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Cardinal IG: Keying Process

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Problem Statement

The current process for setting guide keys into aluminum extrusions is performed manually. It is a tedious and unergonomic process. The team needs to evaluate the process for improvement or replacement.

The keying process is done by hand. Each key has to be placed in a channel one by one. Then keys are secured into the channels by using a wooden block which is smashed against the keys. This process is taking too much time, and it is hard on the employee's hands. When attempting to secure the keys in the channels, a hole begins to wear into their gloves. The employee attempted to fix this problem by placing a piece of cardboard into their glove. Currently, they only have two employees completing this task. One of these employees rarely does this task. This problem needs to be addressed because the person completing it is currently a manager and could be doing more important things. This task is also disliked by the employees and by reducing time completing this task, it would also increase their morale.

Disciplines

Bioresource and Agricultural Engineering | Industrial Technology

IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Cardinal IG: Keying Process

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Client:

Cardinal IG, 716 NE 6th Street, Greenfield, IA, 50849,

- **Roy Molina**, CI Engineer, rmolina@cardinalcorp.com

1 PROBLEM STATEMENT

Problem Statement

The current process for setting guide keys into aluminum extrusions is performed manually. It is a tedious and unergonomic process. The team needs to evaluate the process for improvement or replacement.

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Business Case Statement

Cardinal Glass was founded in Minneapolis, Minnesota in 1962 by M.L. Gordon. Since then, they have grown to employee 6,000 people in 37 locations around the United States. Our project was based out of their Greenfield Iowa location, commonly known as Cardinal IG, insulating glass. Currently, their keying process has slow cycle times, costs too much, and creates unnecessary safety concerns. By reducing cycle times, productivity will increase, and the manager currently working on this task will be free to do other, more important tasks. This solution could potentially help other custom window manufacturers.

2 GOAL STATEMENT

- **Main Objective(s) and Specific Objectives**
  The main objective is to: Develop a keying process, reducing time, cost, and risk.
  Specific objectives include:
  - Design a solution that meets all client's criteria and constraints
  - Create a physical prototype
  - Test prototype
- **Rationale**
  - Improve their current process by reducing cycle times by at least 15%
  - Improve ergonomics and overall safety risks

3 PROJECT PLAN/OUTLINE

A. Methods/Approach

- **Data collection**:
  - The data collected was mostly through time trials.
- **Skills**:
  - TSM 116: Introduction to Design Technology
  - TSM 214: Managing Technology Projects
  - TSM 477: Risk Analysis and Management
- **Solutions**:
  - Prototype #1
  - Prototype #2
  - Prototype #3
- **Organization:**
  - Our team meets with our client week. This was done either through an email or phone call.
  - Each person in our team was assigned a role. Based on the role they were assigned correlated with an assignment that would fall under their role description.
  - Some major milestones for our project included when we received our project, when we created each of our prototypes, and when we created and implemented our final design.

- Whenever we received setbacks we made sure we spent extra time that week focusing on these changes and we verified that these changes were absolutely what they wanted.

B. Timeline

- Research
  - Start: 11/26/2018
  - Finish: 12/24/2018
- Designing of Prototypes
  - Start: 12/03/2018
  - Finish: 01/28/2019
- Prototype Building Phase
  - Start: 02/04/2019
  - Finish: 04/01/2019
- Final Report/Presentation
  - Start: 02/11/2019
  - Finish: 05/02/2019

4 RESULTS

Our project has four main deliverables; design a prototype to reduce cycle time and ergonomic risk, conduct a time study, provide before and after implementation ergonomic assessments, and provide recommendations for future steps. These deliverables are consistent with the project objective and scope. Following steps would be to improve the prototype and move into using stronger materials.

Time Study

Our time study covers the loading process of the key holder, the starting of inserting keys into the spacers, placing the key holder on the bolt, clamping down spacer bundle, and using the clamp to insert the keys fully. Figure 1 in the Appendix shows the data we collected. Our current average time is 75 seconds which matches the current process, however after practice we were able to lower our time further down the table, we would expect this to happen with the current operators as well.

Future Recommendations

We recommend making a few changes to the current design before implementation. The first is getting an aluminum key holder part made. We have some concerns with the difficulty of milling our design because of the inside corners. Our design should work without a bolt hole, other options to attach the key holder could be investigated.

We recommend mounting the hold down clamps 5 in from the end of the quick connect bolt when fully extended. This will give enough space for the spacers to be secured and the key holder is still close enough to insert the keys in one stroke. The clamps should be mounted opposite each other and 8in apart. We recommend mounting the horizontal clamp at the end of the workbench, so the operator can stand on the end to use it.

