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ADNOC GROUP PROJECTS & ENGINEERING

FACILITY LAYOUT & SEPARATION DISTANCES GUIDELINES

AGES-GL-03-001

GROUP PROJECTS & ENGINEERING FUNCTION/ PT&CS DIRECTORATE

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DISTRIBUTION	Specification applicable to ADNOC & ADNOC Group Companies

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In addition, Group Projects & Engineering Function is responsible for communication and distribution of any changes to this specification and its version control.

This document will be reviewed and updated in case of any changes affecting the activities described in this document.

INTER-RELATIONSHIPS AND STAKEHOLDERS

- 1.1** The following are inter-relationships for implementation of this Specification:
- (a) ADNOC Upstream and ADNOC Downstream Directorates; and
 - (b) ADNOC Onshore, ADNOC Offshore, ADNOC Sour Gas, ADNOC Gas Processing, ADNOC LNG, ADNOC Refining, ADNOC Fertilisers, Borouge, Al Dhafra Petroleum, Al Yasat, ADNOC Distribution, ADNOC Drilling, ADNOC L&S, Industrial Gas
- 1.2** The following are stakeholders for the purpose of this Specification:
- (a) ADNOC PT&CS Directorate
- 1.3** This Specification has been approved by the ADNOC PT&CS is to be implemented by each ADNOC Group company included above subject to and in accordance with their Delegation of Authority and other governance-related processes in order to ensure compliance.
- 1.4** Each ADNOC Group company must establish/nominate a Technical Authority responsible for compliance with this Specification.

DEFINED TERMS / ABBREVIATIONS / REFERENCES

‘ADNOC’ means Abu Dhabi National Oil Company.

‘ADNOC Group’ means ADNOC together with each company in which ADNOC, directly or indirectly, controls fifty percent (50%) or more of the share capital.

‘Approving Authority’ means the decision-making body or employee with the required authority to approve Policies and Procedures or any changes to it.

‘Business Line Directorates’ or **‘BLD’** means a directorate of ADNOC which is responsible for one or more Group Companies reporting to, or operating within the same line of business as, such directorate.

‘Business Support Directorates and Functions’ or **‘Non- BLD’** means all the ADNOC functions and the remaining directorates, which are not ADNOC Business Line Directorates.

‘CEO’ means chief executive officer.

‘Group Company’ means any company within the ADNOC Group other than ADNOC.

‘Standard’ means normative references listed in this specification.

‘COMPANY’ means ‘Abu Dhabi National Oil Company or any of its group companies. It may also include an agent or consultant authorized to act for, and on behalf of the COMPANY’.

‘CONTRACTOR’ means the party which carries out the project management, design, engineering, procurement, construction, commissioning for ADNOC projects.

‘SHALL’ Indicates mandatory requirements **“Group Company”** means any company within the ADNOC Group other than ADNOC.

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1 INTRODUCTION

New developments shall have concept framing studies to determine scope, objectives and options. It is a healthy approach to new facility development to initially use 'divergent' thinking to propose a choice of locations and a wide range of options for designs and developments. These framing studies shall consider potential facility location(s) by using Inherently Safer Design (ISD) principles, even before Layout options are developed. The framing studies should include identifying risks or impacts, and opportunities, with consideration of novel and innovative approaches to solutions, as sometimes novel approaches can give a step change in HSE and other performance. This should be done before 'convergent', solution mode thinking is applied.

This document has been developed by COMPANY as a Standard which shall be followed to layout new COMPANY facilities from concept framing to facility operation, and this must not be done in isolation from other development decisions.

This standard ensures that facility layouts manage Major Accident Hazards through ISD approaches but then allows other types of measures (such as FERA) to be used to verify and optimise the layouts made ISD. invoked if inherent safety by separation cannot be achieved practicably. Most layout requirements to meet Occupational Health and Safety objectives as well as maintenance and operational access are covered by other design standards (e.g. Piping Basis of Design AGES-SP-09-001 Ref 1).

The risk-based principles set out in this Standard apply to both, greenfield and brownfield projects, noting that options for inherent safety by separation might be more limited for brownfield (or Offshore) projects. The Standard requires inherent safety to be sought so far as practicable before resorting to mitigating measures such as other passive, active or procedural measures.

The Standard is rooted in COMPANY Values and good industry practice and shall apply to all COMPANY Business areas.

Standard is not a retrospective but can be used, as far as practicable to identify risk reduction opportunities for existing plant.

2 SCOPE

2.1 Inclusions

The scope of this document covers all COMPANY Business areas (apart from the exclusions stated below).

- Upstream Oil or Gas production; ONSHORE facilities, OFFSHORE installations and Artificial Islands;
- Downstream (Gas Processing, Refinery, LNG);
- Petrochemical (Fertiliser and Polyolefins plants);
- Distribution Terminals including outlets (Bulk Storage, Loading bays etc);
- Industrial Gases.

Brownfield Projects: Defined as new permanent facilities that are to be erected inside the boundary (or control) of an existing operating facility. These include permanent modifications and facility expansions.

The principles of good industry practice in this Standard are equally applicable to such projects the associated new equipment. Constraints of space and the presence of existing hazards are noted, meaning greater

reliance may be required on other passive, active or procedural measures to ensure safety of the overall integrated plant. This is consistent with the principles of this Standard.

2.2 Exclusions

- Drilling facilities;
- Temporary modifications at existing operating facilities.

This Standard does not apply to temporary modifications at existing operating facilities, where the risk shall be controlled through a Management of Change (MOC) process (Ref 8) that has its own risk assessment process.

3 DEFINED TERMS / ABBREVIATIONS / REFERENCES

3.1 General Terminology

General Terminology	
BROWNFIELD	Development within the boundary (or control) of an existing operating facility.
CAN (possibility and capability)	Conveys the ability, fitness or quality necessary to do or achieve a specific thing.
CONSULTANT	The party that performs specific services, which may include but are not limited to, Engineering, Technical support, preparation of Technical reports and other advisory related services specified by the party that engages them, i.e. COMPANY, CONTRACTOR or its Subcontractors.
CONTRACTOR	The party which carries out the project management, design, engineering, procurement, construction, commissioning for COMPANY projects.
GREENFIELD	Development outside the boundary (and control) of an existing operating facility or a new operating / processing facility development in new or existing allotted area of the COMPANY.
LICENSOR	Provider of Licensed Technology
MANUFACTURER/VENDOR/SUPPLIER	The party which manufactures and/or supplies equipment, technical documents/drawings and services to perform the duties specified by the COMPANY/CONTRACTOR.
MAY (permission)	The word indicates a permitted option. It conveys consent or liberty to do something.
SHALL	Indicates a requirement

General Terminology	
SHOULD (recommendation)	Indicates a recommendation.
STANDARD	Means this Layout & Separation Distances Guideline
SUB-VENDOR	Any supplier of equipment and support services for an equipment/package or part thereof supplied by a VENDOR.

3.2 Layout Terminology

Layout Terminology	
Block	Blocks represent distinct major parts of a facility. Examples are process units, utility areas, occupied and unoccupied structures, etc. across the facility [CCPS 2nd ed.]
Complex	Collection of facilities that may or may not be owned by the same company but are located within the contiguous boundaries of a specific geographic location, such as an industrial or chemical park. A facility within a complex may feed or take raw materials from another facility in the complex or may be totally independent of its industrial neighbours. [CCPS 2nd ed.]
Equipment	The individual items, e.g. heat exchangers, pressure vessels, etc. that make up a section (see Section).
Facility	Process and utility plants, tanks, buildings, marine structures, pipe racks and roads located within a site boundary. For example, a refinery, chemical plant, storage terminal, distribution centre, or corporate office.
Layout	The relative location of equipment or buildings within a given site.
Module	Any assembly of equipment items and their associated piping, instrumentation, electrical equipment, structure, and fittings combined into a transportable subsection of a process unit or offsite facility.
Plant	A collection of units which normally operate together to produce specific products. A process plant typically has roads on all sides and all the processing equipment within that are intended to be shut down during a maintenance turnaround. For example, a Cat Cracker could have various units; regeneration, reaction, fractionation, gas plant) but this is counted as one process plant. Areas that transfer or store product are not process plants, however they are part of process area.

Layout Terminology	
Plot	Area of the site where units are grouped (e.g., refinery crude distillation unit, chemical plant, or storage terminal is located).
Process Section	An area / part of a unit within a process unit containing a combination of processing equipment that is focused on a single operation. [CCPS 2nd ed.]
Process Unit	A process unit is a collection of Equipment within a Plant focused on a single operation, arranged to perform a defined function. A process unit enables the execution of a physical, chemical and/or transport process, or storage of process material. e.g. A crude distillation unit, crude treatment unit water treatment unit, polyethylene unit., tank farm etc.
Siting	The Process of locating a Complex, Facility, Plant or Unit

3.3 Technical Terminology

Technical Terminology	
Asset	In the context of the ADNOC Standards an asset is an engineered piece of equipment (i.e. it excludes reservoirs, people, etc.). An asset can be categorised in various ways, e.g. in order of increasing detail business unit, offshore platform or onshore plant, process train/unit, equipment type (e.g. pipelines, structures) or equipment with tag numbers
Asset Integrity	The ability of an asset to perform its required function effectively and efficiently for a time period equal to or greater than its intended life with all its risks As Low As Reasonably Practicable (ALARP) Asset Integrity incorporates Technical Integrity and Operating Integrity
Battery limit	The boundary of a process unit enclosing all equipment and unit limit block valves.
Boilover	A violent expulsion of contents caused by a heat wave from the surface burning at the top of the tank reaching the water layer at the bottom of the tank. [CCPS 2nd ed.]
Building / Enclosure	Any structure used or intended for supporting or sheltering any use or occupancy of people.
Combustible Fluid	A fluid handled below its Flash Point
Conceptual design	The initial design of a project when basic parameters are known but design details have yet to be developed.

Technical Terminology	
	[CCPS 1 st ed.]
Concept Safety Assessment	Coarse assessment of risk at Concept Stage of a project based on the limited information available at the time.
Containment	The enclosure of a hazard to prevent or mitigate impact beyond the enclosure boundary.
Credible scenario	Incident likely to occur within a concerned area – typically, jet fire, pool fire, vapour cloud explosions, gas dispersion, toxic gas dispersion and or/ asphyxiants dispersion scenarios that are considered for design. References 10, 18 to [COMPANY HSE-GA-ST07 HSE Design Philosophy& FERA standard -HSE-RM-ST09]
Emergency Shutdown (ESD)	A system of valves, piping, sensors, actuating devices, and logic solvers that takes the process, or specific equipment in the process, to a safe state, i.e., to shutdown, to isolate, de-energise, and depressurise plant, train, or process unit.
Environment	Surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their interrelationships. Surroundings can extend from within an organisation to the local, regional and global systems.
Environmental Aspect	An element of an organisation's activities or products or services that interacts or can interact with the environment.
Environmental Impact	Change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's activities, products or services.
Escalation	Increase in severity of consequences; due to failure of preventative barriers or mitigation measures
Fire Detection Zone (FDZ, same F&G Zone)	A geographical area defined to identify the location of a fire or hazardous leak from containment so that Emergency Response measures can be initiated and targeted.
Fire Zone	Fire zones are areas of the plant sub-divided based on the potential for fire & explosion hazard to cause escalation, as assessed by the consequence and risk modelling. The partition into fire zones is such that the consequence of fire or an explosion corresponding to the reasonably worst event likely to occur in the concerned fire zone shall not impact other fire zones to an extent where their integrity could be put at risk. The partition of the fire zone is intended to limit the consequence (escalation) of credible events but is not intended to avoid the occurrence of the credible events. (Ref. HSE-GA-ST07, HSE Design Philosophy)
Flammable	Refers to any substance, solid, liquid, gas or vapour, that is easily ignited.

Technical Terminology	
	A petroleum liquid is classified as flammable if it has a flashpoint up to and including 55°C.
Flammable Fluid	A fluid handled above its Flash Point
Hazard	The potential to cause harm, including ill health and injury, damage to property, products or the environment; production losses or increased liabilities (HSE-RM-ST01, HSE Risk Management)
Hazardous Area	An area in which a flammable atmosphere is or may be expected to be present in quantities such as to require special precautions for the control of potential ignition sources.
Ignition Source	Source of temperature and energy sufficient to initiate combustion [API]
Infrastructure	The basic facilities, services, and installations needed for the functioning of a site such as transportation and communications systems, water and power lines, and public institutions including emergency response organisations. [CCPS 2nd ed.]
Inherently Safer	A condition in which the hazards associated with the materials and operations used in the process have been reduced or eliminated, and this reduction or elimination is permanent and inseparable from the process. [CCPS 2nd ed.]
Layer of Protection	A concept whereby a device, system, or human action is provided to reduce the likelihood and/or severity of a specific loss event. [CCPS 2nd ed.]
Loading Bay	Vehicle stopping location where loading takes place
Lower Explosive Limit	Lower concentration of gas (by volume and expressed in percentage) in a gas-air mixture that will form an ignitable mixture [API, NFPA]
Manned	Installation on which people are routinely accommodated (Ref. ISO13702) An offshore platform on which at least one person occupies an accommodation space i.e. living quarters. (API RP 14G [Ref.7] definition) In addition, personnel are present for more than 2 hours a day or more than 10% of time.
Minimum Separation Distances	Separation distances aim to ensure that the risk of escalation from a fire and/or explosion event(s) on an adjacent area are tolerable, for most common processes.
Muster area	A designated place where personnel can muster and survive the initial effects of a major incident while awaiting evacuation.

Technical Terminology	
Non-Hazardous Area	All areas not classified as hazardous under normal operations.
Normally manned	Installation on which people are routinely accommodated (Ref. ISO13702) An offshore platform on which at least one person occupies an accommodation space i.e. living quarters. (API RP 14G [Ref.7] definition) In addition, personnel are present for more than 2 hours a day or more than 10% of time.
Normally not manned	Any facility that is not classed as 'Manned' (see definition above)
Occupied buildings	A building is considered occupied if its primary purpose is to provide workspace or accommodation for personnel; or occupied under normal operational conditions averaging 2 man-hr or more per 24 hr period.
Offshore Installation	A buoyant or non-buoyant construction engaged in offshore operations including drilling, production, storage or support functions, and which is designed and intended for use at a location for an extended period.
Operator Shelter	A small single-level building or shelter used by, and usually only by, plant operators during regular working hours, usually located in the operating unit that they are attending.
Plant Road	Road for within plant boundary for routine access.
Restricted Road	Road inside plant boundary where access is restricted and only allowed through Operations Control Measures, like Permit to Work (e.g. maintenance access roads in process areas).
Risk	A combination of the likelihood of a hazard and its impact
Risk Overlap	A situation where risk is imposed from more than one separate location or scenario
Rollover	The spontaneous and sudden movement of a large mass of liquid from the bottom to the top surface of a refrigerated storage reservoir due to the instability caused by an adverse density gradient. Rollover can cause a sudden increase in pressure and can affect vessel integrity. [API 2510]
Segregation	Physical barriers (walls, divisions, etc.) between modules or equipment
Separation	Spatial distance separation between facilities, modules or equipment.
Temporary buildings	Prefabricated buildings, modular buildings, trailers, or other structures used in support of construction or maintenance activities and not intended to be used for the life of the facility.

Technical Terminology	
Temporary refuge / shelter	A location (typically in an enclosure or building) that will enable occupants to survive defined major accidents for the specified endurance period.
Turnaround	A time during which a unit is shut down for repair and maintenance after a normal run, before it is returned to operation. [CCPS 1st ed.]
Unmanned	Any facility that is not classed as 'Manned' (see definition above)
Utility	An energy or services supplier, including electricity, instrument air, steam or heating medium, fuels (oil, gas, etc.), refrigeration, cooling water or cooling medium, or inert gases. [CCPS 2nd ed.]

3.4 Acronyms & Abbreviations

Acronyms & Abbreviations	
ADIBC	Abu Dhabi International Building Code
AFP	Active Fire Protection
AIChE	American Institution of Chemical Engineers
ALARP	As Low As Reasonably Practicable
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
bbl.	Barrel (US)
BLEVE	Boiling Liquid Expanding Vapour Explosion
CAAP	Civil Aviation Advisory Publication
CCPS	Centre for Chemical Process Safety
CCR	Central Control Room
CDS	Central Degassing Station
CFD	Computerised Fluid Dynamics
CICPA	Civil Infrastructure and Coastal Protection Authority
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
CoG	Centre of Gravity
CPI	Coalescing Plate Interceptor
CSA	Concept Safety Assessment
D	Diameter of largest storage tank (m)
DOP	Dropped Object Protection
EAZ	Emergency Awareness Zone
EBS	Environmental Baseline Survey
EER	Escape, Evacuation & Rescue
EERA	Escape, Evacuation & Rescue Assessment
EI	Energy Institute
EIA	Environmental Impact Assessment
ENVID	Environmental hazard Identification
EPZ	Emergency Planning Zone
ER	Emergency Response

Acronyms & Abbreviations	
ERPG	Emergency Response Planning Guidelines
ESD	Emergency Shutdown
ESDV	Emergency Shutdown Valve
ESIA	Environmental & Social Impact Assessment
ESSA	Emergency Systems Survivability Analysis
F&G	Fire and Gas
FCC	Facility Control Centre
FEED	Front End Engineering Design
FERA	Fire and Explosion Risk Assessment
FPSO	Floating Production Storage and Offloading
FSA	Fire Safety Assessment
GHG	Greenhouse Gases
GOR	Gas-Oil Ratio
H ₂ S	Hydrogen Sulphide
H&MB	Heat and Mass Balance
HAC	Hazardous Area Classification
HAT	Highest Astronomical Tide
HAZID	Hazard Identification
HFE	Human Factors Engineering
HP/HT	High Pressure / High Temperature
HSE	Health, Safety & Environment
HSECES	HSE Critical Equipment & Systems
HVAC	Heating, Ventilation & Air Conditioning
IRPA	Individual Risk per annum [/year]
ISD	Inherently Safer Design
ISO	International Standards Organisation
LEL	Lower Explosive Limit (also known as LFL or Lower Flammable Limit)
LNG	Liquefied Natural Gas
LPG	Liquid Petroleum Gas
LQ	Living Quarters
LSIR	Location Specific Individual Risk
LUP	Land Use Planning

Acronyms & Abbreviations	
MAH	Major Accident Hazard
MCC	Motor Control Centre
MOC	Management of Change
MOL	Main Oil Line
N ₂	Nitrogen
NA	Not Applicable
NFPA	National Fire Prevention Association
NM	No Minimum spacing requirement has been established for reasons of fire protection. Use engineering judgment for spacing and provide access for firefighting and maintenance.
NO _x	Oxides of Nitrogen
NRV	Non-Return Valve
P&ID	Piping & Instrumentation Diagram
PFD	Process Flow Diagram
PFP	Passive Fire Protection
PLR	Pig Launcher / Receiver
PPE	Personnel Protective Equipment
QRA	Quantitative Risk Assessment
RA	Risk Assessment
RAM	Risk Assessment Matrix
RDS	Remote Degassing Station
RMS	Remote Manifold Stations
RP	Recommended Practice
RPT	Rapid Phase Transition
S&S	Separation and Segregation
SD	Sustainable Development
SIMOPs	Simultaneous Operations
SO ₂	Sulphur Dioxide
SO _x	Oxides of Sulphur
SOLAS	Safety of Life at Sea
SPM	Single Point Mooring
SSIV	Subsea Isolation Valve
SSSP	Site Specific Safety Plan

Acronyms & Abbreviations	
TR	Temporary Refuge
UAE	United Arab Emirates
VAP	Value Assurance Process
VCE	Vapour Cloud Explosion
WHCP	Wellhead Control Panel

4 REFERENCE DOCUMENTS

4.1 ADNOC Standards

Ref No	Document No	Title
1.	AGES-SP-09-001	Piping Design Basis
2.	AGES-PH-03-002	Fire & Gas Detection and Fire Protection System Philosophy
3.	AGES-PH-03-001	Emergency Shutdown and Depressurisation System Philosophy
4.	HSE-EN-ST01	Environmental Impact Assessment
5.	HSE-EN-ST02	Environmental Protection, Pollution Prevention & Control
6.	HSE-OS-ST21	Management of H ₂ S
7.	HSE-OS-ST29	HSECES Integrity Management.
8.	HSE-OS-ST30	Management of Technical Changes
9.	HSE-GA-ST01	HSE Governance Framework
10.	HSE-GA-ST07	HSE Design Philosophy
11.	HSE-GA-ST10	Social Risk Management Standard
12.	HSE-RM-ST01	HSE Risk Management System
13.	HSE-RM-ST02	HSE Impact Assessment (HSEIA)
14.	HSE-RM-ST03	HAZID ENVID OHID
15.	HSE-RM-ST06	Control of major accident Hazards (COMAH)
16.	HSE-RM-ST07	Escape, Evacuation and Rescue Assessment (EERA)
17.	HSE-RM-ST08	Emergency System Survivability Assessment (ESSA)
18.	HSE-RM-ST09	Fire & Explosion Risk Assessment (FERA)
19.	HSE-RM-ST10	Quantified Risk Assessment (QRA)
20.	HSE-RM-ST13	Inherently Safer Design Standard
21.	N/A	ADNOC Health, Safety and Environmental Policy

4.2 International Codes & Standards

Ref No	Document No	Title
22.	N/A	AICHE CCPS "Guidelines for Facility Siting and Layout". 2 nd edition
23.	API RP 14C	Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems on Offshore Production Platforms.
24.	API RP 14E	Recommended Practice for Design and Installation of Offshore Production Platform Piping Systems.
25.	API RP 14F	Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations.
26.	API RP 14FZ	Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Zone 0, Zone 1 and Zone 2 Locations.
27.	API RP 14G	Recommended Practice for Fire Prevention and Control on Open-type Offshore Production Platforms.
28.	API RP 14J	Recommended Practice for Design and Hazard Analysis for Offshore Production Facilities.
29.	API RP 49	Recommended Practice for Drilling and Well Servicing Operations Involving Hydrogen Sulphide
30.	API 521	Guide for Pressure-Relieving and Depressuring Systems
31.	API 752	Management of Hazards Associated with Location of Process Plant Permanent Buildings
32.	API 753	Management of Hazards Associated with Location of Process Plant Portable Buildings
33.	API 2510	Design and Construction of Liquefied Petroleum Gas Installations (LPG)
34.	API 2610	Design, Construction, Operation, Maintenance, Inspection of Terminal and Tank Facilities
35.	CAAP 70	Abu Dhabi CAAP 70 heliports
36.	CAAP 71	Abu Dhabi CAAP 71 helidecks
37.	CAAP 72	Abu Dhabi CAAP 72 aircraft landing areas

Ref No	Document No	Title
38.	EI 2	Model Code of Safe Practice Part 2: Guidance on the design, construction and operation of petroleum distribution installations
39.	EI 9	Model Code of Safe Practice Part 9: Large bulk pressure storage and refrigerated LPG
40.	EI 15	Model code of safe practice Part 15: Area classification for installations handling flammable fluids
41.	EI 19	Model Code of Safe Practice – Part 19: Fire Precautions at Petroleum Refineries & Bulk Storage Installations
42.	EN 1473	Installation and equipment for liquefied natural gas — Design of onshore installations
43.	GE GAPS 2.5.2	Oil and Chemical Plant Layout and Spacing
44.	ISO 13702	Petroleum and natural gas industries — Control and mitigation of fires and explosions on offshore production installations — Requirements and guidelines
45.	ISO 16903	Petroleum and natural gas industries — Characteristics of LNG, influencing the design, and material selection
46.	ISO 17776	Petroleum and natural gas industries – offshore production installations – guidelines on tools and techniques for hazard identification and risk assessment.
47.	NFPA 30	Flammable and Combustible Liquids Code
48.	NFPA 55	Compressed Gases and Cryogenic Fluids Code
49.	NFPA 59A	Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)
50.	NFPA 90A	Installation of Air-Conditioning and Ventilating Systems
51.	NFPA 101	Life Safety Code
52.	SOLAS	Safety of Life at Sea
53.	N/A	UAE Fire safety code
54.	N/A	Safety and environmental standards for fuel storage sites, Buncefield Standards Task Group (BSTG), Final Report, July 2007

Ref No	Document No	Title
55.	NA	Oil Companies International Marine Form (OCIMF) – Marine loading arms design and construction specification.

5 DOCUMENTS PRECEDENCE

The specifications and codes referred to in this specification shall, unless stated otherwise, be the latest approved issue at the time of Purchase Order placement.

It shall be the CONTRACTOR 'S responsibility to be, or to become, knowledgeable of the requirements of the referenced Codes and Standards.

The CONTRACTOR shall notify the COMPANY of any apparent conflict between this specification, the related data sheets, the Codes and Standards and any other specifications noted herein.

Resolution and/or interpretation precedence shall be obtained from the COMPANY in writing before proceeding with the design/manufacture.

In case of conflict, the order of document precedence shall be

- UAE Statutory requirements
- ADNOC HSE Standard / Codes of Practice
- Project Specifications and other project documents
- Company Specifications and Standards
- National/International Standards & Codes

6 DEVIATION /CONCESSION CONTROL

Any technical deviations to this Philosophy and its attachments including, but not limited to, the COMPANY's General Specifications shall be sought by the CONTRACTOR only through technical deviation request format. Technical deviation requests require COMPANY'S review/approval, prior to the proposed technical changes being implemented. Technical changes implemented prior to COMPANY approval are subject to rejection.

7 HIGH-LEVEL TECHNICAL APPROACH

New developments shall have concept framing studies to determine scope, objectives and options. The main drivers for the development of a facility are costs, production and safety. The framing studies shall include consideration of potential facility location(s) by using Inherently Safer Design principles, even before Layout options are developed. This Standard gives direction for the decisions required for the layout of new COMPANY facilities from concept framing to facility operation.

7.1 Context & Background

The aim of this Section is to set the context for interpreting this Facility layout and Separation distances guidelines so that the Company high-level risk management objectives are achieved. The context is to be set by addressing three main aspects, which are summarised in Table 7-1 under the following headings:

- Business principles & Company Values;
- Breakdown of Risk Types;
- Management of Major Accident Hazard and associated Risk.

Table 7-1: Summary of High-level Objectives for Layout & Separation Standard

1	Business Principles & Company Values					
	Risk Management Goals (priority order)		Ref.		Compliance	
	1	People (safety)	ADNOC HSE Policy	ADNOC Risk Matrix	Regulations (local)	Mandatory Reducing Priority 
	2	Environment			Company Standards	
	3	Asset / Production			International Codes & Stds.	
	4	Reputation			Other Industry Guidance	
2	Breakdown of Risk Types		Role of this Document			
	-	Occupational (Operational) HSE	X		Other / Piping Standards	
	-	Major Accident Risk	P			
3	Management of Major Accident Risk (high-level) - Approach					
	-	Immediate / Local Risk	X		Role of this document is to help manage	
	-	Escalation Risk	P		- Escalation risk; and	
	-	Egress & Evacuation Risk	P		- Egress & Evacuation Risk	
	-	Rescue Risk	X			

7.1.1 Item 1: Business Principles & Company Values

Item 1 in Table 7-1 emphasises the COMPANY's commitment to protecting people, the environment, its assets and reputation, which are described in the ADNOC Health, Safety and Environment Policy [Ref 21]. The right side of Item 1 highlights the COMPANY commitment to performing all its business in compliance with all legal requirements of Abu Dhabi and the United Arab Emirates. These two core Values are the main driving force behind all Company Standards and business approaches.

It is noted in Item 1 that protection of people is the highest priority in terms of risk management goals and conformance with the law is the highest priority in terms of Compliance. Other objectives are stated below these in descending priority order, which include protection of the environment and business assets and reputation on one side, and application of Company Standards, International Codes and Other Industry Guidance, on the other.

7.1.2 Items 2 & 3, 'Breakdown of Risk Types' & 'Management of Major Accident Risk'

Item 2 in Table 7-1 makes a distinction between Occupational Risk (low consequence / high frequency) and Major Accident Risk (high consequence / low frequency accidents). This is done to ensure the focus of this Layout and Separation Standard is understood to target mainly the management of Major Accident Hazard and associated Risk.

Occupational risk, as well as operational requirements for maintenance and access are covered more comprehensively by the REF 1, Piping Design Basis AGES-SP-09-001.

Item 3: Major Accident Risk has been broken down further as follows, to target risk reduction measures:

- Immediate/ Local Risk;
- Escalation Risk;
- Egress & Evacuation Risk; and
- Rescue

It is noted that the role of this Standard is primarily to address 'Escalation Risk' and 'Egress and Evacuation' risk, through considered application of Layout principles and Separation Distances, which is an important way of achieving inherent safety.

7.2 Inherently Safer Design (ISD) Principles

COMPANY requires the principles of Inherently Safer Design (ISD) to be adopted in all new projects. These principles represent the 'good industry practice' as described in ref 20, HSE-RM-ST13. The principles and the effectiveness of applying inherently safe measures as a project progresses are summarised schematically in Table 7-2.

Table 7-2: Schematic of ISD Principles (& Effectiveness Within Project Lifecycle)

Role Of Layout in Risk Management						
Inherently Safer Design (ISD) 		Relevance in Project				
		Concept (& Select)	FEED	Detail Design	Construct	Operate
Reducing Preference	Inherent Safety (<u>through Layout</u>) 					Covered by other Standards (e.g. Piping)
	Passive		Effectiveness of Inherent Safety Measures (Layout Guidance) reduces as project progresses			
	Active					
	Procedures					
Note: 1. ADNOC Design Philosophy requires priority to Inherent Safety, ahead of Passive, Active and Procedural measures. 2. Layout and Spacing is key to providing 'Inherent Safety' (most effective type of measure). 3. Best to use early in design where benefits of Inherently Safer Design (ISD) are greatest. 4. Flexibility to use ISD through layout reduces as project progresses. 5. Operations stage issues (access, maintainability, etc.) largely covered by other standards (e.g. Piping).						

It is apparent from Table 7-2 (left side, labels 1&2) that Inherent Safety is preferred ahead of passive, active and procedural measures, in that order of priority. Layout and spacing are key to providing inherent safety, which can most effectively be used early in project lifecycle. Safety during operations (item 5) is covered by other Standards (e.g. Piping). During Plant modifications the inherent safer principles shall be preserved / enhanced.

Examples of measures falling within each category of the ISD hierarchy and their role in preventing, detecting or mitigating Major Accident Risk are shown in Table 7-3. Once again it is noted that layout and separation are in the highest priority category and are key to escalation prevention.

Table 7-3: Examples of Measures Within ISD Hierarchy

Priority Order	Safety Measures	Initiating Event			Escalation		
		Prevent	Detect	Mitigate	Prevent	Detect	Mitigate
Highest	Inherent Safety						
	- Layout & Separation				P		
	- Elimination	P					
	- Minimisation				P		
	- Substitution	P					
	Passive						
	- Passive Fire Protection (PFP)				P		
	- Blast Walls				P		
	- Dropped Objects Protection	P					
	- Thermal Radiation Shields (for EER facilities)						P
	- Drains						P
	Active						

Priority Order	Safety Measures	Initiating Event			Escalation		
		Prevent	Detect	Mitigate	Prevent	Detect	Mitigate
	- Emergency Shutdown (ESD)				P		
	- Fire & Gas Detection (F&G)		P				
	- Active Fire Protection (AFP)				P		
	- Spill Detection					P	
	- Emergency Depressurisation / Blowdown				P		
Lowest	Procedures						
	- Manual Firefighting				P		
	- Manual Shutdown (Pushbuttons)				P		
	- Personal Protective Equipment (PPE)			P			

7.3 Approach to Layout & Separation - Overview

A general framework has been developed to reflect good industry practice, based on AIChE CCPS 'Guidelines for Facility Siting and Layout' (Ref.22). This is shown in schematic form in Figure 7.3-1, which is intended to show a systematic decision-making process that uses 'building blocks' of increasing levels of detail to accommodate progressive project requirements as it moves from Concept, FEED and through to Detail Design.

The framework recognises the varying levels of information that might be available at each stage of the project, allowing coarse estimates to be used from past precedent to inform early decisions, but has sufficient flexibility to adjust the initial estimates in the light of compelling local consideration using risk assessment and the support of alternative risk reduction measures (passive, active, procedural). Key elements of the framework are illustrated in Figure 7.3-1 and elaborated in the text below.

The planning of each project stage will be expected to require focus on the key elements identified in Table 7-4:

Table 7-4: Planning Framework – Key Elements

1.	Team (competencies).
2.	Information (site /project).
3.	Hazard (& Appropriate Risk Assessment).
4.	Project Implementation.

These elements (and colour scheme) are used as a framework to discuss the layout development requirements for Steps 1, 2 and 3 in Sections 9, 10 and 11, respectively.

7.3.1 Building Block Approach

Figure 7.3-1 describes the building block approach into three main steps (label A).

Step 1 (Facility Location /Orientation): This step is intended to select the location, size and orientation of the new plot. It requires global issues to be considered like terrain, wind direction, environmental sensitivities and security. Social risks if any to be considered at this stage. This task is typically required at concept stage and needs to be done in conjunction with Step 2 (process unit location) at a high level.

Step 2: This step is the next level of detail where the main units (process /utility /other) are placed within the designated plot space. This step also requires the main 'Egress and Evacuation' routes to be marked within the plot, as well as their connection to the wider emergency response arrangements (label B). This step provides an important opportunity to segregate areas with a high potential to source a Major Accident Hazard from areas that are sensitive to such accidents (e.g. populated office, CCR, warehouse, workshop etc.). Typically, utility areas with a lower potential to source a Major Accident Hazard can be placed between the process and the manned areas (label C).

The exact nature of this step depends on the stage of development and specific details of the situation being considered. This step is also applicable in FEED where further refinements to the layout may be needed.

In performing step 2, ISD principles require a cautious approach to be taken. This is done by using estimated building block sizes and separation distances (label D) as a starting point (especially in Concept). These are typically taken from past experience and are provided in this Standard in Appendix A for Block and Equipment separations.

These initial dimensions may be reduced / optimised (or even increased) in subsequent stages through specific assessment (consequence modelling /risk analysis, label E) and the use of alternative risk reduction measures (label F), as described in Section 7.2 above. Layout development is therefore seen as an iterative process that requires progressive refinement that may remove any conservatism within the initial distances used.

This general methodology provides a pragmatic and cautious approach to weigh up safety issues against other project constraints in order to achieve a practicable layout that that is consistent with limiting the risk to 'as low as reasonably practicable' (ALARP).

Step 3: The next level in layout development is to place the individual items of equipment within the plot spaces that have been allocated for the units. This is typically required during FEED stage design. Care is needed to ensure that the equipment is arranged to preserve inherent safety and any 3-dimensional volumes for key safety features affecting Major Accident risk (label G), such as:

- Egress /Escape Routes;
- Fire Fighting Equipment Space (Firewater system, Deluge Valves, etc.);
- Avoidance of Lifting Over Live Plant (Impact / Dropped Objects potential).

Issues of detail for Occupational Safety, and operational /maintenance access are not the focus of this Standard and are addressed in other COMPANY Standards. (Ref Piping Basis of design)

Although there is more limited opportunity to incorporate inherent safety at Detail Design (label G), the ISD principles still apply. The key message for later project stages is that no part of detail engineering should compromise the principles highlighted in the preceding steps (e.g. piping supports or hazardous areas should not compromise Escape Route volumes, etc.).

7.3.2 Hazard Identification (& 'Appropriate' Risk Assessment)

A prerequisite for layout development at any stage of the project is to have an understanding of hazards that is 'appropriate' for the stage of the project (label A). This could involve a simple checklist-based approach in early design (Concept) when little design information is available, to a more complex consequence modelling and risk assessment at FEED and Detail Design stages. The level assessment expected at the various stages of the project is clarified in Section 8.

