

Job Safety Analysis (JSA) with Risk Assessment in Welding of TLB Dipper by Tack Welding

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Abstract

Industrial accidents and disease remain the most terrible human tragedy of modern industry and one of its most serious forms of economic waste. Not only direct but also indirect costs of accidents are tremendously increasing and causing the great national loss. This can be prevented by safety only. As productivity of any organization is interrelated with safety, means increasing and maintaining safety gives good productivity. But due to lack of inspection, supervision and training for safety and no written rules for job description, procedure and safe production from management are the main factors which impeding safety. The use of risk assessment methodologies contributes to prevent and control undesired event i.e. near miss or accident.

Keywords: Job Safety Analysis, Risk Analysis, Risk Assessment

I. INTRODUCTION

Hazard identification and risk assessment is systematic process to protect the health and minimize danger to life of workers, property and environment. It includes the methodological steps to identify hazard related to materials, operations and workplace conditions. In this assess the risk level and applying the possible remedies and corrective actions to reduce the risk. As the part of the project work, hazard identification and risk analysis was carried out in a dipper tack welding process in construction equipment manufacturing industry. In this the risk level is divided into very high, high, medium and low depending upon their consequences and likelihood of hazards and severity. The very high and high risks activities have been marked in red color and dark yellow respectively these are un-acceptance and must be reduced. The risks which are marked in yellow color are tolerable but efforts must be made to reduce risk. The risks which are marked in green have the risk level so low that it is not required for taking actions to reduce its magnitude any further.

II. METHODOLOGY

Risk is the results from hazard i.e. an unsafe condition, unsafe action or situation. Risk is the probability of frequency of hazards during a certain period. Therefore, if hazard is identified and removed first, risk is automatically reduced. Some definitions are as under:

A. Hazard

It is the inherent property of a substance or unsafe condition, unsafe action or situation to cause harm which may cause human injury, damage to property or the environment or some combination of these criteria [2].

B. Risk

It is the likelihood, chance, frequency or probability of an undesired event (i.e. accident, injury or death) occurring within a specified period or under specified circumstances and its gravity (severity), effect or consequences [2].

C. Risk Analysis

Technical process of identifying, understanding and evaluating risk (analyzing cause and effect wise) [2].

D. Risk Assessment

It is a judgment of significance or activities that enable to identify, evaluate and measure risk and uncertainty and their potential impact.

E. Job Safety Analysis

Job Safety Analysis is a termed as 'JSA' and it is defined as the procedure of analyzing the job for the purpose of finding hazards in each steps and developing the safety precautions to be adopted.

This JSA technique can be applied at any stages of process activities and it is the most useful at the stage of planning, design and starting of process [2].

F. Risk Calculation

Risk terms states that "It is the possibility of a certain undesired event occurring within a identified period such that individual or others may be expected to sustain a given level of harm from the realization of specific hazards" [2].

Formula for risk calculation as-

$$R = P \times G$$

Where,

R = Total Risk.

P = Probability of occurrence of event.

G = Severity (Gravity or degree of harm)

Here,

Probability (P) as-

P = 1; Very Low Probability to Occur (Event almost not possible to occur)

P = 2; Lower Probability to Occur (Probability >1 / year)

P = 3; Probable to Occur (Probability >1 month)

P = 4; Highly Probability to Occur (Risk Probability always exist)

Now,

Gravity (G) as-

G = 1; First Aid

G = 2; Minor Accident (Lost Time up to 3 days)

G = 3; Major Accident (Lost Time > 3 &< 30 days)

G = 4; Serious Injury, Fatal (Lost Time > 30, fatal)

G. Standard Risk Matrix

RISK SCORE		GRAVITY			
		1	2	3	4
PROBABILITY	1	1	2	3	4
	2	2	4	6	8
	3	3	6	9	12
	4	4	8	12	16

Fig. 1: Standard Risk Matrix

H. Classification Risk Levels and their Color Codes

Risk levels and their color codes are classified into 4 levels on the basis of their score or calculation they are as shown below:

- 1) Very High Risk Level, Red
- 2) High Risk Level, Orange
- 3) Medium or Moderate Risk Level, Yellow
- 4) Low Risk Level, Green

RISK LEVEL
VERY HIGH (12, 16)
HIGH (8, 9)
MEDIUM (4, 6)
LOW (1, 2, 3)

Fig. 2: Classification of Risk level with color codes.

