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Evaluation of Work Posture and Repetitive Work of Quality Inspectors by RULA and OCRA

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Abstract

This study was carried out at a small scale industry specifically at an Inspection Quality Control (IQC) department (IQC 1-blank gear inspection and IQC 2-gear inspection) as their daily activities frequently use upper limb and repetitive movement. This working condition may affect Work-related Musculoskeletal Disorders (WMSDs). A self-assessment session found that most of the quality inspectors had complaints concerning their health because of their work activities. Hence, 9 respondents out of 18 respond respectively. To identify the main ergonomic risk factors that may cause harm to employees and determine the likelihood of harm arising from exposure to the ergonomic risk factors among quality inspectors towards their work activities, an ergonomics assessment was carried out on upper limb extremities of workers. An approach consisting of four stages as outlined in the Guideline on Ergonomic Risk Assessment (ERA) at Workplace (2017) has been used in this study: 1) Initiating ERA using proactive approaches by using a Checklist of Self Questionnaires. 2) Pain or discomfort identified, using checklist of initial ERA (level 1) requires an initial ERA. 3) The outcome determines what is needed to carry out advanced ERA (Level 2 due to initial ERA score for awkward posture being 6 and 3 for repetitive work, 4) knowing the score, the level of risk and level action with the RULA (Rapid Upper Limb Assessment) method for awkward posture .5) knowing the score, the level of risk and level action with the OCRA checklist method for repetitive work. The higher result of RULA calculation is worth 7 (further investigation and implement changes) and OCRA checklist is 15.29 (medium risk level) indicated that 11.71% predicted workers population to have WMSDs, respectively. Therefore, the work system needs to be improved by recommending the adjustment of the workstation area and work activities to minimise muscle injury to the quality operators.

Keywords: ergonomics, RULA, ORCA, work posture, repetitive work

■ 1.0 INTRODUCTION

A case study conducted by Ansari and Sheikh (2014) found that most of the work in small scale industries are still carried out manually and while in a standing position. Hence, issues of work-related musculoskeletal disorders and injuries in different parts of the body are of great concern. RULA (rapid upper limb assessment) is a survey method developed for use in ergonomics investigations of workplaces where work-related upper limb disorders are reported. Meanwhile, the OCRA (Occupational Repetitive Actions) methods were developed in Italy to analyse workers' exposure to tasks featuring various upper-limb injury risk factors (Croitoru et al., 2015). Poor working conditions are bad news for both employees and employers, resulting in physical suffering and adverse economic impact (Sefouhi & Bouterfa, 2018). The comfort level of the job itself also helps in the productivity of a worker, in error minimisation, reduce absenteeism, and avoid work-related musculoskeletal disorder (WMSDs) among workers. WMSDs result in a high cost to the industry or society as well as reducing production and increasing human suffering and disabilities. Uninterrupted sitting may be particularly problematic; being linked with unfavourable cardio metabolic profiles, regardless of total sitting time

(Chastin *et al.*, 2015). This monotonous and repetitive work, plus unergonomic working tools can cause WMSDs in workers, and will have impact on work productivity (Ayu & Eva, 2015). WMSDs involve sudden or continuous stresses on a worker's musculoskeletal system (e.g., muscles, tendons, ligaments, and bones) and may impair the ability of the worker to perform his or her job, or even cause permanent disability (Wang, Dai & Ning, 2015). The workplace environment plays an important role in employee satisfaction. An organisation attends to its general design and workplace decor; it will also increase its employee productivity (Olabode *et al.,* 2017). Therefore, an ergonomic workplace is a must for a worker to do tasks comfortably. Omoneye (2016) revealed that a significant relationship exists between ergonomic hazards and performance; the study also showed that the more the level of stress reduced through ergonomics inputs and design, the higher the performance among the employees.

The aim of this case study is to find out the job satisfaction level related to the working conditions in the IQC department at a small scale industry by conducting a survey and observation of the workers as well as the workplace condition. The study will take into consideration several factors such as the working environment, working hours, workspace, and equipment and/or tools used. Some recommendations are given to the problems that were identified during the case study.

The objective of this case study is to find the employees' satisfaction level with working conditions at their current workstations. The targeted area, which is the inspection section, is normally busy with the inspection that has to be done to the product and they don't have much time to care or be concerned about the department workspace. As the evaluation of ergonomics has never been done in this company, the case study is also done to find out any ergonomics problem that is dominant at the inspectors' workstations or the workplace. Once the problem is identified, suggestions and recommendation are given to the workers and also the administrator to solve the ergonomics problems in the department. Work ergonomic measures would allow the employees to adopt optimal working postures suitable for a greater job satisfaction of the organisational workforce and expected higher job performance and organisational success (Sri, 2018). The study aims to obtain the value of workers' posture and provide recommendations for the repair system installation done manually. The result of the recommendations to the system can minimise muscle injury to the operators (Rizki & Dhia, 2018).

The provision of safety and health on ergonomics is related with OSHA 1994 and FMA 1967. It is the duty of the employer and self-employed person to ensure the safety, health and welfare at work of all their employees (Section 15 OSHA 1994). Section 4 (c) OSHA 1994 promotes an occupational environment adaptable to the person's physiological and psychological needs. In this case study it's very related with regulation 30(1) and 30(2) for Provision of safety, health and welfare in FMA 1967. Regulation 30(1) stipulates that in every factory where persons employed have in the course of their employment, reasonable opportunities for sitting without detriment to their work, there shall be provided and maintained suitable and sufficient seating facilities for their use. Regulation 30(2) prescribes that a) there shall be provided and maintained for any person employed in that work a seat of a design, construction and dimensions suitable for him and the work, together with a foot-rest if necessary to support his feet in order to reduce fatigue; and b) the arrangement shall be such that the seat is adequately and properly supported while in use for the purpose for which it is provided. According to Departmental of Occupational Safety and Health. (2017) by using The Guidelines on Occupational Safety and Health for Seating at Work enlightens how suitable seating contributes to the safety and health of people at work, for example by helping to prevent back pain.

The IQC department is one of the important sections in the production department of the small scale industry. The department consists of IQC1 and IQC2 sections. The IQC1 section performs the inspection of blank gears. The inspection involves inspecting the inner diameter of the blank gears by inserting the go and no go pin gauge into the hole of the parts. In addition, a tool microscope and magnifier are used to detect defects such as burrs, scratches and dented surfaces. They are also used to inspect the appearance of blank gears. The IQC2 section performs the appearance checking of the gear, which is the final product step before packaging. The inspection also uses tools such as microscopes and magnifiers as well as human vision. All tasks in both sections are executed manually without automation. The pictures below show the tasks performed by the workers and also the layout plan of the IQC1 and IQC2 sections of the small-scale industry.

IQC 1 (Blank gear before machining)	IQC 2 (Gear after machining)
	
Pic 1: Inspector using magnifier for blank gear inspection.	Pic 2: Inspector using manual vision for gear inspection.
	
