# Study and Analysis of Standard factors for Risk and Hazards in Chassis Manufacturing Industry for Buses and Trucks

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*Abstract*— The Bus and Truck industry is a significant lifeline of the country's economic activity. Over three million Heavy vehicles traverse the length and breadth of our country, contributing immensely to movement of commodities, expansion of commerce and enhancement of the GDP. An important fact of this industry is its highly diversified character of ownership. About 90 per cent of vehicles are owned and operated by individual operators having 1 to 3 vehicles in their fleet. Also, over 70 per cent of them are owner-drivers directly depending on trucking for livelihood. The SIMPLEX manufacturers have a large role to play to assist this segment by giving design recommendations on interface aspects, wherever necessary, in order to ensure the safety and performance levels of their vehicles after body building and when used on the road. Various aspects related with the design of Bus and Truck with respect to the cab, the load body, requirements for hazardous goods vehicles, containers and their requirements for mounting, handling and securing, requirements for trailers etc. need to be addressed in the right perspective. Here in this thesis the work under Simplex manufacturing was shown by taking whole manufacturing and assembling of chassis for bus and trucks was considered. As known every machine has their own standards which were created or developed according to their need and safety for environment. So here in this report we present all the required standards for manufacturing used in the manufacturing industry for the safety of human and vehicles which shows all the necessary work under the company and also the modified standards according to the safety needs to overcome hazards.

***Keywords:*** Simplex Metal Processors, Risk, Hazards, Safety Standards, Welding Hazards, Fire Hazards, Material, Electrical. Personal Protective Equipment (PPE), Homer

## I. INTRODUCTION

The primary concern for drivers and passengers is safety. Governments have responded to this key concern and expectation with an increasing number of regulations. Although the details may vary slightly from country to country, the fundamental requirements are almost similar. A vehicle is expected to provide adequate protection to drivers and passengers in a not so serious accident.

One of the important member take part in the system of safety is chassis, here in this thesis I presents all the safety factors which take part while making and assembling the chassis of Trucks and Buses. A full detailed and prospective study was done here based on standard parameters defined by company for safety and hazards of chassis were studied in detail.

Chassis is a French term and was initially used to denote the frame parts or Basic Structure of the vehicle. It is the back bone of the vehicle [1]. A vehicle without body is called Chassis. The components of the vehicle like Power plant, Transmission System, Axles, Wheels and Tyres, Suspension, Controlling Systems like Braking, Steering etc., and also electrical system parts are mounted on the Chassis frame. It is the main mounting for all the components including the body. So it is also called as Carrying Unit.

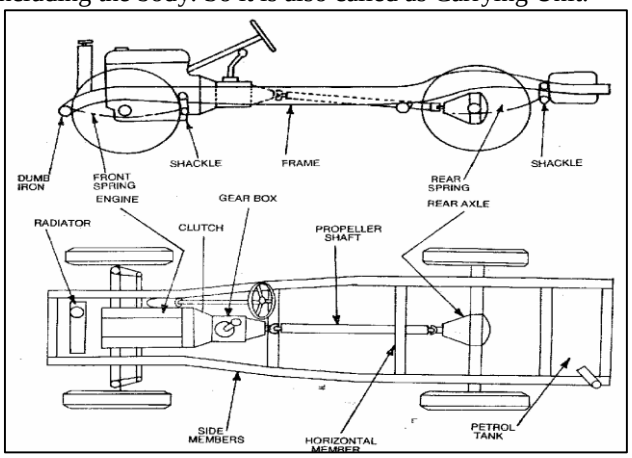


Fig. 1: Layout of Chassis [1]

### A. *Requirements of bodies for various types of vehicle [5]:*

1) The body should be light.
2) It should have minimum number of components.
3) It should provide sufficient space for passengers and luggage.
4) It should withstand vibrations while in motion.
5) It should offer minimum resistance to air.
6) It should be cheap and easy in manufacturing.
7) It should be attractive in shape and color.
8) It should have uniformly distributed load.
9) It should have long fatigue life
10) It should provide good vision and ventilation.

### B. *Other Members of Chassis*

1) Steering Mechanism
2) Braking System
3) Suspension System
4) Seat door and window mechanism
5) Legal Aspects of Vehicle

The motor vehicle act of 1977 is applicable and extends to the whole of India. It was framed in 1939 and amended time to time according to the requirements and necessities of roads and vehicles. This act as amended up to 1977 has 10 chapters, 135 sections and 12 schedules.

