CASE STUDIES

METALWORKING INDUSTRY

WSHCOUNCIL

FOREWORD

On April 2008, Mr Lee Hsien Loong, Prime Minister of Singapore, set the target workplace fatality rate of less than 1.8 to be attained by 2018. Given the momentous task at hand, a multi-pronged approach has been developed, involving all industries and different levels of organisations.

As part of our continued efforts to provide metalworking companies with useful material to promote in-house safety and health, the Workplace Safety and Health Council (Metalworking and Manufacturing) Committee has put together a compilation of case studies to help you engage your workers. Sorted according to work processes, these case studies shed light on the common causes of accidents and offers insights on how these accidents can be avoided. Many of these cases are related to improper machine operations, lifting or material handling. I hope that you will find valuable learning points in these case studies, highlighted in this publication, and apply the knowledge to prevent these mishaps.

Prof Low Teck Seng
Chairman
Workplace Safety and Health Council
(Metalworking and Manufacturing) Committee

WSHCOUNCIL

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MACHINE OPERATION

CASE 1

ALUMINIUM STRIP PIERCES A WORKER'S NECK

Agent/Process

Cutting of aluminium strips.

Description of Accident

A general worker was operating a cutting machine to cut aluminium strips for scraps. While the worker was cutting a piece of 960mm long x 18mm wide x 3mm thick aluminium strip with the circular saw of the cutting machine, an aluminium strip which was pointed at both ends, flew off suddenly towards another worker, who was operating a drilling machine nearby. One end of the pointed strip pierced the drilling machine operator's neck below his left ear. The drilling machine operator died on the same day.

Observations and Findings

- The two workers were working about 6.2m apart.

- The cutting machine was equipped with a two-piece pneumatic clamping device to clamp the work piece onto the worktop for cutting. Investigations revealed that one part of the two-piece clamping device would not be able to clamp down the work piece entirely, as there was still a gap of about 4mm between the worktop and clamping device piece, when activated.

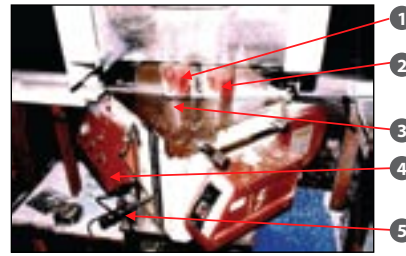
1. The 960mm long x 18mm wide x 3mm thick aluminium strip flew from here towards drilling operator

2. General worker was using this cutting machine to cut aluminium strips

3. Drilling operator was operating this drilling machine about 6.2m away from the cutting maching which was on his left

- The clamping device of the cutting machine involved in the accident was not properly maintained, i.e. not properly adjusted to enable it to clamp the work piece in position.

- The failure to clamp the work piece had resulted in the circular saw blade causing the work piece to be propelled at high speed and fatally injuring the drilling machine operator.



1. This left-hand side plastic block of the pneumatic clamp is 7mm above the worktop
2. This right-hand side plastic block of the pneumatic clamp is 4mm above the worktop
3. The slot in the worktop of the cutting machine
4. The control box of the pneumatic clamp
5. The handle for raising the concealed blade of the circular saw was mounted beneath the worktop of the cutting machine

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Work Planning	• Suitable equipment must be provided to ensure safe work processes
Equipment and Tools	• Clamping device of the cutting machine must be properly maintained.
Training and Awareness	• All personnel should be trained on the correct application of equipment/tools.
Coordination and Communication	• All workers must be encouraged to report any unsafe work conditions such as unsuitable equipment to the supervisor.

CASE 2

WORKER'S PALM GETS CRUSHED

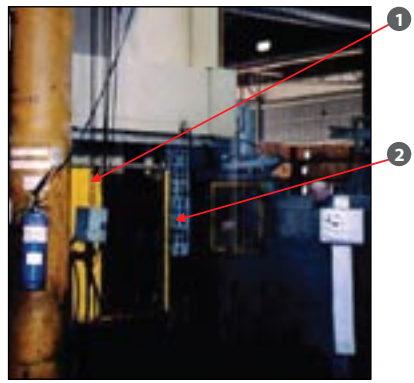
Agent/Process

Die-casting machine.

Description of Accident

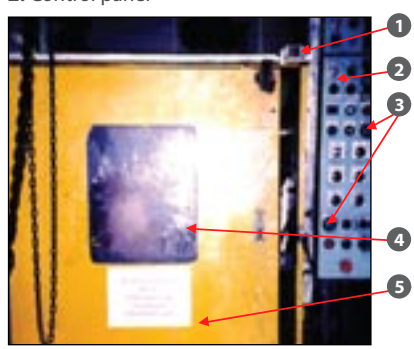
A worker closed the sliding door of a machine and started the machine in the "automatic" mode of operation via two-hand control buttons. As the die-casting process was about to complete its first cycle of operation, the worker saw through the looking glass that a piece of overflow chip was stuck on the ejector pin of the moving die. While the machine was still in the automatic mode of operation, the worker opened the sliding door.

At that time, the dies were in the "open" position. Using a spanner held in his right hand, he knocked off the overflow chip from the moving die. Suddenly, the moving die closed onto the fixed die prior to the commencement of the machine's second cycle of operation. The injured was not able to retract his hand in time and his right palm was caught in between the die and was crushed.



1. Sliding door

2. Control panel



1. Limit switch
* Installed after the accident

2. Control panel

3. Two hand control buttons

4. Looking glass

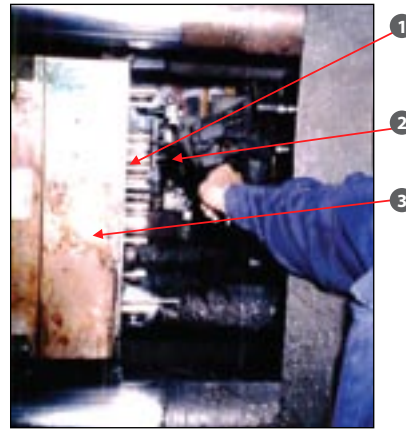
5. Sliding door

Observations and Findings

- The sliding door was not fitted with any interlock which would have stopped the machine when the door was opened during the automatic mode of operation.

- Need for the safety interlock on the sliding door was highlighted before the accident but the installation was not carried out due to the different electrical control circuitry from the other die-casting machines.

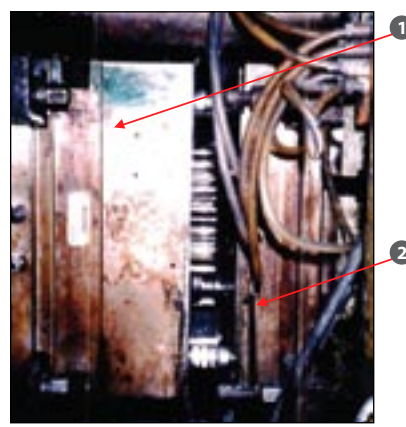
- The worker had been trained to stop the machine first before attempting to access the die area. The worker bypassed the procedure of placing the machine on the manual mode of operation prior to opening the sliding door to access the die.



1. Ejector pins

2. Spanner

3. Moveable die



1. Moveable die

2. Stationary die

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• The machine should be fitted with safety interlocks to stop the machine whenever the door is opened during an operation. • Preventive maintenance of interlocking devices should be put in place to ensure that such devices do not breakdown.
Others (Process design, etc.)	• The operator should have stopped the machine before opening the door to access the die.

CASE 3

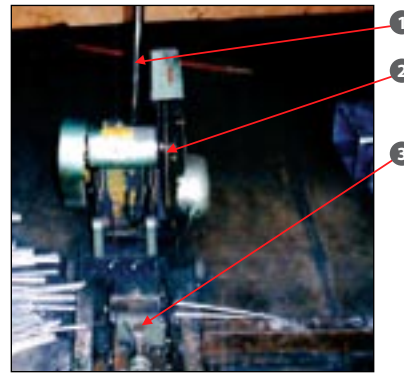
WORKER'S THUMB GETS SEVERED

Agent/Process

An abrasive disc cutter was mounted on four castor wheels. The machine was activated by an "on/off" push button control and the handle on the machine was used to bring the abrasive disc down for cutting the material mounted on the vice. A metal guard at the machine covered the top half of the abrasive disc and the bottom half of the disc was left exposed for the cutting work.

Description of Accident

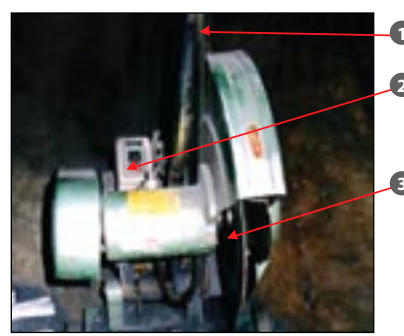
The worker was cutting a piece of a flat bar with the aid of the abrasive disc cutter. The worker used his left hand to operate the handle of the disc cutter and his right hand was holding down the flat bar that was clamped on the vice. While cutting, the machine suddenly jerked violently. However, instead of stopping the cutting operation, the worker attempted to steady the disc cutter by holding down the flat bar with his right hand and continued with the cut. However, the machine did not stop jerking and the worker then decided to release his right hand from the disc cutter and forego the cutting but was too late. On retrieval of his right hand from the machine, his right thumb came into contact with the rotating abrasive disc and the thumb was severed on the spot.



1. The handle for moving the abrasive disc for cutting

2. The abrasive disc

3. The vice for clamping material for cutting



1. The handle for moving the abrasive disc for cutting

2. The "on/off" push button control for activating the disc cutter

3. The metal guard that exposed the bottom half of the abrasive disc for cutting

Observations and Findings

- The disc cutter vibrated violently probably because it was either not balanced or was not maintained properly.

- The unsafe act of the worker also contributed to the cause of the accident. He had attempted to steady the disc cutter by holding down the flat bar clamped on the vice of the disc cutter and continued with the cutting when he should have stopped the operation.

- The worker knew that he had to clamp the flat bar on the vice before he starts cutting the flat bar. He should not have held down the flat bar with his right hand when he found the machine jerking violently as his right hand would come into contact with the abrasive disc of the machine.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• The employer must ensure all equipment is safe to use. • User must ensure grinding or abrasive machines are placed on even ground to operate to avoid vibration. • Grinding or abrasive cutting machines should not be mounted on castor wheels as this will create instability during operation.
Training and Awareness	• Workers are to be instructed on the proper operating instruction before allowing them to operate the machine. • Workers should stop work immediately once an operation poses a potential risk to them and report unsafe working conditions to the supervisor.

MACHINE MAINTENANCE AND TROUBLESHOOTING

CASE 4

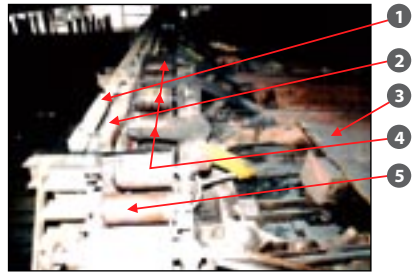
WORKER PINNED BY A STEEL OBJECT

Agent/Process

A semi-finished steel form, known as a billet, was guided and kept in the path of a roller conveyor during an operation by a steel guide weighing about 0.85ton. A limit switch was located at the end of the roller conveyor at the charging area. When the travelling billet went over the limit switch roller, the limit switch would be depressed and activate a sensor. This sensor, in turn, would activate the kicking mechanism of the charging area. The kicking mechanism could only be turned off by an emergency button in the control room at the charging area.

