



Analysis and Design of OSH System of PT ASI Welding Department During the Pandemic

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Abstract. PT Adyawinsa Stamping Industries (ASI) is one of the automotive industry companies operating during the COVID-19 pandemic. As a result, there are government policies that companies need to follow to continue operating safely. Policies related to COVID-19 need to be implemented in conjunction with the company's Occupational Safety and Health (K3). Based on interviews conducted with company representatives, an evaluation is required in order to find out the implementation of policies related to COVID-19 in line with K3 in the *Welding Department*. Initial observations are carried out to determine the actual conditions and identify operational activities. K3 evaluation is carried out by applying *the Failure Mode and Effect Analysis* (FMEA) method to determine the potential hazards. The results of the FMEA evaluation provide a series of hazard priorities and potential dangers that guide the design of improvement proposals. The proposal's design was implemented using *the Participatory Ergonomics* (PE) method involving several stakeholders. The improvement proposal is the result of identifying the needs of the Welding Department workers based on discussions conducted through the PE method. The discussion resulted in a proposed design in the form of reviewing and controlling SOPs and conditions in the field, implementing periodic safety training, and installing instruments to remind workers of K3 in operational activities. The instruments designed in the study are several infographic materials regarding implementing K3 and COVID-19 prevention in the workplace.

Keywords: Failure Mode and Effect Analysis, Participatory Ergonomics, COVID-19. K3

INTRODUCTION

The rapid spread of COVID-19 cases from Wuhan, China to the rest of the world led to the WHO designating COVID-19 as a pandemic on March 11, 2020 (Cucinotta & Vanelli, 2020). The COVID-19 pandemic has caused 37 million positive cases (WHO, 2020). It has significantly impacted aspects of life, such as the closure of educational institutions, the implementation of PPKM, and the 5M health protocol. In addition, the economy also received a big hit.

Indonesia's automotive industry is one of the sectors affected by COVID-19. In the report of the Ministry of Industry of the Republic of Indonesia (2021), there was a decrease in car sales of 48.3% and motorcycles by 43.6%, as well as a decrease in car and motorcycle exports, respectively by 66.8% and 13.6% in 2020. The automotive industry's contribution to the Indonesian economy is quite large, namely Rp 99.16 trillion in investment value and 38.39 thousand direct workers (Ministry of Industry, 2021). The magnitude of this contribution has encouraged companies to resume operations during the pandemic in line with COVID-19 prevention and mitigation.

Given that work accidents continue to occur, a workplace that is safe from work accidents and healthy from the potential spread of COVID-19 is necessary in the pandemic. According to BPJS Employment data reported in IDN Times West Java (March 29, 2022), work accident cases reached 82 thousand, and occupational diseases reached as many as 179 cases, with 65% being due to COVID-19 from January to September 2021.

Good K3 implementation has a great influence on worker productivity (Wahyudi et al., 2018). Workers with high productivity think that K3 in the company has been well applied to them and their work areas (Ayu et al., 2019).

One of the companies that implements K3 is PT ASI, an Indonesian automotive company in Karawang that produces components for four-wheeled vehicles. PT ASI is also included in the companies affected by the COVID-19 pandemic. PT ASI was required to lay off during the pandemic due to a decrease in sales of up to 90% (Sinfonews, 2021). In addition, company workers who are confirmed positive for COVID-19 hampered the pace of operational activities. The number of positive COVID-19 cases in the company can be seen in Figure 1 below.

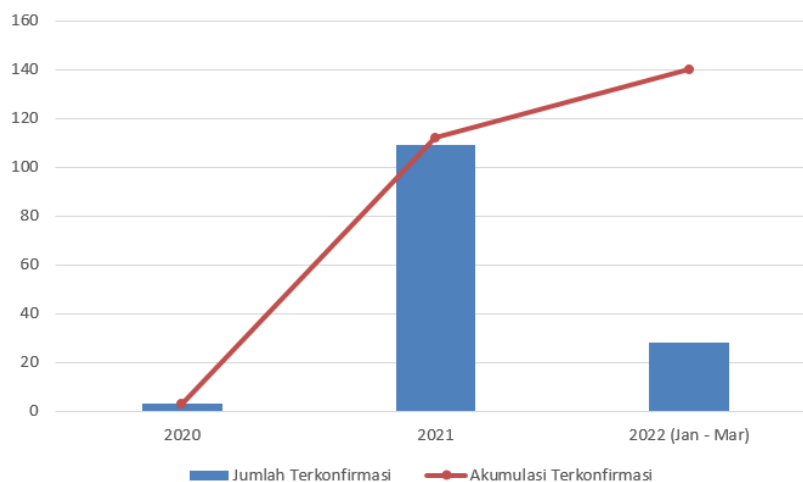


Figure 1. COVID-19 Tracing PT ASI

(PT ASI)

