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STANDARD OPERATIONAL PROTOCOL (SOP) FOR DRY CLEANING OF THE APPROACH CLOTHING (RA) OF THE AMAZONAS MILITARY FIRE BRIGADE

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Abstract: The physical protection of military firefighters is complemented by the use of Personal Protective Equipment. Among them, Apparel Clothing stands out, which is the central theme of this study regarding its washing and processing steps. The search for information was undertaken through a bibliographic review, as this study format offers relevant contributions to the research. Information was found on the correct methods of washing and drying PPE to ensure full enjoyment of its protection benefits. It is hoped that this research will resolve doubts about the correct method of washing and assist the CBMAM institution in the process of implementing a SOP regarding the hygiene of approach clothes.Tooghether us is the team of EST/UEA providing support technic and scientific to solve this problematic surged among the coians fireworkers. The CBMAM commander determinates the creation of a labor force to develop an method practic and fast to sanitize the aprroximation clothes.
Keywords: Military Firefighter, Approach Clothing, Washing, Procedure

INTRODUCTION

Military firefighters (BMs) are a category of professionals within the Security Forces exposed to a high and varied number of occupational risks due to the characteristics of the situations attended, which are capable of causing illnesses and accidents at work. These adverse situations that are inherent to the type of work usually involve extreme situations, such as long hours of exposure to heat and smoke, without rest breaks (FORLIN, 2005).

The health of combatants requires attention because results of analyzes on BMs that acted in the final phase of fires with the presence of elements such as benzofluoranthene and many other types of PAHs with reported carcinogenic action indicated deposition in the skin, suggesting dermal absorption as

a potential route exposure to these agents (BAXTER et al., 2014).

The presence of dust, gases and vapors that come into contact with BM fighters in mission environments is also considered by Baumgart et al. (2017) and Contrera-Moreno (2012), a circumstance that deserves to be treated with great attention and importance.

RA is a wearable PPE that was designed to protect firefighters from the high temperatures emanating from fires. ARs have been used since the 1930s, they consisted of suits that had asbestos or asbestos in their composition, today they are improved PPE (BOMBEIROS, 2022).

The material used to manufacture the AR is made up of a combination of layers of fabric, air and also flame-resistant material and chemical retardants. The RA consists of a cape and pants, both made from a special aramid fiber fabric, which can withstand up to 800ºC during missions. Therefore, the need for careful care when cleaning this suit is inferred (BOMBEIROS, 2022).

RA protects you from contact with chemical materials and prevents superficial wounds from contact with sharp surface objects. Maintaining the integrity and extending the useful life of AR is so important that in some countries it is mandatory to add labels containing cleaning and handling instructions to clothing items (KPN SAFETY, 2021).

DEVELOPMENT

The chemical/physical phenomenon of combustion is explained didactically in operational courses using the fire triangle, which is composed of: oxidizer, ignition source and fuel. In the same way, the example of the fire tetrahedron is used, which adds a chain reaction to the aforementioned elements (CBMDF, 2009).

Figure 01: Triangle of Fire

Source: Britez, Carvalho e Helene (2020).

For clarification purposes, the combustion reaction is illustrated (IARC, 2010) according to the following equation:

$CH4+2O2+Activation\ energy \Rightarrow CO2+2H2O+Heat+Light$

However, it should be noted that the equation above is an ideal situation, of complete combustion of methane, something that does not happen in real fires (CBMDF, 2009).

In urban fires in which polymers are commonly present, these molecules are degraded into simpler monomers, such as: methane, ethane, ethylene, vinylchloride, propylene, benzene, toluene, ethylbenzene, acrylonitrile, styrene, 1,3-butadiene , among others that are equally toxic. The burning of plastic materials also generates hydrogen cyanide (HCN), hydrochloric acid (HCl) and acrolein (CH_2=CHCHO) (IARC, 2010).

In view of the above, this work is justified by the need to implement standardization within the CBMAM corporation (Amazonas Military Fire Department) through the implementation of a SOP for the correct cleaning of ARs in order to increase the useful life of the product and maintain the integrity of its reliability in protecting the BM warfighter.