Description of Accident

A worker and his co-worker were carrying out upgrading works to a charging table while the supervisor attempted to re-align the steel guide of the roller conveyor. As the steel guide was heavy, the supervisor requested the overhead travelling crane operator to assist with the positioning by using an electro-magnet lifter. Suddenly the guide fell onto some rollers and activated a limit switch that controlled the kicking mechanism at the charging area. This mechanism "kicked" the guide in the direction of the two workers. The worker was pinned by



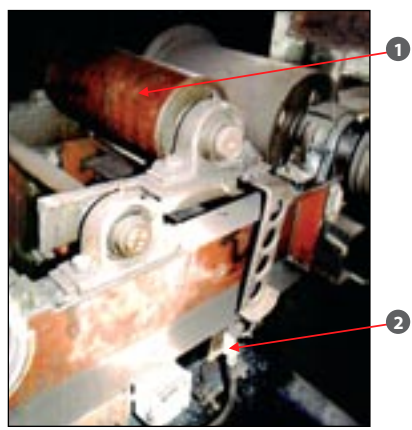
1. Outer steel guide

2. Inner steel guide (involved in the accident)

3. The deceased and his co-workers were working at the platform

4. Rollers conveyor

5. Limit switch roller



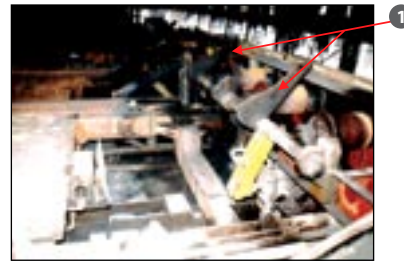
1. Limit switch roller

2. Limit switch that activated the kicking mechanism

the steel guide against the charging table and died as a result.

Observations and Findings

- The factory occupier did not implement lockout procedures.
- The supervisor did not switch off the kicking mechanism of the charging areas.
- The supervisor did not restrict the movement of the guide by securing it.



1. Kickers

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented. • A lockout system should be implemented before any inspection, adjustment, or maintenance is carried out.
Training and Awareness	• All workers must be briefed on and understand the hazards and risks involved and the contents of safe work procedures.
Coordination and Communication	• Work coordination should be carried out prior to work, and all incompatible activities must be highlighted and stopped.

CASE 5

WORKER GETS KILLED BY A STEEL MESH MACHINE

Agent/Process

Grouting work at a steel mesh machine.

Description of Accident

A worker and his co-worker were sent to work on a steel mesh machine. On their third day, work had to be done in the fenced part of the machine. After some time, the co-worker left the work area to restock on cement. When he returned, he found the worker lying beneath the steel mesh machine. The worker was sent to the hospital and subsequently succumbed to his injuries. His cause of death was recorded as "acute respiratory distress syndrome" and "fractured ribs and pulmonary contusions ".

Observations and Findings

- The steel mesh machine was fenced and various parts of the machine within the fencing could move in various directions when activated.

- Two sliding gates were part of the fencing. The gates were provided with interlocking sensors. However, the interlocking sensors were not connected and hence not in working order.

1. The accident happened here

1. The deceased was found on the floor underneath the machine here

- Testing and commissioning of the wire mesh machine was being carried out when the accident happened. There was no instruction given that testing and commissioning of the machine should only be carried out when there was no other work being done at the machine.
- Workers testing the machine could not see workers involved in grouting work.
- The factory owner had failed to lock out/ tag out the machine while grouting work was carried out at the machine.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented; i.e. Procedure for Testing and Commissioning and Procedure for Lockout/ Tagout.
Work Planning	• Testing and commissioning should not be carried out at the same time as grouting work.
Equipment and Tools	• Safety interlocking sensors should be working at all times.
Training and Awareness	• All workers involved must be briefed on and understand the hazards and risks involved and the contents of safe work procedures.
Coordination and Communication	• All workers should be cleared away from the machine before conducting testing and commissioning of machine.

CASE 6

WORKER FALLS THROUGH AN OPENING

Agent/Process

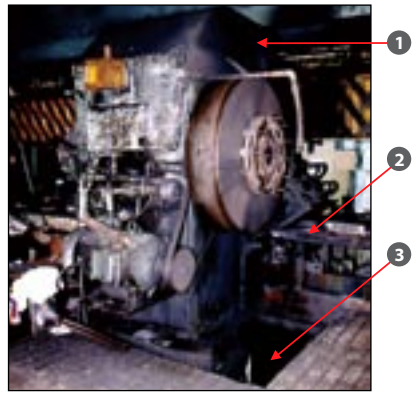
Machine maintenance.

Description of Accident

The worker and his co-worker were assigned to service a machine on the second level. The machine was barricaded with a guard that had to be removed before both could gain access to the work area. After the guard had been shifted, both saw an opening (Opening A) in the metal grating between the machine and the guard. The worker looked for a cover for Opening A. When he found one, a steel plate, he called his co-worker to help him move it. Bending over, they lifted the steel plate to carry it away. While they were lifting, the worker fell into the opening (Opening B, which was hidden below the steel plate) and landed on the first floor and died as a result.

Observations and Findings

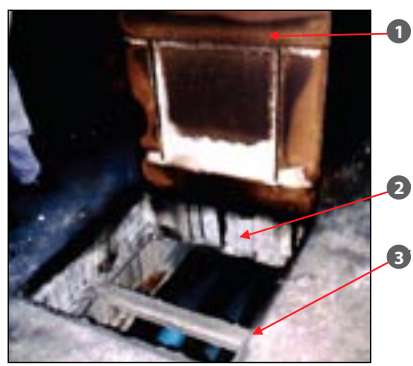
- The co-worker did not know that there was another opening (Opening B) under the steel plate and he did not notice the opening when he was lifting as his body was bent forward during the lifting.



1. Cold Shear machine

2. Shear blade

3. Opening at the Cold Shear machine (Opening A)



1. Cover

2. Opening B

3. Groove

- The opening (Opening B) was part of the factory layout design. The opening was meant for electrical wiring and piping installation. The cover for such an opening should have been secured to avoid inadvertent removal.

1. Opening B

2. The deceased landed here

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Work Planning	• A preliminary survey of the work area should be carried out before embarking on the job.
Equipment and Tools	• The covers for the openings should be fixed to the floor to prevent inadvertent removal.
Training and Awareness	• A warning sign should be posted on the steel cover informing workers about the opening underneath and to prevent workers from removing the cover.
Coordination and Communication	• Coordination between the occupier and the workers could have highlighted the openings and measures put in place to prevent the incident.

CASE 7

WORKER'S TWO FINGERS GET SEVERED

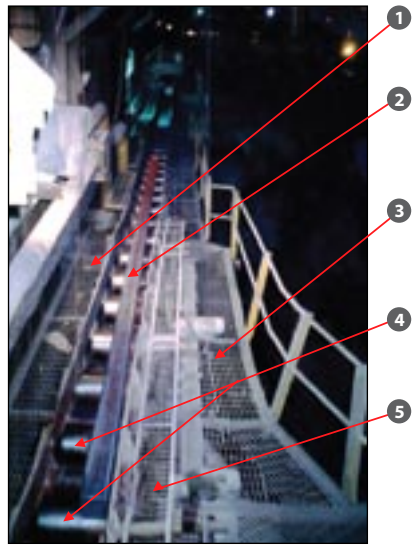
Agent/Process

Inspection of a billet roller conveyor system that transported billets manufactured from a continuous casting machine to a rolling mill. It primarily consisted of rollers driven by motors via a belts-and-pulleys transmission system.

Description of Accident

The worker was inspecting the billet roller conveyor system when he heard an abnormal sound coming from one of four rollers driven by a motor. He climbed onto the inner walk platform to identify the roller which generated the abnormal sound with his left hand holding a torchlight.

While moving along the inner walk platform to detect the source of the abnormal sound, the worker hit against a cable tray at his right buttock cheek. He lost his balance and fell forward. As he fell, his left lower arm hit against the top side protective cover while his right hand went under the protective cover and was caught in between the nip point of the v-belts and two-sheaves pulley of the roller. He suffered severance of his right index finger and right middle finger. He also suffered laceration on his right ring finger.



1. Inner walk platform

2. Billet

3. Outer walk platform

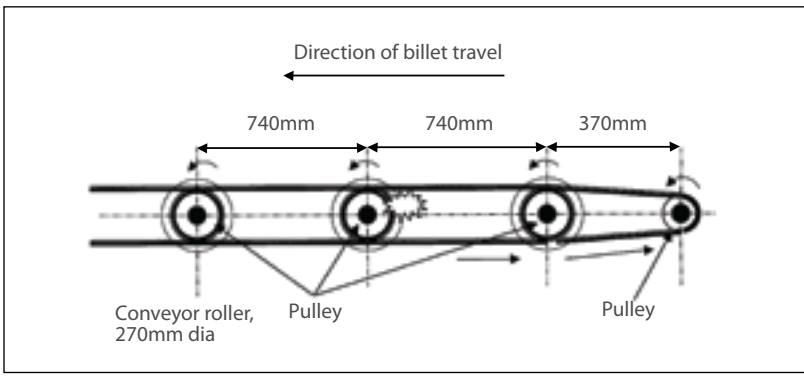
4. Rollers

5. Protective cover

Observations and Findings

- There was inadequate fencing provided on the belts and pulleys system driven by the motor.

- The worker was walking along the inner walk platform that was about 450mm wide with cable tray carrying cables running along the inner walk platform at about 400mm high. After taking into account the space used by the cables and cable tray, the effective space for walking along the inner walk platform was about 250mm.



Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented. • Lockout/Tagout procedures should be implemented before any inspection, adjustment or repair is carried out.
Work Planning	• Present cable tray location is a hindrance to conveyor adjustment and repair works and should be relocated.
Equipment and Tools	• All exposed moving parts should be adequately covered.

CASE 8

WORKER'S TWO FINGERS GET CRUSHED

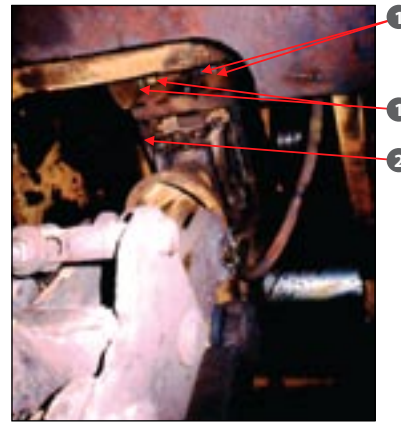
Agent/Process

A billet rolling line, used in the manufacture of rebars, consisted of Roll Stands lined in a series. Hot semi-finished steel bars, known as billets, were extruded from the oven at 1000 °C through the roller passes on each set of rollers at the Roll Stands. The hot billets were then gradually reduced to the size of rebars required.

Description of Accident

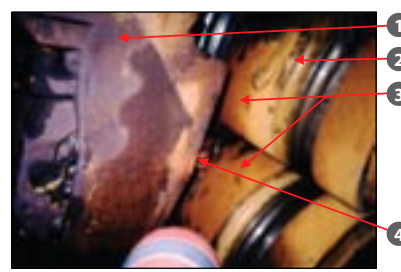
The entire billet rolling line had been switched off to facilitate the change of roller passes. Upon switching off the billet rolling line, all the rollers at the Roll Stands would rotate momentarily before coming to a standstill. At the time of the accident, the worker did not follow his team to Roll Stand A. On his own accord, he went to Roll Stand B to check the condition of the roller guide. His intention was to save the machine down time by speeding up the checking of the condition of the other roller guides at the billet rolling line while his team mates worked at Roll Stand A.

