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ALTERNATIVE ENERGY

SAFETY BRIEFING

DETERMINING PPE SELECTION IN THE NUCLEAR ENERGY PRODUCTION INDUSTRY

Nuclear energy production presents a range of specific hazards including ionising radiation and radioactive contamination, in addition to any present secondary risks. Understanding the nature of typical hazards allows safety and operations managers to make informed choices when developing safety programs and evaluating PPE options.

As a source of low-carbon power – production generates no greenhouse gases or significant emissions – nuclear energy is increasingly in demand. Currently accounting for around 10% of global electricity production, energy is derived from 445 power reactors in 32 countries, with a further 54 reactors under construction worldwide. In addition to power generation, around 50 countries also utilise nuclear energy in 220 research reactors, which are mostly used to produce medical and industrial isotopes.

Potential occupational radiation risk is a serious consideration which must be assessed and controlled. In recognition of the dangers, The International Atomic Energy Agency (IAEA) developed a program to focus on protection of the 23 million workers worldwide that are exposed. The program promotes an internationally harmonised approach and develops safety standards and guidelines to reduce radiation exposure at the workplace for its Member States[1].

Exposure is not limited to functioning reactor sites only, with significant risk associated with other occupational settings including air and space travel, oil and gas production, and the manufacturing, industrial and construction sectors.

> **“Nuclear energy production presents a range of hazards.”**

1. International Atomic Energy Agency (IAEA) – Radiation Protection > Workers

RADIATION EXPOSURE (IRRADIATION) AND CONTAMINATION

Radiation exposure includes applications such as medical imaging or radiotherapy and occurs when a person has been exposed to certain types of waves or particles. Exposure does not necessarily lead to contamination with radioactive material.

Contamination means that radioactive material is on or in a person's body[2]. It is therefore defined as either:

1. External contamination, which occurs when radioactive material makes contacts with skin, hair or clothing – this can be from the air, or in solid or liquid forms.
2. Internal contamination, which occurs when radioactive material is ingested, inhaled or gains entry through broken skin. Once in the body, radioactive materials can accumulate in organs and will continue to emit radiation.

The primary concern in nuclear power generation is ionising radiation risk from exposure to radioactive substances. However, there is additional risk associated with the maintenance, dismantling and decommissioning of reactor facilities. These risks include exposure to radioactive dust and other particles, along with exposure to contaminated water, other liquids and vapours.

> **"Contamination means that radioactive material is on or in a person's body."**

2. Centers for Disease Control & Prevention – Contamination vs Exposure

PPE FOR THE NUCLEAR INDUSTRY

A range of PPE options are available for use in the nuclear industry, the suitability of which is dictated by the occupational hazards associated with specific tasks and activities. As a rule, it is essential that PPE choices be lightweight and well-fitting to ensure that workers can don easily and work comfortably in limited and cramped spaces.

To assist in selection, the IAEA published *Practical Radiation Technical Manual: Personal Protective Equipment*[3], which outlines recommendations for specific PPE types used in defence of radioactive contamination.

HAND PROTECTION

According to IAEA[4], while appropriate protection in terms of glove material choice is essential, it is equally important to ensure that workers have sufficient dexterity when wearing PPE. It recommends the following construction materials, depending on the specific environment and present conditions:

- Lightweight polyvinyl chloride (PVC) or thin natural rubber latex (NRL) for sensitivity, flexibility and good grip or;
- Heavyweight PVC gloves for harsh industrial environments

The guide highlights the importance of determining material suitability based on skin sensitivity or known allergies, along with the exposure to solvents, chemicals and other physical hazards which may compromise the glove's integrity. The presence of secondary risks, such as puncture or cut risk, will also determine suitability.

It is essential to ensure that choices meet with EN 421: *Protective gloves against ionising radiation and radioactive contamination*, which outlines specific requirements and test methods.

