

# ISO/TR 23482-1:2020-02 (E)

## Robotics - Application of ISO 13482 - Part 1: Safety-related test methods

---

<b>Contents</b>		<b>Page</b>
Foreword .....		vi
Introduction .....		vii
1	Scope .....	1
2	Normative references .....	1
3	Terms and definitions .....	1
4	Test conditions .....	2
4.1	General .....	2
4.2	Environmental conditions .....	2
4.3	Test travel surface .....	2
4.4	Safety of persons involved in testing .....	3
4.4.1	General .....	3
4.4.2	Safety harness .....	3
5	Selection of test sample .....	4
6	Test of physical hazard characteristics (universal) .....	4
6.1	Voltage at user-accessible parts .....	4
6.1.1	Principle .....	4
6.1.2	Apparatus .....	5
6.1.3	Procedure .....	5
6.2	Acoustic noise .....	6
6.2.1	Principle .....	6
6.2.2	Apparatus .....	6
6.2.3	Procedure .....	6
6.2.4	Pass/fail criteria .....	7
6.3	Surface temperature .....	7
6.3.1	Principle .....	7
6.3.2	Apparatus .....	8
6.3.3	Procedure .....	8
6.3.4	Pass/fail criteria .....	9
7	Test of physical hazard characteristics (for mobile robot) .....	9
7.1	Injury parameters in collision .....	9
7.1.1	Principle .....	9
7.1.2	Apparatus .....	10
7.1.3	Procedure .....	10
7.1.4	Pass/fail criteria .....	11
7.2	Test of force control for intended and unintended contact with a robot .....	11
7.2.1	Principle .....	11
7.2.2	Apparatus .....	12
7.2.3	Procedure .....	12
7.2.4	Pass/fail criteria .....	13
8	Test of physical hazard characteristics (for restraint type physical assistant robot) .....	13
8.1	Principle .....	13
8.2	Apparatus .....	14
8.3	Procedure .....	16

8.4	Pass/fail criteria .....	17
9	Test of endurance characteristics (universal) .....	18
9.1	Endurance to environmental temperature/humidity fluctuations and vibration combined with these fluctuations .....	18
9.1.1	General .....	18
9.1.2	Temperature/humidity test .....	18
9.1.3	Sealing test .....	19
9.1.4	Robustness test .....	19
9.1.5	Pressure test .....	19
9.1.6	Pass/fail criteria .....	20
9.2	Durability in locomotion (mobile robot) .....	20
9.2.1	Principle .....	20
9.2.2	Apparatus .....	20
9.2.3	Procedure .....	22
9.2.4	Pass/fail criteria .....	22
10	Test of endurance characteristics (for mobile robot) .....	22
10.1	Endurance to collision impact .....	22
10.1.1	Principle .....	22
10.1.2	Apparatus and procedure .....	23
11	Test of static stability characteristics .....	23
11.1	Principle .....	23
11.2	Apparatus .....	23
11.3	Procedure .....	23
11.4	Pass/fail criteria .....	24
12	Test of dynamic stability characteristics with respect to moving parts (for mobile robot) <sup>24</sup> 12.1 Principle .....	24
12.2	Apparatus .....	24
12.3	Procedure .....	24
13	Test of dynamic stability characteristics with respect to travel (for mobile robot) .....	25
13.1	General .....	25
13.1.1	Principle .....	25
13.1.2	Apparatus .....	25
13.1.3	Procedure .....	25
13.2	Stability test on a flat surface .....	26
13.2.1	Braking test on split surface .....	26
13.2.2	Acceleration test on split surface .....	26
13.2.3	Acceleration test from stationary condition .....	26
13.3	Stability test on inclined surface .....	27
13.3.1	General .....	27
13.3.2	Maximum speed test on downward slope .....	27
13.3.3	Downward slope acceleration and braking test .....	28
13.3.4	Upward slope acceleration test .....	29
13.3.5	Downward slope full turn test .....	30
13.3.6	Inclined surface crossing test .....	31
13.3.7	Pivot turn on inclined surface test .....	32
13.4	Stability test for steps and gaps .....	32
13.4.1	General .....	32
13.4.2	Moving upward from stop position .....	32
13.4.3	Moving up at maximum speed .....	33
13.4.4	Moving up while accelerating .....	33
13.4.5	Descending step at low speed .....	34
13.4.6	Descending step at maximum speed .....	34
13.4.7	Gap crossing test .....	35
13.5	Pass/fail criteria .....	36
14	Test of safety-related control functions (universal) .....	37

14.1	Test of integration of electro-sensitive protective equipment (ESPE) .....	37
14.1.1	Principle .....	37
14.1.2	Sampling .....	37
14.1.3	Apparatus .....	37
14.1.4	Procedure .....	38
14.2	Test of operation in slippery environments .....	39
14.2.1	Principle .....	39
14.2.2	Apparatus and procedure .....	40
14.3	Electromagnetic immunity .....	40
14.3.1	Principle .....	40
14.3.2	Apparatus .....	40
14.3.3	Procedure .....	40
15	Response to safety-related obstacles on the ground (for mobile robot) .....	41
15.1	Distance of protective stop .....	41
15.1.1	Principle .....	41
15.1.2	Apparatus .....	41
15.1.3	Procedure .....	43
15.2	Distance and speed in safety-related speed control .....	44
15.2.1	Principle .....	44
15.2.2	Apparatus and procedure .....	45
15.3	Distance of stopping before convex terrain .....	45
15.3.1	Principle .....	45
15.3.2	Apparatus .....	45
15.3.3	Procedure .....	45
15.4	Distance of stopping before concave terrain .....	47
15.4.1	Principle .....	47
15.4.2	Apparatus .....	47
15.4.3	Procedure .....	48
16	Test of safety-related localization and navigation .....	50
16.1	Principle .....	50
16.2	Apparatus .....	50
16.3	Procedure .....	51
17	Test of reliability of autonomous decisions and actions (universal) .....	51
17.1	General .....	51
17.2	Object identification .....	52
17.2.1	Principle .....	52
17.2.2	Apparatus .....	52
17.2.3	Procedure .....	52
18	Command devices (universal) .....	52
18.1	Safe operation in case of connection, disconnection or reconnection of a command device .....	52
18.1.1	Principle .....	52
18.1.2	Apparatus .....	52
18.1.3	Procedure .....	53
18.2	Response to multiple or unintended command devices .....	53
18.2.1	Principle .....	53
18.2.2	Apparatus .....	53
18.2.3	Procedure .....	53
18.3	Safe operation in case of loss of communication by cableless or detachable command devices .....	53
18.3.1	Principle .....	53
18.3.2	Apparatus .....	54
18.3.3	Procedure .....	54
19	Test report .....	54
	Annex A (informative) Information for evaluating test results .....	55

<b>Annex B (informative) Mechanical characteristics of the artificial hypodermis and underneath .....</b>	<b>66</b>
<b>Annex C (informative) Dummy for driverless tests of self-balancing person carrier robot .....</b>	<b>68</b>
<b>Annex D (informative) Examples of the test report format .....</b>	<b>70</b>
<b>Annex E (informative) Measurement test and damage observation on surrogate skin piece: .....</b>	<b>74</b>
<b>Bibliography .....</b>	<b>76</b>