



CEN Workshop 10 – European Handbook for Defence Procurement

Expert Group 4 : Batteries

Final Report

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1 REFERENCE: THE GENERAL FRAMEWORK PAPER AND MAIN TERMINOLOGICAL REFERENCES

This document presents:

- some general information about batteries and standards,
- the list of most relevant standards about batteries to be included into the European Standards Handbook for Defence procurement,

Handbook for Defence procurement,

- some recommendations on the use of standards for the procurement of batteries, and for the procurement of systems including batteries.

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2 INTRODUCTION

2.1 DEFINITIONS OF BATTERIES

In science and technology, a battery is a device that stores energy and makes it available in an electrical form. It usually consists of electrochemical devices such as one or more galvanic cells.

For the present document, the following definition has been given for “battery”:

“A battery is a power and energy storage system. It includes the electrochemical device, and may also include the battery management system, and its own surrounding electronic or mechanical devices (in particular for security).”

2.2 CLASSIFICATION OF BATTERIES

Many diverse systems use batteries. A very wide range of batteries thus exist, with dissimilar characteristics, and various sizes, capacities, and technologies.

2.2.1 Primary and secondary batteries

Batteries may be first classified by two main categories: *primary batteries* (non-rechargeable batteries) and *secondary batteries* (rechargeable batteries).

Most non-rechargeable batteries are small batteries used either for consumer applications (watches, toys, low power tools, small electronic devices) or for military portable equipment (radio, night vision equipment). Some military applications also use specific non-rechargeable batteries (missiles and munitions, torpedoes).

Rechargeable batteries can be restored to full charge several times by application of electrical energy. They now replace non-rechargeable batteries for most consumer applications, in particular for high-tech electronic devices (cameras, laptops, cell phones)

Rechargeable batteries are also used for industrial applications: standby and emergency power, traction, aircraft and aerospace application. These batteries are implemented to power supply systems and connected to power networks to be frequently recharged. Non-rechargeable batteries are not suitable for these applications.

2.2.2 Starting batteries / Deep cycle batteries

Basically two types of rechargeable batteries are identified: *starting batteries* and *deep cycle batteries*. Starting batteries are designed to deliver quick bursts of power (to start thermal engines). Deep cycle batteries are designed to deliver long-term energy, and to be frequently discharged and recharged.

2.2.3 Low power batteries / High power batteries

A distinction is usually made between low-power batteries and high power batteries. Most low-power batteries are consumer battery packs, and may be considered as consumables. They are generally low-cost and made in large volumes. The major low-power battery types are the small batteries used for tools and portable electronics devices, and the SLI batteries (for starting, lightning and ignition) used in automotive applications.

High power batteries may be considered as systems. They are generally specifically designed for the stationary industrial applications and/or complex platforms where they are implemented.

The distinction between low power batteries and high power batteries is a relevant criteria for the selection of standards (*see section 4.5*).

2.2.4 Civil batteries / Military batteries

There is no theoretical difference between batteries used in civil applications and batteries used in military applications. However, military systems have generally higher requirements (high capacity and light weight batteries, wide operating temperature range...), and military applications usually need enhanced batteries.

Most special technologies (*see section 2.4.1 and annex1*) are also dedicated for military specific applications.

2.2.5 Recapitulative table (types of batteries and applications)

Type	Technology / Chemistry	Application
Low power consumer applications batteries	<i>Non-rechargeable</i> Low power Leclanché and Alkaline cells	Consumer applications Most common small batteries used for tools, toys, remote control.
High performance low power batteries	<i>Rechargeable</i> NiCd, NiMh, Lithium-ion	Consumer applications Common rechargeable batteries used for power tools and high-tech consumer applications (cell phones, laptops, camera and camcorders)
	<i>Non-rechargeable</i> Primary Lithium (LiSO ₂ , LiSOCL ₂ , LiMno ₂) <i>Rechargeable</i> Lithium-ion	
Specific long life small batteries	<i>Non-rechargeable</i> Lithium or mercury button and coin cells	Consumer applications Industrial applications Watches, memory back-up, hearing aids, medical implants
SLI batteries (Starting, Lightning & Ignition)	<i>Rechargeable</i> Lead-acid	Consumer applications Industrial applications Batteries used for automotive applications (cars, trucks) to start thermal engine
Traction batteries for consumer applications	<i>Rechargeable</i> Lead-acid, Nickel-Zinc	Consumer applications Bicycles, electric wheelchairs, lawnmowers...
Traction batteries for Industrial applications	<i>Rechargeable</i> Lead-acid, Nickel-Zinc	Industrial applications Electric vehicles
Deep cycle power batteries	<i>Rechargeable</i> Lead-acid, NiCd, NiMh Lithium-ion	Industrial applications
Aircraft batteries	<i>Rechargeable</i> NiCd, lithium-ion	Industrial applications Batteries for aircraft applications
Batteries for satellites and aerospace applications	<i>Rechargeable</i> Silver oxide, lithium-ion	Industrial applications Specific light weight batteries dedicated to aerospace applications
Missile and munitions Single-use batteries	<i>Non-rechargeable (Single-use)</i>	Military applications Specific batteries for short one off discharge and/or very long shelf life
Sea applications	Water activated batteries	Industrial applications Emergency and rescue equipment, life jackets, emergency lightning Military applications Torpedoes
Battery systems for submarines	Lead-acid, Lithium-ion	Military applications Submarines

2.3 CHARACTERISTIC OF BATTERIES

2.3.1 Mains characteristics

Batteries are typically defined by the following major characteristics: *Nominal voltage, rated capacity, cycle life, dimensions, mass, terminals*.

- The *nominal voltage* is the designated value of the voltage which is given by definition for a battery. It depends on the nominal voltage of the cell (which depends on the chemistry) and on the construction of the battery (serial and parallel connections of the cells). The nominal voltage is usually the average voltage at the beginning of discharge (it varies from the actual voltage which usually decreases with discharge).

- The *rated capacity* (for rechargeable deep-cycle batteries) designates the achievable “quantity of energy” that can be stored by the battery. This quantity of energy is available under specified conditions, and depends on the charge/discharge regimes.

The capacity is usually expressed in Amp-hours (AH) or milliamp hours (mAH)

- The *cycle life* characteristic (for a rechargeable battery) is the number of charge/discharge cycles which are available under specified conditions, before the battery loses a specified percentage of its original capacity. This characteristic depend on the depth of discharge of the cycles (cycle life decreases when depth of discharge increases).

- The *dimensions* and the *terminals* are important interface characteristics for the connection of the battery with the system

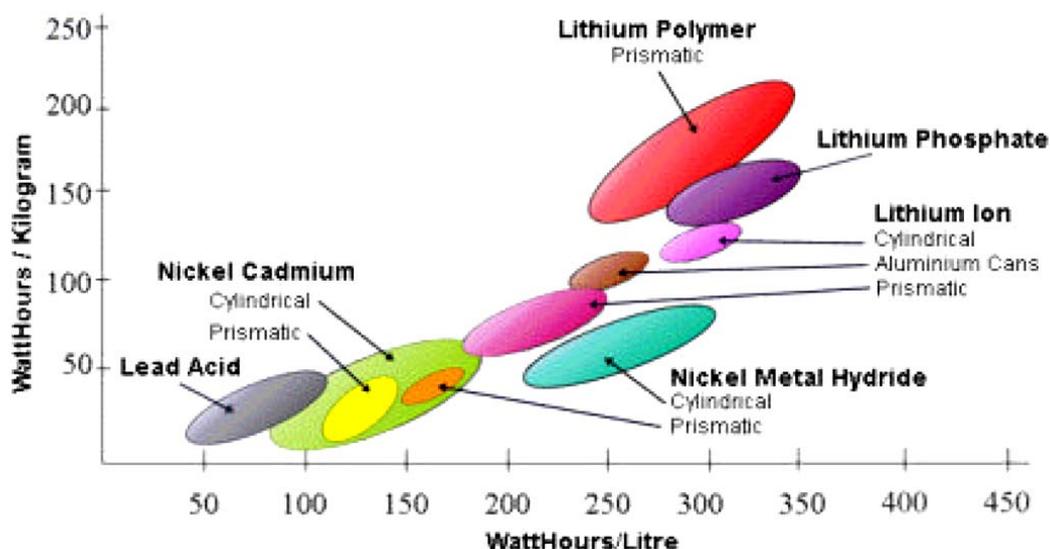
- The *mass* is an important characteristic which differ significantly with the technology of the battery.

2.3.2 Power density / Energy density

The *energy density* is a measure of the amount of energy per unit weight or per unit volume which is commonly used to evaluate and compare performances of different cells and batteries. It is expressed in W.h/kg, or in W.h/l or W.h/dm³.

Note: It important to distinguish the power and energy capacities of individual cells and the capacities of batteries (made of several cells and including packaging and electronics).

Energy densities of battery packs are obviously lower than cell energy density. This is particularly true for military systems, because of the robust packaging compliant with severe requirements.



2.3.3 Charge and discharge current (C-Rate)

The charge and discharge current of a battery is usually expressed in C-Rate. A discharge of 1C draws a

current equal to the rated capacity

For example: a battery which rated capacity is 1000 mAh provides a current of 1000 mA for 1 hour if it is discharged at 1C. The same battery theoretically provides a current of 500 mA for 2 hours if it is discharged at 0.5C, or provides a current of 2000 mAh for 30 min if it is discharged at 2C.

However, due to some energy losses and to the drop voltage, the actual capacity of a battery varies with the charge/discharge regime. A battery has a higher capacity if it is discharge at a lower C-Rate, and a lower capacity if it is discharged at a higher C-Rate.

