Shape Corp.

TOOL QUOTE AND BUILD MANUAL

Safety Specification
SCP-22653734
May 26, 2026

Mission Statement

The Shape Corp. team will:
Supply products through diverse manufacturing services to a worldwide market.
Commit our resources to anticipate and fulfill our customers' needs and quality requirements.
Endeavor through ethical business practices, to produce wealth for our customers, employees, stockholders and communities.

Statement of Confidentiality

shape CORP. | THINKERS. BELIEVERS. DOERS.

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1.1. 7.1.A: Added maximum decibel level for tooling and equipment.
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1.4. 4.4.G: Clarified zero energy state requirement for hydraulic/pneumatic motion devices in Workzone
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1.11. 4.3B/C: Changes to fire suppression requirements; 6.0 Hazardous Energy Control updates; 8.3 Ergonomics requirements for parts over 35lbs.
1.12. **12/23/24: Clarification** of safeguarding devices (when multiple zones, hazards in each accessible zone must be assessed and safeguards implemented).
1.13. 4.3B/C: Changes to fire suppression requirements.
1.14. **03/18/2025:** 6.0 Hazardous Energy Control (Lockout) updates; 8.3 Ergonomics requirements redefined.
1.15. **04/16/25:** 5.1.G: New hazardous motion requirements.
1.16. **08/20/25:** 7.3 updated to new corporate lighting standard.
1.17. **04/20/26:** 4.3: Large dust collectors equipped with a spark detection and a mist sprayer suppression system and all dust collectors no mixing of reactive metals. 3.2.A updated China regulation list.

2. DEFINITIONS

2.1. Detented – Valve type that maintains position regardless of power or air supply state until the valve is energized in the opposite direction.
2.2. Machine Safeguarding Devices - include but are not limited to light curtains, interlocked guards, two-hand controls, safety mats, etc.
2.3. Work Zone – Area where an operator is routinely in the shared space with motion devices, i.e., loading or unloading a fixture.
2.4. Form SCF-4294483 – Equipment Risk Assessment Form
2.5. ANSI – American National Standards Institute
2.6. RIA – Robotic Industries Association
2.7. NEC – National Electrical Code
2.8. NIOSH - National Institute of Occupational Safety and Health
2.9. NFPA – National Fire Protection Association
2.10. OSHA – Occupational Safety Health Agency (MI- Michigan)
2.11. EN – European Standards
2.12. CCC – China Compulsory Certification
2.13. UL – Underwriters Laboratory
2.14. IEC – International Electrotechnical Commission
2.15. EMC – Electro Magnetic Compatibility
2.16. RFID – Radio Frequency Identification

3. INTRODUCTION

3.1. General

3.1.A. All equipment must provide adequate protection for the operator from hazards and safety risks during both normal operation and other foreseeable interactions. Maintenance and servicing of the equipment must be safe and convenient.

3.1.B. The safety functions must be user friendly to encourage the operator to act safely.

3.2. Regulatory Compliance:

3.2.A. In addition to Shape standards, tooling and equipment must also meet or exceed all regional regulatory requirements for the intended destination listed below. Additional may apply depending on the scope of the project.

