

**To study reduction in hand injuries frequency rate  
From 2.05 to 1 at TCL Mithapur.**Mohammad Shafiq M Shaikh<sup>1</sup>, Dr. Nihal Siddiqui<sup>2</sup>, Mr. Varun Raolji<sup>3</sup><sup>1</sup> HSE Dept. University of Petroleum and Energy Studies, Dehradun<sup>2</sup> HSE Dept. University of Petroleum and Energy Studies, Dehradun<sup>3</sup> HSE Dept. Tata Chemicals, Mithapur

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**Abstract-** *The goal of this work is to reduce TRIFR rate at the complex. According to government and industry statistics, hand injuries represent nearly a third of all reported workplace incidents. Approximately 75% of industrial injuries that cause partial disability involve the hands; over 16 million individuals seek emergency care each year for hand injuries. A hand injury occurs in the workplace every 32 seconds. Hand injury prevention begins with a recognition and respect for the hazards. This work shows the study of frequency rate of hand injuries their impact on the TRIFR of industry and techniques to overcome from it by implementation of small changes at work place. The work study is carried through efficiently utilising Lean Six Sigma techniques.*

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**Key words:** DMAIC, TRIFR, Voice of Customer (VoC), Voice of Business (VoB)

**INTRODUCTION**

The human body is an engineering marvel. Our hands consist of 27 bones, ligaments, muscles, tendons, nerves, blood vessels, skin and nails. Working in unison, they provide strength and dexterity which enables us to perform routine tasks and accomplish precision movements. We use our hand constantly. A disabling hand injury can have a dramatic effect on your quality of life. A hand injury can impact not only your ability to perform your job, but daily routines as well. A hand injury can occur in a second, but the social, financial and emotional effects can last a lifetime.

Because we use our hands so frequently, we start to take them for granted and not truly respect the potential risk we place them in. Because of their tremendous versatility, hands are exposed and susceptible to many types of injuries. These include strains and sprains from excessive force, excessive repetitive motion, awkward posture, contact with surface conditions, skin irritation from contact and exposure to hazardous or irritating substances; burns from contact or exposure to electricity, chemicals and hot substances, punctures from tools and other sharp objects, lacerations, cuts ranging from minor to major if tendons or nerves are severed, fractures, broken bones from being crushed or falling and amputations, resulting in a loss of part or all of the hand.

Tata chemicals limited have made significant progress in SHE over the previous years, with zero fatalities in years. Safety continues to be number one concern and, we feel the need to raise the bar on safety continuously

**OBJECTIVE**

Due to complexity of business it is required to set and maintain an Incident preventing structure, which covers different systems essential for Incident prevention which includes

- To study various Incident prevention tools/techniques and their significance.
- To study and analyses the contribution of hand injuries in TRIFR Score and implement the control techniques.

**ABOUT THE PROCESS****DMAIC****Define**

The purpose of this step is to clearly articulate the business problem, goal, potential resources, project scope and high-level project timeline. This information is typically captured within project charter document. Write down what you currently know. Seek to clarify facts, set objectives and form the project team

**Measure**

The purpose of this step is to objectively establish current baselines as the basis for improvement. This is a data collection step, the purpose of which is to establish process performance baselines. The performance metric baseline(s) from the Measure phase will be compared to the performance metric at the conclusion of the project to determine objectively whether significant improvement has been made. The team decides on what should be measured and how to

measure it. It is usual for teams to invest a lot of effort into assessing the suitability of the proposed measurement systems. Good data is at the heart of the DMAIC process

**Analyse**

The purpose of this step is to identify, validate and select root cause for elimination. A large number of potential root causes (process inputs, X) of the project problem are identified via root cause analysis (for example a fishbone diagram). The top 3-4 potential root causes are selected using multi-voting or other consensus tool for further validation. A data collection plan is created and data are collected to establish the relative contribution of each root causes to the project metric, Y. This process is repeated until "valid" root causes can be identified. Within Six Sigma, often complex analysis tools are used. However, it is acceptable to use basic tools if these are appropriate. Of the "validated" root causes, all or some can be

