EFG TRAINING SERVICES
PRIVATE LTD

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SSIC – Hot-work Trade

Learner Guide

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Learning Objective 1

Introduction to Shipyard Safety Instruction Course for Workers (Hot-Work Trade)

Course Objective:

The aim of the course is to provide Learners with the knowledge and skill in performing hot work activities, so that work can be carried out safely.

At the end of the course, the Learner shall be able to explain:

- Introduction to Shipyard Safety Instruction Course for Workers (Hot-Work Trade)
- Know the different types of Hot-work
- Know characteristics of flammable substances
- Understand how vapours/ gases can accumulate in confined spaces
- Understand how fires/ explosions are caused
- Understand case studies on two shipyard fire and explosion accidents
- Know and take safety measures for preventing fire/ explosions

Training format:

Day/ Evening Class

Assessment:

1. Learners need to take assessment at the end of course
2. Written Test (WT)

Training Methodologies

1. Learners are required to take part in group discussion and presentation
2. Training methodologies consists of :

- Lecture with Q&A and sharing of workplace practices
- Case studies
- Group discussion
- Videos and other e-resources and instructional media

Attendance Requirement: Min 100%

Certification:

Upon successful completion of the course of training and pass the assessments, learners will be awarded the certificate of “SSIC Hotwork” Certificate

Duty of Care

- Above all, we are dedicated to ensuring your Health, Safety and Wellbeing.
- Risk management has been applied to all general and practical activities.
- All staff are First Aid & Emergency Trained.
- All Equipment is fully inspected.
- All activities are voluntary. If you feel unwell, unfit, or unsure just tell us.
- If any accident occurs, tell us.
- No tolerance policy for intentionally endangering the health or safety of other students.

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Learning Objective 2

Types of hotwork

Learning Objective

At the end of the Topic, learner is able to identify and explain:

- Types of hotwork

Definition of hotwork

Hot work means, any work involving the use or generation of heat or the production of sparks. Any work which generates heat, flame or sparks is known as hot work.

Common types of Hot Work found in shipyards:

Welding
Oxy-fuel cutting/welding
Riveting
Drilling
Grinding

Welding

Grinding

Gouging

Oxy-Fuel Cutting/Welding

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Learning Objective 3

Characteristics of Flammable Substances

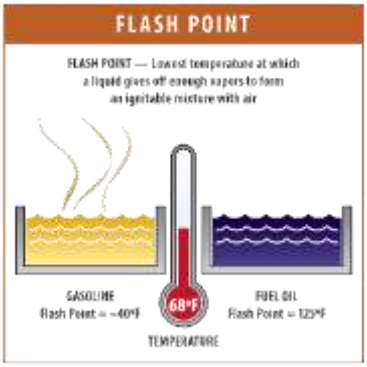
Learning Objective

At the end of the Topic, learner is able to identify characteristics of flammable substances

(i) Volatility of a liquid
(ii) Flash point of a liquid
(iii) Flammable range/Lower explosive limit/Upper explosive limit
(iv) Densities of vapours and gases

What is Flashpoint?
Defines as the minimum temperature required for the flammable liquid to produce sufficient vapour to form a flammable mixture;

With air and will produce a fire when an ignition source is applied at the surface of the liquid.



What is Volatility?
Defined as the ability of a liquid to vaporize.
The volatility of a liquid will increase as heat is applied to the liquid.

Physical Characteristics of Vapours and Gases

- Assume the volume and shape of their containers.
- Are the most compressible state of matter.
- Will mix evenly and completely when in confined.
- Have much lower densities than liquids and solids.

What is Density?

May be defined as the mass of the material per unit volume.
It is usually measured in kilograms per cubic meter.

Gas
It is a substance whose boiling point is below normal ambient temperature at atmospheric pressure.

Vapour
It is gaseous state of a substance which normally exists as a solid or liquid at normal condition.

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Units of Measurement of Gases/Vapours:

Due to significance of the result, the concentrations of the components of the confined space atmosphere, including natural and contaminants, are expressed in variety of units- (%), ppm, mg/m,% of LEL.

These units are inter-related and can be converted from one another.

% by Volume
It is the volume of gas to the total volume occupied by all the components of a mixture of gases present in the space at the same pressure and temperature. The ratio is expressed as a percentage (out of 100).

