

Procedure to sterilise COVID-19 infected PPE by using heat

ITU-DEP-70/30 Rev.21-5-2020

Juan Manuel Jurado Lora
Defence Garments Business Development Director



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1. CURRENT STATUS

The current widespread use of PPE to fight the COVID19 virus is causing an increase in demand which is very difficult to meet by the existing supply capabilities and a significant generation of waste.

Most PPE are manufactured using materials that are unsuitable to be reused and made safe again by means of traditional washing and sterilisation with liquids.

Due to the extreme lack of availability, many PPE users are forced to keep wearing them without performing an effective and safe sterilisation. This might result in an increased risk of virus propagation.

2. OBJECTIVE

Achieve a safe disinfection of face masks, gloves and garments used in the current COVID19 crisis, in such a way that they can be reused again.

Develop a simple, cost and time effective process to ensure mass sterilisation using readily available equipment.

Enable PPE user groups to undertake sterilisation of their own equipment, increasing safety and protection.


Reduce uncertainty by developing a robust procedure, certified by an Accredited Microbiology Institute.

Maximize the safety of the user by expanding the procedure to other types of workwear or garments that can withstand the sterilisation process.


To contribute to the reduction of the environmental impact of the enormous volume of PPE discarded after a single use.

3. PROPOSED SOLUTION

Based on the information available through various channels such as:

 **Stanford**
MEDICINE Stanford, California USA.
<https://stanfordmedicine.app.box.com/v/covid19-PPE-1-2>

+IMC+ 北京国际医疗中心
INTERNATIONAL MEDICAL CENTER-BEIJING
<http://www.imcclinics.com/english/index.php/news/view?id=83>

 **NCBI National Center for Biotechnology Information**
• <https://www.ncbi.nlm.nih.gov/pubmed/14631830>



Sterilisation of COVID19 infected PPE using heat - Procedure

We propose to sterilise COVID19-exposed PPE by subjecting them to a dry, liquid-free process (to avoid component degradation) at a temperature between 70°C to 90°C, using readily available equipment such as household or professional appliances: TUMBLE DRYERS, ELECTRIC OVENS, GAS OVENS, etc. Validate the effectiveness of the process via tests performed at an accredited microbiology laboratory. The lab would perform a controlled contamination of the PPE with COVID19 viruses, then a dry heating of the PPE in a TUMBLE DRYER between 70°C and 90°C to later certify that the PPE are virus free. This decontamination procedure is the least aggressive for the masks and allows up to 20 cycles of treatment while maintaining its effectiveness as evidenced in the reports made by Stanford University School of Medicine available in the following links:

- This report shows that this treatment does not affect the properties of the masks after 20 cycles:
<https://stanfordmedicine.app.box.com/v/covid19-PPE-1-2>
- This other link is the studies that show that the treatment with dry heat 75°C and 30 min does not affect the adjustment of the masks to the face:
<https://www.medrxiv.org/content/10.1101/2020.04.14.20062810v1.full.pdf>

Operating rooms and high-risk healthcare personnel should always use new PPE, not PPE that have been subjected to this procedure.

NOTE: All the equipment and machinery described in this document have been detailed in order to facilitate quick access to users of models that we have verified meet the necessary requirements. We are convinced that there are many other brands and models on the market that can meet these requirements and that they can be added as their validity is verified.

4. PROCEDURE VALIDATION

4.1. Tests at an Accredited Microbiology Laboratory

The validation of this procedure has been performed at the IVAMI (Valencian Institute of Microbiology, Spain). The process followed involved a controlled contamination of the sample with COVID19 viruses, heating the sample in a household standard tumble dryer at temperature between 70°C and 90°C for 30 minutes and then checking the sample again to verify a complete sterilisation.

The official document from IVAMI is the **Report Nº D/20/307** where the virucidal activity of this procedure is confirmed.

4.2. Tumble Dryer

The procedure requires a temperature over 70°C for a set amount of time. We have purposely chosen a readily available household appliance such as a standard tumble dryer.

For larger user groups it is possible to use a higher capacity, industrial grade tumble dryer.



Point 5 details some of the models that have been tested.

4.3. Wireless temperature sensors

A calibrated wireless sensor is the best tool to ensure that the PPE inside the drier drum reach the required temperature of over 70°C and is maintained for more than 30 minutes. Any other temperature measurement outside the drum will not directly correlate to the values inside. It is not recommended to pause the process and open the drum to take temperature measurements either.

There are many commercially available calibrated temperatures sensors with a tolerance of less than 1°C.