To achieve this goal, research efforts are being carried out regarding the characteristics of the specificities of cleaning RAs.

The objectives of the research are: to discuss the importance of sanitizing the approach clothing of CBMAM combatants; Research standardized cleaning and disinfection procedures for approach clothing; Evaluate the efficiency of proposed cleaning methods; Investigate, through laboratory analysis (chromatography, mass spectrometry and, in the future, microbiological analysis) the contaminating factors present in the ARs of CBMAM combatants

The RA model usually consists of 4 layers: external layer composed of 40% Polybenzylimidazole, 58% para-aramid and 2% antistatic fiber; the thermal barrier layer, made up of 95% meta-aramid and 5% para-aramid; an anti-humidity barrier layer, with a 100% polytetrafluoroethylene membrane, a non-woven layer, 85% meta-aramid and 15% para-aramid; and finally a lining composed of 50% flame-retardant viscose and 50% meta-aramid (NUNES, 2021).

METHODOLOGICAL PROCEDURES

The guiding question for this research arose from the initial concern about the health of the combatant in view of the arrival at the CBMAM command of worrying information about the possibility of inhaling potentially carcinogenic particulate material. This material may be accumulating on the suits after returning from incendiary events and being spread into the air by the combatant's movements.

The risk of the firefighter being infected by harmful particulate matter inspired the need to establish a SOP (standard operating procedure) for cleaning the RA in a simple and quick way to ensure that the firefighter can use his special suit to approach the fire in a few minutes. Taking into account the manufacturers' recommendations on washing aramid fiber clothing at most twice a year, it is believed that the implementation of the aforementioned SOP is very advantageous both in terms of increasing the useful life of the combatant's PPE and in providing a timely fit to the overloaded firefighting routine.

Figure 02: Establishment of the research partnership between the institutions

Source: The Authors (2023).

As no data was found in the scientific literature regarding a practical and quick cleaning procedure for RAs, the corporations that came together in this research seek to develop and disseminate a SOP that meets the cleaning needs of the CBMAM flame retardant uniform quickly, efficiently and practicality. The results of the research have already made it possible to publish the first stage of the process in the Atena publishing house in January 2023.

RESULTS

This research was carried out between the months of November 2022 and February 2023 in a multiple partnership between the CBMAM institution and teams of researchers from the laboratories of the Federal University of Santa Maria (UFSM), GERONTEC of FUnATI, chemical analysis

laboratory and microbiology at the Higher School of Technology of the State University of Amazonas (EST-UEA). The search for the result aimed to provide answers to a doubt that was present among the CBMAM military regarding the cleaning procedures of the RAs. Initial steps in this search had been taken in the study by Muniz et al. (2022).

1st stage – Knowing the technical properties of approach clothing

Initially, technical information about the composition of the RA was collected based on manufacturers' manuals and websites specializing in the sale of articles for military firefighters. The searches allowed us to understand the particularities that permeate the cleaning of ARs. This step demystified the erroneous concept that an AR can remain functional even when receiving the same treatment as other types of clothing. He also warned of the risk that the corporation is exposed through improper handling.

2nd stage – Investigation of macro and microscopic residues

AR parts used in a large fire that occurred in the city of Manaus in November 2022 were collected and made up our first test sample. The AR pieces were packed in plastic bags and quickly sent to the GERONTEC laboratory to carry out the sample collection stage.

Two extraction techniques were used: collection using adhesive tape and collection using swabs. Slides were prepared for observation under a microscope as a way of observing the previous proportion of the level of dirt present in the RAs after a mission. We also sought to investigate what types of dirt were present in the ARs.

3rd stage – Identification of possible harmful chemical contaminants

As mentioned previously, the analysis of the data generated in the first stage as well as additional readings clarified the need to delve deeper into the topic. The increasing proportion of the study therefore demanded the use of a greater number of ARs. Thus, in January 2023 new sets of RAs, this time originating from a fire in a shopping center and an explosion in a confined environment with fatal victims.

