

## Ergonomic Analysis for the Armoured Personnel Carrier Driver

Halim Mahfudh<sup>1</sup>, Lilik Zulaihah<sup>2</sup>, Reda Rizal<sup>3</sup>

<sup>1,2,3</sup>Department of Industrial Engineering, Universitas Pembangunan Nasional Veteran Jakarta,  
Tel: (+62)21 7656971  
Email: halimahfud@upnvj.ac.id

### ABSTRACT

*This research studied the ergonomic analysis of the armoured personnel carrier (APC) driver whom work in a cabin. It was motivated by that the design of this APC was originally from foreign country which look like has different body postures. Furthermore, the army duties include carrying personnel are critical job in some conditions. The analysis include the assessment of risk factor for musculoskeletal disorder. The methods that we used are Rapid Upper Limb Assessment (RULA), Rapid Entire Body Assessment (REBA) and Quick Exposure Check (QEC). The results from those 3 methods are similar and show that APC driver job has level risk medium so investigation needed and change may be required.*

*Key words: APC driver; RULA; REBA; QEC, ergonomic*

### 1. INTRODUCTION

In the master plan of acceleration and expansion of Indonesia's economic development (MP3EI), military industry is a priority sector to accelerates economic development. The industry is executed by a public company, which can design and produce some equipments and defence vehicles themselves as APC. A main APC produced was originally designed from France (Septriady, 2011), that has different body postures compare to Indonesian. It can causes possibilities of inconvenience and unhealthiness, including driver's cabin. The driver's cabin is the area from which the driver directly controls the operation of the APC. The seat, steering wheel, pedals and panels influence the driver's posture, which then determine those inconvenience and unhealthiness. For long term period, those can cause musculoskeletal disorder.

Science that studies the interaction of human in their work is Ergonomic. Many tools in Ergonomic are available for the assessment of risk factors for these disorders. Rapid Upper Limb Assessment (RULA), Rapid Entire Body Assessment (REBA) and Quick Exposure Check (QEC) are methods for evaluation of ergonomic risk factor related to upper and lower extremities of the musculoskeletal (entire body) system.

In different studies, these methods have been used to evaluate jobs in many areas.

The purposes of this study were to analyze the risk factor of the APC driver job and to compare ergonomic risk assessment results predicted by RULA, REBA and QEC methods.

We divided this paper to 4 sections. The following section describes methods that used to analyze risk factor, the third section gives the results and discussions. We conclude this study in section 4th with research directions.

### 2. METHODS AND MATERIALS

#### RULA (Rapid Upper Limb Assesment)

RULA was developed to evaluate the exposure of individual workers to ergonomic risk factors associated with upper extremity MSD. The RULA ergonomic assessment tool considers biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities. A single page worksheet as shown in Fig. 1 is used to evaluate required body posture, force, and repetition. Based on the evaluations, scores are entered for each body region in section A for the arm and wrist, and section B for the neck and trunk. After the data for each region is collected and scored, tables on the form are then

used to compile the risk factor variables, generating a single score that represents the level of MSD risk.

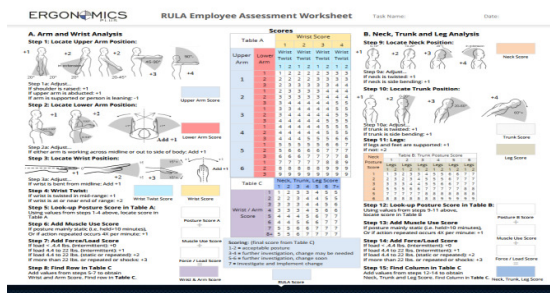


Figure 1. RULA Worksheet

The RULA was designed for easy use without need for an advanced degree in ergonomics or expensive equipment. Using the RULA worksheet, the evaluator will assign a score for each of the following body regions: upper arm, lower arm, wrist, neck, trunk, and legs. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk as outlined below :

Score	Level of MSD Risk
1-2	negligible risk, no action required
3-4	low risk, change may be needed
5-6	medium risk, further investigation, change soon
6+	very high risk, implement change now

Figure 2. Rula score and level of MSD Risk

**REBA (Rapid Entire Body Assessment)**

This ergonomic assessment tool uses a systematic process to evaluate whole body postural MSD and risks associated with job tasks. A single page worksheet as shown in Fig. 3 is used to evaluate required or selected body posture, forceful exertions, type of movement or action, repetition, and coupling.