1) Chapter I – Preliminary Section 1-2.
2) Chapter II – Licensing of driver of motor vehicles (Sections 3-21)
3) Chapter IIA – Licensing of conductors of state carriage (Sections 21A-21J)
4) Chapter III – Registration of motor vehicles (Sections22-41)
5) Chapter IV – Control of transport vehicles (Sections 42-68)

 

6) Chapter IVA – Special provisions relating to state transport undertaking (Sections 68A-68J )
7) Chapter V – Construction, equipment and maintenance of motor vehicles (Sections 69-70)
8) Chapter VI – Control of traffic (Sections 71-91)
9) Chapter VII – Motor Vehicles temporarily leaving or visiting India (Section 92)
10) Chapter VIII – Insurance of motor vehicle against third party Risk (Section 93- 111A)
11) Chapter IX – Offences, penalties and procedure (Section 112-132)
12) Chapter X – Miscellaneous (Section 132A-135)

P.Eraiyanbu et.al [11] Hazard Identification and Risk Assessment (HIRA) is a safety tool used in most automotive industries to identify the hazards and assess the risks in the plant. The primary purpose of the HIRA tool is to assess the risks and prioritize the risks in order to eliminate the hazards in the prioritized order.

Richard W. Bukowski et.al [12] one of the areas in which fire hazard assessment techniques have been applied within regulation is for transportation vehicles. In particular, commercial aviation and passenger rail have utilized fire hazard assessment as a means to achieve safety goals well before these techniques became common in buildings.

Miss.Shraddha Kuthe et.al [13] the automotive chassis forms the structural backbone of a commercial vehicle. The main function of the chassis is to support the components and payload placed upon it.

Himanshu Hiraman Rathod et.al [14] in this paper, effect is been made to review few researches made in the earlier years. In general, the chassis is the base frame of a car, motorcycle, carriage or heavy vehicle.

A.Venkata Dinesh et.al [15] in automobile design, crash and structural analysis are the two most important engineering processes in developing a high quality vehicle. Computer simulation technologies have greatly enhanced the safety, reliability, and comfort, environmental and manufacturing efficiency of today's automobiles.

Mahdi Kheyrkhahan et.al [16] every day in workplaces, continues events occur that cause death and injury. These accidents usually happen because of lack of exploring the potential hazards and lack of training of employees.

## II. WORKING PLATFORM

"Simplex Metal Process started its operations in 2013 to cater to the country's requirement for high-quality transport vehicle chassis. The company set up a state-of-the-art manufacturing facility located in the central region of India at Pithampur for manufacturing chassis truck and busses. Our aim is to manufacture excellent quality products by creating a safe, clean and environment friendly work place." The Simplex Metal Process Plant in Madhya Pradesh has been producing trucks and buses chassis Eicher and man truck. Its products range from chassis to tippers for the construction industry.

Simplex Metal Processors (india) Private Limited is a Private incorporated on 10 March 2011. It is classified as Non-govt Company and is registered at Registrar of Companies, Gwalior. Its authorized share capital is Rs. 40,000,000 and its paid up capital is Rs. 40,000,000. It is involved in Manufacture of Basic Iron & Steel Simplex Metal Processors (India) Private Limited's Annual General Meeting (AGM) was last held on 29 September 2018 and as per records from Ministry of Corporate Affairs (MCA), its balance sheet was last filed on 31 March 2018.

Fig. 2: Chassis in Industry

Directors of Simplex Metal Processors (India) Private Limited are Suresh Gangar, Chandrakant Shripal Shah, Shayam Sundar Mehta, Prashant Chandrakant Shah and Yogesh Kumar Gupta. Simplex Metal Processors (India) Private Limited's Corporate Identification Number is (CIN) U27100MP2011PTC025563 and its registration number is 25563. Its Email address is Simplexprashant@hotmail.com and its registered address is PLOT NO.70D SECTOR NO.III PITHAMPUR INDUSTRIAL AREA PITHAMPUR Dhar MP 454774 IN.

