

DEP SPECIFICATION

GENERAL REQUIREMENTS FOR LARGE CUSTOMIZED FPSOs

DEP 37.90.10.30-Gen.

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for the design, fabrication and installation of Large Customized FPSOs, based on new build hulls of ship or barge shape. Information particular to FPSOs is included in this DEP; otherwise it refers to other, existing Shell DEPs, Shell's Maritime Safety Requirements for Design, Engineering and Construction (DEC), and External Standards. The philosophy of this DEP is not to repeat information available in existing documents, but include material unique to FPSOs not found in other sources.

This DEP is a linking document that provides a means to define the major interfaces on the FPSO and ties together the relevant DEPs, marine standards, and other standards that apply to a new build, large FPSO. This DEP does not provide a full specification, and is intended to be used by the Shell project team in conjunction with a Project-Specific Parameters (Design Basis) document to develop a project-specific specification.

This DEP is intended for 'large', complex facilities with more than 120,000 bopd production. 'Medium' size FPSOs are roughly defined as 60,000 bopd – 120,000 bopd facilities that industry has provided many of, on both a lease or sale basis. For this range of FPSOs, the GFS 37.85.10.20-Gen. "General Functional Specification for Industry Small Medium FPSOs" may be a more suitable document, especially for Lease Operated units.

A focus of this DEP is the interface in design phase of various systems, engineering disciplines and industry methods across the entire FPSO.

This DEP is a revision of the same number dated February 2016.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal. The party who is the **Principal** is defined in the Project Specific Parameters document that accompanies this DEP when it is applied in a project.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.



1.3.2 Specific definitions

Term	Definition
Battery Limit	A boundary between two areas of responsibility, which may be physical (e.g. a flange on a pipe); or represented by a map coordinate; scope of work (design vs. construct), or some other means.
Certification	An independent check by an approved or certified body, of facility systems, components or assets to ensure they meet the necessary requirements and are suitable for operational use while complying with national and international codes and standards, as well as operator specifications.
Certified	Following successful completion of the Certification process an asset is said to be Certified.
Classed	Following successful completion of the Classification process an asset is said to be Classed.
Classification	An independent review and verification including relevant quality control, inspections, audits and engineering calculations by the Classification Society (CS) to ensure that the object being classed has been designed, fabricated, installed and commissioned as required, to satisfy the applicable CS rules.
High-Energy Pumps	Pumps with heads greater than 650 ft (200 m) per stage and requiring more than 300 hp (225 KW) per stage.
Project Specific Parameters document	A specification that accompanies this DEP and is used to add data and requirements specific to a project. It is used to replace text in this DEP with text that fits the specific requirements of the project.
Project Specific Specification (Design Basis) document	A specification that is used to add data and requirements specific to the Project. It is used to replace text in this DEP with text that fits the specific requirements of the Project

1.3.3 Abbreviations

Term	Definition
ADCP	Acoustic Doppler Current Profiler
ALARP	As Low As Reasonably Practicable
AMS	Asset Management System
ANSI	American National Standards Institute
API	American Petroleum Institute
AVR	Automatic Voltage Regulator
CFD	Computational Fluid Dynamics

Term	Definition
DAL	Design Accidental Loads
DEC	Design, Engineering and Construction
DEP	Design and Engineering Practice
DGPS	Differential Global Positioning System
DLE	Dry Low Emissions
DP	Dynamic Positioning
EMC	Electromagnetic compatibility
EMDG	Emergency Diesel Generator
ESDG	Essential Diesel Generator
ETS	Engineering Test System
FCL	Fault Current Limiters
FEED	Front End Engineering and Design
FGS	Fire and Gas System
FPSO	Floating Production Storage and Offloading
FoS	Factor of Safety
GPS	Global Positioning System
HAC	Hazardous Area Clarification
HAZID	Detailed Hazard Identification
HAZOP	Detailed Hazard Operability
HFE	Human Factors Engineering
HI	Hydraulic Institute
HMCS	Hull Monitoring Control System
HPU	Hydraulic Power Unit
HSE	Health, Safety & Environment
HSSE & SP	Health, Safety, Security, Environment & Social Performance
HTF	Heat Transfer Fluid
IACS	International Association of Classification Societies