The new shipment of RAs was sent to the EST UEA chemical analysis laboratory to carry out two tests: I - a chromatographic analysis of possible chemical residues present in the fabrics. II – analysis of the same RAs after implementing previously established cleaning procedures.

At this stage, 42 vials were generated for chromatographic analysis, the first containing only cotton in order to identify which possible contaminants existed in the collection cotton and which could interfere with the result. The others were the result of friction extraction from cotton soaked in the solvents ethyl acetate, N-hexane or ethanol.

Figure 03: Solvents Ethyl Acetate, N-hexane and Ethanol that were used in the extraction

Sourcee: The Authors (2023).

Laudo: Voláteis na Roupa de Aproximação.

Tabela de Amostras

Solvente	1 - Acetato	2 - Hexano	3 - Etanol
Roupa 1	19–RS-MS-1	20-RS-MS-2	21-RS-MS-3
	22–RS-MI-1	23-RS-MI-2	24-RS-MI-3
	37-RL-MS-1	38-RL-MS-2	39-RL-MS-3
Roupa 2	25-RS-MS-1	26-RS-MS-2	27-RS-MS-3
	28-RS-MI-1	29-RS-MI-2	30-RS-MI-3
Roupa 3	31-RS-MS-1	32-RS-MS-2	33-RS-MS-3
	34-RS-MI-1	35-RS-MI-2	36-RS-MI-3
Capacete	40-CAP-1	41-CAP-2	42-CAP-3
Branco	1- BRANCO		

Figure 04: Sample Board

Source: The authors (2023).

The samples were extracted from areas demarcated by 225 cm2 molds (15x15 cm squares) on the upper and lower limbs of the RAs. Soon after, the cotton with the respective sample was placed in an identified vial and stored in the freezer.

Figure 05: Dirty Clothes

Source: The Authors (2023).

Figure 06: Samples for Chromatography

Source: The Authors (2023).

The same procedures were repeated for the RAs after the cleaning process was carried out with a product whose characteristics met the RA manufacturer's guidelines. The product consisted of a saponaceous liquid, sold in 1.5 L bottles and highly concentrated.

4th stage – flame resistance test

Still in January 2023, three more sets of RAs were obtained to undergo a test along with a newly purchased and never before used or washed set of RAs. The test took place in a container for training military firefighters located at the 1st BI (Fire Battalion), located on

Avenida Buriti, Distrito Industrial, Manaus. Participants were properly protected with the necessary PPE and RPE. A SAMU vehicle was also present to provide assistance in case of any complications during the test.

Three fighters wore an AR set, one of them wearing the new AR. The three fighters entered the container that was lit to simulate a fire rescue situation in a confined space. The fourth set of RA was carried into the container by the fighters and deposited next to the flames. The combatants remained under temperatures that exceeded 400ºC, performing movements in order to accumulate the debris exhaled during the test in their ARs. They evaluated the functionality of the air pocket inflation mechanism.

Figure 07: Flame resistance test

Source: The Authors (2023).

At the end of the test, the three combatants removed themselves from the container, bringing with them the fourth set of AR and reported their perceptions and displayed the condition of their respective suits.

5th stage – Microbiological analysis

In February 2023, the investigation phase into the microorganisms present in ARs began. This phase had the support of the EST UEA microbiology laboratory team.

A new set of RAs already used in missions was brought to the laboratory on February 2, 2023 and samples were obtained with the help of swabs. The samples obtained were cultivated in 614 petri dishes (90x15 mm) with Muller-Hinton Agar (76 grams / 2L of culture medium) and Potato Dextrose Agar (97.5 grams / 2.5 L of culture medium). culture).

Figure 08: Petri Dish Seeding

Source: The Authors (2023).

DEVELOPMENT

As the research progressed, new results were added and discussed. The results referring to the solid waste research stage refer to the types of solid waste found in ARs.

The following images demonstrate the large proportion of dirt that was present under microscopic observation, coming from the clothing sample:

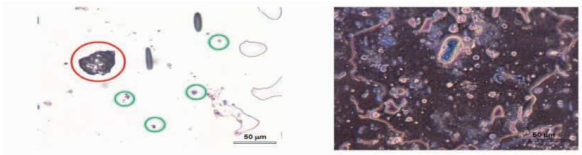

Figure 08: dirty microscope slides

Fonte: Os Autores (2023).