Charge and discharge rates depend on the internal impedance of the battery, and differ with the chemistries. *For example, standard NiCd batteries have low internal resistance and are suitable for high charge and discharge rates.*

The battery charge and discharge rates are very important characteristics which shall be carefully considered. Some applications have loads which need high current and require batteries with high discharge rates. Batteries with high charge rates can be recharged faster.

2.3.4 Memory effect

The memory effect is a cyclic problem caused by a change in crystalline formation inside nickel based cells and which increases the internal impedance. This effect occurs if the batteries are recharged before they are fully discharged. It prevents the batteries from complete discharging or cause rapid self-discharge: the batteries "remember" the previous amount of discharge.

Nickel-cadmium (NiCd) batteries are very susceptible to memory-effect. They need reconditioning (repeated complete charge and discharge cycles) in order to keep their original capacities and performances.

2.4 MAIN TECHNOLOGIES OF BATTERIES

2.4.1 General overview

In the annex 1, the different technologies of batteries are described:

- Alkaline batteries
- Lead-acid batteries
- Nickel-based alkaline batteries (nickel-cadmium & nickel metal hydride)
- Lithium secondary batteries Lithium primary batteries (non-rechargeable)
- Special technologies – Zebra batteries
- Special technologies – Nickel-zinc batteries
- Special technologies – Silver-zinc batteries
- Special technologies – Nickel-hydrogen batteries
- Special technologies – Reserve Batteries
- Special technologies – Metal-air batteries

2.4.2 Main chemistries recapitulative table

	Specific Power & Energy (1)	Cycle life (Min-max) (2)	C-rate	Operating temperature	Self discharge	Cost	General characteristic
Lead-acid	180 W/kg 25-50 Wh/kg 60-75 Wh/l	200-300	10C discharge	-18°C to +50°C	5% / month	low	Low energy density Low cost Reliable (robust & tolerant to abuse) Heavy and bulky
Nickel-cadmium (NiCd)	150 W/kg 50 - 80 Wh/kg	800-2000	>20C discharge for short periods	-40°C to +60°C	15%-20% / month	Low / moderate	High rate charge and discharge Wide operating temperature range Susceptible to memory effect
Nickel-metal hydride (NiMh)	250 - 1000 W/kg 50 - 80 Wh/kg 140-300 Wh/l	300-1500	>10C discharge	-20°C to +40°C	30% / month	Moderate	High energy density Wide operating temperature range High self discharge
Alkaline	280 Wh/dm ³	-				low	Consumer applications Low Cost Good shelf life
Lithium thionyl chloride (Li/SOCl ₂) Bobbin wound construction	1420 Wh/l	-		-55°C to 150°C	low	high	Highest energy density for all commercial lithium types Very long service life (15 – 20 years)
Lithium thionyl chloride (Li/SOCl ₂) Spirally wound construction	800 Wh/l High power	-		-55°C to 85°C	very low	high	High energy density Low self discharge Very long shelf life Wide operating temperature range Transportation restrictions
Sulfur dioxide LiSO ₂	260 Wh/kg 410 Wh/l High power	-		-55°C to 60°C	very low	high	
Manganese dioxide LiMnO ₂	330 Wh/kg 650 Wh/l Moderate power	-		0°C to 60°C	moderate	moderate / high	
Lithium-ion Nickel base	110 - 250 Wh/kg 400 Wh/liter	1000 - 4000	Up to 150C	-20°C to +60°C	1%-2% / month	high	High power and energy densities Relatively low self discharge Require protection circuit to maintain voltage and current in safe limits + Transportation restriction
Lithium-ion polymer Cobalt base	100-130 Wh/Kg	500	< 2C	-20°C to +60°C	5% - 8% /month	Moderate / high	

2.4.3 Cell design, battery assembly and packaging.

Various cell designs and packaging exist for each type of battery (see annex 2)

Lead-acid batteries are generally made with a simple construction of flat plate electrodes suspended in the electrolyte and packed in a suitable plastic container.

Battery packs are made with several individual cells which are combined with serial and/or parallel connection. Cells have specific nominal voltages which depend on the technologies. Cells are connected in series in order to increase the voltage, and are connected in parallel to increase current. Serial/parallel connection allows good design flexibility to attain the voltage and current required by the load and the system.

Packaging designs and households are generally customized to fit with the available space and to meet the environment conditions requirements.

Certain battery packs also include electronic devices (safety devices for lithium-ion battery packs, SMBus interfaces for smart batteries).

3. RECOMMENDATIONS FOR THE PROCUREMENT OF BATTERIES

3.1 GENERAL

The issue of electric power and the issue of batteries are very important. They shall not be underestimated, and shall be carefully considered when designing military systems. Indeed, batteries are mostly very determinant for the performances of the systems where they are implemented. Batteries can directly impact the performances of the systems, but they may also impact their safety, and at least their cost. The issue of batteries is especially critical as systems are portable or miniaturised.

In a general manner, it is first hardly recommended to consider the issue of batteries as early as possible in the design cycle of the systems. In this way, common problems in finding batteries for over-estimated requirements, or in finding batteries to fit with available space left, may be avoided.

It is recommended to consider the whole life cycle of batteries with: - pre-service constraints: design (performances, environment); installation - in-service constraints: maintenance, storage, interoperability, safety - post-service constraints: recycling

The main topics to be taken in consideration are for purchasing batteries and/or designing systems including batteries are: -the performances of the batteries, to be compliant with the requirement of the systems - the size and mass constraints, - the interfaces constraints (mechanical, electrical and communication interfaces), - the operational environment constraints, -the constraints with safety, -the constraints with maintenance, - the constraints with logistics: (quantity of batteries, storage, transportation) -the constraints with interoperability

-the post-service constraints with recycling. At least, cost is obviously a very significant factor in battery selection too. It is much recommended to consider the whole life cost (capital cost + in-service running cost + post-service costs) and not only the acquisition cost.

For the procurement of batteries, all constraints must be balanced according to well-evaluated requirements. It's obvious that over-estimated requirements may severely impact the battery acquisition and cost. In the other hand, some minor limitation may provide significant cost reduction.

3.2 NON RECHARGEABLE BATTERIES VERSUS RECHARGEABLE BATTERIES

For most applications, it is first important to note that there is obviously no choice to do between non-rechargeable and rechargeable batteries, because only rechargeable batteries are suitable. For example, only rechargeable batteries can be used for uninterruptible power systems.

On the other hand, both non-rechargeable and rechargeable batteries may be used for supplying power of small portable equipment.

The main benefit with using rechargeable batteries instead of non-rechargeable ones is cost saving, because rechargeable batteries can be operated several times.

For military applications, the use of rechargeable batteries also impacts the logistics, with some benefits but also some limitations. For instance, the stocks of batteries to supply on the battlefield are lighter. In the other hand, logistics become more complex since it is necessary to deploy some charging means, to charge batteries before use, and to collect back empty batteries.

Furthermore, the storage of rechargeable batteries requires significant maintenance. Because lithium-ion batteries have a lower energy density than primary lithium batteries, they were previously used only for training. However, the need in electric power on the battlefield is growing, and rechargeable batteries are now used for real operational missions too.

To make the choice between non-rechargeable and rechargeable batteries, benefits in cost saving shall be carefully compared to performances and impacts on logistics aspects (see section 3.8)

3.3 MAIN CHARACTERISTICS AND PERFORMANCES

Batteries shall be first obviously specified according to the power consumption requirements of the application:

-Main electrical specifications: the batteries shall be compliant with the working voltage and current required by the application (nominal, maxima and minima, peaks)

-Capacity: the battery capacity shall generally be determined by the usage profile of the application.

For systems which are exclusively powered by batteries (portable equipment), the capacity of batteries directly defines the autonomy of the systems.

It is rather recommended to specify a representative usage profile, including mission times and recharging times, in order to specify the optimal required capacity. An over-specified requirement may severely impact the size and the weight of the batteries.

3.4 SIZE AND MASS CONSTRAINTS

Size and mass constraints are generally very significant criteria for the selection of batteries for most systems and equipment. Furthermore, size and mass of batteries becomes very critical for small portable equipment and miniaturised systems. Batteries are currently a growing part of the total soldier's load.

It is logically recommended to use high power and energy density batteries for portable and miniaturized systems. It is also recommended to drive a system approach for the design of miniaturized systems including batteries, with selecting optimized electric and electronic low consumption components, and with integrating smart power management.

3.5 INTERFACES CONSTRAINTS

Mechanical and electrical constraints are directly connected to the issue of interoperability of batteries. However, with the exception of some civil formats, there is a very few standards for interfaces. Many various sizes of batteries and terminals exist.

In a general manner, looking forward standards, it may be recommended to procure batteries with the same size and the same terminals than common existing in-service batteries (and not developing new sizes and new terminals)

For data interfaces (communication between lithium batteries, charging means, and systems) it is recommended to specify the SMBus standard.

However, the communication between application (SMbus ...) and batteries is not include in this document, because today (09/2010), no standard exists.

3.6 OPERATIONAL ENVIRONMENT CONSTRAINTS

Batteries are subjected to all common mechanical and electrical environment constraints (vibration, acceleration, shocks, sealing, altitude, EMC, NBC...) as all the other sub-systems of the platform (with different levels of severity)

It is recommended to pay careful attention to temperature constraints. Indeed, batteries have a limited range of temperature over which they work. Attempting to use batteries outside their limits could also result in failures and permanent degradation. Performances also vary with the temperature, because the battery capacity is reduced as temperature decreases.

-For the procurement of batteries, minimal and maximal temperatures for operational use (discharging and charging use) and storage shall be stated to contracts.

-It is also recommended to specify the performances of the batteries under the intended operating conditions (see section 4.8.1)

3.7 SAFETY CONSTRAINTS AND RECOMMENDATIONS (SEE ANNEX 2)

Batteries store energy and are potentially dangerous, in particular if they are not carefully designed or if they are abused. Under extreme conditions, certain types of batteries can explode.

