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WORK POSTURE MEASUREMENT AT WELDING WORKSTATION IN THE CONSTRUCTION PROJECT OF PAMULANG UNIVERSITY CAMPUS 3 WITANA HARJA USING QUICK EXPOSURE CHECK (QEC) AND ANTHROPOMETRY METHODS
(Case Study at CV. Rama Teknik)

Adi Candra[1)], Al Quini Dini Chairunicha[2)], Khairunnisa[3)]

Industrial Engineering, Pamulang University, Indonesia
[1)]dosen01304@unpam.ac.id
[2)]alquinidinic@gmail.com
[3)]dosen00743@unpam.ac.id

ABSTRACT

CV. Rama Teknik is a company in the manufacturing industry. The welding workstation at CV. Rama Teknik has registered 22 complaints of Musculoskeletal Disorders (MSDs) related to operators' work posture. Work posture refers to body positioning during work activities, associated with workspace design and task requirements. To mitigate Musculoskeletal Disorders (MSDs) complaints, this study employs the Quick Exposure Check (QEC) method to assess operators' postures, subsequently enabling ergonomic improvements based on anthropometry aimed at reducing MSDs. Findings reveal that welding operators at CV. Rama Teknik exhibit an average exposure level of 74.31%, indicating the necessity for prompt intervention. Modifications are introduced through anthropometric adjustments, specifically the creation of a welding table aligned with operators' anthropometric measurements. Consequently, after adjustments, QEC assessments report a reduced exposure level of 41.49%.

Key Word : Anthropometry, Musculoskeletal Disorders (MSDs), Welding, Quick Exposure Check (QEC)

I. Introduction

Currently, the development of manufacturing and construction industries in Indonesia has undergone various changes, in line with economic growth and infrastructure advancements within the country. This progress brings evolving challenges for these industries, which continuously adapt to shifting economic conditions.

Ergonomics is a discipline focused on optimizing work tasks and environments for individuals. Ergonomics studies have often been applied in manufacturing settings to enhance the interface between humans and machines. Ergonomics aims to balance both social objectives, such as welfare, and economic objectives, like overall system performance. It accounts for physical and psychological human factors, as well as technical and organizational aspects. From this perspective, ergonomics can be defined as both a science and an art, implementing technology to align and harmonize activity or rest facilities with human physical and mental capabilities, ultimately improving quality of life and well-being.

CV. Rama Teknik, a company in the construction manufacturing sector, undertook the development of Pamulang University Campus 3, a project requiring substantial manpower due to the lifting, carrying, and pushing tasks involved. Workers at CV. Rama Teknik often exhibit unnatural postures during construction activities, especially in the welding station, where tasks involve various body positions—standing, bending, squatting—and occasional shifts to the left or right. Prolonged engagement in such tasks may lead to physical fatigue. Poor classification of fatigue levels in the welding segment poses risks, notably musculoskeletal injuries, particularly in the back, due to prolonged

squatting or seated postures required in welding activities, contributing to Musculoskeletal Disorders (MSDs).

To evaluate MSD-related risks, the Quick Exposure Check (QEC) questionnaire was used, assessing four key body parts prone to MSDs: back, shoulders/arms, wrists, and neck. The QEC questionnaires were distributed to all operators at the welding workstation and observers monitoring the operators' postures during tasks. While the operator's version of the QEC focused on their personal experiences and physical strain, the observer's questionnaire emphasized visual assessments of the operator's posture and task duration. This study leverages the QEC method to identify risks and suggests anthropometric improvements tailored to balance work posture with task demands, fostering ergonomically sound movements.

Tabel 1. Welding Operator Complaint Data

Operators	*Back*		*Shoulder/Arm*		*Wrist*		*Neck*	
	Score	*Exposure Score*	*Score*	*Exposure Score*	*Score*	*Exposure Score*	*Score*	*Exposure Score*
1	26	*High*	32	*High*	30	*Moderate*	8	*Moderate*
2	36	*Very High*	42	*Very High*	26	*Moderate*	12	*High*
3	28	*High*	32	*High*	36	*High*	12	*High*
4	36	*Very High*	44	*Very High*	42	*Very High*	16	*Very High*
5	38	*Very High*	44	*Very High*	42	*Very High*	16	*Very High*
6	38	*Very High*	48	*Very High*	46	*Very High*	16	*Very High*
7	18	*Moderate*	20	*Low*	26	*Moderate*	12	*High*
8	34	*Very High*	38	*High*	36	*High*	16	*Very High*
9	36	*Very High*	44	*Very High*	38	*High*	16	*Very High*
10	32	*Very High*	38	*High*	38	*High*	16	*Very High*

