A Sanitary Study of Commercial Laundry Practices*

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WE have applied our knowledge of sanitary sciences to restricting the distribution of bacteria in water, milk, and food. The present paper is a report of a year's study of the sanitary practices in 54 laundries. The purpose of the study was to ascertain the usual practice and then to develop methods of procedures to overcome the sanitary errors, if such existed.

The washing formula can be subdivided into two large groups, one using a high temperature for white clothes and fabrics, the other requiring a low temperature formula to preserve the color of textiles which would be altered by high temperature. Any washing formula must prevent loss of tensile strength, and the whiteness retention must be preserved. Fabrics must not lose more than 10 per cent of their tensile strength after 20 complete washings, and the whiteness retention tests cannot show more than 6 per cent loss. The formula studied by us conformed to these tests. We were concerned only with the bacterial counts of the wash waters and the textiles in the laundry process.

A family's weekly laundry bundle is subdivided into approximately 16 classifications. Each classification receives a different treatment. Space does not allow us to go farther into this aspect of the washing technic, but for the purposes of this report we shall for convenience and simplicity consider but 2 of these formulae: the high temperature white clothes and the low temperature colored clothes formulae.

Tables I and II give the high and low temperature washing formulae. The flush is the wetting process and consists of the addition of water. This is followed by 4 suds. The washing apparatus is drained after each operation. The 4 rinsing processes are to remove the detergents used in the washing process. The last or sour rinse is to remove the residual soaps which may be retained in the clothes. The whole procedure consists of 4 detergency operations for cleansing the clothes and a similar number of rinsing operations to remove the detergent.

Tables I and II also give the purpose of each operation, the holding time, temperature, and the average bacterial count per c.c. of the wash water. The bacterial count is based upon a year's study of 2 laundries, each was tested twice weekly throughout the year.

The high temperature washing proc-

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TABLE I

High Temperature Washing Formula

White Clothes

Operation	*Purpose*	*Temperature Degrees Fahrenheit*	*Holding Time Minutes*	*Average Bacterial Count per c.c. Wash Water (1 Year—120 Experiments)*
Flush	Wets cloth (removes surface soil)	110	5	200,428
1 Sud	Detergent—(soap-alkali)	125	10	94,314
2 Sud	" " "	135	10	42,518
3 Sud	" " "	140	10	8,382
4 Sud	" " " plus 1% Bleach	165–170	15	5
1 Rinse	Removes detergent	165	3	1
2 Rinse	" "	165	3	0.5
3 Rinse	" "	165	3	0.4
4 Rinse	" "	165	3	0.2
After Sour	Removes residue detergent	140 }	10	Sterile
Blue		110 }		

ess does not present many sanitary problems. A temperature of 165° to 175° F. with a chlorine (bleach) concentration of 0.01 per cent in the fourth suds, held for 15 minutes is an effective germicidal process. This temperature prevents accumulation of bacteria inside the washing apparatus. Any deposit of insoluble material does not contain living bacteria. Approximately 75 to 80 per cent of the total wash in laundries is processed by this high temperature method.

The low temperature washing formula presents some interesting sanitary problems. The preservation of the fabrics, silks, woolens, and the colors necessitates a low temperature washing procedure, too low to be of significance as a bactericidal procedure. Dilution by repeated washing and rinsing is the principal mechanism of removal of bacteria from the clothes. The last operation used by laundries consists of the addition of some sour or weak acid to remove the residual detergent and brighten the colors of the clothes. We have found that this operation can be used as a bactericidal process. If the sour used brings the hydrogen-ion concentration down to pH 3.8 to 4.2 and is held for 5 minutes, there is a reduction of the bacterial count. We have therefore utilized this common

TABLE II

Low Temperature Washing Formulae

Light Colored Clothes

Light Colored Clothes—Finished Service

Dark Colored Clothes

Operation	*Purpose*	*Temperature Degrees Fahrenheit*	*Holding Time Minutes*	*Average Bacterial Count per c.c. Wash Water (1 Year—120 Experiments)*
Flush	Wets cloth (removes surface soil)	90–100	5	3,674,055
1 Sud	Detergent (soap-alkali)	100	10	1,979,862
2 Sud	" " "	100	10	1,248,758
3 Sud	" " "	100	10	255,579
4 Sud	" " "	100	10	221,293
1 Rinse	Removes detergent	100	3	88,966
2 Rinse	" "	100	3	67,461
3 Rinse	" "	100	3	43,809
4 Rinse	" "	100	3	35,278
5 Rinse	" "	100	3	24,441
After Sour	Removes residue detergent—brightens colors	95	5	158

procedure and adapted it so as to make a germicidal agent. This requires a carefully controlled operation; the colorimetric determination of the hydrogen-ion concentration must be carried out on each load of clothes washed.