1. **North America:**
   - All applicable OSHA, MIOSHA and ANSI regulations.
   - Electrical Standards for Industrial Machinery – ANSI/NFPA 79
   - Electrical Requirements - NEC and ANSI/NFPA 70
   - Fire Prevention/Prevention- NFPA 69, 652, 664, 484
   - Risk Assessment ISO 12100
   - Safety Control systems – ISO 13849-1
   - Electrical panels, Control Equipment/Components - UL 508/508A
   - Robotic - ANSI/RIA R15.06
   - Laser – ANSI Z136.1, .9 and 21 CFR 1040
2. **Europe:**
   - EU Machinery Directive 2006/42/EC (current law - valid until 01/20/2027)
   - EU2023/1230 “Machinery Regulation” (current law and replaces EU Machinery Directive 2006/42/EC effective 01/20/2027)
   - Low Voltage Directive 2014/35/EU
   - Electrical panels/Control Equip/Component, IEC 61439-1, EN/IEC 60947
   - Risk Assessment EN ISO 12100
   - Safety Control systems – EN ISO 13849-1
   - Personal Protective Equipment Regulation - EU 2016/425
   - EMC Directive 2014/30/EU
   - Laser – IEC 60825-1
3. **China:**
   - Code for fire protection design of buildings GB 50016
   - Safety in welding and cutting GB 9448
   - Safety of machinery — General principles for design - Risk assessment and risk reduction GB/T 15706
   - Electrical safety of machinery—Electrical equipment of machines—Part 1: General requirements GB/T 5226.1
   - Safety of machinery—Safety-related parts of control systems—Part 1: General principles for design GB/T 16855.1

3.2.B. All tooling and equipment must meet all Shape Corp Safety, Environmental, Health and Ergonomic specifications referenced within this manual.

4. GENERAL MACHINE SAFETY

4.1. Equipment Access and Working Platforms

4.1.A. The maximum designed safe load limit of a floor, shelf, or overhead storage area will be calculated, and such equipment must be marked/labeled with a load rating.

4.1.B. Machine components on a platform must be designed to minimize hazards caused by any type of failure that could impact area below platform.

4.2. Machine Access

4.2.A. Operators and maintenance personnel must have access to perishable components without climbing over or onto the equipment, components, devises that are not specifically designed for walking or standing.

4.3. Fire prevention, detection, and suppression

4.3.A. Heat sources (sparks generated from cutting, welding, laser processes, deburr processes, etc.) must be prohibited from contacting combustible or flammable materials.

1. This may be accomplished by isolating, shielding, distance or other engineering controls.

2. As a good practice, combustibles and flammable materials kept a safe distance from heat generating operations (cutting, welding, laser, deburr, etc.) by a minimum of 25' or a barrier made of fireproof material.

4.3.B. Dust collection systems must be utilized to collect particulates from cutting, welding, laser, deburr, and other particulate generating processes inside of facilities (under roof).

1. These dust collectors must be equipped with approved fire detection and suppression systems.

2. To prevent sparks generated during welding, cutting, laser, deburr or other spark generating processes from entering dust collection systems the following, are required:

- A spark arrestor and a deflection plate must be provided on the exhaust intake port, and
- A spark cooler installed in the downstream ducting.

3. Large dust collectors, servicing multiple pieces of equipment, must:

- Have a properly designed and installed spark detection and suppression (i.e. mist) system installed in the ductwork, in addition to a spark cooler.
  NOTE: Suppression system(s) must be compatible with dust collected (i.e. water for steel, specialty chemical for aluminum), and
- Should be located outdoors (not under roof), wherever possible.

4. Large dust collectors, servicing multiple pieces of equipment

5. All dust collectors must be equipped with automatic closure of openings after deployment of required suppression systems as recommended by NFPA 2001 to limit fire risk.

6. Due to the risk of chemical reactions and associated fires, reactive metals (i.e. steel and aluminum) may not be collected in the same dust collector.

7. Laser cutting dust collectors must be equipped with a $CaCO_3$ auto-dispensing unit, designed for the individual collector capacity.

8. Dust collectors with pneumatic purge features must be purchased to reduce fire risk.

4.3.C. Ductwork must be of a permanent/fixed design (not flexible).

4.3.D. Ductwork must have inspection ports installed where points of accumulation are present (elbows) and at least every 100 linear feet.

4.3.E. Reference Document SCF-4294483 (Equipment Risk Assessment) for more details.

4.4. Hydraulic and Pneumatic devices

4.4.A. Hydraulic and Pneumatic devices must be located away from the operator's side of the machine or positioned in the frame of the machine or behind a shielding object to limit effects of hose failure.