7.3.3 ISD Principles in Layout Development

Development of a plot layout will be based on several project defined parameters that include process configuration, operations, manning and storage requirements. It is expected that the development of such parameters will have been subject to ISD considerations and are therefore excluded from the discussion about layout development.

The guidance below applies once the project basis has been defined and is limited to factors that affect ISD as outlined in HSE-RM-ST13 through layout development. The approach is summarised in Table 7-5, which is based on good industry practice (Ref. 53, Section 5), and applies to the following two steps of Figure 7.3-1 above:

- Step 2: Process Unit Layout
- Step 3: Equipment Layout

Key Principle: The key principle underpinning the layout development is to position all items on the equipment list in a way that ensures the safety of people, environment and asset /business.

This involves protecting critical items that are 'Vulnerable' from the 'Sources of Major Accidents'. This should be done using ISD principles and hierarchy described in Section 7.2 above. The high-level objective and approach to layout development is summarised in **Text Box 7-1** and **Table 7-5**.

Text Box 7-1: Key Objective & Approach to Layout Development

- To protect Critical items that are 'Vulnerable' from the 'Sources of Major Accident Hazards'.
- This should be done using ISD principles and hierarchy described in Section 7.2.

Table 7-5: Approach & Principles of Layout Development ('Process Unit' & 'Equipment' Level)

Factors Affecting Layout - Step 2 (Process Unit Layout) - Step 3 (Equipment Layout)			Major Accident						
			Cause	Hazardous Effects				Categorise	
				Fire	Explosion		Toxic		
					VCE	Dust			
i) Hazards (potential for Major Accident)							MAH Sources		Categorise by potential ‘Consequence’ severity (COMPANY Risk Matrix)
	Material (hydrocarbons, chemicals)		P	P					
	Containment conditions (press., temp)		P	P					
	Inventory /release size		P	P					
ii) Hazardous Activities (causes of Major Accident)								Categorise by ‘Likelihood’ (COMPANY Risk Matrix)	
	Transport:								
		Road	P						
		Rail	P						
		Sea	P						
		Air	P						
	Operations:								
		Pigging	P						
		Lifting (dropped	P						
		Loading /unloading	P						
iii) Vulnerabilities							MAH Targets	Manning Based M1: Permanently Manned areas M2: Occasionally manned buildings Ignition Based: I1: Permanent ignition source (flare, fired heaters, etc.) I2: Other ignition sources (LER / non-certified eqpt.).	
	Buildings:								
		Location		P					
		Orientation			P	P			
		Fire resistance		P					
		Blast resistance			P	P			
		HVAC (air handling)			P	P			P
	Occupancy:								
		Location		P					
		No of people		P					
iv) Layout Factors affecting Consequences (or Causes)							N/A	iv) Layout Factors affecting consequences	
	Orientation: Prevailing weather conditions:								
		Air		P					

Factors Affecting Layout - Step 2 (Process Unit Layout) - Step 3 (Equipment Layout)			Major Accident						
			Cause	Hazardous Effects			Categorise		
				Fire	Explosion				Toxic
					VCE	Dust			
		Sea	P						
Separation:									
		Release location		P					
		Topography (/Pooling)		P			P		
		Geometry (congestion etc.)		P	P	P			
Escalation Avoidance - Principles for Layout Development:									
1. Separation: Maximise distance of Vulnerabilities (iii) from Hazards (i) & Hazardous Activities (ii) - onsite & off-site.									
2. Layout Factors: Use prevailing conditions to protect Vulnerabilities (prevailing winds, currents)									

7.3.3.1 Key Factors

The first major column in Table 7-5 shows the key factors to consider when starting to prepare a plant layout. These comprise the identification of:

- Major Accident Hazards
- Activities with Major Accident Hazard potential (causes)
- Vulnerabilities (targets)
- Layout Factors affecting consequences

The second major column identifies whether these factors cause (or source) a Major Accident and columns 3-6 identifying the type of hazardous effects (fire, VCE, Dust, toxic) that can be realised.

Item (i) in the first column generally comprises the identification of inventories that can source a Major Accident Hazard (MAH), and Item (ii) shows the need to identify significant activities that can cause such an accident. Item (iii) takes note of the key vulnerabilities and item (iv) identifies layout factors that can affect the consequences of a MA.

It should be noted that the first three items are mainly features that are required to make the project functional and largely fixed. From a layout perspective, they can be considered a basis for plot development.

Item iv, has factors that can be used by layout development to incorporate ISD principles through parameters like:

- Orientation
- Separation
- Geometry

7.3.3.2 Key Principles:

Key principles for implementing ISD into layout development and addressing the four key factors identified in 7.3.3.1 are stated below:

1. Separation:
Maximise distance from Hazards (i) & Hazardous Activities (ii) to Vulnerabilities (iii);
2. Layout Factors:
Use other 'Layout Factors' to protect Vulnerabilities from Hazards & Hazardous Activities.

Item 1 requires hazard ranges to be understood so that Vulnerabilities can be positioned at a sufficient distance to provide inherent safety against a Maximum Credible Event (MCE). In the early stages of a Project (Concept /Select) there may be insufficient project specific information to assess the required separation. Typical figures are therefore provided as a starting point in tabular form in Appendix A. It is expected that these initial distances will need to be revisited in later stages (FEED & Detail Design) when project specific details (process conditions, personnel numbers, etc.) can be considered.

Item 2 aims to use factors like 'orientation' against prevailing weather conditions, 'separation' distances and 'geometry' (e.g. congestion) to manage the risk.

These principles need to consider both on-site and off-site factors.

It is expected that layout development will be an iterative process as the project progresses to optimise the plot plan so that the overall risk is controlled to ALARP. This process will include more targeted Hazard and Risk Assessment work to provide more refined information for Engineering Design.

7.3.4 Grouping principles

The layout of Process (and other) Units requires them to be grouped in a logical way so that escalation of an initial Major Accident scenario can be avoided, and emergency response can be effective. A second driver for grouping is ease of operations and maintenance, where similar equipment from different process systems would benefit from being placed in close proximity. This can be described as two criteria:

- Primary: Logical process flow – system by system (escalation avoidance by isolation & depressurisation)
- Secondary: Similar equipment (ease of maintenance)

In both instances it is necessary to group systems according to their hazard potential (fuel source) and vulnerability (manned areas and ignition sources) as indicated in Section 7.3.3. Guidance is taken from API 14J (Table 4) to group equipment presenting homogeneous risk; typical equipment system Groupings are shown in **Table 7-6**.

Table 7-6: Typical Grouping of Process Systems (based on API 14J, Table 4)

Area Type	Process /Other Unit	Onshore	Offshore
Well-head	Wellheads	P	P
	Well Services Laydown	P	P
Process - Storage	Hydrocarbon Storage	P	□ □
Process	Separators (& Piping)	P	P
	Other Vessels & Piping	P	P
	Compression	P	P
	ESDVs	P	P

Area Type	Process /Other Unit	Onshore	Offshore
	Pig Traps (& laydown)	P	P
	Pipeline (Risers), ESDVs & Pig Traps	P	P
Process Fired (Utilities)	Flare / Vent	P	P
	Fired Heaters	P	P
Utilities (& Machinery)	Laydown & Storage	P	P
	Power Generation	P	P
	Cooling Water (/Seawater) Pumps	P	P
	Other Utilities	P	P
	Crane(s)	P	P
Safety Sys.	Fire Pumps	P	P
	Fire / Blast Wall	P	P
Emergency Response	Shelter /Muster /TR	P	P
	TEMPSC	NA	P
	Bridge	NA	P
	Boat	NA	P
	Liferaft	NA	P
Manned Areas (including Access routes)	CCR	P	P
	Workshops & Offices	P	P
	Accommodation	P	P
	Helideck	NA	P
	Boat Landing	NA	P
	Bridge (WTW)	NA	P

On facilities processing highly sour fluid, grouping equipment according to toxic gas hazard risk should also be considered and may well be recommended by coarse QRA.

For onshore facilities, these groupings allow the site to be divided into distinct Plot areas (normally rectangular), which provides the following key benefits:

- System by system layout (in specific geographical blocks) to avoid escalation.
 - Containment of Major Accident source (System isolation and depressurisation)
 - Segregation by space to other Systems
 - Linking F&G Detection to Geographic Area & Process Systems
 - Access for Fire fighting
 - Logical Egress & Evacuation from System areas to Main Egress Routes
 - Target fire protection measures for fuel type.
- Segregation of high leak potential equipment (e.g. compression systems)
- Less congestion (promote ventilation & reduce explosion overpressures)
- Large hazardous inventories (Storage tanks) in remote areas.
- Boundary isolation at battery limit for system
- Fire zone definition facilitated to limit credible impact to different unit/plant (for Emergency Response)

Equipment within each block should then be laid out for ease of maintenance to meet the secondary criteria.

7.4 Application & Compliance with Standard

CONTRACTOR shall follow the process described in this Standard for each stage of the project lifecycle.

It is acknowledged that the inherently safer distances quoted in Appendix A may be difficult to achieve in many instances due to space constraint. Any deviation from distances in Appendix A shall be supported by a documented justification covering the 4 key questions presented in Table 7-7, to ensure the risk remains as low as reasonably practicable. Such justification shall be provided at Step 1 (Facility Location) and Step 2 (Process Unit layout).

The justification shall be reasoned arguments supported, if necessary, by quantitative analysis.

The justification shall be subject COMPANY review, and approval by COMPANY Technical Authority.

Table 7-7: Key Questions – Justification to Deviate from ISD Distances

Question		Guidance	Justification
Q1	Why can the separation not be achieved?	Address each significant: - Source of Major Accident; - Sensitive target for Major Accident Clarify key project constraints. (Repeat for each source and sensitive target)	
Q2	What is the potential impact of reducing the distance?	Penalty due to escalation or emergency response affecting safety, environmental impact or asset /production loss.	
Q3	What alternative measures are proposed?	What alternative measures were considered and adopted /rejected? - Inherent safety - Passive - Active - Procedures	
Q4	Why is any residual risk tolerable?	Describe: - Scenarios of concern - Alternative layers of protection provided (prevention detection, mitigation)	
Note: Justification shall be reasoned arguments supported, if necessary, by quantitative analysis. Such justification shall be provided at Step 1 (Location selection) and Step 2 (Process Unit layout).			

7.5 Document Structure

The initial chapters in this Standard are arranged in a sequence that is consistent with the model described in Figure 7.3-1. Their general principles are applicable to, both ONSHORE and OFFSHORE facilities. Key to the technical understanding of this Standard are:

- Section 7 - High-Level Technical Approach
- Section 8 - Hazard Identification (& Risk Assessment)
- Section 9 - Step-1: Select facility location
- Section 10 - Step-2: Layout 'Process Unit' (within facility)
- Section 11 - Step-3: Layout 'Equipment'

An area of COMPANY operations that requires specific mention is addressed in:

- Section 12 - Offshore Installations

The following Section is included to clarify how the implementation of each Project needs to be considered as part of the layout development:

- Section 13 - Construction & Brownfield Issues (Management of Change)

8 HAZARD IDENTIFICATION (& RISK ASSESSMENT)

8.1 Context

The aim of this section is to give guidance about the level of hazard and risk assessment required for each stage of the layout development process, based on good industry practice (Ref.22) and HSE-RM-ST03. This is marked on a simplified version of Figure 7.3-1 and is presented Figure 8.1-1, below. Star labels (1, 2, 3), show the coverage at Concept, FEED and Detail Design, respectively. These labels also show the four key elements of the project planning framework presented in Table 7-4 (Team, Info, etc.).

Figure 8.1-1: Simplified Schematic of Layout Development – Hazard Identification (& Assessment)

Overall Schematic - 'Building Block' Approach to Layout & Separation			Inherently Safer Design (ISD)		Project Application												
					Concept (& Select)	FEED	Detail Design										
			Reducing Preference	Inherent Safety (Role of Layout & Separation)													
				Passive Active Procedures	Layout' measures are most effective for ISD early in Project lifecycle.												
			Step 1: Facility Location (/Orientation)		P		Ensure principles of protection in previous stages are not compromised by detail (e.g. escape routes, lifting over live plant, etc.)										
			Emergency Response		Team	P											
					Info - Site/ Proj.	P											
					Haz. Id. /Ass'mt	P											
					Proj. Implement	P											
Location Option - N																	
Step 2: Process Unit (& Utility and Other Areas)			P		P												
Main Emergency Egress / Access <table><tr><td rowspan="3">Process Units</td><td rowspan="3">Utility Areas</td><td rowspan="3">Manned Areas</td></tr><tr><td>Step 3: Equipment</td></tr><tr><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table> Main Emergency Egress /Access			Process Units	Utility Areas	Manned Areas	Step 3: Equipment								Initial conservative estimate of Building Block area and spacing between them (See Appendix A)		Team	P
						Process Units	Utility Areas	Manned Areas									
									Step 3: Equipment								
Info - Site/ Proj.	P																
Haz. Id. /Ass'mt	P																
Proj. Implement	P																
P		P															
					Team	P											
					Info - Site/ Proj.	P											
					Haz. Id. /Ass'mt	P											
					Proj. Implement	P											

The requirements for Hazard Identification and Risk Assessment are summarised in Table 8-1 for each Building Block level and the nature of information needed for each project stage.

8.2 Overview

A typical checklist is presented in columns 1, 2 & 3 in Table 8-1 for Concept stage where there is little information available. The type of documents and studies normally used for similar steps of the risk assessment process in later stages are identified under the next two columns.

Operations Phase

1. Facility (/System) Description
2. Hazard Identification
3. Credible Initiating Events

4. Major Hazard Effects
5. Potential Consequences
6. Risk Assessment

Construction & Management of Change (SIMOPS /Brownfield Issues)

- Temporary Facilities
- Emergency Response
- Interfaces /Interferences

Subsequent parts of this Section expand on the main headings in this Table, namely

Table 8-1: Hazard Identification & Risk Assessment – Typical Checklist & Studies

Hazard Identification (& Risk Assessment)		Project Stage	Applicability (Building Block Level)		
			Plant Location	Process Unit Layout	Equipment Layout
		Concept	P		
		FEED		P	P
		Detail Design			P
Facility in Operation					
1	Facility (/System) Description				
	Purpose & Scope of Project	P	- P&IDs - PFDs - H&M Balance - Layouts & Routings (onsite & offsite) - Manning Levels		
	Expected lifetime (yrs.)				
	List of Activities & Operations (automatic & manual)				
	Key Design Concepts for Layout (e.g. indoor /outdoor)				
	Materials Present (feed, intermediates, products).				
	Handling Conditions (temp, press, flow, etc.).				
	Operating Modes (including quantity variations).				
	Turnaround Management				
	Inventory Estimates				
	Utilities (special)				
	Climatic Concerns				
	Environmental (/Regulatory) Concerns				
	Materials Transport (on / off site)				
	Waste Disposal Requirements				
	Process Safety Incidents - Historical				
2	Hazard Identification		Hazard identification (HAZID, ENVID) FERA, QRA, ESSA, H ₂ S Zoning (to revise layout if necessary)	Detail Design Development	
	Hazardous Materials (Toxic, flammable, etc.)	P		FERA (update to test sensitivities)	
	Temp / Pressure / Storage Extremes				
	Start-up / Shutdown Hazards				
3	Credible Initiating Events / leak scenarios		P	Follow-up studies to support use of other	
	- Hose leak				
	- Hose failure				

Hazard Identification (& Risk Assessment)		Project Stage	Applicability (Building Block Level)			
			Plant Location	Process Unit Layout	Equipment Layout	
		Concept	P			
		FEED		P	P	
		Detail Design			P	
	- Pump seal leaks - Sample points - Process upsets (vent discharges) - Process upsets (relief discharges) - etc.				measures, e.g.: Passive: - PFP Assessment - Blast Loading Active: - Blowdown Study - F&G Detection - Fire Protection Procedures - Emergency Response - Fire Fighting	
4	Major Hazard Effects		Use Tables in Appendices for Hazard Ranges / Exclusion Zones			
Fires						
- Jet fires						
- Pool fires						
- Flare						
- Fireball (BLEVE)						
- Full Surface (storage tanks)						
Explosion						
- Flash fire / VCE						
- Dust Explosion						
- Vessel Rupture / BLEVE						
- Chemical Explosion						
Toxic						
- Release Scenarios (pressurised gas / liquid evaporation)						
Domino Effects						
- Knock-on Impact of Initial Incident						
Potential Consequences						
5	- People (onsite) - People (offsite / 3rd party) - Environment - Business Risk Assessment	P	- Manning (onsite) - People (offsite) - Environmental sensitivities - Business sensitivities	Review any assumption changes		
6	QRA (e.g. Coarse Risk Assessment)		P	QRA using above information to verify Plant Location & Process Layout	Update QRA with Detail Design info to verify layout	
	QRA (e.g. Coarse Risk Assessment)					
	HSEIA	P	HSEIA-1	HSEIA-2 & 3		

Hazard Identification (& Risk Assessment)	Project Stage	Applicability (Building Block Level)		
		Plant Location	Process Unit Layout	Equipment Layout
	Concept	P		
	FEED		P	P
	Detail Design			P
Construction & Management of Change (SIMOPS / Brownfield Issues)				
	- Construction Camp			
	- Accommodation / Offices	P	P	P
	- Power & Utilities		Develop Details	Develop Details
	- Material /Vehicle movements			
	- Material Storage			
	- Fencing			
	- Hot Work			
	- Vents & Flares			
	Emergency Response			
	- Egress & Evacuation			
	- Shelter in Place	P	P	P
	Interfaces (/ Interferences)		Develop Details	Develop Details
	- F&G Detection and Public Address Systems			
	- Existing facilities — underground (drains, pipes, etc.)	P	Develop Details	Develop Details
	- Existing facilities — above ground			
	- Hazardous Area Impact (e.g. Flare exclusion)			
	- Transport (Vehicles, Helicopter, Ships, etc.)			
	- Transport (Vehicles, Helicopter, Ships, etc.)			

Temporary

8.3 Facility (/System) Description

At each stage of a project it is important to understand the issues at a level of detail that is commensurate with the objectives of that stage. This is reflected in Table 8-1 where the Concept stage understanding is at a relatively high level about the facilities to be provided and the nature of the surrounding environment.

The level of detail required for FEED and Detail design is greater and is typically contained and progressed in project Conceptual Layouts and Routings (onsite & offsite), Process schematics, H&MB, then PFDs, and finally P&IDs.

Materials: In all cases it is expected that the information assembled should cover feedstocks, intermediates and product streams as well as all the other materials used in the production. Material Safety Datasheets shall be collected since they contain key information about the safe handling of the constituent chemicals. Care shall be taken to ensure trace compounds such as mercury, hydrogen sulphide, mercaptans and radioactive elements are also noted.

Process: It is also important to understand the process design and operating conditions (pressures, temperatures, composition etc.), so that the separation requirements for unit operations can be established.

Location, Environment and Infrastructure: Constraints about these aspects are also important at each level of layout development. These are particularly important for offshore oil & gas facilities where access and egress requirements are particularly important in shaping the facility location, orientation and arrangement.

8.4 Hazard Identification

Hazard identification will be carried out in a formal HAZID Study in a systematic manner. The COMPANY Risk Matrix shall be used to identify events that can potentially lead to escalation and high consequences, including those with a low likelihood. Such escalation events, and those that affect Emergency Response shall be the focus of layout development, since this provides is an important way of achieving inherent safety.

8.5 Credible release scenarios

Table 8-1 shows a checklist-based approach is usually enough at Concept stage for facility location, with decisions taken through qualitative reasoning, historical experience and professional judgement.

Assessment of damage at subsequent stages for 'Process Unit' and 'Equipment' layout need to be based on maximum credible scenarios in the light of more detailed process information. These scenarios shall be defined using the consequence based prescriptive approach in the COMPANY FERA Standard. COMPANY FERA and H₂S and QRA Standards (refs 18 ,6 , 19) provide details on Fire, Explosion and Dispersion Hazard Analysis and Separation Distance, including the design scenarios to be used as a basis for design.

8.6 Major Hazard Effects

Damage from Major Accident Events is mainly caused by thermal radiation from fires, overpressures from explosions and toxic exposure from materials that are harmful to people, Environment and Asset.

8.6.1 Fires

The checklist in Table **8-1** is likely sufficient to draw out most major fire scenarios for site location decisions at Concept stage.

A more detailed fire hazard assessment shall be prepared for FEED (Process Unit) level analysis, which will likely require updating during Detail Design.

The aim of the Fire Hazard Assessment (FHA) shall be to identify all fire hazards (including combustible or flammable materials, oxidisers and ignition sources) as well as the identification of people and assets at risk from fire. It should also identify passive and the specific firefighting media (water, foam etc.) required for fixed firefighting systems if required. The FHA should also identify materials that are highly flammable, have low ignition energy or high heat of combustion or are particularly reactive (e.g. LPG, Ethylene, Ethylene Oxide, Propylene Oxide, Polyethylene).

The FHA is an important input to the Fire & Explosion Risk Assessment (FERA), which assesses the hazard ranges associated with process loss of containment in relation to flash fires, jet fires, pool fires or fireball. These hazard ranges, from Maximum Credible Scenarios are important for the layout of Process Units and Equipment items.

Refer to FERA standard HSE-RM-ST09 for further details.

8.6.2 Explosions

The approach to separation requirements against Explosion events is similar to fires, in that the early judgements will likely be based on qualitative reasoning and historical experience. Later in the project, the scope of the FERA will need to cover the potential for vapour cloud explosion (or Boiling Liquid Expanding Vapour Explosion – BLEVE).

The assessment should also consider combustible solids, and the potential for dust explosions.

Refer to FERA standard HSE-RM-ST09 (Ref 18) for further details.

8.6.3 Toxic Release

Early decisions on facility location are especially sensitive to the presence of toxic substances, and their potential dispersion towards populated areas. The initial assessment should be as comprehensive as possible and include the potential for asphyxiation, narcotic effects or enhanced combustion effects of gases such as oxygen, nitrogen, flue gas or carbon dioxide. The assessment should also consider fire scenarios with toxic products of combustion (such as SO₂), as well as smoke.

The risk to personnel is mainly driven by separation distance and the prevailing wind direction. This is because the potential hazard range can be several kilometres, meaning that separation distance alone is not practicable way of managing this risk.

This places greater emphasis on other factors such as orientation with respect to prevailing wind directions as well as other passive and active mitigation measures.

Later decisions in FEED will require consequence modelling to estimate the maximum toxic hazard ranges based on Maximum Credible Scenarios. In view of greater reliance on passive and active measures, it is expected that the risk from such scenarios will need to be validated to be tolerable through use of QRA. This can help determine Land Use Planning zones.

8.6.4 Escalation

Credible secondary events (sometimes called “knock-on” or “domino” effects) may occur after the initial event. The FERA shall assess the potential for fires and explosions to cause further fire events or other major accident hazards (e.g. damage to large toxic substance storage).

The potential for such escalation effects shall be considered in layout development. Refer to FERA standard HSE-RM-ST09 (Ref 18) for further details.

8.7 Consequence Analysis

The hazardous effects mentioned in the preceding Section can lead to undesirable consequences in terms of injury /fatality of people, damage to the environment or the asset.

8.7.1 People – Third Parties

Third party impact shall be evaluated using Land Use Planning criteria specified in COMPANY Standard HSE-RM-ST01 (Ref 9).

Initial assessments can be based on consequences modelling and hazardous effects described in Section 8.6 above (e.g. Toxic, Explosion, Radiation etc.).

It is however likely that risk quantification using QRA will be required, especially if there is a significant quantity of toxic gas present. See Ref (6) HSE-OS-ST21 Management of H2S.

Permanent settlements, public places and transport corridors encroaching the impacted area shall be particularly identified and may require relocation.

8.7.2 People – Working Personnel (COMPANY & CONTRACTORS)

The impact on people doing work for COMPANY also needs to be assessed to ensure they will be protected against Major Accident Events, especially those with a potential for escalation. This element of assessment is most important for the layout of Process Units, where the blocks for Process Units and occupied areas will be arranged relative to each other.

Fire and Explosion Events: The layout will typically be driven by escalation potential and will likely require support from a Fire & Explosion risk assessments (FERA) and an Egress, Evacuation and Rescue (EER) assessment. Refer to EERA standard HSE-RM-ST07 (Ref 16) for further details.

Toxic Exposure: Past experience shows that hazard ranges from credible release scenarios involving toxic inventories can be very large (several kilometres) and therefore cannot be accommodated by separation distance alone. This places greater focus on other inherent safety measures (orientation vs prevailing winds, etc.), as well as active (F&G detection, HVAC isolation in manned areas, etc.) and Emergency Response

procedures and Toxic Gas refuge. H2S Zoning will identify the personnel entry requirement and operational restriction.

The use of QRA shall also be required to verify that, both, COMPANY Individual Risk and Group Risk criteria will not be breached. Refer to QRA standard HSE-RM-ST10 (Ref 19) for further details.

8.7.3 Environmental Impact

The environmental impact on sensitive or protected areas shall also be considered from the earliest stages to ensure the site selection and arrangement of process and equipment is informed by the assessment. This will require an Environmental Impact Assessment (EIA) that includes social impacts, at a level that is commensurate with the stage of the project. Refer ADNOC Social Risk Management Standard HSE-GA-ST10 (Ref 11). This will typically include:

- Gaseous emissions to atmosphere
- Liquid hydrocarbon and chemical spillage
- Wastewater Management
- Solid Wastes
- Energy inefficiency (minimise GHG)
- Efficient material use and waste generation.
- Physical interactions (nuisance, e.g. visual impact, noise, footprint, odour, dust etc.).
- Social Issues (socio-economic impacts on the communities)
- Environmental Sensitivities
- Ecology

Particularly important for plant layout is the design and location of storm water and contaminated water storage ponds; and firewater run off areas to prevent contamination of the surrounding areas.

8.7.4 Asset Protection & Business Continuity

The COMPANY risk management framework requires the potential business impact to be considered alongside the risk to people and the environment. Business impact means anything that can affect the COMPANY assets, operational continuity or its corporate reputation.

This aspect of assessment, and its impact on facility design is interlinked with issues previously discussed for the protection of people and the environment. As an example, protecting the integrity of OFFSHORE structures and buildings has a major contribution to personnel safety, environmental impact and business continuity.

The hazard identification process identified in preceding Sections is predicated on good engineering and operational practices that seek to prevent Major Accidents. These should underpin any layout, and include:

- Site boundary (to manage COMPANY activities);
- Plant access control (to limit personnel access to hazardous process areas);
- Segregation of Process Units (to limit potential escalation);
- Fire Zones (blowdown sections) to contain an incident within a geographical area.

8.8 Risk Assessment

The main objective of the Risk Assessment is to confirm that the risk presented by the proposed facility is tolerable. In every case throughout the project lifecycle, the level of detail required must be enough to give confidence in the decisions taken.

Given the lack of information at Concept stage, risk assessment in the early stages may be through qualitative reasoned arguments for simple processes and through coarse quantification in a Concept Risk Assessment where the operation is more complex.

The preliminary hazards screening discussed above provides a structure to inform such assessment at Concept stage. FEED and Detail Design stage assessment will likely require FERA and QRA level of analysis.

These requirements are explicitly defined in HSEIA standard on the list of mandatory studies for various project phases. Please refer HSEIA standard HSE-RM-ST02 (Ref 5).

8.9 Construction (SIMOPS /Brownfield Issues)

Potential hazards associated with simultaneous operations (SIMOPS), ONSHORE and OFFSHORE, shall be considered during facility layout design and shall consider the requirement for personnel escape and evacuation. The layout shall allow suitable space for the temporary facilities such as early production systems, construction camp, temporary accommodation, temporary power and utilities. For all new facilities a dedicated SIMOPS Matrix shall be prepared to manage risks during simultaneous operation and construction activities, including any planned future phases of expansion.

If after initial facility design, a plot is developed on or adjacent to existing operating facilities then any interaction between the construction and commissioning of the new plant and the existing units shall be subject to SIMOPS review and appropriate risk reduction measures imposed.

SIMOPS at all facilities (but particularly those processing sour gas) shall consider and prepare a practical escape and evacuation strategy and shall consider all available options including shelter in place /Temporary Refuge.

Any construction site should be separated by fencing and distance from operating units and be sufficiently far away to allow hot work on the construction site. Layout should allow for construction vehicle movements and site evacuation and any temporary refuges. From a layout perspective, the key considerations include, interfaces, hazardous area classification and zoning, the use of temporary vents and flares, helicopter operations and escape and evacuation.

Brownfield changes must meet 'Management of Technical Change' (HSE-OS-ST-30) (Ref 8). Any deviation Shall require approval by COMPANY.

9 STEP-1: SELECT FACILITY LOCATION

9.1 Introduction

9.1.1 Objective

New development concept studies often rank alternative location, design and layout options based on several parameters. The aim of this Section is to provide guidance on selection of a 'facility location' from such a shortlist of locations. This comprises Step 1 of the 'Building Block' approach described in Section 7, and Figure 7.3-1.

9.1.2 Context & Scope

The Systematic approach described in Section 7 is based on good industry practice, and draws heavily on guidance provided by the AIChE CCPS (Guidelines for Facility Siting and Layout, Ref.22).

The aim of the approach is to achieve risk that is 'As Low As Reasonably Practicable' (ALARP) with respect to Major Accident events.

The achievement of ALARP risk requires safety concerns to be weighed up against practical and business considerations, noting that all solutions that are 'practical' may not always be 'practicable' once local circumstances, timeframes and commercial factors are factored in. In order to achieve risk that is ALARP a balanced view is needed of both Safety issues and other matters that affect the viability of the project.

For this reason, the scope of this document includes guidance that is wider than safety issues, and also includes practical considerations that typically affect site selection.

9.1.3 Approach

The approach to site selection is been broken down into the four key elements introduced in Table 7-4 and summarised in Table 9-1 below, along with an indication of where the discussion is covered.

Table 9-1: Selection of Facility Location – Key Steps & Guiding Information

Assessment	Step 1: Facility Location			
	Section		Checklist (App.)	CCPS Reference (Ref.22)
	No	Title		
1. Team (Competency)	9.2	Team (Competency	B.2.3	4.3
2. Information (site /project)	9.3.1	Site Information	B.2.4.1	4.7 to 4.15 (except 4.12)
	9.3.2	Information: Support Infrastructure	B.2.4.2	4.17 & 4.12
3. Hazard Id. (& Assessment)	9.4	Hazard Identification (& Assessment)	B.2.1.1	Appendix C
		• Operations		
		• Construction (SIMOPS) Issues	B.2.1.2	

Assessment	Step 1: Facility Location			
	Section		Checklist (App.)	CCPS Reference (Ref.22)
	No	Title		
		Other Safety & Risk Assessment Studies: Concept Safety Assessment (CSA)		
4. Project Implementation	9.5	Implementation: Basis & Constraints	B.2.5	4.2
	9.6	Implementation: Plot Size	A.1 & A.2 B.2.6	4.5
	Materials Handling	9.7.1 Materials Required	B.2.7.1	4.16
		9.7.2 Constraints	B.2.7.2	
		9.7.3 Transport Options – Pipelines	B.2.7.3	
		9.7.4 Transport Options – Road (Trucks)	B.2.7.4	
		9.7.5 Transport Options – Rail	B.2.7.5	
		9.7.6 Transport Options – Marine	B.2.7.6	
		9.7.7 Transport Options – Air Carrier	B.2.7.7	
	9.7.8	Materials Handling – Proposed Plan	B.2.7.8	4.6
	9.8	Implementation: Engineering Design	B.2.8	4.18
	9.9	Implementation: Utilities	B.2.9	4.19
	9.10	Implementation: Other Manpower Issues	B.2.10	4.20

Column 1 identifies the site selection step, and columns 2 and 3 indicate the Section in this document where guidance is covered. Column 4 contains a link to the Appendix where relevant detailed guidance is contained. The final column shows a link to the CCPS Guidelines (Ref.22) and identifies the section informing the present document.

9.1.4 Detailed Guidance

Detailed guidance in the following Appendices is relevant:

- Appendix A: Separation Distances;
- Appendix B: Checklists – Facility Location.

Appendix A:

Appendix A has Tables that contain separation distances that can be treated as 'inherently safer' against most foreseeable credible events. The first set of Tables (Section A.1) contains separation distances for 'Blocks' such as storage tanks, process units and buildings from each other, and the second set of tables (Section A.2) relates to separation distances for equipment items.

Appendix B:

Appendix B has all the detailed checklists for selection of Facility Location, which based on guidance from CCPS (Ref.22). An example structure is shown in Table 9-2.

Table 9-2: Example of Checklist Structure (see Appendix B)

Project Assessment						Relevance		Information	Comment
						Const.	Ops.		
					4.6.5) Rail				
					Regulations				
					Proximity				
					Tanks				
					Existing facility equipment				

The first 6 columns indicate multiple 'Indent levels' (heading, sub-heading, sub-sub... etc.) that allow each aspect to be broken down and considered in progressive levels of detail. This approach allows the checklists to be customised according to the requirements each project, by simply curtailing or expanding the list at the appropriate level of detail.

It is also noted that many of the checklists are appropriate for both 'construction' phase and 'operation' phase requirements. Columns 7 and 8 are intended to prompt the user to ensure both phases are considered for each aspect in the preceding columns.

The actual information gathered may be recorded in column 9, and concluding observations made in column 10.

9.1.5 Level of Detail

It should be noted that selection of a Facility Location is a 'concept level' decision, meaning the degree of evaluation and assessment is expected to be at a preliminary level, and only enough to give confidence that the proposed facility location is correctly selected.

The guidance is therefore high-level, to cover the generality of circumstances likely to be encountered. Where local circumstances require more scrutiny of particular aspects, further assessment should be carried out to support the decision taken. Where necessary, outline layouts may be required to assist with concept and location selection.

9.2 Team (Competency)

The knowledge and experience of the layout team is critical since a wide range of technical and non-technical issues need to be weighed up to reach a decision that limits risk whilst acknowledging practical and commercial constraints. Business needs drive the project, but many decisions are driven by issues that are unavoidable (e.g. reservoir location, legal ownership, geotechnical factors). Others require a compromise of competing factors, and so a widely experienced team is required to reach the optimum decision. The development of a facility is an iterative process. Key competencies required from the Facility Selection Team are summarised in Table 9-3 based on guidance in Ref. 22.

Table 9-3: Summary of Team Competencies

4.2) Site Selection Team – Competencies [4.3 Site Selection Team] - Competencies]	
Non-Technical	
-	Company policies & Guidelines
-	Geographic knowledge
-	Local Regulations
-	Security (normal / turnaround, workers /materials)
-	Transport (onsite /offsite, people & materials)
Technical / Engineering	
	Business case
-	Process
-	Equipment layout, Layout Engineer - Piping
-	Process Safety & Risk Specialist (onsite & offsite issues)
-	Environmental (wastewater, groundwater, air, etc.)
-	Civil Eng. (topography, soil etc.)
	Pipelines
-	Facility Operations

Other discipline inputs may be required depending on the nature of the project; e.g., well engineering, subsea, marine, Electrical, Instrumentation, Mechanical, Structural. The project team leader is responsible for ensuring that all relevant competencies are represented.

The team is responsible for recommending whether a choice of location is acceptable, and which is the preferred location, using reasoned arguments to compare options which may well include the use of the checklists for all potential facility locations. The team may also recommend that further information is to be obtained where missing or imprecise information does not allow confidence in the decision.

9.3 Information: Site

A prerequisite to any decision-making process is to obtain the most up-to-date information available. For the purpose of selecting a facility location this has been broken down into:

- Site Information (Section 9.3.1)
- Information: Support Infrastructure (Section 9.3.2)

9.3.1 Site Information

The following types of information is required about each facility location being considered:

- Maps
- Geological features
- Weather
- Seismic features
- Off-site factors
- Environment
- Infrastructure
- Buildings & structures

These are discussed further in the sections below. A more detailed checklist is for each of these aspects is contained in Appendix B (Section B.2.4.1).

