MODULE ME404
APPLIED MACHINERY AND EQUIPMENT VALUATION - SPECIALISED INDUSTRIES

Objectives

At the end of the program, participants will gain knowledge on:

- Selected specialised machinery and equipment valuations;
- Conducting machinery and equipment data collection for process plants;
- Safety procedures for conducting process plant inspections.

Content

- Applied valuation on specialised Machinery and Equipment
  - Water Desalination Plant
  - Oil Refinery
  - Airport
- Referencing for Process Plants
  - Inspection Procedures
  - Safety Procedures

Methodology

- Lecture
- Discussion
- Q and A

Duration

- 5 days

PROGRAM SCHEDULE

Training Program	:	**Applied Machinery and Equipment Valuation - Specialised Industries**
Duration	:	**5 Days**
Date	:	**2020**

DATE/ TIME	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
0830 – 1030	**Session 1** Applied Valuation on Specialised ME	Continue Session 1	Continue Session 1	**Session 2** Referencing for Process Plants	**Examination**
1030 – 1100					
1100 – 1200	Continue Session 1	Continue Session 1	Continue Session 1	Continue Session 2	**Examination**
1200 – 1300					
1300 – 1330					
1330 – 1530	Continue Session 1	Continue Session 1	Continue Session 1	Continue Session 2	

SESSION PLAN

Training Program	**:**	**Applied Machinery and Equipment Valuation - Specialised Industries**
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<table>
<tr><th>Date/ time</th><th>Session</th><th>Session Objective</th><th>Session Content</th><th>Methodology</th></tr>
<tr><td>Day 1
0830 – 1030
1100 – 1300
1330 – 1530
(6.0 hrs)</td><td>Session 1
Applied Valuation on Specialised ME</td><td>At the end of the session, participants will be will be exposed to the valuation application for water desalination plants.</td><td>• Introduction to Valuation on Specialised ME
• Selected Applied Valuation: Water Desalination Plant
o Overview of water desalination plant economics
▪ Introduction
▪ Economics of water desalination
o Desalination development potential and market forecast
o Desalination processes, construction components, and building services
▪ Desalination technologies
▪ Components of desalination plant and building services
▪ Construction of desalination plant
▪ Operation of desalination plant
o Water desalination plant valuation
▪ Trends in desalination contracts and project finance
▪ Application of valuation methodologies in valuing desalination plants
o Valuation reporting
▪ Introduction
▪ General requirements
▪ Valuation reports
o Issues, problems and challenges
▪ Confusion over terminologies
▪ Complex and dynamic hydrological cycles
▪ Water quantity and quality
▪ Stakeholder perspectives
▪ Ethical issues
▪ Difficulties in valuation
▪ Lack of incentives to value externalities
o Conclusion</td><td>• Lecture
• Discussion
• Q and A</td></tr>
</table>

Date/ time	Session	Session Objective	Session Content	Methodology
Day 2 0830 – 1030 1100 – 1300 1330 – 1530 (6.0 hrs)	**Session 1** Continuation	At the end of the session, participants will be will be exposed to the valuation application for oil refineries.	• Selected Applied Valuation: Oil Refinery ○ Overview of oil refinery economics ○ Oil refinery development trends ○ Introduction to oil refinery valuation ○ Segments of oil and gas industry ▪ Upstream ▪ Midstream ▪ Downstream ○ Introduction to oil refinery valuation ▪ Types of crude ▪ Products ▪ Refinery operation/ process ○ Valuation method ▪ Cost method ▪ Profit method ○ Issues, problems and challenges	• Lecture • Discussion • Q and A
Day 3 0830 – 1030 1100 – 1300 1330 – 1530 (6.0 hrs)	**Session 1** Continuation	At the end of the session, participants will be will be exposed to the valuation application for airports.	• Selected Applied Valuation: Airports ○ Introduction to Airport Valuations ▪ Overview of airport economics ▪ Airport development trends ○ Case study: Valuation of ABC Airport ▪ Objective ▪ Scope ▪ Methodology ▪ Location ▪ General description ▪ Building valuation ▪ Valuation of ME ▪ Basis of valuation ▪ Other assumptions ▪ Valuation methods ▪ Factors affecting value of airport ○ Issues, problems and challenges ○ Conclusion	• Lecture • Discussion • Q and A

Date/ time	Session	Session Objective	Session Content	Methodology
Day 4 0830 – 1030 1100 – 1200 (3.0 hrs)	**Session 2** Referencing for Process Plants	At the end of the session, participants will be able to understand the data collection and inspection process for industrial process plants.	• Inspection Procedures for Process Plants ○ Introduction ○ Inspection procedures ▪ Stage 1: Pre-inspection ▪ Stage 2: Preliminary inspection ▪ Stage 3: During inspection ▪ Stage 4: Post inspection ○ Gathering Information ○ Issues and Challenges During Inspections	• Lecture • Discussion • Q and A
Day 4 1200 – 1300 1330 – 1530 (3.0 hrs)	**Session 2** Continuation	At the end of the session, participants will be able to understand safety procedures during industrial process plant inspection.	• Safety Procedures ○ Introduction ○ Purpose/ importance ○ Safety rules to be followed ○ Safety precautions ○ Actions during emergency situations ○ Safety preparation before inspection ○ Hazards and hazard signs ○ Safety gears ○ Safety signage ○ Safety precautions - suitable attire, tracking position, adherence to plant/factory regulations ○ Fire escape, emergency evacuation and assembly points ○ Local safety regulations ○ Conclusion	• Lecture • Discussion • Q and A

INTRODUCTION TO VALUATION OF SPECIALISED MACHINERY AND EQUIPMENT (ME)

1.0 Introduction

Machinery and equipment valuations are specialised exercises and require experience and specific training to conduct valuations especially in specialised industries. ME valuers are advised to ensure that they have the requisite experience and training before accepting instructions for machinery and equipment valuation of specialized industries. The most important aspect of conducting machinery and equipment valuation of a specialised industry is that ME valuers should understand the whole production process of the industry to be valued. This is to ensure that the ME valuers understand the types of machinery and equipment available in the industry to be valued.

1.1 Types of Specialized Industries

In this module, ME valuers will be taught machinery and equipment valuation of specialised industries. There are many types of specialized industries that require machinery and equipment valuations. It depends on the type and priority of the specialised industries available in the country. The following are some of the specialised industries found in Saudi Arabia candidates may find as they practise machinery and equipment valuation:

a) Mining
- Crude Petroleum and Natural Gas
- Oil Refinery
- Fertilizer
- Phosphate Mining
- Aluminium Processing

b) Manufacturing
- Automotive Industries
- Plastic Industries
- Food Industries
  - Dairy Product
  - Bakery Factories
  - Food Packaging

c) Construction
- Steel Production
- Cement Production

d) Transportation and Communication
- Airports
- Ports
- Communication and Information Technology (IT)

e) Utilities
    - Power Plant
    - Water Desalination Plant

f) Services
    - Health care

g) Agriculture
    - Poultry Industries
    - Abattoir - Slaughterhouses

Three specialized industries have been selected for the purpose of this module and will be discussed in detail including sample valuation reports:

a. Valuation of Water Desalination Plant
b. Valuation of Oil Refinery
c. Valuation of Airport

This module will also cover the topic on the inspection and safety procedures to be considered in preparation of the ME405 module.

ME 404
APPLIED VALUATION OF SPECIALISED
MACHINERY AND EQUIPMENT

WATER DESALINATION PLANT VALUATION

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WATER DESALINATION PLANT

APPLIED VALUATION OF WATER DESALINATION PLANT

1.0 OVERVIEW OF WATER DESALINATION PLANT ECONOMICS

1.1 Introduction

Desalination is a process that extracts minerals from saline water. More commonly, desalination refers to the removal of salts and minerals from a target substance (Ghaffour, 2009). For instance, in the agriculture sector, soil desalination is an important process to reduce soil salinity which is an issue in the farming industry (Global Water Intelligence, 2012).

Saltwater is desalinated to produce water suitable for human consumption or irrigation. One by-product of desalination is salt.

Desalination is used on many seagoing ships and submarines. Most of the modern interest in desalination is focused on cost-effective provision of fresh water for human use. Along with recycled wastewater, it is one of the few rainfall-independent water sources (Quteishat, 2009).

Due to its energy consumption, desalinating sea water is generally more costly than fresh water from rivers or groundwater, water recycling and water conservation. However, these alternatives are not always available, and depletion of reserves is a critical problem worldwide. Currently, approximately 1% of the world's population is dependent on desalinated water to meet daily needs, but the United Nations (UN) expects that 14% of the world's population will encounter water scarcity by 2025 (Reddy and Ghaffour, 2007).

Desalination is particularly relevant in dry countries such as Saudi Arabia and Australia, which traditionally used to rely on collecting rainfall behind dams for water.

1.2 Economics of Water Desalination

Global demand for water is projected to exceed supply by 40% in 2030. As desalination will be a key source for clean water, desalination plants will be an integral component of water infrastructure all over the world. Differing technologies and fields of application create issues in terms of optimal integration and operation. Rising demand, cost and environmental awareness are driving the need for improved efficiency and sustainability.

At the same time, the increasing complexity of projects generates new challenges across the entire plant lifecycle, from planning and construction up to operation and deconstruction phases. Financiers, investors, technology providers, owners and operators of desalination plants need to address these challenges and manage the corresponding risks.

Many water-stressed or arid regions or countries are augmenting their water supply with desalinated water to meet the increased water demand caused by growth triggered by increased population, industrial expansion, tourism, and agriculture development. In some countries, desalination is no longer a marginal or supplemental water resource. Qatar and Kuwait rely 100% on desalinated water for domestic and industrial supplies (Ghaffour, 2009).

Of the global desalted water output, 63.7% of the total capacity is produced by membrane processes and 34.2% by thermal processes. The source water of the desalination process is split with about 58.9% from seawater and 21.2% from brackish groundwater sources, and the remaining percentages are from surface water and saline wastewater. These figures are constantly changing because the desalination market is growing very rapidly. The growth rate is currently about 55% per annum, a truly stunning figure.

The increase of desalination capacity is not only caused primarily by increases in water demand but also by the significant reduction in desalination costs as a result of significant technological advances that result in making desalinated water cost-competitive with other water sources. In some specific areas, desalination is now able to successfully compete with conventional water resources and water transfers for potable water supply (e.g. construction of dams and reservoirs or canal transfers) (Quteishat, 2009).

2.0 DESALINATION DEVELOPMENT POTENTIAL AND MARKET FORECAST

Desalination has great development potential on a global scale. This is attributed to the fact that, out of 71 largest cities that do not have local access to new freshwater sources, 42 are located along coasts (Ghaffour, 2009). Out of the entire world population, 2.4 billion inhabitants representing 39% of the total, live at less than 100 Kilometres from the sea (Quteishat, 2009).

Other than the fact that desalination may be the only option for some countries, there are driving forces behind its development potential, making it more favourable than conventional resource development. Being independent of climatic conditions, rainfall and so on, a primary force is its identification as a secure source of supply. Desalinated seawater is truly a “new” water source and has an essentially unlimited capacity, not subject to sustainability criteria, although perhaps limited by energy production.

Desalination capacity is continuously increasing worldwide, not only in the Middle East and North Africa (MENA) region where water demand is high and other sources of supply are limited, but also in countries where desalination was unthinkable in the past such as in Spain and Australia (both contain arid and semiarid lands). It is expected that the total desalination market will reach over USD 31 billion by 2015 (Pankratz, 2008).

According to the International Desalination Association, in June 2015, 18,426 desalination plants operated worldwide, producing 86.8 million cubic meters per day, providing water for 300 million people. This number increased from 78.4 million cubic meters in 2013, a 10.71% increase in 2 years. The single largest desalination project is Ras Al-Khair in Saudi Arabia, which produced 1,025,000 cubic meters per day in 2014, even though this plant is expected to be surpassed by a plant in California. Kuwait produces a higher proportion of its water than any other country, totalling 100% of its water use (Greenle et al, 2009).

3.0 DESALINATION PROCESSES, CONSTRUCTION COMPONENTS AND BUILDING SERVICES

3.1 Desalination Technologies

The two major types of technologies that are used around the world for desalination can be broadly classified as either thermal or membrane. Both technologies need energy to operate and produce fresh water. Within those two broad types, there are sub-categories (processes) using different techniques. The major desalination processes are identified in **Table 1.0.**

Thermal Technology	Membrane Technology
Multi-Stage Flash Distillation (MSF)	Reverse Osmosis (RO)
Multi-Effect Distillation (MED)	Electrodialysis (ED)
Vapour Compression Distillation (VCD)	Electrodialysis reversal (EDR)

Table 1.0: Desalination Technologies and Processes

3.1.1 Thermal Technology

Thermal distillation technologies are widely used in the Middle East, primarily because the region’s petroleum reserves keep energy costs low. The three major, large-scale thermal processes are Multistage Flash Distillation (MSF), Multi-Effect Distillation (MED), and Vapour Compression Distillation (VCD). Another thermal method, solar distillation, is typically used for very small production rates.

These technologies are discussed briefly as follows:

a. Multi-Stage Flash Distillation (MSF)

Multi-stage flash distillation (MSF) is a water desalination process that distils sea water by flashing a portion of the water into steam in multiple stages of what are essentially counter current heat exchangers. Multi-stage flash distillation plants produce about 60% of all desalinated water in the world.

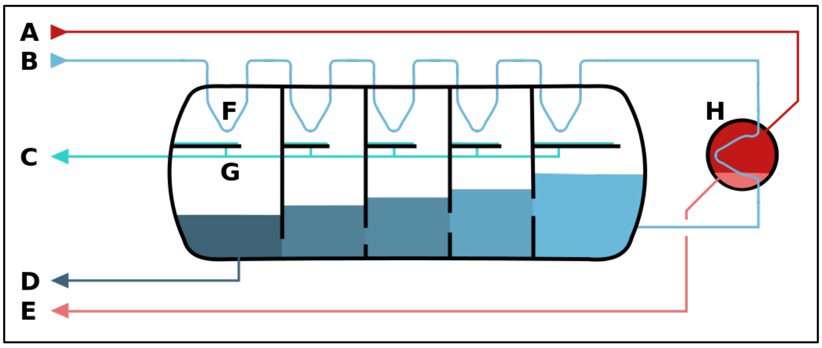


Figure 1: Schematic of a 'once-through' multi-stage flash desalinator

Legend:

A	Steam in	D	Waste out	G	Condensation collection
B	Seawater in	E	Steam out	H	Brine
C	Potable water out	F	Heat exchange		

Figure 2: MSF Desalination Plant at Jebel Ali G Station, Dubai

b. Multiple Effect Distillation (MED)

Multiple effect distillation (MED) works through a series of steps called "effects". Incoming water is sprayed onto vertically or, more commonly, horizontally oriented pipes which are then heated to generate steam. The steam is then used to heat the next batch of incoming sea water. To increase efficiency, the steam used to heat the sea water can be taken from nearby power plants. Although this method is the most thermodynamically efficient, a few limitations exist such as a maximum temperature and maximum number of effects.

Figure 3: Multiple Effect Desalination Plant

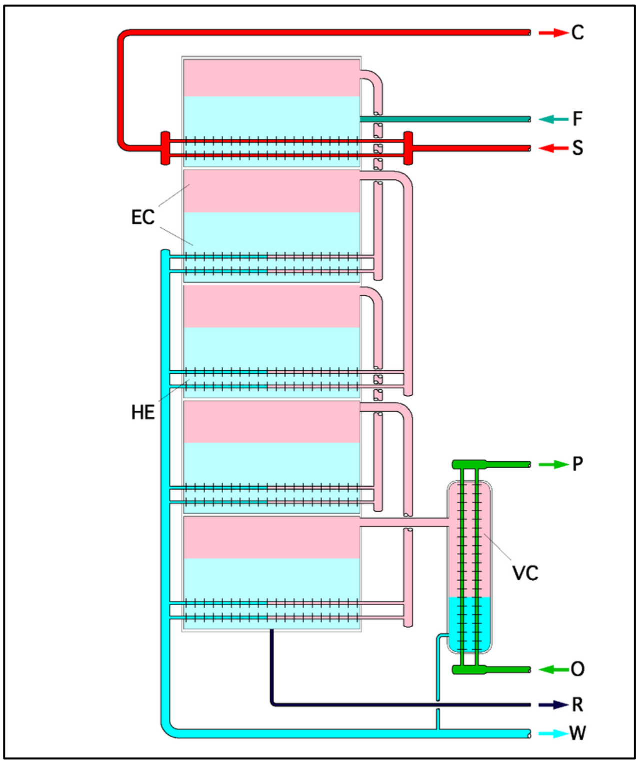


Figure 4: Schematic of a multiple effect desalination (MED) plant.

Note:
The first stage is at the top. Pink areas are vapour, lighter blue areas are liquid feed water. Stronger turquoise is condensate.

Legend:

F	Feed water in	O	Coolant in
W	Fresh water (condensate) out	P	Coolant out
S	Heating steam in	EC	Ejector condenser
C	Heating steam out	HE	Heat exchanger
R	Brine out	VC	Last-stage cooler

c. Vapour Compression Distillation (VCD)

Vapour compression distillation involves using either a mechanical compressor or a jet stream to compress the vapour present above the liquid. The compressed vapour is then used to provide the heat needed for the evaporation of the rest of the sea water. Since this system only requires power, it is more efficient if kept at a small scale.

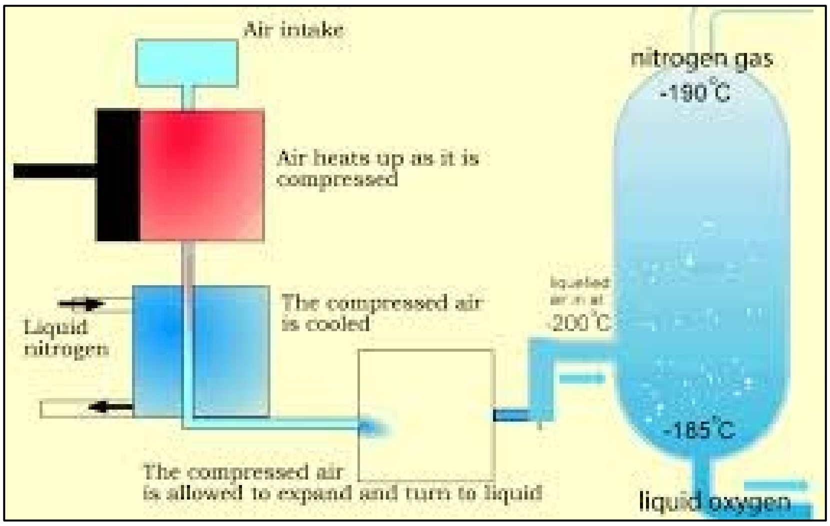


Figure 5: VCD Processes

Figure 6: Vapour Compression Distillation Plant

3.1.2 Membrane Technology

Membrane technologies are primarily used in the United States. These systems treat the feed water by using a pressure gradient to force the water through membranes. The three major membrane processes are Reverse Osmosis (RO), Electrodialysis (ED) and Electrodialysis Reversal (EDR). Membrane distillation is an emerging membrane-based desalination technology.

These technologies are discussed briefly as follows:

a. Reverse Osmosis (RO)

The principal competing process uses membranes to desalt saline water, principally applying reverse osmosis (RO). The RO membrane processes use semipermeable membranes and applied pressure (on the membrane feed side) to preferentially induce water permeation through the membrane while rejecting salts. Reverse osmosis plant membrane systems typically use less energy than thermal desalination processes.

Reverse osmosis (RO) is a water purification technology that uses a semipermeable membrane to remove ions, molecules, and larger particles from drinking water. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property that is driven by chemical potential differences of the solvent, a thermodynamic parameter. Reverse osmosis can remove many types of dissolved and suspended species from water, including bacteria, and is used in both industrial processes and the production of potable water. The result is that the solute is retained on the pressurized side of the membrane and the pure solvent can pass to the other side. To be "selective", this membrane should not allow large molecules or ions through the pores (holes), but should allow smaller components of the solution (such as solvent molecules) to pass freely.

In the normal osmosis process, the solvent naturally moves from an area of low solute concentration (high water potential), through a membrane, to an area of high solute concentration (low water potential). The driving force for the movement of the solvent is the reduction in the free energy of the system when the difference in solvent concentration on either side of a membrane is reduced, generating osmotic pressure due to the solvent moving into the more concentrated solution. Applying an external pressure to reverse the natural flow of pure solvent, thus, is reverse osmosis. The process is similar to other membrane technology applications.

However, key differences are found between reverse osmosis and filtration. The predominant removal mechanism in membrane filtration is straining, or size exclusion, so the process can theoretically achieve perfect efficiency regardless of parameters such as the solution's pressure and concentration. Reverse osmosis also involves diffusion, making the process dependent on pressure, flow rate, and other conditions.

Reverse osmosis is most commonly known for its use in drinking water purification from seawater, removing the salt and other effluent materials from the water molecules.

Figure 7: Reverse osmosis production train, North Cape Coral Reverse Osmosis Plant

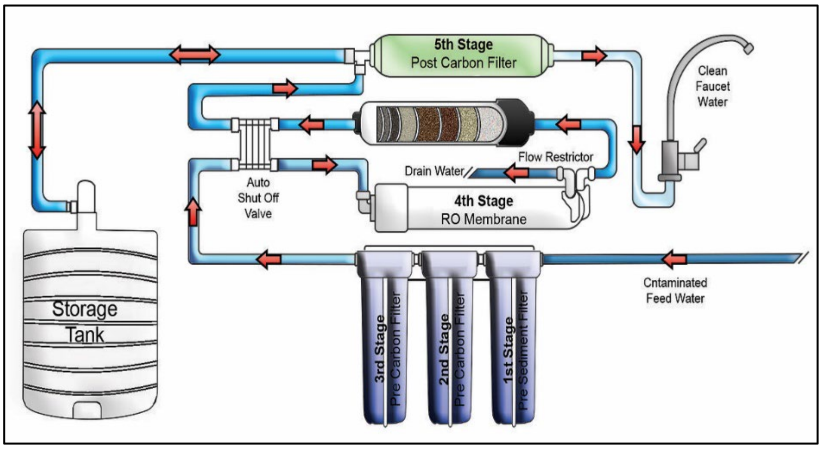


Figure 8: The reverse osmosis water filter process

Figure 9: A semipermeable membrane coil used in desalination

b. Electrodialysis (ED)

Electro-dialysis utilizes electric potential to move the salts through a membrane. **Electrodialysis** (ED) is used to transport salt ions from one solution through ion-exchange membranes to another solution under the influence of an applied electric potential difference. This is done in a configuration called an electrodialysis cell. The cell consists of a feed (dilute) compartment and a concentrate (brine) compartment formed by an anion exchange membrane and a cation exchange membrane placed between two electrodes. In almost all practical electrodialysis processes, multiple electrodialysis cells are arranged into a configuration called an electrodialysis stack, with alternating anion and cation exchange membranes forming the multiple electrodialysis cells.

Electrodialysis processes are different from distillation techniques and other membrane based processes (such as reverse osmosis (RO) in that dissolved species are moved away from the feed stream rather than the reverse. Because the quantity of dissolved species in the feed stream is far less than that of the fluid, electrodialysis offers the practical advantage of much higher feed recovery in many applications.

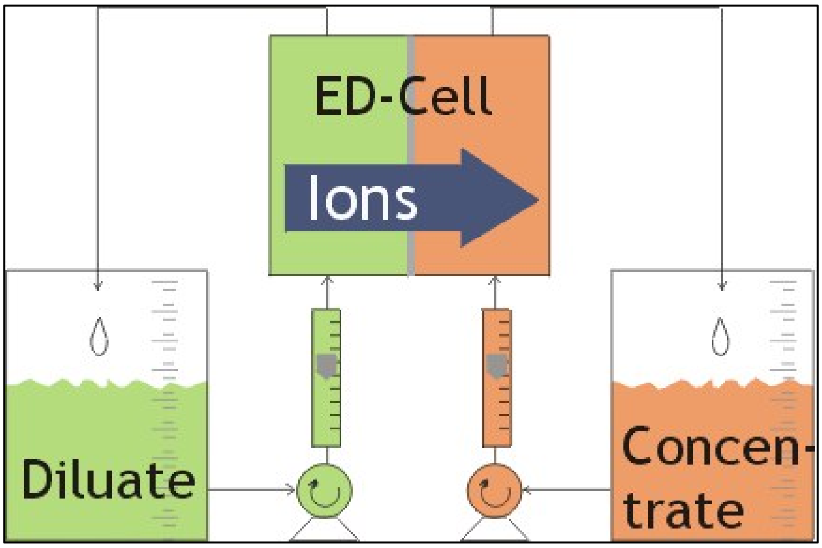


Figure 10: Electrodialysis Process


Figure 11: ED Plant

c. Electrodialysis Reversal (EDR)

Electrodialysis Reversal (EDR) is an electrodialysis reversal water desalination membrane process. An electric current migrates dissolved salt, ions including fluorides, nitrates and sulphates through an electrodialysis stack consisting of alternating layers of cationic and anionic ion exchange membranes. Periodically, the direction of ion flow is reversed by reversing the polarity of the applied electric current.

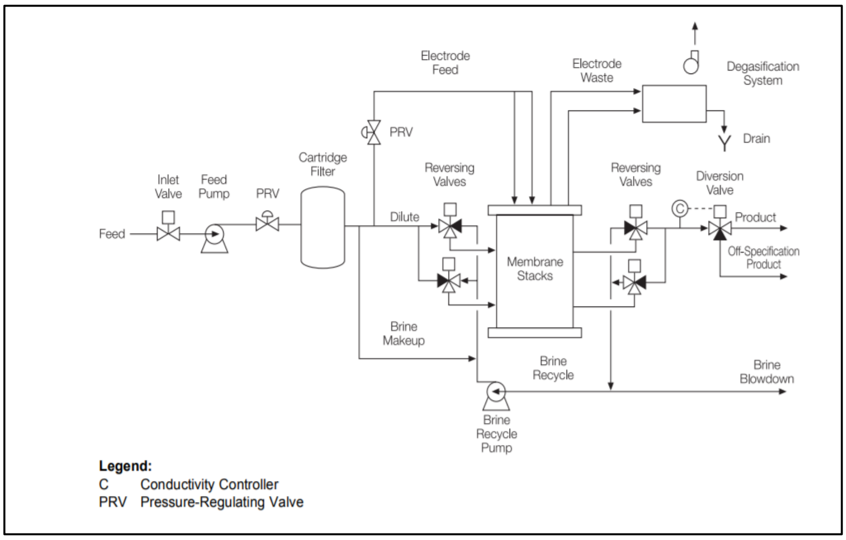


Figure 12: Electrodialysis Reversal Process

3.2 Components of Desalination Plant & Building Services

Normally, the desalination plant comprises the following major facilities/ systems:

- Seawater intake system
- Pre-treatment system
- Reverse Osmosis (RO) treatment system
- Post-treatment system
- Backwash and chemical cleaning system
- Sludge handling system
- Concentrate discharge system
- Auxiliary systems

The following diagram depicts how seawater is turned into fresh water through a typically configured Tubular Reverse Osmosis (TRO) desalination system.