- List and prioritize potential causes of the problem
- Prioritize the root causes (key process inputs) to pursue in the Improve step
- Identify how the process inputs (Xs) affect the process outputs (Ys). Data is analysed to understand the magnitude of contribution of each root cause, X, to the project metric, Y. Statistical tests using p-values accompanied by Histograms, Pareto charts, and line plots are often used to do this.
- Detailed process maps can be created to help pin-point where in the process the root causes reside, and what might be contributing to the occurrence

**Improve**

The purpose of this step is to identify, test and implement a solution to the problem; in part or in whole. Identify creative solutions to eliminate the key root causes in order to fix and prevent process problems. Use brainstorming or techniques like Six Thinking Hats and Random Word. Some projects can utilize complex analysis tools like DOE (Design of Experiments), but try to focus on obvious solutions if these are apparent.

- Create innovative solutions
- Focus on the simplest and easiest solutions
- Test solutions using Plan-Do-Check-Act (PDCA) cycle
- Based on PDCA results, attempt to anticipate any avoidable risks associated with the "improvement" using FMEA
- Create a detailed implementation plan
- Deploy improvements

**Control**

The purpose of this step is to sustain the gains. Monitor the improvements to ensure continued and sustainable success. Create a control plan. Update documents, business process and training records as required.

A Control chart also known as a Swim lane Map, can be useful during the Control stage to assess the stability of the improvements over time by serving as 1. a guide to continue monitoring the process and 2. Provide a response plan for each of the measures being monitored in case the process becomes unstable.

**PROCESS METHODOLOGY**

**3.1 DEFINE**

**Project Charter Verification**

<b>Business Impact :</b> • This project will help us contribute towards our goal of zero incidences and reduce TRIFR	<b>Opportunity or Problem Statement:</b> • Hand injury frequency rate is 2.05 for the year. • 28 hand injuries were recorded out of 55 injuries.
<b>Goal Statement :</b> • To reduce hand injury frequency rate from 2.05 to 1.00 at Mithapur.	<b>Project Scope :</b> <u>In Scope:</u> Injuries to hand <u>Out Of Scope:</u> injuries to other parts of body
<b>Project Plan</b> Define – Measure – Analyse - Improve - Control -	<b>Team Selection :</b>

**Voice of Customer (VoC)**

**VoC Erection and Cement (Departments)**

Voice of the Customer (Actual customer statements and comments)	Key Customer Issues (The real customer concerns, needs or expectations)	Critical Customer Requirements (The specific, precise and measurable characteristics)	Project Y's Key Process Output Variables (List the metrics that measure the characteristics)
Hand injuries are observed while the work is done in groups.	Lacking coordination and inherent site & job specific hazards	Single person must coordinate and communicate during work and site specific ISA for job.	Adherence to Standard Procedures of ISA, Safety Talk
Deviation from work related procedures	Not following right practices	Gap analysis and modification in std.procedure	Enhance knowledge of Std. procedures by trainings
Unhealthy work place	Poor illumination and Congested areas are major concerns while performing work	Illumination as per Std. good housekeeping, sufficient space near work location	Compliance to the illumination standard Area Housekeeping score
Usage of improper tools and equipment	Standard tools should be available every time	Proper tools should be used no improvisation	Adherence to Standard maintenance practices
Manual Intervention causing hand injuries	Not following standards work related procedure and non availability of automation.	Gap analysis and modification in work related standard procedure, & Increase use of automatic tools/ simple machines.	Adherence to work related Standard Procedures
In spite of using hand gloves hand injuries are occurring	Quality of PPEs	Hand Glove with better protection on a scale of 1-5	Compliance to 01. procurement procedure 02. usage of Hand gloves.