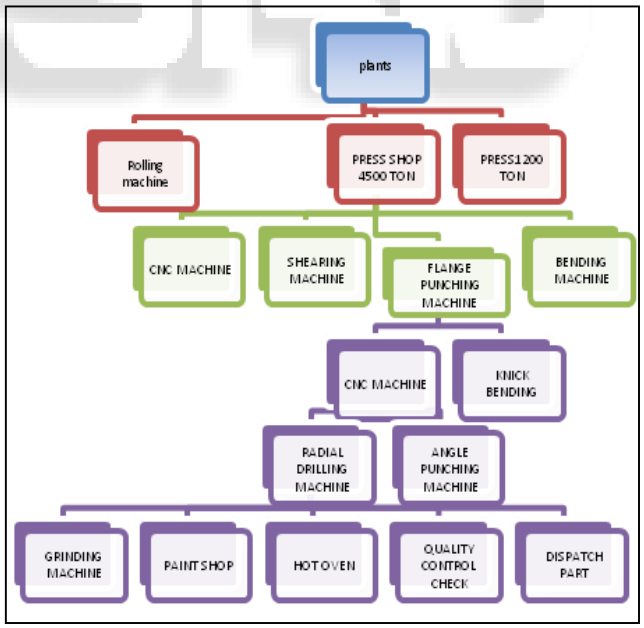


Fig. 3: Company Component and process

## III. TECHNICAL LAYOUTS

The provision of the code shall be applicable to trucks and buses of Gross Vehicle Weight (GVW) above 3.5 tonnes. The requirements shall not apply to the special purpose vehicles of the following categories as defined in CMVR, except in respect of those provisions, which are not compatible with the intended use and function of these vehicles.

1) Category N2
2) Category N3
3) Category T3
4) Category T4

The requirement of this code shall apply to the following types of truck bodies used in conjunction with the categories of trucks and buses

1) Flat Bed or Full Open Body
2) Semi Open or Half Body
3) High Side Deck Body
4) Closed Body
5) Bodies for Carrying ISO Tankers
6) Special Purpose Vehicles.

*A. Technical and Safety Requirement for Chassis*

The trucks and buses are categorized on the basis of design namely rigid axle vehicles and tractor trailer combination. Trucks are further sub-categorized on the basis of truck body construction like the following.

- HSD – High Side Deck body
- FSD – Fixed Side Deck or Half body DSD – Drop Side Deck body
- FB – Flat Bed or Fully open body CLB – Closed Body
- ALC – Aluminum Container STC – Steel container
- SPB – Special Purpose Body

*1) General Requirement for safety:*

- Overall dimensions: The overall dimensions of the load body shall comply with the provisions laid down in Rule 93 of the Central Motor Vehicle Rules, 1989 as amended from time to time.
- Cab and body gap: Clearances / gaps as recommended by vehicle manufacturer should be ensured in respect of tyre, wheel arch, fuel / oil checking and filling, cab (where applicable). In the case of separate cab and load body, the body shall be separated from cabby at-least 50mm behind as shown in Figure -4. The gap may be covered with gap seal for better aerodynamics.
- Stowage space / luggage carrier: Storage space for keeping utility items like tarpaulin, manila rope, assorted tools etc. may be provided in any part of the vehicle or load body. If the same is provided over the load body, it shall meet the following requirements:
- Uniformly distributed static load of 150 kg/$m^2$
- Inertia forces equivalent of 2.5 g.
- Shear force equivalent to 1.5g.
- Further, the maximum load capacity of such a stowage space shall be specified on a plate fitted outside the stowage space.
- Mudguards / Spray suppression devices: The tyres of motor vehicles shall be enveloped with effective mudguards. The mudguards may be mounted on body floor or any part of the chassis frame. Non-rigid flap (metallic or non-metallic) shall be provided at rear of mudguards to prevent splashing of water, dust or muck over the vehicles coming from behind. In addition, the vehicles shall be fitted with spray suppression devices in accordance with AIS-013, relevant for the categories of vehicles specified therein.
- Rope hooks and other provisions: The load bodies shall be so constructed to allow use of covers, wherever required. Rope hooks or any such feature may be provided on sides, front, rear or base of the load body to facilitate spreading and fastening of covers over the body. Sufficient space must be provided on sides of body to depict vehicle related details as specified by National or State Transport Rules.