(**Source**: Personal Data Processing,2024)

The results of the welding operator complaint data in the table above show complaints of Musculoskeletal Disorders among welding operators because there are still poor body postures when welding. On the back there are still 7 out of 10 operators who get a high exposure score, on the shoulders/arms there are 5 out of 10 operators who get a high exposure score, on the wrist there are still 3 out of 10 operators who get a high exposure score, and on the neck there are still 6 out of 10 operators who get a high exposure score.

The Quick Exposure Check (QEC) questionnaire that has been filled out by the welding operator includes, among other things, the maximum weight that must be lifted by the operator is very heavy (more than 20 kg) with a very high level of strength used by one hand (more than 4 kg) for a duration of more than from 4 hours and this work requires very high vision to see in detail, when working the operator also uses tools that produce vibrations for more than 4 hours/day, in carrying out welding work the operator never experiences difficulties in working so the operator does not experience stress during do his job.

The QEC questionnaire was given to all operators at the welding workstation, as well as to observers who observe the operator's body posture during work. Although the QEC questionnaires for operators and observers are different, both are used to evaluate workstation conditions. The operator's body posture while carrying out his duties is the main focus of the observer questionnaire. The operator questionnaire emphasizes the operator's emotions while carrying out their duties, including the load that must be lifted and the duration of the task. Welding station at CV. Rama Teknik is the location for distributing QEC questionnaires.

This research uses the Quick Exposure Check (QEC) method to evaluate or analyze the operator's work attitude by focusing on 4 (four) human muscle points, namely the back, wrist/hand, shoulder/arm,

and neck. After knowing the problems with the QEC method, the author was able to identify alternative solutions using the anthropometric method which aims to balance work posture and tasks to produce ergonomic movements.

Based on the background stated above, the problem formulation that can be put forward in this research is as follows:

1. How to measure the risk level of welding operators when working at CV. Rama Teknik using the Quick Exposure Check (QEC) method?
2. How to prevent complaints of musculoskeletal disorders among welding operators at CV. Rama Teknik with the Anthropometric method?

Based on the problem formulation above, the following objectives are obtained:

1. To measure the risk level of construction workers at work.
2. To prevent complaints of musculoskeletal disorders in operators..

II. RESEARCH METHODOLOGY

The research adopted a qualitative methodology aimed at collecting, analyzing, and interpreting data relevant to the research objectives. This study was conducted within the scope of the Pamulang University Campus 3 construction project, located at Jl. Witana Harja No.18b, Pamulang, South Tangerang City, Banten 15417, during September to October 2023. This research seeks to optimize safe work postures in welding tasks using the Quick Exposure Checklist (QEC) and anthropometry methods. Data collection involved the following, Primary Data: Directly gathered from the research subjects, comprising MSDs complaints collected through questionnaires, interviews, and observations with welding operators at CV. Rama Teknik, Secondary Data: Gathered from diverse sources, including company records, relevant journals, and articles. Secondary sources encompassed books, previous research, internet resources, and corporate documents.

A. *Quick Exposure Check* (QEC)

Quick Exposure Check (QEC) The Quick Exposure Check (QEC) is a research method used to rapidly and effectively evaluate worker exposure to various health and safety risks in the workplace. In welding contexts, QEC identifies and assesses potential hazards faced by welders during their tasks.

The QEC data processing involves the following steps:

Determining Exposure Scores

The exposure scoring sheet utilizes data from operator and observer questionnaires to calculate scores for each body part, including the neck, wrists, shoulders, upper limbs, and back. This scoring helps evaluate injury risks for different body parts based on exposure scores as detailed in Table 2.

Exposure Level Determination (E)

The exposure level (E) is calculated based on the percentage difference between the actual exposure score (X) and the maximum possible score (Xmax). The formula used is:

is a research method used to quickly and effectively evaluate workers' exposure to various health and safety risks in the workplace. In the context of welding, QEC functions to identify and assess potential hazards faced by welders during work.

