Application of the COMAH and Hazardous Substances Consents Regulations to Battery Energy storage Systems (BESS): Does classification as "articles" exempt a technology ?

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Application of the COMAH and Hazardous Substances Consents Regulations to Battery Energy Storage Systems (BESS):

Does classification as “articles” exempt a technology ?

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Purpose and Abstract

This Briefing sets out our understanding of the legislative purpose and interpretation of the Control of Major Accident Hazards (COMAH) Regulations, and the related land-use planning Regulations governing Hazardous Substances Consents (HSC), having regard to their origin in the Seveso Directive (latest version the Seveso III Directive 2012/18/EU[1], "*on the control of major-accident hazards involving dangerous substances*"), and which remain in force throughout the UK. In particular we point out the provisions relating to "loss of control of the processes" i.e. malfunctions that cannot be corrected or controlled, leading to potentially major accidents.

This Briefing is largely confined to the legal question of whether the COMAH and HSC Regulations are applicable to grid-scale Li-ion Battery Energy Storage Systems (BESS). The regime represented by the Regulations is completely agnostic as to technology, and should therefore apply, directly and without amendment, to Li-ion BESS. However the position currently taken by the Health and Safety Executive (HSE) in Great Britain, and by the Health and Safety Executive for Northern Ireland (HSENI), is that BESS are exempt by reason of a classification as "articles" under the Classification, Labelling and Packaging (CLP) Regulation[2], likewise an implementation of a different EU Directive[3].

Based on months of diligent study, we are aware of no legal authorities, be they in statute, regulation, or decided cases, that provide any such exemption for Li-ion BESS technology. Repeated enquiries of the HSE in Great Britain have similarly failed to advise us of any such authorities.

We aim to assist the Court in interpreting an inter-related set of Regulations with international implications, and their application to the particular case of grid-scale Li-ion BESS. Because of a requirement to classify "dangerous/hazardous substances" by the Classification, Labelling and Packaging (CLP) Regulation, and the exemption asserted by the HSE for BESS, under that Regulation, we examine closely the related issues of whether an "article" classification for BESS is (i) correct, under the CLP and related Regulations, or (ii) relevant, under the COMAH and HSC Regulations.

On the contrary, we conclude that (i) Li-ion BESS cannot be considered "articles" under the CLP Regulation; and that (ii) such classification is anyway irrelevant to the operation of the COMAH and HSC Regulations once a major accident potential is recognised. Therefore, we conclude that the COMAH Regulations are applicable to Li-ion BESS above a certain size (measured by energy storage capacity) that a competent engineering analysis can determine. These sizes have been estimated in a paper cited below, but further refinement is beyond the scope of this Briefing. Similarly, installations above the same size as for "lower-tier" COMAH, carry an obligation for the operator to seek Hazardous Substances Consent from the relevant local planning authority.

[1] Directive 2012/18/EU (4 July 2012)
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0018

[2] Regulation (EC) No 1272/2008 of the European Parliament and of the Council
https://www.legislation.gov.uk/eur/2008/1272/article/2

[3] Regulation (EC) No. 1272/2008 on Classification, Labelling and Packaging
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008R1272

Consideration of “loss of control of the processes” is particularly critical in respect of grid-scale BESS based on Li-ion technology. In normal operation Li-ion BESS are innocuous (apart from noise from ancillary plant). However known failure modes (especially that of “thermal runaway”) may lead to major accidents, popularly but incorrectly known as “battery fires”. Dangerous/hazardous substances specified in the Regulations are known to be involved in such accidents. Worldwide, these are matters of record, not speculation. The most recent explosion and fire in the UK occurred in a 20 MW BESS in urban Liverpool in September 2020. Some incidents may involve conventional fires, but the major hazard presented by BESS in a high State of Charge (SoC) is thermal runaway, a failure mode that does not require oxygen to proceed, and against which any firefighting strategy based on “smothering” or restriction of airflow will be useless. In thermal runaway, there may be no flame or fire until the inevitable mixing with air does happen, usually leading to a Vapour Cloud Explosion, followed by actual fire. Further propagation of such “fires” clearly has the potential to result in major accidents.

The secondary technical questions of (a) which dangerous/hazardous substances (controlled by the Regulations) may be generated in “loss of control” accidents in grid-scale BESS, and (b) whether the likely quantities exceed the Controlled Quantities specified in the Regulations, are discussed in a companion technical paper[4] by one of us (EJF), co-authored with Prof Sir David Melville CBE CPhys FInstP. This is already in the public domain. The estimates in that paper are necessarily based on published data in the open literature. A more accurate appraisal of the generation of dangerous/hazardous substances from Li-ion BESS during “loss of control of the processes” can only be determined by actual tests on representative examples of the actual battery cells proposed for, or already installed in, the plant in question. This is a matter for competent and verified engineering trials, and outside the scope of this Briefing.

In Northern Ireland, the operational safety aspects of the Seveso Directive are implemented by the Control of Major Accident Hazards Regulations (Northern Ireland) 2015[5] (“the COMAH Regulations”) and the land use planning aspects by the Planning (Hazardous Substances) (No. 2) Regulations (Northern Ireland) 2015[6] (for brevity herein “the HSC Regulations”). Parallel versions of the COMAH Regulations exist for Great Britain[7], and parallel versions of the HSC Regulations separately for England and Wales[8], and for Scotland[9]. Deriving as they do from the Seveso III Directive, the Regulations are of substantively identical effect, albeit made under different Statutory Instruments and different primary legislation across the several UK jurisdictions.

[4] Fordham, E J and Melville, D (2022) Hazardous Substances potentially generated in "loss of control" accidents in Li-ion Battery Energy Storage Systems (BESS) : storage capacities implying Hazardous Substances Consent obligations.
https://www.researchgate.net/publication/359203817_Hazardous_Substances_potentially_generated_in_loss_of_control_accidents_in_Li-ion_Battery_Energy_Storage_Systems_BESS_storage_capacities_implying_Hazardous_Substances_Consent_obligations

[5] NISR 2015 No. 325 https://www.legislation.gov.uk/nisr/2015/325/regulation/1

[6] NISR 2015 No. 344 https://www.legislation.gov.uk/nisr/2015/344/schedule/2/part/3

[7] SI 2015 No. 483 https://www.legislation.gov.uk/uksi/2015/483/regulation/2

[8] SI 2015 No. 627 https://www.legislation.gov.uk/uksi/2015/627/introduction/made

[9] SSI 2015 No. 181 https://www.legislation.gov.uk/ssi/2015/181/contents/made

Short biographies

EurIng Dr Edmund Fordham is a physicist and engineer, retired since 2018 from the position of Scientific Advisor in Schlumberger, the premier international company in the oilfield services sector. He graduated from Cambridge in 1977 with a double First in Natural Sciences, and is an expert in fluid dynamics, and applications of Nuclear Magnetic Resonance to petroleum-bearing sedimentary rocks. He served in various roles in the company in the UK and USA and assisted in the establishment of a new Research Centre in Saudi Arabia.

Earlier in his career, he worked (1978) on fault scenarios in Liquid-Metal cooled Fast Breeder (nuclear) Reactors (LMFBR), for the then HM Inspectorate of Nuclear Installations, via a fluids engineering consultancy company. His doctoral thesis (1984) was on wind energy, working with the late Prof Sir Martin Ryle FRS (Astronomer Royal, Nobel Prize for Physics 1974). He joined Schlumberger in 1985. His technical career has spanned all classes of energy technologies from renewables to nuclear energy, with 33 years in the oil and gas sector.

He has published over 80 scientific and technical papers and over a dozen issued Patents. He is a Chartered Physicist, qualified as a Chartered Engineer in 1994 and was elected a Fellow of the Institute of Physics (FInstP) in 2000. He remains a registered European Engineer (EurIng).

Throughout his professional life, compliance with health and safety regulations of significant technical content has been routine. These include regulations such as the Control of Substances Hazardous to Health (COSHH) regulations, the Pressure Equipment Directive (PED) and related regulations in foreign jurisdictions, and the regular preparation of Hazard Analysis and Risk Control (HARC) assessments.

Pat Swords is a Fellow of the Institution of Chemical Engineers, a Professional Process Safety Engineer and a Chartered Environmentalist.

He has more than thirty years' of experience in the design and regulatory compliance of industrial projects in Europe, USA, Asia and the Middle East covering such sectors as chemicals, pharmaceuticals, food and energy.

Between 2000 and 2016, he was extensively involved as a consultant on EU technical aid projects in Central and Eastern Europe implementing the industrial pollution control and Control of Major Accidents legislation.

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1.0 The Seveso disaster: "loss of control of the processes"

In 1976 in the Italian town of Seveso, a runaway reaction occurred in a chemical plant resulting in an explosion and the release of toxic and carcinogenic dioxins and leading to significant environmental impact on the surrounding area, with 19 child hospitalizations, 200 cases of chloracne in subsequent weeks, and high plant and animal mortality. The longer term health impacts have been documented in a number of publications, e.g. Eskenazi *et al.* (2018)[10].

This high-profile accident led to the EU adopting its Control of Major Accident Hazards Legislation, commonly called "the Seveso Directive", which has been updated a number of times, with the current 2012/18/EU Directive[11] referred to as Seveso III. Recital (2) of the preamble to the Directive continues to cite the Seveso accident, among other major industrial accidents, as motivation for the measures in the Directive.

It is absolutely fundamental to understanding the legislative intent behind the Seveso Directive, that no dioxins were involved in the production process in that chemical facility in Seveso, *operating as designed*. Those toxic and carcinogenic chemicals were only generated in a runaway chemical reaction, which occurred due to "loss of control of the processes".

The scope of the EU's Seveso legislation has therefore always included specific reference to the "reasonably foreseeable generation" of "dangerous/hazardous substances" during "loss of control of the processes", e.g. Article 3 (Definitions) para. 12:

'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;

These are the requirements that have been translated into UK law via the COMAH Regulations (for Articles 2 through 12 of the Directive) and HSC Regulations (for the land-use planning aspects in Article 13 and elsewhere). The legislative intent has always been to include "loss of control" accidents, with as high a level of rigour as applicable to establishments where "dangerous substances" are present by design.

[10] Eskenazi, B, Warner, M, Brambilla, P, Signorini, S, Ames, J & Mocarelli, P (2018). The Seveso accident: A look at 40 years of health research and beyond. *Environ. Int.* **121**(1), 71-84 doi:10.1016/j.envint.2018.08.051

[11] Directive 2012/18/EU (4 July 2012)
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0018

2.0 Legislative intentions of the Seveso Directive

Various Annexes and FAQs to the Directive clarify the intentions:

Annex I (8): The hazard class Explosives includes explosive articles (see Section 2.1 of Annex I to Regulation (EC) No 1272/2008). If the quantity of the explosive substance or mixture contained in the article is known, that quantity shall be considered for the purposes of this Directive. If the quantity of the explosive substance or mixture contained in the article is not known, then, for the purposes of this Directive, the whole article shall be treated as explosive.

