chapter 9 of the Bureau of Ships Manual. Originally it was felt that this boiling out procedure eliminated the need for a hot water removal requirement for the Grade 3 preservatives. However, high and low pressure steam turbines cannot be subjected to this type of boiling out. Thus, the Naval Engineering Experiment Station was authorized to, "develop rust preventive compounds which would give adequate protection to metals stored under normal atmospheric conditions but would be removable with hot water or low pressure steam." The Bureau of Ships further requested the Station to include "Tectyl 511M." produced by Valvoline Oil Company, with the preservatives to be evaluated. Hot water removal of this preservative was reported to be satisfactory by the Newport News Shipbuilding and Drydock Company.

In complying with the directive issued by the Bureau of Ships, the Engineering Experiment Station obtained 2" I.P. low carbon steel boiler

tubing from stock under No. G-4710-277-4561. A total of ninety-six tubes, 5" in length, were cut from this material. Coatings were applied to these tubes in the following concentrations:

Preservative only	- 2 coats
Preservative only	1 coat
Three parts preservative to 1 part cutback	- 1 coat
One part preservative to one part cutback	- 1 coat

Before the coatings were applied, the tube specimens were solvent degreased and thoroughly dried. To obtain duplicate coatings, each preservative formulation was applied to two separate tubes. The tubes were immersed for one minute and allowed to drain for seventy-two hours before storing. Tubes that received two coats were given the second application after the seventy-two hour drain period. All the treated tubes were stored for six months under normal atmospheric conditions before being shipped to the Laboratory for removability evaluations. Descriptive data, furnished by the Engineering Experiment Station, on the manufacturer, ratio of preservative to cutback, number of coatings applied, and tube identification numbers are given in Table 1.

Analytical Methods and Cleaning Procedures

Analytical Methods

Quantitative procedures were employed as a means of obtaining more realistic data on the amount of preservative removed from the individual tubes. Some difficulty was experienced because the tubes were coated on the outside as well as on the inside and had been packed contiguously before shipment to the Laboratory. Thus, some of the preservative coatings were transferred to adjoining tubes. This necessitated wiping

the outer surface of each tube to insure, as far as practical, that only the original preservative remained on the tube. The original 6" tube sections were cut on a lathe into three parts to permit accurate weighings with an analytical balance. The amount of preservative removed was determined from the difference in tube weights before and after treatment with hot water or steam. Comparison of the weight of a treated tube specimen before and after washing in benzol yielded the weight of unremoved preservative after treatment with hot water or steam.

Procedure for Preservative Removal by Hot Water

The "coated" tube specimens were weighed on an analytical balance and placed in 250 ml. beakers containing glass triangles which prevented the test specimens from touching the bottoms of the beakers. Enough distilled water (200 mls.) was poured into the beakers to insure complete coverage of the tube specimens. These beakers were placed in a water bath. The temperature in the beakers was maintained between 170 and 180 F. Cover glasses, placed on top of the beakers, served to minimize water loss through evaporation. After seven hours, the tubes were removed from the beakers and flushed with hot water to wash off any "loose" compound clinging to the tube surfaces. The droplets of water remaining on tube surfaces were shaken off and the tubes placed in a circulating oven (200 F.) for about five minutes to remove the last traces of moisture. These tubes were cooled in a desiccator and weighed on an analytical balance. Preservative remaining on the test specimens was removed by immersing the tubes individually in three separate beakers of benzol followed by a final rinse in acetone. Specimens were reweighed and the weight difference between the tube

after hot water treatment and its weight following the benzol-acetone rinse was taken as the amount of preservative unremoved by hot water.

Procedure for Removal by Low Pressure (15 psig) Static Steam

The preserved specimens were weighed on an analytical balance and suspended in the vapor section of an autoclave. About four inches of water, enough to cover the heating elements, was placed in the bottom of the autoclave. Steam pressure was maintained at 15 psig for a period of seven hours. At the end of this period, specimens were removed and flushed with hot water to remove any "loose" compound remaining on the tube surfaces. The amount of removed and unremoved preservative was determined in the manner described under the procedure for preservative removal by hot water.

Procedure for Removal by Low Pressure (15 psig) Dynamic Steam

It was necessary to fabricate a "steam chamber" for this evaluation. An 18" section of 4" I.D. pipe was flanged to provide access for inserting and removing the specimens. A 6" section of 3/4" I.D. pipe was welded to each flange for inlet and outlet steam. Pressure gauges were installed at the steam inlet and at the center of the "chamber." A valve was installed at the steam outlet to provide a means for throttling steam flow. A sketch of this set-up is shown in Figure 1.

