WASHING AND LAUNDERING ON BOARD I. N. SHIPS WITH SEA WATER

By B. Sreenivas Rao and C. P. De,

Naval Chemical and Metallurgical Laboratory, Bombay.

ABSTRACT

This paper deals with the use of synthetic detergents for washing and laundering on board I.N. Ships using sea water. Soiled clothes were subjected to washing trials using various concentrations of detergents *viz*, Teepol and Lissapol N with sodium meta-silicate as builder. A sea water washing formula using Teepol as detergent and sodium meta-silicate as builder in equal proportions has been evolved by which fresh water can be economised to the extent of 66% when compared to ordinary soaps and fresh water.

Introduction

Washing and laundering on board Naval Ships is a long standing problem due to difficulties associated with procurement of fresh water in adequate quantities. At present only one I.N. Ship (I.N.S. INVESTIGATOR) has a laundry plant operating with fresh water on board and all other ships have to depend upon shore facilities for laundering. The object of the present investigation was to determine the suitability of using synthetic detergents to enable washing and laundering to be done on board ships with sea water thus leading to an economy of fresh water consumption and also enabling more washing to be done at sea. Improvement in habitability and hygienic conditions, brought about by the increased facilities of washing envisaged, would go a long way in increasing the comfort of the ship's company.

Ordinary Soaps (Sodium or Potassium Salts of fatty acids) which are very effective detergents in fresh water, react with calcium and magnesium ions in sea water forming insoluble calcium and magnesium soaps, which are deposited on the fabrics. Attempts were made in the past to overcome this difficulty using cocoanut oil soaps (marine soaps) containing lower fatty acids (C_6, C_8 and C_1 acids) whose calcium and magnesium salts are comparatively soluble. It has been found that the threshold concentration for effective detergency with cocoanut oil soaps is 6%. At 5% the cleaning efficiency suddenly drops from 81% to 35% [1]. The threshold concentration of 6% is necessary to soften the sea water before effective detergency can begin, whereas less than 1% soap is required for washing with fresh water.

Synthetic surface active agents belonging to anionic, cationic and nonionic types have been developed to overcome the shortcomings of ordinary soaps in the fields of wetting, detergency and emulsification. Anionic types like alkyl aryl sulfonates, alkyl sulfonates and nonionic types like alkylated phenol-ethylere oxide condensates are known to have good detergent properties in media containing electrolytes and/or acids. Methods of washing on board ships were develloped [2] during the last war. Powder form anionic detergents of the alkyl-aryl type were used for laundering at sea during World War II, but were not found very satisfactory. Improved detergents and builder combinations are still under investigation[3].

Mechanism of cleaning by detergents

Detergency means the removal of dirt from solid surfaces by a liquid medium containing surface active agent. It is distinct from the process of removal of dirt either by physical solution in the medium or mechanical dislodgement. Materials possessing detergent properties are widely known—soaps, saponins and lately synthetic surface active agents. The molecule of the detergent contains a non-polar hydrocarbon chain of adequate length and a polar group like carboxyl, sulphonic acid etc. at the other end. At the oil/water interface the detergent molecule orients in such a way that the non-polar hydrocarbon chain is directed towards the oil phase and the polar group is attracted towards the aqueous phase. This is responsible for lowering the interfacial tension between the two phases and thus helping emulsification. The mechanism by which soap and other detergents clean is extremely complex. Generally the 'dirt' is bound to a solid surface by a thin film of oil or grease. Cleaning of such a surface involves displacement of the film by detergent solution which in turn is washed away by the rinse water. Since water has a high surface tension compared to oils, it does not wet the surface of the soiled fabric. The presence of the surface active agent brings down the interfacial tension between water/oil and permits wetting of the substrate of the cloth and the dirt gets dislodged by emulsification of the oil and subsequent suspension.