Safety standards specify "designed-in" safety measures for cell construction (internal fuses and safety vents), chemistry (separators) and batteries packaging. Standards also specify safety qualification tests.

External safety devices are also required for certain types of batteries (lithium-ion batteries for example), to protect batteries against short-circuits, over-charge and over-heat

At least, user safety instructions shall be provided with batteries. These instructions shall include information about any physical and chemical hazard, and describe procedures for handling and using the batteries.

-Safety standards regarding batteries shall be quoted to contracts

-It is hardly recommended to qualify all purchased batteries in regard with safety requirements

-Safety instructions shall be provided with batteries (for handling, using, storage...)

3.8 LOGISTICS AND MAINTENANCE CONSTRAINTS

As it is necessary to take particular precautions for their storage and their transportation, batteries can deeply impact logistics of military systems and equipment,

3.8.1 Storage

During storage, batteries are subject to both self-discharge and decomposition of their chemical contents. With the exception of some technologies which are specifically designed to very long term storage (*see section 3.8.1*), the batteries life is limited even if they are not used.

Storage requirements vary with the different technologies of batteries. Specific procedures shall be followed for each type of chemistry. Batteries need to be stored inside a certain range of temperature (ambient temperature of 20°C - 5°C is generally recommended), and their state-of-charge shall be regularly controlled.

In a general manner, primary batteries have a longer shelf life than rechargeable batteries. Lithium primary batteries have a ~10 years shelf life.

Recommended levels of charge also exist for the storage of rechargeable batteries. State of charge shall be supervised, and batteries may also need to be re-charged during storage to prevent irreparable over-discharge deterioration.

-It is first recommended to purchase a quantity of batteries which precisely fits with the needs, in order to limit the initial stocks (*see section 4.9*).

-Storage constraints shall be stated to contracts : storage duration, minimal and maximal temperatures for storage...

-Constraints with storage (re-charging during storage,...) shall be taken in consideration. Some general guidelines exist for storage. However, manufacturers add various additives to their products to optimize performances, and it is recommended to ask them recommendation for optimum storage (temperature, humidity...).

3.8.2 Transportation

International regulations regarding the transportation of dangerous goods have been amended to ensure safe transportation of high-energy density batteries. In particular, new regulations require all lithium batteries to be tested, packaged, documented and marked according to new DG transportation rules specified by the U.N. Manual of Tests and Criteria.

-The regulations regarding the transportation of dangerous goods (*see annex 3*) shall be stated to contracts.

-The envisaged modes of transportation for the purchased batteries (Air, Road, Rail, Sea) shall be stated to contracts

3.9 STATE-OF-CHARGE MONITORING

Monitoring of effective battery state-of-charge is a very significant aspect for improving maintenance and logistics of batteries. However, it is rarely available with primary technologies, and it is not reliable with lead-acid or nickel-based alkaline rechargeable batteries.

On the other hand, reliable state-of-charge monitoring is available on lithium-ion batteries, and state-

of-charge data can be exchanged with systems via a bus communication.

3.10 RECYCLING

EU directives on batteries and accumulators (91/157/EEC, 98/101/EEC, 93/86/EEC) require that batteries containing more than 25mg of mercury, 0.025% of cadmium by weight, and 0.4% lead by weight to be collected separately for recycling or special disposal. These directives largely affect lead-acid batteries, nickel-cadmium batteries and mercuric oxide batteries.

Recycling requirement may impact logistics aspects because it is necessary to collect batteries after usage (end of life cycle).

- The directives regarding batteries recycling shall be stated to contracts. (*see annex 3*)
- The cost of recycling shall be taken in consideration

3.11 CHARGERS

Careful consideration shall be taken to battery charging. Batteries require various specific charge processes that depend on the technology and the chemistry. The safety, the reliability and the longevity of the batteries depend on the quality of this charge processes.

High power industrial systems with implemented batteries usually include automatic charge and discharge processes management. On the other hand, individual low-power batteries shall be purchased with chargers which perfectly comply with their requirements.

Note: This document does not identify standards for chargers.

3.12 LIFE COSTS / COST OF OWNERSHIP / PROCUREMENT

The cost of ownership of batteries may represent an important part of the total cost of certain systems, in particular for portable equipment. Indeed, the batteries life is quite limited, and is generally much less than the service life of the systems or platform.

The whole cost of ownership shall be considered (capital cost + running costs + cycle life + recycling)

4 RECOMMENDATION CONTENT

4.1 GENERAL - HISTORICAL BACKGROUND

Standards which directly or indirectly deal with batteries are logically very numerous and very various, There are standards documents which directly apply to batteries and that specify standardised characteristics (voltage, dimensions, terminals...),

There are standards documents which indirectly concern batteries, and which deal with some associated topics (safety, installation of batteries, transportation of batteries, EMC, etc...) At least, there are also standards that apply to devices which are commonly used with batteries (chargers, adapters, electrical equipment...)

4.2 OBJECTIVES FOR STANDARDISATION –

In the current climate, there is an increasing trend in introducing COTS and MOTS (Components on the Shelf and Modules on the Shelf), and the benefits of using standards may be too much underestimated. It shall be noted that batteries are the devices for which the need in interoperability is the most critical for armed forces. To quote relevant standards to contracts is a good way to improve interoperability.

In a general manner, civil standards and military standards are very dissimilar:

- Civil standards deal with various general topics relative to the installation and the use of batteries, and in particular with safety. With the exception of the classical formats of small low-power batteries (LR1, LR6, etc) specified by IEC 60086, "standardized batteries" do not exist (even starting batteries used by automotive industry have various sizes and terminals).

- At the opposite, most military standards for batteries actually describe and specify standardised and codified batteries (with NSN numbers) which are designed for in-service equipment.

For examples:

Most common Li-SO₂ batteries used in US Army: BA 5590, BA 5800, BA 5567, BA 5588, BA 5598, BA 5112, BA 5600, BA 5599, BA 5847, BA 5699

Most common Li-SO₂ batteries used in UK Army: G30-101, G15-114, G18-115

Most common Li-LOCl₂ batteries used in French Army: PS 52 and PS 53 B for PR4G Radio, PS 42 and PS 48 B for TRC, P31 A for night vision system, PS 38 A for laser system Civil standards and military standards are not inevitably incompatible. Most military standards even refer to civil standards for general topics (voltage range, dimensions ...). However, civil and military documents generally correspond to dissimilar approaches, and they are not directly comparable.

US	IEC	ANSI	SHAPE	VOLTAGE
N	LR1	910A	Cylinder L 30.2 mm, D 12 mm	1,5 V
AAAA		25A	Cylinder L 42 mm, D 8 mm	1,5 V
AAA	LR03	24A	Cylinder L 44.5 mm, D 10.5 mm	1,5 V
AA	LR6	15A	Cylinder L 50 mm, D 14.2 mm	1,5 V
A			Rectangular prism various sizes.	6V
A			Cylinder L 50 mm, D 17 mm	1,5 V
B			Rectangular prism various sizes, often with taps.	45 V; 60 V, 90 V, etc.
C			Rectangular prism various sizes, often with several taps.	4,5 V; 6 V, 9 V, etc.
C	LR14	14A	Cylinder L 43 mm, D 23 mm	1,5 V
D	LR20	13A	Cylinder L 58 mm, D 33 mm	1,5 V

F			Cylinder L 87 mm, D 32 mm	1,5 V
G			Cylinder L 105 mm, D 32 mm	1,5 V
J			Cylinder L 150 mm, D 32 mm	1,5 V
	3R12		Rectangular prism 67 mm × 62 mm × 22 mm	4,5 V
			Rectangular prism 68 mm square × 115 mm	6 V (note)
PP3	6LR61	1604A	Rectangular prism 48 mm × 25 mm × 15mm	9 V (note)
PP9	6F100	1603	Rectangular prism 51.6mm × 65.1 mm × 80.2 mm high	9 V (note)
	4R25X	908	Square prism 110 mm high × 67.7 mm square, spring terminals	6 V (note)
	4R25	915	Square prism 110 mm high × 67.7 mm square, screw terminals	6 V (note)
	4LR25-2	918A	Rectangular prism 127 mm × 136.5 mm × 73 mm high, screw terminals	6 V (note)
			Rectangular prism 127 mm × 136.5 mm × 73 mm high, screw terminals	12 V (note)

Table 1. — Main formats of alkaline batteries specified by IEC 60086

4.3 STANDARDS, APPLICATIONS AND TECHNOLOGIES

Because of the history of batteries, and the history of technologies, most standards are specific. For instance, they exclusively apply to specific applications, or to specific technologies. Some standards may even be dedicated to a single type of battery.

For example, many standards are dedicated to lead-acid starting batteries and are not suitable for nickel-cadmium batteries, because the methods of tests are not compliant with this technology.

This may result in some risks for the management of procurement, because quoting standards to a contract may possibly become equivalent with prescribing technologies, whereas it is not recommended to impose technological choices to contractors.

Standards which are exclusively dedicated to chemistries are also subject to obsolescence. Because of the recent technological progress, in particular concerning lithium-ion technology, standards which were still relevant two or three years ago now quickly become obsolescent.

Moreover, standards are missing for new technologies. In particular, a few standards are dedicated to lithium-ion technology.