After weighing, the tubes to be evaluated were placed on a thin rod and suspended in the "steam chamber" about 12" apart in a manner that placed them in a direct path of the flowing steam. To ensure that the steam fully enveloped the preserved surfaces, only two tubes were suspended in the "chamber" at one time. Low pressure steam (15 psig)

was maintained in the "chamber." The specimens were exposed to this dynamic steam for seven hours. Upon removal from the "steam chamber," the specimens were flushed in hot water. The amount of preservative removed and unremoved was determined by the method described above for the hot water evaluation.

Results and Discussion

Data obtained on the effects of hot water as well as static and dynamic low pressure (15 psig) steam on Grade 3 preservative removal from boiler tube surfaces are presented in Tables 2 to 4, inclusive. These tubes had been stored under atmospheric conditions for at least six months but not longer than ten months. Results show that the preservatives were not completely removed from the boiler tube surfaces by any of the three methods employed. Generally, the degree of removal was higher with "dynamic" low pressure steam, slightly less with hot water, and least with "static" steam. Evaluating preservative removability on a percentage basis showed the following:

a. Removal by hot water (170 - 180 F), see table 2 - "Tectyl 5-11M", uncut, two coats applied, had the best removability characteristics of any of the preservatives evaluated. An average of two determinations showed that 87% was removed by hot water. "Gulf No Rust D", uncut, one coat, had the least amount removed by hot water (32%).

b. Removal by low pressure "static" steam (autoclave, 15 psig), see table 3 - "Cosmoline 1091", uncut, 2 coats applied, had the largest percentage removal of any of the preservatives evaluated by this method. An average of two determinations showed 73% removal. When "Cosmoline 1091" was solvent cutback at a 1:1 ratio, an average of 9% was removed, the lowest percentage removal of any of the preservative formulations evaluated.

c. Removal by "dynamic" steam (15 psig), see table 4 -
 "Cosmoline 1091," uncut, two coats applied, and "KS-3673," 3:1 preservative to cutback ratio, 1 coat applied, had the best removability characteristics by this method. Approximately 90% of these preservatives were removed by the "flowing" steam. "Cosmoline 1046," uncut, one coat applied, had the least amount removed (38%).

Evaluating preservative removability on the weight remaining per unit area of tube surface showed the following:

a. Hot water removal (170-180 F), see table 2 - "Tectyl 5-11M" and "Tectyl 848" left the smallest amounts remaining on tube surfaces. Generally, Gulf No Rust D" and "NOKORODE 733A" left the largest amounts. Slightly more "Tectyl 894" and "NoxRust 208" remained than "NOKORODE 733A" when the preservatives cutback at a 1:1 ratio were evaluated.

b. Low pressure "static" steam (Autoclave, 15 psig), see table 3 -
 Generally, "Tectyl 5-11M" and "Tectyl 848" had the least amounts remaining on tube surfaces after treatment. Less "Clarke 4000" remained than "Tectyl 848" when the preservatives were cutback at a 1:1 ratio. "Gulf No Rust D" and "NOKORODE 733A", both uncut, left the largest amounts remaining.

c. Low pressure "dynamic" steam (15 psig), see table 4 - Generally, "Tectyl 848" left the least amount on the tube surfaces after treatment. "Tectyl 5-11M" left a smaller amount on the tube surface after treatment when the uncut, one application preserved tubes were evaluated. On two coat preservative applications, "Tectyl 894" "Gulf No Rust D" and "NOKORODE 733A" left the largest amounts remaining; on one coat applications, "Gulf No Rust D" and "Cosmoline 1046" left the greater amounts; with three part preservative to 1 part solvent applications,

"NOKORODE 733A" and "Gulf No Rust D" had the largest amounts remaining; for the 1:1 ratio of solvent to preservative applications, "Cosmoline 1046" and "PETROTECT 3" left the greater amounts.

Evaluating preservative removability on a percentage basis can be misleading. For example: Static steam pressure removed 59% of "Cosmoline 1091", one coat, uncut, and only 9% of the same preservative cutback at a 1:1 ratio. However, examination of the data shown in table 3, sheet 1, reveals that actually more preservative remained on the tube (0.47 grams per square foot) after 59% was removed than on the tube (0.43 grams per square foot) with only 9% removal. Using the more realistic weight per unit area of preservative remaining on tube surfaces after treatment showed that, in general, "Tectyl 5-11M" and "Tectyl 848" left the smallest amounts remaining; in most cases "Gulf No Rust D" and "NOKORODE 733A" left the largest amounts on tube surfaces after treatment.

Three boiler tubes preserved with compounds that were solvent cutback at a 1:1 ratio, were found to have been inadequately protected. Corrosion was noted on the inner surfaces of the tubes after the preservatives were removed. The three rust preventive compounds employed to preserve these tubes were as follows: "RS-3673," (after hot water removal), "Cosmoline 1091" and "Nox-Rust 208", (both after dynamic steam removal). Since "static" steam was found to be a poor means for preservative removal, no attempt was made to examine the inner surfaces of the tubes for corrosion.