9.3.1.1 Maps & Aerial photographs

It will be necessary to gather maps, land surveys and aerial photographs to assess the suitability of the various sites being considered.

Maps will need to show geographical features and be supplemented with aerial or ground survey photographs to provide more detail. Any facilities requiring harbours may need bathymetric maps to show any constraints on marine operations. The information should identify any environmentally sensitive areas along with concentrations of people through community infrastructure (shopping malls, hospitals, etc.). It will be important to identify any National assets as well as existing industrial sites.

This will allow the Facility Location team to assess the surrounding area and define the constraints within which the new facility will have to operate.

The new facility must not only fit in the space but must provide suitable separation from outside population centres considering any land use planning zones and tie-in to existing infrastructure such as roads and sea routes, power and water supplies.

In terms of safety, the most important feature of a facility site is the separation between the facility and public areas. Any choice of location shall consider the potential for a facility to impact public areas beyond the facility boundary in the event of a Major Accident at the site and shall determine any potential 'impacted zone'.

Third party risk shall be evaluated and can be overlaid onto available maps to compare against Land Use Planning criteria and societal risks specified in COMPANY Standard HSE-RM-ST01 (Ref 4). The information to do this may be limited to analogues of any similar facilities during Concept, to a full QRA study during FEED, which will need to be updated in detailed design.

Land use planning criteria are a planning tool for COMPANY to assess new developments, accommodations that are constructed near the existing facility boundary, for siting a facility in the vicinity of existing built up area or master plan updates for existing assets.

The purpose of defining LUP zones is to minimise risk to people around the hazardous facility by specifying how close certain types of facilities can be developed. COMPANY has multiple zone Land Use Planning criteria for acceptable risk to the public, which are given in Ref 4 [HSE-RM-ST01].

Also, if planning permission is required to build on a site, then the proper permission shall be obtained from the relevant authority and any unusual permit conditions on site development (e.g. visual impact) should be considered in choosing the site. In addition, an evaluation to determine if additional land purchase to create a buffer zone is required to safeguard separation distances, particularly if planning regulations are unlikely to provide protection against encroachment, since new sites frequently attract additional development and populations.

9.3.1.2 Geography

Geographical and geological issues are taken to include the terrain (topography) as well as water depth (bathymetry) issues.

The topography should be such that ONSHORE sites have (or can be graded to have) enough flat land to allow all related process facilities to be on the same elevation. Failing that, then facilities built on terraces of differing height shall need to account for the process flow and the likely flow of liquids or dispersed gases from any release. Sites should have good drainage and not be susceptible to storm water damage. Sites should not require substantial land remediation or vegetation clearance.

It is also important to consider that nearby high land can be more seriously affected by thermal radiation from a flare stack than if the landscape is flat. If a facility requires high elevation equipment or stacks that can cause an aerial hazard, then the site should not be near a flight path that may be affected.

Shallow tidal areas or swamps where neither boat nor vehicle can access should be avoided.

Maps of sea depth may be required to assess the approaches of shipping to port facilities. The limit on the draught of vessels needs to be identified together with the need for dredging of sea routes. The flows and currents of navigable waterways shall be known.

Marine and OFFSHORE facilities need to be located so that they have (or can be dredged to have) enough sea depth to allow passage of ships with the largest draught required during construction, operation and decommissioning of the facility considering tide and water currents. High water depth can obviously affect the ability to have an OFFSHORE structure with foundations on the sea floor or affect the need to be anchored or dynamically positioned.

9.3.1.2.1 Geotechnical

Ground conditions are important. Boreholes may be required to determine bedrock strata and soil condition.

The need for remediation such as grading of topsoil, guarding against landslips or the need for piling to improve load bearing strength of the ground is required. In extreme cases these issues can rule out a site location or make the use of a site more costly than anticipated. Soil chemistry is also important to confirm, since this may affect other civil design choices.

9.3.1.3 Weather

Weather issues are taken to include the Environmental data as well as Metocean data for water bodies.

For all potential facility locations, data for all available weather conditions and sea states (metocean data, where applicable) should be collected from a local weather station over at least a 3-year period. Professional advice to be taken if nearest weather station is remote to the site.

A wind rose shall be prepared. It is particularly important to establish the direction of any prevailing winds, as many layout decisions relate to this.

Environmental data is required for any project. This data is used in a project design basis and may affect design temperatures and choice of materials of construction, as well as influence decisions related to dust storms, rainfall, sand dune migration.

Climatic conditions such as temperature inversions are important for the siting of Vents and Flare Stacks – especially when the process streams contain toxic gas.

9.3.1.4 Seismic Issues

All facility locations should be free of natural hazards as far as practicable. These include geohazards such as subsidence, sinkholes, landslides, mud flows, soil liquefaction, earthquakes and volcanic eruptions. Also, to be considered are other natural hazards due to extreme climate and extreme weather events due to ice, snow, rain and wind; such as thunderstorms, flash flooding, sand dune movement, dust clouds. In coastal or OFFSHORE areas, the extreme tidal range and ocean currents should be considered, as well as other natural hazards such as sea state, freak waves, tsunamis, sea floor scouring.

9.3.1.5 Off-site Issues

Neighbouring vegetation and wildlife may be a concern. Clearance of encroaching vegetation is often required to mitigate against forest or scrubland fires. Security fences may need to keep out dangerous animals (e.g. wolves or poisonous snakes).

Neighbouring industrial facilities may impose a risk on the proposed site and have a risk imposed on them by the new facility. Such possibilities should be considered.

The existence of neighbouring built-up areas may well mean that the site has access to emergency services (fire, medical) or similar mutual aid from existing industrial sites. Conversely an undeveloped area may require such provision to be created, including a safe location for evacuation from the site beyond the reach of any potential incident.

Engagement with nearby stakeholders (e.g. nearby communities, landowners, other facilities) is essential.

9.3.1.6 Environmental Issues

The 'Environment' is defined as the surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their interrelationships. These surroundings can extend from within an organisation to the local, regional and global systems.

Environmental issues are therefore very wide-ranging, so nearly always have some effect on the design of a facility and therefore on the cost of development; also, they can be a significant differentiator between options, sometimes constituting a 'showstopper'.

The 'environmental impact' of a facility is defined as the change to the environment, wholly or partially resulting from an organisation's environmental aspects and may be adverse or beneficial. All developments have an inherent impact on the environment that covers both the permanent impact of installation construction as well as the possible risks to the environment of unplanned events during operation (e.g. crude oil spillage).

It is a requirement during concept to determine if there are sensitive environmental receptors nearby such as a nature reserve habitat, RAMSAR sites or IUCN endangered species. An environmental baseline survey is also strongly recommended before any invasive work is done at a site, to be able to confirm the current environmental state before any development takes place.

An understanding of whether a receptor is sensitive to any aspect of the proposed activity is required to establish the level of environmental risk. A receptor can consist of:

- Atmosphere – air quality, including contribution to global warming
- Sea – seabed, marine flora and fauna, seabirds etc.
- Onshore – land take-up, use of natural resources, waste disposal, groundwater etc.
- Human (including socio-economic) – stakeholders, sea users, contractors etc.; and
- Company – compliance, Company reputation.

Focusing on the receptor in its specific environment can be useful in determining whether specialist technical support is required e.g. archaeologists, marine biologists.

The 'environmental aspects' of a facility are defined as those elements of an organisation's activities or products or services that interacts or can interact with the environment.

It is required to identify these aspects before FEED stage through an ENVID, so that alternative designs or technologies and any implications for layout can be considered. The ENVID workshop is the central activity used to determine the full range and significance of Environmental Impacts of a project and the mitigation measures required to minimise harm to the environment. Developments may choose, depending on the issues identified in the ENVID, to conduct a comprehensive Environmental Impact Assessment including Social impacts and compiled as part of HSEIA.

A preliminary environmental impact assessment shall address environmental issues and laws affecting the air, land and water on and surrounding the location during concept. It is required to have a comprehensive list of any local environmental regulations that must be followed and any environmental permitting requirements during FEED.

A preliminary schedule of all wastes produced shall be made during FEED to enable suitable provision for on-site treatment of gaseous, liquid and solid wastes (e.g. vapour recovery, used fire water catchment, sewage treatment). Air pollution from fugitive emissions from process plant should also be considered since neighbours often complain of bad odours. Other environmental impacts such as visual impact, noise and light pollution shall be considered; flare stacks particularly give rise to all three of these issues.

9.3.1.7 Infrastructure Issues

The ability to manage the movement of people and the import and export of raw materials, utilities and products, by rail, sea, air or pipeline shall be assessed in the choice of location and layout of the facility, as infrastructure that does not exist may need to be built.

9.3.1.8 Building & Structure Issues

Facility (whole asset) integrity issues are a key concern for OFFSHORE Structures. Jacket, semi-sub, mooring and positioning designs are required to meet integrity requirements for catastrophic events. Consider the location of the installation with respect to existing Shipping Lanes/Marine Traffic and potential for ship impact. [See HSE-OS-ST29 HSECES Management.].

Buildings that are occupied or contain safety critical equipment should be sufficiently separated from storage tanks and process units. The location chosen should allow for the suitable location of such buildings.

9.3.2 Information: Support Infrastructure

The availability of support infrastructure is considered under the following headings:

- Communication (Section 9.3.2.1)
- Site Security (Section 9.3.2.2)
- Site Evacuation (Section 9.3.2.3)

A more detailed Checklist is provided in Appendix B, Section B.2.4.2.

9.3.2.1 Communication Issues

The facility selection team will need to assess the available telecommunications systems and whether, for example, it might be necessary to lay fibre optic cable or wiring for telephone or computer networks.

There are many communication issues which may affect the choice of location. These include:

- Interference of cell phone, tv, radio
- Communication channels (phone, internet, radio, microwave, 2way radio)
- Packages & mail

9.3.2.2 Site security

The provision of security for the facility will require careful consideration of the project requirements and the support available from the local area. A more detailed Checklist is provided in Appendix B, Section B.2.4.2.

A preliminary Security Vulnerability Assessment will be required to determine security measures likely to be necessary as this might affect the choice of location and is likely to affect aspects of the layout.

It is important to establish if the facility is to be of strategic importance to the country, if so, there may be good reasons for making provision for a military presence to defend against terrorism or war or the theft of materials which may have security implications.

It is mandatory for all onshore facilities to have a secure external fence to prevent unauthorised access by people. No building, plant or structure shall form part of this external boundary but shall be a suitable separation distance away from it. External fences should not prevent escape from the site in an emergency. Site entrances shall always have some form of security and provision needs to be made in the layout. Within the facility intermediate Access Control Systems may be required.

9.3.2.3 Site evacuation

The eventual "Place of Safety" needs to be identified in the event that the facility is to be evacuated following a Major Accident event. Whilst it is often assumed that escaping to outside an ONSHORE facility fenceline is

a safe place, this is not always so and consideration of this (e.g. nearby infrastructure, landscape, access to shelter, medical assistance) may affect choice of location. This is especially true for facilities handling toxic materials.

In the case of OFFSHORE facilities, the preferred mode of evacuation tends to be the way the workforce normally reaches the facility. For example, in the case of an OFFSHORE Complex, a bridge to an accommodation platform may provide this preferred mode of evacuation.

If, however the whole platform complex needs to be evacuated then the OFFSHORE choice of location can consider potential evacuation to nearby existing platforms or existing logistics allowing evacuees to reach a “place of Safety”. The needs for a standby vessel, life boat etc. shall be considered in concept development.

9.4 Hazard Identification (& Assessment)

All facility locations should seek to minimise, both man-made and natural hazards, so far as practicable.

Manmade hazards include the possibility of transportation accidents, such as airplane crash, ship collision and road traffic incidents; security breaches and acts of terrorism or hostile acts by other countries.

Natural hazards include geohazards such as subsidence, sinkholes, landslides, mud flows, soil liquefaction, earthquakes and volcanic eruptions. Also to be considered are other natural hazards due to extreme climate and extreme weather events due to ice, snow, rain and wind; such as thunderstorms, flash flooding, sand dune movement, dust clouds. In coastal or OFFSHORE areas, the extreme tidal range and ocean currents should be considered, as well as other natural hazards such as sea state, freak waves, tsunami, sea floor scouring.

The choice of facility locations shall consider the proximity of emergency support facilities and safe locations to which an entire facility could be evacuated and should not be in an environmentally sensitive area.

In terms of safety, the most important feature of a facility site is the separation distance between the facility and public areas. Any choice of location shall consider the potential for a facility to impact public areas beyond the facility boundary in the event of a credible incident at the site and shall determine any potential ‘impacted zone’. This is especially important if the facility handles large quantities of sour or otherwise toxic gases, which shall require at least coarse QRA for operations staff and offsite societal risk. Even at this stage it may be necessary to consider if any toxic hazards are significant enough to need to be enclosed in buildings or structures to mitigate this risk. Potential sites that are nearby to areas of low population density are preferred to those near to areas of high population density or to sensitive populations such as schools and hospitals; in these cases, the relative locations especially considering the prevailing wind could also be important.

ONSHORE sites should seek enough land area to allow safe separation distances for facility layout. ONSHORE sites should be flat land with good accessibility and good load bearing soil. Generally, ‘Greenfield’ locations (locations without existing development) are preferred. Also, sites that are standalone are preferred, although locations amongst other industrial sites with similar land use or designated land use (e.g. chemical plants, but not warehousing) are generally acceptable, in which case the potential of introducing new ‘Domino’ effects (incident escalation between industrial sites) should be evaluated.

Subsurface oil or gas reservoir location and properties often have a significant impact on surface facility location and layout choices.

Other considerations are then transportation accessibility, accessibility of utilities (electrical power, fuel, cooling water and telecommunications) and land use constraints. A substantial amount of information is desirable in allowing the layout team to recommend a facility location. The quality of this information affects the confidence in the choice made.

The checklist in Appendix B shall be used to gather information about each location. This can then be used to make a comparison between choices and to confirm the acceptability of a location choice.

9.5 Implementation: Basis & Constraints

Clarity about the project basis is an essential starting point to determine the most suitable location and the arrangement of facilities within it. This needs to consider key parties (customers, suppliers and workers) and the design basis covering factor such as operational life, maintenance turnarounds, etc. Manning requirements also need to be understood so that adequate provision can be made for health and welfare.

Site selection and layout development also needs to acknowledge constraints such as current site status, whether it will be a greenfield or brownfield development and any outside influences.

A checklist of aspects to cover under Project Basis is given in Appendix B, Section B.2.5.

9.6 Implementation: Plot Size Required

The size of plot required for the facility is clearly an important starting point for layout development. The building block approach described in Section 7.3, along with the grouping of Process Units and the typical separation distances presented in Appendix A form an important starting point for this purpose. The estimate of land may be compared against similar facilities or constituent parts to verify the plot size. It is however important that existing facilities are not copied directly, since they may have been built to different Standards and affected by constraints that are unique to their operations. It is also important that the shape of the plot allows the layout to accommodate factors related to the prevailing wind.

Also important, will be to make sure there is space for any future planned expansion, since this will not only require space for additional equipment but may involve the challenges of simultaneous production and construction (SIMOPS – Simultaneous Operations).

Apart from these requirements within the site for its operational phase, it is also important to factor in space requirements for initial construction when laydown space, warehousing and a construction camp may be required.

Factors outside the plant boundary also require careful consideration since they could severely restrict both, construction and operational activities. These include the potential requirement to secure a buffer zone to limit risk to people outside the plant boundary, or to secure passage of site traffic through public rights-of-way.

A more detailed checklist of considerations is given in Appendix B, Section B.2.6.

9.7 Implementation: Transport & Materials Handling

This Section considers how materials handling can be addressed for both operations and construction phases. Detailed checklists are presented in the Appendix indicated in Table 9-4.

Table 9-4: Assessment of Transport & Materials Handling

Section	Reference to CCPS (Ref.22)	Checklist Appendix B (link)
9.7.1	Materials Required	B.2.7.1
9.7.2	Constraints	B.2.7.2
9.7.3	Transport Options – Pipelines	B.2.7.3
9.7.4	Transport Options – Road (Trucks)	B.2.7.4
9.7.5	Transport Options – Rail	B.2.7.5
9.7.6	Transport Options – Marine	B.2.7.6
9.7.7	Transport Options – Air Carrier	B.2.7.7
9.7.8	Materials Handling – Proposed Plan	B.2.7.8

9.7.1 Materials Required

In order to assess the requirements for site selection it is necessary to have a clear understanding of materials that will need to be transported both during the operation phase and for construction and turnaround requirements.

Operations phase materials are likely to comprise:

- Feedstock
- Acids and bases
- Lubricants
- Catalysts
- Treatment chemicals
- Utility gases
- Fuel gas (natural gas, LPG)
- Speciality chemicals

For construction, the largest and heaviest items that will need to be transported need to be identified, either in terms of process or construction equipment. The construction strategy should consider the complete route from supplier to site in detail, since any needs to modify road, rail or waterway infrastructure to accommodate such transportation may affect the viability of the project concept. The main issues are weight and size, width and height constraints of roads, dockyards, cranes etc.

Warehousing and storage of raw materials, intermediates, products and waste materials also need to be accommodated in the site layout. This may affect space required for road tankers, railcars or ships at dockside. Logistics areas should take place in a separate area of the facility. It may also be necessary to consider segregating incompatible materials into separate logistics areas.

The import and export routes of materials should also be considered especially since transport of dangerous goods through highly populated areas should be avoided and special handling techniques may be required.

A more detailed checklist is presented in Appendix B, Section B.2.7.1.

9.7.2 Constraints

Layout development also needs to consider constraints that will require special provisions to be made for legal and regulatory reasons during handling, shipping and loading /unloading. There may be operational controls on 'Bonded' tanks or provision required on site for Customs Inspectors, and fiscal metering / gauging requirements.

A more detailed checklist is presented in Appendix B, Section B.2.7.2.

9.7.3 Transport Options – Pipelines

The impact on layout by pipeline transport will need to consider:

- Regulations
- Local preferences
- Topographical data
- Underground infrastructure (inside /outside fence)
- Preferred route (facility entry /exit, terrain outside fence, buried or not and local soil conditions)

A more detailed checklist is presented in Appendix B, Section B.2.7.3.

9.7.4 Transport Options – Road (Trucks)

For transfer of materials to site, the assessment will need to consider off-site factors like the location and capacity of:

- Express and freight yards
- Highways
- Local roads and bridges

Availability of off-site public and private services also play a role in transporting people and materials to the site. Any regulatory constraints on vehicle ownership and operation will need to be identified.

Within the site boundary, there will be a requirement to implement controls (bar-code scanners, cameras, security logistics, trailer weigh scales, etc.).

A more detailed checklist is presented in Appendix B, Section B.2.7.4.

9.7.5 Transport Options – Rail

The issues with rail transport relate to:

- Regulations
- Railroads
- Spur requirement
- Marshalling operations
- Infrastructure
- Car details
- Railroad company

- Explosion risk
- Off-site impact
- On-site transport

Regulatory constraints could be significant if the cargo to be transported is hazardous from a fires, explosion or toxic effects perspective. Any such Regulations will need to be identified and their impact on space and layout arrangements complied with.

The availability of a railroad company to perform many of the rail transport activities for the company should be identified, since this may avoid the requirement to purchase hardware and the training of personnel in such operations.

Information on hardware required, including rail spur, tracks, separation requirements will need to be collected to ensure adequate space is provided.

The effect of railway operations on potential explosion risk due to a release and the congestion created by the rail cars should also be considered.

A more detailed checklist is presented in Appendix B, Section B.2.7.5.

9.7.6 Transport Options – Marine

Issues with marine transport involve:

- Regulations
- Area information
- Capacity of marine facilities
- Marine vessels required
- Shore facilities
- Controls (jetty /dock)
- Emergency response

A more detailed checklist is in Appendix B, Section B.2.7.6.

9.7.7 Transport Options – Air Carrier

Issues with air carrier transport involve:

- Airport type & location
- Helicopter facilities
- Airport hazard (take-off & landing)
- Airport zoning restrictions & warning lights
- Flight path impact
- Airport future expansion.

A more detailed checklist is in Appendix B, Section B.2.7.7.

9.7.8 Materials Handling – Proposed Plan

It is essential to have a plan for materials handling both for onsite movements and for materials going to or from the facility and to consider reception and export facilities. This needs to include construction and maintenance turnaround activities.

The mode of transport (road, rail, air, ship) is a relevant factor for all materials and can involve:

- phase of material (gas, liquid, solid)
- amount of material (bulk shipping, containers, piecemeal)
- consideration of container unit size (drum, ISO container, shipping container)
- movement by cranes, forklift, barge, truck, pipeline
- reception facilities
- onsite storage
- export facilities

The Materials Handling Plan should address the following key aspects based on information gathered from the preceding sections:

- Supplier to Reception Station
- Reception Station to Site
- On-Site
- Construction & Turnaround requirements.

A more detailed checklist is in Appendix B, Section B.2.7.8.

9.8 Implementation: Engineering Design

The philosophy is that the PROJECT shall follow all relevant laws in UAE, all COMPANY philosophies and standards, and international codes and standards; all in accordance with the hierarchy detailed in Section 5 of this standard.

There are engineering design issues that may be relevant to location choice

- Measurement systems (SI)
- Equipment and services suppliers
- International Codes and standards
- Local codes and regulations
- Design factors and corrosion allowance
- Language
- Automation or manual operation
- Process technologies
- turnaround philosophy
- plant design life
- operating mode

A more detailed checklist is in Appendix B, Section B.2.8.

9.9 Implementation: Utilities

The existing utility infrastructure needs to be assessed to see if it meets the projects requirements. Any missing infrastructure or capacity of that infrastructure would need to be built at extra cost. The reliability of the utility supply is also important. Some projects, for example, have resorted to taking electrical feed from different parts of a national grid system to achieve higher supply reliability.

Water is generally used for drinking and washing, as well as for industrial process uses like cooling, boiler feed and firefighting. It is essential that at least potable water is available for any facility or can be imported and stored or produced in adequate supplies. It is also likely that industrial quality water will be required and that may require additional plant on certain facility locations; although for some uses filtered sea water may be sufficient. The lack of cooling water can be mitigated by using fin-fan coolers, which require large layout space.

Steam systems also require considerable space for boilers, feed water, condensate, blowdown, waste heat recovery etc. unless import is possible.

The consumable utilities that need to be considered are

- Electrical power
- Water (sea, potable, industrial, cooling, boiler feed)
- Steam
- Fuel
- Air, nitrogen, inert gas
- Other

A more detailed checklist is in Appendix B, Section B.2.9.

9.10 Implementation: Other Manpower Issues

Access to suitably qualified personnel and contractors may need to be considered. Also, availability of housing for personnel may be a factor.

A more detailed checklist is in Appendix B, Section B.2.10.

10 STEP-2: LAYOUT 'PROCESS UNIT' (WITHIN FACILITY)

10.1 Overview

10.1.1 Objectives & Scope

The aim of this Section is to give guidance on Step 2 of the 'Building Block' approach described in Section 7, and Figure 7.3-1 ('Process Unit' Layout). It should be noted that the scope is not limited to 'process units' but extends to all facilities to be positioned inside the area controlled by COMPANY, including utilities and other manned areas.

Step 2 involves placement of the required process, utility and manned areas within the plot space selected by Step 1. This step also involves marking the main 'Egress and Evacuation' routes within the plot, and their connection to the wider off-site emergency response arrangements.

10.1.2 Approach

The overall approach to Step 2 is summarised schematically in Table 10-1, below using the general project planning framework in Table 7-4, comprising team selection, information gathering, hazard identification and assessment, and project implementation.

Table 10-1: Layout Development Approach (Step 2 – Process Units)

Assessment	Description	Layout Development Process - 'Process Unit'			
1. Team	Site Selection Team – Competencies				
2. Info - Site /Project	Site Information				
	Support Infrastructure				
3. Haz. Id. /Assessment	Hazard Identification - Operations - Construction Other Safety & Risk Assessment Studies	Hazard Identification &		Study Types	Comment
		1 Verify separation distances from previous (Concept) stage.			
		Project specific Information: - Consequence Modelling (fire, explosion, toxic)		Consequence Modelling: - Fire (radiation) - Flash fire (dispersion) - Explosion (overpress.) - Toxic (dispersion)	
		2 Support Layout Optimisation			
		If separation too 'LARGE': - Reduce separation: - Less inventory - Less cost (reduce land prep, piping, etc.).		Safety Studies: - Consequence modelling - FERA - QRA - etc.	In reality, natural project processes drive down plot size for Value reasons (so 'too large' is not likely to be a major issue.
		If separation too 'SMALL': - Increase separation (to improve ISD). - If not possible: - Investigate other measures (passive, active, procedural)		Engineering Safety Studies: - Haz Area Classification - PFP Assessment - Active Fire Protection - EEERA - ESSA, etc.	
4. Project Implementation	Basis & Constraints	Iterative (consistent with CCPS, Fig. 5.1 - reproduced)			
	Materials Handling				
	Engineering Design				
	Utilities				
	Other Manpower Issues				
	Plot Size (& detail)				

```
graph TD
    Step1[Step 1: Identify the process units with their, negative, and total release hazards] --> Step2[Step 2: Identify other potential sources which may, adversely affect the process units and their, safety release hazardability, etc.]
    Step2 --> Step3[Step 3: Determine the site and off-site consequences from these hazards, in personnel, property, and the environment]
    Step3 --> Step4a[Step 4a: Determine the distances for each release code 1]
    Step3 --> Step4b[Step 4b: Determine the distances for each release code 2]
    Step3 --> Step4c[Step 4c: Determine the distances for each release code 3]
    Step3 --> Step4d[Step 4d: Determine the distances for each release code 4]
    Step4a --> Step5a[Step 5a: Evaluate other design alternatives to permit reduction in personnel, property, and/or the environment consequences]
    Step4b --> Step5b[Step 5b: Evaluate other design alternatives to permit reduction in personnel, property, and/or the environment consequences]
    Step4c --> Step5c[Step 5c: Evaluate other design alternatives to permit reduction in personnel, property, and/or the environment consequences]
    Step4d --> Step5d[Step 5d: Evaluate other design alternatives to permit reduction in personnel, property, and/or the environment consequences]
    Step5a --> Step6{Step 6: Is the distance acceptable?}
    Step5b --> Step6
    Step5c --> Step6
    Step5d --> Step6
    Step6 -- No --> Step3
    Step6 -- Yes --> Step7[Step 7: Consider operating for minimal distances between the process unit and units to help reduce the consequences]
    Step7 --> Step8[Step 8: Document the results]
```

Figure 5.1. Flowchart used to Determine the Process Unit Layout Distances of a Facility

Figure 5.1: Flowchart used to Determine the Process Unit Layout Distances at a Facility

The first two columns of Table **10-1** describe the 4 main aspects of layout development, with a more detailed breakdown of Hazard Identification & Assessment is given in the last four columns. This includes the technical objective (verification of separation and support layout development), and the type of studies required. The lower part of the Table shows the project implementation stage an indication that the process is an iterative one.

Implementation requires use of principles outlined in Section 7.3.3, which are reproduced in Text Box **10-1** for ease of reference.

Text Box 10-1: Key ISD Principles for Layout Development

1. Separation:

Maximise distance from Hazards (i) & Hazardous Activities (ii) to Vulnerabilities (iii);

2 Layout Factors:

Use other 'Layout Factors' to protect Vulnerabilities from Hazards & Hazardous Activities.

It is noted that Step 2 provides an important opportunity to use the principles in Text Box **10-1** to segregate areas with a high potential to source a Major Accident from areas that are sensitive to such accidents (e.g. populated offices, CCR, warehouses, workshops, etc.). Typically, utility areas with a lower potential to source a Major Accident can be placed between the process and the manned areas, as shown schematically in Figure **8.1-1**.

Typically, ADNOC follows the concept of Physical separation for Onshore facility unless there are limitations on the plot size. Downsizing supported by various studies is recommended only when plot limitations are unavoidable.

10.1.3 Level of Detail

Placement of process units within the selected facility area is typically a 'FEED' stage requirement where the Engineering design needs to be progressed to a level that gives a +/- cost estimate for financial decisions regarding progression of the project to Detail Design. As such it requires more certainty about the internal nature and working of the proposed facility.

For this reason, the degree of evaluation and assessment should be sufficient to support the decision taken at the required level of confidence.

This typically requires a much more detailed look at the project specifics in terms of the hazards and vulnerabilities that are present so that the plot can be customised to suit. Good industry practice for this step is given in Ref.22, which has been assembled to build on the format presented in Table **9-1** for step 1, and is shown below in Table **10-2**.

10.1.4 Assessment Structure

Columns 1-3 in Table **10-2**, repeat key headings of Step 1 and are retained to show how consideration needs to progress to a more detailed level in columns 4 and 5 for Step 2.

Table 10-2: Process Unit Layout – Main Steps & Guiding Information

Assessment	Issue		Step 2: Process Unit Layout	
	Description	CCPS Chapter	CCPS Chapter	Checklist (Appx)
1. Team (Competency)	Site Selection Team – Competencies	4.3 Site Selection Team		
2. Information (site /project)	Site Information	4.7 Maps & Information	5.7 Step 1 – Location characteristics	
		4.8 Geological		
		4.9 Weather		
		4.10 Seismic		
		4.11 Off-site	5.8 Off-site Issues	
		4.13 Environmental	5.10 Environmental	
		4.14 Infrastructure	5.11 Infrastructure	
		4.15 Building and Structure	Building & Structural (same as Ch 4.15)	B.2.4.1
	Support Infrastructure	4.12 Security	5.9 Security	
		4.17 Communication		
3. Hazard Id. (& Assessment)	Hazard Identification (High-Level) • Operations	Appendix C	5.2 Methodology Overview (Block Layout)	
			5.3 Integration (Block Layout – Facility Location)	
			5.4 Process Units – Preventative Measures	
			5.5 Process Units – Mitigative Measures	
			5.12 Step 2 – Separation (Block – Block)	
	• Construction (SIMOPS) Issues		5.6 Construction & Turnarounds (same as Ch 4.6)	B.2.1.2
	Other Safety & Risk Assessment Studies: • Concept Safety Assessment (CSA)		Other Safety Studies: See Section 10.4 below.	
4. Project Implementation	Basis & Constraints	4.2 Facility Information		
	Plot Size		5.12 Step 2 – Separation (Block – Block)	
		4.5 Plot Size	5.13 Critical & Occupied Structures	C.1.1
			5.15 Process Units	C.1.3
			5.16 Tank Farms	C.1.4
			5.17 Others	C.1.5
			5.18 Utilities	C.1.6
			5.19 Optimising Location of Process Units	
			5.20 Resolving Block Layout optimisation issues	

Assessment	Issue		Step 2: Process Unit Layout	
	Description	CCPS Chapter	CCPS Chapter	Checklist (Appx)
	Materials Handling			
	Materials Required	4.16 Material handling	5.14 Material Handling	C.1.2
	Constraints			
	Pipelines			
	Road (Trucks)			
	Rail			
	Marine			
	Air Carrier			
	Proposed Plan			
	Engineering Design	4.18 Engineering Design		
	Utilities	4.19 Utilities		
	Other Manpower Issues	4.20 Other (manpower related)		

Subsequent parts of this Section outline the expectation for each of the four elements in column 1 of Table **10-2**.

10.2 Team Competencies

The team for 'Process Unit' layout requires similar skills to those described in Section 9.2 for selection of facility location (Ref. 22). It is however important to note that the level of consideration will be more detailed in this instance, meaning that individuals with an aptitude for detail, and thinking across Engineering Disciplines (e.g. Civils, Structural, Process, Mechanical, Piping, Instruments, Electrical, Safety, etc.), should be selected. This will allow the impact of design evolution and conflicting Discipline requirements to be consolidated into one master plant layout.

10.3 Location Information

The increased level of detail required from Step 2 Engineering design means that a more detailed understanding is needed about the location selected. The information required is typically guided by ongoing Engineering and Hazard Identification /Assessment work undertaken within the project. Further guidance on this is available from CCPS Ref. 22 and listed below:

- Location characteristics [Ch 5.7]
- Off-site Issues [Ch 5.8]
- Environmental [Ch 5.10]
- Infrastructure [Ch 5.11]

10.4 Hazard Identification (& Assessment)

The objectives of safety assessment work described in Table **10-1** for Step 2 can be described as:

1. Verify separation distances (from initial Concept stage estimates);
2. Support layout optimisation.

It is emphasised that the process is an iterative one, as shown in from Table **10-1**, which stops when a balance has been achieved between Major Accident safety and other project Value drivers. This is consistent with good industry practice, as described in Ref. 22 (Figure 5.1).

10.4.1 Verification of Separation Distances

The first objective is to verify separation distances used in Step 1 (Concept Stage) when the facility was selected. These would likely be based on typical separation distances from past experience (as in Appendix A) since relevant process information is normally limited at that stage.

The intention of such separation is to avoid escalation of an initiating Major Accident hazard event. The initial work in Step 2 typically comprises consequence modelling, based on Maximum Credible Event (MCE), defined in the ADNOC FERA standard.

The consequence analysis typically estimates 'hazard ranges' to predefined impairment criteria affecting vulnerable people, equipment, or structures.

These become exclusion zones around each source of a Major Accident hazard, meaning that vulnerable items need to be protected against these impact levels (thermal radiation, overpressure, etc.) by separation or other means following the ISD approach (passive, active, procedural).

10.4.2 Layout Optimisation

The second objective of safety study work in Step 2 is to help refine the layout in response to other project constraints (space limitations, cost, material availability, etc.). This is typically done using quantified metrics, where likelihood and potential consequences are typically considered. These methodologies allow the relative merits of other passive, active and procedural measures to be factored into the decision-making process for layout development. Typical safety studies in this category are listed in Table **10-1** (column 5).

10.4.3 Detailed Guidance

Further detailed guidance is given in Ref., representing good industry practice for the following elements of Process Unit layout:

- Methodology Overview (Block Layout) [Ch. 5.2]
- Integration (Block Layout – Facility Location) [Ch. 5.3]
- Process Units – Preventative Measures [Ch. 5.4]
- Process Units – Mitigative Measures [Ch. 5.5]
- Step 2 – Separation (Block – Block) [Ch. 5.12]

10.5 Project Implementation: Basis & Constraints

In order to ensure a consistent basis is provided for all Engineering Disciplines the project Basis of Design will need to be revised for Step 2 in FEED, to include more detail. Preparation of other documents will also be needed ensure the Engineering intent is described in sufficient detail to develop the layout of Process Units. These will typically include:

- Process Flow Diagrams (PFDs)
- Heat & Mass Balance
- Piping & Instrumentation Diagrams (P&IDs)
- Environmental (conditions & requirements)
- Plot area available
- Civils & Structural criteria
- Operations & Manning
- Instrumentation & Control
- Communications
- Utilities
- Regulatory Permit requirements.
- Process Buildings

Clarity on these topics will be essential for any layout development work that needs to be undertaken.

10.6 Implement: Process Unit Layout

Table 10-3: Breakdown of Process Unit Layout (ONSHORE)

Area Type	Process /Other Unit	Onshore
Well-head	Wellheads	P
	Well Services Laydown	P
Process – Storage	Hydrocarbon Storage	P
Process	Hydrocarbon Refining Units	P
	Separators (& Piping)	P
	Other Vessels & Piping	P
	Compression	P
	ESDVs	P
	Pig Traps (& laydown)	P
	Pipeline, ESDVs & Pig Traps	P
Process Fired (Utilities)	Flare / Vent	P
	Fired Heaters	P
Utilities (& Machinery)	Laydown & Storage	P
	Power Generation	P
	Cooling Water (/Seawater) Pumps	P
	Other Utilities	P
	Crane(s)	P
Safety Sys.	Fire Pumps	P
	Fire / Blast Wall	P
Emergency Response	Shelter /Muster /TR	P
Manned Areas	CCR	P
	Workshops & Offices	P
	Accommodation	P

The layout of Process Units will need to be developed in Step 2 through an iterative process as described in Table **10-1**. Initial separation distances to avoid escalation of a Major Accident will need to be verified based on project specific process conditions and estimated hazard ranges.