		Technologies				
		Primary Alkaline	Primary Lithium	Lead-acid	NiCd / NiMh	Lithium-ion
Applications	Starting batteries			IEC 60095-1 IEC 60095-2 IEC 60095-4 CENELEC EN 50342 MIL-PRF-32143	Lack of standards	
	Batteries for Portable equipment	IEC 62133		IEC 61056	IEC 61951-1 IEC 61951-2	IEC 61960 IEEE Std 1625- 2004
	Batteries for Stationary applications		IEC 60086-4	IEC 60896-1 IEC 60896-2 IEC 60896-11 IEC 60896-21 IEC 60896-22	IEC 62620	
	Batteries for traction			IEC 60254-1 IEC 60254-2 IEC TR 61431	IEC TR 61382-1	

Table 2. — Industry Standards and technologies

4.4 CLASSIFICATION OF STANDARDS

Standards may be classified in many different ways:

- Standards can be classified by application:

for example, standards dedicated to starting batteries only

- Standards can be classified by construction (technology and chemistry):

for example, standards which apply to lithium batteries only (cf. § 4.3.)

- Standards documents can also be classified by topic :

general purpose, safety, marking etc...

Moreover, for classification, it shall be noted that these different categories are inevitably linked together: *for example, as most starting batteries are lead-acid batteries, standards which are dedicated to starting batteries only apply to lead-acid batteries (methods of test only available for lead-acid technology).*

Since this document is destined to the purchase of batteries, and to the procurement of systems including batteries, it has been logically decided to classify the selected standards by application. The following categories have been chosen for the classification, for corresponding to the main topics and to the main military systems and applications:

- Lists of preferred products and standardized batteries (see section 5)
- Directives (see section 6)
- Generic standards (for general purpose) (see section 7)
- Standards for starting batteries (see section 8)
- Standards for portable applications batteries (see section 9)
- Standards for traction batteries (see section 10)
- Standards for stationary applications batteries (see section 11)
- Standards for battery systems and special applications (see section 12)

It has also been decided not to sequence standards by construction because, in a technological point of view, different technologies may be selected for the same application. For procurement, it is important not to make a choice in relation to the technology, but in relation to the requirements. Nevertheless, since most standards deal with one chemistry only (and are not compliant with other technologies), the type of chemistry is specified for each selected standard. Keywords and comments are also added to each table of standards for an easy and correct selection.

4.5 CRITERIA FOR THE SELECTION OF RELEVANT STANDARDS

The following criteria have been used for the selection of relevant standards:

- The selected standards directly deal with batteries and/or with topics which are directly relative to batteries,
- The standards which are dedicated to exclusive civil applications are not selected: for examples batteries for household applications, for toys, for medical devices, etc...
- The foreign standards for which equivalent standards exist in European and/or international standards bodies are not selected
- Obsolete and uncommon standards are not selected.

Civil standards and military standards are very dissimilar and are written to be used in the same way: Indeed, it is not possible to make any direct comparison between civil standards and military standards.

Nevertheless, as the battery industry is now mainly driven by civil industry, it is generally rather recommended to prefer the use of civil standards.

For the selection of standards, it has been decided to inventory all the existing and commonly used standards, and to select the most relevant ones.

The most common military standards for the interoperability of batteries are also selected. On the other hand, this document does not make a complete inventory of military specification documents for standardised batteries. Generally, as a document correspond to each battery, or at least to each family of standardised batteries, these documents are too numerous to be listed. However, the main generic lists of approved components (CECC MUHAD, VG LZB) are selected (*see section 6*).

5 GENERIC SPECIFICATION FOR PROCUREMENT / LISTS OF PREFERRED PRODUCTS

5.1 GENERAL

Some documents exist for the recommendation on the use of existing standards and/or existing standardised batteries for the design of military equipment:

The document CECC MUHAD lists a great number of batteries used in French, English, and German military equipment. The last release of the document is dated May 1996 (issue 3), and some included data are now becoming obsolete.

German lists of approved components (LZB) and survey documents included to DIN VG standards handbook give the list of standardised batteries used within the German army.

Note : The application of the German lists of approved components (LZB) is not restricted to German procurement authorities. Like all German Defence Standards (VG-Normen) they have a similar status as German civilian standards and therefore may be used by everybody who regards them useful for his purposes. Intellectual Property Rights (IPR) for German Defence Standards (VG-Normen) are with the German Institute for Standards (DIN). For 2006 it is envisaged to make the LZB electronically available on the Internet in form of database and also to up-date them more frequently.

The UK Ministry of Defence Standard 61-17 provides guide to the introduction of batteries into service, to the application of existing in-service batteries, and to procurement of equipment that includes batteries.

5.2 TABLE OF SELECTED DOCUMENTS

STANDARD	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
CECC MUAHAG VOL 15 IS 2 (01/01/1994) Preferred Products List; Batteries (En)		–	The document CECC MUHAG lists a great number of batteries used in French, English, and German military equipment. The last release of the document is date May 1996 (issue 3). Some data are now becoming obsolete.
DIN VG 95212-14 (01/10/2000) List of approved components (LZB) - Part 14: Non- rechargeable batteries	Primary	–	List of approved components in the German army
DIN VG 95212-15 (01/10/2000) Lists of approved components (LZB) - Part 15: Rechargeable batteries	Secondary	–	List of approved components in the German army
DIN VG 95230-1 (01/07/2002) Sealed nickel-cadmium batteries - Part 1: Summary	Nickel-Cadmium	–	This standard provides a summary of Sealed nickel - cadmium batteries, which are issued in detail specifications of the series VG 95230 and are used and approved within the German army. Cf. VG 95230- 2 for generic specification
DIN VG 95238-1 (01/08/2004) Vented nickel-cadmium storage batteries - Part 1: Batteries and battery assemblies - Survey	Nickel-Cadmium	–	batteries which are issued in detail specifications of the series VG 95238 and are used and approved within the German army. Cf. VG 95238- 2 for generic specification
DIN VG 95284-1 (01/06/1995) Silver-zinc storage batteries - Part 1: Summary	Silver-Zinc	–	This standard provides a summary of silver -zinc storage batteries, which are issued in detail specifications of the series VG 95284. Cf. VG 96284- 2 for generic specification
DIN VG 96915-1 (01/06/2004) Non-rechargeable batteries - Part 1: Survey	Primary	–	This survey lists all non-rechargeable batteries which are used and approved within the German army. Cf. VG 96915- 2 for generic specification
DIN VG 96924-1 (01/08/2000) Sealed lead-acid batteries - Part 1: Summary	Lead-acid	–	This survey lists all rechargeable sealed lead- acid batteries which are used and approved within the German army. Cf. VG 96924- 2 for generic specification
DIN VG 96956-1 (2005) Sealed nickel- metal hydride batteries - Part 1: Summary	Nickel Metal hybrid	–	This standard provides a summary of Sealed nickel – metal hydride batteries, which are issued in detail specifications of the series VG 96956 and approved for the German army. Cf. VG 96956- 2 for generic specification
MODUK DEF STAN 61-17 (31/10/2001) Selection and Introduction of Batteries for Service Use-Issue 4; 10.01		–	Provides guide to the introduction of batteries into service, to the application of existing in-service batteries, and to procurement of equipment that includes batteries
DIN VG 96932-1 (2010) Rechargeable lithium batteries - Part 1: survey	Lithium -Ion		The presented standard is a summary for rechargeable lithium batteries, approved for the German army.
DIN VG 96932-2 (2007)	Lithium-Ion		The presented standard is a generic standard for rechargeable lithium batteries, for the German army

5.3 RECOMMENDATIONS

The CECC MUHAG list of preferred products and The German list of approved components (LZB) may be very relevant for the purchasing of existing standardized batteries. In the opposite, these batteries may be not suitable for systems they have not been designed to be compliant with.

The CECC MUHAG list becomes obsolete. It does not include any reference of new technologies batteries (lithium-ion). This document may be used for the provision of batteries, but it is not recommended for new programs.

6 GENERIC STANDARDS (FOR GENERAL PURPOSE)

6.1 GENERAL

Many standards concern batteries in a general point of view, and are not dedicated to specific applications. They apply to very various topics.

6.2 TABLE OF SELECTED STANDARDS

DIRECTIVE	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
IEC 60086-1 (01/11/2000) Primary Batteries – Part 1: General - Ninth Edition	Primary	General purpose	The purpose of this part of IEC 60086 is to standardize primary batteries with respect to their electrochemical system, dimensions, nomenclature, terminal configurations, markings, test methods, typical performance, safety and environmental aspects.
IEC 60086-2 (01/10/2001) Primary Batteries – Part 2: Physical and Electrical Specifications-Edition 10.1; Edition 10:2000 Consolidated with Amendment 1:2001; Amendment 2: 02-2004	Primary	General purpose	
IEC 60086-4 (01/03/2000) Primary Batteries – Part 4: Safety Standard of Lithium Batteries - Second Edition	Primary Lithium	Safety	Relevant standard for lithium primary batteries Specifies tests and requirements for primary lithium batteries to ensure their safe operation under intended use or reasonably foreseeable misuse Under revision (Oct 2004).
IEC 60086-5 (01/07/2000) Primary Batteries – Part 5: Safety of Batteries with Aqueous Electrolyte - First Edition	Primary	Safety	Specifies tests and requirements for primary batteries with aqueous electrolyte to ensure their safe operation under intended use and reasonably foreseeable misuse.
IEC 60622 (01/10/2002) Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes Sealed Nickel - Cadmium Prismatic Rechargeable Single Cells - Third Edition	Nickel-Cadmium		Specifies tests and requirements for sealed nickel cadmium prismatic rechargeable single cells.
IEC 60623 (01/09/2001) Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Vented Nickel - Cadmium Prismatic Rechargeable Single Cells - Fourth Edition	Nickel-Cadmium		Specifies tests and requirements for vented nickel - cadmium prismatic secondary single cells.
IEC 61434 (01/09/1996) Secondary cells and batteries containing alkaline or other non-acid electrolytes Guide to the designation of current in alkaline secondary cell and battery standards	Secondary		Applies to secondary cells and batteries containing alkaline or other non-acid electrolytes. It proposes a mathematically correct method of current designation which shall be used in future secondary cell and battery standards.
IEC 61959 (01/01/2004) Secondary cells and batteries containing alkaline or other non-acid electrolytes Mechanical tests for sealed portable secondary cells and batteries - First Edition	Secondary	Tests and requirements	Specifies tests and requirements for verifying the mechanical behaviour of sealed portable secondary cells and batteries during handling and normal use
IEC 612259 (01/10/2003) Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes Nickel-Cadmium Prismatic Secondary Single Cells with Partial Gas Recombination - First Edition	Secondary Nickel-Cadmium		Specifies marking, designation, dimensions, tests and requirements for vented nickel - cadmium prismatic secondary single cells where special provisions have been made in order to have partial or, under very specific conditions, full gas recombination.
IEC 61056-1 (01/10/2002) General Purpose Lead-Acid Batteries Valve-Regulated Types; Part 1: General Requirements, Functional Characteristics; Methods of Test - Second Edition	Lead-Acid	General purpose	Methods of test Specifies general requirements and the main characteristics together with the corresponding test methods.
IEC 61056-2 (01/10/2002)	Lead-Acid	Dimensions,	Is applicable to lead-acid batteries of the valve