*2) Technical Requirements:*

- Working stability: The vehicles meant for carrying dangerous and / or hazardous goods shall meet the working stability requirements stated in Section -8 of this Code.
- Mounting of the body or load platform of commercial vehicles: The mounting arrangement for load body shall ensure adequate rigidity of body with the chassis. The mountings shall ensure adequate resistance against lateral / transverse movement of load body in case of braking or sudden acceleration or cornering or while driving on slopes. The recommendations of the OEM's shall be taken as guidelines. For mountings, use shall be made of round holes and suitable bolts with the least possible play, at least at the foremost and rearmost attachment points. Suitable compressible packing (such as rubberized balata duck, or wood) may be used between the chassis and body frame. Thickness of such packing shall be selected to ensure uniform load distribution over chassis frame even in case of minor waviness or twist in the chassis frame / sub-frame. The sub-frame shall be mounted on chassis by means of attachment plates or out- rigger brackets or directly on chassis to prevent longitudinal movement of load body in case of braking and sudden acceleration. Wherever, the U- bolts are used for clamping (in addition to positive mountings as stated above), they shall be used in conjunction with stiffeners to prevent chassis frame from buckling. In case of load bodies not made by OEM or as per OEM designs, the mounting arrangement for the load body or platforms shall be as per recommendations provided by the vehicle manufacturers. Details of recommended practices for load body mounting including list of approved parts to be provided by vehicle manufacturer. OE developed and type approved designs may be used by local body builders.

*3) Safety Requirements:*

- Protection of the occupants of goods-carrying power-driven vehicles against the shifting of loads: The equipment of vehicles shall be in conformity with provisions calculated to reduce the risks run by the driver and the other occupants of goods-carrying vehicles in the event of a forward shift of the load on sudden braking. The occupants of such a vehicle shall be protected by a screen or headboard capable of withstanding without breaking, a uniformly distributed static force of 200 kgf per ton of the vehicle's permissible useful load. This load shall be applied by means of a rigid barrier perpendicular to the longitudinal median axis of the vehicle, covering at least the whole of the cab rear wall situated above the chassis frame, and moving parallel to that axis. This shall be in accordance with the requirements specified in AIS-029. This protective screen or headboard may be detachable.

 

- It must meet the following requirements: its width (measured at right angles to the longitudinal median axis of the vehicle) must be at least equal to the width of the space provided for the occupants and where there is a separate cab, at least equal to the width of the cab.
- In height, it must match at least 800 mm above the level of the loading platform where there is a separate cab, or be of the same overall height as the load compartment where there is no separate cab. It must be secured directly to the chassis or to the front of the loading platform.
- If it is secured to the loading platform or, where appropriate, to the body, the anchorage of that platform to the chassis must be capable of withstanding the thrust transmitted.
- In cases where the cab is integral with the body, the protective screen or headboard may be secured to, or form part of, the body structure.
- Where a power-driven vehicle or a semi-trailer is designed to carry beams, pipes, girders, sheet metal or similar loads, the protective screen or headboard must have a resistance at least equal to that of steel plate not less than 3 mm thick.
- Where a vehicle is equipped with a trestle or bolster behind the cab for the purpose of supporting long loads, such as steel girders or telegraphic poles, the trestle or bolster must be capable of withstanding the combined effect of two forces, each of 600 daN per ton of permissible load, acting forwards and downwards on the top of the trestle.
- This rule shall not apply to tank-lorries and special-purpose vehicles for the carriage of containers, or to special-purpose vehicles for the carriage of indivisible objects, where the latter vehicles and their operation are subject to special regulations.

### B. *Fire Mitigation and Safety*

Fire mitigation on buses and trucks is seen as a key safety issue for bus operators and drivers, bus suppliers and manufacturers, bus passengers and government agencies at all levels. Currently every week in India at least one bus experiences a potentially fatal fire incident. The potential for a fatal bus fire in India does exist, especially for buses operating in high density urban environments or in traffic tunnels. This Advisory has been developed as part of a joint project undertaken by the Bus Industry Confederation (BIC). Any remedies, or risk reduction measures, should follow a hierarchy of measures which can be summarized into four key elements:

- 1st Element — Elimination and or minimization by design.
- 2nd Element — Use of appropriate engineering safeguards such as fire control systems, alarms and in higher risk situation active Fire Protection Systems.
- 3rd Element — Use of appropriate and ongoing protection measures, such as correct maintenance processes and procedures, bus cleaning and ongoing review.
- 4th Element — Use of administrative controls such as training and emergency response procedures and practices.