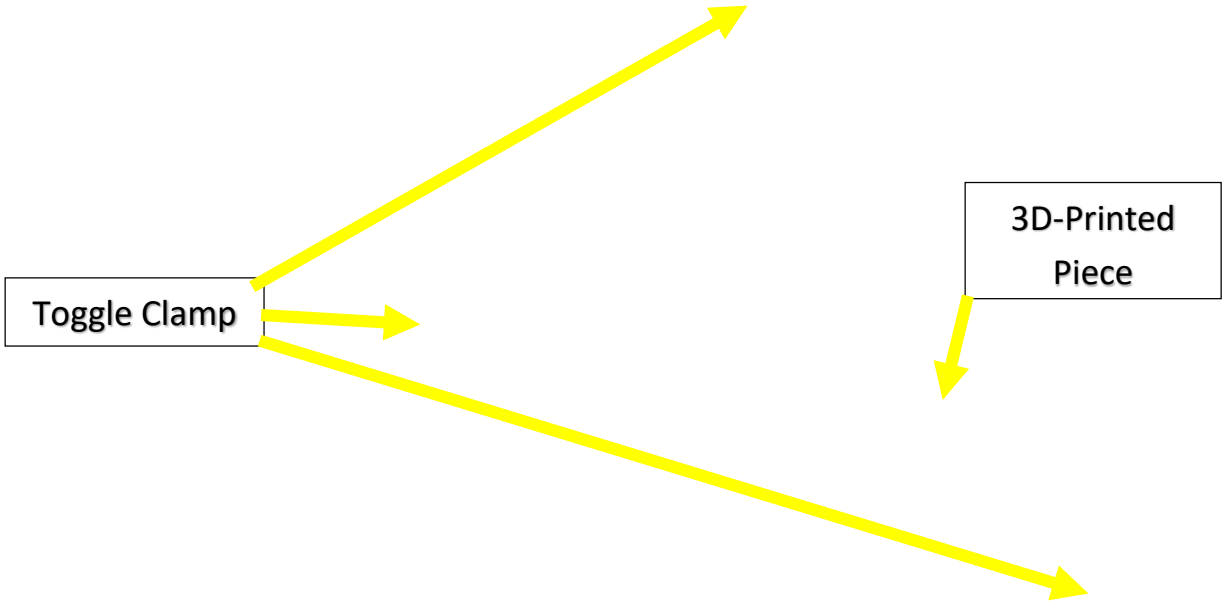
Another recommendation would be to add guides for the bundle of spacers so that the spacers can be aligned the same way every time. Additionally, there is a possibility to remove the need for a backstop

by using a material for gripping the spacers that have high enough static friction. In the current form of the prototype, a backstop is required, so extending the work table for longer spacers would be recommended. If after making changes to the prototype, the implementation works well a dual-action pneumatic cylinder to replace the clamp could be considered. This would add more precision to the current process with higher capability for repeatability.

5 BROADER OPPORTUNITY STATEMENT

Our project helps demonstrate to the workers of cardinal glass that they should expect an ergonomically safe environment. It provides an example to the workers of an undesirable work situation that was identified and resolved. This will hopefully lead to future identification of issues. Developing a culture where workers can identify problem areas is very advantageous to keep good worker morale. Our project relates to many industries that perform intricate tasks. Now that we have a simplified process, there is a clear opportunity for automating in the future. Automation would potentially further reduce cycle time as well as eliminate more risk. In order to automate the process, the human-operated clamp would be replaced by a double acting pneumatic cylinder. This solution would require additional guarding to eliminate the possibility of the system cycling while an operator has a hand in the cycle zone.

6 GRAPHICAL ABSTRACT



7 REFERENCES

Chopra, Shweta. Personal communication.

"Ergonomic Assessment Checklist." *OSHA*, www.osha.gov/sites/default/files/2018-12/fy14_sh-26336-sh4_Ergonomic-Assessment-Checklist.pdf.

Gibson, Benjamin. Personal communication.

Koziel, Jacek. Personal communication.

"Toggle Clamp,750 Holding Capacity (Lb.),7.5 Overall Height (In.),5.45 Overall Length (In.)." *Grainger*, Jan. 2019, www.grainger.com/product/GRAINGER-APPROVED-Toggle-Clamp-13F619.

Vanstrom, Joseph. Personal communication.