The stages of the Quick Exposure Checklist (QEC) data processing process are as follows:

1. Penentuan *Exposure Score*
   Exposure scoring sheet menggunakan data kuesioner dari operator dan pengamat untuk menghitung skor dari setiap kombinasi yang terbentuk guna menentukan skor untuk setiap bagian tubuh. Perhitungan *exposure score* untuk setiap bagian tubuh, meliputi leher, pergelangan tangan, bahu, anggota tubuh bagian atas, dan punggung. untuk menentukan risiko cedera pada ekstremitas dengan memanfaatkan *exposure scoring sheet*. Untuk menentukan tingkat risiko cedera pada anggota tubuh dari nilai *exposure score* dapat dilihat pada **Tabel 2.**

Tabel 2. *Exposure Scoring* QEC

Score	*Exposure score*			
	Low	*Moderate*	*High*	*Very High*
Back (static)	8-15	16-22	23-29	29-14
Back (Dynamic)	10-20	21-30	31-40	41-56
Arm	10-20	21-30	31-40	41-56
Wrist	10-20	21-30	31-40	41-56
Neck	4-6	8-10	12-14	16-18

(Sumber: Purbasari, dkk, 2019**)**

2. Detremine of *Exposure Level* (E)
   The exposure level value is determined by the exposure score value, which is the percentage difference between the actual total exposure score (X) and the maximum total score (Xmax). This formula is used to calculate the exposure level value:

$$\mathbf{E\ (\%) = \frac{X}{X_{maks}} \times 100\%}$$

   Dimana:
   a. X = Skor total untuk paparan risiko cedera pada punggung, bahu/lengan, pergelangan tangan, dan leher, seperti yang ditentukan oleh perhitungan kuesioner;
   b. Xmax = Skor total maksimal untuk postur kerja yang mungkin terjadi pada punggung, bahu/lengan, pergelangan tangan, dan leher.

Ketentuan skor maksimum (Xmaks = 162) diberikan untuk tipe aktivitas statis, seperti duduk atau berdiri dengan seringnya pengulangan (*repetitive)* dan penggunaan tenaga dan bebas yang relatif rendah. Sebaliknya, untuk aktivitas yang dilakukan dengan pengendalian tangan, seperti mengangkat, mendorong, menarik, dan membawa beban, diberikan skor maksimum (Xmaks = 176). Untuk menentukan tindakan yang akan dilakukan setelah perhitungan nilai *exposure level* dapat dilihat pada **Tabel 3.**

Tabel 3. *Action Level* QEC

Total *Exposure Level*	*Action*
< 40%	Aman
40-49%	Perlu penelitian lebih lanjut
50-69%	Perlu penelitian lebih lanjut dan dilakukan perubahan
≥ 70%	Dilakukan penelitian dan perubahan secepatnya

(Sumber: Annisa, dkk, 2019)

3. Determination of Risk Categories
   The risks and level of action required for a particular activity can be categorized based on the calculation results *score exposure total*. (Purbasari, 2019).

B. Antropometri

Anthropometry is a field that studies human body measurements, such as movement, weight, Size and volume. Various industries, such as industrial design, clothing design, ergonomics, and architecture, use anthropometric data to create products that best suit the dimensions of the human body. Anthropometrics consists of 2 parts:

1. Statics Antropometri
   Focuses on measuring individual physical characteristics in a static (still) state standardized;
2. Dynamic Antropometri
   Dynamic anthropometry is concerned with measuring human physical characteristics in a dynamic state. This is achieved by using linear (straight) dimensions and taking measurements on the surface

of the body while the subject is not moving. These measurements are more complicated and difficult to interpret due to the fact that they are obtained in various body positions while the subject is moving(Wijayanti & Laila, 2022)

III. RESULTS AND CONCLUSION

A. Assessment of Work Posture Using the Quick Exposure Checklist (QEC) Method in Welding

The questionnaire given to the operator focused more on the body posture made by the operator when carrying out his work, while the questionnaire given to observers focused more on the operator's feelings about the load that had to be lifted and the time required to complete the task. CV welding operator. Rama Teknik received this QEC questionnaire. You can see **Table 4** below as a recapitulation of the results of observer and operator questionnaires.

