9.00 Statement by Dr Margaret Hughes

My name is Dr Margaret Smith and my role here today is as to present the risks of toxic gases in the very credible event of loss of control causing a toxic fire plume. Toxic gases and particles present real risks to my neighbours, my husband, my 2 small children, my elderly in-laws and myself.

I am a GP and work in Ballymena as a GP partner in Old Bank Surgery and as an Out of hours Doctor for Dalriada Urgent Care. I have also recently been appointed as a medical generalist member of the Appeals tribunal. I qualified as a doctor in 2005 from Queens University Belfast. I qualified as a GP in 2010. I live at 5 Whappstown Road which is 151m from the BESS with my husband and 2 children.

The 2 most dangerous substances I wish to discuss today are Hydrogen Fluoride and Nickel Oxide in inhalable powder form.

Lithium ion battery fires generate intense heat and considerable amounts of gas and smoke. This fact is undisputed by the current literature investigating battery fires and I quote it from a paper in the aerosol Science and Technology Journal which investigated detailed characterization of the particle emissions from battery fires and was published in 2022. (1)

Hydrogen fluoride is the most significant gas produced in terms of toxicity

Hydrogen Fluoride is a very poisonous, colourless gas that readily dissolves in water to yield hydrofluoric acid which is extremely corrosive and has a Ph of 2. Hydrogen fluorides devastating effects are however unrelated to the pH but the toxicity of the acid itself.
It is a gas at room temperature.

There are 3 routes of exposure

- skin/eye contact
- Inhalation
- ingestion

In our scenario inhalation is obviously the most pertinent exposure route.

Inhalation of toxic gases or vapours provokes nasal irritation and inflammation, dryness and mucosal bleeding with subsequent ulceration and/or perforation of nasal septum, erythema and oedema of the oral, nasal and laryngeal mucous membrane. Continued exposure can cause pneumonitis and results in coughing, dyspnoea, stridor, laryngitis, laryngospasm and retrosternal pain, followed by chills, fever, and cyanosis. It has a devastating effect on the trachea and bronchi causing tracheobronchitis, bronchiolar obstruction and bleeding

accompanied by stridor and wheezing. These symptoms are discussed in a review paper in the Macedonian Journal of Medical Sciences published in 2018. (2)

Gaseous HF when reaches the pulmonary tissue provokes oedema and congestion, pleural effusions, pneumonia and even partial or complete lung collapse. CXR revealed pulmonary oedema or diffuse infiltrative shadows over the lungs parenchyma. Ct scan shows diffuse ground glass opacity which is similar to the changes shown in severe covid pneumonitis. Acute respiratory failure may lead to a lethal outcome.

Absorption of the fluoride ions into the blood stream can occur after inhalation and their distribution in cells may result in systemic toxicity. The degree of toxicity and the outcome depends on the HF concentration, duration of exposure, and the time elapsed between exposure and medical treatment.
Fluoride ions are very small and diffuse readily in the aqueous media. Absorbed into the blood stream it is carried to all body organs in proportion to their vascularity (ie how good their blood supply is). They react with calcium and magnesium and form insoluble chelates which provokes local calcium depletion. Calcium is used in cell signalling and low levels can cause fatal cardiac arrhythmias and seizures.

Cases with systemic disorder include electrolyte imbalance, enzyme inhibition, hypovolaemic shock which is life threatening drop in blood pressure, multiorgan failure, acute respiratory distress and cardiac arrythmias in which resuscitation procedures are ineffective.

Diffusion capacity is reduced in HF inhalation. It is thought that oedema of the interstitium by chemical burn results in a defect in gas diffusion.

Centres for disease control and prevention state that People who survive after being severely injured by breathing in hydrogen fluoride may suffer lingering chronic lung disease Eye exposure to hydrogen fluoride may cause prolonged or permanent visual defects, blindness or total destruction of the eye.

