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HSSC
HYDROCARBON SECTOR
SKILL COUNCIL

Participant Handbook

Sector
Hydrocarbon

Sub-Sector
Downstream

Occupation
Bio Ethanol Plant Operations & Maintenance

Reference ID: **HYC/Q4301, Version-1.0**
NSQF Level: 3

Junior Operator – 2G Ethanol Plant

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"Skilling is building a better India. If we have to move India towards development then Skill Development should be our mission."

Shri Narendra Modi
Prime Minister of India

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for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of
Job Role/ Qualification Pack: **'Junior Operator – 2G Ethanol Plant'**
QP No. **'HYC/Q4301 NSQF Level 3'**

Date of Issuance: March 4th, 2020
Valid up to*: March 3rd, 2024

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Authorised Signatory
Hydrocarbon Sector Skill Council

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The preparation of this manual would not have been possible without the Hydrocarbon Industry's support. Industry feedback has been extremely encouraging from inception to conclusion and it is with their input that we have tried to bridge the skill gaps existing today in the industry.

This participant manual is dedicated to the aspiring youth who desire to achieve special skills which will be a lifelong asset for their future endeavours.

About this Guide

Welcome to the **"Junior Operator - 2G Ethanol Plant"** training program. This Participant Hand Book (PHB) will facilitate and train the trainees/participants in the skills necessaray to be a **"Junior Operator - 2G Ethanol Plant"**, in the Hydrocarbon Sector. Besides, it will also enable the trainers to identify the scope within which the training is to be conducted forJunior Operator - 2G Ethanol Plant at Level 3, The PHB will provide the knowledge and skills necessary for the job role.

Junior Operator – 2G Ethanol Plant is responsible for performing operational skills for various work profiles involved in 2G ethanol production. Accordingly, the Participant Handbook (PHB) includes technical as well as behavioural skills required for this job role, and is based on National Skill Qualification Framework NSQF aligned Qualification Pack (QP) as follows:

1. HYC/N4301– Assist in performing 2G Ethanol plant operations
2. HYC/N9301 – Working effectively in a team
3. HYC/N9302 – Maintain health, safety and security procedures
4. DGT/VSQ/N0101 - Employability Module

There are various practical and theoretical exercises given at the end of each unit, which may be used to test the understanding of the trainee on a topic. Trainers can use them for formative and summative assessment. This book is just a beginning, and much of the most exciting learning processes will take place in the classroom and thereafter.

Successful completion of the program shall certify the trainee as a Junior Operator – 2G Ethanol Plant thereby adding value for their employment opportunities as also the entrepreneurship capabilities.

Symbols Used


Key Learning Outcomes


Steps


Exercise


Tips


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It is recommended that all trainings include the appropriate Employability skills Module. Content for the same can be accessed https://www.skillindiadigital.gov.in/content/list

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1. Introduction to Hydrocarbon sector and the job role of Junior Operator - 2 G Ethanol Plant

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Unit 1.1 - Introduction to Hydrocarbon and its Sub-sectors

Unit 1.2 - Roles and Responsibilities of Junior Operator - 2G Ethanol Plant

HYC/N4301

Key Learning Objectives

At the end of this module, the participant will be able to:

1. Discuss the Hydrocarbon Sector
2. Discuss the job of a Jr. Operator - 2G Ethanol plant

Unit 1.1 Introduction to Hydrocarbon and its Sub-sectors

Unit Objectives

At the end of the unit, the participant will be able to:

1. Describe the oil and natural gas sector and its subsectors

1.1.1 Introduction to Hydrocarbon Sector

Hydrocarbons are chemical compounds composed of hydrogen and carbon atoms. They occur in nature deep within the earth's crust and are extracted using very complex methods and technology. Hydrocarbons are the basis of natural gas, crude oil (petroleum), coal, and other energy sources. They are highly combustible or inflammable and are very effective as a source of fuel like gasoline, kerosene, jet fuel, diesel, propane, etc.

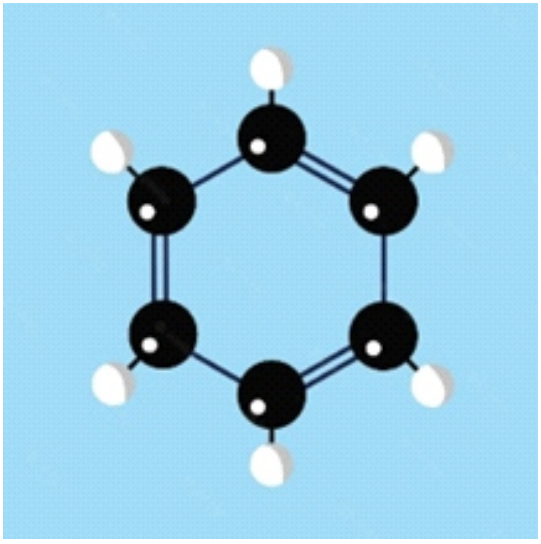

Fig. 1.1 Structure of Hydrocarbon

The hydrocarbon sector consists of oil and gas companies. The oil and gas companies mine hydrocarbons and convert them into energy sources and other derivatives. The majority of global energy production is based on hydrocarbons. Alternative energy sources like solar, wind, geothermal, and nuclear power are gaining popularity due to the negative impact of hydrocarbons on the environment and climate. Refined petroleum or crude oil is used in the production of plastics, lubricants, pharmaceuticals, fertilizers, pesticides, solvents, etc.

The oil and gas sector is one of the world's largest sectors in revenue generation. According to the Industry Research Reports, this sector is generating an estimated US Dollar 5 trillion in global revenue in 2022. Oil is crucial in the global economy as it impacts many industries including transportation, heating and electricity, industrial production, etc.

1.1.2 Overview of the Oil and Natural Gas Sector in India

The oil and natural gas or the hydrocarbon sector play an important role in the country's economic growth. It is one of the eight core industries that is driving economic growth in India. The Ministry of Petroleum and Natural Gas, Government of India in its 'India Hydrocarbon Vision – 2025' framework to guide the policies related to the hydrocarbons sector. Various issues like energy security, interchangeability of technology, and use of alternative fuels are covered. The growth of the country's economy directly impacts the increase or growth in energy consumption as the Gross Domestic Product (GDP) and energy consumption have a direct correlation. Some of the key points of the Hydrocarbon Vision - 2025 are

- To become self-reliant through increased local production and investment in equity oil abroad.
- To improve the quality of life by gradually improving product standards, thus ensuring a cleaner and greener India.
- To develop the Indian hydrocarbon sector as a globally competitive industry through technology upgradation and capacity building across the industry.
- To promote healthy competition and a free market among all the players and improve customer service.
- To ensure oil security by keeping in mind the strategic and defence considerations of the country.

Fig. 1.2 Key Points of the Hydrocarbon Vision – 2025
(Information Source: www.petroleum.nic.in)

India has also set a target to reduce the carbon intensity of the nation's economy by less than 45% by the end of the decade, achieve 50 percent cumulative electric power installed by 2030 from renewables, and achieve net-zero carbon emissions by 2070 . The Government has also set a goal to increase the amount of natural gas in the energy mix from around 6.3% presently to 15% in 2030 .

1.1.3 Sub-sectors in Hydrocarbon Industry

The hydrocarbon industry is involved in the exploration, extraction, processing (refining), transportation and marketing of oil and natural gas products. The industry is broadly divided into three main sub-sectors upstream, midstream and downstream. Besides these three main subsectors, construction can be considered an ancillary sub-sector supporting the hydrocarbon industry.

Upstream

It includes activities and companies related to exploration, extraction and production of oil and natural gas. These companies search for oil reservoirs and drill to extract oil and are known as Exploration and Production (E&P) companies.

Midstream

It includes activites and companies related to processing, storing, marketing and transportation of crude oil, natural gas and natural gas liquids or liquified natural gas like ethane, propane and butane.

Downstream

It includes activities and companies related to refining and processing of crude oil, processing and purifying of raw natural gas, selling and distribution of products derived from crude oil and natural gas.

Fig. 1.3 Sub-sectors in Hydrocarbon Industry
(Image Source: www.freepik.com)

A. The oil and gas sector has three key sub-sectors: Upstream, Midstream and Downstream.

I. Upstream: Upstream refers to the first stage of the oil and gas production process. This involves locating, extracting, and processing crude oil and natural gas reserves from underground or underwater deposits. Upstream activities include exploration, drilling, well construction and oil and gas production. Companies involved in the upstream sector may also be involved in activities such as seismic surveys, geological studies and environmental assessments. The upstream sector is essential for the oil and gas industry as it is responsible for locating and extracting crude oil and natural gas, which are then transported downstream to refineries for processing and distribution.

Fig.1.4 Upstream

II. Midstream: Midstream refers to the stage of the oil and gas production process that involves the transportation and storage of crude oil and natural gas. After recovering them from underground or underwater, the resources must be transported to refineries, which may be located in a different region. Midstream activities include the transportation of oil and gas through pipelines, trucking fleets and tanker ships, as well as the storage of these resources in tanks or underground facilities.

Midstream companies are responsible for the safe and efficient transportation of crude oil and natural gas from upstream production sites to downstream refineries or processing facilities. This can involve the construction and maintenance of pipelines, storage facilities, and other infrastructure. The midstream sector plays a crucial role in the oil and gas industry by providing the necessary infrastructure to transport and store crude oil and natural gas, ensuring a reliable and efficient supply to downstream consumers.

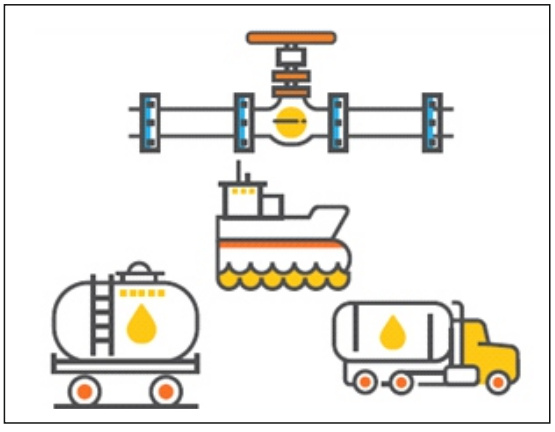

Fig.1.5 Midstream

III. **Downstream:** The downstream sector of the oil and gas industry involves the refining and purification of the raw materials obtained during the upstream phase. This includes refining crude oil and purifying natural gas, as well as marketing and distributing these products to end-users in various forms, such as diesel oil, petrol, gasoline, natural gas, kerosene, jet fuel, heating oil, LPG, lubricants and other petrochemicals. Oil and natural gas products are used in a wide range of applications, from manufacturing paints, dyes, and fibres to producing artificial limbs, hearing aids, and flame-retardant clothing for firefighters. The downstream sector is crucial to the oil and gas industry as it provides the finished products that are used by consumers and businesses around the world. It also represents a significant source of revenue for companies involved in the sector. In short, downstream operations involve converting oil and natural gas resources into fuels and finished products that are essential for daily life.

Fig.1.6 Downstream

Together, the upstream, midstream, and downstream sectors of the oil and gas industry ensure a consistent supply of fuels and materials that contribute to our well-being and safety.

B. Construction as a Sub-sector of the Hydrocarbon Industry

Construction is considered an ancillary sub-sector of the hydrocarbon industry, which is closely related and often involved in the development of hydrocarbon projects. The construction industry is responsible for the design, engineering and construction of infrastructure necessary for the exploration, production, and transportation of hydrocarbons, such as pipelines, refineries, and offshore platforms. While construction is not a direct part of the hydrocarbon value chain, it plays a critical role in enabling the development and operation of hydrocarbon projects. Oil and gas companies often contract construction companies to design, build and maintain the infrastructure.

Some segments of construction sub-sectors in the hydrocarbon industry include:

Onshore Construction
This involves the construction of facilities on land, such as drilling rigs, production facilities, pipelines, and refineries. Onshore construction also includes the building of infrastructure required to support these facilities, such as roads, bridges, and storage tanks.
Offshore Construction
This involves the construction of facilities in offshore locations, such as drilling platforms, production platforms, and pipelines. Offshore construction is often more complex and requires specialized equipment and expertise.

Continued...

Fabrication and Manufacturing

This involves the manufacturing of components used in the construction of oil and gas facilities. This can include the fabrication of steel structures, piping, and other components used in the construction of drilling rigs, production facilities, and refineries.

Engineering and Design

This involves the planning, design, and engineering of oil and gas facilities. This includes the development of detailed engineering drawings and specifications, and the coordination of construction activities.

Environmental Services

This involves the management of environmental impacts associated with oil and gas construction activities. This can include designing and implementing environmental management plans, monitoring and remediation activities.

Fig. 1.7 Segments of Construction Sub-sector In the Hydrocarbon Industry

Oil and Natural Gas Companies in India

Integrated oil companies are associated with the operations of two or more stages of oil production. The various oil and natural gas companies in India are:

1. Bharat Petroleum Corporation Limited (BPCL)

Fig. 1.8 Logo of BPCL

Bharat Petroleum Corporation Limited (BPCL) is a public sector organisation managed by the Ministry of Petroleum and Natural Gas, Government of India. It has refineries in Madhya Pradesh, Kerala and Maharashtra. It deals with various products like crude oil, natural gas, liquified natural gas (LNG), lubricants and petrochemicals. It operates in all three sub-sectors of the hydrocarbon industry- upstream, downstream and midstream.

A. In the upstream sector, BPCL has exploration and production activities through its subsidiary, Bharat PetroResources Limited (BPRL). BPRL has exploration blocks in India, Mozambique, Brazil, Indonesia, and Australia.

B. In the midstream sector, BPCL operates pipelines, storage terminals, and LPG bottling plants. BPCL also has a joint venture with Oman Oil Company for the construction of a new LPG plant and a petrochemical complex in India.

c. BPCL has a large refining capacity of around 27.5 million metric tonnes pe rannum (MMTPA) in its refineries located in Mumbai and Kochi and another 7.8 MMTPA in its refinery located at Bina, Madhya Pradesh as a joint venture with Bharat Oman Refinery Ltd.

Therefore, it can be concluded that BPCL is a vertically integrated oil and gas company that operates across the entire hydrocarbon value chain, from exploration and production to refining, marketing, and distribution.

2. Hindustan Petroleum Corporation Limited (HPCL)

Fig. 1.9 Logo of HPCL

Hindustan Petroleum Corporation Limited (HPCL) is a subsidiary of the Oil and Natural Gas Corporation (ONGC). It has refineries in Maharastra, Andhra Pradesh, Karnataka, Punjab and Rajasthan. It deals with various products like crude oil, natural gas, liquified natural gas (LNG), lubricants and petrochemicals. It operates in all three sub-sectors of the hydrocarbon industry- upstream, downstream and midstream.

A. In the upstream sector, HPCL has exploration and production activities through its subsidiary, Prize Petroleum Company Limited. Prize Petroleum has exploration and production assets in India, including the Mumbai High and Bassein gas fields.

B. In the midstream sector, HPCL operates pipelines and terminals for the transportation and storage of crude oil, petroleum products, and natural gas. The company has a joint venture with other Indian oil and gas companies for the construction of the India-Myanmar-Thailand (IMT) pipeline to transport crude oil and petroleum products from the Middle East to India and Southeast Asia.

C. HPCL has a large refining capacity of around 15.8 million metric tonnes per annum (MMTPA) in its refineries located in Mumbai and Vishakapatnam and another 11.3 MMTPA in its refinery located at HMEL, GGSR as a joint venture with HPCL Mittal Energy Ltd. The company also has a significant presence in the marketing and distribution of petroleum products, including gasoline, diesel, aviation fuel, and lubricants, through its network of retail outlets and dealerships across India.

Therefore, it can be concluded that HPCL is a vertically integrated oil and gas company that operates across the entire hydrocarbon value chain, from exploration and production to refining, marketing and distribution.

3. Indian Oil Corporation Limited (IOCL)

Fig. 1.10 Logo of IOCL

Indian Oil Corporation Limited (IOCL) is a public sector organisation managed by the Ministry of Petroleum and Natural Gas, Government of India. It has refineries in Bihar, Assam, Tamil Nadu, Gujarat, Uttar Pradesh, Haryana and Odisha. It deals with various products like crude oil, natural gas, liquified natural gas (LNG), lubricants and petrochemicals. It operates across all three sub-sectors of the hydrocarbon industry- upstream, downstream and midstream.

A. In the upstream sector, IOCL has exploration and production activities through its subsidiary, Indian Oil Exploration and Production Limited (IOEPL). IOEPL has exploration and production assets in India, as well as in countries such as Libya, Gabon, Nigeria, Yemen, and Canada.

B. In the midstream sector, IOCL operates pipelines, storage terminals, and LPG bottling plants for the transportation, storage, and distribution of crude oil, petroleum products, and natural gas. IOCL is also a part of joint ventures for the development of pipelines such as the India-Myanmar-Thailand (IMT) pipeline and the under-construction gas pipeline from Ennore in Tamil Nadu to Mangalore in Karnataka.

C. In the downstream sector, IOCL has a refining capacity of around 70 million metric tonnes per annum (MMTPA) across its 9 refineries located in India. The company also has a significant presence in the marketing and distribution of petroleum products, including gasoline, diesel, aviation fuel, and lubricants, through its extensive network of retail outlets and dealerships across India.

Therefore, it can be concluded that IOCL is a vertically integrated oil and gas company that operates across the entire hydrocarbon value chain, from exploration and production to refining, marketing, and distribution.

4. Oil and Natural Gas Corporation (ONGC)

Fig. 1.11 Logo of ONGC

Oil and Natural Gas Corporation (ONGC) is a public sector organisation managed by the Ministry of Petroleum and Natural Gas, Government of India. It has refineries in Karnataka and Andhra Pradesh. It deals with various products like crude oil, natural gas, liquified natural gas (LNG), lubricants, petrochemicals and electricity. It operates across all three sub-sectors of the hydrocarbon industry- upstream, downstream and midstream.

A. In the upstream sector, ONGC is involved in the exploration and production of oil and gas reserves. This involves the drilling of wells, the acquisition of seismic data, and the production of crude oil and natural gas from underground reservoirs. ONGC's upstream operations also include offshore exploration and production activities in the Arabian Sea and the Bay of Bengal.

B. In the midstream sector, ONGC is responsible for the transportation and storage of crude oil and natural gas. This involves the construction and operation of pipelines, terminals, and other infrastructure required to transport crude oil and natural gas from the production sites to refineries or other processing facilities.

C. In the downstream sector, ONGC is involved in the refining and marketing of petroleum products. ONGC operates several refineries in India, including the largest refinery complex in the country located in Gujarat. ONGC's downstream operations also include the marketing and distribution of petroleum products through a network of retail outlets and dealerships across India.

Therefore, it can be concluded that ONGC is a vertically integrated oil and gas company, with operations spanning the upstream, midstream, and downstream segments of the industry. This enables ONGC to have greater control over the entire value chain of the oil and gas industry, from exploration and production to refining and marketing.

5. Reliance Petroleum

Fig. 1.12 Logo of Reliance Petroleum

Reliance Petroleum is India's largest private company owned by Mukesh Ambani, specialising in oil and energy. It is a subsidiary of Reliance Industries Limited (RIL) and has two oil rigs Dhirubhai Deepwater (DD) KG-1 and DD KG-2 and a refinery in Jamnagar in Gujarat. It deals with various products like crude oil, oil and natural gas. It operates across all three sub-sectors of the hydrocarbon industry- upstream, downstream and midstream.

1. In the upstream sector, Reliance Petroleum is handled by Reliance Industries Limited. RIL has exploration and production operations in various parts of India, including the Krishna-Godavari basin off the east coast of India and the Cambay basin off the west coast of India.

2. In the midstream sector, Reliance Petroleum is handled by Reliance Gas Transportation Infrastructure Limited (RGTIL), which is a subsidiary of RIL. RGTIL operates a pipeline network that transports natural gas from various sources to customers in various parts of India.

3. In the downstream sector, Reliance Petroleum is handled by Reliance Industries Limited. RIL operates one of the largest and most complex refineries in the world, located in Jamnagar, India. The company also has a vast network of retail outlets across India that sell various petroleum products, including gasoline, diesel, and liquefied petroleum gas (LPG).

Therefore, it can be concluded that Reliance Petroleum is a vertically integrated oil and gas company, with operations spanning the upstream, midstream and downstream segments of the industry.

6. Nayara Energy

Fig. 1.13 Logo of Reliance Petroleum

Nayara Energy Limited (earlier Essar Oil Limited) is a private-sector oil and gas company involved in refining, marketing, producing and retailing petroleum products in India. It has its refinery in Vadinar and Mombasa. It operates in all three sub-sectors of the hydrocarbon industry- upstream, downstream and midstream.

A. In the upstream sector, Nayara Energy has exploration and production activities through its subsidiary, Essar Exploration and Production India Limited. The company has a diverse portfolio of exploration and production assets in India and abroad, including coal bed methane (CBM) assets in India and shale gas assets in the United States.

B. In the midstream sector, Nayara Energy operates pipelines and storage terminals for the transportation, storage, and distribution of crude oil, petroleum products, and natural gas. The company has a network of over 4,000 km of crude oil and product pipelines and over 2 million cubic meters of storage capacity across India.

C. In the downstream sector, Nayara Energy has a refining capacity of around 20 million metric tonnes per annum (MMTPA) across its Vadinar and Mombasa refineries. The company also has a significant presence in the marketing and distribution of petroleum products, including gasoline, diesel, aviation fuel, and lubricants, through its network of over 6,000 retail outlets and dealerships across India and plans to have 8,200+ petrol pumps by 2024 .

Therefore, it can be concluded that Nayara Energy is a vertically integrated oil and gas company that operates across the entire hydrocarbon value chain, from exploration and production to refining, marketing, and distribution.

Notes

1.1.4 Hydrocarbon Sector Skill Council (HSSC)

The Hydrocarbon Sector Skill Council (HSSC) is an organization based in India that is responsible for developing and maintaining the skill standards for the hydrocarbon sector. It is a joint initiative of the Ministry of Petroleum and Natural Gas and the National Skill Development Corporation, aimed at addressing the skill gaps and shortages in the hydrocarbon industry workforce.

HSSC works closely with industry stakeholders, including employers, employees, and training providers, to identify the skills required for the hydrocarbon sector and develop training programs to meet those needs. The council provides accreditation to training providers and certifies individuals who successfully complete the training programs.

HSSC also works to promote career opportunities in the hydrocarbon sector and increase awareness about the sector among the youth in the country. It collaborates with educational institutions and vocational training centres to provide vocational education and training to students and help them acquire the skills required for employment in the hydrocarbon industry.

Hydrocarbon Sector in India – Overview

The hydrocarbon sector has played a crucial role in the Indian economy for a long time as it meets over one-third of the country's energy requirements. India is also one of the biggest consumers of oil and gas globally, and its primary energy consumption has increased twofold in the last twenty years.

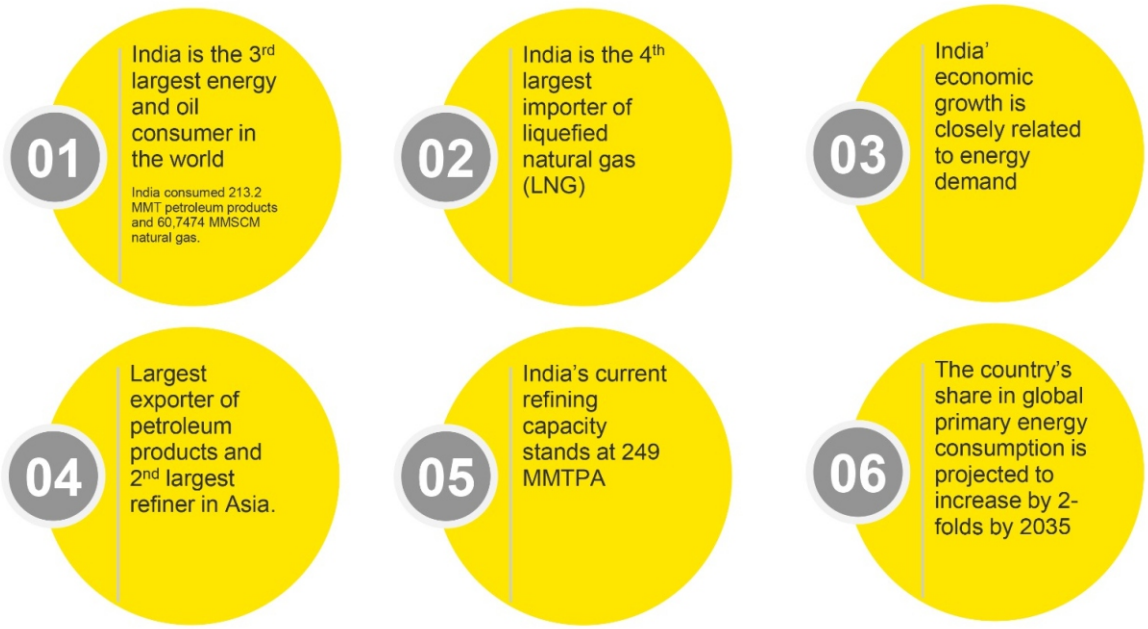

Fig.1.14 Hydrocarbon Sector Overview
Source: https://www.hsscindia.in/sector-overview/

1.1.5 Oil Industry Safety Directorate (OISD) Standards

Oil Industry Safety Directorate (OISD) is an administrative agency of the Government of India's Ministry of Petroleum and Natural Gas that formulates and oversees several self-regulatory measures to improve safety in the Indian oil and gas industry.

Because of the handling, processing, and storage of highly flammable liquid, gas, and vapour, as well as the operation of the facilities at elevated temperatures and pressure or cryogenic conditions, refineries, gas processing, LNG, and petrochemical plants are vulnerable to fire and explosion hazards. These potential hazards are exacerbated by process disruptions, harsh physical conditions, and the unintentional discharge of volatile hydrocarbons.

In recent years, the oil industry has seen major upgrades and capacity built up in petroleum refining, along with the introduction of newer technologies such as Catalytic Hydro-treating, Isomerisation, Hydrocracking, Fluidized Catalytic Cracking, and Delayed Coking, among others, to extract maximum value addition from the product slate. With technological advancements and diversification toward petrochemicals, the complexity of operation has expanded exponentially, as has the obligation of oil and gas businesses to operate safely and efficiently without creating any accidents or harm to their surroundings. Safety management in the hydrocarbon sector is a multidisciplinary job, and everyone must be vigilant for potential causes of fire and accidents and work to remove them.

A workplace incident indicates that prevention was ineffective and that immediate improvements are required. To avoid repetition, everyone at our workstations should learn from previous industrial incidents.

The petroleum rules incorporate six OISD standards:

S. No.	OISD Standard	Description
1	OISD STD 105	Work permit system
2	OISD STD 116	Fire protection facilities for petroleum refineries and oil/gas processing plants
3	OISD STD 117	Fire protection facilities for petroleum depots, terminals, pipeline installations & lube oil installations
4	OISD STD 118	Layouts for oil and gas installations
5	OISD STD 141	Design and construction requirements for cross-country hydrocarbon pipelines
6	OISD STD 156	Fire protection facilities for ports handling hydrocarbons

Table: 1.1 OISD Standards for Petroleum Rules

The gas cylinder rules now incorporate two OISD standards:

S. No.	OISD Standard	Description
1	OISD STD 105	Work permit system
2	OISD STD 116	Fire protection facilities for petroleum refineries and oil/gas processing plants

Table: 1.2 OISD Standards for Gas Cylinder Rules

S. No.	OISD Standard	Description
1	OISD STD 108	Recommended practices on oil storage and handling
2	OISD STD 114	Safe handling of hazardous chemicals
3	OISD STD 116	Fire protection facilities for petroleum refineries and oil/gas processing plants
4	OISD STD 117	Fire protection facilities for petroleum depots, terminals, pipeline installations, and lube oil installations
5	OISD STD 118	Layouts for oil and gas installations
6	OISD STD 128	Inspection of unfired pressure vessels

Table: 1.3 OISD Standards Included in the Oil Mines Regulations 2017

1.1.6 Biofuels- 2G Ethanol

Biofuels

Biofuels are derived from biomass, which is organic matter sourced from recently living organisms like plants, algae, or waste materials. Unlike fossil fuels that take millions of years to form, biofuels are renewable because their organic sources can be replenished relatively quickly. These fuels have emerged as an alternative to fossil fuels, offering benefits such as reduced greenhouse gas emissions and decreased dependence on imported fuels. However, the production and utilization of biofuels entail environmental and social considerations, including changes in land use, competition with food crops, and potential impacts on biodiversity.

In India, biofuels have garnered significant attention and importance due to their potential to address energy security, foster rural development, and promote environmental sustainability. The Indian government has implemented policies and initiatives to encourage the production and adoption of biofuels across the country.

Biofuels can be categorized based on their source and production process, leading to various types with distinct production methods, applications, and benefits. The selection of a specific biofuel is influenced by factors like the availability of feedstock, production expenses, environmental factors, and the intended purpose of the fuel. The primary types of biofuels are as follows:

Ethanol:

Ethanol is a biofuel produced by fermenting and distilling sugar or starch crops such as corn, sugarcane, wheat, or other biomass materials. It is commonly used as a blending agent with gasoline, primarily in the transportation sector. Ethanol can be blended with gasoline in different proportions, such as E10 (10% ethanol, 90% gasoline) or E85 (85% ethanol, 15% gasoline), and it is compatible with flexible fuel vehicles (FFVs).

Continued...

Biodiesel:

Biodiesel is produced from vegetable oils, animal fats, or recycled cooking grease through a process called transesterification. It involves reacting the oils or fats with an alcohol (typically methanol or ethanol) in the presence of a catalyst to produce fatty acid methyl esters (FAME), which can be used as a substitute for or blended with petroleum diesel. Biodiesel can be used in most diesel engines without any modifications.

Biogas:

Biogas is produced through the anaerobic digestion or fermentation of organic waste materials, such as agricultural residues, food waste, animal manure, or sewage. It consists mainly of methane (CH4) and carbon dioxide (Co2). Biogas can be combusted to produce heat and electricity or further processed to remove impurities and upgraded to biomethane, which has similar properties to natural gas and can be used in transportation, heating, and power generation.

