



GUIDE FOR

USE OF SUPERCAPACITORS IN THE MARINE AND OFFSHORE INDUSTRIES

DECEMBER 2017

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

**© 2017 American Bureau of Shipping. All rights reserved.
ABS Plaza
16855 Northchase Drive
Houston, TX 77060 USA**

Foreword

Hybrid electric power applications are increasing in the marine and offshore industries. ABS recognizes the application of supercapacitor technology in support of the hybrid initiatives and its benefits for improving energy efficiency of the onboard power plant. Supercapacitors, as a commercialized energy storage device, exhibit beneficial characteristics such as high power density, a fast charging/discharging process, no thermal runaway characteristics, and wide operating-temperature range. The operating environment typical in the marine and offshore industries may differ from those considered when a supercapacitor system was originally designed and so necessitates a review of the environmental and operational aspects prior to adoption. ABS has produced this Guide to provide requirements and reference standards to facilitate effective installation and operation of on-board supercapacitor systems.

The purpose of this Guide is to establish safety guidelines for owners, operators, shipyard builders, designers, and manufacturers. The supercapacitors covered by this Guide are also referred as Electrical Double Layer Capacitors (EDLC), Electrochemical Capacitors, or Ultracapacitors. Requirements applicable to conventional electrolytic capacitors used for power factor correction or harmonic filtering are contained in Part 4 of the *ABS Rules for Building and Classing Steel Vessels*.

Supercapacitor technology is continuously evolving with respect to materials and design. Alternative arrangements or new supercapacitor technologies may be considered provided it can be shown, through either satisfactory service experience or a systematic analysis based on sound engineering principle, to meet the overall safety standards of this Guide and the ABS Rules.

This Guide becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.



GUIDE FOR

USE OF SUPERCAPACITORS IN THE MARINE AND OFFSHORE INDUSTRIES

CONTENTS

SECTION 1	General.....	1
1	Introduction	1
3	Application	1
5	Scope	1
7	Terminology	2
9	Abbreviations and Acronyms	3
11	References.....	4
11.1	ABS	4
11.3	IEC Standards	4
11.5	Other References	5
11.7	Alternative Standards	5
13	Data and Plans to be Submitted	5
13.1	General.....	5
13.3	Supercapacitor System Submissions	5
13.5	Supercapacitor Cell/Module Submissions	6
13.7	Capacitor Management System (CMS) Submissions.....	6
13.9	Supercapacitor Charger and/or Converter Submissions	7
15	Onboard Documentation.....	7
15.1	General.....	7
FIGURE 1	Supercapacitor Components (only use for reference).....	2
FIGURE 2	Supercapacitor System.....	3
SECTION 2	Supercapacitor System Design and Construction	8
1	Supercapacitor System.....	8
1.1	General.....	8
1.3	System Arrangement.....	8
1.5	Supercapacitor System Used as Emergency/Transitional Source of Power	9
1.7	System Protection	9
1.9	Shore Connection.....	10
1.11	Control, Monitoring, Alarm and Safety Systems	10
1.13	Emergency Shutdown Arrangement.....	10

	1.15	Ambient Temperatures	10
	1.17	Integration.....	11
3		Supercapacitor Cells/Modules	11
	3.1	General.....	11
	3.3	Enclosure and Casing.....	11
	3.5	Cooling and Prevention of Condensation	11
	3.7	Nameplate Data.....	11
	3.9	Cell Connection	12
	3.11	Supercapacitor Cell Life.....	12
	3.13	Supercapacitor Cell/Module Polarity.....	12
5		Supercapacitor Chargers/Converters	12
7		Capacitor Management System.....	12
	7.1	General.....	12
	7.3	Voltage Balancing.....	13
	7.5	Power Management System.....	14
SECTION 3 Supercapacitor System Testing and Installation.....			15
1		Supercapacitor System Testing Requirements	15
	1.1	Supercapacitor Cell Tests and Measurement	15
	1.3	Supercapacitor Module Tests and Measurement	15
	1.5	Supercapacitor Charger/Converter and Management System Tests and Measurement	16
3		Supercapacitor Space.....	16
	3.1	General.....	16
	3.3	Fire Safety	17
	3.5	Ventilation.....	17
	3.7	Environmentally-Controlled Space.....	17
	3.9	Hazardous Area Requirement	18
5		Supercapacitor System Risk Assessment	18
7		Supercapacitor System Operation and Maintenance	19
	7.1	Installation and Commissioning	19
	7.3	Operation and Maintenance	19
TABLE 1		Summary of Type and Routine Tests and Measurement for Supercapacitor Cells	15
TABLE 2		Summary of Type and Routine Tests and Measurement for Supercapacitor Modules	16
TABLE 3		Summary of Tests for Supercapacitor Chargers/Converters and CMS	16
SECTION 4 Supercapacitor System Surveys.....			20
1		General	20
3		Surveys during Construction.....	20
5		Surveys after Construction.....	21
	5.1	General.....	21
	5.3	Annual Surveys	21
	5.5	Special Periodical Surveys	21