Tabel 4. Observer Questionnaire Recapitulation

Operator	Back (static)		Back (Dynamic)		Arm		Neck
	1	2	1	2	1	2	
1	A2	B2	C1	D2	E2	F2	G2
2	A3	B2	C2	D2	E2	F1	G2
3	A2	B2	C1	D2	E2	F2	G2
4	A2	B1	C1	D2	E2	F2	G2
5	A2	B2	C1	D2	E2	F2	G2
6	A2	B2	C2	D2	E2	F3	G2
7	A2	B1	C1	D2	E2	F1	G2
8	A2	B2	C1	D2	E2	F2	G2
9	A2	B1	C1	D2	E2	F1	G2
10	A2	B1	C1	D2	E2	F1	G2

(**Sumber**: Pengolahan Data Pribadi, 2024)

Tabel 5. Employee Questionnaire Recapitulation

Operator	Question							
	H	I	J	K	L	M	N	O
1	H4	I1	J3	K2	L1	M1	N1	O2
2	H4	I2	J2	K2	L1	M3	N3	O1
3	H3	I2	J3	K2	L1	M3	N1	O1
4	H4	I3	J3	K2	L1	M3	N2	O1
5	H4	I3	J3	K2	L1	M3	N1	O1
6	H4	I3	J3	K2	L1	M1	N1	O1
7	H1	I2	J2	K2	L1	M1	N1	O1
8	H3	I3	J2	K2	L1	M3	N3	O1
9	H4	I3	J3	K2	L1	M3	N1	O2
10	H3	I3	J3	K2	L1	M3	N2	O1

(**Source**: Personal Data Processing, 2024)

Dari From the results of the recap of observer questionnaires and welding worker questionnaires which have been distributed and filled in at CV. Rama Engineering. The following recap of the QEC score sheet can be seen in **Table 6**;

Tabel 6. Value Recapitulation QEC

Observed body parts	Value										Average
	Exposure Score Operator										
	1	2	3	4	5	6	7	8	9	10	
Back (static)	26	36	28	36	38	38	18	34	36	32	32,2
Back (Dynamic)	32	42	32	44	44	48	20	38	44	38	38,2
Arm	30	26	36	42	42	46	26	36	38	38	36
Wrist	8	12	12	16	16	16	12	16	16	16	14
Total *Exposure Score*	96	116	108	138	140	148	76	124	134	124	120,4
Exposure Level	59, 25 %	71, 60 %	66, 66 %	85, 18 %	86, 41 %	91, 35 %	46, 91 %	76, 54 %	82, 71 %	76, 54 %	74,31%

(**Source**: Personal Data Processing, 2024)

After the exposure score value is obtained, then determine the exposure level based on a formula so that the exposure level percentage of welding worker 1 is 59.25%, welding worker 2 is 71.60%, welding worker 3 is 66.66%, welding worker 4 is 85.18%, welding worker 5 is 86.41%, welding worker 6 is 91.35%, welding worker 7 is 46.91%, 8 welding workers 76.54%, 9 welding workers 82.71%, 10 welding workers 76.54%, with an average of 10 workers obtained at 74.31%.

B. Usulan Perbaikan Posisi Kerja Pada Stasiun Kerja Pengelasan Dengan Metode Antropometri

Based on the results of exposure level calculations shown in Table 6 at the CV welding workstation. Rama Teknik, the exposure level value is in the range ≥ 70%. This indicates the need for further research and immediate changes to the welding workstation. The exposure score calculation also shows a very high level, which means the risk of injury is very large. Therefore, it is necessary to propose the addition of a work desk to reduce the risk of musculoskeletal injuries. Apart from that, this proposal is also expected to improve the performance of operators.

To make a welding workbench for operators, hand span , arm reach and standing elbow height are needed. Below you can see late data taken from 10 welding operators operator.

Tabel 7. Measurement Result Data

Operator	**Measurement Result Data**		
	JT (cm)	**RT (cm)**	**TSB (cm)**
Operator 1	70	150	98
Operator 2	67	165	122
Operator 3	68	158	115
Operator 4	69	142	96
Operator 5	70	170	100
Operator 6	67	166	120
Operator 7	76	175	130
Operator 8	68	168	124
Operator 9	74	172	123
Operator 10	75	174	156