Emergency Response arrangements within the site will need to be developed, covering Egress and Evacuation routes reserved for this purpose. These will need to be kept clear of any foreseeable Hazardous Area impacts and will need to be interfaced with off-site support infrastructure (evacuation routes, supplementary firewater supplies, etc.) and emergency response services (fire teams, medical evacuation points, hospitals, etc).

Space will also be required for any active emergency response hardware, including firewater storage, pumps, and deluge valve skids, along with Temporary Refuge (TR) or shelters in place.

Further guidance on good industry practice is given in Ref. 22 covering topics summarised in Table **10-4**. This also indicates the Section where the discussion is contained, along with a link to the Checklist in Appendix C.

Table 10-4: Process Unit Layout – Main Steps & Guiding Information

Section	Reference to CCPS (Ref.22)	Checklist Appendix C. (link)
10.6.1	Separation (Block – Block) [Ch 5.12]	
10.6.2	Critical & Occupied Structures [Ch 5.13]	C.1.1
10.6.3	Process Units [Ch 5.15]	C.1.3
10.6.4	Tank Farms [Ch 5.16]	C.1.4
10.6.5	Others [Ch 5.17]	C.1.5
10.6.6	Utilities [Ch 5.18]	C.1.6
10.6.7	Optimising Location of Process Units [Ch 5.19]	
-	Resolving Block Layout optimisation issues [Ch 5.20]	

10.6.1 Separation (Block – Block) [Ch 5.12]

Most process units are located outside. See 10.6.3.5 where process units are located inside a building.

10.6.1.1 Grouping

Process and other systems should be grouped as described in Section 7.3.4 to enable layout development that supports the escalation avoidance objective. The aim of such grouping is to separate items with a hazard potential (fuel source) from those that are vulnerable (manned areas and ignition sources) as indicated in Section 7.3.3. Table **10-3** contains a list of typical groupings in the oil and gas industry and is consistent with guidance in API 14J (Table 4)

On facilities processing highly sour fluid, grouping equipment according to toxic gas hazard risk should also be considered, and may well be recommended by QRA.

For onshore facilities, these groupings allow the site to be divided into distinct Plot areas (normally rectangular.

Equipment within each block should then be laid out for ease of maintenance to meet the secondary criteria.

Multiple trains of the same process are recommended to go in separate fire zones. The layout must allow operation of one train while other train is in turnaround. The same principle applies to any other equipment which has diversity as a requirement to meet reliability or business integrity objectives.

10.6.1.2 Fire Zones

The facility shall be divided into Fire Zones to prevent incident escalation. The concept phase shall split the entire facility into separate fire zones based on asset integrity and business continuity principles. Fire zone definition is as per [HSE-GA-ST07] which follow reasonable worst-case distance of 25 mm hole scenario to define separation distances in the fire zone (refer definition in HSE-RM-ST01). FERA and HSE Design philosophy to be aligned.

The fire zones shall ensure that the consequences of a credible Major Accident event will not damage adjacent fire zones. This is to be done initially by appropriate separation, but where this is not possible then merging of the Fire Zone may be considered as well as other barriers (passive, active, procedural) barriers may be used to limit the risk of escalation.

The 'inherently safer' separation shall be taken from Appendix A, or by safety assessment using process specific information when available, to model a MCE (e.g. consequence modelling, FERA).

For each case where the inherently safer separation against a MCE cannot be achieved, Table 7-7 shall be completed to justify and document the deviation.

This shall be submitted to COMPANY for approval by COMPANY Technical Authority as indicated in Section 7.4.

Each fire zone for an ONSHORE facility shall have a boundary ESD valve, which shall be a minimum of 15m separation from flammable liquid containing plant and shall not be exposed to more than 12.5 kW/m² and 200 mbar pressure.

10.6.1.3 Toxic Zones

Areas that handle sour gas shall be categorised in accordance with COMPANY procedure HSE-OS-ST21 to ensure appropriate safeguards are adopted by personnel entering such H₂S Zones.

Toxic zones have only been explicitly defined by COMPANY for H₂S exposure. Any other toxic gas being processed will require a separate assessment.

Development of the overall Process Unit layout shall aim to minimise the impact of such areas on the overall operability of the facility (e.g. grouping Toxic systems into a part of the facility). This may involve containing process units or equipment with very significant toxic hazard inside a building or enclosure (see 10.6.3.5).

10.6.2 Critical & Occupied Structures [Ch 5.13]

10.6.2.1 Buildings – General

A building is “any structure used or intended for supporting or sheltering any use or occupancy” (NFPA101).

Refer section 7.5 in FERA std for more on building types definitions.

Building designs shall be of suitable structure construction type and meet building codes. The requirements for external walls to be smoke or gas barriers, and fire rated, or blast rated must be determined by project specific analysis, since building codes principally address internal hazards.

A building is a “Critical Building” where the failure of the building could cause or contribute substantially to; or its purpose is to prevent or limit the effect of a major accident or any accident with severe or catastrophic consequences. For buildings / receptors where impairment frequencies are more than the impairment criteria, measures associated with either design such as preventions of fire, reduction in fire duration or passive measures such as fire protection measures shall be provided.

Buildings shall initially be located using the principles and initial separation distances given in this standard. However, these distances shall be validated during consequence analysis performed during FEED.

All buildings should be located so that where possible no special design requirements for external walls (or roof) are required. However, where it is shown that there is no reasonable alternative to being located within range of a fire, explosion or toxic gas hazard, then in concept, preliminary study shall be performed to estimate the specifications required to enable cost optimisation of layout.

All buildings located on a facility shall be explicitly assessed using FERA to verify their protection against Fire, Explosion and Toxic events, as well as domino effects.

Key requirements related to layout for the following types of Structures are outlined below:

- Process (/Facility) Control Building
- Temporary Refuge (TR) & Temporary Shelter
- Living Quarters (LQ)
- Service Bridges
- General Stores
- Chemical Stores
- Other

10.6.2.2 Process (Facility) Control Building

The facility control centre (FCC) shall be located in a non-hazardous area and protected against Maximum Credible Events (MCE) by separation. This shall be demonstrated by Safety Study (e.g. consequence modelling or FERA).

Where the FCC cannot be located at sufficient distance Table 7-7 shall be completed to justify and document the deviation, which shall be subject to Company Technical Authority Verification as indicated in Section 7.4.

10.6.2.3 Temporary Refuge (TR) & Temporary Shelter

Any buildings, rooms or enclosures that are necessary in Emergency Response or as part of EER operations or contain HSECEs should not be in a blast area so far as practicable. If this is not achievable, then it shall be appropriately fire and blast protected and shall retain integrity after the fire or explosion at the design accident load from credible major accidents.

Separate studies shall be carried out as required by ADNOC HSE Standard HSE-RM-ST07 to demonstrate that these structures provide the degree of protection for the period needed to effect safe Egress & Evacuation.

From a layout perspective, any designated TR and Temporary Shelter shall be identified on the facility Plot Plan.

10.6.2.4 Living Quarters

ONSHORE: All residential housing shall be located remote from a hydrocarbon processing plant or Chemical plant perimeter fence, upstream of the prevailing wind direction. However, Land Use Planning risk criteria may require a much larger separation. Location of LQ shall be in line with HSE Risk Management Standard (HSE-RM-ST-01) covering HSE and Land Use Planning. LQ shall additionally comply with the relevant Group Company requirements.

Refer HSE-RM-ST01, HSE Risk Management for further details.

All types of accommodation buildings, temporary or permanent, and fly camps shall be comply with section 7.1.5 of HSE standard HSE-OS-ST21.

OFFSHORE, LQ should be segregated as far as practicable from wellhead areas and the process; preferably on a separate platform; follow the layout principles in Section 7.3.3.

10.6.2.5 Service Buildings

Service buildings are defined as buildings required to service the running of the facility. This includes administration offices, canteen, medical centre, security and fire station.

This also includes other buildings that are not part of the process but may incorporate features specific to the facility such as the control room, changing facilities, workshops, stores, warehouses or laboratories, and as such are typically located nearer to process areas. However, it is recognised that because of their purpose, occasionally some of these buildings may need to be in the plant area in which case they balance proximity to the plant with required blast and fire rating.

ONSHORE, Administration and Office Buildings shall be in close proximity to the main facility entrance and out of toxic zones and impact from fire and explosion. Otherwise these buildings shall be protected against the impact of MAH. ONSHORE, a building risk assessment according to ADNOC FERA, QRA standards shall be carried out to finalise separation distance and building design specifications.

10.6.2.6 General Stores

General stores should be located in an area classified as non-hazardous.

10.6.2.7 Chemical Stores

Chemicals store should be in the plant area, but as far as practicable from manned areas, and main Egress & Evacuation facilities

10.6.2.8 Other issues

- All service buildings should be close to the main site entrance. Car parking should be outside the facility fenceline where practicable.
- The main entrance points for vehicles and pedestrians shall be adjacent to security. Security staff shall have a good view of approach roads
- Road Off-loading to all buildings should not interfere with other site traffic.

- OFFSHORE offices shall be located preferably on the accommodation platform.

10.6.3 Process Units [Ch 5.15] – Emergency Response

The general requirements for Process Unit layout are largely covered Section 10.6.1, Separation (Block – Block) [Ch 5.12], and a checklist of issues to consider is provided in Appendix C, Section C.1.3.

Most process units are located outside. See 10.6.3.5 where process units are located inside a building.

The main aspect outstanding is the provision for Emergency Response, which is dealt with here under the following headings:

- Process Unit Spacing & Arrangements
- Firefighting & Emergency Vehicle Access
- Firefighting Access Roads
- Escape Routes

10.6.3.1 Process Unit Spacing and Arrangements

Guidance on good practice for Emergency Response is provided in Ref. 41 (EI Model Code of Safe Practice – Part 19: Fire Precautions at Petroleum Refineries & Bulk Storage Installations), Section 4.8.5. This requires safety assessment to understand fire scenarios and where they can occur within the process. Key requirements from a layout perspective are:

- Access to credible fire scenarios from two direction;
- Location of firewater equipment
- Firewater ring mains, and hydrants.

A rectangular grid pattern, as described in Section 10.6.1 allows these requirements to be satisfied. Spacing requirements will need to consider the location of firefighting personnel in relation to the fire they are trying to control. The plant areas should be rectangular and accessible on all four sides by a road; no greater than 20000m² in area with no side longer than 200 m. Any plant areas larger than this shall be divided by Fire Zone or at least by fire breaks of at least 15m width; plant roads often serve this purpose.

The above dimension may be modified subject to assessment of escalation potential from the Fire Zone based on FERA & group company approval.

Fire spread can also be limited by installing low walls or kerbing around process areas and connecting it to a hazardous drains system (but not storm water system).

10.6.3.2 Firefighting & Emergency Vehicle Access

ONSHORE facilities shall have access to the public road system suitable for emergency vehicles at least at two points and shall have a patrol/maintenance road around the perimeter.

Within the facility, site roads shall be arranged to permit Emergency Vehicle access using the following road categories:

- Primary Plant Roads
- Secondary Plant Roads

- Plant Access Roads

Detailed dimensions are given in the Piping Basis of Design (AGS-SP-09-001, Ref. 1), and are intended to allow approach from two directions to major fire hazards.

Plant Access Roads shall be provided to allow access within Process Units for firefighting purposes.

Fire water ring mains are typically laid alongside plant roads. At least one access road shall remain passable in any combination of fire scenario and environmental conditions. The turning radius shall accommodate emergency response equipment.

Fire monitors shall be 15 metres away from the edge of the plant area they are intended to protect, as well as at least 3m from the road. The layout shall be such that the fire water can be contained, or drained, to preclude any risk of liquid running fire.

Fire Stations shall be located so far as practicable away from equipment that could release a flammable gas and should be upwind or crosswind from the main process plant.

Fire stations shall be located at a minimum distance of:

- 100 m from equipment that could release a flammable gas and un-ignited cloud.
- 15 m from office buildings.

10.6.3.3 Firefighting Access Roads

Roads serve for firefighting or mobile equipment or both to safely enter or leave a fire area. Single track roads shall have passing spaces at regular intervals. Hard stand areas shall be provided adjacent to open water sources to allow firefighting appliances to be located without blocking access routes. Where elevated platform trucks are used for firefighting, parking space should be provided on the side of road to permit deployment of stabilising outriggers on stable ground. See details in Piping Basis of Design AGS-SP-09-001 (Ref. 1).

The turning radius shall be a minimum of 15 m to accommodate emergency response equipment and shall consider the turning circles of equipment likely to be deployed at the facility.

The potential for the impairment or access to and/or disabling of emergency response and firefighting utilities shall be considered in the facility layout and in the Plant Emergency Response Plans (ERP's).

Speed bumps shall not be provided on routes for firefighting.

During incidents, the downwind side can become inaccessible because of the effects of smoke and radiant heat. In complex multiple incidents, some major roads may become unusable by emergency vehicles because of direct damage (sewer covers blown off, sewers on fire, water and product runoff) or being littered with debris from explosions.

Site roads around storage tank compounds should have parking space for two fire trucks on one side of a road for each fire hydrant or each semi fixed system connection point.

Vehicular accessways shall be as straight as practicable and free of overhead structures except where pipe racks, ducts, and conveyors are located, and shall minimise crossing main drainage systems and cable

trenches. Equipment shall not protrude into accessways. Process equipment shall be located so that the accessways are not classified as being in Zone 0 or 1 areas.

Height clearance indicators/barriers to indicate/prevent potential impact into vulnerable stationary process equipment/piping above accessways and mobile equipment (e.g. crane jib) shall be provided.

10.6.3.4 Egress & Evacuation Routes

Safe means of Egress and Evacuation shall be provided on all facilities for all credible emergency conditions, throughout the year, regardless of whether or not they are regularly manned.

Such routes have been categorised as:

- Primary Escape Routes
- Secondary Escape Routes

The Piping Design Basis (Ref. 1, AGES-SP-09-001) details width and height requirement for these route.

The maximum 'dead end' distance beyond which secondary egress route (e.g. monkey ladder) would be required is also defined in (Ref. 1).

Egress routes shall be available and useable under emergency conditions, from all work locations to the place where people will muster. Egress routes can also serve as an operational access.

Egress routes for emergency evacuation and muster areas during the construction phase shall also be provided. Availability of at least one Egress route under all credible events shall be demonstrated by EERA study.

Ideally all locations accessible by people on a facility should have two routes of egress. Areas that are manned or are regular working areas shall have both a primary and secondary escape route.

The exits from buildings shall be arranged in accordance with ADIBC and UAE Fire Code. FERA and Building Risk Assessment shall determine if building external components (e.g. walls) are to be fire or explosion proof, or gas tight and if building egress locations need to be enhanced due to external hazards.

10.6.3.5 Process Buildings [Ch 5.15.1]

Most process units are located outside. Occasionally for reasons of climate, toxic release potential, noise, odour or quality control, the project may decide that a process unit or equipment needs to be fully enclosed within a structure. Any such process buildings must be treated as a 'block' for layout purposes, although safety assessment is required to determine whether the block can be treated as an unoccupied or non-critical or presents an external hazard.

Process buildings are defined as 'buildings where the primary purpose of the building is to house process equipment rather than people'.

Where process plant is located inside a building, then process hazards are also inside the building and a hazard assessment specific to that process building will be necessary to determine any internal safety requirements (e.g. forced ventilation, fixed firefighting systems, explosion suppression and venting), as well as the extent of any hazard outside the process building, as the separation distances in Appendix A may not be appropriate.

In all cases, ventilation shall be provided to create a suitable atmosphere for personnel, as well as meeting all hazardous area classification requirements.

Process units handling flammable materials should not be inside fully enclosed buildings without good reason due to the increased potential for a vapour cloud explosion even from a small release. Process Units handling high concentrations of toxic materials where releases could result in a fatality can be inside fully enclosed buildings. If the material is toxic and flammable, then a risk assessment may be required to determine the best balance of risks.

10.6.4 Tank Farms [Ch 5.16]

10.6.4.1 General

Tank farms should be located away from occupied buildings in remote parts of the site if practicable so that separation is provided large hazardous inventories and manned areas.

Key aspects to consider include:

- Spill containment (bunds/dykes & drainage)
- Above /underground storage
- Incompatible materials in nearby tanks
- Firefighting requirements (see Section 10.6.3)

Initial separation distances are given in Appendix A, for concept work. Further refinement of these distances will require specific safety assessment studies.

In areas of high ambient temperatures, API Class II liquids can become flammable liquids due to the ambient conditions exceeding the fluid flashpoint temperature.

A checklist of issues to consider is given in Appendix C, Section C.1.4. Further guidance should be taken from the Safety and Environmental Standards for Fuel Storage Sites, Buncefield Standards Task Group (BSTG, Ref. 54). Further guidance is given in Text Box **10-2**.

Text Box 10-2: Guidelines for Layout of Tank Farm

1. Prevailing winds: Locate tank farm downwind of manned areas
2. Slope: On lower elevation than manned, utility and process areas
3. Grouping: According to similar relative risk with respect to fluid stored
4. Segregate reactive fluids and do not locate them in common bunds
5. Tanks > 15 m diameter: To be directly accessible from a firefighting access road on at least one side.
6. Tanks > 40 m diameter: To be arranged in rows not more than one and be adjacent to road or access way, for adequate firefighting accessibility.
7. Tanks containing hazardous material either grouped together or single are required to be surrounded by bund walls to contain the tank contents in the event of a tank rupture. The net volumetric capacity

bund wall must be at least 110% of the volume of the largest tank plus 0.3m freeboard. (See HSE-GA-ST07)

8. Maximum number of tanks in one bunded area shall meet the following requirements:
 - a) single tank size is not limited, except by Risk Assessment
 - b) hydrocarbon storage shall not exceed 120000m³ capacity in total in multiple floating roof tanks
 - c) hydrocarbon storage shall not exceed 60000m³ capacity in multiple fixed roof tanks
 - d) no more than two crude oil tanks larger than 60000m³ each
 - e) no more than 6 tanks in total
9. All tanks within bunded areas, whether it be a group of tanks or single tank must have maintenance and safety vehicle access to two sides of the bunded areas. Only piping connected to the tanks in the bund is allowed to run in the bund.
10. Tank Separation distances should consider the potential of 'Boilover' scenarios where applicable.
11. Tanks storing hydrocarbons shall be located 75m minimum, from any process unit.
12. There should be no more than two rows of tanks between adjacent access roads.
13. Pumps, valve manifolds and transfer piping shall be installed outside of bund walls to minimise the amount of piping, valves and flanges in the bund area.
14. Smaller intermediate tanks less than 38 m³ can be treated as process vessels for spacing concerns (as proposed by CCPS).
15. Bunds may be subdivided with lower walls to contain small spillages into the area relating to a single tank.
16. Tank bunds should be paved or lined to avoid seepage of any spillages into the ground.
17. Storage Area: Location & separation shall be based on specific Risk Assessment

10.6.4.2 LNG Storage

Refrigerated LNG shall not be stored in a process unit and shall be stored remotely from other products.

Design of LNG process Trains and storage shall in strict compliance with relevant Design Standard selected by COMPANY and licensor approved design, meeting all the risk mitigation. Following are the internationally adopted standards on LNG:

- NFPA 59A Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)
- EN 1473 -Installation and equipment for liquefied natural gas — Design of onshore installations
- ISO 16903 Petroleum and natural gas industries — Characteristics of LNG, influencing the design, and material selection.

Any deviation Shall require approval by COMPANY Technical Authority.

Plots shall be graded so that potential spills or leaks of LNG do not drain to areas where water can collect or pool. (The heat transfer from water to LNG is far higher than from the ground, leading to higher evaporation rate.) A spillage of LNG onto water can lead to a rapid phase transition (RPT) event.

For refrigerated dome roof tanks provide spacing between groups of vessels of at least 30m or the largest tank diameter.

10.6.4.3 LPG Storage

Hazard zones from LPG tanks are very large, sometimes extending outside the plant boundary and so must be evaluated early in design phases. LPG storage OFFSHORE is not allowed. ONSHORE LPG storage should be buried or mounded tanks. Pressurised LPG storage within the battery limits of a process unit is not permitted. Pressurised LPG should be stored remotely in a separate Fire Zone from other products.

All LPG storage and associated facilities, (piping, pumps, compressors, vaporisers, control systems) and facilities for loading /unloading bulk road vehicles and rail tankers, shall be located in an open uncongested area on the same area of the site, in a separate Fire Zone from other process facilities.

LPG liquid process inventories (e.g. distillation column bottoms) shall be shielded from the potential direct jet flame impingement from any hydrocarbon piping (especially LNG or LPG) as far as possible.

LPG logistics shall be segregated from other material movements. Loading/unloading facility should be away from main plant facility and separated via a fence with access control. LPG loading should be spaced

- 45 m from other types of loading racks
- 60 m from storage tanks
- 75 m from process equipment
- 150 m from unrelated occupied buildings.

Horizontal vessels that are not buried shall be placed parallel to each other (dished ends not pointing at another vessel). No more than six vessels shall be grouped together. Vessels shall be located so that they cannot be damaged by impact from vehicles.

Further guidance on layout of LPG storage facilities should be taken from Ref. 39 (EI Model Code of Safe Practice Part 9: Large bulk pressure storage and refrigerated LPG).

10.6.5 Others [Ch 5.17]

A checklist is provided in Appendix C, Section C.1.5 to address other areas that include:

- Flares (& vents)
- Facility support operations
- Wastewater operations
- Chemicals storage
- Compressed & liquefied gas storage
- Emergency response (/medical) facilities
- Fire training areas (on-site)
- Miscellaneous (other on-site areas):

This Section gives guidance on the first element, with other aspects already covered in preceding Sections.

10.6.5.1 Flares & Vents

Flares subject the surrounding area to thermal radiation when lit. The thermal radiation impact and the impact of combustion gases and smoke shall be determined. Flare design shall also consider a 'flame out' scenario.

Cold vents subject the surrounding area to the gases dispersed from the vent. A dispersion study shall determine the impact of such vents to determine suitable vent height and location. Cold vent design shall also consider an ignited scenario similar to a flare if the vented gas is flammable.

For layout purposes, a flare or cold vent should be treated as a Process Unit, that has a potential hazard (exclusion) zone due to thermal (radiation) effects or as a source of a gas cloud that is flammable or toxic if it is not combusted.

A flare with a permanently lit pilot is also a potential ignition source for any migrating gas cloud, accidentally released from containment.

The location of flare and vent discharge points shall therefore have to be supported by dispersion and ignited case thermal radiation modelling using consequence analysis. The COMPANY methodology for this is given in References for flare thermal, toxic impact, sterile zone etc. 1. HSE Design Philosophy HSE-GA-ST07 and 2. PPC HSE-EN-ST02 3. HSE-OS-ST21 H2S standard.

The thermal radiation impact footprint due to flares or accidental ignition of any cold vents shall not extend beyond the perimeter fence of an ONSHORE facility. Sterile zones within the facility are to be determined by consequence analysis.

Generally, Flares shall be located; -

1. Remote from process facilities, storage areas, utility areas, and service and office areas.
2. Inside the property line because they are a source of ignition, thermal radiation and vented gas following flameout.

Flares shall be located down-wind, or cross-wind based on flare radiation and dispersion study in line within HSE Design Philosophy.

The flare area shall be devoid of through roads, equipment requiring regular presence of personnel, equipment which cannot withstand thermal radiation or features which constitute a safety concern, e.g. open sewers.

For multiple flares, locations shall be determined following assessment of the need for independent operation or the cases where maintenance of individual flares will be necessary.

OFFSHORE installations shall consider the requirements of Country Civil Aviation Regulations and their impacts upon the design and location of Helidecks (and vice versa).

10.6.6 Utilities [Ch 5.18]

A checklist of utility types that need to be considered is given in Appendix C, Section C.1.6.

Facility utility services shall be grouped together in a non-hazardous area unless the utilities are integral to the process.

Loss of utilities should be a consideration as part of the layout process. Utilities that are critical for safe operation or shutdown (and therefore should be identified as HSECEs) should be safely located or adequately protected in accordance with appropriate performance standards. This will typically mean that equipment such as Fire Water pumps and Emergency Diesel Generators will be located remotely from the process facilities. Redundancy of supply (which may extend to supplies by others external to the facility) should also be considered as part of whole facility design, which may include redundancy of physical location or routing.

The layout shall place utility systems that are essential under emergency conditions in a safe area or failing that determine how they can be protected.

- Diesel Storage Tanks are generally lined up along the primary roads to facilitate filling through Truck Unloading Bays.
- Contaminated water drainage from onsite and offsite areas will be routed to suitable treatment facilities located remote and lowest grade from the plant area.
- Cooling towers should be oriented so that the plume blown by the prevailing wind does not affect downwind process units

Air separation units that manufacture oxygen as a primary product shall be treated as a process unit for the purpose of layout. The layout should consider the implications of any cryogenic liquid spillage.

10.6.6.1 Plant Buildings

Plant buildings are defined as buildings where the primary purpose of the building is to house equipment rather than people. This includes electrical substations, analyser houses, low pressure steam, water pump houses and air compressor buildings. These are usually located within utility areas. Any such plant buildings must be treated as a 'block' for layout purposes, although the block can be treated as an unoccupied and non-critical building which does not present a hazard, unless safety assessment determines otherwise.

Plant buildings may be pressurised where they house an ignition source (e.g. electrical switchgear).

10.6.7 Optimising Location of Process Units [Ch 5.19] & Resolving Issues [Ch 5.20]

Optimising the layout of the Process Unit building blocks is an iterative one that is covered above in Section 10.1.2. In case the initial separation against an MCE is not achievable, alternative measures are required to limit the risk. Such measures shall be selected in the preferred ISD hierarchy of inherent safety, ahead of passive, active and procedural, respectively.

The 'inherently safer' separation shall be taken from Appendix A, or by safety assessment using process specific information when available, to model a MCE (e.g. consequence modelling, FERA).

For each case where the inherently safer separation against a MCE cannot be achieved, Table 7-7 shall be completed to justify and document the deviation.

This shall be submitted to COMPANY for approval by COMPANY Technical Authority as indicated in Section 7.4.

10.7 Project Implementation: Transport & Materials Handling

Materials handling issues have been considered at length in Section 9.7. The requirement at Process unit level is to consider each type of transport is dealt with within or adjacent to the selected facility boundary. A checklist is given in Appendix C, section C.1.2. Further guidance is given in this Section regarding aspects identified in Table 10-5.

Table 10-5: List of Guidance – Materials Handling

Section	Reference to CCPS (Ref.22)	Checklist Appendix C. (link)
	Material Handling [Ch 5.14]	C.1.2
10.7.1	Pipelines	
10.7.2	Road (Trucks) & Rail	
10.7.3	Marine	
10.7.4	Solids	

10.7.1 Pipelines

There shall be isolation valves at the facility boundary to ensure the amount of inventory that can be released within the active part of the facility is minimised.

The pipeline isolation valve shall be located in a remote part of the facility to prevent damage from routine operations and to limit the risk to occupied areas.

Intermediate pipeline isolation shall be provided for ONSHORE pipelines, as a minimum, in accordance with ASME B31.4 and B31.8 codes. Minimum space required for pipeline corridors is defined in pipeline standards.

All incoming and outgoing pipelines should be grouped into a well-defined corridor with adequate clearance between each pipeline and should not pose an obstacle for mobile equipment and personnel operating inside the facility. Main oil or gas import or export lines should be run away from facility occupied buildings.

New OFFSHORE pipelines shall be routed along the landfall of the existing sub-sea pipelines / cables approach where practicable. OFFSHORE Pipeline routing shall take cognisance of future drilling campaigns with respect to Rig Access and potential for Dropped Objects during SIMOPS activities. Pipelines, flowlines and expansion spools near an OFFSHORE facility shall not be routed in the supply boat loading zone where there is unacceptable risk of damage due to anchor drag or dropped objects.

10.7.2 Road & Rail Logistics Areas

Logistics areas are those plant areas concerned with the loading or unloading of products and raw materials in bulk by truck, train, ship, or aircraft. Logistics areas should take place in a separate plant area due to the need for separate security arrangements.

- Loading and unloading facilities for flammable or toxic materials should be downwind or crosswind from process units and for flammable materials from strong sources of ignition, based on the prevailing wind direction.

- Road vehicle loading and unloading stations, for flammable and combustible liquids, should be near the plant gates to minimise internal site traffic and should avoid process areas.
- Road and rail loading and unloading facilities for API Class I or II (2) products shall be located at least 15 m from other sources of ignition, including the site boundary and 15m from any flammables processing area.
- Bulk products shall not be exported by air without specific risk assessment.

For additional guidance on the location and layout of material transfer facilities, see API 2610 and EI Model Code of Safe Practice Part 2: Design, construction and operation of petroleum distribution installations.

10.7.3 Marine

The unloading and loading of LNG and LPG create a hazard of flammable gas clouds from a spillage. Consequently, separation distances from berths to sources of ignition shall be at least:

- Crude and non-LPG Carriers 40 m
- LNG carriers 200 m
- Refrigerated LPG carriers 300 m

These distances are based on the presence of Emergency Shutdown (ESD) systems and Emergency Release Couplings (ERCs) for LNG and refrigerated liquefied petroleum gas (LPG) services.

Marine Mooring: Marine Mooring (SPM) and Loading Arm used for offshore operation / berth shall be designed according to International Maritime Organisation (IMO), Oil Companies International Marine Forum (OCIMF), and specific risk assessment (e.g. QRA).

10.7.4 Solids handling

Solids handling plant (e.g. sulphur granulation) and loading facilities should take place in a separate plant area to prevent dust accumulation in other plant areas and to ensure that an emergency in the main processing facility does not impact the operation of solid handling facility.

The handling of combustible dusts or solids that can generate dust when handled, gives rise to dust explosion hazards. The extent of dust explosion impact shall be studied, and separation distances set accordingly.

11 STEP-3: LAYOUT 'EQUIPMENT' (WITHIN PROCESS UNITS)

11.1 Overview

11.1.1 Objectives & Scope

The aim of this Section is to give guidance on Step 3 of the 'Building Block' approach described in Section 7, and Figure 7.3-1 ('Equipment' Layout). The scope is not limited to equipment within 'process units' but covers all facilities including utilities and manned areas.

It is intended that decisions in step 3 should support the layout principles applied in Steps 1 and 2.

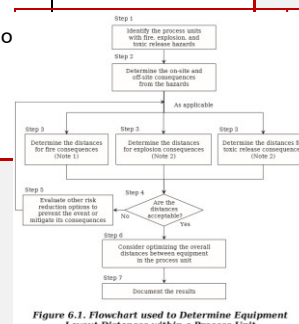
Step 3 involves placement of the required equipment items within the plot spaces selected by Step 2. This step also needs to allow space for operations and maintenance access and for egress routes within the plant areas, and their connection to the wider on-site emergency response arrangements.

11.1.2 Approach

The overall approach to Step 3 is summarised schematically in Table 11-1, below using the general project planning framework in Table 7-4, comprising team selection, information gathering, hazard identification and assessment, and project implementation.

Table 11-1: Layout Development Approach (Step 3 – Equipment)

Assessment	Description	Layout Development Process - 'Equipment' Level		
1. Team	Site Selection Team – Competencies			
2. Info - Site /Project	Site Information Support Infrastructure			
3. Haz. Id. /Assessment	Hazard Identification - Operations - Construction	Hazard Identification & Study Types		Comment
		1	Verify separation distances from previous stage.	
	Other Safety & Risk Assessment Studies	2	Support Layout Optimisation	
			If separation too 'LARGE': - Reduce separation: - Less inventory - Less cost (reduce land prep, piping, etc.). If separation too 'SMALL': - Increase separation (to improve ISD). - If not possible: - Investigate other measures (passive, active, procedural)	Safety Studies: - Consequence modelling - FERA - QRA - etc. Engineering Safety Studies: - Haz Area Classification - PPA Assessment - Active Fire Protection - EEERA - ESSA, etc. In reality, natural project processes drive down plot size for Value reasons (so 'too large' is not likely to be a major issue).
4. Project Implementation	Basis & Constraints	Iterative (consistent with CCPS, Fig. 6.1 - reproduced)		
	Materials Handling			
	Engineering Design			
	Utilities			
	Other Manpower Issues			
	Plot Size (& detail)			



The structure of this Table is similar to that of Table **10-1**, and shares the same technical objectives of verification of separation and supporting layout development. Once again, the lower part of the Table emphasises the iterative nature of the process.

11.1.3 Level of Detail

Placement of equipment within the selected blocks is typically carried out at FEED stage and refined in Detail Design. Items from other types of systems (utilities, manned areas, etc.) are also normally positioned during FEED.

This will help decisions about site preparation (and construction activities) to be taken.

The degree of evaluation and assessment needs to be thorough enough to make final decisions, as the ability to change rapidly diminishes as the project progresses.

This may require a final look at the project specifics in terms of the hazards and vulnerabilities that are present so that the plot can be customised to suit. Good industry practice for this step is given in Ref.22, which has been assembled to build on the format presented in Table **9-1** for step 1, and is shown below in Table **10-2**.

11.1.4 Assessment Structure

Columns 1-4 in Table **11-2**, repeat key headings of Steps 1 and 2, and are retained to show how consideration needs to progress to a more detailed level in columns 5 and 6 for Step 3.

Table 11-2: Process Unit Layout – Main Steps & Guiding Information

Assessment	Issue		Step 2: Process Unit Layout	Step 3: Equipment Layout	
	Description	CCPS Chapter	CCPS Chapter	CCPS Chapter	Checklist (Appendix)
1. Team Competency	Site Selection Team – Competencies	4.3 Site Selection Team			
2. Location Information (each)	Site Information	4.7 Maps & Information	5.7 Step 1 – Location characteristics		
		4.8 Geological			
		4.9 Weather			
		4.10 Seismic			
		4.11 Off-site	5.8 Off-site Issues		
		4.13 Environmental	5.10 Environmental		
		4.14 Infrastructure	5.11 Infrastructure		
		4.15 Building and Structure			
	Support Infrastructure	4.12 Security	5.9 Security		
		4.17 Communication			

Assessment	Issue		Step 2: Process Unit Layout	Step 3: Equipment Layout	
	Description	CCPS Chapter	CCPS Chapter	CCPS Chapter	Checklist (Appendix)
3. Hazard Identification (& Assessment)	Hazard Identification (High-Level) • Operations	Appendix C	5.2 Methodology Overview (Block Layout)		
			5.3 Integration (Block Layout – Facility Location)		
			5.4 Process Units – Preventative Measures		
			5.5 Process Units – Mitigative Measures		
			5.12 Step 2 – Separation (Block – Block)		
	• Construction (SIMOPS) Issues		5.6 Construction & Turnarounds		
4. Project Assessment (for each location)	Basis & Constraints	4.2 Facility Information			
	Plot Size		5.12 Step 2 – Separation (Block – Block)		
		4.5 Plot Size	5.13 Critical & Occupied Structures	6.6 Critical & Occupied Structure (Design Issues)	Appendix D
			5.15 Process Units	6.7 Layout Issues – Equipment	Appendix D
			5.16 Tank Farms		
			5.17 Others		
			5.18 Utilities		
			5.19 Optimising Location of Process Units		
			5.20 Resolving Block Layout optimisation issues		
	Materials Required	4.16 Material handling	5.14 Material Handling		
	Constraints				
	- Pipelines				
	- Road (Trucks)				
	- Rail				
	- Marine				
	- Air Carrier				
	Materials Handling – Plan				

Assessment	Issue		Step 2: Process Unit Layout	Step 3: Equipment Layout	
	Description	CCPS Chapter	CCPS Chapter	CCPS Chapter	Checklist (Appendix)
	Engineering Design	4.18 Engineering Design			
	Utilities	4.19 Utilities			
	Other Manpower Issues	4.20 Other (manpower related)			

11.1.5 Structure of Detailed Step 3 Guidelines

Subsequent parts of this Section are structured as follows to cover Step 3 of the building block process:

- Team Competencies : Section 11.2
- Location Information & Block Layout : Section 11.3
- Hazard Identification (& Assessment) : Section 11.4

- Equipment Layout – Key Layout Principles : Section 11.5
- Equipment Layout – Equipment Specific Issues : Section 11.6
- Critical & Occupied Building Design : Section 11.7

11.2 Team Competencies

The team for 'Equipment' layout requires similar skills to those described in Section 10.2 for Step 2. It is however important to note that the level of consideration will again be more detailed in this instance, meaning that individuals with experience of Detail Design should be selected to ensure the high-level principles established in Steps 1 & 2, for example:

- Clear Escape Routes to ensure EER arrangements are not compromised
- Minimise congestion and good ventilation to protect against VCE damage, etc

11.3 Location Information & Block Layout

The Step 3 Engineering design involves locating the equipment within a layout generated in Step 2.