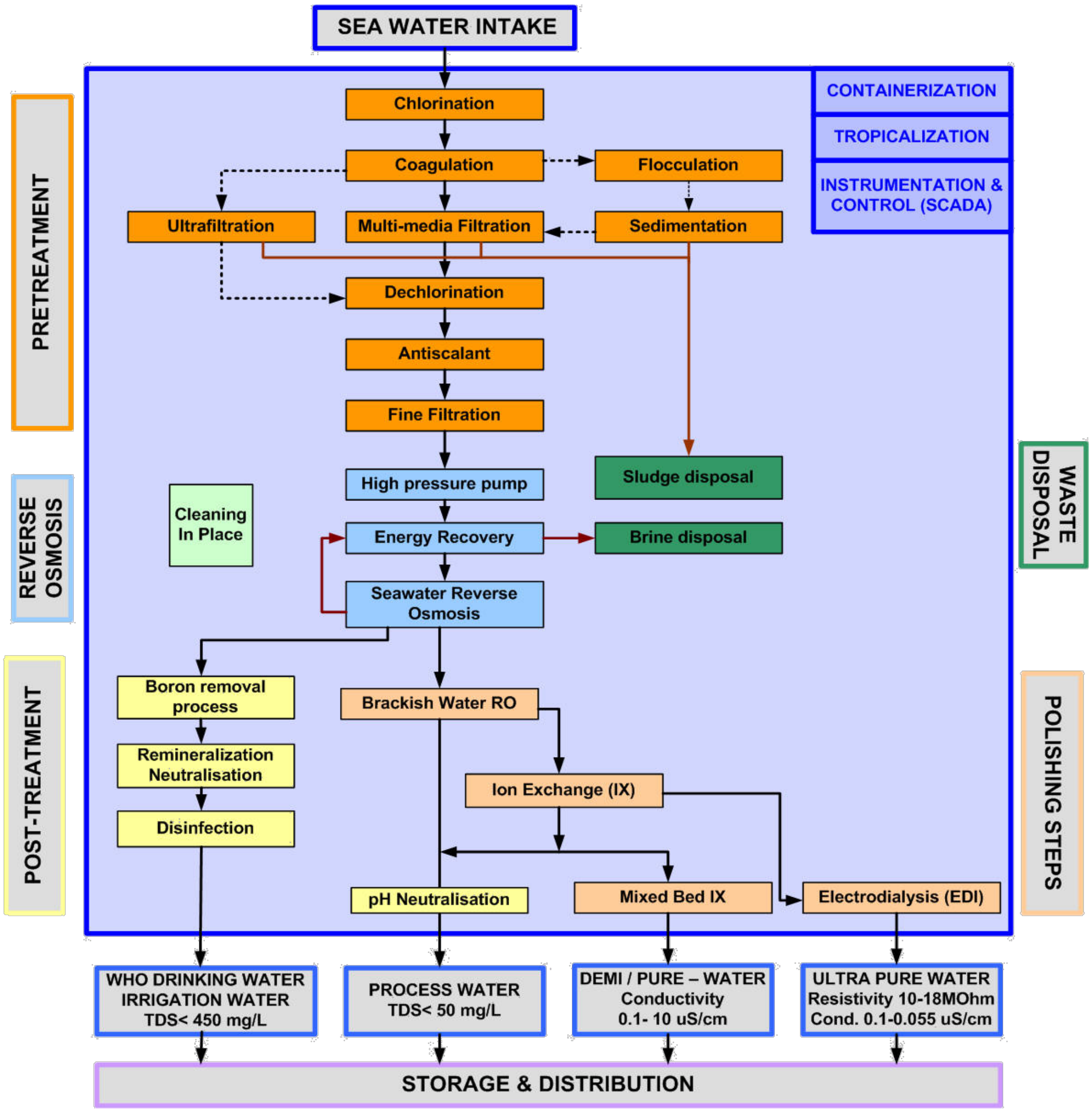


Figure 13: TRO Desalination System

3.2.1 Seawater Intake System

The function of these structures is to collect water with certain quality characteristics which are suitable for the required function, minimising the environmental impact to the surroundings thereof. Such impacts depend upon the type of plant, as the requirements for a combined cycle gas turbine (CCGT) power station, which uses the collected water to refrigerate the circuit, are not be the same as those in respect of a seawater desalination plant, the purpose of which is essentially human consumption.

Accordingly, the most habitual types of intake structures shall be summarised, (focusing upon open intake structures on the sea bed), the parameters for the design thereof and the most recent experiences concerning the design and construction of the intake structures, in respect of which the increase of the sizes thereof is able to be verified, which duly creates the need for more sophisticated structures.

3.2.2 Type of Intake Structure

The principal types of seawater intake structures are as follows:

a. Wells

Water is extracted from the phreatic water-table level, at the coast. The well intakes have the advantage that the water is of higher quality, and accordingly it is a good option for desalination plants. Through the wells, a pump sucks the water, which is then subjected to different filtering systems to separate the sand and other impurities. The disadvantage of this type of seawater intake structure is that the hydraulic capacity will often be reduced because of the silting thereof (clogging with fine particles) that impedes the intake of the necessary flow volume.

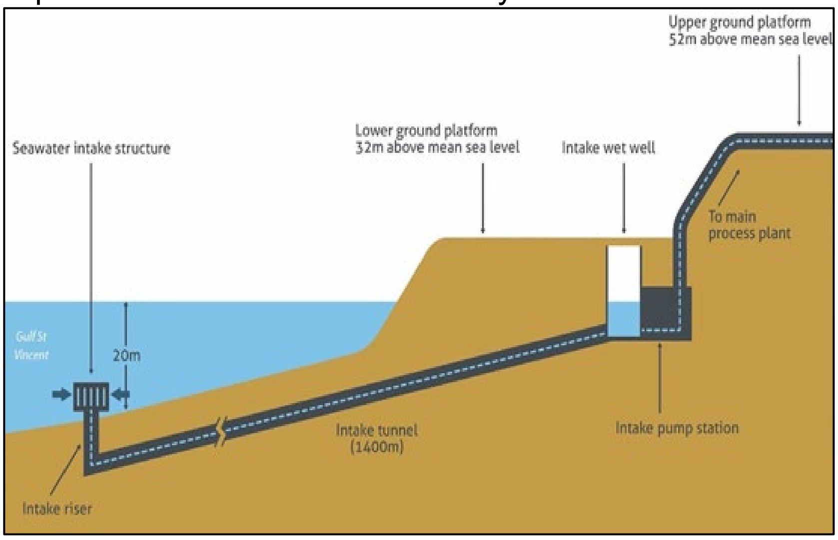


Figure 14: Seawater Intake System

Figure 15: Well Seabed Intake

Figure 16: Well Seabed Intake under construction

b. Direct Coastal Intake

This is normally carried out by means of collection caissons. This type of seawater intake structure is only feasible in certain enclaves, given that the coastal dynamics may “bury them”, and thereby plugging them up. Furthermore, the water collected may be of worse quality, given that along the coast both organic as well as inorganic waste material exists that are dragged along by the marine dynamics. Thus, these intake structures are not recommended in the case of desalination plants or fish farms but are recommendable for refrigeration circuits. The costal dynamics are also problematic, which may cause changes to the level and profile of the coast, which may generate problems in respect of the functional capacity of the water intake structure.

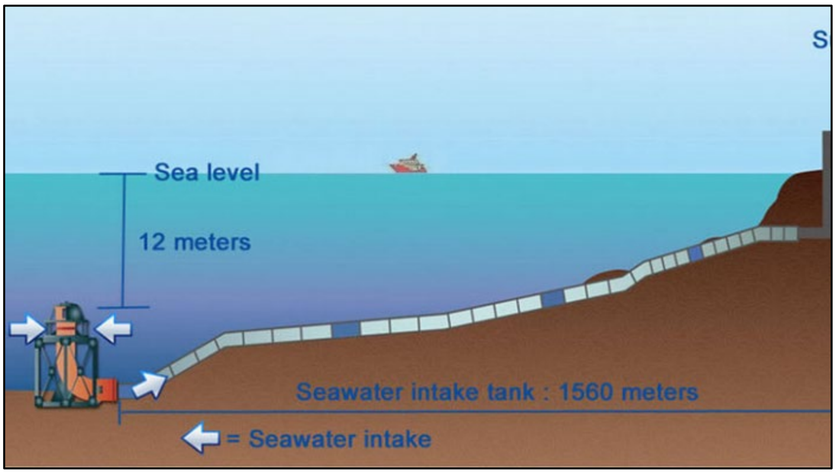


Figure 17: Direct seabed intake

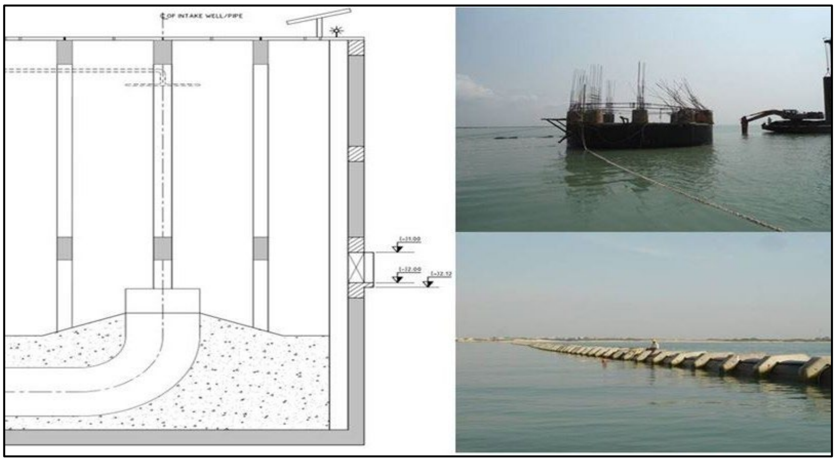


Figure 18: Cross-sectional and photograph of direct seabed intake

c. Open Intake Structures on The Sea Bed

These structures usually have a singular collection structure that is located in a convenient position, at a sufficient sea depth, where the water enters the underwater pipelines, which duly transport the same to land, whereby a pump station pumps the water to its destination. The structure situated in the sea is usually made of concrete or formed by special pieces of Glass-reinforced plastic (GRP) or other plastic materials. The structure is seldom metallic component (for the problems of corrosion). This solution is usually the most advantageous, given that the water quality is guaranteed by selecting the most adequate intake point and the hydraulic capacity is unlimited, provided that the intake structure, the pipelines and the pumps (located at the pump station, on land) are of a sufficient size and power.

Figure 19: Open Intake Structure under Construction

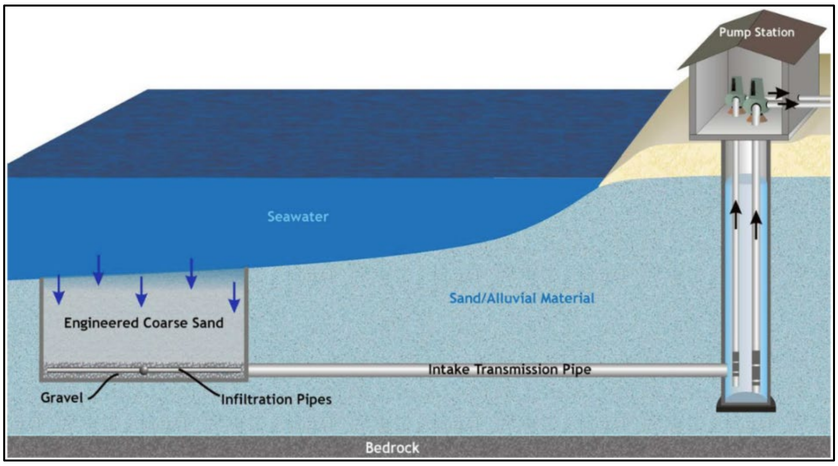


Figure 20: Open intake structure on seabed

3.2.3 Pre-Treatment System

Pre-treatment is an integral part of every seawater reverse osmosis (SWRO) desalination plant. The key purpose of the pre-treatment system is to remove particulates, debris, microorganisms, suspended solids and silt from the source seawater prior to reverse osmosis separation. Ideally, after pre-treatment the only solids left in the seawater would be the dissolved minerals. As long as the seawater system is operated in a manner that prevents minerals from precipitating on the membrane surface, the SWRO membranes could operate without any cleaning for a very long time. Practical experience shows that in close-to-ideal source seawater quality, SWRO membranes may not need to be cleaned for one to two years and their useful life could extend beyond 10 years.

Pre-treatment systems remove most but not all suspended solids contained in the seawater. The suspended solids, particulates and silt that remain after pre-treatment accumulate on the surface of the reverse osmosis (RO) membranes and cause loss of membrane productivity over time. In addition, because seawater naturally contains bacteria as well as dissolved organics, a biofilm of bacteria can form on the membrane surface.

All membranes foul over time. However, the rate and reversibility of fouling are the two key factors that have most profound effect on the performance and efficiency of the seawater reverse osmosis separation process. These factors in turn are closely related to the source seawater quality and the performance of the desalination plant's pre-treatment system.

Two types of pre-treatment systems are typically used to protect the SWRO membranes from fouling: conventional granular media filtration and membrane filtration. Currently, conventional granular media filtration is the predominant pre-treatment technology for large and medium size desalination plants. Conventional seawater pre-treatment filters have configuration and media similar to those used in freshwater filtration applications and could be either gravity or pressure-driven.

Membrane filtration for seawater pre-treatment is relatively recent. At present, less than half a dozen full-scale seawater desalination plants worldwide are using membrane pre-treatment. These systems apply ultrafiltration (UF) or microfiltration (MF) membranes installed in modules through which source seawater is filtered using either pressure or vacuum.

Many recent studies have indicated that membrane filtration technologies have several advantages for seawater pre-treatment as compared to conventional granular media filtration systems.

Side-by-side pilot testing of the two types of systems is also highly recommended to develop background system performance information. The following issues should be taken into consideration when selecting between granular media and membrane pre-treatment filtration for seawater desalination.

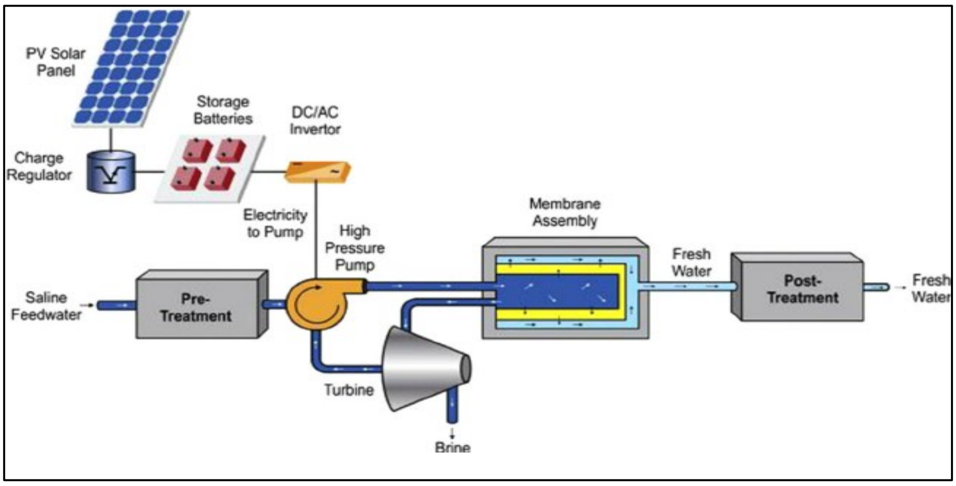


Figure 21: Pre-Treatment Locality in the Desalination Process

Figure 22: The Ultra-Filtration Plant

3.2.4 Reverse Osmosis (RO) Treatment System

Reverse osmosis (**RO**) is a water purification technology that uses a semipermeable membrane to remove ions, molecules, and larger particles from drinking water. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property, that is driven by chemical potential differences of the solvent, a thermodynamic parameter. Reverse osmosis can remove many types of dissolved and suspended species from water, including bacteria, and is used in both industrial processes and the production of potable water. The result is that the solute is retained on the pressurized side of the membrane and the pure solvent is allowed to pass to the other side. To be "selective", this membrane should not allow large molecules or ions through the pores (holes), but should allow smaller components of the solution (such as solvent molecules) to pass freely.

In the normal osmosis process, the solvent naturally moves from an area of low solute concentration (high water potential), through a membrane, to an area of high solute concentration (low water potential). The driving force for the movement of the solvent is the reduction in the free energy of the system when the difference in solvent concentration on either side of a membrane is reduced, generating osmotic pressure due to the solvent moving into the more concentrated solution. Applying an external pressure to reverse the natural flow of pure solvent, thus, is reverse osmosis. The process is similar to other membrane technology applications.

However, key differences are found between reverse osmosis and filtration. The predominant removal mechanism in membrane filtration is straining, or size exclusion, so the process can theoretically achieve perfect efficiency regardless of parameters such as the solution's pressure and concentration. Reverse osmosis also involves diffusion, making the process dependent on pressure, flow rate, and other conditions. Reverse osmosis is most commonly known for its use in drinking water purification from seawater, removing the salt and other effluent materials from the water molecules.

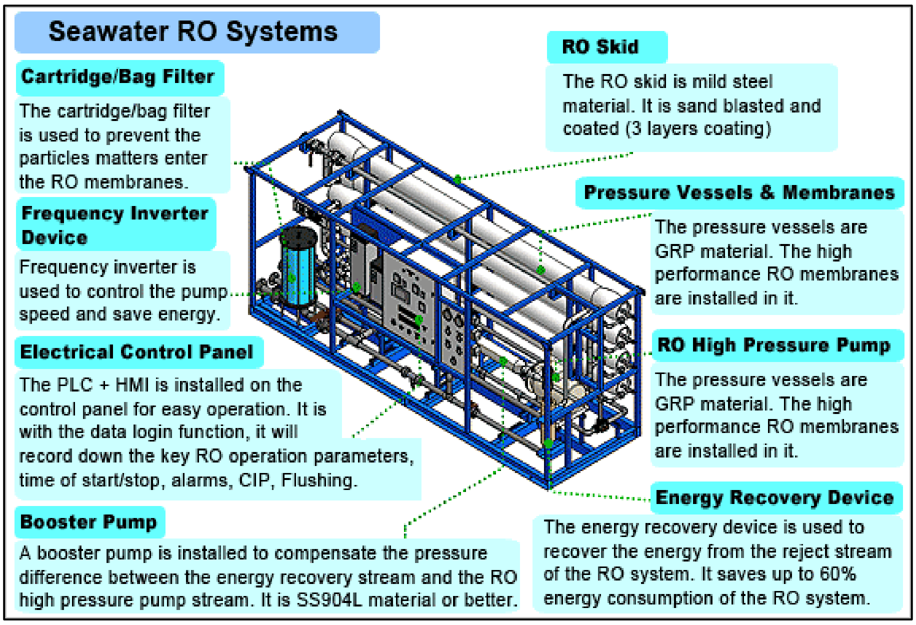


Figure 23: Reverse Osmosis Treatment System and the components

Figure 24: Reverse Osmosis Treatment Machine

3.2.5 Post-treatment System

Post-treatment processes typically include disinfection and corrosion control, and they can include degasification and/or air stripping processes if carbon dioxide and hydrogen sulphide gases are present in the permeate water. Post-treatment is needed for municipal water treatment before the membrane-treated water is delivered to the distribution system as finished water.

An overview conducted by Burbano and others (2007) involving 62 full-scale reverse osmosis (RO) or nano filtration (NF) plants with a production capacity of greater than 1 million gallons per day using either seawater desalination, brackish water desalination (including ground water, surface water and agricultural runoff), or wastewater reclamation provides an insight into post-treatment practices. All the surveyed facilities reported using at least one post-treatment method for permeate conditioning and corrosion control.

These included such methods as caustic addition (31%); blending with raw, semi-treated, or finished water (29%); degasification/ decarbonation (25%); and addition of corrosion inhibitor (14%). Most of the brackish water RO plants responding to the survey reported using degasification/ decarbonation and caustic addition, with the majority blending permeate with groundwater. Permeate disinfection was reported to be used by 85% of the surveyed facilities that responded, most of which used chlorine. Other reported disinfection methods included the use of chloramine (24%) and ultraviolet irradiation (4%).

Figure 25: Post treatment Tank

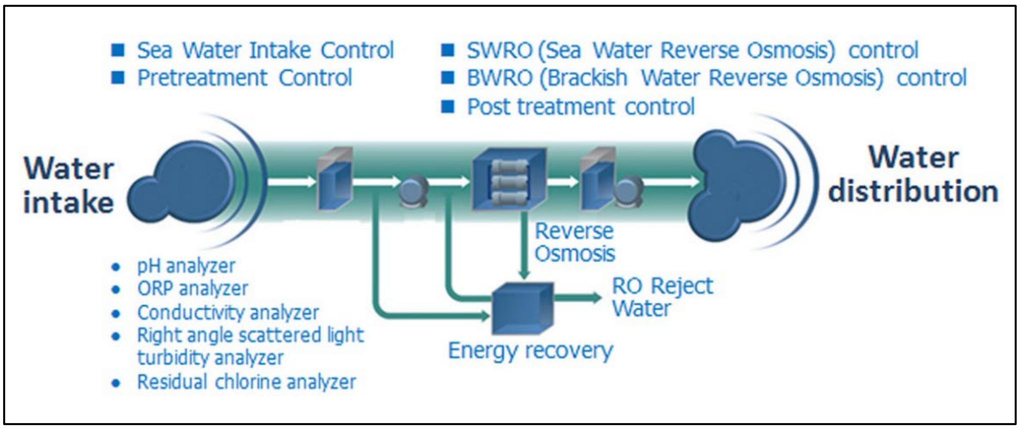


Figure 26: Post Treatment process in Seawater Desalination

3.2.6 Backwash and Chemical Cleaning System

Backwashing of granular media filters involves several steps. First, the filter is taken off line and the water is drained to a level that is above the surface of the filter bed. Next, compressed air is pushed up through the filter material causing the filter bed to expand breaking up the compacted filter bed and forcing the accumulated particles into suspension. After the air scour cycle, clean backwash water is forced upwards through the filter bed continuing the filter bed expansion and carrying the particles in suspension into backwash troughs suspended above the filter surface. In some applications, air and water streams are simultaneously pushed upwards through the granular media followed by a rinse water wash.

Backwashing continues for a fixed time, or until the turbidity of the backwash water is below an established value. At the end of the backwash cycle, the upward flow of water is terminated and the filter bed settles by gravity into its initial configuration. Water to be filtered is then applied to the filter surface until the filter clogs and the backwash cycle needs to be repeated.

Some water treatment filters use surface wash systems that break up the heavily clogged, granular media surface layer. Surface wash systems are buried in the top of the filter media or are suspended above the filter media surface.

Spent backwash water is either discharged without treatment to a sanitary sewer system or is treated and recycled within the plant. Historically, backwash water was discharged directly to surface water supplies; however, direct discharge is now highly regulated through and discouraged. Used backwash water contains high concentrations of particulate material. Typical treatment processes include coagulation, flocculation and sedimentation. High molecular weight synthetic organic polymers are sometimes added to facilitate the formation of settleable floc. Failure of a backwash treatment process and reintroduction of the resulting poor-quality water into the main water purification plant flow stream can cause overall process upsets and result in the production of poor-quality treated drinking water.

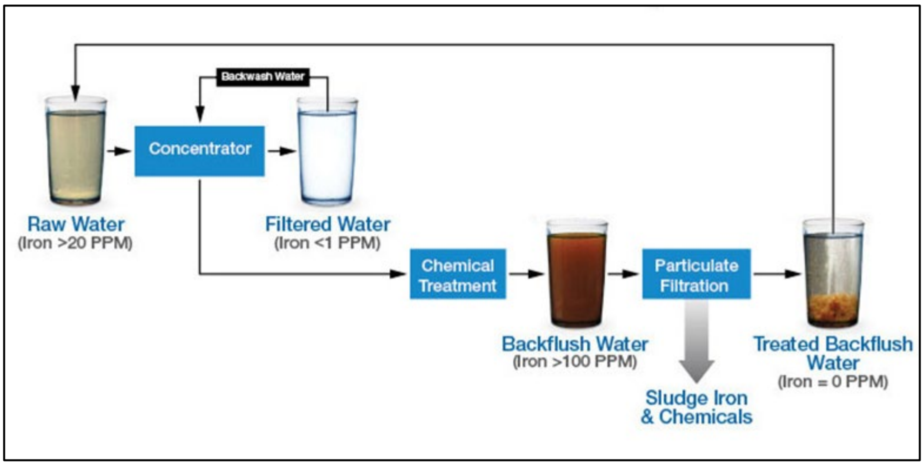


Figure 27: Backwashing procedures and output

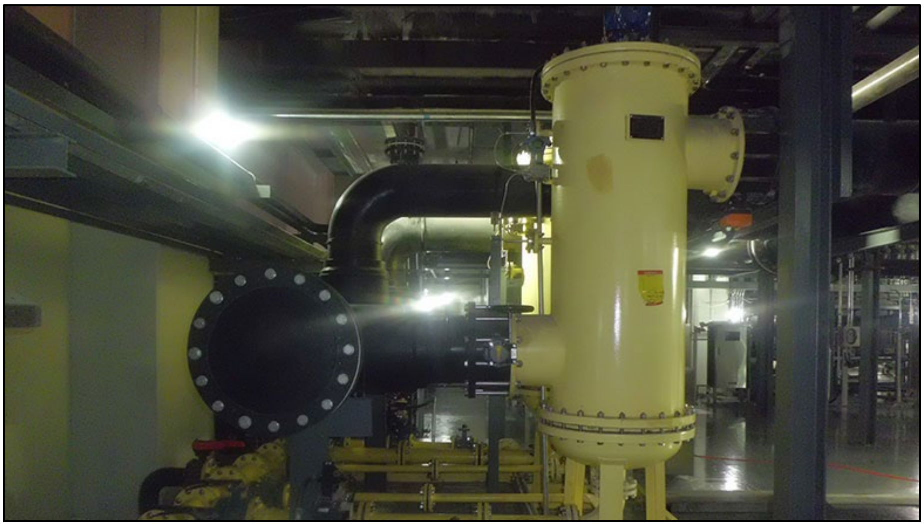


Figure 28: Automatic Backwash Filter

3.2.7 Sludge Handling System

It is also known as sedimentation. After the addition of aluminium sulphate and polyelectrolyte the flocs settle down, as sludge, in the sedimentation tanks. The sedimentation tanks are sometimes called clarifiers because here, the water is being clarified. The removal of sludge is done on a daily basis and the sludge is transferred to the sludge drying beds, while the water is transferred to the filters.

Figure 29: Sludge Clarifier

Whilst technological advances are being made in the field of synthetic semi permeable membranes, currently one of the disadvantages of reverse osmosis is the rate at which the membranes become fouled, generating the requirement for higher pressure and thus more energy in process. A method of reducing the build-up is to pre-treat the intake water by more conventional methods such as using flocculating compounds (e.g. Ferric Chloride) in settling tanks. This too however has its own drawbacks as it produces large amounts of waste sludge which inevitably must be disposed of.

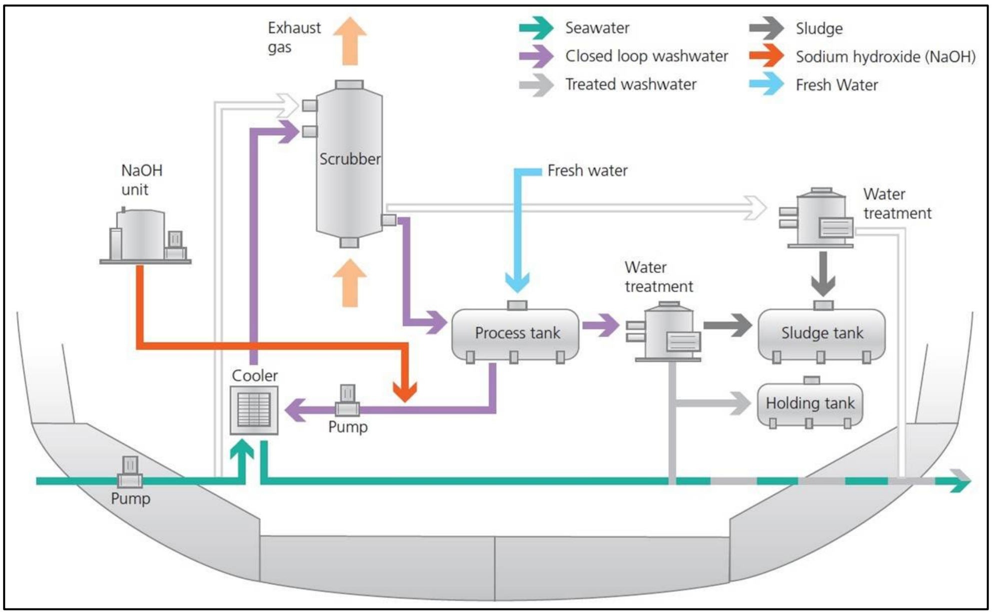


Figure 30: Diagram for Sludge Management System

Current operational procedures see this sludge back loaded to landfill facilities. However, this is done at a very high cost and alternative methods of disposal are being sought to reduce operating costs of future plants. One of these alternative solutions is to combine the pre-treatment sludge with the hyper-saline discharge resulting from the reverse-osmosis process.

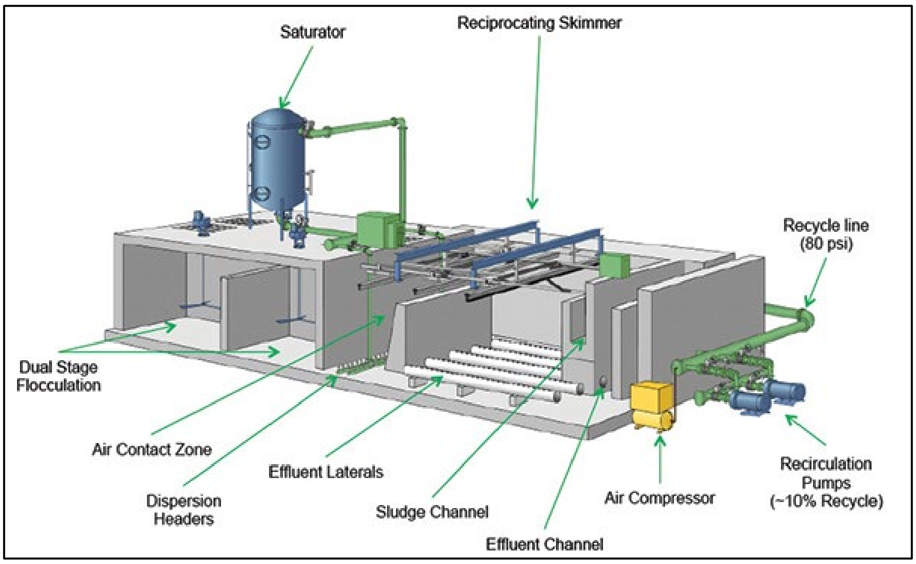


Figure 31: Dissolved Air Floatation System for Sludge Management System

Figure 32: Effective Sludge Handling System

3.2.8 Concentrate Discharge System

Concentrate from seawater desalination plants using open ocean intakes typically has the same colour, odour, oxygen content and transparency as the source seawater from which the concentrate was produced. Therefore, concentrate discharge to surface water bodies (ocean, river, etc.) does not typically change its physical characteristics or aesthetic impact on the aquatic environment, except for its density.

