Transmitted by the Chair of the
SIG on EMB (for reference only)

Informal document **GRVA-19-25**
19th GRVA, 25 June 2024
(For review during the
Troy meeting 20-24 May 2024)
Provisional agenda item 8(b)

Introduction of Electrical Transmission Braking Systems

Workshop hosted by the Special Interest Group on electrical braking systems

TEAMs Meeting

May 2nd , 01:00 PM CEST – 04:00 PM CEST

Public

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Public

1. EBSIG´s Terms of Reference (GRVA-18-54)

A. Energy supply and brake transmission architectures.

1. Identify design principles for the energy supply.

2. Identify the brake transmission arrangements that may be recognised by UN Regulations Nos. 13 and 13-H.

3. Develop recommendations for the methodology of measuring/monitoring the value of energy available in a reserve of energy suitable for use in identifying critical energy thresholds.

4. Identify the safety critical elements of electromechanical braking systems that will require monitoring for fault/failure and the generation of warning signals.

B. Based upon understanding from the above, and building upon the content of the GRVA Informal Document GRVA-15-17:

1. Develop proposals to amend UN Regulation No. 13,

2. Develop proposals to amend UN Regulation No. 13-H, and

3. Make recommendations regarding the application of the electrical system safety principles with respect to other UN Regulations, esp. UN Regulation No. 79.

Public

2. EBSIG´s drafting principles (GRVA-16-07)

The essential principles of the regulations are that a braking system employing stored energy:

1. May have a vacuum, hydraulic, pneumatic, electric, or mixed medium transmission.
2. The transmission must comprise at least two independent braking circuits each acting on a minimum of two wheels.
3. Each of those circuits must have its own independent energy reserve.
4. The value of each reserve must be monitored, and a warning system must be provided to alert the driver if the value falls below a prescribed level.
5. At all times that the vehicle is able to be driven (or be in motion), and there are no faults present in the system, the total value of the energy reserves has to be sufficient to satisfy the performance requirements of regulations.
6. When isolated from its supply, the total energy reserve must allow a defined number of full brake applications and still be sufficient to ensure secondary braking at the end.
7. The energy reserve of each circuit must be maintained at a level that can ensure secondary brake performance should a fault/failure occur in the other circuit.

Public

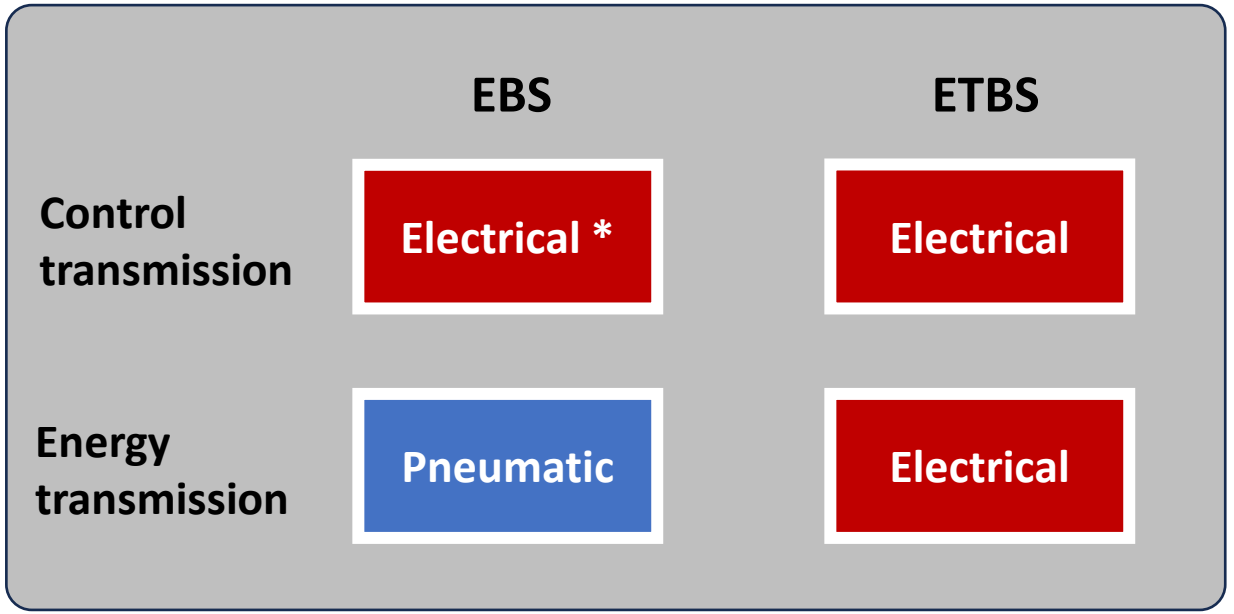
3. Specimen architectures

ETBS versus EBS

2.52. **"*Electronically controlled Braking System*" (EBS) means a service braking system where the control is generating an electrical signal in the control transmission and electrical output signals to devices which generate actuating forces produced from stored or generated pneumatic energy.**

2.53. **"*Electrical Transmission Braking System*" (ETBS) means a braking system of a power-driven vehicle where the service braking force, and transmission, depend exclusively on the use, controlled by the driver, of energy provided from electrical storage devices.**

- This new definition is specific to R13 and covers existing typical layouts on HCVs (since the mid-90's): the so called "Electronic Braking System (EBS)".
- The aim is to avoid any confusion between EBS and ETBS.
- EBS is addressed with special additional requirements of section 5.2.1.27., while ETBS is addressed in new section 5.2.1.35.