This makes clear that the drafters circumvented, and closed off, the possibility of evasion of the provisions by attempting to define certain hazards as "articles". "Explosives" contained within "articles" (e.g. shells, explosive charges) are nevertheless be treated as explosive "substances", whether contained within "articles" or not. This "loophole block" is not explicit for the other hazard classes but the possibility of major accident hazards from large scale electrochemical storage technology was clearly not envisioned at the time of enactment of the Directive, because large-scale Li-ion BESS did not exist.

We read this provision as a specific exemplar of the *inclusion* of "articles" within the scope of the Directive, not as a unique *exception* (which appears to be the current position of HSE and HSENI). The former reading is justified by Note 5 of Annex I:

Annex I (5)[12]: In the case of dangerous substances which are not covered by Regulation (EC) No 1272/2008 [the CLP Regulation] including waste, but which nevertheless are present, or are likely to be present, in an establishment and which possess or are likely to possess, under the conditions found at the establishment, equivalent properties in terms of major-accident potential, these shall be provisionally assigned to the most analogous category or named dangerous substance falling within the scope of this Directive.

In this Note, the drafters have taken great care to ensure that even when "substances" are *not* covered by the CLP Regulations (e.g. by reason of being contained within "articles", as in some waste) then if they are likely to possess, in the operational conditions, major-accident potential (e.g. a thermal runaway accident in a Li-ion BESS), then they should be provisionally assigned the most analogous category within the scope of the Directive.

One may also note that "waste" is explicitly included in the scope of the Directive, and that "waste" frequently contains "articles" (or parts or fragments thereof) and is indeed not classified under the CLP Regulation.

Explicit translation into UK law is made at Schedule 1 Part 3 Notes 5 and 8 of the COMAH Regulations[13] and at Schedule 1 Part 4, Notes 6 and 9 of the HSC Regulations[14], with parallel passages in the other UK jurisdictions, so these provisions are explicitly enacted in UK law.

A European Commission "FAQ – Seveso III" has been issued[15] with explicit discussion of the intentions of Article 3(11) (actually Article 3(12), "11" is an error):

Sev III – Article 3(11) – "Presence of dangerous substances"

[FAQ:] Does this notion aim to cover establishments where dangerous substances may be generated as a result of loss of control of the processes in quantities exceeding the qualifying thresholds in Annex I, even if such establishment would not normally fall under the scope of the Seveso Directive, for reason of the actual or anticipated presence of dangerous substances in quantities above the qualifying thresholds?

[12] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0018
[13] https://www.legislation.gov.uk/uksi/2015/483/schedule/1
[14] https://www.legislation.gov.uk/uksi/2015/627/schedule/1/made
[15] https://circabc.europa.eu/sd/a/840e3d58-8e33-40f5-9d6f-8797338dedfb/faq.pdf

[Answer:] The definition in Article 3(11) refers to:
(1) the actual presence of dangerous substances in the establishment,
(2) the anticipated presence of dangerous substances in the establishment,
(3) the dangerous substances which it is reasonable to foresee that may be generated during loss of control of the process, including storage activities, in any installation within the establishment.

The reference in (3) to "any installation within an establishment" cannot be understood as meaning to restrict the scope of this third scenario to only those substances that could be created as a result of loss of control in installations already covered by the Seveso Directive for reason of the actual or anticipated presence of (other) dangerous substances.

The notions "presence of dangerous substances", "installations" and "establishments" are interlinked and used in a circular way. No conclusions shall be drawn from these cross-references.

The Seveso Directive underlines the need to ensure that appropriate precautionary action is taken to ensure a high level of protection throughout the Union for citizens, communities and the environment (recital (2) of the Directive). Such high level of protection can only be achieved if the necessary prevention and control measures are taken in all establishments where dangerous substances could be present in quantities above the thresholds.

Therefore, if it is reasonable to believe that, in case of an incident, dangerous substances could be created in quantities exceeding the qualifying thresholds, then the operator of the establishment where non-Seveso substances are present or where Seveso-substances are present but below the qualifying quantities, should notify its activities as if it were a Seveso establishment.

In summary, the legislative intent behind the COMAH and HSC Regulations is revealed by considerations including the following:

1. the origin of the legislation in the Seveso disaster (1976), itself a “loss of control” accident where the dangerous substances were not present in normal operation;
2. Recital 2 to the Seveso III Directive, explicitly including Seveso;
3. Annex I Note 5 of the Directive (translated into COMAH at Schedule 1 Part 3 Note 5 and into the HSC Regulations at Schedule 1 (Schedule 2 in NI) Part 4 Note 6) by which “substances” are not covered by the CLP Regulations (e.g. by reason of being contained within “articles” or otherwise) then if they are likely to possess, in the operational conditions, major-accident potential (e.g. a thermal runaway accident in a Li-ion BESS), then they should be provisionally assigned the most analogous category within the scope of the Directive.
4. Annex 1 Note 8 of the directive (translated into COMAH at Schedule 1 Part 3 Note 8 and into the HSC Regulations at Schedule 1 (Schedule 2 in NI) Part 4 Note 9) by which “Explosives” cannot be exempted from the scope of the Regulations simply by being contained within objects classified as “articles”, a clear intention to prevent the Regulations being circumvented by an “articles” classification under the CLP Regulation;
5. The FAQ’s of the European Commission on interpretation of the Directive, where the “loss of control” scenario is explicitly stated *not* to be restricted to “installations already covered by the Seveso Directive” (i.e. already containing “dangerous substances”), and that control measures should be taken in all establishments where dangerous substances could be present in quantities above the thresholds.
6. The same FAQ answer explicitly stating that if dangerous substances *could* be created in accidents, in quantities exceeding the thresholds, then the establishment where “non-Seveso” substances are present should (nevertheless) notify its activities as if it were a Seveso [i.e. COMAH] establishment.

3.0 Implementation of the Seveso Directive in the UK

As outlined in the "Purpose" summary, the operational safety aspects of the Seveso Directive are implemented in the COMAH Regulations[16], supervised (in Great Britain) by the Health and Safety Executive (HSE), and in Northern Ireland by the Health and Safety Executive for Northern Ireland (HSENI).

The land-use Planning aspects of the Seveso Directive (Article 13 and elsewhere) are implemented in what this Briefing calls, for brevity, "the HSC Regulations", though under a variety of statutory instruments in different parts of the UK.

In England and Wales, these are governed by the Planning (Hazardous Substances) Regulations 2015[17]; in Northern Ireland by the Planning (Hazardous Substances) (No. 2) Regulations (Northern Ireland) 2015[18] and in Scotland by the Town and Country Planning (Hazardous Substances) (Scotland) Regulations 2015[19].

Consent must be sought for the introduction of Hazardous Substances from the "hazardous substances authority" which under the Planning (Hazardous Substances) Act 1990[20] is normally the local Planning Authority i.e. in England, the District Council, though various special cases are given in the Act.

In Northern Ireland, the primary legislation is in the Planning Act (Northern Ireland) 2011, Part 4 Chapter 2 (Hazardous Substances)[21].

Requirements for seeking Hazardous Substances Consents (HSC) proceed in parallel with notifications to the COMAH Competent Authority in the case of the COMAH Regulations, because the requirement to do so derives from the same actual, anticipated, or reasonably foreseen generation of the same "dangerous substances" as are defined in the COMAH Regulations. Apart from the change of terminology from "dangerous substances" to "hazardous substances", inspection of the Schedules to (a) the COMAH Regulations and (b) the HSC Regulations, confirms that the substances envisioned are identical.

The Controlled Quantities for HSC are also identical[22] to the Qualifying Quantities (QQ) for "lower-tier" COMAH establishments, so an installation requiring HSC is also a COMAH establishment, and *vice versa*.

Failure to obtain HSC where hazardous substances are present, planned or reasonably foreseeably generated in loss of control, constitutes a specific offence under S. 23 of the Planning (Hazardous Substances) Act 1990 (in England and Wales), or (in Northern Ireland) S. 117 of the Planning Act (Northern Ireland) 2011.

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[16] In Great Britain: SI 2015 No. 483 https://www.legislation.gov.uk/uksi/2015/483/regulation/2
In Northern Ireland: NISR 2015 No. 325 https://www.legislation.gov.uk/nisr/2015/325/regulation/1

[17] SI 2015 No. 627; https://www.legislation.gov.uk/uksi/2015/627/introduction/made

[18] NISR 2015 No. 344; https://www.legislation.gov.uk/nisr/2015/344/schedule/2/part/3

[19] SSI 2015 No. 181; https://www.legislation.gov.uk/ssi/2015/181/contents/made

[20] https://www.legislation.gov.uk/ukpga/1990/10/section/1

[21] https://www.legislation.gov.uk/nia/2011/25/part/4/chapter/2

[22] With two specific exceptions: for Hydrogen and for Natural Gas. The CQs for HSC are lower than those for COMAH.

3.1 Inclusion of "Articles" in the COMAH and HSC Regulations

The inclusion of "articles" (as defined in the CLP Regulation) within the scope of the COMAH and HSC Regulations is both particular and general.

The particular inclusion is for "explosive articles", following Annex I (8) of the Seveso Directive[23]. For completeness, we note that this provision is reproduced in the following Regulations:

COMAH (both GB[24] and NI[25]): in Schedule 1, Part 3, Note 8

HSC (England and Wales[26]): in Schedule 1, Part 4, Note 9
HSC (Northern Ireland[27]): in Schedule 2, Part 4, Note 9
HSC (Scotland[28]): in Schedule 1, Part 2, "Notes to Parts 1 and 2", Note 9

The general inclusion is for "dangerous substances not covered by the CLP Regulation, including waste … which are likely to possess … major-accident potential" (Annex I (5) of the Seveso Directive). This provision is reproduced in the following Regulations:

COMAH (both GB[29] and NI[30]): in Schedule 1, Part 3, Note 5

HSC (England and Wales[31]): in Schedule 1, Part 4, Note 6
HSC (Northern Ireland[32]): in Schedule 2, Part 4, Note 6
HSC (Scotland[33]): in Schedule 1, Part 2, "Notes to Parts 1 and 2", Note 6

This list is provided to demonstrate that the Annex provisions of Seveso have been implemented, and remain in force, in all the UK jurisdictions, for both the operational safety aspects (COMAH), and for the land-use planning aspects (HSC).

[23] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0018
[24] https://www.legislation.gov.uk/uksi/2015/483/schedule/1
[25] https://www.legislation.gov.uk/nisr/2015/325/schedule/1
[26] https://www.legislation.gov.uk/uksi/2015/627/schedule/1
[27] https://www.legislation.gov.uk/nisr/2015/344/schedule/2
[28] https://www.legislation.gov.uk/ssi/2015/181/schedule/1/made
[29] https://www.legislation.gov.uk/uksi/2015/483/schedule/1
[30] https://www.legislation.gov.uk/nisr/2015/325/schedule/1
[31] https://www.legislation.gov.uk/uksi/2015/627/schedule/1
[32] https://www.legislation.gov.uk/nisr/2015/344/schedule/2
[33] https://www.legislation.gov.uk/ssi/2015/181/schedule/1/made

4.0 Schedules of dangerous/hazardous substances in the HSC and COMAH Regulations

4.1 In the HSC Regulations.

The current Regulations were made in 2015 under the authority of the P(HS)A 1990 (England and Wales) or the Planning Act (Northern Ireland) 2011, Part 4 Chapter 2 (Hazardous Substances) and also of the European Communities Act 1972. Their most important aspect is that they define "for the purpose of the Act" (Reg. 3)[34] what are "hazardous substances" (HS) (Reg. 3(a)) and what are the "controlled quantities" (CQ) (Reg. 3(b)).