This is often used where the volume has a greater significance, for example oxygen content, for explosive gas mixtures.

Mass Concentration (mg/m)
This unit is commonly used in medical and metallurgical industries in situation where the chemical is either in liquid or solid state at room temperature. To convert mg/m to percent or ppm, the ideal gas law must be used.

The Ideal gas law states that one gram mole of molecules will occupy 24.5 litres of volume at 25^0 c and at 760 mm of mercury.If the mixture is not under these condition then the correct volume must be evaluated and used.

Flammable Limits and Range
Flammable limits indicate the minimum and maximum concentrations in the air of flammable vapour at which ignition can occur.

There are two types of flammable limits, i.e. the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL).

Flammable range is the range of flammable vapour and air mixture between the LEL and the UEL.

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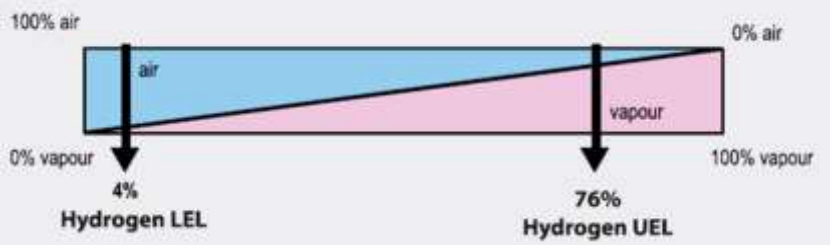
Lower Explosive Limit (LEL)
The lowest concentration (percentage) of a gas or a vapour in air capable of producing a flash of fire in presence of an ignition source.

Upper Explosive Limit (UEL)
Highest concentration (percentage) of a gas or a vapour in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat). Concentrations higher than UFL or UEL are "too rich" to burn.



Flammable Limits of Common Compounds

Concentrations below the Lower Explosive Limit (LEL), are referred to as 'too lean' to burn and concentrations above the Upper Explosive Limit are referred to as 'too rich' to burn.

Example of LEL and UEL

Compound	LEL (%)	UEL (%)
Acetylene	**2.4**	**80**
Butane	**1.5**	**9**
Kerosene	**1.6**	**6**
Crude Oil	**1.0**	**10**

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Learning Objective 4

Accumulation of Vapours/Gases in Confined Spaces

Learning Objective
At the end of the Topic, learner is able to explain how accumulation of Vapours/Gases in Confined Spaces

Liberation & Accumulation of Flammable Gases & Vapours
Flammable gas & vapours pose a serious risk of fire and explosion in shipyard
Various gases are used in ship repair activities and some of these are extremely flammable.

Some times liquid fuel gives off vapour which is flammable and could cause fire and explosion.

The following types of work can cause the accumulation of vapours or gases in confined spaces:Crude oil in the tank gives off vapour

- Vent line of ship fuel tank
- Engine room bilge oil
- Paint mist during spray painting
- Spray Painting / Sludge Removal / Chemical Cleaning
- Chemical mist during chemical cleaning
- Leakage of fuel gases - LPG, acetylene
- Tank cleaning to remove sludges
- Dismantling of valves and pipelines
- Bunkering operation (transferring of oil)
- Painting in confined spaces and hull of ships

Some gas are lighter than air like acetylene. If it is leaked in confined space, it will be accumulated and cause explosion with the contact of ignition source.

Some gases are heavier that air like paint mist, crude oil vapour LPG which could accumulate at the bottom level of any confined locations and subsequently could cause explosion with the contact of ignition source.

Safe Work Practices for Hot-work in Confined Space

- Confined spaces must be certified safe for entry and entry permit issued by the confined space safety assessor.
- There must be adequate means of access/egress to and from the confined space, such as ladders.
- Provide adequate forced ventilation to ensure adequate breathing air and to remove contaminants during hot-work.
- Do not use oxygen to ventilate the confined space.
- Check to Ensure:
  - The hot work area is clearly identified and marked;
  - The hot-work area is clear of any flammable material.

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Safe Work Practices for Hot-work in Confined Space

- Do not place any oxy-fuel gas cylinders in the confined space.
- Fire watchman must be present with the necessary fire fighting equipment during the hot-work.
- Remove gas hoses from the confined spaces and place them neatly on the deck at the end of the day.
- At least one worker from a group of workers must be equipped with a portable gas monitoring meter.