When a coagulant such as ferric chloride or ferric sulphate is used for seawater pre-treatment, the spent pre-treatment filter backwash will have a red colour due to the high content of ferric hydroxide in the backwash water. If this backwash water is blended with the SWRO system concentrate, the concentrate and the entire desalination plant discharge will typically be visibly discoloured.

There is no relationship between the level of salinity and biological or chemical oxygen demand of the desalination plant concentrate – over 80% of the minerals that encompass concentrate salinity are sodium and chloride, and they are not food sources or nutrients for aquatic organisms. The dissolved solids in the concentrate discharged from seawater desalination plants are not of anthropogenic origin as compared to pollutants contained in discharges from industrial/ municipal wastewater treatment plant.

In most recently built seawater desalination plants, the filter backwash water is processed at the desalination plant site by settling. Therefore, the treated backwash water which is combined and discharged with the SWRO system concentrate is also very low in terms of total suspended solids and biochemical oxygen demand. The organics and solids removed from the source seawater are disposed to a landfill as solid residual. As a result, the total suspended solids content of the desalination plant discharge is lower than the solids content of the ambient source seawater collected for desalination. Ambient seawater quality is usually very consistent and over 98% of the seawater concentrate salinity is attributed to five dissolved minerals: sodium, chloride, sulphate, magnesium and calcium.

The five most commonly used concentrate management alternatives are:

i. Surface water discharge;
ii. Sewer disposal;
iii. Deep-well injection;
iv. Land application, and
v. Evaporation ponds.

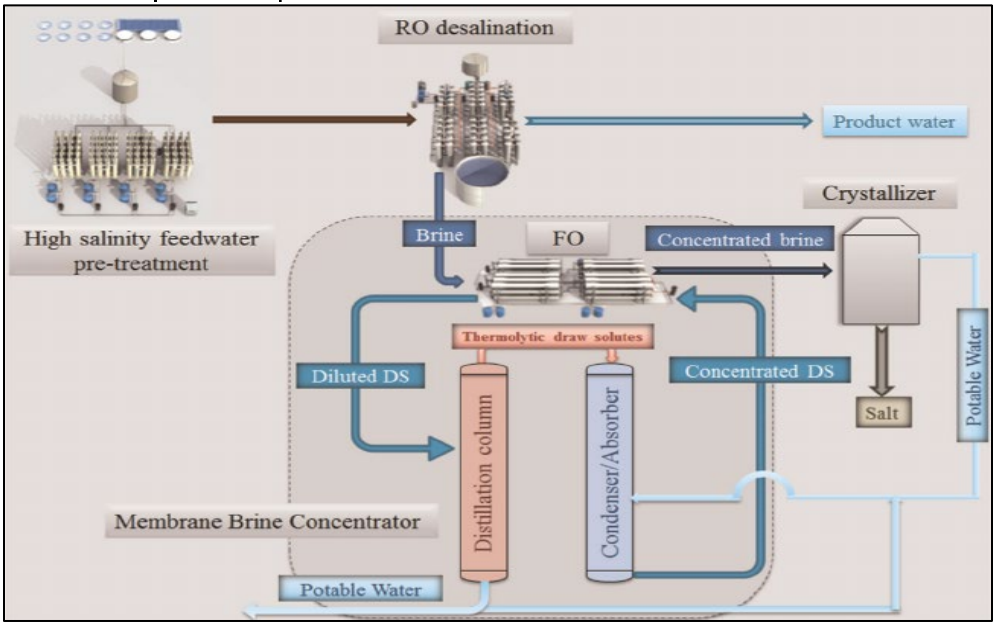


Figure 33: Concentrate Discharge System

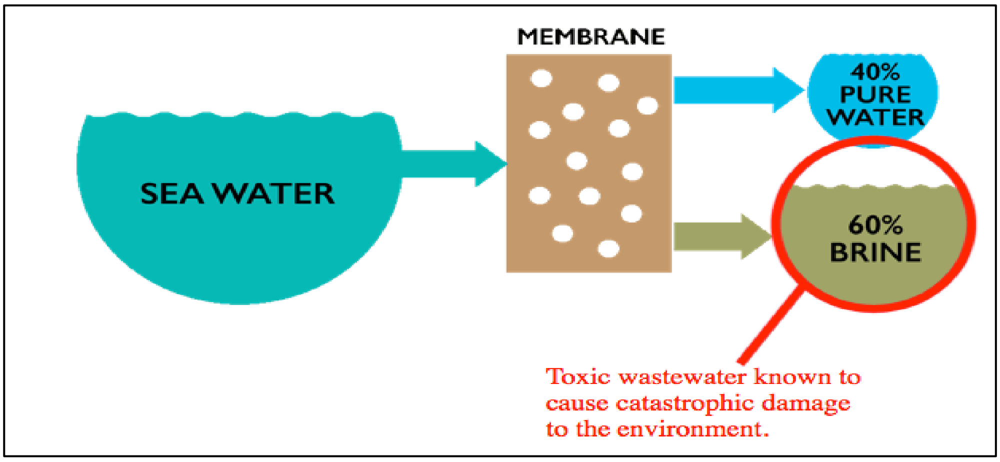


Figure 34: Desalination and Brine issue

Figure 35: Concentrate Disposal

3.3 Construction of the Desalination Plant

Hoarding will be erected around the site prior to the commencement of the foundation work. Pile foundation with reinforced concrete pile caps will be used for the foundations of the buildings. Reinforced concrete slab and raft foundation will be built for the desalination plant. The reinforced concrete buildings will be constructed on site using ready-mix concrete and conventional construction method. All pipework will also be properly supported. Major construction activities would include driving of piles, shaft excavation, micro-tunnelling, pipe jacking, pipe laying, building construction, and installation of electrical & mechanical plant and equipment.

It is anticipated that open onshore intake or submerged intake (approximately 150 metre – 200 metre-long) and outfall pipes (approximately 200 metre – 250 metre long) will be constructed. Intake and outfall will be constructed with trenchless technologies. While localized dredging works for the construction of intake structures and outfall diffusers will be required, dredging works will be minimized as far as practicable to avoid or reduce any potential environmental impacts.

Furthermore, prefabricated intake and outfall structures (e.g. intake openings and diffuser heads) will be transferred and installed onsite.

3.4 Operation of the Desalination Plant

Seawater will be drawn from the seawater intake system for the desalination process. Chlorine is dosed periodically into the intake seawater for control of microbial growth at the intake and the associated screening system.

Seawater will be delivered to the pre-treatment system for pre-treatment by clarification followed by filtration prior to the Seawater Reverse

Osmosis (SWRO) process. Coagulant/polymer will be added to feed water for coagulation and flocculation. Residual chlorine left over from the intake chlorination will be removed by dichlorination process. Process waste streams will be generated from the pre-treatment processes. The process waste streams will include sludge from clarifiers and backwash waste from filters (also known as residual streams).

High pressure feed pumps will drive the seawater through the RO system. The pressurized seawater will be split into two streams, a low pressure permeate stream (product stream) and a high pressure concentrate stream (RO concentrate or waste stream) which is the rejected flow from the RO membranes. The permeate produced in the RO system will be passed into the post-treatment system prior to pumping into the distribution system for potable water uses. The RO membranes will require cleaning with chemicals (i.e. clean in place or CIP) on periodic basis. The waste generated from the RO cleaning process is neutralized and blended with the concentrate for discharge.

Post-treatment processes will include disinfection using chlorine and fluoridation, pH correction and stabilization via hydrated lime and carbon dioxide dosing. A typical Process Flow Diagram of a SWRO desalination plant is illustrated below:

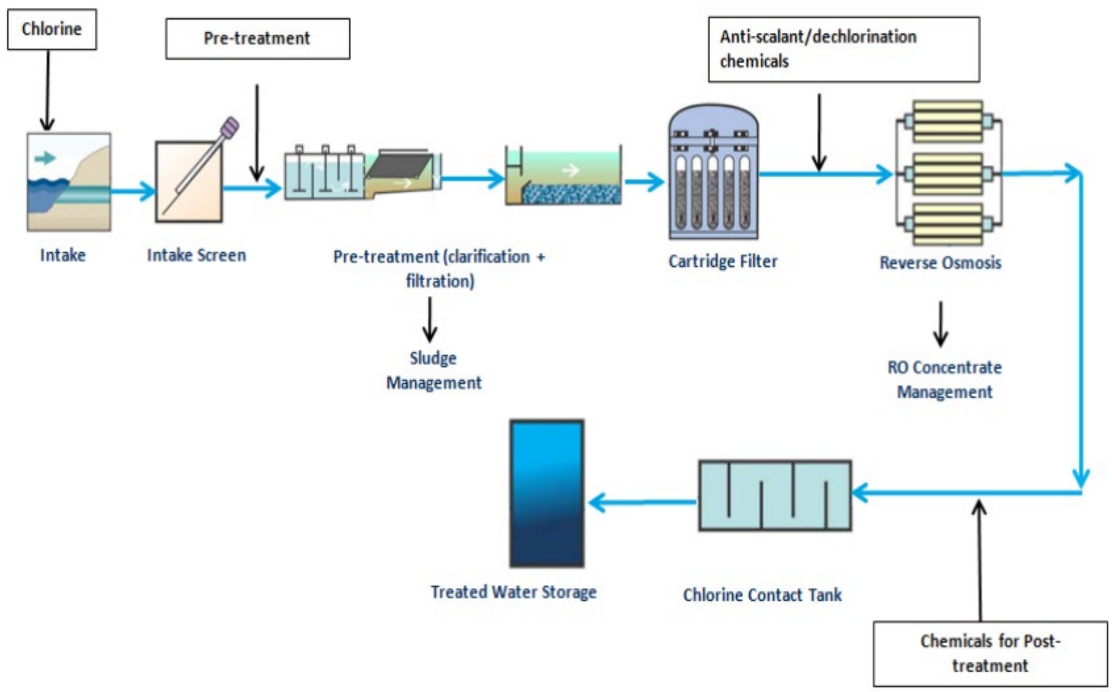


Figure 36: Typical Process Flow Diagram of a SWRO Desalination Plant

4.0 WATER DESALINATION PLANT VALUATION

4.1 Trends in Desalination Contracts and Project Finance

The key source to mobilize funding for these projects has been governments, but the size of foreseen investments has many governments convinced that the private sector has a role to play in this development. Also, many governments want to take advantage of private sector advances in technology and management. These factors have resulted in public-private transaction models that have been successful. They are called Independent Water and Power Producers (IWPP). Other project delivery methods include Build Own Operate (BOO) or Build Own Operate Transfer (BOOT) contracts without initial government ownership, but with contract guarantees.

Most of the recent desalination projects are privately-financed water projects under the BOO/BOOT delivery type. The arrangement of BOO involves a long-term supply contract with the client, who is charged accordingly for the services delivered (e.g., water, power, water and power). With a BOOT scheme, the project bid winner undertakes the same functions, but the project is transferred to the client at the end of the supply contract term.

4.2 Application of Valuation Methodology

4.2.1 Rules of Thumb Method (for reference purposes only)

There are two ways to think about the cost of desalination using this methodology: the cost of a desalination plant, and the cost of water.

A typical large-scale desalination plant produces 100,000 cubic meters of water per day. Assuming a per capita consumption of 300 litres per day, this equates to 300,000 people. The installed cost of desalination plants is approximately SAR1,000,000 for every 1,000 cubic meters per day of installed capacity. Therefore, a large-scale desalination plant serving 300,000 people typically costs in the region of SAR100,000,000. The costs of infrastructure to distribute water must be added to this.

4.2.2 Depreciated Replacement Cost Method

There are assets that are sold quite seldom or never. They are called specialized assets and their value is calculated in business mostly using net replacement cost method and not as a way to value business.

Valuing a Business is an Enterprise Valuation which considers the Income stream over time with a termination value established at some years out. This flows into the discounted cash flow method.

Basically, the assets that can be valued based on this method are:

a. Oil refineries;
b. Power plants;
c. Desalination plants;
d. Installations of basins where constructions, shore development works are directly connected with the owner's business;
e. Other specialty projects;
f. Assets located in private geographical areas;
g. Specialty urban public works;
h. Exhaustible assets (real assets whose value gradually decreasing- e.g. fields with mineral resources, cemeteries, granted grounds).
i. Public sector assets (e.g.: operational infrastructure assets: roads, public roads, railways, airports, facilities for public and defence services).

The net replacement cost related to specialized properties is an estimation procedure used in assessing the value for the existing use. Estimates of the net replacement cost relate to:

a. Cost of specialized buildings;
b. Cost of constructions when some skills are assured in line with the current technology for its operation (restraints to this requirement applies to constructions included on the list of historical, architectural monuments or monuments taken into account to be moth balled);
c. Necessary development cost including cost of infrastructure works, drainage, pumping stations, treatment plants, environmental protection works;
d. Professional fees taxes to get approvals, licenses, impact studies etc;
e. Availability of some regional development subsidies.

   These values are revised with;

   i. Economic depreciation of specialized buildings due to the technological level of similar production processes;
   ii. Structural depreciation of specialized buildings;
   iii. Functional depreciation of specialized buildings;
   iv. Strategically depreciation of specialized buildings;
   v. Depreciation related to environmental legislation.

The capital components are tabulated below:

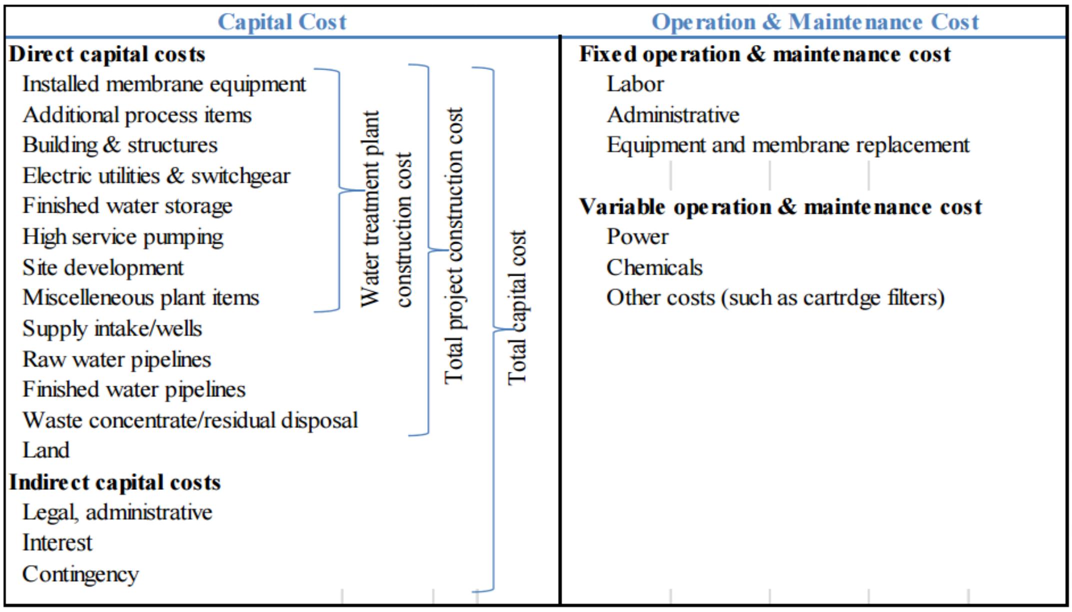


Figure 37: Components of direct capital cost in Desalination Valuation using DRC

The model of DRC Method as follow:

Item		Amount (SAR)
Current Direct and Indirect Capital Cost		A
+ Freight charges	x	
+ Insurance	x	
+ Duties/Tax	x	
+ Transport	x	
+ Installation	x	
		B
Replacement Cost New		C
Less Depreciation		(D)
Capital Value		**E**

5.0 ISSUES, PROBLEMS AND CHALLENGES

Although there are compelling drivers for valuing water, various hurdles exist. These make valuation somewhat challenging to perform, but they also intensify the need to develop a simple, consistent approach for businesses to value water.

5.1 Confusion Over Terminology

Assessing the true value of water requires understanding a complex set of jargons. Many basic terms are often confused, and the volume of terminology is daunting.

Response:
It is important to understand key terms, in particular the difference between value, cost and price. As highlighted previously, the price paid for water usage rarely reflects its true value or the full cost of supplying it. The call for valuing water is partly because of discrepancies between the three terms: value, cost and price. In a corporate context, water-related valuation studies tend to either focus on valuing and enhancing values or on valuing and reducing costs.

5.2 Complex and Dynamic Hydrological Cycle

The hydrological cycle has many different interacting components such as rainfall, river flows, groundwater, glaciers and cloud formation. The dynamic nature of the cycle is exacerbated by normal and abnormal seasonality, climate change, and El Niño and La Niña events, which can all cause extreme and sometimes difficult to predict localized and periodic droughts and floods. The dependence of all ecosystems on water and the critical role ecosystems can play in regulating water flows and purifying water adds a further layer of complexity.

Response:
When assessing water risks and opportunities and valuing water, it is important to consider relevant aspects of the hydrological cycle and hydrological pathways. An appropriate time scale should be adopted for the assessment, and possible alternative climate change scenarios taken into account. Sensitivity analysis can help anticipate potential implications of fluctuations in use availability, droughts and floods and changes to the price of water.

5.3 Water Quantity and Quality Issues

Unlike a metric ton of carbon, which has a uniform global value, the value of one cubic meter of water depends on its supply, demand and quality within a specific watershed. Water quantity also affects water quality, for example in relation to waste dilution and natural assimilation capacities. Water quality also influences the type of abstraction use possible and affects other in-situ values associated with water bodies. In addition, poor water quality can impact human health relating to sanitation, poisons, diseases and parasites, resulting in societal costs. Uncertainties around associated contaminant thresholds and tipping points, especially for highly polluted lakes, can further complicate matters.

Response:
When assessing business water risks and opportunities, it is important to take into account both water quantity and quality issues. Although it can sometimes be useful and appropriate to give water an average societal value, it is important to bear in mind that water will have different values, costs and prices per cubic meter depending on its scarcity, quality and competing uses in relevant watersheds.

5.4 Different Stakeholder Perspectives

Water provides a multitude of stakeholder groups with various competing uses and values. These have been referred to as value perspectives, which are shaped by value drivers (Moss et al, 2003). Furthermore, different decisions may require different emphasis on the aspect of water being valued. For example: businesses and banks tend to be most interested in financial values and generating profits; governments are typically interested in economic growth, jobs and societal values; while non-governmental organizations (NGOs) may be more concerned with the day-today survival of local and indigenous populations and maintaining spiritual and biodiversity values.

Response:
It is essential to recognize the full range of stakeholders that use water or are affected in some way by its use or impacts on it. Equally important is to consider the full range of different types of value that water provides to those stakeholders, and to bear in mind that some values (e.g. spiritual and intrinsic values) cannot effectively be converted to monetary values.

5.5 Ethical Issues

The different values of water also raise ethical issues. Some of these have fundamental implications for valuing and more specifically charging for water use and the affordability of water services. These also link to human health, poverty alleviation and international development issues associated with water.

Response:
Ethical issues surrounding water, including access to water and setting water prices, can be complex and discussions around such issues should be guided by water values, adequate and reliable infrastructure, sustainable service delivery, affordability and equity. The purpose of valuing water is not to commoditize it, but to better understand the value its use provides to different stakeholders, assist resource allocation, incentivize more careful use, and help raise revenues to invest in the sustainable provision of all forms of water-related services, including clean and safe water for human use. For example, many of these issues

have been recognized and addressed by the recent work of the UN Human Rights Council in relation to the human right to access to safe drinking water and sanitation.

5.6 Difficulties in Valuation

Valuing water is complex. A multitude of different values linked to water exist, but few have a market value of their own, so various valuation techniques have to be used. Although many water valuation guides exist, none cater specifically to businesses.

Response:
The approach to valuation does not need to be monetary, and in some cases generalized estimates or approximations are adequate. Qualitative and quantitative approaches may also be sufficient depending on the nature of the problem and of the decision to be made.

5.7 Lack of Incentives to Value Externalities

Because many water-related values have no ties to market value, impacts (positive or negative) may not be taken into account by businesses (i.e. they are externalities). These are societal costs or benefits that are not internalized by a business and as such do not directly affect its bottom line. Expending resources to value such externalities may appear either academic or a risk in that businesses may ultimately end up paying more for them.

Response:
Many initiatives and policy-makers are currently seeking to find ways to internalize these externalities through regulations, taxes and other methods, so it is in a company’s own interest to understand and adapt to this situation. Furthermore, Rio+20’s call for improved integrated reporting and increasing the commitment from businesses to better account for their triple bottom line will add to the peer pressure. Business strategies to deal with internalization include passing on costs to consumers, adopting water-efficient technologies, and locating operations where water is less scarce. In time, those companies and products using less water and reducing impacts on water quality will gain advantage over their competitors.

6.0 CONCLUSIONS

The investment and total water costs/value are primary parameters used by decision makers to select the appropriate desalination technology for a project based on plant capacity, energy consumption, contract delivery type, and other factors, such as the cost to mitigate for environmental impacts. However, cost depends on many parameters and the accuracy of a cost estimate relies on the use of more transparent, high quality software packages to produce accurate results. Cost data reported is commonly not consistent for different technologies or similar-sized facilities, because they are site-specific. Available cost estimation methods and software packages are of different accuracy with error ranges of ± 10 to 50%.

It is quite clear that there is a need to decide on the complexity and content of cost estimation models. Water cost estimation methodologies need to identify and specify all of the parameters that contribute to the desalination cost and develop a structured and transparent procedure for estimation of the desalinated water cost for any facility. These estimates are needed for project planning and budgeting as well as for feasibility studies.

Desalination costs are decreasing for all technologies, particularly in the last decade with the largest cost reduction occurring in RO technology. The reduction in RO treatment cost has been favoured by the growth rate, plant capacity, competition with other technologies, and the vast improvements in RO systems (better process designs, membranes and materials, and lower energy consumption) as well as the simplicity and flexibility of recent project bids. However, the authors believe that desalination costs will not continue to decrease at the same rate in the near future, despite continued improvements in the existing technologies. Equipment, raw materials, and energy costs are rapidly rising which will impact future capital and operating costs.

This notes also has elaborated on the components of desalination plants and the valuation methodologies that can be adopted to determine the market/fair value on the asset.

Refer to **Appendix A** for Example of Water Treatment Plant Valuation.

APPENDIX A

EXAMPLE OF WATER TREATMENT PLANT VALUATION

Below is the example of water treatment plant valuation. It is almost similar in term of construction to water desalination plant but there might be different item of machinery involved.

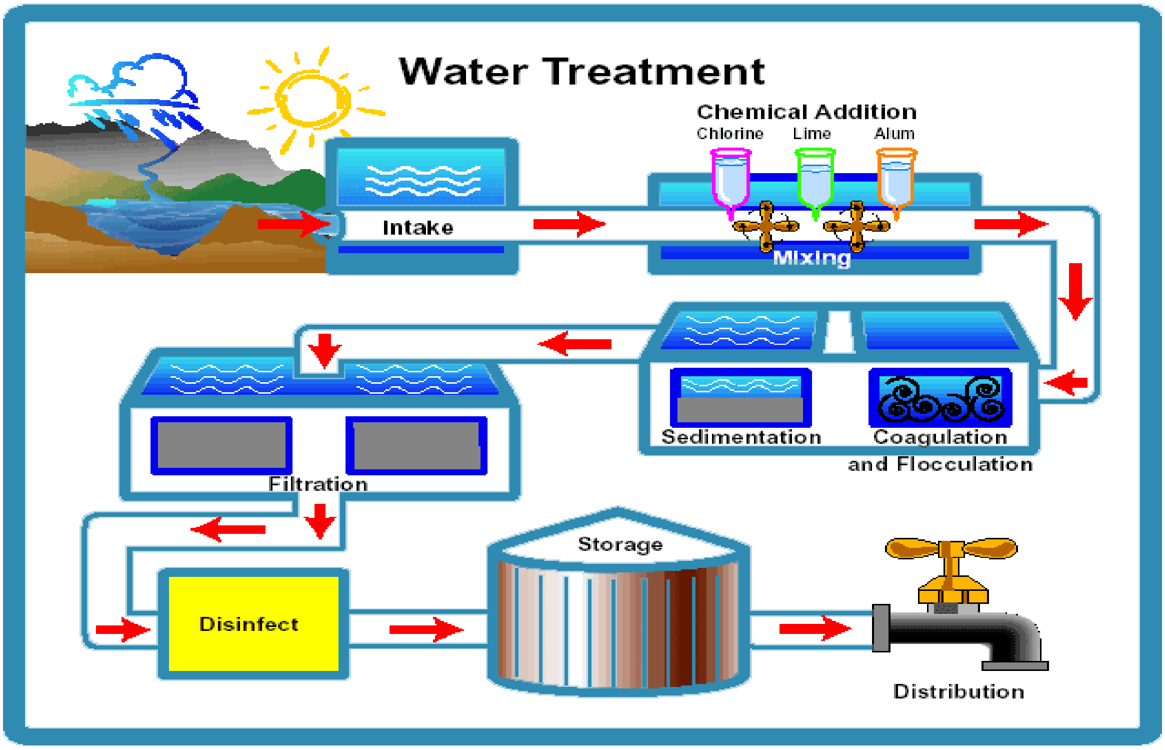


Figure 37: Water Treatment Plant Process

Figure 38: General View of Dam

Figure 39: General View of Water Treatment Plant

Water treatment plant involve twelve (12) process as follows:

a. **Raw Water Resource**
   Raw water supply is obtained from river which is close to the plant. Water is pumped from the river using four submersible pumps each with a capacity of 1,110 m3 per hour which will go through several stages of the treatment process before being available for consumption.

b. **Screening**
   Raw water will go through a screening process at the intake to separate physical materials such as wood, sand, grass and etc.

c. **Aeration**
   Raw water is pumped into the cascade aerator. Here the water is exposed to the atmosphere to increase the oxygen content and will also get rid of the smell and taste of the water through the process of oxidation. This process can also oxidize iron (FeRAM) and manganese to an insoluble state.

d. **Flocculation**
   After aeration, liquid aluminium sulphate is introducing into the raw water. Water flows into two storage tanks where flocculation occurs. The chemical reaction will cause the fine particles to form a viscous (floc) larger and heavier particle. Flow in the coagulation tank is controlled to obtain optimal coagulation. The thicken particles formed will trap bacteria and colour of the water will change. Alum is used to simplify the process of settling.

Figure 40: Flocculation Tank

e. **Sedimentation**
Water containing floc will flow into settling tanks. Here floc will be formed into being larger and heavier which will settle to the bottom of the sedimentation tank and we will have clear water.

Figure 41: Settling Tank

f. **Filtration**
The plant has four units of rapid gravity sand filters that uses river sand as material. Air goes through the sand filter which will trap fine mud on sand filter. Pipes beneath the sand filter will receive crystal clear water that has been filtered. To guarantee the quality of water, sand filters will be cleaned at certain times. The washing process called back wash in this plant is controlled automatically.

g. **Chlorination**
Filtered water will flow into the clean water tank where chlorine is added. Chlorine is to kill germs and microorganisms present in the water to make it safe to drink.

h. **pH adjustment**
Hydrated lime is used to ensure clean water with the desired range in pH value. Water pH is lowered during the coagulation process because of the addition of alum. Therefore, lime is added into the purified water to raise the pH to the desired level. Appropriate pH value is required because if it is acidic (low) it will erode the water supply pipes and if alkaline, it will form deposits on the water supply system.

i. **Fluoridise**
Sodium fluoride is also added into the clean water.

j. **Clean Water Tank**
Clean water will be stored in clean water tanks before being distributed.

k. Water Quality Monitoring

The laboratory in this plant is equipped with water quality testing equipment. Water quality tests are conducted on a sample of raw water, on the water sediment and clean water. Water samples are taken every two hours and tested in the plant laboratory to ensure water supplied is in compliance with the standards as established by the Ministry of Health. Water quality parameters for pH values, turbidity, residual chlorine and fluoride monitored directly with online test equipment.

l. Water Distribution System

From the clean water tank, water is pumped into the reservoir (with a capacity of: 13.5 million litters). through pipes with a diameter of 750mm along the 9 kilometres route. From this reservoir water is supplied to the water distribution system through pipes of diameter 900mm and 700mm.

Refer to **Appendix B** for details valuation on Water Treatment Plant.