General Purpose Lead-Acid Batteries (Valve-Regulated Types) Part 2: Dimensions, Terminals and Marking-Second Edition		Terminals, Marking	regulated type for cyclic and standby application with the rated capacity not exceeding 25 Ah.
IEC 62281 (01/05/2004) Safety of Primary and Secondary Lithium Cells and Batteries during Transport-First Edition Primary & Secondary Lithium	Primary & Secondary Lithium	Safety Transportation	Most relevant standard for safety of transportation of lithium batteries
IEC 60950 -1 Information technology equipment - Safety; Part 1 - General requirements	All	Safety requirements	Applies to equipment with integrated batteries.
IEC62368-1 Audio/Video, Information and Communication Technology Equipment - Part 1: Safety	All	guidance	This International Standard is a product safety standard that classifies energy sources, prescribes safeguards against those energy sources, and provides guidance on the application of, and requirements for those safeguards. The prescribed safeguards are intended to reduce the likelihood of pain, injury and, in the case of fire, property damage. The objective of the INTRODUCTION is to help designers to understand the underlying principles of safety in order to design safe equipment.

DIRECTIVE	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
DIN VG 95230-1 (01/07/2002) Sealed nickel-cadmium batteries - Part 2: Generic specification	Nickel-Cadmium	Generic specification	
DIN VG 95238-2 (01/10/1978) Vented nickel-cadmium storage batteries; basic specification	Nickel-Cadmium	General purpose Generic specification	
DIN VG 95284-2 (01/09/1978) Silver-zinc storage batteries; basic specification	Silver-Zinc	General purpose Generic specification	
DIN VG 96915-2 (01/11/2000) Non-rechargeable batteries – Part 2: Generic specification	Primary	General purpose Generic specification	
DIN VG 96924-2 (01/06/1999) Sealed lead-acid batteries – Part 2: Generic specification	Lead-Acid	General purpose Generic specification	
DIN VG 96937-1 (01/12/1996) Battery connector – Part 1: Requirements, tests; detail specification	Battery connectors	Connectors	The standard covers connectors within in the meaning of the DIN VDE 0627 (used in German army)
DIN VG 96937-2 (01/12/1996) Battery connector – Part 2: Mounting guide lines; detail specification	Battery connectors	Connectors	The standard is valid for the mounting and cabling of connectors according to VG 96937-3 (used in German Army)
DIN VG 96937-3 (01/12/1996) Battery connector – Part 3: Dimensions, masses; detail specification	Battery connectors	Connectors, Dimensions, Masses	The standard is valid for connectors to be used in connection with conducting wire cross-section of 35 mm ² for connecting batteries. (used in German army)
DIN VG 96956-2 (2005) Sealed nickel- metal hydride batteries – Part 2: Generic specification	Nickel- Metal Hydride		
IEC 61429 (01/01/1995) Marking of Secondary Cells and Batteries with the International Recycling Symbol ISO 7000-1135 First Edition	Lead-Acid Nickel-Cd	ISO Marking ISO 7000-1135	Defines the conditions of utilization of the recycling symbol of the International Organization for Standardization (ISO) associated with the chemical symbols indicating the electrochemical system of the battery.
IEC 62133 (2002) Secondary cells and batteries containing alkaline or other non-acid electrolytes Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications - First Edition	Nickel- Metal Hydride	Safety requirements	From June 27, 2011, batteries must be tested and certified to IEC 62133 only

IEC 62133 (2002) Secondary cells and batteries containing alkaline or other non-acid electrolytes Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications - First Edition	Primary and secondary lithium	Safety requirements	From June 27, 2011, batteries must be tested and certified to IEC 62133 only
UL 1989 (30/03/2010) UL Standard for Safety Standby Batteries- Fourth Edition;			These requirements cover instrument batteries, enclosed batteries, emergency lighting and power batteries and uninterruptible power supply batteries
UL 2089 (12/12/2003) UL Standard for Safety Vehicle Battery Adapters- Second Edition, Reprint with Revision Trough and Including 30/03/2006			Commonly used standard for safety of vehicle adapters
CENELEC PREN 50226 (01/01/1995) Electromagnetic Compatibility of Rechargeable Cells or Batteries		EMC	Main standard for EMC of rechargeable batteries
MIL-PRF-49471 (30 November 2000) Performance Specification, Batteries, Non-rechargeable, High Performance	Non-rechargeable		
EPBA Guidelines to Environmental battery marking in Europe			Relevant document

7 STANDARDS FOR STARTING BATTERIES

7.1 General

Starting batteries, also called SLI batteries (for starting, lightning and ignition), are commonly used to start and run internal combustion engines. These batteries can provide a high starting current for a short time, and may work for thousands of cycles in normal starting use.

IEC 60095-x standards are the most commonly used standards for civilian automotive and transportation (trucks) applications. These standards can also be used for military vehicles (and tactical and combat vehicles) but some specific requirements may be stipulated (marking, use at low temperature,...). Recent batteries are compliant with EN 50342 standard which supersedes IEC 60095-1.

NATO STANAG 4015 standard is commonly used to ensure interoperability of batteries for tactical vehicles.

Since most car batteries are lead-acid batteries, it is important to note that all existing standards specifically dedicated to starting batteries only apply to lead-acid technology. As the abandonment of lead-acid technology is programmed in the future, we can imagine that all these standards will become obsolete.

7.2 Table of selected standards

STANDARD	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
IEC 60095-1 (01/12/2000) Lead-Acid Starter Batteries – Part 1: General Requirements and Methods of Test – Sixth Edition	Lead-Acid	General specifications & requirements	IEC 60095 parts 1, 2 & 4 standard are applicable to lead-acid starting batteries with a nominal voltage of 12 V, used primarily as a power source for the starting and igniting of internal combustion engines, lighting and for auxiliary equipment of internal combustion engine vehicles IEC 60095-1 standard prescribes safety and performance requirements such as cranking performance, electrical capacity, charge acceptance, charge retention, cycle endurance, water consumption, vibration resistance, electrolyte retention (leakage) and safety labelling. IEC 60095-2 specifies the main dimensions of starter batteries of four standard series; the location of the terminals with respect to the fastening system; the dimensions of tapered terminals of starter batteries; the marking of the polarity. IEC 60095-4 applies to lead-acid batteries used for starting, lighting and igniting of heavy trucks.
IEC 60095-2 (01/01/1984) Lead-Acid Starter Batteries Part 2: Dimensions of Batteries and Dimensions and Marking of Terminals-Third Edition; Amendment 1-1991; Amendment 2-1993		Dimensions Marking	
IEC 60095-4 (01/01/1989) Lead-Acid Starter Batteries Part 4: Dimensions of Batteries for Heavy Trucks -First Edition; Amendment 1-1996			
CENELEC EN 50342 Lead-Acid Starter Batteries – General Requirements, Methods of Test and Numbering (01/04/2001) – Includes Amendments A1:2001 and A2:2001; Incorporates Corrigendum March 2003; Supersedes EN 60095-1:1993 + A2:1995 + A11:1995 + A12:1999 + A13:1997	Lead-Acid	General specifications & requirements Methods of test	New standard that superseded IEC 60095-1 standard
NATO STANAG 4015 ED 3 Starter Battery Spaces for Tactical Land Vehicles	12V-100Ah & 12V-45Ah lead-acid batteries (can be used with other technologies)	Mechanical & electrical interfaces Terminals	The aim of this Agreement is to ensure that the space allocated to the housing batteries in tactical land vehicles and their associated holding down and electrical connecting arrangements, will comply to known parameters thereby allowing replacement batteries from NATO member nations to be accommodated. NATO STANAG 4015 standard is compliant with IEC 60095-4
MIL-PRF-32143 (5 March 2004) Performance Specification, Batteries, Storage: Automotive, Valve Regulated Lead Acid	Lead-Acid		

(VRLA)			
VG 96924-1 (2006-09) Sealed lead-acid batteries — Part 1: Summary;	Lead-Acid		The presented standard is a summary for sealed lead-acid batteries.
VG 96924-2 (2007-09) Valve regulated lead-acid batteries — Part 2: Generic specification;	Lead-Acid		This standard is a generic specification for valve regulated lead-acid batteries.

7.3. Recommendations and best practices

It is recommended to specify the use of civilian standards (GENELEC EN 50342 and/or IEC 60095-1, IEC 60095-2 and IEC60095-4) which are commonly used for civil starting batteries. Nevertheless, it is important to ensure that the supplied batteries fully answer the requirements of the vehicle, and the environmental specification (security, work at low temperature).

Note : Even if civil standards are specified, it may be impossible to use civil batteries designed for cars and truck for combat vehicles.

