CHAPTER XI

Decontamination of Clothing and Equipment

1. Definitions

GAS.—Includes any chemical substance, solid, liquid or gaseous, used in war for its poisonous, blistering or irritant effect on the human body.

NON-PERSISTENT GAS.—A gas which forms a cloud (not necessarily visible) immediately it is released, and leaves no liquid contamination on the ground.

PERSISTENT GAS.—A gas in liquid form which evaporates slowly and so continues to give off dangerous vapour for a long period. Both vapour and liquid may have harmful effects. Typical examples are tear gases, blister gases and nerve gases.

CONTAMINATION.—The liquid or vapour remaining on an object or person as a result of exposure to gas (usually persistent gas).

DECONTAMINATION.—A process intended to remove or destroy the contaminating gas.

METHODS

2. Essentials of decontamination

Should the necessity arise, decontamination would be undertaken in laundries or other similar places by the trained laundry crews. The process consists of the conversion of the contaminant into harmless compounds, the change being brought about by keeping the goods submerged in boiling water for about 30 minutes. This treatment can be applied to all white cotton or linen goods without deleterious effect, but with woollens, some rayons, and most dyed work, damage may occur, and any such damage must be accepted. It has been established that the shrinking and harshening (felting) of woollens does not render them unserviceable, and the effects on most rayons are slight. Unless coloured work can be roughly classified, the running of dyes must also be accepted. Whilst the actual process of decontamination is comparatively simple, certain fundamental precautions must be observed before, during and after the process (*see* para. 5).

3. Effecting decontamination

All affected clothing must be freed from contamination before it can be worn again. The method used is dependent on the nature of the contamination, whether liquid or vapour; on the material from which the article is made: cotton, wool, leather, rubber, etc., and on the equipment available. The decontamination of clothing may be carried out by one of the following methods:

(*a*) WEATHERING

Suitable for certain items of clothing and equipment which have been subjected to vapour contamination only. Consists of exposure to the open air until the gas has evaporated.

(*b*) BOILING

All types of Service clothing and equipment except those containing leather and oilskin.

(*c*) STEAM TREATMENT

In this process, which takes place in a high-pressure disinfector, the gas is partially evaporated by heat and vacuum treatment, followed by the destruction of the remainder by means of pressure steam.

(*d*) IMMERSION IN HOT WATER

A temperature of 203°–210° F. should not be exceeded for articles made wholly or partly of oiled fabric.

A temperature of 120°–130° F. should not be exceeded for articles made wholly or partly of leather.

Satisfactory decontamination of all items which can safely be subjected to boiling can also be achieved by immersion in water at temperatures below boiling-point. The process period, however, becomes longer as the temperature of the water used is reduced.

TEMPERATURE	PERIOD OF IMMERSION
° *F.*	*Hours*
212	½
194	1 ½
176	2
159	3
140	7
122	24
104	48
86	96

From the above table it can be readily seen that if suitable provision is available for decontamination by boiling, the whole process is speeded up and a much larger volume of work can be dealt with in a given time. The time factor is a major consideration and under the conditions prevailing speed of action is essential.

4. Processes used

The foregoing remarks are of general application. In Table 10 particulars have been tabulated to illustrate a decontamination procedure which may reasonably be adopted in H.M. ships in which laundry machinery is available.

5. Precautions

(*a*) TRAINED STAFF.—All personnel must be fully trained so that they may have a proper appreciation of the dangers involved and so accept, with full confidence, the measures provided to counteract them. In this connection all persons engaged in handling contaminated articles and in carrying out the decontamination process must be dressed in suitable protective clothing, including a respirator. Staffs should also be exercised in decontamination work when wearing protective clothing, so that they may become familiar with the actual conditions under which they would be expected to perform these duties.

(*b*) CHANGING AND WASHING FACILITIES.—It is essential to provide suitable accommodation—known as cleansing stations—in which the staff may change into and out of protective clothing. Such facilities form a normal part of a ship's internal organisation.

(*c*) PROTECTIVE MEASURES are provided, and it is the responsibility of individual operators to safeguard themselves from injurious effects by the proper use of the protective devices supplied. These include:

The respirator.

Protective clothing, either heavy or light type.

Ointments.

Dressing and undressing routines.

Detailed instructions regarding (*a*) and (*b*) are given during the comprehensive training course.