APPENDIX B

EXAMPLES OF WATER TREATMENT PLANT VALUATION
Date Of Valuation : 8.1.2018
Purpose Of Valuation : Privatisation (Market Value)

Formula :-			
Value (DRC)	**=**	**(A) X (B) = (C)**	
		(C) X (G) X (H) = (I)	

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
1) AERATOR										
Aerator 1: 15.4 m x 9.9 m Reinforced Concrete Aerator erected on 3.0m H reinforced concrete structural support complete with access stairways, handrailing, platform, valves, piping and fittings	SAR 2,744,280	1	SAR 2,744,280	2008	10	50	0.63	1	SAR 1,728,896	SAR 1,729,000
Aerator 2 15.4 m x 9.9 m Reinforced Concrete Aerator erected on 3.0m H reinforced concrete structural support complete with access stairways, handrailing, platform, valves, piping and fittings	SAR 2,744,280	1	SAR 2,744,280	2008	10	50	0.63	1	SAR 1,728,896	SAR 1,729,000
2) MIXING										
60.0 m x 6.0 m Reinforced Concrete Mixing tank c/w 2- Mixer driven by electric motor c/w gearbox Piping, fittings, cablings and connections	SAR 3,240,000	1	SAR 3,240,000	2008	10	50	0.63	1	SAR 2,041,200	SAR 2,041,000
3) FLOCCULATION										
64 unit 3.28 m x 3.56 m Reinforced Concrete Flocculation tank c/w 2- Mixer driven by 1.0 Hp motor electric motor c/w gearbox Piping, fittings, cablings and connections	SAR 105,120	1	SAR 105,120	2008	10	50	0.63	64	SAR 4,238,438	SAR 4,238,000
4) SEDIMENTATION CLARIFIER										

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
5 unit 60.00 m x 3.28 m Reinforced Concrete Lamella plate Clarifier c/w 4- "Rotork" 'MQ300F 07.1' Aqtuator Piping, fittings, cablings and connections	SAR 1,771,200	1	SAR 1,771,200	2008	10	50	0.63	5	SAR 5,579,280	SAR 5,579,000
5) FILTER TANK										
6 unit 8.2 m x 14.2 m Reinforced Concrete Filter tank c/w Rapid sand gravity filter Gate in water motorised penstock driven by "Rotork" 'IQ10F10A' Aqtuator Gate out water motorised penstock driven by "Rotork" 'IQ10F10A' Aqtuator Air Blower motorised penstock driven by "Rotork" 'Q100F07.1' Aqtuator Filter Controle Console c/w Meter indicator, switches button and connections Pipings, fittings, cablings and connections	SAR 1,047,960	1	SAR 1,047,960	2008	10	50	0.63	5	SAR 3,301,074	SAR 3,301,000
Filter Gallery Motor Control Centre (MCC) Board 1220x800x2200mm Starter Panel @ 2 Panel Panel 1 & 2: Amp meter and Volt meter Switches and light indicator 415V/240V Incoming Supply unit switch Actuator 3 switch Spare switch Actuator 3 switch	SAR 40,000	1	SAR 40,000	2008	10	25	0.4	2	SAR 32,000	SAR 32,000

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
Miscellaneus switch										
Filter Gallery PLC Board 800x600x2000 mm Filter gallery control panel @ single panel	SAR 40,000	1	SAR 40,000	2008	10	25	0.4	1	SAR 16,000	SAR 16,000
Battery "Nimac" Unicad Nikle Cadmium Batteries 24 Volts 35 Amp DC supply	SAR 20,000	1	SAR 20,000	2008	10	15	0.22	1	SAR 4,400	SAR 4,000
Clarifier Desludging Panel 900x240x1000 mm Filter gallery control panel @ single panel c/w Control panel switch, meter and light indicator	SAR 20,000	1	SAR 20,000	2008	10	25	0.4	1	SAR 8,000	SAR 8,000
6) TREATED WATER TANK										
80 m x 70 m x 4 m H, 22,400 m³ rectangular reinforced concrete underground tank c/w Chlorine dosing Steel ladders, pipings, valves, fittings, cablings and connections	SAR345	1	345	2008	10	50	0.63	22400	SAR 4,868,640	SAR 4,869,000
7) TREATED PUMPING STATION										
i) Treated Water Pump No. 1 - 10 "Ebara" '450VYIIM' Centrifugal Pumps driven by "Tatung" 'TIK-FCKT N' 750 kW electric motor and connections c/w "Rotork" '18A F10A' Actuator pipings, valve, fittings, cablings and connections	SAR 750,000	1	SAR 750,000	2008	10	25	0.4	10	SAR 3,000,000	SAR 3,000,000
Overhead Travel Crane (OTC) "Misia" 8.0 tons Single girder OTC, on 70.67 I Beam complete with	SAR 160,000	1	SAR 160,000	2008	10	25	0.4	1	SAR 64,000	SAR 64,000

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
motor, chain rope and hoist										
Treated Water Motor Control Centre (MCC) Board 1300x800x2200 mm Panel Board @ 2 Panel Panel 1 & 2: Amp meter and Volt meter Amp meter and Volt meter switch and light indicator 300A - Incoming supply from treatedwater pumping Miscellaneous switch Gantry crane switch Distribution Feeder switch	SAR 40,000	1	SAR 40,000	2008	10	25	0.4	2	SAR 32,000	SAR 32,000
Treated Water Water Pump Instrument Panel 1300x600x1400 mm Treated water instrument panel @ single panel c/w Digital meter for: Treated water main pressure Treated water main flow Wash water main flow Raw water flowrate Wash water main pressure Treated water level No. 1 Treated water level No. 2 Wash water tank level Switches and light indicator	SAR 40,000	1	SAR 40,000	2008	10	25	0.4	1	SAR 16,000	SAR 16,000
Battery "Nimac" 'SEB 100-24-15' Unicad Nikle Cadmium Batteries	SAR 20,000	1	SAR 20,000	2008	10	25	0.4	1	SAR 8,000	SAR 8,000

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
24 Volts 15 Amp DC supply										
8) MAIN DISTRIBUTION ROOM 415V										
4200x1250x2200 mm 1500A Treated Water Pump Main Switchboard @ 6 Panel Panel 1: MCC Chlorination Feeder No. 1 switch MCC Treated Water Feeder No. 1 switch MCC Chemical Feeder No. 1 switch MCC Filter Gallery Feeder No. 1 switch Spare switch Panel 2-6: ACB Coupler 1 "Terasaki" 'Tempower' ACB Amp meter, Volt meter, Power factor meter and switches Switches and light indicator	SAR 40,000	1	SAR 40,000	2008	10	25	0.4	1	SAR 16,000	SAR 16,000
Air Compressor Room 1.2 m Ø x 2.0 m H Mild Steel vertical air receiver tank c/w 2 - "Ingersoll Rand" '2545' Twin Head Air compressor driven by "Ingersoll Rand" 'TV2 132 M4' 7.5 kW electric motor c/w control panel,switches, light indicator and connections	SAR 20,000	1	SAR 20,000	2008	10	25	0.4	1	SAR 8,000	SAR 8,000
Air Compressor Starter Panel 1300x600x1400 mm Air compressor starter panel @ single panel c/w Amp meter, Volt meter and switches Miscellaneous switch Air compressor No. 1 switch Air compressor No. 2 switch	SAR 20,000	1	SAR 20,000	2008	10	25	0.4	1	SAR 8,000	SAR 8,000

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
Switches and light indicator										
9) MAIN SUIS ROOM 11kV										
19200x1800x2150 mm Main Switchboard @ 24 Panel Panel 1 – 24: 11 kV switchgear LBS (Spare) Panel = K1 Switch Switches and light indicator	SAR 40,000	1	SAR 40,000	2008	10	25	0.4	24	SAR 384,000	SAR 384,000
10) CHEMICAL TREATMENT PLANT BUILDING										
Lime Tank 3.0 m Ø x 9.0 m (H) mild steel silo c/w 1.0 m Ø x 1.2 m (H), Mild steel tank c/w mixer driven by motor Pipings, fittings, cablings and connections	SAR 450,000	1	SAR 450,000	2008	10	25	0.4	2	SAR 360,000	SAR 360,000
Lime Plant Local Control Panel (LCP) 800x400x1800 mm LCP board for Lime plant @ single panel c/w 415V Incoming supply Switches and light indicator	SAR 20,000	1	SAR 20,000	2008	10	25	0.4	1	SAR 8,000	SAR 8,000
Potasium Permagonate Mixing Tank 1.85 m Ø x 2.2 m (H) stainless steel tank c/w "Grundfos" pump driven by 0.37 kW Electric Motor Pipings, fittings, cablings and connections **Potasium Permagonate Local Control Panel (LCP)**	SAR 170,000	1	SAR 170,000	2008	10	25	0.4	1	SAR 68,000	SAR 68,000

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
800x400x1800 mm LCP board @ single panel c/w Switches and light indicator										
Prepoly Mixing Tank 800 x 800 x 2200 mm Stainless Steel Tank c/w Mixer driven by motor 2 - Pump driven by motor Control panel and switches Pipings, fittings, cablings and connections	SAR 360,000	1	SAR 36,000	2008	10	25	0.4	2	SAR 28,800	SAR 29,000
Powder Activated Carbon Tank 1.0 m Ø x 1.2 m (H), Mild steel tank c/w mixer driven by motor Pipings, fittings, cablings and connections **Active Carbon Local Control Panel (LCP)** 800x400x1800 mm LCP board @ single panel c/w Switches and light indicator	SAR 135,000	1	SAR 135,000	2008	10	25	0.4	2	SAR 108,000	SAR 108,000
Poly aluminium Storage Tank 3.0 m Ø x 4.5 m (H), 26,500 litre Fibre tanks c/w Mixer driven by motor Pipings, fittings, cablings and connections c/w Switches and light indicator	SAR 65,000	1	SAR 65,000	2008	10	30	0.46	3	SAR 89,700	SAR 90,000
Fluoride Mixing Tank 3.0 m x 3.0 m x 4.0m (Depth) capacity 36 m³ concrete structure tank c/w mixer driven by "ABB" 2.2 kW motor	SAR 160,000	1	SAR 160,000	2008	10	30	0.46	1	SAR 73,600	SAR 74,000

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
Piping, fittings, cablings and connections										
AIR BLOWER ROOM "Longtech" 'LT-250A' Pressure 0.4 kg, High Pressure Roots Blower driven by 2 - "Teco" 150 HP Electric Motor Pipings, valve, fittings, cablings and connections	SAR 150,000	1	SAR 150,000	2008	10	25	0.46	1	SAR 69,000	SAR 69,000
11) CHLORYNATION BUILDING										
Chlorination 1560 Kg Chlorine Cylinders c/w piping, valves, nozzles, control panel, indicator light, keys switch, detectors and all associated accessories	SAR 150,000	1	SAR 150,000	2008	10	25	0.46	1	SAR 69,000	SAR 69,000
Chlorination Room "Siemens " 'V2000' 6000 Chlorine gas disinfection c/w fittings, cablings and connections (Pre Chlorine)	SAR 15,000	1	SAR 15,000	2008	10	25	0.46	1	SAR 6,900	SAR 7,000
12) WASH WATER TANK										
16m Ø X 3.1m H , 900 m^3 cylindrical reinforced concrete tank, erected on 10.0m H reinforced concrete structural support complete with access stairways, valves, piping and fittings	SAR 3,200,000	1	SAR 3,200,000	2008	10	50	0.63	1	SAR 2,016,000	SAR 2,016,000
13) SURGE VESSEL										
2.0 m Ø x 8.0 m L Mild Steel Horizontal surge vessel tank complete with valves, piping and fittings	SAR 20,000	1	SAR 20,000	2008	10	50	0.63	1	SAR 12,600	SAR 13,000

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
14) **WASTE WATER RECOVERY TANK**										
15.0 m x 15.0 m x 5.0 m Reinforced Concrete tank c/w 2 pumps driven by motor to aerator 2 pumps driven by motor to sludge holding tank Stainless steel lader with safety cage piping, valve, fittings, cablings and connections	SAR 260,000	1	SAR 260,000	2008	10	50	0.63	1	SAR 163,800	SAR 164,000
15) **SLUDGE HOLDING TANK**										
15.0 m x 15.0 m x 5.0 m Reinforced Concrete tank c/w 2 pumps driven by motor Stainless steel ladeer with safety cage Pipings, valve, fittings, cablings and connections	SAR 95,000	1	SAR 95,000	2008	10	30	0.46	1	SAR 43,700	SAR 44,000
16) **SLUDGE THICKENER**										
14m Ø X 6.0m H , 900 m³ cylindrical reinforced concrete tank, erected on 1.0m H reinforced concrete structural support complete with access stairways, valves, pipings and fittings	SAR 470,000	1	SAR 470,000	2008	10	30	0.46	2	SAR 432,400	SAR 432,000
17) **SLUDGE LAGOON**										
6,975 m2 Sludge Lagoon No. 1 - 4	SAR 70,000	1	SAR 70,000	2008	10	30	0.46	4	SAR 128,800	SAR 129,000
18) **LABORATORY**										
i) Analyser Rack (Raw Water) A set of Online Analyser mounted on 2000mm x 1850 mm aluminium board consist of: i) Raw water turbidity "Endress + Hauser" 'Liquisys M' Turbidimeter ii) Raw water PH "Endress + Hauser" 'Liquisys M' pH meter iii) Raw water colour	SAR 50,000	1	SAR 50,000	2008	10	25	0.4	1	SAR 20,000	SAR 20,000

Items	Cost New (A)	Adj. Factor (B)	Adj. Value (C)	DOM (D)	Actual Age (E)	EL (F)	Dep. (G)	Unit (H)	Value (DRC) (I)	Value (say) (J)
WATER TREATMENT PLANT										
"Integra" wedgewood analytical										
iii) Others "HACH" 'DR 2800' Spectrophotometer	SAR 5,000	1	SAR 5,000	2008	10	25	0.4	1	SAR 2,000	SAR 2,000
TOTAL									**SAR 30,783,125**	**SAR 30,783,000**

DOM – Date of Manufacturing
EL – Economic Life

REFERENCES

Al-Mashharawi, S.K., Ghaffour, N., Al-Ghamdi, M., and Amy, G.L. (2012). Evaluating the efficiency of different MF and UF membranes used as pre-treatment for RO Red Seawater desalination, in Desalination & Water Treatment Press, extracted from http://dx.doi.org/10.1080/19443994.2012.699449.

Arras, W., Ghaffour, N. and Hamou, A. (2009). Performance evaluation of BWRO desalination plant – A case study, in Desalination; Volume 235, page 170-178.

Awerbuch, L. (2004). Hybridization and dual-purpose plant cost considerations, MEDRC International Conference on Desalination Costing, Conference proceeding, Lemesos, Cyprus, December 2004.

Drouiche, N., Ghaffour, N., Naceur, M.W., Mahmoudi, H., and Ouslimane, T. (2011). Reasons for the fast-growing seawater desalination capacity in Algeria. In Water Resources Management; Volume 25, page 2743- 2754.

Elimelech, M. and Phillip, W. A. (2011). The future of seawater desalination: Energy, technology and the environment. In Science; Volume 333, page 712-717.

Ettouney, H., El-Dessouky, H., Faibish, R.S., and Gowin, P.J. (2002). Evaluating the economics of desalination. In Chemical Eng. Proc.; Volume 98; page 32-39.

Gacem, Y., Taleb, S., Ramdani, A., Senadjki, S., and Ghaffour, N. (2012). Physical and chemical assessment of MSF distillate and SWRO product for drinking purpose. In Desalination; Volume 290, page 107–114.

Ghaffour, N. (2009). The challenge of capacity-building strategies and perspectives for desalination for sustainable water use in MENA, Desalination and Water Treatment, page 48-53.

Ghaffour, N., Missimer, T., and Amy, G.L. (2012). Combined desalination, water reuse and aquifer storage and recovery to meet water supply demands in the GCC/MENA region. in Desalination & Water Treatment, downloaded from http://dx.doi.org/10.1080/19443994.2012.700034.

Ghaffour, N., Reddy, V.K. and Abu-Arabi, M. (2011). Technology development and application of solar energy in desalination: MEDRC contribution. In Renewable and Sustainable Energy Reviews; Volume 15, page 4410-4415.

Global Water Intelligence (GWI/IDA DesalData) (2012), Market profile and desalination markets, 2009 – 2012 yearbooks and GWI website: http://www.desaldata.com/

Greenlee, L.F, Lawler, D.F., Freeman, B.D., Marrot, B., and Moulin, P. (2009). Reverse osmosis desalination: water source, technology, and today's challenges, in Water Research; Volume 43, page 2317-2348.

Hopner, T., and Lattemann, S. (2002). Chemical impacts from desalination plants – a case study of the northern Red Sea, in Desalination; Volume 152, page 133-140.

Huehmer, R., Gomez, J., Curl, J., and Moore, K. (2011). Cost modeling of desalination systems, International Desalination Association (IDA) Congress, 2011, Perth, IDAW/PER11-302.

International Accounting Standards Boards (2013). International Accounting Standards, 2013 Edition.
International Valuation Standard Council (2017). International Valuation Standards, 2017.

Kiand, F.H. (2004). Supply of desalinated water by the private sector: 30 MGD Singapore seawater desalination plant, MEDRC International Conference on Desalination Costing, Conference proceeding, Lemesos, Cyprus, 28 December 2004.

K.C. Ng, H.T. Chua, C.Y. Chung, C.H. Loke, T. Kashiwagi, A. Akisawa, and B.B. Saha (2001). Experimental investigation of the silica gel-water adsorption isotherm characteristics. In Appl. Thermal Eng.; Volume 21, page 1631–1642.

Lattemann, S. and Höpner, T. (2008). Environmental impact and impact assessment of seawater desalination. In Desalination; Volume 220, page 1-15.

Lattemann, S., Kennedy, M.D., and Amy, G. (2010). Seawater desalination - A green technology? Journal of Water Supply: Research and Technology – AQUA; Volume 59, page 134-151.

Li, Z., V. Yangali Quintanilla, R. Valladares Linares, Q. Li, T. Zhan, and G. Amy (2011). Flux Patterns and Membrane Fouling Propensity during Desalination of Seawater by Forward Osmosis. In Water Research; Volume 46, page 195-204, doi: 10.1016/j.watres.2011.10.051.

Mahmoudi, H., Saphis, N., Goosen, M., Sablani, S., Sabah, A., Ghaffour, N., and Drouiche, N. (2009). Assessment of wind energy to power solar brackish water greenhouse desalination units - A case study. In Renewable and Sustainable Energy Reviews; Volume 13, page 2149-2155.

Mahmoudi, H., Abdellah, O., and Ghaffour, N. (2009). Capacity building strategies and policy for desalination using renewable energies in Algeria. In Renewable and Sustainable Energy Reviews; Volume 13, page 921- 926.

M.A.K. Al-Sofi, A.M. Hassan, G.M. Mustafa, A.G.I. Dalvi, and M.N.M. Kither (1998). Nanofiltration as means of Achieving Higher TBT of ≥ 120 oC. In Desalination, Year 1998, page 123-129.

Maliva, R.G., Guo, W., and Missimer, T.M. (2006). Aquifer storage and recovery: Recent hydrogeological advances and system performance. In Water Environment Research; Volume 78, page 2428-2435.

Maurel, A. (2006). Seawater/brackish water desalination and other non-conventional processes for water supply, 2nd edition book, Lavoisier, ISBN 10:2-7430-0890-3.

Miller, J. E. (2003). Review of water resources and desalination technologies: Sandia National Laboratories, Report 2003-0800, Volume 54.

Missimer, T.M. and Storves, S.S. (2002). Feedwater quality variation and the economics of water plant operation: The Island Water Association brackish water RO treatment facility, Sanibel Island, Florida. Proceedings of the World Conference on Desalination and Water Reuse, Bahrain, year 2002, page 11, 2002.

Moch, JR; I. Moch & Associates, Inc., Wilmington de USA, A 21st century study of global seawater reverse osmosis operating and capital costs, BHRO1-16, AWWM conference, Atlanta GA, USA, 30 March 2003.

Pankratz, T. (2008). MEDRC workshop on Membrane Technology Used in Desalination and Wastewater Treatment for Reuse (www.medrc.org), Muscat, Oman, March 2008.

Peters, T. and Pintó, D. (2010). Seawater intake and partial pre-treatment with Neodren - results from investigation and long-term operation, in Desalination and Water Treatment; Volume 24, page 117-122.

Quteishat, K. (2009), Desalination and water affordability, SITeau International Conference, Casablanca, Morocco, January 2009.

Rahmawati, K., Ghaffour, N., and Amy, G.L. (2012). Boron removal efficiency from Red Sea water using different SWRO/BWRO membranes, Journal of Membrane Science, downloaded from http://dx.doi.org/10.1016/j.memsci.2012.09.004.

Reddy, K.V. and Ghaffour, N. (2007). Overview of the cost of desalinated water and costing methodologies, in Desalination; Volume 205, page 340-353.

Sommariva, C. (2007). Desalination Management and Economics book, sponsored by Mott MacDonald and published by Faversham House Group, UK.

Voutchkov, N. (2004). Beach wells vs. open surface intake, in Water and Wastewater International; Volume 19, page 22-23.

Vrouwenvelder, J.S., Hinrichs, C., Van der Meer, W.G.J., Van Loosdrecht, M.C.M., and Kruithof, J.C. (2009). Pressure drop increase by biofilm accumulation in spiral wound RO and NF membrane systems: Role of substrate concentration, flow velocity, substrate load and flow direction, in Biofouling; Volume 25, page 543-555.

Wade, N.M. (1993), Technical and economic evaluation of distillation and reverse osmosis desalination processes, in Desalination; Volume 93, page 343-363.

Waly, T., Saleh, S., Kennedy, M.D., Witkamp, G.J., Amy, G., and Schippers, J.C. (2009). Will calcium carbonate really scale in seawater reverse osmosis? In Desalination and Water Treatment, Volume 5, page 146-152.

Wilf, M., Awerbuch, L., Bartels, C., Mickley, M., Pearce, G. and Voutchkov, N. (2007). The guidebook to membrane desalination technology. Balaban Desalination Publications.

Zejli, D., Ouammi, A., Sacile, R., Dagdougui, H., and Elmidaoui (2010). An optimization model for a mechanical vapour compression desalination plant driven by a wind/PV hybrid system. In Applied Energy, Volume 88, page 4042-4054.

ME 404

APPLIED VALUATION OF SPECIALISED MACHINERY AND EQUIPMENT

OIL REFINERY VALUATION

APPLIED VALUATION OF OIL REFINERY

1.0 OVERVIEW OF OIL REFINERY ECONOMICS

Petroleum refining is a unique and critical link in the petroleum supply chain, from the wellhead to the pump. The other links add value to petroleum mainly by moving and storing it (e.g., lifting crude oil to the surface; moving crude oil from oil fields to storage facilities and then to refineries; moving refined products from refinery to terminals and end-use locations, etc). Refining adds value by converting crude oil into a range of refined products, including transportation fuels. The primary economic objective in refining is to maximize the value added in converting crude oil into finished products.

In many businesses, profits or losses result primarily from the difference between the cost of inputs and the price of outputs. In order to have a competitive edge, a business must make higher-value products using lower-cost inputs than competitors. In the oil refining business, the cost of inputs (crude oil) and the price of outputs (refined products) are both highly volatile, influenced by global, regional, and local supply and demand changes. Refineries must find the sweet spot against a backdrop of changing environmental regulation, changing demand patterns and increasing global competition among refiners to be profitable.

The overall economics or viability of a refinery depends on the interaction of three key elements: the choice of crude oil used, the complexity of the refining equipment (refinery configuration) and the desired type and quality of products produced. Refinery utilisation rates and environmental considerations also influence refinery economics.

Using more expensive crude oil (lighter, sweeter) requires less refinery upgrading but supplies of light, sweet crude oil is decreasing and the difference between heavier and more sour crudes is increasing. Using cheaper heavier crude oil means more investment in upgrading processes. Costs and payback periods for refinery processing units must be weighed against anticipated crude oil costs and the projected difference between light and heavy crude oil prices.

2.0 OIL REFINERY DEVELOPMENT TRENDS

Crude oil is one of the most valuable commodities in the world, but only after it has been refined into petroleum products. Crude oil refining is a key transformation step in the midstream sector of the oil and gas value chain because it adds commercial value to the oil by transforming it into many different marketable products.

There are 655 refineries, located in 116 countries that collectively have a daily capacity of about 80.6 million barrels per day (bpd). Their annual throughput is about 75 million bpd, for an average capacity utilisation of 85%. Some countries including the United States have exceeded this utilisation level in recent years.

For both economic and flexibility reasons, the bulk of the world's refining takes place near downstream product markets, with major refinery capacity located in the United States, Western Europe and key countries in the Asia Pacific region. The crude oils for these refineries are transported, often over long distances, by pipeline or in crude tankers from major producing fields, mainly in the Middle East, Russia, South America and Africa. Many other refineries are located in producing countries, where domestic crudes are refined into petroleum products for local or regional markets. In some cases, the refined products are transported to distant markets. The products, once refined, are then distributed to commercial and retail markets via clean cargo ships, barges, pipelines, trains and/or trucks.

3.0 SEGMENT OF OIL AND GAS INDUSTRY

The oil and gas industry is usually divided into three major sectors:

- Upstream
- Midstream
- Downstream

3.1 Upstream

Upstream is commonly known as the exploration and production (E & P) section. It covers all activities related to searching for, recovering, and producing crude oil and/or natural gas from underground or underwater fields. This sector covers drilling of exploratory wells, and subsequent drilling and operating the wells that recover and bring the crude oil, natural gas and related liquids to the surface.

Some of the major activities in this sector include:

- Geological and geophysical (G & G) surveys are used to explore possible sites;
- Searches for underground or underwater crude oil and natural gas fields;
- Leases and permissions from the landowners to drill are acquired;
- Drilling exploratory wells (costly).

There are several types of oil platform (rigs) in upstream sector:

a. **Offshore Mobile Rigs:**
   i. Barge rig (3 - 10 meter of water)
   ii. Jack-up rig (10 - 120 meter water)
   iii. Semi-submersible (60- 1,500 meter of water)
   iv. Drillship (300 - 3,600 meter of water)

b. **Offshore Fixed Rigs (Offshore platform rigs)**

i. Land rigs
ii. Truck mounted
iii. Hydraulic hoist
iv. Modular/containerised

3.2 Midstream

Midstream activities include the processing, storing, transporting and marketing of oil, natural gas and natural gas liquids. The midstream sector involves the transportation (by pipeline, rail, barge, oil tanker or truck), storage, and wholesale marketing of crude or refined petroleum products.

Pipelines and other transport systems can be used to move crude oil from production sites to refineries and deliver the various refined products to downstream distributors. Natural gas pipeline networks aggregate gas from natural gas purification plants and deliver it to downstream customers, such as local utilities.

Major activities involved in the midstream sector include:

- Transportation (pipeline, rail, barge, oil tanker, and/or trucks;
- Marketing of wholesale products.

3.3 Downstream

The downstream sector of the oil and gas industry involves the refining of the crude oil and/or raw natural gases obtained in the upstream sector as well as selling or distributing the products obtained. This includes facilities such as petrochemical plants, oil refineries, natural gas distribution companies, retail outlets (i.e. gas stations), etc. Many products are derived from the refining of crude oil and these may include diesel oil, liquefied petroleum gas (LPG), asphalt, petroleum coke, gasoline, fertilizers, antifreeze, plastics, rubbers, pesticides, synthetic rubber, jet fuel and many more.

The major activities in the downstream sector include:

- Refining
- Transport to retail facilities
- Marketing the finished products

4.0 INTRODUCTION TO OIL REFINERY VALUATION

An oil refinery is an industrial process plant where crude oil is processed and refined into more useful products. Each refinery has a unique physical configuration, as well as unique operating characteristics and economics.

A refinery’s configuration and performance characteristics are determined primarily by the refinery’s location, vintage, availability of funds for capital investment, available crude oils, product demand (from local and/ or export markets), product quality requirements, environmental regulations and standards, and market specifications and requirements for refined products.

4.1 Types of crude

There are more than 150 different types of crude oil in the world. The basic choice of which crude to refine is between light sweet crudes and heavier crudes. Heavier crudes, more sour crudes have more sulphur contents and have a higher proportion of heavier hydrocarbons composed of longer carbon chains. Heavy crude oils are cheaper and increasingly plentiful, but more expensive to refine since it requires significant investments and have higher processing costs (higher energy inputs and additional processing to meet environmental requirements).

Light sweet crudes have higher refining value than heavier (more sour crudes) because light crudes have higher natural yields of the components that go into the more valuable light products and sweet crudes contain less sulphur. Hence, light sweet crudes require less energy to process and call for lower capital investment to meet given product demand and quality standards than heavier, more sour crudes.

4.2 Products of Oil Refineries

Petroleum refineries convert crude oils and other input streams into dozens of refined products including:

- Liquefied petroleum gases (LPG)
- Methane
- Gasoline
- Jet fuel
- Kerosene (for lighting and heating)
- Diesel fuel
- Petrochemical feedstock
- Lubricating oils and waxes
- Home heating oil
- Fuel oil (for power generation, marine fuel, industrial and district heating)
- Asphalt (for paving and roofing uses)

4.3 Oil Refinery Operation/Process

The physical and chemical transformations that crude oil undergoes in a refinery take place in numerous distinct processes, each carried out in a discrete facility, or process unit. Large modern refineries comprise as many as fifty distinct processes, operating in close interaction. Table 1.0 below shows the different classes of petroleum refining process.