For the specification of land tactical vehicles, NATO STANAG 4015 standard is recommended to specify the spaces dedicated to starting batteries, and to ensure interoperability of these batteries.

8 STANDARDS FOR BATTERIES FOR PORTABLE APPLICATIONS

8.1 Introduction

The main existing standards which deal with batteries for portable applications apply to technologies that are less and less used for that type of application. Indeed, lithium-ion technology replaces most of the other chemistries used before (nickel-cadmium in particular). Thus, a lot of standards are now becoming obsolete.

In spite of the massive use of batteries for portable application in the civil world (for mobile phones and portables computers), a very few standards apply to lithium-ion batteries for portable equipment. Standardized batteries do not yet exist.

8.2 Table of existing relevant standards

STANDARD	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
CENELEC EN 50272-4: Safety requirements for secondary battery installations – Part 4: Batteries for use in portable appliances			
IEC 60086-4: Primary batteries - Part 4: Safety Standard of lithium batteries - Second edition.	Primary lithium	Safety	
IEC 61960 (01/12/2003) Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for portable applications-First Edition	Secondary Lithium	General purpose Performance Tests Dimensions Marking	Most relevant standard for lithium secondary batteries for portable applications Specifies performance tests, designations, markings, dimensions and other requirements for secondary lithium single cells and batteries for portable applications. The objective of this standard is to provide the purchasers and users of secondary lithium cells and batteries with a set of criteria with which they can judge the performance of secondary lithium cells and batteries offered by various manufacturers.
IEC 62133 (2002) Secondary cells and batteries containing alkaline or other non-acid electrolytes Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications - First Edition	Alkaline	Safety	Specifies requirements and tests for the safe operation of portable sealed secondary cells and batteries (other than button) containing alkaline or other non-acid electrolyte, under intended use and reasonably foreseeable misuse.
IEC 61056-3 (01/01/1991) Portable Lead-Acid Cells and Batteries (Valve - Regulated Types) Part 3: Safety Recommendations for Use in Electric Appliances - First Edition	Lead-Acid	Safety	Low relevant standard : Lead- acid batteries are not used for military portable applications anymore
IEC 61951-1 (01/04/2003) Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes - Portable Sealed Rechargeable Single Cells - Part 1: Nickel - Cadmium-Second Edition; Replaces IEC 60285:1999, IEC 61440:1997, and IEC 60509:1988	Nickel-cadmium	General purpose Design Dimensions Marking	Most relevant standard for Ni-Cd batteries for portable applications Specifies performance This part of IEC 61951 specifies marking, designation, dimensions, tests and requirements for portable sealed nickel-cadmium small prismatic, cylindrical and button rechargeable single cells, suitable for use in any orientation.
IEC 61951-2 (01/04/2003) Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes - Portable Sealed Rechargeable Single Cells - Part 2 Nickel – Metal Hydride-Second Edition; Replaces IEC 61436:1998 and IEC 61808:1999	Nickel-Metal-Hydride	General purpose	Most relevant standard for Ni-Mh batteries for portable applications This part of IEC 61951 specifies marking, designation, dimensions, tests and requirements for portable sealed nickel- metal hydride, small prismatic, cylindrical and button rechargeable single cells, suitable for use in any orientation
MIL-PRF-32052 (7 December 1999) Performance Specification, Batteries,			Main military standard used for military radio batteries. Associated voltages are specified in

Rechargeable, Sealed			MIL-STD 810. May become obsolete.
IEEE Std 1625- 2004 Livium ® Standard for Rechargeable Batteries for Portable Computing	Rechargeable	Design Quality Reliability Tests	Establishes criteria for design analysis for qualification, quality, and reliability of rechargeable battery systems for portable computing. It also provides methods for quantifying the operational performance of these batteries and their associated management and control systems, including considerations for end-user notification.
Standardization Agreement STANAG no. 4169 issue 1. "Electrical connectivity standards for dismounted soldier system"	-	General purpose Interoperability	Most relevant standard for integrated soldier systems, deals with connectivity of batteries

8.3 Recommendations

- IEC 61960 is the most relevant existing civil standard for lithium batteries dedicated for portable equipment
- IEC 61951-1 and IEC 61951-2 are the most relevant existing civil standards for nickel-cadmium and Ni-Mh batteries dedicated for portable application
- IEC 62133 standard is the most relevant and commonly used civil standard to specify safety of lithium batteries for portable applications (cf. §6)
- Standardization Agreement STANAG 4169 is the most relevant standard dedicated to integrated soldier system for interoperability of batteries
- IEEE Std 1625-2004 Livium® Standard is a recent standard dedicated to batteries for portable computers.
- If necessary, specify a Communication interface between application and Batteries
- Check for new existing standards (IEEE in particular)

9 STANDARDS FOR TRACTION

9.1 General

Traction relates to the propulsion of vehicles using battery operated electric motors. No vehicle of this type are yet used in armies, but some experimental electric combat vehicles already exist, and it is expected that future generation could be electric powered.

IEC has developed standards for traction batteries through a joint working group between technical committees TC 69 and TC 21. The work has two main objectives: 1) Electric road vehicles and 2) Industrial electric trucks. During the most active period, which mainly was before the turn of the century, other organizations were also engaged in the development of standards for electric road vehicle batteries. These include ISO, SAE, JSI and the European groups CENELEC and CEN. However, the most important groups developing specifications for electric car batteries are EUCAR (European council for automotive research and development, mainly the car manufacturers) in Europe and USABC (United States Advanced Battery Consortium, with members from the car industry, electric utilities and the Department of Energy) in USA. These organizations have developed updated specifications for both pure electric road vehicles and the different versions of hybrid electric vehicles.

While EUCAR's specifications are proprietary for the group members, the USABC's standards and related test methods are freely available.

9.2 Table of selected standards

STANDARD	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
IEC 60254-1 (01/03/1997) Lead-Acid Traction Batteries - Part 1: General Requirements and Methods of Test-Third Edition	Lead-Acid		IEC 60254 is applicable to lead acid traction batteries used as power sources for electric propulsion. The tests defined are relevant to all traction battery applications which include road vehicles, locomotives, industrial trucks and mechanical handling equipments. The object of this standard is to specify certain essential characteristics of traction batteries or cells, together with the relevant test methods of those characteristics.
IEC 60254-2 (01/11/2000) Lead-Acid Traction Batteries - Part 2: Dimensions of Cells and Terminals and Marking of Polarity on Cells-Edition 3.1	Lead-Acid		
CENELEC EN 50272-3 (24/10/2002) Safety requirements for secondary batteries and battery installations Part 3: Traction batteries		Safety	
CENELEC PREN 50276 (01/01/1997) Gaseous Emissions Produced by Traction Batteries - Ventilation and General Safety Requirements for Closed Charging Areas		Safety	
IEC TR 61431 (01/01/1995) Guide for the Use of Monitor Systems for Lead-Acid Traction Batteries-First Edition	Lead-acid	Monitoring	
IEC TR 61382-1 (01/01/1996) Nickel/Cadmium Rechargeable Cells and Batteries for Electric Road Vehicle Propulsion Applications - Part 1: Dynamic Discharge Performance Test (DDPT) and Dynamic Endurance Test (DET)-First Edition	Nickel-Cadmium		
IEC 61982-2 (01/08/2002) Secondary Batteries for the Propulsion of Electric Road Vehicles - Part 2: Dynamic Discharge Performance Test and Dynamic Endurance Test- First Edition			Specifies tests and requirements for capacity and endurance tests for secondary batteries used for vehicle propulsion applications. Its objective is to specify certain essential characteristics of cells and batteries used for propulsion of electric road vehicles together with the relevant test methods for their specification.

<p>IEC 62619 Safety requirements for secondary lithium batteries for hybrid vehicles and mobile applications</p>	<p>Secondary Lithium</p>	<p>Safety</p>	
<p>IEC 62620 Secondary cells and batteries containing alkaline or other non acid electrolytes- Large format secondary lithium cells and batteries for stationary and motive applications</p>	<p>Alcaline and Secondary lithium</p>		
<p>IEC 61982-4 Secondary batteries for the propulsion of electric road vehicles</p>	<p>Secondary Lithium</p>	<p>Testing</p>	<p>Performance testing for Li-ion and batteries</p>
<p>IEC 61982-5 Secondary batteries for the propulsion of electric road vehicles</p>	<p>Secondary Lithium</p>	<p>Safety</p>	<p>Safety testing for Li-ion and batteries</p>
<p>IEC 61982-3 (01/06/2001) Secondary Batteries for the Propulsion of Electric Road Vehicles - Part 3: Performance and Life Testing (Traffic Compatible, Urban Use Vehicles-First Edition</p>			<p>Is applicable to performance and life testing of electrical energy storage systems for general purpose, traffic compatible, light urban use electric road vehicles that are designed for transportation of passengers or goods in city centre driving. For the purposes of this standard, the electrical energy storage system is defined as one that is recharged electrically though some of the test procedures may be applicable to fuel cells and other "mechanically" rechargeable systems. The test procedures may also be applicable to electrical energy storage systems used in some types of hybrid-electric vehicle though detailed consideration of electrical energy storage systems for hybrid vehicles will be addressed separately</p>