The following sours have been studied:

Sodium Acid Fluoride
Sodium Silico Fluoride
Ammonium Acid Fluoride
Ammonium Silico Fluoride
Acetic Acid

Table III gives the average amount of each sour to be added per lb. of clothes in order to obtain the required hydrogen-ion concentration. The buffered sours are safer and more satisfactory. The organic acids can be added in excess and will then reduce the tensile strength of the textiles in the wash.

TABLE III

One and One-half Grams of Each of the Following Sours Were Added per lb. of Clothes—Hydrogen-ion Concentration and Bacterial Count Determined at 5 Minutes' Holding Time

	pH	*Bacteria per c.c.*
Sodium Acid Fluoride	4.3	40
Sodium Silico Fluoride	4.4	127
Ammonium Acid Fluoride	4.2	12
Ammonium Silico Fluoride	4.4	101
Acetic Acid	5.0	280

teria. Space does not permit a detailed discussion of methods of determining the degree of bacterial seeding of cylinders. Table IV gives the average number of bacteria cultured from wooden cylinders per sq. in. of surface before and after cleaning from 6 laundries. Table V gives a method of cleaning cylinders which we have found to be very effective and practical. Sodium silico fluoride dissociates at high temperature and acts as a solvent for the calcium soap residues as well as a germicidal agent. Twenty minutes holding time at 190° to 195° F. in the presence of this acidity destroys the bacterial flora in deposits. Rinsing at high temperature, followed by the use of caustic soda to neutralize the acids in the wooden cylinders, followed again by hot rinses, leads to a clean cylinder with a very low bacterial count on its surface.

TABLE IV

Examples of Average Bacterial Count per Square Inch of Surface of Dirty and Clean Cylinders

Laundry	*Before Cleaning*	*After Cleaning*
A	529,740	18
B	2,910,600	25
C	3,559,500	41
D	3,100,750	4
E	2,153,000	36
F	612,550	11

TABLE V

A Method for Cleaning Wooden Cylinders in Laundries

Procedure	*Purpose*	*Time Minutes*	*Temperature Degrees Fahrenheit*
2 lb. Sodium Silico Fluoride	Acid to dissolve insoluble soap residue and kill bacteria	20	190–195
Hot Rinse	Remove residual acid and destroy bacteria	5	170
Hot Rinse	Remove residual acid and destroy bacteria	5	170
2 lb. NaOH	Neutralize acidity and remove residue	20	190–195
Hot Rinse	Kill remaining bacteria and remove residual chemicals	5	170
Hot Rinse	Kill remaining bacteria and remove residual chemicals	5	170

The low temperature washing formula allows insoluble residues to be built up on the inside of the machines. The cylinders become coated with insoluble calcium soaps and other materials which harbor many living bac-

Table VI gives the results of bacterial counts of the last souring rinse from 3 laundries using the same washing formula before and after the cylinders were cleaned. Table VII records an average low temperature

TABLE VI

Bacterial Count per c.c. of Rinse Water Before and After Cleaning of Wooden Wash Cylinder

	After Sour Rinse	
Laundry	*Before Cleaning*	*After Cleaning*
A	160	35
B	2,080	23
C	13,860	40

dirty cylinder wash. It is self evident that bacteria are being added from some source to the wash waters. The 4th and 5th rinse waters contain more than twice the number of bacteria that were present in the 3rd rinsing operation. The souring process was not effective because of the inexhaustible bacterial reservoir on the surface of the cylinder in contact with the clothes.

TABLE VII

Influence of Clean Cylinders upon the Sanitary Efficiency of Low Temperature Washing Formula

Bacterial Count per sq. in. of Cylinder Before Cleaning	*Bacterial Count of Wash Water per c.c. Before Cleaning*		*Bacterial Count per sq. in. of Cylinder After Cleaning*	*Bacterial Count of Wash Water per c.c. After Cleaning*	
2,910,600	Flush	378,000	25	Flush	300,590
	1 Sud	262,080		1 Sud	252,000
	2 Sud	270,900		2 Sud	49,330
	3 Sud	126,000		3 Sud	47,500
	4 Sud	136,000		4 Sud	45,100
	1 Rinse	133,100		1 Rinse	43,100
	2 Rinse	14,490		2 Rinse	13,600
	3 Rinse	11,530		3 Rinse	9,900
	4 Rinse	26,200		4 Rinse	4,820
	5 Rinse	24,300		5 Rinse	4,410
	After Sour	2,080		After Sour	23

washing process with bacterial counts per c.c. of the wash water, using the same machine before and after cleaning of the cylinder. It is apparent that the sanitary efficiency of the process is not satisfactory when the cylinder acts as a bacterial reservoir during the procedure. We wish to call attention to the irregularity of the counts in the

There is a seasonal variation in the bacterial counts of clothes received by laundries. During the warm months the bacterial flora of clothes is much higher than during cold months of the year. Table VIII gives the summary of a year's cycle by months in one laundry studied.