- Very high risk: Not acceptable: The risk is not acceptable and must strongly attached. There is needed to implement immediate countermeasures in order to reduce the level of the risk at least to a tolerable level.
- High risk: Improvable: The risk is not acceptable and must be improvable. There is needed to implement rapid countermeasures in order to reduce the level of the risk at least to a tolerable level.
- Medium risk: Tolerable: The risk is tolerable. There is needed to evaluate possible countermeasures in order to reduce the level of the risk to an acceptable level. Continuous improvement approach is required.
- Low risk: Acceptable: The risk is acceptable. Continuous monitoring about safety conditions is required.

I. Countermeasures or Control

When determining controls and considering changes to existing control, consideration shall be given to reducing the risks according to the following hierarchy [5]:

- Elimination
- Substitution
- Engineering controls
- Signage / warnings and administrative control
- Personal Protective Equipment

J. Methodology Process

A method includes the following steps for the routine work i.e. the work which relates to the production unit:

- 1) Selection of the job
- 2) Divide the job into number of task
- 3) Notice the hazards associated with each task separately
- 4) Analysis the risk
- 5) Score the risk from standard risk matrix
- 6) Prioritize the risk
- 7) Firstly take action on the very high, high, medium risk level and further on low risk level
- 8) Provide effective countermeasures or control to reduce risk levels such that try to bring the risk to the tolerable limit i.e. low risk level
- 9) Again score the risk.

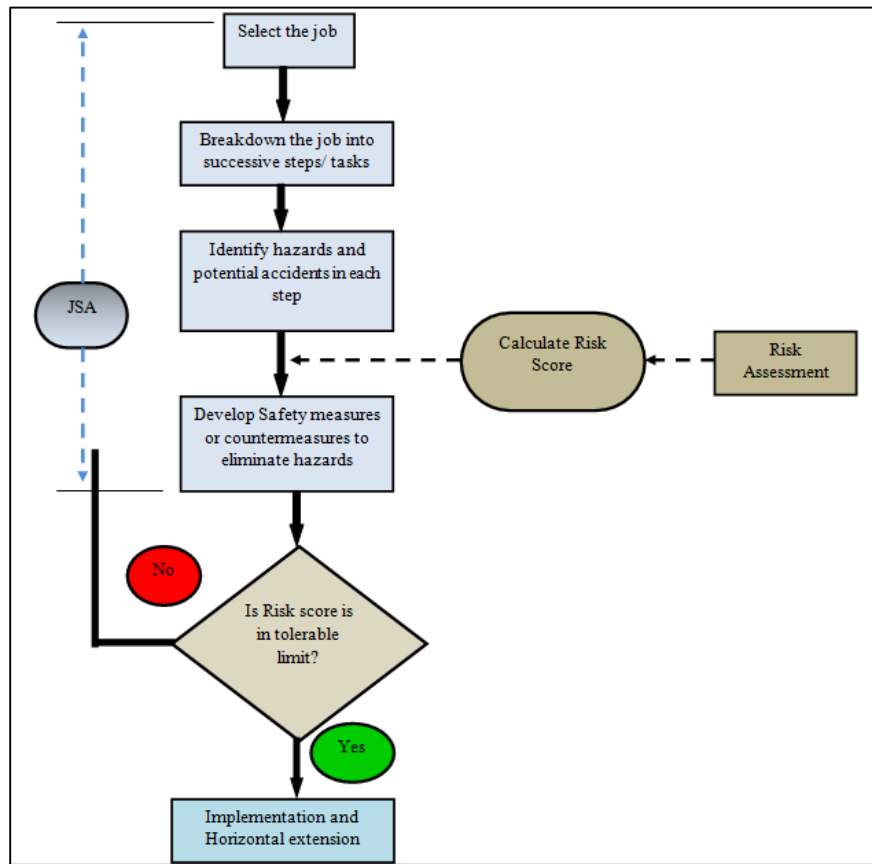


Fig. 3: Basic Flow Chart of JSA with Risk Assessment process.