10 STANDARDS FOR STATIONARY APPLICATIONS BATTERIES

10.1 General

10.2 List of selected standards

STANDARD	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
IEC 60896-1 Stationary Lead-Acid Batteries – General Requirements and Methods of Test Part 1: Vented Types	Lead-Acid		Cf. IEC 60896-11 (01/12/2002)
IEC 60896-2 (1995) Stationary Lead-Acid Batteries General Requirements and Methods of Test Part 2: Valve Regulated Types	Lead-Acid		Cf. IEC 60896-21 (01/02/2004)
IEC 60896-11 (01/12/2002) Stationary lead- acid batteries Part 11: Vented types General requirements and methods of tests-First Edition. Replaces IEC 60896-1	Lead-Acid		Is applicable to lead-acid cells and batteries which are designed for service in fixed locations (i.e. not habitually to be moved from place to place) and which are permanently connected to the load and to the d.c. power supply. Batteries operating in such applications are called "stationary batteries". Any type or construction of lead- acid battery may be used for stationary battery applications
IEC 60896-21 (01/02/2004) Stationary lead- acid batteries Part 21: Valve regulated types Methods of test-First Edition; Replaces IEC 60896- 2:1995	Valve regulated Lead-Acid	Methods of test	Applies to all stationary lead-acid cells and monobloc batteries of the valve regulated type for float charge applications, (i.e. permanently connected to a load and to a d.c. power supply), in a static location (i.e. not generally intended to be moved from place to place) and incorporated into stationary equipment or installed in battery rooms for use in telecom, uninterruptible power supply (UPS), utility switching, emergency power or similar applications. The objective of this part of IEC 60896 is to specify the methods of test for all types and construction of valve regulated stationary lead acid cells and monobloc batteries used in standby power applications
IEC 60896-22 (01/02/2004) Stationary lead- acid batteries Part 22: Valve regulated types Requirements-First Edition	Valve regulated Lead-Acid		Applies to all stationary lead-acid cells and monobloc batteries of the valve regulated type for float charge applications, (i.e. permanently connected to a load and to a d.c. power supply), in a static location
IEC 62620 Secondary cells and batteries containing alkaline or other non acid electrolytes- Large format secondary lithium cells and batteries for stationary and motive applications	Alcaline and Secondary lithium		
CENELEC PREN 50105 (01/01/1992) Stationary Lead-Acid Batteries – General Requirements and Test Methods - Valve Regulated Types	Lead-Acid		
CENELEC PREN 50272-2 (01/01/1997) Safety Requirements for Secondary Batteries and Battery Installations Part 2: Stationary Batteries			

10.3 IEEE Guides

STANDARD	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
IEEE 1184 Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems (01/01/1994)	Lead-acid Nickel-Cadmium	Guide for selection / Recommended practice / Sizing	Describes the characteristics of the various battery energy systems available and how that users can select the system best suited to their requirements.
IEEE 1189 Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications (31/07/1996)	Lead-Acid	Guide for selection / Recommended practice / Sizing	Methods for selecting the appropriate type of valve - regulated, immobilized-electrolyte, recombinant lead-acid battery for any of a variety of potential stationary float applications are described.
IEEE 485 Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications (20/03/1997)	Lead-Acid	Guide for selection / Recommended practice / Sizing	Methods for defining the dc load and for sizing a lead-acid battery to supply that load for stationary battery applications
IEEE 1115 Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications (30/03/2000)	Nickel-Cadmium	Guide for selection / Recommended practice / Sizing	Methods for defining the dc load and for sizing a nickel-cadmium battery to supply that load are described. Installation, maintenance, qualification, testing procedures
IEEE 1375 Guide for the Protection of Stationary Battery Systems (19/03/1998)		Guide for Protection	Guidance in the protection of stationary battery systems
IEEE 1187 Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Storage Batteries for Stationary Applications (01/01/2002)	Valve-regulated Lead-Acid	Guide for selection / Recommended practice / Sizing	Provides guidance for the installation and installation design of valve -regulated lead acid (VRLA) batteries.
IEEE 484 Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications (12/09/2002)	Vented Lead-Acid		Provides procedures for storage, location, mounting, ventilation, instrumentation, preassembly, assembly, and charging of vented lead-acid batteries
IEEE 1106 Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications (01/01/1995)	Nickel-Cadmium	Guide for selection / Recommended practice / Sizing Maintenance Installation	Installation design, installation, maintenance and testing procedures, and test schedules that can be used to optimize the life and performance of vented nickel-cadmium batteries used for continuous-float operations
IEEE 1188 Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications (20/08/1996)	Valve-regulated Lead-Acid	Recommended Practice for Maintenance	Maintenance, test schedules and testing procedures that can be used to optimize the life and performance of valve-regulated lead-acid (VRLA) batteries for stationary applications
IEEE 450 Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications (01/01/2002)	Vented Lead-Acid		Maintenance, test schedules, and testing procedures that can be used to optimize the life and performance of permanently installed, vented lead-acid storage batteries used for standby power applications

11 STANDARDS FOR BATTERY SYSTEMS AND SPECIAL APPLICATIONS

11.1 Batteries for aerospace applications

Most aircraft batteries are of the lead-acid or nickel-cadmium type, and lithium-ion also come in this market. They are used in several embedded systems including emergency power, lightning and turbine starting.

11.2 Table of existing relevant standards for aerospace applications

STANDARD	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
IEC 60952-1 (1988) Aircraft Batteries Part 1: General Test Requirements and Performance Levels			CENELEC EN 60952-1 (01/01/1993)
IEC 60952-2 (01/01/1991) Aircraft Batteries Part 2: Design and Construction Requirements First Edition;		Design construction	CENELEC EN 60952-2 (1993)
IEC 60952-3 (01/01/1993) Aircraft Batteries Part 3: External Electrical Connectors First Edition		Connectors	CENELEC EN 60952-3 (01/01/1995)
CEN EN 2570 (01/01/1996) Aerospace Series - Nickel -Cadmium Batteries - Technical Specification	Nickel-cadmium	Formats	
CEN EN 2985 (01/01/1996) Aerospace Series - Nickel -Cadmium Batteries of Format A Type			
CEN EN 2986 (01/01/1996) Aerospace Series - Nickel -Cadmium Batteries of Format B Type			
CEN EN 2987 (01/01/1996) Aerospace Series - Nickel -Cadmium Batteries of Format C Type			
CEN EN 2988 (01/01/1996) Aerospace Series - Nickel -Cadmium Batteries of Format D Type			
CEN EN 2991 (01/01/1996) Aerospace Series - Nickel -Cadmium Batteries of Format E Type			
CEN EN 2993 (01/01/1996) Aerospace Series - Nickel -Cadmium Batteries of Format F Type			

11.3 Batteries for submarine

The main submarine batteries are used in cycling mode in conventional submarines, and in floating mode in nuclear propelled submarines. Some military standards (STANAG) exist for some parts of these batteries (cooling water, electrolyte, and purified water), but they are dedicated to lead-acid batteries.

11.4 Table of existing relevant standards for submarine systems

STANDARD	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
NATO STANAG 4389 ED 1 AMD (26/07/1990) Terms and Definitions Covering Submarine Main Lead Acid Batteries-Amendment 1: 8/3/94	Lead-Acid		
NATO STANAG 4390 ED 1 AMD 1 (26/07/1990) Tests and Requirements for Submarine Main Lead-Acid Batteries-Amendment 1: 8/3/94	Lead-Acid		
NATO STANAG 4391 ED 1 AMD 1 (06/08/1991) Cooling Water for Submarine Main Lead Acid Batteries-Amendment 1: 8/3/94	Lead-Acid	Cooling Water	
NATO STANAG 4287 ED 1 AMD 3 (01/01/1988) Electrolyte for Submarine Main Lead Acid Batteries-Amendment 3, 8/3/94	Lead-Acid	Electrolyte	
NATO STANAG 4248 ED 1 AMD (18/02/1988) Purified Water for Submarine Main Lead Acid Batteries-Amendment 3, 8/3/94	Lead-Acid	Purified Water	

ANNEX 1

Main technologies of batteries (general overview) (see section 2.4.1)

Alkaline batteries

Alkaline batteries are the most common non-rechargeable batteries used for consumer applications (toys, remote controls, lights and clocks...)

Alkaline batteries are rarely used for military applications.

Lead-acid batteries

Lead-acid is the most ordinary and affordable chemistry for rechargeable batteries. Two types of lead-acid batteries exist: *SLI* lead-acid batteries (Start Light and Ignition) which are commonly used to start and run internal combustion engines, and *Deep-cycle* lead-acid batteries which are used for supplying power. Lead-acid remains the technology of choice for SLI batteries, because they can provide high starting current for a short time, and may work for thousands of cycles in normal starting use. They are also robust and quite tolerant to abuse. Deep-cycle batteries are used to supply power to stationary applications (UPS) or industrial electric vehicles. These batteries are very cost-effective, but performances are quite low. Nickel based batteries and Lithium-ion batteries are now preferred for this market. Some varieties of lead-acid batteries exist:

-*Flooded lead-acid* batteries are the more conventional battery technology, with the electrodes and separators immersed in the liquid electrolyte and a vented design. They need maintenance.

-*Valve Regulation Lead Acid (VRLA)* batteries – also called *Sealed Lead Acid (SLA)* batteries – have a pressure valves which open only under extreme conditions instead of simple vent caps. This construction prevents electrolyte loss through expiration or spillage.

-*Absorbed Glass Mat (AGM)* batteries – also called *Dry lead-acid* batteries – are VRLA batteries with fibreglass. This construction promotes the recombination of hydrogen and oxygen during charging.

-Gel batteries are VRLA batteries where the electrolyte is immobilized into a gel. The construction promotes the recombination of hydrogen and oxygen during charging. These batteries shall be charged at low rate (C/20), and are suitable for UPS applications.

Nickel-based alkaline batteries (nickel-cadmium & nickel metal hydride)

Nickel-based rechargeable batteries are used for a wide range of purposes: standby batteries for stationary applications (UPS), batteries for electric and hybrid vehicles, aircraft batteries...

NiCd and NiMh batteries are also largely used for low power portable equipment (radios, tools, toys,...) However, they are now losing market share to lithium-ion technology for high-tech electronics.