## IV. METHODOLOGY

The automotive industry occupies a significant place in the Indian economy. The well- developed industry acts as a catalyst and gives energy to the economic growth of the country and also increased accidents to the workers due to work place hazards. In the manufacturing of auto components carries with them workplace hazards, the hazards and risks connected with welding operations, assembly operation by machine or manual in shock absorber manufacturing industry was identified and controlled using risk matrix techniques. The findings reveal that major tasks were associated with the events of material handling, machine operation, maintenance of any machinery, packing and housekeeping. Hazards of varying degrees were identified and the associated risk was classified with trivalent risk, Low risk, Medium risk, High risk, Very high risk. The tasks carried out with those hazards and risks are suggested with control measures and recommendations.

The auto mobile manufacturing industry is a wide range of companies and organizations involved in the design development manufacture, marketing, and selling of motor spare parts. It is one of the world's most important economic sectors by revenue. It is one of the hazardous industries. Unsafe conditions and practices in automotive industries lead to a number of accidents and causes loss and injury to human, material damages, loss, cases, interrupt production etc [30].

### A. *Hazard Identifications*

Hazard identification is a vital part of the workplace safety process. This document is useful for those employers who don't have the time, expertise or knowledge to undertake the process. These simplify a thing that identify hazards, enter them in a Hazard Register, assesses the level of risk they pose and suggests ways of controlling them [31].Hazard identification is the process of identifying all hazards in the workplace. Several things can help identify hazards in the work area and job site.

1) Walking around the workplace to inspect what is in the general area.
2) Asking other employees what they think about anything they have noticed.
3) Reviewing a work instruction or job safety analysis.
4) Inspecting an operator's manual.
5) Reviewing previous incident reports.
6) Looking at Occupational Safety and Health Administration (OSHA) or other regulatory book.

### B. *Risk Assessment*

A risk assessment is simply a careful examination of what, in your work, could cause harm, to people, so that you can weigh up weather you can taken enough precautions or should do more prevent harm. Workers and other have a right to protect from harm caused by a failure to take reasonable control Measures. A HAZARD is anything that may cause harm, such as chemical, electrical, working from ladder, etc., A RISK is the chance, high or low, that somebody could be harmed by these and other hazards, together either an induction of how serious the harm could be.

 

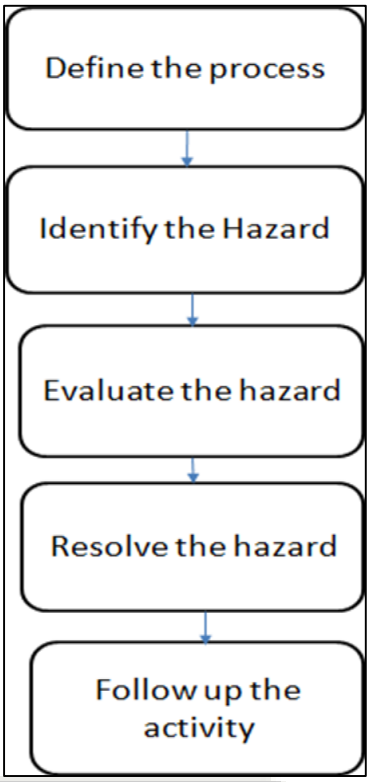


Fig. 4: Risk Assessment and Hazard identification Procedure [37]

1) Identify the hazards.
2) Decide who might be harmed and how.
3) Evaluate he risks and decide on precautions.
4) Record your findings and implement them.
5) Identification of hazards present in any undertaking and evaluation and the extent of the risks involved, taking into account whatever precautions are being undertaken [34].
6) Risk Assessment is the determination of quantitative or qualitative estimate of risk related to a well-defined situation and a recognized hazard.
7) Qualitative: Object probability estimate based upon known risk information applied the circumstances being considered.
8) Quantitative: This type is subjective, based upon personal judgment backed by generalized data risk.