4.4.B. The maximum anticipated working pressures in any hydraulic system must not exceed the safe working pressure rating of any component used in that system

4.4.C. All accumulation tanks/air receivers must be equipped with pressure relief devices.

4.4.D. Electrically controlled hydraulic or pneumatic solenoid valves must be applied in such a manner that in the event of a power failure there shall be no hazard to personnel or damage to the equipment.

4.4.E. Workpiece clamping solenoid valve(s) must remain energized throughout the working cycle until the unclamp solenoid is energized. Pneumatic motion devices must be controlled by two-position, double-solenoid-operated, five-way, detented valves to maintain position upon loss of air or power supply, unless otherwise approved.

4.4.F. A redundant pneumatic safety dump valve to remove pneumatic energy from valves banks controlling motion device (cylinders, clamps, etc.) is required for each Work Zone.

4.4.G. All pneumatic and hydraulic motion devices within the Workzone must be brought to a zero-energy state when the Point of Operation guarding is not active (i.e., light curtain blocked, safety gate not closed, etc.). Motion devices must not continue to store energy that can cause unexpected motion while de-energized.

4.5. Rotating Hazards

4.5.A. Rotating Hazards (e.g. Saw Blades, Flywheels, Spindles, etc) must be brought to a zero-energy state prior to allowing access into the safeguarded area. This can be accomplished by several methods.

1. Control Reliable Standstill/Zero Speed Monitoring (Preferred)
2. Mechanical Braking/Time Delay (With Approval)

4.5.B. Access to the hazard through interlocked guards must be restricted until a safe condition is reached (Solenoid Locking Gate Switch)

5. MACHINE SAFEGUARDING

5.1. Machine Safeguarding General

5.1.A. Machine safeguarding must prevent worker's hands, arms, and other body parts from contacting the point(s) of operation and other dangerous moving parts (pinch points).

5.1.B. All hinged or wheeled guarding (designed to be opened/closed) must be interlocked.

5.1.C. All doors in guards must have solid frame attaching the guard to the hinge.

5.1.D. Gates must be painted black with yellow frame. The yellow designates the guard and the black expanded metal allows better viewing of objects within the guarded area.

5.1.E. All interlocked gate doors must be capable of being locked open and must be able to be opened from both inside and outside of the machine.

- Locking the door open must prevent any interlock switches from closing.
- Any guarding that has holes/points for locks that do not prevent the interlock switch from closing must be removed or permanently covered.

5.1.F. Safety interlock devices are required on all non-fixed barrier guards in which an operator is required to enter the motion envelope.

5.1.G. Actuation of any safeguarding device (light curtain, interlock guard, etc.) must stop all equipment motion accessible and reset the machine in all modes: auto, manual, and other.

1. For equipment with multiple zones, hazards in each accessible zone must be assessed and safeguards implemented.
2. Where equipment continues to move after de-energization creating a hazard (saw blades, CNC bits, etc.) machines must be equipped with a braking mechanism or safety device (i.e. locking interlock) to protect team members from hazardous motion.

5.1.H. Guard Interlocks

1. All safety guard interlocks must be of the non-contact type (RFID, coded magnetic) and integrated to the safety relay or safety controller.
   - Locking the door open must prevent any interlock switches from actuating. Any guarding that has holes/points for locks that do not prevent the interlock switch from actuating must be removed or permanently covered.
2. Mechanical type interlocks (keyed, tongue, hinge or plunger styles) are permitted only if two, redundant switches are installed on each door or gate and integrated into separate safety relay input channels.
   - Exception: A single Mechanical Interlock with integrated RFID/Non-Contact safety switch is allowed.
3. All interlocks must be tamper resistant and not easily defeatable without tools.
4. Interlocks must be designed to prevent wear or damage due to miss-alignment, excessive loading or frequent use and not be used as a physical end of travel stop
5. Safety Doors or Gates that are used as Point of Operation guarding with a high frequency of operation must utilize non-contact type interlock switches.