Function of 'Builders'

If dirt particles and oil droplets are not suspended in a solution in a stable and highly dispersed condition, they would tend to coalesce into aggregates large enough to be redeposited on the cleaned surfaces. This phenomenon is observed when using synthetic detergents alone praticularly the alkyl-aryl sulfonates. This defect has been overcome by using inorganic agents like polyphosphates [4] and silicates and organic materials like carboxy methyl cellulose along with the detergent. These modifying agents are known as "builders". It is believed that inorganic builders prevent redeposition through modification of electrical forces between soil and substrata and in some cases by protective colloid action [5]. Carboxy methyl cellulose has the latter effect to a high degree and, in addition, forms an adsorbed layer on the fabric forming a surface less receptive to soil.

Selection of detergent

Two commercial surface active agents Teepol (Shell Chemicals) and Lissapol N (Imperial Chemical Industries) were selected for investigation. Teepol is an anionic agent, a secondary sodium alkyl sulphate. It is produced by sulfonation of cracked petroleum olefins. The liquid-form containing 22 p.c. of active ingredient was used. Lissapol N, an aqueous solution of alkylated phenol ethylene oxide condensate, is a nonionic type of surface active agent represented by the formula

$$R-O-C_2H_4(-OC_2H_4-)_n\ OH$$

Since the lowering of surface tenson of aqueous solutions and interfacial tension between water/oil are important properties for evaluation of detergency, the surface tension of various concentration of the above two detergents in sea water and interfacial tension between sea water solutions and liquid paraffin were determined in the laboratory using Cambridge Du Nuoy's Tensiometer. Results are given in Tables I and II.

TABLE I

Surface Tension Measurements

Sr. No.	Sample	Surface tension dynes/cm	Temp. °C
1	Sea Water	73·4	28·6
2	Teepol in Sea Water		
	0·1 p.c.	31·6	30
	0·2 p.c.	31·3	30
	0·3 p.c.	31·0	30
	0·5 p.c.	31·0	30
3	Lissapol in Sea Water—		
	0·1 p.c.	33·2	30
	0·2 p.c.	33·1	30
	0·3 p.c.	33·0	30
	0·5 p.c.	33·0	30

TABLE II

Interfacial Tension Measurements

Sr. No.	System	Interfacial Tension dynes/cm	Temp °C
1	Sea Water/Liquid Paraffin	42·0	29·5
2	0·2 p.c. Teepol in Sea Water/Liquid Paraffin	3·2	31·2
3	0·3 p.c. Teepol in Sea Water/Liquid Paraffin	3·2	31·2
4	0·2 p.c. Lissapol in Sea Water/Liquid Paraffin	3·7	30·0
5	0·3 p.c. Lissapol in Sea Water/Liquid Paraffin	3·7	30·0

The values shown above indicate that the two agents lower the surface and interfacial tensions to desired values at concentrations as low as 0·1% and were therefore selected for laboratory trials.

Laboratory trials

Laboratory detergency trials were carried out on samples of white desized cotton cloth (5 cm × 5 cm) which were uniformly soiled by immersion for three minutes in the following soiling composition (250 ml.) at room temperature:

Carbon black	6 gm.
Carbon tetrachloride ..	3000 gm.
Turbine lubricating oil ..	2 gm
Hydrogenated vegetable oil	1 gm.

The samples were dried at 105°C to remove the volatile solvent. The amount of soil deposited on the fabric was found to be about 0·10 mgm/cm² of the fabric. The soiled samples (4 Nos.) were then washed in 250 ml. conical flasks containing 100 ml. detergent solution in a 'Microid' Shaker for 15 minutes at a temperature of about 50°—60°C. The samples were given two rinses of sea water of 100 ml. each at 45°C and 40°C respectively followed by another two rinses with tap water at room temperature to remove the dissolved salts.

Satisfactory detergency was obtained by using 0·3 and 0·4 p.c. of Teepol and Lissapol. The detergency was, however, slightly inferior to that obtained with ordinary soap and fresh water. Slight improvement in detergency was observed by incorporating equal concentration of sodium metasilicate builder with the synthetic detergents. The evaluation of detergency was carried out in the laboratory by visual observation only in the absence of a photoelectric reflectance photometer.