APPENDIX 1	Commentary on Supercapacitors	22
1	General	22
3	Supercapacitor Properties	22
3.1	Construction	22
3.3	Supercapacitor Electrical Characteristics	22
3.5	Supercapacitor Connections	23
5	Supercapacitor Use	23
5.1	Classes.....	23
5.3	Benefits	23

This Page Intentionally Left Blank



SECTION 1 General

1 Introduction

ABS recognizes the application of supercapacitor technology in the marine and offshore industries and its benefits for improving energy efficiency. This Guide has been developed to facilitate the effective installation and operation of supercapacitors. This Guide is to be used in conjunction with and as a supplement to Part 4 of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)* and the *ABS Rules for Building and Classing Mobile Offshore Drilling Units (MODU Rules)*, or other ABS Rules as applicable. The basic safety principles such as having sufficient power generation (storage) capacity, adequate standby and emergency power sources, continuity of supply in the event of a fault, and general electrical safety (such as proper cable sizing, appropriate insulation, appropriate equipment enclosure ratings, etc.) contained in the ABS Rules are to be followed in general. Those specific requirements are not repeated in this Guide.

3 Application

This Guide is applicable to marine and offshore assets designed, constructed, or retrofitted with a supercapacitor system used as an additional source of power with a capacity greater than 50 Wh. An optional notation **ESS-SC** may be granted to those assets once the supercapacitor installation has complied with the requirements of this Guide.

When Type Approval for supercapacitor system components is requested, applicants should contact ABS for the approval process. For ABS Type Approval Program requirements, please refer to 1-1-4/7.7, Appendix 1-1-A3, and Appendix 1-1-A4 of the *ABS Rules for Conditions of Classification (Part 1)*. See Section 2, Table 1 for certification details. Alternative certification schemes are also available as documented in 1-1-A3/5.5 of the *ABS Rules for Conditions of Classification (Part 1)*.

5 Scope

The supercapacitors covered by this Guide are also referred as Electric Double-Layer Capacitors (EDLC), Electrochemical Capacitors, or Ultracapacitors. For requirements applicable to conventional electrolytic capacitors used for harmonic filtering, please refer to the requirements in 4-8-2/9.23 of the *Steel Vessel Rules*.

This Guide addresses the requirements related to supercapacitors installed onboard marine and offshore assets classed by ABS that meet the requirements in Subsection 1/3 of this Guide.

Capacitor-type energy storage technology is a field that is continuously evolving with respect to materials and design. Alternative capacitor-type energy storage technologies and arrangements may be considered provided it can be shown, through either satisfactory service experience or a systematic analysis based upon sound engineering principles, to meet the overall safety requirements of this Guide and the ABS Rules.

7 Terminology

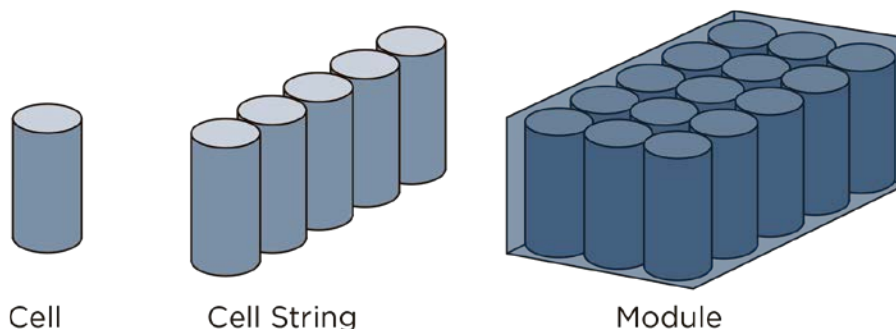
Electrochemical Capacitor. An electric energy storage device where an electrical charge is stored as a result of non-Faradaic processes at one or both of the electrodes. (A subset of electrochemical capacitors referred to as an “asymmetric electrochemical capacitor” have non-Faradaic processes at one electrode and Faradaic processes at the other electrode.) The unique highly-porous electrode increases its surface area for holding a charge, resulting in much larger capacitance and energy density than other types of capacitors. Electrochemical capacitors differ from common electrolytic capacitors in that they store a charge at the liquid-solid interface of the electrodes when a potential is applied rather than in a solid dielectric material covering the surfaces of the electrodes. Some other common names for an electrochemical capacitor are “double layer capacitor”, “ultracapacitor”, “electrochemical double layer capacitor”, “supercapacitor”, and EDLC. [UL 810A]

Supercapacitor Cell. The basic electric energy storage unit inside of a supercapacitor system, which contains an assembly of electrodes, electrolyte, separator, and current collectors.