> **"It is essential that PPE choices be lightweight and well-fitting."**

BODY PROTECTION

IAEA offers advice on selection of protective suits based on expected contamination types – including surface or airborne – and forms (solid, liquid, aerosol or gas)[5]. These include permeable suits (inferring air permeability), which typically offer greater comfort and are suitable for long-term wear, through to non-permeable suits (i.e. those made with a monolithic barrier which are impermeable to air) made of rubber, plastic-coated or non-woven fabrics and designed for more challenging conditions. Suits are available in ventilated and non-ventilated options, with suitability again determined by the tasks being undertaken and subsequent exposure risks. The standards that govern protective clothing are:

- EN 1073-1: Protective clothing against solid airborne particles including radioactive contamination; and
- EN 1073-2: Protective clothing against radioactive contamination.

3. Practical Radiation Technical Manual: Personal Protective Equipment
4. Practical Radiation Technical Manual: Personal Protective Equipment – Gloves for protection against radioactive contamination – p 28.
5. Practical Radiation Technical Manual: Personal Protective Equipment – Guide for choosing protective suits – p 26.

GLOVE CONNECTORS

An essential link between hand and body protection, glove connectors create a tight seal between glove and cuff, delivering an advanced protection solution.

Constructed using the latest polymer technology, glove connectors are designed to work with a wide variety of glove thicknesses and utilise a ribbed cone and collar that provide a secure attachment.

To ensure they are fit for purpose, glove connectors should be tested in accordance with ISO 17491-3:2008 - *Determination of resistance to penetration by a jet of liquid (jet test).*

FACE PROTECTION

Depending on the tasks being carried out, some form of face protection will be required. Full face shields protect the wearer from chemical splashes and may be worn with goggles to protect the eyes. Other tasks may necessitate the use of full-face mask respirators. A thorough risk assessment will identify present hazards and help determine the most appropriate form of face protection.

FOOT PROTECTION

To achieve full head-to-toe protection IAEA recommends the use of protective footwear, which includes shoes, boots, overshoes and booties. As with previously mentioned PPE types, the specific application, hazard and level of risk will determine the applicable PPE to be used. In some instances – where there is risk of minor spills or drips for example – the use of disposable single-wear overshoes may suffice. In environments that present greater hazards in terms of exposure to radioactive materials, a fully encapsulated impermeable suit that incorporates footwear may be required.

> **"The specific application, hazard and level of risk will determine the applicable PPE to be used."**

SAFETY FIRST

While nuclear accidents are rare, IAEA says in-depth analysis identified a weakness in safety culture as the cause in most cases[6]. It sees Japan's Fukushima Daiichi accident in 2011 as the inciting incident for a rapid and concerted cultural shift, which has seen operational safety become a global priority for the sector.

As the demand for cleaner energy grows in response to climate change concerns, nuclear power generation is increasingly touted as a viable alternative to carbon intensive sources. Given that it offers a continuous and reliable supply – in contrast to variable renewable sources (such as solar or wind) that generally require back-up power – more reactor construction is planned, including development in countries that have no existing nuclear plants[7].

This increase in demand must be met with a culture of prioritising safety, ensuring that identification and selection of suitable PPE to protect against the specific hazards that a nuclear environment presents, is based on stringent risk assessment and a thorough program of ongoing monitoring.

6. IAEA – Building trust in nuclear's safety culture
7. IAEA – How does nuclear power fit into the clean energy transition?

Ansell Healthcare Products LLC
111 Wood Avenue, Suite 210
Iselin, NJ 08830 USA

Ansell Healthcare Europe NV
Riverside Business Park
Blvd International, 55,
1070 Brussels, Belgium

Ansell Limited
Level 3, 678 Victoria Street,
Richmond, Vic, 3121
Australia

Ansell Services (Asia) Sdn. Bhd.
Prima 6, Prima Avenue,
Block 3512, Jalan Teknokrat 6
63000 Cyberjaya, Malaysia