Table 1.0: Classes of Refining Processes

Class	Function	Examples
Crude Distillation	Separate crude oil charge into boiling range fractions for further processing	• Atmospheric distillation • Vacuum distillation
Conversion ("Cracking")	Break down ("crack") heavy crude fractions into lighter refinery streams for further processing or blending	• Fluid catalytic cracking (FCC) • Hydrocracking • Coking
Upgrading	Rearrange molecular structures to improve the properties (e.g., octane) and value of gasoline and diesel components	• Catalytic reforming • Alkylation • Isomerization • Polymerization • Etherification
Treating	• Remove hetero-atom impurities (e.g., sulphur) from refinery streams and blend stocks • Remove aromatics compounds from refinery streams	• FCC feed hydrotreating • Reformer feed hydrotreating • Gasoline and distillate hydrotreating • Benzene saturation
Separation	Separate, by physical or chemical means, constituents of refinery streams for quality control or for further processing	• Fractionation (numerous) • Aromatics extraction
Blending	Combine blend stocks to produce finished products that meet product specifications and environmental standards	• Gasoline blending • Jet and diesel blending
Utilities	Refinery fuel, power, and steam supply; sulphur recovery; oil movements; crude and product storage; emissions control; etc.	• Power generation • Sulphur recovery

4.3.1 Crude Distillation

Crude oil distillation is the front end of every refinery, regardless of size or overall configuration. It has a unique function that affects all the refining processes downstream of it. Crude distillation separates raw crude oil feed (usually a mixture of crude oils) into several intermediate refinery streams (known as “crude fractions” or “cuts”), characterized by their boiling ranges (a measure of their *volatility*, or propensity to evaporate).

Each fraction leaving the crude distillation unit is:

- Defined by a unique boiling point range and;
- Made up of hundreds or thousands of distinct hydrocarbon compounds, all of which have boiling points within the cut range.

These fractions include (in order of increasing boiling range) light gases, naphtha, distillates, gas oils and residual oil (as shown in **Figure 1**). Each goes to a different refinery process for further processing.

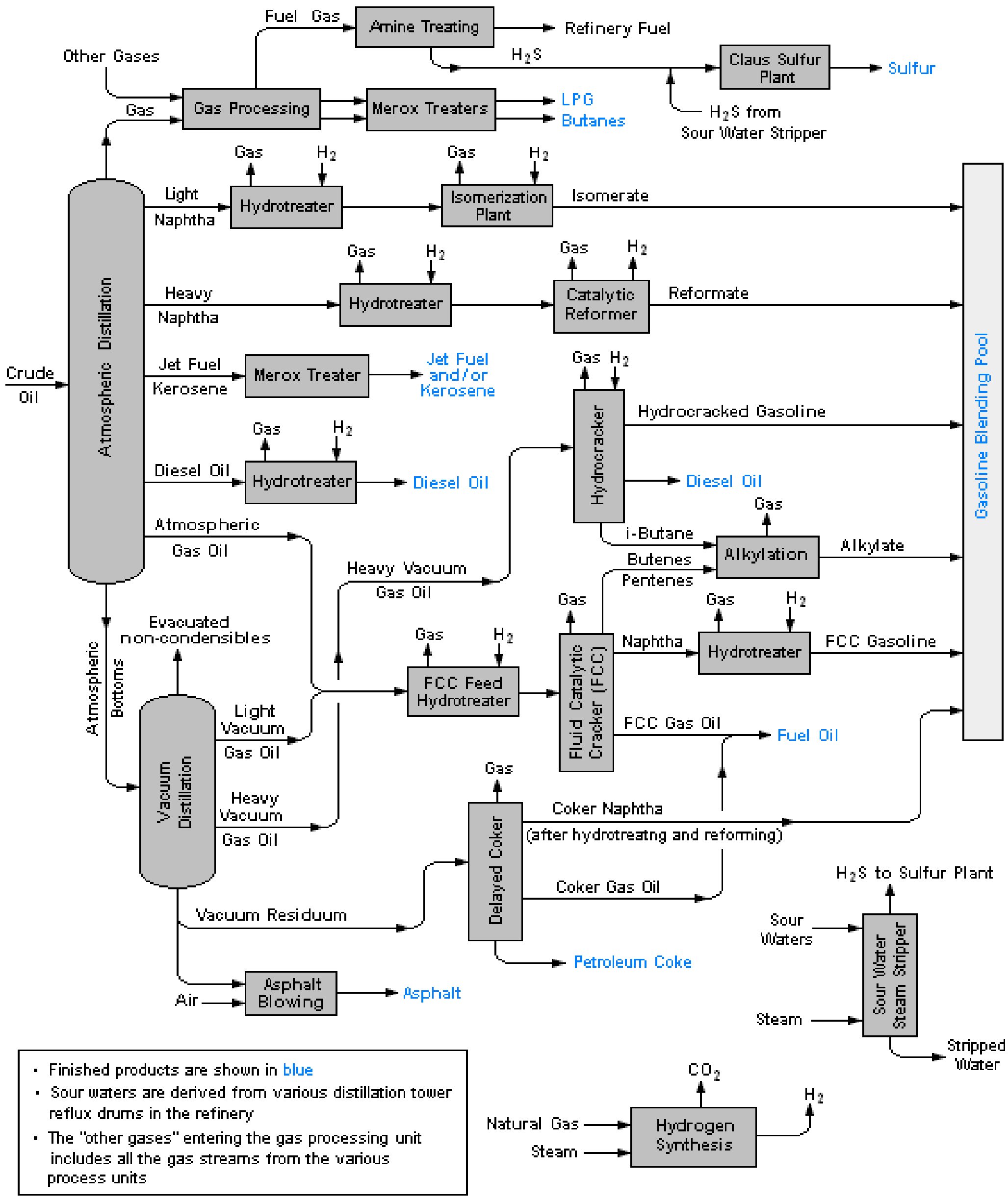


Figure 1: *Process* flow chart of a notional (typical) modern refinery producing a full range of high-quality fuels and other products.

The *naphtha* is gasoline boiling range materials. It is usually sent to upgrading units (for octane improvement, sulphur control, etc.) and then to gasoline blending. The *distillates*, including kerosene, usually undergo further treatment and then blended to jet fuel, diesel and home heating oil. The *gas oils* go to conversion units, where it is broken down into lighter (gasoline, distillate) streams. Finally, the *residual oil* (or *bottoms*) is routed to other conversion units or blended to heavy industrial fuel and/ or asphalt. The bottoms have relatively little economic value – indeed lower value than the crude oil from which they come. Most modern refineries convert, or upgrade, the low-value heavy ends into more valuable light products (gasoline, jet fuel, diesel fuel, etc.).

4.3.2 Conversion (Cracking) Processes

Conversion processes carry out chemical reactions that fracture "crack" large, high-boiling hydrocarbon molecules (of low economic value) into smaller, lighter molecules suitable, after further processing, for blending to gasoline, jet fuel, diesel fuel, petrochemical feedstocks, and other high-value light products. Conversion units form the essential core of modern refining operations because they:

- Enable the refinery to achieve high yields of transportation fuels and other valuable light products,
- Provide operating flexibility for maintaining light product output in the face of normal fluctuations in crude oil quality, and
- Permit the economic use of heavy, sour crude oils.

The conversion processes of primary interest are *fluid catalytic cracking* (*FCC*), *hydrocracking,* and *coking*.

a. ***Fluid Catalytic Cracking* (*FCC*)**

FCC is the single most important refining process downstream of crude distillation, in terms of both industry-wide throughput capacity and its overall effect on refining economics and operations. The process operates at high temperature and low pressure and employs a catalyst to convert heavy gas oil from crude distillation (and other heavy streams as well) to light gases, petrochemical feed stocks, gasoline blend stock (*FCC naphtha*), and diesel fuel blend stock (*light cycle oil*).

FCC also produces significant volumes quantities of light gases, including olefins. Light olefins are highly reactive chemicals that are valuable either as petrochemical feed stocks or as feed stocks to the refinery's upgrading processes (which produce high-octane, low-sulphur gasoline blend stocks). With suitable catalyst selection, FCC units can be designed to maximize production of gasoline blend stock (FCC naphtha), distillate blend stock (light cycle oil), or petrochemical feed stocks.

b. Hydrocracking

Hydrocracking, like FCC, converts distillates and gas oils from crude distillation (as well as other heavy refinery streams), primarily to gasoline and distillates. Hydrocracking is a catalytic process that operates at moderate temperature and high pressure. It applies externally generated hydrogen to crack distillate and heavy gas oil feeds into light gases, petrochemical feed stocks, and gasoline and diesel fuel blend stocks.

Like FCC, hydrocracking offers high yields of light products and extensive operating flexibility. Product yields from hydrocracking depend on how the unit is designed and operated. At one operating extreme, a hydrocracker can convert essentially all of its feed to gasoline blend stocks. Alternatively, a hydrocracker can produce jet fuel and diesel fuel, with combined with small volumes of gasoline material.

Hydrocracking has a notable advantage over FCC; the hydrogen input to the hydrocracker not only leads to cracking reactions but also to other reactions that remove hetero-atoms – especially sulphur – from the hydrocracked streams. These “hydrotreating” reactions yield hydrocracked streams with very low sulphur content and other improved properties.

Consequently, hydrocracked streams are especially useful blend stocks for ultra-low-sulphur fuels (ULSF) production. Hydrocracked streams are not only near sulphur-free but also low in aromatics content. Aromatics are hydrocarbons having ring-shaped molecules. Aromatics in the distillate boiling range have poor engine performance (i.e., low cetane number) and poor emission characteristics in diesel fuel. The chemical reactions in hydrocracking break open the aromatic rings, and thereby produce premium distillate blend stocks with outstanding performance and emissions characteristics. Consequently, hydrocrackers in refineries with FCC and/ or coking units often receive as feed the high-aromatics-content, high-sulphur distillate streams from these units.

Hydrocracking is more effective in converting heavy gas oils and producing low-sulphur products than either FCC or coking, but hydrocrackers are more expensive to build and operate, in large part because of their very high hydrogen consumption.

c. Coking

Coking is a thermal, non-catalytic conversion process that cracks residual oil, the heaviest residue from crude distillation, into a range of lighter intermediates for further processing. Coking is the refining industry's primary (but not sole) means of converting residual oil – the "bottom of the crude barrel" – into valuable lighter products.

The cracked products from coking comprise light gases (including light olefins), low quality naphtha (*coker naphtha*) and distillate streams (*coker distillate*) which must be further processed, and large volumes of *coker gas oil* and of *petroleum coke*.

The coker gas oil is used primarily as additional FCC feed. However, coker gas oil contains high levels of sulphur and other contaminants, which make it a less valuable FCC feed than straight run gas oils.

Depending on the crude oil, the petroleum coke produced in the coker can be sold for various end uses, used as fuel in refinery or external power plants, or simply buried.

4.3.3 Upgrading Processes

Upgrading processes carry out chemical reactions that combine or re-structure molecules in low-value streams to produce higher-value streams, primarily high-octane, low sulphur gasoline blend stock. The upgrading processes of primary interest all employ catalysts, involve small hydrocarbon molecules, and apply to gasoline production.

The most important of the many upgrading processes are *catalytic reforming, alkylation, isomerization, polymerization,* and *etherification*.

a. Catalytic Reforming

Catalytic reforming (or, simply, "reforming") is the most widely used upgrading process. Reforming units process various naphtha streams (primarily, but not exclusively, straight run naphtha from crude distillation).

Reformers carry out many catalytic reactions on these naphtha streams that significantly increase the octane of these streams (in some instances by as much as 50 octane numbers). The reformer output (called *reformate*) is premium, high-octane gasoline blend stock.

Catalytic reforming is a core refining process. It is both the primary refinery source of incremental octane for gasoline and the primary means of regulating the octane of the gasoline pool. Reforming can produce reformates with octanes > 100 RON (Research Octane Numbers).

Reforming is the only refining process in which product octane is subject to control by manipulation of operating conditions. Minor adjustments in operating conditions allow reformers to operate at different "severities", to produce reformate octanes anywhere in the range of 85 to 100 RON.

Reformers have another important refinery function. Aromatics compounds have a higher carbon-hydrogen ratio than the hydrocarbon compounds from which they produced in reforming. Consequently, reformers produce hydrogen as a co-product. Reformer-produced hydrogen supplies about 45% of the hydrogen consumed in refineries.

The high concentration of aromatic compounds in reformate is the main source of reformate octane. These aromatics compounds are also valuable as petrochemical feedstocks. Hence, many refineries located near petrochemical centres have processes to extract some of these aromatics for sale as petrochemical feedstock.

Aromatics, especially benzene, are deemed to be toxic compounds, which has led to external pressures to generate incremental octane from sources having lower aromatic content.

b. Alkylation

Alkylation combines light olefins with iso-butane to produce a high-octane (≈ 90–94 RON) gasoline blend stock (*alkylate*). The light olefins and most or all of the iso-butane come from the refinery fluid catalytic cracking (FCC) unit. Hence, alkylation units are found only in refineries having FCC units. Due to the nature of the alkylation process, alkylate contains no aromatics and no sulphur, making it a premium gasoline blend stock.

Virtually all alkylation units use a strong liquid acid catalyst – either hydrofluoric acid (HF) or sulphuric acid (H_2SO_4), depending on the process. Both processes require careful operation because of the possible environmental and public health hazards posed by the acids. Concern with HF unit centres mainly on possible release of highly toxic HF vapour. Concern with H_2SO_4 units centres more on the handling, storage, and transportation of large volumes of the concentrated strong acid.

c. Isomerization

Isomerization rearranges the low-octane and *normal*-paraffin molecules in light straight-run (SR) naphtha to produce the corresponding, higher-octane and *iso*-paraffins, thereby significantly increasing the octane of the resulting naphtha stream (*isomerate*) and making it a valuable gasoline blend stock.

As an additional process benefit, isomerization produces a product containing essentially no sulphur and no benzene. Hence, some refineries recently have added isomerization capacity as a means of meeting stringent new benzene standards on their gasoline output.

d. Polymerization

Polymerization combines two or three light olefin molecules to produce a high-octane, olefinic gasoline blend stock (*poly gasoline*) component.

Polymerization is a relatively inexpensive process. But it is not widely used, because poly gasoline is a relatively undesirable gasoline blend stock. It is highly olefinic, and olefins are unstable in gasoline.

e. Etherification

Etherification combines olefins produced by FCC plants with a purchased alcohol (methanol or ethanol) to produce an *ether* (a class of oxygen-containing organic compounds).

Ethers are premium gasoline blend stocks, with very high octane and other desirable blending properties.

The most common etherification process combines methanol with iso-butene to produce Methyl Tertiary Butyl Ether (MTBE). Other ethers in commercial use (though only in small volumes) include Ethyl Tertiary Butyl Ether

(ETBE) (made from ethanol and iso-butene) and Tertiary Amyl Methyl Ether (TAME) (made from methanol and iso-amylene. Ethers are produced in both refinery-based units (which tend to be small) and in dedicated merchant plants (which tend to be much larger).

4.3.4 Treating (Hydrotreating) Processes

Treating processes carry out chemical reactions that remove hetero-atoms (e.g., sulphur, nitrogen, heavy metals) and/or certain specific compounds from crude oil fractions and refinery streams, for various purposes.

The most important purposes are:

- Meeting refined product specifications (e.g.; sulphur in gasoline and diesel fuel, benzene in gasoline, etc.) and;
- Protecting the catalysts in many refining processes from deactivation ("poisoning") resulting from prolonged contact with hetero-atoms. By far the most widely used of the various treating technologies is catalytic hydrogenation, or *hydrotreating*.

Hydrotreaters remove hetero-atoms by reacting the refinery streams containing the hetero-atom(s) with hydrogen in the presence of a catalyst. The hydrogen combines with the hetero-atom(s) to form non-hydrocarbon molecules that are easily separated from refinery streams.

Hydrotreating has many forms and degrees of severity; as a result, it goes by many names in the refining industry and in the literature. Hydrotreating focused on sulphur removal is often referred to as *hydro-desulfurization*; hydrotreating focused on nitrogen removal is called *hydro-denitrification*; and so on.

Hydrotreating conducted at high severity (i.e., high temperature, pressure, and hydrogen concentration) often involves some incidental hydrocracking as well. Deep hydrotreating of this kind is called *hydro-refining*.

Hydrotreating conducted at low severity is used to modify certain characteristics of specialty refined products (e.g., various lubricating oil properties) to meet specifications. Mild hydrotreating is often called *hydro-finishing*.

Most refineries that produce light products have many hydrotreating units. They operate on many different crude oil fractions, intermediate refinery streams, feedstocks, and blend stocks, ranging from light naphtha to heavy residue, and serve many purposes.

4.3.5 Separation Processes

Virtually all refinery streams are mixtures of hydrocarbon compounds. *Separation* processes use differences in the physical and chemical properties of these compounds to separate one refinery stream into two or more new ones.

Distillation or *fractionation*, the most common separation process, uses differences in boiling point temperatures to effect separations into relatively lighter (lower boiling) and relatively heavier (higher boiling) mixtures. Distillation employs well-established technology and is doubtless the most widely used refining process; distillation units (*fractionators*) are ubiquitous in refineries.

Distillation units require significant inputs of thermal energy, to boil the more volatile components of the mixture being separated. Consequently, a refinery's distillation units, including crude distillation, collectively account for a significant fraction of the refinery's total energy use.

Extraction, another common separation process, uses differences in the relative solubility of different compounds in a liquid solvent to remove specific compounds from hydrocarbon mixtures. The most common refining application of extraction is *aromatics extraction*, which selectively removes certain aromatics compounds from the highly aromatic reformate stream produced in catalytic reforming. The extracted aromatics (benzene, toluene, and xylenes) are primary petrochemical feedstocks.

4.3.6 Product Blending

Product blending, the operation at the back end of every refinery, regardless of size or overall configuration, blends refinery streams in various proportions to produce finished refined products whose properties meet all applicable industry and government standards, at minimum cost. The various standards pertain to physical properties (e.g., density, volatility, boiling range); chemical properties (e.g., sulphur content, aromatics content, etc.), and performance characteristics (e.g. octane number, smoke point).

Production of each finished product requires multi-component blending because:

- refineries produce no single blend component in sufficient volume to meet demand for any of the primary blended products such as gasoline, jet fuel, and diesel fuel;

- many blend components have properties that satisfy some but not all of the relevant standards for the refined product into which they must be blended; and
- cost minimization dictates that refined products be blended to meet, rather than exceed, specifications to the extent possible. Typically, gasoline is a mixture of ≈ 6–10 blend stocks; diesel fuel is a mixture of ≈ 4–6 blend stocks.

Gasoline blending is the most complex and highly automated blending operation. In modern refineries, automated systems meter and mix blend stocks and additives.

On-line analysers (supplemented by laboratory analyses of blend samples) continuously monitor blend properties. Computer control and mathematical models establish blend recipes that produce the required product volumes and meet all blend specifications, at minimum production cost. Blending of other products usually involves less automation and mathematical analysis.

4.3.7 Utilities and Support Operations

Refineries encompass many additional process units of varying complexity and purpose. Some produce specialty products (waxes, lubricants, asphalt, etc.); others control emissions to air and water; and still others provide support to the mainline processes discussed above.

The primary support facilities include:
- Hydrogen production and recovery,
- Sulphur recovery (from desulfurization processes)
- Light gas handling and separation,
- Wastewater treatment
- Oil movement and storage
- Electricity and steam generation

Hydrocrackers and hydrotreaters require substantial inputs of hydrogen. As noted above, some of the refinery hydrogen requirement is met by by-product hydrogen produced in the reformer. The rest of the hydrogen requirement is met by on-purpose hydrogen production units in the refinery or (in some locales) by purchases of hydrogen from near-by merchant hydrogen plants. These units produce hydrogen from natural gas. Because on-purpose hydrogen is expensive, regardless of its source, most refineries also have facilities for recovering and recycling the spent hydrogen in hydrocracking and hydrotreating effluent streams.

Refinery processes use fuel and steam to heat and/ or boil process streams and to provide the energy needed to drive chemical reactions, and they use electricity for running pumps and compressors. Some refineries purchase fuel (natural gas), electricity, and/ or steam; others generate some or all of their utilities on-site. On-site generation involves traditional steam boilers and power generation facilities, or co-generation. Co-generation is the integrated production of electricity and steam, at very high thermal efficiency, using either purchased natural gas or refinery-produced light gas as fuel.

Table 2.0: Common Process Units and Facilities in Oil Refinery Plant

Unit	Function
Desalter Unit	Washes out salt from the crude oil before it goes into the atmospheric distillation unit.
Atmospheric Distillation Unit	Distils crude oil into fractions.
Vacuum Distillation Unit	Further distils residual bottoms after atmospheric distillation.
Naphtha Hydrotreater Unit	Desulphurizes naphtha from atmospheric distillation. Naphtha must be hydrotreated before being sent to a Catalytic Reformer Unit
Catalytic Reformer Unit	Contains a catalyst to convert the naphtha boiling range molecules into higher octane reformate. The reformate has a higher content of aromatics, olefins, and cyclic hydrocarbons. An important by-product of a reformer is hydrogen released during the catalyst reaction. This hydrogen is then used either in hydrotreaters and hydrocracker.
Distillate Hydrotreater Unit	Desulphurizes distillate (e.g. diesel) after atmospheric distillation.
Fluid Catalytic Cracking (FCC) Unit	Upgrades heavier fractions into lighter, more valuable products.
Hydrocracker Unit	Upgrades heavier fractions into lighter, more valuable products.
Coking unit	Processes asphalt into petrol and diesel fuel, leaving coke as a residual product.
Alkylation unit	Produces high octane component for petrol blending.

Unit	Function
Dimerization unit	Converts olefins into higher-octane gasoline blending components. For example, butanes can be dimerized into isooctane which may subsequently be hydrogenated to form isooctane.
Isomerization Unit	Converts linear molecules into higher octane branched molecules for blending into petrol or feeding into alkylation units.
Steam reforming Unit	Produces hydrogen for the hydrotreaters or hydrocracker.
Liquefied gas storage units	Tanks for propane and similar gaseous fuels at pressures sufficient to maintain them in the liquid form; these are usually spherical or bullet-shaped.
Storage tanks	Tanks for crude oil, Intermediate tanks and finished products, usually cylindrical, with some sort of vapor enclosure and surrounded by an earth berm to contain spills.
Cooling water systems	For circulating cooling water.
Boiler plants	For steam generation.
Wastewater collection and treating systems	Make such water suitable for reuse or for disposal.

Other Utility Systems (Offsite):

- Electric power distribution
- Fuel oil and fuel gas facilities
- Water supply, treatment, and disposal
- Plant air systems
- Fire protection systems
- Flare, drain and waste containment systems
- Plant communication systems
- Roads and walks
- Railroads
- Jetty
- Fence
- Buildings
- Vehicles
- Product and additives blending facilities
- Product loading facilities

5.0 VALUATION METHODS

Oil refinery is special property and not commonly traded in the market, so there will be some limitations in the valuation applications. The actual characteristics, specifications, capacity, purpose of valuation and types of information available will determine the method of valuation. Two methods of valuation will be discussed - the Cost and Profit Methods.

5.1 The Cost Approach

The approach requires a certain level of knowledge about the economics and technology of the industry. To apply the cost method, we must determine the current cost of the ME or reinstatement cost new.

Reinstatement Cost New is defined as 'the current cost of a similar new item having the nearest equivalent utility as the property being valued. There are two approaches in using the cost method:

a. Reinstatement Cost New (RCN)

Item		SAR
Reinstatement with new plus installation, commissioning, freight, tax etc		N
x Inflationary provision for the next n year(s)	x	X
Insurance Value		**XXX**
Say		SAR XXXX

b. Depreciated Replacement Cost (DRC)

Depreciated Replacement Cost (DRC) is the current cost of replacing an asset with a modern equivalent asset, less deductions for age, physical deterioration and technical and functional obsolescence, and economic obsolecence, taking into account the total estimated life of an asset and anticipated residual value (if any).

The model of DRC Method as follow:

Item		SAR	
Current price new (FOB)			XX
Add	Freight charges	a	
	Insurance	b	
	Duties/ Tax	c	
	Transport	d	
	Installation	e	
	Commissioning	f	
			X
Replacement cost new			XXX
Less Depreciation			(D)
Capital Value			**XXXX**

Steps to be followed to arrive value are as below:

- Ascertaining replacement cost new
- Calculating physical deterioration, functional and economical obsolescence.

Replacement cost new can be ascertained by any one of the following three methods:

- By floating inquiry from supplier or manufacturer
- By applying cost index to historical/ original cost.
- Marshall Valuation Services Database

To the casual observer, all refineries appear to be the same. In reality, each refinery is a unique and complex industrial facility, with some flexibility in the crude oils can process and the mix of products can refine.

Each refinery constantly weighs a number of factors, including which various conversion units operate. However, there are limits to how flexible a refinery can be. The configuration and complexity of each facility determine the types of crude oil that can be processed and the products that can produce.

Location and transportation infrastructure further limit the degree to which a refinery can access various types of crude and other supplies. These factors impact energy and labour costs, as well as regulatory constraints and compliance costs.

5.2 Profit Method

The second method is Profit Method which is a preferred technique for valuing income producing properties such as oil refinery. This method is based on the principle that the market value of an industry that is dependent on its ability to generate profits. This means that profits generated by an industry including the value of land, buildings and other related items. In this method the lifespan of plant and machinery as well as raw materials for the remaining period shall be considered. Profit method is based on the concept that the market value of plant and machinery is dependent on the benefits that can be derived from business carried on plant and machinery. The theory of this approach is a tenant willing to pay a share of profits from its business as a rent to the owner of the plant and machinery.

The profit method consists of several steps for estimating the expected future benefits and translating these benefits into a lump sum value at a particular point in time. In estimating the future benefits, business accounts for at least the last three years have to be obtained in order to analyse the trend that has developed.

Expense data should be obtained in the same manner as revenues to ensure that the patterns of both inputs are a fair reflection of trade which an efficient operator can achieve in the fair market.

If the accounts do not follow an accepted trend, carry out critical analysis to establish where inadequate controls are being used and then adjust the account to present a fair reflection of the business potential which could be achieved by an efficient and competent operator.

The model of profit method as follows:

Item	SAR	SAR
Gross Revenue Per Annum (Average)		
Products Sales	X	
Rental Of Buildings	X	
Rental Of Equipment	X	
Etc.*1	X	
Gross Profit Per Annum		**XX**
Less:		
Operation Expenditures Per Annum		
Administration & Management	X	
Sales Marketing & Advertisements	X	
Maintenance	X	
Management Fee	X	
Utilities Cost	X	
Etc.*2	X	
		(XX)
Net Profit Per Annum		**XX**
Less		
Divisible Balance	X	
Interest on Capital Operation @ i%	X	
Tenant Share @ i%	X	
		(XX)
Gross Rental Per Annum		**XX**
Less		
Outgoings Per Annum	X	
Insurance	X	
Quiet Rents & Assessment	X	
		(XX)
Net Rental		**XX**
Year's Purchase For Corporate Tax @ i% for n*3 years	x	YP
Capital Value		**XXX**

Note:
*1 – Other revenue(if any).
*2 – Cost of Operations is not exhaustive to what has been listed.
*3 – n is based on number of the remaining leased or in perpetuity.

6.0 ISSUES, PROBLEMS AND CHALLENGES

Some challenges occur during the exercise are as follows:

- Difficulties in determining what information is needed and locating the sources.
- Difficulties in obtaining pertinent data.
- Accuracy of information - different information from records and on sites
- Complex nature of the assignment – various types and classification of oil refinery plants.

7.0 CONCLUSION

Oil refinery valuation is not an ordinary exercise. It requires a deep understanding towards the daily operation of the system, system involves, life span of the system and the monetary spend to develop and operate the system. Although the three standard valuation approaches — Income, Market and Cost are applicable for companies in the oil and gas industry, each segment within the industry value chain has its own unique operations and characteristics, making certain approaches and methodologies for the valuation more appropriate than others. Due to the complexity of oil refinery plant nature and the process system involves, in determining of value, one of the best methods to be adopted is by using the depreciated replacement cost depending on the client instructions.

Refer to **Appendix A** for details valuation on Oil Refinery Plant.