Learning Objective 5

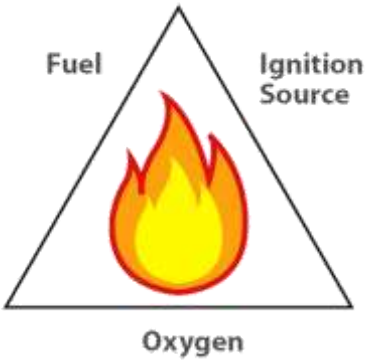
Causes of Fire and Explosion

Learning Objective
At the end of the Topic, learner is able to explain causes of fire and explosion:
- Chemistry of fire - Fire triangle
- Oxygen enrichment

How Does Fire Occur?
Three elements, i.e. Fuel, oxygen and an ignition source such as heat, are needed to be present in the correct concentration for a fire or an explosion to occur.

These three elements can be represented in a FIRE triangle.

If any one of these elements is not present (or is not present in a proper proportion) the fire or explosion will not occur.



The Fire Triangle

Any combustible material –
Solid, Liquid or Gas.

Sufficient oxygen must be present in the atmosphere surrounding the fuel for fire to burn.

Ignition source – such as hot work.

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Oxygen Enrichment

An oxygen enriched atmosphere contains greater than 23.5% oxygen.
An oxygen enriched atmosphere will cause flammable materials to burn violently in the presence of an ignition source.

What can cause Oxygen Enriched Atmosphere?

Leak of oxygen hoses in confined spaces can cause the oxygen level in the confined space to increase and thus becomes oxygen enriched. Never use pure oxygen to ventilate the confined space.

Types of Fire
There are three basic types of fires commonly found at the workplace:

Class A
Common ordinary materials such as wood, paper, plastic and clothe etc

Class B
Refers to fire involving fuels such as oil and chemicals (flammable liquids) or flammable gases such as LP, Acetylene, etc.

Class C
Refers to electrical fire

Cause of fire and explosion
Common Sources of Fuel

- Non-gas freed tanks which had contained petroleum products.
- Vapours from sludge removal/tank cleaning.
- Gas hose leaks such as acetylene, LPG.
- Vapours from flammable solvents.
- Vapours from spray painting.
- Bunkering operations.

Places Where Fuel Can Be Found
Fuel can be found almost anywhere on board a ship.

Some common places are listed below.

- Engine room
- Pump room
- Cargo tanks, including fuel oil tanks
- Pipe lines
- Double bottom tanks
- Heating coils
- Crew cabins
- Wheel house
- Battery room
- Chain locker

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- Forecastle store

Common Ignition Sources

- Hot-work;
- Lighted cigarette butt;
- Static electricity;
- Lighted match, spark igniter;
- Non-flameproof lighting
- Welding
- Cutting
- Grinding

Grinding

Gas Cutting

Non-Flameproof Lighting

Good practices to prevent fire and explosion

Good Practices

- Cylinders are properly stored in a secured place with fall protection and warning signs.
- Acetylene and Oxygen cylinders are kept separately

Bad Practices

- Cylinders are stored in an unsecured place without any fall protection or warning signs.
- Acetylene and Oxygen cylinders are kept close to each other.
- Damaged hoses are used in the cylinders.

As Stipulated by the WSH (S&SR) Regulations 2008

- For Oxygen and acetylene tank, the following must be installed:
- Non-return valve between gas torch inlet and gas hose of every oxy-fuel equipment.
- Flash-back arrestor at every fuel gas and oxygen outlet and pressure regulator outlet.
- Anti-leakage device – Confined space oxygen and fuel gas line.

During break :

- Supply valve of gas cylinder and manifold shall be closed.
- Gas torch, manifold and hoses shall be taken to the weather deck.
- If it is not practicable, ventilation shall be provided for the work area
- Only competent person shall perform inspection and maintain register.