The location information required is typically identified during Step 2 FEED Engineering and Hazard Identification /Assessment work. It will need to be updated in Detail Design as more item specific Vendor information is received in terms of size and weight. Further guidance on this is available from Ref. 22 .

11.4 Hazard Identification (& Assessment)

The objectives of hazard assessment work for Step 3 can be described as elaborating where necessary on studies done in stage 2, including safety assessment for verification of Separation Distances and optimisation of equipment layout following ISD hazard management strategies.

11.4.1 Verification of Separation Distances

The first objective is to verify separation Distances for stage 2 and 3. Again, the equipment separation distances would likely be based on typical separation distances from past experience (see Appendix A) but refinement may be possible due to safety studies at FEED or detailed design stages.

The main difference expected in Step 3 is that less focus is expected on distance verification by Consequence Modelling since the separation between equipment is normally small compared to the error margin in Consequence Modelling estimates.

It is expected that the work will be more geared towards layout optimisation using alternative protection measures from the ISD hierarchy and protective measures out of FERA results discussed in Section 7.3.3.

This especially the case for toxic effects, where the dispersion distances to the normally modelled concentration levels (can be quite large by comparison with equipment separation within a Process Unit.

HSE-OS-ST21 Management of Hydrogen Sulphide is applicable for engineering design basis aspects for locating manned areas away from H₂S impact or that barriers (PPE, BA) are introduced for the safety of both company personnel and the public ensuring minimum impact.

The main exception to this observation is that more detailed item specific information will become available in Detail Design, which will need to be represented on the layouts. It is normal for preceding Steps to have used conservative estimates, meaning that detailed information should not result in a larger equipment footprint. However, if a larger area is required at Step 3 than estimated at Step 2, then the degree of protection will likely require reassessment (part of the iterative hazard Assessment process).

11.4.2 Layout Optimisation

In Step 3 equipment layout within a Process Unit should initially be driven by the process flow and the grouping of equipment by type (e.g. putting ignition sources such as fired heaters together). Then separation distance tables can be employed to review and modify the layout. Finally, consequence analysis which should supplement the default separation distances, should consider fire, explosion and toxic impact can be further employed to review and modify the layout.

This is typically done initially at FEED, and is subject to the iterative Hazard Assessment process described in Table 11-1, using the ISD approach described in Section 7.3.3. Some of the details may require further assessment in Detail Design as more item specific Vendor information is received.

11.4.3 Detailed Guidance

Further detailed guidance for Step 3 is given in Ref. 22, representing good industry practice for Equipment layout as follows:

- Methodology Overview (Equipment Layout) [Ch. 6.2]
- Separation (Equipment – Equipment) [Ch. 6.2.2]
- Integration (equipment Layout in Blocks) [Ch. 6.3]
- Equipment – Preventative Measures [Ch. 6.4]
- Equipment – Mitigative Measures [Ch. 6.5]
- Critical & Occupied Structures [Ch. 6.6]

- Equipment [Ch. 6.7]

11.4.4 Structure of Detailed Step 3 Guidelines

Subsequent parts of this Section are structured as follows to cover Step 3 of the building block process:

- Equipment Layout – Key Layout Principles : Section 11.5
- Equipment Layout – Equipment Specific Issues : Section 11.6
- Critical & Occupied Building Design : Section 11.7

11.5 Equipment Layout – Key Layout Principles

11.5.1 Assumptions

Hazardous Area Classification: The Principles outlined in this Section assume that good engineering practice will be applied to ensure potential ignition sources during normal operations are avoided by applying one of the industry recognised Hazardous Area Classification Codes (e.g. EI 15, Ref. 40).

This means that the following type of items shall not be located in areas that are Classified as Hazardous.

- Gas turbines/generators
- Electrical switchgear
- Workshops
- Stores, etc.

11.5.2 Layout Features & their Objectives

A number of important layout features (/principles) have been developed to assist the Layout Discipline in preparing an 'Equipment' level plot plan. These features fall within the following categories:

Hardware Issues:

1. Hazardous Equipment Arrangement
2. Piperack arrangement
3. Critical Equipment / Structures
4. Spill Containment
5. Fire & Gas Detection
6. Storage Tanks (& arrangement of associated equipment).
7. Buried /Mounded

Space between Process Units

8. Separation (increased)
9. Safety Air Intakes
10. Multi-level layout
11. Walkways through Process Unit
12. Maintenance /Access
13. Passive Protection
14. Enclosing Walls

Understanding the role of these features is important when seeking to balance any conflicting requirements. In order to do this, their benefits have also been categorised in relation to Operability and Maintenance, and Major Accident Risk. The benefits are listed in Text Box **11-1** and incorporated into Table **11-3**.

Table **11-3** has been prepared to correlate each layout feature to their specific Operability and Risk Management objectives. This Table is directed at the Layouts Discipline as an easy reference for plot plan development.

It should be noted that some of the features are beneficial and a number are detrimental to the objectives stated. These have been marked as 'prefer' and 'avoid', respectively.

Text Box 11-1: List of Objectives & Benefits

Operability & Maintenance

Risk Management

- Prevention (Avoid Initiating Event)
- SCE (Survivability)
- Detection (Trigger Active Responses)
- Mitigation (Escalation Avoidance)
 - Knock-on (/Domino Effect)
 - VCE (Ventilation, Congestion)
 - Emergency Response (Egress / Escape, Fire-fighting Access)

Table 11-3: Key Layout Principles (& their Objectives)

Step 3 Layout Features – Equipment Level				Objectives									
				Operability & Maintenance	Risk Management								
					Prevention	SCE	Detection	Mitigation					
								Escalation Avoidance				ER	
				Avoid Initiating Event	Survivability	Trigger Active Responses	Knock-on (/Domino Effect)	VCE		Egress / Escape	Fire-fighting Access		
								Ventilation	Congestion				
Process Unit Equipment / Hardware													
1	Hazardous Equipment Arrangement	Use Tabulated equipment separation from Appendix A.	Prefer	P					P	P	P		P
		Similar eqpt. Together (pumps, vessels, etc.)		P					P				P
		Vents						P					
		Closed Drains & Flare Knock-Out Vessels		P									

Step 3 Layout Features – Equipment Level				Objectives											
				Operability & Maintenance	Risk Management										
					Prevention	SCE	Detection	Mitigation							
								Escalation Avoidance				ER			
								Avoid Initiating Event	Survivability	Trigger Active Responses	Knock-on (/Domino Effect)	VCE		Egress / Escape	Fire-fighting Access
Ventilation	Congestion														
		Multiple eqpt. Rows between passageways	Avoid	X	X				X	X	X	X			
		Lifting over live plant		X	X										
2	Piperack arrangement	Liquid at lowest level	Prefer					P							
		Straight runs within Process Unit							P	P	P				
3	Critical Equipment / Structures	ESD & Blowdown Valves – protection	Prefer			P									
		Firewater – Deluge Valve Protection				P				P	P				
		Firewater System Outlets	Prefer					P				P			
		Manned Structures	Avoid					X							
4	Spill Containment	Primary, Secondary & Tertiary	Prefer					P							
5	Fire & Gas Detection	Avoid blocking Line-of-Sight devices (gas /flame)	Prefer					P							
		Avoid dead spots						P							
6	Storage Tanks (& arrangement of associated equipment).	Pumps (outside bund)	Prefer	P				P				P			
		Isolation valves (outside bund)		P				P				P			
		Drains – Isolation valve (outside bund)		P				P							
		Cooling / heating /firefighting piping – impact on Egress routes inside bund	Avoid								X				
		Multiple tanks in same banded areas						X				X			
7	Buried /Mounded	Tanks & equipment	Prefer					P							
Space Between Process Equipment															
8	Separation (increased)	Road to Equipment (impact avoidance)	Prefer		P										

Step 3 Layout Features – Equipment Level				Objectives								
				Operability & Maintenance	Risk Management							
					Prevention	SCE	Detection	Mitigation				
								Escalation Avoidance		ER		
					Avoid Initiating Event	Survivability	Trigger Active Responses	Knock-on (/Domino Effect)	VCE		Egress / Escape	Fire-fighting Access
Ventilation	Congestion											
9	Safety Air Intakes & Vents	From Safe Areas	Prefer		P			P				
10	Multi-Level layout	Liquid at lowest level	Prefer					P				
		Decking – Grated						P	P			
11	Egress & Escape Routes through Process Unit	Unobstructed	Prefer						P	P	P	
		No encroachment of Hazardous Areas						P	P	P		
12	Maintenance & Operations	Access for Equipment	Prefer	P							P	
13	Passive Protection *	Fire (/blast) Wall	Avoid					X	X	X		
		Passive Fire Protection	Prefer			P		P				
14	Walls & Barriers *	Modules: Full /partial enclosure of Structures	Avoid						X	X		
		Plated decks						X	X			
		Shielding (radiation)						X	X			

* - Preference for ISD approach, however with in process area (equipment to equipment impact) and within fire zone, mitigation measures such as passive and active system need to be implemented to avoid escalation.

Each of the layout features are clarified further in the sub-sections below with respect to their 'equipment level' importance.

11.5.3 Hazardous Equipment Arrangement

11.5.3.1 Use Tabulated separation from Appendix A.

The initial separation between items of equipment should be based on separation distances contained in Appendix A of this document.

Where the item is not listed, a suitable alternative should be selected based on its hazard potential with respect to fire risk. The COMPANY Risk Matrix should be used to assess the fire hazard potential (likelihood & consequences).

11.5.3.2 Similar eqpt. Together (pumps, vessels, etc.)

Equipment of a similar mechanical and hazard type should be placed in close proximity, so far as practicable, to improve maintainability and constructability and allow fire hazards to be segregated for ease of firefighting and Emergency Response.

11.5.3.3 Vents

11.5.3.3.1 Non-Flammable Vents:

Vents for non-flammable components (such as N₂, CO₂, exhaust gas) should also be subject to a dispersion study to evaluate a suitable location and elevation.

Disposal of flammable materials to cold vent (rather than flare) shall not normally be allowed unless exceptionally permitted by a specific risk assessment study. The study shall demonstrate safety of personnel in the event of an ignited discharge case from the vent.

The justification shall be documented using Table 7-7, and submitted for COMPANY verification.

11.5.3.3.2 Exhaust Gas vents

Any vent that can exhaust a gas (including any incorporated liquid droplets or suspended solids) that can burn shall be subject to the design criteria of a flare system.

Any vent that emits non-flammables should be located taking into account the dispersion of the gas to a point where the concentration of any gas component is below any harmful concentration level.

Exhaust gas vents are a concern because high gas flowrates can impact atmospheric temperature and concentration of oxygen in air, and these together with the jet momentum are a hazard to helicopter operations.

Exhaust vents are a key consideration OFFSHORE especially in relation to helicopter operations. OFFSHORE facilities need to consider the requirements of Country Civil Aviation Regulations and their impacts upon the design and location of Helidecks (and vice versa)

11.5.3.4 Closed Drains & Flare Knock-Out Vessels

Closed Drains and Flare Knock-out vessels should be placed within the controlled Process Utilities part of the facility since they will likely contain hazardous materials during normal operations (generally at low pressure). The main issue with both vessels is the requirement for free-draining piping which may place constraints on their location.

11.5.3.4.1 Closed Drains Vessel

The issue of free draining into a Closed Drains system will be worsened by no pressure being available to drive the fluid into the vessel. It is therefore more likely that additional Drains Vessel and pumping system will be required for this purpose.

The Drains vessel may be placed inside a sump with controlled access. All associated pumps and instrumentation shall be placed to allow maintenance without needing to enter the sump.

11.5.3.5 Multiple equipment rows

Multiple Rows Between Passageways: Arrangement of equipment in multiple rows between accessways shall be avoided, so far as practicable.

This is generally not good for operability, maintenance without lifting over live plant or for firefighting. It will also tend to make the layout more congested and be detrimental to ventilation, therefore increasing VCE potential.

Multiple trains: 'Handed' arrangement of duplicated streams should be avoided, meaning process Trains should be laid out identically (i.e. copied, and not mirror-image). This is to reduce the potential for human error during operations and maintenance.

11.5.3.6 Lifting over live plant

Lifting over live plant for any foreseen maintenance or operational requirement shall be avoided. Placement of Equipment requiring regular maintenance such as Exchangers (bundle pulling) should be considered to avoid lifting over live facility.

If this is not possible, then a justification shall be documented using Table 7-7, and submitted for COMPANY verification.

11.5.4 Piperack arrangement

See AGES-SP-09-001 (Ref 1) for more details.

11.5.4.1 Liquid at lowest level

Piping carrying liquid should be placed on the lower parts of a multi-level piperack, so far as practicable. This is to avoid dripping liquid escalating an initiating fire scenario and also allows any gas carrying pipework at the higher elevations to disperse into free air.

11.5.4.2 Straight runs within Process Unit

Piperacks within a Process Unit should be arranged in straight runs so far as practicable and shall not be routed over the top of equipment items (or piping with flanges) that contain hazardous material.

This is to limit the amount of congestion in the area, which is beneficial against potential VCE, and will help avoid escalation in the event of a fire from nearby item of equipment (or flange).

11.5.5 Critical Equipment /Structures

- ESD & Blowdown Valves – protection
- Firewater – Deluge Valve Protection
- Firewater System (Location & Protection)
- Manned Structures

11.5.5.1 ESD & Blowdown Valves – protection

ESD Valves: ESD valves that are intended to segregate a fire or gas release incident within a given geometric 'Fire Zone' shall be located outside the Fire Zone', so far as practicable. If this is not possible, for example since the same ESD valve is used to isolate the adjacent Fire Zone then the valve shall be placed at the boundary between the zones.

The valves shall be protected against a fire or VCE event for the period and overpressure determined by Safety Assessment (e.g. FERA Study).

Blowdown Valves: Blowdown valves will typically need to be placed near to the item of equipment they are intended to depressurise.

Blowdown valves shall therefore be protected against a fire or VCE event for the period and overpressure determined by Safety Assessment (e.g. FERA Study).

11.5.5.2 Firewater – Deluge Valve Protection

Deluge valve skids shall be placed outside the area they are intended to protect to ensure they are protected against a fire or VCE event for the period and overpressure determined by Safety Assessment (e.g. FERA Study).

11.5.5.3 Firewater System Outlets

Firewater Ring Main: The requirement for a fire water ring main shall be determined by the Project Safety and Emergency Response Philosophy (note: positioning of the firewater tanks and pumps is a Step 2, Process Unit level decision).

At the equipment level, if the Safety Philosophy requires the running of hoses from hydrants, the ring main and outlets (hydrants, monitors, etc.) shall be placed outside the area they are intended to protect to ensure they are protected against a fire or VCE event for the period and overpressure determined by Safety Assessment (e.g. FERA Study).

Hydrants and hose boxes provision is specified in the Fire Detection & Protection standard (Ref 2). See also AGES-SP-09-001 for more details.

11.5.5.4 Manned Structures

Any occupied structures shall not be placed within a Fire Zone containing hazardous materials.

This includes Operator Shelters, which be at least 15 m from the nearest process equipment / piping containing flammable liquids or vapours and 15 m from fired heaters.

Smoke shelters shall be located in an unclassified area and outside the process plant boundary or fence.

If this is not possible, then a justification shall be documented using Table 7-7, and submitted for COMPANY verification.

11.5.6 Spill Containment (Primary, Secondary & Tertiary)

Primary containment of any process plant is the pressure containing envelope in which the process takes place (pipes, vessels, tanks etc.). Asset Integrity (AI) regimes maintain the ability of the pressure containing envelope to perform its required function effectively and efficiently whilst safeguarding life and the environment. Any loss of containment leading to a liquid release should be contained to prevent escalation or safety/environmental impact off the facility; with liquids being retained for suitable treatment.

A philosophy for secondary and tertiary containment shall be defined for vessels and tankage containing liquids that are combustible, flammable, toxic, subject to boilover, or potentially damaging to the environment.

Secondary containment shall be provided by grading, kerbs and drainage or by bunds (dykes). Suitable drainage shall prevent the spread of major hydrocarbon spills from one fire zone to another as well as for storm drainage and handling used fire water. The natural slope of the land should be used where practicable. Accumulation of liquid pools or the spreading of pools between plant areas and towards the safe locations shall be prevented.

Tertiary containment involves collection and safe disposal of major leaks or firewater entering the site drains system.

Text Box 11-2: Methods for Spill Containment (Secondary & Tertiary)

Secondary:

- Liquid containing equipment to be at grade or with solid floors beneath
- Pipes containing liquids to be on lowest level of piperacks
- Secondary containment (bunds / dykes) for storage tanks
- Kerbing to contain small spillages
- Drip trays for items for items like pumps and in general equipment skids where flanges are broken for maintenance
- Slopes designed to make liquid spillages run away from equipment

Tertiary

- Routing to drainage pond for used fire water in tank areas

11.5.7 Fire & Gas Detection

Line-of-Sight Devices: At the equipment level, the location of F&G detection devices that rely on line-of-sight to the fire or gas cloud, shall be located to avoid their line-of-sight being interrupted by other items or structures.

Point Devices: Point detection devices that identify the presence of fire, smoke, heat or gas at a particular location shall be positioned to avoid dead spots and ensure they give a true representation of the area they are monitoring.

11.5.8 Process Area Tanks (& arrangement of associated equipment).

Location of Intermediate Tanks (rundown/day tank) within Process Unit:

- Intermediate Tanks are only allowed for process operations (e.g. start-up /shutdown) reasons and not for product storage, in which case small intermediates tanks (38 m3 maximum) are permitted.
- Large storage tanks (>38 m3 capacity) shall not be permitted without justification and shall require COMPANY approval.

Equipment Arrangement:

- Tanks in process areas shall be placed in separate bunded areas
- Pumps (outside bund)
- Isolation valves (outside bund)
- Drains – Isolation valve (outside bund)
- Cooling / heating /firefighting piping – shall not impact Egress routes inside bund

If this is not possible, then a justification shall be documented using Table 7-7, and submitted for COMPANY verification.

11.5.9 Buried /Mounded (Tanks & Equipment)

Process components with particularly large and/or hazardous inventories (especially highly volatile C3-C5 hydrocarbons), such as pipelines, slug catchers and LPG storage may be buried or mounded to reduce the impact of a loss of containment, although this does lead to other issues relating to ensuring continued integrity of the pressure containing envelope.

Environmental factors (e.g. flood risk) and the need for drainage (including assessing the water table level) need to be considered to ensure that burial is practical.

11.5.10 Separation (increased)

Road to Process Unit: A minimum separation of 15m shall be used between any road and any item containing hazardous material to avoid vehicle impact from the road.

Alternative measures such as barriers shall be used in case this separation is not met, such as where the road is provided for maintenance access of that equipment.

11.5.11 Safety Air Intakes & Vents

11.5.11.1 Building & Process Equipment

Air intakes for buildings and process equipment should be sited the maximum distance possible from Hazardous Areas, as defined for ignition prevention for siting of electrical and other equipment. These should preferably be upwind and away from areas where air contamination by dust, flammable or toxic gas can occur.

The design of HVAC systems for the buildings shall be in accordance with NFPA 90A or equivalent standards. All air inlets shall be located in non-hazardous areas, as far as practicable away from possible hydrocarbon leakage sources.

In all cases the air intakes for buildings and process equipment shall be located a minimum of 3 m from any Zone 2 boundaries.

11.5.11.2 Gas Turbines & Generators

Gas turbines and generators should be located, so far as practicable, in an unclassified area from a Hazardous Area Classification perspective. If this is not practicable:

- Gas turbines shall not be permitted in hazardous areas classified as Zone 0 and 1.
- Gas turbines in Zone 2 shall be enclosed and gas detectors shall be fitted at both combustion air and ventilation air inlets to trigger shutdown action.

11.5.12 Multi-level layout

It is generally preferred that equipment is installed at ground level to ease access. However due to lack of space or the need for gravity flow between equipment multiple level structures may be needed. Where a fire risk exists, the top of any multi-level structure should be within range of fire hydrants or monitors or shall have its own firefighting system.

11.5.12.1 Liquid Inventories:

Where multi-level structures are unavoidable, it is preferable to position liquid containing equipment on the lowest level to avoid any spills and drips affecting people and plant below them, so mitigating the risk of escalation.

11.5.12.2 Grated Decking

The decks of levels above the ground (or lowest) level should be grated, so far as practicable, maximise ventilation and therefore mitigate the risk from potential VCE events.

11.5.13 Egress & Escape Routes through Process Unit

11.5.13.1 Walkways

Walkways passing through Process Units can be used to provide Egress and Escape routes that join with the main site Egress & Escape routes determined at the Process Unit layout stage (Step 2).

Marked & Kept Clear: All designated Egress & Escape routes shall be marked on the plot plan and physically to ensure they are kept clear of any obstructions.

Onshore escape route dimensions shall be a minimum of 2100mm high; and 1200mm wide for primary routes and 1000mm wide for secondary routes.

11.5.13.2 Hazardous Area Classification

Within Process Unit: Any designated Egress & Escape route within a Process Unit shall not be affected by a Zone 1, Hazardous Area.

Main Site Egress & Evacuation Routes outside Process Unit: These shall not be allowed in any Hazardous Area Classification zone.

If this is not possible, then a justification shall be documented using Table 7-7, and submitted for COMPANY verification.

11.5.14 Maintenance & Operations Access

All items of equipment within each Process Unit shall be designed to allow access for routine and non-routine maintenance. This shall ensure:

- Space: Equipment withdrawal volume (e.g. tube bundle from heat exchanger)
- Egress & Escape: Un-obstructed route for personnel working on the equipment item to reach a designated Egress and Escape route
- Lifting: Avoid lifting over live plant to perform operations & maintenance

11.5.15 Passive Protection (fire /blast wall)

Where passive protection is required to protect critical structures and manned areas, it is important to understand and evaluate any detrimental impact on VCE risk.

A Safety Study shall be performed to document the impact of any such passive fire / blast structured on VCE. This shall be performed at FEED to ensure appropriate mitigation measures are considered from the earliest stages of the Project.

11.5.16 Walls & Barriers

Enclosing walls / barriers should be avoided as far as practicable. They can sometimes be required for operational or safety reasons, as:

- Modules: Full /partial enclosure of Structures
- Plated decks (spill containment, walkway protection on lower deck)
- Shielding against radiation

VCE: In all such cases the potential impact on VCE risk shall be assessed in a Safety Study. The study shall include the potential for internal explosion within any Modules and document the protective measures to be taken.

The VCE study shall be submitted to COMPANY for approval by COMPANY Technical Authority.

11.6 Equipment Layout – Equipment Specific Issues

The following is a commentary of the layout objectives that shall be followed for specific items of equipment.

11.6.1 Vessels

Vessels with leak points (e.g. sample valves) shall be located so that any combustible liquid that leaks shall be directed away from the vessel (and the process inventory within it).

11.6.2 Reactors

Reactors are where chemical reactions occur, and since there may be potential uncontrolled reaction scenarios within these unit operations, a risk assessment is required with a safety study to determine if there are specific reasons for selecting separation distances specific to the risks of that reactor, since risks from such units are very variable.

Space shall be allowed for the removal of reactor internals including any catalysts.

11.6.3 Pumps

Pumps handling flammable or combustible materials shall not be located underneath walkways, pipe runs or other process equipment, unless barriers are used for segregation.

Pumps handling LPG and other light hydrocarbon services (or heavier hydrocarbons above their flash point) shall be located to be accessible for firefighting and more than of 3 m from pipe racks and major process structures.

11.6.4 Compressors

ONSHORE, locate process gas compressors downwind from other process plant, on the periphery of their fire zone and as far as possible from ignition sources, at least 30 m downwind from fired heaters and at least 7.5 m from any other flammable containing equipment.

11.6.5 Heat Exchangers

Shell & tube heat exchangers shall be located and arranged for suitable access and the ability to remove tube bundles during maintenance.

11.6.6 Air cooled Heat Exchangers

Air cooled heat exchangers shall not be located above equipment containing flammable materials.

11.6.7 Fired Equipment

Fired heaters shall be treated as ignition sources and must be separated from equipment containing flammable substances as far as reasonably practicable. The minimum distance between a potential hydrocarbon leak source and such fixed ignition sources shall always meet the requirements of the electrical hazardous area code used.

Fire equipment should preferably be at the outer sides of the installation in a dedicated fire zone. Away from fuel sources and minimum 30 m from Hydrocarbon processing facility (oil and gas) LPG process unit 60 m.

11.6.8 Transfer Lines

Transfer lines between equipment shall be kept short with simple piping design.

11.6.9 Fuel Supply Lines

Lines shall fall towards users without low points which might collect condensate.

11.6.10 Columns

Space shall be allowed for the removal of column internals.

11.6.11 Fans

Space shall be allowed for the removal of filters, shafts, bearings etc.

11.6.12 Electrical systems

HV equipment is considered an Ignition source and should be kept well away from hydrocarbon inventories and shall not be in an electrical hazardous area.

Primary substations should be located adjacent to on-site power generation and/or the public utility intake and should be located to optimise onward power distribution and allow for future expansion.

HV equipment should up-wind of the prevailing wind from large sources of water vapour such as cooling towers and should be away from dust and fume producers such as generators, diesel engines and dirt roads.

Consideration should be given for the routing of all overhead medium and high voltage power distribution lines from the primary substation to secondary during plant layout design. Overhead power lines to be at least 150m away from drilling, wellheads, main oil and/or gas flowlines.

11.6.13 Safety Equipment

Space shall be allocated for safety equipment such as extinguishers, stretchers; although layout of such items is usually not finalised until detailed design.

11.6.14 Slug Catchers

Due to their high inventory of hydrocarbons, including C2-C5 components, then Slugcatchers can present significant hazards.

Separation from people or occupied buildings should be maximised and hazard minimised by applying ISD principles.

Burial of slug catchers should be considered. Sufficient separation shall be derived by analysis, noting that significant separation from other equipment and units can be required as blowdown is often not feasible and long duration dispersion and jet fire scenarios are possible.

Finger type slug catchers are usually designed to pipeline codes and have a large footprint. They shall be protected from dropped objects and vehicle impact damage.

Vessel type slug catchers if designed according to vessel codes can incorporate blowdown and fire protection and can potentially be located with other unit operations.

11.6.15 Pig Launchers & Receivers

Pig launchers and receivers should be installed horizontally and located at the edge of the facility. Pig trap systems should be located adjacent to each other for ease of pigging operations. Locating pig launchers and receivers in an open area provides good natural ventilation. Access shall be provided for lifting cranes, for pipeline hydro-testing, dewatering, drying and inerting where this is anticipated.

Since the principle hazard is ejection of pig or hydrocarbons from open hatch, the end of pig launcher should point to an open space – outboard OFFSHORE and should not point towards people, buildings, roads or access ways, safety critical equipment or hydrocarbon containing equipment. Analysis shall be required to determine a required separation distance if the risk from an ejected pig is significant or retention wall/barrier shall be provided.

OFFSHORE Export line launchers and receivers should be located away from the wellbay area, higher risk process equipment, known ignition sources, highly travelled personnel routes, and material handling areas.

ONSHORE Pig traps should be located at least 15 m from any type of equipment, other than adjacent pig traps and have access for light trucks and be within a secure fenced area.

11.7 Critical & Occupied Building Design

11.7.1 Structures

11.7.2 Partially Enclosed Structures

The design of partially enclosed structures shall be justified where necessary and it will have to be determined if the volume can be treated as “open outdoors” or a “confined space” for many design issues. Generally, any

partial enclosure that reduces natural ventilation to below 6 air changes per hour will influence the zoning for hazardous area classification and may also allow toxic vapours to persist.

11.7.3 Enclosed Structures

The use of fully enclosed structures for process plant shall have its own separate hazard assessment. This shall determine the need for hazard mitigation outside the building, although some issues are more obvious, for example blow out panels should not be directed towards accessways or sensitive equipment.

11.7.4 External walls

Building codes focus on the structural strength of external walls and make very few recommendations with regards to their fire or blast resistance. The specification of fire resistance, blast resistance and as a barrier to toxic gases shall be addressed by consequence analysis.

11.7.5 Building Air Intakes

Air intakes for buildings shall be located at least 5 m away from any hazardous or exhaust discharges and at 3m outside Zone 2 hazardous areas and in any case should be located at the maximum practicable distance from hazardous areas, irrespective of the minimum distances required by area classification codes, and preferably be upwind and away from areas where air contamination by dust, flammable or toxic gas can occur.

12 OFFSHORE INSTALLATIONS

12.1 Introduction – Offshore Guidelines

12.1.1 Objective

The aim of this Section is to outline how the principles described in preceding Sections can be used to develop an OFFSHORE layout, noting key similarities and highlighting important differences that require particular attention.

12.1.2 Scope

This Section is intended to cover the ‘topside’ layout of a facility within the Operating influence of COMPANY (i.e. 500m exclusion zone around offshore structures).

The general principles in this document apply equally to single platforms as well as Complex multi-platforms facilities and does not distinguish between choice of substructure (fixed platform, fixed floating, weather veining, island arrangement, etc.).

This is because the principles described comprise a structured method for layout development based on the ‘Building Block’ approach that is described in Ref.22, for ONSHORE facilities.

12.1.3 Context – How to these Guidelines for OFFSHORE

Early stages of an OFFSHORE development can involve multiple and diverse concepts being considered. These may include fixed platforms, multi-platform complexes, artificial islands, floating facilities, etc. Each concept type will have its own basis that will affect the layout features, operational constraints, Emergency Response arrangements, CAPEX, OPEX, etc.

At Concept Stage, it is intended that principles in this Section should be applied individually to each option, in order to give confidence that all options are developed on a sound basis, before one is selected to carry forward.

Layout development in FEED & Detail Design can then use the general approaches described in Section 10 and 11 to refine the layout, with appropriate focus on OFFSHORE issues.

12.1.4 High-Level Approach

At the highest level, the approach proposed in this document requires ISD principles to be applied to protect vulnerable items against Major Accident hazard events (e.g. Manned Areas, Emergency Response arrangements, safety systems, etc.).

The layout development process is noted to be iterative, requiring Hazard Identification and Assessment to be carried out to support layout development until one that is satisfactory is obtained. The overall process is outlined in Section 8, and explained for Steps 1-3 in Sections 9 to 11.

The main difference for OFFSHORE application of these principles is due to the smaller size of OFFSHORE facilities, where the location of Major Accidents event is concentrated near to the key items that are vulnerable. This means that the typical inherently safer separation distances proposed in Appendix A will be difficult to achieve. The iterative nature of the ISD process, means that alternative measures may be used instead of separation in the order of preference required, namely Inherent Safety, Passive, Active or Procedural.

12.1.5 Structure of Guidelines (Offshore)

The OFFSHORE Guidelines described in this Section covers the three-step building-block approach described in Figure **8.1-1**, namely:

- Step 1: Facility Location
- Step 2: Process Unit Layout (within Facility)
- Step 3: Equipment Layout (within Process Units)

These topics are discussed for the OFFSHORE by difference with the ONSHORE guidelines in the Sub-sections below.

The structure of the guidelines has been kept to be consistent with preceding ONSHORE in Sections 9 to 11, for ease of cross-reference, i.e.

- Team (competencies) : Section 12.2
- Information (site /project) : Section 12.3
- Hazard (& Appropriate Risk Assessment) : Section 12.4
- Project Implementation
 - Step 2 (Process Unit) : Section 12.6
 - Step 3 (Equipment) : Section 12.7

12.2 Team (Competencies)

A summary of competencies required for each Step of the ONSHORE building-block approach is given in Table **12-1**, which identifies the respective Step in column-1, and a pointer to the ONSHORE information in columns 2 & 3. Applicability of the individual steps within a project lifecycle is clarified in columns 4-6, with a commentary about the differences for OFFSHORE captured in column 7.

Table 12-1: Comparison with ONSHORE: Team Competencies

Step	Reference to ONSHORE Section		Project Stage			Differences for OFFSHORE
			Concept	FEED	Detail Design	
1	9.2	'Facility' Location	P	P		Non-Technical: • Similar to ONSHORE Technical:
2	10.2	'Process Unit' Layout		P		Technical: • All skillsets with Offshore Bias - Specialist support on: • Marine Operations • Helicopter operations • Offshore Tanker loading /unloading • Offshore Drilling • Offshore Well Services
3	11.2	'Equipment' Layout		P	P	Similar to Onshore

The main difference in required skillsets is seen to be for Steps 1 & 2, in the early stages of the project lifecycle. It is expected that a greater level of technical know-how will be required covering some of the activities that will be unique to Offshore operations, like marine, helicopter operations, offshore tanker loading /unloading, offshore drilling and well services.

This will help define specific topside characteristics for such activities so that they can be taken into account from the earliest stages, when various conflicting factors affecting inherent safety will need to be balanced.

Equipment level layout (Step 3) has some additional detailed constraints due to space restrictions, and perhaps greater use of multi-level layouts, but essentially the skillsets required are similar to ONSHORE (Technical).

12.3 Information (site /project)

Information required for OFFSHORE facilities is largely similar to that needed for ONSHORE. The main areas of additional focus relate to:

- Environmental conditions (air, sea and subsea)
- Weight (equipment)

Environmental information is especially important for decisions about inherent safety like orientation that will affect pipeline, supply vessel, helicopter and drilling /well service rig approaches, as well as the location of the flare / vent stack.

The second factor identified is the equipment weight, which can have an important bearing on project viability through its impact on structural design (topsides and the substructure).

12.4 Hazard (& Appropriate Risk) Assessment

The Guidelines below highlights how the approach in this document can be given an OFFSHORE specific focus in order to achieve a layout that supports ALARP risk.

In order to do this, it is important to understand the relationship between potential Major Accident events, their likelihood and the critical items that may be vulnerable. This has been done in the following sub-section using typical examples to illustrate the points.

It should be noted that each Project is expected to carry out Hazard Identification and Assessment reviews that are specific to the details of the Project. For this purpose, the Process Units for an OFFSHORE facility have been grouped as described in Table 12-2.

Table 12-2: Breakdown of Process Unit Layout (OFFSHORE)

Area Type	Process /Other Unit	Offshore
Well-head	Wellheads	P
	Well Services Laydown	P
Process	Separators (& Piping)	P
	Other Vessels & Piping	P
	Compression	P

Area Type	Process /Other Unit	Offshore
	ESDVs	P
	Pig Traps (& laydown)	P
	Pipeline (Risers), ESDVs & Pig Traps	P
Process Fired (Utilities)	Flare / Vent	P
	Fired Heaters	P
Utilities (& Machinery)	Laydown & Storage	P
	Power Generation	P
	Cooling Water (/Seawater) Pumps	P
	Other Utilities	P
	Crane(s)	P
Safety Sys.	Fire Pumps	P
	Fire / Blast Wall	P
Emergency Response	Shelter /Muster /TR	P
	TEMPSC	P
	Bridge	P
	Boat	P
	Liferaft	P
Manned Areas	CCR	P
	Workshops & Offices	P
	Accommodation	P
	Helideck	P
	Boat Landing	P
	Bridge (Walk to Work)	P

12.4.1 Model of 'Major Accident' Risk – OFFSHORE

Table **12-3** has been prepared to show the relationship between platform activities, the potential Major Accident events related to the activities, their location and potential impact on topside facilities. The Table also identifies key features (wind, sea currents, etc.) that can provide an inherently safer operating environment for each activity, if used in an appropriate fashion.