Term	Definition
IMO	International Maritime Organisation
IPF	Instrumented Protective Function, now known as SIF (Safety Instrumented Function)
LIRA	Logistics Infrastructure and Resource Assessment
MAC	Main Automation Contractors
MAHs	Major Accident Hazards
MDE	Maritime, Design and Engineering
MDMT	Minimum Design Metal Temperature
MDT	Minimum Design Metal Temperature
MESC	Materials and Equipment Standards and Code
MMT	Minimum Metal Temperature
MOC	Management of Change
MPDS	Multi-Purpose Dynamic Simulation
MPM	Maritime Process Model
MT	Magnetic Particle
MWL	mean water level
OPB	out of plane bending
OTS	Operator Training Simulator
P/V	Pressure/Vacuum
PAGA	Public Address and General Alarm
PAS	Process Automation System
PCHE	Printed Circuit Heat Exchangers
PDMS	Plant Design Management System
PMI	Positive Material Identification
PSBR	Process Safety Basic Requirement
QCQD	Quick Connect/Quick Disconnect
RAO	Response Amplitude Operators
RCM	Reliability Centered Maintenance

Term	Definition
RIV	Riser Isolation Valve
RMMS	Real-Time Metocean Monitoring System
RRRV	Rate of Rise of Recovery Voltage
SCE	Safety Critical Elements
SI	International System
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SOLAS	Safety of Life at Sea
SSIV	Sub Sea Isolation Valve
TEG	Triethylene Glycol
TMMS	Transport Manual for Maritime Safety
TRV	Transient Recovery Voltage
TSA	Thermally Sprayed Aluminium
USC	US Customary
VE	Visual examination
VOCs	Volatile Organic Compounds
VRU	Vertical Reference Unit
WHO	World Health Organization

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (12).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2016. The only changes are to DEP cross-references to reflect changes in the DEP library in 2017.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. TECHNICAL SPECIFICATION

2.1 INTRODUCTION

This DEP is not a DEM1 DEP but it references and requires the use of DEM1 DEPs.

2.2 QUALITY MANAGEMENT

1. Refer to DEP 82.00.10.10-Gen.

2.3 GENERAL DESIGN

1. Equipment shall have been used previously in similar service for a minimum of three years within Shell or other operating companies.
 - a. Any equipment that does not meet this requirement shall be subject to novelty assessment and approval by the Principal.

2.4 REGISTRATION, REGULATORY COMPLIANCE, CLASS AND CERTIFICATES

2.4.1 Flag registration

1. The FPSO shall be flagged by a country designated as the flag state in the Project Specific Specification (Design Basis) document.
2. The flag state may be the same as the coastal state.

2.4.2 Classification

1. The FPSOs hull, accommodation, hull machinery, marine and utility piping systems, marine electrical, automation and navigation equipment, and mooring system shall be designed, constructed and classed by a member of the International Association of Classification Societies (IACS) as mandated by the Shell Maritime Safety Requirements for Design, Engineering, Construction of FPSOs.
2. The process plant (Topsides) shall be certified unless the applicable National regulatory regime requires Classification of the vessel.
3. For a disconnectable FPSO, the FPSO shall meet Classification Society Requirements for a Trading Tanker.

2.5 RELIABILITY AND AVAILABILITY

1. Claimed Mean Time to Repair figures shall be supported by spares availability or credible logistic delay estimates.
2. A Reliability Availability Model shall be used to identify Production critical systems.
3. Production critical and HSSE critical systems (as identified in the HSSE case) shall be analysed using Reliability Centered Maintenance (RCM) approved by the Principal to determine the most appropriate maintenance strategies.
 - a. Data from previous RCM studies may be used, subject to conditions specified in the Project Specific Parameters document.
4. Following the derivation of the maintenance, inspection and spares strategies, the reliability availability model shall be updated to reflect these strategies and iteratively analysed to ensure the required availability is achieved.
5. The overall FPSO availability shall be as specified in the Project Specific Specification (Design Basis) document.

2.6 SOIL SURVEYS, SEABED SURVEYS AND SEABED PREPARATIONS

1. Fieldwork for geotechnical investigations shall be in accordance with SN NORSOK G-001.

2.7 METOCEAN

The Metocean design data is specified in the Project Specific Parameters document.

2.8 ABANDONMENT

1. Components shall be designed such that, when they have reached the end of their useful life, they can be decommissioned and either dismantled and removed, or abandoned, in accordance with applicable regulatory requirements.

3. HULL

3.1 MARITIME, DESIGN AND ENGINEERING

3.1.1 General

The three pillars which form the basis of the Shell minimum Maritime Safety Requirements/Group Standards for Design, Engineering and Construction are:

- *Flag State Requirements*
- *Classification Society Rules*
- *DEC database*

The requirement for an FPSO to be 'Flagged and Classed' is contained in the DEC.

1. Coastal State requirements may apply when the coastal state in whose water the FPSO will operate is different from the flagstate.

3.1.2 Maritime DEC standard

The DEC standard defines the additional safety requirements over and above those stipulated in International Maritime Organisation (IMO) Statutory regulations administered through flag states, and Classification Society Rules. The DEC is part of the framework to ensure that maritime risk is managed to an acceptable level.