Special attention should be paid if intoxicated persons are children. Because of their relatively larger surface area: body weight ratio, children are more vulnerable to the hydrofluoric acid and larger doses are inhaled because of greater lung surface area: body weight ratio and increased minute ventilation per kg weight compared to adults. Additionally, vulnerability to corrosive agents is greater because of the relatively smaller diameter of their airways

The seriousness of poisoning caused by hydrogen fluoride depends on the amount, route and length of time of exposure, as well as the age and pre-existing medical condition of the exposed person.

There are a number of guideline levels of toxicity for Hydrogen Fluoride which are used.

SLOT, the specified level of toxicity, is one level of toxicity used by HSE in relation to the provision of land use planning and is defined as severe distress to almost everyone in the area, substantial fraction of exposed population requiring medical attention. Some people seriously injured, requiring prolonged treatment

The SLOT level of toxicity is quoted at 400ppm of HF.

SLOT is not indicative of a safety level.

There are a number of guidelines dealing with Hydrogen fluoride safety levels.

One such set of levels are the: Acute Exposure Guideline Levels (AEGL) which are, as stated by HSE (GB):

set through a collaborative effort of the public and private sectors across the international community and have formal development standards. As a result of this consensus, they are considered a consistent set of values used worldwide.
Review Of Dense Gas Dispersion For Industrial Regulation and Emergency Preparedness and Response. HSE. 24th June 2021, page 64.

The AEGLs have been derived from Data on irritant effects in humans and lethal and sub lethal effects in six species of mammal (monkey, dog, rat, mouse, guinea pig, and rabbit).

The data were considered adequate for deriving the three AEGL classifications for five exposure periods.

- The AEGL1 is the level which is thought to cause non disabling side effects, notable discomfort, irritation, or certain asymptomatic non sensory effects. However the effects are not disabling and are transient and reversible upon cessation of exposure - 1ppm at 10 mins and 1 hour.

- The AEGL2 is irreversible or other serious, long lasting adverse health effects or an impaired ability to escape - 95 ppm at 10 minutes and 24 at 60 minutes.

- The AEGL3 levels associated with life threatening health effects or death - 170 ppm at 10 minutes and 44 at 60 minutes.

According to the gas modelling in F2 weather conditions at the lower ground floor of the Burrows' house the HF level is estimated to be 225 ppm. At their upper ground floor level the HF level is estimated to be 380ppm (on the edge of SLOT). Both of these levels exceed

AEGL3 and exposure to these levels could cause life threatening health effects or death. Can I point out that the Burrows living space is situated at upper ground level.

The McGarry Arthurs at 110m from the BESS if exposed to the predicted 120PPM of Hydrogen Fluoride as per the Gexcon modelling at F2 weather conditions for 10 minutes – this could result in long lasting adverse health effects or an impaired ability to escape. In reality with other co-morbid health conditions this could occur more rapidly.

Our house situated 151m from the BESS would be exposed to 80PPM which falls into the AEGL 3 level if exposed for 30 minutes ie. life threatening health effects or death and it falls into the AEGL2 category if exposed between 10 and 30 minutes ie. causing long lasting adverse health effects or an impaired ability to escape.

Premrath et Al in their paper – Detailed characterisation of particle emissions from battery fires state that after thermal runaway inception a continuous increase in emissions were observed for 400 seconds after which emissions gradually returned towards baseline levels after 1000 seconds. This shows that the largest percentage of emissions occur in this time frame. Worryingly therefore the 180 minutes used for the GEXCON modelling is actually underestimating the concentrations of HF by a factor of 6.

There is another level: Immediately Dangerous to Life or Health (IDLH40) This level is set by the National Institute for Occupational Safety and Health . IDLH exposure conditions are those that result in an immediate threat to life or health. The values associated with IDLH constitute the airborne concentration from which a worker could escape without injury or irreversible health effects should their respiratory protection equipment fail under the above exposure conditions. The IDLH value is designed as a maximum concentration above which only breathing apparatus providing maximum protection to the user should be used. The level set for this is 30PPM.