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Lesson Objective 6

Case Studies on Shipyard Fire and Explosion Accidents

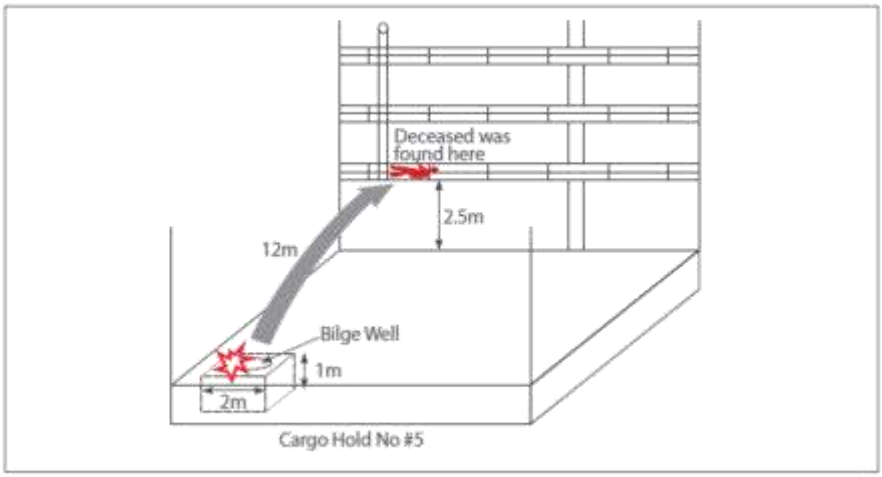
At the end of the session, learners should be able to identify cause of accident and recommend corrective and preventive action

Case Study 1 – Worker Killed In Explosion During Repair Works

Brief Description of Accident

The deceased and his co-worker were tasked to cut and remove the bolts and nuts of a check valve within a bilge well (2m length x 1m breadth x 1m height) of the cargo hold. The deceased carried out the cutting work while his co-worker was acting as the fire watchman.

After removing two sets of bolts and nuts, the deceased stopped work to take a break. During his break, gas leaked out from the LPG supply he had been using and accumulated within the bilge well. Upon resuming work, the deceased lit the oxygen- LPG torch near the manhole opening of the bilge well, causing an explosion and a fire. The blast threw the deceased 12m away at an elevated height of 2.5m from the bilge well.



Showing where the deceased was found.

Findings
Observations and Findings
Man

- The co-worker was not trained to operate the gas meter and therefore did not conduct a gas check before resuming work.
- The project manager and the safety engineer failed to recognise that the bilge well is categorised as a confined space.

Method

- Measures for safe work in confined spaces were not implemented.
- lPG should not be used for any hot work carried out below deck.

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Source : WSHC Marine Accident Case Study

Machine

- It was found that it was difficult to shut off the LPG supply completely. There was also a small cut on the LPG hose; however, the amount of LPG vapour released from this cut would not have been enough to create an explosion. As a result, it was inferred that the explosive mix of gases had probably accumulated during break time due to leakage from the deceased's oxygen-LPG torch.

Case Study 2 – Mt Indiana

Brief Description of Accident

DATE : 27/11/92
At about 2.20pm, a fire broke out in the no. 3 center (3C) cargo tank of the tanker INDIANA. which killed 8 workers and injured 14 others.

What Happened?

The cargo tank contained crude oil as the last cargo. Prior to entering the shipyard, the cargo tank was cleaned of the sludge. At the shipyard, hot work permit was issued to cut the bulkhead between no. 2C and 3C tanks.

To facilitate the removal of the transverse bulkhead steel plates, an access opening had to be cut on the deck.

A worker started to cut the deck access with a cutting torch and as he was cutting the deck plate, sparks were falling into the tank and onto the sludge.

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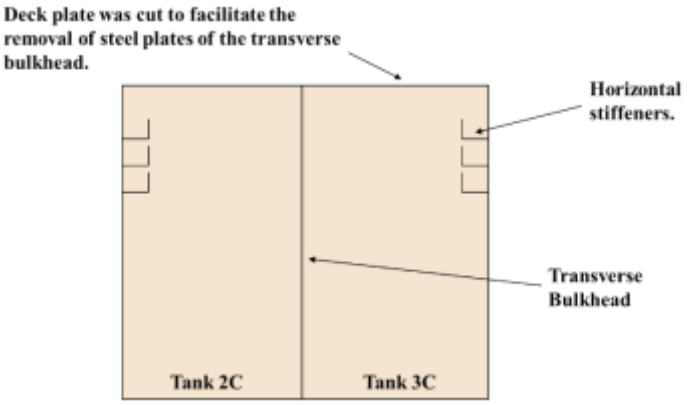


The parks from the oxy-fuel gas cutting ignited the sludge on the horizontal stiffeners.