However, after the cleaning procedures with the listed product, the same procedures were repeated and brought surprising and satisfactory results in terms of cleaning. Below are photos of the microscopic slides showing the good results of the product's effects on the

tissue:

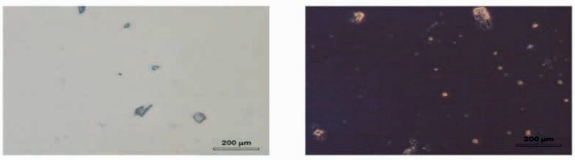

Figure 09: Microscope slides with dirt reduction

Source: The Authors (2023).

The results regarding the research stage of the chemical elements impregnated in the RA fibers brought initial results that were quite worrying. The presence of organochlorine molecules, a compound known for its carcinogenic potential, was detected.

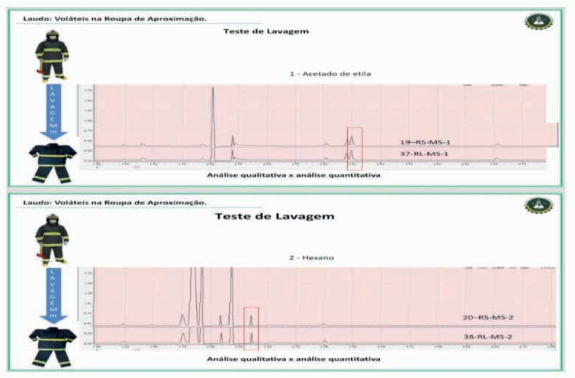

Figure 10: Chromatogram

Source: The Authors (2023).

The flame resistance stage brought worrying results by revealing that all three RAs that had already been used on missions and washed at home by combatants suffered losses in their functionality. The new RA was the only one that presented a satisfactory result in terms of fire resistance.

Combatants who wore previously used ARs reported feeling hot and burning their skin. When leaving the container, their RAs showed signs of burning tissue fibers, except for the new RA.

Figure 11: Burn marks on approach suit

Source: The Authors (2023).

FINAL CONSIDERATIONS

The results obtained with the use of the vacuuming technique and the use of the product were quite satisfactory for cleaning that does not require a washing machine. Considering that the CBMAM corporation has a very intense routine for dealing with incidents, it is necessary to establish a SOP that allows for adequate cleaning of RAs in a practical and satisfactory manner, saving combatants time as each person is responsible for cleaning their respective RA.

Careful cleaning of RAs with the help of a standardized flowchart can help prevent dermatological diseases and even cancer by avoiding the aspiration of soot particles from fires that adhere to the fabric and are released from it in the hours following the return of the mission through the physical movements of the combatant (GOMES, 2020).

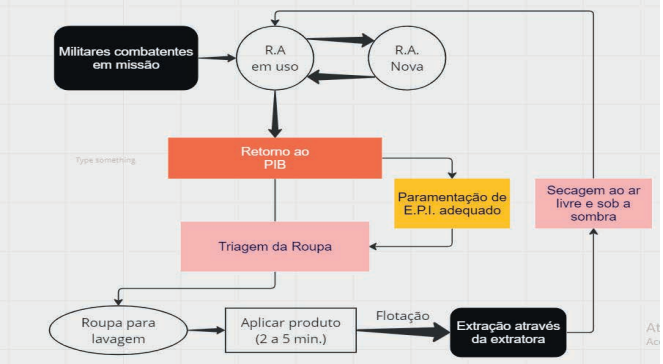

Figura 12: Flowchart prepared in the study

Source: The Authors (2023).

The construction of the flowchart above, including steps of the standard operating procedure, will help to eliminate informality, disparity in procedures and possible ineffectiveness or damage to RA material during cleaning. The definition of a product approved by experts consulted in this research will guarantee cleaning with a true reduction in bacterial load and solid particles.