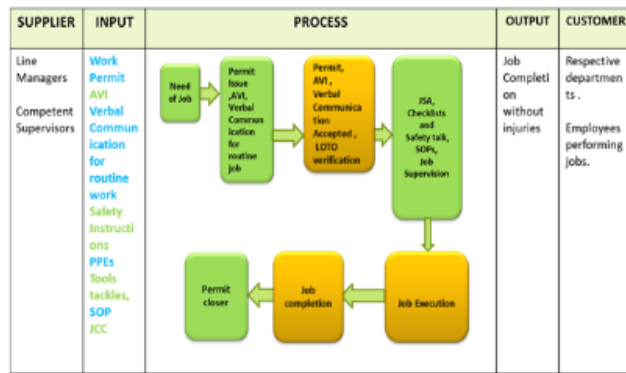
**VoC MUW & Soda Ash**

Voice of the Customer (Actual customer preferences and comments)	Key Customer Issue(s) (The real customer concerns, wishes or expectations)	Critical Customer Requirements (The specific, precise and measurable characteristics)	Project Y's Key Process Output Variables (List the metrics that measure the characteristics)
Use of non appropriate key for opening valves	Non standard methods and tools leading to hand injuries	Standard tools and tactics availability and practices for opening valves	Adherence to Standard Procedures of valve opening
Problem in valve operation because of position	Position of valve with respect to other nearby valves and equipment is not correct.	Enough space for movement of valve Spinner for moving it 180°	No of hand injuries
Valves are difficult to operate causing hand injuries	Valves are getting stuck up	Regular rousing and maintenance of valves	Adherence to schedule of Rousing and maintenance
Ignorance and let it go attitude	Poor Sensitivity towards work hazards	Achievement to safety procedures	Behavior Safety improvement training.
No. using hand protection while performing work	Feeling uncomfortable while using Hand Protection	Usage of right hand protection performing work	Compliance to usage of Hand gloves.

**VoB of Business**

Voice of the Business	Key Business Issue(s)	Critical Business Requirements	Project Y's Key Process Output Variables
Safety is value for TCL	Hand injuries are increasing impacting TRIFR number.	TRIFR should be within target	TRIFR SCORE
Safety must not be compromised as far as business is concerned	Moral or Engagement of People is affected	Safe Working Environment	

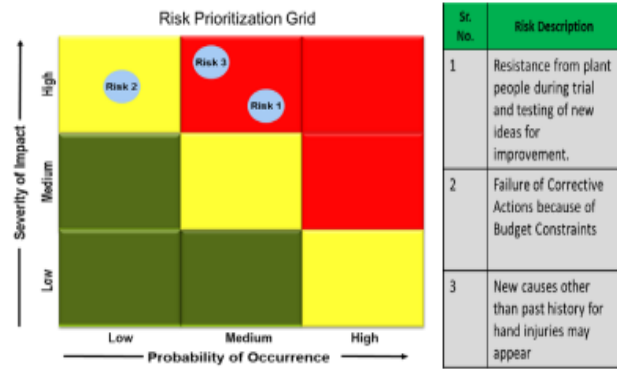
**SIPOC – Occurrence of hand injuries**



**Metrics**

INPUT Metrics	PROCESS Metrics	OUTPUT Metrics
Type of Work Permit along with supporting check list and JSA	Written Permit/AVI signed by authorities. Effective Verbal Communication for Routine work Location, Equipment, Time Duration , Isolation, LOTO, Linked Dept, JSA, Safety talk, PPE's, Standard Tools tackles, Supervision, closure of permit	Number of hand injuries
Types of PPEs Required		
Standard tools and tackles.		
SOPs & JCC		

**Risk Analysis and Prioritization**



**Operational Definitions**

Perf. Measure	Type	Units	Operational Definition
Injury	Discrete	NOs	Any Injury such as a cut, fracture, sprain, or amputation that results from a work-related incident or an exposure involving an incident in the work environment is an occupational injury. Conditions resulting from insect, animal, or snake bites or one-time exposure to chemicals are injuries. Chemical burns resulting from one-time exposure are also injuries.
Hand Injury	Discrete	NOs	Any injury to hand such as a cut, fracture, sprain, or amputation that results from a work-related incident or an exposure involving an incident or chemical burns to hand resulting from one-time exposure are in the work environment is a hand injury.
TRI	Discrete	NOs	TRI (Total recordable injury ) include all three categories of injury that is LWC,RWC & MTC