** Existing systems all have a pneumatic backup*

Public

3. Specimen architectures

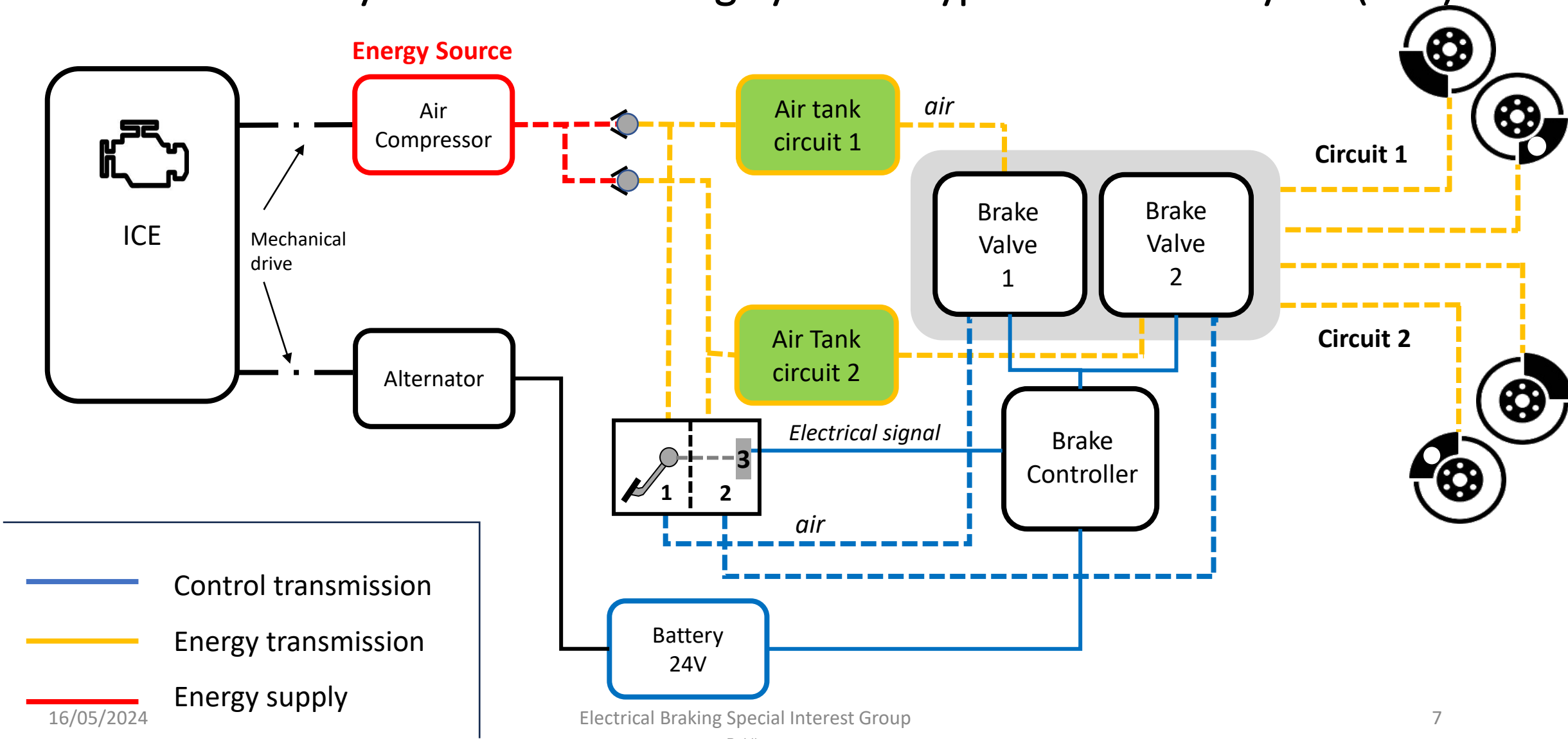
Caution (about the layouts)

- The following layouts are only indicative diagrams, not actual implementations.
- They do not aim to show an exhaustive view of all possibilities.
- The principles of the different layouts could be mixed and give new layouts.

Public

3. Specimen architectures

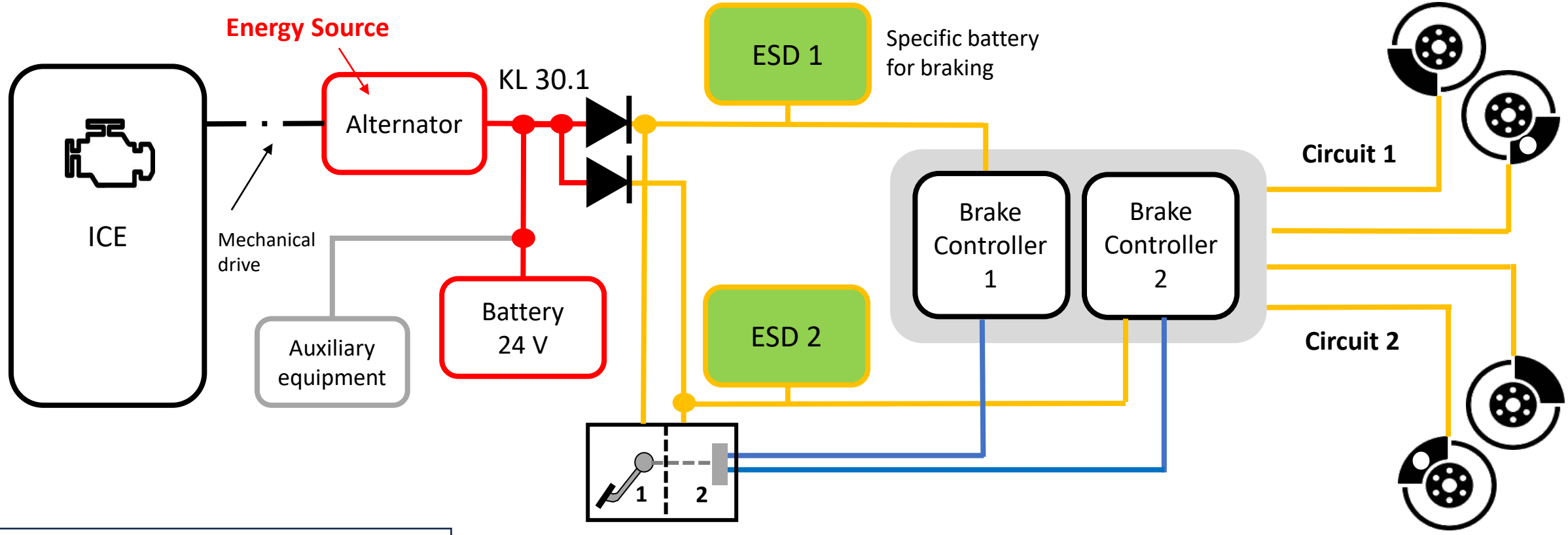
Electronically Controlled Braking System - Typical HCV EBS layout (R13)



Public

3. Specimen architectures

ETBS - Layout 1 - Specific battery for braking



Control transmission

Energy transmission

Energy supply

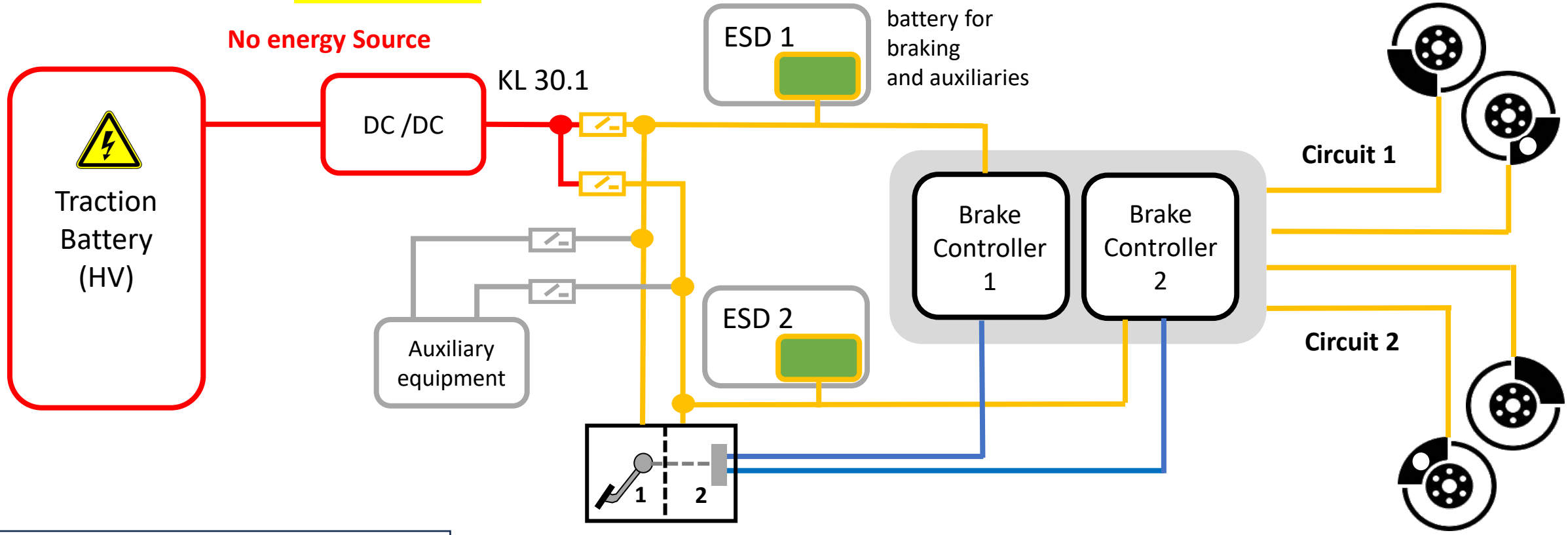
Highlights:

- The energy in the Electrical Storage Devices (ESD) can only be used by the braking system.
- This layout has an energy source (the alternator).
- The energy source is part of the electrical supply.