Pic 3: Example of the workstation in IQC1.	Pic 4: Example of the workstation in IQC2
	
Pic 5: Inspector performing manual hole inspection using go and no go pin gauge.	Pic 6: Inspector position while executing task. (Video)

Figure 1: Posture adopted during working

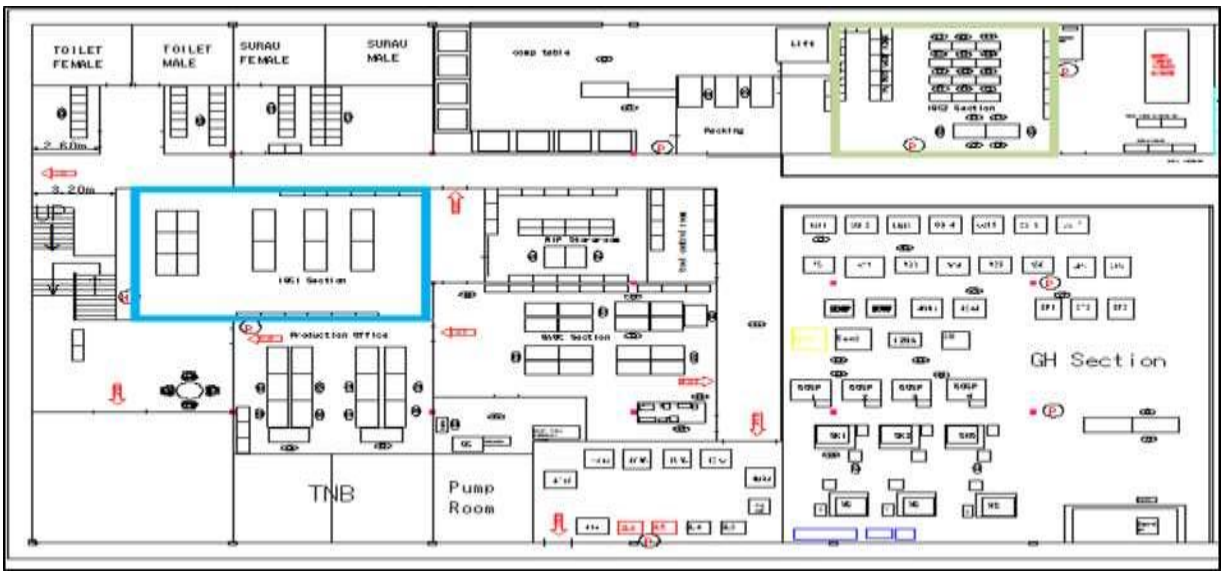


Figure 2: The plant layout

2.0 METHODOLOGY

The survey was conducted in the IQC department which is a department under the production department. There are two sections, IQC1 and IQC2 (100% appearance), in this department. Eighteen sets of self-assessment questionnaires were distributed to the company's workers with the permission of the human resource department.

The questionnaires in the initial ERA checklist approach were taken for the survey to get some data for the case study. The questionnaires comprised questions that are related to the ergonomic factors as mentioned in the problem description section (body position, health, vibration, ventilation, sound, lighting, working hours, and temperature). Each worker was asked to answer the questions with a tick on any body parts discomfort/pain, left or right, yes or no answer for self-assessment musculoskeletal as per Appendix 1 in the ERA guideline (refer to Appendix 1) and Cornell Musculoskeletal and Hand Discomfort Questionnaires as per Appendix 2. The data were evaluated based on the percentage of each factor in the initial ERA. Based on the result, the worker's risk level would be determined from the Advanced ERA and the factors that need recommendation for further ergonomic study will be determined.

2.1 Respondents

Eighteen subjects were selected based on workstations at IQC 1 and IQC 2. The demographic background of the subjects is shown in Table 1.

Table 1: Demographic background of respondents

Gender	Age	Education background	Number of workers
Female	< 20	SPM	0
	21–30		3
	31–40		8
	41–50		7
			18

Table 2: Result of Initial Ergonomic Risk Assessment Form

A	B	C	D	*E*		F
Risk factors	Total score	Minimum requirement for advanced assessment	Result of initial ERA	Any pain or discomfort due to risk factors as found in Musculoskeletal Assessment (refer Part 3.1) (Yes/No)		Need advanced ERA (Yes/No)
Awkward Postures	13	≥6	6	YES/NO If YES, please tick (/) which part of the body		Yes
Static and Sustained Work Posture	3	≥1	1	Neck	√	Yes
				Shoulder	√	
Forceful Exertion	7	1	0	Upper back	√	No
				Upper arm	√	
				Lower back	√	
Repetition	5	≥1	3	Forearm	√	Yes
Vibration	4	≥1	0	Wrist	√	No
Lighting	1	1	0	Hip/buttocks		No
Temperature	1	1	0	Thigh		No
Ventilation	1	1	0	Knee		No
				Lower leg		
Noise	2	≥1	0	Feet		No

Since the task requires 100% human effort, a survey on the job satisfaction level is needed to find out whether the workers are satisfied with the current working conditions. This form and checklist for initial ERA (refer to Appendix 3) and advanced ERA will help to identify any complaints or dissatisfaction regarding certain ergonomic factors that may have mentally and physically affected the workers' health.

The factors for ergonomic study are as below [2]:

Human:

- Body position – Most of the workers perform their task in a sitting position and requires repetitive motion of the wrist and fingers. For the workers, during the job execution, the body position while sitting requires strength on the neck and the backside of the body by using the RULA (Rapid Upper Limb Assessment) Checklist (refer to Appendix 2).

- Health – The repetitive tasks performed may mentally and physically affect the workers' health. The repetitive tasks are identified and listed by using OCRA (Occupational Repetitive Assessment) checklist (refer to Appendix 4)

Work environment:

- Ventilation – The workers need to inspect the parts after the cleaning process, which uses hydrocarbon. The hydrocarbon vapour may affect the health of workers if they're exposed to it for a long period. Therefore, ventilation is important to reduce the effect of the hydrocarbon vapour to the workers.
- Sound/noise – The IQC1 working area is located in a large room which personnel from other departments can easily access. The noise from outside of the IQC section (from the production site) can easily penetrate through when the door is opened and closed. This is the same for the IQC2 section even though IQC2 has a closed working area. This can disturb the workers' concentration while working.
- Lighting – Lighting is a very important factor in a workplace. The inspection job includes appearance checking which requires proper and sufficient lighting to detect defects. Since the inspection process is done manually, improper lighting (too bright or too dim) may cause eye strain or headache in the workers.
- Working hours – The normal working hour for this plant is 8 hours per day with overtime of 3 hours per day for weekdays and also 12 hours of overtime on off days (Saturday and Sunday). There are shift work hours for both departments.
- Temperature – The working area/room uses three air conditioners to cool the air and keep the workers comfortable. Air conditioning also prevents parts from being affected by the temperature. The room temperature ranges from 24°C to 28°C and the humidity ranges from 41% to 48%.

Workspace:

- Chair – The workers execute their tasks in a sitting position. Therefore, the chair is an important workstation equipment for the workers. The chair's adjustability is important to ensure the comfort and safety of the workers.
- Table workspace – The workers place the parts before and after inspection on the table. The space should be large enough for the workers to place their forearm on the table and also to avoid clutter because of the parts being arranged on the table. This will help to prevent workers from performing tasks in an awkward position and to avoid errors or mishandling of parts due to the lack of space. In addition, a well-arranged workspace helps to add comfort and reduces the stress level of workers.

Machine:

- Equipment and maintenance of the equipment – The equipment used are simple equipment. The workers use tool microscopes, magnifiers and pin gauges to inspect the parts. There is no equipment automation. The workers are required to plug the pin gauges in and out of the holes in a repetitive manner. This requires the repetitive use of the wrist and fingers. The tool microscope needs to be adjusted to a proper setting according to the Standard Operating Procedure for visual inspection. The tool microscope is equipped with its own light, which helps to provide sufficient lighting for visual inspection. Proper maintenance of this equipment is important so that the workers can smoothly execute their task thus achieving the desired productivity target.