We note that Reg. 3 describes "hazardous substances" as being "substances, mixtures or preparations, present as raw materials, products, by-products, residues or intermediates" – which covers a very wide range of forms in which "substances" may be present.

The hazardous substances HS and their controlled quantities CQ (always listed by weight, in tonnes) are itemised in Schedule 1 to the Regulations[35] (Schedule 2 in Northern Ireland[36]), which has three Parts, each in two Columns. Column 1 lists the hazardous substances HS (Reg. 3(a)) and Column 2 lists the controlled quantities CQ in tonnes (Reg. 3(b)).

Part 1 ("Categories of Substances") lists hazardous substances according to the "hazard categories" contained in the CLP (Classification Labelling and Packaging) Regulation. These include Health Hazards (Section H), Physical Hazards (Section P), Environmental Hazards (section E) and "Other" Hazards (Section O). To decide if a particular substance falls within any of these hazard categories require consulting the CLP Regulations and the very many listings of chemicals contained therein, and their defined hazard categories. Reg. 3(a)(i) specifies that any substance falling into one of these categories in Part 1 is a "hazardous substance" for the purposes of the Act.

Part 2 ("Named Hazardous Substances") lists named hazardous substances with well-known hazards and specific controlled quantities which may be different from the CQ in Part 1 determined on the basis of the Hazard Category of the substance. Reg 3(a)(ii) specifies that any substance specified in Part 2 is a hazardous substance for the purposes of the Act.

Part 3 ("Substances used in Processes") defines a hazardous substance as:

> Where it is reasonable to foresee that a substance falling within Part 1 or Part 2 ("HS") may be generated during loss of control of the processes, including storage activities in any installation within an establishment, any substance which is used in that process ("S").

Reg. 3(a)(iii) defines a HS as one "meeting the description in Column 1 of Part 3 of that Schedule" i.e. Schedule 1 (Schedule 2 in NI) to the Regulations. "The description in Column 1" is quoted above.

[34] https://www.legislation.gov.uk/uksi/2015/627/regulation/3/made
[35] https://www.legislation.gov.uk/uksi/2015/627/schedule/1/made
[36] https://www.legislation.gov.uk/nisr/2015/344/schedule/2

In other words, *any substance "S" whatever* is to be considered a hazardous substance (HS) for the purposes of the Act, under Reg 3(a)(iii) and Schedule 1 Part 3 Column 1 — provided only that it is "*reasonable to foresee*" the HS *listed* in Parts 1 or 2 being "*generated* [from S] *during loss of control of the processes*".

The Controlled Quantity (CQ) of the substance(s) "S" (e.g. the chemical components of battery cells) is defined in Column 2 of Part 3, and reads:

> The amount of S which it is believed may generate (on its own or in combination with other substances used in the relevant process) an amount equal to or exceeding the controlled quantity of the HS in question.

In other words, the CQ of substances "S" (e.g. battery chemical components) are those amounts which may generate quantities of Hazardous Substances (listed in Parts 1 or 2), above the CQs for those *listed* HS, "during loss of control of the processes".

The provisions of Part 3 are frequently overlooked, consistently so in Planning Applications for BESS installations across the UK. Yet the Regulations are the UK implementation of the Seveso III Directive. As discussed, the entire history of the Seveso directive shows that it was always intended to cover not only hazardous substances present by design, but also hazardous substances generated where "control of the processes is lost".

Moreover, "loss of control" accidents in Li-ion BESS are the principal safety hazard that these systems present to the public and to the environment. In normal operation, they will be innocuous, and the chemicals on which the battery technology is based are either not listed in Parts 1 or 2 at all, or else are typically present below the CQs. In other words, Parts 1 and 2 are unlikely to compel the operator of a Li-ion BESS to seek HSC.

Part 3 is an entirely different matter. The well-known phenomenon of "thermal runaway" is a known failure mode of Li-ion batteries, and is equally well-known to generate HS in the hazard classes H1 and P2 of Part 1 and at least one "Named HS" in Part 2 when such accidents occur[37].

The substances "S" are then all the chemicals integral to the Li-ion cells, which under Part 3 and Reg. 3(a)(iii) are to be considered as "hazardous substances" (HS), even though not listed in Parts 1 or 2, because they have the potential to generate "*listed* HS" during "loss of control of the processes" i.e. if thermal runaway[38] or a "battery fire" occurs.

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[37] Fordham, E J and Melville, D (2022) Hazardous Substances potentially generated in "loss of control" accidents in Li-ion Battery Energy Storage Systems (BESS) : storage capacities implying Hazardous Substances Consent obligations.
https://www.researchgate.net/publication/359203817_Hazardous_Substances_potentially_generated_in_loss_of_control_accidents_in_Li-ion_Battery_Energy_Storage_Systems_BESS_storage_capacities_implying_Hazardous_Substances_Consent_obligations

[38] Fordham, E J, Allison, W & Melville, D (2021) "Safety of Grid-scale Li-ion Battery Energy Storage Systems", 5 June 2021
https://www.researchgate.net/publication/352158070_Safety_of_Grid_Scale_Lithiumion_Battery_Energy_Storage_Systems

4.2 In the COMAH Regulations.

In Schedule 1 to the COMAH Regulations, there are just two "Parts", and three "Columns". Part 3 comprises many technical "Notes" to Parts 1 and 2. Column 1 lists the categories or named "dangerous substances". The change from "hazardous" (HSC Regulations) to "dangerous" (COMAH Regulations) is consistent, but inspection shows that an identical list of substances is involved. Column 2 specifies the thresholds ("Qualifying Quantities", or QQs) in tonnes for "lower-tier" COMAH establishments, and Column 3 specifies the QQs for "upper-tier" COMAH.

As noted above, lists of categories in Part 1 and the named substances in Part 2 are the same as those in Parts 1 and 2 to the Schedules to the HSC Regulations.

With two specific exceptions[39], the Qualifying Quantities (QQs) for lower-tier COMAH establishments are the same as the Controlled Quantities (CQs) specified in the HSC Regulations.

Part 1 ("Categories of Substances") lists "dangerous" substances according to the "hazard categories" contained in the CLP Regulation, just as in Part 1 of the Schedule to the HSC Regulations. These include, as for the HSC Regulations, Health Hazards (H), Physical Hazards (P), Environmental Hazards (E) and "Other" Hazards (Section O).

Part 2 ("Named Dangerous Substances") lists named dangerous substances with well-known hazards and specific Qualifying Quantities (lower-tier Column 2, upper-tier Column 3) which may be different from the QQs in Part 1 determined by Hazard Category.

Unlike the HSC Regulations, there is no "**Part 3"** ("Substances used in Processes") in the Schedules to the COMAH Regulations, because the "loss of control" provisions are set out directly at the level of the definition of a "dangerous substance" (S. 2(1) Interpretation), following closely the wording of Article 3 (12) of the Seveso III Directive itself:

"presence of a dangerous substance" means:
the actual
or anticipated
presence of a dangerous substance in an establishment,
or of a dangerous substance 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 a quantity equal to or in excess of
the qualifying quantity listed in the entry for that substance in column 2 of Part 1
or in column 2 of Part 2 of Schedule 1,
and "where a dangerous substance is present" is to be construed accordingly;

The COMAH Regulations specify, directly and explicitly, at the level of the above definition, that "reasonably foreseeable generation of dangerous substances during loss of control" must be considered as one of three possibilities (actual, anticipated, or foreseeable generation) in the interpretation of the phrase: "presence of a dangerous substance".

There is therefore no need for a "Part 3 (Substances used in processes)" because that possibility is already covered at the level of a definition.

[39] Hydrogen and Natural Gas

The only requirement is that the dangerous substances "foreseeably generated" in loss of control should be one (or more) of those listed in Parts 1 and 2, and this is amply demonstrated by multiple sources in the technical literature. The paper by Fordham and Melville[40] itemises the many possibilities, with references to the primary literature.

We note that there is no requirement anywhere in the COMAH definitions regarding the *source material* for the "Part 1 or Part 2 dangerous substances" that are foreseeably generated in loss of control.

There is no restriction regarding *any* categorization under the CLP Regulation (i.e. as "articles" or as "substances or mixtures") for the source material. The CLP classification, *before control is lost*, is simply irrelevant to the COMAH loss of control definition.

The only requirement is that *once generated in accidents*, the "dangerous substances" should be one or more of those specified in Parts 1 or 2 (and *classified* according to the CLP Regulation, *per* Part 3 Note 1).

We are aware of no restrictions, anywhere in law, that provides any exemption for "articles" that may subsequently be the source of "dangerous substances". Moreover, multiple lines of correspondence with HSE in Great Britain[41], explicitly asking for citations to any such legal authorities, have failed to advise us of any such provision.

Therefore, we see no ground for supposing that a classification as an "article" by the CLP Regulation (even if correct) provides an exemption for Li-ion BESS or indeed any other technology. We find none in the COMAH Regulations, and any such provision elsewhere would violate the legislative intention, having regard to the origin of the Regulations in the Seveso Directive, with the prevention of major industrial accidents as its central purpose.

We conclude that there are no exemptions anywhere in the COMAH Regulations for industrial plant classified by CLP as an "article": the CLP classification *prior to* the "loss of control" incident is mentioned nowhere. It is the CLP classification of the dangerous substance(s) *after their foreseeable generation* in loss of control that governs the application of the COMAH Regulations.

[40] Fordham, E J and Melville, D (2022) Hazardous Substances potentially generated in "loss of control" accidents in Li-ion Battery Energy Storage Systems (BESS) : storage capacities implying Hazardous Substances Consent obligations.
https://www.researchgate.net/publication/359203817_Hazardous_Substances_potentially_generated_in_loss_of_control_accidents_in_Li-ion_Battery_Energy_Storage_Systems_BESS_storage_capacities_implying_Hazardous_Substances_Consent_obligations

[41] Full file available.

5.0 Summary of the "Loss of Control" provisions in the COMAH and HSC Regulations

5.1 In the COMAH Regulations: the wording of the "loss of control" provisions (2(1) Interpretation) mirrors directly the wording of the Seveso Directive itself (Article 3 (12)) by inclusion of "loss of control" provisions directly in the definition of a "dangerous substance":

"presence of a dangerous substance" means:
the actual
or anticipated
presence of a dangerous substance in an establishment,
or of a dangerous substance 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 a quantity equal to or in excess of
the qualifying quantity listed in the entry for that substance in column 2 of Part 1
or in column 2 of Part 2 of Schedule 1,
and "where a dangerous substance is present" is to be construed accordingly;

There is no restriction regarding *any* categorization under the CLP Regulation (i.e. as "articles" or as "substances") for the source material, *before control is lost*. The CLP classification *before* loss of control is simply irrelevant to the COMAH definition.