Public

3. Specimen architectures

ETBS - Layout 2 - Multipurpose battery for braking and auxiliaries



Control transmission

Energy transmission

Energy supply

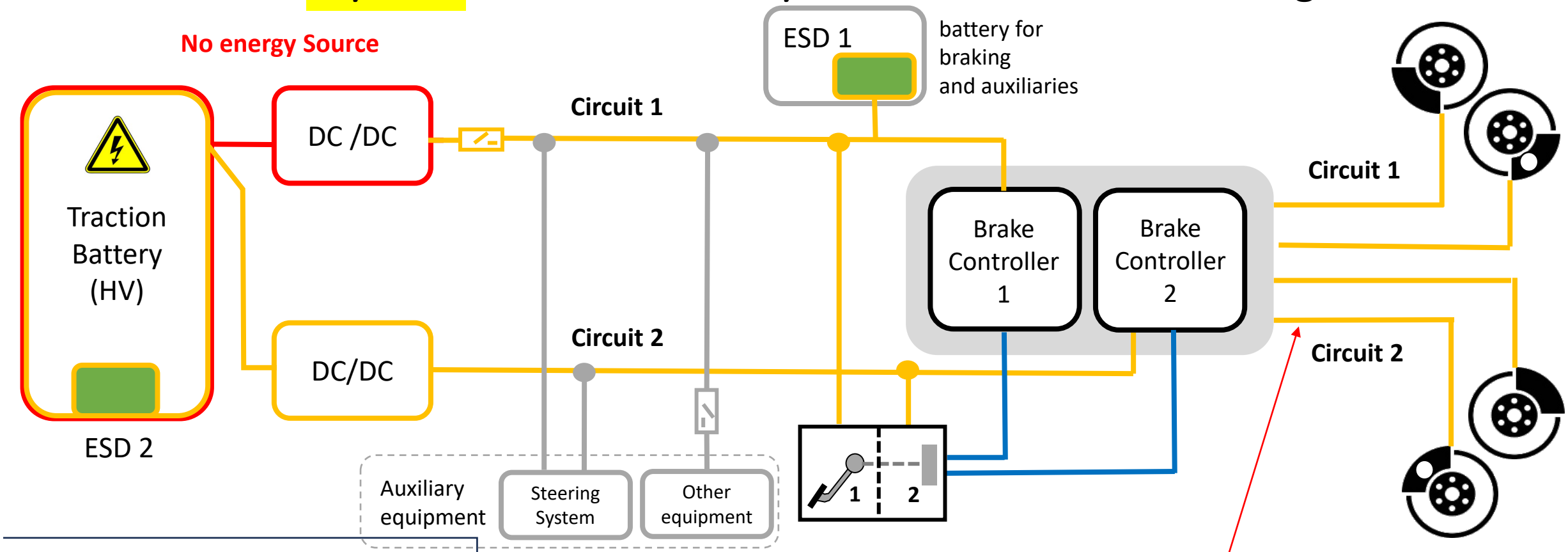
Highlights:

- The energy in the Electrical Storage Devices (ESD) can be used by the braking system and by auxiliary equipment.
- This layout has no energy source (a traction battery is not a source).

Public

3. Specimen architectures

ETBS - Layout 3 - Traction battery used as an electrical storage device

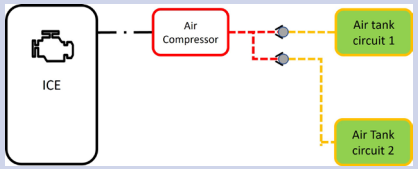
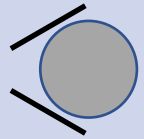
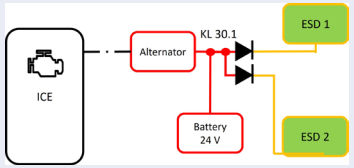
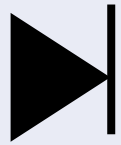
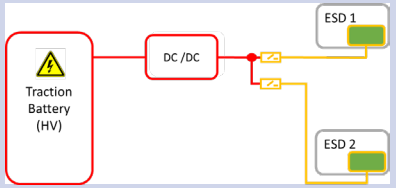
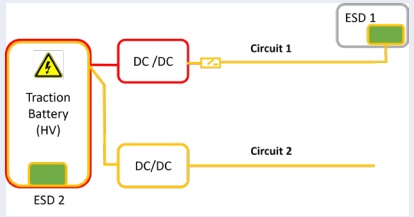


Highlights:

- The traction battery is both the electrical supply of circuit 1 and the electrical storage device of circuit 2 (which has no supply).
- Another energy medium than electricity may be used to power the brakes, e.g. an electro-hydraulic converter could be used to power hydraulic brakes. Such a layout remains an ETBS since the reserves remains electrical storage devices. This possibility is also valid for the other layouts.

4. Brake circuit isolation

Different technical solutions in dependance of the architecture

Architecture		Protection Element	
Electronically Controlled Braking System - Typical HCV EBS layout (R13)		**Circuit Protection Valve**	
ETBS - Layout 1 - Specific battery for braking		**Diode**	
ETBS - Layout 2 - Multipurpose battery for braking and auxiliaries		**Active Separating and Connecting Element (ATV)**	
ETBS - Layout 3 - Traction battery used as an electrical storage device		**Active Separating and Connecting Element (ATV)**	

Public

4. Brake circuit isolation

Active Separating and Connecting Element (ATV)

- Technological solutions for ATVs exist
- ATVs are used in production vehicles today
- They may be standalone components, or integrated into other ECUs (e.g. Zone Controllers)
- ATVs are an important part of safe vehicle power supply system
- They can be used to ensure independency in systems other than braking systems

Public

5. Periodical Technical Inspection (PTI)

- Procedure to check that the means of detection to trigger the warning signals are operational.
- Reference braking force:
  - Reference brake values extended from pneumatic systems, therefore applicable to more vehicle categories.
  - First time that reference braking forces are introduced in R13H (alignment on R13).
  - Must be possible to evaluate the relationship between the brake demand and the measured braking force on a roller brake tester.
  - The manufacturer must describe the method by which this can be realized.
- Challenge:
  - Application of reference braking values for ETBS systems is not standardized (e.g. brake demand value could be as a percent value, a voltage, brake pedal force or stroke, pressure).
  - ETBS is a technology in its infancy; being too prescriptive at this stage could limit the possibilities for development.
  - PTI requirements could be reviewed in the medium term, based upon market experience.