| S. No | Questions |
|---|---|
| 1. | All switches & indicators are clearly marked, readily visible, obvious, understandable and in the local language? |
| 2. | All switches & indicators as well as LOTO devices are located outside the danger area. |
| 3. | All switches & indicators can be operated safely. |
| 4. | The system is designed to stop safely in an emergency. |
| 5. | The control system is designed so that failure or bypass of a component will prevent starting or recycling. |
| 6. | Two handed controls are self-checking so that if one Button fails or is wedged close, the system will not operate. |
| 7. | All visible / audible alarm signals are clear |

Table 1: Equipment Control Systems

| S. No | Questions |
|---|---|
| 1. | The STOP button/ EMERGENCY stop / are located Within the normal reach area of the operator and the STOP- instruction overrides the START- instruction. |
| 2. | The equipment / machine can only be initiated by the operator's positive action |
| 3. | The EMERGENCY button causes a SAFE shut down when activated which is appropriate to the operation. |
| 4. | Emergency Stops must be reset manually. |

Table 2: Start - stop - emergency stops

| S. No | Questions |
|---|---|
| 1. | The operator is adequately protected against falling / ejected parts (both emergency & production situations). |
| 2. | The equipment, tools and supports have been installed Securely. Consider vibration control via appropriate mounting and construction to reduce or eliminate effect on operator. |
| 3. | There is sufficient illumination, lighting fixtures functioning properly including the maintenance access points. |
| 4. | Is the floor free from trip, slip, falling hazards and floor in dry & good condition? |
| 5. | Is the first aid kit available and having OHC or Hospital for the further treatments? |
| 6. | Is the employee's access limited to regular hour of operation? |
| 7. | Are written SOP for each machine available and executedby all employees and understandable and in the local language? |
| 8. | Procedures for „Safe Systems of Work", applicable to this equipment, have been developed and trained for set up, maintenance and cleaning activities. |
| 9. | Is the employees prohibited use of mobiles inside the operation? |
| 10. | Operators are not exposed to temperature extremes and operator is not exposed to sharp points or edges from tooling, fixtures and other machinery parts. |
| 11. | Operating does not require excessive effort, stretching or repetitive actions that may lead to ergonomic injuries. |
| 12. | Adequate features have been installed for LOTO & Multiple LOTO is used. (Electrical, hydraulic, pneumatic, chemical, pressurized gases, etc.,) |
| 13. | Comprehensive warning signs are posted to warn of risks and any mandatory PPE requirements. |
| 14. | Requirements of PPE are adequate for the operation. |
| 15. | Warning lights and sounds are available and working properly |
| 16. | There is safe access and egress to and from the equipment. |
| 17. | Is there having adequate distance between the machines? |
| 18. | The risks of explosion(s), de-fragmentation or detonation have been properly anticipated. |
| 19. | Employees are properly protected against risks of producing sparks and slag that can exit machine. |

 

| | |
|---|---|
| 20. | Electrical hazards have been anticipated and guarded against. |
| 21. | Was the measured noise level confirmed to be below 75 db at operator position? |
| 22. | Is the gases that used for the operation has protected and sensor devices has installed to give alert? |
| 23. | Is the active and passive fire protection devices have installed? |
| 24. | Are all the machines free from debris and clearing at the time? |
| 25. | Equipment is only used under appropriate conditions and for its intended purpose (proper use of equipment) |
| 26. | Repairs, adjustments or alterations to safety systems are only carried out by authorized personnel |
| 27. | Employees are properly protected against risks of fire and / or release of products from the equipment. |
| 28. | There is no chances of fall or lose the objects and that affects the person while handling. |
| 29. | There are no chances to electrocution in the Machine |
| 30. | Appropriate control measures has followed if the operator handing sharp objects |
| 31. | There is no chance to getting injury if handling hot objects? |
| 32. | Cooling system appears to be adequate and complete |
| 33. | Auto or manual water drain valve is attached in the machine if the water reaches the particular temperature |
| 34. | Is the workers not Contacting with oil or grease continuously? |
| 35. | The air used only to clean the dust or debris only not to clean hand or clothes etc., |
| 36. | Dressed properly & avoided loose clothes, jewelers etc., |
| 37. | Workers knows how to report incidents and perform to do in emergency alarm |