Job satisfaction level:

- The workplace environment is the one of the factors affecting job satisfaction. Workplace conditions, such as humidity, indoor air quality, and acoustics have important relationships with workers' satisfaction and performance. The study not only focuses on identifying the main ergonomic risk factors that may cause harm to employees but also focuses on the job satisfaction level and the workers' intention to quit from the job. Therefore, there is a need to study whether the workers in the IQC1 and IQC2 departments are happy or dissatisfied with the current work conditions**.**

3.0 RESULTS AND FINDINGS

3.1 RULA

The assessment using the RULA worksheet is presented in Appendix 3. Table 3 presents the different categories of risk levels as obtained after analysing the posture.

Table 3: Categorisation under RULA Level

RULA Level	0	1	2	3
RULA score	1-2	3-4	5-6	7
Risk level	Negligible	Low	Medium	High
Reqd. Action	Acceptable	Investigate further	Investigate further and change soon	Investigate and change immediately
Percentage of workers	-	22 (4)	44 (8)	33 (6)

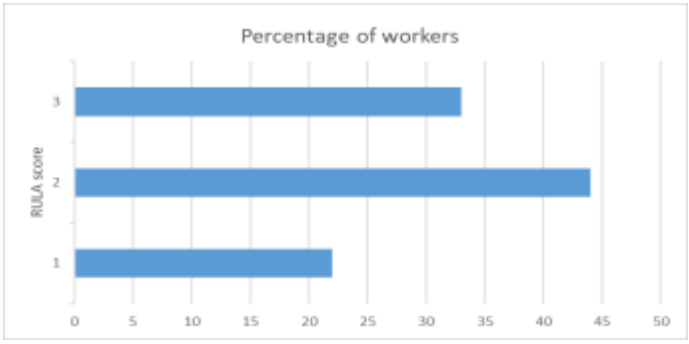


Figure 3: Percentage of workers under RULA Level

Figure 3 shows that around 33% of the workers are at high risk level and needs to be investigated and changed immediately, whereas 44% workers were found at medium risk levels and needs to be investigated further and changed soon. Around 22% of the workers are working in the category of ‑Investigate further‖. The results of the posture analysis using RULA are shown in Table 2. These results reveal that all categories of the risk levels exist in job postures. The table shows that the postures of 33% of workers performing the activities are at high-risk levels. A further investigation with an immediate change was recommended to these workers. The table also shows that none of the workers are at negligible risk level. The study was done on workers working in two sections of the industry and their activities were similar. The posture analysis was done according to these activities using the same sequence in the RULA and OCRA Checklists.

■ 3.2 OCRA

When these units were studied using the OCRA checklist analysis method (Tool), it was observed that the major body parts of the workers were working in postures at Medium risk and Dark red levels in Table 4. The step for using OCRA is outlined in Appendix 4.

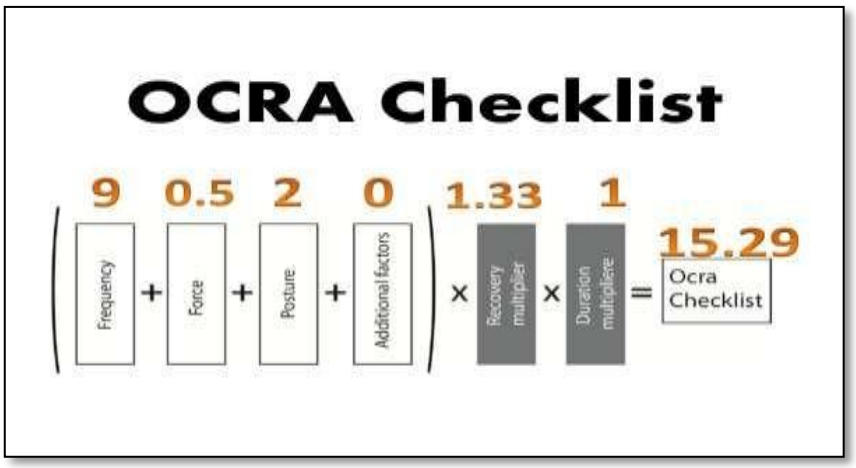
Table 4: Categorisation score under OCRA Level

REVISED OCRA CHECKLIST SCORE

OCRA CHECKLIST	OCRA INDEX	LEVEL	RISK	PREDICTED WORKER POPULATION WITH WMSDs (%)
< 7.5	< 2.2	Green	Acceptable risk	< 5.3
7.6 – 11.0	2.3 – 3.5	Yellow	Very low risk	5.3 – 8.4
11.1 – 14.0	3.6 – 4.5	Light red	Medium – low risk	8.5 – 10.7
14.1 – 22.5	4.6 – 9.0	Dark red	Medium risk	10.8 – 21.5
≧22.6	≧9.1	Purple	High risk	> 21.5

OCRA shows that most of the workers in the IQC1 and IQC 2 operation were working in acceptable posture and a necessary change may be required for them. All eighteen of the workers in the jobs were at medium risk levels with the total OCRA checklist at 15.29, dark red level and needed a necessary change. It was found that if the workers continued to work in the same posture they would suffer from MSDs related to the neck, trunk, and wrist in the near future.

Table 5: Prediction of Worker Population with WMSD



■ 4.0 DISCUSSION

a) The body posture:

In the RULA survey, 33% of respondents said that they aren't seated at their workstation for a long period of time, 44% said that they are doing the same movement for a long period of time, 22% said that they are working in a comfortable body position, All workers are performing tasks using arms, hands and fingers repetitively and frequently movement for a minute in time, and some said that they do feel physically exhausted at the end of the working day and some don't. The results from the interview of the workers showed that most of them were doing repeated tasks which did not really physically exhaust them. Even though the workers claimed that they were performing the same movement for a long period of time, the task did not extend to more than 3 hours. It was observed that the workers were given four rest periods with durations of 10 minutes in the morning, 40 minutes for lunch break, and 10 minutes for rest period (evening session). This may be the reason most workers did not physically feel exhausted after performing their task.

b) Health:

Most of the respondents claimed that they do not have sleep problems. The health of inspectors in the OHTA inspection department are considered good. However, some of them frequently experience muscle cramp while sleeping. This may due to the overuse of the muscles and dehydration. However muscle cramps are harmless, as the muscle cramps do not last for a long time. The pain on their neck, head, waist, wrist and fingers is caused by the repeated movements done by the workers using their lower arm especially wrist and fingers and also their sitting posture. The workers are advised do some lower arm exercises.

c) Equipment:

All respondents agreed that they are using equipment in good condition, and feel comfortable and safe while using the equipment. They also said that the equipment are located at a proper location for their use and management provides training on how to use the equipment and feel that the management are concerned with the workers' safety in choosing proper equipment and also quickly repair damaged equipment.

d) Workstation seating:

The workers claimed that they could easily adjust their chairs. However, in our observation they could not adjust their chairs to various positions, they could only adjust the height and the back support of the chairs. These findings show that not all chairs are in good condition. Some chairs can only be adjusted for seating height but not for back support. Some workers add cushions on their seat to increase the comfort level while sitting.

e) Workstation:

All of the respondents were satisfied with their workstation and felt comfortable at their workstation. However, their workstation layout is congested and cluttered. From our observation, this is due to the sudden increase in the volume of parts that they need to inspect which infrequently occurs.

f) Ventilation:

All respondents said that the rooms are not too hot. However, they feel that the room is too cold and has

an unpleasant odour. The workers said that there is too little air movement in the room and claimed that the air is too dry. The majority of the workers feel the room is too cold because they are working close to the air conditioning units. The unpleasant odour comes from the parts that are washed with hydrocarbon.

g) Acoustics:

The observation indicated that the noise level is satisfactory and their workstations don't have problems with noise. The management has made effort to minimise the noise level at their workplace.

h) Lighting:

All respondents said that their workstations have sufficient lighting and the management provided a flexible lighting system. Also, all the respondents said that the management always ensure that they have sufficient lighting and feel that the lighting system helps to improve their work productivity. All in all, 100% of the workers are satisfied with the lighting provided in the inspection room.

j) Complaints regarding body health:

The workers said that sometimes their body feels weak. However, they don't easily feel annoyed with their workstation environment. Moreover, only a few of them claimed that they easily get tired while working. However, none of the workers feel that they are powerless. Finally, none of the employees feel that their heart beats too fast due to problems related to work. It can be said that not all workers have serious complaints related to their body health.

k) Work Satisfaction:

The workers said that they are satisfied, happy and not feeling frustrated with their job. Only some of them stated that they feel their job is repetitive, boring and they easily get tired and angry when thinking about the job.

l) Intention to Leave:

Workers indicated that they love to work and care for the company. They also feel proud working in this company and willing to work hard for the company. It is clear that the workplace satisfaction is a factor to keep the workers at the company. However, the workers do have the intention to leave the company. Further interviews need to be conducted to investigate whether the intention is related to the workstation environment or other factors that are totally not related to the workstation environment. It is clear that the workplace satisfaction is a factor to keep the workers at the company.