Now we have considering tasks in DipperTack Welding Operation in Fabrication process they are in following ways-

- Task 1: Fitting of Boss sub assembly on bucket end side of dipper: In this task operator has to lift the boss sub assembly manually by hand which has the weight of 15.6 KG from tode bin box. Thus, hazards are of fall of material, and ergonomics problem of excessive bending and , fracture injury may could be occur
- Task 2: Positioning of Dipper Box on Fixture: In this task operator has to lift the dipper box through simply fixing of hook without latches (locking hook) and no lifting tackle for dipper box. Thus, thereare a more chances of fall of dipper box from hook which could cause any major injury to operator.
- Task 3: Fitting of Bosses in dipper: In this task, operator has to go for picking up the boss from the bin which has weight of 8 KG and cylindrical shape boss could be slip from his hands. Thus, operation involving of excessive forces which cause strain on hand and waist.
- Task 4: Mounting of Nav sub assembly: In this task no lifting tackle available to lift effectively the nav sub assembly, so they lift by hand which having the sharp edges on corners. Thus, there may be chances of cut injury and fall of component.
- Task 5: Dipper side plate fitting: No lifting tackle available to lift side plate of dipper from bin. Thus, operator has to bend more which involve more bending of waist could causes strain on waist and in hand.
- Task 6: Fitting of rocket sub assembly: In this task no lifting tackle available to lift effectively the rocket sub assembly, so they lift by hand which having the sharp edges, Thus, there may be chances of cut injury and fall of component.
- Task 7: Start of Tack welding: Fixture or manipulator having the hydraulic based system pipes for tightening and fix above mention parts in their location which are in open condition. There could be forcefully leakage of hot oil from hoses if any component falls on it which may lead any to any serious injury. Secondly, during welding operation, no proper platform for working as operator has to stand on fixture platform and no fumes extractor found on work station to extract out harmful gases. Glare which comes when the arc is struck, heat radiation from welding can cause headache, fatigue, eye damage and burn injury.
- Task 8: Unloading the dipper: After the welding operation, next task is to unload the dipper from manipulator. As no their no lifting tackle found so operator fix the hook and sling around the dipper and lift it above the operators height. Thus, in this task there will be chances of burn injury and fall of component which leads to any major injury.

Safety risk assessment of dipper tack welding workplace on basis of above mentioned tasks and movement of operator as shown in table below:

Table – 1
Safety Risk Assessment for Dipper Tack Welding Station

Safety Risk Assessment- Dipper Tack Welding										
Statio n no.	Task no.	Unsafe Condition (Hazard)	Risk Description	Before Risk			Countermeasure Description	After Risk		
				P	G	R		P	G	R
1	1	Presence of compressed air blow, spatters	Eye injury due to Particle penetration	3	2	6	Provision of Welding shield & Goggle	3	1	3
1	1	Presence of abrasive material in work place	Body injury on account of abrasion/scratch	2	1	2	Use of PPE	2	1	2
1	1	Machine/tool/parts not properly arranged	Body injury due to Hit/Impact/Crush from machine/tools/parts	3	1	3	Workplace organization	1	1	1
1	1	Presence of sharp objects at work place	Cut injury due to penetration of sharp objects	3	1	3	Use of Hand Gloves	2	1	2
1	1	Presence of uneven surfaces/holes/openings on floor in work area	Body injury due to fall	2	2	4	Repairing of Floor	1	1	1
1	1	Use of improper tools e.g. hammers mushroomed, bent etc.	Body injury	3	2	6	Provision of Hammer	1	1	1
1	1	Inadequate free space in walkways/aisles	Body injury due to hit/collision	3	1	3	5S Required	1	1	1
1	1	Unavailability of emergency communication signs (exits, evac, fire exits etc.)	Injury due to collision/ stampede during emergency evacuation	2	2	4	Provision of emergency signs	1	1	1
1	1	Unavailability of proper hooks, Tackle & fixtures for lifting parts	Body injury due to fall of parts	4	3	12	Lifting Tackle for Dipper boss s/a	1	4	4
1	1	Absence of signs/instruction to wear PPEs at work station	Body injury due to non usage of PPEs	1	3	3	PPE Requirements posted	1	2	2
1	1	PPEs not inspected regularly and not in good condition	Body injury due to failure of PPE	1	3	3	Operators trained on care of PPE	1	2	2
1	1	Operation requiring reaching below waist	Fatigue/ body strain	4	2	8	Provision of Dipper boss s/a trolley	1	1	1
1	2	Presence of abrasive material	Body injury on account of	2	1	2	Use of PPE	2	1	2