After a visual check of the rollers at Roll Stand B, the worker put his right hand on the guide sheave of the roller guide to feel for the condition



1. The rollers with four pairs of roll passes found here

2. The roller guide that had to be shifted to a new pair of roll passes



1. The roller guide

2. A brand new pair of roll passes

3. The two rollers with four pairs of roll passes

4. The guide sheave that the injured was feeling with his right hand

of the guide sheave. While doing so, his right hand was caught between the rotating rollers and the roller guide. The worker shouted for help and his co-workers came to help. On retrieving his right hand from the rollers, the worker found that the distal phalanxes of his right middle and ring fingers were badly crushed.

The worker claimed that when he was checking the exterior of the roller guide at Roll Stand B, he had noticed the rollers moving slowly to a standstill. He had presumed that by the time he put his right hand to feel the guide sheave of the roller guide, the rollers would have come to a standstill.

Observations and Findings

- The worker had misjudged the time taken for the rollers to come to a standstill when he put his right hand in to feel the guide sheave.

- The worker had disregarded the instructions from his supervisor to work at Roll Stand A and had instead gone on to check the roller guide at Roll Stand B.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Training and Awareness	• Constant reminders of safe work methods should be given.
Coordination and Communication	• All relevant workers should adhere to stipulated work instructions and avoid taking short cuts.

MATERIAL HANDLING

CASE 9

WORKER KILLED BY A TOPPLING OBJECT

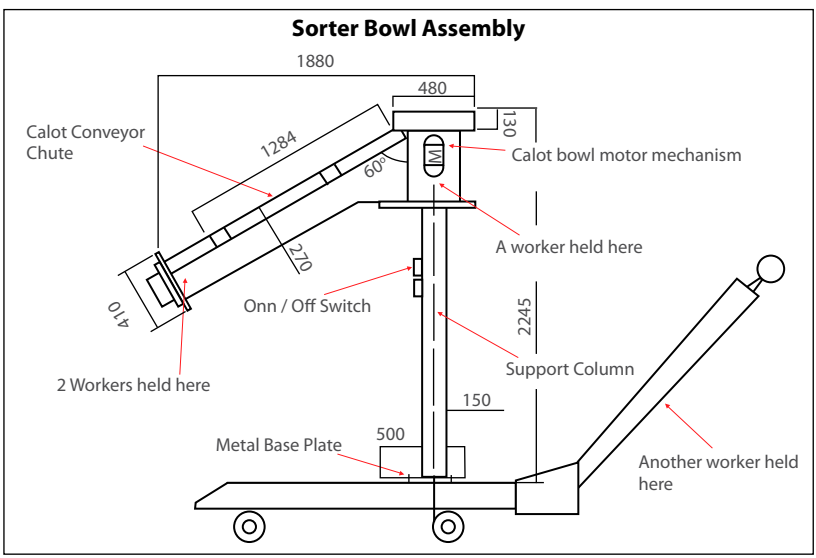
Agent/Process

Material handling.

Description of Accident

A team of workers was assigned to relocate an extruder machine within the factory. The team dismantled the sorter bowl assembly from the main body of the extruder machine and placed it in the upright position on top of the metal forks of a hydraulic pallet jack. The workers then supported, balanced and pushed the sorter bowl assembly along a passageway of the production floor for a distance when they encountered a height limit bar.

The team stopped to assess the situation. The supervisor instructed that the sorter bowl assembly be placed on the production floor. The team began to tilt and lower the sorter bowl assembly. During the process, the sorter bowl assembly suddenly fell onto the chest of one of the workers. The worker died in the hospital the same day.



Observations and Findings

- The sorter bowl assembly was about 267cm in height, 50cm in diameter and weighed 250kg.

- The supervisor had attended the Lifting Supervisor Course and had more than 8 years of working experience on manual handling of articles and machinery. One of the workers had attended the Rigger and Signaling Course and had more than 15 years of working experience on manual handling of articles and machinery. The worker had attended the Safety Orientation Course and had more than 10 years of work experience in moving heavy machinery.

- The shifting of the sorter bowl assembly in the upright position was not the best method. The sorter bowl assembly was unstable and the shifting method exposed the workers to the risk of being struck by the object being handled. The sorter bowl should have been placed horizontally on the hydraulic jack instead. The width of the passageway of the production floor was wide enough for the work to be performed.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Work Planning	• Before moving or transporting a load, a survey of the intended path of travel should be conducted to ensure that there are no obstructions.
Equipment and Tools	• Appropriate mode of transportation should be used to transport a load. Lifting equipment, like an overhead crane or forklift, should be used, if available.
Others (Process design, etc.)	• The load should be made stable and secure before moving it.

CASE 10

WORKER'S RING FINGER GETS SEVERED

Agent/Process

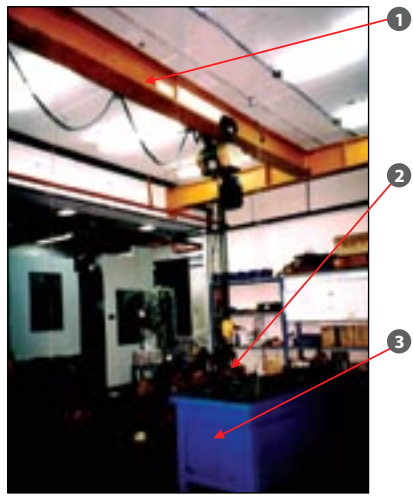
Overhead travelling crane.

Description of Accident

A worker was operating an overhead travelling crane to lift the upper half of a mould base to assemble into the lower half of the mould base, which was on a working table. During the sequence of movements, the upper half of the mould suddenly slipped and hit the worker's right ring finger and severed it.

Observations and Findings

- The mould base was 460mm wide x 385mm long x 430mm high and weighed about 400kg.
- The worker used a lifting belt to tie to the two eye-bolts of the mould base to lift up the mould.
- The overhead crane had been examined by an approved person one month prior to the accident.
- The worker had been working for about three months in the factory and had four years of similar experience prior to joining the company. He had been trained on the safe operation of the overhead crane when he started work with the company.



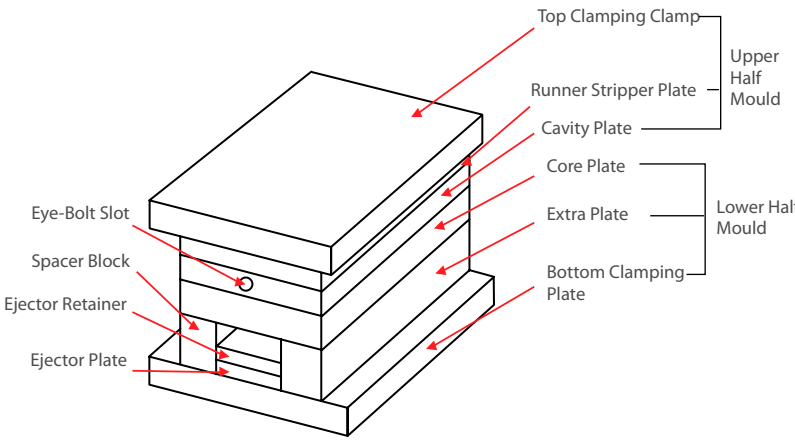
1. Overhead crane

2. Lifting belt

3. Working table

- The worker said that when the upper half mould base was lifted up to a height of about 150mm above the working table, the mould suddenly slipped and hit his right ring finger.
- The probable cause of the accident may be due to the imbalance of the mould when it was being lifted, which caused the mould to slip and hit the worker's finger.

Sketch Showing The Steel Mould Base



Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• Loads should be properly balanced and securely rigged before lifting.
Training and Awareness	• Crane operators should be trained on the correct rigging methods.

FORKLIFT OPERATION

CASE 11

WORKER GETS PINNED UNDER AN OVERTURNED FORKLIFT

Agent/Process

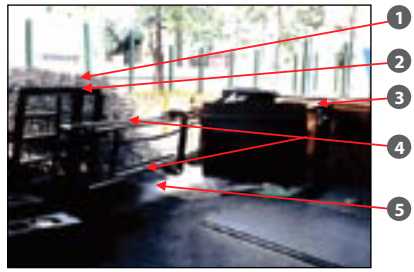
A forklift operator was using a forklift truck to transport stacks of wire mesh from the welding area to the storage area in the factory.

Description of Accident

The operator had picked up a stack of wire mesh from the welding area and drove the forklift towards the storage area that was located outside the entrance of the factory building. He raised the forks of the truck as it moved towards the entrance of the building. Suddenly, the forklift truck tilted to its left and overturned at the entrance of the building. The operator jumped out of the driver seat as the forklift truck overturned. However, he fell to the ground and was pinned underneath the mast of the overturned forklift truck. He succumbed to his multiple injuries a few hours later.

Observations and Findings

- The forklift truck was last serviced two months earlier by a contractor;
- The forklift truck was rated 3ton, the total weight of the stack of wire mesh was about 720kg, measuring 6500mm long and 1390mm wide;



1. The stack of wire mesh the operator was transporting with the forklift
2. The backrest
3. The overturned forklift truck
4. The mast
5. The deceased was pinned here under the mast

- The operator had attended the Forklift Operation Course and was issued a Certificate of Completion of the course more than two years earlier;
- The forklift truck overturned probably because the load was raised too high and affected the stability of the forklift truck when the operator was turning it out of the factory building.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• As far as practicable, forklifts should be fitted with seatbelts.
Training and Awareness	• Every forklift operator must be trained and competent.
Coordination and Communication	• All risk assessment findings and safe work procedures must be communicated to the work personnel.
Others (Process design, etc.)	• Forklifts should not be driven with the forks raised. • Refer to CP 101: 2004 Power counterbalance forklift for more details.

CASE 12

SUPERVISOR KILLED BY FALLING ANGLE BARS

Agent/Process

Forklift operation.

Description of Accident

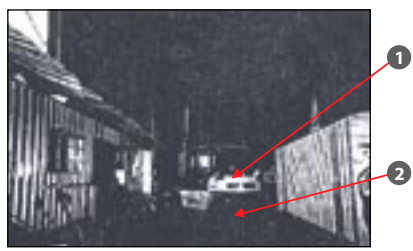
A supervisor had instructed a worker to transfer a bundle of angle bars from the trailer to the workshop with a forklift truck. There were some storage containers on both sides of the access path of the forklift truck. As the width of the access path was too narrow for the length of the angle bars, the supervisor instructed the worker to lift the angle bars above the roof level of the containers. During this movement, the load on the fork tilted and hit the roof of the containers. The load fell off from the fork and pinned the supervisor down. The supervisor died on the same day.

Observations and Findings

- The length of the steel angle bars was measured to be about 6m. The width of the access path for the forklift truck was measured to be about 4.4m.

- The worker alleged that he had indicated to the supervisor that it would be difficult to carry out the transferring operation as the angle bars were too long for the access

1. Containers



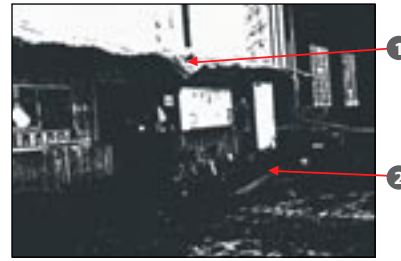
1. Forklift truck involved in the accident

2. Steel angle bars which were placed on the fork of the forklift before the accident

path before commencement of the work.