Conclusions

It is concluded that:

- a. None of the Grade 3 rust preventive compounds evaluated, under

the conditions described, can be completely removed by hot water (170-180F) or low pressure "wet" steam ("static" or "dynamic").

b. "Tectyl 5-11M" and "Tectyl 848", in most cases, would leave the least weight per unit area of preservative on tube surfaces after exposure to hot water or steam.

c. Generally, "Gulf No Rust D" and "NOKORODE 733-A" would leave the greatest weight per unit area of preservative on tube surfaces after exposure to hot water or steam.

d. Some Grade 3 compounds ("S-3673", "Cosmoline 1091", and "Nox-Rust D") when cut back at a 1:1 ratio would not afford proper protection to preserved surfaces.

e. Evaluating removability on a weight per unit area of preservative remaining on tube surfaces after treatment is more practical than determining the percent rust preventive removed by the treatment.

f. Dynamic low pressure (15 psig) "wet" steam is slightly more effective than hot water (170-180 F) for removing Grade 3 rust preventives from metal surfaces after prolonged storage.

g. Static low pressure steam is the least effective means of removing these Grade 3 preservatives.

Recommendations

It is recommended that:

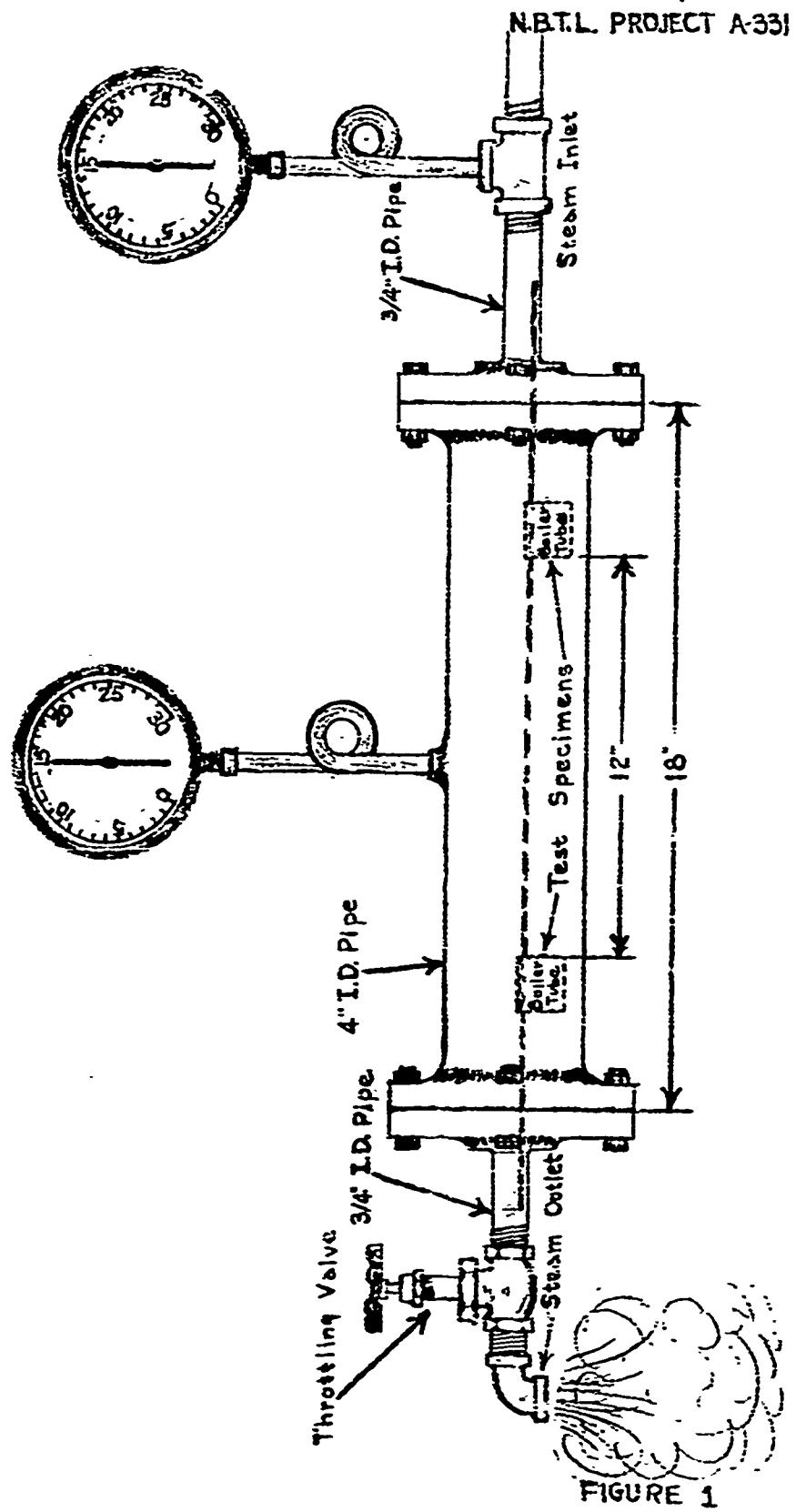
a. None of the preservatives evaluated be accepted if complete removal of the Grade 3 compounds by hot water or low pressure steam is required.