Star-labels (A-E) are used to highlight key features that are important in understanding Major Accident risk. These are used as pointers in the description below.

The overall Table is structured, at the highest level, to identify 'Operational Features' on the left and key 'Design Drivers' affecting inherent safety on the extreme right.

The left side starts with Label 'A' in the first main column, where key OFFSHORE activities are identified. These fall into two main categories, 'Planned' or those required as a result of 'Major Accidental' events.

Label 'B' shows a column to note the frequency of each activity, which is an important factor in assessing the likelihood of a Major Accident resulting from a failure of the activity.

Label 'C' aims to identify the key types of hardware that could be affected by such a Major Accident event. This is broken down into two main categories, 'off-platform' and 'on-platform' hardware. The on-platform hardware has been further categorised and placed in a sequence that aims to provide segregation between manned areas (extreme right) and the most hazardous inventories (on left side). Reference is also made to the main Emergency Response arrangements required (TR, Lifeboat, etc.). A matrix arrangement is used in the respective rows for each activity to indicate the location of potential Major Accident event and the Emergency Response provisions.

Label 'D' is at the very bottom part of the Table where the main Major Accident types are categorised. Each accident type is marked in the appropriate column to identify the location of the Major Accident, which in combination with the preceding information adds to the understanding of risk.

The Table also contains, on the extreme right (label 'E'), key features (Design Drivers) that give increased inherent safety for the respective activity. This can be used to inform decisions about which feature (wind, currents, etc.) is important to achieving an inherently safer layout.

This overall view covering the causes, location and type of Major Accident, along with key Design Drivers, is especially useful where conflicting requirement need to be weighed between different activities to decide on a balanced way forward.

Table 12-3: Schematic of Offshore Activities & Major Accident Risk Issues

Operations																														Design Drivers (																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
Activities		Freq.	Hardware Needed (& Relative Location of Major Accident)																												Other		Environmental																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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											Well-head		Process				Process Fired		Utilities (& Machinery)				Safety Sys.		Emergency Response				Manned Areas																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
													Supply Vessel		Pipelines		Umbilicals		Power Cables		Bridge		Boat		Helicopter		Drilling Vessel / Rig		Service Vessel						Wellheads		Well Services Laydown		Separators (& Piping)		Other Vessels & Piping		Compression		ESDVs		Pig Traps (& laydown)		Pipeline (Risers), ESDVs & Pig Traps		Flare / Vent		Fired Heaters		Laydown & Storage		Power Generation		Cooling Water (/Seawater) Pumps		Other Utilities		Cranes(s)		Fire Pumps		Fire / Blast Wall		Shelter /Muster /TR		TEMPSC		Bridge		Boat		Liferaft		CCR		Workshops & Offices		Accommodation		Helideck		Boat Landing		Bridge (WTW)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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12.4.2 High-Level ISD Approach to OFFSHORE Layout

At the highest level the approach to OFFSHORE layout development is identical to that used for ONSHORE. Inherently safer design principles introduced in Section 7.3.3 and presented for each Step in Sections 9 to 11, still apply.

The main difference is due to the smaller footprint of a typical OFFSHORE facility, meaning the location of Major Accident events will be concentrated close to the key items that are vulnerable, including manned areas. The impact on layout development is that the typical inherently safer separation distances proposed in Appendix A will be difficult to achieve.

This means that the iterative part of the ISD process, where alternative passive, active and procedural measures are investigated to compensate for the protection shortfall, is triggered much sooner in the process.

The impact of space constraints on typical application of ISD principles is highlighted in Table 12-4 using the hierarchy of ISD steps presented in Section 7.2. The type of measures identified are relevant to Steps 1, 2 and 3 of the building-block approach.

Table 12-4: OFFSHORE Topsides Layout – Typical Application of ISD Principles

Type of Safety Measure		Applicable OFFSHORE?	Impact on Layout	Relevant Steps		
				1	2	3
				Concept		
					FEED & Detail Design	
Inherently Safer	Separation	Not likely	Not much space on OFFSHORE topsides	X	X	X
	Orientation	Yes	Can be effective measure, especially for off-platform interactions (supply vessels, helicopters, drill rigs, pipeline impact, etc.)	P		
	Segregation	Yes	Arrangement of manned /utilities /high hazard process, etc – same as onshore	P	P	
	Elevation	Yes	Liquid spill at lowest level to reduce escalation potential.		P	
Passive	Fire / Blast Walls	Yes	More likely to be needed if facility is manned.		P	
	Passive Fire Protection	Yes	More likely to be needed to prolong escalation beyond time to safely evacuate the facility.		P	P
	Grating	Yes	Multiple levels more likely – grated decks preferred for gas dispersion and limiting VCE overpressures		P	P
	Shielding	Yes	Radiation shielding (only if not practicable by distance)		P	P
	Shielding Firewater pump /Deluge valve	Yes	Safety systems (e.g. firewater ring main), locate in shadow of primary structure (protect against VCE, impact damage)		P	P
		Yes	Locate in safe areas (preferably diverse locations with diverse fuels)		P	P

Type of Safety Measure		Applicable OFFSHORE?	Impact on Layout	Relevant Steps		
				1	2	3
				Concept		
					FEED & Detail Design	
Active		Yes	Limited impact on Layout			P
Procedural						

Implementation of each of these Safety Measures is addressed in the following sub-sections as it applies to the building block Steps in question.

12.5 Implementation: Step 1 – Facility Location

12.5.1 ISD – Orientation

The schematic representation of Major Accident events in Table **12-4** has been used to illustrate how issues can be identified and ISD measures can be weighed up, prioritised and adopted to improve safety.

It should be noted that this is an indicative example only and that specific assessment is required covering such arguments for the actual facility and situation being considered. This should include hazards that are specific to the OFFSHORE working environment, such as marine operations, etc.

The first ISD measure identified in Table **12-4** is Orientation. An example of how the conflicting requirements of various activities can be weighed up is illustrated in Table **12-5** which is a condensed form of Table **12-3**.

Table 12-5: OFFSHORE Topside Layout – ISD ‘Orientation’ Issues (Example)

Operations																				Design Drivers (Ops)																	
Activities		Freq.	Hardware Needed (& Relative Location of Major Accident)																	Oth.	Env'mntal																
			Off-Platform			On-Platform															Air		Sea														
						Well-head		Process		Process Utilities		Utilities		Safety Sys.		Emergency Response		Manned Areas																			
Supply	Drilling Vessel /	Service	Wellhead	Well Services Laydown	Separator	Risers, ESDVs & Pig	Flare /	Chemical	Laydown &	Crane(s)	Fire	Fire / Blast	Shelter /Muster/TR	TEMPSC	Liferaf	CC	Helidec	Bridge	Weight	Wind	Curren	Tide															
Planned																																					
1	Production Ops.	Cont.				X		1	X	1	X			X	X	X	XX	X	X	X	1																
2	Import / Export	Cont.						2						X	X	XX	X			X	2																
3	Pigging	4wk						3	X					X	X	XX	X			X	3																
4	Well Services	50wk			4	X	X							X	X	XX	X			X	4																
5	Drilling	100wk		5		5	X							X	X	XX	X				5																
6	Personnel Transfer	1day																6	X	6																	
7	Supply (Materials)	3days	7									7	X						X		7																
Accidental																																					
	Evacuation	25yrs													XX																						
	Escape	25yrs													X																						
Major Accident Events (potential locations)																																					
	Hydrocarbons				X	X	X	X	X									X																			
	Non-Process Fires									X			X				X																				
	Marine Collisions	X	X	X								X																									
	Dropped Objects	X	X	X	X	X						X																									
	Transport																X																				
	EER														X	X																					
					Sources										Vulnerabilities																						

An example assessment of the issue is summarised in Table 12-6, which is intended to help balance the arguments.

Table 12-6: OFFSHORE Topside Layout – ISD ‘Orientation’ Assessment (Example)

Activity Details			Source		Critical Areas		ISD Measure			
Ref.	Activity	Freq.	Location		EER	Manned	A) Wind			B) Current
1	Production Ops.	Cont.	Process	Separators	None expected from initiating event.		Right	to	Left	
2	Import / Export	Cont.		Risers, ESDVs & Pig Traps						
3	Pigging	4wk								

Activity Details			Source		Critical Areas		ISD Measure			
Ref.	Activity	Freq.	Location		EER	Manned	A) Wind			B) Current
4	Well Services	50wk	Well-head				Left	to	Right	
5	Drilling	100wk								
6	Personnel Transfer	1day	Manned Areas	Helideck						
7	Supply (Materials)	3days	Utilities	Laydown & Storage						Against Current
For Illustration of Approach Only										

12.5.1.1 Prevailing Wind Direction (label 'X')

It is apparent from star label 'X' in Table **12-5**, that there are multiple activities competing to have prevailing wind support them.

Columns 1 and 2 in Table **12-6** identify the relevant activities, with the frequency of the activity indicated in column 3. Columns 4 and 5 identify the location of the Major Accident and the critical areas /structures are in column 6. The preferred direction for each activity is described in columns 7-9.

It is apparent that items 1,2 and 3 have a preference for wind to be from 'right to left' whereas activities 4,5 and 6 would prefer the opposite direction. In order to assess which activities take priority, a measure is needed for the risk presented.

In this example, a simplistic approach of the frequency of the activity has been used to make the assessment.

The assessment has concluded that a wind direction from 'Right to Left' should be selected due to high frequency of the activity (implying higher risk):

- 1 – Production Operations (continuous)
- 2 – Import /Export (continuous)
- 3 – Pigging (4weekly).

This choice is detrimental to the following activities:

- 4 – Well services (50days)
- 5 – Drilling (100days)
- 6 – Helicopter transfer (1day).

It is noted that the frequency of activity 6 (helicopter transfer, 1day) is relatively high and arriving at the facility at the tail is not ideal. In such instances, a helideck location allowing diagonal approach should be investigated.

12.5.1.2 Prevailing Current Direction (label 'Y')

It is apparent from star label 'Y' in Table **12-5**, that supply vessel approach has a preference to approach into a current to allow a better controlled approach. In this instance since there are no competing activities, prevailing current should be used to decide the supply vessel approach, and therefore the location of topside laydown area and crane location.

12.5.1.3 Note on Methodology

It is stressed that the present examples are only intended to demonstrate the Approach and Methodology for Layout Development at Step 1.

It is acknowledged that the real risk picture will be more complicated since each activity will have a different likelihood of failing and causing a Major Accident. The potential consequences of each Major accident will also be different.

If this level of detailed understanding is important to the layout decision, then more refined assessment based on qualitative, semi-quantitative or full QRA approaches should be used to assist.

12.6 Implementation: Step 2: Process Unit Layout

12.6.1 ISD – Segregation

The use of segregation of hazards of various categories can be applied in a similar fashion to onshore facilities and as illustrated in Table **12-3**.

12.6.2 ISD – Elevation

There is increased pressure to stack systems at OFFSHORE facilities due to space restrictions.

One inherently safer approach to reduce the potential for escalation in such circumstances is to locate liquid inventories at the lowest level, if practicable. This will avoid liquid drips onto other systems and therefore avoid escalation in the event of a fire

12.6.3 Passive – Fire & Blast Walls

Fire and blast walls are used to protect vulnerable areas and are particularly important on an OFFSHORE facility due to space restrictions.

It is important to identify their requirements early in the project since this feature can add significant weight to the facility topsides and substructure, with the knock-on impact on project cost and viability.

12.7 Implementation: Step 3: Equipment Layout

This Section is structured to cover the remaining equipment level protective measures initially followed by guidance on typical OFFSHORE equipment types identified in Table **12-7**.

Table 12-7: Structure of Equipment Level Guidance – OFFSHORE

Area Type	Process /Other Unit	Section
General	Operations & Maintenance	12.7.2
	Control Room	12.7.3
	Cables	12.7.4
Process	Process Equipment	12.7.5
	Pig Traps (& laydown)	12.7.6
	Drains	12.7.7
Process Fired (Utilities)	Flare / Vent	12.7.8
Utilities (& Machinery)	Power Generation	12.7.9
	Electrical Switchgear	12.7.10
	Stores	12.7.11
	Crane(s)	12.7.12
	Firewater System	12.7.13
	Lifeboat / Survival Craft	12.7.14
Safety Systems	Primary Escape Routes	12.7.15
Emergency Response	Secondary Escape Routes	12.7.16
	Escape Route Arrangement	12.7.17
	Stairway & Landing	12.7.18
	Workshops & Offices	12.7.19
	Helideck	12.7.20
Manned Areas	Boat Landing	12.7.21

12.7.1 Protective Measures

12.7.1.1 Passive – PFP

Passive Fire Protection (PFP) provides a method of reducing separation from potential fires if there is a risk of escalation before the endurance time required.

This need for this measure is typically assessed in Step 2 (Process Unit Layout), during FEED.

12.7.1.2 Passive – Grating

The use of multiple levels on an OFFSHORE facility means there is a need for decking between levels. The use of grating is promoted to improve ventilation and therefore limit the potential for VCE, and the magnitude of overpressures if a VCE were to occur.

Grated decks also help keep the topside weight down, which is generally beneficial for project viability.

12.7.1.3 Passive – Shielding

There are two aspects to shielding that are relevant to an OFFSHORE facility:

- Specially installed radiation shields
- Shielding behind structural members

Radiation Shields: The lack of separation distance from potential fires OFFSHORE means there will be pressure on using shielding to protect vulnerable items against radiation. Shielding should be avoided so far as practicable since it can add congestion and confinement and therefore increase the risk of VCE events causing escalation.

Where essential, consideration should be given to the porous / louvered variety to ensure air flow restriction is minimised.

Structural Members: Safety systems like firewater ring mains can be located in the shadow of primary structure so that they are offered protection against potential VCE or impact damage.

These items are matters of detail and would typically be considered in Steps 2 and 3, during FEED and Detail Design.

12.7.1.4 Active – Firewater /Deluge

Active firewater systems may be used to prevent escalation or to extinguish pool fires. Their use should be considered as part of the overall iterative layout development process.

Where they are needed, key components like the firewater pumps and the deluge valve skids should be located such that they are not vulnerable to the initiating event.

12.7.1.5 Procedural

Procedural measures have limited impact on layout OFFSHORE beyond the normal provision of Egress and Escape routes.

In the event that there is a need for manual firefighting, for example on an OFFSHORE island facility, then the layout will need to make provision for fire teams to attend the incident. In such an event, guidance can be taken from ONSHORE provisions

These aspects would typically be considered in Steps 2 and 3.

Protective Measures

12.7.2 Operations & Maintenance

12.7.2.1 General

Access for operations and maintenance requirements should be reviewed, including focus on the following aspects:

- Heat Exchangers: Plot area for pulling heat exchanger bundles should be indicated on the lay-out drawings to verify the space requirements;
- Operational (& Drilling Areas): Layout of the floors and surrounding drains for efficient and safe working environment;

- Drains: Arranged to minimise slipping hazards and prevent accumulation of fluids.

12.7.2.2 Access

- Operating and inspection points should be accessible and visible from operating aisles, preferably without the help of auxiliary facilities and ladders.
- External access ways should be provided, so far as practicable, at each level and around the perimeter of the facility.
- Walkways should be at a constant elevation and stairs positioned to optimise access during operations.

12.7.2.3 Lifting

Specialist rigging and associated scaffolding requirements should be kept to a minimum.

Pad eyes should be provided for equipment that requires frequent removal for maintenance, such as:

- Major control valves and actuators.
- Large relief valves.
- Filters /coalescers.
- Choke valves on Xmas trees.
- Hydraulic actuators.
- Heat exchangers.

The layout should prevent lifting operations over live hydrocarbon equipment.

12.7.2.4 Laydown areas

Laydown areas may be shared between equipment in order to minimise the deck space required.

Exterior laydown areas should be provided at each deck level depending on crane location and anticipated usage.

12.7.3 Control Room

The Central Control Room (CCR) should be as far away as possible from the high hazard areas (e.g. wellheads, risers and gas compression).

Where living quarters are provided, the CCR should be integral with the living quarters.

The CCR should have access to office accommodation and the process/utility areas.

The CCR should be remote from sources of noise and vibration (e.g., emergency generators, air compressors).

Fire and blast protection for the CCR should be in accordance with the regulatory requirements for TRs.

12.7.4 Cables

Equipment should be located to minimise the number and length of critical cable runs

12.7.5 Process Equipment

12.7.5.1 Vessels

The bottom tangent line of vertical vessels or the underside of horizontal vessels should be located at least one meter above deck level.

Instrument and valve access should be located so that there is head room available, which may include the space between the roof beams.

Bunds/dikes, plating, and combing should be considered around vessels with large liquid inventories to limit spill surface area and prevent environmental releases.

12.7.5.2 Process pumps

1. Pumps should be laid out to provide for the straight length requirement of the suction lines, with minimum total suction line lengths.
2. Space adjacent to high pressure pumps should be provided for minimum flow and balance piston control sets.
3. Pump location should satisfy NPSH requirements.
4. The layout should allow for motors to be removed for maintenance.
5. There should be sufficient space to remove the pump impellers, so that they can be moved to the laydown areas and/or workshops using a trolley.
6. Space for mechanical handling equipment, such as runway beams, shall be provided.
7. For reciprocating pumps, additional space should be allowed for rod and piston removal and for pulsation dampeners.
8. The location of submersible water pumps should be arranged so that a straight lift by the facility crane through an access hatchway or by purpose-built permanent lifting facilities is available for maintenance and/or replacement.

12.7.5.3 Compressors

1. Compressor nozzle orientation should be selected to eliminate the need for removal of piping for maintenance.
2. Space should be allowed for compressor engine/motor, cylinders and piston rod removal and runway beams to facilitate transporting them via access ways to the laydown area.
3. Allowance for temporary strainers on compressors should be made in the piping layout.
4. On barrel type compressors, space should be allowed for removal of the rotor cartridge.
5. Space should be allowed for compressor large bore piping, isolation and non-return valves.
6. Space should be allowed for compressor minimum flow recycle/anti-surge control valves sets.

7. Space should be allowed for compressor blowdown valves.
8. The compressor utility equipment should be incorporated in the base plate.
9. If the compressor utility equipment is not incorporated in the base plate, allowance should be made for oil tanks, pumps, and exchangers adjacent to the compressors so that the oil drains back to the tank by gravity.
10. Suction lines should be short and direct, provided that any requirement for straight lengths of pipe work are incorporated.
11. The compressor suction lines should be self-draining, either back into the upstream vessel or forward into the compressor itself.
12. No potential traps or long horizontal sections should be designed into the piping system.
13. The compressor casing drains should be arranged such that the liquid accumulated in the compressor casing flows back to the upstream suction vessel.
14. The drains may then be left open whenever the machine is not running.
15. The design of pipe supports should account for the operating loads (e.g., vibration) for reciprocating machines.
16. Required elevation differences (e.g. suction knock-out vessels relative to compressors), should be accounted for.

12.7.5.4 Heat exchangers

1. Shell and tube heat exchangers should be stacked but not more than two high.
2. Space should be allowed for removal of a tube bundle and the floating head of a shell and tube heat exchanger.
3. Exchangers in condensing duty should be located so that they drain freely to the downstream scrubber/knock out vessel.
4. Access ways should be provided to permit the tube bundle to be removed to the local laydown area or to the workshop.
5. Air fin coolers should have free ambient air flow to the cooler and unimpeded exhaust flow.
6. Access should be provided to the header boxes, the fan, and motor of air fin coolers.
7. Large air fin coolers should be mounted with their tubes in a horizontal plane.
8. Impact of hot air discharge on operations and personnel (e.g., helicopter flight routes, crane operators, derrick operators) should be accounted for in locating air fin coolers.

12.7.6 Pipelines, Pig Traps (& laydown)

Pig launchers and receivers should be installed horizontally and located at the edge of the facility. Pig trap systems should be located adjacent to each other for ease of pigging operations. Locating pig launchers and receivers in an open area provides good natural ventilation.

Access shall be provided for lifting cranes, for pipeline hydro-testing, dewatering, drying and inerting where this is anticipated. Facilities for handling pigs between the pigging area and crane laydown area should be provided.

Since the principle hazard is ejection of pig or hydrocarbons from an open hatch, the end of pig launcher should point to an open space – outboard and should not point towards people, buildings, or access ways, safety critical equipment or hydrocarbon containing equipment. Analysis shall be required to determine a required separation distance if the risk from an ejected pig is significant.

Export line launchers and receivers should be located away from the wellbay area, higher risk process equipment, known ignition sources, highly travelled personnel routes, and material handling areas.

Pipeline Risers shall not be installed outside the jacket of a fixed facility, where they could be vulnerable to ship impact or dropped objects.

12.7.7 Drains

Drains systems should be categorised as follows:

- Open non-hazardous area drains
- Open hazardous area drains
- Closed hazardous drains
- Instrumentation drains / vents

The fluids should drain by gravity through the drains system to the collection tank or drains caisson.

Solid decks should drain to a central drainage collection point.

Areas containing liquid hydrocarbons should be provided with drip pans and connected to the hazardous drain system.

12.7.8 Flare / Vent

Manned areas or sensitive equipment shall not be subjected to unacceptable levels of thermal radiation or fumes during flaring. Refer HSE philosophy for flare radiation, dispersion and noise criteria

The use of a flare tower or flare boom should be assessed for each project.

The distance between the flare and helideck should be maximized.

Flare design scenarios include emergency flaring scenarios such as blowdown that will be for a (relatively) short duration and operational flaring which is likely to be of longer sustained periods of time (e.g., if an offshore pipeline requires depressurisation or if a compressor is down and temporary flaring is permitted).

12.7.9 Power Generation

12.7.9.1 Gas turbines/generators

1. Gas turbines and generators should be located in a non-hazardous area, preferably on the bridge-linked platform that is remote from the hazardous drilling, risers and process facilities.
2. The air intake should be sited the maximum possible distance from hazardous areas.
3. The air intake should be sited no less than 3 m above 100-year storm wave level in order to avoid water ingress.
4. The air intakes should be located so that powder and dust do not become ingested. Since most particulate matter in the air is generated on the facility from drilling operations and grit blasting, the preferred arrangement is for air intakes to be located above the upper deck level.
5. Re-circulation from the exhaust back to the inlet should be prevented for gas turbines/generators.
6. Gas turbine exhausts should be pointed vertically upwards and discharge above the helideck.
7. Exhaust flue emissions should be such that it does not interfere with helicopter, production, drilling and crane operations.
8. Exhaust flue emissions should be directed so they do not become ingested in the HVAC or engine intakes.
9. Location of gas turbine/generator equipment should allow for removal and handling of critical components for maintenance, such as gas generators or hot path components.
10. Gas turbine/generator equipment should be located adjacent to high voltage switchgear.

12.7.10 Electrical Switchgear

1. Switchgear rooms should be located in a non-hazardous area, preferably on the bridge-linked platform that is remote from the hazardous drilling, risers and process facilities.
2. Switchgear rooms should be provided with two means of access.
3. Allowance should be made at the conceptual design stage for the space and access required for ventilation and/or heating of switchgear rooms.
4. Switchgear cabinets should have both front and rear access.
5. Water or other fluid services should not be routed through or above switchgear rooms.

12.7.11 Stores

1. General stores should be located in an area classified as non-hazardous, preferably on the bridge-linked platform that is remote from the hazardous drilling, risers and process facilities.
2. The stores should be located adjacent to a laydown area and the workshops.
3. The chemicals and explosive store should:
 - be located as far as is practicable from the TR, escape routes and muster areas;
 - have two separate parts, for detonators to be stored in isolation;
 - not be sited near the radioactive store;
 - be of a jettisonable type; and
 - be located on walkway extensions to make it easier to barrier off.
4. The radioactive store should:
 - be located as far as is practicable from the TR;
 - not be sited near an explosive store;
 - be of the jettisonable type; and
 - be located on walkway extensions to make it easier to barrier off.
5. The radioactive store shall have a barrier at 7.5 μ Sieverts/hour.

12.7.12 Crane(s)

Crane lifting routes shall be designed to avoid lifting over critical infrastructure. See also Section 12.7.2.4 (Laydown areas)

12.7.13 Firewater System

Fire pumps should be located in a non-hazardous area and are often placed on the lower decks

12.7.14 Lifeboat / Survival Craft

Muster area should have sufficient free floor area to accommodate maximum number of personnel on board and allow donning personal protection equipment (PPE) (e.g., breathing air, survival gear).

The type of lifeboats/survival craft, e.g., free fall type or davit type, would be dependent on the geographical area and vessel type but davit type are preferred.

Lifeboat/survival craft embarkation areas should provide sufficient space for mustering, donning of lifejackets and lifeboat abandonment suits.

Space should be allowed for storage bins for the lifejackets and abandonment suits. When no local standard exists, the clear deck area for the muster area of 0.46 m² (5 ft²) per person shall be used, but more area (at least 0,75 m² (8 ft²) per person) may be required if survival gear is used.

Protected access should be provided along each side of the lifeboat/survival craft, if it allows boarding from both sides.

12.7.15 Primary Escape Routes

Primary Escape Routes are generally located at the periphery of the platform that will direct personnel from working areas to Temporary Refuge (TR) or to the point of evacuation. At least one evacuation route shall provide a safe egress during a blowout or major hydrocarbon release. Access from the helideck to the LQs shall not be through hazardous areas.

A clear width of 1200mm and 2300mm headroom shall be maintained to permit the passage of personnel bearing injured personnel. Wider escape routes with minimum 1500 mm width are required where more than 50 personnel are present, such as accommodation areas.

Unmanned platform Primary escape route width can be reduced further based on the specific justification and during occupancy when any event won't impact the personnel escape.

12.7.16 Secondary Escape Routes

Secondary Escape Routes are generally located at working areas that will direct personnel to Primary Escape Routes.

A clear width of 1000mm and 2200mm headroom is typically maintained where escape in one direction is required.

Unmanned platform secondary escape route width can be reduced further based on the specific justification and during occupancy when any event won't impact the personnel escape.

12.7.17 Escape Route Arrangement

Escape routes should direct personnel away from smoke or fire or toxic gas or process hazards and should physically be separated from flare, vents and explosion panels.

Escape routes should run in straight lines having no obstructions or turns with clear line of sight from deck corner to deck corner, comprising only walkways and stairs. Stairways should be located at platform deck edges to optimise deck space.

12.7.18 Stairway & Landing

Stairway landings leading to the primary escape route are typically 1200mm-1500mm wide and 2200mm long to permit the handling of stretcher cases bearing injured personnel during emergency. The maximum height between stairway landings shall be 3660 mm.

12.7.19 Workshops & Offices

Workshops should be located in an area classified as non-hazardous, preferably on the bridge-linked platform that is remote from the hazardous drilling, risers and process facilities.

Mechanical/fabrication workshops should be located adjacent to the lay down area.

12.7.20 Helideck

Design of helidecks shall be in accordance with latest revision of UAE Civil Aviation Regulations (UK CAP 437 may be used as a guide otherwise). The installation helideck shall allow helicopter access to allow helicopters to approach and depart against prevailing winds. Helicopters should normally approach helidecks into the wind. The 210° approach sector shall be free, up to 1 km away, of any obstacle to air Civil Aviation and in particular of any flare, drilling mast/pole, crane and exhaust chimney. The platform helideck should be located on the highest structure of the platform, in close proximity to the living quarters, typically located above the LQ and preferably at highest platform level.

The helipad/helideck shall not be in an electrical hazardous area, the distance between any flare and helipad/helideck should be maximised and gases from exhaust stacks shall not impair helicopter flight.

Exhaust gas vents are a particular concern because gas flowrates can be quite high and atmospheric temperature and concentration of oxygen in air are impacted, and these together with the jet momentum are a particular hazard to helicopter operations.

Exhaust vents are a key consideration offshore especially in relation to helicopter operations. Facilities need to consider the requirements of Country Civil Aviation Regulations and their impacts upon the design and location of Helidecks (and vice versa)

12.7.21 Boat Landing

Boat landings location should be downstream of the most dominant prevailing wind, swell or tidal currents in order to minimise the likelihood of collision by a drifting boat. Boat should normally approach the boat landings against swell and current. The position and operation of the boat landing shall take into consideration the possible presence of a jack-up barge or rig alongside the platform, including flaring from the platform, jack-up barge or tender support rig. Appropriate operational constraints shall be put in place whenever flaring takes place and impacted to the boat landing area.

They shall NOT be located;

1. On the same platform side as import and export risers.
2. Above export pipelines corridors that are not suitably protected against maximum load impact by boats using the landing.
3. Boat/ cargo vessel positioning should minimise the potential for vessel impact on facility /platform

Layout should ensure that the crane operator has a direct view of the supply boat deck.

Dropped Object Protection (DOP) shall be provided to protect against direct impact and swing loads during crane transfer operations. Loads shall not be lifted over live plant / equipment. Structural design shall include Boat fenders with relevant impact design criteria considering the Vessel/Boat details.

13 CONSTRUCTION & BROWNFIELD ISSUES (MANAGEMENT OF CHANGE)

13.1 Section Objectives

The aim of this Section is to clarify how these Guidelines relate to Brownfield projects and Construction activities.

They are written for Project Layout Teams in order to reinforce the messages contained in the preceding Sections and are based on good industry practice (Ref.22).

13.2 Brownfield Projects

13.2.1 Context

A 'brownfield' project is defined as a development within the boundary (or control) of an existing operating facility.

It is noted that the boundary of any project starts from supplier(s) of the materials (feedstocks, chemicals, etc.) and ends at the product handover point of the customers (Ref.22). All projects therefore involve some element of brownfield work, even if it is just a tie-in to an existing facility, which is under the control of a third-party.

With this context the need to work with the third-party from the earliest stages of the project is highlighted since this will require their involvement, support and permission.

Good industry practice recognises this and therefore requires the consideration of such issues from the earliest stages of the project (Step 1, facility location selection). This is because for a given project intent, some or many of the required interfaces might be different.

Key considerations will include the impact on:

- Construction
- Operations
- Maintenance
- Future expansion (foreseen)
- Decommissioning.

It is noted that plot plan impact on Decommissioning considerations is generally small since the provisions for construction and ongoing maintenance will normally suffice for this purpose.

13.2.2 Layout Considerations – Brownfield

The discussion below highlights some of the Brownfield issues that need to be considered when plot plans are prepared for a project. It is stressed that these considerations need to be integrated into the overall project from the earliest stages (Step 1, selection of Facility Location) and are not separate from the operational phase requirements.

13.2.2.1 Premise

Overriding authority of the working areas will be with the third-party Operations Team.

13.2.2.2 Key Brownfield Objectives

1. Agree with third-party where, when, what and how the project is to be implemented at their facility.
2. Agree Operations support required.
3. Ensure safety of personnel (Project & third-party).
4. Minimise disruption to Operations personnel.
5. Agree scope (location & type) of work under Project control.

With this context, each of the key questions is addressed below.

13.2.2.3 Where?

The third-party will need to agree which part of their facility can be used to tie-in to. This may require a joint effort to establish the most appropriate location, taking note of process requirements as well as implementation issues.

13.2.2.4 When?

The Project timescales will also require agreement since implementation of the Project could require considerable support from the third-party.

This could be in the shape of pre-work, like tie-in preparations, which could be done when opportunities arise in the period leading up to full Project implementation. It will also involve considerable Operations support during the construction phase, for which resources will need to be assigned.

13.2.2.5 What?

The third-party will need to know what permanent and temporary facilities might be required as well as the type of activities that might be undertaken. Of particular note for layout development are:

Temporary Facilities:

- Construction Camp
- Accommodation / Office space
- Fencing (access control, sterile zone exclusion, etc.)
- Commissioning facilities (vents, flares, etc.)

Interfaces

- Security /access control
- Power, Services & Utilities

Activities

- Vehicle movements
- Hot work

Emergency Response

- Alarm Communications
- Egress & Evacuation routes & arrangements
- Shelter in Place (if required)

It should be noted that all such aspects are contained in the Appendix B and Appendix C (Steps 1 & 2) to ensure consideration is integrated into the Project from the earliest stages.

13.3 Construction

Consideration of the Construction phase is also integrated into the 3-Step building-block approach (Ref.22). Checklists have been provided in Appendix B and Appendix C (Steps 1 & 2) to prompt consideration in the following Sections:

Step 1: Facility Location

- Section B.2.1.2 Construction Phase (concept Screening)
- Section B.2.4.1 Site Information
- Section B.2.6 Plot Size Requirements
- Section B.2.7 Project Assessment: Transport & Materials Handling
- Section B.2.7.8 Materials Handling - Proposed Plan

Step 2: Process Unit Layout

- Section C.1.2 Material Handling (Ch. 5.14)

The overall framework of guidance and supporting good industry practice is summarised in Figure **7.3-1**.

13.4 Conclusion

Consideration of Brownfield and Construction issues should be integrated into the Project from its earliest stages.

Appendix A. SEPARATION DISTANCES

A.1. Block Spacing (Off-site)

The following separation distance tables are given for use in the early stages of a project.

The first set of tables deals with the layout of larger components called 'blocks'. The second set of tables deals with 'equipment' layout.

Separation distances aim to ensure that the risk of escalation from fire and/or explosion event(s) on an adjacent area are tolerable, for most common processes. The numbers are based on typical separation distances from past experience and will need to be validated by Fire & Explosion assessments based on project specific process conditions and estimated hazard ranges.

Note that facility layout for plant with toxic hazards will use the principles in this standard and risk management (often by QRA), but not by separation distance Tables.

Key points to note:

1. Any deviation from the distances in Tables A1 – A8 in this Standard shall be justified using Table 7-7 shall be completed to justify and document the deviation. Such deviation shall be submitted for COMPANY review and approval by COMPANY Technical Authority.
2. All distances used from the Tables in this Appendix shall be validated using FERA.
3. The distances proposed in this Appendix are not intended to address Toxic risk, which shall be addressed through specific study and risk assessment tools such as QRA as well as HSE-OS-ST21 Management of H2S.
4. The distances proposed in this Appendix are minimum starting points and may be increased if required, for example, due to operational or construction reasons.