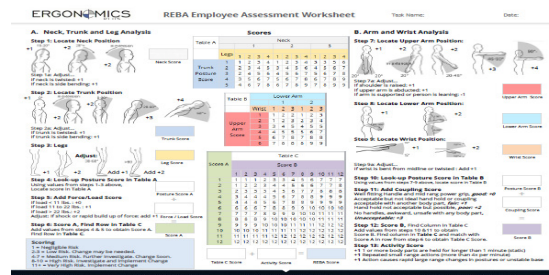


Figure 3. Reba worksheet

The REBA was designed for easy use without need for an advanced degree in ergonomics or expensive equipment. You only need the worksheet and a pen. On second thought, you probably should finish reading and studying this guide, and I suppose a clipboard would help as well. Using the REBA worksheet, the evaluator will assign a score for each of the following body regions: wrists, forearms, elbows, shoulders, neck, trunk, back, legs and knees. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk:

Score	Level of MSD Risk
1	negligible risk, no action required
2-3	low risk, change may be needed
4-7	medium risk, further investigation, change soon
8-10	high risk, investigate and implement change
11+	very high risk, implement change

Figure 4. Reba score and level of MSD Risk

**QEC (Quick Exposure Check)**

One tool that has been designed specifically to meet the requirements of practitioners is the Quick Exposure Check. It was developed at the Robens Centre for Health Ergonomics (Li and Buckle 1998).

QEC includes the assessment of the back, shoulder/upper arm, wrist/hand, and neck, with respect to their posture and repetitive movement. Furthermore, information about task duration, maximum weight handled, hand force exertion, exposure to vibration, the visual demands of the task and subjective responses to the work is obtained from the worker. Therefore, the total QEC scores for each task is based on a combination of scores of each body part

assessed by the observer and worker. The QEC assessment sheet includes questions which are designed to quantify the exposure risk for those main body part. The ratings are weighted into scores and added up to summary scores for different body parts and other items as driving, vibration, work pace and stress. The total exposure scores to determine risk level of task can be obtained from the total scores of four body parts are added and the product is divided by the maximum maximum possible score. There are four categories for risk level. The QEC worksheet and risk categories level are shown in Fig. 5 and 6.

Score	Risk level	Represent
< 40%	Low risk	Satisfactory level
41% - 50%	Moderate risk	More investigations is needed, interventions may be required
51% - 70%	High risk	Investigations and interventions are required
> 70%	Very high risk	Investigations and interventions are urgently required

Fig. 6 QEC level risk

### 3. RESULT AND DISCUSSION

#### RULA

##### Part A

Posture Group A consists of the upper arm, forearm (lower arm), wrist and the rotation of the wrist (wrist twist).

a. Posture Upper Arm. The posture of the upper arm in the process of preparation that have 20° because the preparation process of the workers at the time of driving the "upper arm is abducted" because when the wheel panzer score of 1.

b. Posture Forearm (lower arms). Posture forearm preparation process, that have 60°-100° because in the process of preparation of the hands of the bottom does not make the process repeated movement because the preparation process operator driving, do not select additional because both hands are not mutually do the job with each intermittent motion score of 3.

c. Posture Wrists. Wrist posture preparation process that selected 15° for wrist motion just moved from 15° to 15° back and did not select additional because of the wrist does not do a turnaround score of 3.

d. Posture round the wrist (wrist twist). Wrist posture round preparation process that been "mainly in the handshake position" because the operator does not perform round the wrist.

##### Part B

Posture Group B consists of the neck, trunk, and legs.

a. Posture Neck (neck), neck posture preparation process that selected 20° + as carriers continue to focus neck so that the neck bent over and did not select additional 20° because the neck is not experiencing the movement or spinning.

b. Posture trunk, posture trunk preparation process that the researchers chose 20°-60° because the position of workers' torso bent over 20° operators focus on the future and not selected for additional operator position does not rotate while doing the job.

The image shows a detailed QEC assessment worksheet. It is divided into two main parts: 'Observer's Assessment' and 'Worker's Assessment'. The 'Observer's Assessment' section includes questions about the worker's posture (Back, Neck, Shoulder/Arm, Wrist/Hand) and their responses. The 'Worker's Assessment' section includes questions about the worker's exposure to various factors like vibration, work pace, and stress. Below these sections is the 'Exposure Scores' section, which is a grid of boxes for each body part (Back, Shoulder/Arm, Wrist/Hand, Neck) and each assessment category. Each box contains a score and a small chart. At the bottom, there are total scores for each body part and an overall total score.

Fig. 5 QEC assessment worksheet

c. Posture feet (legs). Posture foot the preparation that have "legs and feel are well supported and in an evenly balanced posture" because the position of the feet parallel and Activity Score load and activity of the preparation that have a score of weight and activity score group A and group B, for group A and B selected Muscle use is "pusture is mainly static, e, g. Held for longer than 1 minute or repected more than 4 times per minute "due to operator position do the job more than 1 minute, choose less than less than 4.4 lbs in Group A for the work that bring load less than 4.4 lbs load.

**Skor A**

This table shows the upper arm 1, lower arm 3, wrist 3, and wrist twist. o determine the value of the score and we observed the third column where it will meet 3

**Skor B**

In the scores section B shows the position of the neck, trunk and legs. On the column to explain the position of the neck, trunk and legs the two position, the neck 1, trunk 2 position and legs position 1. To determine the value of the score and observed the two column where it will meet 1.