		<i>in work place</i>	<i>abrasion/scratch</i>							
1	2	Machine/tool/parts not properly arranged	Body injury due to Hit/Impact/Crush from machine/tools/parts	3	1	3	Workplace organization	1	1	1
1	2	Presence of sharp objects at work place	Cut injury due to penetration of sharp objects	3	1	3	Use of Hand Gloves	2	1	2
1	2	Presence of uneven surfaces/holes/openings on floor in work area	Body injury due to fall	2	2	4	Repairing of Floor	1	1	1
1	2	Spillage of oils/nut & bolts, Presence of cables/hoses etc. on floor	Body injury due to slip	3	2	6	Provision of Tray below the fixture	2	1	2
1	2	Inadequate free space in walkways/aisles	Body injury due to hit/collision	3	1	3	5S Required	1	1	1
1	2	Unavailability of emergency communication signs (exits, evac, fire exits etc.)	Injury due to collision/stampede during emergency evacuation	2	2	4	Provision of emergency signs	1	1	1
1	2	Unavailability of proper hooks, Tackle & fixtures for lifting parts	Body injury due to fall of parts	4	3	12	Lifting Tackle for Dipper box	1	3	3
1	2	Absence of signs/instruction to wear PPEs at work station	Body injury due to non-usage of PPEs	1	3	3	PPE Requirements posted	1	2	2
1	2	PPEs not inspected regularly and not in good condition	Body injury due to failure of PPE	1	3	3	Operators trained on care of PPE	1	2	2
1	3	Machine/tool/parts not properly arranged	Body injury due to Hit/Impact/Crush from machine/tools/parts	3	1	3	Workplace organization	1	1	1
1	3	Spillage of oils/nut & bolts, Presence of cables/hoses etc. on floor	Body injury due to slip	3	2	6	Provision of Tray	2	1	2
1	3	Inadequate free space in walkways/aisles	Body injury due to hit/collision	3	1	3	5S Required	1	1	1
1	3	Unavailability of emergency communication signs (exits, evac, fire exits etc.)	Injury due to collision/stampede during emergency evacuation	2	2	4	Provision of emergency signs	1	1	1
1	3	Hoists, cranes, ropes, chains not maintained properly	Body injury due to fall of objects on account of brakages/malfunctioning of hoists, cranes, ropes, chains	1	4	4	Maintenance Daily check list	1	3	3
1	3	Hoists & lifting devices not marked with capacity	Body injury on account of failure of hoist/lifting device due to wrong selection of hoist/lifting device	1	4	4	Provision of marked with capacity	1	3	3
1	3	Unavailability of proper hooks, Tackle & fixtures for lifting parts	Body injury due to fall of parts	4	3	12	Lifting Tackle for Boss	1	3	3
1	3	Absence of signs/instruction to wear PPEs at work station	Body injury due to non-usage of PPEs	1	3	3	PPE Requirements posted	1	2	2
1	3	PPEs not inspected regularly and not in good condition	Body injury due to failure of PPE	1	3	3	Operators trained on care of PPE	1	2	2
1	3	Operation involves awkward repetitive motions	Fatigue/ body strain	4	2	8	Provision of heighted boss trolley	2	1	2
1	4	Presence of abrasive material in work place	Body injury on account of abrasion/scratch	2	1	2	Use of PPE	2	1	2
1	4	Machine/tool/parts not properly arranged	Body injury due to Hit/Impact/Crush from machine/tools/parts	3	1	3	Workplace organization	1	1	1
1	4	Presence of sharp objects at work place	Cut injury due to penetration of sharp objects	3	1	3	Use of Hand Gloves	2	1	2
1	4	Presence of uneven surfaces/holes/openings on floor in work area	Body injury due to fall	2	2	4	Repairing of Floor	1	1	1
1	4	Spillage of oils/nut & bolts, Presence of cables/hoses etc. on floor	Body injury due to slip	3	2	6	Provision of Tray	2	1	2