5.1.I. Openings in barrier guarding all openings must comply with chart below

Distance of opening from point of operation		Maximum Width of Opening
0.5 to 1.5	……..	1/4
1.5 to 2.5	……..	3/8
2.5 to 3.5	……..	1/2
3.5 to 5.5	……..	5/8
5.5 to 6.5	……..	3/4
6.5 to 7.5	……..	7/8
7.5 to 12.5	……..	1 1/4
12.5 to 15.5	……..	1 1/2
15.5 to 17.5	……..	1 7/8
17.5 to 31.5	……..	2 1/8
Over 31 Inches	……..	6

5.2. Point of Operation Safety Devices

5.2.A. General

1. Point of operation safeguarding devices are required at all stations where the operator is required to enter the motion envelop of the machine on a routine basis, e.g., to load a part.

2. All intended motion accessible through the device must be disabled. Machine mode is unaffected during normal operation.

3. Point of Operation safety circuits must incorporate monitored reset for the safety relay controlling the affected Workzone.

5.2.B. Safety distance calculations for point of operation devices must be shown in machine schematic. Location of calculation must be on same sheet as device interconnection. Formula and definitions are shown in Appendix 9.2.

5.2.C. Light Curtains

1. Horizontal separation of light curtains cannot exceed 4” between active beams of curtain sets or between the machine and the first active beam.

5.2.D. **Operator Actuators**

1. Anti-Repeat Operation - Where continuous cycles of operation are not desired mode of operation, the circuit must be designed so that continuous cycle(s) cannot be achieved. Specifically, continuous cycles must not result even though the CYCLE START button(s) is held depressed continuously in the START position.

2. Two-hand Operation - Two pushbuttons must be provided at each operator station for protection against pinch points or other movement hazards and must include all the following:

- The circuits must require maintained depression of each button throughout the complete cycle or until a point is reached in the cycle where no hazard to the operator(s) exists.
- Each pair of buttons must be guarded and located so that operation by means other than the two hands of the operator is prevented.
- When more than one two-hand control station is required (i.e., dual press stations), all buttons must be concurrently depressed to initiate the cycle and released between successive operations.

6. HAZARDOUS ENERGY CONTROL (LOCKOUT)

6.1. A lockable energy isolating device must be provided for all hazardous energy sources on every piece of equipment.

6.1.A. Pneumatic isolating devices must be positioned downstream of the filter and the regulator and must dissipate residual pressure when the valve is turned off.

6.1.B. Each machine must have auxiliary lockout points on equipment when power is supplied from remote location.

6.1.C. A lockout points must be accessible from ground level and outside of machine guarding.

6.2. A lockout procedure must be provided for each piece of equipment as follows:

6.2.A. Using the standard Shape form (SCF-1362603);

6.2.B. Permanently post the instruction on the machine (aluminum or plastic placarding); and

6.2.C. Form submitted electronically to the Shape Corp Engineer who will route it to EHS for document control.

6.3. Individual lockout points must be permanently labeled, corresponding with the lockout instruction.

7. ENVIRONMENTAL REQUIREMENTS:

7.1. Noise levels

7.1.1. Tooling or equipment must not have a noise decibel level of 85 DBA or greater at a time weighted average at any operator station. The noise decibel level target on equipment and tooling is 75 DBA on a time weighted average at any operator station and must be quoted as an option if additional requirements are needed to meet the target. Ref. Document SCF-4294483 Equipment Risk Assessment

7.1.2. Dot Peen style part marking systems for specific applications are allowed with prior approval only and must have noise reduction measures to meet the decibel level requirements above.

7.2. Chemicals

7.2.1. If tooling or equipment has a discharge of fluid/solid waste or air contaminants and is provided by the supplier, a material safety data sheet for the chemical/contaminant must accompany the quote, be approved by Shape Corp EHS Manager and provided in the Maintenance Manual.

7.2.2. Mechanical ventilation is required to protect operators from chemical vapors/fumes that meet or exceed the permissible exposure limit.

