



Morris, USA, 29.06.2021

A fire and series of explosions involving 184,000 pounds of lithium-ion batteries stored at a Federal Paper Board facility in Morris, USA, on 29 June 2021. Both officials and those involved in the rescue operation did not realise that the building, unused since the plant closed (nearly 35 years ago), contained around 100 tonnes of lithium-ion batteries. Firefighters initially attempted to douse the fire with water, unaware of the presence of the batteries, so early attempts by firefighters to extinguish the fire escalated the fire and led to a series of explosions. Heavy rains overnight also contributed to the out-of-control situation. By Wednesday morning, local officials had ordered the evacuation of around 1,000 homes and businesses in the area, evacuating between 3,000 and 5,000 nearby residents for more than three days (EPA 1309187).

Between 2017 and 2021, fire departments in the United States responded to **an annual average of 36,784 fires at industrial or manufacturing properties**, according to data from NFPA. That's more than 100 such fires every day.

<https://www.nfpa.org/news-blogs-and-articles/blogs/2024/06/24/south-korea-battery-factory-fire-highlights-need-for-better-battery-regulation>



Seoul, South Korea, 24.06.2024

A massive factory fire that began after several lithium batteries exploded has killed at least 22 people in South Korea. The blaze broke out on Monday morning at the Aricell plant in Hwaseong city, about 45km (28 miles) south of the capital Seoul. Local television footage showed large smoke clouds and small explosions going off as firefighters sought to put out the fire. A part of the roof had collapsed. Fire official Kim Jin-young said 18 Chinese, one Laotian and two South Korean workers had been confirmed as among the dead. A final body had yet to be identified, and there are fears at least one more person may be missing. "Most of the bodies are badly burned so it will take some time to identify each one," Mr Kim said, according to news agency AFP.

<https://www.bbc.com/news/articles/crggmeyj7o>

Flammability of lithium-ion batteries and the possibility of a major accident

According to the law, can a fire/explosion or release of dangerous substances from lithium ion batteries be a major accident?

LEGISLATION - DEFINITIONS

Regulation 2023/1542

'battery' means any device delivering electrical energy generated by direct conversion of chemical energy, having internal or external storage, and consisting of one or more non-rechargeable or rechargeable battery cells, modules or of packs of them, and includes a battery that has been subject to preparation for re-use, preparation for repurposing, repurposing or remanufacturing;

The Seveso III Directive

'dangerous substance' means a substance or mixture covered by Part 1 or listed in Part 2 of Annex I, including in the form of a raw material, product, by-product, residue or intermediate;

'presence of dangerous substances' means the actual or anticipated presence of dangerous substances in the establishment, or of dangerous substances which it is reasonable to foresee may be generated during loss of control of the processes, including storage activities, in any installation within the establishment, in quantities equal to or exceeding the qualifying quantities set out in Part 1 or Part 2 of Annex I;

'major accident' means an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by this Directive, and leading to serious danger to human health or the environment, immediate or delayed,

CLP Regulation

'article' means an object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition;

point 2.1.1.1

(articles, not substances)

b) explosive articles, except devices containing explosive substances or mixtures in such quantity or of such a character that their inadvertent or accidental ignition or initiation shall not cause any effect external to the device either by projection, fire, smoke, heat or loud noise;

In contrast, in the US, **lithium-ion batteries are not treated as articles according to the official position of the EPA and OSHA** (Occupational Safety and Health Administration):

„OSHA has determined that lithium-ion batteries are not considered to be “articles” and are subject to the OSHA HCS regulations. Lithium-ion batteries are not considered to be articles because although they are sealed, they have the potential to leak, spill, or break during normal conditions of use and in foreseeable emergencies causing exposure to chemicals.” (EPA LIB)

This paper was created on the basis of results of a research task carried out within the scope of the 6th stage of the National Programme "Governmental Programme for Improvement of Safety and Working Conditions", funded by state services of the Ministry of Family, Labour and Social Policy (under the name of the Ministry of Family and Social Policy prior to December 12th, 2023). Task no. 3.ZS.10 entitled "Analysis and assessment of major-accident hazards in non-Seveso establishments". The Central Institute for Labor Protection – National Research Institute is the Programme's main co-ordinator.



<https://wyborcza.pl/7,177851,29210431,w-wielkiej-brytani-baterie-sa-przyczyna-setek-pozarow-rocznie.html>



<https://ctsl.org/news/large-lithium-battery-fires-created-toxic-smoke-and-evacuations-jacksonville-and-gothenburg>

Which of the hazardous substances generated in a lithium ion battery fire can be considered the most dangerous?

Review of gas emissions from lithium-ion battery thermal runaway failure — Considering toxic and flammable compounds, Bugryniec PJ, Resendiz EG, Nwophoke SM, Khanna S, James C, Brown SF, Journal of Energy Storage 87 (2024) 111288

The review work includes an analysis of the available test results of different batteries, with different charge levels. Oxygen availability (i.e. air vs. inert atmosphere or open vs. closed space) also affects the composition of the resulting products. However, it can be concluded that the gases resulting from the combustion of lithium-ion batteries consist mainly of CO₂, CO, H₂ and hydrocarbons. Toxic combustion products are mainly CO, HCl, HCN, NO, SO₂, HF, fluorinated carbonates, POF₃, COF₂, acrolein and formaldehyde. Up to 35 toxic substances were identified in the publication analyses, which vary according to chemical composition and charge level.

How can the quantities of dangerous substances generated in a fire be related to the thresholds set by law?

LiPF₆ is thermally unstable above about 70°C

LiPF₆ → LiF + PF₅ (and is easily hydrolysed)

PF₅ + H₂O → POF₃ + 2HF

LiPF₆ + H₂O → POF₃ + LiF + 2HF

Theoretically, hydrogen fluoride can only be formed from the LiPF₆ electrolyte according to the above reactions. It can therefore be assumed that no more hydrogen fluoride will be formed than correlates (stoichiometrically) quantitatively with the electrolyte.

Proposition to discussion

Lithium-ion batteries are worth considering not only as a **potential source of toxic hazardous substances**, which under adverse conditions may pose a threat to human life and health, but also as a **potential source of domino effects**, due to their potential for fire and explosion should a fire occur.

WHAT DO YOU THINK?

Agnieszka Gajek
agnieszka.gajek@ciop.pl

Central Institute for Labor Protection - National
Research Institute, Poland