Findings

Sludge on stiffeners not properly removed. Molten slag fell onto the sludge and caused vapours to be ignited.

Case Study 3 – Workers Suffocated To Death Due To Fire Caused By Hot Works

Brief Description of Accident

In the void space of the vessel, workers were employed by three different companies to carry out various works. At the port and starboard side of the topside tank, some other workers were carrying out steel renewal work.

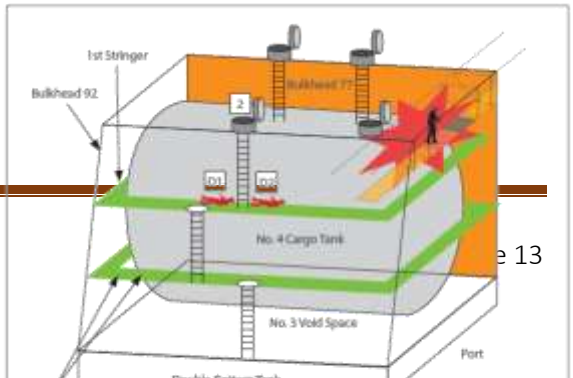
While carrying out steel renewal works, sparks from hot works ignited the exposed insulation surrounding the cargo tank, resulting in thick smoke at the port side of the void space.

Steel removal work done on top side tank.

New steel plate to be fitted to the bottom of top side tank.

What Happened

While most of the workers were evacuated immediately, two workers were later found at the access point of the



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vessel and subsequently succumbed at the hospital.

Source : WSHC Marine Accident Case Study

Observations and Findings

Man
- No fire watchmen were deployed for the intended hot works.

Method
- Insulation material in way of the hot works was not properly covered by fire cloth.

Machine
- Not Applicable

Material
- Polyurethane insulation is highly flammable but was not properly covered.

Environment
- Work space was congested and restricted.

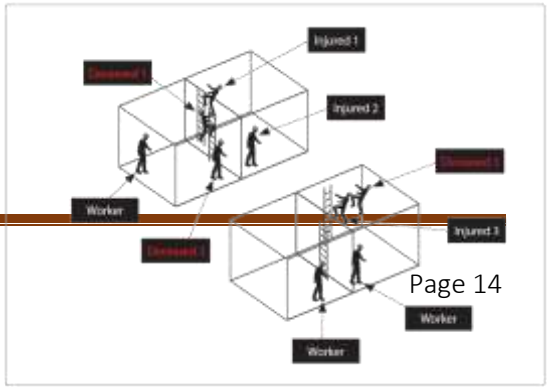
Case Study 4 - Flash Fire During Spray Painting Killed Three Workers, Injured Another Six

What Happened

On the day of the accident, permits were issued to spray paint four ballast tanks. Ventilation of the ballast tanks was arranged prior to the spray painting. During the spray painting works, portable explosion-proof handheld lamps were hung near the tank hatch openings while the painters inside the tanks used battery-operated torches. A flash fire broke out in one of the tanks leaving three workers dead due to injuries sustained in the fire and injuring another six.

Observations and Findings
Man
• The foreman did not read the permit to work, where it was indicated that the use of torch lights were forbidden during spray painting.

Method



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• Forced ventilation used to introduce atmospheric air did not adequately lower the concentration of flammable gas within the tank.

Machine
• Non-intrinsically safe torches were provided for use within a flammable environment.

Source : WSHC Marine Accident Case Study

Lesson Objective 7

Prevention of Fire and Explosion

At the end of the session, learners should be able to explain:

- Vessel safety co-ordination committee (VSCC)
- Permit-to-work systems
- Detection of combustible gases and vapours (fuel)
- Prevention of flashback in gas hoses/piping/torches
- Fire watch
- Inspection and maintenance of hot-work tools (gas torches) and other safety requirements for burning and cutting operation

Formation of Vessel Safety Coordination Committee

Vessel Safety Coordination Committee
A Vessel Safety Co-ordination Committee shall be formed to coordinate all works on board the vessel.

The Committee Shall Comprise of:
- Chairman – SRM
- Secretary – Safety Officer
- Members

Members of the VSCC shall include:
- Trade Supervisors;
- Contractor supervisors; and
- Master, owner or agent of the ship or their representatives.

