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ANNEXES 1 to 2

ANNEXES

to the

Commission Delegated Regulation

supplementing and amending Regulation (EU) 2023/1542 of the European Parliament and of the Council by laying down minimum values for the electrochemical performance and durability of rechargeable industrial batteries, technical and safety parameters, and standards concerning the battery passport

ANNEX I

Requirements concerning minimum values for the electrochemical performance and durability of rechargeable industrial batteries

1. DEFINITIONS

For the purposes of this Annex, the following definitions shall apply:

- (1) 'residential battery energy storage system' means a stand-alone stationary battery energy storage system which is designed for installation and use in a domestic environment, or in both domestic as well as other environments, in a space without dedicated safety infrastructure;
- (2) 'lead-based battery' means a battery containing lead or lead compounds as the principal electrochemically active material;
- (3) 'repetitive energy supply battery' means a rechargeable industrial battery designed to be charged and discharged regularly, the application of which is expected to correspond to at least 40 FEqC per year;
- (4) 'full equivalent charge-discharge cycles' or 'FEqC' means the ratio of the total discharged battery energy to the useable energy capacity at the time of placing on the market or putting into service;
- (5) 'useable energy capacity' means the energy available to the user when discharging a fully charged battery down to the operation limit set by the battery management system or manufacturer;
- (6) 'on-demand battery' means a rechargeable industrial battery designed to be charged and discharged sporadically or to deliver back-up services, the application of which is expected to correspond to less than 40 FEqC per year;
- (7) 'ancillary components' means any components required to ensure the reliable operation of the battery, including battery management systems, thermal management systems and control units, and excluding inverters or other power conversion systems;
- (8) 'ambient temperature' means the time-averaged environmental temperature to which the battery is exposed;
- (9) 'depth of discharge' means the ratio, as a percentage, of the charge delivered by a battery during a discharge event to the useable capacity, with the ratio averaged over all discharge events;
- (10) 'charge C-rate' means the time-averaged ratio of the applied charging current to the rated capacity during all charge operations, which may be estimated as the ratio of the time-averaged charging power to the rated energy;
- (11) 'discharge C-rate' means the time-averaged ratio of the applied discharge current to the rated capacity during all discharge operations, which may be estimated as the time-averaged ratio of the discharging power to the rated energy.

2. MINIMUM VALUES

1. Rechargeable industrial batteries with a capacity greater than 2 kWh, except those with exclusively external storage, shall comply with the following requirements:

- (a) for residential battery energy storage systems, other than lead-based batteries and on-demand batteries:
 - (1) the capacity fade as a percentage divided by *stress factor*_{CF,REP} is to be less than 4%;
 - (2) the expected lifetime in cycles multiplied by *stress factor*_{ELC,REP} is to be greater than 3000 FEqC;
 - (3) the energy round trip efficiency as a percentage is to be greater than 93%;
 - (b) for repetitive energy supply batteries, other than lead-based batteries and residential battery energy storage systems:
 - (1) the capacity fade as a percentage divided by *stress factor*_{CF,REP} is to be less than 10%;
 - (2) the expected lifetime in cycles multiplied by *stress factor*_{ELC,REP} is to be greater than 1000 FEqC;
 - (c) for lead-based repetitive energy supply batteries, other than residential battery energy storage systems:
 - (1) the capacity fade as a percentage divided by *stress factor*_{CF,REP} is to be less than 15%;
 - (2) the expected lifetime in cycles multiplied by *stress factor*_{ELC,REP} is to be greater than 500 FEqC;
 - (d) for on-demand batteries:
 - (1) the capacity fade as a percentage divided by *stress factor*_{CF,OND} is to be less than 5%;
 - (2) the expected lifetime in years multiplied by *stress factor*_{ELY,OND} is to be greater than 10 years.
2. Batteries designed to be used both as a repetitive energy supply battery and an on-demand battery shall comply with the requirements for repetitive energy supply batteries.
 3. Section 5 shall apply to batteries that have been subject to preparation for re-use, preparation for repurposing, repurposing or remanufacturing.