(*d*) VENTILATION.—The ventilation of the space in which the work is carried out must be adequate to prevent the accumulation of gas, and as a minimum it must be sufficient to remove the steam generated. Steps must also be taken to ensure that contamination is not spread through the ventilation system to otherwise clean areas. The importance of ensuring efficient ventilation cannot be overstressed. Some blister gases, mustard for example, produce no immediately recognizable sensation or effect (some persons cannot even detect the smell except in high concentrations) and the effects may not become apparent until it is too late to prevent serious injury.

(*e*) DOUBT REGARDING POSSIBLE CONTAMINATION.—Should any doubt arise as to whether or not an article of clothing or equipment is contaminated it should always be treated as contaminated.

(*f*) CLEANING UP.—When the work of decontaminating the clothing is completed, the deck, machinery, tables, bins, trolleys, drains (scuppers), sumps, etc., must be thoroughly decontaminated by an approved procedure. The polished surfaces of machinery can be decontaminated by swabbing with rags or cotton waste damped with paraffin or mineral oil. It is essential also for the protective clothing itself to be decontaminated before it is used again. Internal fittings of washing machines should not normally require special treatment as these are constantly subjected to the decontaminating effect of the boiling water. In fact, if care is exercised when loading the washing machine, there is no reason why contaminated articles of clothing should contact any item of laundry equipment other than the washing machines. Contamination will occur only from contact with the protective clothing worn by the operator or carrier during his movements around the laundry.

(*g*) MARKING.—All bins or receptacles used for holding or transporting contaminated material, must be given distinguishing marks to ensure that they are not used for any other purpose before they have been decontaminated.

6. Notes on the process

(*a*) Decontamination is a process which aims at the removal of the gas contaminant only and does not include washing in the true laundry sense. If articles have to be washed as well as decontaminated, the two processes must be kept entirely separate and the decontamination completed first.

(*b*) Open pocket machines should not have more than one vertical division and should be of metal; wooden machines are unsuitable. Similarly machines with " Y " or " D " pockets (*i.e.*, in lateral divisions) are useless for decontamination, as the articles must be completely immersed in water during the whole of the process—such machines are, however, not normally provided for Admiralty services.

(*c*) Washing machines must be maintained in an efficient state, as leakage from a machine may seriously effect the efficiency of the process and increase the risk to the operators.

(*d*) The gas-proof bags or metal bins containing the contaminated clothing must be left in the open and should be isolated from all other work until required. The clothing should be loaded straight from the containers into the machine with the absolute minimum of handling.

(*e*) The load must be " poled " if possible at intervals during the decontamination process to ensure that all parts of the goods are submerged in the water. Any parts which are not submerged may become damaged by the acidity which develops during the breaking down of the blister gas. Under the slightly alkaline conditions of water pertaining when washing cottons and linens, this acidity can do no harm. The acidity has little or no effect on woollens and plain water only is used, *i.e.*, no alkali is added. The woollens must, however, be kept submerged.

(*f*) The temperature of the load must be maintained at over 200° F. for half an hour (except for leather or oiled fabrics). Thermometers should be fitted to all machines to indicate that this requirement is met.

(*g*) The intermittent rotation of the cage is necessary to effect the occasional redistribution of the load and thus add to the efficiency of the process.

(*h*) A portion of the last rinse may be retained when using machines of the side-opening type, and made up with additional warm water for use in washing the next load.

PROCEDURE

7. Sorting and classifying

The sorting of contaminated clothing must be done *outside the laundry*, preferably in the open air thus reducing the vapour concentration to a minimum. Clothing should be placed directly in the bins or gas-proof paper sacks in the following classifications:

(*a*) White cotton clothing such as towels, shirts, underwear, sheets, pillow-cases, handkerchiefs, etc. } Cottons
(*b*) Coloured cotton clothing such as shirts, collars, action working dress, overalls, etc. }
(*c*) Blue service uniforms } Woollens
(*d*) Greatcoats and caps }
(*e*) Miscellaneous woollen articles, jerseys, socks, flannels, etc. }
(*f*) Blankets }
(*g*) Boots and other leather articles.
(*h*) Rubber articles.
(*j*) Webbing.
(*k*) Protective clothing.
(*l*) Respirators.

Articles of clothing may be further sub-classified if capacity exists but in general the main objects to be achieved are:

To obtain the initial separation of " cottons and linens " from " woollens," and

To obtain the further separation in the two main categories of " coloured work " from " whitework."