The only requirement is that *once generated in accidents*, the "dangerous substances" should be one or more of those specified in Parts 1 or 2 (and *classified* for their hazard classes according to the CLP Regulation, *per* Part 3 Note 1).

5.2 In the HSC Regulations: parallel wording appears in Part 3 ("Substances used in Processes" of Schedule 1 (Schedule 2 for the Northern Ireland Regulations), where a "hazardous substance" is defined as:

> Where it is reasonable to foresee that a substance falling within Part 1 or Part 2 ("HS") may be generated during loss of control of the processes, including storage activities in any installation within an establishment, any substance which is used in that process ("S").

Reg. 3(a)(iii) defines a HS as one "meeting the description in Column 1 of Part 3 of that Schedule" i.e. Schedule 1 to the Regulations (for Northern Ireland, Schedule 2). "The description in Column 1" is quoted above.

In other words, *any substance "S" whatever* is to be considered a hazardous substance (HS) for the purposes of the Act, under Reg 3(a)(iii) and Schedule 1 Part 3 Column 1 — provided only that it is "*reasonable to foresee*" the *listed* HS (in Parts 1 or 2) being "*generated* [from S] *during loss of control of the processes*".

As in the COMAH Regulations, the CLP classification of "Substance(s) S" is irrelevant to the HSC Regulations. Any substance whatever "used in that process" is required to be considered. In the case of the HSC Regulations, it might be argued that a CLP classification as an "article" would exclude the many "substances" used in battery cells, and that the Regulations therefore do not apply, by reason of battery cells being "articles".

Any such interpretation would immediately be inconsistent with the COMAH Regulations, and their joint origin in the Seveso Directive, thus violating their known legislative intent. Nevertheless, because the argument is currently used by HSE and HSENI, we examine the question in some detail below.

6.0 HSE Guidance Notes to the COMAH Regulations

HSE have issued Guidance in a document "L111" [42] which reproduces the Regulations themselves, together with lists of Guidance Notes. Notes 56 and 57 read:

> 56 Operators should consider substances which may be generated during a loss of control of a process, including storage activities as defined in this regulation. Operators should consider all types of scenarios, including during process and storage, that it is reasonable to foresee may lead to dangerous substances being generated.
>
> 57 The definition is not intended to bring into scope premises which do not manufacture, use or store dangerous substances, solely because of dangerous substances being generated in an accident. For example, a warehouse holding non-dangerous substances is not in scope of the Regulations solely because a fire might generate dangerous substances above threshold quantities.

Note 56 appears to be a clear "plain English" rendering of the requirements under the fundamental definitions in 2(1): if it is "reasonable to foresee" dangerous substances being generated in loss of control situations, then the Regulations apply.

Note 57 however directly and immediately contradicts the preceeding Note 56, and asserts an exception for premises that do not "manufacture, use or store" dangerous substances, just because dangerous substances may be generated in an accident. It also contradicts the written law, in the Interpretation at 2(1) of the COMAH Regulations, in Schedule 1 Part 3 of the HSC Regulations, or the Definitions at Article 3(12) of the Seveso III Directive.

Note 57 appears to have no basis in law and the contradiction with Note 56 is immediate and appears unresolvable. The "warehouse" example is a "storage activity" which is explicitly covered by Note 56, yet explicitly excluded in Note 57. No other authority is cited supporting the alleged "exemption" and we are aware of none that might apply.

Note 57 also asserts intentions ("is not intended") behind the legislation which are not borne out by the legislative history of the Seveso Directive[43], the FAQs issued by the European Commission[44], or simply by the Regulations themselves[45]. Indeed an out-of-context reading of Note 57 might even result in the conclusion that the Seveso plant itself would not have been "in scope" of the Regulations.

We note that HSE has no authority to "make regulations or other instruments of a legislative character" (Health and Safety at Work Act 1974 S.13(5)(c)[46]). Accordingly, Note 57 of the Guidance Notes would appear to be *ultra vires.*

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[42] The COMAH Regulations 2015: Guidance on Regulations L111 (3rd edition) ISBN 978 0 7176 6605 8 https://www.hse.gov.uk/pubns/priced/l111.pdf

[43] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0018

[44] https://circabc.europa.eu/sd/a/840e3d58-8e33-40f5-9d6f-8797338dedfb/faq.pdf

[45] In Northern Ireland: NISR 2015 No. 325 https://www.legislation.gov.uk/nisr/2015/325/regulation/1

[46] https://www.legislation.gov.uk/ukpga/1974/37/section/13

6.1 Current position of the Health and Safety Executive and HSENI

The Health and Safety Executive (HSE) is not directly responsible for the operation of Planning law and disclaims any special expertise to advise on Planning issues. However it is the statutory body responsible for the operation of the COMAH Regulations which are the operational safety aspect of the Seveso III Directive, and the HSC Regulations arise as an integral aspect of that Directive.

Also, the HSE is a Statutory Consultee for major Planning applications such as those under the Planning Act 2008 which may be designated Nationally Significant Infrastructure Projects (NSIP), and has a duty to advise local Planning authorities on health and safety matters. As such the HSE has a significant influence over the operation of the HSC Regulations in practice.

Correspondence with the HSE has however yielded the assertions that

(i) "BESS are not in scope of COMAH"[47], and
(ii) "HSC requirements … do not currently apply to BESS"[48]

A full portfolio of correspondence is available.

The only justification provided for these positions was that batteries are classified as "articles" under the CLP Regulation and were therefore exempt from the provisions of the COMAH Regulations and, by implication, from the HSC Regulations.

Subsequent correspondence with HSE has not provided any answer to a request for the specific clause in statute, regulation or case-law that exempts BESS from COMAH or HSC. We are aware of no such clauses.

A similar position appears to have been taken by HSENI, although in the case of HSENI, a recent response[49] to the Planning Dept of Ards and North Down Borough Council states:

> Large scale battery facilities, also known as BESS (Battery Energy Storage Systems) have the potential to require a Hazardous Substance Consent and be subject to the COMAH Regulations. HSENI advises that the applicant should provide details (type and mass) of any dangerous substance;
> 1. Stored or produced during normal operation
> 2. That can result from a fire, explosion or other event if there is a loss of control of the process.
> Once this information is provided, it can then be assessed if a Hazardous Substance Consent and COMAH Regulations are applicable.

The letter is reproduced herein. These responses are, unlike the position of HSE (GB), consistent with our understanding of the law as set out in this Briefing.

Therefore the rest of this Briefing examines closely the only specific reason provided by HSE in Great Britain, which is that batteries are classified as "articles" under the CLP (Classification Labelling and Packaging) Regulation.

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[47] Letter to Dr E J Fordham from Ms Sarah Albon, Chief Executive of HSE, 22 February 2021
[48] Letter to Mrs Lucy Frazer QC MP 21 December 2021
[49] Letter 13 May 2022 Re Planning Application LA06/2022/0251/F, HSENI Ref CN202204-0007, from Notifications Team, HSENI, 83 Ladas Drive, Belfast BT6 9FR

Planning Department
Ards and North Down Borough Council
The Council Office
2 Church Street
Newtownards
BT23 4AP

13 May 2022

Dear Sir/Madam

PLANNING APPLICATION: LA06/2022/0251/F
HSENI REF: CN202204-0007
LOCATION: Lands located directly adjacent to and south of Newtownards Electricity Substation, Ballyharry Business Park, Berkshire Rd, Newtownards BT23 7HH

Large scale battery facilities, also known as BESS (Battery Energy Storage Systems) have the potential to require a Hazardous Substance Consent and be subject to the COMAH Regulations.

HSENI advises that the applicant should provide details (type and mass) of any dangerous substance;
1. Stored or produced during normal operation
2. That can result from a fire, explosion or other event if there is a loss of control of the process.

Once this information is provided, it can then be assessed if a Hazardous Substance Consent and COMAH Regulations are applicable.

HSENI notes there are a number of dwellings near the proposed development. HSENI advises the planning officer to consider the HSENI Technical Note regarding the risks from fire and explosion involving a single BESS container. This note was provided to DfI by HSENI for distribution to Local Planning Authorities.

In considering this application, HSENI assumes the applicant will meet all the Health and Safety at Work (NI) Order 1978 requirements and relevant statutory provisions if planning permission is granted.

Yours faithfully

Notifications Team
HSENI
Health & Safety Executive
Northern Ireland

83 Ladas Drive, Belfast, BT6 9FR, Northern Ireland
Telephone: 028 9024 3249 Helpline: 0800 0320 121
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Email: mail@hseni.gov.uk Web: www.hseni.gov.uk

7.0 The CLP Regulation within the COMAH and HSC Regulations: definition of "articles"

The CLP Regulation is an integral part of the HSC Regulations and is explicitly referenced in Note 1: Substances and mixtures are classified in accordance with the CLP Regulation.

The identical words are in Note 1 in Part 3 of the COMAH Regulations.

Reg. 2(5) (England and Wales)[50] (and similarly under Reg. 2(2) and 2(3)(b)[51] in the Northern Ireland Regulations) explicitly references:

References in these Regulations to Regulation (EC) No 1272/2008[52] of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures ("the CLP Regulation") are references to that Regulation as amended from time to time.

Similar references to the CLP Regulation appear in S. 2(1) "Interpretation" of the COMAH Regulations (both Great Britain and Northern Ireland versions).

Article 2 of the CLP Regulation[53] itself, "Definitions" 7, 8 and 9, reads:

7. 'substance' means a chemical element and its compounds in the natural state or obtained by any manufacturing process, including any additive necessary to preserve its stability and any impurity deriving from the process used, but excluding any solvent which may be separated without affecting the stability of the substance or changing its composition;
8. 'mixture' means a mixture or solution composed of two or more substances;
9. '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;

This definition of the difference between a "substance" and an "article" is not discussed further in the CLP Regulation itself. Reg. 3 of the HSC Regulations[54] includes more extensive descriptions as "substances, mixtures or preparations … present as raw materials, products, by-products, residues or intermediates" however there is no further explanation of the words which could be understood as aspects of the chemicals integral to battery cells.

Applying the Definition 9, if one asks: does the "special shape, surface or design" determine the function of a Li-ion battery cell to "a *greater* degree than does its chemical composition" ? – then the scientific answer is arguably "No", because a variety of "form factors" (cylindrical, prismatic or pouch being the most common) are used to make Li-ion batteries and multiple forms, "shapes, surfaces and designs" can be (and are) adopted using essentially *identical* chemistries. Therefore, the "special shape, surface or design" cannot be the *predominant* aspect of the technology.