A.1.1. Table 1: Block Separation Distances

Table 1: Block Separation Distances (m)	Refrigerated Storage	ATM storage tank walls	Occupied Buildings	Control Room 7) 12)	Process plants/utilities areas handling flammable products	Utilities areas not handling flammable products	Main Electrical Substation 12)	CPI/API	Materials Yard	Transfer Pumps in tank farm	Main Pipeway / Piperack	Cooling Towers	LPG Loading Bays	Main Plant Road	Restricted Plant Road	Property Boundary	Fire Pumps
Refrigerated Flammable Storage	10)	50	100 9)	100	100	60	100	60	50	30	30	45	100	30	15	60	100 9)
ATM storage tanks >38m3 without BOILOVER Potential	50	10)	100 9)	75	100	60	90	15	100	15	15	60	100	60	15	30	100 9)
Occupied Buildings	100 9)	100 9)	5	NA	150	30	NA	100	NA	100	30	15	150	30	30	10	15
Control Room 7) 12)	100	75	NA	x	75	30	30	15	NA	30	30	30	75	30	5	30	NA
Process plants/utilities areas handling flammable products	100	100	150	75	50/25 5)	50/25 5)	60	15	100	50/25 5)	15	30	75	15	15	60	100
Utilities areas not handling flammable products	60	60	30	30	50/25 5)	15	30	15	30	30	15	15	75	NA	NA	30	30
Main Electrical Substation 12)	100	60	NA	30	60	30	x	15	NA	60	30	60	60	30	15	15	30

Table 1: Block Separation Distances (m)	Refrigerated Storage	ATM storage tank walls	Occupied Buildings	Control Room 7) 12)	Process plants/utilities areas handling flammable products	Utilities areas not handling flammable products	Main Electrical Substation 12)	CPI/API	Materials Yard	Transfer Pumps in tank farm	Main Pipeway / Piperack	Cooling Towers	LPG Loading Bays	Main Plant Road	Restricted Plant Road	Property Boundary	Fire Pumps
CPI/API	60	15	100	15	15	15	15	x	100	15	15	15	45	15	7.5	60	100
Materials Yard	50	100	NA	NA	100	30	NA	100	x	10	15	30	100	NA	NA	NA	NA
Transfer Pumps in tank farm	30	15	100	30	50/25 5)	30	60	15	10	x	NA	7.5	50	15	7.5	60	100
Main Pipeway / Piperack	30	15	30	30	15	15	30	15	15	NA	x	30	15	3	3	30	15
Cooling Towers	45	60	15	30	30	15	60	15	30	30	7.5	7.5	30	7.5	3	30	15
LPG Loading Bays (6)	100	100	150	75	75	75	60	45	100	50	15	30	45	15	15	60	100
Main Plant Road	30	60	30	30	15	NA	30	15	NA	15	3	7.5	15	x	NA	15	3
Restricted Plant Road	15	15	30	3	15	NA	15	7.5	NA	7.5	3	3	15	NA	x	5	15
Property Boundary	60	30	10	30	60	30	15	60	NA	60	30	30	60	15	5	x	10

Table 1: Block Separation Distances (m)	Refrigerated Storage	ATM storage tank walls	Occupied Buildings	Control Room 7) 12)	Process plants/utilities areas handling flammable products	Utilities areas not handling flammable products	Main Electrical Substation 12)	CPI/API	Materials Yard	Transfer Pumps in tank farm	Main Pipeway / Piperack	Cooling Towers	LPG Loading Bays	Main Plant Road	Restricted Plant Road	Property Boundary	Fire Pumps
Fire Pumps	100 9)	100 9)	15	NA	100	30	30	100	NA	100	15	15	100	3	15	10	x

Notes	
1	60 m can be used as an initial estimate for sterile area in the absence of any thermal radiation calculations.
2	At the boundary of the sterile area the heat radiation level at maximum emergency relief rate shall be 6.3 kW/m ² maximum (excluding the effect of solar radiation).
3	The property limit/Plant fence shall be minimum of 90m from flare and at Plant fence the heat radiation level at maximum emergency relief rate shall be 3.15 kW/m ² maximum (excluding the effect of solar radiation).
4	During flaring events that may occur during normal operations (including start up and shut down but excluding emergency and upset events), the heat radiation (excluding the effect of solar radiation) shall not exceed 1.5 KW/m ² at the boundary of the sterile area
5	50 m for pressurised liquids – 25 m for gases
6	At least 45m from other types of loading racks
7	For reinforced building

Notes	
8	60 m from process equipment in isolated areas (i.e. not part of a congested process area) that present a significant risk such as pumps, pressure vessels, relief valves to atmosphere, flares, process vents, and low pressure storage (including their associated loading and unloading racks) that could, during an unexpected operational upset, release flammable or toxic products
9	60 m from atmospheric storage tanks having a tank sidewall greater than 5 m in height and containing lighter hydrocarbons (high volatile) and condensates. 30 m from atmospheric storage tanks contain other (less volatile) flammables
10	Spacing of atmospheric storage tanks inside diked walls containing class 1, 2 and 3 petroleum products and unclassified materials shall be in accordance with the Tank table
11	Loading areas shall be outside plant fence (drums and GRG storage not considered under this point).
12	Control building and Electrical Substation final position/design shall be confirmed by FSA/QRA Studies.

A.1.1. Table 2: Tank -Tank Spacing Chart

Table 2: TANK - TANK SPACING CHART Distances are a factor of Tank Diameter of biggest tank (tank edge to tank edge)	Floating & Cone Roof Tanks <3000 Barrels	Floating & Cone Roof Tanks 3000 to 10,000 Barrels	Floating Roof Tanks 10,000 to 300,000 Barrels	Floating Roof Tanks > 300,000 Barrels	Cone Roof Tanks 10,000 to 300,000 Barrels (Class II, III)	Cone Roof Tanks 10,000 to 150,000 Barrels (Class I Inerted)	Pressure Storage Vessels (Spheres, Drums, Bullets)	Refrigerated Dome Roof Storage Tanks
Floating & Cone Roof Tanks <3000 Barrels	0.5							
Floating & Cone Roof Tanks 3000 To 10,000 Barrels	0.5	0.5						
Floating Roof Tanks 10,000 To 300,000 Barrels	1	1	1					
Floating Roof Tanks >300,000 Barrels	1	1	1	1				
Cone Roof Tanks 10,000 To 300,000 Barrels (Class II, III)	0.5	0.5	1	1	0.5			
Cone Roof Tanks 10,000 To 150,000 Barrels (Class I Inerted)	1	1	1	1	1	1		
Pressure Storage Vessels (Spheres, Drums, Bullets)	1.5	1.5	1.5	2	1.5	1.5	1	
Refrigerated Dome Roof Storage Tanks	2	2	2	2	2	2	1	1
Tanks with Boilover potential -> Site boundary	4							

Note 1: LPG to be stored in a separate Fire Zone to other types of storage.

A.1.2. Table 3: Tank & Flare Spacing Chart

Table 3: TANK & Flare SPACING CHART Distances are in Metres	Process Units Blocks	Utility Units Blocks	Main Control Room	Unit Control Room or Instrument House	Main Electrical Substation or Motor Control Centre	Unit Electrical Substation or Motor Control Centre	Fire Station or Medical or Emergency centre	Onsite Populated Buildings	Property Line	Public Right of Way	Offsite Populated Buildings
Atmospheric or Low Pressure (<1 barg) Storage ≤38m ³ WITHOUT BOILOVER potential	8	8	60	15	60	15	60	60	8	15	60
Atmospheric or Low Pressure (<1 barg) Storage >38m ³ WITHOUT BOILOVER potential	100	60	75	75	90	75	100	75	30	30	75
Refrigerated Flammable storage	100	60	100	100	100	100	100	100	60	75	100
Pressurised Storage (including > 5 tonnes LPG in any group of LPG Bullets) (1) (2) (3)	75	75	75	75	75	75	100	100	100	100	100
Atmospheric storage with Boilover potential	100	60	150	150	150	150	150	150	150	150	150
Elevated Standalone Flare (4)	100	100	150	100	100	100	150	150	150	150	150

Notes	
1	Distance is for above ground, unmounted LPG Bullets
2	LPG spheres are not recommended and require a specific Risk Assessment.
3	Buried LPG bullets can follow Figure 4.4A
4	Provisional distance only for concept. Definitive design requires Flare modelling.

A.1.3. Table 4: Building Block Spacing Chart

Table 4: Building Block SPACING CHART Distances are in Metres	Process Units Blocks	Utility Units Blocks (including non- flammable Process)	Main Pipeway / Piperack	Main Internal Roads	Secondary Internal Roads	Property Line	Public Right of Way	Offsite Populations
Main Electrical Substation or Motor Control Centre	60	30	30	30	15	15	15	15
Main Control Room	75	30	30	30	5	30	30	30
Fire Station or Medical or Emergency centre	150	30	30	30	30	10	15	15
Onsite Populated Buildings	150	30	30	30	30	10	15	15
Property Line	60	30	30	15	5	X	NA	NA

A.1.4. Table 5: Miscellaneous Equipment Spacing Chart

Table 5: Miscellaneous equipment SPACING CHART Distances are in Metres		
From	To	Distance (m)
Waste Yard	Process Block	RA (1)
Railcar loading (Sulphur loading facilities)	Control room	400
Railcar loading (Sulphur loading facilities)	Granulators	300
Railcar loading (Sulphur loading facilities)	last transfer tower / surge hopper	100
Logistics Areas	Any equipment containing flammables or ignition source	15
Emergency Diesel Generators	Any equipment containing flammables	100
Fire Water Pumps	Any equipment containing flammables	100
Fire Water Pumps	Process Units at CDS's, RDS's & RMS's	150
ESD/Unit Block Valves	Any equipment containing flammables	15
Deluge valve skids	Equipment/Package being protected by that deluge	15

Table 5: Miscellaneous equipment SPACING CHART Distances are in Metres		
Fire Water monitors/ hydrants	Any equipment containing flammables	15
Fire Water monitors/ hydrants	Road edge	3
Typical minimum separation distances - based on reason (default if no specific guidance given)		Distance (m)
Operation, maintenance, egress from equipment/building		5
Separation from flammables processing to ignition source		15
Separation from flammable vapour cloud source to ignition source		30
Separation from hazardous inventory storage to process plant		60
Separation of critical safety equipment from flammable process plant or storage		60
Separation of personnel (manned buildings) from flammable process plant or storage		60

Notes:

1 Risk Assessment (RA) required for specific case to consider nature of waste and the potential impact on (/ from) surrounding facilities'.

A.2. Equipment Spacing (On-site)

A.2.1. Table 6: Equipment Spacing Chart

Table 6: EQUIPMENT SPACING All units are (m)	Atm. Storage Hazardous	Atm. Storage Non-Hazardous	Large Pump House (8)	Compressor Buildings (8)	Analyser Room	Motor Control Centre	Fired Heaters and Boilers	Steam Generators	Internal Combustion Engines/ Gas turbines	Metering skid	Compressors	Pig Traps	High Hazard Pumps	Intermediate Hazard Pumps	Moderate Hazard Pumps	Air Cooled Condensers	Heat Exchangers	Instrument air compressors	Columns, Separator, Drums	Reactors	Pipe Racks	ESD
	(9)	(9)	90	90	90	90	90	75	90	90	90	90	90	90	90	90	90	90	90	90	15	30
Atm. Storage Hazardous (10)	(9)	(9)	90	90	90	90	90	75	90	90	90	90	90	90	90	90	90	90	90	90	15	30
Atm. Storage Non-Flammable (10)	(9)	(9)	45	30	15	15	45	30	30	45	30	15	45	45	(1)	(1)	45	15	45	45	15	10
Large Pump House	90	45	25	25	10	60	15	30	8	45	25	15	30	15	10	8	8	15	15	30	3-10 (2)	10
Compressor Buildings	90	30	25	25	15	60	30	45	25	15	x	15	30	15	10	8	15	15	15	30	3-10 (2)	15 (3)
Analyser Room	90	15	10	15	x	60	15	15	15	15	15	15	15	15	10	10	15	15	15	15	15	15

Table 6: EQUIPMENT SPACING All units are (m)	Atm. Storage Hazardous	Atm. Storage Non-Hazardous	Large Pump House (8)	Compressor Buildings (8)	Analyser Room	Motor Control Centre	Fired Heaters and Boilers	Steam Generators	Internal Combustion Engines/ Gas turbines	Metering skid	Compressors	Pig Traps	High Hazard Pumps	Intermediate Hazard Pumps	Moderate Hazard Pumps	Air Cooled Condensers	Heat Exchangers	Instrument air compressors	Columns, Separator, Drums	Reactors	Pipe Racks	ESD
	90	15	60	60	60	x	60	30	60	60	60	60	60	60	60	60	60	30	60	60	30	60
Motor Control Centre (4)	90	45	15	30	15	60	8	15	8	45	45	15	30	30	15	30	30	15	30	30	15	15
Fired Heaters and Boilers	75	30	30	45	15	30	15	x	15	30	45	15	30	30	15	30	30	15	30	15	15	15
Steam Generators	90	30	8	25	15					30	15	15	15	15	15	30	30	15	15	15	3-15 (2)	15
Internal Combustion Engines / Gas turbines	90	45	45	60	8	15	3			x	50	15	45	45	15	15	15	15	15	30	15	15
Metering Skid	90	30	25	60	45	30	30	45	15	50	8	15	(1)	(1)	(1)	8	15	15	15	30	3-10 (2)	15
Compressors	90	15	15	15	15	60	15	15	15	15	15	x	15	(1)	15	15	15	15	15	30	15	x
Pig Traps	90	45	30	30	15	60	30	30	15	45	(1)	15	(1)	(1)	(1)	15	(1)	15	(1)	30	3	15
High Hazard Pumps	90	45	15	15	15	60	30	30	15	45	(1)	15	(1)	(1)	(1)	15	(1)	15	(1)	30	3	15
Intermediate Hazard Pumps	90	45	15	15	15	60	30	30	15	45	(1)	15	(1)	(1)	(1)	15	(1)	15	(1)	30	3	15

Table 6: EQUIPMENT SPACING All units are (m)	Atm. Storage Hazardous	Atm. Storage Non-Hazardous	Large Pump House (8)	Compressor Buildings (8)	Analyser Room	Motor Control Centre	Fired Heaters and Boilers	Steam Generators	Internal Combustion Engines/ Gas turbines	Metering skid	Compressors	Pig Traps	High Hazard Pumps	Intermediate Hazard Pumps	Moderate Hazard Pumps	Air Cooled Condensers	Heat Exchangers	Instrument air compressors	Columns, Separator, Drums	Reactors	Pipe Racks	ESD
Moderate Hazard Pumps	90	(1)	10	10	10	60	15	15 (1)	15	15	(1)	15	(1)	(1)	3	5	(1)	15	(1)	30	3	10
Air Cooled Condensers	90	(1)	8	8	10	60	30	30	30	15	8	15	15	15	5	x	8	15	15	30	x	15
Heat Exchangers	90	45	8	15	15	60	30	30	30	15	15	15	(1)	(1)	3 (1)	8	(1)	15	(1)	30	3- 15 (2)	15
Instrument air/non-flammable compressors (6)	90	15	15	15	15	30	15	15	15	15	15	15	15	15	15	15	15	x	15	15	x	x
Columns, Separator, Drums	90	45	15	15	15	60	30	30	15	15	15	15	(1)	(1)	(1)	15	(1)	15	(1)	30	3- 15 (2)	15
Reactors	90	45	30	30	15	60	30	15	15	30	30	30	30	30	30	30	30	15	30	x	5	15
Pipe Racks	15	15	3-10 (2)	3-10 (2)	15	30	15	15	3- 15 (2)	15	3- 10 (2)	15	3	3	3	x	3- 15 (2)	x	3- 15 (2)	5	x	x
ESD/Unit Block Valves	30	10	10	15 (3)	15	60	15	15	15	15	15	x	15	15	10	15	15	x	15	15	x	x

Notes:	
1)	For good operational and maintenance access and for safe egress a minimum of 3 meter should be left between lined-up equipment (piping and instrumentation installed, except as noted in the table
2)	Areas under piperacks shall be kept clear for emergency and maintenance vehicles. Where two distances are given. The smaller refers to unit piperack and the larger to main piperacks.
3)	These distances are applicable to ESDV valves used as zone battery limit, isolation valves and in zones in which the capacities contain flammable liquids. Minimum distance may be reduced to 7.5m with additional protection.
4)	Motor control centre building shall be construct as non-hazardous pressurised building.
5)	This spacing requirement is not applicable to the driver of a compressor but is applicable to the horizontal distance between the driver of one compressor and possible source of hydrocarbon release from another compressor.
6)	Instrument air compressor are to be located in a non-hazardous utilities area at least 15 meters away from process equipment containing hydrocarbon.
7)	An underground fire water main will be installed to ring the battery units of process units and atmospheric / pressure storage areas. Fire hydrants / monitors will be provided every 50 meters around storage areas and spaced 15 m away from process fluid hazard
9)	Spacing of atmospheric storage tanks inside diked walls containing class 1, 2 and 3 petroleum product and unclassified materials shall be in accordance with Tank tables
10)	Critical isolation and ESD valves can be inside the bund area with adequate fire protection

A.2.2. Table 7: Outside Plant Spacing Chart

Table 7: Outside Plant Spacing Distances (m)		All Type Drilling Operations	Gas Wells	Oil Wells	Oil Flow Lines	All Gas Flow lines	Main Oil Lines\ Export Gas lines\Trunk lines\ Transfer lines	RDS & RMS
HAZARDOUS	Gas Wells	50 (1)	50 (1)					
	Oil Wells	50 (1)	50 (1)	50 (1)				
	Oil Flow Lines	50 (1)	50 (1)	50 (1)	1			
	All Gas Flow lines	50 (1)	50 (1)	50 (1)	10 (16)	10 (16)		

Table 7: Outside Plant Spacing Distances (m)		All Type Drilling Operations	Gas Wells	Oil Wells	Oil Flow Lines	All Gas Flow lines	Main Oil Lines\ Export Gas lines\Trunk lines\ Transfer lines	RDS & RMS
	Main Oil Lines\ Export Gas lines\Trunk lines\ Transfer lines	50 (15)	50 (15)	50 (15)	15	15	15 (13,15,16)	
	RDS & RMS (Process plants)	150 (17)	150 (17)	150 (17)	150 (17)	150 (17)	150 (17)	NA/NA
	All Type Drilling Operations	200	50 (1)	50 (1)	50 (1)	50 (1)	50 (1)	150 (17)
	Power cables underground	100	100	100	30	30	30	150 (17)
NON- HAZARDOUS	Water supply wells	50	50	50	50	50	50	150 (17)
	Water pipelines	50 (1)	50 (1)	50 (1)	1	10	NA	150 (17)
	Fibre Optic Cable & Telephone lines	50 (1)	50 (1)	50 (1)	10 (14)	10 (14)	10 (14)	150 (17)
	Public Establishments (Type 1) (3)	Beyond EAZ	Beyond EAZ	Beyond EAZ	Beyond EAZ	Beyond EAZ	Beyond EAZ	Beyond EAZ
	Public Establishments (Type 2) (4)	Beyond EPZ	Beyond EPZ	Beyond EPZ	Beyond EPZ	Beyond EPZ	Beyond EPZ	Beyond EPZ
	Administration Buildings	Beyond EPZ	Beyond EPZ	Beyond EPZ	Beyond EPZ	Beyond EPZ	Beyond EPZ	Beyond EPZ
	Accommodations & canteens	Beyond EAZ	Beyond EAZ	Beyond EAZ	Beyond EAZ	Beyond EAZ	Beyond EAZ	Beyond EAZ
IGNITION	Railways (7)	200	200	200	200	200	200	200
	Plant Flares (5)	500	500	500	150	150	150	150
	Power Lines - Overhead (6)	150	150	150	150	150	150	150

Notes	
1	50 m distance is based on potential Fire zone from wells. The distance may be further increased based on SIMOPS, Drilling, workover, Operations/Construction requirements
2	All distances are based on upwind Direction and shall be reviewed based on the conditions mentioned in the other notes.
3	Public Establishments Type 1: Public Residential Areas, Religious Places, Schools, Farms, Hospitals with inpatient treatment facilities, industrial works/workshops having worker accommodations etc which are considered as sensitive receptors. EAZ is the Emergency Awareness Zone of distance equivalent to 10 ppm H ₂ S Zone)
4	Public Establishments Type 2: Public Roads, Gas Stations, Restaurants, Industrial works/workshops not having worker accommodations, government offices, parks etc where public presence is expected for a limited time. EPZ is the Emergency Planning Zone of distance equivalent to 76 ppm H ₂ S zone)
5	Plant flares include fixed or permanent flare stacks designed for the plants (for example, RDS, RMS, GRS, CDS or other Plant units). This also include mobile flare stacks/units.
6	33KV overhead line could be reduced to 100 m
7	For railways the exclusion zones shall be 200 m minimum both sides
8	All Wells separation distances provided in this table shall be applicable for off pad (stand-alone) wells and shall not be applicable for Well Pad. Plats, Production Clusters etc
9	Separation distances would not discount for ALARP Risk Reduction measures.
10	All distances are from the skid boundary not to be considered from unit/ Equipment.
11	The distances given are the minimum recommended safe distance. Initial leverage for the design, however FSA shall determine actual requirements.
12	Distance between new and existing MOL lines 15 as per corrdoring philosophy. However for other buried pipelines (trunklines/pipelines) this can be reduced to 10m with the requirement of note 13 below
13	Adding a new buried pipeline adjacent /parallel to an existing buried pipeline, separation distance shall be 10 m. However minimum space for constructability and requirements of construction/maintenance right of way has to be ensured (refer to clause no. II.4.3.2 of Standard Specification)
14	Applicable for laying new Fibre Optic Cable (FOC) next to existing MOL/Trunk line/Transfer line. However, FOC is laid simultaneously along with a buried pipeline could be laid in the same trench as per standard agreed by project team
15	The above safety distances exclude future expansion requirements of flowline/pipeline/MOL Corridors. Adequate future expansion margins shall be considered. This distance is required for drilling rig/equipment manoeuvrability
16	When multiple buried pipelines are installed together, then these can be installed in common trench with minimum pipe edge to edge inter distance (refer to clause no. II.4.3.2 of Standard Specification) to facilitate maintenance activity
17	This distance is for planned expansion of the process facilities

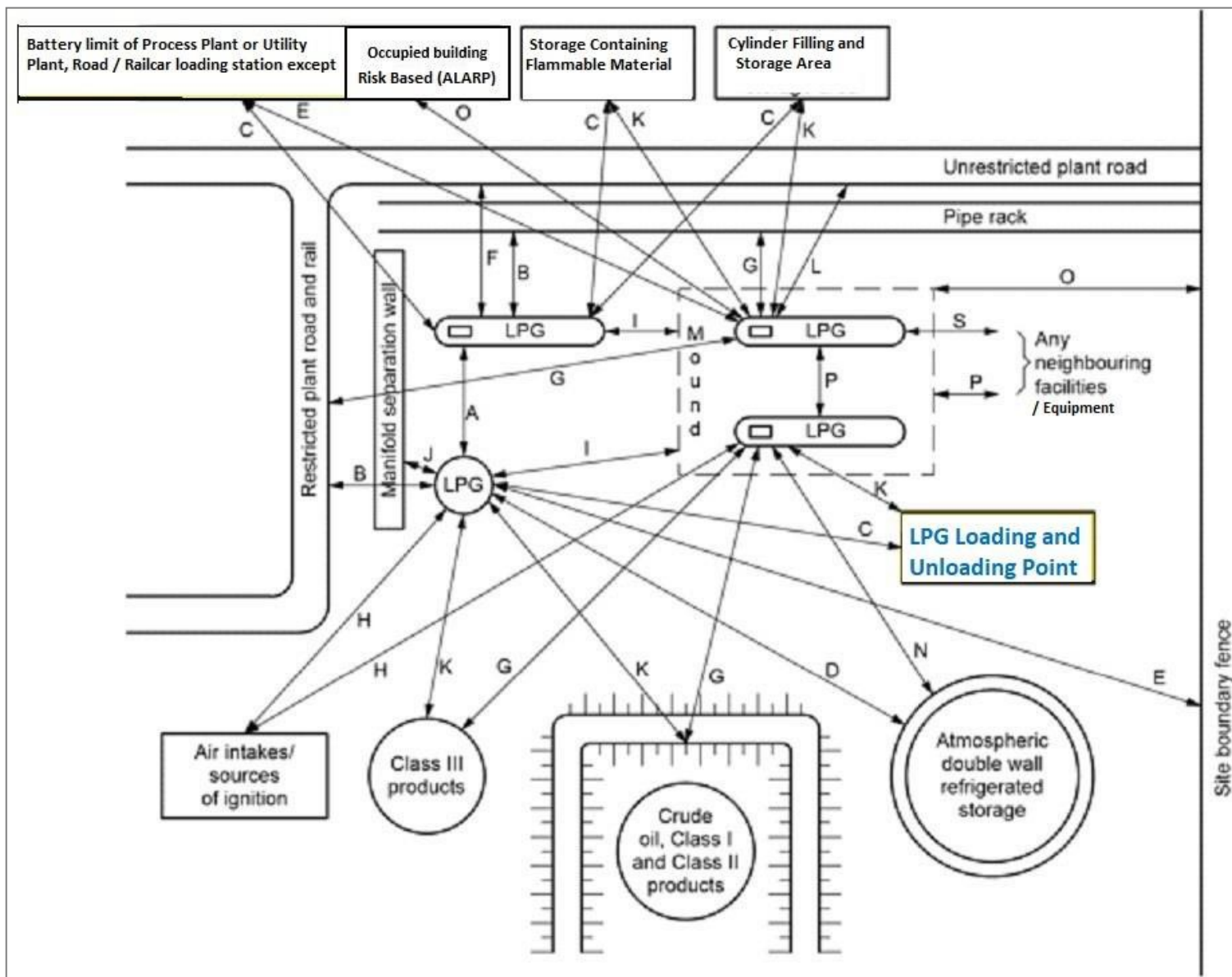
A.2.3. Table 8: Equipment Spacing Inside Wellhead Area

Table 8: SEPARATION DISTANCES Equipment Spacing inside Wellheads Area (m)	Wellhead	Oil & Gas Well Head Piping	ESD Valve	Chemical Injection Skid	Isolation valves/HIPPS	Choke valves	Depressurization Vent	Solar Panel	Passive Cooling Shelter	WHCP	Ground bed (Cathodic Protection)	Burn Pit
Wellhead	50 (3)											
Oil & Gas Well Head Piping	-	-										
ESD Valve	3 (1)	-	-									
Chemical Injection Skid	50 (3)	7.5 (5)	7.5 (5)	-								
Isolation valves/HIPPS	50 (3)	-	-	7.5 (5)	-							
Choke valves	3 (3)	-	-	7.5 (5)	-	-						
Depressurization Vent	RA	RA	RA	RA	RA	RA	-					
Solar Panel	50 (3)	5	5	15	5	5	RA	-				
Passive Cooling Shelter	50 (3)	5	5	15	5	5	RA	-	-			
WHCP	50 (3)	5	5	15	5	5	RA	-	-	-		
Ground bed (Cathodic Protection)	100	-	NA	NA	NA	NA	NA	NA (7)	NA	NA	-	
Burn Pit	120 / RA	120 / RA	120 / RA	120 / RA	120 / RA	120 / RA	120 / RA	120 / RA	120 / RA	120 / RA	120 / RA	-

Notes	
1	Minimum 3m within wellhead area or inside valve compound
2	This table is applicable for off pad well only and not applicable for well pads or Plats or Production clusters
3	50 m distance is based on potential Fire zone from wells. Distance may be increased based on SIMOPS, drilling, workover, operations/construction requirements.
4	All the distances provided in the table shall be measured from edge of the Equipment / Curbing.
5	7.5 m distance is based on 37.5 kW/m ² radiation from Chemical Injection. The distance may be further reduced based on the hazardous area classification and radiation control measures.
6	All distances in the table are fixed considering safety requirements such as fire case, area classification, etc. Further spacing between the equipment / facilities shall be considered based on drilling, workover, accessibility, constructability, maintainability and operability
7	Solar panel for CP ground bed shall be installed inside same compound adjacent to each other.

A.2.4. Table 9: Equipment Spacing - LPG

Table 9: LPG Pressurised Vessels Spacing Distances (m)		A (1)	B	C	D (2)	E	F	G (3)	H	I	J	K (3)	L	M (2)	O (8)	P	S
Individual LPG vessel capacity	< 135 m ³	(D1+D2)/4	15	50	1.5 Dr	15	15	7.5	15	5	5	15	10	Dr	RA	1	3
	> 135m ³ <= 265 m ³	(D1+D2)/4	15	50	1.5 Dr	25	22.5	7.5	22.5	15	5	15	22.5	Dr	RA	1	3
	> 265m ³ <= 500 m ³	(D1+D2)/4	15	50	1.5 Dr	25	30	7.5	30	15	5	15	30	Dr	RA	1	3
	> 500 m ³	(D1+D2)/4	15	50	1.5 Dr	25	30	7.5	30	15	5	15	30	Dr	RA	1	3



Notes	
1	D1 and D2 are the diameters of two adjacent vessels
2	Dr is the diameter of the outer tank of a refrigerated storage tank
3	Separation distances are measured from exposed nozzles, tank fittings of the vessel nearest to the hazard
4	Relative orientation of mounded and above ground storage is for representative purposes only
5	The distance from a sphere to an unrestricted plant road is the same as from an aboveground horizontal vessel to an unrestricted plant road (F)
6	The distance from an aboveground horizontal vessel to a restricted plant road is the same as from a sphere to a restricted plant road (B)
8	Subject to Risk Assessment (RA)
9	Occupied Building covers non blast resistant occupied building, Fire Station, Main Intake Electrical Substation and Control Room

Appendix B.CHECKLISTS – FACILITY LOCATION

B.1. blank

B.2. Checklists

B.2.1. Hazard Identification (High-Level)

B.2.1.1. Operations Hazards (Concept Screening)

Hazard Identification (& Risk Assessment)		
Facility in Operation	Y/N	Comments
1 Facility (/System) Description		
Purpose & Scope of Project		
Expected lifetime (yrs.)		
List of Activities & Operations (automatic & manual)		
Key Design Concepts for Layout (e.g. indoor /outdoor)		
Materials Present (feed, intermediates, products).		
Handling Conditions (temp, press, flow, etc.).		
Operating Modes (including quantity variations).		
Turnaround Management		
Inventory Estimates		
Utilities (special)		
Climatic Concerns		
Environmental (/Regulatory) Concerns		
Materials Transport (on / off site)		
Waste Disposal Requirements		
Process Safety Incidents – Historical		
2 Hazard Identification		
Hazardous Materials (Toxic, flammable, etc.)		
Temp / Pressure / Storage Extremes		
Start-up / Shutdown Hazards		
3 Credible Initiating Events		
- pipe/Hose leak		
- Hose failure		
- Pump / compressor seal leaks		
- Sample points		
- Process upsets (flare/vent discharges)		
- Process upsets (relief discharges)		
4 Major Hazard Effects		
Fires		
- Jet fires		Use Tables in Appendices for Hazard Ranges / Exclusion Zones

Hazard Identification (& Risk Assessment)		
Facility in Operation	Y/N	Comments
- Pool fires		
Jet Fire		
Fireball (BLEVE)		
- Full Surface (storage tanks)		
- Hose failure (truck or rail)		
Explosion		
- Flash fire / VCE		
- Dust Explosion		
- Vessel Rupture / BLEVE		
- Chemical Explosion		
Toxic		
- Release Scenarios (pressurised gas / liquid evaporation)		
Domino Effects		
- Knock-on Impact of Initial Incident		
5 Potential Consequences		
- People (onsite)		
- People (offsite)		
- Environment		
- Business / Reputation		
6 Risk Assessment		
QRA (e.g. Concept Risk Assessment)		

B.2.1.2. Construction Phase (concept Screening)

Hazard Identification (& Risk Assessment)		
Construction	Y/N	Comments
Temporary Facilities		
- Construction Camp		
- Accommodation / Offices		
- Power & Utilities		
- Material /Vehicle movements		
- Material Storage		
- Fencing		
- Hot Work		
- Vents & Flares		
Emergency Response		
- Egress & Evacuation		
- Shelter in Place		

Hazard Identification (& Risk Assessment)		
Construction	Y/N	Comments
Interfaces (/ Interferences)		
- F&G Detection and Public Address Systems		
- Existing facilities - underground (drains, pipes, etc.)		
- Existing facilities - above ground		
- Hazardous Area Impact (e.g. Flare exclusion)		
- Transport (Vehicles, Helicopter, Ships, etc.)		
- Transport (Vehicles, Helicopter, Ships, etc.)		

B.2.2. General

B.2.3. Site Selection Team – Competencies

4.2) Site Selection Team - Competencies [4.3 Site Selection Team] - Competencies]	
Non-Technical	
-	Company policies & Guidelines
-	Geographic knowledge
-	Local Regulations
-	Local language
-	Security (normal / turnaround, workers /materials)
-	Transport (onsite /offsite, people & materials)
Technical / Engineering	
-	Process
-	Equipment layout
-	Process Safety & Risk Specialist (onsite & offsite issues)
-	Environmental (wastewater, groundwater, air, etc.)
-	Civil Eng. (topography, soil etc.)
-	Pipelines

B.2.4. Location Information

B.2.4.1. Site Information

4.3) Location Information		Relevance		Information	Comment
		Const.	Ops.		
Site Info					
	4.7 Maps & Information				
	Geographical				
	Environmental (sensitive areas)				
	Public				
	Community infrastructure				
	National Assets				
	Adjacent areas (Existing Complex)				
	4.8 Geological				
	Terrain				
	Soil				
	Excavation (sheet piling or well point systems)				
	In-ground pipe corrosion potential				
	Stray electrical ground currents (20mile range)				
	Cathodic Protection requirements in vicinity				
	Soil stability				
	Earthquakes				
	Landslides				
	Sinkholes				
	Soil liquefaction (quicksand)				
	Debris flows and rockfalls.				
	Rockfalls				
	Structural loading data (foundation types, settlement)				
	Construction loads (soil compacting etc.)				
	Boring & soil bearing test info				
	Contaminant remediation				
	Soil erosion prevention (vegetation)				
	Soil disposal area				
	Dredging / fill requirements				

4.3) Location Information			Relevance		Information	Comment
			Const.	Ops.		
		Bulkheads to prevent soil slumping (& sizes)				
		Presence of tunnels, mine shafts, or injection wells				
		Frost penetration depth (& dates)				
		Natural hazards				
		Natural underground caverns				
		Large tidal swings				
		Salty coastal air				
		Tsunami				
		Volcano				
4.9 Weather						
		Annual Average Temp.				
		Coldest Month (Avg. Temp)				
		Lowest One-Day-Mean Temp				
		Extreme Low Temp				
		Summer Wet Bulb / Winter Dry Bulb				
		Humidity				
		Wind Speed				
		Mean Wind Speed				
		Prevailing Wind Direction				
		Rainfall (10yr, one month, day, hour, 30mins)				
		Snow load				
		Ice load				
		Severe weather				
		Fog				
		Tornados				
		Hurricanes or typhoons				
		Floods				
		Flood control organisation				
		Flood model				
		Who maintains levees & navigable waterways				

4.3) Location Information			Relevance		Information	Comment
			Const.	Ops.		
		Drought				
		Dust storm				
		Icing & heavy snows				
		Lightning - strike frequency				
		Lightning strike risk - operations delays				
		4.10 Seismic				
		Earthquake zone				
		Active fault lines				
		Seismic coefficient for design (local authorities / structural engineers)				
		4.11 Off-site				
		Neighbouring forests and vegetation				
		Neighbouring industrial facilities				
		Emergency Response (external services)				
		Stakeholder Outreach				

4.3) Location Information			Relevance		Information	Comment
			Const.	Ops.		
		Site Info				
		4.13 Environmental				
		Environmental impact assessments (EIA)				
		Environmental regulations				
		Air issues				
		Land issues (hazardous waste control)				
		Water issues				
		Noise issues				
		Luminosity				
		Flares				
		Incinerator /boiler				
		Biological hazards				

4.3) Location Information				Relevance		Information	Comment
				Const.	Ops.		
Site Info							
	4.14 Infrastructure						
		Public					
			Road				
			Rail				
			Marine				
			Air				
		Transport Requirements (Construction / Operations)					
			Road				
			Rail				
			Marine				
			Air				
		Utilities					
			Electric				
			Water				
			Fuel gas				
			Gas				
	4.15 Building and Structure						
		Parking					
		ISD study (vehicle hazards)					

B.2.4.2. Support Infrastructure

4.3) Location Information			Relevance		Information	Comment
			Const.	Ops.		
Support Infrastructure						
	4.17 Communication					
		Languages				
		Interference potential				
		Radio				
		TV				
		Cell phone				
		Microwave				
		Types				
		Phone				
		Intra-Site Phones				
		Internet				
		Microwave				
		Radio				
		Regulations: 2-way communication				
		Electronic data acquisition Eqpt.				
		Haz Area Issues				
		Packages & mail (couriers)				
		Local				
		Global				
		Overnight Service				
		Other Options				
	4.12 Security					
		Local Info				
		Patrols (police, coastguard, etc.)				
		Security - perimeter walls				
		History of kidnappings etc.				