Table 3: General risks

Risk Matrix is used at some stage in risk assessment to characterize the various levels of risk as the product of the harm probability categories and harm severity categories. This simple mechanism to increase visibility of risks and leads to provide the solution [38]. This methodology has seven stages as listed below; Likelihood has the possibility to occurrences of the event in six states are practically impossible very unlikely, unlikely, likely, very likely and imminent or certain. The action priority of the risk has been calculated in five levels are no action required [39], can be deal with as convenient, deal with as soon as possible, needs resolving quickly and immediate action required.

| Code | Occurrence |
|---|---|
| 1 | Practically impossible |
| 2 | Very unlikely |
| 3 | Unlikely |
| 4 | Likely |
| 5 | Very likely |
| 6 | Imminent / certain |

Fig. 5: Likelihood

| Code | Frequency |
|---|---|
| 1 | Very rare (yearly or less) |
| 2 | Rare (a few per year) |
| 3 | Unusual (once per month) |
| 4 | Occasional (once per week) |
| 5 | Frequent (daily) |
| 6 | Continuous |

Fig. 6: Exposure

| Code | Extent of injury |
|---|---|
| 1 | Loss time |
| 2 | Minor injury |
| 3 | Major injury |
| 4 | Single fatality |
| 5 | Multiple fatalities |
| 6 | Many fatalities |

Fig. 7: Extents of Injuries

1) The exposure level of the risk has been calculated in six levels are very rare, rare, unusual, occasionally, frequently and continuous.
2) The injury intensity of the risk has been calculated in six levels are loss time, minor injury, major injury, single fatality, multiple fatalities and many fatalities
3) The property damage level has been calculated in six states are from zero to million and above.
4) The possible consequences of the risk has been calculated in six levels are noticeable, important, Serious, very serious, disaster and catastrophe.
5) The action priority of the risk has been calculated in five levels are no action required, can be deal with as convenient, deal with as soon as possible, needs resolving quickly and immediate action required.
6) The risk rating has been calculated in five levels are trivial or low risk, low risk, medium risk, high risk and very high risk.

| Code | Loss |
|---|---|
| 1 | > Rs. 100/- damage |
| 2 | > Rs. 1,000/- damage |
| 3 | > Rs. 10,000/- damage |
| 4 | > Rs. 100,000/- damage |
| 5 | > Rs. 1,000,000/- damage |
| 6 | > Rs. 10,000,000/- damage |

Fig. 8: Property Damages

 

| Code | Event |
|---|---|
| 1 | Noticeable |
| 2 | Important |
| 3 | Serious |
| 4 | Very serious |
| 5 | Disaster |
| 6 | Catastrophe |

Fig. 9: Possible Consequences

| Code | Risk rating & Action priority |
|---|---|
| 1 | Insignificant, no action required |
| 2 | Not serious, can be deal with as convenient |
| 3 | Less serious, deal with as soon as possible |
| 4 | Serious, needs resolving quickly |
| 5 | Urgent, immediate |

Fig. 10: Risk Factor

| Code | Risk | Risk acceptable / not acceptable |
|---|---|---|
| 1 | Trivial or low risk | Risk acceptable (RA) |
| 2 | Low risk | Risk acceptable (RA) |
| 3 | Medium risk | Risk not acceptable (RNA) |
| 4 | High risk | Risk not acceptable (RNA) |
| 5 | Very high risk | Risk not acceptable (RNA) |

Fig. 11: Risk Rating

The first step in the project is to gain a detailed knowledge about the process in which the project work is to be carried out. The detailed study includes individual activity carried out in the factory. [40-44] a detailed study is made on the individual equipment or process that is studied. This study includes the working principle of the equipment, the working condition and the standards to be followed, the safety precautions taken, etc. The technique used for evaluating the risk level by calculating the Risk Priority Number (RPN) for each hazard. An RPN is the quantitative estimate of the risk associated with each hazards.

| Rating | Description | Examples of Description |
|---|---|---|
| 5 | Almost certain | Event occurs often and constant exposure to hazard. Very high probability of damage. |
| 4 | Likely | Event might probably occur and known history of occurrence. Frequent exposure to hazard. High probability of damage. |
| 3 | Possible | Event could occur at some time and history of single occurrence. Regular or occasional exposure to hazard. Moderate probability of damage. |
| 2 | Unlikely | Event is not likely to occur and known occurrence. Infrequent exposure to hazard. Low probability of damage. |
| 1 | Rare | Event may occur occasionally and no reported occurrence. Rare exposure to hazard. Very low probability of damage. |