■ 5.0 RECOMMENDATION

Based on the results obtained in the study, certain improvements can be made related to the ergonomic factors i.e. health, seating workstation, workstation, and ventilation. Following the hierarchy of control: elimination, substitution, engineering control, administrative and personnel protective equipment, our recommendations are listed below:

■ 5.1 Engineering control (Short term)

For workspace factor, it is advised that the supervisor limits the volume of parts that can be placed on the worker's inspection table. For example, if there are 2000 pcs (1000pcs/lot) of parts that need to be checked, only one lot is allowed to be placed on the worktable. Once the first lot is done, then the worker needs to transfer the finished lot to other departments and proceed with the next lot on the working table for inspection (Figure 4).

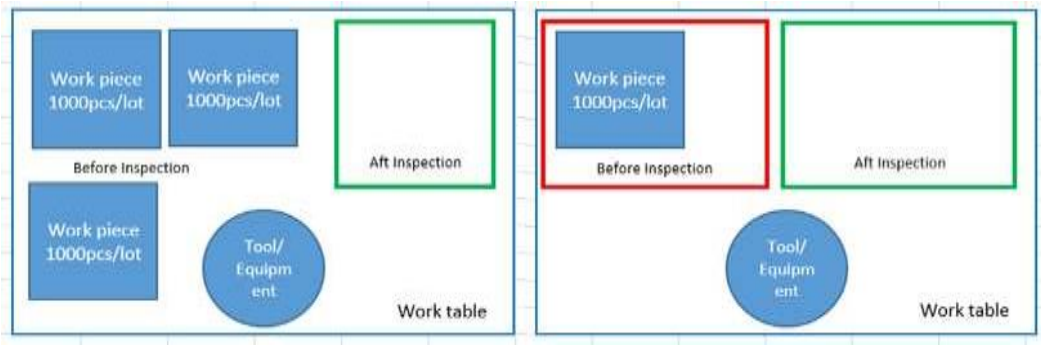


Figure 4: Left: Worktable with no quantity limit for placing work pieces.
Right: Worktable with quantity limit for placing work pieces.

For the ventilation factor, it is advised that the workers wear masks for most of the working hours to prevent from breathing in the hydrocarbon vapour during the inspection work and the management can install an air filter/air purifier in the room to reduce the hydrocarbon odour.

Microscope workstation — looking through a microscope for extended periods is not what we were designed for. It requires holding our bodies in an unnaturally rigid position. It is important to adopt a correct, ergonomic working posture. This means fitting the workstation to the worker, not vice versa. It is also important to take regular breaks. Ideally, the microscope should be on a bench, which is adjustable for height, and the seating position is adjusted followed by the bench height. Figure 5 and Figure 6 show a microscope workstation with improvements in working posture.

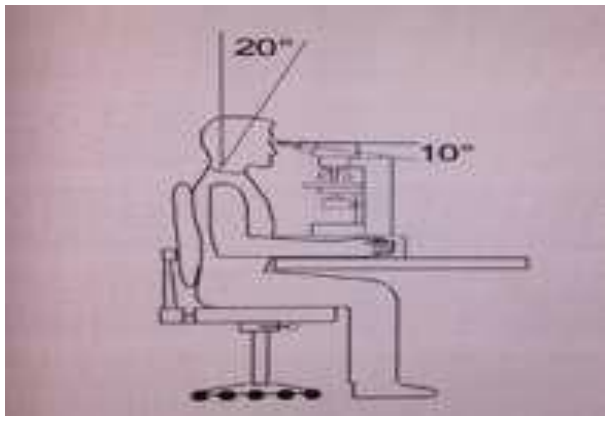


Figure 5: Microscope workstation

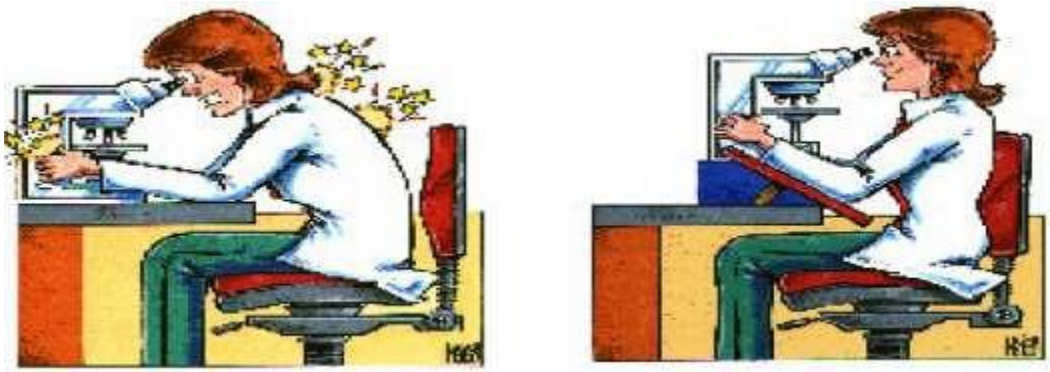


Figure 6: Improvement to Microscope Workstation

■ 5.2 Engineering control (long term)

For workstation seating

The size of the seat is important. It should be wide enough to seat big people comfortably. It should be deep enough to support the legs of tall people properly, but not so deep that shorter workers cannot use the backrest. The backrest should give firm support to the lower and middle part of the back. The management must take proper action to ensure that all workers are provided with height-adjustable seats to suit workers ranging from the very short to the very tall and have backrests in good condition. Sitting in one position for long periods can lead to discomfort and inefficiency, and ultimately may cause long-term ill effect. Many people who work sitting down can avoid discomfort by changing position, or by standing up and moving around. Other jobs may be less flexible unless opportunities for movement are deliberately built in, for example by giving workers a greater variety of tasks or arranging the workstation so that workers can be either siting or standing. So in the future, our suggestion is the management needs to change the seating at workstations (redesign work station) as shown in the guideline on seating at work (see Figure 7)

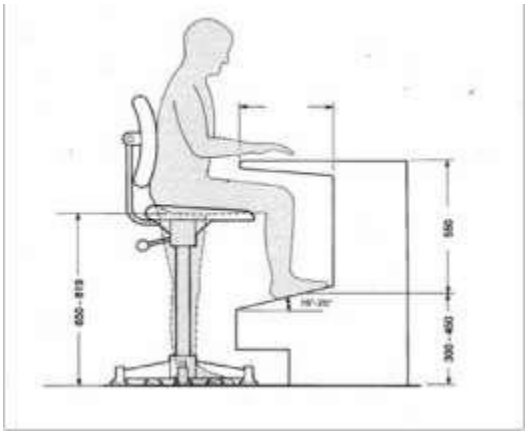


Figure 7: Workstation where workers can sit or stand

■ 5.3 Administrative control (short term & long term)

For health factor, it is advised that the workers do exercises to reduce the muscle tension in their neck, head, waist, wrist, and fingers for a few minutes once in the morning and once in the evening every day. The management can help by organising a training session, which will teach them how to do the exercises for this purpose. The workers should also be given a work-rest schedule to relieve their muscles of mechanical stress. The workers can also be put under task rotation.