Hydroprocessed Esters and Fatty Acids (HEFA):

HEFA biofuels are produced from various feedstocks, including vegetable oils, animal fats, or algae. They undergo a hydroprocessing conversion process, which removes impurities and transforms the feedstock into a fuel that is chemically similar to petroleum-based jet fuel or diesel. HEFA biofuels are used primarily in aviation as sustainable jet fuel.

Pyrolysis Oil:

Pyrolysis oil, also known as bio-oil or biocrude, is produced through the thermal decomposition of biomass in the absence of oxygen. The process, called pyrolysis, converts the biomass into a liquid oil-like substance. Pyrolysis oil can be refined and upgraded for use in various applications, including heating, power generation, and as a feedstock for the production of other biofuels.

Synthetic Fuels:

Synthetic biofuels, such as synthetic gasoline or synthetic diesel, are produced through advanced processes like gasification and Fischer-Tropsch synthesis. These fuels are derived from biomass or other carbon-containing materials and have similar properties to fossil fuels. Synthetic biofuels can be used as drop-in replacements for gasoline and diesel without requiring modifications to existing engines or infrastructure.

Fig.1.15 Primary Types of Biofuels

2G ethanol

2G ethanol, or second-generation ethanol, is ethanol produced from non-food sources or lignocellulosic biomass. Unlike 1G ethanol, which comes from food crops like corn or sugarcane, 2G ethanol is derived from agricultural residues (e.g., corn stover, wheat straw, rice husks), dedicated energy crops (e.g., switchgrass, miscanthus), wood chips, or other non-food plant materials. It represents an advanced method of ethanol production.

1. 2G ethanol serves as a sustainable energy source, reducing reliance on fossil fuels and aiding in climate change mitigation. It is renewable and helps decrease greenhouse gas emissions, as well as aligns with global efforts to combat climate change.

2. It contributes to the diversification of the energy supply by utilizing non-food biomass feedstocks, reducing competition between food and fuel production. This helps to ensure food security while meeting energy demands.
3. 2G ethanol facilitates the utilization of waste and residues, converting agricultural, forest and organic waste into valuable ethanol. This process, therefore, utilizes waste products that would otherwise be discarded, adding economic value to the agricultural and forestry sectors.
4. It offers reduced environmental impact, with potential greenhouse gas emission reductions of up to 90% compared to gasoline.
5. 2G ethanol enhances energy security by decreasing dependence on fossil fuel imports and promoting self-sufficiency. This helps to reduce the vulnerability to changes in global oil prices.
6. The production of 2G ethanol contributes to rural development and job creation, stimulating rural economies and improving the income of farmers and local communities.
7. It contributes to improved air quality by emitting lower levels of pollutants compared to conventional gasoline. It can be used as a standalone fuel or blended with gasoline.

In summary, 2G ethanol is vital due to its role as a sustainable energy source, diversification of energy supply, efficient waste and residue utilization, reduced environmental impact, enhanced energy security, rural development and job creation, as well as improved air quality.

2G ethanol plant

A **2G ethanol plant** is a specialized facility constructed for the purpose of converting lignocellulosic biomass into ethanol. It consists of multiple units and equipment designed to handle biomass, carry out pre-treatment and enzymatic hydrolysis processes, enable fermentation, and conduct distillation and purification steps to produce high-quality ethanol. These plants employ advanced technologies and specialized equipment to efficiently convert non-food biomass feedstock into ethanol while optimizing yield and minimizing energy consumption.

2G ethanol plants specifically utilize biomass sources like agricultural residues, forestry residues, energy crops, and wood chips, rather than relying on food-based feedstocks. The resulting ethanol can be blended with gasoline or used independently as a fuel in vehicles compatible with it. It serves as a renewable and environmentally friendly alternative to conventional fossil fuels.

The operation of 2G ethanol plants entails several essential steps, including preparing the biomass feedstock, subjecting it to pre-treatment to enhance its conversion potential, employing enzymatic hydrolysis to break down complex carbohydrates into fermentable sugars, initiating fermentation with the aid of microorganisms, and applying distillation and purification processes to obtain pure ethanol. Additional steps such as dehydration may also be carried out to achieve the desired ethanol concentration.

By enabling the production of 2G ethanol, these plants play a crucial role in advancing the development and commercialization of sustainable biofuels. They contribute to mitigating greenhouse gas emissions, enhancing energy security through diversification, and facilitating the transition towards a more sustainable and diverse energy portfolio.

The process of producing ethanol in a 2G ethanol plant typically involves the following steps:

Feedstock Preparation: The biomass feedstock, such as agricultural residues or energy crops, is collected and prepared for further processing. This may involve activities like chopping, shredding, or grinding the feedstock to increase its surface area and facilitate subsequent steps.

Pretreatment: The pretreatment step aims to break down the complex structure of the biomass and make the cellulose and hemicellulose more accessible for further conversion. This can involve processes such as mechanical milling, chemical treatment, or steam explosion.

Enzymatic Hydrolysis: In this step, enzymes are added to the pretreated biomass to convert the cellulose and hemicellulose into fermentable sugars. Enzymes break down the complex carbohydrates into simpler sugars like glucose and xylose.

Fermentation: The fermentable sugars obtained from enzymatic hydrolysis are then subjected to fermentation. Microorganisms, such as yeast or bacteria, are added to the sugar solution, and under controlled conditions, they convert the sugars into ethanol through a process called anaerobic fermentation.

Distillation and Purification: The resulting ethanol mixture is distilled to separate the ethanol from water and other impurities. This is typically done using a combination of distillation columns and purification processes like molecular sieves or adsorption techniques.

Dehydration: In this final step, any remaining water is removed from the ethanol to reach the desired concentration, usually around 99%. Dehydration can be achieved through various methods, including molecular sieves, azeotropic distillation, or membrane separation.

Fig.1.16 Process of Producing Ethanol in a 2G Ethanol Plant

2G Ethanol Plants in India

2G ethanol plants in India are facilities dedicated to the production of second-generation ethanol, also known as cellulosic ethanol or advanced biofuel, using non-food biomass feedstocks. India has been actively promoting the development and implementation of 2G ethanol technology to diversify its energy sources, reduce dependence on fossil fuels, and mitigate environmental impact.

In India, there are several 2G ethanol plants that have been established. Below are a few examples:

Indian Oil Corporation Limited (IOCL), Panipat:	IOCL has set up a demonstration-scale 2G ethanol plant in Panipat, Haryana. The plant utilizes agricultural residues like rice straw and wheat straw as feedstock.
Bharat Petroleum Corporation Limited (BPCL), Bina:	BPCL has established a 2G ethanol plant in Bina, Madhya Pradesh. This plant uses lignocellulosic biomass as its feedstock.
Hindustan Petroleum Corporation Limited (HPCL), Bathinda:	HPCL has set up a 2G ethanol plant in Bathinda, Punjab. The plant employs non-food biomass feedstocks such as paddy straw, cotton stalk, and sugarcane trash.

Continued...

Praj Industries, Pune:	Praj Industries, a prominent company in the bioenergy sector, has implemented multiple 2G ethanol projects in India. One notable project is located in Pune, Maharashtra.

Fig.1.17 Examples of2G Ethanol Plants in India

Government Initiatives on Bio-Fuels

The Indian government has introduced various measures to encourage the production and utilization of biofuels, specifically 2G ethanol, with the goal of reducing reliance on fossil fuels, promoting sustainable development, and mitigating environmental impact. These initiatives demonstrate India's dedication to fostering biofuels as a sustainable and renewable energy solution. By creating a supportive environment for the development, production, and utilization of biofuels, the government aims to enhance energy security, promote rural development, and achieve environmental sustainability.

In line with these objectives, the government has established ambitious targets for ethanol production and blending in the country. These targets include increasing the percentage of ethanol blended with gasoline and facilitating the establishment of numerous 2G ethanol plants nationwide. The government has set specific timelines and milestones to achieve these targets, providing a clear roadmap for the growth and advancement of the 2G ethanol sector.

The establishment of 2G ethanol plants in India signifies the country's commitment to promoting sustainable and renewable energy sources. These plants contribute to the reduction of greenhouse gas emissions, enhance energy security by utilizing biomass feedstocks, and support rural development by creating employment opportunities and reducing dependence on fossil fuels. Overall, the government's initiatives in the biofuels sector play a crucial role in advancing India's transition towards a more sustainable and environmentally friendly energy landscape.

The following are some of the key government initiatives for biofuels and 2G ethanol in India:

National Policy on Biofuels:

The Indian government introduced the National Policy on Biofuels in 2018, which provides a comprehensive framework for the promotion of biofuels in the country. The policy focuses on promoting advanced biofuels, including 2G ethanol, by setting blending targets, creating an enabling regulatory framework, and providing incentives for biofuel production and use.

Ethanol Blended Petrol (EBP) Program:

The government launched the EBP Program, which mandates the blending of ethanol with petrol. Initially, it mandated a 5% blending level, which has been progressively increased. The program has provided a significant market for ethanol and has encouraged investments in ethanol production, including 2G ethanol.

Pradhan Mantri JI-VAN Yojana:

The government introduced the Pradhan Mantri JI-VAN (Jaiv Indhan- Vatavaran Anukool fasal awashesh Nivaran) Yojana to support the commercial production of biofuels, including 2G ethanol. The scheme focuses on supporting projects that utilize agricultural and forestry residues, as well as municipal solid waste, to produce biofuels.

Continued...

Financial Incentives:

The government provides various financial incentives to promote biofuel production, including 2G ethanol. These incentives include soft loans, interest subsidies, viability gap funding, and capital grants to encourage the establishment and operation of biofuel projects.

Research and Development Support:

The government supports research and development activities in the field of biofuels, including 2G ethanol. This support aims to advance technology development, improve efficiency, and reduce the cost of biofuel production.

Policy Support for Feedstock Availability:

The government has implemented policies to promote the availability of feedstocks for biofuel production. For example, it has encouraged the use of agricultural residues, like paddy straw and sugarcane bagasse, by facilitating their collection, storage, and transportation for biofuel plants.

Fig.1.18 Key Government Initiatives for Biofuels and 2G Ethanol in India

Notes

Unit 1.2 Role of Junior Operator - 2G Ethanol Plant

Unit Objectives

At the end of the unit, the participant will be able to:

1. Explain the roles and responsibilities of Jr. Operator - 2G Ethanol plant
2. Explain the importance of a Jr. Operator - 2G Ethanol plant

1.2.2 Roles and Responsibilities of Junior Operator - 2G Ethanol Plant

A Junior operator in a 2G ethanol plant assists in the day-to-day operations and maintenance of the facility. They operate and monitor equipment, ensuring smooth functioning and adhering to standard operating procedures. Overall junior operators play a crucial role in supporting the efficient and safe operation of the 2G ethanol plant. Some important roles and responsibilities of a junior operator are:

Equipment Operation: Junior Operators are responsible for operating various equipment and machinery within the plant, such as pumps, valves, conveyors, and control systems. They follow standard operating procedures (SOPs) to ensure smooth and efficient operation.

Process Monitoring: Junior Operators monitor process parameters, such as temperature, pressure, flow rates, and levels, to ensure that the production process is running within specified parameters. They make adjustments as necessary and report any deviations or abnormalities to senior operators or supervisors.

Routine Maintenance: Junior Operators assist in routine maintenance tasks, such as lubricating equipment, cleaning filters, inspecting equipment for wear or damage, and performing basic troubleshooting. They may also assist maintenance technicians in more complex maintenance and repair activities.

Safety and Compliance: Junior Operators adhere to safety protocols and follow all safety guidelines to maintain a safe working environment. They are responsible for identifying potential safety hazards, reporting incidents, and participating in safety training programs. They also ensure compliance with environmental regulations.

Sample Collection and Analysis: Junior Operators collect samples of feedstock, intermediate products, and final ethanol for quality control purposes. They may assist laboratory technicians in conducting basic tests and recording the results accurately.

Documentation and Reporting: Junior Operators maintain accurate records and logs of equipment operation, process parameters, maintenance activities, and any deviations from standard procedures. They report operational data and incidents to supervisors or senior operators.

Fig.1.19 Roles and Responsibilities of Junior Operator - 2G Ethanol Plant

Skills and attributes required for a junior operator

The junior operator in the 2G ethanol plant requires a range of skills and attributes to ensure successful performance in their role and smooth functioning of the plant. The following are the skills and attributes required for a junior operator:

Technical Aptitude: A strong understanding of equipment operation, process parameters, and troubleshooting is crucial for effectively operating and maintaining machinery in the plant.

Attention to Detail: Junior operators must have keen attention to detail to monitor equipment, process parameters, and quality control measures accurately. This helps identify and address any deviations or abnormalities promptly.

Safety Consciousness: Safety is a top priority in an ethanol plant, so junior operators need to prioritize safety protocols, guidelines, and procedures to maintain a safe working environment for themselves and their colleagues.

Communication Skills: Effective communication is essential for collaborating with supervisors, senior operators, and team members. Junior operators should be able to convey information clearly and report any issues or observations accurately.

Problem-Solving Abilities: The ability to analyze situations, identify problems, and implement appropriate solutions is valuable. Junior operators should possess problem-solving skills to address equipment malfunctions, process deviations, or maintenance issues effectively.

Adaptability and Flexibility: Ethanol plant operations can be dynamic, with changing conditions and priorities. Junior operators should be adaptable and flexible, capable of adjusting to evolving circumstances and working effectively in a fast-paced environment.

Teamwork and Collaboration: Ethanol production is a team effort, so junior operators should be able to work well within a team, contribute positively, and support their colleagues.

Physical Stamina: The role of a junior operator may involve physical activities such as equipment operation, maintenance tasks, and occasionally working in physically demanding environments. Having good physical stamina and the ability to work standing or in different conditions is important.

Analytical and Critical Thinking: Junior operators should possess analytical and critical thinking skills to analyze process data, troubleshoot issues, and make informed decisions regarding equipment operation and maintenance.

Fig.1.20 Skills and attributes required for a junior operator

1.2.2 Importance of Junior Operator - 2G Ethanol Plant

Importance of Junior Operator – 2G Ethanol Plant

The role of a Junior Operator in a 2G ethanol plant holds significant importance for the successful and efficient operation of the facility. The following are some reasons highlighting the importance of a Junior Operator in a 2G ethanol plant:

Operational Support: Junior Operators provide essential support in the day-to-day operations of the plant. They assist in equipment operation, monitoring process parameters, and ensuring smooth functioning of machinery. Their presence helps maintain a continuous and uninterrupted production process.

Safety and Compliance: Safety is paramount in an ethanol plant, and Junior Operators play a crucial role in upholding safety standards. They follow safety protocols, identify potential hazards, and report any safety concerns promptly. Their diligence helps create a safe working environment and ensures compliance with regulatory requirements.

Maintenance Assistance: Junior Operators contribute to routine maintenance tasks within the plant. They assist in equipment lubrication, cleaning, and basic troubleshooting. By actively participating in maintenance activities, they help prevent equipment malfunctions, reduce downtime, and optimize plant performance.

Quality Control: Junior Operators often play a role in quality control processes. They collect samples of feedstock, intermediate products, and final ethanol, which are then tested for various parameters. By adhering to sampling protocols and accurately documenting results, they contribute to maintaining the desired quality standards of the ethanol production.

Communication and Collaboration: Junior Operators serve as a vital link between supervisors, senior operators, and other team members. They communicate operational data, report incidents, and effectively collaborate with the team to ensure efficient coordination and information sharing. Their role facilitates smooth communication and enhances overall plant performance.

Fig.1.21 Importance of junior operator

Summary

- Hydrocarbons are chemical compounds composed of hydrogen and carbon atoms. They occur in nature deep within the earth's crust and are extracted using very complex methods and technology.
- The hydrocarbon sector consists of oil and gas companies. The oil and gas companies mine hydrocarbons and convert them into energy sources and other derivatives.
- The oil and natural gas or the hydrocarbon sector play an important role in the country's economic growth.
- The Ministry of Petroleum and Natural Gas, Government of India has laid out the 'India Hydrocarbon Vision – 2025' framework to guide the policies related to the hydrocarbons sector.
- The hydrocarbon industry is involved in the exploration, extraction, processing (refining), transportation, and marketing of oil and natural gas products.
- The industry is broadly divided into three main sub-sectors upstream, midstream and downstream. Besides these three main subsectors, construction can be considered an ancillary sub-sector supporting the hydrocarbon industry.

- Oil Industry Safety Directorate (OISD) is an administrative agency of the Government of India's Ministry of Petroleum and Natural Gas that formulates and oversees the implementation of several self-regulatory measures aimed at improving safety in the Indian oil and gas industry.
- Upstream refers to the first stage of the oil and gas production process. This involves locating, extracting, and processing crude oil and natural gas reserves from underground or underwater deposits.
- Midstream refers to the stage of the oil and gas production process that involves the transportation and storage of crude oil and natural gas.
- The downstream sector of the oil and gas industry involves the refining and purification of the raw materials obtained during the upstream phase.
- Construction is considered an ancillary sub-sector of the hydrocarbon industry, which is closely related and often involved in the development of hydrocarbon projects.
- Bharat Petroleum Corporation Limited (BPCL) is a public sector organisation managed by the Ministry of Petroleum and Natural Gas, Government of India.
- Hindustan Petroleum Corporation Limited (HPCL) is a subsidiary of the Oil and Natural Gas Corporation (ONGC).
- Indian Oil Corporation Limited (IOCL) is a public sector organisation managed by the Ministry of Petroleum and Natural Gas, Government of India.
- Oil and Natural Gas Corporation (ONGC) is a public sector organisation managed by the Ministry of Petroleum and Natural Gas, Government of India.
- Reliance Petroleum is India's largest private company owned by Mukesh Ambani, specialising in oil and energy.
- Nayara Energy Limited (earlier Essar Oil Limited) is a private-sector oil and gas company involved in refining, marketing, producing and retailing petroleum products in India.
- The Hydrocarbon Sector Skill Council (HSSC) is an organization based in India that is responsible for developing and maintaining the skill standards for the hydrocarbon sector.
- Biofuels are derived from biomass, which is organic matter sourced from recently living organisms like plants, algae, or waste materials. Unlike fossil fuels that take millions of years to form, biofuels are renewable because their organic sources can be replenished relatively quickly.
- In India, biofuels have garnered significant attention and importance due to their potential to address energy security, foster rural development, and promote environmental sustainability. The Indian government has implemented policies and initiatives to encourage the production and adoption of biofuels across the country.
- 2G ethanol, or second-generation ethanol, is ethanol produced from non-food sources or lignocellulosic biomass. Unlike 1G ethanol, which comes from food crops like corn or sugarcane, 2G ethanol is derived from agricultural residues (e.g., corn stover, wheat straw, rice husks), dedicated energy crops (e.g., switchgrass, miscanthus), wood chips, or other non-food plant materials.
- A 2G ethanol plant is a specialized facility constructed for the purpose of converting lignocellulosic biomass into ethanol. It consists of multiple units and equipment designed to handle biomass, carry out pre-treatment and enzymatic hydrolysis processes, enable fermentation, and conduct distillation and purification steps to produce high-quality ethanol.

- The operation of 2G ethanol plants entails several essential steps, including preparing the biomass feedstock, subjecting it to pre-treatment to enhance its conversion potential, employing enzymatic hydrolysis to break down complex carbohydrates into fermentable sugars, initiating fermentation with the aid of microorganisms, and applying distillation and purification processes to obtain pure ethanol. Additional steps such as dehydration may also be carried out to achieve the desired ethanol concentration.
- 2G ethanol plants in India are facilities dedicated to the production of second-generation ethanol, also known as cellulosic ethanol or advanced biofuel, using non-food biomass feedstocks. India has been actively promoting the development and implementation of 2G ethanol technology to diversify its energy sources, reduce dependence on fossil fuels, and mitigate environmental impact.
- The Indian government has introduced various measures to encourage the production and utilization of biofuels, specifically 2G ethanol, with the goal of reducing reliance on fossil fuels, promoting sustainable development, and mitigating environmental impact. These initiatives demonstrate India's dedication to fostering biofuels as a sustainable and renewable energy solution.
- The establishment of 2G ethanol plants in India signifies the country's commitment to promoting sustainable and renewable energy sources. These plants contribute to the reduction of greenhouse gas emissions, enhance energy security by utilizing biomass feedstocks, and support rural development by creating employment opportunities and reducing dependence on fossil fuels.

Exercise

Answer the following questions:

1. Write a brief note on the hydrocarbon industry and its various sub-sectors.

_____
_____
_____

2. List the different oil and natural gas companies in India.

_____
_____
_____

3. What is biofuel and its types?

_____
_____
_____

4. What is 2G Ethanol?

_____
_____
_____

5. Discuss the roles and responsibilities of the junior operator – 2G ethanol plant.

_____
_____
_____

Fill in the Blanks:

1. Hydrocarbons are chemical compounds composed of _____and _____atoms.
2. _____are the basis of natural gas, crude oil, coal, and other energy sources.
3. The _____ is the face of the company and bridges the gap between the consumers and the company.
4. Unlike _____, which comes from food crops like corn or sugarcane, _____is derived from agricultural residues - e.g., corn stover, wheat straw, rice husks.
5. _____ are derived from biomass, which is organic matter sourced from recently living organisms like plants, algae, or waste materials.

Scan the QR Code to watch the related video

Sub-sectors in Hydrocarbon Industry

youtu.be/6ozmKhahk8M

Biofuels

youtu.be/ZGmwtDffc74

Business Matters | Ethanol blended with petrol | Will India benefit from it?

www.youtube.com/watch?v=QXIv20U3gpQ

How to Start Ethanol Production Business | Highly Demand New Business

www.youtube.com/watch?v=I4tz8NqAI6g

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MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

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National
Skill Development
Corporation
Transforming the skill landscape

HSSC
HYDROCARBON SECTOR
SKILL COUNCIL

2. Assist in carrying out 2G Ethanol plant operations

Unit 2.1 - Bio-mass/Feedstock Storage and Handling

Unit 2.2 - Monitoring and Controlling the 2G Ethanol Production Process Process

Unit 2.3 - Safe and Efficient Operational Procedures

HYC/N4301

Key Learning Objectives

At the end of this module, the participant will be able to:

1. Provide assistance in handling Biomass storage, Feed Stock Handling System- Milling, Conveying and Wet washing
2. Providing assistance in operating 2G ethanol production processes and related equipment
3. Providing assistance in operating safe and efficient operations
4. Follow environmental compliance and sustainability practices

Unit 2.1 - Bio-mass/Feedstock Storage and Handling

Unit Objectives

At the end of the unit, the participant will be able to:

1. Explain how to check and finalize appropriate biomass/feedstock materials based on availability and suitability
2. Describe the importance of biomass storage, handling, and pre-treatment in the 2G ethanol production process

2.1.1 Introduction to 2 G Ethanol Production Processes

2G ethanol, also known as second-generation ethanol, refers to the production of ethanol from non-food-based biomass sources. Unlike first-generation ethanol, which is primarily produced from edible crops such as corn or sugarcane, 2G ethanol production focuses on utilizing agricultural residues, forest residues, dedicated energy crops, or even municipal solid waste as feedstocks. This approach helps to minimize the competition between food and fuel production and promotes the utilization of abundant and renewable biomass resources.

The production of 2G ethanol involves advanced technologies and processes to convert complex carbohydrates, lignocellulosic materials or other non-food biomass into ethanol. These feedstocks often consist of cellulose, hemicellulose and lignin, which require more intricate processes to break them down and extract fermentable sugars for ethanol production.

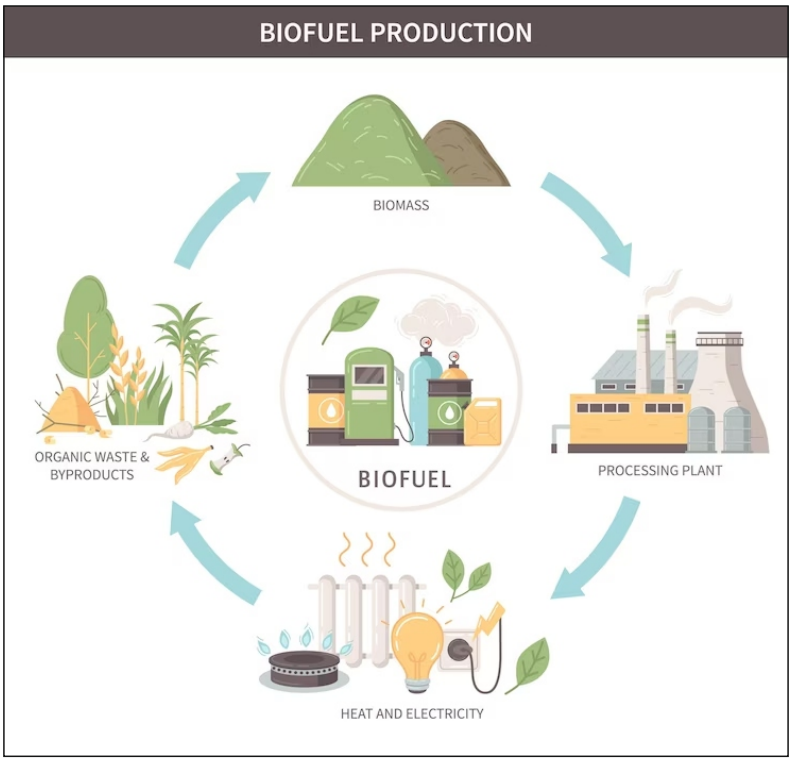


Fig. 2.1 Bio-fuel Production Cycle

Biochemical Conversion for 2G Ethanol Production

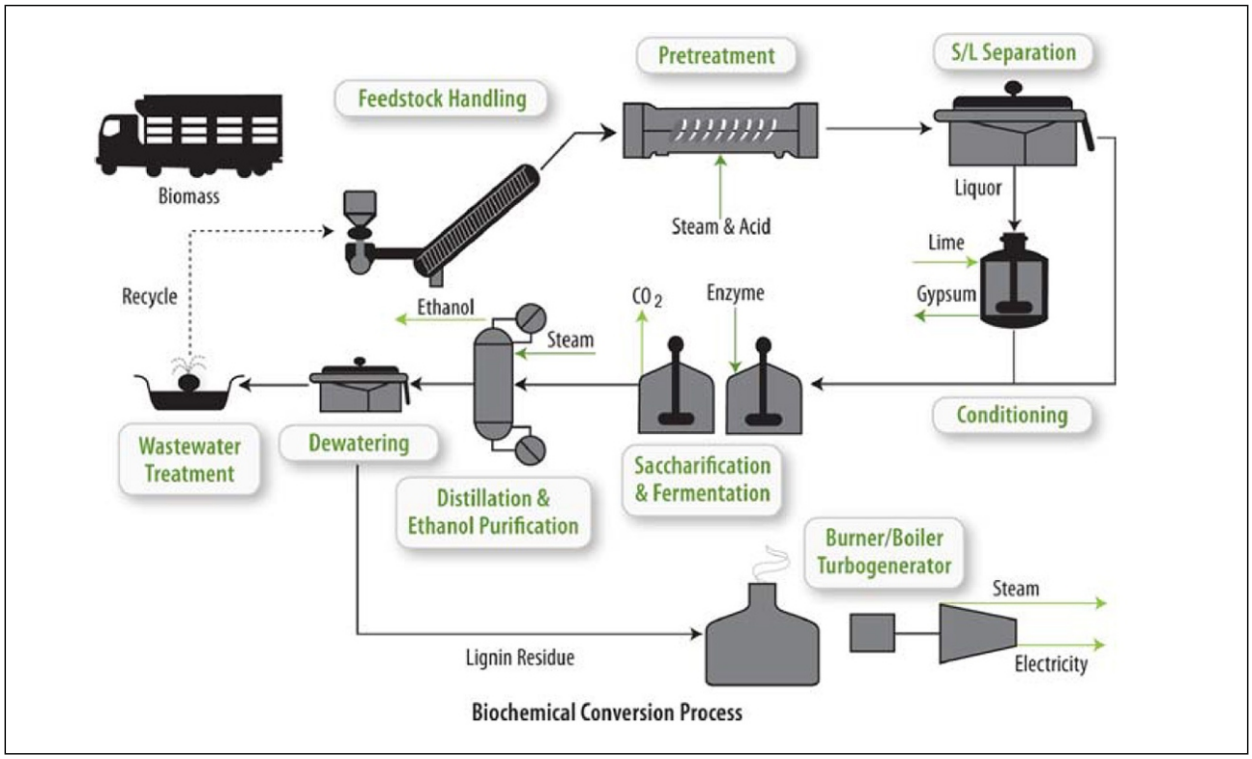


Fig. 2.2 Biochemical Conversion Process
Source: https://www.nrel.gov/bioenergy/biochemical-conversion-techno-economic-analysis.html

Biochemical conversion involves the use of microorganisms or enzymes to break down the complex carbohydrates in biomass into simple sugars, which can then be fermented into ethanol. The key steps in the biochemical conversion process include:

Material Storage and Handling

The biomass/feedstock is collected from various sources, transported and stored for further treatment. The feedstock handling system is used to convey the material for further pre-treatment processes. It consists of processes like size reduction, stone separation, removal of foreign particles and wet washing of the feedstock.

Pre-treatment of Bio-mass/Feedstock

In this step, hydrolysis is carried out to convert Xylan to Xylose in a reactor and fed to the enymatic hydrolysis system. The main aim of this step is to break down the lignin structure and make the cellulose and hemicellulose more accessible for enzymatic hydrolysis. Different methods of pre-treatment are available to achieve this.

Enzymatic Hydrolysis

Enzymes are applied to the pretreated biomass to convert cellulose and hemicellulose into fermentable sugars. Cellulases and hemicelluloses break down complex polymers into glucose, xylose and other sugar monomers.

Continued...

Co-Fermentation

The obtained sugar solution is fermented using yeast or bacteria to convert the sugars into ethanol. Yeast strains such as Saccharomyces cerevisiae or genetically modified microorganisms are commonly used. The fermentation process converts the sugars into ethanol and carbon dioxide.

Distillation and Purification

After fermentation, the ethanol is separated from the fermentation broth through distillation and further purification processes. This involves the removal of water, impurities, and unfermented sugars to obtain high-purity ethanol.