b. If less than complete removal is acceptable, "Tectyl 511M" and "Tectyl 848" were in most cases the best preservatives evaluated based

on weight per unit area of compound remaining on tube surfaces after hot water or low pressure steam treatment.

c. The boiling out procedure described in Chapter 9 of the Bureau of Ships Manual is better than hot water or low pressure steam for removal of Grade 3 preservatives from boiler watersides.

PIPING ARRANGEMENT FOR PRESERVATIVE REMOVAL
(FLOWING 15 PSIG STEAM)



Key to Coatings on Boiler Tube Sections

No.	Material	Material to		No.	Material	Material to	
		Solvent	Coats			Solvent	Coats
		Ratio				Ratio	
101	"Tectyl 5-11W"	1:0	2	141	"Tectyl 894"	1:0	2
102	Valvoline Oil	1:0	2	142	Valvoline	1:0	2
103	Company	1:0	1	143	Oil Company	1:0	1
104		1:0	1	144		1:0	1
105	(1)	3:1	1	145	(2)	3:1	1
106		3:1	1	146		3:1	1
107		1:1	1	147		1:1	1
108		1:1	1	148		1:1	1
109	"Cosmoline 1091"	1:0	2	149	"Tectyl S48"	1:0	2
110	E.F. Houghton &	1:0	2	150	Valvoline Oil	1:0	2
111	Company	1:0	1	151	Company	1:0	1
112		1:0	1	152		1:0	1
113	(2)	3:1	1	153	(1)	3:1	1
114		3:1	1	154		3:1	1
115		1:1	1	155		1:1	1
116		1:1	1	156		1:1	1
117	"Cosmoline 1046"	1:0	2	157	"Shell Gold	1:0	2
118	E.F. Houghton &	1:0	2	158	Application CP	1:0	2
119	Company	1:0	1	159	Compound	1:0	1
120		1:0	1	160	Code 73 579,"	1:0	1
121	(1)	3:1	1	161	Shell Oil Co.	3:1	1
122		3:1	1	162		3:1	1
123		1:1	1	163	(2)	1:1	1
124		1:1	1	164		1:1	1
125	"Nox-Rust 208"	1:0	2	165	"MS-3673"	1:0	2
126	Daubert Chemical	1:0	2	166	Esso Standard	1:0	2
127	Company	1:0	1	167	Oil Company	1:0	1
128		1:0	1	168		1:0	1
129	(2)	3:1	1	169	(3)	3:1	1
130		3:1	1	170		3:1	1
131		1:1	1	171		1:1	1
132		1:1	1	172		1:1	1
133	"NOKORODE 733A"	1:0	2	173	"Petrotect 3"	1:0	2
134	Lion Oil Company	1:0	1	174	Pennsylvania	1:0	2
135		1:0	1	175	Refining Co.	1:0	1
136		1:0	1	176		1:0	1
137	(2)	3:1	1	177	(2)	3:0	1
138		3:1	1	178		3:0	1
139		1:1	1	179		1:1	1
140		1:1	1	180		1:1	1

Key to Coatings on Boiler Tube Sections

No.	Material	Material to		No.	Material	Material to	
		Solvent	Ratio			Solvent	Ratio
181	"Clarke 4000"	1:0	2	189	"Gulf No-Rust	1:0	2
182	Clarkson	1:0	2	190	D; Gulf Oil	1:0	2
183	Laboratories	1:0	1	191	Corp.	1:0	1
184		1:0	1	192		1:0	1
185	(2)	3:1	1	193	(2)	3:0	1
186		3:1	1	194		3:0	1
187		1:1	1	195		1:1	1
188		1:1	1	196		1:1	1

(1) Proprietary product supplied by manufacturer.

(2) Material qualified under MIL-C-16173B as Grade 3 corrosion preventive.

(3) Product under test when tubes were coated.