1	4	Inadequate free space in walkways/aisles	Body injury due to hit/collision	3	1	3	5S Required	1	1	1
1	4	Unavailability of emergency communication signs (exits, evac, fire exits etc.)	Injury due to collision/ stampede during emergency evacuation	2	2	4	Provision of emergency signs	1	1	1
1	4	Hoists, cranes, ropes, chains not maintained properly	Body injury due to fall of objects on account of brakages/malfunctioning of hoists, cranes, ropes, chains	1	4	4	Maintenance Daily check list	1	3	3
1	4	Hoists & lifting devices not marked with capacity	Body injury on account of failure of hoist/lifting device due to wrong selection of hoist/lifting device	2	4	8	Provision of marked with capacity i.e. SWL	1	4	4
1	4	Unavailability of proper hooks, Tackle & fixtures for lifting parts	Body injury due to fall of parts	3	4	12	Lifting Tackle for Nov s/a	1	3	3
1	4	Absence of signs/instruction to wear PPEs at work station	Body injury due to non-usage of PPEs	1	3	3	PPE Requirements posted	1	2	2
1	4	PPEs not inspected regularly and not in good condition	Body injury due to failure of PPE	1	3	3	Operators trained on care of PPE	1	2	2
1	4	Operation involves awkward repetitive motions	Fatigue/ body strain	4	2	8	Provision of heighted Nav trolley	2	1	2
1	5	Presence of abrasive material in work place	Body injury on account of abrasion/scratch	2	1	2	Use of PPE	2	1	2
1	5	Machine/tool/parts not properly arranged	Body injury due to Hit/Impact/Crush from machine/tools/parts	3	1	3	Workplace organization	1	1	1
1	5	Presence of sharp objects at work place	Cut injury due to penetration of sharp objects	3	1	3	Use of Hand Gloves	2	1	2
1	5	Presence of uneven surfaces/holes/openings on floor in work area	Body injury due to fall	2	2	4	Repairing of Floor	1	1	1
1	5	Spillage of oils/nut & bolts, Presence of cables/hoses etc. on floor	Body injury due to slip	3	2	6	Provision of Tray	2	1	2
1	5	Inadequate free space in walkways/aisles	Body injury due to hit/collision	3	1	3	5S Required	1	1	1
1	5	Unavailability of emergency communication signs (exits, evac, fire exits etc)	Injury due to collision/ stampede during emergency evacuation	2	2	4	Provision of emergency signs	1	1	1
1	5	Hoists, cranes, ropes, chains not maintained properly	Body injury due to fall of objects on account of brakages/malfunctioning of hoists, cranes, ropes, chains	1	4	4	Maintenance Daily check list	1	3	3
1	5	Hoists & lifting devices not marked with capacity	Body injury on account of failure of hoist/lifting device due to wrong selection of hoist/lifting device	1	4	4	Provision of marked with capacity	1	3	3
1	5	Unavailability of proper hooks, Tackle & fixtures for lifting parts	Body injury due to fall of parts	4	3	12	Lifting Tackle for side plate	3	3	9
1	5	Absence of signs/instruction to wear PPEs at work station	Body injury due to non-usage of PPEs	1	3	3	PPE Requirements posted	1	2	2
1	5	PPEs not inspected regularly and not in good condition	Body injury due to failure of PPE	1	3	3	Operators trained on care of PPE	1	2	2
1	6	Presence of abrasive material in work place	Body injury on account of abrasion/scratch	2	1	2	Use of PPE	2	1	2
1	6	Machine/tool/parts not properly arranged	Body injury due to Hit/Impact/Crush from machine/tools/parts	3	1	3	Workplace organization	1	1	1
1	6	Presence of sharp objects at work place	Cut injury due to penetration of sharp objects	3	1	3	Use of Hand Gloves	2	1	2
1	6	Presence of uneven surfaces/holes/openings on floor in work area	Body injury due to fall	2	2	4	Repairing of Floor	1	1	1