- The worker had attended the Forklift Driver's Training Course and had obtained the certificate three years earlier.

- The accident had occurred because the angle bars were transported in an unsafe manner, i.e. they were placed on the fork and raised above the roof of the containers. The angle bars became unstable during this, fell off and hit the supervisor who was in the path.



1. Dented roof

2. The bundle of steel angle bars involved in the accident

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented. • Forklifts should never be overloaded. • Loads should be secured properly.
Work Planning	• A preliminary study of the route to assess obstacles or constraints should have been carried out prior to moving the bars.
Coordination and Communication	• During such lifting activities, all other personnel should stay clear of the travel path.
Others (Process design, etc)	• A safe and appropriate path and method of transporting the bars should have been identified before commencing the transfer. • Use appropriate and the safest mode of transportation.

CASE 13

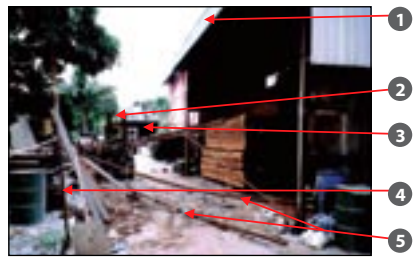
SUPERVISOR KILLED BY A COLLAPSING SHELTER

Agent/Process

Forklift operation.

Description of Accident

A supervisor was checking some materials stored under a shelter. A forklift truck was parked under the shelter with the rear end of the forklift truck about 1m away from one of the two steel columns supporting the outer end of the shelter. The steel column was located immediately next to the driveway. A worker started the forklift truck and reversed it. Suddenly, there was a loud sound and the shelter collapsed. A steel rafter (part of the shelter's roof) of the collapsed shelter hit the supervisor on the head and killed him.



1. The shelter was extended from the roof of this timber store over the entire driveway fronting the timber store

2. Position of the forklift truck after the accident

3. The main gate of the factory

4. This steel column of the shelter was still in its upright position next to the kerb while the other column was toppled by the forklift truck

5. Structural members of the collapsed shelter

1. The material store

2. The fallen steel rafter of the collapsed shelter landed between the mast and the driver's cabin of the forklift truck

3. The shelter extended from the roof of the timber store over the entire driveway fronting the timber store

Observations and Findings

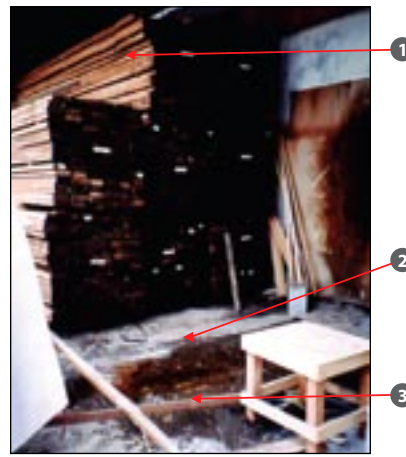
- The worker had not attended the Forklift Driver's Training Course but he has been driving the forklift in the factory occasionally for the past four months.

- The worker had, without first checking, reversed the forklift truck into the steel column after starting the engine.

collapsed when the forklift truck reversed into one of the two columns supporting the shelter

4. Position of the forklift truck after the accident

5. The toppled steel column lying on the driveway between the forklift truck and the kerb of the driveway



1. On the day of the accident the supervisor ferried these timber planks to this timber store from the lorry parked outside the main gate

2. At the time of the accident the supervisor was here checking and counting the timber planks in the store

3. This fallen rafter hit the supervisor

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• Forklift trucks should have the necessary warning lights and beepers and reverse mirrors. They should be in good working condition at all times.
Training and Awareness	• Only trained, competent and authorised forklift operators are allowed to operate forklifts.
Coordination and Communication	• The driver of the forklift should have checked his surroundings to ensure that it was clear before driving or reversing the forklift.

LIFTING OPERATION

CASE 14

LORRY CRANE DRIVER GETS PINNED UNDER H-PILES

Agent/Process

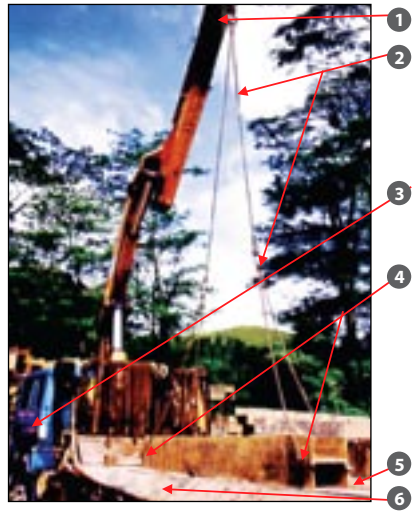
Unloading of H-piles from a lorry crane.

Description of Accident

A lorry crane driver was helping another fellow lorry crane driver to rig a stack of five H-piles on the deck of his lorry crane. After rigging the H-piles and while still standing on the left side of the deck, the lorry crane driver told the fellow driver to initiate the lift. After the load was lifted just above the deck, the lorry crane driver suddenly shouted and the fellow driver stopped the lifting immediately. The stack of H-piles toppled towards the left side of the lorry and fell to the ground except for the bottom piece. The toppling H-piles swept the lorry crane driver to the ground and one piece pinned him on his neck. The lorry crane driver died on the spot.

Observations and Findings

- The accident could be caused by the unsafe rigging method adopted by the lorry crane driver. He had rigged a stack of five pieces of H-piles of different lengths by securing the hooks of the chain slings to the bottom-most H-piles.



1. The crane of the lorry crane used for the unloading

2. Two-legged chain sling

3. Driver's cabin

4. The rigging of the H-pile was simulated

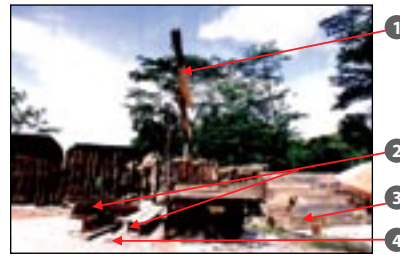
5. Tailboard end

6. Left sideboard

- The lorry crane driver was not a trained rigger and no trained rigger was appointed to rig up the H-piles for lifting by the crane of the lorry crane.

- No lifting supervisor was appointed to supervise the lifting operation of the H-piles.

- Some of the two-legged chain slings used for the lifting were not tested by an approved person at the time of the accident.



1. The lorry crane

2. Four pieces of H-pile toppled to the ground

3. Stack of H-piles before the accident took place

4. Fellow driver was fatally wounded here

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• All lifting equipment must be inspected and certified safe for use by an authorised examiner.
Training and Awareness	• All personnel involved in lifting operations must be trained and competent. • Lifting supervisors must be appointed for all lifting operations.
Coordination and Communication	• All risk assessment findings and safe work procedures must be communicated to the work personnel. • Every lifting operation must be supervised by an appointed Lifting Supervisor, or in the absence of the Lifting Supervisor, a set of safe work procedures must be implemented and communicated to the work personnel.

CASE 15

WORKER IS PINNED BETWEEN A GANTRY CRANE AND A BUILDING COLUMN

Agent/Process

Gantry crane operation.

Synopsis of Accident

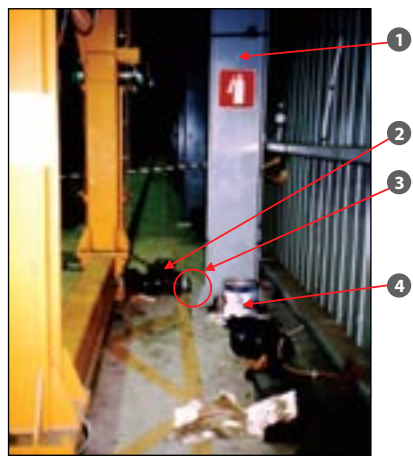
S, a gantry crane operator was operating a gantry crane inside a workshop to hoist a bundle of metal pipes and some angle bars. The materials were to be transferred from the front entrance of the shop to the other end of the shop. When the loaded gantry crane travelled about 4m into the shop, S heard some people shout and he immediately stopped the lifting operation. He saw a few workers gather around the motor area of the crane. He ran to take a look and saw M pinned between the travel motor of the gantry crane and a column of the shop. M was conveyed to hospital where he succumbed to his injuries on the same day.

Observations and Findings

- The crane was equipped with a warning siren, blinking lights and ultrasonic sensors. These devices were to alert people in the shop and warn them to stay away from the approaching crane during lifting operations. The devices were tested after the accident and were found to be in good working condition.

1. Accident occured here

2. Load carried by the crane at the time of accident



1. Columns

2. Motor of the crane

3. M was found here

4. Steel bucket

- There were yellow demarcation lines along the track of the gantry track to serve as a visual check for people to stay away from the demarcated zone. The motor of the crane was within the demarcated line.

- The outermost edge of the motor was about 12cm from the column. A steel bucket containing grinding wheels and other tools were seen placed beside the column where the accident occurred. It was alleged that the bucket belonged to M and M was assigned to carry out grinding operations in the shop on the day of the accident.

- The accident could have occurred when M was squatting at the column to get his tools from the bucket. The crane had travelled faster than M probably anticipated and he was pinned by the motor against the column when he tried to stand up to avoid being hit.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Work Planning	• The work environment should be checked to ensure that no one is in the path or within close proximity of the suspended load when it is being transferred. • Maintain an unobstructed passageway, at least 750mm in width on each side of each rail, parallel to and extending the entire length of the tracks of the gantry crane.
Training and Awareness	• All personnel should be trained in the correct application of equipment/tools.

CASE 16

WORKER GETS KILLED BY TOPPLING SCAFFOLD FRAMES

Agent/Process

Operation of overhead travelling crane.

Description of Accident

An overhead travelling crane was used to transfer structural steelwork between a storage area and a nearby fabrication yard in the workshop. Prior to the accident, a worker and a co-worker were working near a metal platform while an overhead crane operator was operating an overhead travelling crane between the metal platform and the storage area. It was believed that when the crane moved towards the storage area, the chain sling that was attached to the chain block of the crane got entangled with the bundle of scaffold frames that was placed at the top of the metal platform. The entanglement pulled the bundle of scaffold frames to the ground and injured the worker and the co-worker. Both workers were sent to hospital and the worker passed away a few weeks later.