It is chemistry and the chemicals which are the entire basis of the Li-ion battery technology, and commercial advantage and technological advance have all arisen from intensive research on the precise details of the electrode chemistries (particularly in the cathodes) and electrolyte composition, and details are usually a closely guarded trade secret. Hence it is clear that it is the "chemical composition" which is fundamental to the operation of a Li-ion cell. Of course, the arrangement of electrodes, electrolyte and

[50] https://www.legislation.gov.uk/uksi/2015/627/regulation/2
[51] https://www.legislation.gov.uk/nisr/2015/344/regulation/2
[52] https://www.legislation.gov.uk/eur/2008/1272/contents
[53] https://www.legislation.gov.uk/eur/2008/1272/article/2
[54] https://www.legislation.gov.uk/uksi/2015/627/regulation/3

separator in layers is also required for the cell to function as a battery. But variations in the geometry, shape, packaging and even differences in the thicknesses of the layered structure would not matter (though they might well affect its efficiency or energy density). So it is hard to argue that "shape" determines function to a *greater* degree than "composition"; the reverse is the case.

Understood thus, Li-ion battery cells are *not* "articles" under Definition 9 of the CLP Regulation, although a naïve reading disregarding the nature of battery technology, and the chemical substances within a cell, might conclude the reverse.

7.1 The legislative intent behind the CLP Regulation: the UN GHS system

Furthermore, the legislative background to the CLP Regulation must be understood, because this originates as an EU Directive EC 1272/2008[55] and the various Recitals are included in the UK Regulation[56], giving effect to the adoption of the United Nations Globally Harmonised System (GHS) for the Classification and Labelling of Chemicals:

(5) With a view to facilitating worldwide trade while protecting human health and the environment, harmonised criteria for classification and labelling have been carefully developed over a period of 12 years within the United Nations (UN) structure, resulting in the Globally Harmonised System of Classification and Labelling of Chemicals (hereinafter referred to as 'the GHS').

(6) This Regulation follows various declarations whereby the Community confirmed its intention to contribute to the global harmonisation of criteria for classification and labelling, not only at UN level, but also through the incorporation of the internationally agreed GHS criteria into Community law.

(8) Therefore it is essential to harmonise the provisions and criteria for the classification and labelling of substances, mixtures and certain specific articles within the Community, taking into account the classification criteria and labelling rules of the GHS, but also by building on the 40 years of experience obtained through implementation of existing Community chemicals legislation …

(12) The terms and definitions used in this Regulation should be consistent with those set out in Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), with those set out in the rules governing transport and with the definitions specified at UN level in the GHS, in order to ensure maximum consistency in the application of chemicals legislation within the Community in the context of global trade. The hazard classes specified in the GHS should be set out in this Regulation for the same reason.

A further reference to United Nations Treaty agreements is made via the Seveso III Directive 2012/18/EU[57] from which the HSC Regulations originate; the Recitals to this Directive include:

(5) The Convention of the United Nations Economic Commission for Europe on the Transboundary Effects of Industrial Accidents, which was approved on behalf of the Union by Council Decision 98/685/EC of 23 March 1998 concerning the conclusion of the Convention on the Transboundary Effects of Industrial Accidents, provides for measures regarding the prevention of, preparedness for, and response to industrial accidents capable of causing

[55] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R1272
[56] https://www.legislation.gov.uk/eur/2008/1272/introduction
[57] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0018

transboundary effects as well as for international cooperation in this field. Directive 96/82/EC implements the Convention within Union law.

The Convention of the UNECE on the Transboundary Effects of Industrial Accidents[58] was ratified by the UK on 5 August 2002, so the UK is and remains a party to this Convention independently of EU membership.

Recital (9) of the Seveso III Directive reiterates (*inter alia*) the commitment to the GHS:

… Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, which implements within the Union the Globally Harmonised System of Classification and Labelling of Chemicals that has been adopted at international level, within the structure of the United Nations (UN) …

The latest edition[59] (2014) of Annex I to the UNECE Convention includes the important agreement:

For the identification of hazardous activities, Parties [i.e. Convention signatories] shall take into consideration the actual or anticipated hazardous properties and/or quantities of all hazardous substances present or of hazardous substances which it is reasonable to foresee may be generated during loss of control of an activity, including storage activities, within a hazardous activity.

This echoes the language appearing in Part 3 of Schedule 1 of the HSC Regulations[60] and of the definitions in Reg. 2(1) of the COMAH Regulations[61], that hazardous substances reasonably foreseeably generated in loss of control are to be taken into consideration. This is therefore an international UN Convention commitment in addition to being a component of the Regulations via the Seveso III Directive.

The subsequent list of Hazardous Substances broadly follows those in the Schedules to the HSC and COMAH Regulations (although the Controlled Quantities are larger, being related to a Convention on Transboundary Effects), and similarly defines hazard categories:

Category in accordance with the United Nations Globally Harmonized System (GHS) of Classification and Labelling of Chemicals

The GHS system for classification is thus relevant in UK law through multiple routes:

1. through the EU Directive EC 1272/2008 giving rise to the CLP Regulation, incorporating the internationally agreed GHS into EU law;
2. through the Seveso III Directive 2012/18/EU, re-affirming the intention of EC 1271/2008 to implement the GHS in EU law, and the earlier Directive 96/82/EC incorporating the UNECE Convention into EU law;
3. the UK ratification of the UNECE Convention in 2002, independently of EU membership.

[58] https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-6&chapter=27&clang=_en
[59] https://treaties.un.org/doc/source/docs/ECE_CP.TEIA_30_Add.1-E.pdf
[60] https://www.legislation.gov.uk/uksi/2015/627/schedule/1
[61] https://www.legislation.gov.uk/uksi/2015/483/regulation/2

7.2 Scope of the GHS system and Definitions of "Articles"

The GHS manual[62] from the UNECE directly (8th edition, 2019) declares under 1.3.2.1 "Scope of the system":

1.3.2.1.1 The GHS applies to pure substances and their dilute solutions and to mixtures. "Articles" as defined in the Hazard Communication Standard (29 CFR 1910.1200) of the Occupational Safety and Health Administration [OSHA] of the United States of America, or by similar definition, are outside the scope of the system.

Thus a UN system, the GHS, incorporated into EU law by Directive EC 1272/2008 and by 2012/18/EU (the Seveso III Directive) and adopted in UK law as the CLP Regulation, the HSC Regulations and the COMAH Regulations, and adhered to in a UNECE Convention, explicitly references a US regulatory agency (OSHA) standard for its definition of an "article".

The question then becomes, how does OSHA define "articles" ?

7.3 Definitions of articles by OSHA

The OSHA Hazard Communication Standard (HSC) is the US implementation of the GHS system. OSHA has already provided specific interpretation in the USA on the classification of Li-ion batteries (other than consumer products) under the cited 29 CFR 1910.1200. This is publicly available[63] and (appealing to an earlier decision regarding lead-acid batteries) concludes:

Similarly, lithium-ion batteries (or lithium battery-powered devices) on a whole, although sealed, have the potential to leak, spill or break during normal conditions of use and foreseeable emergencies and expose employees to chemicals which can pose health (e.g., lithium cobalt, graphite) and/or physical (e.g., burns, fire) hazards, and therefore, **cannot be considered an article.**

The consequences included the obligation for:

… a manufacturer or importer of lithium-ion batteries or products which contain lithium-ion batteries that are not consumer products must develop and make available safety data sheets. *See* 29 CFR 1910.1200(g)(1). In addition, the battery or product must be properly labeled in accordance with HCS 2012. *See* 29 CFR 1910.1200(f)(1)

The earlier OSHA decision (2004) on lead-acid batteries[64] is directly available from OSHA and explains why consumer products are exempt:

The consumer products exemption applies when a product is defined a "consumer product" by the Consumer Safety Act (15 U.S.C. 2051 *et seq*.), and "the employer can show that it is used in the workplace for the purpose intended by the chemical manufacturer or importer of the product

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[62] Globally Harmonised System of Classification and Labelling of Chemicals (GHS). 8th revised edition, 2019. ST/SG/AC.10/30/Rev.8 Sales No. E.19.II.E.21 ISBN 978-92-1-117199-0 https://unece.org/fileadmin/DAM/trans/danger/publi/ghs/ghs_rev08/ST-SG-AC10-30-Rev8e.pdf

[63] Letter 17 December 2015, from T. Galassi, Director of Enforcement Programs, OSHA, Washington DC to "Labelmaster Services, Inc." https://blog.labelmaster.com/wp-content/uploads/OSHA-Interpretation-on-Lithium-Batteries-as-Articles-December-2015.pdf

[64] US Dept Labor, Occupational Safety and Health Administration, Letter from R E Fairfax, Director of Enforcement Programs 8 July 2004. https://www.osha.gov/laws-regs/standardinterpretations/2004-07-08

and its use results in a duration and frequency of exposure which is not greater than the range of exposures that could reasonably be experienced by consumers when used for the purpose intended" [29 CFR 1910.1200(b)(6)(ix)]. It is not clear to us that these batteries are a "consumer product" as that term is defined by the Consumer Products' Safety Commission. The term "consumer product" means any article, or component part thereof, produced or distributed (i) for sale to a consumer for use in or around a permanent or temporary household or residence, a school, in recreation, or otherwise, or (ii) for the personal use, consumption, or enjoyment of a consumer in or around a permanent or temporary household or residence, a school, in recreation, or otherwise . . . (15 U.S.C. 2052). UPS batteries are not generally sold for use as a consumer product.

Likewise, Li-ion battery cells designed for grid-scale BESS are not generally (or indeed ever) sold for use as a consumer product; therefore the earlier reasoning given by OSHA continues to apply, as endorsed by the 2015 interpretation: Li-ion batteries, other than those specifically exempted as a "consumer product" under the Consumer Safety Act (51 USC 2015) in the USA, are *not* considered as "articles" by OSHA.

7.4 Consequences of the OSHA definition for GHS and the CLP Regulation

In the USA, OSHA does not consider Li-ion batteries to be "articles" unless they are consumer products exempted by other provisions of US law.

Therefore, by Para. 1.3.2.1.1 of the GHS Manual, Li-ion cells (other than consumer products) are *not* articles under the GHS, and remain within its scope.

Therefore, by all the multiple routes adopting the GHS within EU and UK law, neither can they be considered "articles" for purposes connected to the GHS, implemented within EU and UK law by the CLP Regulation. Specifically Recital (12) to the CLP Regulation explicitly states:

(12) The terms and definitions used in this Regulation should be consistent with those set out in Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), with those set out in the rules governing transport and with the definitions specified at UN level in the GHS, in order to ensure maximum consistency in the application of chemicals legislation within the Community in the context of global trade. The hazard classes specified in the GHS should be set out in this Regulation for the same reason.

Therefore, the consistency required by Recital (12) would require that Li-ion batteries (other than consumer products) are *not* considered as "articles" under the CLP, and as in the USA under their Hazard Communication Standard, should be labelled appropriately.

7.5 Classification of substances and articles under REACH

The remaining reasoning to consider is that of the EU whose Directives incorporated into UK law the CLP Regulation, the HSC Regulations, and the COMAH Regulations. The CLP Regulation adopts the GHS system, but that system specifies simply a methodology for classification of chemicals. The further step was taken in the REACH Regulation [Registration, Evaluation, Authorisation and Restriction of Chemicals] of EC 1907/2006[65].