EFFECT OF HOT WATER (170-180F) ON RUST PREVENTIVE REMOVAL

Company Name	E.S. Ident. No.	Dilution Ratio - Preservative to Cutback	No. of Coats Applied	Wt. of Preservative on Tube Specimens - gms/ft ²	Wt. of Preservative Removed - gms/ft ²	Wt. of Preservative Unremoved - gms/ft ²	Preservative Removed - %
<u>Valvoline Oil Company - "Testyl 2-11M"</u>	<u>103</u>	<u>1:0</u>	<u>1</u>	<u>1:0</u>	<u>1</u>	<u>1:0</u>	<u>1</u>
	101	1:0	1	1:0	1	1:0	1
	102	1:0	1	1:0	1	1:0	1
	104	1:0	1	1:0	1	1:0	1
	105	3:1	1	1:1	1	1:1	1
	106	1:0	1	1:0	1	1:0	1
	107	1:1	1	1:1	1	1:1	1
	108	1:0	1	1:0	1	1:0	1
	109	1:0	1	1:0	1	1:0	1
	110	1:0	1	1:0	1	1:0	1
	111	1:0	1	1:0	1	1:0	1
	112	1:0	1	1:0	1	1:0	1
	113	3:1	1	1:1	1	1:1	1
	114	1:0	1	1:0	1	1:0	1
	115	1:1	1	1:1	1	1:1	1
	116	1:0	1	1:0	1	1:0	1
	117	1:0	1	1:0	1	1:0	1
	118	1:0	1	1:0	1	1:0	1
	119	1:0	1	1:0	1	1:0	1
	120	1:0	1	1:0	1	1:0	1
	121	3:1	1	1:1	1	1:1	1
	122	1:0	1	1:0	1	1:0	1
	123	1:1	1	1:1	1	1:1	1
	124	1:0	1	1:0	1	1:0	1
	125	1:0	1	1:0	1	1:0	1
	126	1:0	1	1:0	1	1:0	1
	127	1:0	1	1:0	1	1:0	1
	128	1:0	1	1:0	1	1:0	1
	129	3:1	1	1:1	1	1:1	1
	130	1:0	1	1:0	1	1:0	1
	131	1:1	1	1:1	1	1:1	1
	132	1:0	1	1:0	1	1:0	1
	133	1:0	1	1:0	1	1:0	1
	134	1:0	1	1:0	1	1:0	1
	135	1:0	1	1:0	1	1:0	1
	136	1:0	1	1:0	1	1:0	1
	137	1:0	1	1:0	1	1:0	1
	138	1:0	1	1:0	1	1:0	1
	139	1:0	1	1:0	1	1:0	1
	140	1:0	1	1:0	1	1:0	1
	141	1:0	1	1:0	1	1:0	1
	142	1:0	1	1:0	1	1:0	1
	143	1:0	1	1:0	1	1:0	1
	144	1:0	1	1:0	1	1:0	1
	145	1:0	1	1:0	1	1:0	1
	146	1:0	1	1:0	1	1:0	1
	147	1:0	1	1:0	1	1:0	1
	148	1:0	1	1:0	1	1:0	1
	149	1:0	1	1:0	1	1:0	1
	150	1:0	1	1:0	1	1:0	1
	151	1:0	1	1:0	1	1:0	1
	152	1:0	1	1:0	1	1:0	1
	153	1:0	1	1:0	1	1:0	1
	154	1:0	1	1:0	1	1:0	1
	155	1:0	1	1:0	1	1:0	1
	156	1:0	1	1:0	1	1:0	1
	157	1:0	1	1:0	1	1:0	1
	158	1:0	1	1:0	1	1:0	1
	159	1:0	1	1:0	1	1:0	1
	160	1:0	1	1:0	1	1:0	1
	161	1:0	1	1:0	1	1:0	1
	162	1:0	1	1:0	1	1:0	1
	163	1:0	1	1:0	1	1:0	1
	164	1:0	1	1:0	1	1:0	1
	165	1:0	1	1:0	1	1:0	1
	166	1:0	1	1:0	1	1:0	1
	167	1:0	1	1:0	1	1:0	1
	168	1:0	1	1:0	1	1:0	1
	169	1:0	1	1:0	1	1:0	1
	170	1:0	1	1:0	1	1:0	1
	171	1:0	1	1:0	1	1:0	1
	172	1:0	1	1:0	1	1:0	1
	173	1:0	1	1:0	1	1:0	1
	174	1:0	1	1:0	1	1:0	1
	175	1:0	1	1:0	1	1:0	1
	176	1:0	1	1:0	1	1:0	1
	177	1:0	1	1:0	1	1:0	1
	178	1:0	1	1:0	1	1:0	1
	179	1:0	1	1:0	1	1:0	1