Observations and Findings

- Investigations showed that there was a lifting supervisor appointed for the lifting operations at the workshop. However, he did not oversee the lifting operation at the time of accident and he did not

1

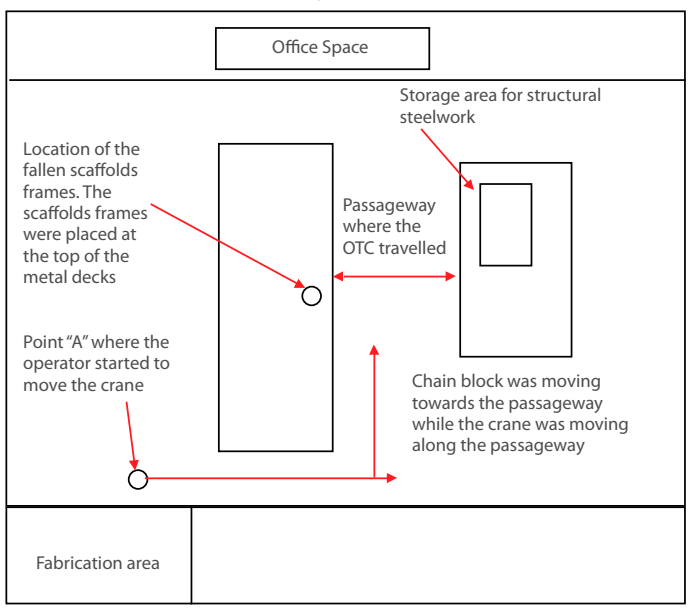
1. The OTC operator positioned himself at this location when the crane moved from the column of the metal decking towards the storage area for the metal decks.

introduce a proper lifting procedure for the operation to brief the crane operator. The lifting supervisor had completed a lifting supervisor safety course.

- The crane operator did not see the crane when it was moving from the metal platform to the storage area because he positioned himself in such a way that his line of sight on the crane was blocked by the surrounding metal decks. He mainly pressed the buttons on the control pendant to move the chain block and the crane towards the storage area.

- Investigations revealed that prior to the accident, the bundle of scaffold frames placed on top of the metal platform were not securely tied to the metal platform. The height of the metal platform was about 3.5m and the height of the bundle of scaffold frames was about 1.2m. The bundle of scaffold frames weighed about 0.7tons.

Sketch Showing the Layout of the Place of Accident



Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Work Planning	• Proper planning of the route of the lifting operations must be carried out to ensure that there is no structure or other objects that could be hit or entangled by the suspended load. • The work environment must be checked to ensure that no personnel are in the path or within close proximity of the suspended load when it is being transferred.
Equipment and Tools	• Equipment or materials, especially those that are stored at height, should be properly secured to ensure that they do not fall easily.
Training and Awareness	• All personnel executing the lifting operation (e.g. lifting supervisor, crane operator, signaller, etc.) must be appropriately trained. • The lifting operation must be made known to those that may be affected by it and/or may be working in the vicinity.
Coordination and Communication	• Lifting processes must be supervised by a qualified Lifting Supervisor, or in his absence, a set of lifting procedures established by him must be followed and must be communicated to all affected personnel. • When the overhead crane operator does not have a clear sight of any part of the lifting operation; a trained signaller must be appointed to assist the operation.

CASE 17

WORKER FALLS AND GETS CRUSHED BY AN ELECTRICAL DISTRIBUTION BOX

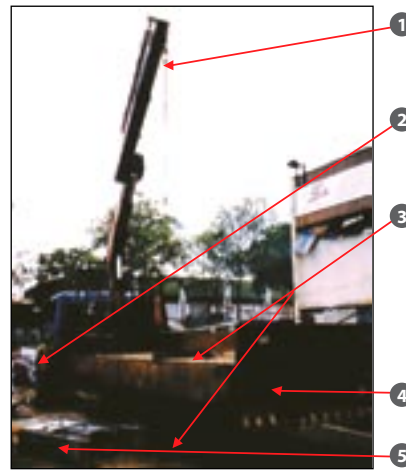
Agent/Process

Lifting operation.

Description of Accident

A worker and a lorry crane operator were unloading some scrap electrical distribution boxes (DB) by using a lorry crane. The scrap electrical DBs were contained in a metal bin placed on the back on the lorry. The worker would rig up the scrap DBs and guide the lorry crane operator to hoist and unload the DBs from the lorry.

The lorry crane operator claimed that they had successfully unloaded four DBs prior to the accident. He further claimed that the worker had rigged the fifth DB by wrapping a chain sling around one of the stands and hooked back onto the chain sling. While the worker was on the deck of the lorry guiding the scrap electrical DB, which was hoisted by the lorry crane, he accidentally slipped and fell to the ground. The hoisted scrap electrical DB dislodged simultaneously from the lifting gear and fell to the ground, crushing the worker.



1. The lifting gear used to rig the fifth scrap electrical DB prior to the accident

2. Lorry crane operator claimed that he was standing here operating the crane (lorry loader when the accident occurred)

3. The deceased was standing here guiding the hoised fifth scrap electrical DB when he accidentally fell to the ground

4. The lorry crane involved in the accident

5. This was the scrap electrical DB that dislodged from the lifting gear and fell onto the deceased who was on the ground

Observations and Findings

- The lifting gear used to hoist the DB comprised a two legged chain sling attached to an oval ring at the top end and two open-ended hooks (without safety catches) at the bottom end. One of the hooks was found to be defective – the hook had deformed (it had a widened throat opening) beyond its original shape.

- Investigations revealed that the worker could have probably used the chain sling with the defective hook to rig the fifth scrap DB prior to the accident, thus causing the hook to dislodge from the chain sling and resulting in the accident.

- The occupier was unable to provide any documentation (lifting gear examination certificate) to prove that the lifting gear used to hoist the scrap DB prior to the accident was examined by an Approved Person.

- There was no Lifting Supervisor, Rigger or Signalman appointed by the occupier for the hoisting operation prior to the accident because the occupier was not aware of the requirements.

- The deceased was not a trained Rigger when he performed the rigging of the scrap DBs prior to the accident.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• All lifting equipment must be examined regularly by an Authorised Examiner and the relevant documentation kept on record. • All lifting equipment must be checked for defects before use.
Training and Awareness	• A competent Lifting Supervisor should be appointed for lifting operations in a workplace. • Rigging of loads should only be carried out by a trained Rigger.

CASE 18

WORKER'S FOURTH FINGER GETS PARTIALLY AMPUTATED

Agent/Process

Workshop overhead crane.

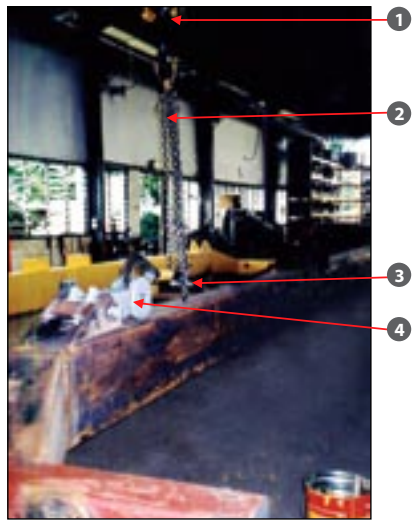
Description of Accident

A worker was positioning a wire rope sling (weighing about 200kg) in between two brackets of a gravity lever, using an overhead crane in the workshop. As he was lowering the wire rope, he saw a bolt lying in between the two brackets. As he was removing the bolt, the end of the wire rope suddenly fell down and struck against his right fourth finger. As a result of the accident, he suffered partial amputation to his right fourth finger.

Observations and Findings

- The worker had worked in the company for about one year prior to the accident and had done similar installations on many occasions.

- Investigations revealed that the worker had probably placed part of the wire rope on top of the gravity lever and slackened the tension on the chain sling. Thus, when he was retrieving the bolt, he could have moved the wire rope or chain sling and caused the end of the wire rope to slip off from the top of the gravity lever.

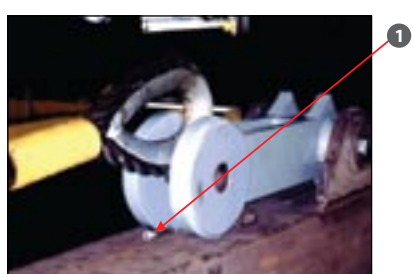


1. Hook block of overhead crane

2. Chain sling

3. Wire rope

4. Gravity lever



1. Bolt to be retrieved

- The cause of the accident was due to the wrong method of work adopted by the worker when attempting to retrieve the bolt during the lowering of the wire rope into the gravity lever.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Training and Awareness	• All lifting operators should be briefed on the safe work procedures. • During lifting operations, workers involved should anticipate falling loads and keep limbs or parts of the body out of harm's way.

CASE 19

WORKER'S MIDDLE FINGER GETS PARTIALLY AMPUTATED

Agent/Process

Ten tonne overhead crane.

Description of Accident

A worker intended to lift up a valve spindle (about 300kg) onto a trolley using a 10-ton overhead traveling crane. He rigged one sling of the overhead crane to the valve spindle via a four-legged chain sling. He then pressed the button on the control pendant to lift up the spindle but there was no response. He held the slack of the chain sling with his left hand and simultaneously operated the control pendant with his right hand to lift up the valve spindle. Suddenly, the valve spindle was lifted up and his left middle finger was caught in one of the chains of the chain sling. As a result of the accident, he suffered a partial amputation to his left middle finger.

Observations and Findings

- The worker had attended Safety Instruction Course for Lifting Supervisor and had carried out similar lifting of valve spindles using chain sling on many occasions.

1. Control pendent

2. Valve spindle

- The worker was aware that the button on the control pendant of the overhead crane could hoist up load in two speeds. When depressed slightly, the load would move at about 0.8m per minute. If the button was depressed further, the hoisting speed was about 5m per minute.

- The 10-ton overhead crane had been tested by an approved person seven months earlier. Prior to and after the accident, there was no report of any malfunction of the hoisting button on the control pendant of the crane.

- The cause of the accident was due to the worker holding the chain sling with his left hand while he operated the control pendant of the overhead crane to hoist up the valve spindle. In his haste to lift up the valve spindle, he could have depressed the button slightly further such that the hoisting was carried out at the higher speed. He did not realise that part of his left middle finger was placed in the gap between the chains. As such, when the chain sling tensioned, his finger was caught in between the chains.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Work Planning	• Wherever possible, such lifting operations should be coordinated and undertaken by two persons.
Equipment and Tools	• Check the pendant controls to ensure that it is in good working order before using it.
Others (Process Design, etc.)	• Hands should never be placed on a chain sling used for lifting a load, before or during a lifting operation.

CASE 20

WORKER LOSES HIS LEFT LITTLE FINGER

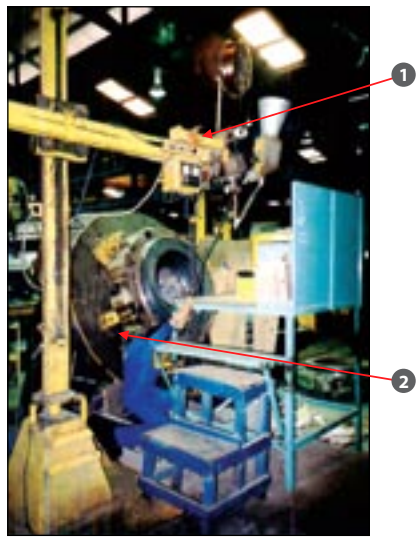
Agent/Process

Overhead travelling crane.

Description of Accident

A worker was welding a work piece on a turn-table. During welding, weld-dross was generated. He operated the control pendant for the turn-table to tilt the turn-table down to a very steep, close to upright position, to clear the weld-dross. After clearing the weld-dross, he operated the control pendant to tilt the turn-table back to the horizontal position for further welding. However, the turn-table could not be tilted up from its steep position.