Therefore it stands to reason that the site boundary around the compound should be large enough to ensure that levels of HF beyond the perimeter of the compound does not exceed this level (requiring respiratory protection equipment) in any weather condition.
A paper published in 2023 called Hazards of lithium-ion battery energy storage systems (BESS),mitigation strategies, minimum requirement, and best practices (8)– commented that a conservative approach is recommended when dealing with the potential for toxic gases. It states that HF can pose a serious toxic threat due to its low IDLH concentration of 30PPM and AEGL2 concentration of 95 ppm over 10 minutes.

The community emergency exposure levels are concentrations that causes adverse health effects
The levels are level I, II & III and are designated alert, evacuation and death levels respectively. These were developed by Clement International Corporation

Level 1 was 1.5, level II was 7 and level III was 50 ppm. As per the gas consequence modelling all of the aforementioned properties fall into the death category. So I am sure you can understand our grave concern.

So, when the Appellant's consultant on hazardous substances consent *Synergy Engineering and Environment* states:

> *the plume at a **SLOT concentration of 400ppm** will **not reach ground level at any properties** and there is **no possible harmful effect of a toxic plume.***

It is not correct to make a statement in respect of damage to health that uses only the SLOT reference parameters in isolation, when all of these other parameters that lead up to SLOT have been produced to protect public safety.

Synergy are not correct. If I were to make such a statement, I would be deemed negligent.

Clyde Shanks, the Planning Consultants, repeat this assertion (p A14, para 5.16) and wrongfully attribute it also to be by Gexcon and Golder. If the agent can point to where exactly Gexcon and Golder make this incorrect assertion, I would like to know. As I read Gexcon's report, Gexcon purely carried out the instructions of the developer which specifically did not include a risk assessment of the predicted HF concentrations at the neighbouring properties. Golder made no such assertions either. And it would appear Savills' simply repeated Synergy's incorrect statement.

So I would like the Commissioner to be clear. This statement by Synergy and the Agent that there will be ***no possible harmful effect of a toxic plume*** is not correct and if I had made it, I would be negligent.

I therefore ask the Commissioner to disregard Synergy's report and any reference to it that supports this wholly incorrect claim.

Under the Human Rights Act 1998, we ask the Commissioner to address the following breaches of human rights:-

(a) Article 2 (right to life); *Everyone's right to life shall be protected by law.*
(b) Article 8: *Everyone has the right to respect for his private life, his home and his correspondence.*

The second major risk of total loss of control is inhalable nickel oxide.

Hazardous substances consent states that local planning authorities must consider the long term need for appropriate distances between hazardous establishments and local population. Contravention of hazardous substances regulations can be a serious and immediate risk to people in the area.

The regulations state that

hazardous substances are substances, mixtures or preparations—and present as raw materials, **products, by-products,** residues or intermediates;

Loss of control cannot be entirely mitigated for and therefore there should be safety parameters integrated during planning that maintain the safety of the surrounding population.

One necessary parameter is an appropriate safe distance.

This facility should not be in close proximity to our homes or gardens where the closest home is 46 metres from the facility

Nickel compounds in inhalable powder form are named in Planning (Hazardous Substances) Regulations, Schedule 2, Part A *Named Substances*, Item 11. The controlled quantity of this substance is just 1 tonne. Many of the other substances have quantities in the tens and hundreds of tonnes

There is 40.7 tonnes of Nickel Oxide on site. Just over 3 tonnes in each container. So if only 1 third of one container was consumed in a thermal runaway event this is in breach of the thresholds requiring a hazardous substances consent application.