Dehydration

To achieve the desired ethanol concentration (usually around 95%), the ethanol-water mixture obtained from distillation undergoes further purification through molecular sieves or azeotropic distillation processes. These methods remove the remaining water to obtain anhydrous (water-free) ethanol.

Fig. 2.3 Steps Involved in Biochemical Conversion Process

Sections in a 2 G Ethanol Production Plant

The various sections in a 2 G Ethanol production plant are as follows:

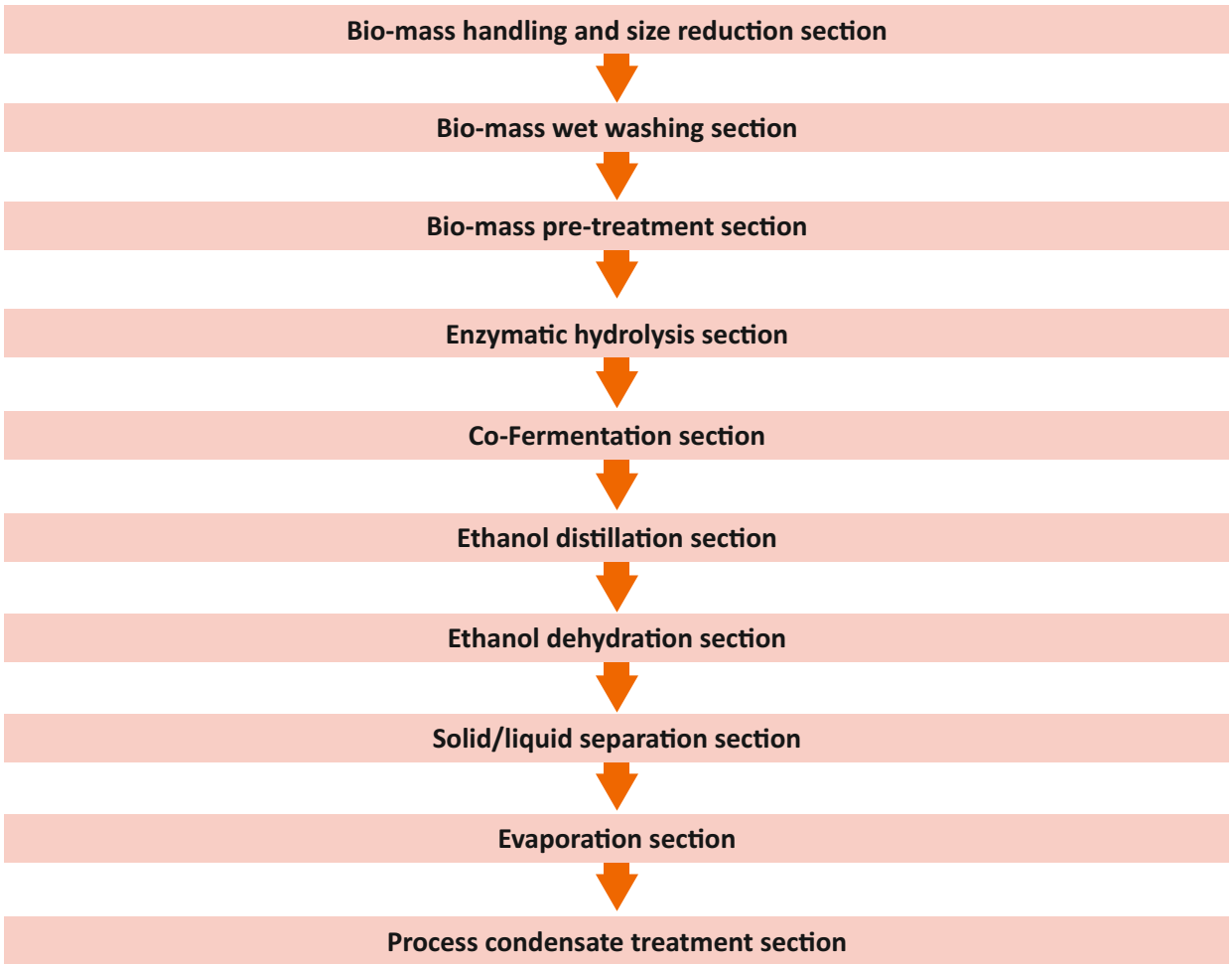


Fig. 2.4 Sections in a 2 G Ethanol Production Plant

2.1.2 Bio-mass/Feedstock Material

2G Ethanol is known by various names such as second-generation fuel, advanced biofuel or cellulosic ethanol as it is produced by cellulose, a plant fibre. The second-generation fuels are produced from various non-edible (non-food) bio-mass/feedstock. The cell wall of plant cells is basically made up of cellulose, which cannot be digested by human beings and most domestic animals. Therefore, instead of wasting these inedible parts of plants, they can be used as the substrate for 2G ethanol production. The primary sources of biomass/feedstock for 2G ethanol production are:

Lignocellulosic biomass from crops that are harvested inedible parts of crops and plants like wheat straw, rice straw, corn stover (stalks, leaves, and cobs), cotton stalks, sugarcane pulp remains after sugar extraction (bagasse), etc.

Other plant sources or energy crops like switchgrass specifically grown for ethanol production in lands unsuitable for agriculture, contaminated land, etc.

Wood wastes that are by-products of the wood industry such as wood chips and sawdust.

Forest residues like branches, bark and tops are obtained from fallen trees, trimmed branches and other forestry operations.

Municipal solid waste includes organic waste from households and commercial establishments such as food, yard and paper wastes.

Fig. 2.5 Primary Sources of Biomass/Feedstock For 2G Ethanol Production

2.1.3 Availability and Suitability of Bio mass/Feedstock Material

Since 2G ethanol can be manufactured from different types of bio-mass/feedstocks, they may need different processing technologies to extract the biofuel from them. The parameters to be considered for the assessment of the suitability of various bio-mass/feedstock for 2G Ethanol production are:

Cellulose Content

The biomass/feedstock should have a high cellulosic content, as this is the primary component that can be converted into ethanol through enzymatic hydrolysis.

Lignin Content

Lignin is a complex polymer that provides structural support to plants. However, it is resistant to breakdown and hampers the enzymatic hydrolysis process. Biomass with lower lignin content is preferable, as it requires less pre-treatment and is more easily converted into ethanol.

Carbohydrate Content

The biomass/feedstock should have a high concentration of fermentable carbohydrates, such as glucose, xylose and arabinose. These sugars can be readily fermented by microorganisms into ethanol. Different feedstocks may have varying sugar compositions, so it is important to assess their carbohydrate content.

Availability and Sustainability

The biomass/feedstock should be readily available in large quantities to ensure a sustainable supply chain. It is essential to consider factors such as crop productivity (Annual yield in tonnes/hectare), land availability, water usage and the environmental impact associated with feedstock cultivation.

Pre-treatment Requirements

Some feedstocks may require pre-treatment processes to make the cellulose more accessible to enzymatic hydrolysis. The severity and cost of pre-treatment should be evaluated to determine the overall feasibility and economics of ethanol production from a particular feedstock.

Specific Conversion Rate to Ethanol (litres/metric tonne)

The conversion rate of biomass to ethanol can vary depending on several factors, including the feedstock used, the specific pre-treatment and hydrolysis processes, fermentation efficiency, and the overall technology employed. Generally, the conversion rate is measured in terms of litres of ethanol produced per metric tonne (l/mt) of feedstock.

Enzymatic Hydrolysis Efficiency

The ease and efficiency of converting the feedstock's cellulose into fermentable sugars through enzymatic hydrolysis are crucial. Some feedstocks may have structures that are more resistant to enzymatic breakdown, requiring additional processing steps or higher enzyme dosages.

Fermentability

The feedstock should be amenable to fermentation by microorganisms, preferably with high ethanol yield and tolerance. Certain feedstocks may contain inhibitors or compounds that hinder fermentation, affecting the overall ethanol production efficiency.

Energy Output/Input Ratio

Assessing the energy inputs and outputs of the feedstock-to-ethanol conversion process is important. The feedstock should provide a positive energy balance, meaning that the energy output in the form of ethanol should exceed the energy input required for cultivation, harvesting, transportation, pre-treatment, and conversion.

Annual Ethanol Yield (litres/hectare)

The annual ethanol yield in litres per hectare (l/ha) can vary depending on the feedstock, cultivation practices, climate conditions, and the efficiency of the ethanol production process.

Economic Feasibility

The economic feasibility of producing ethanol from a specific feedstock should be considered. Factors such as feedstock cost, conversion efficiency, capital investment, operational costs, and market demand for ethanol influence the overall profitability of the production process.

Fig. 2.6 Parameters for Assessment of Suitability of Feedstock for 2G Ethanol Production

The following template can be used to note down all the parameters to assess suitability of feedstock for 2G ethanol production:

Type of Bio-mass/Feedstock	Sugarcane Bagasse	Agricultural Residue (Straw/Corn Stover)	Energy Crops	Wood Waste	Forest Residues	Municipal Solid Waste
Cellulose Content %	35-42	34-38	35-40	40-44	30-50	20-30
Hemicellulose Content %	18-25	17-25	20-30	25-35	15-35	5-15
Lignin Content %	20-24	15-20	12-18	20-30	10-20	5-15
Conversion Rate to Ethanol (l/MT)	300-400	200-250	250-300	200-300	200-250	100-150
Pre-treatment requirement	Mechanical, Dilute acid pre-treatment, Steam Explosion	Mechanical, Alkaline pre-treatment, Steam Explosion	Mechanical, Alkaline pre-treatment, Steam Explosion	Mechanical, Organosolv/ Acid pre-treatment, Steam Explosion	Mechanical, Organosolv/ Acid pre-treatment, Steam Explosion	Mechanical sorting and biological pre-treatment

Continued...

Type of Bio-mass/Feedstock	Sugarcane Bagasse	Agricultural Residue (Straw/Corn Stover)	Energy Crops	Wood Waste	Forest Residues	Municipal Solid Waste
Enzymatic Hydrolysis Efficiency %	70-90	50-80	50-80	60-90	40-70	30-70
Fermentability	High	Medium	Medium	Medium	Medium	Low
Energy Output/Input Ratio (EROI)	8:1 to 20:1	5:1 to 10:1	5:1 to 15:1	5:1 to 10:1	4:1 to 10:1	1:1 to 5:1
2G Ethanol Yield (l/T)	100-250	50-150	120-260	50-180	80-200	10-50

Table 2.1 Sample Template to Assess Availability and Suitability of Feedstock for 2G Ethanol Production

The following table shows the approximate conversion rates of commonly used bio-mass/feedstocks in 2G ethanol production:

Type of Bio-mass/Feedstock	Lignocellulosic Biomass		Energy Crops	Wood Waste	Forest Residues	Municipal Solid Waste
	Sugarcane Bagasse	Agricultural Residue (Straw/Corn Stover)				
Approximate Conversion Rate in litres/metric tonne (l/mt)	300-400	200-250	250-300	200-300	200-250	100-150

Table 2.2 Conversion Rates of Bio-mass/Feedstock

The following table shows the approximate ethanol yield ranges of commonly used bio-mass/feedstocks in 2G ethanol production:

Type of Bio-mass/Feedstock	Sugarcane	Corn	Energy Crops
Approximate Ethanol Yield in litres/hectare (l/ha)	4,000-6,000	600-800	3,000-5,000

Table 2.3 Ethanol Yield of Bio-mass/Feedstock

2.1.4 Feedstock Handling and Storage Systems

Feedstock handling

Fig. 2.7 Feedstock Conveyor System

The first step in the ethanol production process involves conveying the feedstock, which refers to the transportation or movement of the raw materials used for ethanol production. The various types of conveyor systems used for handling and transporting feedstock are belt conveyors, screw conveyors, chain conveyors, pneumatic conveyors, chutes, bucket elevators, etc. and hoods used for dust extraction. The selection of the appropriate conveyor system depends on factors such as the characteristics of the feedstock, the distance of transportation and the specific layout of the production facility. Efficient conveyor systems ensure smooth material flow, minimize manual handling and improve the productivity of the production unit.

Next, the feedstock may undergo a de-stoning and screening process. De-stoning involves removing unwanted solid materials like seeds, stones, pebbles, etc. that may be present in the feedstock. This is important to prevent damage to equipment and ensure the quality of the final product. Screening involves the separation of larger particles or impurities from the feedstock using a mesh or sieve. This helps to achieve a more uniform and consistent feedstock size, which can improve the efficiency of subsequent processing steps.

In addition to de-stoning and screening, magnetic particle separation is used to separate magnetic particles from the feedstock. Magnetic separators are used to attract and remove ferrous or magnetically susceptible materials, such as metal fragments or particles, from the feedstock. This helps to ensure the purity and quality of the feedstock, minimizing the presence of contaminants that could negatively impact the ethanol production process.

Storage of feedstock

Fig. 2.8 Storage of Feedstock

Long-term storage plays a vital role in the biomass feedstock logistics supply chain, enabling biorefineries to operate consistently throughout the year, regardless of fluctuations in feedstock availability on a daily, monthly or seasonal basis. Effective storage methods are essential to preserve biomass and prevent uncontrolled losses due to microbial degradation. Inadequate storage conditions can result in challenges related to biomass handling, size reduction, pre-processing, and overall conversion processes. The conversion of biomass feedstocks into fuels involves various unit operations, including supply and logistics operations such as harvesting, collection, transportation, storage, and formatting. Harvesting can occur annually (e.g., corn, wheat, sorghum), perennially (e.g., switchgrass, miscanthus), or over multiple years (e.g., willow, pine). For agricultural residues like corn stover, common practices involve dry, baled logistics systems. The grain fraction is typically harvested together with the biomass residue. Windrows, formed either during or after harvest, facilitate stable storage conditions by drying the biomass in the field. The biomass is then collected into bales, which are stored either alongside the fields or at centralized locations until further use. To meet the particle size requirements of biorefineries, size reduction of biomass may occur at the biorefinery or at biomass feedstock depots. To improve the densification of biomass into low-moisture pellets, guarantee stable storage, and save transportation costs, depot concepts have been put forth. These depots serve as intermediate locations for biomass processing and preparation before it reaches the biorefinery.

The two common methods of bio-mass storage are:

1. Dry Storage System

The dry storage systems are used to provide a stable storage solution over extended periods. The current practice for field-side storage of agricultural residues involves bale stacks covered with tarps to prevent moisture accumulation from rain. To prevent soil moisture absorption, it is recommended to use improved surfaces underneath the bottom bales. Bale-based storage can effectively maintain biomass stability under optimal conditions but requires careful management to ensure stable storage conditions.

2. Wet Storage System

On the other hand, wet storage systems offer an alternative approach to feedstock supply logistics, drawing inspiration from established practices in the forage industry. Wet, anaerobic storage systems, known as ensiling, have consistently demonstrated successful preservation of biomass for long-term storage in livestock feed and forage applications. Wet biomass logistics systems have been used for corn stover to address concerns about the risk of fires causing terrible loss of stacked biomass. Here, the herbaceous biomass is chopped in the field at moisture contents ranging from 40% to 65% (wet basis), and the chopped biomass is transported in silage trucks. Anaerobic storage systems such as silage bags, bunkers or drive-over piles are utilized to limit oxygen exposure and preserve the biomass. When anaerobic conditions are maintained, ensiled biomass can remain stable for long periods.

Type of Bio-mass/Feedstock	Dry Storage	Wet Storage
Straw	✓	
Corn Stover	✓	✓
Energy Crops	✓	✓
Sugarcane Bagasse		✓

Table 2.4 Storage Methods of Bio-mass/Feedstock

Modifications in the Storage Systems

In the feedstock industry, it is common practice to make modifications to biomass before anaerobic storage in order to enhance stability. The objective of these modifications is to create a low pH environment that promotes stable storage and preserves the desirable qualities of the feedstock. These modifications can involve the direct application of acids or alkali to the biomass or microbial changes aimed at encouraging specific fermentation pathways. Both of these approaches have proven effective in reducing storage losses.

Wet-washing of feedstock

The washing process takes place at normal room temperatures. The wet-washed and appropriately sized feedstock is transferred from the wet-washing system to the pre-treatment section using a belt or chain conveyor. The water used for washing is directed to the clarification section for recycling. The clarified water is reused in the washing process, while the sediment settled at the bottom of the clarifier will be sent for water recovery in the evaporation section.

2.1.5 Pre-treatment Procedures to Prepare Feedstock for Fermentation

Pre-treatment procedures are essential in preparing feedstock for fermentation in 2G ethanol production. These procedures aim to enhance the accessibility and digestibility of the biomass by breaking down complex structures and reducing inhibitory compounds. Some of the common pre-treatment methods used in the preparation of feedstock for fermentation are:

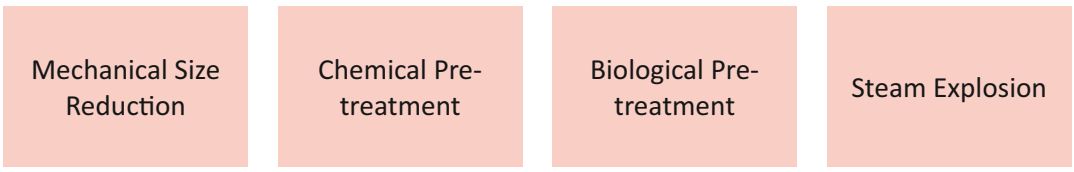


Fig. 2.9 Pre-treatment Methods to Prepare Feedstock for Fermentation

I. Mechanical Size Reduction

Feedstock is often subjected to mechanical size reduction techniques such as milling, grinding, or chopping. Mechanical size reduction is an important pre-treatment procedure used to prepare biomass for fermentation in 2G ethanol production. This process involves reducing the particle size of the biomass, which enhances its surface area and facilitates enzymatic access to the cellulose and hemicellulose components. The selection of the mechanical size reduction method depends on the properties of the biomass, desired particle size and the equipment available. Proper size reduction of the biomass improves

the efficiency of subsequent enzymatic hydrolysis, allowing for better release of fermentable sugars for fermentation into ethanol. Some of the common methods of mechanical size reduction are:

Milling	Milling involves the use of equipment such as hammer mills, attrition mills or ball mills to grind biomass into smaller particles. The biomass is fed into the mill, where it is subjected to mechanical forces that break it down into finer fragments. Milling can be adjusted to achieve the desired particle size distribution.
Grinding	Grinding is similar to milling but typically involves finer particle size reduction. It is commonly performed using equipment such as grinders, pulverisers or knife mills. The biomass is passed through the grinding equipment, where it is crushed and pulverised into smaller particles.
Chopping	Chopping is a mechanical size reduction method used for fibrous or stalky biomass, such as corn stover or sugarcane bagasse. It involves cutting the biomass into smaller pieces using specialized equipment, such as feedstock choppers or shredders. Chopping improves the accessibility of cellulose and hemicellulose by reducing the length and size of the fibrous materials.

Fig. 2.10 Mechanical Methods to Prepare Feedstock for Fermentation

II. Chemical Pre-treatment

Chemical pre-treatment involves the application of chemicals to the biomass to disrupt its structure, remove inhibitory compounds and increase the accessibility of cellulose and hemicellulose for enzymatic hydrolysis. The selection of the chemical pre-treatment method depends on factors such as the biomass type, composition and desired fermentation outcomes. Each method has its advantages and disadvantages in terms of effectiveness, cost and environmental impact. Chemical pre-treatment aims to optimize the release of fermentable sugars from biomass, enhancing the efficiency and yield of ethanol production during fermentation. The common chemical pre-treatment methods include:

Acid Hydrolysis	Acidic solutions such as sulphuric acid or hydrochloric acid are used to hydrolyse hemicellulose and disrupt lignin, making cellulose more accessible to enzymes. This process releases sugars from the biomass for fermentation. The acid breaks the glycosidic bonds between the sugar units, releasing fermentable sugars that can be subsequently converted into ethanol during fermentation.
Alkaline Pre-treatment	Alkaline solutions such as sodium hydroxide or ammonium hydroxide are applied to remove lignin and improve the enzymatic digestibility of cellulose and hemicellulose. Alkaline pre-treatment increases the availability of fermentable sugars for ethanol production.
Organosolv Pre-treatment	Organic solvents such as ethanol or methanol along with acid or alkali are used to dissolve lignin and break down the biomass structure. Organosolv pre-treatment can improve enzymatic digestibility and increase the release of fermentable sugars.

Continued...

Ozonolysis	Ozonolysis is a chemical pre-treatment method that utilizes ozone gas to break down lignin and disrupt the biomass structure. Ozone reacts with lignin, oxidizing it and making the cellulose more accessible to enzymes. Ozonolysis has shown promise in improving the efficiency of enzymatic hydrolysis and subsequent ethanol production.

Fig. 2.11 Chemical Pre-treatment Methods to Prepare Feedstock for Fermentation

III. Biological Pre-treatment

Biological pre-treatment involves the use of microorganisms or enzymes to degrade or modify the biomass. This method utilizes specific fungi or bacteria that produce enzymes capable of breaking down lignocellulosic components. Biological pre-treatment can enhance the accessibility of cellulose and hemicellulose, improving overall fermentation efficiency. Biological pre-treatment methods offer the advantage of being environmentally friendly and can be tailored to specific biomass types. Some of the common biological pre-treatment methods used in 2G ethanol production are:

Fungal Pre-treatment	Certain fungi, such as white-rot fungi (Phanerochaete chrysosporium), are capable of degrading lignin in the biomass. These fungi produce enzymes, including ligninolytic enzymes like lignin peroxidase, manganese peroxidase, and laccase, which can break down lignin and modify the biomass structure. Fungal pre-treatment can enhance the digestibility of cellulose and hemicellulose, leading to increased sugar release during fermentation.
Bacterial Pre-treatment	Certain bacteria, such as cellulolytic bacteria (Clostridium thermocellum), produce cellulases and other enzymes capable of degrading cellulose and hemicellulose. Bacterial pre-treatment involves the cultivation of these bacteria on the biomass substrate, allowing them to secrete enzymes that break down the complex polysaccharides into fermentable sugars.
Enzymatic Pre-treatment	Enzymatic pre-treatment utilizes commercially available enzymes or enzyme cocktails to degrade the lignocellulosic components of the biomass. Cellulases, hemicelluloses, and lignin-modifying enzymes are applied to the biomass, facilitating the breakdown of cellulose, hemicellulose, and lignin. Enzymatic pre-treatment can enhance the accessibility of sugars, improving the efficiency of subsequent fermentation.
Composting	Composting involves the controlled decomposition of biomass by microbial activity under aerobic conditions. This process helps to partially degrade lignin and other complex compounds, making the biomass more amenable to enzymatic hydrolysis. Composting can enhance the bioavailability of cellulose and hemicellulose, increasing the efficiency of ethanol production.

Fig. 2.12 Biological Pre-treatment Methods to Prepare Feedstock for Fermentation

IV. Steam Explosion

Steam explosion is a widely used method for preparing biomass for fermentation in 2G ethanol production. Steam explosion involves subjecting biomass to high-pressure steam followed by a sudden release of pressure. This process ruptures the biomass structure, making it more susceptible to enzymatic hydrolysis. Steam explosion pre-treatment increases the digestibility of cellulose and hemicellulose. The steps involved in steam explosion pre-treatment are:

Biomass Preparation

The biomass is first ground or chipped to a suitable particle size to increase its surface area and facilitate the penetration of steam during the pre-treatment process.

Steam Treatment

The biomass is then exposed to high-pressure steam at temperatures typically ranging from 160 to 260 degrees Celsius. The steam penetrates the biomass, causing the temperature and pressure to rise rapidly.

Rapid Depressurization

After a specified time, the pressure is rapidly released, causing the biomass to undergo explosive decompression. This sudden release of pressure causes the biomass to rupture, resulting in the disruption of its lignocellulosic structure.

Effects of Steam Explosion

Steam explosion pre-treatment has several beneficial effects on biomass. It causes the breakdown of lignin, making the cellulose and hemicellulose more accessible to enzymes during enzymatic hydrolysis. It also increases the porosity of the biomass, facilitating the penetration of enzymes and improving the efficiency of sugar release.

Solid-Liquid Separation

After the steam explosion, the pretreated biomass is typically separated from the liquid fraction. The liquid fraction may contain solubilized sugars, degradation products and other compounds that can be further processed or treated as desired.

Fig. 2.13 Steam Explosion Process to Prepare Feedstock for Fermentation

2.1.5 Pre-treatment Procedures to Prepare Feedstock for Fermentation

Safety controls and instrumentation help to ensure safe and efficient operations during the pre-treatment processes. Automatic operation systems are implemented to monitor and control various parameters throughout the pre-treatment process. These systems use sensors, controllers and actuators to automate critical functions such as feedstock flow, temperature control, pressure regulation and valve operation. By automating these processes, it reduces the risk of human error and enables consistent and reliable operation while enhancing safety.

Weighing systems are employed to accurately measure the quantity of feedstock and other additives during the pre-treatment process. This system incorporates various weighing systems like load cell, belt-scale, batch and tank weighing systems that provide real-time feedback on the mass or volume of materials being added or processed. By maintaining precise control over the input quantities, the weighing system ensures the proper feedstock-to-additive ratios and helps optimize the efficiency and effectiveness of the pre-treatment process. A weighbridge is commonly used as a weighing system to measure the weight of incoming and outgoing vehicles carrying feedstock, biomass, or other materials. A weighbridge, also known as a truck scale or a weigh station, is a heavy-duty platform designed to accurately measure the weight of vehicles and their cargo.

A vibratory screen system is utilized to separate and classify feedstock particles based on size. It consists of vibrating screens or sieves that utilize vibration or mechanical agitation to separate materials into different size fractions. This helps to ensure uniformity and consistency in particle size distribution, which is crucial for downstream processing steps. The vibratory screen system enhances process efficiency and minimizes the risk of equipment blockages or disruptions.

Unit 2.2 Monitoring and Controlling the 2G Ethanol Production Process

Unit Objectives

At the end of the unit, the participant will be able to:

1. Describe the process of enzymatic hydrolysis and co-fermentation techniques
2. Explain how to operate distillation and dehydration equipment to separate and purify ethanol
3. Explain the procedures for solid-liquid separation, evaporation, and condensate treatment in residue handling

2.2.1 Enzymatic Hydrolysis Process

During the pre-treatment process prior to enzymatic hydrolysis, the conversion of Xylan into Xylose takes place in a reactor where a slurry with a concentration of approximately 18% to 20% is maintained. To meet the necessary demands, a mixed acid solution is continuously supplied. The slurry undergoes treatment at temperatures ranging from about 160 to 190 degrees Celsius and a pressure of 10 to 12 bar. Once the reactor process is complete, the slurry is subjected to a Flash Vessel, followed by transfer to the Enzymatic Hydrolysis section. The water obtained from the steam flashing process is recycled back into the overall production process.

The pre-treated slurry is introduced into the pre-hydrolysis reactor. In this reactor, specific reaction conditions are maintained, including a pH range of 5.0 to 5.5, a temperature of approximately 50 to 55 degrees Celsius, and atmospheric pressure, before the addition of enzymes. Enzymes are added to the reactor in the necessary dosage. The reaction continues within the pre-hydrolysis reactor for several hours. Subsequently, the contents are transferred to the main hydrolysis reactor for further processing.

The enzymatic hydrolysis process occurs over a certain duration, usually ranging from several hours to a day or more. During this time, the enzymes break down the cellulose and hemicellulose into soluble sugars, primarily glucose and xylose. Enzymes work by slicing the glycosidic bonds present in the polysaccharides and releasing the sugar units.

Enzymes are expensive and valuable components in the hydrolysis process. To improve cost-effectiveness, enzyme recycling systems are often implemented. After the initial hydrolysis, the liquid fraction containing the sugars is separated from the solid residue (cellulose residue). The liquid is further processed for ethanol fermentation, while the solid residue may undergo additional enzymatic hydrolysis cycles to extract as much sugar as possible.

2.2.2 Co-Fermentation Process

The fermentation process allows for the efficient conversion of a variety of sugars, including glucose and xylose, into ethanol. Modified organisms (GMO), in the form of Genetically Modified Activated Dry Yeast (ADY) is combined with water in a yeast slurry preparation tank. This yeast slurry is then transferred to a pre-fermenter for further propagation. The slurry obtained from the hydrolysis reactor, which is rich in sugars, is cooled to a temperature range of 32 to 34 degrees Celsius and introduced into the fermenter. Pre-fermenters are also utilized for yeast propagation, and various nutrients are added in specific dosages as required. The volume from the pre-fermenter is subsequently transferred to the main fermenter for the fermentation process.

Once the desired alcohol content is achieved, the fermented wash is moved from the fermenter to a beer well, and from there, it is transferred to the distillation section for further processing. The carbon dioxide (CO_2) generated during fermentation is safely released through a GMO filter at a designated location. This ensures that any potential contaminants or unwanted particles are removed before the CO_2 is vented.

2.2.3 Distillation Process

The distillation process in 2G ethanol production separates and purifies ethanol from the fermentation or hydrolysis products. It involves using distillation columns to separate components based on their boiling points. The feed solution is preheated and introduced at the bottom of the column, where lower boiling point components vaporize and rise through the stages. Vapour-liquid separation occurs, and the ethanol-rich vapour is condensed and collected as purified ethanol. Impurities are removed as by-products, and additional purification steps may be taken to enhance ethanol quality. To produce fuel-grade ethanol, the fermented mash from the co-fermentation section is distilled and dehydrated.

A split distillation process is carried out, which consists of the stripping and rectification sections.