TABLE VIII

Laundry B

Light Colored Clothes

Average Monthly Flush

Last Rinse and After Sour

Bacterial Counts per c.c. for 1 Year

	Flush	*Last Rinse*	*After Sour*	*Maximum Temperature*
January	885,750	19,850	76	46° F.
February	322,925	17,484	37	42° F.
March	349,465	9,236	92	47° F.
April	744,480	13,248	112	66° F.
May	2,876,487	51,504	224	77° F.
June	4,498,500	20,331	361	84° F.
July	14,063,111	27,149	427	88° F.
August	18,514,530	27,122	430	95° F.
September	16,288,870	36,378	426	91° F.
October	2,055,090	55,188	388	72° F.
November	1,203,697	16,050	216	56° F.
December	850,045	19,646	119	48° F.

Staphylococcus albus is the predominant bacterium in the flora in all wash waters from flush to the after sour rinse. This is the microörganism that increases in the clothes during the warm weather months of the year. The flora in the after sour rinse are usually large china white colonies of *Staphylococcus albus*.

A part of this high count after the souring operation was due to dirty cylinders. This is shown in Table IX. If the low temperature washing formula is used several times each day a wooden cylinder will build up a surface deposit in 4 to 6 weeks that will materially influence the sanitary quality of the washing process. We have found that if a cylinder is cleaned properly, and then once a week this cylinder is used for high temperature washes, it will perform in a sanitary manner for at least 6 weeks before it will show by both surface swab and rinse water high bacterial counts. If the clean cylinder is used on alternating days for high and low temperature washes, it will remain clean for several months.

TABLE IX

Influence of Clean Cylinders on the Average Monthly Bacterial Count During Summer Months

Low Temperature Washing Formula

	July, 1937	*August, 1937*
Cylinders cleaned:	May 1, 1937	August 1, 1937
Flush	14,063,111	4,536,962
Last Rinse	27,149	27,122
Sour Rinse	427	218
Maximum Monthly Temperature	88° F.	95° F.

Table X gives a résumé of a series of experiments to determine the relationship between the bacterial counts in the water and the bacteria on the clothes. We are more interested in the bacteria remaining on the wearing apparel than in those in the wash waters. Test clothes were put into the wash clothes and removed after various operations. Five square inches were cut out under aseptic precautions and bacterial counts made on each sq. in. sample. The technic was to suspend the inch square sample in 10 c.c. sterile saline and shake in a machine for 10 minutes. One, 2, and 4 c.c. samples were used for shake plate counts and the inch square fabric was transferred to a sterile Petri dish and covered with melted cooled nutrient agar. The bacterial count was calculated and the last column represents averages of these experiments. Bacteria are removed from the clothes during the washing process as would be expected from the wash water count. The extraction operation (centrifugation) removes the excess water and we found this process was very effective in removing bacteria. The extraction operation lasts 10 minutes. The remaining bacteria are destroyed by ironing.

TABLE X

Relationship Between Distribution of Bacteria in Wash Waters and Fabrics

Average of 54 Experiments

Fast Colored Clothes Low Temperature Washing Formula

	Total Bacterial Count per c.c. of Wash Water	*Total Bacterial Count per sq. in. of Cloth*
Flush	3,201,950	3,776
First Suds	1,025,333	813
First Rinse	84,870	201
Last Rinse	16,263	84
After Sour Rinse	201	36
Extractor		
Immediately	345	33
3 Minutes	28	10
9 Minutes	19	4
After Ironing		0

We have conducted numerous ironing experiments. We have substantiated previously published reports from other sources that the high moist temperature is an effective process in killing bacteria, vegetative forms as well as spores. We have added bacteria (*B. subtilis, B. welchii, B. megatherium,* Staphylococcus, Streptococcus, *B. coli* and *B. pyocyaneus*) to

fabrics in high concentrations before passing through the ironing machines. All fabrics—using 12 inch square pieces submerged in broth flasks—were sterile after ironing.

We do not feel that the demonstrated efficiency of the ideal ironing process should be depended upon to remove large numbers of bacteria from clothes. This is similar to expecting pasteurization to make dirty milk wholesome for human consumption.

SUMMARY

The high temperature washing formula used for white clothes and fabrics has sufficient temperature and holding time to insure a safe procedure from a public health standpoint.

The low temperature washing formula used for other classifications requires more attention. The cylinders or machines need frequent cleaning to prevent bacterial accumulation on their surfaces. The souring operation must be carried out at a hydrogen-ion concentration of between pH 3.8 and 4.2 to insure low bacterial counts.

The extraction and ironing procedures remove or kill the residual adherent bacteria in all instances studied by us.