The worker then tried to use an overhead travelling crane to assist in bringing the turn-table back to the horizontal position. He squatted down and used his left hand to hook the crane's chain sling near the lowest chuck-bolt of the turn-table while he held the crane's control pendant with his right hand. He then tapped the "UP" button of the crane's control pendant to gradually raise the crane hook in order to tension the chain sling anchored to the chuck-bolt. However, the crane hook suddenly raised and tensioned the chain sling, which caught the



1. Lifting gear

2. Turning-table mounted with a cylinder cover

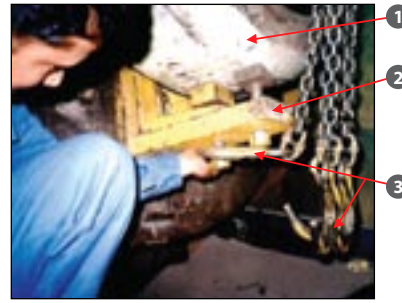
worker's left little finger. As a result his left little finger was amputated.

Observations and Findings

- The crane was examined by an approved person three months earlier. There was no report of any problem with the hoist motor.

- The hoist motor could be operated under creep speed or full load speed. The creep speed was 1/6 of the full load speed. The selection of these speeds was activated by either depressing the required button of the crane's control pendant lightly or fully. The worker was aware of these operating speeds before the accident.

- Further tests revealed that the operator had to be attentive when he attempted to half-press the button to operate the hoist in creep speed. Otherwise, he would not activate the hoist's motion or



1. Cylinder cover

2. Chuck of turning-table

3. Eyehooks of lifting gear

he may fully depress the button instead.

- The worker could have accidentally depressed the "UP" button on the crane control pendant fully while he was concurrently holding the chain-sling's eye hook against the chuck-bolt of the turn-table.

- The factory occupier had failed to ensure that all workers were fully instructed on the proper rigging method for lifting up the turn-table with a crane, and the dangers and precautions to be observed in connection with such work.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Work Planning	• Wherever possible, such lifting operations should be coordinated and undertaken by two persons.
Equipment and Tools	• Check the pendant controls to ensure that it is in good working order before using it.
Others (Process design, etc.)	• Hands should never be placed on a chain sling used for lifting a load, before or during the lifting operation.

MATERIAL STORAGE

CASE 21

STORE ASSISTANT FALLS OFF A CANTILEVER RACK

Agent/Process

Retrieving parts from a cantilever rack.

Description of Accident

A lorry driver was at a factory to collect some stainless steel pipes from the warehouse. The store assistant, directed the lorry driver to park the lorry with its tail board near one end of a 6m high cantilever rack. The rack was used for storing crates of pipes on its arms. The store assistant was standing on the third level arms of the cantilever rack near the tail end of the lorry. With his right hand gripping the under side of a fifth level arm of the rack, the store assistant used his left hand to pull out pieces of pipes one at a time from a crate placed on the fifth level arm of the rack. The lorry driver took the pipes from the store assistant while standing on the lorry and placed them onto the lorry. While the store assistant was reaching for the crate of pipes stored on the eighth level arms of the rack from the fifth level arm, he fell from the rack and landed on the concrete floor between the rack and the lorry. The store assistant succumbed to serious head injuries a few days later in the hospital.

1. The 6m high cantilever rack that was used for storing crates of pipes on its arms
2. The store assistant was standing here on a crate stored on the third level arms to pull out piped from the crate stored on the fifth level arms
3. Fifth level arms
4. Third level arms
5. The lorry was parked here to collect the pipes
6. The store assistant landed here on the concrete floor

Observations and Findings

- The store assistant could have stepped on a nearly empty wooden crate on the fifth level arm while he tried to reach for the crate on the eighth level arm. The crate could have toppled and fallen off from the fifth level. After losing his foothold, the store assistant could have lost his grip and fallen off the rack.

- A reach truck was available in the warehouse to facilitate the storing and retrieving of goods from the cantilever racks. The store assistant did not know how to drive the reach truck but it was common practice in the warehouse for those who could operate the reach truck to assist the others in operating the reach truck when necessary.

- On the day of the accident, the store assistant did not approach any of the co-workers in the warehouse to bring down the crates of pipes needed. Instead, he chose to climb up the rack.

1. The crate of pipes that fell was stored on the eighth level arms of the cantilever rack

2. One of the five uprights of the rack

3. Eighth level arms

4. According to the lorry driver the crate of pipes to be transported was stored here on the fifth level arms of the rack

5. Fifth level arms

6. The store assistant was standing here on a crate stored on the third level arms to pull out pipes from the crate stored on the fifth level arms

7. Third level arms

8. The store assistant landed here on the concrete floor

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• A reach truck should be used to retrieve goods from cantilever racks.
Training and Awareness	• All workers must be briefed on the hazards and risks involved and the contents of safe work procedures. • Relevant workers should be trained on how to operate a reach truck.
Coordination and Communication	• All risk assessment findings and safe work procedures must be communicated to the work personnel.

CASE 22

WORKER IS CRUSHED BY TOPPLING STEEL BEAMS

Agent/Process

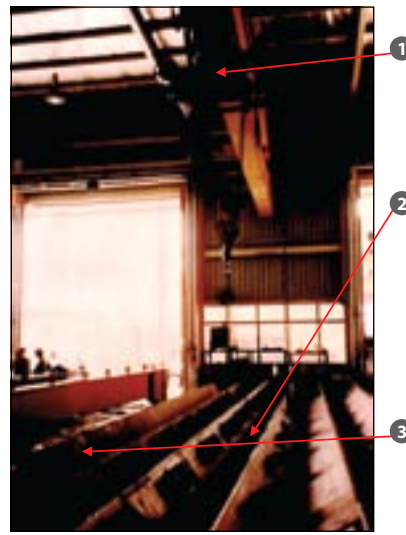
Painting of steel beams.

Synopsis of Accident

A worker moved on to the next beam upon completing the painting of one steel beam. As this steel beam was placed too close to other steel beams, he operated an overhead crane at the workshop to shift it up to make room for the paint work. When he was pressing the control button to the "UP" position, the hook of the crane got entangled with the steel beam next to him. The steel beam then toppled, hitting the adjacent steel beams which fell like dominoes. As a result, a co-worker was crushed by the toppled steel beams.

Observations and Findings

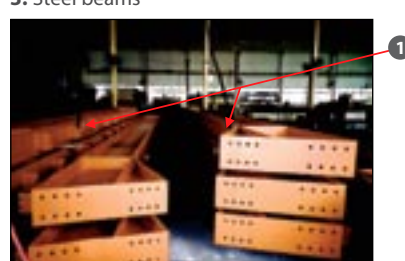
- The steel beams were placed with the narrow sides resting on the ground and were not supported for stability.
- The steel beams should be placed securely in place with the use of proper racks to prevent any toppling or accidental displacement.
- There was likely no proper procedure for rigging and lifting the steel beams.



1. Overhead crane

2. Deceased was found here

3. Steel beams



1. Steel beams

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Work Planning	• Steel beams should be placed securely using proper racks to prevent any toppling or accidental displacement.
Training and Awareness	• All relevant workers must be briefed on and understand the hazards and risks involved and the contents of safe work procedures. • All relevant workers should be trained on how to operate an overhead crane.
Coordination and Communication	• Ensure all co-workers are cleared from the work area before performing lifting operation with the overhead crane.
Others (Process design, etc.)	• All materials and equipment must be stored and stacked in a safe and secure manner.

CASE 23

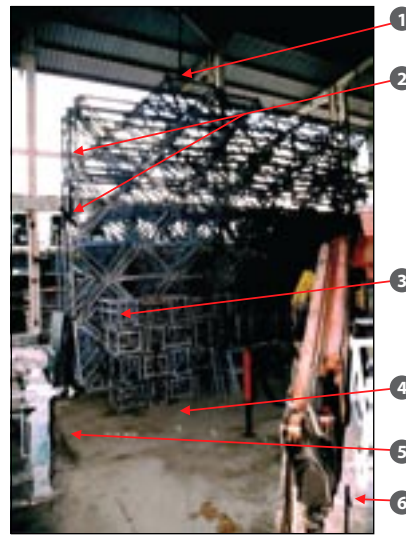
WORKER FALLS FROM A STACK OF PLATFORM BEAM TRUSSES

Agent/Process

Stacking of platform beam trusses.

Description of Accident

Three workers, S, M and K, were stacking platform beam trusses in the factory with the aid of a lorry crane operated by a crane operator. The existing stack of beams was five levels high. K rigged each beam with a chain sling and operated the crane to lift it onto the stack. S and M were stationed on the stack to assist the operation. After the crane had just lifted a beam and placed it near one end of the stack at about the seventh level, S and M started to tie the beam with galvanized wires. S was then on top of the seventh level and M was on top of the sixth level. Suddenly, the beams at the area where they were working slid downwards. M fell about 5.3m and landed on the floor. S fell about 6m and landed on the floor. At the same time, a beam dropped and hit S on the head. M was injured but discharged subsequently. S passed away in hospital on the same day.



1. The ninth level of the stack of beams was not fully stacked

2. The beams at the end of the stack were stacked upright

3. The stack of masts in front of the stack of beams

4. A fallen beam landed here and hit the head of S

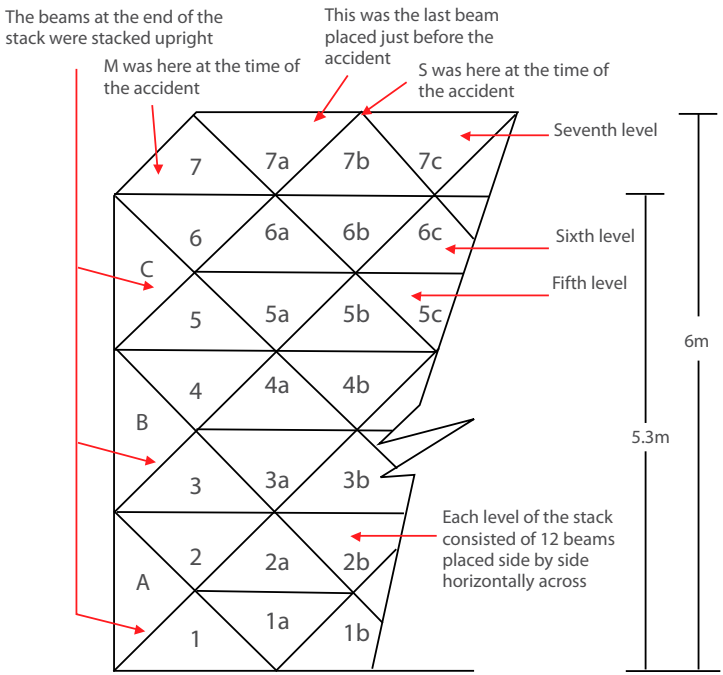
5. M landed here

6. Lorry Crane

Observations and Findings

- On the day of the accident, the occupier did not appoint a qualified lifting supervisor to supervise the lifting of the beams for stacking.
- Prior to the accident, the company did not have a safe work procedure for the stacking of beams.
- There was no supporting structure to ensure the stability of the stack.
- Some of the beams might not be sufficiently and securely bound together with galvanized wires.

Sketch Shows the Front View (Partially) of the Stack of Beams which was Stacked to 7 Levels High at the Time of the Accident



Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented e.g. working at height and stacking of materials.
Equipment and Tools	• Binding materials and supporting structures used should be adequately strong to hold the stacks of beams in a stable manner.
Training and Awareness	• A qualified lifting supervisor should be appointed for all lifting operations.
Coordination and Communication	• Lifting processes must be supervised by a qualified Lifting Supervisor, or in his absence, must adhere to a set of lifting procedures established by him and be communicated to all affected personnel.
Personal Protective Equipment	• Fall arrest devices such as safety harnesses with proper anchorage points should be provided for personnel that are working at height.