APPENDIX A

EXAMPLE OF OIL REFINERY PLANT VALUATION
Date of Valuation : 8.1.2018
Purpose of Valuation : Privatisation (Market Value)

Nos.	Items	Cost New (A)	Adj. Factor (B)	Adjusted Value (C)	Date Of Manufactured (D)	Actual Age (E)	Economic Life (F)	Dep. (G)	Value (DRC) (I)	Value (say) (J)
A)	**CRUDE DISTILLATION UNIT (CDU)**									
I)	**HYDROTREATER STRIPPED PRODUCT / FEED EXCHANGER**									
	Hydrotreaters Stripped Product / Feed Exchanger, 10 Bar erected on steel structural support complete with piping, valve, fittings, cablings and connections	SAR 200,000	1.4	SAR 280,000	2008	10	30	0.46	SAR 128,800	SAR 129,000
II)	**DESALTER**									
	Desalter 1.0 m Ø x 3.0 m (L) stainless steel vessel erected on steel structural support complete with piping, valve, fittings, cablings and connections	SAR 4,000,000	1.4	SAR 5,600,000	2008	10	30	0.46	SAR 2,576,000	SAR 2,576,000
III)	**FURNACE**									
	"Gasco" Diesel Furnace 2.0 m Ø x 8.0 m (H) steel tank c/w 1.2 m Ø x 10.0 m (H) Steel Chimney Control Panel, switches button and connections Access stairways, handrailing, platform, valves, pipings and fittings	SAR 700,000	1.4	SAR 980,000	2008	10	30	0.46	SAR 450,800	SAR 451,000
IV)	**FRACTIONATION UNIT**									
	Fractionation Unit 1.50 m Ø x 7.0 m (H) stainless steel tank tower c/w Overhead condenser Reflux drum Off-Gas KO Drum Off-Gas Compressor Cooler (cooling water) N2 Buffer Vessel 2-Side product stripper Bottom product pump Access stairways, handrailing, platform, valves, pipings and fittings	SAR 8,000,000	1.4	SAR 11,200,000	2008	10	30	0.46	SAR 5,152,000	SAR 5,152,000
		Total RCN		**SAR 18,060,000**						**SAR 8,308,000**

See notes on the next page:

Note:-

1 Cost New item is information enquiry from the supplier or manufacturer.

2 Adjustment factor comprised of transportation(10%), tax(10%), insurance(5%), installation(5%), testing and commissioning(10%).

3 Economic life is information from manufacturer/ New Zealand Inland Revenue Depreciation Rate, 2008.

4 Depreciation is based on the Rushton's Table.

5 DRC Formula : (A) X (B) = (C)

(C) X (G) X (H) = (I)

ME 404

APPLIED VALUATION OF SPECIALISED MACHINERY AND EQUIPMENT

AIRPORT VALUATION

APPLIED VALUATION OF AIRPORT

1.0 INTRODUCTION

This session will discuss the methods of valuation of the building and ME of airport. Among the items highlighted will be the components involved and a brief overview of some of the ME valuations of airport operation. In most cases, ME valuations of an airport is requested for insurance purposes. Insurance valuation are based on the insurance contract and terms agreed between insurer and policy holder.

1.1 Overview of Airport Economics

According to the association of corporate counsel 2013/14 publication, Saudi government has always been actively concerned with the growth of the country's infrastructure.

Among major projects involved are the construction of domestic, regional and international airports. To name a few, the international airports are King Abdul Aziz international airport, King Khalid international airport, King Fahd international airport, Prince Muhammad bin Abd Aziz international airport and Taif international airport. Regional airports are Abha airport, Al-Ahsa airport, Al-Jouf airport, Hail airport, King Abdullah bin Abdul Aziz Airport, Nejran Airport, Prince Abdul Mohsin bin Abdul Aziz airport, Prince Naif bin Abdul Aziz airport and Prince Sultan bin Abdul Aziz airport. Domestic airports mainly Al Wajh airport, Al Qaismah, Al Dwadmi, Arar, Bisha, Gurayat and many others.

During the airport conference in Dubai 2010, Dr Ali Al Zahrani, Director of corporate planning has indicated that the General Authority of Civil Aviation of Saudi Arabia (GACA) was given a mandate by the Saudi leadership to transformation all airports in Saudi Arabia and to:

- become an independent authority
- achieve 100% financial self-sufficiency by the year 2020
- liberalise the aviation sector in Saudi Arabia

The contribution of airport business to Kingdom of Saudi Arabian GDP in the year 2010, can be briefly explain as below, where the aviation sector contributes SAR 30.2 billion (1.8%) to Saudi Arabian GDP comprising of:

- SAR 16.7 billion directly contributed through the output of the aviation sector (airlines, airports and ground services);
- SAR 6.4 billion indirectly contributed through the aviation sector's supply chain; and

- SAR 7.1 billion contributed through the spending by the employees of the aviation sector and its supply chain.

In addition, there is SAR 23.6 billion in 'catalytic' benefits through tourism, which raises the overall contribution to SAR 53.8 billion, or 3.2% of GDP.

In terms of economic characteristics, airports have a very high fixed infrastructure costs. Airports with low traffic volumes will find it difficult to recover high fixed costs. Based on the economies of scale it will mean that as traffic increases over time, cost can be spread over higher traffic volumes. For example, for increasing returns to scale of up to 1 million passengers per year, it will need a constant return to scale of more than 1 million passengers per year. Another aspect which also needs to be considered is the economies of scope. The economies of scope mean that as traffic increases, airport can diversify into more profitable sources of income.

In term of sustainability of the value, timing is very important and should not be complicated by the following aspects:

- Long term planning horizon
- 30-year asset lives
- Volatility in airline markets
- Changing aircraft technology

The economic characteristics on the inflexible use of assets is sometime needed when it comes to the stage between degree of incremental expansion possible and alternative use. Example of inflexible usage can be tabled as below:

Asset	Incremental capacity expansion	Alternative use
Runway	Limited	No
Taxiways/ apron	Moderate to high	No
Passenger terminal	High	Yes
Cargo terminal	High	Yes
Carpark	High	Yes

In terms of handling long haul traffic compared to short haul traffic, any airport operator will need to consider the costs involved such as:

- Number of aerobridges required for larger aircrafts
- More apron space and wider runways and taxiways
- More space for departing passengers
- Baggage system costs
- Customs and immigration

Besides that, the revenue aspect from long haul traffic is higher than short haul since:

- Longer passengers dwell time (layover times)
- Duty free and retail outlet activities
- Higher spend from non-resident passengers

Airport revenue can be classified into the following grouping:

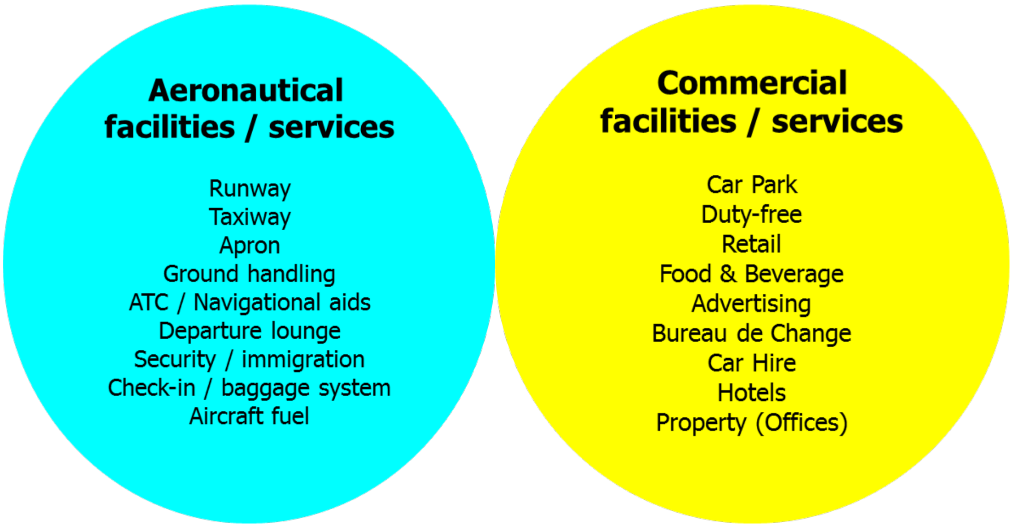


Figure 1: Classification of Airport Revenue

1.2 Airports Development Trends

Initially, it started with small airstrips/grass strips with basic facilities for leisure and hobby which come with low infrastructure cost and can accommodate small aircraft (2 – 4 seaters). As aircraft grew in size, grass strips can no longer take the aircraft weights. Paved surfaces are required to withstand the load and this has led to the construction of runways, taxiways and aprons (RTA) with higher infrastructure costs. As demand for air travel increases, there is a need for basic facilities to accommodate larger facilities. As the number of passengers increases with different profiles, better facilities and services are needed such as more sophisticated facilities/systems which are required to enhance flow and safety. Over the years all this improvement demands reasonable operating cost to ensure sustainability of the airport.

Airport Development Trends	Sample Photo
Grass field	
Simple airfield	
Paved surface	
Proper runway, taxiway and apron (RTA)	

2.0 SAMPLE CASE STUDY: VALUATION OF ABC INTERNATIONAL AIRPORT

2.1 Objectives

The objectives of this sample case study are:

- To determine the methods adopted in valuing the airport buildings and ME for the purpose of insurance valuation;
- To identify factors affecting the airport buildings and ME for the purpose of insurance valuation.

2.2 Scope

This case study will discuss the following item:

- The purpose of valuation;

- Two major components of the valuation, i.e. the buildings and the ME valuation.

As stated in the introduction, this session will only highlight the ME valuation. In addition, where buildings are considered as ME then it will be included in the valuation. The emphasis of this case study will be on the following:

Table 1.0: Methodology of Building Valuation and ME

Type of Property	Topic	Source
Building (only structures that is considered as ME)	• The valuation processes • Basis of valuation • Method of valuation • Factors affecting value • Valuation	• Information provided by KULB Company, the project consultant of ABC Airport • Valuation Report of ABC Airport • Bill of Quantities (BQ) of the buildings involved
Machinery & Equipment	• The valuation processes • Basis of valuation • Methods of valuation • Factors affecting value • Valuation	• Valuation Report of ABC Airport

2.3 Location

The ABC International Airport, is located on the southern tip of the Town A. Geographically, it is situated approximately 70 kilometres to the south of Town B and about 45 kilometres from the Town C.

Primary access to and from Town A is from a short spur off the North-South Expressway Central Link (ELITE) from the point where the North-South Central Link turns east to join the existing ABC Expressway. A second access is via the eastern route, running near the existing interchanges on the ABC Expressway.

Access by train service is via the Express Rail Link (ERL) which provides direct access between the Main Terminal Building and the city terminal at Town B. Other modes of public transport to and from ABC Airport-are express buses, limousines, taxis, Uber and Careem.

2.4 General Description

ABC Airport is built on a 100-sq. km. (i.e. 10,000 hectares or 25,000 acres) land which makes it one of the largest airport sites in the world.

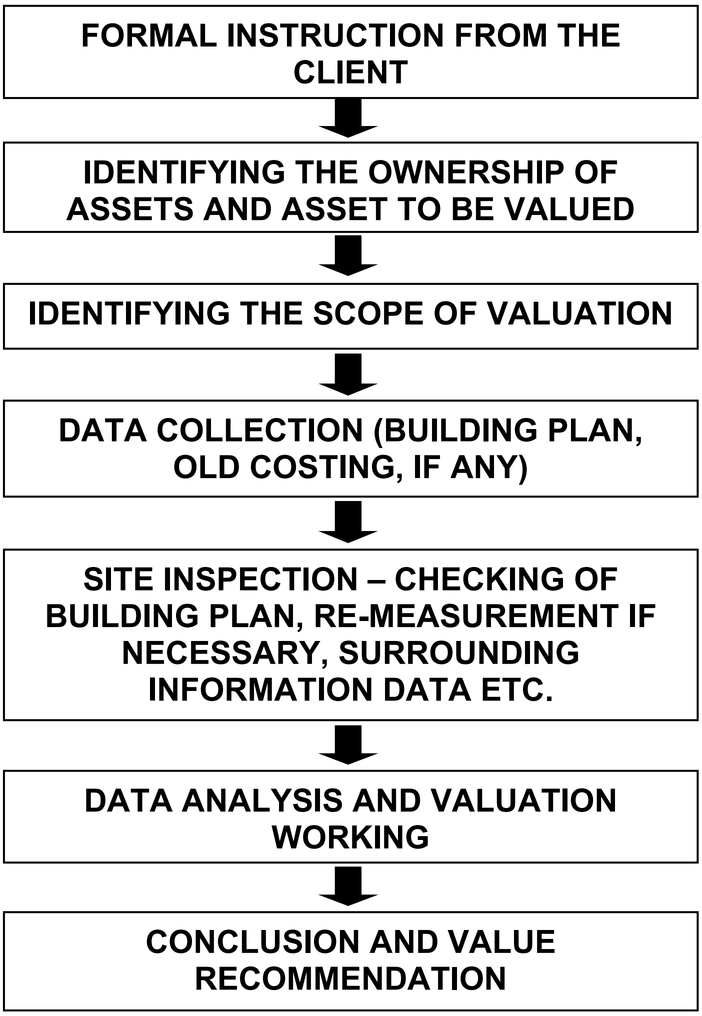
Phase 1 development, which commenced its commercial operations on 28 June 1998, only occupies approximately 25% or 2,500 hectares of the total land area allocated for KLIA. The present airport developments are constructed on the eastern part, leaving the western part and the remaining areas for future expansion. The undeveloped portion and fringes of the airport have retained their natural vegetation of palm oil, rubber and mangrove, which serves as a buffer zone.

2.5 Building Valuation

2.5.1 The Valuation Process

The procedures for building valuation are as follows:

Figure 2: Valuation Process of the ABC Airport building



2.5.2 General Description of ABC Airport Buildings

The buildings and facilities in phase 1 are designed to cater for an annual capacity of 25 million passengers per annum. The major facilities in phase 1 include:

a. A mega Passenger Terminal Complex (PTC) consisting of three buildings:
    - Main Terminal Building (MTB)
    - Contact Pier (CP)
    - Satellite Building with an Airside Transit Hotel located on the mezzanine floor.
b. Two 4,000-metre long parallel runways with associated extensive system of taxiways and apron;

c. A 130-metre high air traffic control tower and an apron tower which is 52 metres in height;

d. Comprehensive landside and airside support facilities such as cargo, aircraft maintenance, flight catering services, short term and long-term car parking.

e. Other aviation and non-aviation business facilities for operators, agents, concessionaires and handlers.

f. Express Rail Link (ERL) which shuttles passengers from XYZ Sentral station in Town B to ERL station at Main Terminal Building.

2.5.3 Building Description

The buildings that are included in the valuation report are located within the area designated for the ABC International Airport or- ABC (as in the International Air Transport Association code). The list of the buildings owned by the Airport Company comprises the following buildings and facilities below:

Table 2.0: List of Buildings and Facilities Involved in The Valuation

No.	Name of Building / Facilities
1.	Main Terminal Building (MTB)
2.	Contact Pier Building (CP)
3.	Commuter Rail Station
4.	Satellite Building and Airside Hotel
5.	ABC Hotel
6.	Long Term Car Park Complex
7.	Short Term Car Park Complex
8.	Main Fire Station, Training Tower and Smoke Chamber
9.	Small Fire Station
10.	Airfield Safety Unit Building
11.	Runway 1 & 2
12.	Taxiway
13.	Apron
14.	Marshall Stands
15.	Airside Service Road
16.	Engine Ground Blasting Aviation
17.	Control fencing, Guard House and Border
18.	6 Security Post
19.	Decompression Chamber
20.	Tunnel
21.	Centralised Warehouse
22.	Engineering Complex
23.	Southern Common Area Facility (SCAF)
24.	South Bus Terminal
25.	Waste Water Treatment Plant
26.	Reclorination Plant
27.	Helicopter Pad

2.6 Valuation of Machinery and Equipment (ME)

2.6.1 The Valuation Process

In the process to arrive at the insurance value, we have conducted the following procedures:

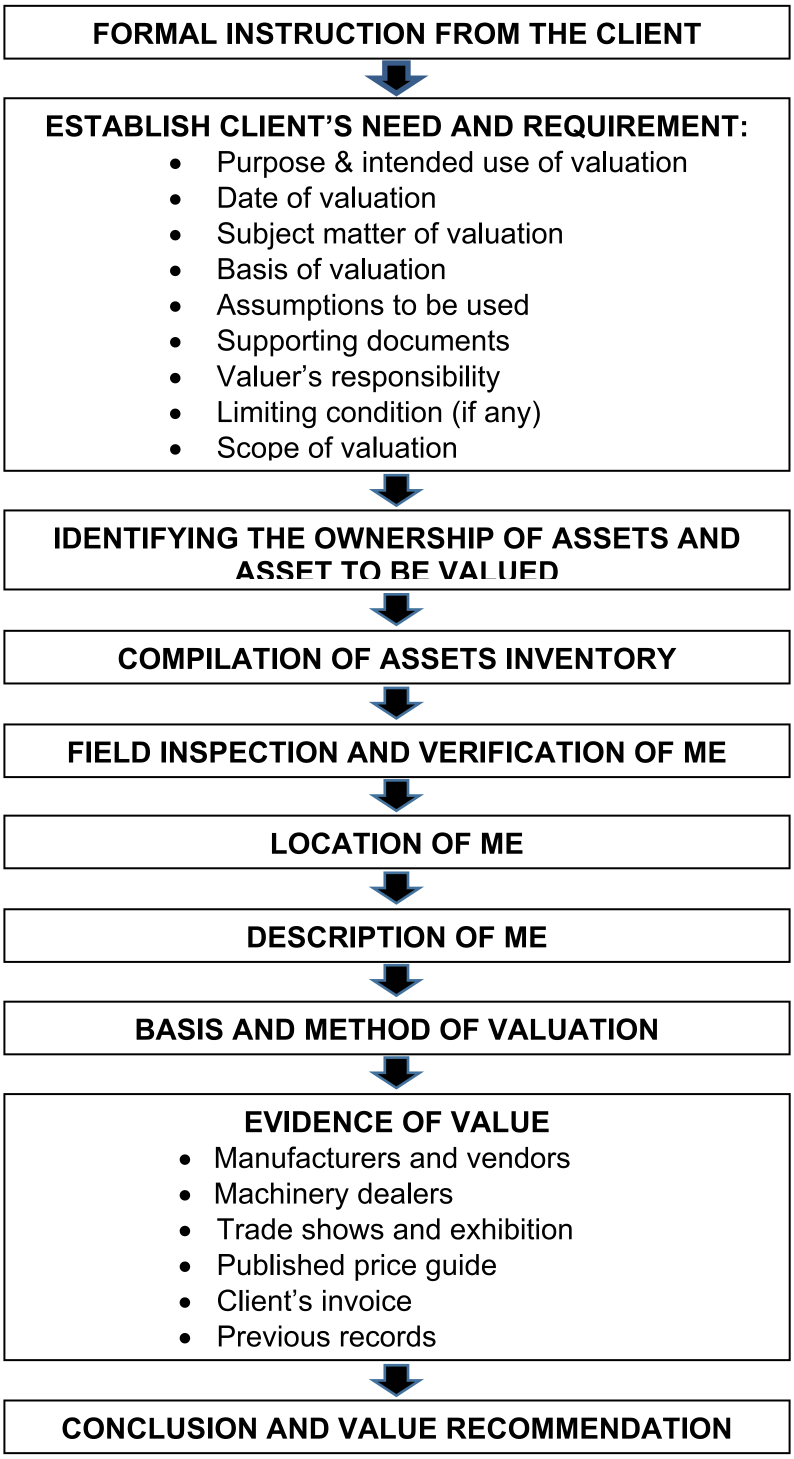


Figure 3: Valuation Process of the ABC Airport building

2.6.2 Macro Description of ABC Airport

a. Baggage Handling System (BHS)

Generally, the process flow within the baggage handling system can be classified as follows:

- A total number of 216 check-in counters are available at the departure level which belongs to the 6 check-in islands for the standard-size baggage.
- In addition, there are 2 oversized baggage (also known as OOG line) reversible lines with off-line screening machine and weighing scale available at both ends of the 6 check-in islands.


Figure 4: Check in Islands - Main Terminal Building

Once checked-in, the baggage first travel through an automated bar-code scanner. This place is actually an array of bar-code scanner arrange 360 degrees around the conveyor belt, including underneath. This device will scan the bar codes of about 90% of the bags that pass by. Then it will pass through the 1st level screening machine.

Conveyors take each bag to the appropriate destination by passing the following sections:

- Main Sorter (either Main Sorter 1 or Main Sorter 2)
- Screening and Sniffing Room (3rd level screening)
- Explosive Detection System and Workstation (EDS)
- Non- read line for luggage without proper tag
- Final Sorter with make-up chutes (either Final Sorter 1 or Final Sorter 2). (Baggage handlers will load the bags onto carts or into special containers that goes right into the airplane).
- All bags to Satellite Building will then be routed to the High-Speed Conveyors that passes through the 1.1 km tunnel. These bags will be sorted once again. (Two sets of Final Sorters with make-up chutes is available at the satellite building)

An Early Baggage Storage (EBS) line is available at the basement level. This EBS can cater for approximately 1,200 bags at one time for transit and early check-in bags. Supplementary check-in is located at Bus Station and Car Park Areas. For the passengers using Express Rail Link

(ERL) services, luggage/baggage will be transferred from ERL will be unloaded at the Ground Level Railway Station.

All arrival bags will be unloaded onto the break down conveyor at both the satellite and main terminal (transfer sorter and high-speed tunnel conveyor are dedicated for bag from Satellite building) delivered at the bags reclaim area.

Movement, monitoring and security of the baggage handling system are control by the BHS control room namely the Central Control Room (CCR) at the Main Terminal Building (MTB) and the Secondary Control Room (SCR) at the satellite building. Both CCR and SCR are identical. In practice the SCR is on standby and used only when CCR is under maintenance or not functioning.

At the BHS section the overall breakdown length of conveyor are as follows:

Within MTB	:	14.0 km
Tunnel	:	10.0 km (10 lines of high speed conveyor system with 1 km each and from our observation it is 1.30 km)
Within Satellite	:	9.0 km
Car Park	:	1.0 km
Total length	:	34.0 km

The valuation includes the value for baggage security system as part of the baggage handling system.

Refer to **Appendix A** for example of valuing an airport conveyor system – baggage handling system.

b. Track Transit System (TTS)

The track transit system which is also known as an Automated People Mover (APM) System is fully automated and driverless transit system. Designed to carry 5,800 passengers per hour per direction, the CX-100 vehicles are capable of operating as single-car trains or up to 3-car trains. Recently the system was upgraded to 3-car trains from 2-car trains to accommodate the increasing number of passengers on board. The system length is approximately 1.3 kilometre and the time taken to travel is approximately 2 minutes.

The APM system operates on dual guideway between two stations and serve passengers from Main Terminal Building to Satellite Building and vice versa.

Figure 5: Automated People Mover (APM)

In general, the whole APM system also includes:

- the design
- supply and system engineering and integration of the driverless trains
- signalling
- communications system
- power supply
- automated platform screen doors
- switches
- equipment and maintenance facilities
- testing, commissioning, transport and training services
- security system
- Firefighting equipment and
- Workshop

c. Aircraft Crash Recovery System Equipment (ACRES)

In the event of an accident along the runway, the Aircraft Recovery System Equipment (ACRES) is required to enable an aircraft to be moved to a safe area, allowing the authorities to reopen the runway as quickly as possible.

Figure 6: Aircraft Crash Recovery System (ACRES)

A complete range of Aircraft Crash Recovery System Equipment (ACRES) available from this unit is as follows:

- Pneumatic elevators system
- Control consoles
- Distribution consoles
- Mobile air compressor
- Protective Pads
- Air delivery hoses and coupling
- Tethering cables and winch assemblies
- Temporary road system.

d. Fire Vehicle for AFRS (Airport Fire and Rescue Services)

The AFRS is on standby and ready round the clock to respond to aircraft emergencies at ABC international airport.

AFRS members operate a variety of emergency vehicles including Ziegler (Airport Crash Tender), water tenders, emergency rapid vehicles, ambulances, officer in charge vehicle, command control vehicles and sky lift trucks with turntable aerial ladders.

Figure 7: Fire Vehicle for AFRS

These vehicles are required to safely mitigate fires and other emergencies on aircraft as required by the ICAO (International Civil Aviation Organization) standards and practices.

e. Runways and Road Sweepers

There are a total number of 11 road sweepers available within the airport. They have been designed to perform specific tasks such as liquid pick up, metal pick up, rubber removal, nozzle for suction and high-speed runway sweeping. The vehicles used are as follows:

- Truck road sweepers
- Medium road sweepers
- Light road sweepers (also known as scrubber)

Figure 8: Runway and Road Sweepers Truck

f. Aircraft Mock-up (Fire Simulator)

Aircraft mock-up is designed to replicate emergency scenarios for the normal commercial aircraft such as a Boeing 737 fuselage, and features cockpit, gallery, toilet, overhead luggage, seat row, roof flashover, cargo, engine compartment and wheel area.

All fixtures are made of steel. The total length of the simulator is 20 meters with 3 meters diameter and the entire structure weighs approximately 150 tons.

The fire simulator is mainly for the purpose of training facilities for firefighters. This facility is required to provide realistic training for fire fighters to reflect, as accurately as possible, those situations that could occur in an aircraft accident.

Figure 9: Aircraft Mock-up (Fire Simulator)

The facility allows fire fighters to raise internal temperatures to 250°C and safety systems have been installed to allow a fully managed and controlled operation.

g. Passenger Boarding Bridges (PBB)

Passenger Boarding Bridges (PBB) are also known as Passenger Loading Bridges (PLB). This moveable bridge is enclosed, and extends from the terminal gate (known as "hammer head") allowing passengers to board on airplane without having to go outside. It is permanently attached at one end by a pivot to the terminal building and has the ability to swing left or right, to be raised or lowered and extended or retracted, and for the aircraft end seal to pivot, in order to accommodate aircraft of different sizes and contours.

These motions are controlled by an operator’s station at the cab area of the PBB. Normally each PBB are driven by 9 units of motors and actuators. The airport gates will generally have a series of lines painted on the apron to assist in parking different types of aircraft in an appropriate position for the PBB operator to dock with the fuselage.

Figure 10: Passenger Boarding Bridges (PBB)

There is a total of 75 units of PBB located at airport. 35 units of PBB which are manufactured by “Jet Way” (known as jet way passenger bridge) are located at the Main Terminal, whilst the satellite building PBB was supplied by “Bukaka”. PBB are also equipped with the following accessories, i.e. preconditioned air supply system, ground power unit, portable water system and the visual docking guidance system.

Other ancillary services connected to the PLB are CCTV, fire detector, alarm buzzer, split and packaged air conditioning units, and foam hydrant (Water Cannon). Altogether there are 65 units of foam hydrant whereas 20 units are located at the main terminal and the remaining 45 units at the satellite building. There are 4 units of electric power system that supply electric power to the PLB and are distributed into 2 units being located at the main terminal, while the remaining 2 units at the satellite building.

h. Airfield Ground Lighting (AGL) System for Runways or Taxiways and Aprons (RTA) Lighting

Runway lighting system is a configuration of lights which define the lateral and longitudinal limits of the usable landing area. Several types of light fixtures are used along the runway and approach lighting system. Series circuits are used for supplying electrical energy to the lights.

Generally, the two runways i.e. 1 (14L/32R) and Runway 2 (14R/32L) is lit by:

- Approach
- Threshold
- Runway end
- Touchdown zone
- Wing bar
- Runway centre line
- Edge and
- PAPI light

Figure 11: Aerial View of ABC Airport

The lighting facilities within the taxiway consist of centreline, edge and stop bar lights meanwhile parking apron are mainly made up of high mast flood lights.

i. Electrical Substation Equipment

Electrical Power Sub Station (EPS) consists of a 33KV distribution network of 33/11KV substation and an 11 KV distribution network of 11/0.415KV substation. For the purposes of this valuation report, five (5) units of 33/11 KV substations and 42 units of 33/11KV substations (four are switching stations) are recorded.

These five 33/11KV substations are similar in construction and consist of the following items:

- Substation building
- 33KV double bus bar gas insulated switchgear
- 33/11KV, 30 MVA oil power transformers
- 11KV double bus bar metal clad switchgear
- 11/0.415Kv oil filled transformers of various capacities
- 415V main switchboard
- 110V DC battery system
- Remote control panels and relay panels
- 11KV neutral earthing equipment

These 33/11KV substations are located within the ABC airport area as individual buildings and also as rooms within buildings.

The 11/0.415KV substations too are rather similar in construction and consist of the following items:

- Substation building
- 11KV metalclad switchgear
- 11/0.415Kv oil filled transformers of various capacities
- 415V main switchboard
- 110V DC battery system

2.7 Basis of Valuation For ME

For the purpose of insurance valuation, the basis adopted is the **Reinstatement Cost New (RCN)**. According to the Saudi Machinery and Equipment Valuation Manual issued by TAQEEM, reinstatement costs, under reinstatement policy, should reflect an estimate of the costs necessary to replace or rebuild the insured property or asset to a condition substantially the same as, but not better or more extensive than, its condition when new.

As at the date of valuation, the increase in value is the value (including relevant fees and installation) of reinstating the asset to an as new condition including where appropriate;

- the use of current equivalent technology
- material and
- services

In arriving at the insurance value, reasonable comparisons of the ME have been made with regard to the:

- Quality
- productivity and

- Output relative to other items available in an industry as at the date of valuation.

2.8 Other Assumptions

- The insurance value can also be defined as the cost necessary to replace, repair or rebuilt the insured property to a condition substantially the same as but not better or more extensive than its condition when new.
- Based on such prices which are currently available from various manufacturers and suppliers of Plant and Machinery and where such Plant and machinery are no longer available, based upon the nearest equivalent, or last known price or estimated construction cost of such plant and machinery.
- Any individual prices contained within the Valuation bear reasonable relationship to the actual plant and machinery as valued. The individual figures could be also subjected to fluctuation circumstances.