3. MEASUREMENT AND CALCULATION METHODS

The method for determining the electrochemical performance and durability parameters referred to in Section 2 shall be in line with Article 15 of Regulation (EU) 2023/1542 and with the provisions set out in this Section.

3.1. Electrochemical performance and durability parameters

3.1.1. Capacity fade

The capacity fade shall be evaluated after at least 152 days or after at least 350 FEqC. For repetitive charge-discharge tests, the number of FEqC may for this purpose be estimated by multiplying the number of cycles with the depth of discharge.

The stress factor shall be calculated as follows:

- (a) For repetitive energy supply batteries:
 $stress\ factor_{CF,REP} = SF_{T,REP} \cdot SF_{DOD} \cdot SF_{Crate}$
 where:
- (1) $SF_{T,REP}$ is the individual contribution regarding ambient temperature for a repetitive energy supply battery;
 - (2) SF_{DOD} is the individual contribution regarding the depth of discharge;
 - (3) SF_{Crate} is the individual contribution regarding the charge and discharge C-rate;
- (b) For on-demand batteries:
 $stress\ factor_{CF,OND} = SF_{T,OND}$
 where $SF_{T,OND}$ is the individual contribution regarding the ambient temperature for an on-demand battery.

The individual stress factor contributions shall be determined in accordance with Section 3.2.

3.1.2. Expected lifetime in cycles

The expected lifetime in cycles shall be determined as soon as the battery's useable energy capacity, at the time of placing on the market or putting into service, plus any energy capacity held in reserve and intended to be released as the battery ages, has decreased by 30%, or when its functionality or safety is compromised, whichever occurs first.

The expected lifetime in cycles shall be expressed in FEqC, where the number of FEqC may be estimated by either multiplying the number of full cycles within the operation limits with the mean value between the initial state of health and the state of health at the end of the battery's service life, or by multiplying the number of partial cycles with the ratio between the average energy delivered per partial cycle and the useable energy capacity at the time of placing on the market or putting into service.

The stress factor shall be calculated as follows:

$$stress\ factor_{ELC,REP} = SF_{T,REP} \cdot SF_{DOD} \cdot SF_{Crate}$$

The individual stress factor contributions shall be determined in accordance with Section 3.2.

3.1.3. Expected lifetime in years

The expected lifetime in years shall be determined as soon as the battery's useable energy capacity, at the time of placing on the market or putting into service, plus any energy capacity held in reserve and intended to be released as the battery ages has decreased by 30%, or when its functionality or safety is compromised, whichever occurs first.

The stress factor shall be calculated as follows:

$$stress\ factor_{ELY,OND} = SF_{T,OND}$$

The individual stress factor contribution shall be determined in accordance with Section 3.2.

3.1.4. Energy round trip efficiency

The energy round trip efficiency shall be determined under normal operating conditions, taking into account all necessary ancillary components to ensure the battery's functionality and safety.

3.2. Stress factor determination

Individual stress factor contributions shall be extracted from Table 1 and Table 2, based on the reference conditions of ambient temperature, depth of discharge, charge C-rate and discharge C-rate used to measure, calculate or estimate the electrochemical performance and durability parameters referred to in Section 2.

If the battery temperature is deliberately regulated within a specific range by means of cooling or heating measures, $SF_{T,REP}$ and $SF_{T,OND}$ shall be equal to 1.

For load profiles with frequent minor discharge events, the depth of discharge may be estimated as the difference between the 75th and 25th percentile state of charge.

If accelerated ageing test methods are used to estimate the electrochemical performance and durability parameters referred to in Section 2, the reference conditions to determine the stress factors shall reflect the conditions for which the battery has been designed.