Some of these sensors are shown on point 6 of this document.

4.4. Sealed waterproof bags

The bag must comply with the following requirements to avoid any virus spread due to hot air escaping the bag:

- Waterproof fabric
- Resistant to temperatures up to 120°C
- Sealed closure system
- Suitable to be placed in a bucket, covering the rim in such a way that the contaminated PPE can be safely placed inside.

More details about the bags are show on point 7.

5. TUMBLE DRYERS

We have analysed both household appliances for small groups or individual use and commercial and heavy-duty industrial tumble dryers.

5.1. HOUSEHOLD TUMBLE DRYERS

These are the main features of a suitable tumble dryer:

- The whole process must be done in DRY conditions as most PPE cannot be cleaned using water because they will get damaged and suffer a loss of protection.
- Able to reach a temperature above 70°C and maintain it for at least 30 minutes.
- It should be verified by the use of wireless thermometers, that inside the PPE introduced in the dryer drum, this temperature is exceeded during the required time.



IMPORTANT NOTE:

Most modern tumble dryers have an automated moisture control system. This system constantly monitors the humidity level inside the drum so that if a fully dry condition is detected, they will stop to save energy. This system needs to be bypassed for the required procedure to take place.

In particular, tumble dryers featuring "heat pump" technology are not suitable because they are designed to work with temperatures below 70°C as a key element of their energy saving capabilities.

"CONDENSER" type tumble dryers can be used as long as they fulfill the requirements indicated above.

Please find below as an example a couple of dryers where we have been able to verify the compliance with the required features.

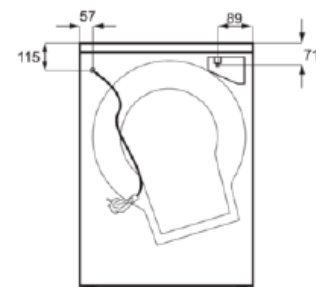
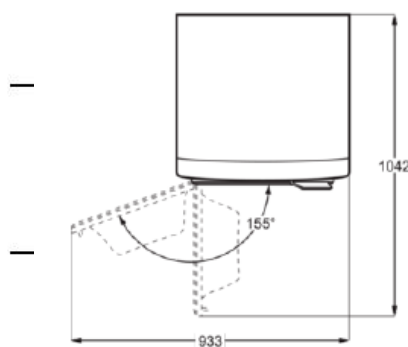
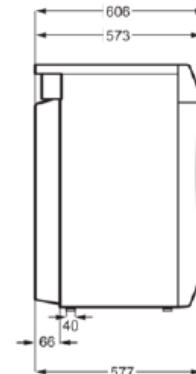
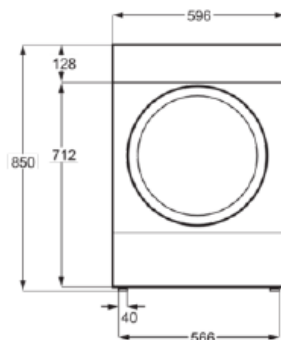
This dryer has been tested for its full dry temperature curve and has been verified that it does not need to disconnect moisture sensors.



Sterilisation of COVID19 infected PPE using heat - Procedure



ZDP7202PZ1 Secadora de tambor



Características :

- Capacidad de secado: 7 kg
- Secadora de condensación: la ropa se seca mediante una corriente de aire caliente y el vapor del agua se condensa en un depósito interior, lo que permite su instalación en cualquier lugar.
- Secado por sensores (automático)
- Secado por tiempo
- Función Autorreverse
- Inicio diferido
- Indicadores de: Limpieza condensador, Inicio diferido 3h, Inicio diferido 6h, Inicio diferido, Filtro con pelusa, Programa suave, Programa antiarrugas 90 min, Depósito lleno, Secado en 60 min
- Posición y capacidad del depósito condensación: Panel izquierda, 4.66
- Fácil acceso la limpieza del filtro desde el frontal de la secadora
- Patas: 4 patas ajustables

Datos técnicos :