For an FPSO project, the DEC standards provides the minimum mandatory design safety requirements that are to be adopted in the design and construction of the FPSOs hull structure, accommodation, hull marine systems, machineries, electrical, automation and navigation systems, mooring system and other maritime equipment in the hull.

3.2 MARINE CODES AND STANDARDS

3.2.1 Hierarchy of Codes and Standards within the Hull and Marine Scope

1. In the event of conflict between requirements detailed below, the following hierarchy shall be followed for the hull and marine scope:
 - a. National Governmental Regulations of the country where the FPSO is to operate, if more stringent than those listed below;
 - b. International Regulations, if more stringent than those listed below;
 - c. Rules of the selected Classification Society;
 - d. The Project Specification documentation (e.g., Scope of Work, Technical Specification, Schedule of Prices, HSE) Company approved plans and documents;
 - e. Company Standards, as and to the extent applicable in the project specification, if more stringent than those listed below;
 - f. International Recognised Standards (e.g. ISO);
 - g. Industry Guidelines and Standards (e.g. Oil Companies International Marine Forum (OCIMF));
 - h. Contractors procedures, practice and standards (detailed design or construction phase).

3.2.2 National government regulations

1. The project shall assess what National Regulations will apply to the FPSO from the time it arrives in the waters over which the National Government has jurisdiction to the time it will depart at the end of its life in the oilfield.
2. The project shall ensure the unit as designed and constructed complies with all National Regulations.

3.2.3 Internationally or nationally recognised

The following is a list of Marine Codes and Standards that have typically been applied to large new build FPSOs for the hull and marine scope.

1. The standards listed in Table 3.1 through to Table 3.20 shall be applied to the hull and marine scope unless otherwise defined by specific requirements in this DEP or the Project specific documentation.
2. In case of conflict between the general listing in Table 3.1 through to Table 3.20 and specific requirements elsewhere in this DEP, the more specific guidance shall govern.
3. The applicability of each code or standard should be reviewed by project team in context of the project specific scope, to remove potentially conflicting standards or non-applicable standards.
4. Table 3.15 should be taken as guidance unless operating in a region where their use is mandatory:

Table 3.1 International Maritime Organisation (IMO)

International Convention of Load lines, 1966, as amended by IMO Resolutions A231 (VII), A319 (IX), A320 (IX), A411 (XI), A513 (XIII), and A514 (XIII)
International Convention for Safety of Life at Sea (SOLAS) and amendments as far as applicable to an FPSO
International Convention for Prevention of Pollution from Ships (MARPOL 73/78)
International Convention on Tonnage Measurement of Ships, 1969, as amended by IMO resolution A493 (XII) and A494 (XII)
International Convention for the Prevention of Collision at Sea (COLREGS), 1972 (consolidated edition 1990) with amendments (applies to transportation of the Hull only e.g. from construction yard to oilfield)
International Convention on the Control of Harmful Anti-Fouling Systems on Ships 2001
Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU)
International Life Saving Appliances (LSA) Code
International Bulk Chemical (IBC) Code (if integral chemical tanks are to be fitted)
International Ship and Port Facilities Security (ISPS) Code
International Code for the Application of Fire Test Procedures (FTP)
Resolution MSC 215(82) Performance Standard for Protective Coatings (PSPC) for Water Ballast Tanks
Resolution MSC 288(87) Performance Standard for Protective Coatings (PSPC) for Cargo Oil Tanks
Resolution A.686(17) Codes on Alarms and Indicators
Resolution A.719(17) Prevention of Air Pollution on Ships
Resolution A.749 (18) Code on Intact Stability (IS)
Resolution A.343 (IX) Recommendation on Method of Measuring Noise Levels at Listening Posts
Resolution MSC.35(63) as amended by MSC 132 (75) Guidelines for Emergency Towing Arrangements on Tankers
Resolution A.765(18) Guidelines for Safety of Towed Ships and other Floating Objects including Installations, Structures and Platforms at Sea
Resolution A.468(XII) Code of Noise Levels on Board Ships
Resolution A.653(16) Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling and Deck Finish Materials
Resolution A.813 - General requirements for electromagnetic compatibility (EMC) for all electrical and electronic ships equipment
MSC.1/Circ.1374 Requirements to Prohibit use of Asbestos in any Area
MSC/Circ 773 Pilot Transfer Arrangements - Required Boarding Arrangements for Pilots
MSC.1/Circ 1331 Guidelines for Construction, Installation, Maintenance and Inspection/Survey of Means of Embarkation and Disembarkation
MSC.215 (82) Performance Standard for Protective Coatings for Dedicated Seawater Ballast Tanks in all Types of Ships
MSC.288(87) Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude