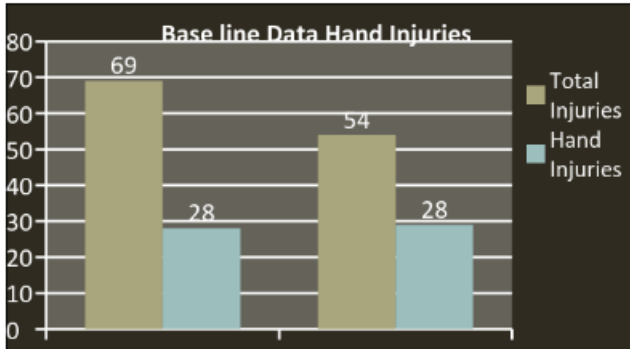
Metric	Perf. Measure	Type	Units	Operational Definition
Y2	TRIFR (Total Recordable Injury Frequency Rate)	Cont.	No of Injuries/Million man hrs.	TRIFR = Total Recordable Injuries × 1000000 / Total man hours worked
Y1	hand injury frequency rate	Cont.	No of hand Injuries/Million man hrs.	Hand injury FR rate = Total Hand injuries × 1000000 / Total man hours worked

Perf. Measure	Type	Units	Operational Definition
LWC (Lost work day Case)	Discrete	NOs	Any occupational injury that prevents the employee from reporting to work on any subsequent scheduled shift is an LWC.
RWC (Restricted Work Case)	Discrete	NOs	Any occupational injury that prevents the employee from doing any part of his or her regularly scheduled job on any subsequent scheduled shift is an RWC.
MTC (Medical Treatment Case)	Discrete	NOs	Any occupational injury requiring treatment by a physician or by registered professional personnel under the standing orders of a physician or requiring any retreatment is an MTC.
FAC (First Aid Cases)	Discrete	NOs	Any occupational injury involving one-time treatment that does not require a medical professional is an FAC

Perf. Measure	Type	Units	Operational Definition
People Cause	Discrete	NOS	People cause is define as one of the contributing cause for any injury which includes behavior of employee health of employee, effectiveness of supervision and behaviors of the people accompanying.
Physical Cause	Discrete	NOS	Physical cause is define as one of the contributing cause for any injury which includes weather condition, chemicals exposure, condition of tools, PPEs, Machinery & surrounding conditions.
System Cause	Discrete	NOS	System cause is define as one of the contributing cause for any injury which includes written down procedures ; effectiveness of corrective and preventive measures taken on previous incidents and training to the employee.

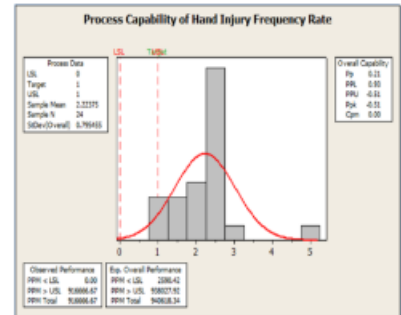
Performance Measure	Date Source and Location	How Will Data Be Collected	When Will Collect Data	When Will Data Be Collected	Sample Size	Stratification Factors	How will data be used?
Hand Injury Frequency rate	Injury File	Sorted out from Accident Investigation Form	QIB	14-07-2013	2 YEARS( 50 Data Points)	Type of employee, Age & Exp. Department. Area in which injury occurred Shift Injury Type Type of Job With permit, Without permit or routine job Cause for injury LAI/MC	Pareto Chart, Dot Plot, Hypothesis Testing, Regression
No of Hand Injury	Accident Investigation Form	Sorted out from Accident Investigation Form	QIB	14-07-2013	2 YEARS( 50 Data Points)		Pareto Chart, Dot Plot, Hypothesis Testing, Regression

Baseline Data



Process Capability - Hand Injury Frequency Rate

- ◆ 24 data points collected between 2011-12 and 2012-13
- ◆ Sample Mean is 2.22
- ◆ St. Dev. Is .79, the data is normally distributed
- ◆ Ppk. (Process performance capability) is -.51 indicating that the process is exceeding the USL and needs improvement.