8 APPENDIXES

8.1 DESIGN

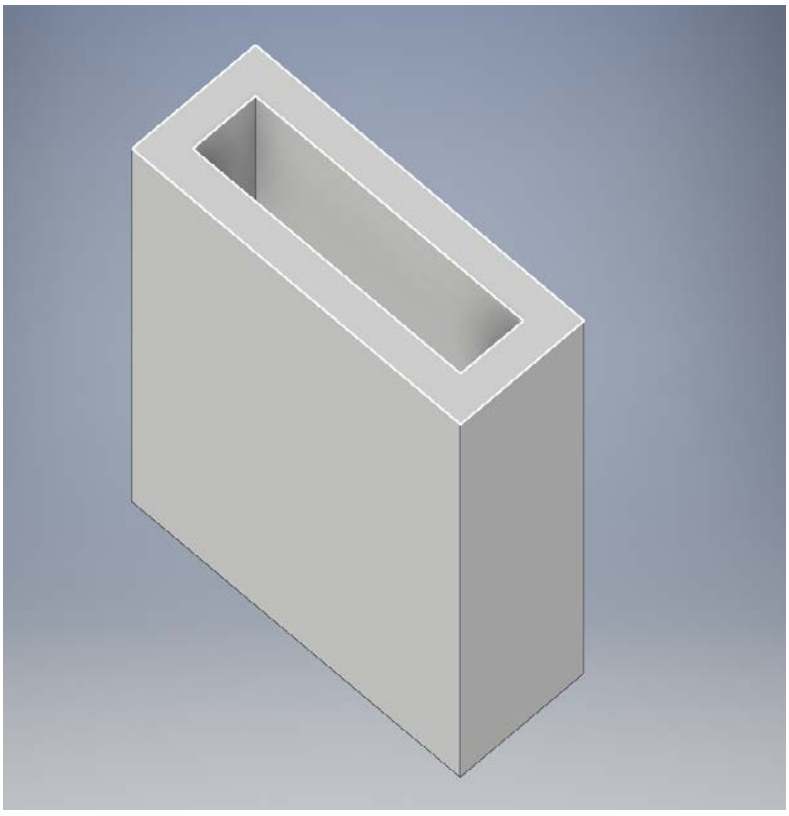


Figure 1: Prototype #1 - Proof of Concept

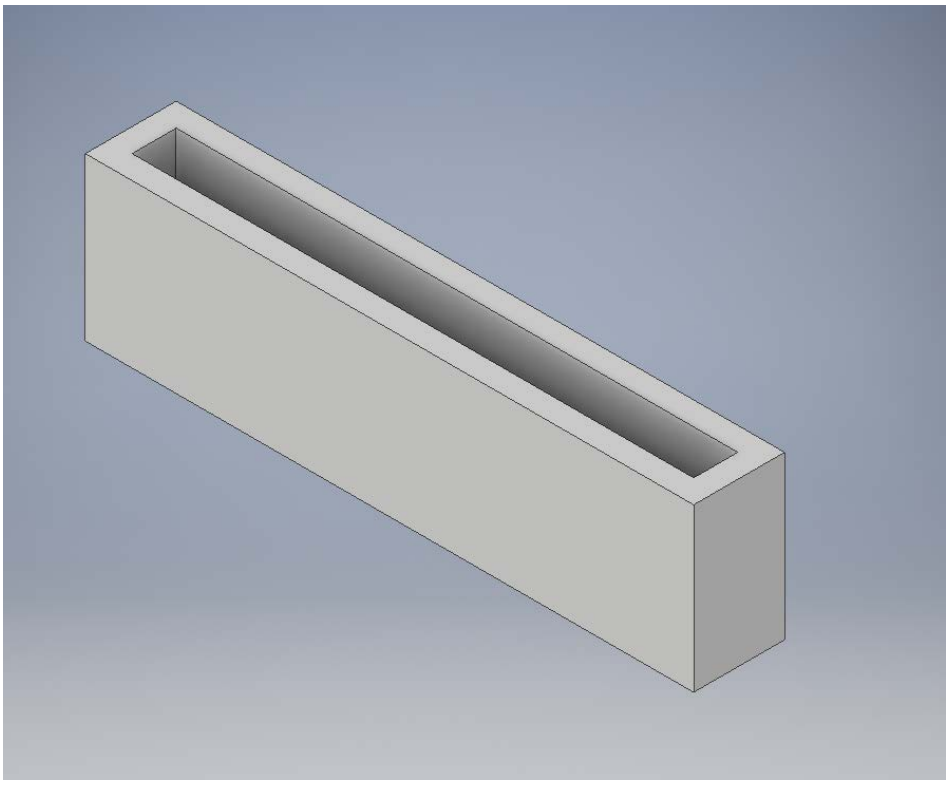


Figure 2: Prototype #2 - Full 24 Key Holder

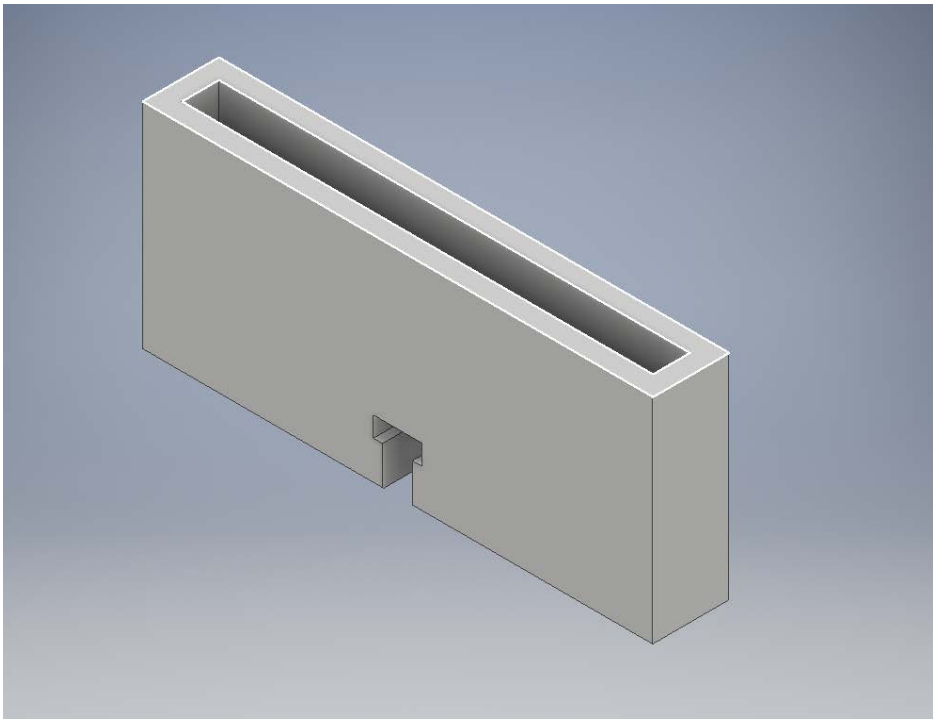


Figure 3: Prototype #3 - Final Design

8.2 TIME STUDY

Time Study			
	Trial #	Time(s)	
	1	80	
	2	90	
	3	84	
	4	98	*Outlier Deleted from Average Calculation*
	5	101	*Outlier Deleted from Average Calculation*
	6	98	*Outlier Deleted from Average Calculation*
	7	83	
	8	81	
	9	73	
	10	74	
	11	72	
	12	70	
	13	64	
	14	62	
	15	66	
	Average	74.9 seconds	

Table 1: Time Trials

8.3 BILL OF MATERIALS

Bill of Materials			
Item	Quantity	Unit Price ($)	Total
Toggle Clamp, Flanged Base	1	46.23	46.23
Toggle Clamp (hold down)	2	38.13	76.26
Key Holder Box	1	26.67	26.67

Table 2: Bill of Materials

8.4 RISK ANALYSIS

Severity of Consequences					
Category/ Descriptive Word	Personnel Illness/ Injury	Equipment Loss ($) **	Down Time	Product Loss	Environmental Effect
I Catastrophic	Death	>1M	>4 months		Long-term (5 yrs or greater) environmental damage or requiring >$1M to correct and/or in penalties
II Critical	Severe injury or severe occupational illness	250K to 1M	2 weeks to 4 months	Values as for Equipment Loss	Medium-term (1-5 yrs) environmental damage or requiring $250K-1M to correct and/or in penalties
III Marginal	Minor injury or minor occupational illness	1K to 250K	1 day to 2 weeks		Short-term (<1 yr) environmental damage or requiring$1K-$250K to correct and/or in penalties
IV Negligible	No injury or illness	1K	<1 day		Minor environmental damage, readily repaired and/or requiring < $1K to correct and/or in penalties