7.2.3. Over-Spray and drainage must be contained and access provided for removal of waste material.

7.3. Lighting

7.3.1. Illumination will be as follows:

7.3.1.1. General Workspaces: 14+ Footcandles / 300+ Lux

7.3.1.2. Quality Inspections Stations: 93+ Footcandles / 1000+ Lux

7.3.2. Lighting inside workstations will be wired such that lighting is deenergized when:

7.3.2.1. The work center is not active, or

7.3.2.2. A period of inactivity.

7.3.3. Lighting inside workstations must be able to be energized by team members for safe entry/access during servicing/maintenance.

8. ERGONOMIC REQUIREMENTS

8.1. Work centers must be designed to meet the ergonomic standards identified in Appendix 11.1.

8.2. Ergonomic risks must be evaluated for all manual material handling, including equipment setup and change over, using the Equipment Risk Assessment Form (SCF-4294483).

8.2.1. Ergonomic risks must consider all manual material handling, including loading and unloading, safe launch and part checking processes.

8.2.2. Automation or zero lift processes are required to repetitively maneuver parts/components greater than 35lbs (16kg).

8.2.2.1. Mechanical lift assists are prohibited for parts/components greater than 35lbs (16kg) unless explicitly approved by the Chief Operating Officer.

8.3. For manual material handling (typically load and unload), a NIOSH Lifting Equation study must be performed to calculate the Recommended Weight Limit (RWL).

8.3.1. Please consult Shape Corp EHS for support if needed.

8.4. Engineering or administrative controls must be implemented to reduce the risk of musculoskeletal injuries and illnesses for lifts exceeding the RWL.

8.4.1. All engineering controls for ergonomics must meet the quoted machine cycle time requirements.

8.4.2. The work envelope must be designed to provide neutral position of the shoulder and arm.

8.5. Hand Tools

8.5.1. If powered or manual tool weighs more than six (6) pounds or torque is greater than 50 Nm, a balancing or support arms are required.

8.5.2. Airline swivel connectors are required to reduce handling forces caused by twisting or binding airlines.

8.5.3. Pneumatic tools must be designed to exhaust air away from the team member's body.

8.5.4. Hand tools required for deburring, grinding or other regular operations must be equipped with anti-torque and anti-vibration devises or otherwise equipped to limit the effect of repetitive use by team members. Racks/holder must be provided.

9. COMMON PROCESS SAFETY REQUIREMENTS

9.1. Conveyors

9.1.1. Conveyors will be properly guarded so that an Team Member will not be caught or trapped by the sudden movement of a conveyor; or be caught or trapped between the conveyor and a stationary/moving part.

9.1.2. Conveyors in a series must be electrically interlocked so that when any conveyor in the series is stopped for any reason, the initial stopping causes the upstream conveyors to stop if continued operation creates a hazard.

9.1.3. Maintenance walkways must be provided not less than 18” wide along all conveyors.

9.2. Presses (Mechanical, Hydraulic, and Pneumatic)

9.2.1. Safety blocks must be provided for all presses and must be capable of preventing the ram of the press from falling from its own free weight.

9.2.2. Blocks must be interlocked to the controls of the equipment to verify that blocks are outside of the die or press bed prior to machine actuation.

9.3. Welding\Cutting\Laser

9.3.1. Curtains and/or shields must be provided to contain expulsion on all spot welders and prevent operator exposure to all UV light from welding operation.

9.3.2. Mechanical ventilation will be used to remove exhaust fumes from all Mig, Tig welding or Laser welding/cutting/deburring operations and must protect operators from particulates that meet or exceed the permissible exposure limit.

9.4. Plastic Molding

9.4.1. An exposed heated surface which could cause an injury must be covered or guarded to prevent contact by any Team Member.

