GreenLead Shielding

Environmental Concious Solutions

AN INNOVATIVE CANADIAN APPROACH TO REDUCTION OF RADIATION PROTECTION GREEN HOUSE GAS

ARSP - ADVANCED RADIATION SHIELDING PARTITION

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AN INNOVATIVE CANADIAN APPROACH OF RADIATION PROTECTION GREEN HOUSE GAS REDUCTION IN HEALTHCARE SETTINGS - ARSP - ADVANCED RADIATION SHIELDING PROTECTION

INTRODUCTION

"The healthcare sector generates approximately 10% of the total carbon emissions in the United States. Radiology is thought to be a top contributor to the healthcare carbon footprint" [1]

Canada demonstrates a strong commitment to protect the environment and combat climate change to meet net zero by 2050 in accordance with the Paris Agreement. Advancing radiation shielding technology to reuse lead resources will assist in meeting this agenda. The ARSP "Advanced Radiation Shielding Protection" Barrier is a cutting-edge resource conservation solution designed by Radiation Shielding Specialists with over 75 years of radiation shielding installations. This patented design transforms the traditional radiation shielding installation of single use lead sheet into a reusable penetration free unbroken barrier that can be reused for the 200 year lifecycle of the lead. Our goal is to reduce radiation shielding lead sheet production by 90% by the year 2050 which aligns with the commitments of the Paris Agreement. This would equate to the elimination of 1,603,800 lbs of sheet lead produced annually, in Canada, and the annual elimination of 130,954,584 lbs globally.

If implemented across Canada in Healthcare facilities, the ARSP Barrier could potentially reduce Canadian greenhouse gas emissions by approximately 13,680,000,000 kg of CO_2 over the life cycle of the lead sheets based on 900 tonnes of lead sheet annually.

So, what does this really mean? Using the EPA Greenhouse Gas Equivalencies Calculator[2], 13,680,000 000 kg CO_2 is equivalent to greenhouse gas emission from:

- 1,724,140 homes energy use for one year
- 2,661,780 homes' electricity use for one year
- 3,044,214 combustion engine vehicle driven for one year
- 16,313,642 acres of forests in one year

"According to the European Lead Sheet Association, over 100,000 tonnes of lead sheet are used globally each year." [3] 66% of that sheet lead is used in radiation shielding and by implementing the ARSP barrier globally, the lead sheet smelting greenhouse gas CO_2 footprint could be reduced by 1,003,200,000,000 kg over the life cycle of the lead sheets.

Using the EPA Greenhouse Gas Equivalencies Calculator[2], 1,003,200,000,000 kg CO_2 is equivalent to greenhouse gas emission from:

- 126,436,927 homes energy use for one year
- 195,197,202 homes' electricity use for one year
- 223,242,375 combustion engine vehicle driven for one year
- 1,196,333,738 acres of forests in one year

Why is the ARSP so beneficial to the Paris Accord 2050 net zero agenda? It offers unprecedented radiation protection providing a sustainable future.

1. **HEALTHCARE BENEFITS TO USING THE ARSP SYSTEM**
   Since the inception of radiation shielding in healthcare facilities, lead sheet has been the chosen material to reduce ionizing radiation to legislated safe levels. In all radiography shielding installations, lead sheet has been a single use product. Until now - the introduction of the ARSP Barrier unique design allows the lead sheet "radiation shielding" to be reused for the life cycle of the lead. Additionally, this design meets all radiation shielding codes and guidelines worldwide.
   The implementation and mandated use of the ARSP Barrier will drastically reduce GHG ensure a safer environment for all.
   The absence of penetrations to the face of the lead ensures a continuous shield, minimizing the risk of radiation leakage or hotspots. Integrating the ARSP Barrier within a single wall dual cavity assembly provides convenience and efficiency in an unbroken barrier installation. Placing the lead protection within the wall cavity maximizes shielding effectiveness of the lead-lined walls. This design ensures optimal radiation attenuation while maintaining an eco-conscious environment and allows for the resource conservation of the lead plates.
2. **LEAD IS TOXIC TO PEOPLE AND THE ENVIRONMENT**
   There is no safe level of lead exposure. [4] Lead exposures account for 853,000 deaths annually vs. 852,000 for all other occupational risk factors (or 1.1 million AIDS related deaths). [5] ARSP will significantly reduce the amount of lead that is required in healthcare facilities and Canada could lead the world in helping to

reduce the mining of Lead and the disastrous effects it has on the children of the world.