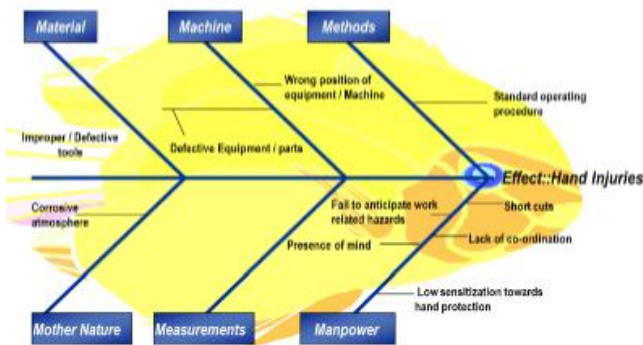


Analyze Phase

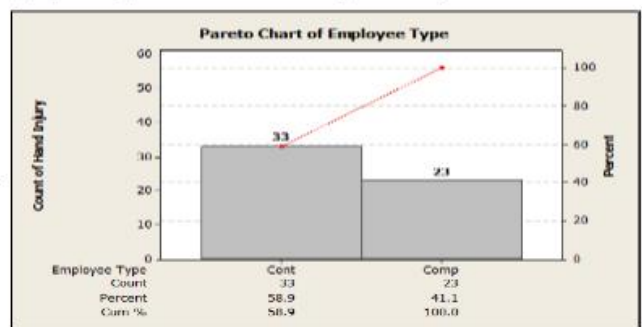
Analyze – Executive Summary

- Top most departments where injuries are occurring – Soda Ash, Erection, MUW
  - Most of the hand injuries are occurring while doing routine work in case of company employees and routine + permit work in case of contract employees
  - Pareto analysis shows that major reason for injuries is because of unsafe act of the person
  - Most of the hand injuries are occurring to Operator, fitter, helper & cleaner.
  - Most hand injury types observed are fracture & cut
  - Finger and for arm are sub part of hand which are mostly injured as per analysis.
- Analysis shows that In Soda Ash & MUW while operating valves company employees getting hand injury.

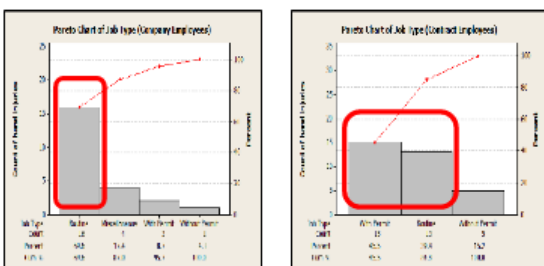
Cause & Effect Diagram



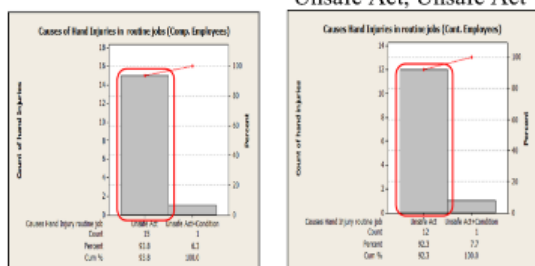
Employee Type Wise Pareto Analysis of Injuries



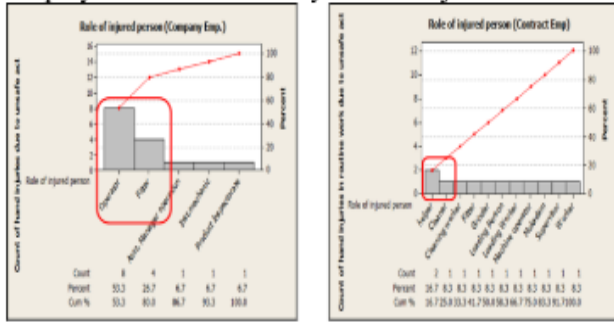
Analysis of Contract & Company Employees by Job Type