**Skor C**

Score table C is the result of scores A plus score load and score B plus with a score grip. Score A that is 3 and B taht is 4 will determine the column and the value of the score table C it will meet 3

Table 1:Value Level Measures RULA

Score Rula	Level Risk	Level Action	Action
3	Medium Risk	4	Further investigation, change may be needed

**REBA**

This stage is the beginning of a process operator at a score while driving Panzer.

**Part A**

a. Torso and back carriers are currently grinding > 60° to the front of the body, REBA scores given 2 while scoring change +1 for the torso to bend.

b. Neck. Carriers neck position while doing work an angle > 20° with REBA score 2 and score changes 1 for crooked.

c. Legs operator when performing activities to hold the body in a sitting position is given a score of 1. To score changes 0.

d. Burden is lifted by the operator 11-22 lbs given REBA score 1, while a score of 0 because the load change is not experiencing sudden extra load.

**Part B**

a. Upper arm. The movement of the upper arm operator is in a position 45°-90° then REBA score is 3, while for score changes +1 this is because the position of the shoulder ride while doing the activity.

b. Forearm. The movement of the forearm > 100° front of the body, the REBA score was 2 for score updates is 0.

c. Wrists operator > 15° forward while REBA score given is 2 while scores of amendments +1 for wrist spin.

d. Operator grip when holding the load can not be accepted even though allowing the REBA score is 2.

e. Activities unstable then REBA score is +1 it is in because atktivitas conducted operators while doing his job is not stable on work attitudes.

**Score Table A**

This table shows the position of the body, neck and legs. neck position is at position 2, the foot is positioned on one and the torso in position 2.

**Score Table B**

In the scores section B shows the position of the upper arm, forearm and wrist. Table B to explain the position of the upper arm are in the third position, the forearm and wrist position 2 at position 2. To determine the value of the score and observed the third column where it will meet 5.

**Score Table C**

Score table C is the result of scores A plus score load and score B plus with a score grip. Score A and B will determine the column and the value of the score table C it will meet 5.

Table 2:Value Level Measures REBA

Score REBA	Level Risk	Level Action	Action
5	Medium Risk	4	Futher investigation,change soon

After performing calculations using the Worksheet we get score Reba 5 with a medium level of risk and level of action 4,

this means that the necessary action as soon as possible.

**QEC**

Based on the recapitulation of the answers to the questionnaire on the carrier and then calculated the value it's exposure, where exposure score was calculated profit of each part of the body such as the back, shoulders / upper arms, wrists, and neck with considering 5 combination / interaction of postures with force / load, movement style / load, posture with duration, and the duration of the movement.

The following is a recapitulation of the calculation of exposure scores on the score sheet for the operator QEC panzer driver can be seen in table 3 :

Table 3 : Observer's Assessment Results

The event name	Operator	Name of the operator	Back		Shoulder/ Arm		Wrist/hand		Neck
			1	2	1	2	1	2	
Armored car driver	1	-	A1	B2	C2	D2	E2	F2	G1

Table 4 : Workers Assessment Results

The event name	Questions								
	H	J	K	L	M	N	P	Q	
Armored car driver	H1	J2	K2	L2	M2	N2	P1	Q3	

From the above table is the beginning of the recapitulation QEC method are filled by observers and operators.

After getting the exposure value observer recapitulated score for the operator.

Table 5 :Exposure recapitulation Score

Members of the body who observed	Value Exposure Score
	Operator
Backs (move)	16
Shoulder/Arm	24
Wrist/Hand	30
Neck	10
Total Exposure Score	80
Exposure Score(%)	49,38%

Based on the above table Score Exposure value obtained was 49.38, which means for further action needs further investigations.

**4. CONCLUSION**

The evaluation of body posture of the APC driver while driving to determine risk factor of musculoskeletal disorder has been carried

out by RULA, REBA and QEC tools. The study reveals that exposure to unsafe ergonomics and postural risks among APC driver were evident form the findings of exposure (QEC) and risk (RULA, REBA) results. It can be concluded from that RULA score is 3 so has level risk medium with level action 4 which means further investigations needed, changes may be needed, REBA score is 5 so also has level risk medium with level action 4 which means further investigations needed, changes needed soon and finally QEC total exposure score is 49,38% so has moderate risk which means further investigations needed, interventions may be required. This study recommends the implementation of ergonomic interventions especially to improve back, arm, wrist, shoulder and neck posture which cause high scores.

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Nasional Veteran, Jakarta. He received her Master of Industrial Engineering from Institut Teknologi Bandung in 1992 and her doctoral of Engineering of Agricultural Industry from Bogor Agricultural Institute in 2004. Her research interests are in the area of Production Planning & Control, Ergonomic and Operation Management. He is the Vice Chancellor of Student Affairs now. His email address is <[halimahfudh@upnvi.ac.id](mailto:halimahfudh@upnvi.ac.id)>

## **AUTHOR BIOGRAPHIES**

**Halim Mahfudh** is a lecturer in Program Study of Industrial Engineering, Faculty of Engineering, Universitas Pembangunan