Pilot Scale Trials

Pilot scale trials were carried out with laboratory-soiled overalls, aprons etc. Good detergency was obtained when the materials were agitated for 20 minutes in sea water containing 0·4 p.c. Teepol and 0·4 p.c. Sodium metasilicate at 50°C. Lissapol is a nonionic detergent and could function effectively only in the presence of combined builders like sodium carboxy methyl cellulose and polyphosphates [5].

Service Trials

Investigations on the optimum detergent and builder concentrations required for obtaining the most satisfactory results were carried out using the laundry plant of I.N.S. Investigator. The plant is provided with arrangements for heating and consists of an electrically operated reversible rotating drum (3 ft. long and 2 ft. diameter). As a corollary to the main investigation, a fresh water washing formula was also evolved to economise time and expense. The formula is given in Table III.

TABLE III

Fresh Water Washing Formula

Load—30 pieces of soiled cloth (23 lb.) of miscellaneous sizes supplied by the ship's company

Sr. No.	Sequence of operation	Temperature	Fresh Water (Gallons)	Detergents	Time
					Mins.
1	1st Wash	170°F	15	1% Soap 1% Soda	30
2	Drain	..	..	..	..
3	2nd Wash	140°F	10	1% Soap 1% Soda	30
4	Drain	..	..	..	..
5	1st Rinse	120°F	10	..	10
6	Drain	..	..	..	..
7	2nd Rinse	110°F	10	..	10
8	Drain	..	..	..	..
9	3rd Rinse	85°F	7	..	10
10	Drain and Load Removed for drying.	..	..	..	..
	Total fresh water used ..	..	52 gallons	Total time	90

Sea water trials were carried out with various concentration of built synthetic detergents (Teepol and Lissapol N) using the procedure outlined in Table III by replacing the fresh water for the two washes entirely by sea water and using two final rinses with fresh water to decrease the dissolved chloride content which might have harmful effects on the skin. The method found successful in our trials is given below in Table IV.

TABLE IV

Sea Water Washing Formula

Sr. No.	Sequence of operation	Temperature	Water (Gallons)	Detergents	Time
1	1st Wash	170°F	15 (Sea Water)	0·3% Teepol 0·3% Sodium metasilicate	Mins. 30
2	Drain	..	..	..	..
3	2nd Wash	140°F	10 (Sea Water)	0·2% Teepol 0·2% Sodium metasilicate	30
4	Drain	..	..	..	..
5	1st Rinse	120°F	10 (Sea Water)	..	10
6	Drain	..	..	..	..
7	2nd Rinse	110°F	10 (Sea Water)	..	10
8	Drain	..	..	..	..
9	3rd Rinse	85°F	10 (Fresh Water)	..	10
10	Drain	..	..	..	..
11	4th Rinse	80°F	7 (Fresh Water)	..	10
12	Drain and load removed.	..	..	..	..
	Total Sea water used		45 gallons	Time	100
	Total Fresh water used.		17 gallons.		

The residual sodium chloride content of the wash water after the first fresh water rinse was found to be 1 p.c. which was further reduced to 0·2 p.c. after the second wash.

Discussion and acknowledgement

(a) The optimum concentration required for satisfactory washing is found to be 0·3 and 0·2% Teepol with equal concentrations of sodium metasilicate as builder in the two washes respectively. Lissapol being a nonionic detergent does not give satisfactory performance with the builder sodium metasilicate.

(b) It is observed that as against 52 gallons of fresh water required for washing 30 pieces of soiled clothing with Soap/fresh water system, only 17 gallons of fresh water are consumed with detergent/Sea water washing system. Thus an economy of fresh water to the extent of about 66 p.c. can be achieved. A further economy can be obtained if the wash water after the final rinse is utilised for the first fresh water rinse in a subsequent wash.

(c) The cost of detergent and builder required for washing one piece of clothing works out to 6 pies approximately.

(d) It is recommended that the process outlined in Table IV be adopted for use on board I.N. Ships and that washing machines of suitable capacity may be installed.

(e) Production of bar forms of detergent using a combination of surface active agent, sequestering agents and cocoanut oil soaps is under investigation.

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