Public

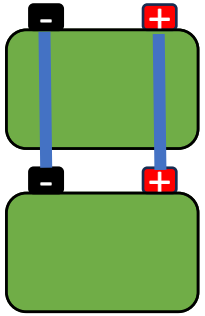
Coffee Break

Public

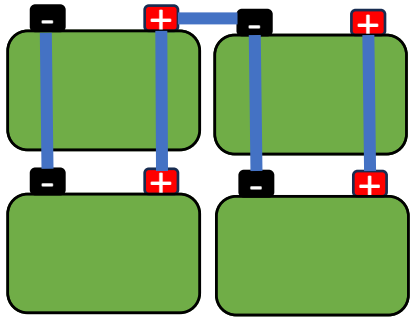
6. Terminology
6.1. Electrical Storage Device

"*Electrical storage device*" means a device, or combination of individual devices, each capable of storing an electrical charge and of providing electrical power to the braking system transmission. Electrical storage devices which are connected in series and/or parallel for the purpose of supplying a single braking circuit, shall be considered as one electrical storage device within this Regulation.

A combination of devices in series
= one electrical storage device.



A combination of devices in parallel
= one electrical storage device.

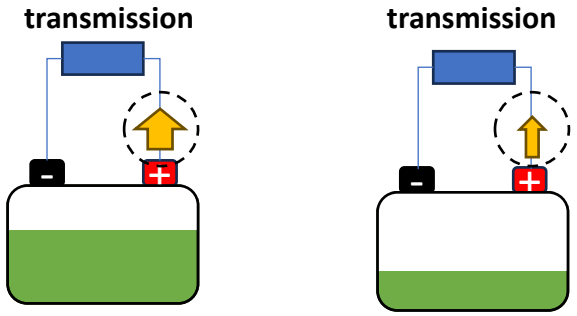


A combination of devices in series and parallel
= one electrical storage device.

Public

6. Terminology
6.2. Electrical Storage Device

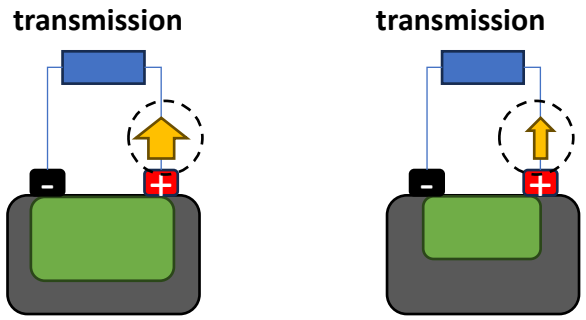
The "*state of an electrical storage device*" means its ability to provide power (W) and quantity of energy (Wh) at the time.



This is the useful extractable power and energy (which is available to the transmission) based on the condition at the time.

This may vary with battery temperature.
This will vary during discharge and re-charge.

The "*performance of an electrical storage device*" means its ability to provide power (W) and quantity of energy (Wh) when fully charged.

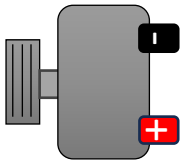
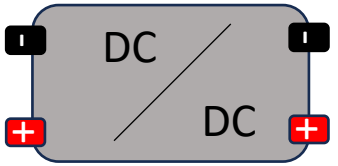


This is the useful extractable power and energy (which is available to the transmission) when fully charged. This may reduce over time through use.

The "*effect of ageing*" is quantifying the irreversible degradation of the performance of an electrical storage device, due to e.g., the effects of time, use, and environmental exposure.

Public

Terminology
6.3. Energy Source and Electrical Supply

	 Alternator (similar to compressor)	 Battery / Capacitor (similar to an air tank)	 DC/DC (similar to a pressure regulator)
"*Energy source*" means a device that both <u>generates</u> and provides energy required for the braking system.	✓ Is a source because it **generates** electrical energy	✗ Is not generating, but only releasing stored energy	✗ Is not generating, but only processing (high voltage) electrical energy to (low voltage) electrical
"*Electrical supply*" means a device (e.g. battery, REESS, generator, fuel-cell or a combination of these components) that <u>supplies</u> electrical power to the braking system's electrical storage device(s).	✓ As part of the supply	✗/✓ In most layouts it is a storage device. However, it can be part of a supply (e.g. Traction battery that supplies the braking system's electrical storage device).	✓ Is part of the supply

Public

7. Principles to manage energy

- The energy medium is the fundamental difference between an Electric Transmission Braking Systems (ETBS) and current technology (electrical energy versus compressed air).
- In case of ETBS, the energy, that can be provided to the braking system must be predicted whereas in a pneumatic braking system the available energy is measurable.
- Unlike pneumatic pressure, the electric energy cannot be directly measured but only be assessed based on monitoring of several physical parameters.
- The most relevant parameter is not the energy which is stored in an electrical storage device at any time, but rather the energy and the power which is capable of being provided to the electrical load (i.e., the brake).

Public

8. Energy Management System (EMS)

General tasks how measure and manage electrical energy

1. Measure and/or monitor in real time the energy available in the reserve in all operating conditions and over the lifetime (high/low temperatures, ageing, …).
2. Determine the value of the power and the energy that can be provided to the brake transmission (e.g., the effect of resistance on the flow of energy).
3. Compare that value with the known threshold value required to meet the specific performances required by the regulations.
4. To generate a warning to the driver in real time in accordance with the known threshold value.

Public

8. Energy Management System (EMS)

Pneumatic Braking System vs. ***"Electrical Transmission Braking System"***

Pneumatic Braking Systems (PBS)

- the reserve of energy can be measured and monitored at any time directly (by direct means at TA and PTI)

Electrical Transmission Braking System (ETBS) according to para. 2.5.3. (UN R13) and para. 2.34. (UN R13H)

- the reserve of energy **cannot** be measured and monitored at any time directly.
- multiple signals (voltage, current, temperature) are necessary to be observed to measure, monitor, and deduce the output power of the Electrical Storage Device (reference: para 2.48 (UN R13), para. 2.30 (UN R13H))

"Electrical Transmission Braking System" (ETBS) means a braking system of a power-driven vehicle where the service braking force, and transmission, depend exclusively on the use, controlled by the driver, of energy provided from electrical storage devices.