The VSCC shall meet daily, including Sundays and public holidays, when any hazardous work is being carried out on the ship and at such other times the chairman of the VSCC may decide.

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Role of VSCC

- Review and discuss all matters relating to the safety and health of the persons involved in the respective works;
- Draw up a plan for the co-ordination of the works to ensure the works carried out are compatible;
- Ensure that all first-line supervisors and the master, owner or agent of the ship are informed of the plan;
- Review daily, all work in progress on the ship;
- Plan and co-ordinate the movement and storage of hazardous materials;
- Review daily, the validity of all permits;
- Monitor all hot works carried out on the ship;
- Ensure that every confined space is checked for concentrations of oxygen, dangerous gases and flammable vapours;
- Ensure that every person is provided with and uses the appropriate PPE; and
- Make arrangements and location for safety signs and permits on board the ship.

Implementation of Hot-Work Permit

Under the WSH (Shipbuilding & Ship-Repairing) Regulations 2008, the occupier of a shipyard and the master, owner or agent of ship in a harbour shall:

- Implement a permit-to-work system;
- Appoint a safety assessor;
- Ensure that no high risk work is carried out without a permit-to-work.

The occupier of a shipyard or the master, owner or agent of a ship in the harbour, shall implement a hot-work permit system.

The hot-work permit system shall provide that the hot work is carried out with due regard to the safety and health of persons carrying out the hot-work.

What is Permit-To-Work System?

The Permit-To-Work system was established as a tool to control all hazardous works carried out in the shipyard, especially on board the ship, so that these works can be carried out safely without any incident and injury to workers.

Permit to work system

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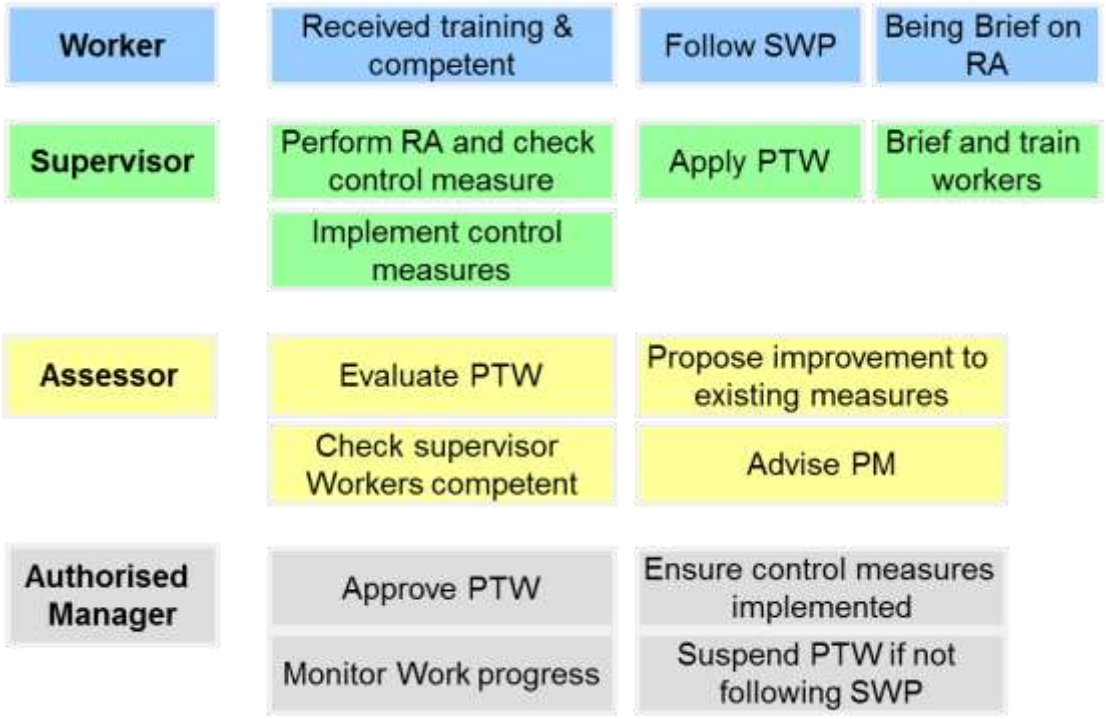

Stage 1:
Application for Hot-Work Permit

An application for a hot-work permit shall be made by the trade foreman or supervisor who is familiar:

- With the hot work schedule;
- With the nature of the hot work to be carried out;
- With the risks and hazards involved.
- Every application for a hot-work permit shall be accompanied by sketches showing the exact locations where the hot-work is to be carried out.

