

**GUIDELINE  
FOR  
GLOVEBOX ERGONOMICS**

**AGS-G013-2011**

**July 2011**

**AMERICAN GLOVEBOX SOCIETY  
STANDARDS DEVELOPMENT COMMITTEE**

All Rights Reserved  
Copyright 2011

No portion may be duplicated without written consent of the American Glovebox Society.

ISBN: 1-892643-03-0

Extra copies may be requested from  
American Glovebox Society  
526 South E Street  
Santa Rosa, CA 95404  
(800) 530-1022  
(707) 578-4406 (fax)  
[www.gloveboxsociety.org](http://www.gloveboxsociety.org)

## **DISCLAIMER**

This American Glovebox Society (AGS) Guideline for Glovebox Ergonomics, AGS-G013-2011, has been compiled from established practices and member and contributor experiences. Its intended use is strictly as a guide. It is not intended to replace direct professional medical advice and oversight. Its direction may be altered to suit individual applications. The AGS, its membership, and contributors assume no responsibility for any liability arising out of its use or application.

# TABLE OF CONTENTS

<b>AGS STANDARDS DEVELOPMENT COMMITTEE</b> .....	viii
<b>ACKNOWLEDGMENTS</b> .....	ix
<b>AGS TECHNICAL COMMITTEE DOCUMENT COMMENT FORM</b> .....	xi
<b>1 SCOPE</b> .....	1
1.1 Limitations.....	1
1.2 Purpose.....	1
<b>2 SUPPORTING DOCUMENTS</b> .....	1
<b>3 TERMS AND DEFINITIONS</b> .....	1
<b>4 BACKGROUND</b> .....	3
4.1 Human Factors.....	3
4.2 Ergonomic Risk Factors.....	4
4.3. Screening Mechanisms.....	5
4.4 Control Strategies.....	5
4.5 Ergonomic Training and Education.....	6
<b>5 PRE-DESIGN ANALYSIS</b> .....	6
5.1 Task Analysis.....	7
5.2 Glovebox Operator Information.....	8
5.3 Equipment Location.....	9
<b>6 DESIGN CRITERIA</b> .....	10
6.1 Glovebox Shell Profile and Frame.....	10
6.2 Transfer Devices and Doors.....	11
6.3 Gloveports.....	14
6.4 Half-Suit Ports.....	17
6.5 Material Handling.....	17
6.6 Glovebox Environment.....	23
6.7 Shielding.....	23
6.8 Windows and Visibility.....	23
6.9 Lighting.....	24

6.10	Instrumentation .....	27
6.11	Process and Ventilation Filters.....	27
6.12	Mechanical Drive Location.....	27
6.13	Thermal-Related Stress .....	28
6.14	Shelving .....	28
6.15	Glovebox Location.....	29
<b>7</b>	<b>VERIFICATION AND VALIDATION .....</b>	<b>29</b>
7.1	Design Review .....	29
7.2	Computer Simulation .....	30
7.3	Full Scale Mock-Ups.....	32
<b>8</b>	<b>GLOVES AND SLEEVES .....</b>	<b>32</b>
8.1	Glove Material .....	33
8.2	Glove Film Thickness .....	34
8.3	Hand Dimensions .....	34
8.4	Hand-Specific or Ambidextrous Glove Configuration .....	35
8.5	Glovebox Glove Length.....	35
8.6	Grasping Capability .....	35
8.7	Overgloves and Undergloves .....	36
8.8	Perspiration Control .....	36
8.9	Glove Sleeves.....	36
8.10	Other Factors.....	37
<b>9</b>	<b>OPERATOR BIOMECHANICAL CONSIDERATIONS .....</b>	<b>37</b>
9.1	Shoulder .....	38
9.2	Elbow .....	45
9.3	Lower Back and Neck.....	49
9.4	Health and Well Being.....	54
<b>10</b>	<b>OPERATIONAL CONDITIONS .....</b>	<b>54</b>
10.1	Glovebox Organization and Housekeeping.....	54
10.2	Glovebox Internal Environment.....	55
10.3	Ambient Environment.....	55
10.4	Personal Protective Equipment .....	56
<b>11</b>	<b>CONCLUSION.....</b>	<b>58</b>

<b>12 REFERENCES</b> .....	59
<b>APPENDIX A: Ergonomic Self-Survey (Example)</b> .....	61
<b>APPENDIX B: Extended Glovebox Ergonomic Evaluation</b> .....	63
<b>APPENDIX C: Anthropometrics for Caucasian Population</b> .....	65
<b>APPENDIX D: Normative Data for Grip Strength and Pincer Strength</b> .....	67
<b>INDEX</b> .....	69