Nickel-cadmium (NiCd) is a relatively low-cost technology, but cadmium is a toxic metal which is deprecated on environmental grounds, so nickel-cadmium batteries are progressively replaced by nickel metal hydride batteries.

Nickel metal hydride (NiMh) batteries are similar to nickel-cadmium batteries, but are less toxic and offer higher capacities

Lithium primary batteries (non-rechargeable)

Primary lithium batteries are used for some specific civil applications (coin batteries for watches, cameras, medical implants), but the commercial market is generally moving toward rechargeable batteries (lithium-ion batteries). On the other hand, lithium primary batteries are largely used for most military portable equipment.

Lithium primary batteries offer very good performances for military specs: highest energy capacity, wide operating temperature range, readiness and robustness

Some variants of chemistries exist. Lithium sulphur dioxide (Li/SO₂) batteries have been commonly used for years, but they are now progressively abandoned because they are composed of pressurized cells which are not tolerant to abuse and may explode. They are now replaced by lithium manganese dioxide (Li/MnO₂) or lithium thionyle chloride (Li/SOCl₂) batteries which have a higher energy density and are safer.

Lithium secondary batteries

Lithium-ion has quickly become a very popular technology for all high-tech consumer application (computers, cell phones, camcorders...) and volume production has now brought prices down. This technology is very versatile, and high power versions are also competitive for many various purposes: stationary applications, electric and hybrid vehicles, battery systems for aircrafts, satellites and submarines, etc...

Lithium-ion technology has many advantages over other secondary chemistries: high energy density, high cell voltage, no memory effect, low self-discharge, long life cycle, low maintenance and no required scheduled cycling.

The major limitation with lithium-ion technology concerns safety design: lithium-ion batteries shall include mechanical thermal and electronic protections against short-circuits, overcharge and over-heat.

Lithium-cobalt (LiCoO₂) and lithium-manganese (LiMn₂O₄) are the two main variants of lithium-ion cells which have been commercially developed. More affordable lithium-ion polymer batteries have also been developed for mass production markets (laptops and cell phones).

Lithium-ion Nickel base has been developed for industrial and military applications: long life (up to 20years), high cycling capability, low fading.

Lithium-ion becomes the technology of choice for military portable equipment for switching from non-rechargeable batteries to rechargeable batteries (*see section 4.2*)

Special technologies – Zebra batteries

Zebra batteries are Sodium Nickel Chloride (Na-NiCl₂) medium power batteries which must be operated at high temperature (over 300°C). This technology is suitable for large capacity batteries (>20KWh) and is mainly dedicated to electric traction applications (electric vehicles and railway).

Special technologies – Nickel-zinc batteries

Nickel-zinc is a recently developed technology that could become an alternative to lead-acid, nickel-cadmium and nickel metal hybrid chemistries for automotive and traction applications. These batteries are characterized by a high specific energy and power capability. They can operate within a wide range of temperatures, and are of a relatively low cost.

Special technologies – Silver-zinc batteries

Silver-zinc (AgZn) technology is well known as the "first battery in space". This first high power and specific energy technology was very used in the 60s, but is now replaced by lithium-ion technology. Some specific military systems (missiles, torpedoes) still use silver-zinc batteries.

Special technologies – Nickel-hydrogen batteries

Nickel-hydrogen batteries are high performances hybrid systems that combine technologies of batteries and fuel-cells (nickel oxide positive electrode similar to nickel-cadmium cell, and a hydrogen negative electrode similar to hydrogen-oxygen fuel-cell).

Nickel-hydrogen batteries have a high power and energy density, and a very long cycle life (40000 cycles). This technology is exclusively dedicated to space applications, in particular for powering geosynchronous (GEO) and low earth-orbit (LEO) satellites during eclipse periods ("night" = shadow of the Earth).

This technology has been progressively replaced by lithium-ion onboard satellites

Special technologies – Reserve Batteries

- **Reserve batteries** – also called deferred-action batteries – are special purpose batteries that can be stored in an inactive state and activated at the time (the electrolyte is stored separately from the electrodes, and activates the battery when it is introduced into the active cell area).

Reserve batteries have the double benefit of avoiding deterioration of the active materials during storage and eliminating the loss of capacity due to self discharge. They are usually dedicated to applications which need a very long shelf life (>10 years). They are mainly used for emergency and rescue equipment, and for some specific military applications (missiles, munitions and torpedoes).

The main reserve batteries are spin-activated batteries, water activated batteries and thermal batteries.

-**Spin-activated lead-acid batteries** – also called **Ampoule batteries** – are lead-acid reserve batteries which are traditionally used for military fuses in marine applications.

-**Water Activated batteries** (magnesium-silver chloride Ag-CIMg) are single use batteries which electrochemical reaction is activated by water as the name implies. These batteries can be indefinitely stored in dry condition, and can be immediately activated by adding or immersing in water. Water activated batteries are mainly used for air and sea rescue equipment (life jackets, emergency lightning...). Regarding military applications, most combat torpedoes are powered by forced flow sea water activated batteries.

-**Thermal batteries** are batteries which electrolyte is solid and inactive at ambient temperature and is activated by the application of heat from an external source. These batteries are also reliable for very long storage with no maintenance. They provide high power when activated for a short time, and are exclusively used for military applications (combat torpedoes and guided missiles).

-**Spin-activated lithium batteries** are special lithium reserve batteries (lithium-thionyl chloride Li/SOCL₂) which have been developed for some very specific military artillery applications (munitronic devices delivered by sub-munitions). These batteries are activated after impact on the ground.

Special technologies – Metal-air batteries

Metal-air batteries use the oxygen of the air for their electrochemical reaction (the anode is metallic, and the oxygen is the cathode reactant). Metal-air batteries are characterized by a high energy volumetric density. This technology also may be low-cost, and be environment-friendly.

In the past, large zinc-air batteries were used for railroad applications and for some other applications requiring long life and a low rate of battery discharge. Button zinc-air batteries are also used in items such as hearing aids. *Zinc-air* and *aluminium-air* batteries are coming back and are now envisaged to power miniaturized applications (laptops, military micro-systems...)

ANNEX 2

The *cylindrical cell* is the most traditional and widely used packaging for common alkaline, nickel-based, and lithium-based cells. It is also available for lead-based cells. The cylindrical design has the benefits to withstand internal pressure and to provide good mechanical stability. Battery manufactures are switching to prismatic design for small power nickel-based and lithium-ion cells (for portable applications), but high power cells remain cylindrical. Cylindrical cells can have bobbin-type or spirally type electrodes.

The *prismatic cell* design has been developed for thin batteries dedicated to small electronic devices (in particular for cell phones). This packaging is mostly reserved for lithium technology (polymer lithium-ion technology is exclusively prismatic). Prismatic cells are easier to stack inside battery packs with optimal space utilisation.

The *button cell* and *coin cell* design has been exclusively designed for single -cell miniaturized batteries (cells for watches, earring aides, memory back-up). This design is mostly reserved for mercury primary technology, or for some nickel-based rechargeable chemistry.

The *pouch cell* is a recent design which is not commercially used yet. It is reserved to lithium-based chemistries.

ANNEX 3

INFORMATIVE

1 General

Some directives concern (directly or not) batteries, in particular for the recycling of batteries, and for the safety of transportation.

2 Table of directives for recycling

DIRECTIVE	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
EU 91/157/EEC (01/01/1991) Council Directive on Batteries and Accumulators Containing Certain Dangerous Substances	All technologies	Recycling	Important directives The aim of Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances is to approximate the laws of the Member States on the recovery and controlled disposal of those spent batteries and accumulators containing dangerous substances
EU 93/186/EEC (04/10/1993) Commission Directive Adapting to Technical Progress Council Directive 91/157/EEC on Batteries and Accumulators Containing Certain dangerous Substances			
EU 98/101/EEC (12/22/1998) Commission Directive 98/101/EC of 22 December 1998 adapting to technical progress Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances (Text with EEA relevance)			
2006/66/CE			

3 Table of directives for transportation

DIRECTIVE	TECHNOLOGY	KEYWORDS	COMMENTS / RELEVANCE
ST/SG/AC.10/Rev.13 Recommendations for the transportation of dangerous goods		Safety Transportation	Cf. ST/SG/AC.10/Rev.13 United Nations recommendations on the transportation of dangerous goods Cf. ST/SG/AC.10/Rev.13 for generic data
ST/SG/AC.10/11/Rev.3/Amend.1 Recommendations for the transportation of dangerous goods Tests and criteria amendment1 : lithium batteries		Safety Transportation	
ICAO / IATA : 2004 Dangerous Goods Regulations 45th edition			
IMO : IMDG code , 2002 edition (International Maritime Code for Dangerous Goods)			
ADR : Restructured ADR volumes 1 and 2 applicable from January 2003			
RID : Règlement concernant le transport international ferroviaire de marchandises			
			Directives for transportation on roads (ADR), railways (RID), maritime traffic (IMDG), inland water traffic (ADN) and air traffic (ICAO / IATA)

Dangereuses, 1999			
ADN: Accord européen relatif au transport international des marchandises dangereuses par voie de navigation intérieure Rhin			

STANDARDS		KEYWORDS	COMMENTS / RELEVANCE
IEC 62281 Safety of Primary and Secondary Lithium Cells and Batteries during Transport-First Edition Primary & Secondary Lithium		Transportation	Most relevant standard for safety of transportation of lithium batteries
UN 3090 / UN 3091: Lithium metal batteries		Transportation	Dangerous good : Class 9
UN 3480 / UN 3481: Lithium ion batteries		Transportation	Dangerous good : Class 9

2 Recommendations

It is highly recommended to reference all the listed directives into the contracts for the procurement of military systems.

It is also recommended to supervise directives and regulations that could be voted and become applicable during the provision, and to ask the contractors to manage the risks associated to these instructions.