3. **REDUCING GREENHOUSE GAS EMISSIONS BY RESOURCE CONSERVATION – ARSP DESIGNED LEAD PLATES ARE REUSABLE FOR THE LIFECYCLE OF THE LEAD**
   Sustainable practices such as reutilizing the ARSP lead plates by extending the lead lifecycle by reducing the overall need for new lead sheets in future renovations. Room renovations, on average, occur every 9 years or when additional shielding is required due to workload increases. By reusing the unbroken ARSP lead plates and not requiring new sheet lead to be installed, will not only decrease energy consumption but will ultimately significantly lower the associated greenhouse gas emissions. The ARSP system is the only known radiation barrier that has the ability to reduce the mining of new lead ore that contributes to the dangerous GHG and environmental concerns.
4. **COATING APPLICATION TO REDUCE LEAD DUST**
   Applying a coating to the ARSP Barrier can help reduce the release of lead dust particles during the natural oxidization properties of raw lead, enhancing safety and minimizing potential lead dust contamination in the workplace. Proper containment of lead dust is essential for maintaining a clean and safe environment.

Overall, the features and benefits of the ARSP Barrier demonstrate a commitment to effective radiation protection, environmental responsibility, and long-term sustainability in healthcare and other relevant applications.

HEALTHCARE BENEFITS TO USING THE ARSP SYSTEM

Advancements in radiation shielding technology are of paramount importance as they contribute to enhanced protection against ionizing radiation, which is a known Class 1 carcinogen. This has a significant impact on various industries, particularly healthcare, where radiation-based technologies such as X-rays are extensively used for diagnostic and therapeutic purposes. By improving radiation shielding capabilities, the ARSP Barrier ensures the safety of healthcare personnel and patients by minimizing their exposure to ionizing radiation.

In 2012, an international conference on radiation protection in medicine, cosponsored by the IAEA and the World Health Organization (WHO), was held in Bonn, Germany resulting in a proposal of 10 priorities, referred to as The Bonn Call-for-Action.

One of the main aims of the Bonn Call-for-Action was to strengthen the radiation protection of patients and health workers overall.
In Canada, there was a commitment to invest in the development of innovative projects in radiation protection. The ARSP Barrier would be in alignment with this initiative.

The unbroken lead design of the ARSP Barrier is a significant advantage in terms of radiation shielding. By eliminating penetrations to the face of the lead, the barrier ensures that there are no weak points or gaps that could allow radiation to pass through. This aligns with the requirements set by The Health Canada Safety Code 35, page 19 which states "Shielding **must** be constructed to form an unbroken barrier and if lead is used, it should be adequately supported to prevent “creeping”.[16]

The ARSP Barrier 6" dual cavity single wall partition integrates with the interlocking shielding lead plate assembly to create an unbroken radiation shielding barrier. The design provides comprehensive protection ensuring its overall shielding effectiveness and code compliance. The risk of radiation leakage is minimized, and the shielding performance is optimized. This is particularly important because the barrier can now be installed easily by non radiation shielding specialists while maintaining the code requirements and this would expedite the installation due to the shortage of radiation shielding specialists.

By offering a radiation shielding barrier that guarantees no penetration, leakage or hotspots, the ARSP Barrier provides peace of mind for staff and the public working in radiation-sensitive environments. This assurance helps to instill confidence in the effectiveness of the shielding system and ensures that radiation exposure is minimized.

LEAD IS TOXIC TO PEOPLE AND THE ENVIRONMENT

Lead remains the most effective material that meets the conditions and specifications set out in various construction and safety codes for radiation protection. Its high density and high mass attenuation coefficient make lead sheets the most common material used for radiation shielding applications including: [6]

- facilities with X-ray machines (e.g., hospitals doctor and dentist offices);
- nuclear, industrial and research facilities;
- security scanners; and
- low-level nuclear waste storages.