2.9 Methods of Valuation

In arriving at the insurance value of the ME, the methods adopted are as follows:

2.9.1 Sales Comparison Approach

The sales comparison approach uses transactions in the marketplace to derive a value for the ME based on the actions of buyers and sellers. Actual sales are analysed and adjusted to the ME being valued. Adjustments are made for:

a. size: the capacity of the ME
b. complexity of the ME
c. time: differences in ME economics between the date of valuation and the time of the sale
d. age: determining if the sale is physically of a similar new age and level of technology as the subject and
e. location.

By formula, the calculation are as follows:

Item		SAR
Adjusted sales price plus installation, commissioning, freight, tax etc		F
x Inflationary/Trending provision for the next n year(s)	x	X
Insurance Value		**G**
Say		SAR H

2.9.2 The Cost Approach

The approach requires a certain level of knowledge about the economics and technology of the industry. To apply the cost method, we must determine the current cost of the ME or reinstatement cost new.

Reinstatement Cost New is defined as 'the current cost of a similar new item having the nearest equivalent utility as the property being appraised. There are two approaches in using the reinstatement cost method:

a. Using the inflationary rate

Item		SAR
Original cost (1998) (Inclusive all cost incurred to installed it)		I
x Inflation rate (1998 – 2006)	x	J
Current ME Market Value		**K**
x Inflationary/Trending provision for the next n year(s)	x	X
Insurance Value		**L**
Say		SAR M

b. Cost New Method

Item		SAR
Reinstatement with new plus installation, commissioning, freight, tax etc		N
x Inflationary/Trending provision for the next n year(s)	x	X
Insurance Value		**P**
Say		SAR Q

2.10 Factors May Affect the Valuation of ME in ABC Airport.

Factors considered in arriving at the ME insurance value are as follows:

a. Pre-Production expenses - Item like salaries, rent, lighting etc.
b. Expenditure for test-run of machinery.
c. Compensation for delayed delivery of machinery (if any).
d. Consideration for the know-how to erect and commission of a plant – Foreign company to supply the technical know-how to erect and commission a ME.
e. Expenses on installation / erection of machinery – expenses connected with the installation of ME such as travelling for ME engineers, insurance premium for ME, letter to suppliers etc.
f. Guarantee Commission - Occurs when the purchaser paid commission to a bank for a standing guarantee for the purchase of ME from foreign firm.
g. Salaries, guest-house expenses for erection staff, traveling expenses, etc. – During the period of construction and all expenses contribute to the installation of ME.
h. Staff training expenses – Only related for installation only. If occur for maintenance and operational processes - to be excluded.
i. Material cost, labour cost and Freight for handling.
j. Freight for moving.
k. Electrical, piping, foundation.
l. Sales tax.
m. Engineering, architect and other professional fees.
n. Administrative, accounting, consulting and legal fees.
o. Temporary insurance during installation.
p. Licenses, permits and fees for installation.
q. Security cost during installation.

3.0 ISSUES, PROBLEMS AND CHALLENGES FOR ABC AIRPORT ASSIGNMENT

Some difficulties occur during the exercise are as follows:

- Complex nature of the assignment.
- Lack of universally accepted best practices.
- Complexity in determining the interest being valued and function.
- Difficulties in determining what information is needed and locating the sources.
- Difficulties in obtaining pertinent data.
- Determining the functional utility of an airport.
- Assessing the economic life of improvements.

4.0 CONCLUSION

Airport valuation is not an ordinary exercise. It requires a deep understanding of the daily operation of the system, system involved, life span of the system and the money spend to develop and operate the system. In normal property valuation, the method adopted can be either comparison method, cost method or income method. However, due to the complexity of the ABC Airport nature and the systems involved, in arriving at the insurance value, the best method to be adopted is the reinstatement cost new. Thus, the consideration of the original price and the availability of the original cost assist the valuation team in arriving at the indication of the new cost price. However, the inflationary rates used are based on valuer's experience and ability to apply those rates. This approach can be reviewed with the finding of the new reinstatement cost of the same or equivalent model in the market.

Refer to **Appendix B** for the additional notes valuing an airport.

APPENDIX A

EXAMPLE OF VALUING AN AIRPORT CONVEYOR SYSTEM – BAGGAGE HANDLING SYSTEM

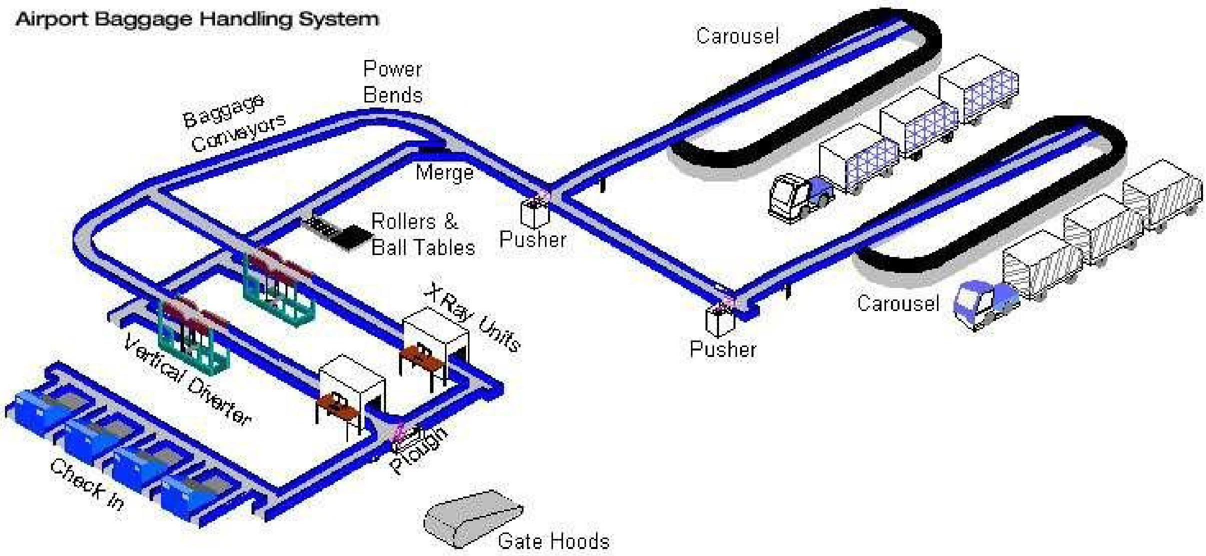


Figure 12: Airport Baggage Handling System

A baggage handling system (BHS) is a type of conveyor system installed in airports that transports checked luggage from ticket counters to areas where bags can be loaded onto airplanes. A BHS also transports checked baggage coming from airplanes to baggage claims or to an area where the bag can be loaded onto another airplane.

The most common conveyor belts are general-use belts. These solid belts typically feature materials including rubber or a fabric such as nylon, polyester, neoprene, or nitrile. Belt properties determine the conveyor belt's primary applications. Grocery stores commonly use PVC conveyors belts, and airport components of conveyor consist of conveyor belt, electric motors, gears, pulleys mounted on a special structure.

Example 1:

Valuation of general conveyors for insurance purposes.

The basis of valuation for insurance purpose is the Reinstatement Cost New (RCN). In the case of machinery and equipment, it is the "cost (including the cost of freight, insurance and installation) of replacing it with a new machinery and equipment items, which is a similar, modern substitute".

Description of conveyors:

The general conveyor is designed to move baggage quickly through airport configurations. Generally, these conveyors smoothly and reliably transport baggage through the terminal to make-up units for destination batches. Baggage can travel effectively and efficiently to meet or exceed the demands of any airport.

The Baggage Handling System (BHS) components consists of a drive section, one or more slider bed conveyors and a tail section. To accommodate changes in elevation, a standard angle knuckle conveyor can be added. General conveyors can transfer bags both horizontally and on inclines or declines.

Conveyor Lines:

Item Descriptions

A1	990mm General Conveyor, 20m long driven by “Sew” motor and connections.
A2	990mm General Conveyor, 6m long driven by “Sew” motor and connections.
A3	990mm General Conveyor, 15m long driven by “Sew” motor and connections.
A4	990mm General Conveyor, 40m long driven by “Sew” motor and connections.

Example calculation of Reinstatement Cost New:

Nos	Items	Replacement Cost New	Inflation factor	Total
1	990 mm General conveyor, 20m long driven by “Sew” motor and connections	SAR215,000	X 1.025	SAR220,375
				SAR220,375

Nos	Items	Replacement Cost New	Inflation factor	Total
2	990 mm General conveyor, 6m long driven by “Sew” motor and connections	SAR65,000	X 1.025	SAR66,625
				SAR66,625

Nos	Items	Replacement Cost New	Inflation factor	Total
3	990 mm General conveyor, 15m long driven by “Sew” motor and connections	SAR162,000	X 1.025	SAR166,050
				SAR166,050

Nos	Items	Replacement Cost New	Inflation factor	Total
4	990 mm General conveyor, 40m long driven by “Sew” motor and connections	SAR430,000	X 1.025	SAR440,750
				SAR440,750

Note :

a) Replacement cost new for each item is obtained from the supplier.
b) Replacement cost new for each item including the cost of transportation, installation, testing and commissioning and taxes.
c) Multiplier (x 1.025) inflation factor is based on the current inflation rate in Saudi Arabia. Current inflation rate in Saudi Arabia is around 2.5%

Nos	Items	Nos. of Unit	Gate No.	Reinstatement Cost New
1	990 mm General conveyor, 20m long driven by “Sew” motor and connections	1	A1	SAR220,375
2	990 mm General conveyor, 6m long driven by “Sew” motor and connections	1	A2	SAR66,625
3	990 mm General conveyor, 15m long driven by “Sew” motor and connections	1	A3	SAR166,050
4	990 mm General conveyor, 40m long driven by “Sew” motor and connections	1	A4	SAR440,750
	Total Reinstatement Cost New			**SAR893,800**

Example 2:

Valuation of General Conveyors for Market Value Purpose.

The basis of valuation is market value (Ex-situ). Market value of machinery and equipment (Ex-situ) is:

- Market value of machinery and equipment as a whole for removal from the premises; or
- Market value of machinery and equipment as individual items for removal from the premises.

Conveyor Lines

Item Description:

A1 990mm General Conveyor, 20m long driven by “Sew” motor and connections.

A2 990mm General Conveyor, 6m long driven by "Sew" motor and connections.

A3 990mm General Conveyor, 15m long driven by "Sew" motor and connections.

A4 990mm General Conveyor, 40m long driven by "Sew" motor and connections.

Example calculation of market value (Ex-situ) using Depreciated Replacement (DRC) method.

Nos.	Items	Nos. Of Unit	Gate no.	Replacement Cost New	Depreciation Effective multiplier (depreciation @ 53%)	Depreciated Replacement Cost (DRC)
1	990 mm General conveyor, 20m long driven by "Sew" motor and connections	1	A1	SAR215,000	X 0.47	SAR101,050
				Total		**SAR101,050**

Less:

Dismantle	SAR5,000
Transportation	SAR2,000
Market Value (Ex-Situ)	**SAR94,050**

Nos	Items	Nos. Of Unit	Gate no.	Replacement Cost New	Depreciation Effective multiplier (depreciation @ 53%)	Depreciated Replacement Cost (DRC)
2	990 mm General conveyor, 6m long driven by "Sew" motor and connections	1	A2	SAR65,000	X 0.47	SAR30,550
				Total		**SAR30,550**

Less:

Dismantle	SAR1,500
Transportation	SAR 600
Market Value (Ex-Situ)	**SAR28,450**

Nos	Items	Nos. Of Unit	Gate no.	Replacement Cost New	Depreciation Effective multiplier (depreciation @ 53%)	Depreciated Replacement Cost (DRC)
3	990 mm General conveyor, 15m long driven by "Sew" motor and connections	1	A3	SAR162,000	X 0.47	SAR76,140
				Total		**SAR76,140**

Less:

Dismantle	SAR3,750
Transportation	SAR1,500
Market Value (Ex-Situ)	**SAR70,890**

Nos	Items	Nos. Of Unit	Gate no.	Replacement Cost New	Depreciation Effective multiplier (depreciation @ 53%)	Depreciated Replacement Cost (DRC)
4	990 mm General conveyor, 40m long driven by "Sew" motor and connections	1	A4	SAR430,000	X 0.47	SAR202,100
				Total		**SAR202,100**

Less:

Dismantle	SAR10,000
Transportation	SAR4,000
Market Value (Ex-Situ)	**SAR188,100**

Note:

a) Market value of machinery and equipment as a whole for removal from the premises.
b) Economic life span of general conveyors is around 15 years.
c) Replacement cost new for each item is obtained from the supplier.
d) Estimation of dismantle cost (SAR250.00 per meter run) is obtained from the supplier.
e) Estimation of transportation cost (SAR100.00 per meter run) is obtained from the contractor.
f) All costs to remove the general conveyors to the new location are fully borne by the buyer.
g) Effective multiplier of 0.47 (53% depreciation) is based on the Rushton's Table (diminishing balance).
h) Depreciation (obsolescence of physical, functional and economic).

Nos	Items	Nos. Of Unit	Gate no.	Market Value (Ex-situ)
1	990 mm General conveyor, 20m long driven by "Sew" motor and connections	1	A1	SAR94,050
2	990 mm General conveyor, 6m long driven by "Sew" motor and connections	1	A2	SAR28,450
3	990 mm General conveyor, 15m long driven by "Sew" motor and connections	1	A3	SAR70,890
4	990 mm General conveyor, 40m long driven by "Sew" motor and connections	1	A4	SAR188,100
	Total Market Value (Ex-situ)			**SAR381,490**

APPENDIX B

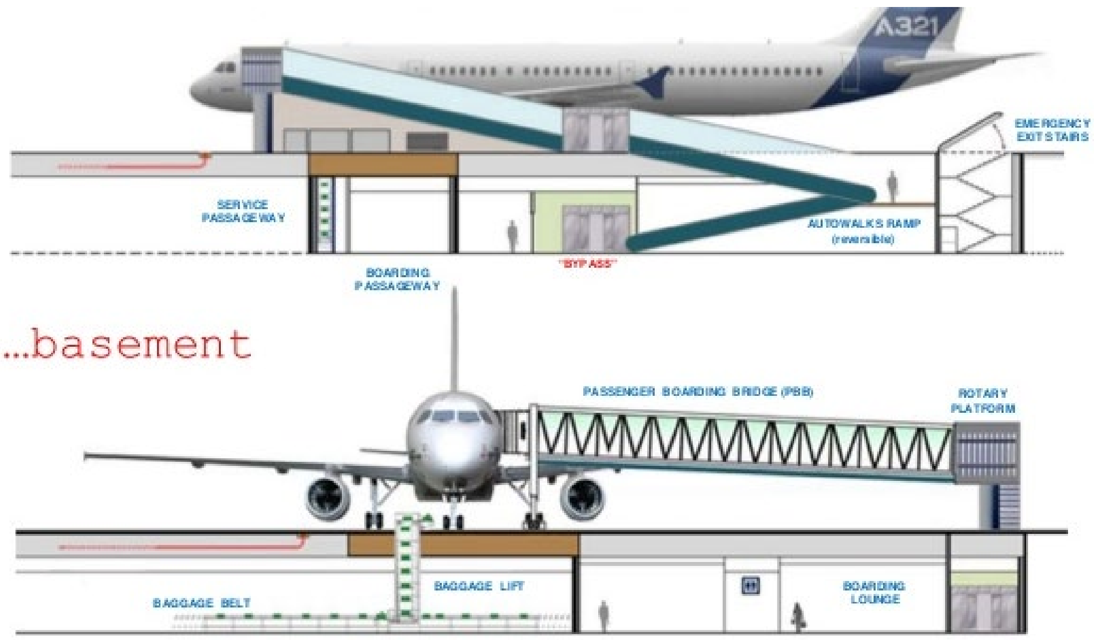
ADDITIONAL NOTES: VALUING AN AIRPORT

There are five (5) main components that must be considered when valuing machinery and equipment in an airport. They are as follows:

A. Airfield Ground Light System (AGL)
B. Baggage Handling System (BHS)
C. Passenger Boarding Bridge (PBB)
D. Airport Fire and Rescue Services (AFRS)
E. Sub-Station

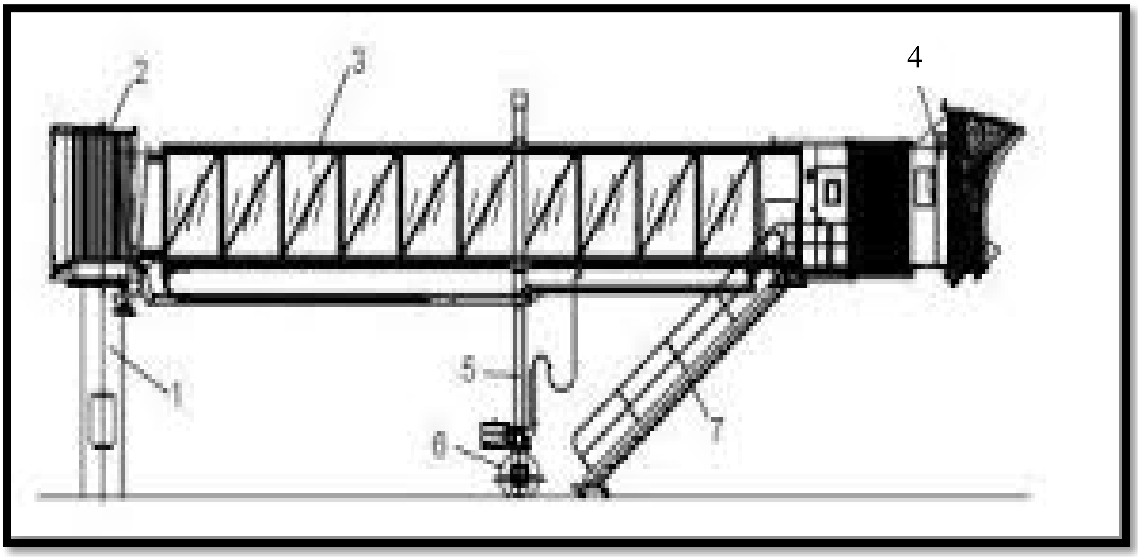
For this exercise, we will only value the Passenger Boarding Bridge (PBB) components at the satellite building.

Below are the pictures showing passenger boarding bridge.



Passenger Boarding Bridges (PBB) are also known as aerobridges. These moveable bridges are enclosed and extend from the terminal gate (known as "hammer head") allowing passengers to board into aircraft in a safe and comfortable environment without having to go outside. The main components of a PBB are the *rotunda,* the *tunnels*, the *cab*in bridge head and the vertical *lift columns*. When boarding an aircraft, the *rotunda* is the first section of the boarding bridge that passengers will enter. It is supported by a fixed support column and superficially attached to the airport terminal building.

The assembly is designed so that no loads or vibrations are transmitted to the building. The rotunda is designed as the pivoting end of the boarding bridge in the vertical and horizontal direction. As the main pivot, the rotunda allows the bridge to swing a total of 175 degrees, 87.5 degrees clockwise and 87.5 degrees counter clockwise from the corridor centreline.



1: Support column
2: Rotunda
3: Tunnels
4: Cabin
5: Elevation system
6: Drive system
7: Service stairs

A PBB may have two or three telescoping tunnels. The extension and retraction of the telescoping tunnels, the swivel of PBB to the right and left side, the adjustment of vertical lift columns height, the movement of wheel boogey and the movement of the canopy and attach to the aircraft door are controlled by a system recognized as touch screen console control system complete with Programmable Logic Control (PLC) system which located at the cabin bridge head area of the PBB.

Generally, the airport gates will have a series of lines painted on the apron to assist in parking different types of aircraft in an appropriate position for the PBB operator to dock with the fuselage.

PBB are also equipped with the following support components such as Pre-Conditioned Air System (PCA), Ground Power Unit System (GPU), Visual Docking Guidance System (VDGS) and Outdoor Closed-Circuit Television (CCTV) which located at the left side of hammer head building for the purpose of PBB security.

Other ancillary services connected to the PBB are CCTV (to monitor wheel boogey movement), fire detector, alarm buzzer, split and packaged air conditioning units, and foam hydrant.

Altogether there are 75 units of PBB stationed at the airport, vis a vis thirty-five (35) units jet way model are stationed at the contact pier (international flights), while the remaining twenty-two (22) bukaka model are stationed at the satellite building (domestic flights).

The details of 22 units of PBB are as follows:

No.	Location
1.	C1- (right)
2.	C1- (left)
3.	C2- (right)
4.	C2- (left)
5.	C3- (right)
6.	C3- (left)
7.	C24- (right)
8.	C24- (left)
9.	C26- (right)
10.	C26-(left)
11.	C31
12.	C33
13.	C32- (right)
14.	C32-(left)
15.	C34- (right)
16.	C34-(left)
17.	C35- (right)
18.	C35-(left)
19.	C36- (right)
20.	C36-(left)
21.	C37- (right)
22.	C37-(left)

Refer to **Appendix C** for details valuation on passenger boarding bridge in satellite building

APPENDIX C

MACHINERY AND EQUIPMENT VALUATION FOR INSURANCE PURPOSE (REPLACEMENT COST NEW)
Item: Passenger Boarding Bridges (BUKAKA)
Example of Airport Valuation

Date of Valuation : 1.1.2019

Location: Satellite Building, ABC Airport

Formula :-
Value (RCN) (A) X (B) = (C)
(C) X (D) = (E)

Inflation Factor : Inflationary provision for n^{th} year
(Formula: $(1+i)^n$ where, i = rate of interest
n = duration (year)

NOS.	ITEMS	NOS. OF UNIT (a)	GATE NO.	PRICE (PER UNIT) (b)	PRICES (c)	INFLATION FACTOR (d)	TOTAL PRICES (e)	DETAILS
1	"RAMPWAY BUKAKA" 'R2-15/21' Serial No: 060-SPG-234 Two tunnel glass wall passenger boarding bridge type Apron Drive Telescoping Passageway with maximum 21 metres extension and 15 metres	1	C1 (RIGHT)	SAR2,196,875.00	SAR2,196,875.00	1.05	SAR2,306,718.75	Price per unit for each items including the cost of transportation, installation, testing & commissioning and taxes.
	"JETAIRE" 'XPC 7500-321-00-40' Serial No: 60166 75 tons cooling capacity Pre- Conditioned Air System assembled under passenger boarding bridge with dimension 2200 mm (width) x 4270 mm (length) x 1530 mm (height) c/w other PCA components.							
	"MITSUBISHI" 'HC - 3C90E' 90kVA Serial No: 95 - AX83N1 - 04 Frequency Converter to convert electrical supply from 415V, 50Hz AC Power to 200/115V, 400Hz c/w other GPU components.	1		SAR153,125.00	SAR153,125.00	1.05	SAR160,781.25	
	"FMT" 'APIS' Serial No: PRO 70939 (Main) Visual Docking Guidance System (automatic controller system) with dimension 980 mm (width) x 430 mm (length) x 1510 mm (height) c/w other VDGS	1		SAR161,466.66	SAR161,466.66	1.05	SAR169,539.99	
	"ANSUL" Serial No: 84836, 100 gallons foam tank with dimension 2000 mm (height) x 960 mm (diametres) connected to water piping system c/w other FFS components.	1		SAR40,000.00	SAR40,000.00	1.05	SAR42,000.00	
	TOTAL						**SAR2,679,039.99**	

NOS.	ITEMS	NOS. OF UNIT (a)	GATE NO.	PRICE (PER UNIT) (b)	PRICES (c)	INFLATION FACTOR (d)	TOTAL PRICES (e)	DETAILS
2	"RAMPWAY BUKAKA" 'R3-17/34' Serial No: 060-SPG-243 Three tunnel glass wall passenger boarding bridge type Apron Drive Telescoping Passageway with maximum 34 metres extension and 17 metres retraction of Telescoping Tunnel System c/w other PBB components.	1	C1 (LEFT)	SAR2,596,875.00	SAR2,596,875.00	1.05	SAR2,726,718.75	Price per unit for each item including the cost of transportation, installation, testing & commissioning and taxes.
	"JETAIRE" 'XPC 7500-321-00-40' Serial No: 60167 75 tons cooling capacity Pre- Conditioned Air System assembled under passenger boarding bridge with dimension 2200 mm (width) x 4270 mm (length) x 1530 mm (height) c/w other PCA components.							
	"MITSUBISHI" 'HC - 3C90E' 90kVA Serial No: 95 - AX83N1 - 04 Frequency Converter to convert electrical supply from 415V, 50Hz AC Power to 200/115V, 400Hz c/w other GPU components.	1		SAR153,125.00	SAR153,125.00	1.05	SAR160,781.25	
	"ANSUL" Serial No: 85537, 100 gallons foam tank with dimension 2000 mm (height) x 960 mm (diametres) connected to water piping system c/w other FFS components.	1		SAR40,000.00	SAR40,000.00	1.05	SAR42,000.00	
	TOTAL						SAR2,929,500.00	

NOS.	ITEMS	NOS. OF UNIT (a)	GATE NO.	PRICE (PER UNIT) (b)	PRICES (c)	INFLATION FACTOR (d)	TOTAL PRICES (e)	DETAILS
3	"RAMPWAY BUKAKA'' 'R3-15/29' Serial No: 060-SPG-244 Three tunnel glass wall passenger boarding bridge type Apron Drive Telescoping Passageway with maximum 29 metres extension and 15 metres retraction of Telescoping Tunnel System c/w other PBB components. "JETAIRE" 'XPC 7500-321-00-40' Serial No: 60163 75 tons cooling capacity Pre- Conditioned Air System assembled under passenger boarding bridge with dimension 2200 mm (width) x 4270 mm (length) x 1530 mm (height) c/w other PCA components.	1	C3 (RIGHT)	SAR2,546,875.00	SAR2,546,875.00	1.05	SAR2,674,218.75	Price per unit for each item including the cost of transportation, installation, testing & commissioning and taxes.
	"MITSUBISHI" 'HC - 3C90E' 90kVA Serial No: 95 - AX83P9 - 02 Frequency Converter to convert electrical supply from 415V, 50Hz AC Power to 200/115V, 400Hz c/w other GPU components.	1		SAR153,125.00	SAR153,125.00	1.05	SAR160,781.25	
	"FMT" 'APIS' Serial No: PRO 70934 (Right) & PRO 70923 (Main) Visual Docking Guidance System (automatic controller system) with dimension 980 mm (width) x 430 mm (length) x 1510 mm (height) c/w other VDGS components.	2		SAR161,466.66	SAR322,933.32	1.05	SAR339,079.99	
	"ANSUL" Serial No: 85572, 100 gallons foam tank with dimension 2000 mm (height) x 960 mm (diametres) connected to water piping system c/w other FFS components.	1		SAR40,000.00	SAR40,000.00	1.05	SAR42,000.00	
TOTAL							SAR3,216,079.00	

ME 404

REFERENCING FOR PROCESS PLANT

INSPECTION PROCEDURE FOR PROCESS PLANT

INSPECTION PROCEDURE OF A PROCESS PLANT

1.0 Introduction

The valuation of ME has been around since valuation was created. This field or discipline requires advanced training and a very complex set of skills which are different from those required by the real estate valuers. Knowledge of engineering, economics, fabrication, construction and accounting are all important due to the special nature of this specialised subject. It is also important for a ME valuer to understand basic mechanical engineering such as machine design, machine process flow, machine engineering plans and the ability to communicate with suppliers and manufactures about the engineering products. The time necessary to train good inspection techniques will depend on the ability of each ME valuer having been exposed to various types of ME.

In the earlier modules, participants have been briefed on general inspection procedures and how to conduct a proper inspection for ME valuation. It is vital for all ME valuers to really understand and plan their inspections so that nothing is left unrecorded in the inspection notes.

According to International Valuation Standard 2020, IVS 102 investigations and compliance section 20.1 which requires that “investigations made during the course of a valuation assignment must be appropriate for the purpose of the valuation assignment and the basis(es) of value.”

Proper inspection procedures are important in ensuring comprehensive coverage of ME so that all notes related to such subject have been verified and taken into account.