The clothing should be taken to the laundry in the sealed bags or other containers only as capacity exists in the laundry to deal with it.

8. Apportionment of duties

In the difficult conditions envisaged, the work of ensuring a smooth routine in the laundry will call for careful organization on the part of the laundry officer, who must therefore be fully acquainted with all aspects of the procedure. It is suggested:

(*a*) That in view of the comparatively small numbers of trained laundry crew available in H.M. ships and of the strenuous nature of the duties involved *i.e.*, working in a humid atmosphere in protective clothing, the trained staff be allocated duties in the laundry only and that such duties be on a short shift basis. Assuming a crew of 9

Decontamination in washing machine	1	Crew of 9 in rotation
Hydro extraction and drying	1	1 hour duty
Folding and re-issue ..	1	2 hours off.

Longer continuous periods of duty may be possible in the case of operator(s) engaged in preparing goods for re-issue. The crew engaged in these duties could be dressed in light protective clothing, thus reducing fatigue. These personnel would be known as " operators."

(*b*) That the initial sorting operation, and the subsequent transfer of the decontaminated clothing from the sorting area to the laundry, should be done by additional personnel selected from the ship's company. These men would be known as " carriers " and would be dressed in heavy protective clothing. They would transport the classified clothing to the laundry and load the washing machine under the guidance of the trained operator. The carrier must on no account attempt other operations on the washing machine, and once the machine is loaded he should return to the sorting area. Great care should be taken by the " carrier " when loading the machine to reduce his contact with it to a minimum, and thus keep it as free from contamination as possible. A further member of the trained crew could be present at the sorting area to advise on classification.

Notes

(*a*) The operator should prepare the machine to receive the load from the carrier.

(*b*) The carrier should only load, care being not to touch the machine or surrounds more than is absolutely necessary.

(*c*) All subsequent work, *i.e.*, poling, turning on steam, water, etc., should be done by the operator.

(*d*) The operator should take the earliest opportunity to decontaminate portions of the machine which the carrier may have touched. This work must be done before removing the load, and can probably best be done during the heating up stage.

(*e*) The machine should be unloaded by the operator and the contents passed to the hydro-extractor operator. It will probably be most convenient to unload into a clean trolley.

9. Preparation of laundry

It should be possible by careful preparation, to restrict the area in the laundry subjected to positive danger of contamination to a minimum.

A typical arrangement of laundry is illustrated in Fig. 97.

The number of washing machines, etc. required for use would be dependent upon the bulk of work to be decontaminated, but if possible one or more machines should be retained " clean."

In this arrangement, the following measures are suggested:

(*a*) One washing machine only should be used for decontamination purposes.

(*b*) The machine, and access to it, should be separated from the rest of the laundry by the erection of a temporary gas-proof screen.

(*c*) The absorbent surfaces of all laundry equipment, *i.e.*, the lower bucks of presses, the rollers of flatwork ironing machines, etc., should be covered with protective material.

The above arrangement confines the area liable to positive contamination by liquid to that in the immediate vicinity of the washing machine. If a truly gas-proof screen can be contrived, conditions of operation for hydroing, drying and sorting would be considerably eased. In general, however, it must be assumed that such an arrangement does not provide positive freedom from vapour, and all operators engaged on any form of decontamination within the main laundry bulkhead must wear protective clothing.

Where the drying and issue rooms are remote from the laundry washing compartment, operators