## List of Figures

Figure 6.1. Examples of glovebox profiles.....	10
Figure 6.2. Example of a round airlock with a horizontally swinging hinged door .....	12
Figure 6.3. Example of a vertically swinging round airlock door .....	12
Figure 6.4. Example of a rectangular airlock with a vertically sliding door .....	13
Figure 6.5. Rectangular airlock used to transfer large equipment into and out of a glovebox .....	13
Figure 6.6. Horizontal gloveport orientations .....	15
Figure 6.7. Vertical gloveport orientations.....	16
Figure 6.8. Angular gloveport orientations .....	16
Figure 6.9. Half suit.....	17
Figure 6.10. Example of a pinch grip versus a power grip.....	20
Figure 6.11. Example of a specialty tool utilizing an ergonomic knurled handle .....	20
Figure 6.12. Example of an operator extended reach tool with a vertical handle .....	21
Figure 6.13. Glovebox with shielding .....	23
Figure 6.14. Example of light source positioning to reduce glare.....	25
Figure 6.15. Comparison of a recommended arrangement with one that has contrast problems .....	26
Figure 7.1. Example of Rapid Upper Limb Assessment (RULA) of glovebox operation.....	30
Figure 7.2. Simulation demonstrating operator’s glovebox view.....	31
Figure 7.3. Clash detection between human arm and process equipment .....	31
Figure 7.4. Wooden mock-up of a glovebox .....	32
Figure 8.1. Glove sleeve: glove attached to straight sleeve.....	37
Figure 9.1. Examples of operators at lower and upper anthropometric ranges .....	38
Figure 9.2. Muscles of the rotator cuff and the acromion .....	39
Figure 9.3. Shoulder flexion angle .....	39
Figure 9.4. Right shoulder force data chart for moving 20 lb with varying degrees of elbow range (Reference 12.10).....	40

## List of Figures (Continued)

Figure 9.5.	Rotator cuff strengthening exercise – external rotation .....	41
Figure 9.6.	Rotator cuff strengthening exercise – internal rotation.....	41
Figure 9.7.	Rhomboid strengthening to reduce rounded shoulder posture.....	41
Figure 9.8.	Example of operator with improved shoulder biomechanics because of the step platform – shoulder angle is less than 70 degrees .....	42
Figure 9.9.	Example of operator with risk of shoulder impingement – shoulder angle is above 70 degrees .....	42
Figure 9.10.	Loosening the finger tips first can assist in removing hands from the gloves .....	43
Figure 9.11.	Example of the correct way for removing the arm. The elbow is angled down as the arm is removed from the gloves and the shoulder blade is pinched back.....	43
Figure 9.12.	Example of the neutral positions when using a tool to assist reaching .....	44
Figure 9.13.	Example of awkward posture reaching without the use of a tool .....	44
Figure 9.14.	Example of improving reach by placing non-reaching hand against inside of glovebox wall.....	44
Figure 9.15.	Demonstrates the reduction of reach thus causing increased operator shoulder stress.....	44
Figure 9.16.	Elbow depicting area of lateral tendonitis (tennis elbow).....	45
Figure 9.17.	Wrist neutral and wrist extension.....	46
Figure 9.18.	Stretching the forearm flexors.....	46
Figure 9.19.	Stretching the forearm extensors.....	46
Figure 9.20.	Grasping a container with two hands .....	47
Figure 9.21.	Improper grasping with palm down .....	47
Figure 9.22.	Sliding a container with thumb up .....	47
Figure 9.23.	Reducing forces by applying proper biomechanics .....	48
Figure 9.24.	Elimination of pinch grip and wrist extension by altering forearm position.....	49
Figure 9.25.	Rhomboid exercise.....	50
Figure 9.26.	Compressive forces for various movements of a 15-lb weight .....	51
Figure 9.27.	Compressive forces for various movements of a 30-lb weight .....	51
Figure 9.28.	Anti-fatigue mat .....	52
Figure 9.29.	Anti-fatigue overshoes .....	53
Figure 9.30.	Glovebox operator utilizing a footrest .....	53

## List of Tables

Table 5.1	Tabular task analysis example .....	8
Table 6.1	Anthropometric data for eye heights.....	24
Table 6.2	Illumination levels for the interior glovebox activities .....	24
Table 6.3	Lighting checklist.....	27
Table 8.1	Typical glove material physical properties .....	34
Table 8.2	Typical hand sizes and lengths for various underglove sizes.....	36
Table 9.1	Platform height needed for various height workers using a 52-in. centerline gloveport height.....	42