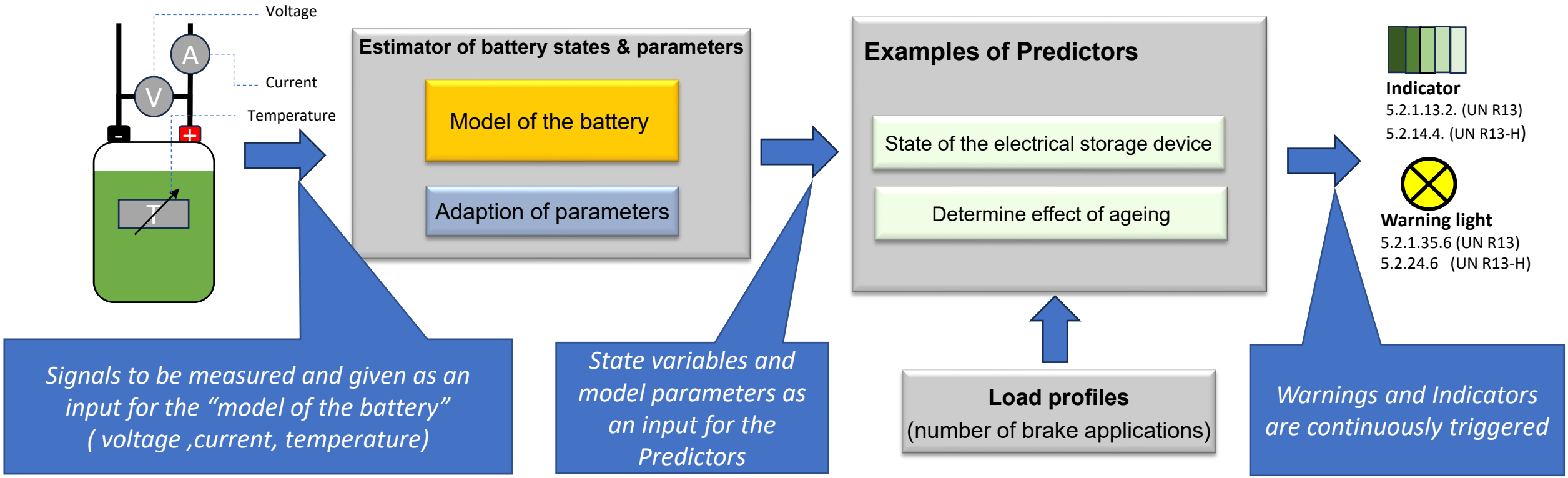
➔ **Definition of Energy Management System (EMS)** according to para. 2.51. (UN R13) and para. 2.33. (UN R13-H)

"Energy Management System" means, an electrical device(s), being part of, or used by, an electrical transmission braking system, that monitors critical variables that impact on the performance and state of the electrical storage devices (e.g., voltage, temperature, internal resistance, effect of ageing, state of charge, power consumption, charging cycles, etc.) and deduces the actual capability of the devices to fulfil the performance requirements of this Regulation.

Public

8. Energy Management System (EMS)

(Example: Lead acid battery state detection| basic principle)



- Influences like low temperature, high temperature ,the exchange of electrical storage device, ageing; long-time parking shall be considered and covered.
- Technological solutions for EMS are available from various suppliers, their reliability is field-proven.
- EMS shall demonstrate compliance according to
  - 5.2.1.35.8.2. / 5.2.1.35.8.3. (UN R13) respectively 5.2.24.8.2. / 5.2.24.8.3. (UN R13-H)
  - UN-R13-Annex18 and UN-R13H-Annex 8

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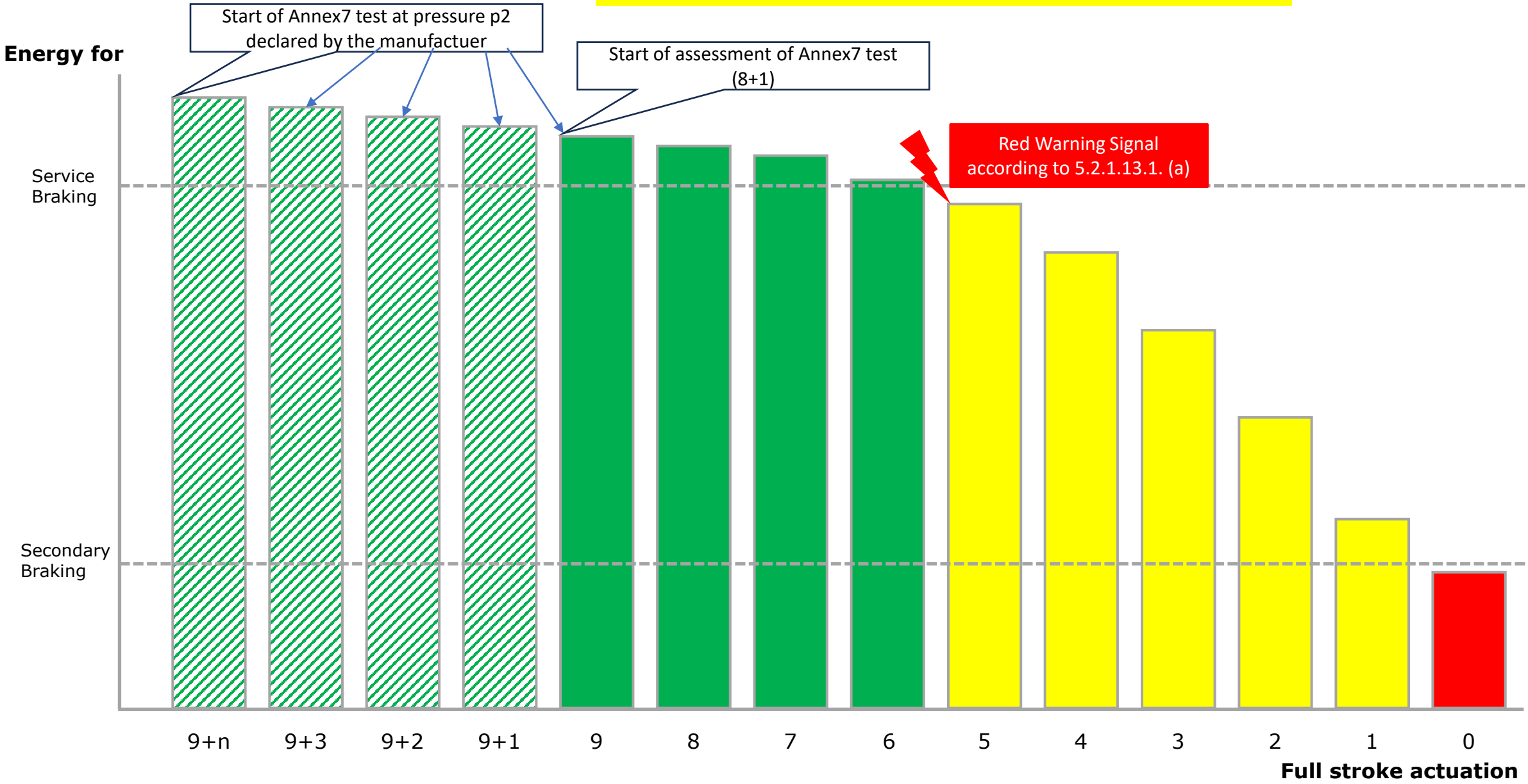
9. Annex 7 / Annex 4