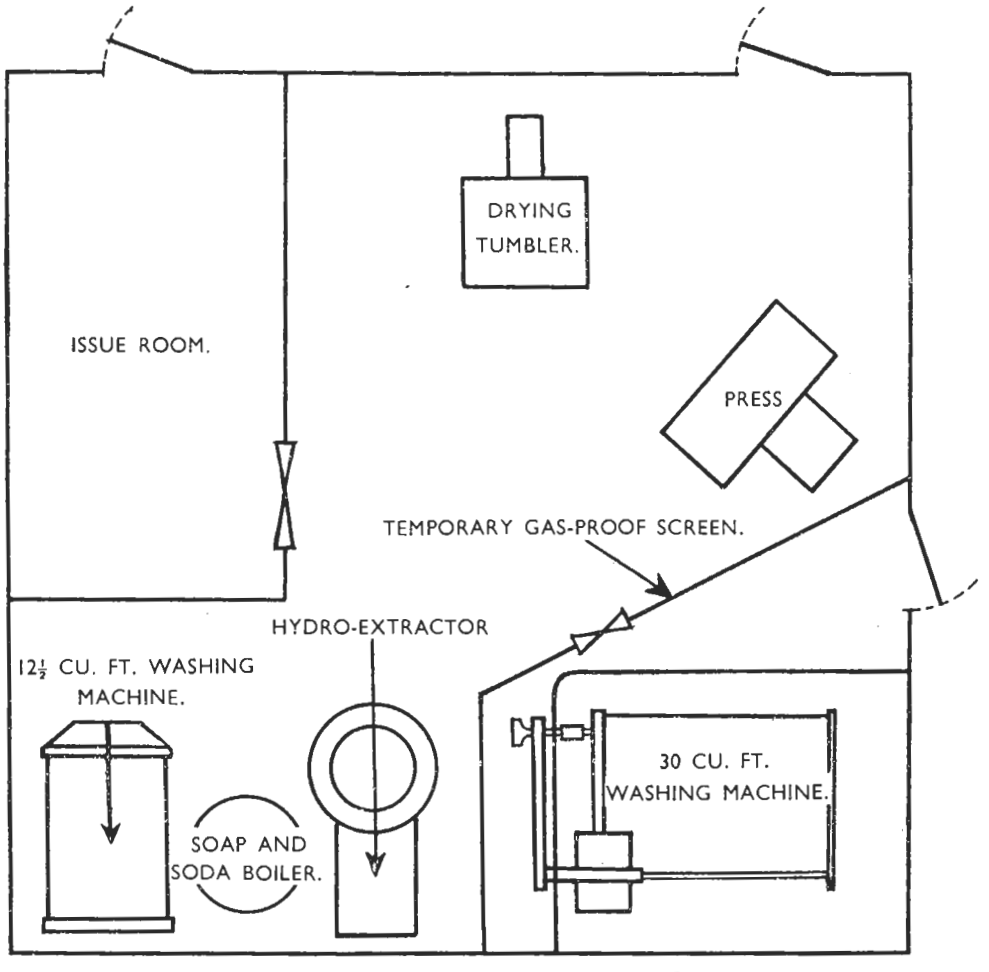

Fig. 97.—Siting of a temporary gas proof screen.

engaged on these duties need not wear protective clothing when handling decontaminated clothing. There are so many factors involved, however, that the declaration of safe working conditions must be left to the discretion of the responsible officers concerned.

DECONTAMINATION USING WASHING MACHINES

10. General Notes

(*a*) All cottons, linens and woollens can be decontaminated in the washing machine by using the same general procedure, but work should be undertaken in the separate classifications listed.

Cottons and linens: Alkali is used.
Woollens: No alkali.
Impregnated A.V. Clothing: Powdered chalk.
} See Table 10

(*b*) The correct loading rate is $2\frac{3}{4}$ lb. dryweight of clothing for each cubic foot of cage capacity, and this loading rate should not be exceeded.

30 cu. ft. machine. Normal load, 105 lb. Decontamination load, 80 lb.

12½ cu. ft. machine. Normal load, 43 lb. Decontamination load, 35 lb.

28·5 cu. ft. (end open). Normal load, 100 lb. Decontamination load, 78 lb.

(*c*) The machine must be kept stationary during the whole of the process, except for the periodical rotations referred to.

11. Side opening machine

OPERATOR

(1) Admit warm water to a depth of 8 in.

(2) Add alkali, dependent upon the nature of the load (see (*a*) above), at the rate of 1 oz. for every cu. ft. of cage capacity, *i.e.*, 12½ oz. in a 12½ cu. ft. machine or 30 oz. in a 30 cu. ft. machine.

CARRIER

(3) Load the machine under the guidance of the operator to the correct degree of loading, taking care

not to spread contamination to the machine or surrounds.

OPERATOR

(4) Fill the machine with warm water to the maximum dip and ensure that the clothes are well submerged by pushing them under the water with a metal rod. This operation is termed " poling."

(5) Close the machine, admit steam, and bring the water to the boil.

(6) Decontaminate such portions of the machine as may have been touched by the " carrier."

(7) As the temperature of the water approaches 200° F., rotate the cage 2 or 3 times using the hand turning gear. This redistributes the load and ensures free circulation of the water through the clothing.

(8) When boiling point is reached, open the machine and give a further poling to ensure that the load is submerged.