4.3) Location Information				Relevance		Information	Comment
				Const.	Ops.		
			History of visa restrictions				
			Special security measures				
			Hunting season impact				
			Other wildlife				
			History of theft / vandalism				
			Political environment (vs Company Values)				
			Political shift - impact on business				
			Violent demonstrations, sabotage or terrorism				
			Special vulnerability				
			Drug precursors				
			Weapons precursors				
			Project requirements				
			Security - accessibility				
			Fences & guards				
			Fence gates: Signs & locks				
			Video surveillance				
			Use of construction police / security for operations				

B.2.5. Basis & Constraints

Project Assessment			Relevance		Information	Comment
			Const.	Ops.		
Basis & Constraints [4.2 Facility Information]						
		Project Basis (/Requirements)				
		Key Parties				
		Design Basis				
		Manpower Resources				
		Constraints (/Surrounding)				
		Site Information				

Project Assessment			Relevance		Information	Comment
			Const.	Ops.		
		Current Status of Site				
		3rd Party Influences				
		Plot Size Requirement [4.5 Plot Size]				
		Layout /Dimensions expected				
		Offsite risk (included?)				
		Future expansion (suitability?)				
		Cost & rights-of-way				
		Land for laydown, warehousing & construction camp				

B.2.6. Plot Size Requirements

Project Assessment		Relevance		Information	Comment
		Const.	Ops.		
4.5) Plot Size Requirement [4.5 Plot Size]					
	Layout /Dimensions expected				
	Offsite risk (included?)				
	Future expansion (suitability?)				
	Cost & rights-of-way				
	Land for laydown, warehousing & construction camp				

B.2.7. Project Assessment: Transport & Materials Handling

B.2.7.1. Materials Required

Project Assessment		Relevance		Information	Comment
		Const.	Ops.		
4.6) Transport & Material Handling [4.16 Material handling]					
	4.6.1) Materials Required - Type, - Quantity - Frequency				
	Feedstocks				
	Acids				
	Bases				
	Speciality				
	Chemicals				
	Inhibitors				
	HF				
	Aluminium pyrophoric catalyst				
	Initiators				
	Regulated substances				
	Gases				

Project Assessment					Relevance		Information	Comment
					Const.	Ops.		
				N2				
				O2				
				Natural gas				
				LPG				
				Lubricants				
				Greases				
				Oils				
				Others				

Project Assessment					Relevance		Information	Comment
					Const.	Ops.		
				Construction & Turnaround [4.6 Construction & Turnaround]				
				Parallel projects - disturbance				
				Personnel - site access (Operations/Maintenance, Construction)				
				Security - materials (construction Camp /route to site)				
				Permits				
				Construction				
				Environmental (construction)				
				Groundwater				
				Quality (impact on cement foundations)				
				Protection /monitoring requirements (dykes, spill ways, etc.)				
				Transport				
				Jetties /docks - availability for ship delivery				
				Construction				
				Heavy haul roads (for largest vessels /skids, supplier to site)				
				Bridge weight limits				
				Bridge Height Limits				
				Water unloading				

Project Assessment					Relevance		Information	Comment
					Const.	Ops.		
				Access to public highways /railways				

B.2.7.2. Constraints

Project Assessment					Relevance		Information	Comment
					Const.	Ops.		
4.6) Transport & Material Handling [4.16 Material handling]								
	4.6.2) Constraints							
		Laws & Regs						
			Handling					
			Shipping					
			Loading					
			Unloading					
		Controls						
			Bonded tanks					
			Customs Inspectors (on site)					
			Measurement (gauged or meter?)					

B.2.7.3. Transport Options - Pipelines

Project Assessment					Relevance		Information	Comment
					Const.	Ops.		
	Transport Options - Assessment Required vs Available)							
	4.6.3) Pipeline							
		Regulations						
		Regulations applicable						
		Minimum clearance (roads & highways)						
		Burial depth						
		Local preferences						

Project Assessment					Relevance		Information	Comment
					Const.	Ops.		
				Topographical Data				
				Soil conditions				
				Frost penetration depth				
				Underground (inside /outside fence)				
				Utilities				
				Natural gas				
				Electric cables				
				Water				
				Sanitary sewer				
				Chemical treatment sewers				
				Water mains				
				Rainwater runoff				
				River discharges				
				Above ground (inside / outside fence)				
				Utilities				
				Feedstock /Products				
				Preferred Route				
				Facility entry / exit				
				Rights-of-way requirements?				
				Trough				
				Flood plains				
				Flood levees				
				Navigable waters				
				Buried / above ground				
				Problems				
				Rock excavation				
				Quicksand				
				Sinkholes				
				Corrosion protection				

B.2.7.4. Transport Options – Road (Trucks)

Project Assessment					Relevance		Information	Comment
					Const.	Ops.		
				4.6.4) Road (Truck)				
				Off-site: General				
				Express & freight yard.				
				Existing highway capacity				
				Local Roads & Bridges				
				Max Loads				
				Max Width (including right turns)				
				Facility - Highway (new roads?)				
				Restrictions				
				Curfew				
				Seasonal limits				
				Public road congestion (transport risk)				
				One-way traffic flows (required?)				
				Off-site services				
				Public transport (to /from facility)				
				Private trucking services - available?				
				Compliance				
				Regulatory Constraint (passenger vehicles & trucks)				
				Ownership				
				Use				
				On-site transport				
				Controls				
				Trailer tracking (bar-code scanners)				
				Cameras				
				Computer Access (security & logistics)				
				(Locking gates (truck entry)				

Project Assessment					Relevance		Information	Comment
					Const.	Ops.		
				Trailer weigh scales				
				No of scales				
				Building (printer & instruments)				

B.2.7.5. Transport Options - Rail

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
			4.6.5) Rail				
			Regulations				
			Railroads				
			Spur requirement				
			Marshalling operations				
			Infrastructure				
			Car - Platform				
			Car - Building				
			Car Details (for special materials)				
			Railroad company (interface & services)				
			Rates				
			Pull & axle loads				
			No of cars (full /empty)				
			Explosion risk				
			Off-site Impact				
			On-site transport				

B.2.7.6. Transport Options - Marine

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
			4.6.6) Marine				
			Regulations				
			Marine - Waterways?				
			Tanker /barge operations				
			Governmental customs access				
			Area Information				
			Harbour Map				

Project Assessment					Relevance		Information	Comment
					Const	Ops		
				Data				
				Operating requirements				
				Capacity of Marine Facilities				
				Functional Limits				
				3rd Party Services				
				Marine Vessels Required (for feedstock & product)				
				Type (& no. off)				
				Marine crew required				
				Typical vessels available				
				Jetty /docking facilities				
				Marine Vessels Required (Construction)				
				Shore facilities				
				Ballast water / bunkering system				
				Instrumentation				
				Building for printer and instrumentation				
				Utilities				
				Lighting				
				Storage areas with foundations/roofs				
				Potable water and sewerage systems				
				Automatic cleaning and purging systems				
				Temporary accommodations				
				Access paths away for crew members				
				Controls (jetty /dock)				
				Tracking				
				Locking gates				
				Traffic				
				Gates /arms to prevent crossing in emergency conditions.				
				Logistics: 3rd party maritime companies				

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
			Video surveillance				
			Marine dock Emergency Response				
			Personnel				
			Escape Routes				

B.2.7.7. Transport Options – Air Carrier

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
			4.6.7) Air Carrier Issues				
			Airport				
			Cargo				
			Passenger				
			Distance				
			Helicopter facilities				
			Airport hazard				
			Take-off & landing				
			Airport zoning restrictions & warning lights				
			Flares				
			Towers / structures				
			Flight path impact				
			Process discharge hazards (relief /vents)				
			Airport - future expansion impact on facility				

B.2.7.8. Materials Handling - Proposed Plan

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
			4.6.8) Proposed Plan				
			Suppliers - Reception Station (each item)				

Project Assessment			Relevance		Information	Comment
			Const.	Ops.		
		Availability				
		Transport methods				
		Limitations				
		Reception Station - Site (Infrastructure)				
		Road				
		Rail				
		Marine				
		Air				
		On site				
		Materials reception				
		Product distribution				
		Movement within site				
		Special fork lift areas				
		Site storage				
		Construction & Turnaround [4.6 Construction & Turnaround]				
		Parallel projects - disturbance				
		Personnel - site access (Ops/Maint, Construction)				
		Security - materials (construction Camp /route to site)				
		Permits				
		Groundwater				
		Transport				

B.2.8. Engineering Design

Project Assessment			Relevance		Information	Comment
			Const.	Ops.		
		4.7) Engineering Design [4.18 Engineering Design]				
		Measurement Systems				
		Calibrating instruments? (Metric?)				

Project Assessment		Relevance		Information	Comment
		Const.	Ops.		
	Weights and measures				
	Preferred				
	Facility Procedures				
	Codes, standards, design factors, and units				
	Local codes or regulations				
	Structural steel and reinforced concrete				
	Architectural design				
	Pressure vessels				
	Electrical design				
	Piping				
	Boilers				
	Plumbing and sanitary systems (architectural)				
	Working conditions				
	Spacing of process units				
	Permissible noise level.				
	Health ordinances				
	Specific suppliers				
	Raw materials				
	Natural resources				
	Fabricating equipment				
	Alternative design standards vs local codes?				
	Building Design Approval requirements				
	Architecture				
	Materials of construction				
	Codes applicable to temporary construction				
	Imported steel vs Local Spec Steel				
	Local shape, weight & standard sizes				
	Bessemer or open-hearth steel				
	Local piping preferences				
	Codes or Stds				

Project Assessment		Relevance		Information	Comment
		Const.	Ops.		
	Impact on Company Standards				
	Regulations - Design				
	Wind loading				
	Snow loading				
	Corrosion Allowance				
	Local practice for structural steel design				
	Standard system of units & measures				
	Language				
	Communication				
	Design documentation				
	Automation level (impact on equipment spacing)				
	Automatic				
	Manual				
	Layout drivers				
	enclosed loading vs outside loading				
	Process technologies to be employed.				
	Turnaround philosophy				
	Expected life of plant				
	Operation mode				
	hrs/day				
	days/week				
	Utility				

B.2.9. Utilities

Project Assessment		Relevance		Information	Comment
		Const.	Ops.		
	4.8) Utilities				
	[4.19 Utilities]				
	Electric power supply				

Project Assessment		Relevance		Information	Comment
		Const.	Ops.		
	Water supply				
	Steam supply				
	Fuel supply				
	Air supply				
	Other utility supplies				

B.2.10. Other Manpower Issues

Project Assessment		Relevance		Information	Comment
		Const.	Ops.		
4.9) Other Manpower Issues [4.20 Other (manpower related)]					
	Personnel				
	Other support personnel and operations				
	Housing				

Appendix C. CHECKLISTS – PROCESS UNIT LAYOUT

C.1. Blank

C.1.1. Critical & Occupied Structures (Ch. 5.13)

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
5.13	Critical and Occupied Structures						
	4.15	Building and Structure		See list in Appendix B			
	5.13.1	Locating critical and occupied structures					
		5.13.1.1	Optimizing structure locations within the process unit				
			Dispersion				
			Fires				
			Blast loads (preliminary)				
		5.13.1.2	Structure occupancy risks - Maximum Credible Event (MCE, API RP 752).				
		5.13.1.3	Explosion risk				
		5.13.1.4	Fire risk				
		5.13.1.5	Toxic risk				
		5.13.1.6	Domino effect (education)				
		5.13.1.7	Security				
	5.13.2	Process control buildings (exposure to hazards)					
	5.13.3	Shelters (exposure to hazards)					
	5.13.4	Blast resistant buildings (locations where required)					
	5.13.5	Buildings - outside process areas: hazard exposure)					

C.1.2. Material Handling (Ch. 5.14)

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
5.14	Material Handling						
	5.14.1	On-site and off-site transport:					
		5.14.1A	Access Points				
			Facility				
			Hazardous materials				
			Emergency Response				

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
			Emergency Response (potentially inaccessible e.g. rail)				
			Facility speed limit				
		5.14.1B	Route for hazardous material:				
			Forklifts				
			To /from facility				
			Construction & Turnaround				
			Normal operations				
			Start-up /shutdown / special ops				
		5.14.1C	Lifting				
			Normal operations				
			Special operations				
			Personnel (lifts, etc.)				
		5.14.1D	Travel route optimisation (avoid people & short as possible)				
	5.14.2	Transfer pumps (distance from tank farms)					
	5.14.3	Pipeline metering stations					
	5.14.4	Pipeway routes - above ground					
			Pipeways				
			Cable trays				
	5.14.5	Piping routes - below ground					
	5.14.6	Truck and rail loading and unloading racks					
			Truck loading				
			Rail (un)loading				
	5.14.7	Railways - Path for rail cars to:					
		5.14.7.1	On-site main railways				
		5.14.7.2	On-site railway spurs				
		5.14.7.3	On-site rail loading racks and platforms				
		5.14.7.4	On-site rail sidings				
	5.14.8	Piers and wharves					
			Transport to facility				
			Pipelines (underground and above ground)				
			Truck or rail				
	5.14.9	Air carriers					
			Requirement?				
			Accessibility of airfields /heliports				

C.1.3. Process Units (Ch. 5.15)

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
5.15	Process Units						
	5.15.1	Process unit locations (list)					
			Outdoors				
			Partially enclosed				
			Enclosed (indoors)				
	5.15.2	Distances between process units					
			Footprint (area) for each unit				
			Hazard type (categorise)				
			Roadways control (outside and inside)				
			Special maintenance areas				
			Laboratory areas (& hazardous sample storage)				
			Chemicals storage				
			Hazardous solid waste (storage & disposal)				
	5.15.3	Modularization					
	5.15.4	Accessibility:					
			Operational				
			Maintenance				
	5.15.5	Emergency accessibility					
	5.15.6	Logistics (hazardous materials)					
			Shipping				
			Receiving				
	5.15.7	Special and tolling operations					

C.1.4. Tank Farms (Ch. 5.16)

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
5.16	Tank Farms						
	5.16.1	Tank farm locations					
	5.16.2	Underground storage tanks					
			Location				
			Integrity management				
	5.16.3	Aboveground storage tanks					
			Location				
			Integrity management				

C.1.5. Other Areas (Ch. 5.17)

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
5.17	Other Areas						
	5.17.1	Flares					
			Types				
			Location & size				
	5.17.2	Facility support operations					
			Types				
			Location & size				
	5.17.3	Wastewater operations					
			Types				
			Location & size				
	5.17.4	Chemicals storage					
			How (toxic)				
			Location (toxic)				
			How (reactive)				
			Location (reactive)				
	5.17.5	Compressed & liquefied gas storage					
			How (compressed gas)				
			Location (compressed gas)				
			How (liquefied gas)				
			Location (liquefied gas)				
	5.17.6	Emergency response (/medical) facilities					
			Types on-site				
			Location & size				
	5.17.7	Fire training areas (on-site)					
			Types				
			Location				
	5.17.8	Miscellaneous (other on-site areas):					
			Types (e.g., landfills, firewater ponds, etc.).				
			Location & size				

C.1.6. Utilities (Ch. 5.18)

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
5.18	Utilities						
	5.18.1	Electrical power supplies					

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
			Distribution				
			Back-up systems (UPS)				
		5.18.1.1	Electrical substations				
			Location				
			HVAC arrangements				
		5.18.1.2	Outdoor electrical switch racks: Location				
		5.18.1.3	Remote LER / SIH				
			Location				
			Occupation				
	5.18.2	Water supply source					
		5.18.2.1	Drinking (potable) water				
		5.18.2.2	Boiler feed water				
		5.18.2.3	Firewater				
		5.18.2.4	Once-through cooling water systems				
		5.18.2.5	Service water				
		5.18.2.6	Other water				
	5.18.3	Steam supply					
			Source				
			Location & size				
			Distribution network				
	5.18.4	Cogeneration facilities					
			Types				
			Location & size				
	5.18.5	Fuel Gases and Liquids					
			Type (fuel gas)				
			Location (fuel gas)				
			Type (liquid fuel)				
			Location (liquid fuel)				
	5.18.6	Air compressors					
			Air system types (e.g., instrument air, breathing air).				
			Sizes				
			Locations				
			Distribution network				
	5.18.7	Utility cooling towers					
			Location & size				
	5.18.8	Other utility systems (location & size)					
		5.18.8.1	Oxygen?				

Project Assessment				Relevance		Information	Comment
				Const.	Ops.		
		5.18.8.2	Nitrogen?				
		5.18.8.3	Other inert gases?				
		5.18.8.4	Dedicated hot oil systems?				
		5.18.8.5	Others?				

Appendix D. CHECKLISTS – EQUIPMENT LAYOUT

Line Item	Section in Chapter 6		
1	6.6	Critical and occupied structure design issues	
2		6.6.1	Applying Inherently Safer Design (ISD) strategies Describe the ISD strategies that have been considered.
3		6.6.2	Design issues with modular units Describe where modular units will be located.
4		6.6.3	Design issues with single and multi-level structures Describe where single and multi-level structures will be located.
5		6.6.4	Design issues with partially enclosed structures Describe where partially enclosed structures will be located.
6		6.6.5	Design issues with enclosed structures Describe where enclosed structures will be located.
7		6.6.5.1	Modelling enclosed structure vapor cloud explosions Describe the modelling of vapor cloud explosions in enclosed structures.
8		6.6.5.2	Managing combustible dusts Describe how combustible dusts will be managed
9		6.6.5.3	Providing ventilation systems Describe ventilation systems which are going to be used as a layer of protection (i.e., a safeguard)?
10		6.6.5.4	Providing explosion vents Describe where explosion vents will be located.
11		6.6.5.4	Consider the overpressure and relief philosophy
12		6.6.6	Design issues with blast resistant modules Describe where blast resistant modules will be located.
13	6.7	Layout issues for equipment	
14		6.7.1	Applying Inherently Safer Design (ISD) strategies Describe the ISD strategies that have been considered.
15		6.7.2	Vessels Describe where vessels handling hazardous materials will be located.
16		6.7.3	Reactors Describe where reactors handling hazardous materials or with runaway reaction potential will be located.
17		6.7.4	Pumps Describe where pumps handling hazardous materials will be located.

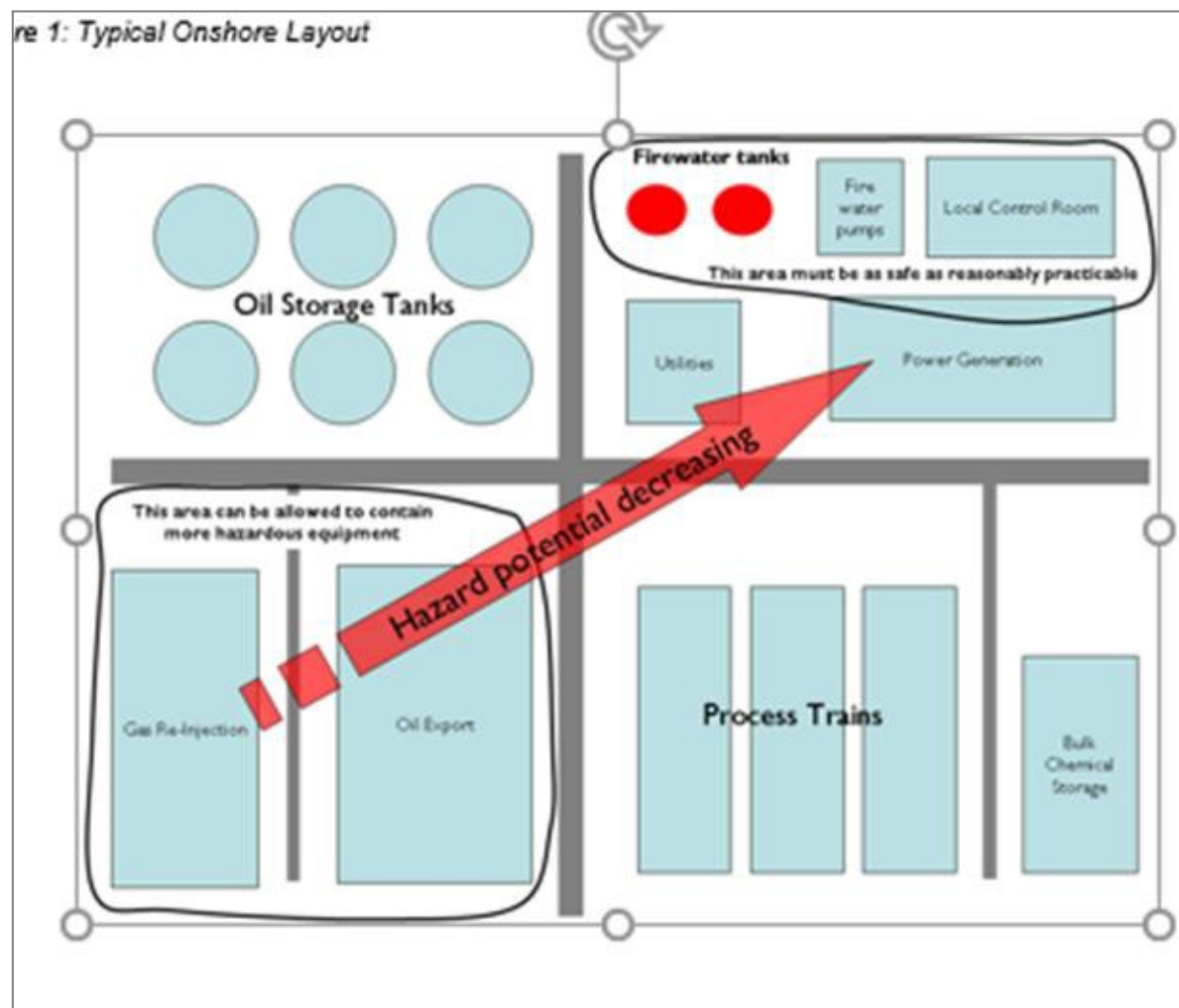
Line Item	Section in Chapter 6		
18		6.7.5	Gas compressors and expanders Describe where gas compressors and expanders handling hazardous materials will be located.
19		6.7.6	Equipment with air intakes Describe the locations of equipment with air intakes.
20		6.7.7	Heat exchangers Describe where heat exchangers handling hazardous materials will be located.
21		6.7.8	Air cooled heat exchangers Describe the locations of air-cooled heat exchangers.

Appendix E.SUMMARY OF LINKS TO CHECKLISTS

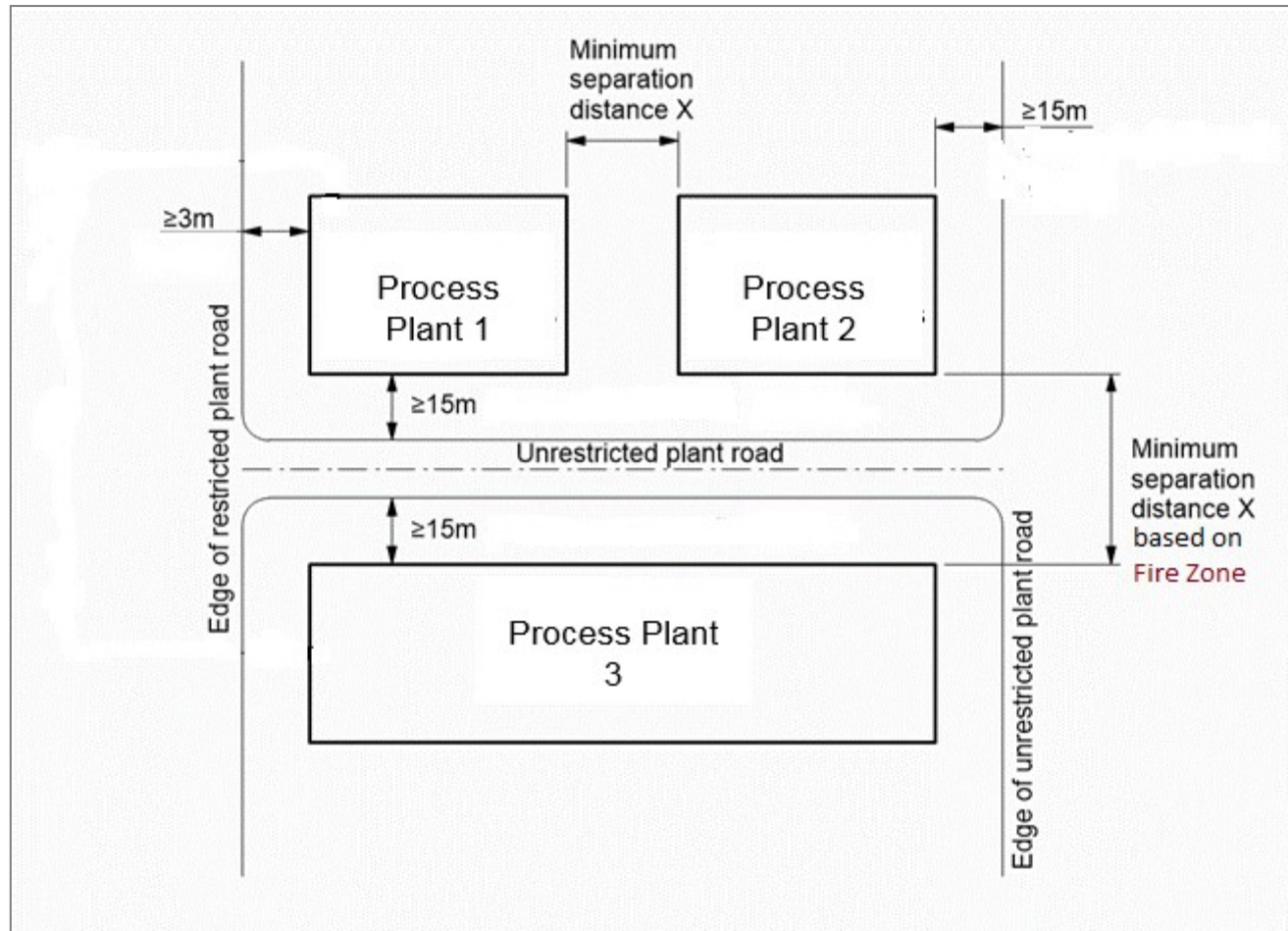
Assessment	Step 1: Facility Location				Step 2: Process Unit Layout	
	Section		Checklist (App.)	CCPS Reference - Chapter (Ref. 35)	Checklist (Appx)	CCPS Reference - Chapter (Ref. 35), or Others as Indicated
	No.	Title				
1. Team (Competency)	9.2	Site Selection Team – Competencies	B.2.3	4.3 Site Selection Team		
2. Information (site /project)	9.3. 1	Site Information	B.2.4.1	4.7 Maps & Information		5.7 Step 1 - Location characteristics
				4.8 Geological		
				4.9 Weather		
				4.10 Seismic		
				4.11 Off-site		5.8 Off-site Issues
				4.13 Environmental		5.10 Environmental
				4.14 Infrastructure		5.11 Infrastructure
				4.15 Building and Structure	B.2.4.1	Building & Structural (same as Ch 4.15)
	9.3. 2	Support Infrastructure	B.2.4.2	4.12 Security		5.9 Security
				4.17 Communication		
3. Hazard Id. (& Assessment)	9.4	Hazard Identification (High-Level) • Operations	B.2.1.1	Appendix C		5.2 Methodology Overview (Block Layout)
						5.3 Integration (Block Layout - Facility Location)
						5.4 Process Units - Preventative Measures
						5.5 Process Units - Mitigative Measures
						5.12 Step 2 - Separation (Block - Block)
		• Construction (SIMOPS) Issues	B.2.1.2		B.2.1.2	5.6 Construction & Turnarounds (same as Ch 4.6)
4. Project Implementation	9.5	Basis & Constraints	B.2.5	4.2 Facility Information		
	9.6	Plot Size	A.1 & A.2			5.12 Step 2 - Separation (Block - Block)
			B.2.6	4.5 Plot Size	C.1.1	5.13 Critical & Occupied Structures
					C.1.3	5.15 Process Units

Assessment	Step 1: Facility Location				Step 2: Process Unit Layout	
	Section		Checklist (App.)	CCPS Reference - Chapter (Ref. 35)	Checklist (Appx)	CCPS Reference - Chapter (Ref. 35), or Others as Indicated
	No.	Title				
					C.1.4	5.16 Tank Farms
					C.1.5	5.17 Others
					C.1.6	5.18 Utilities
						5.19 Optimising Location of Process Units
						5.20 Resolving Block Layout optimisation issues
	Materials Handling	9.7.1	Materials Required	B.2.7.1	4.16 Material handling	C.1.2 5.14 Material Handling
		9.7.2	Constraints	B.2.7.2		
		9.7.3	Transport Options - Pipelines	B.2.7.3		
		9.7.4	Transport Options – Road (Trucks)	B.2.7.4		
		9.7.5	Transport Options – Rail	B.2.7.5		
		9.7.6	Transport Options – Marine	B.2.7.6		
		9.7.7	Transport Options – Air Carrier	B.2.7.7		
		9.7.8	Materials Handling - Proposed Plan	B.2.7.8		
	9.8	Engineering Design		B.2.8	4.18 Engineering Design	
	9.9	Utilities		B.2.9	4.19 Utilities	
	9.10	Other Manpower Issues		B.2.10	4.20 Other (manpower related)	

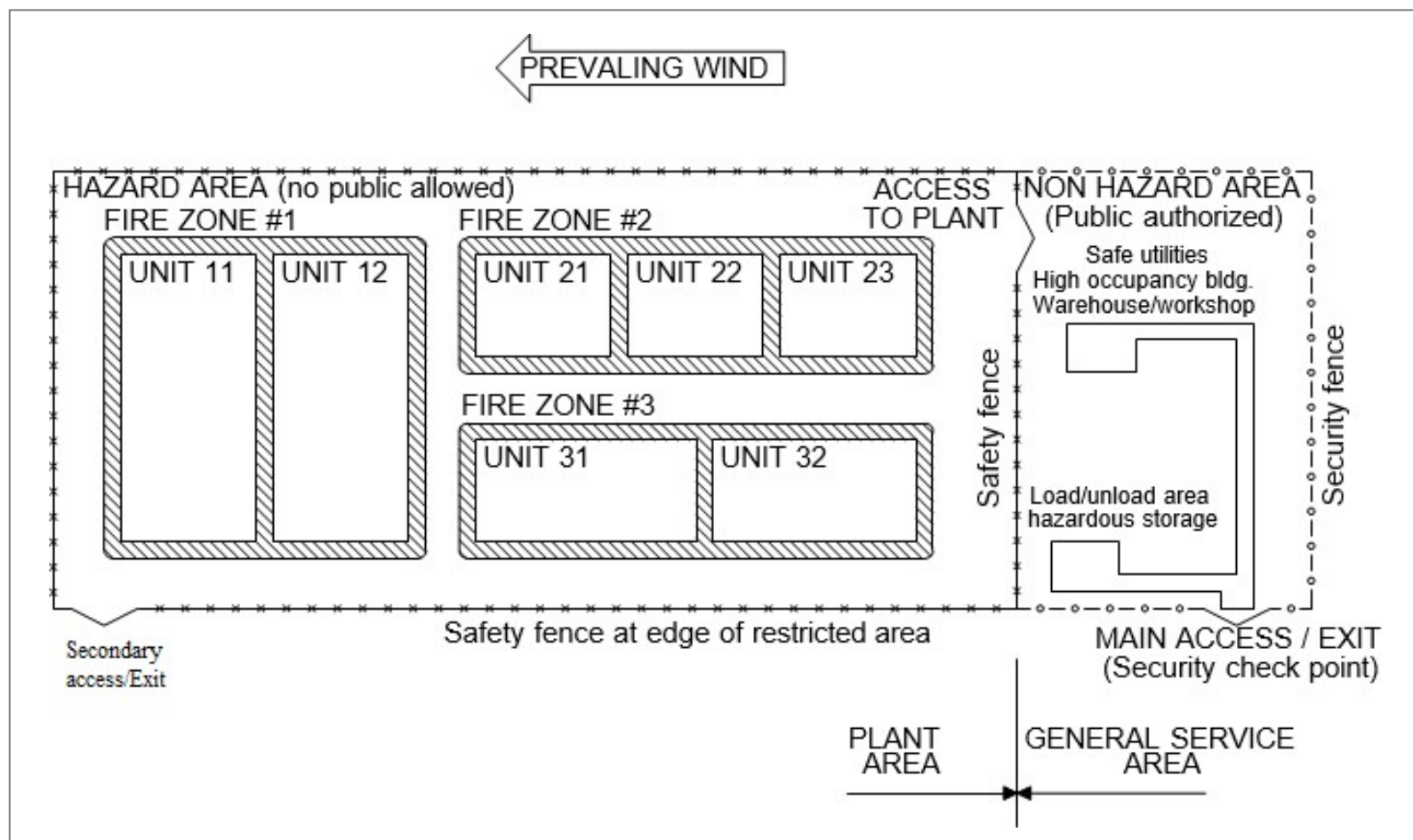
Appendix F. LAYOUT EXAMPLES



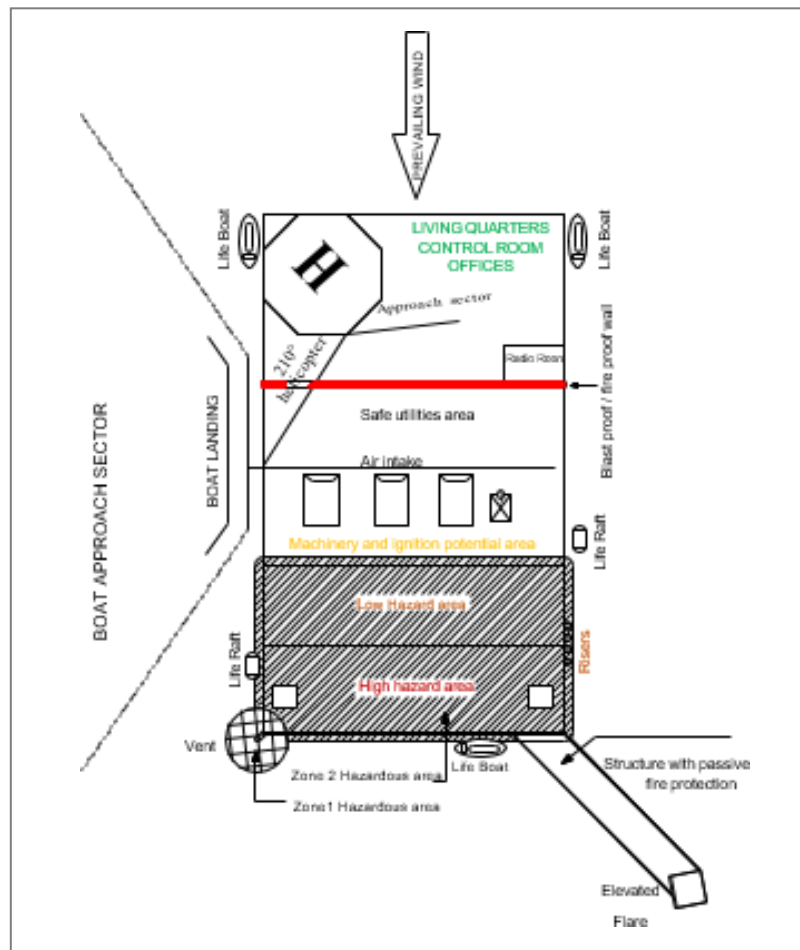
Onshore Separation



Example Onshore



Typical Offshore Layout



Typical layout of OFFSHORE Complex / Fixed Platforms