	180	1:0	1	1:0	1	1:0	1
	181	1:0	1	1:0	1	1:0	1
	182	1:0	1	1:0	1	1:0	1
	183	1:0	1	1:0	1	1:0	1
	184	1:0	1	1:0	1	1:0	1
	185	1:0	1	1:0	1	1:0	1
	186	1:0	1	1:0	1	1:0	1
	187	1:0	1	1:0	1	1:0	1
	188	1:0	1	1:0	1	1:0	1
	189	1:0	1	1:0	1	1:0	1
	190	1:0	1	1:0	1	1:0	1
	191	1:0	1	1:0	1	1:0	1
	192	1:0	1	1:0	1	1:0	1
	193	1:0	1	1:0	1	1:0	1
	194	1:0	1	1:0	1	1:0	1
	195	1:0	1	1:0	1	1:0	1
	196	1:0	1	1:0	1	1:0	1
	197	1:0	1	1:0	1	1:0	1
	198	1:0	1	1:0	1	1:0	1
	199	1:0	1	1:0	1	1:0	1
	200	1:0	1	1:0	1	1:0	1
	201	1:0	1	1:0	1	1:0	1
	202	1:0	1	1:0	1	1:0	1
	203	1:0	1	1:0	1	1:0	1
	204	1:0	1	1:0	1	1:0	1
	205	1:0	1	1:0	1	1:0	1
	206	1:0	1	1:0	1	1:0	1
	207	1:0	1	1:0	1	1:0	1
	208	1:0	1	1:0	1	1:0	1
	209	1:0	1	1:0	1	1:0	1
	210	1:0	1	1:0	1	1:0	1
	211	1:0	1	1:0	1	1:0	1
	212	1:0	1	1:0	1	1:0	1
	213	1:0	1	1:0	1	1:0	1
	214	1:0	1	1:0	1	1:0	1
	215	1:0	1	1:0	1	1:0	1
	216	1:0	1	1:0	1	1:0	1
	217	1:0	1	1:0	1	1:0	1
	218	1:0	1	1:0	1	1:0	1
	219	1:0	1	1:0	1	1:0	1
	220	1:0	1	1:0	1	1:0	1
	221	1:0	1	1:0	1	1:0	1
	222	1:0	1	1:0	1	1:0	1
	223	1:0	1	1:0	1	1:0	1
	224	1:0	1	1:0	1	1:0	1
	225	1:0	1	1:0	1	1:0	1
	226	1:0	1	1:0	1	1:0	1
	227	1:0	1	1:0	1	1:0	1
	228	1:0	1	1:0	1	1:0	1
	229	1:0	1	1:0	1	1:0	1
	230	1:0	1	1:0	1	1:0	1
	231	1:0	1	1:0	1	1:0	1
	232	1:0	1	1:0	1	1:0	1
	233	1:0	1	1:0	1	1:0	1
	234	1:0	1	1:0	1	1:0	1
	235	1:0	1	1:0	1	1:0	1
	236	1:0	1	1:0	1	1:0	1
	237	1:0	1	1:0	1	1:0	1
	238	1:0	1	1:0	1	1:0	1
	239	1:0	1	1:0	1	1:0	1
	240	1:0	1	1:0	1	1:0	1
	241	1:0	1	1:0	1	1:0	1
	242	1:0	1	1:0	1	1:0	1
	243	1:0	1	1:0	1	1:0	1
	244	1:0	1	1:0	1	1:0	1
	245	1:0	1	1:0	1	1:0	1
	246	1:0	1	1:0	1	1:0	1
	247	1:0	1	1:0	1	1:0	1
	248	1:0	1	1:0	1	1:0	1
	249	1:0	1	1:0	1	1:0	1
	250	1:0	1	1:0	1	1:0	1
	251	1:0	1	1:0	1	1:0	1
	252	1:0	1	1:0	1	1:0	1
	253	1:0	1	1:0	1	1:0	1
	254	1:0	1	1:0	1	1:0	1
	255	1:0	1	1:0	1	1:0	1
	256	1:0	1	1:0	1	1:0	1
	257	1:0	1	1:0	1	1:0	1
	258	1:0	1	1:0	1	1:0	1
	259	1:0	1	1:0	1	1:0	1
	260	1:0	1	1:0	1	1:0	1
	261	1:0	1	1:0	1	1:0	1
	262	1:0	1	1:0	1	1:0	1
	263	1:0	1	1:0	1	1:0	1
	264	1:0	1	1:0	1	1:0	1
	265	1:0	1	1:0	1	1:0	1
	266	1:0	1	1:0	1	1:0	1
	267	1:0	1	1:0	1	1:0	1
	268	1:0	1	1:0	1	1:0	1
	269	1:0	1	1:0	1	1:0	1
	270	1:0	1	1:0	1	1:0	1
	271	1:0	1	1:0	1	1:0	1
	272	1:0	1	1:0	1	1:0	1
	273	1:0	1	1:0	1	1:0	1
	274	1:0	1	1:0	1	1:0	1
	275	1:0	1	1:0	1	1:0	1
	276						