(9) Close the machine and allow the water to boil vigorously for 30 minutes, taking the time from the moment boiling begins.

(10) Rotate the inner cage one complete revolution, using the hand turning gear, at intervals of 10 minutes throughout the boiling period.

(11) After the load has been boiling for 30 minutes, open the outer door and give the load a further " poling " before turning off the steam.

(12) Release the water from the machine.

(13) Rinse once with hot water, filling the machine to its maximum dip. The clothes should be agitated either by " poling " or by one rotation of the cage. Discharge the water after rinsing for 2 to 3 minutes.

(14) Rinse again using warm water to maximum dip. A portion of this water, *i.e.*, to a dip of 8 in. may be used for washing the next load.

(15) After the final rinsing as at (14) the decontamination process is complete, and the goods may be removed from the machine for hydroing and drying prior to issue to individuals or return into store.

Note : Great care must be exercised during the removal of the load from the washing machine to prevent possible re-contamination due to contact with contaminated surfaces.

Woollens should be gently turned over and prodded down and not vigorously " poled " as for cottons.

12. End opening machine

(*a*) The construction of this machine is fundamentally different from that of the side opening type, and in connection with its possible requirement for decontamination purposes, the following points assume importance:

(*b*) The machine can be completely filled with water, so that the clothes in the cage are totally submerged during the whole of the process, rendering " poling " unnecessary.

(*c*) The door cannot be opened when the machine is loaded, making " poling " impracticable in any event.

(*d*) Hand turning gear is not provided and revolution of the cage to obtain the periodical redistribution of the load must be carefully effected by means of the power drive.

CARRIER

(1) Loading should begin when the cage is empty. The machine should be loaded to the accepted degree under the supervision of the operator.

OPERATOR

(2) Close the machine and fill with warm water to the highest level possible, *i.e.*, to a level just above that of the top of the cage.

(3) Add alkali, according to the type of material being dealt with, at the rate of 1 oz. for every cubic foot of cage capacity.

(4) Admit steam and bring to the boil.

(5) Decontaminate such portions of the machine as may have been touched by the " carrier."

(6) As the temperature approaches 200° F., revolve the machine 2 or 3 revolutions using the power drive.

(7) Allow the clothing to boil briskly for 30 minutes, taking the time from the moment the water begins to boil.

(8) Rotate the cage one complete revolution, using the power drive, at intervals of 10 minutes, throughout the boiling process.

(9) After the load has been boiling for 30 minutes turn off steam and release all the water from the machine.

(10) Rinse with hot water, filling the machine to maximum dip as at (2). Revolve the cage once and release the water after 2 to 3 minutes rinsing.

(11) Rinse again in warm water.

(12) Release the water and unload the machine, taking care to avoid contact with contaminated surfaces.

FINISHING

13. Hydro-extraction

After washing, all decontaminated cotton and woollen articles should be hydroed. The goods should be loaded into the machine in accordance with the normal scale of loading, *i.e.*, 12 lb. dryweight per cubic foot of cage capacity.

27-in. machine, approx. 3 ½ cu. ft.—42 lb. load.

30-in. machine, approx. 6 cu. ft.—72 lb. load.

Woollens should be hydroed for about 5 minutes, other goods until the steady flow of water from the waste pipe has ceased.

14. Drying

After hydroing the goods should be completely dried in the drying-tumbler, or in the drying-room if no tumbler is available. In the conditions prevailing it is unlikely that the laundry staff could undertake the complete finishing of laundry goods and these will be issued therefore in the rough-dried condition only, after re-sorting.

15. Deodorization

Clothing contaminated with lewisite retains a strong smell of geraniums even after decontamination. The smell can be removed by airing in the open, although as long as 14 days may be required to effect its complete removal. This deodorization can be done in 2 hours, however, by the immersion of the clothing in a cold solution of 2 lb. of Chloramine T to 10 gallons of water. One gallon of the solution is required for each pound of clothing. After treatment the clothes should be rinsed and hydroed again. Deodorization in the Chloramine T solution can be done in the washing machine, but the machine should not be used for this purpose to the exclusion of the main requirements, *i.e.*, initial decontamination.

LEATHER AND OILSKIN

16. Decontamination of leather articles

Leather articles are irreparably damaged if subjected to direct contact with steam or boiling water. Decontamination by weathering or by the evaporation of the gas in hot dry air conditions is possible, but the process is slow and the results uncertain. Baking is also liable to cause damage, especially if the articles are not thoroughly dried beforehand.