1	6	Spillage of oils/nut & bolts, Presence of cables/hoses etc. on floor	Body injury due to slip	3	2	6	Provision of Tray	2	1	2
1	6	Inadequate free space in walkways/aisles	Body injury due to hit/collision	3	1	3	5S Required	1	1	1
1	6	Unavailability of emergency communication signs (exits, evac, fire exits etc)	Injury due to collision/ stampede during emergency evacuation	2	2	4	Provision of emergency signs	1	1	1
1	6	Hoists, cranes, ropes, chains not maintained properly	Body injury due to fall of objects on account of brakages/malfunctioning of hoists, cranes, ropes, chains	1	4	4	Maintenance Daily check list	1	3	3
1	6	Hoists & lifting devices not marked with capacity	Body injury on account of failure of hoist/lifting device due to wrong selection of hoist/lifting device	2	4	8	Provision of marked with capacity i.e. SWL	1	4	4
1	6	Unavailability of proper hooks, Tackle & fixtures for lifting parts	Body injury due to fall of parts	4	3	12	Lifting Tackle for rocket	1	3	3
1	6	Absence of signs/instruction to wear PPEs at work station	Body injury due to non-usage of PPEs	1	3	3	PPE Requirements posted	1	2	2
1	6	PPEs not inspected regularly and not in good condition	Body injury due to failure of PPE	1	3	3	Operators trained on care of PPE	1	2	2
1	6	Operation involves awkward repetitive motions	Fatigue/ body strain	4	2	8	Provision of rocket trolley	2	1	2
1	7	Presence of compressed air blow/Welding Spark	Eye injury due to Particle penetration	3	4	12	Cover provided on exposed out hoses.	3	1	3
1	7	Presence of abrasive material in work place	Body injury on account of abrasion/scratch	2	1	2	Use of PPE	2	1	2
1	7	Machine/tool/parts not properly arranged	Body injury due to Hit/Impact/Crush from machine/tools/parts	4	2	8	Increase the height of stand	2	1	2
1	7	Spillage of oils/nut & bolts, Presence of cables/hoses etc. on floor	Body injury due to slip	3	2	6	Provision of Tray	2	1	2
1	7	Inadequate free space in walkways/aisles	Body injury due to hit/collision	3	1	3	5S Required	1	1	1
1	7	Unavailability of emergency communication signs (exits, evac, fire exits etc.)	Injury due to collision/ stampede during emergency evacuation	2	2	4	Provision of emergency signs	1	1	1
1	7	Absence of signs/instruction to wear PPEs at work station	Body injury due to non-usage of PPEs	1	3	3	PPE Requirements posted	1	2	2
1	7	PPEs not inspected regularly and not in good condition	Body injury due to failure of PPE	1	3	3	Operators trained on care of PPE	1	2	2
1	7	Presence of hot or cold (e.g. liquid nitrogen) objects/surfaces/extreme temperature	Burn injury due to exposure of temperature/extreme cold	3	2	6	Provision of hand gloves & sleeves	2	1	2
1	7	Presence of optical radiations (laser, welding, torching)	Eye injury/Illness due to impact on nervous system on account of exposure to optical radiation	3	2	6	Provision of Welding shield & Goggle	3	1	3
1	7	Noise during operation (>85 dB)	Induced hearing loss/permanent hearing loss due to continuous exposure to noise	3	2	6	Provision of Ear Plug	3	1	3
1	7	Welding Fumes During operation	toxicity (loss of lungs disease due to welding fumes)	3	3	9	Provision of Welding mask	3	2	6
1	8	Presence of abrasive material in work place	Body injury on account of abrasion/scratch	2	1	2	Use of PPE	2	1	2
1	8	Machine/tool/parts not properly arranged	Body injury due to Hit/Impact/Crush from machine/tools/parts	3	1	3	Workplace organization	1	1	1
1	8	Presence of sharp objects at work place	Cut injury due to penetration of sharp objects	3	1	3	Use of Hand Gloves	2	1	2
1	8	Inadequate free space in walkways/aisles	Body injury due to hit/collision	3	1	3	5S Required	1	1	1