At PT ASI, one of the efforts to create a safe work area is implementing SOPs to operate machines correctly and procuring PPE. However, work accidents often occur due to unsafe actions from workers and abnormal processes that are not in accordance with SOPs. Unsafe actions taken by workers include skipping the steps in the SOP, removing PPE while working, and ignoring the established health protocols.

Observations made in the company provide information that the Welding Department is at a high risk of work accidents, and operational processes during the pandemic are more risky for its workers. Work accidents that occur in the Welding Department can be seen in Table 1.

Table 1. Welding Department Work Accident

It	Types of Accidents	Frequency
1	Hit <i>by part</i>	3
2	Pinched machine	4
3	Tergores <i>part</i>	18
4	Exposed to hot water	2

The welding department has several machines operated by workers, who are divided into two shifts and have their own stations. Each worker's workstation is less than 2 meters away, which can increase the potential for COVID-19 transmission. Figure 2 below shows some parts of *the Welding Department*.

The COVID-19 pandemic has affected PT ASI's production activities, so adapting the COVID-19 prevention policy to the K3 implemented is necessary. Therefore, an analysis is carried out to determine the risk of hazards that may arise using FMEA. The results of the hazard risk identification are then used as input for the design of the K3 concept that can be applied in companies with the PE method. With this research, it is hoped that companies can find out the risk of hazards that arise and reduce work accidents during the pandemic.

METHOD

The research focuses on identifying hazards and hazard risks in the *Welding Department* of PT ASI to implement good K3. According to Government Regulation No. 50 of 2012, Article 1 Paragraph 2, Occupational Health and Safety (K3) is all activities carried out to ensure and protect the safety and health of the workforce through the prevention of occupational accidents

and occupational diseases. Identification of hazard risk and potential hazards is carried out using FMEA. The results of this identification became input in the design of the proposed K3 system of the Welding Department during the pandemic.

The identification of potential hazards and work accidents of *the Welding* Department was carried out in research with direct observation in the field. This was done to understand the flow of the operational activities in the *Welding* Department. The stages of the *welding* process are incoming materials from the warehouse or work *in the process area*. Then, *welding work* is carried out at the workstation. The components to be worked on are taken from the inbound area, processed on the workbench using a *welding machine* and placed in the *outbound* area for the following process. The working area of *the Welding* Department can be seen in Figure 3.

The results of identifying potential hazards and work accidents are then grouped into several categories. The category of work accidents used is according to HSEWatch Universal Services Limited (2022) and Hughes in Kustiyaningsih (2011). Identification based on accidents that have occurred before is grouped into the categories of being hit by falling materials, coming into contact with moving machinery, being exposed to fire or hot objects, and being exposed to hazardous materials or objects. The other category is the result of identification based on observation of the department's operational process



Figure 2. Welding Department of PT ASI



Figure 3. Welding Department Work Area

The results of the grouping of hazard identification and potential hazards are included in the subsequent FMEA evaluation process. In the FMEA, the category of work accidents

obtained will be the failure mode in the FMEA. The category of work accidents will be analyzed so that the causes, frequency, and detection that can be carried out from the occurrence of work accidents or potential dangers that may occur in the future can be known.

Table 2. FMEA Severity Scale

Value	Impact	Wound Explanation
1	Minor individuals do not feel a great impact	Exposed to debris
2	Mild impact (<i>short term</i>), individuals can still be active	Sunburn, scratches, bruises, minor slices
3		Blisters, light ankles, light dislocations, slips
4	Moderate impact: Individuals are unable to do activities for 1-2 days	Cuts, minor burns, <i>mild concussion</i> , heat/cold inflammation
5		Sprains, sprains, minor cracks/fractures
6	Serious impact: The individual is unable to continue the activity for a long time.	Hospitalized for less than 12 hours, fractures, bone displacement/discussion, <i>concussion</i> , difficulty breathing
7	Serious impact: The individual is unable to continue the activity for a long time.	Hospitalized for more than 12 hours, ruptured blood vessels, severe frostbite/heat, loss of consciousness
8	Life-changing impacts, death/disability	Severe injuries that require treatment, such as spinal and head injuries
9		Death of one individual
10		Death of more than one individual

FMEA is a method used to determine, identify, and eliminate potential hazards and accidents from an activity process (Stamatics, 2003). FMEA can help understand the consequences of failures (Setiasih & Junadi, 2017). The steps taken to provide good FMEA results are as follows.