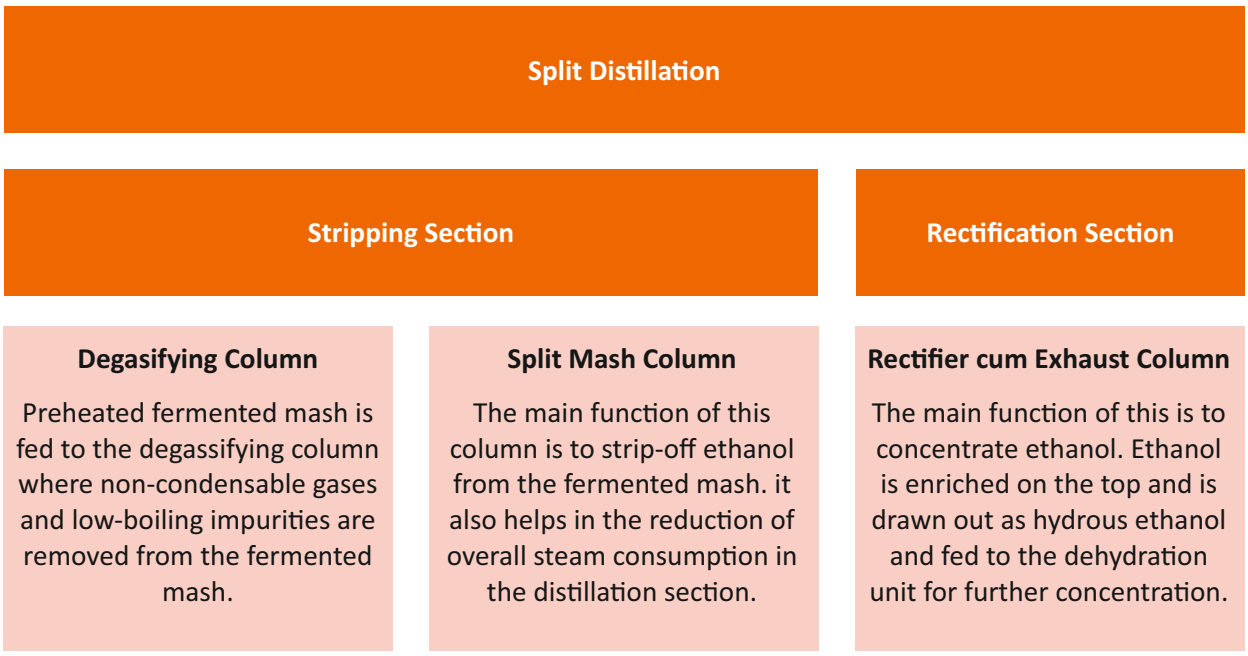


Fig. 2.14 Distillation Process

2.2.4 Dehydration Process

The dehydration process involves passing the rectified feed through a series of molsieve beds. Molsieve which are specialized adsorbent beds designed to selectively remove water from the ethanol solution. Molsieves, such as molecular sieves or zeolites, have a high affinity for water molecules, allowing them to be adsorbed while leaving behind ethanol. To ensure continuous operation and bed regeneration, twin beds are used, with one bed in dehydration mode while the other undergoes regeneration. The timing of the dehydration-regeneration exchange is determined by set time cycles and depends on the specifications of the feed and product. During the regeneration process, the adsorbed water and ethanol content are released and recycled back into the system for reprocessing. The feed is pumped into the Vapouriser Tank. The vapour from the overhead of the vaporizer tank is superheated to the required operating temperature in a superheater and then circulated to sieve bed 1, which is assumed to be in dehydration mode. After passing through the molsieve, the vapour is condensed. The regeneration operation facilitates the release of moisture from the molsieve, preparing sieve bed 2 for the next cycle.

The condensed liquid is directed to a simmering column to improve the quality of the product by removing low-boiling impurities from the fuel-grade ethanol. The bottom product of the simmering column is considered fuel-grade ethanol and is sent to storage after being cooled. The low-boiling impurities separated from the top of the simmering column are sent to a technical alcohol storage tank as a by-product.

2.2.5 Solid-liquid Separation Process

Solid-liquid separation is a vital process in 2G ethanol production that involves separating solid materials from liquid solutions. The process typically includes feed preparation, settling tanks for gravity-based separation, filtration methods like centrifugation or vacuum filtration, centrifugation for enhanced separation, drying to remove moisture from the separated solids, and appropriate disposal or utilization of the solid residue. Solid-liquid separation improves the quality of the liquid phase, ensuring the production of high-quality ethanol and the smooth operation of subsequent stages in ethanol production.

The spent mash from the distillation unit is pumped to the solid-liquid separation section. The liquid stream (Thin Slop) should be supplied to the evaporation section, and the solid stream should be used as a feed to the boiler.

2.2.6 Evaporation Process

The Thin Slop undergoes further concentration through water evaporation in evaporators, resulting in the production of concentrated syrup. This concentrated syrup is then mixed with the solid stream obtained from solid-liquid separation before being fed into the boiler.

Evaporators are specialized equipment designed to facilitate the removal of water through vaporization. Evaporators can be of various types, such as single-effect, multi-effect, or falling film evaporators, depending on the specific requirements of the production facility. Heat is applied to the feed solution in the evaporator, typically through steam or hot water to raise its temperature. The heat energy causes the water in the solution to evaporate and form vapour. The evaporated water vapour is separated from the remaining liquid components. This separation can be achieved using techniques such as vapour-liquid separators or distillation columns, where the water vapour is condensed and collected.

The final product of the evaporation process is a concentrated syrup with a higher concentration of the desired components such as ethanol and other valuable compounds.

The condensed water, known as condensate, undergoes further treatment. Some portion of the condensate is recycled back into the process to conserve water and minimize waste. The remaining condensate may be sent to polishing units or water treatment facilities for additional purification before disposal or reuse.

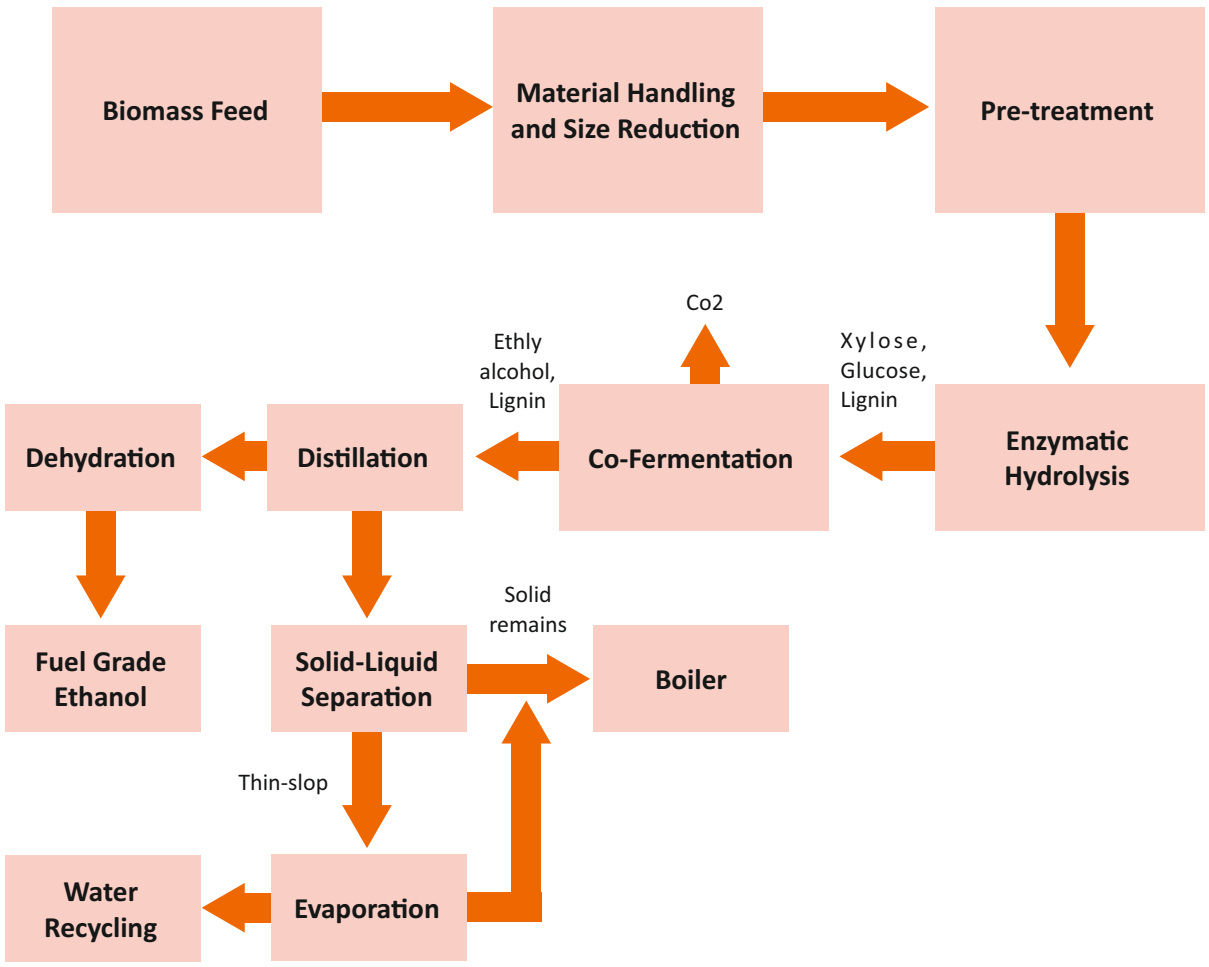


Fig. 2.15 Flow Chart of 2G Ethanol Production Process

2.2.7 Condensate Polishing Treatment

The purpose of condensate polishing treatment is to ensure the quality and purity of the condensed water before it is reused or discharged. This treatment step focuses on removing residual dissolved solids, organic matter, suspended particles, and other impurities present in the condensate. The condensed water from the evaporation plant will undergo treatment using anaerobic and aerobic biological processes, along with separation in a condensate polishing unit. The treatment involves filtration, ion exchange, adsorption, and chemical processes to remove dissolved solids, organic matter, suspended particles, and contaminants. Regular monitoring ensures compliance with quality standards. After treatment, the processed condensate will be directed outside the battery limit (OSBL) to be used for utility makeup or can be reused for various purposes within the production facility or discharged if it meets environmental regulations. The sludge generated during the biological process will be utilized as fertilizer for agricultural fields.

Unit 2.3 Safe and Efficient Operational Procedures

Unit Objectives

At the end of the unit, the participant will be able to:

1. Explain the safe handling of utility systems, including boilers, water treatment plants, and cooling towers
2. Describe the significance of product storage, inventory management, and quality control in ethanol production
3. Follow safety protocols and emergency response procedures, including fire-fighting systems
4. Explain the role of control systems (DCS) and electrical systems in maintaining plant operations
5. Describe the functions and utilization of fire-fighting systems and weighbridges
6. Explain reporting logs, finding and faults to the Senior Operator

2.3.1 Safe Operations and Handling of Utility Systems

Safe operations and handling of utility systems like boilers, water treatment plants and cooling towers are essential for multiple reasons. These include safeguarding employee safety, preventing equipment damage, promoting energy efficiency, protecting the environment and ensuring regulatory compliance. By adhering to safety protocols and guidelines, organizations can minimize accidents, injuries and occupational hazards. Proper handling techniques reduce equipment failures, prolong asset lifespan and minimize maintenance costs. Energy efficiency is improved through optimized fuel consumption and reduced energy waste. Safe operations also contribute to environmental protection by minimizing pollutant emissions and the release of contaminants. Compliance with regulations is crucial to avoid legal consequences and penalties.

The following safety features have to be ensured while handling utility systems to protect workers, equipment and the environment and prevent accidents:

Training and Certification

Properly train and certify personnel on utility systems safety and operations

Compliance with Regulations

Adhere to safety regulations and codes through regular inspections

Risk Assessment

Conduct a thorough risk assessment and implement mitigation measures

Installation and Maintenance

Follow manufacturer guidelines and perform regular maintenance

Safety Devices and Controls

Equip boilers with appropriate safety devices and regularly test them

Chemical Handling and Storage

Ensure proper handling, storage and labeling of chemicals used plant

Continued...

Adequate Ventilation Maintain proper ventilation to remove harmful gases and fumes	**Emergency Preparedness** Establish emergency procedures and provide necessary fire suppression equipment	**Personal Protective Equipment (PPE)** Provide workers with suitable PPE and train them on its usage
Regular Monitoring and Inspections Monitor boiler operations and conduct inspections	**Continuous Monitoring and Alarms** Install monitoring systems and alarms to detect any abnormal conditions	**Documentation and Record Keeping** Maintain accurate records of operations, maintenance and safety procedures

Fig. 2.16 Safety Features to be Ensured while Handling Utility Systems

Safe operations of boilers

The solid fuel-fired boiler package is commonly employed to fulfil the plant's steam needs. The boiler produces high-pressure steam, which is distributed to the process plant through a steam distribution network. To lower the steam pressure as needed, a Pressure Reduction De-Superheater (PRDS) system is utilized. Additionally, a portion of the condensate generated by the process plant is returned back to the boiler package.

The boiler package comprises the following:

- **Complete boiler system including combustion system, super-heaters, evaporators, air pre-heaters and economisers**
- **Boiler feed water system including a pressurized de-aerator tank, boiler feed water pump and chemical dosing system**
- **Fuel and ash handling system**
- **Pollution control system**
- **Chimney and balanced draft system**
- **Electrical and instrumentation system**

Fig. 2.17 Boiler Package in 2G Ethanol Plant

The operational process of boilers in 2G ethanol plants involves several steps to ensure efficient and safe production. Some of the operational process of boilers in 2G ethanol plants are :

Startup

Prior to starting the boiler, a pre-startup inspection is conducted to ensure all safety devices are in place and functional. The fuel supply and ignition systems are prepared and the boiler is brought up to the desired operating pressure and temperature.

Fuel Supply

The boilers in 2G ethanol plants typically use biomass as a fuel source, such as agricultural residues or dedicated energy crops. The biomass is processed and stored in a designated area. It is then fed into the boiler through a fuel delivery system, such as a conveyor or auger, ensuring a steady and controlled fuel supply.

Combustion

The fuel is ignited within the boiler's combustion chamber, where it undergoes a controlled combustion process. The combustion produces heat, which is transferred to the water circulating within the boiler's tubes or pipes.

Heat Transfer

The heat generated from the combustion process is transferred to the water or steam circulating within the boiler. This heat transfer occurs through conduction, convection and radiation, increasing the temperature of the water or generating steam.

Steam Generation

In 2G ethanol plants, the primary purpose of boilers is to generate steam. The high-pressure steam produced in the boiler is collected and directed to the steam distribution system for various applications within the plant, such as process heating, distillation or power generation.

Boiler Controls

The operation of boilers is regulated and controlled through a sophisticated control system. The control system monitors and adjusts factors such as fuel supply, combustion air flow, water level, pressure and temperature to maintain safe and efficient boiler operation.

Safety Measures

Boilers are equipped with various safety devices and controls to ensure safe operation. These include pressure relief valves, flame safeguards, water level controls, temperature controls and emergency shutdown systems. Regular inspections and maintenance are conducted to ensure the safety devices are in working order.

Water Treatment

Proper water treatment is essential to prevent scaling, corrosion, and fouling within the boiler. Water treatment processes, such as softening, demineralization or chemical treatment, are employed to remove impurities and maintain the water quality within acceptable limits.

Continued...

Continuous Monitoring

Boiler operations are continuously monitored to ensure optimal performance and identify any issues or abnormalities. Parameters such as pressure, temperature, fuel consumption, emissions and water quality are regularly monitored and recorded.

Maintenance and Cleaning

Regular maintenance and cleaning of the boiler are crucial to ensure its efficiency and longevity. This includes periodic inspections, cleaning of heat transfer surfaces, replacement of worn-out components and adherence to maintenance schedules provided by the manufacturer.

Fig. 2.18 Operational Process of Boilers

The following figure shows the various activities in the boiler operations, risk associated with them and ways to mitigate and control them:

Working near boiler

- **Associated hazard:** Heat and noise
- **Risk rating:** Medium to high
- **Impact on health**: Burns, and hearing impairment
- **Measures to mitigate and control risk:** Proper training and use of PPE

Boiler maintenance

- **Associated hazard:** Mechanical hazard
- **Risk rating:** Medium
- **Impact on health:** Electrocution and physical injuries
- **Measures to mitigate and control risk:** Proper training and use of PPE, montoring leakages

High-pressure steam leakage from steam pipes and boilers

- **Associated hazard:** Burns
- **Risk rating:** High
- **Impact on health:** Burn injuries
- **Measures to mitigate and control risk:** Use of PPE, regular inspection and maintenance, availability of first aid kit in close proximity

Boiler maintenance

- **Associated hazard:** Mechanical hazard
- **Risk rating:** Medium
- **Impact on health:** Electrocution and physical injuries
- **Measures to mitigate and control risk:** Proper training and use of PPE, montoring leakages

Incomplete combustion of fuel in boiler

- **Associated hazard:** Asphyxiation from carbon monoxide
- **Risk rating:** High
- **Impact on health:** Fatal damage
- **Measures to mitigate and control risk:** Online monitoring of carbon monoxide, regular monitoring of boiler combustion section and flue gas outlet

High-pressure steam

- **Associated hazard:** Explosion
- **Risk rating:** High
- **Impact on health:** Severe burn injuries, damage to equipment
- **Measures to mitigate and control risk:** Use of PPE, regular inspection and maintenance, storage areas of raw material and flammable materials should be away from boiler, adequate fire fighting systmes and first-aid

Content Source: M/s Bharat Plus Ethanol Pvt. Ltd.

Fig. 2.19 Hazards, Risks and Measures to Control and Mitigate Risks Related to Boilers

Safe operations of water treatment plants

Raw water is pumped to various parts of the plant to meet the process and other requirements. It is used for the following purposes:

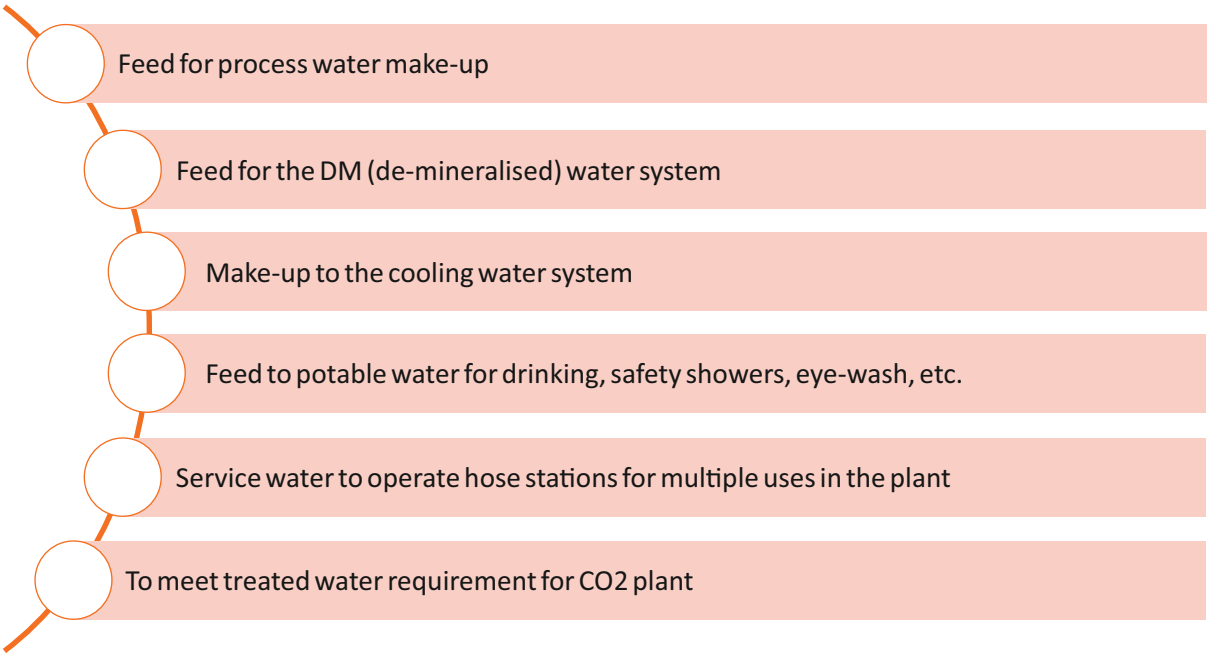


Fig. 2.20 Uses of Raw Water in 2G Ethanol Plant

De-Mineralized water in 2G Ethanol Plant is required for the boiler feed water make-up for the generation of steam. The water from blow-down of boiler and cooling tower is treated through reverse osmosis (RO) and recycled.

To ensure the quality and suitability of water for the above purposes within the plant, the following operations are carried out in the water treatment plant:

Intake and Pre-Treatment

Raw water is drawn from a source such as a river, well or municipal supply. It undergoes pre-treatment processes to remove large particles, debris and sediment through screening, filtration or sedimentation.

Clarification

The pre-treated water enters a clarification unit where chemicals or coagulants are added to facilitate the settling of suspended solids. This process helps remove fine particles, colloidal matter and organic substances.

Filtration

After clarification, the water passes through a series of filters, such as multimedia filters or activated carbon filters. These filters further remove smaller particles, residual solids and organic compounds, improving water clarity and reducing turbidity.

Reverse Osmosis (RO)

In some cases, a reverse osmosis system is employed to treat water for specific applications. RO uses a semi-permeable membrane to remove dissolved salts, minerals and other contaminants from the water, producing purified water known as permeate.

De-Mineralization (DM)

If further removal of minerals is required, a de-mineralization process may be implemented. This can involve additional treatment methods such as ion exchange or electro-deionization to reduce the concentration of dissolved solids.

Disinfection

Once the water is treated and purified, disinfection is typically performed to eliminate bacteria, viruses, and other microorganisms. Chlorination, ultraviolet (UV) disinfection or other appropriate methods may be employed.

pH Adjustment and Chemical Conditioning

The pH of the treated water may be adjusted to meet specific requirements using chemicals such as acids or alkalis. Additionally, chemicals may be added to prevent scaling, corrosion or microbial growth within the plant's water distribution system.

Continued...

Storage and Distribution

The treated water is stored in tanks or reservoirs before being distributed to various points of use within the 2G Ethanol plant. Pumps, pipelines and control systems are employed to ensure the efficient and reliable distribution of water.

Monitoring and Quality Control

Continuous monitoring and regular sampling of the treated water are conducted to verify its quality and compliance with applicable standards. Parameters such as pH, turbidity, dissolved solids and disinfection levels are monitored to ensure water quality and consistency.

Maintenance and Servicing

The water treatment plant requires regular maintenance, including equipment inspections, cleaning and servicing of filters, membranes, pumps and other components. This helps maintain optimal performance and prolong the lifespan of the treatment system.

Fig. 2.21 Operations in Water Treatment Plant

Safe operations of cooling towers

A cooling tower functions as a heat exchanger, where heat is removed from water through contact with air. It utilizes water evaporation to dissipate heat from processes in the plant. In a water-cooling tower, waste heat is released to the atmosphere by cooling a water stream to a lower temperature. These cooling towers are known as evaporative cooling towers. The process is referred to as evaporative, because a small portion of the water being cooled evaporates into a moving air stream, resulting in significant cooling for the remaining water. The heat from the water is transferred to the air, raising its temperature and relative humidity. This heated air is then released into the atmosphere.

2.3.2 Importance of Product Storage, Inventory Management and Quality Control

The storage and inventory management infrastructure required for the feed/intermediate and finished products in the 2G Ethanol Plant is based on factors such as material balance, unit capacities, block flow diagrams, storage policies and shutdown procedures. The storage capacity is determined by considering the rates of feed and product in the process units, the importance of smooth operations, turnaround schedules, emergency scenarios and other relevant factors. The storage facilities are divided into the following sections:

Bio-mass storage and transfer

- Feed bio-mass (such as rice straw) is stacked in an open area in the plant and placed into a conveyor by a mechanical loader.
- Secondary fuel (such as cotton stalk) is stacked in an open area and placed into a conveyor by a mechanical loader to feed to the boiler unit.

Continued...

Chemical, yeast and enzyme storage

- Chemicals in solid-form are stored in warehouse and hose in liquid-form are stored in tanks. Yeast is stored in a closed packing and enzyme is stored in cold room (8-10 degree Celsius) in enzyme container.

Intermediate storage and transfer

- 2 days intermediate product storage is considered in the plant.
- 1-day intermediate storage of lignin-rich wet cake which is fed to the boiler as fuel is considered.
- 1-day storage period is considered for thin slop in a tank.

By-product storage and transfer

- By-products such as ash from boiler, mud/slit from wet washing, dewatered sludge from PCTP, fusel oil and technical alcohol from distillation require storage facilities.

Ethanol storage and dispatch

- Ethanol is stored in tanks which are free from moisture and dispatched through road tankers.

Fig. 2.22 Storage Facilities in 2G Ethanol Plant

Inventory management is crucial to ensure efficient production, minimize waste and meet the demands. Key considerations include maintaining an adequate supply of raw materials, managing finished product inventory, proper storage and warehousing, implementing inventory tracking systems, conducting reconciliation and auditing, accurate demand forecasting, integrating quality control processes, collaborating with suppliers and customers and implementing waste management practices. Efficient inventory management optimizes production, reduces costs, meets customer demands and ensures a smooth supply chain operation.

Quality control plays a critical role in ensuring the production of high-quality 2G ethanol. Quality assurance procedures, including standard operating procedures (SOPs), are established to ensure consistent quality throughout the production process. These procedures outline the specific steps and protocols to be followed at each stage to minimize variations and maintain product integrity. The following quality checks should be performed:

Raw Material Testing	The quality control process begins with testing the raw materials used in the production of ethanol, such as lignocellulosic biomass. This testing includes assessing the moisture content, composition and potential contaminants to ensure they meet the required specifications.
Process Monitoring	Continuous monitoring of the various stages of the ethanol production process is essential to maintain consistent quality. Parameters such as temperature, pressure, pH levels, enzyme activity and fermentation progress are monitored to identify any deviations from the desired standards.
Laboratory Analysis	Regular laboratory analysis is conducted to assess the quality of intermediate and final products. This includes testing for ethanol concentration, impurities, chemical composition, and other relevant parameters. These analyses help identify any issues or variations in product quality.

Fig. 2.23 Quality Checks in a 2G Ethanol Plant

2G ethanol production is subject to regulatory and industry standards regarding product quality. Ethanol plants must comply with these standards, which may include limits on impurities, ethanol concentration and other quality parameters. Regular testing and documentation are required to demonstrate compliance and also traceability. This includes recording test results, batch numbers, production dates and other relevant information. It allows for easy tracking and identification of any issues that may arise. Personnel involved in quality control should receive adequate training on testing procedures, equipment operation and data interpretation. Ensuring the competence of the quality control team helps maintain accurate and reliable results. If any quality deviations are identified, appropriate corrective actions should be implemented to address the issues. Additionally, a culture of continuous improvement should be fostered, with regular evaluations and adjustments to enhance the quality control process.

A distributed control system (DCS) is a computerized control system used to monitor and control various processes and equipment in industries such as manufacturing, power generation, chemical plants, and oil refineries. The DCS consists of a network of controllers distributed throughout the plant, connected to sensors, actuators and other devices. The DCS plays a crucial role in ensuring efficient and safe operation of the plant. Some key features and functions of the DCS in a 2G ethanol plant:

Process Monitoring and Control	The DCS continuously monitors and controls various parameters and variables in the plant, such as temperature, pressure, flow rates, levels and compositions. It provides real-time data on process conditions and allows operators to make adjustments and optimize plant operations.
Centralized Control	The DCS provides a centralized control platform where operators can access and control different process units and equipment from a single interface. This enables efficient monitoring and control of the entire plant, ensuring coordinated operation and seamless integration of different processes.
Alarm Management	The DCS is equipped with an alarm management system that generates alarms based on predefined thresholds and abnormal conditions. Operators receive alarm notifications to take appropriate actions, troubleshoot issues, and ensure plant safety. The DCS helps prioritize alarms, suppress nuisance alarms and provide alarm history for analysis and improvement.
Data Acquisition	The DCS collects and stores real-time process data from various sensors and instruments. It gets data on process conditions, equipment status and performance parameters for monitoring and analysis. It allows operators and engineers to access past data and identify trends or anomalies for process optimization.
Control Strategies	The DCS employs control strategies and logic to regulate process variables and ensure optimal performance. It uses proportional, integral, and derivative (PID) control algorithms to maintain setpoints, adjust control loops and respond to process disturbances. The DCS also allows for the implementation of advanced control techniques for improved process efficiency.
Human-Machine Interface (HMI)	The DCS provides a user-friendly HMI that allows operators to interact with the system and visualize process data. The HMI displays real-time data, trends, graphics and alarms, enabling operators to monitor the plant status, make informed decisions and respond to abnormal conditions effectively.

Continued...

System Integration	The DCS integrates with other plant systems, such as safety systems, electrical systems, and data networks. It enables communication and coordination between different subsystems, ensuring seamless operation and exchange of information for effective plant control and monitoring.
Safety Interlocks	The DCS incorporates safety interlocks to prevent hazardous situations. It monitors safety parameters and initiates actions, such as shutting down equipment or activating emergency procedures, when safety limits are exceeded.
Redundancy and Fault Tolerance	To enhance system reliability, the DCS often incorporates redundancy and fault-tolerant features. Redundant controllers, power supplies and communication networks are employed to minimize the risk of system failure and ensure continuous operation.

Fig. 2.24 Functions of Distributed Control System (DCS)

Motor Control Centre (MCC) Panel

The Motor Control Centre (MCC) panel is a central control unit in a 2G ethanol plant that houses motor starters, protection devices, and control circuits for motors and related equipment. Its key functions include controlling motor operation, providing motor protection, facilitating manual or automatic control, distributing electrical power, monitoring motor status, detecting faults, enabling remote control, ensuring safety, facilitating maintenance and troubleshooting and maintaining documentation and records. The MCC panel is essential for the efficient and safe operation of electrical systems, ensuring reliable performance and effective maintenance of motor-driven processes in the plant.

The following figure shows the various activities in the power room and diesel generator set operations, risk associated with them and ways to mitigate and control them:

Working in power room

- **Associated hazard:** Electrution, noise
- **Risk rating:** High
- **Impact on health:** Physical injury, fatal damage, hearing loss
- **Measures to mitigate and control risk:** Proper training and use of PPE, acoustic enclosures

Working near DG

- **Associated hazard:** High noise
- **Risk rating:** Medium
- **Impact on health:** Hearing loss
- **Measures to mitigate and control risk:** Proper training and use of PPE, acoustic enclosures

Continued...