However, lead is a toxic heavy metal that is on the List of Toxic Substances of the Canadian Environmental Protection Act, 1999 (CEPA 1999). It requires lead ore to be

mined, smelted and rolled into a useable form and has potential to cause great harm to the environment.
"Lead wreaks its havoc silently and insidiously," [7] Similar to ionizing radiation, poisonous lead exposure is not visible to those impacted.

There are 4 main sources of lead poisoning – ingestion, inhalation, dermal and Endogenous Exposure. [8] The first two are the major causes of lead poisoning of children. Dermal exposure is concerning for the workers installing the lead sheets and endogenous exposure is concerning as it impacts military personnel if they have shrapnel in their body but more concerning is the "Trans-placental exposure to the unborn child can happen if the mother is exposed to lead." [8]

It is shocking to learn that approximately 1 in 3 children are poisoned by lead and that "in 2019, at least 900,000 premature deaths globally or 1.6% of all deaths, were attributed to lead poisoning – a similar number to deaths caused by HIV/AIDS" [9]

Some of the harmful effects of lead poisoning are: It Causes Neurological Damage in Children, it Causes Reproductive Problems and it Accumulates in Multiple Organs of the Body. "Lead is one of the harmful heavy metals that can gravely affect our health. It's a cumulative toxicant, and most of the time, you notice the symptoms when the level of exposure is already high." [10]

With all the environmental mandates around the world, it is alarming to see that the lead production has not decreased. In fact "According to the US Geological Survey, global mined lead production approximately doubled between 1994 and 2019."[7] This has significant environmental impacts.

One such environmental impact is air pollution. "Air pollution is the leading environmental health risk humans now face. Worldwide, almost one third of the cardiovascular disease burden is attributable to indoor and outdoor air pollution (17% and 13% respectively), second-hand tobacco smoke (3%) and exposure to lead (2%)." [11] Studies show, air emissions from lead recycling facilities in underdeveloped countries are significantly higher. For example, one plant in Mexico has 10 times more lead air emissions than a plant in the USA or Canada. [5]

Limiting Lead and the impacts to the environment are a huge benefit of the ARSP system. Not only will it reduce the amount of lead required but it will also limit the amount of lead dust and the secondary exposure to workers families.

REDUCING GREENHOUSE GAS EMISSIONS BY RESOURCE CONSERVATION

The long lifespan of the lead sheets used in the ARSP Barrier is indeed impressive and aligns with the expected durability of lead as a material. The ability to reuse these lead sheets, for up to 200 years, brings significant GHG reduction benefits and contributes to carbon neutrality while maintaining sustainable development in a green building methodology.

The impact of radiation shielding on the environment is calculated by determining the carbon foot print of the material per kg of that material. "It specifies that lead used in these applications has a carbon footprint of between 30 and 76 kg of carbon dioxide (CO_2) per kg of material"[6]

"In Canada, lead sheets are mainly used for radiation protection and to a lesser extent in building applications such as flashing, cladding and roofing. The three Canadian lead sheet manufacturers produced approximately 738 tonnes of lead sheets in 2011, mostly for the domestic market. There were also approximately 124 tonnes (i.e., 14% of the total demand) of lead sheets imported into Canada[6]

In 2011 – the total tonnes of lead sheets (produced and imported) in Canada was a total of 862 tonnes. In our analysis, we have used the estimation that currently we are using approximately 900 tonnes of lead sheeting, per year, in Canada for radiation protection.

900 tonnes of lead sheet equals 68,400,000 kg of CO_2. Over the 200 year life cycle of sheet lead, this means, that it would produce 13,680,000 000 kg CO_2

The estimation that the ARSP Barrier could potentially reduce Canadian greenhouse gas emissions by approximately 13,680,000,000 kg of CO_2 over the lifespan of the lead sheets is remarkable.