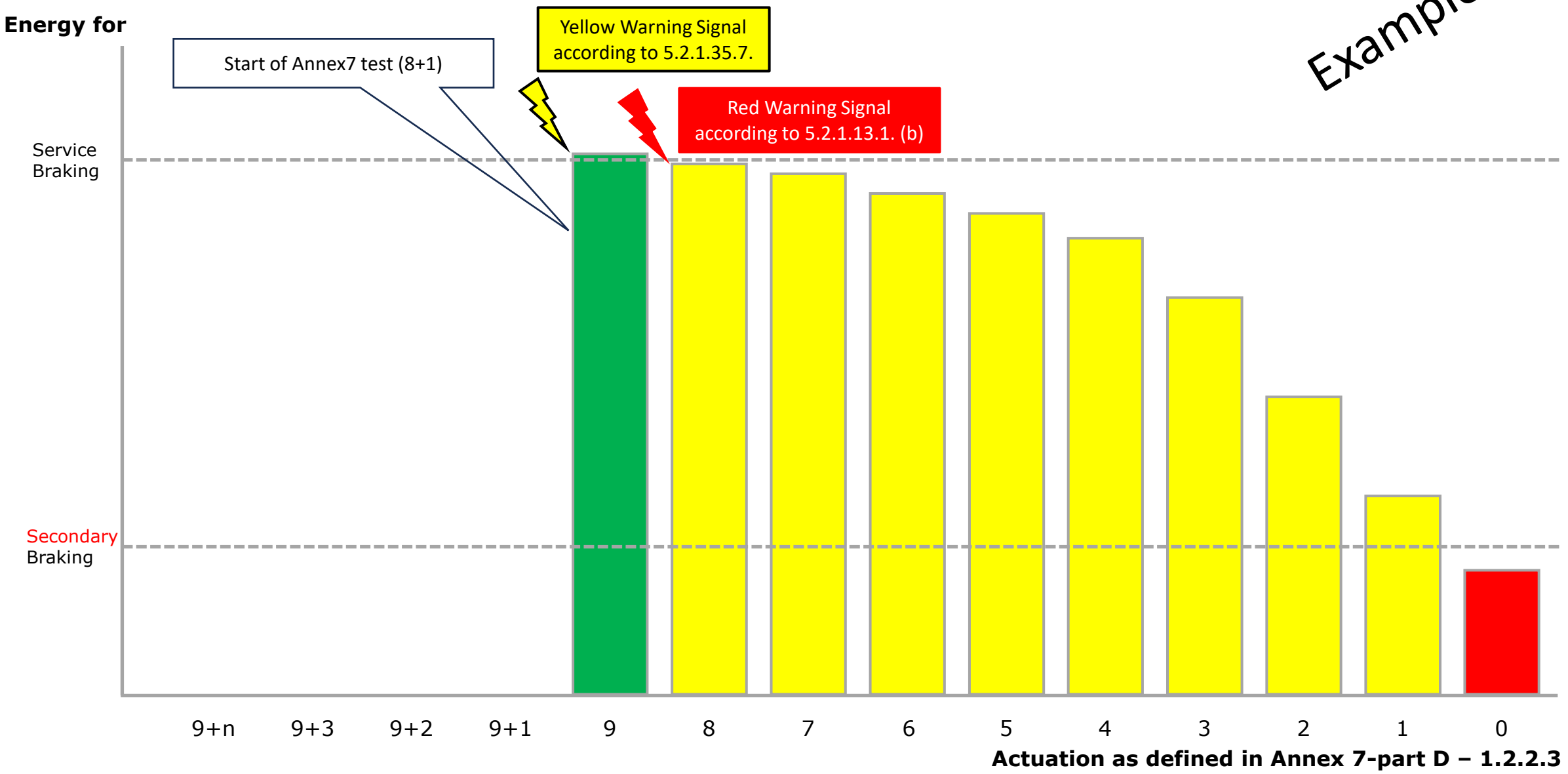
UN R13 / Annex 7 Part A, compressed-air braking systems



Public

9. Annex 7 / Annex 4 Part D, §1.2.ff. (ETBS)

Example 1



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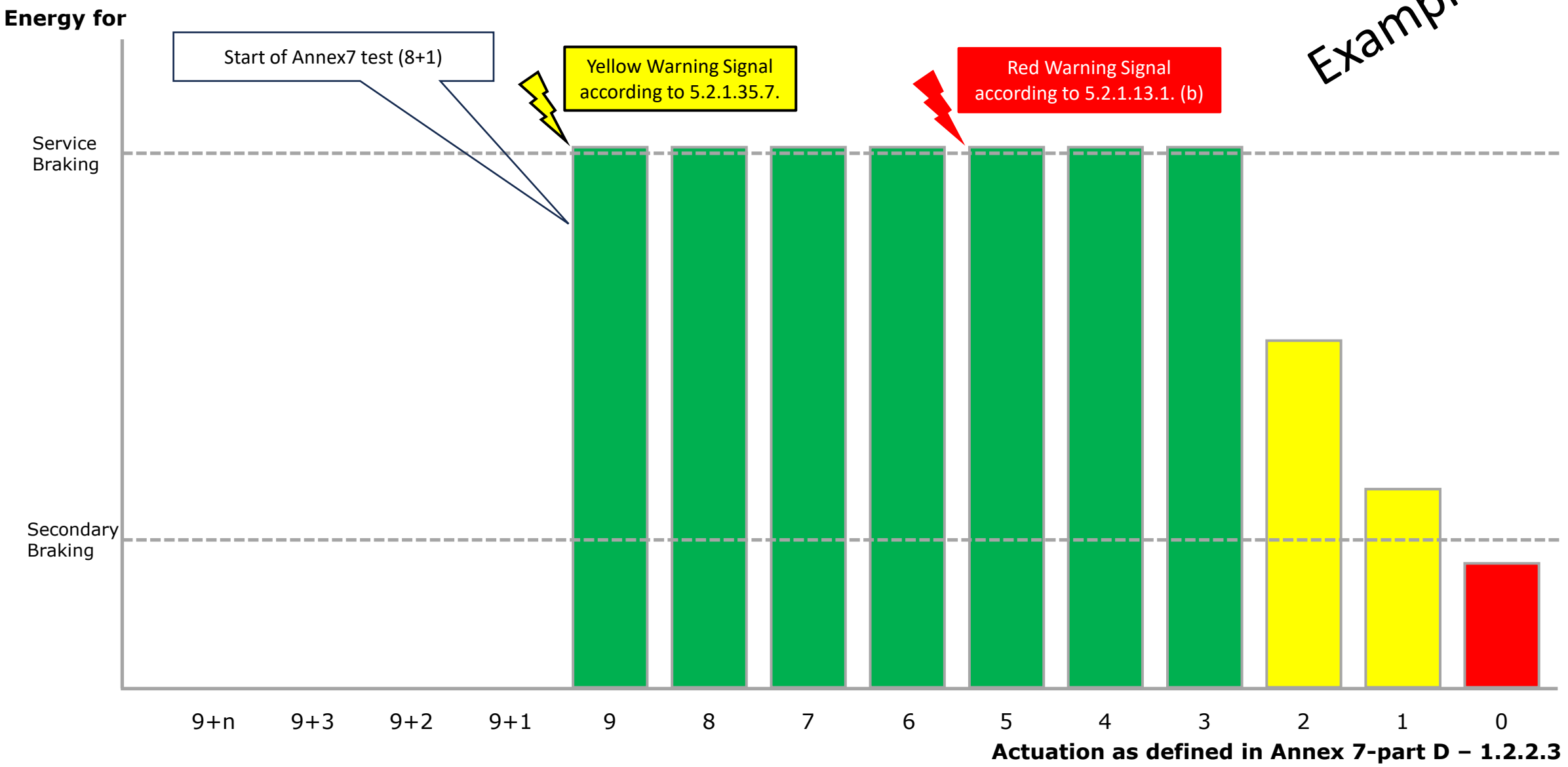
9. Annex 7 / Annex 4 Part D, §1.2.ff. (ETBS)

Example 2



Public

9. Annex 7 / Annex 4 Part D, clarificatio

Annex 7, para. 1.2.3.3.: *"Each actuation shall cause a demand (a_{ref}) on the brake actuators necessary to deliver the maximum possible deceleration designed to be delivered by the system in the Type-0 condition (e.g. cold brakes, Type-0 speed, laden, fully charged electrical storage devices), limited to 8.0m/s².*
The demand value to the brake actuators may be reduced to a lower value $a_{reduced}$, while not being lower than the prescribed service braking deceleration. In this case, the duration-T of each full stroke actuation shall be increased as per according to the following formula below: ….. "

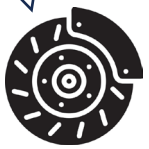
Case 1

Deceleration (maximum)
a_{ref}=**7**m/s²

Control Transm.