Exposures

**Life Cycle = 25 yrs;

Probability of Mishap**		
Level	Descriptive Word	Definition
A	Frequent	Likely to occur repeatedly in system life cycle
B	Probable	Likely to occur several times in system life cycle
C	Occasional	Likely to occur sometime in system life cycle
D	Remote	Not likely to occur in system life cycle, but possible
E	Improbable	So unlikely it can be assumed occurrence may not be experienced
F	Impossible	Physically impossible to occur

A Risk Assessment Matrix*

Severity Of Consequences	Probability of Mishap**					
	F Impossible	E Improbable	D Remote	C Occasional	B Probable	A Frequent
I Catastrophic					1	
II Critical				2		
III Marginal			3			
IV Negligible						

Risk Code/ Actions: 1 Imperative to suppress risk to lower levels; 2 Operation requires written, lime-limited waiver, endorsed by management; 3 Operation permissible

Note: Personnel must not be exposed to hazards in Risk Zones 1 and 2.

**Life Cycle = 25 yrs.

8.5 ERGONOMIC ASSESSMENT

Ergonomic Assessment Checklist	**Date**	**Activity Assessed**	
Risk Ratting (circle one) **High Medium Low** *See Notes on bottom of form to obtain the Rating*	**Organization**		**Point of Contact**
	Personnel Observed		
	BLDG NO/Location		**ROOM/AREA**

Ergonomic Assessment Checklist

Risk Factors	**Yes**	**No**
1. Have any shop workers been previously diagnosed with any of the following CTD's: Carpal tunnel, Tendonitis, Tenosynovitis, De Quervain's disease, Trigger Finger, White finger, Hand Arm Segmental Vibration Syndrome, Muscle strains, or Back ailments?		
2. Have there been any worker complaints concerning ergonomic issues?		
3. Do employees perform high repetition tasks? (100 reps/hour to 2000 per/day)		
4. Do the employee's routine tasks require repeated heavy lifting? (>20 lbs) or occasional heavy lifting (>50 lbs)		
5. Are employees using awkwardly designed tools, which cause the worker to operate the tool outside of a neutral position for an extended period of time? (> 1 hour)		
6. Do employees perform tasks with an awkward head or neck position for an extended period of time? (1 to 3 hours)		
7. Do employees perform tasks that require awkward back angles to be held for extended periods of time (2 to 3 hours)? i.e…hunching, bending, or squatting		
8. Do employees perform tasks with an awkward elbow angle for an extended period of time (1 to 3 hours) or with extreme force application?		
9. Do employees perform tasks with an awkward elbow abduction angle for an extended period of time (1 to 3 hours) or with extreme force application?		
10. Do employees perform tasks with an awkward wrist flexion angle for an extended period of time (1 to 3 hours) or with extreme force application?		
11. Do employees perform tasks with an awkward wrist extension angle for an extended period of time (1 to 3 hours) or with extreme force application?		
12. Do employees perform tasks with an awkward back/hip flexion angle for an extended period of time (1 to 3 hours) or with extreme force application?		
13. Do employees perform tasks with an extreme reaching distance for an extended period of time (1 to 3 hours) or with extreme force application?		
14. Do employees perform tasks with an odd work station height (either standing or sitting) for an extended period of time (1-3 hours) or with extreme force application?		
15. Are high impact tools used routinely? i.e., riveters, bucking bars, or impact wrenches		
16. Are high vibration producing tools used routinely? i.e., die grinders, sanders, weed eaters		
17. Do employees perform tasks at an extreme height (high or low) for an extended period of time (1 to 3 hours) or with extreme force application?		
18. Are there any other areas of concern either from your observations or employee complaints?		