- Tipo : Secadora de condensación
- Capacidad de secado (Kg) : 7
- Etiqueta Energética : Clase B
- Tambor : Estándar
- Filtro OKOFlow : No
- Funciones de los pulsadores : Inicio diferido (LED), Tipo de secado, On/Off, Opciones, Programas, Inicio/Pausa
- Programas de algodón : No
- Programas Sintéticos : --
- Duración estándar del programa de secado Seco para el Armario a 1000 rpm : 129
- Duración estándar del programa de secado Seco para el Armario a media carga y 1000 rpm : 72
- Consumo de energía Modo Apagado (W) : 0.5
- Consumo eléctrico ponderado en el modo «en espera» en W : 0.5
- Consumo energético estándar del ciclo de secado Seco para el Armario a 1000 rpm : 4.23
- Consumo energético estándar del programa de secado Seco para el Armario a media carga y 1000 rpm : 2.29
- Duración ponderada del programa (min) : 96
- Clase de la eficiencia de la condensación en una escala de G (menos eficiente) a A (más eficiente) : B
- Eficiencia de la condensación ponderada del programa normal de algodón con carga total y parcial' : 81
- Eficacia ponderada de condensación : 81
- Nivel de Potencia Sonora dB(A) : 67
- Instalación : de libre instalación
- Alto (mm) : 850
- Ancho (mm) : 596
- Fondo (mm) : 577
- Fondo total (mm) : 606
- Frecuencia (Hz) : 50
- Voltaje (V) : 230
- Potencia (W) : 2800
- Color : Blanco
- Marca : Zanussi

Descripción del

Secadora de 7 kg, Inicio diferido 3-6-9 h, Programas automáticos, Blanca, Clase B / A (Energía, condensación)



Sterilisation of COVID19 infected PPE using heat - Procedure

SIEMENS

**iQ500, Lavadora-secadora, 10/6 kg,
1400 rpm
WD4HU540ES**



A



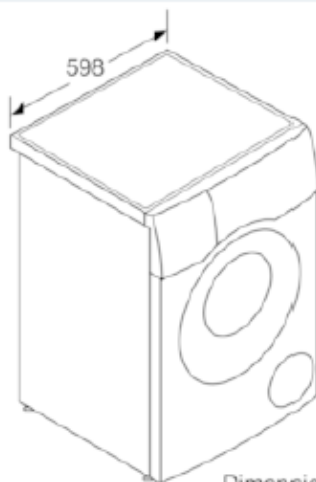
Lavar&secar todo en un solo ciclo en tan solo 60 min es posible con la lavadora función secado. Además, se conecta a tu móvil vía Home Connect

- ✓ Acceso y control de tu lavadora estés donde estés con la App Home Connect (disponible para iOS y Android).
- ✓ Lavar y secar en solo 60 min es ahora posible gracias al nuevo programa lavar&secar 60 min.
- ✓ El sensor de humedad evita que las prendas encojan durante el secado.
- ✓ Programa microfibras+impregnación: lavado respetuoso con las prendas outdoor impermeables.

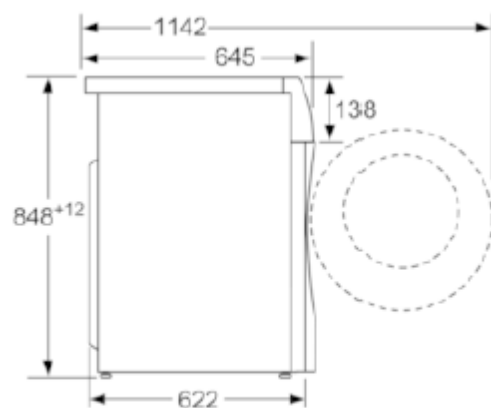
Equipamiento

Datos técnicos

Tipo de construcción : Independiente
Encimera extraíble : No
Bisagra de la puerta : Izquierda
Longitud del cable de alimentación eléctrica (cm) : 210
Altura de la encimera extraíble (MM) : 850
Dimensiones del aparato: alto x ancho x fondo (sin puerta) : 848 x 598 x 620
Peso neto (kg) : 84,307
Volumen del tambor : 70
Consumo eléctrico standby/red. Consultar el manual de instrucciones sobre cómo desactivar el módulo WIFI : 1,1
Temporizador en espera/red : 20,0
Código EAN : 4242003850398
Potencia de conexión (W) : 2050
Intensidad corriente eléctrica (A) : 10
Tensión (V) : 220-240
Frecuencia (Hz) : 50
Certificaciones de homologación : CE, VDE
Consumo energía (lavado y secado, carga completa) : 6,82
Consumo energía (sólo lavado) : 1,22
Consumo de agua (lavado y secado, carga completa) : 125



Dimensiones en mm



Dimensiones en mm

This is a washer-dryer made by SIEMENS and featured on this procedure because it has been verified his TEMPERATURE/TIME curve and its compliance with the requirements. The correct machine settings have to be used, in particular programming for a drying cycle at the temperature and time required, as well as closing the water inlet valve to minimise any risk of moisture. As a final reminder it is important to double check that the moisture control system is deactivated.