Stage 2:
Evaluation of Hot-Work Permit

On receipt of the hot-work permit, the safety assessor shall:

- Assess whether all reasonably practicable measures have been taken to ensure the safety and health of the persons who will be carrying out the hot work;
- Together with the trade foreman or supervisor, inspect the hot work site and its surrounding area to ensure there are no hazards present.
- The safety assessor, after his inspection of the site, shall endorse the hot-work permit pass it to the SRM for his approval.

Stage 3:
Approval and Issue of Hot-Work Permit By SRM

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Upon receipt of the application for the hot-work permit, the SRM shall be satisfied that :

- There has been a proper evaluation of the hazards and risks involved;
- No incompatible work will be carried out at the same time and in the same vicinity;
- All reasonably practicable measures will or have been taken to ensure the safety and health of the affected persons; and
- All affected persons are informed of the hazards associated with the high risk work.

The SRM shall then issue the permit-to-work by signing stage 3 of the PTW.

Stage 4:
Notification of Completion of Work

Upon completion of the work, the trade Foreman/Supervisor shall sign Stage 4 of the Hot-work permit and hand over the permit to the Safety Assessor.

Copies of Hot-Work Permit
The SRM shall retain a copy of the permit-to-work.
The trade foreman/supervisor shall display one copy of the permit-to-work at the vicinity of the work and retain another copy.

The safety assessor shall display one copy of the permit-to-work at the permit-to-work chart on the ship and retain another copy.

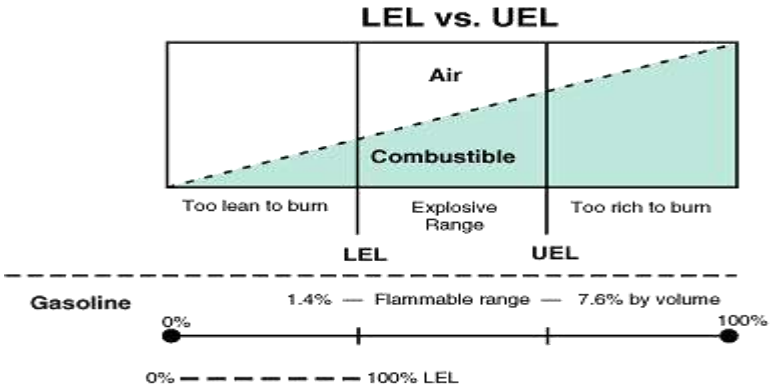
Daily Review Hot-Work Permit By SRM
The SRM shall review and assess the need to continue the hot-work on a daily basis and revoke the hot-work permit if he thinks fit to do so.

Duty To Report Incompatible Work

It shall be the duty of any person who is aware of any work being carried out which is incompatible with any hot-work being carried out, to immediately report the work to his supervisor, the Workplace Safety and Health Officer, Workplace safety and health coordinator or the SRM.

Detection of Flammable Gases/Vapours

Confined spaces must be tested by a competent person for oxygen, flammable and toxic gas content prior to entry.



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Continuous Gas Monitoring

If a group of workers are working in a confined space, one of the workers must be equipped with a portable gas monitoring meter.
If there is a sudden change in the atmosphere of the confined space, the alarm of the gas meter will sound, and all workers to evacuate immediately.

Prevention of Flashbacks in Oxy-fuel Hoses

A flashback is a reverse flow of oxygen into the fuel gas hose or fuel into the oxygen hose, producing an explosive mixture in the hose. A flashback may result in an explosion of the cylinder.

- Before lighting the cutting torch, purge the gas hoses.
- The purging will remove any potentially explosive gas mixtures that may be present in the gas hoses.
- To prevent backflow of gases, a non-return valve (check valve) must be fitted between each gas torch inlet and gas hose from the oxy-fuel equipment.
- Install flashback arrestors at the pressure regulator outlets of every gas cylinder.