[65] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006R1907

This survives after EU exit by the UK in the form of "UK REACH" under the bureaucratic masterpiece title of:

"The REACH etc. (Amendment etc.) (EU Exit) Regulations 2020" [66].

We note once more that Recital (12) of the CLP Regulation requires consistency with REACH in addition to consistency with the UN GHS:

(12) The terms and definitions used in this Regulation should be consistent with those set out in Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), with those set out in the rules governing transport and with the definitions specified at UN level in the GHS, in order to ensure maximum consistency in the application of chemicals legislation within the Community in the context of global trade. The hazard classes specified in the GHS should be set out in this Regulation for the same reason.

REACH established the European Chemicals Agency (ECHA) whose role includes not only the registration of chemicals, but also the determination of appropriate "Harmonised Classifications" according to the GHS methodology. Harmonised Classifications are legally binding.

The CLP Regulation does not explore the question of what constitutes an "article" further than Definition 9, which we have argued does *not* establish BESS cells as "articles".

However the ECHA has developed considerable guidance on discriminating "articles" from "substances or mixtures" for the purposes and obligations of REACH[67], specifically on "requirements for substances in articles", in a detailed Guidance manual. Figure 2 of Subchapter 2.3 ("Deciding whether and object is an article or not") provides a detailed flow chart, abstracted herein:

[66] https://www.legislation.gov.uk/uksi/2020/1577/introduction/made

[67] ECHA (2017). "Guidance on requirements for substances in articles" June 2017, Version 4.0, https://echa.europa.eu/documents/10162/23036412/articles_en.pdf/cc2e3f93-8391-4944-88e4-efed5fb5112c

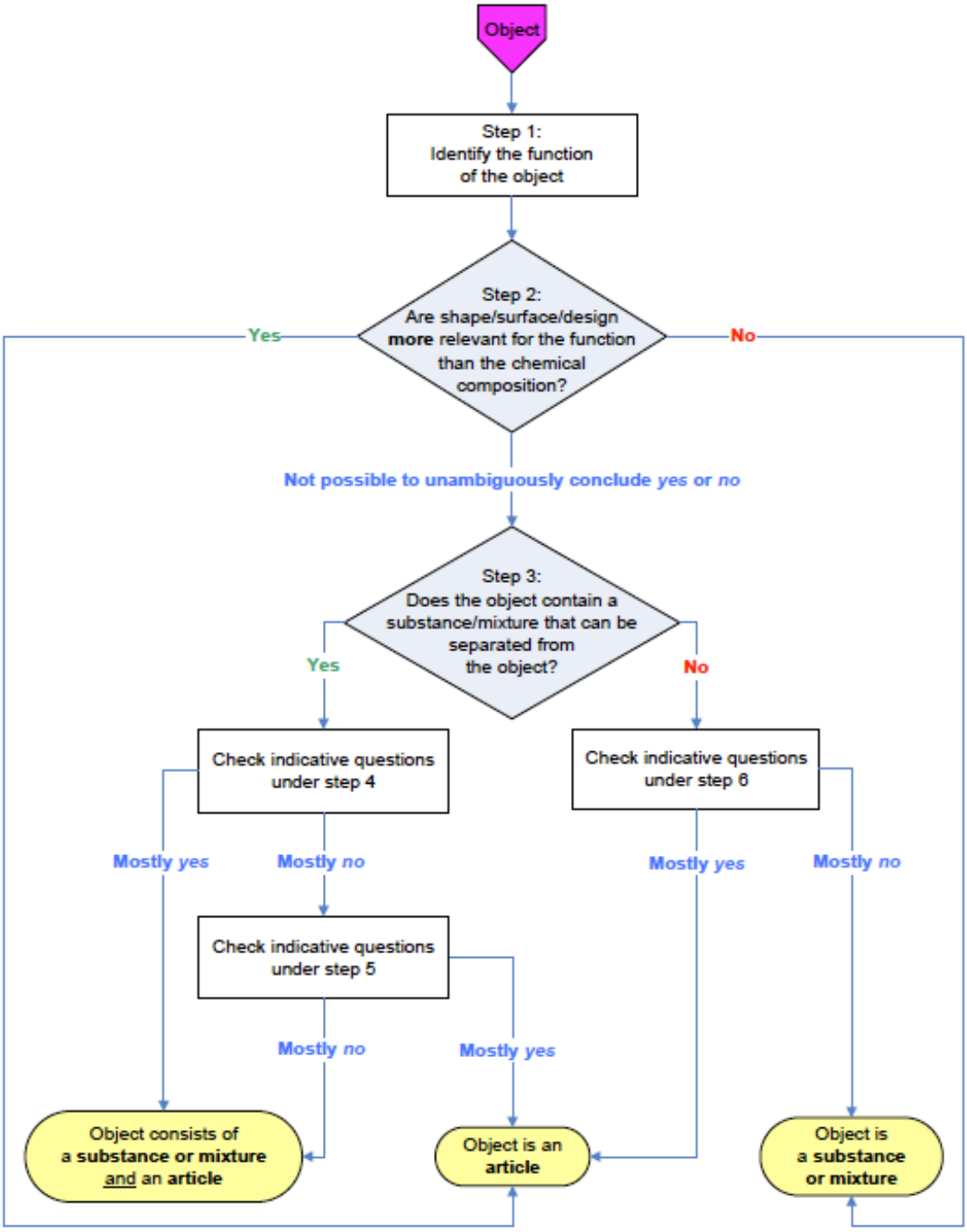

Figure 2: Decision-making on whether an object is an article or not

"Step 2" of this decision tree essentially reproduces the Definition 9 of the CLP Regulation, but instead of an implied binary decision, it provides a third option for the resolution of ambiguous cases. As discussed above, if the decision is binary, we believe that a battery cannot perform its function without the detailed chemical composition being precisely correct and optimised. Hence the answer to the question in step 2 is unambiguously "No", leading immediately to the conclusion that the "object" (a battery cell) is a "substance or mixture". Clearly battery cells are not pure "substances", but this reasoning concludes that a battery cell should be considered a chemical "mixture" under the CLP Regulation, and thus within scope of that Regulation.

The introduction of a third option for the purposes of REACH creates the possibility of marginal cases, including an object being a combination of a "substance or mixture" *and* an "article". Subsequent discussion refines this case to two further sub-categories (i) a combination of an "article" (functioning as a container or carrier material) *and* a "substance or mixture", and (ii) an "article" with an *integral* "substance or mixture".

Illustrative examples of its reasoning are given in Appendix 3, specifically including a "battery" (although the discussion clearly relates to disposable consumer batteries which are not rechargeable). Table 6 of Appendix 3 is reproduced herein, and shows explicitly that for REACH purposes (Registration *etc* of chemicals) a consumer "battery" is regarded as an "article with integral substance or mixture".

Table 6: Summary of borderline cases described in Appendix 3

Object	Conclusion	
	article with an integral substance/mixture	combination of an **article** (functioning as a container or a carrier material) and a **substance/mixture**
printer cartridge		x
spray can with paint		x
thermometer with liquid	x	
printer ribbon		x
wet cleaning wipe		x
wax tape for skis		x
adhesive tape for fixing carpets	x	
battery	x	
desiccant bag		x
detector tube	x	
candle		x

Therefore the position of the ECHA is that batteries are "articles with integral substance(s)" and that Registration (and other obligations under REACH) is only required where the substance(s) are intended to be released from the "article".

This guidance for REACH purposes (Registration, Evaluation, Authorisation and Restriction etc) clearly accepts that even consumer batteries have a "combination" classification and contain "substances or mixtures" that are "integral" to the "article". The guidance is important for the operation of REACH, which concerns registration and other obligations upon manufacturers, but it does not directly affect the operation of the Seveso Directive, for reasons discussed below.

7.6 Summary of the classification of battery cells under various Regulations and rulings.

We may summarise the various definitions and rulings as follows.

1. The CLP Regulation adopts the UN GHS methodology in EU and UK law;
2. The CLP Regulation commits to the definitions specified at UN level;
3. The Seveso III Directive further adopts the UNECE Convention on Transboundary Effects of Industrial Accidents into EU law, and the UK ratified the UNECE Convention independently of EU membership;
4. The UNECE Convention again categorizes hazardous substances by the UN GHS;
5. The UNECE GHS manual defines “articles” by the Hazard Communication Standard of the OSHA in the USA, which implements the UN GHS in the USA;
6. OSHA rulings definitively *reject* the “article” classification for Li-ion batteries (and other battery technologies), other than consumer products, and mandate labelling accordingly;
7. An “article” classification for Li-ion batteries that are not consumer products would therefore violate the commitments made in the CLP Regulation itself, and create inconsistency internationally, against the stated intentions of the CLP Regulation.
8. Having regard to the nature of the technology, application of the Definition (9) of an “article” in the CLP Regulation to Li-ion cells for BESS leads to the conclusions that Li-ion battery cells are not “articles” by Definition (9);
9. The Guidance Notes for the purpose of the REACH Regulation concludes that batteries (answering the description of non-rechargeable consumer products) are “articles with integral substance(s)”, recognising that battery technology is electrochemical in nature and contains chemicals that are indeed “substances” or “mixtures” under the definitions of the CLP and the GHS;
10. The Seveso III Directive and its implementation in the HSC and COMAH Regulations does refer to the *classification* of “substances and mixtures” by the CLP Regulation;
11. It also (Note 6) explicitly incorporates hazardous substances that are *not* covered by the CLP Regulation if they have “major accident potential”;
12. The Seveso III Directive and its implementation in the HSC and COMAH Regulations explicitly includes “explosive articles” as P1a or P1b Explosives;
13. Subject to testing by the procedures of the UNECE Manual of Tests and Criteria (mandated by the CLP Regulation), Li-ion cells in a high State of Charge may qualify as “explosive articles”.

Therefore:

A. Under the CLP Regulation and its stated intentions and commitments, Li-ion batteries (other than consumer products) are *not* “articles”, by specific OSHA rulings that govern the GHS definitions at UN level.

B. Having regard to the nature of the technology, the CLP Regulation Definition of an “article” also leads to the conclusion that a Li-ion battery is *not* an “article”.

C. Guidance notes for the REACH Regulation conclude that batteries (answering the description of a non-rechargeable consumer product) are “articles with integral substance(s)” for the purposes of REACH, recognising thereby that batteries contain integral chemicals that are “substance(s)” or “mixtures” by the CLP definitions.

D. The Seveso III Directive and HSC Regulations explicitly *include* “hazardous substances” that are *not* covered the CLP regulation if they have major accident potential.

E. The Seveso III Directive and the HSC Regulations explicitly *include* “explosive articles” in hazard classes P1a and P1b, and Li-ion cells in a high State of Charge may qualify as “explosive articles” if tested by the procedures of the UN MTC, itself specified as the definition of an “explosive” in the CLP Regulation.