1. Conduct initial observations to identify hazards and potential hazards during activities.
2. Analyze the results of hazard identification and potential hazards to determine the severity that can occur.
3. Analyze hazards and potential hazards to determine the frequency of occurrence of these hazards or potential hazards.
4. Identify controls for hazards and potential hazards.
5. Calculate *the Risk Priority Number* (RPN) of each hazard and potential hazard by

multiplying the severity, occurrence, and *detection*.

6. Design improvements to eliminate hazards and potential hazards.

The severity scale used in the study is based on the Incident Severity Scale (Davidson, 2005), shown in Table 2.

The scale of the incidence rate (*occurrence-ance*) used in the study is the *occurrence-ance scale*, according to Wang, Chin, Poon, and Yang (2009). Table 3 is the *occurrence-ance* value used.

Table 3. FMEA Occurrenceance Value Scale

Value	Incidence Rate	Probability of Events
10	>1 in 2	Very high and unavoidable
9	1 in 3	
8	1 in 8	High and frequent
7	1 in 20	
6	1 in 80	Moderate and occasionally occur
5	1 in 400	
4	1 in 2000	Low and relatively rare
3	1 in 15,000	
2	1 in 150,000	Very low and almost never
1	1 in 1,500,000	

The detection scale used is the *detection scale*, according to Wang et al. (2009), and can be seen in Table 4. The severity, occurrence, and detection assessment results are input to calculate the *Risk Priority Number* or RPN (McDermott et al., 2008). The RPN value determines the priority level of potential hazards and occupational accidents (Kim & Zuo, 2018). RPN is obtained by calculating using the following application.

$$RPN = S \times O \times D \quad \text{Press. 1}$$

The FMEA evaluation involves the company, namely the staff and *supervisors of the Welding Department and EHS in HRGA (Human Resource & General Affair)*.

Table 4. FMEA Detection Value Scale

Value	Detection Rate	Possibility Detected
10	Almost impossible	No control tool can detect the form and cause of failure
9	Very rare	Today's control tools are challenging in detecting the form and cause of failure.
8	Infrequently	Today's control tools are challenging in detecting the form and cause of failure.
7	Very Low	The ability of the control tool to detect the form and cause of failure is very low
6	Low	The ability of the control tool to detect the shape and cause of failure is low.
5	Keep	The ability of control tools to detect the form and cause of moderate failure
4	Somewhat high	The ability of the control tool to detect the form and cause of failure is rather high.
3	Tall	The ability of the control tool to detect the form and cause of high failure
2	Very High	The ability of the control tool to detect the form and cause of failure is very high.
1	Almost Definitely	The ability of control tools to detect the form and cause of failure is almost certain.

Participatory Ergonomics is used to design proposals that can reduce work accidents or the impact of work accidents. *Participatory Ergonomics* (PE) is a method to improve the work system by involving workers in the process (Van Eerd et al., 2010). According to Burgess-Limerick (2018), worker involvement in designing and implementing workplace changes can increase productivity and reduce the risk of accidents because it gives control to workers as experts in their field. In addition, PE ensures that the parties involved can get a safe, healthy working environment, with a small risk of accidents, with adaptation to changes that can be appropriately implemented (Sukpto, 2006)

In this study, applying the PE method is expected to ensure feasibility and increase the possibility of implementing proposals to reduce potential hazards and work accidents.

RESULT

The results of this study include the grouping of the identified hazards and potential hazards, evaluation using FMEA and RPN calculations, and design proposals to reduce potential hazards and work accidents. Table 5 shows the results of the grouping of hazard identification and potential hazards.