Table 4: Probability of Occurrence

RPN is assigned to each hazard based on three factors:

1) Probability of occurrence
2) Severity rate
3) Hierarchy of controls
4) Risk Score = Probability Rate X Severity Rate
5) During the risk assessment following type of jobs/situations/conditions was considered [45].
6) Routine: Done by Usual / Regular method of procedure.
7) Non Routine: Unusual / Non-Regular of procedure.
8) Normal Condition: Risks converted to tolerable conditions by way of engineering control or by using PPE.
9) Abnormal Condition: Deviation from normal condition, which requires immediate attention.
10) Emergency Condition: Hazards and Risks, which are contained or mitigated by invoking emergency procedures.

Criteria for Risk Assessment are developed through brain storming and discussion by core team. The scoring is based on

- Severity: Type of injury or the effect of injury on the persons and type of intervention required / expected duration.
- Probability: Chances / likelihood of occurrence or past data on when it had occurred.
- Control Ranking: Type of control and issues related to implementation / adherence.

## V. CONCLUSION AND RECOMMENDATION

Hazard Identification and Risk Assessment (HIRA) study were made on the various hazards of different equipment's and process were found and assessed. Recommendations are provided to avoid the occurrence of such hazards. Applicable legal requirements are studied and provided in detail. In this paper I performed Hazard Identification and risk assessment technique to assess all hazards and established priorities and so that the most dangerous situations will be addressed first and those least likely to occur major problems are considered. This project has provided an excellent opportunity and experience in making safety measures for task like material handling, Machine operation, Maintenance of an typical industrial machinery, loading, unloading and housekeeping in welding and assembly machinery shop. The first step for emergency preparedness and maintaining a safe workplace is defining and analyzing hazards. Although all hazards should be addressed, resource limitations usually do not allow this to happen at one time. Hazard identification and risk assessment can be used to establish priorities so that the most dangerous situations are addressed first and those least likely to occur

 

and least likely to cause major problems can be avoid. The recommendations are provided to avoid the occurrence of such hazards. Safety instructions, extract of risk rating matrix and safe operating procedures were updated.

*A. Recommendation for Vehicle Body*

1) It has good driving characteristics.
2) It has sufficient stability and strength.
3) It is capable of carrying out the transport work safely. Twisting and sideways movements are more common behind the cab but diminish the further back along the truck one goes. In addition, lengthways and sideways forces must be absorbed by the attachments. Along the front part of the sub frame / helper-frame, the attachments should be pivoted as much as possible so as to allow maximum chassis movement in relation to the road/ground.
4) For the most rigid bodywork, flexible two-way attachments are used along the whole length of the frame. The bodywork must have the freedom to move in relation to the chassis frame. The more rigid the bodywork, the greater the movement in the attachment is required. With the exception of the most rigid bodywork, attachment plates are used along the rear section of the sub frame/helper-frame.

| Description | Weight in kg | CG height from the ground in m | Moment in kgm |
|---|---|---|---|
| Cab | 450 | 1.410m | 634.5kgm |
| Engine | 546 | 1.008m | 550.37kgm |
| Gear box | 135 | 0.727m | 98.15kgm |
| Front axle | 500 | 0.508m | 254.0kgm |
| Rear axle | 940 | 0.508m | 447.00kgm |
| Frame & misc | 1830 | 0.887m | 1623.2kgm |
| | 4401 | -- | 3607.22kgm |

Table 5: Location of CG height under unlade condition with 10.00 × 20 tyres

Location of CG Ht. Of unladen chassis + cab from ground level 3607.22 / 4401 = 0.8196m

| Description | Total wt. in kg | G height from the ground, m | Moment in kgm |
|---|---|---|---|
| Chassis + cab | 4401 | 0.746 | 3283.12 |
| Tank + payload + canopy + piping | 11490 | 2.185 | 22116.57 |
| Sub frame | 280 | 1.023 | 286.44 |
| | 16171 | -- | 25686.13 |

Table 6: Location of CG height under laden condition with 10.00 x 20 tyres

Location of CG of laden chassis 25686.13 / 16171 = 1.588m.

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