1	8	Unavailability of emergency communication signs (exits, evac, fire exits etc.)	Injury due to collision/ stampede during emergency evacuation	2	2	4	Provision of emergency signs	1	1	1
1	8	Hoists, cranes, ropes, chains not maintained properly	Body injury due to fall of objects on account of brakages/ malfunctioning of hoists, cranes, ropes, chains	1	4	4	Maintenance Daily check list	1	3	3
1	8	Hoists & lifting devices not marked with capacity	Body injury on account of failure of hoist/lifting device due to wrong selection of hoist/lifting device	1	4	4	Provision of marked with capacity	1	3	3
1	8	Unavailability of proper hooks, Tackle & fixtures for lifting parts	Body injury due to fall of parts	4	3	12	Lifting Tackle for Dipper	1	3	3
1	8	Absence of signs/instruction to wear PPEs at work station	Body injury due to non-usage of PPEs	1	3	3	PPE Requirements posted	1	2	2
1	8	PPEs not inspected regularly and not in good condition	Body injury due to failure of PPE	1	3	3	Operators trained on care of PPE	1	2	2
1	8	Operation requiring reaching below waist	Fatigue/ body strain	4	2	8	Provision of Dipper trolley	2	1	2

III. RESULTS AND DISCUSSION

Thus, from table no.1 of safety risk assessment we come to an result that as there are 93 risks to operators are involved in the process of dipper tack welding operation due to unsafe workplace condition and activities involved in operation, in which 44 are of low risk level, 32 are of medium risk level, 9 are of high risk level and 8 are of very high risk level before taking any countermeasure. But further we have observe that after taking countermeasures we have 88 low level risk and 4 are under medium risk level, 1 high and zero very high risk level, result as shown below in table no.2 and graphically in fig. 4.

Table - 2
Result of Safety Risk Assessment

Risk Level	Before	After
Very High Risk	8	0
High Risk	9	1
Medium Risk	32	4
Low Risk	44	88

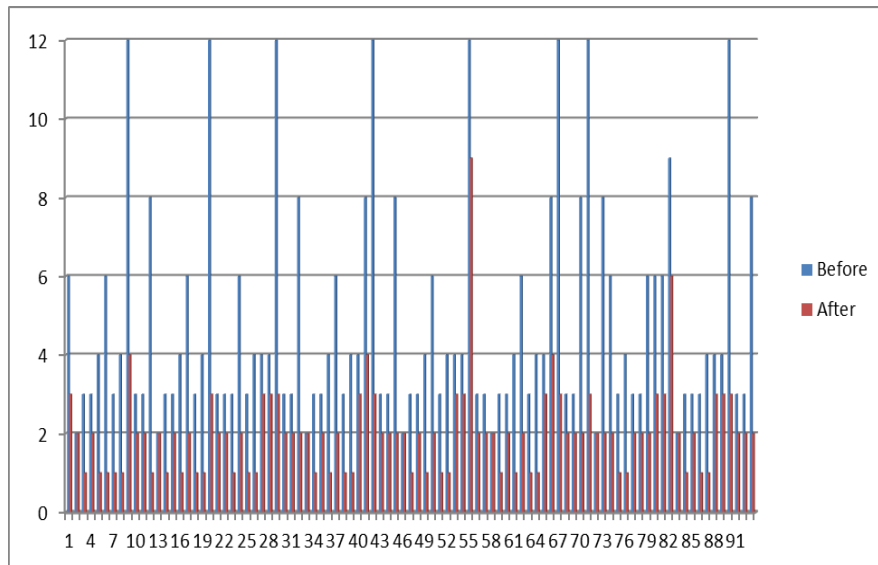


Fig. 4: Graphical representation of before risk vs. after risk.

Firstly industry has to classify the hazards, assess the related risks and bring the risks to tolerable level on a constant basis by taking effective countermeasure or control because unsafe conditions and practices in industry leading to a number of accidents and causes loss and injury to human lives, damages the property, interrupt production etc.

IV. CONCLUSION

- Each of the hazards that remain poses some risk to the workers and the community in the operation of the plant. These risks need to be identified specifically and evaluated. Risks are controlled in several ways and these indicate other source of risk.
- For any manufacturing industry to be successful it should have to meet not only the production requirements, but also have to sustain the highest safety standards for all concerned. Therefore, Job safety analysis with risk assessment is a systematic method of identifying and analyzing the hazards associated with an activity and establishing a level of risk for each hazard on the task and movement level basis.
- By taking effectively countermeasure we will bring the risk only up to tolerable limit & acceptable limit in all areas of activities but cannot eliminate the hazards and risk completely from the workplace because in manufacturing industry many machinery, substances and activities are in use so there is always have possibility to cause some injury to operators. Thus, there is always some residual risk in process industry.

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