■ 6.0 CONCLUSION

Such considerations including sufficient resting time, sufficient lighting, good air ventilation, good equipment made the workers feel unburdened and less stressed when doing their job. It is highly recommended that the company management think and take necessary action for further improvements in the current working conditions of the workers. The necessary low cost ergonomic solutions have already being applied such as adding cushions for support and comfort but more needs to be done to the improve the workers' chairs. Some recommendations were already discussed in the previous section, which can help to improve the working environment for the workers. This will result in the workers being more productive and loyal to the company, thus ensuring the company's success and high profitability.

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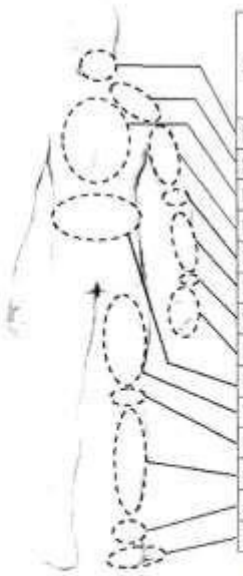
APPENDIX 1: SAMPLE SELF ASSESSMENT (QUESTIONNAIRE)

Appendix 1: SELF ASSESSMENT MUSCULOSKELETAL PAIN / DISCOMFORT SURVEY FORM (Refer to Part 2.1)

Instruction:

1. Tick (√) on any body parts (Column A) if you feel discomfort/pain during your work in the last 12 months
2. For those body parts you were feeling pain/discomfort, tick (√) (Column B) if in your opinion, the pain is due to your work.



Body Parts	A: I have pain/ discomfort in the following body parts.		B: I think the pain/ discomfort comes from work.	
Neck	✓		✓	
Shoulder	✓		✓	
Upper back	✓		✓	
Upper arm	L	R	L	R
Elbow	L	R	L	R
Lower arm	L	R	L	R
Wrist	L	R	L	R
Hand	(L)	(R)	(L)	(R)
Lower back				
Thigh	(L)	(R)	(L)	(R)
Knee	L	R	L	R
Calf	L	R	L	R
Ankle	L	R	L	R
Feet	L	R	L	R

Name: Shalani Devi A/P Kalimuthu Staff ID No.: 1159

Department: IBC 2 Job tasks Quality Inspector

Contact No.: 014-6222860 Email: Shalu@yahoo.com

Date: 2/06/19

(Do not write anything in the below section. To be filled by trained person only)

Is/Are the symptom(s) work related? Yes ☐ No ☐

Comments: _____

_____

Name: _____ Signature and stamp:

Date: _____

APPENDIX 2: INITIAL ERA CHECKLIST

Ergonomics Risk Factors Assessment
The followings are results from ergonomics risk factors assessment.
Awkward Posture
Checklist for Awkward Posture

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)		Activities / Remarks
			Yes	No	
Shoulders	Work with hand above the head OR the elbow above the shoulder	More than 2 hours per day		/	
	Work with shoulder raised	More than 2 hours per day	/		
Shoulders	Work repetitively by raising the hand above the head OR the elbow above the shoulder more than once per minute	More than 2 hours per day		/	
Head	Working with head bent downwards more than 45 degrees	More than 2 hours per day	/		
	Working with head bent backwards	More than 2 hours per day		/	

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)		Activities / Remarks
			Yes	No	
	Working with head bent sideways	More than 2 hours per day	/		
Back	Working with back bent forward more than 30 degrees OR bent sideways	More than 2 hours per day	/		 
	Working with body twisted	More than 2 hours per day		/	
Hand/ Elbow/ Wrist	Working with wrist flexion OR extension OR radial deviation more than 15 degrees	More than 2 hours per day	/		 

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)		Activities / Remarks
			Yes	No	
					
	Working with arm abducted sideways	More than 4 hours per day	/		
	Working with arm extended forward more than 45 degrees OR arm extended backward more than 20 degrees	More than 2 hours per day		/	
Leg/ Knees	Work in a squat position.	More than 2 hours total per day		/	
	Work in a kneeling position	More than 2 hours per day		/	
Sub Total (Number of tick(s))			**6**	**0**	

NOTE:
The total score for awkward posture is 13. Yes score of 6 and above will initiate an advanced assessment.
Static and Sustained Work Posture
Checklist for Static and Sustained Work Posture

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)		Activities / Remarks
			Yes	No	
Trunk/ Head/ Neck/ Arm/ Wrist	Work in a static awkward position as in Table 3.1	Duration as per Table 3.1 (i.e. More than 1 minute continuously)		/	
Leg/Knees	Work in a standing position with minimal leg movement	More than 2 hours continuously		/	
	Work in static seated position with minimal movement	More than 30 minutes continuously	/		 
Sub Total (Number of tick(s))			**1**	**0**	

NOTE:
The total score for static and sustained work posture is 3. Yes score of 1 and above will initiate an advanced assessment.

Ergonomics risk factors: (manual handling)

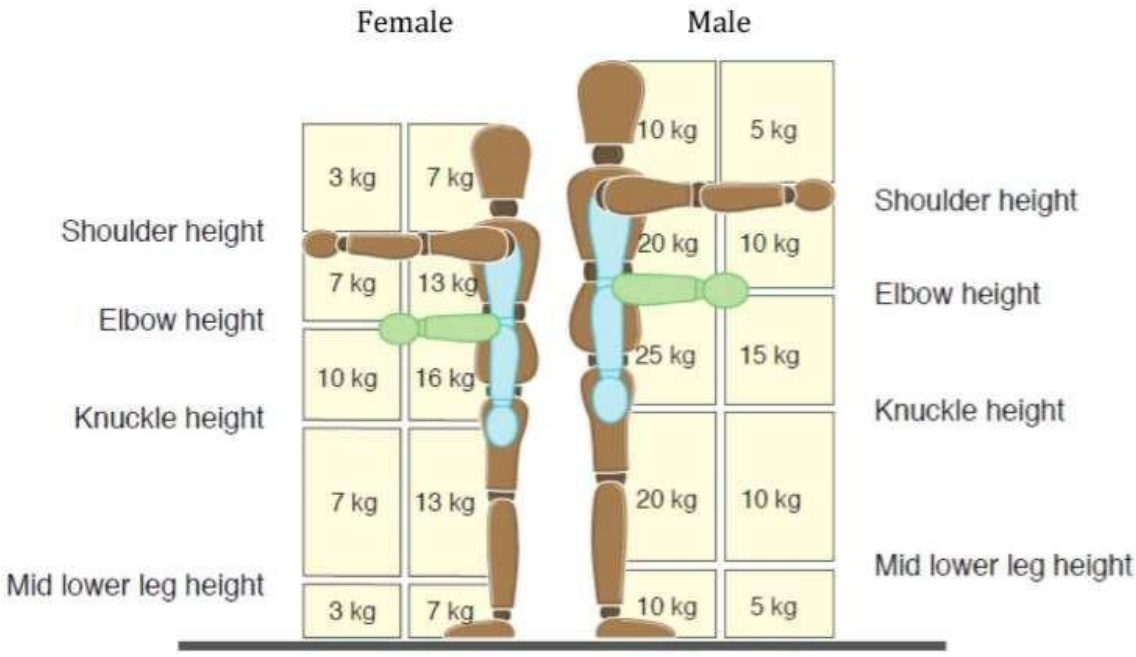


Figure 3.1: Recommended weight

Ergonomics risk factors: forceful exertion
(Manual handling - Lifting and/or Lowering)