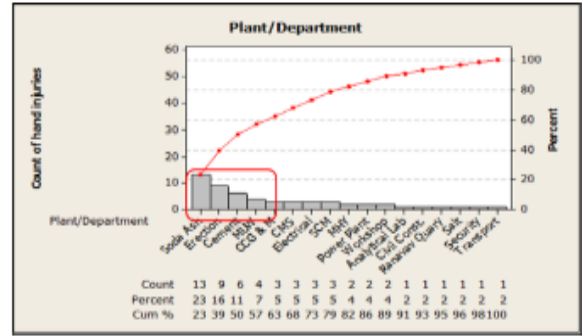
Analysis of Contract & Company Employees of Routine Jobs by Unsafe Act, Unsafe Act +Condition



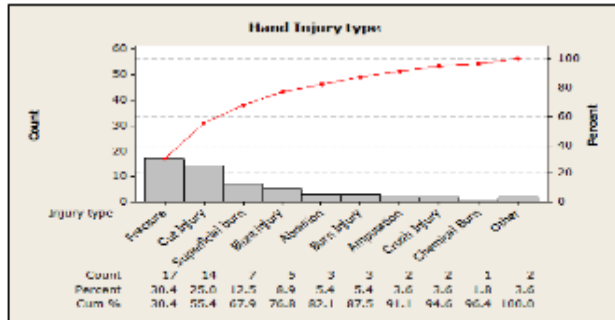
Pareto Chart Analysis of Contract & Company Employees of Unsafe Act by Role of Injured Person



Analysis of all Hand Injuries Department Wise



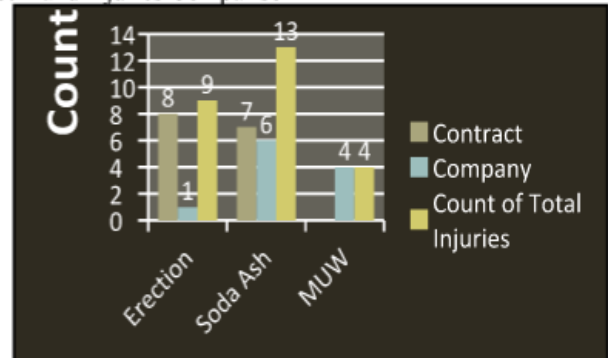
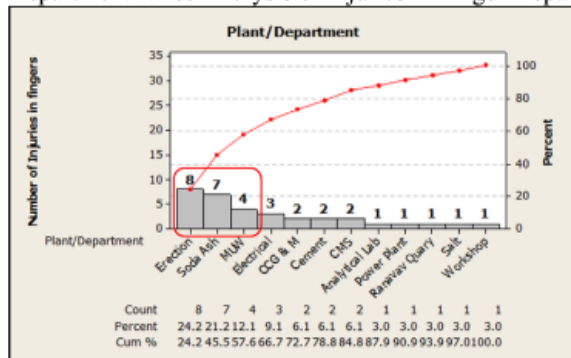
Analysis of all Hand Injuries by Type



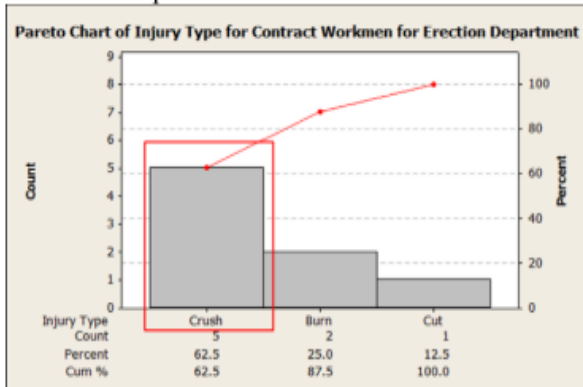
Analysis of Hand Injuries - Sub Part of Hand Wise