5.2. COMMERCIAL AND HEAVY-DUTY INDUSTRIAL TUMBLE DRYERS

These appliances must meet the same requirements as their household equivalent with regards to temperature and time.

This is the smallest capacity tumble dryer where we have verified its suitability with the procedure.



Main specifications		
Capacity (1:20 loading ratio)	kg (lb)	13 (28.7)
Capacity (1:25 loading ratio)	kg (lb)	10.4 (22.9)
Drum volume	dm3 (cu ft)	260 (9.2)
Drum diameter	mm (in)	736 (29.0)
Sound level	dB(A)	< 61
Electric Heating		
Power	kW	12.3
Machine dimensions		
Width	mm (in)	798 (32.5)
Depth	mm (in)	985 (43.0)
Height	mm (in)	1522 (66.1)
Electrical versions		
Gas/Steam 200-240V 1Ph 50/60Hz	kW(A)	0.9 (5)
Electric 200-208V 3Ph 50/60Hz	kW(A)	13.2 (39)
Electric 380-400V 3Ph 50/60Hz	kW(A)	13.2 (22)
Electric 415V 3Ph 50/60Hz	kW(A)	13.2 (21)
Reduced Electric 200-208V 3Ph 50/60Hz	kW(A)	9.9 (29)
Reduced Electric 380-400V 3Ph 50/60Hz	kW(A)	9.9 (17)
Reduced Electric 415V 3Ph 50/60Hz	kW(A)	9.9 (16)



6. WIRELESS TEMPERATURE SENSORS

As explained earlier, these sensors will help us to verify that the required temperature has been reached and maintained for the set amount of time. It is essential that they are placed inside the sealed bag together with the PPE.

These sensors will constantly measure the internal drum temperature. They are the tool to verify that the procedure has been followed in such a way to achieve a successful sterilisation.

Information is stored inside the sensor itself and can be downloaded via a USB port into a computer straight after the drying process has finished.

Requirements:

- Temperature range up to 120°C at least. Even if the working temperature must be between 70°C and 90°C it is important to ensure that temperatures above 90°C are not reached so that the PPE is not damaged.
- They need to be precise, tolerance below 1°C.
- Rugged construction, able to withstand vibration and shocks caused by the rotating drum.
- Durability must be around 1 year, including the batteries.

Based on our initial research, we have found the following two temperature sensors that meet the required specifications.

6.1. TEMPERATURE SENSOR-DATALOGGER-357-704



Datalogger USB – Extended Temperature Range



This datalogger measures and stores up to 32000 individual temperature data values in a range between -40°C to 125°C (+257°F). A 316 stainless steel outer shell provides excellent corrosion resistance properties as well as superior shock and vibration resistance, offering a IP67/NEMA 4X rated sealing. Powered by 2/3AA 3.6V Lithium batteries able to store data for up to three years. Setting and data transfer is done via a USB port using a software compatible with Windows 7, 8 and 10. Data can be showed as graphs or exported.

- Extended Temperature Range: -40 to +125°C (-40 to +257°F)
- Outer shell made of 316 stainless steel
- IP67 rated
- Setting and data transfer via USB port
- Data logging can be done in manual or programmed mode
- Includes internal battery and software
- Programmable parameters: device ID, units of measurement °C or °F, logging interval (1s, 10s, 1m, 5m, 30m, 1h, 6h 12h) logging start and finish, data overwrite (always keeps the last values overwriting the oldest)

LINK: https://www.tcdirect.es/Default.aspx?level=2&department_id=130/9



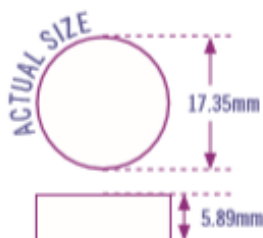
6.2. SIGNATROL SL53T



SL53T
Records Temperatures Up To 125°C
Temperature Only

TEMPERATURE RANGE
0°C to 125°C

ACCURACY
±0.5°C from +20°C to +75°C
±1.0°C from 0°C to +20°C and
+75°C to +115°C
±1.5°C from +115°C to +125°C



SL50 INTERFACE-USB

USB communication interface for connecting all SL50 series data loggers to a computer.

TempIT-LITE (Free of Charge)

This enables all SL50 series miniature button data loggers to be issued with all relevant parameters set and data retrieved and displayed using a powerful graphics engine.