Table 1
Assignment of ranges of reference conditions to individual stress factor contributions for on-demand batteries

Ambient temperature	
Range	$SF_{T,OND}$
below 0 °C	0.5
≥ 0 °C, < 10 °C	0.62
≥ 10 °C, < 17 °C	0.75
≥ 17 °C, < 22 °C	0.9
≥ 22 °C, < 27 °C	1
≥ 27 °C, < 33 °C	1.3
≥ 33 °C, < 40 °C	2
≥ 40 °C, < 48 °C	4
≥ 48 °C, < 55 °C	7
≥ 55 °C, < 60 °C	10
above 60 °C	15

Table 2
Assignment of ranges of reference conditions to individual stress factor contributions for repetitive energy supply batteries

Ambient temperature		Depth of discharge		Charge or discharge C-rate, whichever is larger	
Range	$SF_{T,REP}$	Range	SF_{DOD}	Range	SF_{Crate}
below -10 °C	2	below 10%	0.55	below 1 h ⁻¹	1

Ambient temperature		Depth of discharge		Charge or discharge C-rate, whichever is larger	
Range	$SF_{T,REP}$	Range	SF_{DOD}	Range	SF_{Crate}
$\geq -10\text{ °C}, < 0\text{ °C}$	1.3	$\geq 10\%, < 30\%$	0.67	$\geq 1\text{ h}^{-1}, < 2\text{ h}^{-1}$	1.3
$\geq 0\text{ °C}, < 10\text{ °C}$	1.1	$\geq 30\%, < 50\%$	0.83	$\geq 2\text{ h}^{-1}, < 3\text{ h}^{-1}$	1.6
$\geq 10\text{ °C}, < 17\text{ °C}$	0.95	$\geq 50\%, < 70\%$	1	above 3 h^{-1}	3
$\geq 17\text{ °C}, < 27\text{ °C}$	1	$\geq 70\%, < 90\%$	1.15		
$\geq 27\text{ °C}, < 33\text{ °C}$	1.3	above 90%	1.33		
$\geq 33\text{ °C}, < 40\text{ °C}$	1.8				
$\geq 40\text{ °C}, < 48\text{ °C}$	2.8				
$\geq 48\text{ °C}, < 55\text{ °C}$	5				
$\geq 55\text{ °C}, < 60\text{ °C}$	7.5				
above 60 °C	10				

4. TECHNICAL DOCUMENTATION

The technical documentation referred to in Annex VIII to Regulation (EU) 2023/1542 shall include:

- (a) information indicating whether the battery was designed as a residential energy battery storage system, a repetitive energy supply battery, an on-demand battery, or any combination thereof;
- (b) in the case of residential battery energy storage systems, other than lead-based batteries and on-demand batteries, information on which ancillary components were considered when determining the energy round trip efficiency. For such systems that have integrated inverters or other power conversion systems and cannot perform their intended use without these, information on the extent to which the declared round trip efficiency of the battery may deviate from the overall efficiency of the battery and integrated inverter or other power conversion system;
- (c) the reference conditions referred to in Section 3.2, first paragraph, provided separately for each electrochemical performance and durability parameter for which minimum values apply;
- (d) for batteries that have not been subject to preparation for re-use, preparation for repurposing, repurposing or remanufacturing, the determined stress factors as follows:
 - (1) for repetitive energy supply batteries:
 $stress\ factor_{CF,REP}$ and $stress\ factor_{ELC,REP}$
 - (2) for on-demand batteries:
 $stress\ factor_{CF,OND}$ and $stress\ factor_{ELY,OND}$

- (e) for batteries that have been subject to preparation for re-use, preparation for repurposing, repurposing or remanufacturing:
 - (1) where the requirements as set out in Section 2, point 1 are deemed to be met in accordance with Section 5.1, documentary evidence for previous compliance;
 - (2) where the requirements as set out in Section 2, point 1 are met in accordance with Section 5.2, the reference conditions and stress factor values from operational data;
 - (3) where the requirements as set out in Section 2, point 1 are replaced according to Section 5.3, the reference conditions, stress factor values, and weighting factors from operational data as well as the reference conditions and stress factor values for the intended application.