Brake Control Unit

Energy Transm.



$a_{executed}$=**7**m/s²

a_{ref}=$a_{executed}$=**7**m/s²

T=**8**s

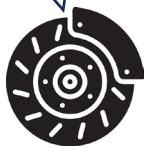
Case 2

Deceleration (limited)
a_{ref}=**8**m/s²

Control Transm.

Brake Control Unit

Energy Transm.



$a_{executed}$=**8**m/s²

a_{ref}=$a_{executed}$=**8**m/s²

T=**8**s

Case 3

Deceleration (reduced)
$a_{reduced}$=**6.43**m/s²

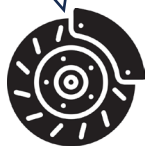
$a_{reduced\_min}$=**6.43**m/s²

$a_{reduced\_min}$=**5**m/s²

Control Transm.

Brake Control Unit

Energy Transm.



$a_{executed}$=**6.43**m/s²

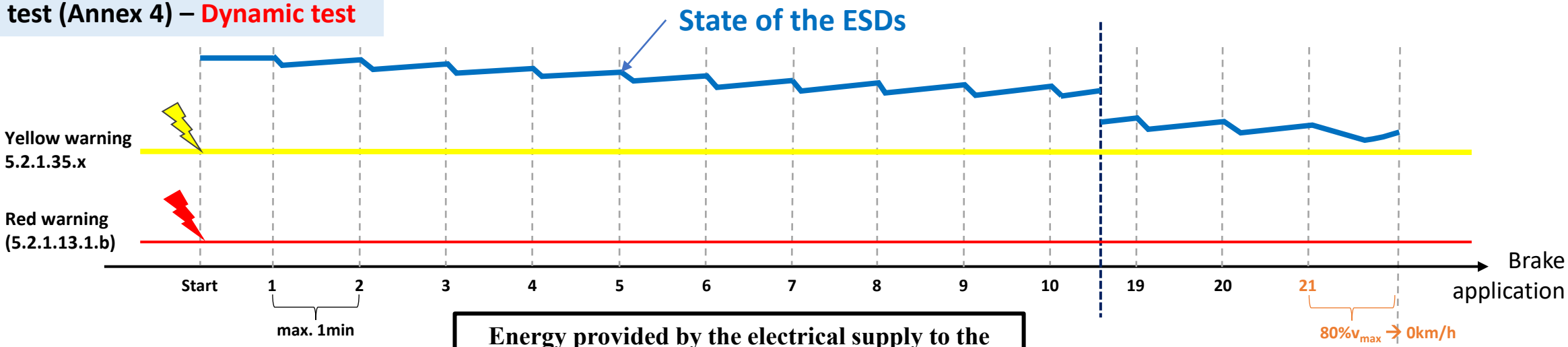
a_{ref}≠$a_{reduced}$
$a_{reduced}$=$a_{executed}$=**6.43**m/s²

T=8/6.43*8s
T=9.95s

Public

9. Annex 7 /Annex 4 Part D, Section 2 (test of the capacity of the electrical supply)

Type-I test (Annex 4) – Dynamic test

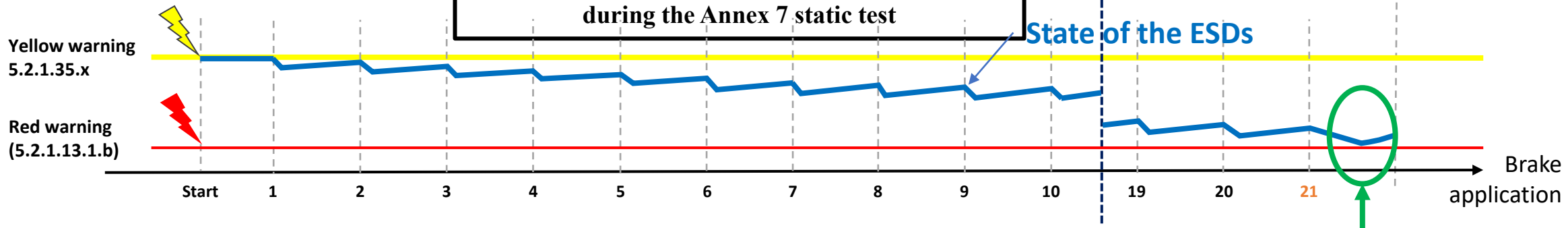


Capacity of the electrical supply (Annex 7, Part D, section 2) - Static test

Energy provided by the electrical supply to the electrical transmission during Type-I dynamic test (followed by the hot performance test)