Chen et Al in a 2020 paper included in the journal of Hazardous substances called Identification and Characteristic Analysis of powder ejected from a lithium ion battery during thermal runaway at elevated temperatures concluded that the ejected powders consisted of carbon organics, carbonates,metals and metal oxides (including nickel oxide). (3) This paper detailed the chemical decomposition of the NMC cathode into first dinickel trioxide Ni_2O_3 and then Nickel Oxide with evolution of free Oxygen. Both of these compounds are identified in the Planning of Hazardous substances regulations Schedule 2 Part A Item 11. In this paper the authors stated that the work conducted revealed the accident hazard of LIB and its solid thermal runaway product. They stated that the ejected powder during thermal runaway can be hazardous and dangerous to people.

Essl et al : in a paper published in the Journal – Batteries in 2020 (4) - analysed collected powders and found powders with ‘huge amounts of nickel’ and confirm that the majority are smaller that 10 square micrometres and can therefore be inhaled deeply into the lungs. This analysis confirms the generation of Nickel containing particulates in inhalable powder form hence meeting the description of the named hazardous substances Nickel Oxide in inhalable form.

Barone et Al published a paper in 2021 called Lithium-ion battery explosion aerosols: Morphology and elemental composition. (7). This paper showed than NMC aerosols consisted of 0.03-0.1 micrometres nanoparticles, 0.1-3 micrometre microspheres and 5-10 micrometre anode and cathode fragments.
All of these sizes are respirable aerosols.

Adverse health effects associated with cobalt inhalation include asthma, pneumonia and wheezing and manganese exposure can lead to disabling neurological effects

HSE published a paper in 2023 from their own Science and Research centre (5)
The authors synopsis explained that lithium ion batteries most often use cathodes containing lithiated nickel, manganese and cobalt oxides. It states that similar materials are known human carcinogens. The paper states that nickel, cobalt and manganese are present in the smoke as well as the near field residues and are in similar ratios to those expected from the cathodes within these batteries
The paper states that;- the methods of analysis used here do not allow the comprehensive determination of the metal containing compounds species; this is the subject of further work. However, it is not unreasonable to expect metal oxides to be formed from a combustion event, and some of the oxides of cobalt, manganese and in particular nickel are known to be hazardous to human health. The health impact of such an exposure depends not only on the species present, but also to the bioavailability of the compounds, influenced by solubility and, for inhaled absorption, particle size. Certainly, initial effects from exposure to the aforementioned metal oxides would present as skin and inhalation irritations. More long-term health effects can include cancer and neurological issues. These compounds would also have a detrimental effect on the environment and the wildlife in surrounding areas. The potential hazard of such exposures should be taken into account when considering hazards when dealing with batteries after a burning event.

Held et al published a paper called Thermal runaway and fire of electric vehicle lithium-ion battery and contamination of infrastructure facility. (6)
Thermal runaway and fire of a battery of type NMC 111 produced soot consisting mainly of heavy metal-oxides of nickel, manganese and cobalt (each 18–20% by mass) .

The quantities of the heavy metals nickel, cobalt and manganese as well as lithium are still high at 100m distance.

Therefore in summary of the evidence regarding Nickel Oxide in inhalable powder form:

- Li ion cells of the nmc are well known in the current literature to generate not only gases but soot and particles in thermal runaway failures.
- The chemical nature of the emissions are known from analysis to contain large quantities of compounds largely oxides of Nickel, Manganese and Cobalt
- Such particles travel in excess of 100ms.
- The particles are respirable due to their small size.
- They therefore meet the description of inhalable particle form.
- The carcinogenic properties of Nickel Oxide in inhalable powder form are recognised and have led to their designation as a Named Hazardous substance.
- Cobalt and Manganese oxides also have adverse health implications.

Hydrogen fluoride and inhaled nickel oxide are both compounds which can cause a major risk to health. Hydrogen fluoride can cause acute respiratory failure and systemic toxicity resulting in death and more long term issues such as chronic lung disease. Nickel oxide is highly carcinogenic in inhalable form which we have shown it to be with evidence from several papers. Quantities of Nickel Oxide particles is still high at 100m distance from the source of a LIB fire. The potential distance that they travel overall is unknown. This facility needs to be a safe distance from our homes to mitigate for loss of control.

References

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