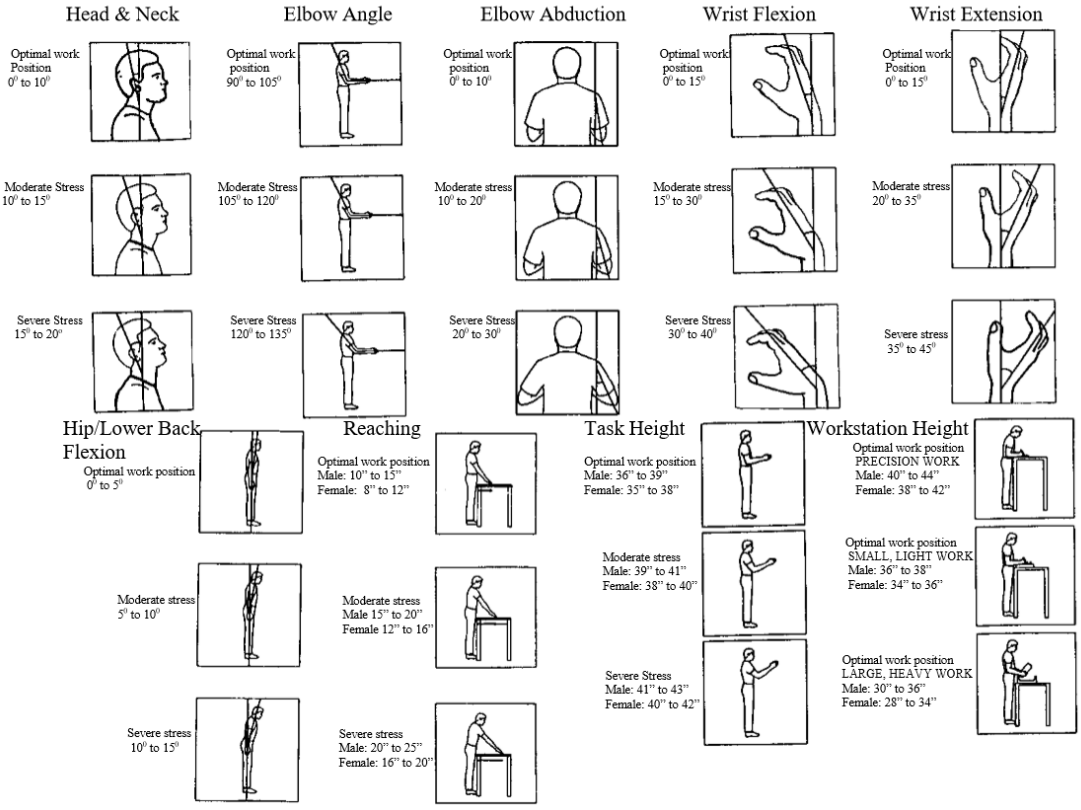
*Note if there is a **Yes** checked in any block please use page two to give a brief explanation of what the activity is or what the worker complaint was.

High Risk: If you answered Yes to #1 (and the shop has done nothing to fix it), if Yes to #2 or 3 and two other Yes's in #'s 4 through 15, or if Yes to six or more in #'s 4 through 15.
Medium Risk: If you answered Yes to #1 (and the shop has made changes), if Yes to #2 or 3 and one other Yes in #'s 4 through 15, or if Yes to three to five in #'s 4 through 15.
Low Risk: If no Yes's in #'s 1, 2, or 3 and less than 3 Yes's in #'s 4 through 15.

Ergonomic Survey Evaluation	Date	Activity Assessed

Ergonomic Survey Checklist Evaluation Explanation		
Question number & Activity Name	Brief Explanation – use this section if you answered yes to any questions on page 1 (please list corresponding question number) and briefly outline any risks associated with an activity	Risk Factors

Name of Assessor	Name of Reviewer


Head & Neck
Optimal work Position 0° to 10°
Moderate Stress 10° to 15°
Severe Stress 15° to 20°
Elbow Angle
Optimal work position 90° to 105°
Moderate Stress 105° to 120°
Severe Stress 120° to 135°
Elbow Abduction
Optimal work position 0° to 10°
Moderate stress 10° to 20°
Severe Stress 20° to 30°
Wrist Flexion
Optimal work position 0° to 15°
Moderate stress 15° to 30°
Severe Stress 30° to 40°
Wrist Extension
Optimal work Position 0° to 15°
Moderate stress 20° to 35°
Severe stress 35° to 45°
Hip/Lower Back Flexion
Optimal work position 0° to 5°
Moderate stress 5° to 10°
Severe stress 10° to 15°
Reaching
Optimal work position Male: 10" to 15" Female: 8" to 12"
Moderate stress Male 15" to 20" Female 12" to 16"
Severe stress Male: 20" to 25" Female: 16" to 20"
Task Height
Optimal work position Male: 36" to 39" Female: 35" to 38"
Moderate stress Male: 39" to 41" Female: 38" to 40"
Severe Stress Male: 41" to 43" Female: 40" to 42"
Workstation Height
Optimal work position PRECISION WORK Male: 40" to 44" Female: 38" to 42"
Optimal work position SMALL, LIGHT WORK Male: 36" to 38" Female: 34" to 36"
Optimal work position LARGE, HEAVY WORK Male: 30" to 36" Female: 28" to 34"