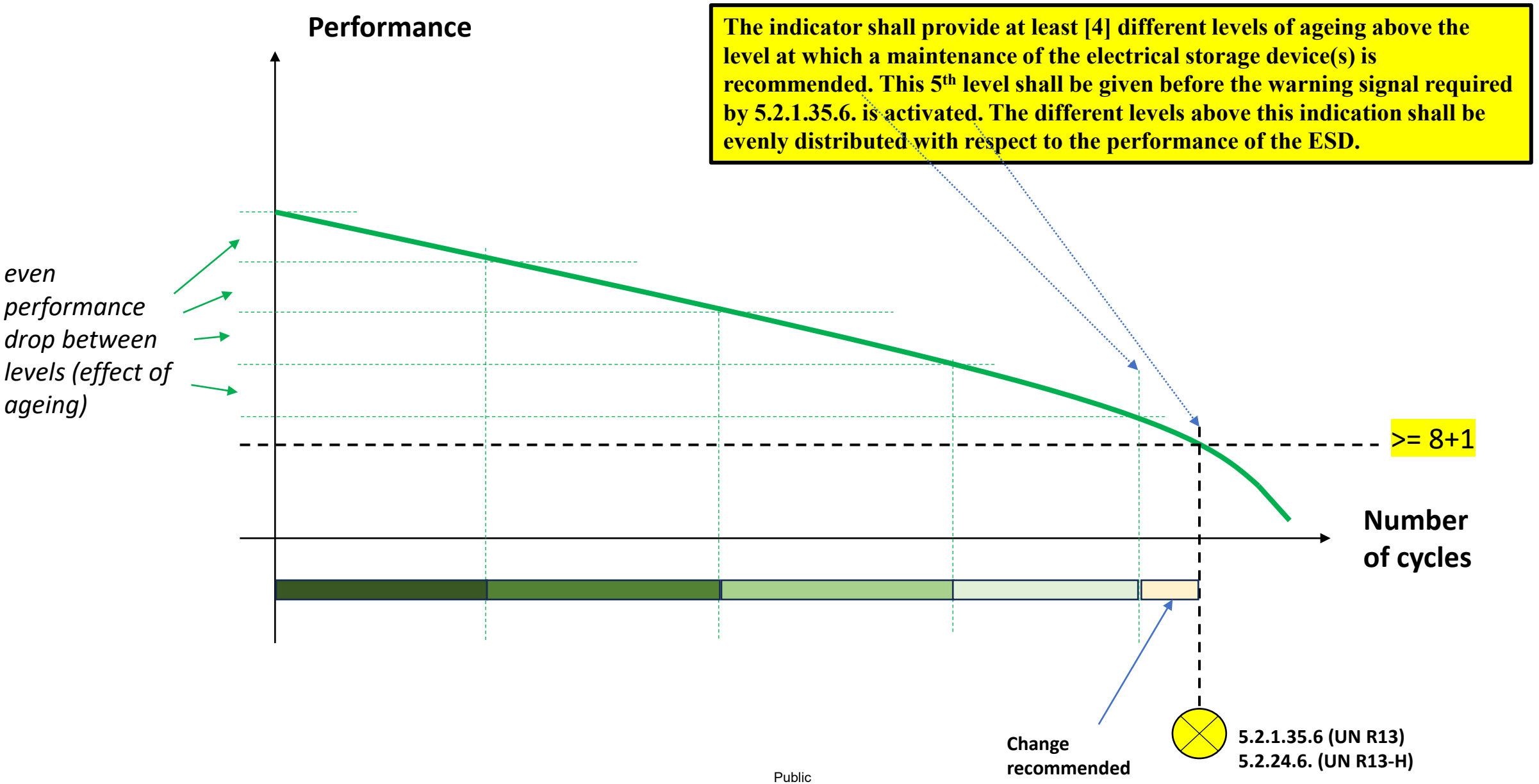
=

Energy provided to the electrical transmission during the Annex 7 static test



PASS Condition: the state of the ESDs is above the level of the red warning, and the Pw warning is not activated

10. Indicator



Public

11. Auxiliary Equipment

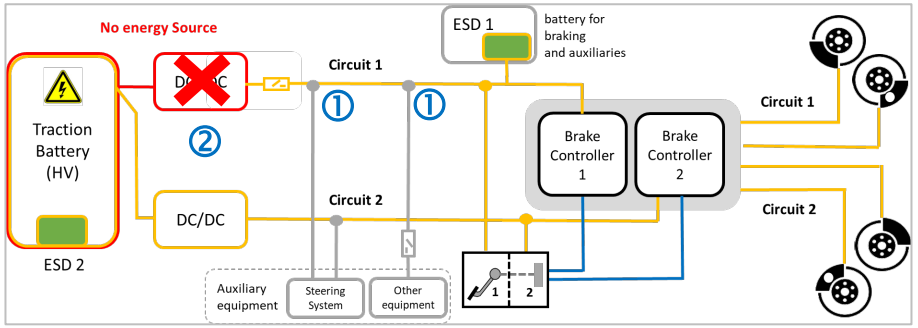
- Circuit with electrical supply -

2.55./2.35. "Auxiliary equipment" means, for the purposes of this Regulation, the collective of systems, functions, or components, including those that are essential to the operation of the vehicle, that are supplied with energy from the same energy reserves as the braking system.

Relevant situation according to 5.2.1.35.10. (5.2.24.10.):

① Auxiliary Equipment is supplied from the same ESD as the braking system
② Failure of the electrical supply that is providing energy to this ESD

Indicative layout



A) Switching off auxiliary equipment
B) Automatically bringing the vehicle to standstill
C) A combination of both (first switching off parts of aux. eq., later the standstill)

IMPORTANT: The operation of auxiliary equipment required to satisfy the performance requirements of another safety related UN regulation shall not be affected.

*) Service brake performance cannot be achieved, or 4+1 actuations are still possible, whichever occures first

Public

11. Auxiliary Equipment

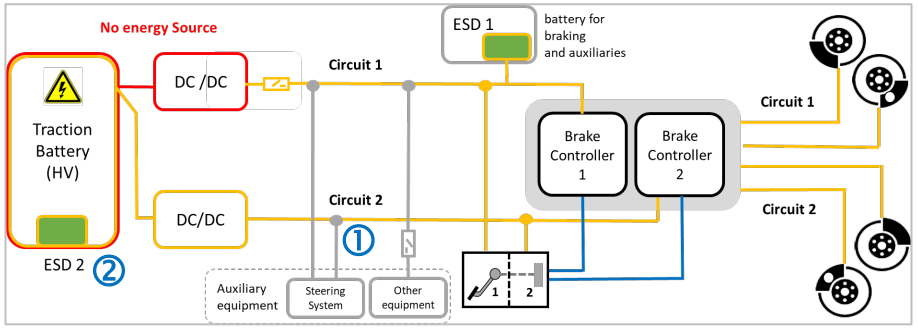
- Circuit w/o electrical supply -

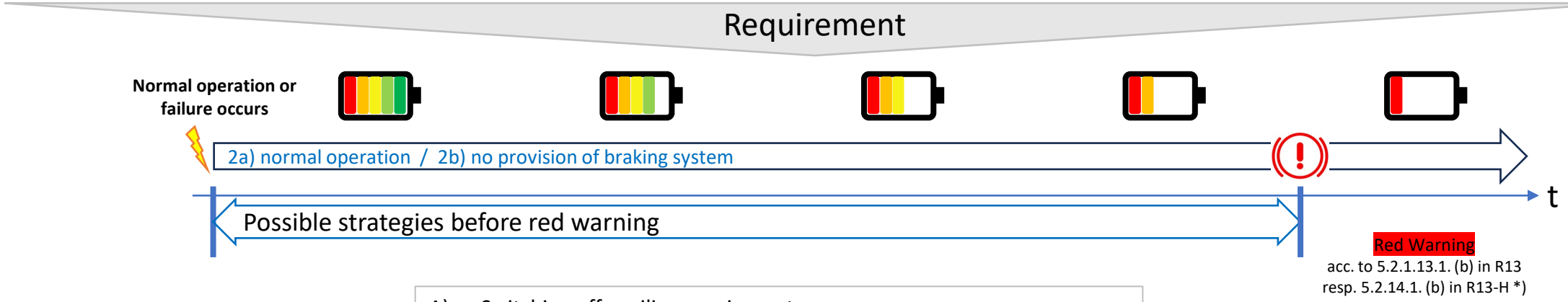
2.55./2.35. "Auxiliary equipment" means, for the purposes of this Regulation, the collective of systems, functions, or components, including those that are essential to the operation of the vehicle, that are supplied with energy from the same energy reserves as the braking system.

Relevant situation according to 5.2.1.35.10. (5.2.24.10.):

① Auxiliary Equipment is supplied from the same ESD as the braking system
② a) No electrical supply (e.g. Traction Battery is one ESD) -> non-fault
b) Failure that prevents Traction Battery from providing braking system

Indicative layout





A) Switching off auxiliary equipment
B) Automatically bringing the vehicle to standstill
C) A combination of both (first switching off parts of aux. eq., later the standstill)

IMPORTANT: The operation of auxiliary equipment required to satisfy the performance requirements of another safety related UN regulation shall not be affected.

*) Service brake performance cannot be achieved, or 4+1 actuations are still possible, whichever occures first

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