Supercapacitor Cell String. A number of supercapacitor cells or modules connected in series to achieve a large voltage level of the supercapacitor system.

Supercapacitor Module. A group of supercapacitor cells connected together in a series and/or parallel configuration with or without protective devices and monitoring circuitry.

FIGURE 1
Supercapacitor Components (only use for reference)



Supercapacitor Pack/Rack/Stack. Energy storage device that is composed of one or more supercapacitor cells or modules electrically connected. It has monitoring circuitry that provides information to a supercapacitor system.

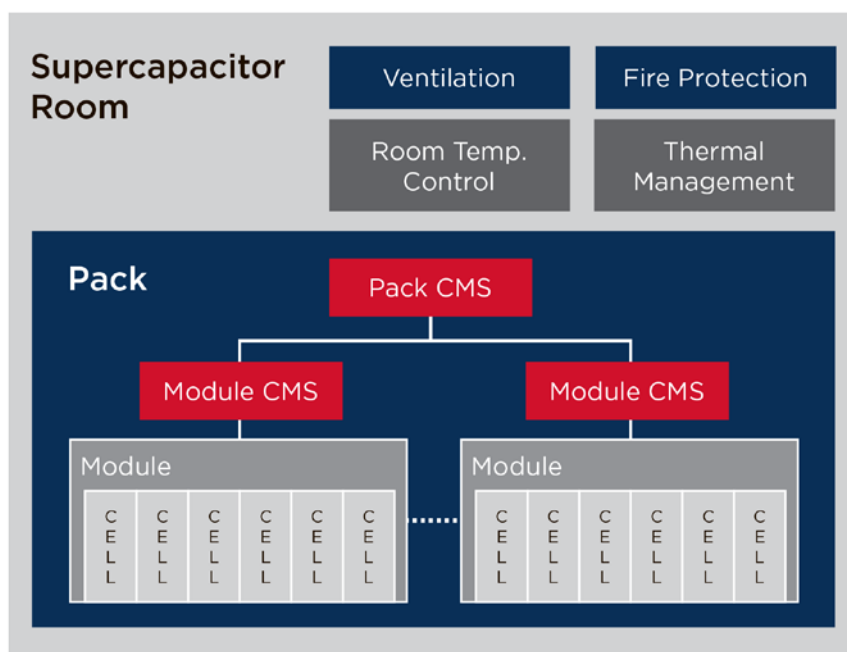
Capacitor Management System. A supervision system that contains control, monitoring, balancing, and protective functions of the supercapacitor system. It monitors and/or manages its state, calculates secondary data, reports that data, and/or controls its environment to influence the supercapacitor’s safety, performance, and/or service life.

Cell Balancing. The mechanism of forcing all supercapacitor cells within a supercapacitor module to have identical voltages. Cell balancing is achieved by means of a “balancing circuit” (usually implemented as part of the capacitor management system). Without a balancing circuit, one or more cells (as a result of different internal equivalent series resistances) may become undercharged or overcharged, either of which can lead to a failure of the capacitor module. Cell balancing is not an instantaneous process and requires a period of time before cell voltages are balanced.

Supercapacitor Space. Physical installation room including decks, bulkheads, overheads and all functions and components which contribute to keep the supercapacitor system in the defined space at a specific set of environmental conditions (also known as capacitor room/compartment).

Supercapacitor System. A complete system that contains one or more supercapacitor cells/modules/packs with Capacitor Management System, ancillary devices, and protective components. An example supercapacitor system is illustrated in Section 1, Figure 2.

FIGURE 2
Supercapacitor System



Power Management System (PMS). A complete switchboard and generator control system that controls power generation and distribution, including multiple switchboards and ring bus systems. The PMS on board marine and offshore assets is responsible for functions such as load sharing among different power sources and load shedding when generated power is insufficient.

State of Charge (SOC). Available capacity in a supercapacitor cell/module expressed as a percentage of rated capacity.

State of Health (SOH). An indication of the general condition of a supercapacitor cell/module compared to its ideal conditions (i.e., a new supercapacitor cell/module). The unit of SOH is expressed as a percent number (e.g., 100% means the supercapacitor cell's condition match all nominal manufacturer specifications).

Concept of Operations (CONOPS). A CONOPS is a user-oriented document that describes system characteristics for a proposed system from the user's viewpoint. [IEEE 1362-1998]

9 Abbreviations and Acronyms

The following abbreviations and acronyms are applied to the terms used in this Guide:

ABS:	American Bureau of Shipping
CMS:	Capacitor Management System
CONOPS:	Concept of Operations
DPS:	Dynamic Positioning System
DVTP:	Design Verification Test Procedures
EMI:	Electromagnetic Interference