8.0 Conclusions

We conclude: that Li-ion batteries, other than consumer products –

a. are definitively *not* "articles" by rulings of OSHA in the USA;

b. *cannot* be considered "articles" under the UN GHS, which explicitly adopts OSHA definitions;

c. *cannot* be considered "articles" under the CLP Regulation, under explicit commitments to definitions at UN level and global international consistency;

d. *cannot* be considered "articles" without also violating treaty obligations under the UNECE Convention on Transboundary Effects of Industrial Accidents;

e. do *not* meet the Definition (9) of an "article" under the CLP Regulation when the nature of the technology is considered;

f. may be regarded as "articles *with integral substance(s)*" for the purposes of REACH, recognising the presence of "substance(s)", whilst said purposes are not the purposes of the Seveso Directive, HSC or COMAH;

g. are explicitly *included* in the scope of the Seveso Directive, HSC and COMAH once their major accident potential is recognised, irrespective of CLP classification;

h. are explicitly *included* in the scope of the Seveso Directive, HSC and COMAH if they qualify as "explosive articles".

For the specific UK implementation in the HSC Regulations, if the question is asked:

"what are those substances S that may be regarded as hazardous substances under Part 3 ?"

the answer is:

All those "chemicals, substances, mixtures or preparations" that either:

(a) constitute the battery cell
(under the OSHA rulings, adopted in the CLP definitions via the UN GHS, or by direct consideration of the nature of the technology and the CLP definition),
or, alternatively,

(b) are integral to the battery cell regarded as an "article with integral substance(s)",
(under the REACH examples, regarding the purposes of Registration, Evaluation Authorisation and Restriction) or, alternatively,

(c) are present in battery cells recognised as having major accident potential
(under the provisions of Part 4, Note 6 to the HSC Regulations)

For the COMAH Regulations, there is no "Part 3", because the generation of dangerous substances listed in Parts 1 and 2 "during loss of control of the processes" is part of the Definition of "presence of a dangerous substance" in S. 2(1). We are aware of no exemption or restriction on this definition, either in the CLP Regulation or elsewhere, to exclude from the scope of the Definition dangerous substances that may be generated from "articles".

The CLP classification of Li-ion BESS appears to us simply irrelevant to the application of the COMAH Regulations, but as for the HSC Regulations, the same considerations in any event apply, namely that Li-ion BESS do not meet the definition of an "article" under the

commitment to international consistency set out in the Recitals to the CLP Regulation, nor to the definitions in the UNECE Convention, nor to the commitment to consistency with REACH, and are explicitly included in the scope of COMAH under Part 3, Note 5.

8.1 Correctness and relevance of classification as "Articles":

In our statement of Purpose, we undertook to examine closely the related issues of whether an "article" classification for BESS is (i) correct, under the CLP and related Regulations, or (ii) relevant, under the COMAH and HSC Regulations. We conclude:

8.1.1 Correctness:

Battery Energy Storage Systems, and specifically Li-ion BESS, other than consumer products (which cells for BESS never are) cannot be considered as "articles" without violating commitments to international consistency made in the CLP Regulation itself, arguably do not meet the basic definition of an "article" when the nature of the technology is properly considered, and are "articles with integral substance(s)" under REACH, consistency with which is again required by the Recitals to the CLP Regulation.

These are classifications fully in accord not only with the CLP Regulation and its consistency commitments, but also in accord with the basic common sense of anyone who understands that batteries (of whatever type) are electrochemical devices based on a layered structure of chemical "substances" and that those substances are fundamental to its operation as a battery.

8.1.2 Relevance:

8.1.2.1 For the COMAH Regulations: the Definitions at S. 2(1) explicitly cover generation of dangerous substances during loss of control, without any exemption or restriction of which we are aware that would exclude from the scope of the Definition dangerous substances that might be generated from "articles".

The CLP classification is therefore simply irrelevant to the application of the COMAH Regulations to Li-ion BESS, from which "dangerous substances", thus classified under the CLP Regulation, are well-known to be generated during loss of control of the processes.

Finally, Part 3 Note 5 explicitly includes substances "not covered by the CLP Regulation".

8.1.2.2 Under the HSC Regulations: where hazardous substances generated during loss of control are explicitly considered under Part 3, with reference to "Substances S used in processes", it might be argued that source materials are restricted to those classified as "substances" under the CLP Regulation. However this would be immediately inconsistent with the related COMAH Regulations, violating their known legislative intent. A variety of readings as provided shows that batteries are recognised as either "substances or mixtures" or "articles with integral substance(s)", in full accord with common sense, and that therefore Part 3 of the HSC Regulations should apply.

Finally, Part 4 Note 6 explicitly includes substances "not covered by the CLP Regulation".

8.2 In Summary

We conclude that the current position of HSE that grid-scale BESS are not "in scope of COMAH" (or of HSC) by reason of a classification as "articles" under the CLP Regulation appears to be simply wrong, and unsustainable.

Appendix. Explosive articles.

The explicit inclusion of “explosive articles” has been mentioned at several points, deriving from Annex I (8) of the Seveso Directive, translated into COMAH at Schedule 1, Part 3, Note 8, and into the HSC Regulations at Part 4, Note 9 (Part 2 in the Scottish Regulations).

It should be noted that Explosive Articles are included in COMAH under Schedule 1, Part 1, Section ‘P’ (Physical Hazards) as either P1a Explosives or P1b Explosives, depending on the Division to which the explosive substance(s) (or articles) are assigned under prescribed testing methods. They are similarly included in the HSC Regulations in the relevant Schedule, Part 1, in the same hazard classes.

Therefore, the inclusion of Explosive Articles under Part 1 of the Schedules requires immediate consideration under both the COMAH and HSC Regulations, and there is no question of considering “loss of control” under Part 3 (HSC Regulations) or within the COMAH and Seveso definition of “presence of a dangerous substance”. Explosive Articles are regulated under COMAH and HSC whether control is ever lost, or not.

Moreover, determination of Controlled Quantities (HSC) or Qualifying Quantities (COMAH) is much simpler, since the tonnage of Explosive Articles in a fixed installation is a known parameter from the basic engineering design, and no tests or modelling of “loss of control” situations need be carried out.

We therefore examine the question: Are Li-ion BESS cells Explosive Articles[68] ?

A.1 Empirical phenomenology

There is no doubt that Li-ion cells can certainly fail explosively, in modes that would be regarded as “explosive” in ordinary language.

Failure behaviour is also known to depend of the cell’s State of Charge (SoC); acceptance of electrical current or charge alters the battery’s internal chemical state, which is then altered again upon discharge. Failure modes will depend on the internal chemical state, so the mechanism for different behaviour is clear. Moreover consideration of the stored electrochemical Energy suggests immediately that highly charged cells will be more dangerous in failure than discharged ones. The law of Conservation of Energy implies that stored energy in large quantity has the potential to cause major damage; lesser quantities of stored energy can only do lesser degrees of damage.

The SoC of a Li-ion BESS cell in normal operation will pass through multiple states as a matter of routine; charging and discharging routinely is the entire purpose of battery technology. It would be unusual if BESS cells did not pass through a high State of Charge at least once daily. For example, the failure of the Liverpool BESS in September 2020 is now known to have been been in a high SoC at the time of failure.

[68] This material is examined in more detail in the paper by Fordham and Melville cited elsewhere: Section 3.2, pages 22-27 of: Fordham, E J and Melville, D (2022) Hazardous Substances potentially generated in "loss of control" accidents in Li-ion Battery Energy Storage Systems (BESS) : storage capacities implying Hazardous Substances Consent obligations.
https://www.researchgate.net/publication/359203817_Hazardous_Substances_potentially_generated_in_loss_of_control_accidents_in_Li-ion_Battery_Energy_Storage_Systems_BESS_storage_capacities_implying_Hazardous_Substances_Consent_obligations

Li-ion battery cells can fail explosively either by heating (which is the central failure risk of Li-ion cells undergoing thermal runaway) or by electrical overcharging, or by internal failure when in a high SoC (both of the latter being typical initiating events of thermal runaway accidents).

We abstract in this Appendix photographic examples from publicly available internet videos,
(i) for small cylindrical consumer cells of 2.6 Ah (about 9 – 10 Wh); [69]
(ii) what appears from the rectangular form to be a stack of pouch cells, in a deliberate fire test initiated by overcharging; [70]
(iii) in a field test on actual Li-ion BESS cells carried out by Prof Paul Christensen, Professor of Pure and Applied Electrochemistry at Newcastle University, and recently (14 October 2021) delivered in a speech to an Australian technical conference [71].

The photographic abstracts in the following demonstrate empirical behaviour of Li-ion cells, in a high SoC, ranging from a small consumer cell to an electric vehicle module of capacity 1.7 kWh.

It should be noted that even the EV module example is still over 1000 times smaller, in terms of energy storage, than the capacity of even a small cabin containing Li-ion BESS modules, which are typically sized in MWh (megawatt-hours, or millions of watt-hours) rather than kWh (kilowatt-hours, of thousands of watt-hours).

These photographs of Li-ion cell failures plainly show disruption which would be described in ordinary language as "explosive", with both projectile hazards, and "fireballs" emitting obviously considerable radiant heat. The video evidence certainly suggests, *prima facie*, that charged Li-ion cells should be regarded as Explosive Articles in Division 1.2 or Division 1.3 which certainly seems to correspond qualitatively, in the test abstracted in Figure A.2, to the description in Annex I Reg. 2.1.2.2(c) of the CLP Regulation[72]:

Division 1.3: Substances, mixtures and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard:
(i) combustion of which gives rise to considerable radiant heat; or
(ii) which burn one after another, producing minor blast or projection effects or both;

However controlled and verified tests on Li-ion BESS cells, in a high State of Charge (to be expected regularly if not continuously in normal battery operation) that would establish definitively if such cells qualify (or not) as "Explosive articles" for regulatory purposes, have not, to the best our knowledge, ever been carried out.

We outline in the subsection following the abstracted photographs, the prescribed tests that would be required to establish of a Li-ion BESS cell in a high SoC qualifies as an "Explosive article", or not.

[69] Li-ion batteries video: 2.6 Ah consumer cells. https://www.youtube.com/watch?v=CUgbmCSmSNY
[70] Li-ion batteries video: stack of pouch cells https://www.youtube.com/watch?v=EDhE0pk3FeQ
[71] PV Magazine "Insight", online conference 14 October 2021, Presentation 6 "Rundown on thermal runaway" by Prof Paul Christensen https://www.youtube.com/watch?v=A9B5M8qHQQ0&t=3716s
[72]
https://www.legislation.gov.uk/eur/2008/1272/annex/I/division/2/division/2.1/division/2.1.2/division/2.1.2.2

A.1.1 Small cylindrical consumer cells:

Frames from the first video are abstracted in **Figure A.1**, illustrating the damage done to a non-faulty cell, simply by overheating externally. The failure is certainly explosive, with an obvious projectile hazard in addition to considerable heat release. The cell is fully charged.

Other examples of explosive failure with projectile hazard are shown initiated by mechanical abuse. The same video makes the point that discharged cells do not fail explosively and are not dangerous unless abused to the point of destruction and exposure of their contents.