2.0 Inspection Procedures

Under Module ME402, referencing module on inspection procedures is divided into four (4) steps:

i. Stage 1 : Pre-inspection preparation
ii. Stage 2 : Preliminary inspection
iii. Stage 3 : During inspection
iv. Stage 4 : Post inspection

2.1 Stage 1 : Pre Inspection

Before site inspection is carried out, participants need to identify:

a) The purpose of valuation: sale/purchase, insurance or financial.
b) Date of valuation. The date of valuation will be determined based on:
   - date of inspection; or

- date of valuation as provided in the act or ordinance (if Statutory Valuation); or
- other dates as required by the client

c) Determine the basis of valuation either market value, reinstatement value, indemnity value or others.

d) Before inspection, participants must have suitable tools for inspection as follows:
   - Pencil
   - Torch light
   - Measuring tape
   - Camera
   - Inspection note pad
   - Small towel
   - Safety equipment:
     - safety boots
     - safety helmet
     - safety glasses
     - ear plug

2.2 Stage 2 : Preliminary Inspection

Participants will conduct a general observation of the production plant as well as the surrounding areas. The participants are expected to:

a) Arrange a meeting with client. Have a briefing with the plant manager/supervisor on the machinery as well as the security aspect along with safety protocol or class.

b) Get the financial statement, production costs, income and overhead costs (if any).

c) On the maintenance schedule, gather information on historical costs, level of maintenance and costs of repair for the last 3 years.

d) Get the inventory list or machinery register of the plant and machineries

e) Collect data/information from machinery register, maintenance's log books, contract documents of machinery procurement or operation manuals

f) Get photograph of each machinery

g) Estimate the time needed for the overall inspection

h) Plan the proposed inspection properly

2.3 Stage 3 : During Inspection

Procedures at this stage will involve:

a) Safety precautions
   - Wear appropriate attire

- Wear safety equipment such as goggles, ear plugs, helmet and safety boots (if necessary)
- Follow the safety procedures
- Do not:
    - touch or test any machinery without permission
    - remove any machinery
    - switch on or switch off any electrical switch panel
    - enter any room or section without permission

b) Inspection Process

The purpose of the inspection is to prepare an inventory list and collect physical data on the ME. A good record and reference for each item is the most important aspect in ME valuation. Inspection processes are as follows:

i. Preparation of ME inventory

- The purpose of the inventory list is to record as much as possible the relevant data, to enable participants to determine the value. Inventory listing can be done on personal computer or tablets with data entry and scanning, dictation or by note taking.

ii. Data collection during inspection

During the inspection, the following data/information is needed:

- Client's asset no./Identification no. (if available)
- Machine type
- Name of manufacturer
- Model/type
- Serial number
- Year of manufacture
- Country of origin
- Size and capacity
- Condition of the machine
- New or used machine
- Original cost, date of purchase/installation and ancillary item attached to the machinery
- Details of attachments and accessories
- Materials of construction if process equipment or specialty item
- Type and details of driver: chain drive/V belt drive, gear drive, chain to gear, reducer drive, etc
- Prime mover, electric motor or engine driven i.e horse power, phase, voltage, amperage and revolutions per minute

- Reference to special foundations, platform, servicing connections i.e. wiring, plumbing/piping installation, other excessive installation cost (if any or relevant).
- Modifications or renovations from the standard machinery
- The valuer/appraiser might also look at who is handling the maintenance of the equipment as they have a great deal of information and data on the machine,

All data/information above should be recorded in an inspection note.

iii. Photograph
Take photograph of all machinery (if permitted).

iv. Machinery Description
Details of machinery need to be described sufficiently to give a correct description of the machinery. There is no specific format but usually the format will be in the sequence i.e. brand, type of machine, model, serial number, capacity, year of manufactured, country of origin and the machine condition.

2.4 Stage 4 : Post Inspection

After finished the inspection, participants must check all their inspection notes to ensure no item left out. The Valuer should have the contact details of the plant manager or CFO should they need any additional information

Participants will begin data gathering process in their office for each machine. The required data/information can be gathered from:

a) Manufacturers
b) Supplier of the machine
c) Trade exhibition materials
d) Internet
e) Price catalogues
f) Customer's invoices
g) Advertisements
h) Auctioneers
i) Plant and machinery database
j) Previous valuation reports, or
k) Client's annual reports

Notes:

- It is important to keep all previous valuation records for future reference. Such data that needs to captured will include:

  i) Asset description
  ii) Asset number

iii) Original purchase date
iv) Original purchase cost
v) Asset category
vi) Asset location and
vii) Valued reported

- It is very important to understand that details of inventories and all equipment to be valued, must be thoroughly inspected and verified.
- There are also other factors which need attention while gathering information such as following:

  - Warranties
  - After sales service
  - Documents manuals
  - Resident engineer
  - Special training/workshop
  - Licensing
  - Permits
  - Distribution rights etc

3.0 Gathering Information

The information about the equipment should comprise the following items:

i. Fundamental inventory information:
   a. Quantity
      - Number of items recorded in Stock Keeping Unit (SKU)

   b. Description
      - Model, physical description, date of acquisition/purchase etc

   c. Cost
      - Individual or each based upon purchase price

   d. Unit of measure
      - Weight, height, tonnage, case, boxes, capacities of each items

ii. Other important information which is needed in additional are as follows:
   a. Stock Keeping Unit (SKU) number or assignment
   b. Classification or category codes
   c. Manufacturer
   d. Type
   e. Usage/activity, or sales history
   f. Location
   g. Condition (Depreciation and obsolescence)

iii. Segregation and description of all items can be classified as follows:
   a. Departments
   b. Levels

c. Room by room
d. Process Flow
e. Trending charts
f. For manufacturers (raw material, work in progress (WIP) and finished product)

iv. During Inspection, which is gathering of information and data, it also advisable to get information from the company personnel such as:

a. Manufacturing division (CFO or Controller)
b. Marketing and Purchasing section
c. Factory supervisor or Factory Manager
d. Charge man or a designated Person in Charge (PIC)

v. On-site data gathering, ME is very mechanical in nature. Therefore, before proceeding with the inspection, it is advised that the ME valuers do some research on the background information of the production/ business of the plant to be able to relate with data collected:

a. Manufacturing
b. Sales and marketing
c. Returns and repairs
d. Raw material purchasing
e. Quantity and quality of information gathered on site and their value characteristic
f. Percentage of completion and incomplete process flow

vi. Once the inspection is completed, information derived from on-site can be summarised as follows:

a. Comparing the descriptive information supplied to the actual physical item to which it refers.
b. Verification that inventory or SKU quantities provided are reasonable.
c. Inventory quality or condition
d. Method of stocking including location references

Please take note that remarks on items which are obsolete, out of use, or state of disrepair. Also note items which belong to third party and are in use or stored at the company site (not to be valued)

While conducting inspections on site it is advisable to have opening and closing meetings to ensure all information needed has been gathered.

4.0 Issues and Challenges During Inspections

ME valuers should really understand that while conducting any valuation task on ME valuation certain measures must be taken into consideration to overcome any issues which might arise.

Issues and challenges that normally occur during inspections can be summarised as follows:

i. The complexity of the task in general
ii. Absence of standard guidance notes
iii. Multiple ownerships
iv. Accuracy of information
v. Availability of relevant data and documents
vi. Inspection schedules
vii. Various dates to be adhered to (i.e.: date of purchase, installation, commissioning etc)
viii. Obtaining the functionality of each assets
ix. Assessment of economic life
x. Best practice within the locality
xi. Evidences of comparables
xii. Assets moving around the plant such as forklifts. The Valuer will want to tag assets as they are listed so they are not double counted.

ME 404

REFERENCING FOR PROCESS PLANT

SAFETY PROCEDURES

SAFETY PROCEDURES DURING ME INSPECTION

1.0 Introduction

Sometimes the risk associated with a work task/inspection may be obvious, such as involving dangerous machinery or chemical. Other times the risks are not so obvious such as inspection around unloading goods area or packing boxes in a warehouse.

Safety procedures should be the number one priority to ME valuers. ME valuers should always be aware of the risk involved when conducting their work and should always be mindful of how to avoid injuries or accidents while doing the ME inspections.

The importance of observing safety procedures during ME inspections are as follows:

a. To ensure safety and work safely in inspecting the facility
b. To be able to evacuate when the need arises during inspection.
c. To prepare in advance and bring along all safety equipment before commencing inspection.
d. Ability to understand all safety signage.

2.0 The Purpose of Safety Procedures

The purpose of safety procedures are as follows:

a. Identifying and using protective clothing or equipment appropriately.
b. Carrying out basic safety checks on equipment before inspection.
c. Following safety instructions.
d. Knowing what to do if someone is injured during inspection.
e. Knowing the importance of using/wearing protective clothing or equipment.
f. Knowing what a hazard is anything that could injure you or make you sick.
g. Taking appropriate action when we notice something is hazard or unsafe at work.
h. Taking appropriate action when the fire alarm turns on.
i. Knowing why it is important to follow evacuation procedures.
j. Using appropriate methods to move objects at the work place.

3.0 Safety Rules That Need To Be Followed

Before entering the inspection area, ME valuer must observe some of the following rules:

a. Follow safety instructions.
b. Wash your hands.
c. Wear personal protective equipment (PPE).

d. Follow arrow to the exit.
e. Train other team members on how to use PPE.

4.0 The importance of safety precaution and procedures

During inspection it is very important for ME valuers to appreciate and understand why they must go through safety briefings, wear proper safety attires and know all safety signage. Within the premise where ME valuer is inspecting ME, it should be noted that some safety signage fixed to the wall provide guidance that must be observed all the times. Example of the signage are as follows:

a. Walkways to exit.
b. Authorised person only.
c. No smoking.
d. No handphone allowed.
e. Wear safety/hard hat.
f. Wear safety boots.
g. Safety Glasses

5.0 Actions to Be Taken During Emergency

Actions to be taken during emergency are as follows:

a. If emergency occurs during inspection, we should immediately notify and call our team leader or the building supervisor for their help.
b. Locate any nearby first aid box or emergency telephone box to ask for assistance.
c. Usage of fire extinguishers, CO2 or any powder or chemical firefighting equipment must be done according to the Plant instruction.
d. Do not panic and stay calm to avoid unnecessary things to happen.

6.0 Safety preparation before inspection

Before ME valuers schedule any inspection, they must follow the steps listed below:

a. Inform the client prior to date of inspection.
b. Schedule an appointment for safety briefing.
c. Understand workplace hazards.
d. Prepare safety gears needed for the assignment
e. Submit names and ID numbers of team members involved.
f. Get special pass if necessary (daily, weekly or monthly passes)
g. Identify person in charge to assist you with your inspections.

7.0 Why We Need to Know About Hazards

Knowing that hazards can cause danger and may hurt any ME valuer while carrying out inspection. It is important to know that hazard is anything that can:

a. Cut you.
b. Trip you.
c. Burn you.
d. Crush you.
e. Hurt your hearing.
f. Hurt your eyes.
g. Make you sick.
h. Cause you pain.
i. Poison

8.0 Hazard Signs

During inspection you may come across the signs below and must be alert on necessary action to be taken or observed.

a. Forklift Hazard

The forklift hazard sign lets you know that a forklift is operating in the area. To avoid being hurt by the forklift we need to be in the designated walkway and not run and keep alert.

b. Slippery Surface

Slips and trips result in thousand of injuries every year. The most common ones are musculosskeletal injuries, cuts, bruises, fractured and dislocations. More serious injuries can also occurs. Most common slips occur during fall from low heights such as stairs and curbs, falling into hole or a ditch or into a body of water. Therefore the most appropriate personal protective equipment that should be worn is slip-resistant footwear.

c. Do Not Watch Welding Arc

The above sign indicates that the area is prone to sparks, arc flash, spatter, heat and radiation, also it can cause hurt to your eyes. The safe inspection behaviour around this area is that you should wear appropriate PPE gear. This might require welding screens or perhaps safety goggles.

9.0 List of Safety Gear

It is most commonly known as personal protective equipment (PPE). PPE is equipment that will protect against health or safety risks at work. It can be as follows:

a. Goggles

Goggles are forms of protective eyewear that usually enclose or protect the area surrounding the eyes in order to prevent particulates, water or chemicals from striking the eyes.

Figure 1: Goggle or Safety Glass

b. Ear plugs or earmuffs

Ear plugs or earmuffs can reduce the decibel exposures, providing protection against hearing loss. Ear plugs provide the greatest amount of protection if they are inserted correctly.

Figure 2: Ear Plugs or Earmuffs

c. Safety vests (Reflective Gear)

Safety vest is important for operating heavy equipment or driving through the site. You aren't easily seen without the bright material being reflected in the lights of vehicles and equipment, but with reflective gear, you will stand out much better. If your work places are on a road that is travelled by the public, it is important that you wear safety gear to enhance your visibility to travellers.

Figure 3: Safety Vest

d. Safety gloves

Safety gloves can provide protection against some moderate concentrated chemicals. They can be used in laboratory work provided they are strong enough to protect against the specific chemical being handled. The risk of cuts and abrasions also can be minimized by wearing leather gloves

Figure 4: Safety Gloves

e. Safety boots

Steel toe boots and shoes protect your feet, help prevent injuries to them, and reduce the severity of injuries that may occur in the workplace. It also useful as a precautionary measure when the factory or process plant is near the jungle which might be full of venomous animals.

Figure 5: Safety Boots

f. Hard hats

Hard Hat may be mandatory in some facilities. Injuries to the head due to falling objects or bumps from hazards are often serious and have been known to be fatal. Wearing a hard hat not only protects the top of your head, it can also protect those things attached to your cranium. Such items include your eyes, ears, nose, and mouth.

Figure 6: Hard hats

g. Masks

Masks are a necessity in many professions and for a variety of tasks in the workplace or at home. Some industries require the use of face shields when workers are exposed to flying objects, molten metal, liquid chemicals, acids or caustic liquids, chemical gasses or vapours, or potentially hazardous light radiation.

Figure 7: Face Mask

h. Flame resistant (FR) apparel

This clothing made from 100% cotton or wool may be acceptable if its weight is appropriate for the flame and electric arc conditions to which a worker might be exposed. As heat levels increase, these materials will not melt, but they can ignite and burn.

Figure 8: FR Apparel

i. Gas detectors

Gas detector is a device that detects the presence of gases in an area. Gas detector also can be used to detect combustible flammable and toxic gases and oxygen depletion.

Figure 9: Gas Detector

10.0 Knowing About Safety Sign

a. Eye Protection

Figure 10: Sample of Eye Protection Signage

Always ensure that ME valuers use goggle or safety glass when they see eye protection sign.

b. Hearing Protection

Figure 11: Sample of Hearing Protection Signage

Seeing this sign means that ear plugs must be used. An earplug is a device that is inserted in the ear canal to protect the user from loud noises or the intrusion of water, foreign bodies, dust or excessive wind .

Sometimes you can use disposable earplugs. Most disposable earplugs are elastic ones made of memory foam, that is typically rolled into tightly compressed cylinder (without creases) by the user's fingers and then inserted in the ear canal. Once released, the earplug expands until it seals the canal, blocking the sound vibrations that could reach the eardrum.

c. Safety Vests

Figure 12: Sample of Safety Vest Signage

Safety vests are found in yellow, orange or red and have reflective stripes, with insignia and letters printed on them.

Types of safety vests to be used depend on the user, work environments or types of industry.

d. Gloves

Figure 13: Sample of Glove Aware Signage

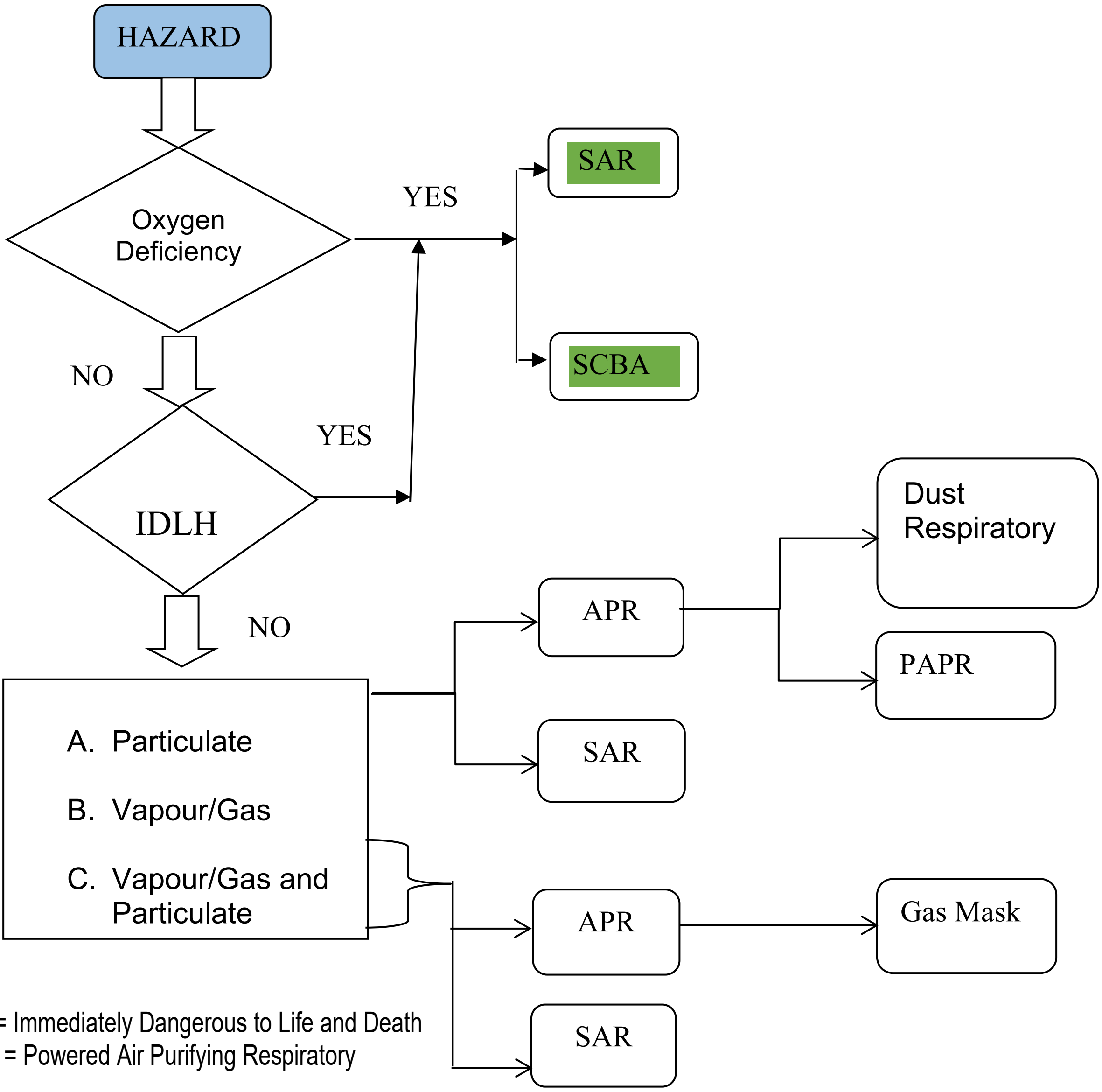
Work gloves for PPE inspections worn during work projects that cover and protect the hands from the wrist to the fingers. Work gloves are meant to protect the user’s hands and fingers from unnecessary wounds such as cuts, blisters, splinters, skin punctures or other heat and chemical burns.

11.0 Types of Protective Device

The types of respiratory protection are as follows:

a. Air purifying respiratory (APR)
b. Supplied air respiratory (SAR)
c. Self-contained breathing apparatus (SCBA)

Selection of respiratory protective device is illustrated as follow:



IDLH = Immediately Dangerous to Life and Death
PAPR = Powered Air Purifying Respiratory

12.0 Chemical Suits and Gloves

Chemical suits and gloves are used to protect our body from injury or expose to hazardous chemical through dermal absorption and ingestion. On the other hand, the respiratory protective devices protect us from hazardous chemicals which may enter to our body by inhalation

13.0 Risk Mapping Group

Physical Hazards

Examples:

- Noise
- Heat
- Ventilation
- Light
- Machines
- Vibration

Ergonomics

Examples:

- Positions
- Loads
- Effort
- Fatigue
- Repetition

Chemicals

Examples:

- Dusts
- Liquids
- Gases
- Mists
- Vapours

Stress

Examples:

- Shift Work
- Over-Supervision
- Responsibility
- Lack of Control

Other

Examples:

- Germs
- Radiation
- Snakes, bees other insects etc.

14.0 Fire Escape, Emergency Evacuation and Assembly Point

At all times, when conducting inspection, ME valuers must be fully knowledgeable about the emergency evacuation procedures. These procedures are essential and crucial for saving lives and in ensuring minimal confusion, and to evacuate in a safe and timely fashion. Normally all ME valuers will be briefed about the fire escape procedures before conducting any ME inspections. This is a standard procedure required by any building owners. For larger premises it is sometimes mandatory for visitors or new workers to attend a safety briefing before they are allowed to enter the building.

Among other things needed to be consider in the fire evacuation procedures are as follows:

a. Identify the location of the fire assembly point.

Figure 14: Sample of Fire Assembly Point Signage

b. Know the escape routes at all times. Observe all fire escape plans available within the premises.

Figure 15: Fire Escape Plan

c. Keep all team members informed and listen to announcement made during emergency.
d. Identify potential danger and familiarise yourself with any potential high risk for fire breakouts etc.
e. If you are carrying a cell phone in the plant then the plant supervisor should have your contact details of your team at all times.

15.0 Conclusion

At all time, the ME valuer must adhere to the plant policies on what to wear while on the job site such as clothings, safety glasses and gloves. No exceptions to these policies. as it is the policy. PPE equipment must be properly looked after and stored when not in use. For example, it might be stored in dry, clean cupboard. If it is reusable it must be cleaned and kept in good condition.

In conclusion always remember that:

a. Suitable PPE equipment is provided during inspection
b. Adequate protection for its intended use
c. Those using it are adequately trained in its safe use
d. Proper maintenance and any defects are replaced
e. It is returned to its storage after use.

ME 404

APPLIED MACHINERY AND EQUIPMENT VALUATION - SPECIALISED INDUSTRIES

EXERCISE QUESTIONS

EXERCISE QUESTIONS
TAQEEM MACHINERY AND EQUIPMENT VALUATION
TRAINING PROGRAMME

MODULE	**:**	**Advanced Level 1: Applied M & E Valuation - Specialised Industries**
SUBJECT CODE	**:**	**ME404**
DATE	**:**	**2021**

1. Which of the following is **NOT** the method used in Thermal Technology of seawater desalination?

   A. Multi-Stage Flash Distillation (MSF).
   B. Reverse Osmosis (RO).
   C. Multi-Effect Distillation (MED).
   D. Vapour Compression Distillation (VCD).

2. All of the following are the indirect capital costs considered in a water desalination plant valuation including _______________.

   I. Legal
   II. Administrative
   III. Bank loan interest
   IV. Contingency cost

   A. I and II only
   B. II and III only
   C. III and IV only
   D. All of the above

Question 3 – 6. Fill in the blank.

Reverse Osmosis	Distil	Multi-effect distillation
Direct coastal intake	Net replacement cost	

3. ____________________ is a water purification technology that uses a semipermeable membrane to remove ions, molecules, and larger particles from drinking water.

4. Three (3) types of intake structure include well, ______________ and open intake structure on the sea bed.

5. Types of thermal technology in water desalination plant are multi-stage flash distillation, ________________________ and vapour compression distillation.

6. Multi-stage flash distillation (MSF) is a water desalination process that _______________ sea water by flashing a portion of the water into steam in multiple stages of what are essentially counter current heat exchangers.

7. All of the following are the desalination technologies **EXCEPT** ______________.

    I. Thermal technology
    II. Membrane technology
    III. Seismic technology
    IV. Turbo technology

    A. I and II only
    B. II and III only
    C. III and IV only
    D. All of the above

8. _____________ is also known as Sedimentation.

    A. Backwash and chemical cleaning
    B. Disinfection and corrosion control

C. Sludge handling system
D. Concentrate discharge

9. In term of handling long haul traffic compared to short haul traffic, any airport operator will need to consider the cost involved **EXCEPT**.

A. Number of aerobridges required for larger aircraft.
B. More apron space and wider runway and taxiway.
C. Custom and immigration.
D. Number of equipment for aircraft crash recovery system.

10. Formal instruction to undertake any valuation of machinery and equipment can be obtained from _____________.

A. Security Guard.
B. Branch Manager.
C. Client
D. Plant Valuer.

11. ________ is important to identify before machinery and equipment to be valued.

A. Size of the asset
B. Weight of the equipment
C. Length of the machine
D. Ownership of the asset

12. Compilation of evidences from various sources is important to derive an excellent ME valuation conclusion.

The above statement refers to _____________

A. Data analysis
B. Statement of account.
C. Yellow pages.
D. Supplier information.

13. Which of the following statement does not belong to the luggage handling group?

    A. Main sorter is the initial sorting of any luggage.
    B. Screening is an x' ray machine that scan each luggage
    C. Early baggage storage is used to stored heavy duty luggage.
    D. Movement, monitoring and security of the luggage is controlled by the central control room.

14. What is the level of screening for screening and sniffing room in Baggage Handling System (BHS)?

    A. 1st level screening
    B. 2nd level screening
    C. 3rd level screening
    D. 4th level screening

15. On arrival luggage can be taken from _____________.

    A. Baggage reclaim area.
    B. Baggage ticketing counter.
    C. Baggage collecting conveyor.
    D. Make-up chute.

16. It is a ground device that uses lights to assist a pilot in landing an airplane at the airport.

    Name the device.

    A. PASI
    B. VISI
    C. PAPI
    D. VIGS

17. The picture below is known as ________________ .

A. AREAS

B. ASEAS

C. ACRES

D. AESAR

18. The following are some of road sweeper available within the airport **EXCEPT** ______.

A. Truck Road Sweeper.

B. Scrubber.

C. Medium Road Sweeper.

D. Suction Road sweeper.

19. The agency that control and regulates airports standards and practices for safely mitigate fire and other emergencies on aircraft known as ________________.

A. World Transport Airline Congress (WTAC).

B. International Civil Aviation Organization (ICAO)

C. International Air Transport Association (IATA)

D. National Air Traffic Service (NATS)

20. The products of oil refineries are as follows **EXCEPT** ______________

A. Gasoline.

B. Methanol.

C. Diesel fuel.

D. Home heating oil.

21. ___________ produce hydrogen for hydrotreaters or hydrocracker

A. Isomerization unit

B. Steam reforming unit

C. Dimerization unit

D. Distillate Hydrotreater unit

22. The major activities in this sector include marketing the finished products and transport to retail facilities

The statement above refers to the ____________sector.

A. upstream

B. midstream

C. downstream

D. none of the above

23. The following are the major activities in Upstream sector __________

I. Drilling exploratory wells.

II. Searches for underground or underwater crude oil & natural gas fields.

III. Geological & geophysical (G&G) surveys are used to explore possible sites.

IV. Leases & permissions from the land owners to drill are acquired.

A. I, II and III

B. II,III and IV

C. I, III and IV

D. All above

Question 24 – 27.

Match the correct answer from Column B against statement given in Column A

	Column A		Column B
24.	Produces high octane component for petrol blending	I	Isomerization Unit
25.	Converts olefins into higher-octane gasoline blending components. For example, butanes can be dimerized into isooctane which may subsequently be hydrogenated to form isooctane	II	Dimerization unit
26.	Processes asphalt into petrol and diesel fuel, leaving coke as a residual product	III	Alkylation unit
27.	Converts linear molecules into higher octane branched molecules for blending into petrol or feeding into alkylation units	IV	Coking unit

28. An ability to communicate with the suppliers and manufacturers relates to _________.

    A. Value of the machine.
    B. Date of purchase.
    C. How to operate the machine.
    D. Engineering product details.

29. Plant valuer need to conduct proper inspection because____________.

    A. To understand the process flow.
    B. To ensure safety.
    C. To get correct information.
    D. To get detail of the account.

30. The fundamental inventory information will include model, physical description, date of acquisition/purchase and many others.

    The statement above refers to the __________________ .

A. Quantity.
B. Description.
C. Unit of measure.
D. Status of assets.

31. Which of the following are factors of gathering information?

I. Warranties and after sales service
II. Documents manual
III. Licensing and Permits
IV. Resident engineer

A. I and II
B. I, II and III
C. III and IV
D. All the above

32. Plant valuer need to differentiate various date when getting information with regards to each individual machine.

Date of valuation can be based on the following date **EXCEPT**.

A. Date of inspection.
B. Date of instruction.
C. Date required under statutory provision.
D. Date of preventive maintenance.

33. Which of the following statement does not consider a safety rule that need to be follow?

A. Follow safety instruction.
B. Wear Personal Protective Equipment.
C. Call ambulance for help.
D. Follow arrow to the exit.

34. Which of the following below is not considered as safety precaution and procedure?.

A. Walkways to exit.
B. Authorised person only
C. No smoking
D. Do not wear safety boot

35. Which of the following items can be considered as Personal Protective Equipment **EXCEPT.**

A. Socks
B. Safety boots
C. Goggles
D. Helmets

36.

If emergency occurs during inspection we should immediately inform and notify our Team Leader or the building supervisor for their help.

The statement above relates to _____________.

A. Action to be taken during emergency.
B. Safety preparation before inspection.
C. Safety rules that need to be followed.
D. Knowing about hazard.

37. *The signage below indicate that the area is prone to ______________.*

I. Sparks

II. Arc flash

III. Radiation

IV. Lightning

A. I & II

B. I, II and III

C. II, III & IV

D. All the above

38. In general the type of respiratory protection are as follow **EXCEPT** ______________.

A. Air Purifying Respirotory (APR)

B. Supplied Air Respiratory (SAR)

C. Oxygen Breathing Tank (OBT)

D. Self Contained Breathing Apparatus (SCBA)

****

THIS IS THE END OF THE EXERCISE QUESTION PAPER

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EXERCISE ANSWER

1. B
2. D
3. Reverse osmosis
4. Direct coastal intake
5. Multi effect distillation
6. Distils
7. C
8. C
9. D
10. C
11. D
12. A
13. C
14. D
15. A
16. C
17. C
18. D
19. B
20. B
21. B
22. C
23. D
24. III
25. II
26. IV
27. I
28. D
29. C
30. B
31. D
32. D
33. C
34. D
35. A
36. A
37. B
38. C