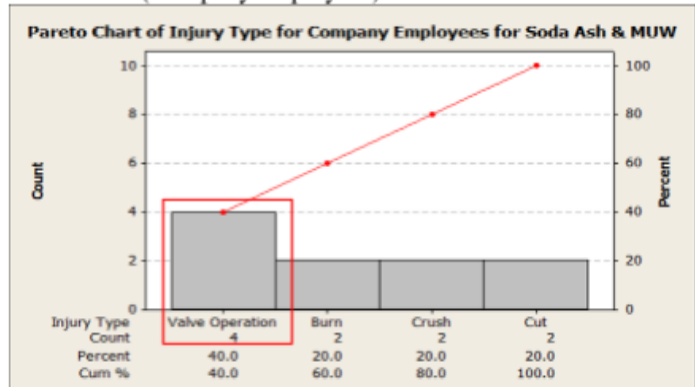
Department Wise Analysis of Injuries in Finger Department wise Hand injuries Comparison



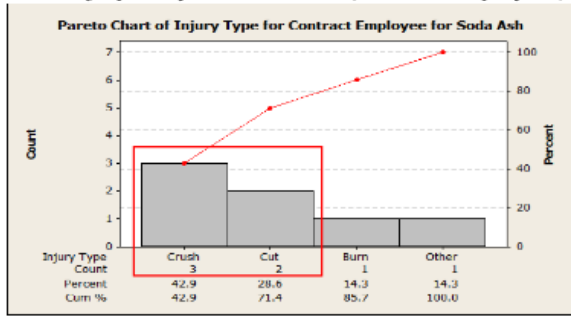
Analysis of hand injuries for contract workmen - Erection Dept.



Hand injury analysis - Soda Ash & MUW (Company employees)



Hand injury analysis – Soda Ash (Contract employees)



Prioritization of Critical Xs

Effect (Y)	Critical Root Cause (X)	Hypothesis for Relationship	In/Out of Team's Control	Impact <sup>2</sup>	Score (Control x Impact)	Priority of Effort	
Hand Injuries	Position of equipment or part of equipment	All critical root causes have Direct linkage with hand injuries		5	9	45	2
	Non standard tools / Defective tools			6	9	54	1
	Poor adherence to SOP or no availability of SOP / JSA			4	9	36	3
	Poor Safety Engagement of employees			3	9	27	4

Improvement Phase  
Prioritized List of Solutions

Critical Root Causes X	Priority of Effort	Potential Solution	How Developed?
No Task Base JSA/Poor adherence to SOP	1	1) Implementation of Task base JSA in all category permit (Starting with Cat.1) 2) SOP review for the activities involved hand injuries (JCC)	Fish Bone Analysis
Poor Safety Engagement of employees and low sensitivity towards work place hazards which leads hand injury	2	1) To prepare and rolled-out awareness module on 'Importance of hand Protection' 2) To cover all employees of Soda ash, MUW and Erection under hand protection awareness module 3) Analysis of last three years training data shows that 254 company employees have not undergone any safety training. Behavioral Improvement program covering importance of hand protection to be organized for these employees.	Fish Bone Analysis
Position of equipment or part of equipment which leads to improper posture	3	1) To review locations & position of valves which has potentiality to cause hand injury (Pilot project at Bicarb Plant)	Fish Bone Analysis

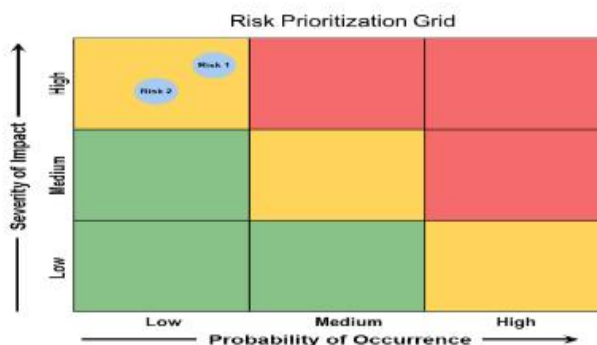
Evaluation of Potential Solutions

1	1) Implementation of Task base JSA in all category permit (Starting with Cat.1) 2) SOP review for the activities involved hand injuries (JCC)
2	1) To prepare and rolled-out awareness module on "Importance of hand Protection" 2) To cover all employees of Soda ash, MUW and Erection under hand protection awareness module 3) Analysis of last three years training data shows that 254 company employees have not undergone any safety training. Behavioral Improvement program covering importance of hand protection to be organized for these employees.
3	1) To review locations & position of valves which has potentiality to cause hand injury (Pilot project at Bicarb Plant)