Table 5. Categories Work Accidents

It	Categories Work Accidents / Workplace Diseases	Information
1	Hit by falling materials	Work accidents occur when a worker's body part is hit or hit by a material that falls during work.
2	Contact with moving machines.	Work accidents occur when a worker's body part is pinched or hit by a part of the operated machine.
3	Injured in the transportation and transfer of materials	Work accidents occur when there is unnatural contact between workers and the material being handled that causes injuries
4	Exposure to fire or hot objects	Accidents that occur when there is contact between workers and fire during the operation of <i>welding machines</i>
5	Exposure to hazardous materials or objects	Work accidents occur when workers come into contact with supporting materials during machine operation at workstations
6	Accidents related to transportation and vehicles	Work accidents related to vehicles and transportation on the production floor, such as material handling equipment (trolleys, <i>hand trucks</i> , etc.)
7	<i>Overexertion and Repetitive Stress Injuries</i>	Work accidents due to repetitive work movements that gradually affect the muscles or nerves of workers
8	Operators are in areas without distancing.	Illness caused by department operators crowding in adjacent areas so that the potential for COVID-19 increases

FMEA evaluation is carried out by assessing *the severity, occurrence, and detection* of the impact of accidents identified in the accident category. RPN is then obtained for each impact of work accidents. Table 6 summarizes the results of the RPN calculation.

After the RPN is obtained for each work accident impact, the RPN value is sorted from the largest so that the impact of the work accident with the most severe risk is known so that it can be prioritized. The results of the RPN sorting carried out can be seen in Table 7.

Based on the RPN sequencing, the impact of work accidents with the highest risk is being pinched by materials, sprains, skin turning red due to heat, and burns. A pareto diagram is then created to visualize the information obtained. The results of the RPN data mapping in the pareto diagram can be seen in Figure 4.

Table 6. Summary of FMEA and RPN Results

Categories Work Accidents / Occupational Diseases	No	Impact of Work Accidents	S	Or	D	RPN
Hit by falling materials	1	Clamp material	7	5	4	140
	2	Scratch wounds	3	5	3	45
Contact with moving machines	3	Abandoned,	5	5	4	100
	4	Lacerations (stitches)	7	4	3	84
Injured in the removal and transfer of materials	5	Material scratch wound	4	5	3	60
Exposure to fire or hot objects	6	Skin becomes red due to heat	4	6	4	96
	7	Burns	6	4	4	96
Exposure to hazardous materials or objects	8	Burns	6	4	4	96
	9	Slashed wounds	4	4	5	80
Transportation-related accidents	10	Minor injuries	3	4	5	60
	11	Abandoned,	5	4	4	80

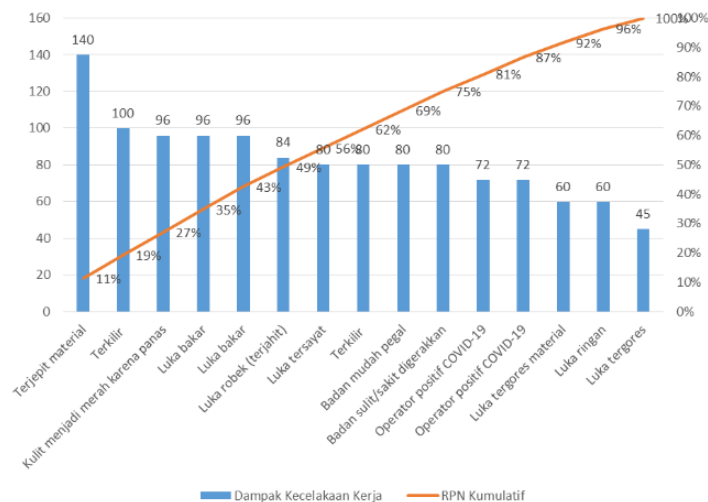


Figure 4. Diagram Pareto RPN

Implementing Participatory Ergonomics in design proposals is carried out by forming a group with participants, namely delegates from the Department of *Welding* and *Human Resources* who handle *Environment Health and Safety* (EHS). The delegation of each department includes workers and heads of the departments concerned.

Participants were introduced to PE to equalize knowledge about the approach before further discussion could be held. The discussion was conducted to discuss work accidents and their impacts, as well as the results of the FMEA assessment showing the hazards and hazard risks of the Welding Department's operational activities.

Based on previous RPN calculations, priority has been obtained for overcoming the impact of work accidents. The discussion was then reconvened to discuss this to ensure that the objectives of each participant could be aligned and synchronized so that a single goal could be achieved that could benefit all parties concerned. This prioritization is carried out using *judgment, assessing work accidents with RPN*, which is not the highest but can be prioritized.