Working height (where force is applied)	Recommended weight (male or female)	Current weight handled	Exceed limit?	
			Yes	No
Between floor to mid-lower leg				/
Between mid-lower leg to knuckle				/
Between knuckle height and elbow				/
Between elbow and shoulder				/
Above the shoulder				/

Repetitive Lifting and Lowering
(Manual handling - lifting and/or lowering with repetitive operation)

If employee repeats operation	Weight limit* should be reduced by
Once or twice per minutes	30%
Five to eight times per minutes	50%
More than 12 times per minute	80%

Lifting and Lowering with Twisted Body Posture
(Manual handling- lifting and/or lowering with twisted body posture)

If employee twists body from forward facing to the side	Weight limit* should be reduced by
45 degrees	10%
90 degrees	20%

Ergonomics risk factors: forceful exertion
Pushing and/or Pulling

Activity	Recommended weight	
	Male	Female
Stopping or starting a load	Approximately 1000kg load (equivalent to 200N pushing or pulling force) on smooth level surface using well-maintained handling aid	Approximately 750kg load (equivalent to 150N pushing or pulling force) on smooth level surface using well-maintained handling aid
Keeping the load in motion	Approximately 100kg load (equivalent to 100N pushing or pulling force) on uneven level surface using well-maintained handling aid	Approximately 70kg load (equivalent to 150N pushing or pulling force) on uneven level surface using well-maintained handling aid

Ergonomics risk factors: forceful exertion
Handling in Seated Position

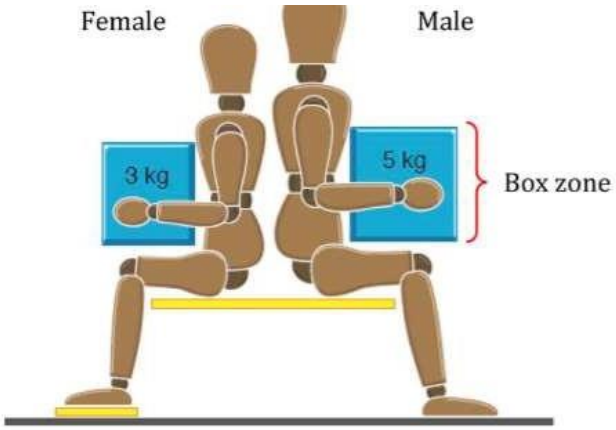


Figure 3.2: Recommended weight for seated position

Implementation of activities

Summary for implementation of activities

Factor	Condition	Outcome
Floor Surface	Dry and clean floor in good condition	Acceptable
	Dry floor but poor condition, worn or uneven	Conduct advanced ERA
	Contaminated/wet or steep slping flor or unstable surface or unsuitable fotwear	
Other environmental factors	No factors present	Acceptable
	One or more factor present (i.e. por lighting condition, extreme temperature)	Conduct advanced ERA
Carry distance	2 m – 10 m	Acceptable
	More than 10 m	Conduct advanced ERA
Obstacles en route	No obstacles and carry route is flat	Acceptable
	Steep slope or up steps or through closed doors or trip hazards or using ladders	Conduct advanced ERA

An advanced ERA for manual handling activity with carrying operation should be conducted if the outcome of any of the factor above is not acceptable.

Summary table for a single manual handling activity (forceful exertion)

Activity (where applicable)	Recommended weight limit	Exceed limit?	
		Yes	No
Lifting and lowering only; or	Based on Figure 3.1 and Table 3.3		/
Repetitive lifting and lowering; or	Based on Figure 3.1 and Table 3.4		/
Twisted body posture while lifting and lowering; or	Based on Figure 3.1 and Table 3.5		/
Repetitive lifting and lowering with twisted body posture; or	Based on Figure 3.1 and Table 3.4 and Table 3.5		/
Pushing and pulling; or	Based on Table 3.6		/
Handling in seated position; or	Based on Figure 3.2		/
Carrying	Based on Table 3.7		/

Forceful exertion in any of the manual handling activities in Table 3.8 with a YES, score of 1 requires an advanced assessment.

Ergonomics risk factors: Repetitive Motion

Checklist for Repetitive Motion

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)		Activities / Remarks
			Yes	No	
Neck, shoulders, elbows, wrists, hands, knee	Work involving repetitive sequence of movement more than twice per minute	More than 3 hours on a ―normal‖ workday OR More than 1 hour continuously without a break	/		
	Work involving intensive use of the fingers, hands or wrist or Work involving intensive data entry (i.e. key-in)		/		
	Work involving repetitive shoulder/arm movement with some pauses OR continuous shoulder/arm movement		/		
	Work using the heel/base of palm as a ―hammer‖ more than once per minute	More than 2 hours per day		/	
	Work using the knee as a ―hammer‖ more than once per minute.	More than 2 hours per day		/	
Sub Total (Number of tick(s))			**3**		

NOTE:
The total score for repetition is 5. Yes score of 1 and above will initiate an advanced assessment.

Ergonomics risk factors: Hands-Arm and Whole Body Vibration

Checklist for vibration

Body parts	Physical Risk Factor	Max. Exposure Duration	Please tick (/)	
			Yes	No
Hand-Arm (segmental vibration)	Work using power tools (e.g. battery powered/ electrical pneumatic/hydraulic) without PPE*	More than 50 minutes in an hour (i.e. More than 80% in hour)		/
	Work using power tools (i.e.: battery powered/electrical/ pneumatic/hydraulic) with PPE	More than 5 hours in 8 hours shift work (i.e. More than 60% in 8 hours shift work)		/
Whole body vibration	Work involving exposure to whole body vibration	More than 5 hours in 8 hours shift work (i.e. More than 60% in 8 hours shift work)		/
	Work involving exposure to whole body vibration combined with employee complaint of excessive body shaking	More than 3 hours in 8 hours shift work (i.e. More than 40% in 8 hours shift work)		/
Sub Total (Number of tick(s))			**0**	