EFFECT OF HOT WATER (170-180F) ON RUST PREVENTATIVE REMOVAL

Company Name	Clarkson Laboratories - "Clarke 4000"		Gulf Oil Corporation "Gulf No-Rust D"													
E.S. Ident. No.	183	185	187	189	191	193	195									
Dilution Ratio - Preservative to Cutback	1:0	1:0	3:1	1:1	1:0	3:1	1:1									
No. of Coats Applied	2	1	1	1	1	1	1									
Wt. of Preservative on Tubg Specimens - gms/ft ²	1.031	0.788	0.570	0.843	0.474	0.389	0.212	0.223	2.450	2.774	1.669	1.779	0.938	1.203	0.554	0.856
Wt. of Preservative Removed - gms/ft ²	0.432	0.384	0.299	0.350	0.301	0.252	0.117	0.150	1.262	1.055	0.512	0.580	0.372	0.600	0.193	0.374
Wt. of Preservative Unremoved - gms/ft ²	0.599	0.404	0.271	0.493	0.173	0.137	0.095	0.073	1.188	1.719	1.157	1.199	0.566	0.503	0.361	0.432
Preservative Removed - %	44	49	52	42	64	65	55	67	52	38	31	33	40	50	35	43
Preservative Unremoved - %	56	51	48	58	36	35	45	33	48	62	69	67	60	50	65	57

Table 2, Sheet 4

EFFECT OF "STATIC" STEAM (AUTOCLAVE - 15 PSIG) ON RUST PREVENTIVE REMOVAL

Company Name, E.E.S. Ident. No., Dilution Ratio - Pre- servative to Outback No. of Coats Applied Wt. of Preservative on tube Specimens - gms/ft ² Wt. of Preservative Removed - gms/ft ² Wt. of Preservative Unremoved - gms/ft ² Preservative Re- moved - % Preservative Un- removed - %	Lion Oil Company "NOKORODE 732A"		Valvoline Oil Company "Testol 894"					
	134	136	138	140	142	144	146	148
1:0	1:0	3:1	1:1	1:0	1:0	3:1	1:1	1:1
2	1	1	1	2	1	1	1	1
2.699	1.359	0.898	1.027	1.377	1.111	0.667	0.535	0.535
1.855	0.843	0.279	0.372	0.720	0.572	0.322	0.117	0.117
0.844	0.516	0.619	0.655	0.657	0.539	0.445	0.418	0.418
69	62	31	36	52	52	33	22	22
31	38	69	64	48	48	67	78	78

EFFECT OF STATIC STEAM (AUTOCLAVE - 15 PSIG) ON RUST PREVENTIVE REMOVAL

Company Name	Valvoline Oil Company - "Trotol 848"		Shell Oil Co. "Shell Cold Application C.P. Compound, Code 73, 579"					
	150	152	154	156	158	160	162	164
E.E.S. Ident. No.	150	152	154	156	158	160	162	164
Dilution Ratio - Preservative to Outback	1:0	1:0	3:1	1:1	1:0	1:0	3:1	1:1
No. of Coats Applied	2	1	1	1	2	1	1	1
Wt. of Preservative on Tube Specimens - gms/ft ²	0.563	0.478	0.351	0.294	1.068	0.702	0.574	0.336
Wt. of Preservative Removed - gms/ft ²	0.194	0.241	0.124	0.115	0.404	0.244	0.166	0.109
Wt. of Preservative Unremoved - gms/ft ²	0.169	0.237	0.227	0.179	0.684	0.458	0.408	0.227
Preservative Removed - %	33	50	35	39	37	35	29	31
Preservative Unremoved - %	47	50	65	61	63	65	71	69
Company Name	Esso Standard Oil Company "WS 3673"		Pennsylvania Refining Company "Retrotect 3"					
	176	168	170	172	174	176	178	180
E.E.S. Ident. No.	176	168	170	172	174	176	178	180
Dilution Ratio - Preservative to Outback	1:0	1:0	3:1	1:1	1:0	1:0	3:1	1:1
No. of Coats Applied	2	1	1	1	2	1	1	1
Wt. of Preservative on Tube Specimens - gms/ft ²	0.939	0.518	0.808	-----	0.870	0.754	0.647	0.717
Wt. of Preservative Removed - gms/ft ²	0.477	0.148	0.328	-----	0.299	0.303	0.139	0.187
Wt. of Preservative Unremoved - gms/ft ²	0.462	0.370	0.480	-----	0.571	0.451	0.508	0.530
Preservative Removed - %	51	29	41	---	34	40	22	26
Preservative Unremoved - %	49	71	59	---	66	60	78	74