Fire Prevention – Use of Fire Extinguisher

P – Pull

A – Aim

S – Squeeze

S - Sweep

Appointment of Fire Watchman

The shipyard must appoint a fire watchman for all hot works. The fire watchman must be trained in basic fire fighting and must be provided with the necessary firefighting equipment.

Duties Of Fire Watchman

The fire watchman shall:

- Keep watch over the area in which the hot-work is being carried out and the surroundings for any fire throughout the duration of the hot-work; and

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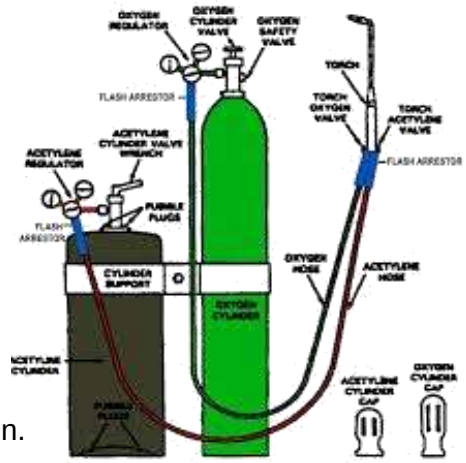
- In the event of a fire, to extinguish or control the fire if it is within his means to do so.

Inspection and Maintenance of Hot Work Tools



Oxy-Fuel Gas

The common gases used in the shipyards are:

- Oxygen
- Acetylene
- LPG (Propane)

Oxygen

- Oxygen is colourless and odourless.
- Oxygen is not flammable but it supports combustion.
- Oxygen is heavier than air.
- Fire will burn with high intensity in an oxygen enriched environment.

Acetylene

- Acetylene is a very flammable gas.
- Acetylene is lighter than air.
- Acetylene has smell but is colourless.

LPG

- LPG is heavier than air.
- LPG is also a flammable gas.
- LPG has smell but is also colourless.

Inspection and Maintenance of Hot Work Tools

Pressure gauges on gas cylinders to be in good condition.
Shut off gas valves and remove gas hoses from confined space after work.

Gas Cutting

- Oxygen and Acetylene Cylinder Cages must be kept at least 6 m apart from each other.
- Oxygen or acetylene cylinders shall be kept at a distance of at least 6 m from hot work area.
- Ensure Flashback Arrestors and non return valve in place before ignite the Cutting Torch.
- Ensure Flashback Arrestors and non return valve in place before ignite the Cutting Torch.

Oxy-fuel Hose Connections
The clips below shall be used for hose connections.

Oxy-fuel Hose Connections

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Jubilee clips shall not be used for hose connections as these clips can cause leaks when the clips are being tightened or loosened (cut into the hoses).

Safe Work Practices

Before carrying out any hot work with oxy-fuel equipment, do the following:

- Check gas hoses and its fittings to ensure no damage;
- Wear the necessary PPE.
- Purge gas hoses before lighting the cutting torch;
- Use flint guns or spark lighters to light the gas torch. Do not use cigarette lighters.
- Prevent gas hoses from coming into contact with heat sources;
- Gas cylinders must be secured in an upright position. Do not lay gas cylinders horizontally on the floor;
- All equipment and fittings including gas hoses, torches, blowpipes, pressure regulators, nozzles and connections, shall be inspected and tested by a competent person or the safety officer once in every 14 days to ensure that they are free from defects and leaks.
- During breaks, turn off the gas supply at the manifold and disconnect the hoses.
- Remove gas hoses from the confined spaces at the end of the day and place it neatly on the deck.

Welding Hazards

Metal Fume Fever

- Metal fume fever is an illness caused by exposure to metal fumes.
- Symptoms include chills, fever, muscle ache, coughing and nausea.

Prevention of Metal Fume Fever

- Avoid direct contact with toxic fumes.
- Use local exhaust ventilation where possible.
- Wear the appropriate PPE such as respirators

Safe Work Practices

- Check welding equipment before use.
- Do not use damaged equipment, especially damaged electrode holder.
- Remove electrodes from the electrode holders when not in use.

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- Do not insert electrodes into the holders with bare hands.
- Welding cables to be hung on cable hangers and not laid on deck or wet surface.
- No welding shall be carried out in wet conditions.
- All electrode holders, welding cables, cable connectors and other arc welding equipment shall be inspected by a competent person once in every 30 days.

End