Table 7. RPN Sorting Results

No	Impact of Work Accidents	RPN	RPN Kumu-latif	%Kumu-lative
1	Clamp material	140	140	11%
3	Abandoned,	100	240	19%
6	Skin becomes red due to heat	96	336	27%
7	Burns	96	432	35%
8	Burns	96	528	43%
4	Lacerations (stitches)	84	612	49%
9	Slashed wounds	80	692	56%
11	Abandoned,	80	772	62%
12	The body aches easily	80	852	69%
13	Difficult/sick body moved	80	932	75%
14	Operator positive for COVID-19	72	1004	81%
15	Operator positive for COVID-19	72	1076	87%
5	Material scratch wound	60	1136	92%
10	Minor injuries	60	1196	96%
2	Scratch wounds	45	1241	100%

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DISCUSSION

The F.F.F.

The FMEA work began by observing operational activities in the Welding Department *and conducting interviews with delegates from EHS and the Welding Department. Based on the observations, several factors contribute to the severity, incidence, and detection of work accidents* and detection as control in the Welding Department.

Some workers do not use PPE under applicable rules and do not follow health protocols properly and correctly. Some use *aprons* but do not wear masks, and some use *aprons* but do not use *safety goggles*. Although the situation can be considered safe at that time because there was no unexpected process, workers must remain focused and obey the applicable rules. This is done to maintain the safety and health of workers and their work environment, especially during a pandemic that increases the risk of workers getting sick.

One cause of work accidents is workers' low awareness of the importance of implementing good K3. Therefore, workers' awareness of the need to follow these rules certainly needs to be increased to maintain the safety of others and create a healthy and conducive work environment for workers to carry out their operational activities.

The FMEA assessment is carried out to obtain a score that reflects the real situation in the Welding Department. The severity, occurrence, and detection values were obtained by conducting observations and interviews with the EHS delegation and the Welding Department.

The perspective of each party was considered to bridge the *gap* formed due to differences of opinion between the delegates and the observation results.

RPN results from a risk calculation considering *the severity, occurrence, and detection* of work accidents. Based on the RPN obtained, it is known that the impact of work accidents with the highest risk is being pinched by materials, sprains, and skin becoming red due to heat. The RPN value for each impact of the work accident is 140, 100, and 96 consecutively. With the RPN value, the three impacts of work accidents must be overcome first. It is different if the priority is determined based on only the highest severity, occurrence-ance, or detection values. Each aspect will have its priorities because the impact of work accidents with the highest severity does not necessarily have the highest occurrence or detection value. Therefore, there is a possibility that the priority is not managed efficiently because there is a high probability that the impact of the work accident with the highest severity is prioritized but has a low occurrence and good detection.

Based on the determination of priorities using RPN, it can be seen that the impact of work accidents related to the COVID-19 pandemic is not a priority. This is due to the fact that the *Welding* Department is of the opinion that the category of work accident impact related to COVID-19 on the FMEA evaluation sheet can be overcome later compared to other work accidents. Therefore, the RPN value of this category is not too large, so it does not become a priority, such as being pinched by materials, sprained, and skin turning red due to heat. This shows that the knowledge of several parties in the *Welding department* regarding COVID-19 is not in line with the EHS, supported by the discussion process that has been carried out previously. This difference in perception of COVID-19 will be dangerous if there is an outbreak or an increase in the positive rate of COVID-19 again. Thus, compromises are needed so that workers in the department can still be protected during operational activities during the pandemic.

Proposal Design

Based on the FMEA results, the proposal was then designed using the PE method. The companies involved in the FMEA evaluation are again involved in this process. The discussion was held to determine the priority of work accidents according to the RPN calculation results. This is done to equalize perception and purpose. Priority determination is also done using judgment, assessing work accidents with a low RPN but are better prioritized.

The discussions conducted between each PE participant resulted in some of the needs of *the Welding Department workers*. *Identifying these needs is the initial input for designing proposals to minimize the impact of work accidents*. The recapitulation of need identification is as follows.

1. Control of work procedures
2. *Safety and health* refreshment
3. Educate the spread and prevention of COVID-19 in the workplace
4. Adequate PPE

The proposed improvements were designed based on the needs of the welding department workers identified in the design discussion using PE. Based on the results of the discussion, it is known that existing accidents are relatively due to *human error* or the workers' fault. Therefore, the proposed proposals are more about ways that can be done to increase workers' awareness of safety and health in the workplace. The recapitulation of the results of the proposal design can be seen in Table 8.