EFFECT OF STATIC STRESS (AUTOCLAVE - 15 PSIG) ON RUST PREVENTIVE REMOVAL

Company Name	E.S. Ident. No.	Dilution Ratio - Preservative to Cutback	No. of Coats Applied	Wt. of Preservative on Tube Specimens - gm/ft ²	Clark's 4000"		Gulf Oil Corporation "Gulf No Rust D"		
					184	186	190	192	194
	1:0	1:0	1	1:1	1:1	1:0	1:0	3:1	1:1
	2	1	1	1	1	2	1	1	1
	0.754	0.650	0.355	0.233	1.857	1.569	0.931	0.445	
	0.124	0.068	0.084	0.078	0.781	0.703	0.091	0.061	
	0.630	0.562	0.271	0.155	1.076	0.866	0.840	0.384	
	17	14	24	34	42	45	10	14	
	83	86	76	66	58	55	90	86	

EFFECT OF "DYNAMIC" STEAM (15 PSIG) ON RUST PREVENTIVE REMOVAL

Company Name E.E.S. Ident. No. Dilution Ratio - Pre- servative to Cutback No. of Coats Applied Wt. of Preservative on Tube Specimens - gms/ft ² Wt. of Preservative Removed - gms/ft ² Wt. of Preservative Unremoved - gms/ft ² Preservative Re- moved - % Preservative Un- removed - %	Valvoline Oil Company - "Test 5-11M"		E. F. Houghton & Co. - "Cosmoline 1097"	
	102 104	106 108	110 112	114 116
	1:0 2	3:1 1	1:0 1	3:1 1
	0.422	0.298	1.363	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.132	0.194
	83	64	90	77
	17	36	10	23
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.110	0.227	0.194
	83	63	80	58
	17	37	20	42
	0.422	0.298	1.141	0.851
	0.349	0.188	0.914	0.657
	0.073	0.1		

EFFECT OF "DYNAMIC" STEAM (15 PSIG) ON RUST PREVENTIVE REMOVAL

Company Name	Valvoline Oil Company - "Tectyl 848"				Shell Oil Co., "Shell Cold Application P.P. Compound, Code 72,579"			
	150	152	154	156	158	160	162	164
E.E.S. Ident. No.								
Dilution Ratio - Preservative to Cutback	1:0	1:0	3:1	1:1	1:0	1:0	3:1	1:1
No. of Coats Applied	2	1	1	1	2	1	1	1
Wt. of Preservative on Tube Specimens - gms/ft ²	0.450	0.564	0.392	0.299	1.059	0.765	0.647	0.423
Wt. of Preservative Removed - gms/ft ²	0.364	0.452	0.329	0.211	0.822	0.505	0.483	0.339
Wt. of Preservative Unremoved - gms/ft ²	0.086	0.112	0.063	0.088	0.237	0.259	0.164	0.084
Preservative Removed - %	81	80	84	71	78	66	75	30
Preservative Unremoved - %	19	20	16	29	22	34	25	20

Company Name	Esso Standard Oil Company - "WS 3673"				Pennsylvania Refining Company - "Petrotect 3"			
	165	168	170	172	174	176	178	180
E.E.S. Ident. No.								
Dilution Ratio - Preservative to Cutback	1:0	1:0	3:1	1:1	1:0	1:0	3:1	1:1
No. of Coats Applied	2	1	1	1	2	1	1	1
Wt. of Preservative on Tube Specimens - gms/ft ²	0.941	0.725	0.902	0.539	1.064	0.730	0.568	0.702
Wt. of Preservative Removed - gms/ft ²	0.723	0.592	0.811	0.319	0.869	0.524	0.368	0.472
Wt. of Preservative Unremoved - gms/ft ²	0.218	0.133	0.091	0.220	0.195	0.206	0.200	0.230
Preservative Removed - %	77	82	90	59	82	72	65	67
Preservative Unremoved - %	23	18	10	41	18	28	35	33

Table 4, Sheet 3

EFFECT OF "DYNAMIC" STEAM (15 PSIG) ON RUST PREVENTIVE REMOVAL

Company Name E.S. Ident. No. Dilution Ratio - Pre- survative to Outback No. of Coats Applied Wt. of Preservative on Tubg Specimens - gms/ft ² Wt. of Preservative Removed - gms/ft ² Wt. of Preservative Unremoved - gms/ft ² Preservative Re- moved - % Preservative Un- removed - %	Clarkson Laboratories - "Clarke 4000"		Gulf Oil Corporation - "Gulf No Rust 10"					
	182	184	186	188	190	192	194	196
	1:0	1:0	3:1	1:1	1:0	1:0	3:1	1:1
	2	1	1	1	2	1	1	1
	0.990	0.719	0.296	0.261	1.927	2.123	0.747	0.397
	0.802	0.524	0.169	0.118	1.569	1.607	0.376	0.258
	0.188	0.195	0.127	0.143	0.358	0.516	0.371	0.139
	81	73	57	45	81	76	50	65
	19	27	43	55	19	24	50	35