5. BATTERIES THAT HAVE BEEN SUBJECT TO PREPARATION FOR RE-USE, PREPARATION FOR REPURPOSING, REPURPOSING OR REMANUFACTURING

5.1. Batteries previously deemed compliant with minimum values

Batteries that have been subject to preparation for re-use, preparation for repurposing, repurposing or remanufacturing and which do not fall under Article 10(4) of Regulation (EU) 2023/1542, shall be deemed to comply with the minimum values set out in Section 2 if those batteries:

- (a) have already been placed on the market or put into service and have been compliant with one of the delegated acts referred to in Article 10(5) of Regulation (EU) 2023/1542; or
- (b) are units of a model of which another unit has already been placed on the market or put into service that has been compliant with one of the delegated acts referred to in Article 10(5) of Regulation (EU) 2023/1542; or
- (c) have been compliant with the battery energy based minimum performance requirements for battery durability set out in Regulation (EU) 2024/1257 of the European Parliament and of the Council¹, or in UN Global Technical Regulation No 22 on in-vehicle battery durability for electrified vehicles.

5.2. Batteries for which operational data demonstrates that they meet minimum values

Batteries that have been subject to preparation for re-use, preparation for repurposing, repurposing or remanufacturing and do not fall under Section 5.1 or Article 10(4) of Regulation (EU) 2023/1542 may be demonstrated to comply with the minimum values as set out in Section 2, point 1 by taking into account their previous use and application as follows:

¹ Regulation (EU) 2024/1257 of the European Parliament and of the Council of 24 April 2024 on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability (Euro 7), amending Regulation (EU) 2018/858 of the European Parliament and of the Council and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009 of the European Parliament and of the Council, Commission Regulation (EU) No 582/2011, Commission Regulation (EU) 2017/1151, Commission Regulation (EU) 2017/2400 and Commission Implementing Regulation (EU) 2022/1362 (OJ L, 2024/1257, 8.5.2024, ELI: <http://data.europa.eu/eli/reg/2024/1257/oj>).

- (a) For residential battery energy storage systems, other than lead-based batteries and on-demand batteries:
- (1) The requirement set out in Section 2, point 1(a)(i) shall be considered to be met if the capacity fade as a percentage, extracted from operational data and determined after at least 152 days or at least 350 FEqC, divided by $stress\ factor_{CF,REP}^{operat.}$ is less than 4%
 where:
 - $stress\ factor_{CF,REP}^{operat.}$ is calculated as set out in Section 3.1.1, second paragraph, point (a) and Section 3.2 using the reference conditions from operational data;
 - (2) The requirement set out in Section 2, point 1(a)(ii) shall be considered to be met if the decrease in useable energy capacity as a percentage, extracted from operational data and determined after at least 3000 FEqC, divided by $stress\ factor_{ELC,REP}^{operat.}$ is less than 30%
 where:
 - $stress\ factor_{ELC,REP}^{operat.}$ is calculated as set out in Section 3.1.2, third paragraph and Section 3.2 using the reference conditions from operational data;
 - (3) The requirement set out in Section 2, point 1(a)(iii) shall be considered to be met if the initial energy round trip efficiency as a percentage, extracted from operational data and determined in accordance with Section 3.1.4, is greater than 93%;
- (b) For repetitive energy supply batteries, other than lead-based batteries and residential battery energy storage systems:
- (1) The requirement set out in Section 2, point 1(b)(i) shall be considered to be met if the capacity fade as a percentage, extracted from operational data and determined after at least 152 days or at least 350 FEqC, divided by $stress\ factor_{CF,REP}^{operat.}$ is less than 10%;
 - (2) The requirement set out in Section 2, point 1(b)(ii) shall be considered to be met if the decrease in useable energy capacity as a percentage, extracted from operational data and determined after at least 1000 FEqC, divided by $stress\ factor_{ELC,REP}^{operat.}$ is less than 30%;
- (c) For lead-based repetitive energy supply batteries, other than residential battery energy storage systems:
- (1) The requirement set out in Section 2, point 1(c)(i) shall be considered to be met if the capacity fade as a percentage, extracted from operational data and determined after at least 152 days or at least 350 FEqC, divided by $stress\ factor_{CF,REP}^{operat.}$ is less than 15%;
 - (2) The requirement set out in Section 2, point 1(c)(ii) shall be considered to be met if the decrease in useable energy capacity as a percentage, extracted from operational data and determined after at least 500 FEqC, divided by $stress\ factor_{ELC,REP}^{operat.}$ is less than 30%;