OTHER CASES

CASE 24

WORKER FALLS FROM A STEPLADDER

Agent/Process

Retrieving materials from a material rack.

Description of Accident

A worker was cleaning an electrostatic powder coating machine when a co-worker informed him that he was going up to the material rack to retrieve some materials. The co-worker used a stepladder to go up to the fifth shelf of the material rack. The worker continued to clean the powder coating machine. A while later, the worker suddenly heard a sound coming from the material rack. He turned and saw the co-worker lying on the floor next to the material rack. On checking, he found the co-worker bleeding from his nose. The co-worker was sent to hospital and passed away two days later.

Observations and Findings

- The fifth shelf of the material rack was about 2.64m from the floor.
- The stepladder was about 2.15m tall, 51cm wide and had no guardrail on its sides.
- It was most probable that the co-worker fell about 2.64m to the ground from the fifth shelf of the material rack.

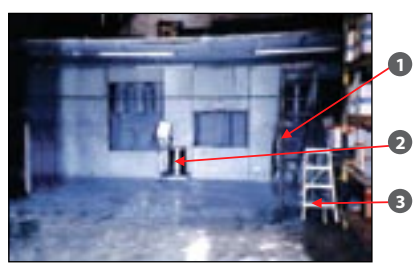
1. The shelf above the material rack

2. The fifth shelf

3. Carton box containing epoxy powder was placed here

4. The stepladder. The co-worker placed it here to go up to the fifth shelf of the material rack

5. The co-worker was found lying here after the accident



1. The stepladder

2. The electrostatic powder coating machine

3. The 'A' frame ladder

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented, i.e. Procedure for Safe Use of Stepladders.
Equipment and Tools	• Proper stepladder with guardrails should be used.
Training and Awareness	• All relevant workers must be briefed on the hazards and risks involved in the use of a stepladder and the contents of Procedure for Safe Use of Stepladders.
Personal Protective Equipment	• A proper safety belt or fall arrest device should be provided for all works that are carried out above 2m.

CASE 25

WORKER KILLED BY A RUPTURED PRESSURE RECEIVER

Agent/Process

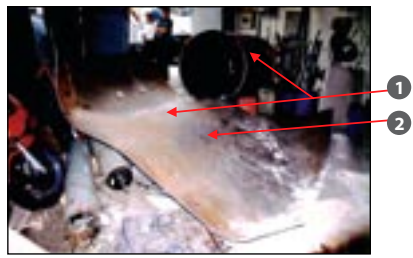
Testing of pressure receiver.

Synopsis of Accident

A worker came back to his workshop after breakfast and saw his co-worker filling a pressure receiver with nitrogen gas from a cylinder. The worker asked his co-worker if there was any leak and whether he needed any help. The co-worker replied that there was no leak and he could handle the pressure test himself. The worker went to the back of the workshop to carry on with some welding work. Moments later, he felt a strong gush of wind from the front of the workshop and the workshop blacked out. When he rushed to the front, he saw that the pressure receiver had ruptured and the workshop was in a mess. The co-worker was killed instantly in the accident.

Observations and Findings

- The refrigeration plant pressure receiver that had ruptured was about 330cm long and about 93cm in diameter. The shell was made up of two 9mm-thick steel plates welded together. After the accident, one of the steel plates of the shell had opened up completely and the 12mm thick dish-end that was joined to it was



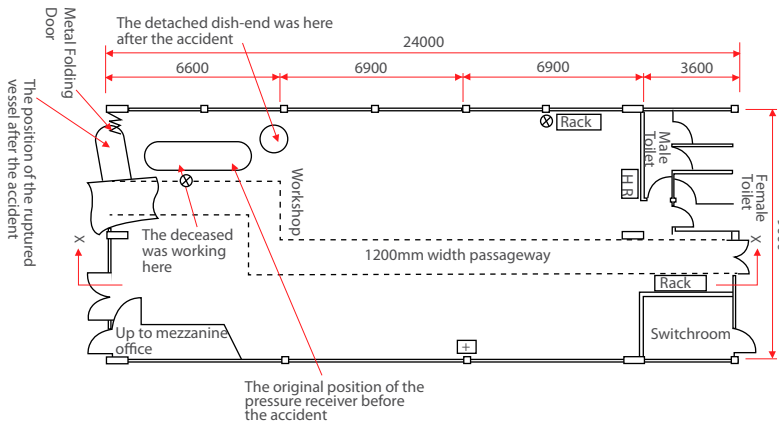
1. Two 9-mm steel plates formed the vessel shell

2. One of the steel plates had 'opened' up after the accident

completely detached and found a distance away.

- The factory owner revealed that the pressure receiver was operated at pressures up to 15 bars. There was no design calculation.
- The workers had fabricated the vessel based on a schematic drawing and a Bill of Materials.
- Examination of the weld seam of the damaged pressure receiver revealed that there was lack of penetration and lack of fusion of the welds into the parent metal.
- Investigations revealed that there was no welding procedure specification or procedure qualification record for the welding of the pressure receiver.
- The workers had not undertaken any welding competency test.
- There was no non-destructive test or examination conducted on the pressure receiver to check on the quality and the integrity of the weldments before the pressure test was carried out.
- There were no safety precautions or measures taken in conducting the pneumatic pressure test.

Plan view of the workshop



Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• The pressure receiver should have been designed and fabricated by qualified and competent persons and examined and approved by an Authorised Examiner.
Training and Awareness	• "Skilled workmen" such as welders must undergo the relevant training and certifications.
Others (Process design, etc.)	• Hazardous tasks, like pressure testing, should be carried out by trained personnel, in accordance with specified standards and safe work methods and within proper test cells.

CASE 26

WORKER GETS ELECTROCUTED WHILE REMOVING AN EXTENSION CORD

Agent/Process

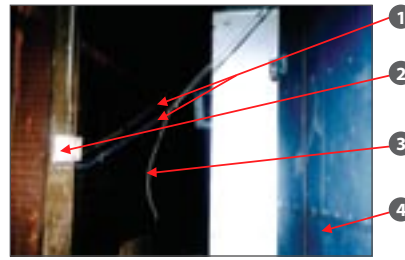
Handling electrical connections.

Description of Accident

Some workers were preparing to shift an aluminium container to a new premise. One of the workers went to the back of the aluminium container to remove the extension cable from a double 3-pin electrical socket outlet of 230 volts. The extension cable was connected to a fluorescent light and a refrigerator inside the container. About 10 minutes later, his co-worker realised that the worker who went to the back of the container had not returned. The co-worker then went to the back of the container to look for him and found him lying motionless on the floor. The worker was pronounced dead by paramedics upon their arrival at the scene. According to the autopsy report, there was an electric mark over the palmar surface of the worker's right hand thumb. The cause of death was stated as electrocution.

Observations and Findings

- The double 3-pin electrical socket outlet of 230 volts was mounted onto a metal structure of the workshop behind the container. The 230 volts electrical outlet was connected to a 20 ampere re-



1. Two electrical wires of the fluorescent light that was directly connected to the electrical socket outlet

2. The electrical socket outlet of 230 volts

3. Disconnected grey wire

4. Aluminium container

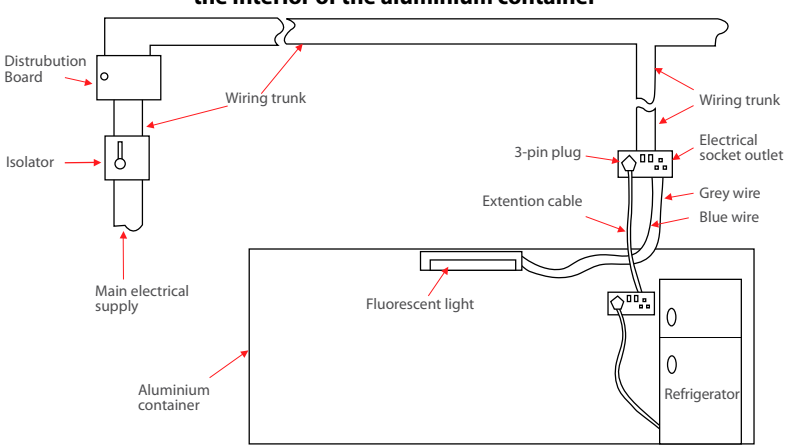
wireable fuse at the distribution board. The distribution board was connected to a 60 ampere isolator. The fuse wire of the re-wireable fuse would take quite a while to blow when there is an over current. Investigations showed that the fuse wire connected to the electrical socket outlet did not blow to cut off the electric supply. No earth leakage current board was installed.

- It was claimed that the worker who was electrocuted had installed the fluorescent light and the wiring connection inside the container. Investigations revealed that the fluorescent light was connected directly to the electrical socket outlet of 230 volts using two electrical wires, i.e. blue wire and grey wire. Such electrical installation was not done in accordance with accepted principles of sound and safe practice. The deceased was not a licensed electrical worker.

- Investigations revealed that the grey wire of the fluorescent light was disconnected from the electrical socket outlet and the blue wire was still connected directly to the electrical socket outlet of 230 volts. The insulation of the blue wire was damaged and the wire inside it was exposed.

- It is probable that the worker who was electrocuted was trying to pull out the wires and hence damaged the wires. He then accidentally came into contact with the exposed wire and received an electric shock.

Sketch of the electrical wiring layout and the interior of the aluminium container



Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• Electrical equipment should be fitted with earth leakage circuit breakers.
Training and Awareness	• Electrical installations should only be undertaken by a trained and qualified electrician or a licensed electrical worker.
Others (Process design, etc)	• Electrical fittings and connections should be inspected for damage or defects before use.

CASE 27

WORKER CRUSHED BY A TOPPLING STIFFENER PLATE

Agent/Process

Fabrication of stiffener structures of a crane column.

Description of Accident

A worker was tasked by his supervisor to fabricate a stiffener structure of a crane column. The stiffener structure comprised two upright stiffeners measuring about 6m x 1m x 40mm and weighed about 1.5 ton. The stiffeners were hoisted to position on a working base by means of an overhead travelling crane. The worker was working in between the stiffeners. The overhead crane was released after the worker had tack-welded brackets to hold the stiffeners on the working base. Suddenly, one of the two upright stiffeners toppled onto his back. The worker managed to free himself from the fallen stiffener and was sent to hospital where he succumbed to his injuries on the same day.

Observations and Findings

- The supervisor claimed that the worker was instructed by him to fabricate the stiffener structures. However, he did not instruct the worker on how or what methods to adopt to fabricate the stiffener structures. There were no safe work procedures or work methods instituted for the fabrication of the stiffener structures by the occupier prior to the accident.

- Three brackets were found tack-welded to the working base to hold the stiffener that toppled on the worker. Only two of the brackets were tack-welded to the stiffener and one of the brackets was found to have failed after the accident.

- A 3 ton lever block was found near the site of the accident. It was claimed that the worker was squatting between the two upright stiffeners prior to the accident. The worker was operating the lever block to hook across the two stiffeners to align the second stiffener.