DG maintenance operations

- **Associated hazard:** Physical hazards and electrocution
- **Risk rating:** High
- **Impact on health:** Injuries and burns
- **Measures to mitigate and control risk:** Use of PPE, restricted entry of staff, use of flame-proof fittings

HSD storage area

- **Associated hazard:** Leakage, fire
- **Risk rating:** High
- **Impact on health:** Severe burns and injuries
- **Measures to mitigate and control risk:** Storage should be away from ignition source, monitoring for lspills and leakages, adequate fire-fighting systems

Fig. 2.25 Hazards, Risks and Measures to Control and Mitigate Risks in Power Room and Diesel Generator Set Operations

Notes

2.3.4 Fault-finding, Maintaining Logs and Reporting

Fault-finding involves a systematic approach to identifying and diagnosing faults or abnormalities in the plant processes and equipment. This may involve monitoring performance indicators, analyzing data, conducting inspections and utilizing automation and control systems to detect deviations from normal operating conditions, setting-up alarm systems, etc. It also relies on the operator expertise and determination to follow standard operating procedures, conduct regular inspections and employ diagnostic tools.

The steps to be followed to while maintaining a log of the faults:

i. Record the identified fault in a logbook or form as per SOP

ii. If other operators have witnessed/experienced the same issue, make a note of that

iii. If the fault has occurred in the past, make a note of that

iv. Make suggestions or seek guidance to avoid recurrence or halting of the work

A sample format for maintaining a log of the faults is shown below:

ABC Company Ltd. Fault Reporting Form							
Date	**Process/Equipment Description**	**Serial Number/Identification**	**Location**	**Fault/ Issue Description**	**Impact on Work**	**Action Taken**	**Reported by- Name and Signature**

Fig. 2.25 Sample Fault Reporting Form

Reporting faults to the seniors on time will minimize the possible risks and hazards related to process, tools and equipment, and prevent major failures and serious injuries or mishaps in the 2G ethanol plant operation. The following are the benefits of reporting faults:

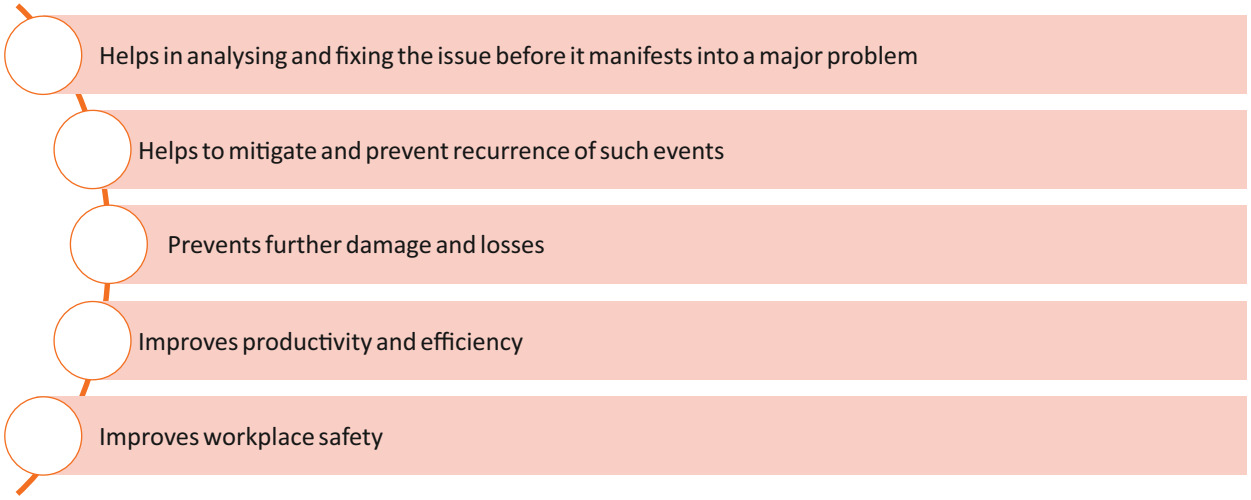


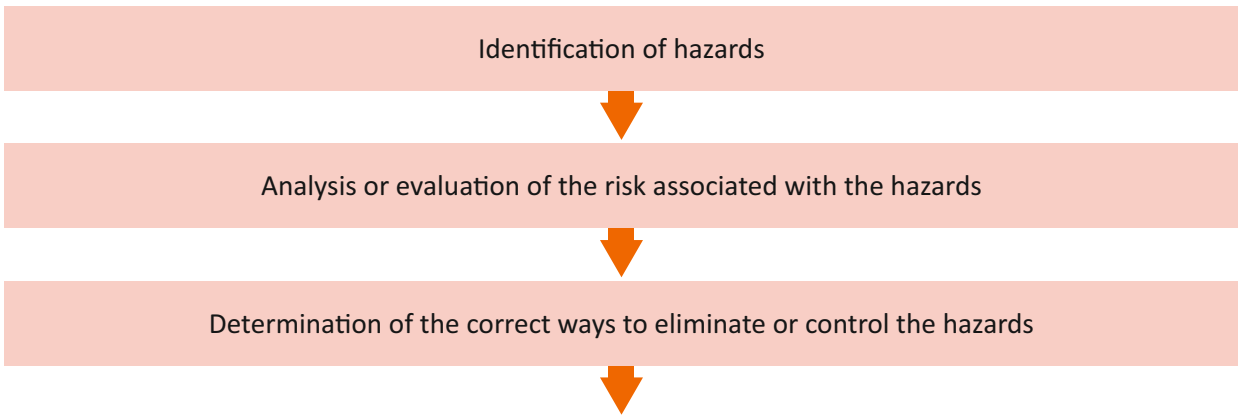
Fig. 2.26 Benefits of Reporting Faults

2.3.6 Safety Protocols and Emergency Response Procedures

The first step in implementing safety protocols is risk and hazards identification, assessment and management along with emergency response plans. A hazard is something that can potentially cause injury or harm whereas risk refers to the probability that an individual may experience harm or negative health effects when exposed to a hazard.

Hazard assessment involves identifying potential situations, events, and processes within an industrial workplace that have the potential to harm workers and the surrounding population. It is the process of determining the probabilities of specific harmful events occurring within a defined area over a specified time period.

Risk assessment It involves the evaluation and assessment of risks, as well as the determination of the potential harm that may arise from a specific hazard, which has the potential to cause damage to both people and property in the surrounding area. The following are the steps involved in hazard identification and risk assessment:



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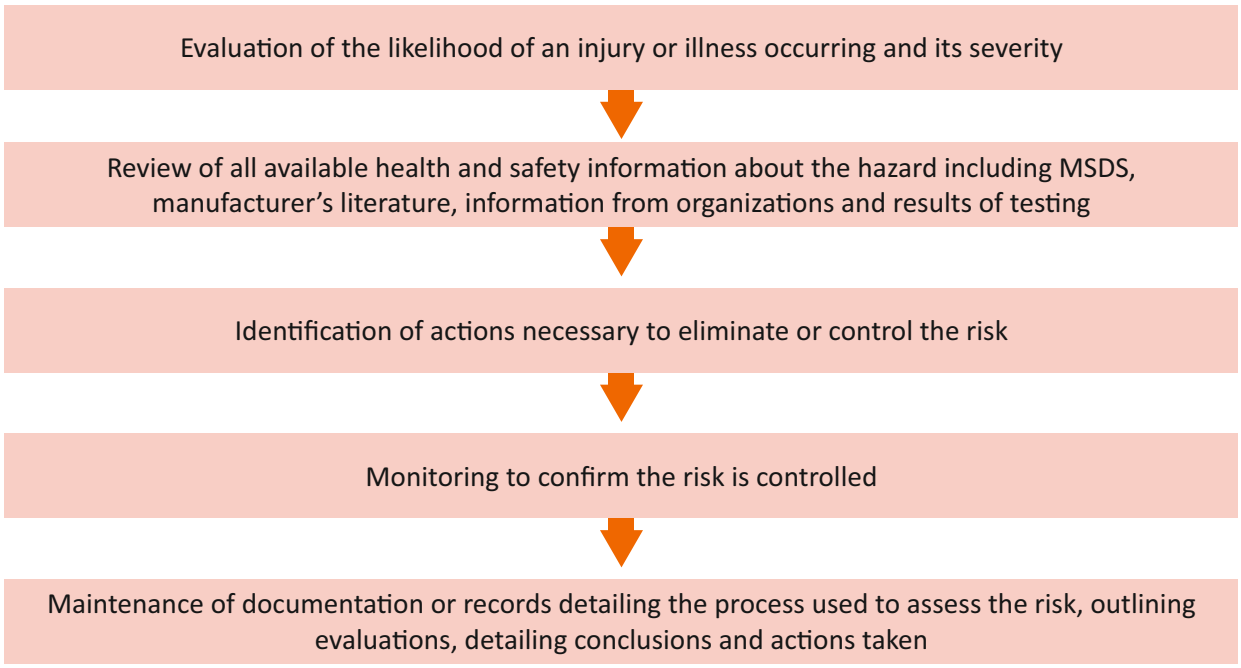

Fig. 2.27 Steps for Risk Assessment

The following figure shows the various activities in the plant, risk associated with them and ways to mitigate and control them:

Raw material and chemicals storage and handling

- **Associated hazard:** Fire accidents, leakages, exposure to dust
- **Risk rating:** High
- **Impact on health:** Burns, respiratory disorders and injuries
- **Measures to mitigate and control risk:** Proper training and use of PPE, regular inspection and monitoring, good loading and unloading practices to avoid spillage, adequate ventilation in storage facilities

Storage and handling of bagasse

- **Associated hazard:** Spillage from tankers
- **Risk rating:** Less
- **Impact on health:** Physical injuries
- **Measures to mitigate and control risk:** Proper tarining and use of PPE, regular inspection of storage area

Fuel storage

- **Associated hazard:** Fire accidents
- **Risk rating:** High
- **Impact on health:** Burns, respiratory disorders and injuries
- **Measures to mitigate and control risk:** Storage should be away from boilers, have provision for fire hydrant system and sprinklers, avoid welding and gas cutting in the surrounding area

Continued...

Alcohol storage

- **Associated hazard:** Fire, exposure, inhalation and ingestion
- **Risk rating:** High
- **Impact on health:** Injuries and burns
- **Measures to mitigate and control risk:** Storage should be away from boilers, have provision for fire hydrant system and sprinklers, avoid welding and gas cutting in the surrounding area

Working in fermentation and distillation section

- **Associated hazard:** Exposure to heat, fire, explosion, slip, trips and falls of operators
- **Risk rating:** High
- **Impact on health:** Injuries and burns
- **Measures to mitigate and control risk:** adequate operator training, installation of pressure indicators and alarms, adequate ventilation

Working at height

- **Associated hazard:** Slip, trips and falls of operators
- **Risk rating:** High
- **Impact on health:** Physical injuries
- **Measures to mitigate and control risk:** Use of safety belts and other PPE, installation of barriers and adequate supervision

Fig. 2.28 Hazards, Risks and Measures to Control and Mitigate Risks

Content Source: M/s Bharat Plus Ethanol Pvt. Ltd.

The various Personal Protective Equipment (PPE) to be used by operators to ensure safety are:

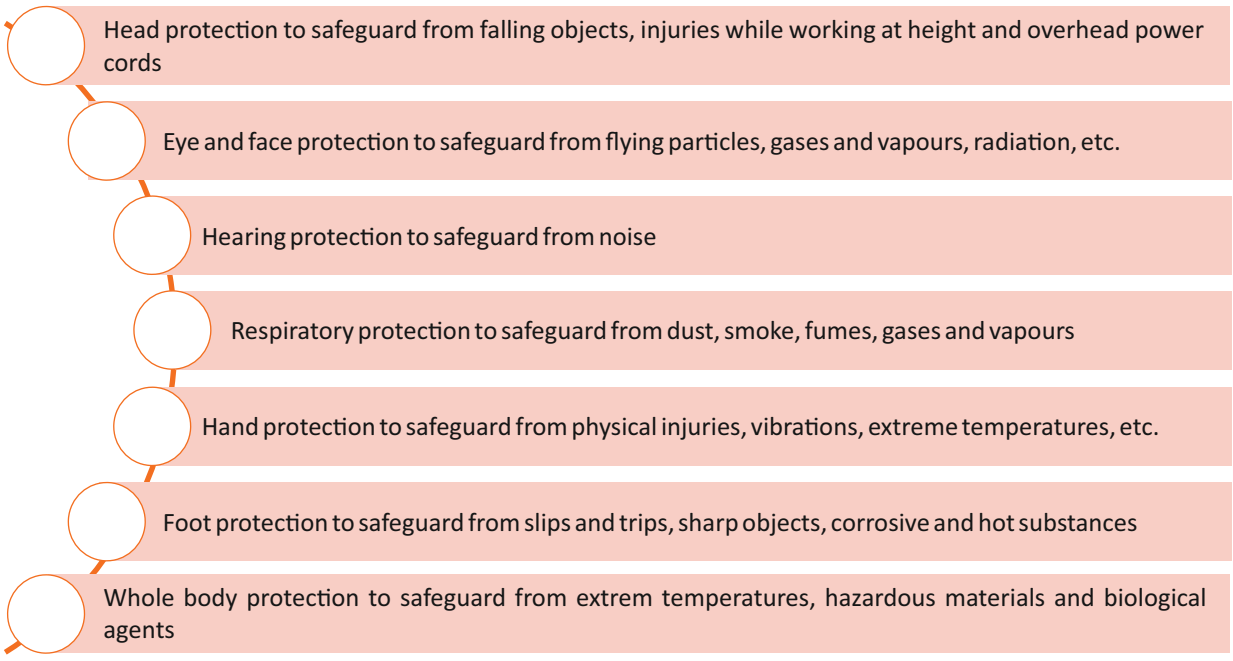

Fig. 2.29 PPE to be Used by Operators

Emergency preparedness plan

Emergencies can arise in the plant due to natural disasters like floods, earthquakes, cyclones, fires, etc. or from manmade disasters like excessive leakage of pollutants, plant failure, damage to storage tanks, leakage of flammable material, etc. Apart from emergency planning for disaster due to fire, which is covered in the following subunit, the general emergency preparedness plan should have the following:

1. Alarm and communication systems:

A siren should be made available within the plant premises and be controlled by the Security office. Its purpose is to provide a warning signal in the event of emergencies. The siren will be activated based on instructions given to the shift in charge, who will be present at all times. An emergency signal is indicated by waxing and waning sound for three minutes and an all-clear signal is indicated by a continuous siren for one minute.

For efficient communication, walkies and talkies should be located strategically, robust telephone system for both internal and external communications.

2. First aid:

A well-equipped first aid centre should be set up and maintained 24 hours a day by a compounder/dresser and a doctor. Additionally, an ambulance should be available on-site to transport individuals requiring medical assistance to the hospital.

3. Safety and security:

The safety department, headed by a Safety Manager, should be available 24 hours a day to address emergency situations. Essential safety equipment will be strategically distributed throughout the plant to handle any unforeseen events. Safety awareness posters and placards will be displayed at various locations within the plant premises. The security needs of the company premises should be overseen by the Chief Security Officer (CSO), with assistance from a fire officer. In addition to their regular security responsibilities, the team will fulfil the necessary roles during a disaster management operation as members of the crisis control team.

4. Emergency Control Centre (ECC):

An Emergency Control Centre (ECC) should be established to direct and coordinate emergency operations. The ECC, located in a low-risk area, should be equipped with communication systems and provides shelter to the Emergency Management Staff during emergencies. Only a limited number of prearranged individuals should be allowed in the ECC to minimize interference and confusion. The ECC should always be prepared with essential equipment and supplies, including updated disaster management plans, emergency contact information, communication devices, safety equipment, fire extinguisher details, maps of the facility, and assembly area layouts.

5. Evacuation procedure:

During a disaster, an evacuation procedure should be implemented to ensure the safety of individuals. It involves orderly and organized evacuation from the affected area to designated safe locations. The procedure should include steps such as activation of the evacuation plan, issuing alerts and clear instructions to communicate the evacuation order, establishing evacuation routes and assembly points, providing assistance to those in need, preparing evacuation facilities with necessary resources, guiding people to leave in an orderly manner, maintaining headcounts of evacuated individuals and providing continuous updates and monitoring. The primary goal should be to prioritize the safety and well-being of individuals by facilitating their timely and organized movement to designated safe locations.

2.3.7 Functions and Utilisation of Fire-fighting Systems and Weighbridges

Fire-fighting Systems

The primary hazard that poses a significant risk in ethanol manufacturing plants is fire, and it is crucial to have measures in place to control and mitigate such incidents. Even a small fire spark can lead to machine damage and substantial economic losses. To prevent and promptly control fires, a dedicated firefighting system and team should be established. This team will maintain and keep ready various types of equipment and arrangements to combat fires effectively, such as:

Fig. 2.30 Fire-fighting Equipment

The entire plant should be equipped with an electrical fire alarm panel for comprehensive coverage. Regular inspections will be conducted by an inspection group to ensure the functionality of fire extinguishers in fire stations, machines, and other areas. Emergency telephone number boards will be prominently displayed at key locations. The company will also conduct periodic general inspections to assess fire safety measures.

For firefighting with water, it is essential to have adequate and dependable arrangements, including:

i. The provision for fire brigade and fire hydrants.

ii. Installation of pipelines along vulnerable areas and surrounding regions.

iii. Valves strategically placed to control the water supply to desired locations or redirect it as necessary.

iv. Overhead tanks that operate through gravitational force to provide water during power failures.

v. Water sources from overhead tanks and raw water reservoirs.

For firefighting with fire extinguishers, except for carbonaceous fires that can be handled with water, appropriate fire extinguishers are necessary. It is essential to have an adequate number of readily accessible extinguishers in easily approachable locations.

Furthermore, additional spray groups from the system will be redirected to the affected area. In the case of a fire on a belt, the belt will be cut near the burning section to prevent further damage. After extinguishing the fire, the area will be properly prepared for reuse. To control fires in alcohol storage tanks, a foam system will be installed. The foam generated by this system separates the fuel from the oxygen, preventing the occurrence of fire and explosions. The foam forms a blanket over the fuel surface, smothering the fire, while the water content of the foam helps cool the fuel. Additionally, the foam blanket suppresses the release of flammable vapours that could mix with the air.

Weighbridges

A weighbridge, also known as a weighing bridge or a weigh station, is a specialized platform or structure designed to accurately measure the weight of vehicles and their loads. It typically consists of a sturdy platform with sensors or load cells placed strategically beneath it. These sensors or load cells detect the weight applied on the platform and convert it into an electrical signal, which is then measured and displayed on an external indicator or computer system. The platform is usually large enough to accommodate different types of vehicles, such as trucks, trailers and heavy machinery. Weighbridges can be either above-ground or pit-mounted, depending on the specific requirements and design of the installation. Above-ground weighbridges are constructed with ramps on either side to allow vehicles to drive onto the platform, while pit-mounted weighbridges are installed at ground level with the platform flush to the ground.

Weighbridges in a 2G ethanol plant serve important functions and are utilized in various ways as described below:

Weighing of Raw Materials

- They are used to measure and record the weight of raw materials, such as biomass, feedstock or other ingredients, before they are processed for ethanol production. Accurate weighing ensures proper inventory management and adherence to production requirements.

Weighing of By-Products and Waste

- They are also employed to measure the weight of by-products, such as spent biomass or residual materials, as well as waste generated during the ethanol production process. This helps in monitoring and managing the waste disposal and recycling processes.

Load Monitoring

- They are used to monitor and control the load of vehicles carrying raw materials or finished products within the plant premises. This ensures compliance with weight restrictions and prevents overloading, which can cause safety hazards and damage to infrastructure.

Quality Control

- They may be utilized to verify the quantity and quality of incoming raw materials or outgoing ethanol products. This information is crucial for quality control purposes and for maintaining consistency in production processes.

Inventory Management

- They assist in accurate inventory management by providing real-time weight measurements of raw materials, intermediates, and finished products. This helps in tracking and controlling the stock levels, optimizing production planning, and ensuring a steady supply chain.

Data Recording and Documentation

- They often include data recording systems that capture weight measurements and associated information. This data is valuable for traceability, record-keeping, compliance purposes, and generating reports related to production, inventory, and logistics.

Fig. 2.31 Functions and Utilisation of Weighbridges

2.3.8 Environmental Compliance and Sustainability Practices

Environmental compliance and sustainability practices in a 2G ethanol plant play a crucial role in ensuring the plant's operations align with environmental regulations and contribute to sustainable development.

Emission Control

The plant should implement measures to control and minimize emissions of greenhouse gases, volatile organic compounds (VOCs) and other air pollutants. This may involve using advanced emission control technologies, such as catalytic converters and scrubbers, to reduce the environmental impact of the plant's operations.

Waste Management

Proper waste management is essential to minimize the environmental impact of the plant. This includes implementing effective waste segregation, recycling and disposal practices for various waste streams generated during the ethanol production process. Recycling and reusing waste materials, such as biomass residues, can contribute to a more sustainable and circular economy.

Water Conservation

The plant should prioritize water conservation practices to reduce water consumption and minimize the strain on local water resources. This may involve implementing water-efficient technologies, optimizing water usage in various processes and utilizing water treatment and recycling systems to minimize water wastage.

Energy Efficiency

Promoting energy efficiency in the plant's operations helps reduce overall energy consumption and greenhouse gas emissions. Implementing energy-efficient equipment, optimizing process parameters, and adopting renewable energy sources, such as solar or biomass energy, can contribute to sustainable energy practices.

Sustainable Sourcing

The plant should prioritize the use of sustainably sourced raw materials, such as agricultural residues or dedicated energy crops, to ensure minimal impact on land use, biodiversity, and ecosystem services. Compliance with relevant certification standards, such as sustainability certification schemes for biomass feedstock, can help ensure responsible sourcing practices.

Environmental Monitoring

Regular monitoring of environmental parameters, such as air quality, water quality, soil quality and noise levels, is essential to assess the plant's environmental performance and identify areas for improvement. This monitoring can help ensure compliance with environmental regulations and enable prompt corrective actions when necessary.

Stakeholder Engagement

Engaging with local communities, regulatory bodies, and other stakeholders is crucial to foster transparency, address concerns, and incorporate their perspectives into the plant's environmental management practices. This can involve conducting regular dialogues, sharing information and actively seeking feedback to build positive relationships and promote sustainable practices.

Summary

- 2G ethanol, also known as second-generation ethanol, refers to the production of ethanol from non-food-based biomass sources. Unlike first-generation ethanol, which is primarily produced from edible crops such as corn or sugarcane, 2G ethanol production focuses on utilizing agricultural residues, forest residues, dedicated energy crops, or even municipal solid waste as feedstocks.
- The production of 2G ethanol involves advanced technologies and processes to convert complex carbohydrates, lignocellulosic materials or other non-food biomass into ethanol.
- Biochemical conversion involves the use of microorganisms or enzymes to break down the complex carbohydrates in biomass into simple sugars, which can then be fermented into ethanol.
- Since 2G ethanol can be manufactured from different types of bio-mass/feedstocks, they may need different processing technologies to extract the biofuel from them.
- The various types of conveyor systems used for handling and transporting feedstock are belt conveyors, screw conveyors, chain conveyors, pneumatic conveyors, chutes, bucket elevators, etc. and hoods used for dust extraction.
- In addition to de-stoning and screening, magnetic particle separation is used to separate magnetic particles from the feedstock. Magnetic separators are used to attract and remove ferrous or magnetically susceptible materials, such as metal fragments or particles, from the feedstock.
- Long-term storage plays a vital role in the biomass feedstock logistics supply chain, enabling biorefineries to operate consistently throughout the year, regardless of fluctuations in feedstock availability on a daily, monthly or seasonal basis.
- The dry storage systems are used to provide a stable storage solution over extended periods. The current practice for field-side storage of agricultural residues involves bale stacks covered with tarps to prevent moisture accumulation from rain.
- On the other hand, wet storage systems offer an alternative approach to feedstock supply logistics, drawing inspiration from established practices in the forage industry.
- In the feedstock industry, it is common practice to make modifications to biomass before anaerobic storage in order to enhance stability.
- The washing process takes place at normal room temperatures. The wet-washed and appropriately sized feedstock is transferred from the wet-washing system to the pretreatment section using a belt or chain conveyor.
- Pre-treatment procedures are essential in preparing feedstock for fermentation in 2G ethanol production. These procedures aim to enhance the accessibility and digestibility of the biomass by breaking down complex structures and reducing inhibitory compounds.
- Feedstock is often subjected to mechanical size reduction techniques such as milling, grinding, or chopping. Mechanical size reduction is an important pre-treatment procedure used to prepare biomass for fermentation in 2G ethanol production.
- Chemical pre-treatment involves the application of chemicals to the biomass to disrupt its structure, remove inhibitory compounds and increase the accessibility of cellulose and hemicellulose for enzymatic hydrolysis.
- Biological pre-treatment involves the use of microorganisms or enzymes to degrade or modify the biomass.
- Steam explosion is a widely used method for preparing biomass for fermentation in 2G ethanol production.

- Safety controls and instrumentation help to ensure safe and efficient operations during the pre-treatment processes. Automatic operation systems are implemented to monitor and control various parameters throughout the pre-treatment process.
- During the pre-treatment process prior to enzymatic hydrolysis, the conversion of Xylan into Xylose takes place in a reactor where a slurry with a concentration of approximately 18% to 20% is maintained.
- The fermentation process allows for the efficient conversion of a variety of sugars, including glucose and xylose, into ethanol. Modified organisms (GMO), in the form of Genetically Modified Activated Dry Yeast (ADY) is combined with water in a yeast slurry preparation tank.
- The distillation process in 2G ethanol production separates and purifies ethanol from the fermentation or hydrolysis products.
- The dehydration process involves passing the rectified feed through a series of molsieve beds. Molsieve which are specialized adsorbent beds designed to selectively remove water from the ethanol solution.
- Solid-liquid separation is a vital process in 2G ethanol production that involves separating solid materials from liquid solutions.
- The Thin Slop undergoes further concentration through water evaporation in evaporators, resulting in the production of concentrated syrup.
- The purpose of condensate polishing treatment is to ensure the quality and purity of the condensed water before it is reused or discharged.
- Safe operations and handling of utility systems like boilers, water treatment plants and cooling towers are essential for multiple reasons. These include safeguarding employee safety, preventing equipment damage, promoting energy efficiency, protecting the environment and ensuring regulatory compliance.
- The solid fuel-fired boiler package is commonly employed to fulfil the plant's steam needs. The boiler produces high-pressure steam, which is distributed to the process plant through a steam distribution network.
- Raw water is pumped to various parts of the plant to meet the process and other requirements.
- De-Mineralised water in a 2G Ethanol Plant is required for the boiler feed water make-up for the generation of steam.
- A cooling tower functions as a heat exchanger, where heat is removed from water through contact with air. It utilizes water evaporation to dissipate heat from processes in the plant.
- The storage and inventory management infrastructure required for the feed/intermediate and finished products in the 2G Ethanol Plant is based on factors such as material balance, unit capacities, block flow diagrams, storage policies and shutdown procedures.
- Inventory management is crucial to ensure efficient production, minimize waste and meet demands.
- Quality control plays a critical role in ensuring the production of high-quality 2G ethanol. Quality assurance procedures, including standard operating procedures (SOPs), are established to ensure consistent quality throughout the production process.
- A distributed control system (DCS) is a computerized control system used to monitor and control various processes and equipment in industries such as manufacturing, power generation, chemical plants, and oil refineries.
- The Motor Control Centre (MCC) panel is a central control unit in a 2G ethanol plant that houses motor starters, protection devices, and control circuits for motors and related equipment.

- Fault-finding involves a systematic approach to identifying and diagnosing faults or abnormalities in the plant processes and equipment.
- Reporting faults to the seniors on time will minimize the possible risks and hazards related to process, tools and equipment, and prevent major failures and serious injuries or mishaps in the 2G ethanol plant operation.
- The first step in implementing safety protocols is risk and hazards identification, assessment and management along with emergency response plans.
- Emergencies can arise in the plant due to natural disasters like floods, earthquakes, cyclones, fires, etc. or from manmade disasters like excessive leakage of pollutants, plant failure, damage to storage tanks, leakage of flammable material, etc.
- A siren should be made available within the plant premises and be controlled by the Security office. Its purpose is to provide a warning signal in the event of emergencies.
- A well-equipped first aid centre should be set up and maintained 24 hours a day by a compounder/dresser and a doctor.
- The safety department, headed by a Safety Manager, should be available 24 hours a day to address emergency situations.
- An Emergency Control Centre (ECC) should be established to direct and coordinate emergency operations.
- During a disaster, an evacuation procedure should be implemented to ensure the safety of individuals. It involves orderly and organized evacuation from the affected area to designated safe locations.
- Fire-fighting Systems - The primary hazard that poses a significant risk in ethanol manufacturing plants is fire, and it is crucial to have measures in place to control and mitigate such incidents.
- A weighbridge, also known as a weighing bridge or a weigh station, is a specialized platform or structure designed to accurately measure the weight of vehicles and their loads.
- Environmental compliance and sustainability practices in a 2G ethanol plant play a crucial role in ensuring the plant's operations align with environmental regulations and contribute to sustainable development.

Exercise

Answer the following questions:

1. What are the steps involved in the biochemical conversion for 2G ethanol production?

2. LList the various sources of biomass/feedstock for 2G ethanol production.

3. Explain the pretreatment procedures to prepare the feedstock for fermentation in brief.

4. Explain the distillation and dehydration processes.

5. List the safety features to be ensured while handling utility systems.

6. Explain the importance of quality checks in a 2G ethanol plant.

7. What is the role of Distributed Control Systems (DCS) in plant operations?

8. Write a brief note on emergency response procedures.

9. What ate the functions and utilization of fire-fighting systems in a 2G ethanol plant?

10. Describe the environmental compliance and sustainability practices in a 2G ethanol plant.

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From stubble to ethanol – how this 2G ethanol plant in Panipat is turning the table on air pollution

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From stubble to ethanol – how this 2G ethanol plant in Panipat is turning the table on air pollution

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3. Working effectively in a team

Unit 3.1 - Working effectively in a team

HYC/N9301

Key Learning Outcomes

At the end of this module, the participant will be able to:

1. Discuss the communication skills
2. Define the teamwork and communication and handling the work patiently with team and customers

Unit 3.1 - Working effectively in a team

Unit Objectives

At the end of this unit, the participant will be able to:

1. Identify importance of effective communication
2. List out essential skills required for effective communication
3. Identify barriers to effective communication
4. Define how to work effectively in team

3.1.1 Effective communication

Effective communication is a process of exchanging ideas, thoughts, knowledge and information such that the purpose or intention is fulfilled in the best possible manner. In simple words, it is nothing but the presentation of views by the sender in a way best understood by the receiver.