Implementation RACI CHART							
Step	Important Dates	Action/Task	Responsible	Accountable	Consulted	Informed	Comments
1		Implementation of Task base JSA in all category permits (Starting with Cat.1)	Safety LSS project Team	Functional Heads	Sr. Manager - Safety & Health	GM SHE	
2		SOP review for the activities involved hand injuries (JCC)	HODs	Functional Heads	Sr. Manager - Safety & Health	GM SHE	
3		To prepare and rolled out awareness module on 'Importance of hand Protection'	Safety LSS project Team	Varun Raoji	Sr. Manager - Safety & Health	HODs	
4		To cover all employees of Soda ash, MUW and Erection under hand protection awareness module	Safety LSS project Team	Varun Raoji	Functional Heads	GM SHE	

5	Analysis of last three years training data shows that 254 company employees have not undergone any safety training. Behavioral Improvement program covering importance of hand protection to be organized for these employees.	Safety LSS project Team	Varun Raoji	Sr. Manager - Safety & Health	GM SHE /HODs
6	To review locations & position of valves which has potentiality to cause hand injury (Pilot project at Bicarb Plant)	Safety LSS project Team	Functional Heads	Sr. Manager - Safety & Health	GM SHE /HODs

Implementation Risk Assessment



Implementation Risk Management Plan

No.	Risk Description	Risk Management Plan (How to Avoid / Transfer / Mitigate / Accept)	Who	When
1	Adherence to task base JSA not followed properly after the implementation of solution.	Safety Observation is to be increased	Plant in charge/ Supervisor / Safety Pro	Daily
2	Poor response from employees in attending the training	Proper training plan & schedule, advance information to HOD to relive employees for training	HR/Safety Pro./HOD	Monthly

Control Phase  
Process Control / Response Plan

Control Action Number	Control Action	Responsible Individual	Applicable Control Charts and Metrics					Reaction Plan
			Freq.	Process Step	Target Value	Upper Control Limit	Lower Control Limit	
1	Rectification of Identified Points	Anand Ganthi	Monthly	Rectification of points	90%	100%	80%	Highlight the issue to the higher authorities
2	Task base JSA in category 1 permit should be followed	Varun G Raoji	Weekly	JSA	100%	100%		consequence management

Training Plans

Required Training		
Required Training	Responsible	Status
Hand protection awareness module	Varun Raoji	Compliance: Erection : 82 % Soda Ash : 16 %
Behavior improvement training include hand protection awareness module	Varun Raoji	Out of 254 employees 110 employees covered and rest will be covered by 30 <sup>th</sup> April 2014

Transition to Process Owner: RACI Chart

Step	Due Date	Action/Task	Responsible	Accountable	Consulted	Informed	Comments
1		Task base JSA in category 1 permit	Department Heads	Functional Heads	D K Thakur	R J Buch	
2		Rectification of Identified Points in Ergonomic survey of valve operation - Bicarb plant	Anand Gandhi	S.Roy	D B Shukla	D K Thakur	

Results & discussion Control – Storyboard

Control Action Number	Control Action	Responsible Individual	Freq.	Process Step	Applicable Control Charts and Metrics			Reaction Plan
					Target Value	Upper Control Limit	Lower Control Limit	
1	Identification of Identified Points	Anand Gandhi	Monthly	Rectification of points	95%	100%	85%	Highlight the issue to the higher authorities
2	Task base JSA in category 1 permit should be followed	Varun G Raolji	Weekly	JSA	100%	100%		consequence management

Required Training	Responsible	Status
Hand protection awareness module	Varun Raolji	Compliance: Erection : 82 % Soda Ash : 16 %
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Conclusions

1. Ergonomic Survey to be done for Valve Operations in Bicarb Plant.
2. Designed Hand Protection Module.
3. Training Imparted on Hand Protection.
4. To reduce hand injuries frequency rate from 2.05 to 1 at TCL Mithapur.

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