Procedimento Operacional Padrão - Assepsia das Roupas de Aproximação de Incêndio do Corpo de Bombeiros Militar do Amazonas

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OBJETIVOS

•Geral: Padronizar o procedimento de assepsia das roupas de aproximação de Incêndio do Corpo de Bombeiros Militar do Amazonas

*** Específico:**

- Divulgar dentro da corporação a importância de um procedimento aceitável, eficaz e prático para higienização das roupas de aproximação (RA) associado ao uso correto a cada ocorrência.
- Preservar a vida útil das roupas de aproximação.
- Promover o cuidado à saúde ocupacional do bombeiro militar.

ALCANCE: Bombeiros militares combatentes da capital e interior.

SIGLAS:
- **CBMAM** (Corpo de Bombeiros Militar do Amazonas)
- **RA** (Roupa de Aproximação)
- **EPI** (Equipamento de Proteção Individual)
- **EPR** (Equipamento de Proteção Respiratória)

DEFINIÇÕES

EXTRATORA: É um equipamento desenvolvido para limpezas profissionais ou domésticas de diversos materiais como tecidos de carpetes, estofados, pisos frios entre outros. O Modelo **Karcher SE 4001** de alta pressão mais removedor foi o elencado para limpeza das roupas de aproximação (RA) de incêndio.

LIMPADOR: **Limpador universal Flot 500 -** Produto elencado para assepsia das RAs, flotador biodegradável.

GAIOLA: **Gaiola de Acondicionamento-** Suporte vasado contendo cabides para pendurar as Ras à sombra para secagem após lavagem.

PROCEDIMENTO

1- Após toda ocorrência de grande vulto o militar deverá separar a roupa de aproximação (RA) de incêndio em sua base ou batalhão para realizar assepsia dessa roupa;
2- Será feita a inspeção visual do estado da roupa para realizar a aspiração de quaisquer detritos e sujidades sólidos, utilizar equipamento de proteção individual (EPI) para procedimento, como: macacão tipo tyvek, luva de procedimento e/ou óculos de proteção;
3- A partir daí será necessário colocar essa roupa sobre uma bancada de forma que o militar consiga se posicionar para execução de limpeza
4- Para execução de limpeza será necessário a presença de dois militares, um para segurar a roupa, outro para utilização da extratora
5- A extratora deverá ser testada antes do manuseio, seguindo às instruções de uso conforme fabricante, a mesma deverá ser ligada na voltagem de 127V.
6- O processo de limpeza começa a partir da aspiração das sujeiras mais leves, em seguida será aplicado o produto ou solução química à superfície da roupa de aproximação de forma bem distribuída, deixar agir por 5 min.
7- Após agir no tempo necessário(5min), realizar a sucção do produto adicionado ao local limpeza, retirando a solução juntamente com a impureza na área trabalhada. Tudo isso fica reservado como água suja, que será dispensado após o uso.
8- A limpeza com aspersão e sucção da extratora deverá ser feita pelo menos duas vezes na parte externa e na parte interna da roupa, com movimentos retilíneos e aleatórios conforme a necessidade da RA.
9- Após limpeza pendurar a roupa à **sombra**, para a secagem em suporte suspenso ou gaiola de acondicionamento.

PREPARAÇÃO DO PRODUTO

- Para limpeza pesada da RA oriunda de ocorrência de grande vulto, utilizar limpador Universal Flot 500 na diluição 1:2 do produto, colocar a solução no dispenser da extratora e dispersar sobre toda a roupa representando tanto da parte externa quanto interna;
- Na diluição 1:2 será uma parte do produto flotador para uma parte de água corrente, homogeinezar a solução antes do uso.

Observações: É importante seguir de **forma criteriosa** todas etapas de assepsia da roupa de aproximação, aliado ao uso correto dessa roupa com seus equipamentos de proteção individual (EPI) e equipamentos de proteção respiratória (EPR) durante toda ocorrência. Relatar qualsquer intercorrências que ocasionalmente surjam para constante aperfeiçoamento deste POP.

EPR

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Figura 13: POP Institucional

Fonte: Os Autores (2023).

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