The proposed improvement in the form of control of SOPs and the field is an effort to increase workers' awareness of K3. Detailed instructions are needed to clarify the activities that should be carried out when things are out of control. So, workers know the procedures that can be carried out and avoid accidents. The control in question can be in the form of regular checks as a reminder for workers. This includes pandemic-related rules requiring workers to continue implementing health protocols in the workplace.

Another proposal is to plan and carry out periodic *safety training*. As discussed earlier, the EHS and the Welding Department assume that human error caused the accident relatively. Therefore, it is important to implement training related to safety on the production floor. Based on the discussions, *safety training* is given to new workers during the introduction period and after a work accident. This is considered less effective because these efforts are only carried out when danger has occurred. The renewal of *safety training* mentioned in the detection of FMEA is also limited to areas or activities that are part of certain work accidents or potential accidents. In addition, new workers who received training during the introduction period were not familiar with the system in question.

Table 8. Recapitulation of Proposal Design Results

It	Problem	Necessity	Solution
1	Accidents continue to occur even though work instructions have been installed	Procedure control work	Control of SOPs and the field
2	Workers often take <i>unsafe actions</i>	<i>Safety and health</i> refreshment	Procurement of <i>periodic</i> safety training
3	Workers do not use PPE by applicable rules	Adequate PPE	Installation of instruments to remind workers of good OSH implementation
4	The implementation of health protocols on the production floor is still low.	Educate the spread and prevention of COVID-19 in the workplace	Installation of instruments to remind workers of health protocols

In the last proposal in the study, the designed instrument can be used as an educational tool and reminder for workers. The instrument is in the form of an infographic poster that contains short, concise, and clear warnings. The poster design explains what may happen if PPE is improperly used. This takes inspiration from spooky images on cigarette packs in Indonesia. Similar to the purpose of the spooky image on cigarette packs, the existence of images that show the impact of accidents that occur when not using PPE is expected to awaken the awareness of workers who see the poster. The designed instrument can be seen in Figures 5, 6, and 7.



Figure 5. PPE Instrument Proposal Design (1)



Figure 6. PPE Instrument Proposal Design (2)



Figure 7. COVID-19 Instrument Proposal Design

Figure 6 also shows other instrument designs for PPE. In Figure 5 and Figure 6, color determination is based on ergonomic color theory, which uses contrasting colors to attract attention and stimulate psychological responses (Williams, 2003; Woodson, 1981).

In Figure 5, yellow is used over white to give a prominent impression because the most crucial message is found in the part that has the background. The color difference between the yellow background and the two illustrations conveys a short message: using PPE to avoid accidents like this. The image of part (a) relies more on conveying a message through illustrative symbols with minimal explanatory sentences. The purpose of such a design is to simplify the message so that anyone who sees it can more easily receive it.

Meanwhile, Figure 6 has a simpler symbol but a more detailed message. The symbol uses yellow on black, which provides high contrast so that the appeal is clearly visible. Therefore, when the poster is installed in the Welding Department, the color can attract workers' attention, and they will read the information in the poster.

Other instruments designed are an appeal to implement regulations related to COVID-19. Contrast is created by using yellow on top of a dark background color as the core of the explanation. The design is relatively simple, emphasizing explanatory points made with yellow writing and simple illustrations in addition to explanatory points. This is done in the hope that the information to be conveyed remains dense and accurate without misunderstandings by workers who read it. The proposed design for COVID-19 suppression in the workplace can be seen in Figure 7.

CONCLUSION

The results of the identification of hazards and potential hazards using FMEA on conditions in the Welding Department during the pandemic show that the identification of potential hazards and work accidents can be grouped into eight categories, namely being hit by falling materials, contact with moving machinery, being exposed to fire or hot objects, as well as being exposed to hazardous materials or objects, accidents related to transportation, *overexertion and repetitive stress injuries*, and operators who are in the area without keeping their distance. Based on the impact of work accidents identified from this category, it is known that the impact of work accidents that often occur is being pinched by materials, sprains, and skin becoming red due to heat. Each of the impacts of the work accident has a value of RPN 140, 100, and 96.

Proposed designs supporting production in the *Welding* Department during the pandemic are reviewing and controlling SOPs and conditions in the field, planning and carrying out *periodic safety training* for workers, and installing instruments to remind workers of occupational safety and health in operational activities.

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