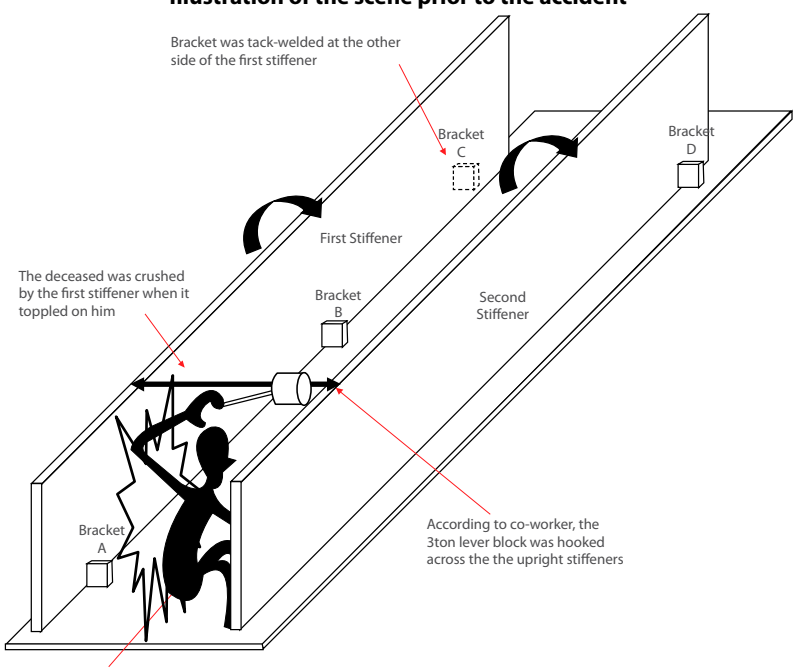
- Investigations revealed that the use of the lever block to align the second stiffener could have introduced a lateral force to the two stiffeners, resulting in the welds on the brackets failing and thus causing the stiffener to topple on the worker.

- The accident could have been prevented if adequate supports were provided to support the stiffeners, even if lateral forces were introduced during the fabrication of the stiffener structure.

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• Supports of adequate strength should be provided for stiffeners left in upright positions, especially where lateral forces would be introduced.

Illustration of the scene prior to the accident



CASE 28

WORKER IS PINNED UNDER A TOPPLED I-BEAM

Agent/Process

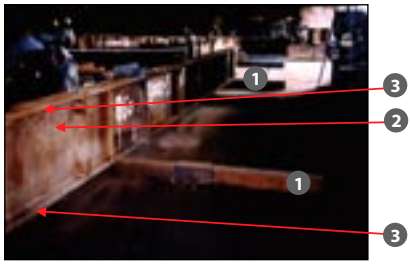
Fabrication (welding) of a working deck.

Description of Accident

A worker was fabricating a working deck that would be used as working platforms for road construction work. The working deck was fabricated by welding I-beams, of the same cross-sectional dimensions but differing lengths, together so as to obtain the desired length. The worker was assigned to weld two pieces of I-beams, one was about 11.5m long and the other was 3.5m long. Prior to the accident, the longer I-beam was resting in a vertical position. The longer I-beam suddenly toppled and killed the worker.

Observations and Findings

- Investigations showed that there was no securing mechanism put in place to prevent the I-beams from toppling. There was no written safe work procedure instituted for such welding jobs.



1. Supporting I-beams

2. Web of the I-beam

3. Flange of the I-beam

- The I-beam involved in the accident was found to be unstable because of its high centre of gravity and the end surface resting on the ground was rusty and not flat.

Photograph showing the position of the deceased during the accident (simulated by the co-worker)

Lesson Learnt

Risk Assessment	• Risk assessments must be carried out prior to work operations.
Safe Work Procedure	• Safe work procedures must be developed and implemented.
Equipment and Tools	• Supports of adequate strength should be provided for stiffeners left in upright positions, especially where lateral forces would be introduced.
Training and Awareness	• All personnel should be trained and cautioned not to place or store anything that is not stable or secured, which may result in injury when they collapse or fall.
Others (Process design, etc)	• The I-beam should as far as possible be placed horizontally at ground level to be processed. • When there is any material or structure that needs to be left in a manner where its stability may be compromised, appropriate securing devices should be used to ensure that they do not collapse or fall.

USEFUL REFERENCES

Singapore Standards and Codes of Practice

The following is a list of some Singapore Standards and Codes of Practice related to Workplace Safety and Health, 23 of which are Approved Codes of Practice (ACOPs). These ACOPs are marked out with a '*'. ACOPs are intended to be used as a yardstick to assess whether reasonable practical measures have been taken in regards to the upkeep of safety and health standards at the workplace. A notice of the issue of the ACOPs has been published in the Government Gazette.

*CP 14 : 1996 Code of Practice for Scaffolds
*CP 20 : 1999 Code of Practice for Suspended Scaffolds
*CP 23 : 2000 Code of Practice for Formwork
*CP 27 : 1999 Factory Layout – Safety, Health and Welfare Considerations
CP 28 : 1984 The Construction, Care and Safe Use of Shears
CP 35 : 1996 The Selection, Care and Maintenance of Steel Wire Ropes for Hoisting
*CP 37 : 2000 The Safe Use of Mobile Cranes
CP 42 : 1988 Guarding and Safe Use of Woodworking Machinery
CP 53 : 1999 Safe Use of Industrial Robots
*CP 62 : 1995 Safe Use of Tower Cranes
*CP 63 : 1996 (2005) Lifting of Persons in Work Platforms Suspended from Cranes
*CP 74 : 1998 Selection, Use and Maintenance of Respiratory Protective Devices
*CP 76 : 1999 Selection, Use, Care and Maintenance of Hearing Protectors
*CP 79 : 1999 Safety Management System for Construction Worksites
*CP 84 : 2000 Entry into and Safe Working in Confined Spaces
CP 86 : 2000 Safe Use of Lasers in the Building and Construction Industry
CP 87 : 2001 Illumination in Industrial Premises
*CP 88 : Part 1: 2001 Code of Practice for Temporary Electrical Installations Part 1: Construction and Building Sites
*CP 88 : Part 3: 2004 Code of Practice for Temporary Electrical Installations Part 3: Shipbuilding and Ship-Repairing Yards
*CP 91 : 2001 Lockout Procedures
CP 92 : 2002 Manual Handling
CP 98 : 2003 Preparation and Use of Material Safety Data Sheets (MSDS)
CP 99 : 2003 Industrial Noise Control
CP 100 : 2004 Hazardous Waste Management

*CP 101 : 2004 Power Counterbalance Forklift
CP 537 : 2008 Safe Use of Machinery

*SS 98 : 2005 Industrial Safety Helmets
SS 297 : 1996 Steel Wire Ropes for Hoisting
SS 343-1 : 2001 Lifting Gear
SS 343-2 : 1989 Hooks
SS 343-3 : 1990 Shackles
SS 402-1 : 1997 Industrial Safety Belts and Harnesses – General Requirements
SS 402-2 :1997 Industrial Safety Belts and Harnesses – Permanent Anchors Requirements
SS EN 420 : 2004 Protective Gloves – General Requirements and Test Methods
*SS 473-1 : 1999 Personal Eye Protectors – General Requirements
*SS 473-2 : 1999 Personal Eye Protectors – Selection, Use and Maintenance
SS 485 : 2001 Slip Resistance Classification of Public Pedestrian Surface Materials
SS 497 : 2002 Design, Safe Use and Maintenance of Overhead Traveling Cranes
SS 506-1 : Occupational Safety and Health (OSH) Management System-Specification
SS 506-2 : General Guidelines for the Implementation of OSH Management System
*SS 508-1 : 2004 Graphical Symbols – Safety Colours and Safety Signs - Design Principles for Safety Signs in Workplaces and Public Areas
SS 508-2 : Graphical Symbols – Safety Colours and Safety Signs – Design Principles for Product Safety Labels
*SS 508-3 : 2004 Graphical Symbols – Safety Colours and Safety Signs - Safety Signs Used in Workplaces and Public Areas
SS 508-4 : Graphical Symbols – Safety Colours and Safety Signs – Design Principles for Graphical Symbols for Use in Safety Signs
*SS 510 : 2005 Safety in Welding and Cutting (and other Operations Involving the Use of Heat)
*SS 513-1 : 2005 Personal Protective Equipment – Safety Footwear
*SS 513-2 : 2005 Personal Protective Equipment – Test Methods for Footwear
SS 514 : 2005 Office Ergonomics
SS 528-1 : 2006 Full-body Harnesses
SS 528-2 : 2006 Lanyards and Energy Absorbers
SS 528-3 : 2006 Self-retracting Lifelines
SS 528-4 : 2006 Vertical Rails and Vertical Lifelines Incorporating a Sliding-type Fall Arrester

SS 528-5 : 2006 Connectors with Self-closing and Self-locking Gates
SS 528-6 : 2006 System Performance Tests

New Code on Protection of Persons Working in Trenches, Pits and other Excavated Areas

The above list is accurate as of 31 December 2008. All the Code of Practices and Singapore Standards listed are published by SPRING Singapore and can be purchased at **www.singaporestandardseshop.sg.** You can also consult the same website for more updated information on what is available.

Publications

More can be found on the WSH Council Website (www.wshc.gov.sg) under "Publications".

Forklift

- WSH Alert – Safe Use of Forklift
- Forklift Safety Checklist
- Forklift Technical Advisory
- More about Forklift

Working at Height

- Technical Advisory

Safe Use of Mobile Elevated Work Platform (MEWP)

- Fact Sheet

Flammable Hazardous Substances

- Technical Advisory
- Compliance Assistance Checklist
- Presentation Slides

Lifting Equipment

- Technical Advisory
- More about Lifting Equipment

Safe Use of Machinery

- Technical Advisory

Power Presses

- Technical Advisory (July)

Work in Noisy Environment

- Technical Advisory
- More about Work in Noisy Environment

Work at Height

- Compliance Assistance Checklist
- Self-Assessment Toolkit
- Technical Advisory
- More about Work at Height

Training Materials

To raise awareness of hazards specific to the metalworking industry and to train staff accordingly, the former WSH Metalworking Advisory Committee has developed a series of WSH training materials. Each of the PowerPoint materials are accompanied by trainers' notes to facilitate the training process. Companies can download the materials for free and utilise them as safety awareness and training materials.

Manual Handling of Materials

- Manual Handling of Materials
- Session Plan for Manual Handling for Materials

Noise and Hearing Conservation

- Noise and Hearing Conservation
- Session Plan for Noise and Hearing Conservation

Risk Management for Metalworking Industry

- Risk Management for Metalworking Industry
- Session Plan for Risk Management

Safe Operation of Forklifts

- Safe Operation of Forklifts
- Session Plan for Safe Operation of Forklift

Safe Operation of Machines

- Safe Operation of Machines
- Session Plan for Safe Operation of Machines

Useful Links

Workplace Safety and Health Council
www.wshc.gov.sg

Ministry of Manpower
www.mom.gov.sg

Singapore Institution of Safety Officers
www.siso.org.sg

Singapore Standards eShop
www.singaporestandardseshop.sg

Health and Safety Executive – Metalworking
www.hse.gov.uk/metalworking

National Institute for Metalworking Skills, Inc.
http://www.nims-skills.org/home

U.S. Department of Labor – Occupational Safety and Health Administration - Machineguarding E-Tools
http://www.osha.gov/SLTC/etools/machineguarding/additional_references.html

Chemical and Other Safety Information, The Physical and Theoretical Chemistry Laboratory, Oxford University
http://msds.chem.ox.ac.uk/

Published in June 2009 by the Workplace Safety and Health Council in collaboration with the Ministry of Manpower.