- (d) For on-demand batteries:
- (1) The requirement set out in Section 2, point 1(d)(i) shall be considered to be met if the capacity fade as a percentage, extracted from operational data and determined after at least 152 days or at least 350 FEqC, divided by $stress\ factor_{CF,OND}^{operat.}$ is less than 5%
 where:
 - $stress\ factor_{CF,OND}^{operat.}$ is calculated as set out in Section 3.1.1, second paragraph, point (b) and Section 3.2 using the reference conditions from operational data;
 - (2) The requirement set out in Section 2, point 1(d)(ii) shall be considered to be met if the decrease in useable energy capacity as a percentage, extracted from operational data and determined after at least 10 years, divided by $stress\ factor_{ELY,OND}^{operat.}$ is less than 30%
 where:
 - $stress\ factor_{ELY,OND}^{operat.}$ is calculated as set out in Section 3.1.3, second paragraph and Section 3.2 using the reference conditions from operational data.

The operational data shall encompass the previous use phase of the battery and be extracted from periodically recorded information within the battery management system or another equivalent system containing such information. The data shall be accurate, reliable and complete.

5.3. Batteries meeting adapted values according to operational data

5.3.1. Adapted minimum values

Batteries that have been subject to preparation for re-use, preparation for repurposing, repurposing or remanufacturing and do not fall under Section 5.1 or 5.2 or Article 10(4) of Regulation (EU) 2023/1542, may demonstrate compliance if they meet adapted minimum values for the updated electrochemical performance and durability parameters after their change of status taking into account their previous use as follows:

- (a) For residential battery energy storage systems, other than lead-based batteries and on-demand batteries:
 - (1) replacing the requirement set out in Section 2, point 1(a)(i),
 the capacity fade as a percentage, evaluated after at least $time_{CF}$ or at least $FEqC_{CF}$, divided by $stress\ factor_{CF,REP}$ and divided by $weight_{CF}$ shall be less than 4 %
 where:
 - $time_{CF}$ is the adapted time criterion for capacity fade determination calculated as set out in Section 5.3.2, first paragraph, point (a);
 - $FEqC_{CF}$ is the adapted FEqC criterion for capacity fade determination calculated as set out in Section 5.3.2, first paragraph, point (a);
 - $weight_{CF}$ is the weighting factor for capacity fade calculated as set out in Section 5.3.2, first paragraph, point (a);

- (2) replacing the requirement set out in Section 2, point 1(a)(ii):
the expected lifetime in cycles multiplied by $stress\ factor_{ELC,REP}$ and divided by $weight_{ELC}$ shall be greater than 3000 FEqC
where:
 - $weight_{ELC}$ is the weighting factor for the expected lifetime in cycles calculated as set out in Section 5.3.2, first paragraph, point (b);
- (b) For repetitive energy supply batteries, other than lead-based batteries and residential battery energy storage systems:
 - (1) replacing the requirement set out in Section 2, point 1(b)(i),
the capacity fade as a percentage, evaluated after at least $time_{CF}$ or at least $FEqC_{CF}$, divided by $stress\ factor_{CF,REP}$ and divided by $weight_{CF}$ shall be less than 10%;
 - (2) replacing the requirement set out in Section 2, point 1(b)(ii):
the expected lifetime in cycles multiplied by $stress\ factor_{ELC,REP}$ and divided by $weight_{ELC}$ shall be greater than 1000 FEqC;
- (c) For lead-based repetitive energy supply batteries, other than residential battery energy storage systems:
 - (1) replacing the requirement set out in Section 2, point 1(c)(i),
the capacity fade as a percentage, evaluated after at least $time_{CF}$ or at least $FEqC_{CF}$, divided by $stress\ factor_{CF,REP}$ and divided by $weight_{CF}$ shall be less than 15%;
 - (2) replacing the requirement set out in Section 2, point 1(c)(ii):
the expected lifetime in cycles multiplied by $stress\ factor_{ELC,REP}$ and divided by $weight_{ELC}$ shall be greater than 500 FEqC;
- (d) For on-demand batteries:
 - (1) replacing the requirement set out in Section 2, point 1(d)(i):
the capacity fade as a percentage, evaluated after at least $time_{CF}$ or at least $FEqC_{CF}$, divided by $stress\ factor_{CF,OND}$ and divided by $weight_{CF}$ shall be less than 5%;
 - (2) replacing the requirement set out in Section 2, point 1(d)(ii):
the expected lifetime in years multiplied by $stress\ factor_{ELY,OND}$ and divided by $weight_{ELY}$ shall be greater than 10 years
where:
 - $weight_{ELY}$ is the weighting factor for the expected lifetime in years calculated as set out in section 5.3.2, first paragraph, point (c).