We can say that it generally involves:

- **Sender:** The person who initiates the process of communication by sending a message.
- **Receiver:** The one to whom the message is to be delivered.

Characteristics of effective communication

Just delivering a message is not enough; it must meet the purpose of the sender. Keeping this in mind, let us discuss the elements which make communication effective:

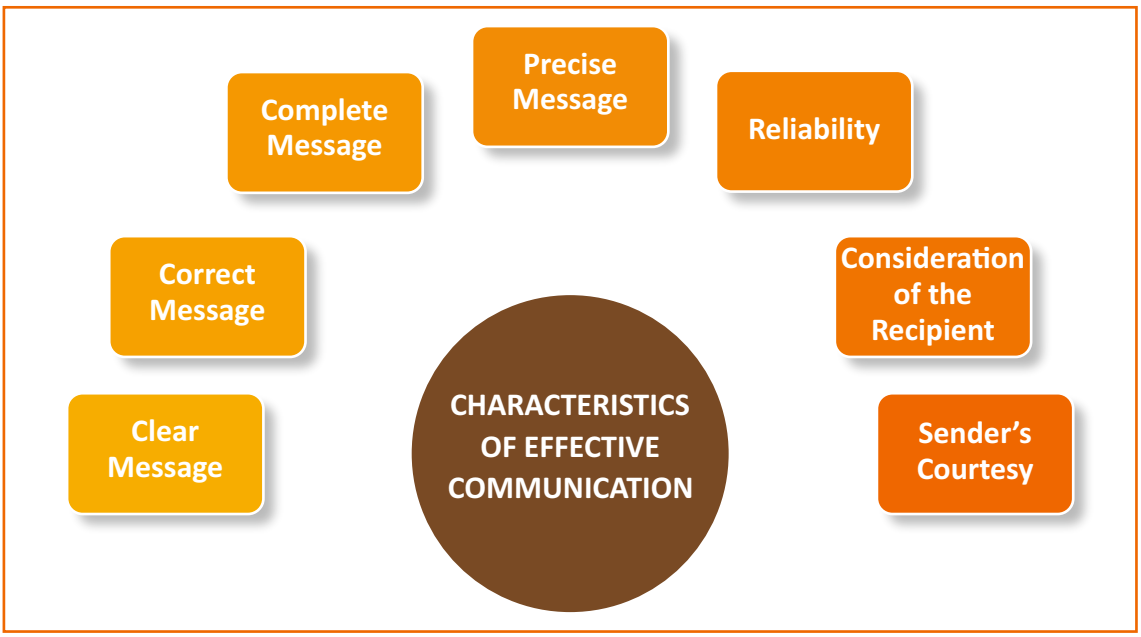

Fig: 3.1 Effective communication

- **Clear message:** The message which the sender wants to convey must be simple, easy to understand

and systematically framed to retain its meaningfulness.

- **Correct message:** The information communicated must not be vague or false in any sense; it must be free from errors and grammatical mistakes.
- **Complete message:** Communication is the base for decision making. If the information is incomplete, it may lead to wrong decisions.
- **Precise message:** The message sent must be short and concise to facilitate straightforward interpretation and take the desired steps.
- **Reliability:** The sender must be sure from his end that whatever he is conveying is right by his knowledge. Even the receiver must have trust on the sender and can rely on the message sent.
- **Consideration of the recipient:** The medium of communication and other physical settings must be planned, keeping in mind the attitude language, knowledge, education level and position of the receiver.
- **Sender's courtesy:** The message so drafted must reflect the sender's courtesy, humbleness and respect towards the receiver.

Effective communication skills

Conveying a message effectively is an art as well as a skill developed after continuous practice and experience. The predetermined set of skills required for an influential communication process are as follows;

Fig: 3.2 Effective communication skills

- **Observance:** A person must possess sharp observing skills to gain more and more knowledge and information.
- **Clarity and brevity:** The message must be drafted in simple words, and it should be clear and precise to create the desired impact over the receiver.
- **Listening and understanding:** The most crucial skill in a person is he must be a good, alert and patient listener. He must be able to understand and interpret the message well.
- **Emotional intelligence:** A person must be emotionally aware and the ability to influence others from within.

- **Self-efficacy :** Also, he/she must have faith in himself and his capabilities to achieve the objectives of communication.
- **Self-confidence:** Being one of the essential communication skills, confidence enhances the worthiness of the message being delivered.
- **Respectfulness:** Delivering a message with courtesy and respecting the values, believes, opinions and ideas of the receiver is the essence of effective communication.
- **Non-verbal communication:** To connect with the receiver in a better way, the sender must involve the non-verbal means communication too. These include gestures, facial expressions, eye contact, postures, etc.
- **Selection of the right medium:** Choice of the correct medium for communication is also a skill. It is necessary to select an appropriate medium according to the situation, priority of the message, the receiver's point of view, etc.
- **Providing feedback:** Effective communication is always a two-way process. A person must take as well as give feedback to bring forward the other person's perspective too.

Barriers to effective communication

There are certain obstacles which sometimes hinder the process of communication, making it less useful for the sender as well as the receiver. These barriers are categorized under three groups. Let us understand these in detail below.

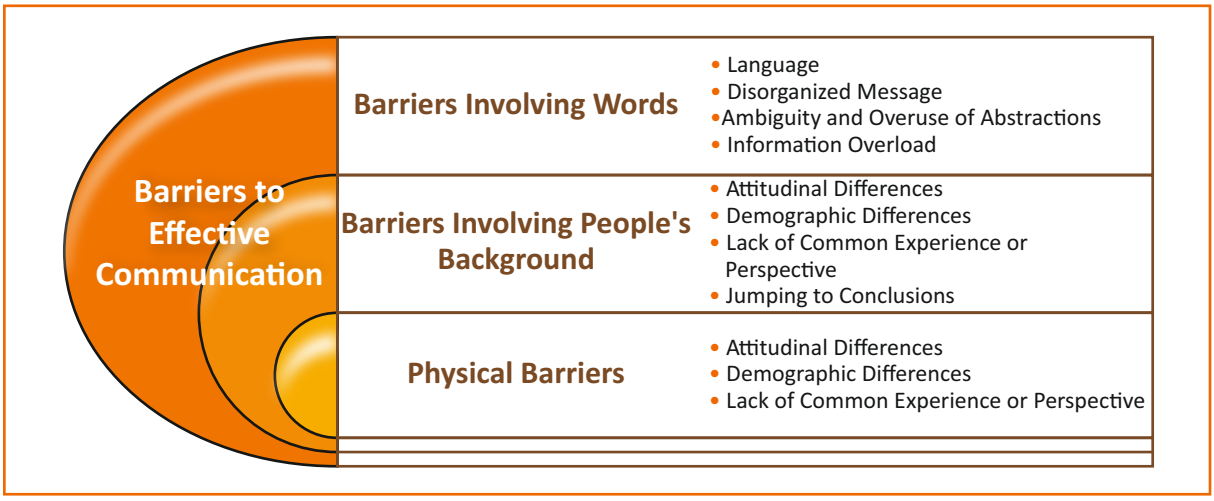

Fig: 3.3 Barriers to effective communication

Barriers involving words

Words play an essential role in the process of communication. Any disturbance or distraction in the way a message is presented may lead to miscommunication. Following are the different types of communication barriers related to words:

- **Language:** It is a medium of communication. If the sender is making excessive use of technical terms, it will become difficult for the receiver to understand the message clearly.
- **Ambiguity and overuse of abstractions:** Even if the message is presented in a non-realistic or vague context involving a lot of notions, the receiver won't be able to connect with the idea properly.

- **Disorganized message:** When the words are not organized systematically to form a powerful message, it loses its efficiency and meaning.
- **Information overload:** The effectiveness of communication reduces when a person keeps on speaking for an extended period. Thus, leading to the receiver's exhaustion, who won't be able to keep track of everything that is conveyed.

Barriers involving people's background

People belong to different backgrounds, i.e., Culture, education level, gender, etc. These attributes majorly affect the efficiency of the communication process. It involves the following related obstacles:

- **Attitudinal differences:** At times, people are resistant to understand or change their mind when they have set their views about a particular topic. Their attitude obstructs meeting the purpose of the communication.
- **Demographic differences:** The difference in age, generation, gender, status, tradition, etc., Creates a lack of understanding among people and thus, hinders the process of communication.
- **Lack of common experience or perspective:** The experiences of a person develops their perspective of seeing things in a particular way. This perspective varies from person to person. Therefore, it becomes difficult for a receiver to relate with the sender's experience or views as he might have never gone through it himself.
- **Jumping to conclusions:** Some people lack the patience of listening to others and often jump to conclusions between the communications, thus neglecting the motive of the message.

Physical barriers

These barriers can be experienced directly but challenging to overcome. These include:

- **Physical distance:** When people communicate over long distances, they miss out the non-verbal aspect of communication, since the gestures and expressions of the receiver cannot be interpreted.
- **Noise:** The environment or the communication system sometimes involve unwanted noise which interrupts the process of communication making it inefficient.
- **Physiological barriers:** One of the most common barriers to effective communication is the physical disability of the people involved. Some of these are hearing impairment, poor eyesight, stammering, etc.

Thus, we can say that the significant purpose of communication is to pass on the information to the receiver in such a manner that it does not lose its significance. At the same time, the message must be received in its purest form.

3.1.2 Communicate with supervisor

Good communication with your supervisor is important to both of you. There are five important aspects to remember when communicating with your supervisor:

- You must be able to follow instructions.
- You need to know how to ask questions.
- You should report any problems and results of your work.
- You should accurately record and give messages to your supervisor.
- You need to discuss your job performance.

Following instructions is important at all times, but especially during your training period. Your supervisor will be watching to see how well you do this. Use your senses to follow instructions correctly.

- **Concentrate:** Focus your attention on the supervisor. Don't be distracted by noise and movement.
- **Listen:** Pay attention to the words being spoken. If you hear unfamiliar words or terms, ask for clarification. Listening also means interpreting body language, voice inflections, and gestures. If this non-verbal communication is confusing, ask the supervisor to clarify what you don't understand.
- **Watch:** Sometimes a supervisor demonstrates how a task is performed. If necessary, ask the supervisor to repeat the process until you understand it completely. Sometimes a task may be too complex or time-consuming to demonstrate. In such cases, you probably will receive general instructions. If there are details you don't understand, ask for guidance to continue the task.
- **Question:** After you have listened and watched, ask questions. A good supervisor will encourage you to ask questions. It's better to ask a question than to make a mistake because you didn't understand.
- **Write:** Write down in a small notebook the important points to remember about the instructions you get. Don't write while your supervisor is talking or demonstrating something. Do it at a break in the instructions.
- **Practice:** With your supervisor's permission, perform the task. Make sure you have fully completed the job. This may include putting tools away or cleaning up your work area. Don't leave your work partially completed.

3.1.3 Achieve goals in the workplace

Creating goals in the workplace can help you achieve personal and professional success. Setting timeliness and taking steps to reach milestones can help you excel in your role and advance your career.

What is the importance of achieving goals in the workplace?

Setting goals is important because it helps you define how you should move toward achieving professional short- and long-term objectives both for your personal career and your company. They can give you motivation for improving skill sets, learning new skills or growing your responsibilities. Setting and achieving workplace goals can also show management that you are committed to the success of the organization. Some benefits of setting workplace goals are:

- **They give you direction:** A well-planned goal helps you move forward in the direction you need or want to go. For example, if you want to become a sales manager someday, writing down that goal with specifics on what steps you will take to achieve it can help you to begin working on your goal right away.
- **They help you stay on track:** A specific goal gives you a solid plan for accomplishing a task or project. You can look often at your goal to help you stay motivated. For example, if you need to write a training guide for new employees, you can look at the time line needed to reach that goal on a daily or weekly basis. This reminder can help you meet your deadline.
- **They make large projects easier:** You can divide your goals into smaller tasks so you do not become overwhelmed with a large project. For example, writing an entire training guide might seem daunting. However, if you set a goal to write one section of the guide each day or week, you will see progress on the task and feel a sense of accomplishment.
- They help with time management. When you have a deadline for a task, sending specific goals for each phase of the project will help you finish the task on time and eliminate distractions.

How to accomplish goals

Use these steps to help you set and achieve workplace goals to advance your career or succeed in your role:

1. **Create goals that inspire you:** When sending workplace goals, choose ones that will inspire you. Think of tasks or accomplishments that will advance your career or relate to your core values. Your desire to accomplish these goals will help you remain motivated and work toward achieving them.

   You can also use rewards to help motivate you to complete your goals. Develop a system to celebrate your progress, such as taking a break or having a snack for achieving small goals during the day, or attending an event or taking a vacation after accomplishing larger goals.

2. **Write down your goals:** Writing out your goals on paper, a calendar or a computer can reinforce them and provide a visual reminder to work toward them. Written goals allow you to access and view them often. To begin achieving your goals, write down each one and create a plan and time line to reach them.

3. **Use smart goals:** Smart goals are a methodology for setting goals that makes them easier to track and accomplish. Using this method gives you clear directions on how to define and plan achieving your goals. Here are the components of a smart goal

    - **Specific:** This part of the goal-setting process is critical for the success of accomplishing goals. Write the goals in a well-defined and clear manner so that you or anyone else in the workplace can understand them. Always use precise action words. For example, **"increase sales"** or **"earn a promotion"** are unspecific goals, but **"increase sales by 10% this month"** or **"become assistant manager by the end of the year"** are specific goals, and their clarity makes them easier to work toward.
    - **Measurable:** Use numbers, dates and other objective criteria when setting your goals so you can measure and view your progress.
    - **Achievable:** When you set a goal, check that it is feasible. Look at how much time you have each day, week or month to accomplish a task and set a realistic plan for accomplishing it. Be sure you have the training, tools and resources to achieve the goal.
    - **Relevant:** When you are trying to reach goals, especially in the workplace, they should relate to your career and the direction you want to go. Understand your particular skill sets and expertise in the job, and make the goal relevant to them.
    - **Time-bound:** Similarly to the measurable aspect of smart goals, you should have a clear time frame for accomplishing every goal. Knowing when a project needs to be completed will help you focus on all the tasks that need to be accomplished to meet the deadline.

4. **Re-evaluate your goals periodically:** It is important to look at the progress of your goals regularly. Depending on the depth of the plan, you can re-evaluate daily, weekly, monthly or biannually. Look at the actions you've taken to move forward with your goal, and if they are successful, continue to do those things. If you find that the goal is harder to achieve than you originally planned, make adjustments so you can increase your progress.

    For example, if you have committed to writing five blog posts per week for the company website, and you are finding it difficult to accomplish those numbers, try writing only four posts per week or changing your schedule so you have more time to write. Speak with your team members or management and get approval for the new plan.

5. **Keep striving toward your goals:** As you move toward accomplishing your goals, you want to maintain the excitement of and commitment to achieving them. Here are a few things to keep in mind when you are accomplishing your goals

    - **Be excited about the process:** One of the reasons you created goals was because you wanted a change. Stay passionate about the **"why"** of your goal. Keep positive on the small steps you are making toward the plan, and reward yourself when a time-bound goal is met.
    - **Find support and encouragement:** Surround yourself with people who encourage you to accomplish your goals. Spend time with positive co-workers, friends, family members and others who believe in what you are trying to achieve. A kind and encouraging word can inspire you to keep moving toward the completion of your goal.
    - **Visualize your success:** One of the best aspects of goal setting is enjoying the results at the end. Always visualize yourself succeeding, and use your goals to help you be happy and successful in the workplace.

3.1.4 Work effectively in a team

When a mix of people with different skills and varying levels of experience are pulled together in a team, it can lead to more effective and innovative solutions, which is great news for businesses. Employees can often feel happier being part of something bigger too, which can lead to higher productivity and lower staff turnover. As a result, team working is an important skill that employers often look for in job candidates. It's therefore a skill you shouldn't overlook.

Tips to improve your teamwork

Working with other people may seem simple enough but working in a team can be a complicated dynamic to navigate effectively. Here are nine key tips you should follow to improve your team working skills.

1. **Get into the right mindset:** Working alone means that you can set your own schedule and tackle tasks in a way that suits you best. In a team, you need to share ideas, divide workloads and go with group consensuses for decisions. By understanding this shift and accepting the differences, you will be able to set the right mindset and get stuck into the new team dynamic.
2. **Understand what's required of you:** Before you begin, make sure you understand your role, responsibilities in the team, deadlines, how everyone plans to work together, why the team was created, the teamwork processes and practices as well as what the ultimate goal of the team is. By doing this, you will be able to contribute much more effectively.
3. **Put in 100% effort:** Don't hide behind others or let other team members take on the bulk of the work. Be prepared to put in an equal amount of effort as others, so you complete the work assigned to you within the time frame that's been set. A good team player would also notice when others are struggling and help. The overall team will perform better as a result.
4. **Communicate, communicate and communicate:** The importance of communication in a team can't be underestimated. It's vital that everyone shares their progress and raises issues quickly so they can be dealt with. Don't forget that communication isn't just about talking but listening to others too. Without this level of open and honest conversation, problems may be missed, and projects can rapidly fall behind.
5. **Share your ideas:** When you've come up with an exciting new idea, you may want to rush to your boss to share it. But when working as a team, you must share your ideas and resources with your team members. Arguing afterwards over who gets the credit won't do any favours for you, as your boss will see that you're not a team player.
6. **Keep an open mind:** Brainstorming as a team is a great way to come up with a range of new and exciting ideas. While you may think your idea is the best, others might not always agree with you. You may also not agree with everyone else's ideas. Don't be difficult or overly negative about other people's ideas. Understand that everyone has the right to their own opinions and as a team, you will go with the consensus.
7. **Get to know each other:** Take time to get to know the rest of your team. This will make it much easier for you all to work together effectively going forward. There may be instances when you don't get on with a certain team member, but for the benefit of everyone, it's important that you always try and remain professional.
8. **Stay positive:** Don't complain all the time or place blame on single members of the team. You're

all in it together. If you notice the morale is dropping, provide encouragement where needed. Take time to celebrate your team's achievements too. A happier, more positive team will work much better together and achieve even better results.

9. **Be adaptable:** When working on a project, deliverables may change, team members may come and go, or you may face unexpected obstacles. You need to be someone who can adapt quickly to new situations, which will ensure the team continues to work together effectively.

Summary

- Effective communication is a process of exchanging ideas, thoughts, knowledge and information such that the purpose or intention is fulfilled in the best possible manner.
- Listening and understanding is the most crucial skill in a person is he must be a good, alert and patient listener.
- The effective communication certain characteristics such as clear, correct, precise, complete, and reliable message.
- Non-verbal communication includes, gestures, facial expressions, eye-contact, postures, etc.
- Effective communication is always a two-way process and providing feedback is an essential part of it.
- Certain obstacles sometimes hinder the process of communication, language barriers, ambiguity, overuse of abstractions, information overload.
- Physiological Barriers are the physical disability of the people involved. Some of these are hearing impairment, poor eyesight, stammering, etc.
- Goal setting gives direction and help with time management.
- SMART goals are a methodology for setting goals that makes them easier to track and accomplish.
- Working effectively in a team can lead to more effective and innovative solutions at workplace

Exercise

1. **The clear exchange of ideas and information is .....**
   a) Listening
   b) Communication
   c) Sympathy
   d) Social isolation

2. **The characteristics of communication when the sender must be sure from his end that whatever he is conveying is right by his knowledge is called .....**
   a) Correct message
   b) Complete message
   c) Reliability
   d) Sender's Courtesy

3. **Which type of barriers to effective communication is the physical disability of the people to communicate effectively?**
   a) Noise
   b) Physiological Barriers
   c) Physical Barriers
   d) Emotional Barriers

4. **SMART goals are a methodology for setting goals that makes them easier to track and accomplish. What does S stand for in SMART?**
   a) Sales
   b) Specific
   c) Smart
   d) Seamless

5. **..... as a team is a great way to come up with a range of new and exciting ideas.**
   a) Reflection
   b) Staying positive
   c) Brainstorming
   d) Communication

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Teamwork can make a Dreamwork
www.youtube.com/watch?v=6fbE52YDEjU

Motivation - leader and teamwork
www.youtube.com/watch?v=9MO1aY1xC80

4. Maintain health, safety and security procedures

Unit 4.1 - Maintain health, safety and security procedures

HYC/N9302

Key Learning Outcomes

At the end of this module, the participant will be able to:

1. Identify the importance of promoting a safe working environment
2. Identify how to reduce risk
3. Define hospital electrical safety measures
4. Define hospital fire safety measures
5. Define hospital environment safety measures
6. Explain medical emergencies
7. Explain the procedure of dealing with medical emergency
8. Identify the basic fire awareness
9. Explain the first aid process
10. Explain the cardiopulmonary resuscitation (CPR) process

Unit 4.1 - Maintain a Safe Working Environment

Unit Objectives

At the end of this unit, the participant will be able to:

1. Identify the importance of promoting a safe working environment
2. Identify how to reduce risk
3. Define hospital electrical safety measures
4. Define hospital fire safety measures
5. Define hospital environment safety measures
6. Explain medical emergencies
7. Explain the procedure of dealing with medical emergency
8. Identify the basic fire awareness
9. Explain the first aid process
10. Explain the cardiopulmonary resuscitation (CPR) process

4.1.1 Introduction

Commitment to health and safety should be at the top. Everyone at a workplace, including employer, supervisor, workers, employees and customers must take the responsibility to promote health, hygiene and safety.

Definition of health

As defined by the World Health Organization (WHO), health is a "state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity''.

Definition of safety

Safety is the state of being 'safe', the condition of being protected from harm or other non-desirable outcomes. Regular risk assessments should be conducted at retail stores to identify health and safety problems, and initiate necessary measures to eliminate or mitigate them as far as possible.

4.1.2. Health and safety requirements

It is imperative to ensure that the retail space is safe for everyone in the area especially for employees and the customers. It is always expected from every sales associate to identify and follow health and safety needs laid down by the retailer and the law, which are in place to act as a monitor to avoid all kinds of health or safety hazards.

Following are the factors to keep in mind while undertaking health and safety measures at a retail store:

1. **Abiding by the law:** A retailer has to show that he or she is following all safety practices in his retail store.
2. **Risk assessment:** A risk assessment examines the hazardous conditions at a workplace to identify risks and implement measures to prevent or reduce the risks.
3. **Safety readiness from expected perils:** As per the health and safety legislation, it is required to follow health and safety rules.
4. **Ergonomics:** It is the science of matching a retail store's requirements to the retailer's capabilities. For example, if a retailer hires a weak person to lift heavy boxes for hours on end, there are more chances of risk injury to the employee due to poor ergonomics.
5. **Air quality:** Without inadequate ventilation, air starts to collect mold, fungus, bacteria or odours in a retail store. Law recommends installing machines that cycle fresh outdoor air and circulates it throughout the store.
6. **Visual inspection of premise:** As per the law, it is important to visually inspect the store premises to ensure no hazards are visible, which include uneven flooring, spills and misplaced boxes.
7. **Crime:** The retailer should install a surveillance camera in different parts of the store for safety purposes. Hiring a guard may also help monitor the store.
8. **Training:** Employees of the retail store should be trained to tackle any situation inviting danger.
9. **Insurance:** The retailer must get the retail store insured.

4.1.3 Promoting a safe working environment

The fundamental goal of any safety program is to ensure that workers are not exposed to sources of energy such as high-voltage electricity, high-temperature fluids, toxic chemicals, moving parts, or falls from heights. Therefore, before working on a piece of equipment, the associated sources of high energy must be identified and secured. In the case of a pump, e.g., The following energy sources are probably present.

- **Rotating energy:** The driver, drive shaft, and impeller all turn. It is important that they be secured from inadvertent movement (even if the motor has been de-energized) before anyone works on the pump.
- **Electrical energy:** If the pump has an electrically driven motor, the electricity supply to it must be properly isolated.
- **Heat energy:** If the pump is driven by a steam turbine, or if there is steam tracing around it, it is important to ensure that the steam, and the associated steam condensate system are properly isolated.
- **Chemical energy:** If the pump normally handles hazardous chemicals that are toxic or a health hazard, it has to be properly cleared of them.

- **Flammable/explosive energy:** If the pump handles hydrocarbons, or other materials that could ignite, they have to be cleared, often using an inert gas such as nitrogen.
- **Potential energy:** If the pump is not located at grade, it may be possible for a person to fall off it (and if it is at grade there may be a pit below it).

Energy control procedures can be placed into one of the four categories shown - below (in the preferred order).

- Removal of the hazard.
- Positive isolation of the hazard.
- Lockout/tagout of the hazard.
- Administrative controls.

Venting and draining requirements

- Equipment and systems, provided with isolation for servicing, should be equipped with vent and drain valves as required to relieve pressure and remove fluids from the isolated equipment.
- Isolated components containing high pressure or a significant volume of vapour should be equipped with a vent valve. If the potential exists for venting of a significant volume of vapour the vent should be tied into the appropriate flare or vent system. For high-pressure services, the vent should include a throttling valve in addition to the isolation valve to control the rate of venting.
- Isolated components containing a significant volume of liquid should be equipped with a drain valve. If the volume of liquid is large, the drain should include a throttling valve in addition to the isolation valve to control the rate of draining and to prevent large volume gas blow by to the drain system.

Manways

When removing the first manway, the following guidelines can be used:

- Loosen bolting on the manway and remove all but four bolts. These are at the 12, 3, 6, and 9 o'clock positions.
- The last bolts on the manway should be loosened and carefully spread open to ensure that there is no pressure trapped in the vessel.
- When it is confirmed that there is no residual pressure in the vessel, the four bolts can be removed, and the manway taken off.

Electrical equipment

Electrical equipment can be isolated as follows:

- Shut down the equipment using the selector switch followed by the master disconnect.
- Ensure that all power sources are locked and tagged out.
- Stored electrical energy must be discharged to obtain zero energy state.
- When working on or near exposed de-energized electrical equipment, a qualified person should use test equipment to ensure that all circuits are dead.

Mechanical equipment

- Release or block all stored mechanical energy including that contained in springs and items under tension.
- Use blocks, pins, or chains to restrain energy when equipment cannot be brought to a zero potential energy state.
- Padlocks, lockouts, blinds, and tags should be used to lockout and tagout mechanical energy.
- If additional energy sources are present, follow the applicable methods of energy isolation listed in this section.

Pipe plugs

Plugs are sometimes used in pipeline repair; they create a vapour barrier when a line has been isolated and de-pressured, but has not been completely cleared of flammable, combustible, or toxic materials. Expandable plugs are also used to isolate sections of gravity drain systems such as sewers. Examples include plumbers plugs - which consist of two parallel disks that compress an elastic material together to form a seal on the inside diameter of the pipe - and inflatable bladders - which are inflated either pneumatically or hydraulically

4.1.4 How to Reduce Risk

To reduce risk, you must:

- Make sure that your own health and hygiene does not pose a risk to others.
- Make sure that your seniors know where you are.
- Check for health, safety and security risks when working and report if you see any hazards.
- **Use approved procedures when carrying out work that could be dangerous including:**

  1. Correct moving and handling techniques.
  2. Appropriate hygiene procedures.
  3. Correct protective clothing for the situation, environment and activities.
  4. Storing equipment and materials and dealing with spillages and getting rid of waste.

- **Take immediate and appropriate action to deal with emergencies, including:**

  1. Security problems.
  2. Accidents.
  3. Fire.

- **Use your skills and experience until appropriate help arrives: You must:**

  1. Call for the appropriate help.
  2. Continue to provide help until someone who is qualified to deal with the emergency is available.
  3. Support patients and others including family carers who may be affected by the emergency.
  4. Record and report incidents and emergencies accurately and fully in line with your organisation's policies.

4.1.5 Near misses and dangerous occurrences

Not only is the investigation of accidents and incidents important, it is also useful to investigate near misses and dangerous occurrences which did not result in injury. Just because no- one has been injured on one occasion does not mean that if the event happened again the result would be the same.

Whether the incident is classed as an accident, a near miss or a dangerous occurrence, the investigation should carry the same degree of importance, and the findings will be as useful in any event in preventing a recurrence. Specific lessons should be noted to identify why control measures already in place failed to prevent the incident and what further measures should be introduced to rectify the situation. General lessons learned from one incident will also be useful throughout an organization to increase awareness about health and safety issues.

4.1.6 Categorizing incidents

Hazards related to oil and gas industry

Hazards in oil and gas industry can be divided into two broad categories:

1. **Safety and injury hazards:** Workers in oil and gas industry are generally susceptible to the following safety and injury hazards.

Safety and Injured Hazard	Possible Causes
Motor Vehicle Accident	• Often the roads leading to well sites lack firm shoulders and other safety features. • Fatigue due to long driving distance and long working shifts.
Contact Injuries	• Workers being stuck by, entangled, or crushed by tools, machinery or other objects.
Fire and explosions	• Presence of highly combustible hydrocarbons. • Presence of oxygen/ignition source.
Slip, Trips and Falls	• Frequent need to work at elevations. • Uneven Surface. • Improper use or non-availability of fall protection systems.
Confined Space	**According to NIOHS, confined space refers to space, which by design has:** • Limited openings for entry and exit. • Unfavourable natural ventilation. • Not designed for continuous employee occupancy. Example of confined space in Oil and Gas Industry are storage tanks, pipelines, Silos, etc.

Table: 4.1 Possible cause of injure/hazard

2. Workers in oil and gas industry are generally susceptible to following agents which lead to various health and illnesses hazard, chemical hazards (toxic, corrosive, carcinogens, asphyxiates, irritant and sensitizing substances); physical hazards (noise, vibration, radiations, extreme temperature); biological hazards (virus, parasites, bacteria); ergonomic hazards (manual handling activities, repetitive motions, awkward postures); and psychosocial hazards (overwork, odd working hours, isolated sites, violence).