It is necessary to purchase both the SL53T sensor and the USB SL50 INTERFACE cable. Free software TempIT-LITE, can be downloaded on the link below:

<https://www.signatrol.com/products/data-logger-software/tempit-graphical-analysis-software>



SL50 SERIES - MINIATURE BUTTON DATA LOGGER TECHNICAL SPECIFICATIONS

PRODUCT	SL51	SL52, SL53, SL54 & SL55
POWER SUPPLY	Internal, non-replaceable 3.0V lithium battery	
BATTERY LIFE	10 years or 1 million samples	Approx 1 year at 80°C and approx 5 years at 30°C (10 min sampling) see battery life calculator on our website
SAMPLING	1 to 255 minutes	2 seconds to 24 hours (SL53 & SL55 1 second to 24 hours)
MEMORY SIZE	2048 readings	8192 measured values with 8 bits (4096 SL54) or 4096 measured values for 11 bit (2048 SL54)
RESOLUTION	0.5°C (8 bits)	0.5°C (8 bits) or 0.07°C (11 bits) / 0.64% RH (8 bits) or 0.04% RH (11 bits)
RESPONSE TIME	Approximately 90 seconds (in air)	
DIMENSIONS	Ø 17.35mm × 5.89 mm	
WEIGHT	4g (SL54 5g)	
HOUSING MATERIAL	305 stainless steel	
PROTECTION CLASS	IP55— splash proof; IP68— enclosures for higher protection classes are available (see pages 6 & 7)	
EX-CERTIFICATION	ATEX Certified & Meets EN50014 and EN50020 standards for Group I (Zone 0) gas atmospheres only	
PC CONNECTION	USB interface	
TIME, MAX. DEVIATION	± 2 minutes per month	
RECORDING MODES	Ring buffer or stop when full	
START TIME DELAY	Max. 45 days at 1 minute measuring frequency	Max. 12 months at 1 minute measurement frequency
START ON ALARM	No	Possible
CALIBRATION	Annual re-calibration reminder function setting	



CALIBRATION & RE-CALIBRATION SERVICE

We can provide you with an individual UKAS ISO 17025 traceable calibration certificate with each of your new data loggers as an option. In addition, we can also provide you with a 3-day turnaround UKAS ISO 17025 traceable re-calibration service for your existing data loggers. We provide our standard 3-point default re-calibration or, your own custom 3-point calibration range at no additional cost. Extra points can be added at an additional cost if required. Please contact for your calibration requirements.

STARTER KITS

Starter kits are available providing you with everything you need to get going.

THE KIT INCLUDES:

- 2 or 5 data loggers of your choice
- Each data logger comes with an individual 3-point UKAS traceable calibration certificate
- TempIT-PRO software
- A USB communications / programming cable

DISTRIBUTOR IN SPAIN:

Instycal S.L.
Parque Industrial Los Llanos
C/ Extremadura, 145
41909 Salteras
(Sevilla)
Tfno. +34 954 999 601