5.3.2. Weighting factor calculation

The weighting factors shall be calculated as follows:

- (a) For capacity fade:

The value of $weight_{CF}$ shall be determined by means of the following two equations and shall be whichever is the smaller, rounded to two decimal places:

$$(1) \quad 1 - t^{\text{operat.}} \cdot stress\ factor_{CF}^{\text{operat.}} \div 152$$

$$(2) \quad 1 - FEqC^{\text{operat.}} \cdot stress\ factor_{CF}^{\text{operat.}} \div 350$$

where:

- $t^{\text{operat.}}$ is the number of days the battery was operational in the previous use phase;
- $FEqC^{\text{operat.}}$ is the number of FEqC that the battery underwent in the previous use phase;
- $stress\ factor_{CF}^{\text{operat.}}$ is calculated as set out in Section 3.1.1, second paragraph, point (a) for repetitive energy supply batteries and Section 3.1.1, second paragraph, point (b) for on-demand batteries, combined with Section 3.2, using the reference conditions from operational data.

For determining the updated capacity fade after a change of status of the battery, the points of evaluation are calculated as follows:

$$time_{CF} = weight_{CF} \cdot 152 \text{ days}$$

$$FEqC_{CF} = weight_{CF} \cdot 350 \text{ FEqC};$$

- (b) For expected lifetime in cycles:

$$weight_{ELC} = 1 - FEqC^{\text{operat.}} \cdot stress\ factor_{ELC}^{\text{operat.}} \div threshold_{ELC}$$

where:

- (1) $stress\ factor_{ELC}^{\text{operat.}}$ is calculated as set out in Section 3.1.2, third paragraph and Section 3.2 using the reference conditions from operational data;
- (2) $threshold_{ELC}$ is equal to 3000 FEqC for residential battery energy storage systems, 500 FEqC for lead-based batteries, and 1000 FEqC for other batteries;

- (c) For expected lifetime in years:

$$weight_{ELY} = 1 - t^{\text{operat.}} \cdot stress\ factor_{ELY}^{\text{operat.}} \div 10 \div 365$$

Where $stress\ factor_{ELY}^{\text{operat.}}$ is calculated as set out in Section 3.1.3, second paragraph and Section 3.2 using the reference conditions from operational data.

The operational data shall encompass the previous use phase of the battery and be extracted from periodically recorded information within the battery management system or another equivalent system containing such information. The data shall be accurate, reliable and complete.

ANNEX II

Amendments

Annexes IV, V and VII to Regulation (EU) 2023/1542 are amended as follows:

- (1) Annex IV is amended as follows:
 - (a) in point (1), the words ‘under reference conditions’ are replaced by the words ‘under reference conditions, and declared by the manufacturer’;
 - (b) point (2) is replaced by the following: ‘“Capacity fade” means the decrease over time and upon usage in the amount of charge that a battery can deliver under reference conditions, with respect to the original capacity’;
 - (c) in point (4), the words ‘at the rated voltage’ are replaced by the words ‘under reference conditions’.
- (2) Annex V is amended as follows:
 - (a) in point 8, the first sentence is replaced by the following: ‘The safety performance of a battery in internal short-circuit situations shall be addressed by thermal propagation protection as set out in point 6.’.
- (3) Annex VII is amended as follows:
 - (a) in Part A, point 4 is replaced by the following: ‘where possible, the evolution of self-discharging rates;’.