Normally, a lead sheet is punctured during installation and thereby making it a single use product. By implementing the ARSP Barrier, the lead sheet remains penetration free and can be reused and becomes sustainable. The ability to reuse lead plates in future room renovations allows for efficient and cost-effective modifications to radiation shielding configurations. Instead of having to acquire entirely new shielding materials, the ARSP Barrier enables the existing lead plates to be repurposed and integrated into the modified layout. This results in significant cost savings by reducing the need for new

materials and installations. Furthermore, the adaptability of the ARSP Barrier to evolving needs within healthcare facilities or other environments, requiring radiation shielding, is highly beneficial. As the requirements or layout of a facility change over time, the ARSP Barrier's design allows for easy adjustments or expansions without having to entirely replace the shielding system. This adaptability ensures that the barrier can accommodate the evolving demands and configurations of different spaces while maintaining its effectiveness in radiation protection.

The reduction in greenhouse gas emissions aligns with the global efforts to mitigate climate change and minimize the environmental impact of various industries, including healthcare. The reusability and adaptability of the ARSP Barrier contribute to sustainability by minimizing waste generation and reducing the overall environmental impact associated with radiation shielding projects. Instead of discarding lead plates and other materials during renovations or upgrades, the barrier enables their continued use, promoting responsible resource management.

With the ARSP System, should the shielding requirements change, radiation shielding plates can be easily upgraded by adding additional layers. Should a building be decommissioned, plates can be sold to another facility or returned to our factory and repurposed to be donated for re-use by underprivileged communities or developing countries.

Lead-lined gypsum wall board (drywall) is even less environmentally friendly. The lead sheeting glued on the back (of the GWB) is also peppered with holes and cannot be reused due to the numerous mechanical fasteners penetrating through. Before this lead can be recycled, it has to be removed from the drywall, which is a hazardous and labor-intensive process. The concern being the lead residue remains on the gypsum wallboard (drywall); the GWB disposed as hazardous material and not as normal building waste.

According to a scientific study, using the then current consumption rates; environmental analyst, Lester Brown suggested the lead supply could run out within 18 years based on an extrapolation of 2% growth per year. Using our patented ARSP System would help reduce lead consumption. The un-pierced lead plates can easily be re-used, again and again. Should additional attenuation be required, you can just add another lead plate on top of the previously installed lead plate. No wastage and take advantage of LEED credits through Innovation in Design Strategies.

It is Imperative to reduce and control the use of lead because:”

- Lead exposure is a large problem with social costs on the order of $5-10 trillion annually, most of which come through neurological damages and losses in IQ causing lost income later in life.

- Strategies for reducing lead exposure are mostly context- and source-dependent, but generally preventing new lead entering the environment seems more tractable than removing existing lead.

We believe that the problem of lead exposure deserves more attention than it currently receives in the neartermist effective altruism community. Exposure to lead causes many problems. High levels of lead exposure can be fatal. Even at low levels of exposure, lead exposure causes neurological damage, especially in children. Lead exposure is associated with many cognitive and behavioral problems and is a significant risk factor for cardiovascular diseases, mental disorders, and kidney disease. Worldwide, lead exposure is estimated to impose a 21.7 million DALY burden (for comparison, malaria causes a 46.4 million DALY burden) and we think the true value is likely 30-100% larger. The economic costs of lead exposure, primarily lost earnings due to reductions in IQ, are estimated to total around a trillion dollars annually but we think the true value is 30-50% of this size. If one adopts a logarithmic income utility model, the utility value of this dollar burden is an order of magnitude higher, since 94% of the loss occurs in low- and middle-income countries (LMICs) which have on average 10x lower incomes than the USA."[19]

In summary, the reusability and adaptability of the lead plates in the ARSP Barrier provide cost savings and flexibility for future room renovations or additional shielding needs. This feature promotes sustainability by reducing waste and demonstrates the barrier's ability to adapt to changing requirements within healthcare facilities or other environments that require radiation shielding. This commitment to reduce and eliminate the production of sheet lead by 90% is an ambitious plan to assist Canada in meeting the Paris Agreement to be net zero by 2050.