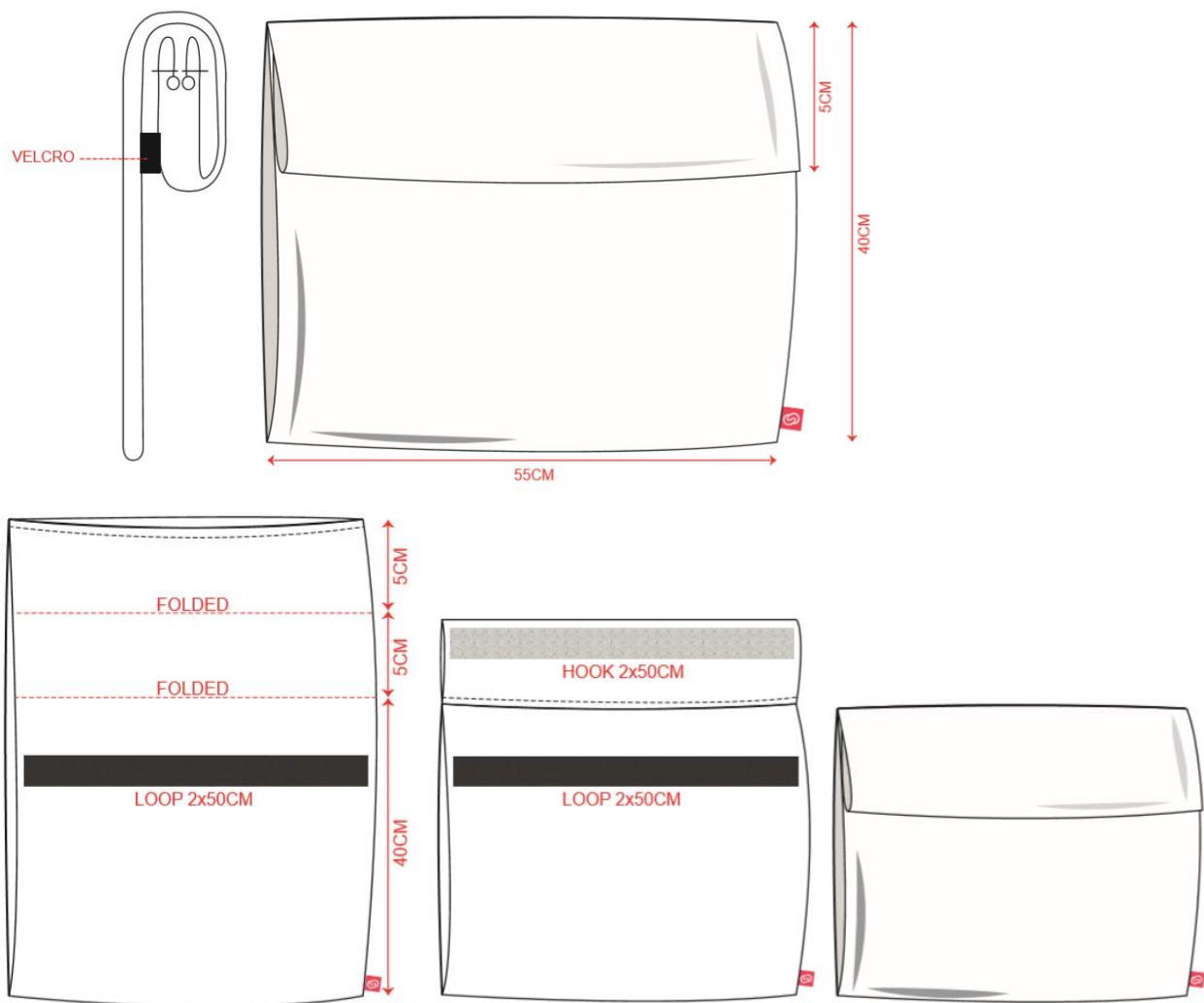
7. SEALED WATERPROOF BAG

To avoid the risk of virus contamination from the hot air coming out of the dryer, a bag that meets the following requirements should be used:

- Waterproof fabric
- Resistant to temperatures up to 120°C
- Sealed closure system
- Suitable to be placed in a bucket, covering the rim in such a way that the contaminated PPE can be safely placed inside.
- For multiple users it is recommended to label each bag to a person.



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Placing the bag in a holding system so that the PPE to be sterilised can be safely placed inside together with the wireless temperature sensor:





Sterilisation of COVID19 infected PPE using heat - Procedure

Other types of commercially available bags include the ones used for outdoor activities:

USING WATERPROOF PVC FABRIC:



USING WATERPROOF POLYAMIDE FABRIC:



8. ALTERNATIVE EQUIPMENT

As an alternative to tumble dryers it is possible to use other devices that meet the following criteria:

- Able to perform a DRY process, without using water or any other chemical that can damage or alter the PPE properties.
- Controlled shock and vibration so that the PPE are not damaged.
- Able to reach and maintain a temperature above 70°C but below 90°C during more than 30 minutes
- No contact zones with the sealed bag with local temperatures over 100°C.
- For effective temperature control on PPE, wireless thermometers placed between the PPE should be used to record the temperature of the entire cycle.

Examples of equipment:

- ✓ **Household electric ovens.**
 - Special attention not to reach temperatures higher than recommended.
 - Do not place the bags directly on metal surfaces. Use wood or cardboard instead.
- ✓ **Industrial electric and gas ovens:**
 - Same temperature restrictions as above.
 - Allow for the use of trays and trolleys that contain several bags.
 - Do not allow for direct contact between the bags and any metal surface.



Sterilisation of COVID19 infected PPE using heat - Procedure

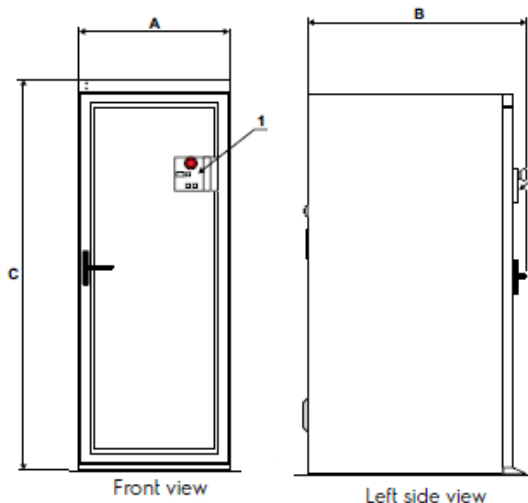
- The temperature must be controlled at different heights. To do this, place wireless thermometers at least in the upper and lower tray where the extreme temperatures will occur and verify that they are in the range 70°C and 90°C.