9.4.2. An injection molding machine must be equipped with an interlocked safety gates that are designed and constructed to:

9.4.2.1. Prevent any Team Member from reaching into the clamping mechanism.

9.4.2.2. Cover the mold area opposite the operator.

9.4.3. Safety gates on injection molding machines must be interlocked by any 2 of the following:

9.4.3.1. An electrical mold-closing control.

9.4.3.2. Hydraulic or pneumatic valves that control mold closing.

9.4.3.3. A mechanical device that prevents mold closing.

9.5. Robotic Cells

9.5.1. Robots or similar programmable motion device must be interlocked to prevent it from entering a point of operation area when the area is not isolated by safeguarding systems.

9.5.2. The zone interlocks must be redundant and meet or exceed PL “d “ (Performance Level) or Category 3 as required in EN ISO 13849-1. The interlock devices may include base ring limit switches, light curtains, and or movable barriers. Use of logic devices to limit robot motion (other than FANUC DCS) is not allowed.

9.5.3. A properly activated live-man/teach pendant device must be required to move a robot while a person is within a controlled area, i.e. to teach a weld path. Design must allow only one robot teach pendant to be activated at full speed (T2, greater than 250 mm/sec) at a time in a single controlled area.

9.5.4. For robotic cells, an E-stop Disconnect switch (lockable) must be installed for operator lockout/access and be located near the commonly used safety gate entrance. For multi entrance cells more than one lockable E-stop disconnect may be required.

9.6. Laser Systems

9.6.1. All production laser systems must comply with ANSI Z136.1/9, 21 CFR 1040 and IEC 60825-1 safety standards

9.6.2. All Class 3 and 4 production lasers must be safeguarded and reclassified as Class 1

9.6.3. Protective housing (totally enclosed) around equipment/beam path must be incorporated as the primary safety control measure for Class 3 and 4 lasers unless not feasible due to process constraints.

9.6.4. Beam must be directed downward/away from operator.

10. ELECTRICAL SAFETY CONTROLS

10.1. General

10.1.1. All machinery emergency stop, access and point of operation guarding safety circuitry must be designed and implemented such that any single failure of a device will not lead to loss of the circuits stop function.

10.1.2. The minimum level for control reliability of the safety circuit for all equipment is PL “d “ (Performance Level) or Category 3 as required in EN ISO 13849-1.

10.1.3. Risk assessment must be completed per EN ISO 12100.

10.1.4. Intelligent safety system (Light curtains, RFID Non-contact switches, etc.) must use safety interface relays of same manufacturer or another manufacturer only if documented approval is provided.

10.2. Safety Circuit Design:

10.2.1. Stop function must be initiated through de-energizing the device via hard-wire interlocking.

10.2.2. All equipment disabled by any safety device must be restarted only by deliberate sequence of actions by the operator, i.e. not by gate closure or light curtain being re-enabled.

10.2.3. Safety device actuation must not create other hazards i.e. parts falling from lifts.

10.2.4. Each device must have dual, safety rated contacts with an auxiliary contact for annunciation purposes.

10.3. E-Stop Devices

10.3.1. E-stop devices must be located at each operator station as well as at main control panels.

10.3.2. E-stop pushbuttons must be red, mushroom type with a yellow switch label and be 2 position push-pull.

10.3.3. For multi-station and large machine where stop buttons are not within easy reach, a pull cord operated E-Stop switch, extending the full length of the machine, must be provided with trip indication.

10.3.4. E-Stop actuation must stop all equipment motion and reset the machine mode from either auto or manual mode.

10.4. Equipment Grounding

10.4.1. Fencing, guarding, moving parts of the equipment (including hinged, sliding, or pinned parts), and separately mounted apparatus including portable and pendant accessories, must be effectively bonded to ground. Sliding parts separated by air or oil are not considered bonded together. The one exception is non-powered equipment.

10.4.2. The main control panel must be bonded to ground through the secondary power distribution ground bus or as directed by Shape’s Electrical Engineering Department. A ground rod is not an acceptable method of bonding.