COATING APPLICATION TO REDUCE LEAD DUST

In the Medical Healthcare Facilities we are concerned with the inhalation of lead dust. "We speculate that the lead shielding materials disintegrate over time and the lead dusts escape the capillary pores of plasterboards or cracks of aprons and enter the x-ray room environments. Therefore, environmental lead accumulated in the hairs of radiological professionals during working period. Lead sheet has been frequently and

worldwide used to shield radiation in the department of radiology due to its high barrier property of radiation. However, the potential hazards of lead are ignored. This study found for the first time that increased lead concentrations in the hairs of radiographers using lead aprons for radiation protection and working in the space which installed lead shielding." [12]

With medical personal having higher concentrations of lead in their system, it can lead to secondary transmission to their families – especially their children. "It is important to note that occupational exposures can result in secondary exposure for workers' families if workers bring home lead-contaminated dust on their Skin, Hair, Clothes, Shoes, or Tools" [13]

According to a study of radiation shielding lead in nuclear medicine located on the NIH website - the "shielding may present an insidious health hazard because of the dust that is readily removed from the surfaces of lead objects. The lead dust may become airborne, contaminate floors and other nearby surfaces, and be inadvertently inhaled or ingested by patients." And the conclusion was that "Lead contamination is present within nuclear medicine departments, and corrective measures should be considered" [14]
"Uncoated metallic lead is widely used as radiation shielding in research and development, nuclear medicine and radiology, and various manufacturing processes. The common use of lead shielding, however, may present an insidious health hazard due to lead dust. Field and laboratory measurements were collected to evaluate the distribution and removal of lead from radiation shielding material as well as to measure airborne exposures during large shielding emplacement projects. The data indicate that lead is readily dispersed from visibly oxidized as well as freshly-cleaned shielding but that a single coating of polyurethane can reduce lead removal by nearly three orders of magnitude. Although 8-hour time-weighted average exposures for workers constructing lead shielding structures were nearly all below the Occupational Safety and Health Administration's action level of 30 micrograms/m3 (due to short work periods), the distribution of airborne lead concentrations during this kind of work demonstrates a potential for overexposure." [15]

Coating the ARSP lead sheets is an important measure to address concerns associated with lead dust in healthcare buildings. Lead dust can be hazardous if inhaled or ingested, and its containment is crucial to ensure a safe environment for healthcare workers and patients. Since lead dust on radiation technicians can be carried home with them and expose their children through secondary exposure.

By applying a coating to the lead sheets, the ARSP Barrier reduces the risk of lead dust contamination. The coating acts as a protective layer, preventing the release of lead

particles into the surrounding environment. This minimizes the potential for lead dust inhalation or ingestion, promoting a healthier and safer environment for all occupants addressing the concerns associated with oxidized lead dust, enhances safety, and ensures compliance with regulations and guidelines for occupational health and safety.

CONCLUSION

The ARSP Barrier represents a significant advancement in X-ray shielding technology and will help Canada lead the way in setting a new standard in this specialized field. It not only addresses various challenges associated with radiation shielding but it will help Canada in its goal to achieving their 2050 Net Zero Initiative.

The key advantages of the ARSP Barrier include:

1. Resource Conservation – because of its unprecedented unbroken barrier design, which ensures continuous shielding without penetrations to the face of the lead, the lead sheets can be reused in future renovations and will reduce the amount of lead smelting in Canada for the life cycle of the lead.
2. Lead Dust Containment – The coating applied to the lead sheets will contain the dangerous lead dust that has been virtually unmanaged at this point.
3. Unprecedented Radiation Shielding Integrity - The system ensures a 100% unbroken barrier and it can be easily integrated within its dual wall cavity assembly, providing convenience and efficiency in installation. The barrier offers lead protection within the wall cavity, shielding against incidental angular rays, and an extended lead sheet lifespan, resulting in cost savings and reduced material consumption.

If implemented across Canada in Healthcare facilities, the ARSP Barrier could potentially reduce Canadian greenhouse gas emissions by approximately 13,680,000,000 kg of CO_2 over the life cycle of the lead sheets.

Globally, “According to the European Lead Sheet Association, over 100,000 tonnes of lead sheet are used globally each year.” [15] 66% of that sheet lead is used in radiation shielding and by implementing the ARSP barrier globally, the lead sheet smelting greenhouse gas CO_2 footprint could be reduced by 1,003,200,000,000 kg over the life cycle of the lead sheets.

Our goal is to reduce radiation shielding lead sheet production by 90% by the year 2050 which aligns with the commitments of the Paris Agreement.

Footnotes

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