➤ Drying cabins

- Can maintain temperature between 70°C and 85°C for more than 30 minutes.
- Possibility of hanging or placing on trays at different levels



Garment finishing cabinet FC4 8



Dimensions in mm

A	Width	870
B	Depth	1300
C	Height	1975



9. PPE REMOVAL PROCEDURE

No used PPE must get into contact with any object other than the open bag where it will be placed for the sterilisation procedure.

To aid with the process it is possible to place a 1 x 1 m piece of fabric or paper, to avoid that any PPE is dropped on the floor. The fabric can also be placed inside the bag for sterilisation. If paper or cardboard is used, it needs to be disposed of by folding it over the side free from contamination.

Please see below for videos with advice on how to perform these actions safely:

UNIVERSITY COLLEGE LONDON HOSPITALS- NSH
<https://www.youtube.com/watch?v=WXMpAraPZeg>

SALUSPLAY – Putting on and removing PPE
<https://www.youtube.com/watch?v=PjDZkIhS0a4>

HOSPITAL UNIVERSITARIO FUNDACION ALCORCON
<https://www.youtube.com/watch?v=0BN-hU4oAtI>

HOSPITAL UNIVERSITARIO MARQUES DE VALDECILLA
<https://www.youtube.com/watch?v=zh-0br7NrDY>

OSAKIDETZA
<https://www.youtube.com/watch?v=OurZpwRPEQ8>

CLINICA UNIVERSIDAD DE NAVARRA
<https://www.youtube.com/watch?v=W07nqrUF3IU>

GOBIERNO DE NAVARRA-DEPARTAMENTO DE SALUD
<https://www.youtube.com/watch?v=J7CV6abHNNw>



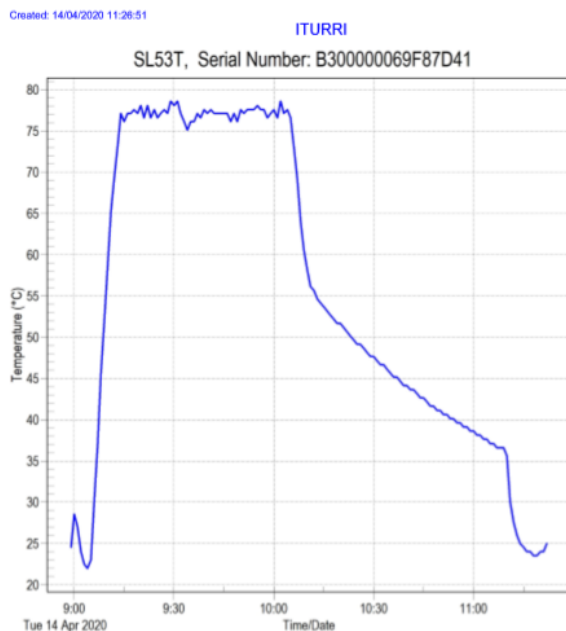
10. PPE STERILISATION PROCEDURE

10.1. Tumble drying programming

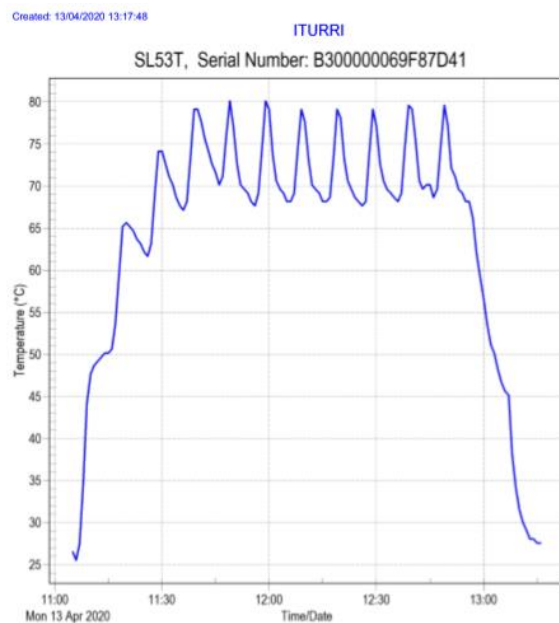
Before the first sterilisation procedure, to work with a dryer cycle that meets the time of more than 30 minutes at a temperature of more than 70 °C required for decontamination, an initial test should be done with the wireless thermometer, simulating the protocol with PPE or uncontaminated clothing, putting them in the waterproof bag along with the thermometer. Once the programmed cycle has been completed, we will download the thermometer's data record into the computer, which will give us a TEMPERATURE/ TIME curve with which we will verify that the time required at more than 70°C and less than 90°C is met.