   The following table identifies the potential health effects from key processes in oil and gas industry:

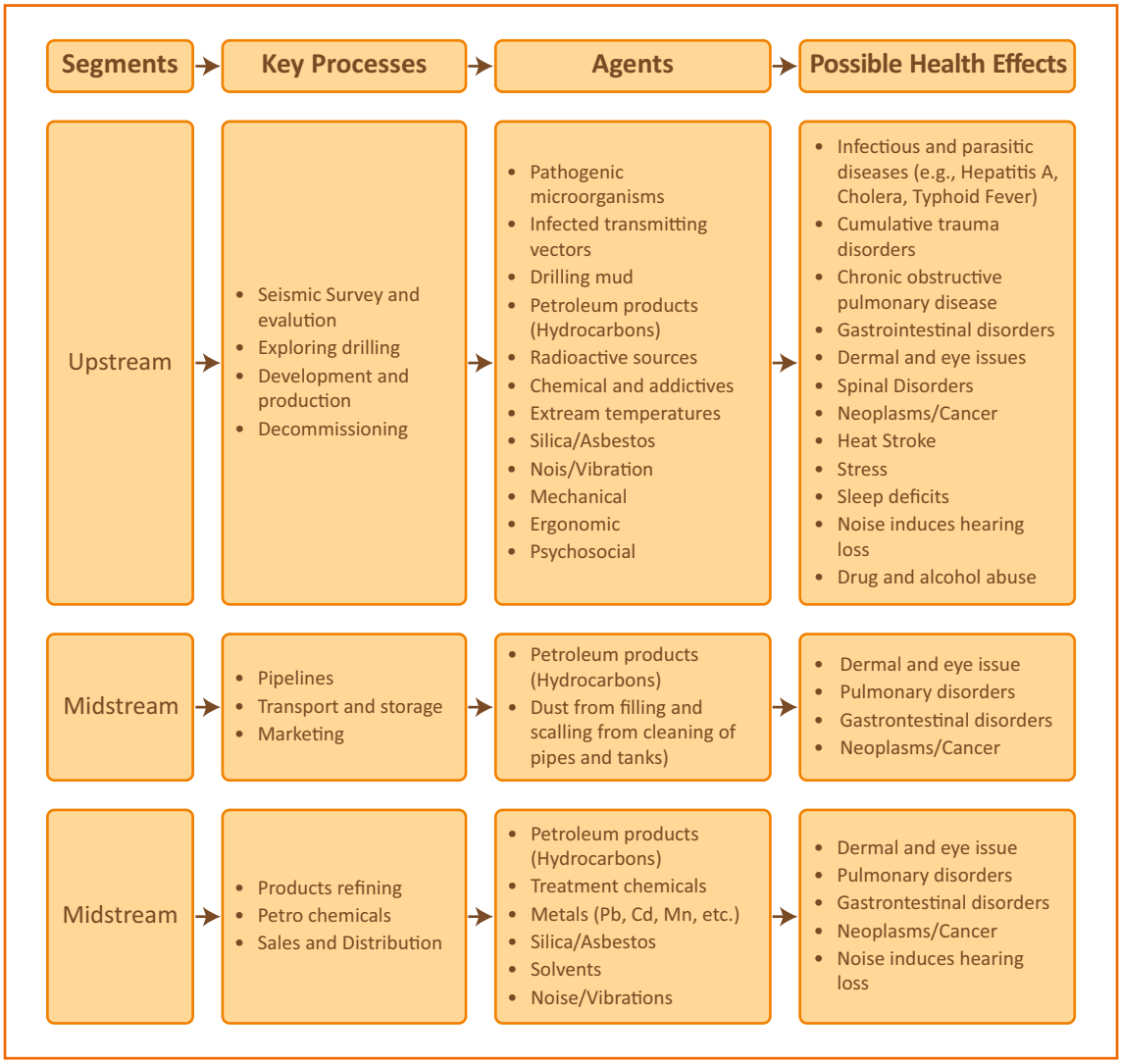


Fig: 4.1 Potential health effects from key processes

4.1.7 Managing occupational safety and health risks

The aim of occupational safety and health risk management is to identify and assess safety and health hazards existing at the workplace and to define appropriate control and retrieval steps.

Business processes in oil and gas industry are very complex. Hence it is essential that a systematized approach should be used for managing occupational safety and health hazards. Its solution model can be based on the PDCA cycle.

Fig: 4.2 PDCA Cycle

4.1.8 Risk management process

Risk management is crucial for preventing work related injury and illness. It includes:

- Identifying the risks.
- Evaluating and prioritizing the risks.
- Implementing preventive/protective measures to control the risk.

There are a number of circumstances in the oil and gas industry where a proper risk management process is essential. For example:

- **Job safety analysis:** It is a process of systematically evaluating certain jobs, tasks, processes or procedures and eliminating or reducing the risks or hazards to as low as reasonably practical (ALARP) in order to protect workers from injury or illness.
- Workplace inspections and audits.

- **Change management:** Identification of new hazards, introduction of new equipment/process, or regulatory needs.

Generally risk management process in the oil and gas industry involves the following key steps:

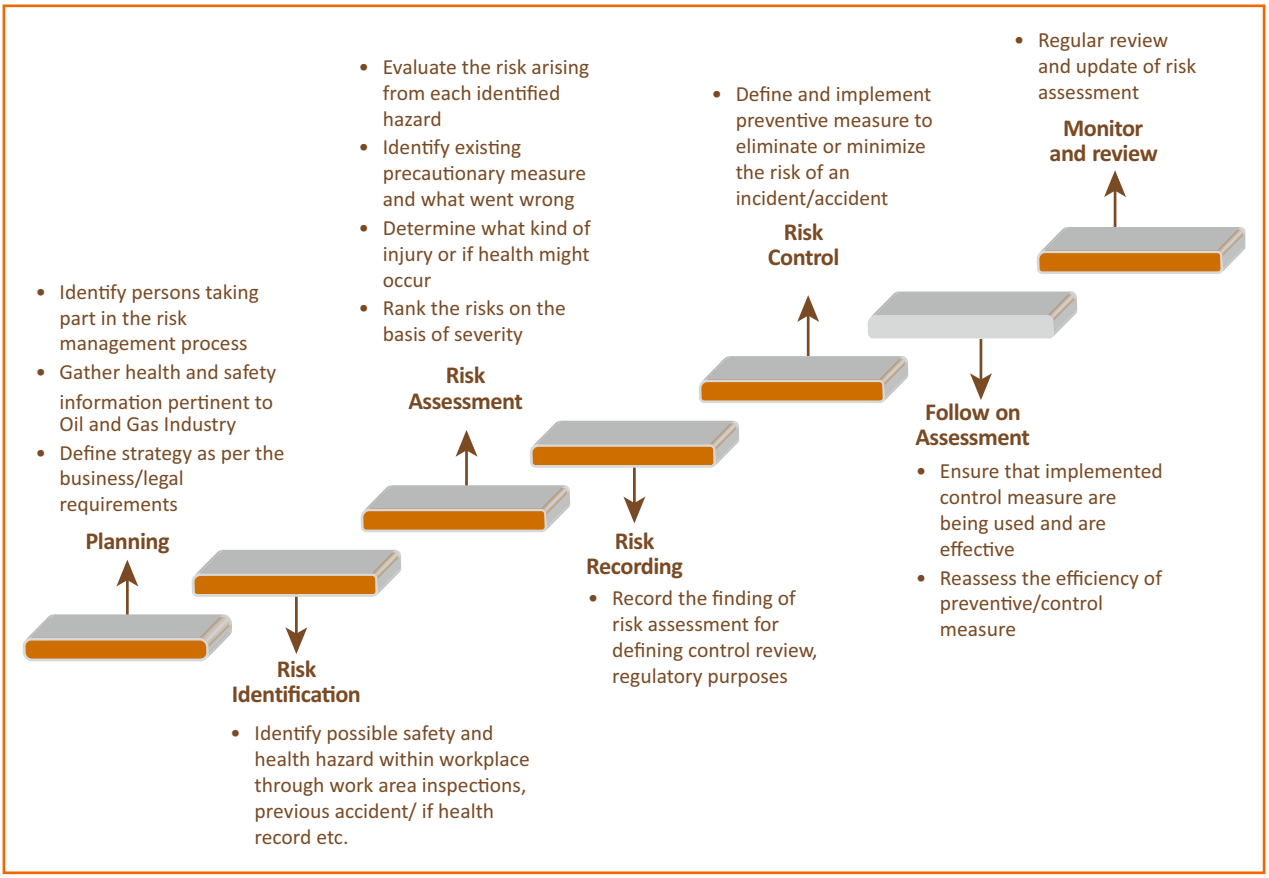


Fig: 4.3 Risk Management process

4.1.9 Personal protective equipment (PPE)

Personal protective equipment (PPE) is a clothing or equipment worn by workers to protect them from fire, exposure to toxic chemicals and direct impact. PPE should only be used when engineering designs and operating or maintenance practices do not provide a sufficiently safe work environment.

The need for PPE can be determined with a risk analysis, which will be structured along the following lines:

- Can the hazard be removed? If so, there will be no need for PPE.
- Can the consequences of the hazard be reduced? If so, it may be possible to work with a lower level of PPE.
- Can the likelihood of occurrence be reduced? This may not change PPE requirements, but it will reduce the chance of someone being injured.

Only when the above analysis has been completed, should consideration be given to the types of PPE to be used. A job hazards analysis (JHA) will help determine what type of PPE is needed and when and where it should be worn.

Clothing

Proper clothing will help keep acidic, corrosive, oily, dirty, or dusty materials off the body. Even if clothing with special PPE capabilities is not required, the following rules should be observed at all times and in all work site locations.

- Shorts are never permitted. Workers should always wear full-length pants (trousers) that cover the entire leg.
- Full cover shoes should always be worn. They should have non slip soles. Many companies require that shoes always have toe protection - often in the form of a steel toe cap.
- Hard hats should always be worn.

The effectiveness of clothing with regard to safety and health is affected by the following three factors:

- **Insulation:** High insulation is generally desired in cold weather and not wanted when temperatures are high.
- **Permeability:** This is the measure of the resistance to water vapour movement throughout the clothing.
- **Ventilation:** The ability of ambient air to move throughout the fabric itself or through garment openings.

Flame-resistant clothing

If normal clothing catches fire, it will continue to burn even if the ignition source is removed or if the affected worker moves away from the fire. Flame-resistant material self-extinguishes on removal of the ignition source. Clothing made of flame-resistant material is known as flame-resistant clothing (FRC), which will not continue to burn in such situations, nor will it melt like some synthetic fabrics.

It is used to make coveralls, lab coats, and fire hoods, and is now routinely worn by workers on process facilities at all times. It is also worn by workers who come in contact with energized electrical equipment.

- **Impervious clothing:** Impervious clothing provides protection from splash and should be worn during jobs where it is possible to come in contact with highly acidic or corrosive materials.

  Such jobs may include the following:

  1. Breaking lines.
  2. Opening equipment.
  3. Jobs where liquid materials could splash or spray.

  Workers wearing impervious clothing are more likely to suffer from heat stress.

- **Laboratory clothing:** The clothing requirements for laboratory work will depend on the materials being handled.

  Laboratory workers often handle hazardous chemicals directly; therefore, they will often be required to wear coats, goggles, and chemical-resistant gloves.

Emergency PPE

Emergency responders need specialized PPE in order to fight fires and to enter areas that may be contaminated with toxic chemicals.

- **Fire fighter protective clothing:** Fire fighter protective clothing, sometimes referred to as bunker gear, is worn by all members of fire teams and helideck fire guards. (Only those who are properly trained should wear this type of clothing.) Its use is required for those fighting fires beyond the incipient stage.

  The type of clothing will vary according to the local environment. However, the following should be the minimum requirements:

  1. Fire coat and/or leggings. The coat should be of knee length.
  2. Insulated fire boots - at least calf height with non slip sole tread and reinforced safety toe cap.
  3. Safety gloves.
  4. Self-contained breathing apparatus (SCBAS) for entering smoky areas.

  Fire fighter clothing should not restrict the person's movements. It should also be stored such that it cannot be contaminated or affected by heat, sunlight, or dampness.

- **Proximity suits:** heat-reflecting proximity suits are used by properly trained persons for taking actions such as closing a critical valve that is located close to a fire that has not yet been extinguished. On many offshore platforms, at least one person wearing a proximity suit will be on the helideck when helicopters are landing and taking off.

  Fire entry suits are used for entering flame areas but only for precise snatch rescue work where the casualty location is known and not for fire fighting under any circumstance.

Respiratory protection

Although every attempt should be made to make sure that workers are never exposed to toxic or harmful vapours, there will be times when some form of respiratory protection is needed, if only as a precaution.

- **Fixed breathing air systems:** Respiratory protective equipment should be used in areas that do not have a safe breathing environment, or where there is the possibility of an unexpected release of toxic gas or particulates.

  When respirators are used in atmospheres where the concentration of toxic gases could approach the immediately damaging to life and health (IDLH) level, standby personnel carrying SCBA should be present, along with suitable rescue equipment such as harnesses and hoists.

- **Respirators: the five most widely used types of respirator are as follows:**

  1. **Air-purifying respirators:** Air-purifying respirators contain material that traps and purifies the air that the worker is breathing. They can trap either solid materials (particulates or dust) or toxic gases depending on the material used in the filter. Respirators of this type can be single or multiple use (replacement cartridges are put into the respirator for multiple use). In general, respirators in this category do not provide a high level of protection and should not be used when the concentration of toxic gas is close to IDLH (immediately dangerous to life or health).

2. **Supplied air respirators:** Supplied air respirators are connected via a hose to a supply of air. The air can come from a compressor or from cylinders. (If a compressor is used, it is essential that the air supply cannot become contaminated by fumes in the area.) Respirators of this type are safer than any type of system that purifies air because they do not rely on trapping or containing hazardous chemicals.
3. **Self-contained breathing apparatus (SCBA):** SCBAS are similar to supplied air respirators except that the air is supplied from a cylinder, usually carried by the worker. They are used for short-duration tasks, emergency rescue, escape, and process control procedures. The air supply is generally rated for 30 minutes, but this time is reduced if the work being performed is strenuous.
4. SCBAS should be inspected before each use; emergency units should be inspected at least monthly.
5. **Chemical canister re breathers:** Chemical canister re breathers are used only for emergency egress. The canister contains a special chemical that evolves as oxygen when contacted by the moisture and carbon dioxide in exhaled breath (the co2 and moisture are retained).
6. They are suitable for high concentrations of contaminants and oxygen deficient atmospheres, but they are negative-pressure respirators that rely upon a perfect face-to-mask seal, which limits their use to emergency situations only.
7. **Disposable respirators:** These are intended for single use. They are primarily used for protection against nuisance dusts and non-toxic particles.

Use of respirators

Before using a respirator, the following checks should be carried out:

- The respirator should be checked for correct fitness before every use.
- Employees should not wear items such as facial hair or eyeglasses that could prevent a good seal. Employees who wear prescription glasses while working should be provided with specially designed units.
- All respirators should be inspected before each use to assure all parts are present and in good working order. There should be no cracks in the rubber or lenses and head straps should be properly elastic. Hoses should be checked by being stretched and then looking for cracks.
- A check for leaks should be carried out by covering the mask with the palms of the hands and then inhaling gently. If the mask is pulled toward the face then the fit is good. The leak check is particularly important for negative pressure respirators.
- The pressure in SCBA tanks should be as specified. The regulator pressure should be about the same as that of the cylinder. The low-pressure alarm should be checked.

Head protection

Hard hats/helmets protect the head from impact and penetration from falling or flying objects, overhead spills of hot or hazardous liquids, and electric shock.

They should be worn at:

- Construction sites.
- When near lifting operations or overhead work.
- All process plant areas.

Hard hats are made of rigid plastic, sometimes with a mid line reinforcement ridge. Different styles are available (those made in the form of a traditional cowboy hat are often not permitted on process facilities).

Inside the helmet is a suspension that spreads the helmet's weight over the top of the head and that also provides a space of approximately 30 millimetre between the helmet's shell and the wearer's head so that if an object strikes the shell, the impact is less likely to be transmitted directly to the skull. The suspension generally has an adjustment knob or strap so that the hat can be used for different head sizes.

Hand protection

Gloves should be worn when hands are exposed to hazardous substances or to sharp, rough, or hot objects. The following types of glove are used.

- Leather palm gloves are often worn when carrying out heavy duty work. They resist heat, sparks, sharp, and rough objects, and provide some cushioning against blows, but they provide minimal protection from hydrocarbons and liquids.
- Impervious gloves are made of materials such as neoprene, PVC, or nitrile. They are used when handling hydrocarbons or corrosive chemicals such as acids and caustic.
- Gauntlet-type gloves, which extend above the cuff and protect the wrist and forearm, should be worn when there is a possibility of splashing.
- Cotton gloves protect against dirt and abrasion but are not heavy enough for use with rough or sharp materials.
- Latex gloves provide for maximum dexterity but provide limited protection.
- They are used in light service, such as laboratory work and to keep oil, grease, and liquids off the skin.
- Welders gloves are made from treated leather that provides protection against heat, welding sparks, splatter, and hot slag.
- Insulated gloves are used in laboratories for handling distillation pots and other hot objects.
- Electrician gloves protect against electrical shock.

Foot protection

Shoes used in process facilities should be notched or grooved to prevent slipping on oily or wet surfaces. They should also have a heel to assist with climbing ladders. Boots or shoes with steel toe caps should be used when a dropped object could crush a person's foot.

The following guidelines should be considered:

- Soles should be notched or grooved to prevent slipping on oily or wet surfaces.
- Boots or shoes should have oil-resistant soles and a heel.

- Rubber boots or overshoes can be worn to protect the feet and shoes from excessive water, oil, muck, or corrosive material.
- **Footwear of the following types should not be worn:**
- Tennis and deck styles.
- Deep lug and hiking style soles.
- Crepe soles.
- Smooth leather soles.
- Western style or narrow throat boots.
- Lace-up and zipper style boot higher than 8 inches.
- Slip-on boot higher than 12 inches.

Eye protection

- Eye protection should be used when there is a reasonable probability of eye injury.
- Employers must ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapours, or potentially injurious light radiation.
- Employers must ensure that each affected employee uses eye protection that provides side protection when there is a hazard from flying objects.
- Detachable side protectors (e.g., Clip-on or slide-on side shields) meeting the pertinent requirements of this section are acceptable.
- Employers must ensure that each affected employee who wears prescription lenses while engaged in operations that involve eye hazards wears eye protection that incorporates the prescription in its design or wears eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses.
- Employers must ensure that each affected employee uses equipment with filter lenses that have a shade number appropriate for the work being performed for protection from injurious light radiation.

Safety glasses

In general, safety glasses should be worn whenever a person is working outside at a process facility, working indoors with hazardous chemicals, and in most non office work areas. Prescriptive lenses must comply with the overall safety glass policy.

Chemical goggles

Chemical goggles protect against splashing liquids, flying solids, and other harmful materials. Examples of work that may require chemical goggles are the following.

- Light chipping.
- Dusty work.
- Cutting wire.

- Using grinders.
- Handling mineral wool or fibreglass.
- Handling hazardous liquids.

4.1.10 Signs

Signs are widely used throughout the process industries to advise people of hazardous conditions and to provide directions as to what actions to take in various situations. It should, however, be remembered that **"red lights don't stop cars - brakes stop cars"**; it is always best to engineer a solution to a hazard than to warn people about that hazard.

Training programs should include an explanation of the signs that are used by the company.

Where possible signs should be symbolic only, i.e., They should not contain wording. This policy reduces problems communicating with an international workforce. However, some signs that use symbols only can be confusing. For example, the **"falling rock"** sign would appear to warn against rocks falling on vehicles. In fact, it is more to do with the fact that fallen rocks may be on the roadway. If supplemental wording is necessary, then all the languages that are typically used at the site should be included.

Types of sign

Guidance as to the types of signs and their meanings is provided in the following sections.

Fig: 4.4 Prohibition Sign

Prohibition

Prohibition signs mean **"you must not"** or **"do not do. . .,"** Or **"stop."** Signs of this type have a red circle, a white interior, and a red bar, the sign can be supplemented with more specific information.

Other examples of prohibition signs include the following:

Other examples of prohibition signs include the following:

- No smoking.
- No open flames.
- Non-potable water.
- Prohibition sign.
- Prohibition sign with information.
- Do not enter.
- Do not fish.
- Do not use crane for personnel transfer.

Fig: 4.5 Example of prohibition sign

Mandatory action

Mandatory signs mean **"you must do. . ."** Or **"carry out this action,"** or simply

Fig: 4.6 Mandatory Sign

"obey." They are often used when special PPE (personal protective equipment) is required.

Other examples of mandatory signs include the following:

- Hearing protection required.
- Wash hands.
- Chock wheels.
- Ground fuel truck.
- Hard hat area.
- Doors must be kept closed.
- Goggles required.
- Face shield required.

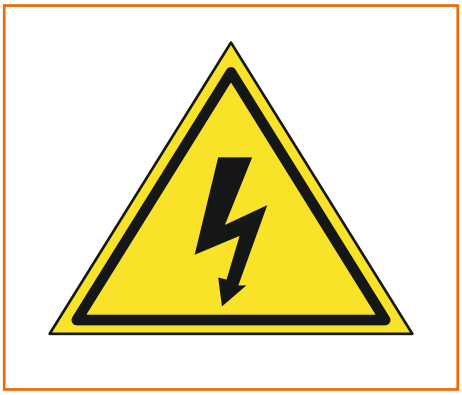


Fig: 4.7 Warning Sign

Warning

Warning signs are yellow triangles using black lettering.

Other examples of warning signs include:

- H2s gas.
- Corrosive liquids.
- Radiation.
- Equipment automatic start.
- Open trenches.
- High temperature.
- Flammables.

Safe condition

A green square or rectangle indicates a safe condition, a means of escape or the location of safety equipment.

Other examples of safe condition signs include:

- Emergency shower station.
- Emergency eyewash station.
- Potable water.
- Emergency shut down.
- First aid.
- Trash.

Fig: 4.8 Fire Safety Sign

Fire safety

Red square or rectangle is to do with fire safety.

Fig: 4.9 Fire exit sign

4.1.11 Medical emergencies

Everyone plans for emergencies. That is the reason why we keep a first aid kit with ourselves. At work, however one is exposed to a lot of stress and physical activity. This could lead to certain medical emergencies. It's better to be prepared with the first aid measures and knowledge of implementing them on ourselves and on others. This module equips you with that information. Pay attention to these medical emergency procedures to understand how to conduct you in theses crucial movements. Pay attention during these sessions.

Dealing with medical emergency

A medical emergency is an accidental injury or a medical crisis that is severe. These could be situation where.

- The person is not breathing.
- Stroke or heart attack.
- Severe bleeding.
- Shock.
- Poisoning.
- Burns.

A medical emergency requires your immediate attention, sometimes even before you call emergency services for help.

It is crucial that you know the emergency medical service (ems) number, for your own safety and the safety of others.

Do not

- Give the victim anything to eat or drink.
- Hold the victim.
- Splash or pour any liquid on the victim's face.
- Shift the victim to another place (unless it is the only option to safeguard the victim from the injury).

Bleeding

- Put pressure to the wound with a pressure bandage. Raise the wounded portion to slow the bleeding.
- Pressure the associated points if necessary then apply an additional pressure to reduce the bleeding.

Fainting

- Fainting is a small loss of consciousness which is caused by a momentary reduction of the blood flow to the brain.
- A small loss of consciousness can cause the person to fall.
- A very slow pulse.
- Cold skin with sweat and pale appearance.

Causes of fainting:

1. Taking in too little quantity of foodstuff and liquids (dehydration).
2. Low BP.
3. Deprivation of sleep.
4. Fatigue.

First aid for fainting:

1. Place the victim lying on his/her back and raise his/her legs above the heart level.
2. Check the victim's airway to ensure it is clear.
3. Check for the indications of breathing, coughing, or movement.
4. Loosen clothing (neck ties, collars, belts etc.).
5. If consciousness is not regained within one minute call ems.

Shock

Shock occurs with the failure of the circulatory system due to which insfficient oxygen reaches the tissues. If this condition is not treated immediately, important organs can fail, which can ultimately lead to death. Fear and pain makes effect of shock worse.

First aid for shock:

1. Place the victims resting down (if feasible).
2. Raise the legs 10-12 inches, unless you doubt for a back injury or broken bones.
3. Cover the victim to preserve the body temperature.
4. Give the victim room for fresh air.
5. If victim wants to vomit then- position him/her on his/her left side.
6. Loosen restrictive clothing.

Muscle cramps

- Stretch out the cramped muscle to neutralize the cramp.
- Give massage to the cramped muscle rigidly.
- Apply hot water bottle to the affected area.
- Seek medical help if the cramp continues.
- Avoid unnecessary movements and activities which can cause pain.
- Apply some ice which will help in reducing pain and swelling.
- Apply light pressure with an elastic wrap or a bandage which can also help in reducing the swelling.
- Raise the cramped limb at the level of the heart which further reduces pain and swelling.

Fractures

A fracture is a break or crack in the continuity of the bone.

Dislocation

A dislocation is the displacement of one or a lot of bones at a joint. It usually happens in the shoulders, elbow, thumb, fingers and also the lower jaw.

First aid for dislocations & fractures:

1. Immobilize the effected part.
2. Stabilise the effected part.
3. Use a cloth as a sling.
4. Use board as a sling.
5. Carefully transfer the victim on a stretcher.
6. Call a doctor.

4.1.12 Basic fire awareness

Fire is a chemical reaction that requires three elements to be present for the reaction to take place and continue.

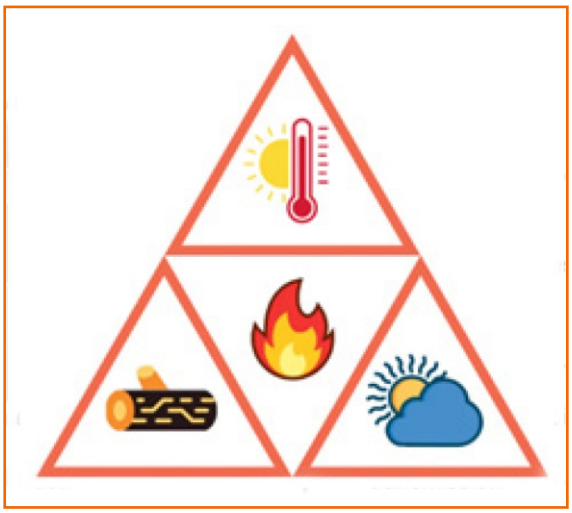


Fig: 4.10 Basic cause for fire

1. **Heat:** A heat source is responsible for the initial ignition of fire, and is also needed to maintain the fire and enable it to spread. Heat allows fire to spread by drying out and preheating nearby fuel and warming surrounding air.
2. **Fuel:** Fuel is any kind of combustible material. It's characterized by its moisture content, size, shape, quantity and the arrangement in which it is spread over the landscape. The moisture content determines how easily it will burn.
3. **Oxygen:** Air contains about 21 per cent oxygen, and most fires require at least 16 percent oxygen content to burn. Oxygen supports the chemical processes that occur during fire. When fuel burns, it reacts with oxygen from the surrounding air, releasing heat and generating combustion products (gases, smoke, embers, etc.). This process is known as oxidation.

These three elements typically are referred to as the **"fire triangle."** Fire is the result of the reaction between the fuel and oxygen in the air.

Causes of fire

- **Electrical:** e.g. overloading of circuits, faulty old or bad connections causing sparks or generating a heat source, poor maintenance, lack of ventilation and cooling, static electricity etc.
- **Heating appliances:** for example clothing left on boilers to dry, no sparks guards on open fires or stoves, left unattended while cooling, sited close to combustible materials, faulty temperature control etc.
- **Process dangers:** e.g. overheating of machinery, heat generated by friction, uncontrolled sparking, breakdown in cooling process, chemical reaction, poor quality ventilation and temperature control etc.
- **Flammable dusts:** e.g. poor extraction, process proximity to heat or spark source, no containment system, no monitoring or measuring system etc.
- **Carelessness:** For example smoking, inadequate precautions while welding, drilling or cutting, horseplay or interference with safety equipment, removal of guards etc.
- **Bad housekeeping:** For example lack of maintenance of work area and equipment, oil/fuel leaks and spillage's ignored, overflowing bins and waste baskets, no safe procedures for disposing of combustible waste etc.
- **Spontaneous combustion:** For example chemicals not stored at correct temperature, chemicals mixed incorrectly, combustible materials or waste left unattended etc.
- Poor judgment and human error.
- Failure to follow instructions.
- Misuse of faulty electrical equipment.
- **Electrical appliances:** Many fire started by electrical appliances are associated with lamps and heat developed by filament. Portable lamps are a frequent source of trouble the common causes as follows.

  i. Lead wires damaged.

  ii. Lamp taken in to atmosphere which has explosive dust, gas or vapour.

  iii. Bulb loose in socket.

  iv. Bulb easily broken (take care properly).

Classification of fire

Before we move forward and study about fire prevention and the safety equipment required for the same, we need to understand the different types of fire. This information is extremely important as it can help you choose the appropriate means to extinguish the fire.

Classes of Fire	
Class A Fires are related to solid materials (wood, paper, cloth, trash, rubber and plastics, charcoal, etc.)	
Class B Fires are related to flammable liquids (paint, diesel, gasoline, petroleum oil, and pain).	
Class C Fires are related to flammable gases (energized electrical equipment like motors, appliances, transformers, propane, and methane). Electrical equipment such as appliances, wiring, and breaker panels, etc. These categories of fires become Class A, B, and D fires when the electrical equipment that initiated the fire is no longer receiving electricity).	
Class D Fires are related to flammable metals (combustible material like aluminium, sodium, potassium, magnesium). These fires burn at extremely high temperatures and require special suppression agents.	
Class E Fires are related to electrically energized objects, wiring, and electrical appliances. These fires are caused because of faulty heaters or electrical appliances overheating.	
Class K Fires related to cooking oil and greases like vegetable fat and animal fat.	

Table: 4.2 Classification of fire

Fire extinguisher

Fire extinguishers are designed to tackle specific types of fire. There are five different classes of fire and several different types of fire extinguishers.