Figure A.1: (a) A charged 2.6 Ah cell being deliberately overheated.

(b) at the point of rupture

(c) the cell takes off as a rocket red hot. 5:56 mins to 6:24 mins.

(d) seconds later the discharge is complete, and the cell is

A.1.2 Stack of small rectangular cells, probably pouch "form factor":

Frames from the second video are abstracted in **Figure A.2**, showing what appears to be a stack of rectangular format pouch cells being tested behind a reasonably secure fire bunker. The initiating event is deliberate overcharging; the first cell then explodes with a conspicuous fireball and sideways dual jets of flame; later in the sequence other cells go sequentially into thermal runaway with similar fireball behaviour as they fail.

Figure A.2. (a) Stack of fully-charged pouch cells in fire bunker for thermal runaway tests. (b) The first cell fails explosively in a white-hot fireball at 0:09/2:13 minutes.
Subsequent jets of flame last another 8 seconds; a second cell goes into thermal runaway (0:33/2:13 minutes) with a similar fireball, lasting about 5 seconds; and 5 or 6 such fireballs occur up to 1:55/2:13 mins of the recording.

(b): 0:09 minutes. This fireball emerges in less than 0.5 s from first precursors:

A.1.3 Field tests by Prof Paul Christensen, Newcastle University

Figure A.3 shows a sequence of frames from a video from Prof Christensen, showing the effect if mechanical damage on a single Electric Vehicle module of stored energy 1.7 kWh, and in a 100% State of Charge. The energy of 1.7 kWh is substantially larger than either of the previous videos, but still much smaller than the stored energy of a grid-scale BESS, where even small storage cabins can accommodate around 2 MWh, i.e. over 1000 times larger than the energy in the EV module shown in these videos.

Figure A.3 (a). A 23 kg hammer and nail begins to fall on the EV Li-ion module:

Figure A.3 (b). The hammer at the instant of penetration:

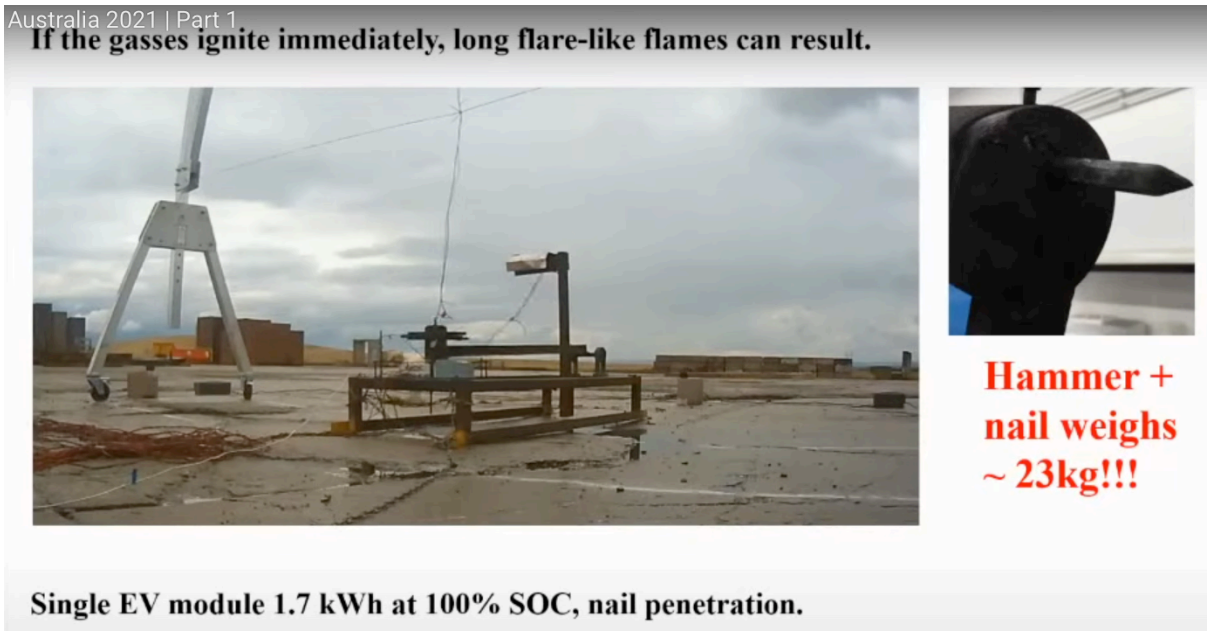

Figure A.3 (c). The hammer of 23 kg weight is thrown back into the air as the cells in the EV battery module disrupt explosively:

Figure A.3(d). A fraction of a second later, a black cloud of what is said by Prof Christensen to be “cathode material” emerges.

It should noted that this black cloud potentially contains inhalable Nickel Oxides, a “Named Dangerous/Hazardous substance” under Part 2 (Item 11)[73] with particularly low CQ or QQ in Column 3 of the Schedule to the COMAH Regulations. Potential generation of just 1 tonne would classify such installations as “higher-tier” COMAH if the chemical content is verified.

[73] https://www.legislation.gov.uk/nisr/2015/325/schedule/1

Figure A.3 (e). Ignition of flammable gases follows in a fraction of a second later, with a large fireball emitting considerable radiant heat:

Figure A.3 (f). The “long, flare-like flames” last for several minutes as the fire progresses after the initial explosion and ignition

A.2 Regulatory definitions of "Explosive articles"

The hazard class P1a Explosives includes those substances, mixture or articles that have Explosive properties in Divisions 1.1, 1.2, 1.3, 1.5 or 1.6 of the CLP Regulation[74] for which ECHA Guidance Notes are available[75].

Annex I Reg. 2.1.2.2(b) defines a Division 1.2 substance, mixture or article as:
Division 1.2: Substances, mixtures and articles which have a projection hazard but not a mass explosion hazard;

Annex I Reg. 2.1.2.2(c) defines a Division 1.3 Explosive as:
Division 1.3: Substances, mixtures and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard:
(i) combustion of which gives rise to considerable radiant heat; or
(ii) which burn one after another, producing minor blast or projection effects or both;

Annex I Reg. 2.1.2.2(d) defines a Division 1.4 Explosive as:
Division 1.4: Substances, mixtures and articles which present no significant hazard: substances, mixtures and articles which present only a small hazard in the event of ignition or initiation. The effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. An external fire shall not cause virtually instantaneous explosion of almost the entire contents of the package;

Division 1.4 Explosives do not qualify as Explosives in Hazard Class P1a but they are included in Hazard class P1b. Hence any Explosive in Divisions 1.1 to 1.6 inclusive is a Hazardous Substance in Part 1 of Schedule 1[76]. The CQ for P1a Explosives (Divisions other than 1.4) is 10 tonnes; the CQ for P1b Explosives (Division 1.4 Explosives) is 50 tonne.

There are test procedures mandated in the CLP Regulation for assignment of substances, mixtures or articles to the various Divisions of the Explosives class. These are referenced to the United Nations Recommendations on the Transport of Dangerous Goods (UN RTDG) Manual of Tests and Criteria[77] (MTC) published by the UN Economic Commission for Europe (UNECE) which sets out clear standards of testing for assignment of articles or substances to the various Divisions of Explosives. It is explicitly mandated by the CLP Regulation, as seen in many places, but explicitly in Annex I Reg. 2.1.4.1[78]:

2.1.4.1.The classification of substances, mixtures and articles in the explosives hazard class and further allocation to a division is a very complex, three step procedure. Reference to Part I of the UN RTDG Manual of Tests and Criteria is necessary.

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[74] https://www.legislation.gov.uk/eur/2008/1272/annex/I/division/2/division/2.1/division/2.1.2/division/2.1.2.2

[75] "Guidance in the application of the CLP criteria" Regulation EC 1272/2008 on classification labelling and packaging of substances and mixtures" ECHA version 5.0 July 2017 https://echa.europa.eu/documents/10162/23036412/clp_en.pdf/58b5dc6d-ac2a-4910-9702-e9e1f5051cc5

[76] https://www.legislation.gov.uk/uksi/2015/627/schedule/1

[77] United Nations (2019). Manual of Tests and Criteria, 7th revised edition, ST/SG/AC.10/11/Rev.7 UN Publication Sales No. E.20.VIII.1 ISBN 978-92-1-130394-0 https://unece.org/fileadmin/DAM/trans/danger/publi/manual/Rev7/Manual_Rev7_E.pdf

[78] https://www.legislation.gov.uk/eur/2008/1272/annex/I/division/2/division/2.1/division/2.1.4/division/2.1.4.1

Section 16 of the MTC defines "Test Series 6" which is the critical set of tests for assignment of explosives, as in the decision flowchart required by the CLP Regulation Annex I, Figure 2.1.3[79], distinguishing the various Divisions. It is not known whether tests according to this specification have ever been explicitly carried out for BESS cells (as opposed to consumer product batteries) but they are the tests mandated by the CLP Regulation.

For example Test 6 (c) is an "External fire (bonfire) test" with the stated objective "to determine whether there is a mass explosion or a hazard from dangerous projections, radiant heat and/or violent burning when involved in a fire". The test package is to be not less than 0.15 m^3 (150 litres) which is significantly larger than the stack of cells shown in the test of Figure A.2. The test package is placed on a support grid above a wood, kerosene or gas fire which achieves a temperature of 800 °C, and there are witness screens (2mm thick aluminium sheets) in four quadrants at 4 m from the edge of the test packages.

Allocation criteria on the basis of this bonfire test are given in section 16.6.1.4 of the MTC[80]. Because the available evidence from Figure A.2 is in a much smaller test packaged than specified in the MTC, it is not possible to decide definitively how a specified test package (150 litres) would behave in such a fire test. However the behaviour in Figure A.2 already corresponds to the 1 m fireball criterion of paragraph 16.6.1.4.5 (a) which would assign a 150 litre test package to Division 1.4. A standard size test package of 150 litres would be significantly larger and very plausibly would exhibit a larger fireball passing criterion 16.6.1.4.4 (a) (fireball greater than 4 m distance) which would assign the article to Division 1.3. The burning time or irradiance criteria of paragraph 16.6.1.4.4 (c) would also assign the article to Division 1.3 and from the behaviour in Figure 2 the burning time is much shorter than the criterion's 35 seconds, albeit for a smaller package than the 100 kg reference.

Likewise it is not possible to say how the field test shown in Figure A.3 would behave in the "bonfire test" if carried out according to the prescribed specification.

Such determinations would require actual tests according to the specifications laid out in the UN MTC. Because the behaviour is known to depend on the cell's SoC, such tests should be performed at several different SoCs, including 100% charged.

Although cells may be shipped and installed at lower SoCs than 100% (30% is the recognised standard SoC for shipping consumer product Li-ion batteries) the cells in a BESS are designed to be taken to high SoCs several times a day: that is the normal design operation of a BESS functioning for grid-scale energy storage.

[79] See e.g. Guidance on application of CLP criteria, version 5.0 July 2017, page 99
[80] Page 171 of the MTC, 7th edition.