As an example, the two graphs shown below have been obtained in the Zanussi ZDP7202PZ1 model dryer, verifying that both short and long cycles maintain a temperature above 70°C for more than 30 minutes:

SHORT CYCLE 50 minutes



LONG CYCLE 75 minutes



10.2. Placing the PPE and sensor inside the bag

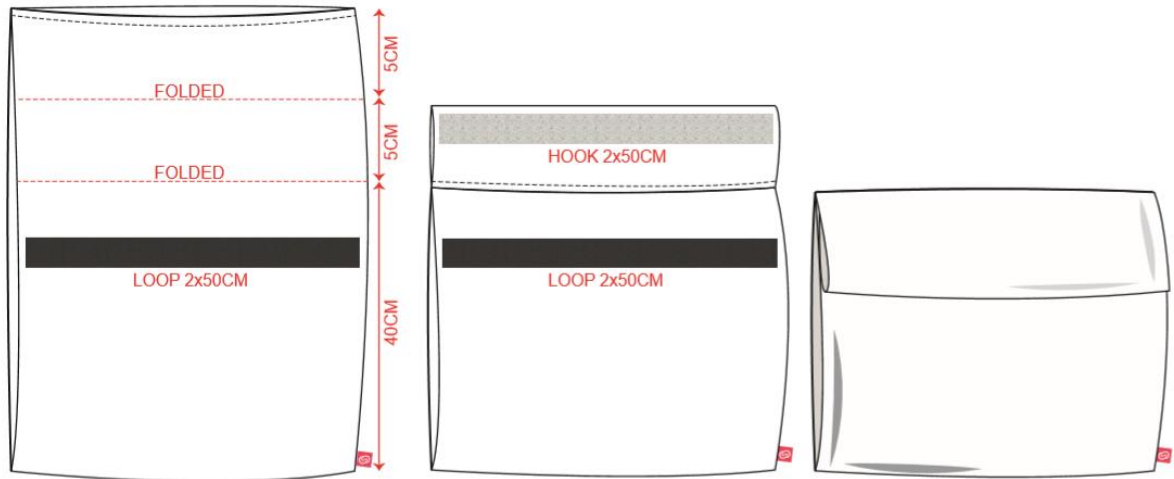
Once this is done the bag can be sealed manually placing the hands on the non-contaminated side:





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Next, the bag can be fully and safely sealed by folding it twice and securing it with the Velcro as shown:



Next the bag can be placed inside the tumble dryer for the sterilisation process to begin. Once this is finished and the bag is removed from the appliance and opened, the sensor can be retrieved and connected to a computer to download and analyse the data, making sure that the correct temperature curve has been achieved.



11. NOTES RELATED TO RESPONSIBILITY IN THE APPLICATION OF THIS PROCEDURE

The aim of this process is to help users affected by the lack of availability of PPE equipment, by offering them an alternative to reuse such equipment.

The validity of this protocol is based on the information available from various expert Organizations such as those indicated in point 3 and on the results obtained in the IVAMI Microbiology Laboratory, report No. D/20/307

ITURRI SA will not be held responsible by the results of the application of this procedure by any user, company or organisation.

The condition of the used PPE is essential to avoid infection by the COVID19 virus and as such it is not advisable to sterilise PPE that are damaged or broken.

It is the users' responsibility to verify the condition of their PPF and the correct application of this procedure.

12. FINAL NOTES

We must consider that our interest is to share the information with the community as soon as possible so this document will be disseminated considering that it can be updated with all the information of interest to help their objectives obtained in the near future.

This document is published in an open way so that any user can benefit from its application. For those organisations or groups of users who request it, Iturri has the capacity and experience to supply the various types of equipment required to carry out the protocol, as well as the possibility of providing the service for large groups.

We are aware that the need to use PPE for protection against viruses and bacteria will not be limited to the time it takes to solve the present crisis, but will extend over time, becoming a widespread requirement for daily use. Therefore, the possibility of their safe reuse through a decontamination process can solve a serious supply problem and greatly reduce the generation of waste and its ecological impact.