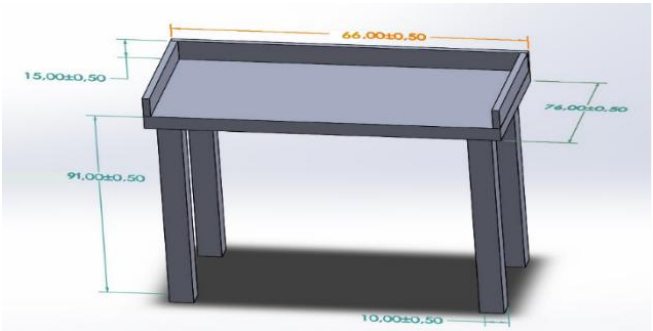
Operator	Measurement Result Data		
	JT (cm)	RT (cm)	TSB (cm)
Mean	70.4	164	118.4
SD	3.20	10.29	16.98
BKA	76.8	184.58	152.36
BKB	64	143.42	84.44
Percentil 5th	65,13	147,07	90,46
Percentil 95th	75,66	180,92	146,33

(**Source**: Personal Data Processing, 2024)

So the details that will be used to make the welding workbench are as follows:

1. Table leg height
   The height of the table legs is obtained from anthropometric data. The average standing elbow height from the 5th percentile value is 91 cm. Data from the 5th percentile is used to adjust the height of the workbench to match the natural height of the welder's elbows, reducing strain on the back and shoulders during work;
2. Table width
   The width of the table is obtained from anthropometric data. The average hand reach forward with the 95th percentile is 76 cm. Data from the 95th pencil is used so that the table width is comfortable to use, the welding tools and controls are deep
   range;
3. Table length
   The length of the table is obtained from anthropometric data. The average hand span with the 5th percentile is 66 cm. Data from the 5th percentile is used to make the table width comfortable for all operators and helps determine the work area that the welder can reach without moving his body, thereby optimizing equipment layout.

The anthropometric data of workers at the welding station were collected to determine the dimensions of the workbench to be designed. This data was used to define the size of the welding table. The anthropometric data required for welding operators includes elbow height while standing, arm reach, and arm span. The height, length, and width of the table were determined by each of these data points. The table legs were measured with a height of 91 cm, a table width of 76 cm, and a table length of 66 cm. This information was obtained from the anthropometric measurements of the welding station operators. Therefore, the design result of the welding workbench at the CV. Rama Teknik welding station can be seen in Figure 1.



(Source: Personal Observation)

Figure 1. Proposed Workbench Design

From the proposed design of the welding workstation table in Figure 1, which has been adjusted to match the anthropometric data of welding operators, it is expected to improve the operators' position and working posture. Previously, operators tended to work with a hunched back, hands positioned below shoulder level, and seated with bent legs throughout the task, which could lead to musculoskeletal disorders (MSDs). The proposed design, measured based on anthropometric data, is anticipated to improve the welding operators' working position and posture, making it more comfortable and reducing complaints related to musculoskeletal disorders (MSDs).

The proposed welding workstation design results in a better and more comfortable working position compared to the previous setup. It ensures an upright back posture, a neck position that is not overly bent, hands positioned above the shoulder level, and legs standing straight. According to the proposed design, the working posture using the table during tasks achieves an improved exposure level, as measured using the Quick Exposure Check (QEC) method, which can be seen in Table 8 below:

Table 8: Shows the QEC values before and after improvement

Before Improvment		After Improvment		Gap
Exposure Level	Action Level	Exposure Level	Action Level	
74,31%	The research and changes are carried out as soon as possible.	41,49%	Further research is needed.	32,82%

(**Sumber**: Pengolahan Data Pribadi, 2024)

After the improvements, the QEC value calculation at the welding workstation using the welding table showed that the average exposure level of 10 welding operators initially was 74.31%, and after the improvements, it decreased to 41.49%, representing a reduction of 32.82%. This indicates a significant decrease in the QEC exposure level before and after the improvements were implemented.

IV. Conclusion

Based on the analysis results to measure the risk level of construction workers at CV. Rama Teknik using the QEC method for welding operators, the average exposure score was 120.4, and the exposure level was 74.31% from 10 welding operators. Based on the analysis to prevent musculoskeletal disorders among welding operators at CV. Rama Teknik, the anthropometric method was used to propose a welding table design. The proposed design, based on anthropometric implementation applicable to CV. Rama Teknik, includes the following dimensions: the table leg height at the 5th percentile is 91 cm, the table width at the 95th percentile is 76 cm, and the table length at the 5th percentile is 66 cm. After implementation, the exposure level for welding operators decreased to 41.49% from the initial 74.31% before implementation.

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