Editorial

New development of research on personal protective equipment (PPE) for occupational safety and health

There exist various kinds of physical, chemical, and biological hazards in the workplace. To protect workers from these hazards, it is not controversial that environmental management measures to remove or reduce these harmful factors and to improve the quality of workplaces through an engineering approach are fundamental solutions. However, in reality, there are many work sites where such decisively effective measures cannot be applied. In such situations, a work management approach utilizing personal protective equipment (PPE) is considered an alternative and significant means for protecting the safety and health of workers.

Recent industrial development, automation, and digitalization has led to increased safety and reduced need for personal protection at many workplaces, while there still remain a considerable number of jobs that continuously require protection and many countries where traditional work methods are prevalent. Simultaneously, the threats have changed and new types of risks have emerged due to changed processes, new chemicals and materials, and work routines. Thus, there are still several industries where the workers need to be protected from contamination within processes by utilizing PPE.

So far, many types of PPE have been developed to tackle this scenario. Nevertheless, their effectiveness and usability still remain incomplete. Thus, a new breakthrough for PPE is currently required.

Progress in advanced fiber materials, knitting and weaving technologies, fabric fabrication techniques, nanomaterials, and fiber composite materials technologies have been remarkable in recent years. Therefore, applying the results of these advanced technologies to the development of PPE is a highly promising approach.

On the other hand, even though protection of targeted harmful factors is successfully achieved by using effective PPE, such high performance of protection is likely to entail additional workloads on workers. One of the main burdens is the thermal impact caused by evaporative resistance and thermal insulation derived from the characteristics of PPE materials. The higher the evaporative resistance and insulation of the PPE, the greater is its heat stress, which tends to exacerbate the physiological and psychological heat strains of the users. Therefore, when designing and developing PPE, it is important to achieve both protective performance and thermal comfort considering its thermal properties.

From this viewpoint, this special issue was planned to represent state-of-the-art knowledge on the development and evaluation of PPE. It is presented by many internationally distinguished experts representing the fields of physical (stabbing[1], radiant heat[2], cold[3, 4], ionizing radiation[5], vibration[6]), chemical[7, 8], and biological[9] hazard protection and assessment of thermal properties[10–12] of PPE and the environmental impacts on occupational safety and health.

Of particular note is that this special issue includes the latest results[1, 5, 9] of an ongoing research project "Creation of new functions and structural materials for protective clothing/PPE and establishment of evaluation method suitable for on-site activities" (Project leader: Professor Hideaki Morikawa, Shinshu University) supported by JSPS KAKENHI Grant Number 15H01789, the Ministry of Education, Culture, Sports, Science and Technology.

Thus, we believe that this special issue provides recent and significant information of international (Brazil[8], China[10], Finland[3], Netherlands[2], Norway[3, 4], Poland[11], Switzerland[7, 11], Sweden[3], the UK[8], and the USA[2, 8, 12]) and Japanese[1, 5, 9] research progress on PPE at work. Even so, this issue has a limitation in that we could not cover every PPE that is important for occupational safety and health, especially concerning head protection, foot protection, protection against falls, ballistic protection, eye and face protection, hearing protection, and respiratory protective devices.

Therefore, the present special issue is an intermediate stage of progress in the relevant field, and we need to plan the next special issue in the near future by gathering a wider range of experts with comprehensive knowledge in specific PPE areas of use.

References

1) Bao L, Wang Y, Baba T, Fukuda Y, Wakatsuki K, Morikawa H (2017) Development of a high-density nonwoven structure to improve the stab resistance of protective clothing material. Ind Health **55**, 513–520.
2) Heus R, Denhartog EA (2017) Maximum allowable exposure to different heat radiation levels in three types of heat protective clothing. Ind Health **55**, 529–536.
3) Jussila K, Rissanen S, Aminoff A, Wahlström J, Vaktskjold A, Talykova L, Remes J, Mänttäri S, Rintamäki H (2017) Thermal comfort sustained by cold protective clothing in Arctic open-pit mining—a thermal manikin and questionnaire study. Ind Health **55**, 537–548.
4) Naesgaard OP, Storholmen TCB, Wiggen ØN, Reitan J (2017) A user-centred design process of new cold-protective clothing for offshore petroleum workers operating in the Barents Sea. Ind Health **55**, 564–574.
5) Yamauchi M, Sakuma S (2017) Development of bioassay system for evaluation of materials for personal protective equipment (PPE) against toxic effects of ionizing radiations. Ind Health **55**, 580–583.
6) Shibata N (2017) Effect of shelf aging on vibration transmissibility of anti-vibration gloves. Ind Health **55**, 575–579.
7) VAN Wely E (2017) Current global standards for chemical protective clothing: how to choose the right protection for the right job? Ind Health **55**, 485–499.
8) Shaw A, Coleone-Carvalho AC, Hollingshurst J, Draper M, Machado Neto JG (2017) Development of a new test cell to measure cumulative permeation of water-insoluble pesticides with low vapor pressure through protective clothing and glove materials. Ind Health **55**, 555–563.
9) Shimasaki N, Shinohara K, Morikawa H (2017) Performance of materials used for biological personal protective equipment against blood splash penetration. Ind Health **55**, 521–528.
10) Wang F (2017) Measurements of clothing evaporative resistance using a sweating thermal manikin: an overview. Ind Health **55**, 473–484.
11) Psikuta A, Koelblen B, Mert E, Fontana P, Annaheim S (2017) An integrated approach to develop, validate and operate thermo-physiological human simulator for the development of protective clothing. Ind Health **55**, 500–512.
12) Bernard TE, Ashley CD, Garzon XP, Kim JH, Coca A (2017) SP: Prediction of WBGT-based clothing adjustment values from evaporative resistance. Ind Health **55**, 549–554.

Shin-ichi SAWADA

National Institute of Occupational Safety and Health, Japan

Kalev KUKLANE

Lund University, Sweden

Kaoru WAKATSUKI

Shinshu University, Japan

Hideaki MORIKAWA

Shinshu University, Japan