10.4.3. All equipment, including equipment mounted enclosures or devices, must be bonded to the main control enclosure.

10.5. Start of Cycle

10.5.1. Machines of 20 feet in length or width, or with more than one operator, must have both an audio and visual alarm system warning personnel that the machine is going into auto mode and movement is pending.

10.5.2. Alarm must occur only if initial cycle start conditions are met. No motion must occur during the alarm period which must last a minimum of 5 seconds.

10.6. Safety Blocks

10.6.1. Equipment requiring safety blocks must be interlocked with the e-stop circuit and must remove all control power when removed from their stored position. An approved safety interlock switch must be used.

11. APPENDICES:

11.1. Work Practice Guidelines for Manual Material Handling

Aspect	Description	Limits
Work Surface Height	Distance from standing surface to top of work surface or plane of loading/unloading	Min = 34.0'' Max = 38.0'' Optimal = 36.0"
Working Hand Height	Height where work is actually performed	Min = 38.0" Max = 46.0" Optimal = 42.0"
Work Station Width	Minimum width of a workstation that surrounds the Operator	Min = 30''
Forward Reach (one arm)	Maximum distance from midline of body to any point the operator must reach forward within the workstation	Max = 27.5''
Forward Reach (both arms)	Maximum distance from midline of body to any point the operator must reach forward within the workstation	Max = 25.2''
Lateral Reach	Maximum distance from the midline of the body to any point (one either side) the operator must reach within the workstation	Max = 20.75
Upper Reach	Maximum distance the operator must reach upwards within the workstation.	Not to exceed shoulder height GOAL: 48'' (5th % female)
Work Envelope	Maximum rotation of the entire work station.	Max = 120 degrees
Height of Visual Display (eye level)	Distance from the standing surface to the visual display at eye level	Min = 60.3'' Max = 64.7''
Height of Controls (standing work stations)	Distance from the standing surface to the controls in a standing work station	Min = 40.0'' Max = 55.0''
Height of controls (Supplemental work stations)	Distance from standing surface to the controls in a supplemental work station.	Min = 35'' Max = 65''
Awkward Wrist Positions	Length of time an operator is required to hold an awkward wrist position in a workstation.	Max = 30 sec
Angle of Rotation	Maximum angle measured from operator midline that operator is required to rotate the torso within the workstation.	Max = 60 degrees

11.2. Safety distance calculations for point of operation devices:

11.2.1. Applications for North America

Formula:

$$Ds = K \times (1.25 \times Ts + Tr) + Dpf$$

Definitions:

Ds -The Safety Distance, in mm

K - 1600 mm per second. (Ref. the OSHA 29CFR1910.217, and ANSI B11.19 recommended hand-speed constant)

Ts - The overall stop time of the machine (in seconds) from the initial stop signal to the final ceasing of all motion, including stop times of all relevant control elements and measured at maximum machine velocity.

Tr - The maximum response time, in seconds, of the Point of Operation safety device. (Ref. manufacturer's specification)

Dpf - Added distance due to the light curtain depth penetration factor as prescribed in OSHA 29CFR1910.217, and ANSI B11.19. Calculated using light curtain manufacturer's specification for resolution using the formula (in mm):

Dpf = 3.4 × (S - 7) where S is the resolution of the light curtain (for S ≤ 63 mm).

11.2.2. Applications for Europe or Asia

Formula:

$$S = 1.25 \times (K \times T) + C$$

Definitions:

S - The minimum distance, in mm, from danger zone to light screen center line

K - Hand-speed constant; 2000 mm/s (for Min. Distances < 500 mm) 1600 mm/s (for Min. Distances > 500 mm) (Ref. ISO 13855)

T - The overall machine stopping response time (in seconds), from the physical initiation of the safety device and the machine coming to a stop (or the hazard removed).

C - Additional distance, in mm, based on intrusion of a hand or object towards the danger zone prior to actuation of a safety device. Calculate using the formula (in mm): C = 8 × (d - 14) where d is the resolution of the light curtain (for d ≤ 40 mm).