Types of fire extinguisher	Identification		
	Use	Fire class	Colour code
Water extinguisher 	• Water removes heat and extinguishes the fire. • Water must not be used on fires involving live electrical equipment as it can cause electrocution. • Water must not be used on metal fires.	Class a fire.	Signal red. 
Dry chemical powder (DCP) extinguisher 	• DCP extinguishers put out fire by coating the fuel surface with chemical powder. • This separates the fuel from the oxygen in the air and prevents vapour formation.	Class b & c fire.	Red with a blue panel above the operating instructions. 
Foam type extinguisher 	• The extinguishing agent is aqueous film forming concentrate in water which forms air foams when discharged through an aspirating nozzle. • It has a blanketing effect excluding oxygen from the surface of the fuel as it spreads on the fuel. • Prevents vapour formation from the surface of the burning liquid.	Class a & b fire.	Red with a cream panel above the operating instructions. 

Types of fire extinguisher	Identification		
	Use	Fire class	Colour code
Carbon dioxide extinguisher 	• Co2 extinguish the fire by displacing oxygen in the surrounding air. • Its principal advantage is that it does not leave any residue. • Can be used on electrical/ electronic equipment. • Co2 is not suitable for fires involving metals.	Class b & c fire.	Red with a black panel above the operating instructions. 
Special dry powder	• Special extinguishing agents are used for extinguishing metallic fires. • Dry powders extinguish the fire by forming a crust on metal surface excluding air and also absorb heat from the metal surface.	Class d fire	Red with a blue panel above the operating instructions. 

Table: 4.3 Classes of fire extinguisher

Correct use of a fire extinguisher

The method of using a fire extinguisher is to follow P.A.S.S. PASS is the acronym for, pull the pin (p), aim (a), squeeze (s) and sweep (s).

1. **Pull the pin:** to use an extinguisher in a proper way, the first step is to pull the handle's pin.
2. **Aim:** the next step is to aim the extinguisher's nozzle. The direction should be towards the fire's base. This is because the sprayed foam at the top will diminish or extinguish only the fire at the top. This will not serve the purpose for which the extinguisher is used. The burned down flame may spring up to life if it gets enough oxygen or any combustible material.
3. **Squeeze:** then, in an extremely controlled manner, you need to release the agent. This can be done by squeezing the trigger.
4. **Sweep:** if you see in the second step, you already read that you should direct the nozzle at the fire's base. You will sweep the extinguisher's nozzle from left to right. Continue with this process until you put out the fire. You need to act fast as most extinguishers' discharge time is nearly 10-20 seconds.

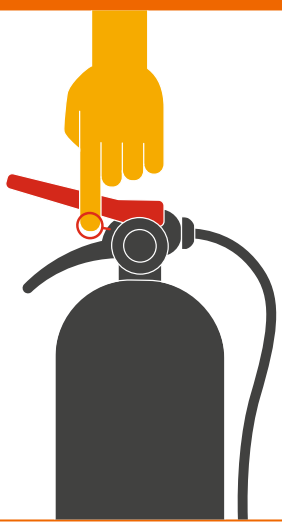
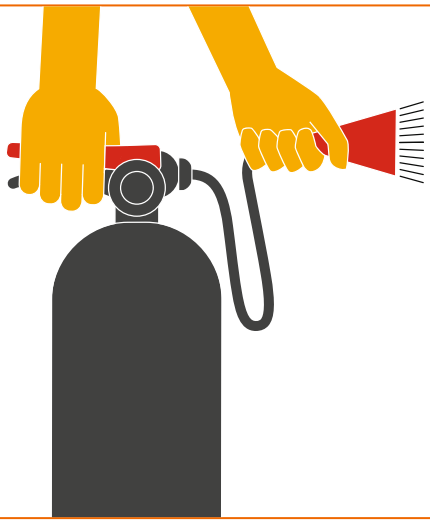
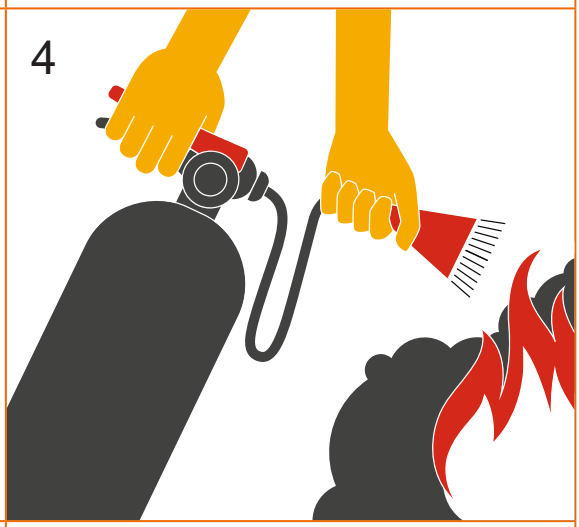
PASS Technique	
1 	2 
Pull out the safety pin as instructed on the label	**Aim the nozzle at the base of the fire**
3 	4 
Squeeze the lever	**Sweep the fire using the extinguisher's discharge**

Table: 4..4 Fire extinguisher PASS method

How to deal with fire

If the house has got fire, you need to take following steps:

- If the fire is very small and can be handled, you should deal with it yourself. Otherwise, you should come out of the house with other family members.
- Call the fire brigade and also the neighbours for help.
- If your clothes got fire, lie down on the floor and roll around so that the flames may smooth.
- If you are trapped in a fire in a room, bent down on your knees and try not to inhale the smoke as much as possible.
- You should crawl toward the exit as soon as you can.

- You can use the fire extinguisher on the small fire, but you should get yourself trained on it.

Methods of starving fire

On discovery of a fire, everything possible should be done to starve the fire by removing the oxygen and combustible material. The prevention procedure is as follows.

- Close all the doors and windows;
- Cover small fires with a blanket or other suitable objects;
- Cool the fire down;
- Remove combustibles;
- Switch off all electricity main switch; and
- If available, use the appropriate extinguishers.

Remove bystanders from the danger area to a safe place. Keep an access route open for the fire brigade or emergency services and look out for looters as people may take advantage of the confusion caused by the fire to steal valuables.

Fire emergency procedures (do's & don'ts)

The general principles (do's and don'ts) when conducting basic fire-fighting is as follows.

Do's

- Ensure the back-up assistance is available before tackling a fire;
- Ensure that an escape route is available before tackling the fire;
- Follow instructions on the extinguisher's label;
- Apply the extinguisher medium to the base of the flames and move the nozzle in a rapid side-to-side action;
- Drive the flames away from you;
- For vertical fires, start at the base of the flames and move upwards;
- If the fire is outdoors, approach the fire from the windward side;
- When approaching the fire, adopt a crouching position that provides protection against heat and smoke;
- Keep alert for any changes in the fire pattern;
- When tackling a fire involving electrical equipment, isolate the power as soon as possible to prevent re-ignition; and
- Ensure that the fire has been completely extinguished and no spark remains.

Don'ts

- Do not place yourself at risk;
- If the fire is too big, evacuate the area immediately;
- Never tilt or invert any extinguisher during operation unless it is the turnover type;
- When extinguishing the fire of a flammable spillage, never walk on the liquid spillage. This can

prevent injuries in the event of the names flashing back;

- When tackling flammable liquid fires using a controllable discharge type extinguisher, spray the medium until the fire is completely extinguished; and
- After the fire has been extinguished, back off slowly and never turn your back on it.

Fire evacuation steps

The sequence of an evacuation situation is:

- Detection.
- Decision.
- Alarm.
- Reaction.
- The movement to an area of refuge or an assembly station/ area.
- Transportation.

Rescue techniques during fire hazard

(A) Responding to fire

- The fire alarm system must be initiated, and an alert must be raised.
- A safe evacuation path must be identified before dealing with the fire.
- The appropriate class of fire extinguisher must be chosen.
- The P.A.S.S. technique must be adopted for extinguishing the fire.
- Immediate evacuation must be initiated if the extinguisher is exhausted and the fire still exists.
- Call security or local emergency services.
- Summon the fire fighting services at the earliest.
- Stay as far as possible from smoke, because the smoke may comprise toxic gases.
- Cover your mouth and nose with a damp cloth. Place a damp cloth above the person too and ensure that the person does not inhale toxic gases.
- Look out for the nearest emergency exit routes and call out for people, who you can take along with you.
- While opening a door, first touch the door with the back of your palm.
- Wrap the person with a blanket to protect him/ her from fire.
- Start moving out of the building carefully as you have to carry a person with yourself.
- Always use a staircase and not the elevator.
- Do not rush.
- As you move out of the building, gather people, whoever you come across.
- Always move downstairs and avoid returning to the burning premises, until the fire-fighters arrive.

(B) Initiate evacuation

- Stop your work immediately but do not panic.

- Gather and carry only the most important items like a cell phone before leaving with the person.
- Leave the house via the nearest door bearing an **"exit"** sign.
- Report to the person's parents over the telephone if they are not present.
- Call 101 for fire emergency or 108 for other natural disaster help.
- Incorporate first aid treatment to the person, if needed.

(C) Emergency evacuation process

- On hearing an evacuation alarm or instruction of any people inside or outside the house regarding fire, immediately cease all activity and secure personal valuables.
- Assist any person in immediate danger, but only if safe to do so.
- If practical, and only if safe to do so, secure any activity or process that may become hazardous or suffer damage if left unattended as a consequence of evacuation.
- Act in accordance with directions given by emergency control personnel and evacuate the building immediately.
- Assist with the general evacuation if directed to do so by emergency control personnel.
- Assist with the evacuation of disabled occupants.
- In a fire, do not use a lift to evacuate a building.
- Move calmly to the nominated evacuation assembly area and do not leave the evacuation assembly area until the all clear has been given.
- Follow the instructions of relevant emergency services personnel and campus emergency control personnel.

4.1.13 First aid

First aid is the first assistance or treatment given to a casualty or a sick person for any injury or sudden illness before the arrival of an ambulance, the arrival of a qualified paramedical or medical person or before arriving at a facility that can provide professional medical care.

Aims of first aid

The aims of first aid are:

- To preserve life,
- To prevent the worsening of one's medical condition,
- To promote recovery, and
- To help to ensure safe transportation to the nearest healthcare facility.

Role of first aider: Remember pact

P - Protect
A - Assess

C - Care
T - Transport-Triage

(A) Vital signs

Vital signs are measurements of the body's basic functions. Normal vital signs change with age, sex, weight, exercise tolerance, and overall health. The four main vital signs that are usually monitored are given as follows.

Vital Signs	Good	Poor
Heart Rate	60-100 beats per minute	Less than 60 or greater than 100 beats per minute
Respirations	14-16 breaths per minute	Less than 14 breaths per minute
Skin	Warm, pink and dry	Cool, pale and moist
Consciousness	Alert and orientated	Drowsy or unconscious

Table: 4.5 Vital sign

(B) Four a's

Awareness	Assessment	Action	After care
• Observe • Stop to Help	• Assess what is required to be done. • Ask yourself, 'Can I do it?'	• Do what you can. • Call for expert medical help. • Take care of your and the bystander's safety.	• Once you have assisted the victim, stay with him/her till expert care arrives.

Table: 4.6 Four a's

(C) Degrees of burns

1st Degree Burn	2nd Degree Burn	3rd Degree Burn	4th Degree Burn
Will recover by it-self in a few days. Action Required: Place under running water.  	Serious but recovers in a few weeks. Action Required: Place clean wet cloth over the burnt area.  	Very Serious and will require skin grafting. Action Required: Place a clean dry cloth over the burnt area.  	Extremely Serious and requires many years with repeated plastic surgery and skin grafting, is life threatening. Action Required: Leave open and prevent infection.  

Table: 4.7 Burn classification

(D) First aid techniques for common injuries

Some common techniques to first aid common injuries.

Injury	Symptom	Do's	Don'ts
Fracture	• Pain • Swelling • Visible bone	• Immobilise the affected part. • Stabilise the affected part. • Use a cloth as a sling. • Use board as a sling. • Carefully Transfer the victim on a stretcher.	• Do not move the affected part. • Do not wash or probe the injured area.

Burns (see Degrees of Burn table)	• Redness of skin. • Blistered skin. • Injury marks. • Headache/seizures.	• In case of electrical burn, cut-off the power supply. • In case of fire, put out fire with blanket/coat. • Use water to douse the flames. • Remove any jewellery from the affected area. • Wash the burn with water. 	• Do not pull off any clothing stuck to the burnt skin. • Do not place ice on the burn. • Do not use cotton to cover the burn.
Bleeding	• Bruises. • Visible blood loss from body. • Coughing blood. • Wound/ Injury marks. • Unconsciousness due to blood loss. • Dizziness. • Pale skin.	• Check victim's breathing. • Elevate the wound above heart level. • Apply direct pressure to the wound with a clean cloth or hands. • Remove any visible objects from the wounds. • Apply bandage once the bleeding stops.	• Do not clean the wound from out to in direction. • Do not apply too much pressure (not more than 15 mins). • Do not give water to the victim.

Table: 4.8 First aid techniques for common injuries

4.1.14 Cardiopulmonary resuscitation (CPR)

Cardiopulmonary resuscitation (CPR) is a lifesaving technique. It aims to keep blood and oxygen flowing through the body when a person's heart and breathing have stopped. CPR can be performed by any trained person. It involves external chest compressions and rescue breathing. CPR performed within the first six minutes of the heart stopping can keep someone alive until medical help arrives.

Fundamentally these are referred to as abc of life. The process is always referred to perform in an emergency:

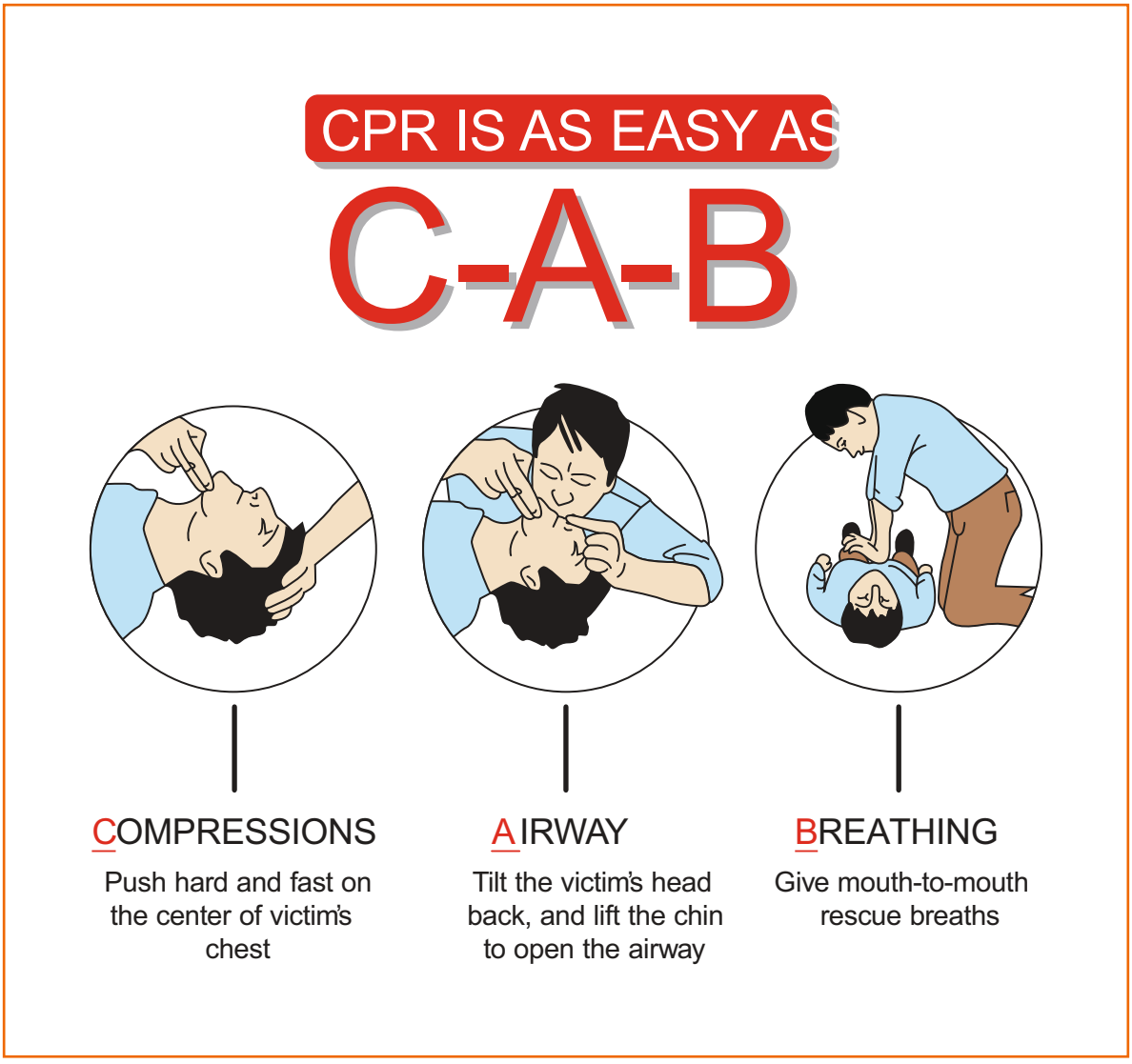


Fig: 4.11 CPR Process

Performing hands-only CPR

If a person is not breathing, his or her heartbeat will stop. These CPR steps (chest compressions and rescue breaths) will help circulation and get oxygen into the body.

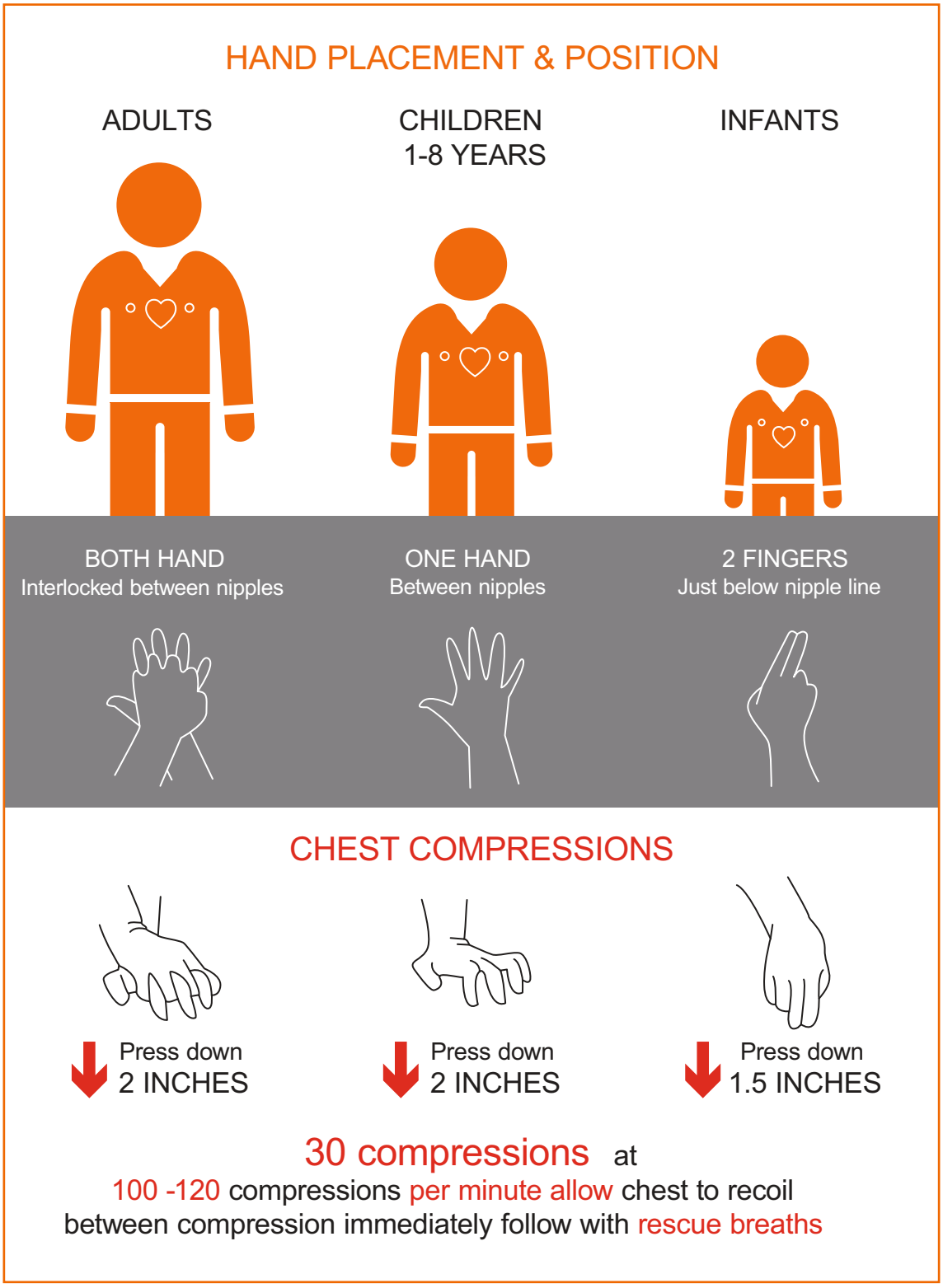


Fig: 4.12 Performing CPR Steps

Step 1: Position your hand Make sure the victim is lying on his back on a firm surface. Kneel beside him and place the heel of your hand on the centre of the chest.	
Step 2: Interlock fingers Keeping your arms straight, cover the first hand with the heel of your other hand and interlock the fingers of both hands together. Keep your fingers raised so they do not touch the Victim's chest or rib cage.	
Step 3: Give chest compressions Lean forward so that your shoulders are directly over the victim's chest and press down on the chest about two inches. Release the pressure, but not your hands, and let the chest come back up. Repeat to give 30 compressions at a rate of 100 compressions per minute.	
Step 4: Open the airway Move to the victim's head. Tilt his head and lift his chin to open the airway again. Let his mouth fall open slightly.	
Step 5: Give rescue breaths Pinch the nostrils closed with the hand that was on the forehead and support the victim's chin with your other hand. Take a normal breath, put your mouth over the victim's, and blow until you can see his chest rise.	
Step 6: Watch chest fall Remove your mouth from the victim's and look along the chest, watching the chest fall. Repeat steps five and six once.	
Step 7: Repeat chest compressions and rescue breaths Place your hands on the chest again and repeat the cycle of 30 chest compressions, followed by two rescue breaths. Continue the cycle.	

Table: 4.9 Performing CPR steps

4.1.15 Accident/incident report forms

There are many kinds of accident/incident report forms but all do the same job – they all include the findings of the investigation and determine the causes of the incident. They also provide recommendations to prevent further occurrences. There are also various computer programs which have been developed to record and analyse data. Whatever the format, they all state.

- **What happened:** The injuries/losses/costs.
- **How it happened:** The event itself.
- **Why it happened:** The causes, root, underlying and immediate.
- **Recommendations:** Any action to be taken to remedy the situation and prevent any recurrences.

The use of standardized report forms ensures that the investigation process is correctly adhered to and that information can be reported back to management. Follow- up actions can easily be taken following appropriate recommendations within the report. Standardized report forms can also act as a checklist.

An efficient recording system will:

- Ensure the information is correctly and accurately presented.
- Allow the data to be analysed easily in order to discover common causes or trends.
- Ensure data which may be required for future reference is included.
- Identify issues which may help prevent any recurrence of the accident.

Report forms should be reviewed on a regular basis to ensure that any recommendations have been implemented.

Summary

- As defined by who, health is a “state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity’’.
- Safety is the state of being ‘safe’, the condition of being protected from harm or other non-desirable outcomes.
- Workers in oil and gas industry are generally susceptible to certain safety and injury hazards such as, motor vehicle accident, contact injuries, fire and explosions, slip, trips and falls etc.
- Workers in oil and gas industry are generally susceptible to chemical hazards, physical hazards, biological hazards, ergonomic hazards, psychosocial hazards.
- It is important that driver, drive shaft, are secured from inadvertent movement before anyone works on the pump.
- It is important to ensure that the steam - and the associated steam condensate system - are properly isolated.
- A systematized approach PDCA should be used for managing occupational safety and health hazards.
- Risk management includes, identifying the risks, evaluating and prioritizing the risks, implementing

preventive/protective measures to control the risk.

- Job safety analysis is a process of systematically evaluating certain jobs, tasks, processes or procedures and eliminating or reducing the risks or hazards in order to protect workers from injury or illness.
- Personal protective equipment (PPE) is a clothing or equipment worn by workers to protect them from various hazards.
- Fire extinguishers are designed to tackle specific types of fire.
- There are five different classes of fire, class a, b, c, d, e, k.
- There are different types of fire extinguishers, water extinguisher, dry chemical powder, foam type extinguisher, carbon dioxide extinguisher, special dry powder.
- The fire extinguishers are used by following PASS technique.
- First aid is the first assistance or treatment given to a casualty or a sick person for any injury or sudden illness before the arrival of an ambulance.
- Cardiopulmonary resuscitation (CPR) is a lifesaving technique. It aims to keep blood and oxygen flowing through the body when a person's heart and breathing have stopped.

Exercise

1. **A ..... examines the hazardous conditions at a workplace to identify risks and implement measures to prevent or reduce the risks.**
   a) Risk assessment
   b) Ergonomics
   c) Air quality
   d) Visual Inspection

2. **These are the clothing or equipment worn by workers to protect them from fire, exposure to toxic chemicals and direct impact.**
   a) Risk Identification
   b) Personal Protective Equipment (PPE)
   c) Proximity suits
   d) Administrative controls

3. **The method of using a fire extinguisher is to follow P.A.S.S. PASS is the acronym for, Pull the Pin (P), Aim (A), Squeeze (S) and .....**
   a) Swing
   b) Sweep
   c) Swipe
   d) Send

4. **These are the type of burns which are very serious and require skin grafting.**
   a) 1st degree burn
   b) 2nd degree burn
   c) 3rd degree burn
   d) 4th degree burn

5. **What does CPR stand for?**
   a) Cardiac personal resuscitation
   b) Caring personal rescue
   c) Cardiopulmonary rescue
   d) Cardiopulmonary resuscitation

6. **These are the signs which mean "You must not" or "Do not do. . .," or "Stop."**
   a) Prohibition signs
   b) Mandatory action signs
   c) Warning signs
   d) Fire safety signs

7. **This occurs with the failure of the circulatory system due to which insufficient oxygen reaches the tissues.**
   a) Fractures
   b) Shock
   c) Muscle cramps
   d) Dislocation

8. **These are the class of fire that are related to solid materials.**
   a) Class B
   b) Class C
   c) Class D
   d) Class A

9. **Which of the following is strictly prohibited in fire emergency procedures?**
   a) Apply the extinguisher medium to the base of the flames
   b) Do not drive the flames away from you
   c) Follow instructions on the extinguisher's label
   d) Ensure that the fire has been completely extinguished

10. **In order to be a first aider one must remember PACT, what does P stand for in PACT?**
    a) Prevent
    b) Protect
    c) Prioritize
    d) Process

Scan the QR Code to watch the related video

Classes of fire
www.youtube.com/watch?v=xnZZruGjKBA

Types of Fire Extinguishers and Their Uses
www.youtube.com/watch?v=GjSoxJF3RD4&t=13s

Personal Protective Equipment (PPE) Introduction
www.youtube.com/watch?v=loQ9Dbsy2ag

Fire Emergency Procedures - Animated Safety Video
www.youtube.com/watch?v=7gHEtGY4chE

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6. Annexure

Annexure - QR Codes

Annexure - QR Code

Serial No.	Module No.	Unit Number	Topic Name	Page No.	URL	QR Code
1.	1. Introduction to the Hydrocarbon Sector and the job role of Junior Operator - 2 G Ethanol Plant	Unit1.1 - Introduction to Hydrocarbon and its Sub-sectors	Sub-sectors in Hydrocarbon Industry	25	youtu.be/6ozmKhahk8M	
2.			Biofuels		youtu.be/ZGmwtDffc74	
3.		Unit 1.2 - Roles and Responsibilities of Junior Operator - 2G Ethanol Plant	Business Matters | Ethanol blended with petrol | Will India benefit from it?		www.youtube.com/watch?v=QXIv20U3gpQ	
4.			How to Start Ethanol Production Business || Highly Demand New Business		www.youtube.com/watch?v=I4tz8NqAI6g	
5.	2. Assist in carrying out 2G Ethanol plant operations	Unit 2.1 - Bio-mass/Feedstock Storage and Handling	From stubble to ethanol – how this 2G ethanol plant in Panipat is turning the table on air pollution	70	www.youtube.com/watch?v=YaahvuKDfTQ	

Annexure - QR Code

Serial No.	Module No.	Unit Number	Topic Name	Page No.	URL	QR Code
6.	2. Assist in carrying out 2G Ethanol plant operations	Unit 2.2 - Monitoring and Controlling the 2G Ethanol Production Process	Bioethanol Production from Rice Straw	70	www.youtube.com/watch?v=A9BB-A2uc0I	
7.			Production of 2G Bioethanol by a Continuous Process		www.youtube.com/watch?v=0k5hdMvyR5I	
8.		Unit 2.3 - Safe and Efficient Operational Procedures	Risk Assessment Training		www.youtube.com/watch?v=dzOK0GCw05o	
9.	3. Working effectively in a team	Unit 3.1 - Working effectively in a team	Teamwork can make a Dreamwork	82	www.youtube.com/watch?v=6fbE52YDEjU	
10.			Motivation - leader and teamwork		www.youtube.com/watch?v=9MO1aY1xC80	

Annexure - QR Code

Serial No.	Module No.	Unit Number	Topic Name	Page No.	URL	QR Code
11.	4. Maintain health, safety and security procedures	Unit 4.1 - Maintain health, safety and security procedures	Classes of fire	119	www.youtube.com/watch?v=xnZZruGjKBA	
12.			Types of Fire Extinguishers and Their Uses		www.youtube.com/watch?v=GjSoxJF3RD4&t=13s	
13.			Personal Protective Equipment (PPE) Introduction		www.youtube.com/watch?v=loQ9Dbsy2ag	
14.			Fire Emergency Procedures - Animated Safety Video		www.youtube.com/watch?v=7gHEtGY4chE	
15.	5. Employability Skills (30 Hours)		Employability Skills	121	www.skillindiadigital.gov.in/content/list	

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