



AMRA STANDARD

AMRA-220:2022(en)

Edition: 1
2022-07-22

**Mobile Robots -
Safety Requirements, Verification and
Validation**

(P.1 ~ P.8 preview with watermark)

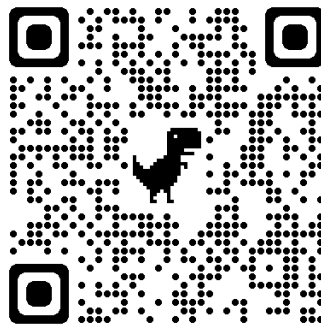
NOTICE

This document is copyright protected.
© AMRA Autonomous Mobile Robot Alliance 2022

All rights reserved. Inquiries and comments relative to the contents of this document should be addressed to AMRA. Without prior written permission, no part of this document may be reproduced or utilized in any form, including posting on the internet or an intranet. AMRA retains the copyright on the material. By downloading this file, the individual agrees not to charge for or resell the resulting material.

For more information, contact:
Autonomous Mobile Robot Alliance (AMRA)
contact@amr-alliance.org
<https://www.amr-alliance.org/>

For standard improvement, submit comments:
<https://forms.gle/b8TWPmYCqiJqgxBy7>



INTRODUCTION

Safety is always the top priority for the manufacturers of mobile robots. The AMRA-220 Standard provides fundamental guidelines for manufacturers to comply with, as well as advanced protective measures to consider. It identifies significant hazards and risk assessment associated. It lays out general safety requirements and protective measures for different types of hazards. This standard also touches on the aspects of requirements for safety-related parts, information for use, and verification and validation.

The AMRA-220 standard is drafted by the experts in working group #2 (WG2), reviewed by the technical committee (TC) and approved by the board. The contributing members, listed alphabetically below, have graciously devoted great endeavors to this standard.

Board

Approved AMRA-220:2022(en) on 2022-07-18

AU Optronics
CASTEC International Corp.
CiLS

Delta Electronics
DFI
Flytech Technology

ITRI [Chair]
Pepperl+Fuchs Taiwan
Wistron Corporation

Technical Committee

Reviewed AMRA-220:2022(en) on 2022-06-17

AU Optronics
Axiomtek
Delta Electronics

DFI
ITRI [Chair]
Kaneka Taiwan

Pepperl+Fuchs Taiwan
Wistron Corporation

Working Group #2 Experts

Formed the draft of AMRA-220:2022(en)

Alan Wang
Crystal Tseng
Cynric Chiu
Chun-Lin Wu
Jean Chen
Jennifer Chang [Co-chair]

Joseph Wu
Josh Jhang
Justin Tuen [Chair]
Ken Chen
Lola Chang
Louis Lin

Maggie Wu
Phillip Hsiao
Robin Lin
Roy Xu
Shu-Yen Lo
Steven Wu

Steven Yen
Tom Tsui
Yi-Hong Chen

CONTENTS

1. SCOPE, OBJECTIVE AND PARTICULAR STANDARDS	9
1.1 Scope	9
1.2 Objective	9
1.3 Particular safety standards	9
2. NORMATIVE REFERENCES	10
3. TERMS AND DEFINITIONS	12
3.1 User	12
3.2 Operator	12
3.3 Exposed person	12
3.4 People	12
3.5 Overload power protection	12
3.6 Over-limit protection	12
3.7 Trapping zone	12
3.8 PCBA	12
3.9 Hardware redundancy	13
3.10 SOC (State of charge)	13
3.11 SOH (State of health)	13
3.12 BMS (Battery Management System) / BMU (Battery Management Unit)	13
3.13 Battery firmware	13
3.14 Protective device	13
3.15 Acceptable risk	13
3.16 Unacceptable risk	13
3.17 Power source	13
3.18 Potential ignition source	14
3.19 Power cord	14
4. HAZARD IDENTIFICATION AND RISK ASSESSMENT	15
4.1 General guidelines	15
4.2 Significant hazards	15
5. GENERAL SAFETY REQUIREMENTS AND PROTECTIVE MEASURES	18
5.1 Protection against mechanical hazards	18
5.1.1 Hazardous shape	18
5.1.2 Trapping zone	18
5.1.3 Center of gravity of mobile robot changed by the load	19
5.1.4 Moving and/or rotating parts inside the mobile robot	20
5.1.5 Exposed moving and/or rotating parts	21
5.2 Protection against electrical hazards	21

5.2.1 Live electrical parts	22
5.2.2 ESD (electrostatic discharge)	23
5.2.3 EMC (electromagnetic compatibility)	24
5.2.4 High voltage parts	24
5.3 Protection against hazardous electrical components	24
5.3.1 PCBA	24
5.3.2 Battery	25
5.3.2.1 Safety requirements in design	25
5.3.2.2 Safety requirements in information for use	27
5.3.3 Sensor	27
5.3.4 Wiring and harness cable	27
5.4 Protection against hazardous emissions	27
5.4.1 Hazardous substances	28
5.5 Protection against hazards associated with spread of fire	28
5.6 Protection against hazardous environment in which the mobile robot is used	29
5.6.1 Ambient temperature	29
5.6.2 Travel surface	29
5.6.3 Illumination	30
5.6.4 Liquid	30
5.6.5 Dust	30
5.7 Protection against hazards associated with normal wear and tear	31
6. SPECIFIC REQUIREMENTS OF SAFETY-RELATED PARTS IN CONTROL SYSTEM OF A MOBILE ROBOT	32
6.1 Protection against hazards associated with traveling robots	32
6.1.1 Speed limitation	32
6.1.2 Stop Function	32
6.1.2.1 Emergency stop	33
6.1.2.2 Protective stop	34
6.1.3 Obstacle avoidance	35
6.2 Protection against ergonomic hazards	35
6.2.1 HMI for awareness	35
6.2.2 Unintended user behaviors	35
6.2.2.1 Overweight load	36
6.2.2.2 Oversized load	36
6.3 Protection against hazards associated with cyber attacks	36
7. INFORMATION FOR USE	37
8. VERIFICATION AND VALIDATION	38
ANNEX A. CHANGES BETWEEN VERSIONS (INFORMATIVE)	40

ANNEX B. EXAMPLES FOR RISK ACCEPTABILITY (INFORMATIVE)	41
ANNEX C SAFETY TESTS REFERENCES OF BATTERIES (INFORMATIVE)	43



TABLES

<u>Table 1. List of significant hazards</u>	<u>16</u>
<u>Table 2. Type of loads</u>	<u>19</u>
<u>Table 3. Examples of load guards</u>	<u>20</u>
<u>Table 4. Examples of grounding connection</u>	<u>22</u>
<u>Table 5. Comparison of emergency stop and protective stop</u>	<u>33</u>
<u>Table 6. Examples of protective stop function</u>	<u>34</u>
<u>Table 7. List of verification and validation methods for significant hazards</u>	<u>38</u>
<u>Table C.1. List of safety tests of batteries</u>	<u>43</u>

FIGURES

Figure 1. Examples of hazardous shape	18
Figure 2. Examples of safe working space	21
Figure 3. Example of wiring construction	23
Figure 4. Example BMS/BMU system diagram	25
Figure 5. Example of protection transition diagram for battery protection	26
Figure B.1 Risk assessment matrix	41
Figure B.2 Example of risk assessment matrix with acceptabilities	42
Figure B.3 Example of risk assessment matrix with risks	42