***PPE related with protection to vibration**

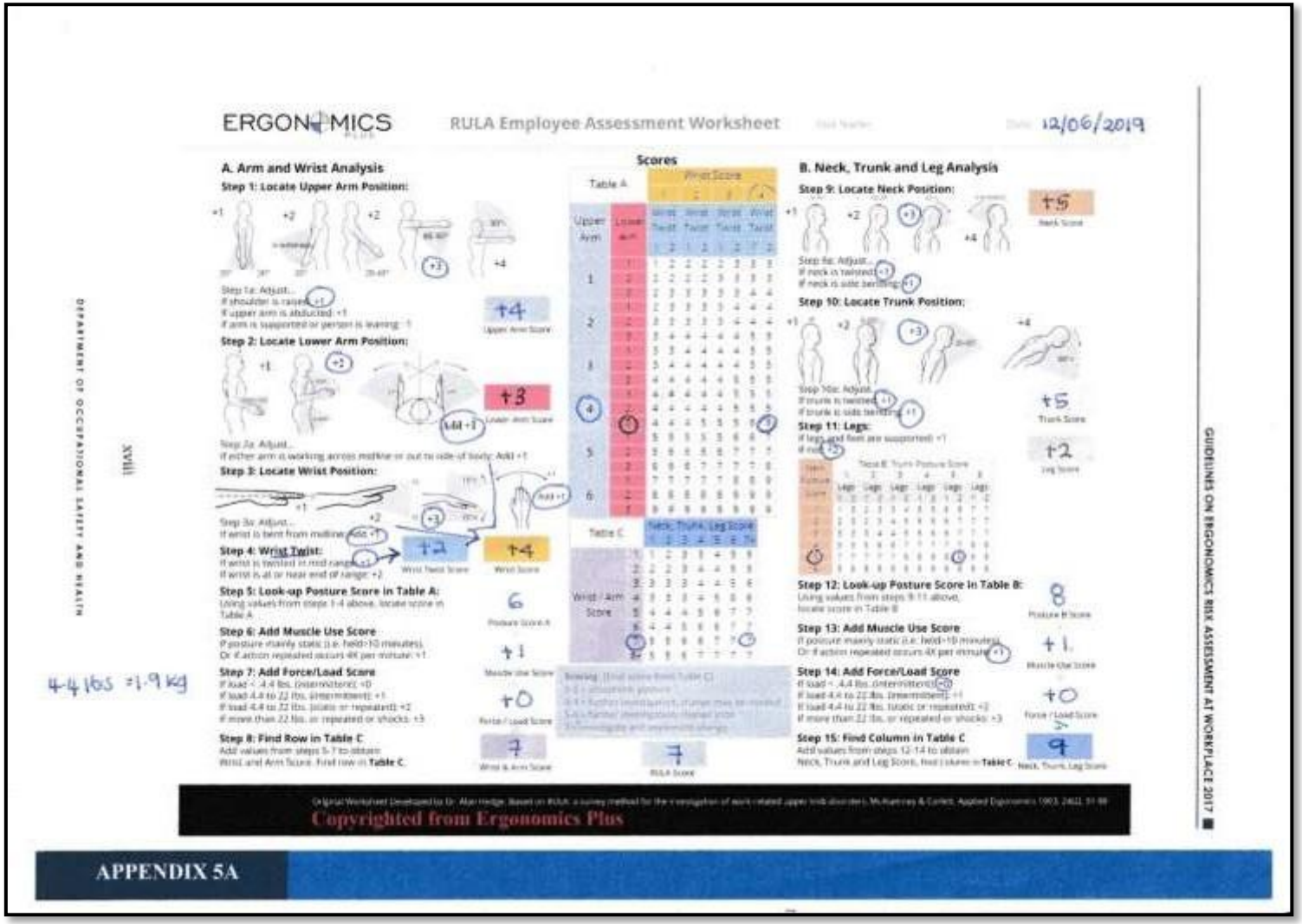
Note: The total score for vibration is 4. YES score of 1 and above will initiate an advanced ERA assessment.

Ergonomics risk factors: Environmental Risk Factors

Physical Risk Factor	Please tick (/)	
	Yes	No
Inadequate lighting		/
Extreme temperature (hot/cold)		/
Inadequate air ventilation or poor IAQ		/
Noise exposure above PEL		/
Exposed to annoying noise more than 8 hours		/
Sub Total (Number of tick(s))	0	

Note: Any evidence of extreme temperature in the workplace (YES, score 1) require an advanced assessment.

APPENDIX 3: RULA CHECKLIST



APPENDIX 5A

ERGONOMICS PLUS

RULA Employee Assessment Worksheet

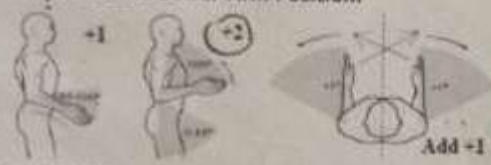
Task Name:

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:

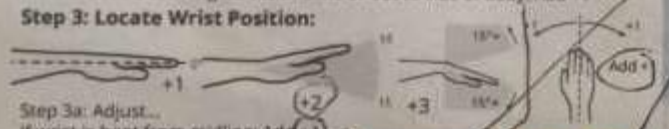
Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Step 2: Locate Lower Arm Position:



Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:



Step 3a: Adjust...
If wrist is bent from midline: Add +1

Step 4: Wrist Twist:

If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Step 5: Look-up Posture Score in Table A:

Using values from steps 1-4 above, locate score in Table A

Step 6: Add Muscle Use Score

If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Step 7: Add Force/Load Score

If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Step 8: Find Row in Table C

Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**.

Scores

+2 Upper Arm Score

+2 Lower Arm Score

Wrist Twist Score

+4 Wrist Score

4 Posture Score A

+1 Muscle Use Score

+0 Force / Load Score

5 Wrist & Arm Score

Table A

Upper Arm	Lower Arm	Wrist Score 1	2	3	4
		Wrist Twist 1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	3	3	3	3	4
	3	2	3	3	3	3	4	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	4	4	4	5
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	5	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C

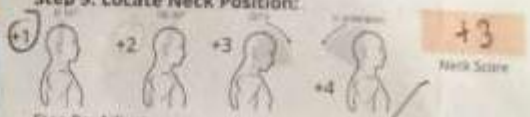
Wrist / Arm Score	Neck, Trunk, Leg Score 1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

6 RULA Score

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:



+3 Neck Score

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

+3 Trunk Score

Step 11: Legs:

If legs and feet are supported: +1
If not: +2

+1 Leg Score

Table B: Trunk Posture Score

Neck Posture Score	1 Legs 1	2	2	3	3	4	4	5	5	6	6
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:

Using values from steps 9-11 above, locate score in Table B

4 Posture B Score

Step 13: Add Muscle Use Score

If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

+1 Muscle Use Score

Step 14: Add Force/Load Score

If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

+0 Force / Load Score

=

Step 15: Find Column in Table C

Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C**.

5 Neck, Trunk, Leg Score

ERGONOMICS PLUS

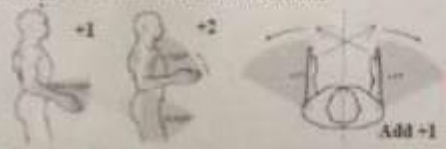
RULA Employee Assessment Worksheet

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:

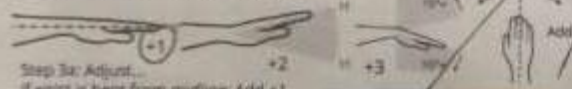
Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Step 2: Locate Lower Arm Position:



Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:



Step 3a: Adjust...
If wrist is bent from midline: Add +1

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Step 7: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**

Scores

+2 Upper Arm Score

+1 Lower Arm Score

+1 Wrist Twist Score

+3 Wrist Score

3 Posture Score A

+1 Muscle Use Score

0 Force / Load Score

4 Wrist & Arm Score

Table A

Upper Arm	Lower Arm	Wrist Score 1 Twist 1	1 Twist 2	2 Twist 1	2 Twist 2	3 Twist 1	3 Twist 2	4 Twist 1	4 Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	8
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C

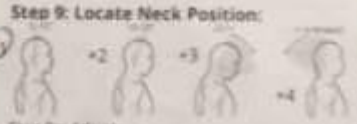
Wrist / Arm Score	Neck, Trunk, Leg Score 1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Scoring: (Final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7+ = investigate and implement change

3 RULA Score

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:



Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

Neck Posture Score	Trunk Posture Score 1 Legs	1 Legs	2 Legs	2 Legs	3 Legs	3 Legs	4 Legs	4 Legs	5 Legs	5 Legs	6 Legs	6 Legs
1		1	2	1	2	3	2	3	4	5	5	6	6	7	7
2		2	3	2	3	4	3	4	5	5	6	6	7	7	7
3		3	3	3	4	4	4	5	5	6	6	7	7	7	7
4		5	5	5	6	6	7	7	7	7	7	8	8	8	8
5		7	7	7	7	7	8	8	8	8	8	8	8	8	8
6		8	8	8	8	8	8	9	9	9	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Step 14: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find column in **Table C**