It is necessary therefore to treat leather articles by immersion in water of a comparatively low temperature, namely, 120 to 130° F.

(*a*) Articles worn over clothing, footwear, gaiters, etc.—immerse for 2 hours.

(*b*) Braces, webbing, worn next to or adjacent to the skin—immerse for 6 hours.

Notes

(i) If decontamination is done in the washing machine, the cage may be rotated and the load prodded as for cottons.

(ii) One gallon of water should be used for each pound of leather, and the temperature must be kept within the limits specified.

(iii) As much of the free liquid contamination as possible should be wiped off before the immersion treatment.

17. Drying

After immersion the goods should be drained and allowed to dry evenly in a warm atmosphere (approx. 100° F.). Boots and shoes should be dried on trees or formers. If these are not available, the footwear should be packed to shape with paper.

Certain made-up leather articles containing glue are liable to be damaged even by this immersion process, and nearly all leather goods will require polish or dubbin to restore the flexibility of the leather.

18. Decontamination of oilskin

The decontamination of oilskin clothing requires particular care to prevent damage to the oil proofing. Boiling water must not be used because of the deleterious effect of steam on the proofing and the similar liability to damage occasioned by agitation. It is important, therefore, to keep the oilskin garments flat and to prevent them sticking together or rubbing. A laundry machine is not suitable for this operation

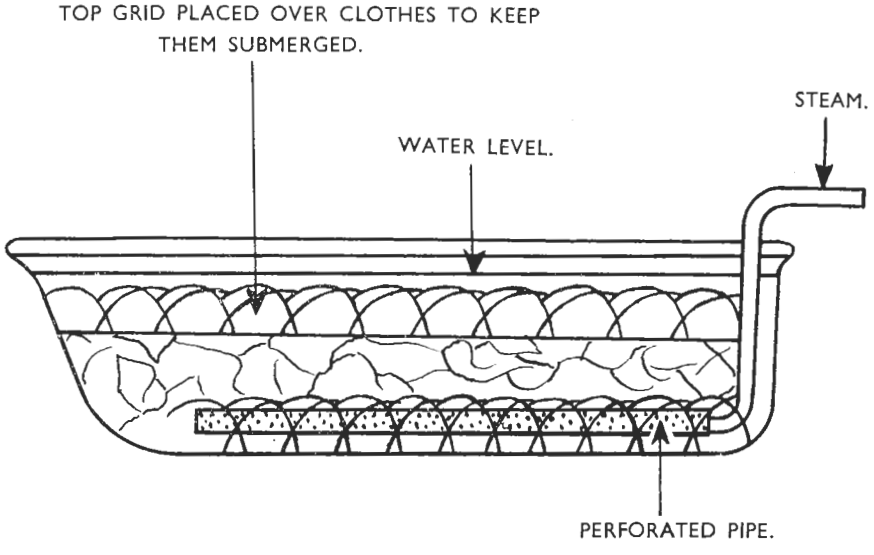

Fig. 98.—Use of long bath for decontamination purposes.

and the process of decontamination must be carried out in a long bath or suitably fitted tank.

The process of decontamination consists of folding the oilskin articles, using the minimum number of folds, and placing them on a grid in a bath or tank full of water. A heavy grating is placed on top to keep the oilskins immersed. The water should be maintained at a temperature of between 203° F. and 210° F. (just below boiling point) for the period shown in Table 10.

About 6–8 heavy oilskin suits can be dealt with in one full bath. The water should be changed between each batch. On completion of the immersion, the oilskin clothing must be removed very carefully to prevent the oil film surfaces sticking together and so stripping off the protective layer. The garments should then be placed on hangers and allowed to dry. Drying should be effected preferably in a well ventilated space in a temperature not exceeding 120° F.

IMPROVISATION

19. In small ships in which no laundry machinery, or unsuitable machinery (domestic washing machines), is installed, the equipment for effecting decontamination must be improvised. A satisfactory arrangement can be made by using the long bath normally installed in officers' bathrooms.

A typical arrangement is shown in Fig. 98.

The processes and temperatures for different types of materials are generally the same as those adopted for decontamination when using the washing machine.

If the bathroom is provided with one side-scuttle only, ventilation should be augmented by the use of portable suction fans of the type used in cleaning closed tank compartments.