Neck Score

+2 Trunk Score

+1 Leg Score

2 Posture B Score

+1 Muscle Use Score

0 Force / Load Score

3 Neck, Trunk, Leg Score

APPENDIX 4: OCRA CHECKLIST

Using the OCRA analysis method, it was observed that the major parts of the workers were working in posture at Medium risk and Dark red level. The step for using OCRA refer the step below:

STEP 1

STEP 1: WORK INFORMATION

ORGANIZATIONAL DATA: DESCRIPTION		MINUTES
Duration of shift	Official	
	Real	510
Official break	By contract	
Other breaks (besides official)		20
Lunch break	Official	
	Real	40
Non-repetitive work	Official	
	Real	0
NET DURATION OF REPETITIVE WORK (1)-(2)-(3)-(4) = (5)		450

STEP 2

STEP 2: TASK INFORMATION

- Net total cycle time $= \frac{\text{Net duration of repetitive work} \times 60}{\text{No.of pieces (or No.of cycles)}}$

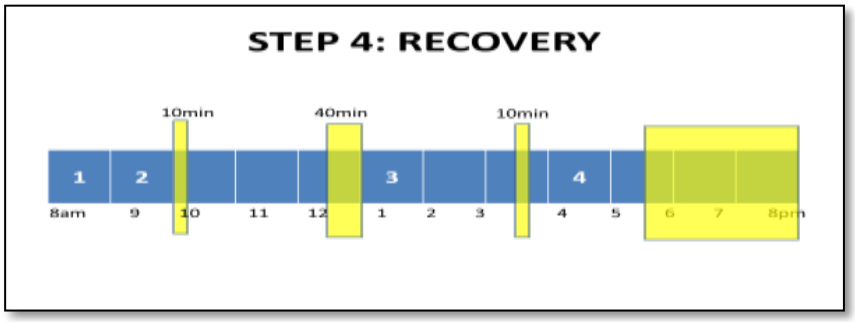
ORGANIZATIONAL DATA: DESCRIPTION		MINUTES	
NET DURATION OF REPETITIVE WORK (1)-(2)-(3)-(4) = (5)		450	(5)
No. of pieces (or cycles)	Scheduled (KPI)	10000	
	Real	13200	(6)
NET TOTAL CYCLE TIME OR RATE (second) (5)*60/(6) = (7)		2s	(7)
TOTAL TIME OF OBSERVED CYCLE OR OBSERVATION PERIOD		2s	(8)
% DIFFERENCE BETWEEN OBSERVED CYCLE TIME & OFFICIAL CYCLE TIME		35%	(9)

STEP 3

STEP 3: MULTIPLIER OF THE NET DURATION OF THE REPETITIVE WORK PERFORMED DURING THE SHIFT

Net duration of repetitive work (minutes)	Duration multiplier
60-120	0.5
121-180	0.65
181-240	0.75
241-300	0.85
301-360	0.925
361-420	0.95
421-480	1
Over 480	1.5

STEP 4



REVISED RECOVERY MULTIPLIER

NO. OF HOUR WITHOUT RECOVERY	RECOVERY MULTIPLIER
0	1
0.5	1.025
1	1.05
1.5	1.086
2	1.12
2.5	1.16
3	1.2
3.5	1.265
4	1.33
4.5	1.4
5	1.48
5.5	1.58
6	1.7
6.5	1.83
7	2
7.5	2.25
> 8	2.5

STEP 5

STEP 5: FREQUENCY

$$\text{FREQUENCY FACTOR} = \frac{\text{NO. OF TECHNICAL ACTIONS} \times \text{TIME (s)}}{60\ \text{s}}$$

4 x (450mins x 60s) / 60s

4 x (27,000s) / 60s = 1800 f

FREQUENCY	FREQUENCY FACTOR SCORE WHEN [illegible]	FREQUENCY FACTOR SCORE WHEN [illegible]
< 22.5	0.0	0.0
22.5 – 27.4	0.5	0.5
27.5 – 32.4	1	1
32.5 – 37.4	2	2
37.5 – 42.4	3	4
42.5 – 47.4	4	5
47.5 – 52.4	5	6
52.5 – 57.4	6	7
57.5 – 62.4	7	8
62.5 – 67.4	8	9
67.5 – 72.4	9	10
>72.4	9	10

STEP 6

FORCE OF 3-4		FORCE OF 5-6-7		FORCE OF 8-9-10	
Time as %	Score	Time as %	Score	Time as %	Score
5	0	0.33	4.0	0.33	6.0
10	0.5	1.0	8.0	1.00	12.0
18	1.0	1.5	9.0	1.33	13.0
26	1.5	2.0	11.0	1.67	14.0
33	2.0	2.5	11.0	2.00	15.0
37	2.5	3.0	12.0	2.33	16.0
42	3.0	3.5	13.0	2.67	17.0
46	3.5	4.0	14.0	3.00	18.0
50	4.0	4.5	15.0	3.33	19.0
54	4.5	5.0	16.0	3.67	20.0
58	5.0	5.63	17.0	4.00	21.0
63	5.5	6.25	18.0	4.33	22.0
67	6.0	6.88	19.0	4.67	23.0
75	6.5	7.50	20.0	5.00	24.0
83	7.0	8.13	21.0	5.63	25.0
92	7.5	8.75	22.0	6.25	26.0
100	8.0	9.38	23.0	6.88	27.0
		10.0	24.0	7.50	28.0
				8.13	29.0
				8.75	30.0
				9.38	31.0
				10.00	32.0

STEP 7

STEP 7: AWKWARD POSTURE

TIME IN AWKWARD POSTURE	TIME	SCORE
Shoulder The arms are kept at about shoulder height, without support, (or in other extreme postures) for:	10% - 24% of the time 25 - 50% of the time 51 – 80% of the time > 80% of the time	2 6 12 24
Elbow The elbow executes sudden movements (wide flexion-extension or prono-supination, jerking movements, striking movements) for:	25 – 50% of the time 51 – 80% of the time > 80% of the time	2 4 8
Wrist The wrist must bent in an extreme position, or must keep awkward postures (such as wide flexion/extension, or wide lateral deviation) for	25 – 50% of the time 51 – 80% of the time > 80% of the time	2 4 8
Hand The hand take objects or tools in pinch, hook grip, pinch or other different kinds of grasp for	25 – 50% of the time 51 – 80% of the time > 80% of the time	2 4 8

STEP 8

ADDITIONAL FACTOR	
BLOCK A: PHYSICO-MECHANICAL FACTORS	
2	Inadequate gloves (uncomfortable, too thick, wrong size) used > ½ time for the task.
2	Presence of 2 or more sudden, jerky movements per minute.
2	Presence of at least 10 repeated impacts (use of hands as tools to hit) per hour.
2	Contact with cold surfaces (< 0°C) or performa tasks in cold chambers for > ½ time for task.
2	Use of vibrating tools at least 1/3 of the time. Assign a score of 4 if these tools involve a high degree of vibration (e.g., pneumatic hammers, etc.).
2	Tools are used that cause compression of muscle and tendon structures (check for the presence of redness, calluses, wounds, etc., on the skin).
2	> ½ time is spent performing precision tasks (tasks on areas of < 2 or 3 mm), requiring the worker to be physically close to see.
2	> 1 additional factor (e.g., ...) is present at the same time for > ½ the time.
3	≥ 1 additional factors (e.g., ...) are present almost the entire cycle.
BLOCK B: SOCIO-ORGANISATIONAL FACTORS.	
1	The work rate is determined by the machine, but 'recovery spaces' exist allowing the rate to be sped up or slowed down.
2	The work rate is entirely determined by the machine.