Oil Tankers and Double-Side Skin Spaces of Bulk Carriers
MEPC Circ. 139 Guidelines for the Application of Revised MARPOL Annex I Requirements to FPSO's
International Safety Guide for Oil Tankers and Terminals (ISGOTT)
Guidelines for Safe Ocean Towing

Table 3.2 Classification Society

Set of Rules suitable for an FPSO type of unit from the selected Classification Society

Table 3.3 Shell maritime requirements

Maritime Safety Requirements/Group Standards for Design, Engineering and Construction (DEC)

Table 3.4 International Standards Organisation (ISO)

ISO 4406 18/16/13, Flushing Standards
ISO 6954:2000 Guidelines for Overall Evaluation of Vibration in Merchant Ships
ISO 7547:2004: Ships and marine technology-Air-conditioning and ventilation of accommodation spaces –Design conditions and basis of calculations.
ISO 8501-1:2007 Preparation of steel substrates before application of paints and related products
ISO 8502-3:1992 Preparation of steel substrates before application of paints and related products -- Tests for the assessment of surface cleanliness -- Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
ISO 8502-9:1998 Preparation of steel substrates before application of paints and related products -- Tests for the assessment of surface cleanliness -- Part 9: Field method for the conductometric determination of water-soluble salts
ISO 8861 Shipbuilding - Engine Room Ventilation in Diesel Engine Ships - Design Requirement and Basis of Calculation
ISO 15138 Petroleum and Natural Gas Industries, Offshore Production installations - Heating Ventilation and Air Conditioning
ISO 13709:2003 Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
ISO 21049:2004 Pumps - Shaft Sealing Systems for Centrifugal and Rotary Pumps
ISO 13691 High Speed Special Purpose Gear Units
ISO 10816 Mechanical Vibration
ISO 15664 Acoustics - Noise Control - Design Procedures for Open Plant
ISO 13852 Part 1 Cranes – Offshore
ISO 13000 Cranes – Bridge and Gantry Cranes
ISO 2372 Criteria for Assessment of Mechanical Vibrations in Machines

ISO 799 Pilot Ladders
ISO 20340 Paint & Varnishes Performance Requirements for Protective Paint Systems for Offshore and Related structures
ISO 8501 Preparation of Steel Substrates Before Application of Paints and Related Products – Visual Assessment of Surface Cleanliness
ISO 15138:2007 Petroleum and natural gas industries. Offshore production installations. Heating, ventilation and air-conditioning (Covers equipment standards to varying extents. Where necessary, particular equipment standards should be referred to in the relevant equipment descriptions in the project specification document)
ISO 1461 Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles: Specifications and Test Methods
ISO 8468 – Ships and marine technology - Ship's bridge layout and associated equipment - Requirements and guidelines
ISO 17894 - Ships and marine technology. Computer applications. General principles for the development and use of programmable electronic systems in marine applications
ISO 11064 - Ergonomic Design of Control Centres
ISO 14694:2003 Industrial fans – Specifications for balance quality and vibration levels
ISO 19901-1 Metocean Design and Operating Conditions
ISO 19901-5 Weight Control During Engineering and Construction
ISO 19901-6 Marine Operations
ISO 19904-1 Petroleum and natural gas industries – Floating offshore structures – Part 1: Monohulls, semi-submersibles and spars

Table 3.5 International Association of Classification Societies (IACS)

IACS Recommendation 47 Shipbuilding & Repair Quality Standard, JIQS
IACS Recommendation 31 Inclining Test Unified Procedure
IACS UR S14 for a seagoing vessel

Table 3.6 British Standards Institute (BSI)

BS EN 81 Safety Rules for the Construction and Installation of Lifts
BSI PD CLC/TR 50426 - Assessment of inadvertent initiation of bridge wire electro-explosive devices by radio-frequency radiation

Table 3.7 Oil Companies International Marine Forum (OCIMF)

Mooring Equipment Guidelines (MEG3)
Recommendations on Equipment for the Towing of Disabled Tankers
Recommendations for Equipment to be Employed in the Bow Mooring of Conventional Tankers at Single Point Moorings
Offshore Loading Safety Guidelines with Special Relevance to Harsh Weather Zones
Tandem Mooring and Offloading Guidelines for Conventional Tankers at F(P)SO Facilities

Ship to Ship Transfer Guide (Petroleum)

Table 3.8 Tanker Structures Co-operative Forum (TSCF)

TSCF 25: Guidelines for minimum of 25 years system specification
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Table 3.9 International Telecommunications Union

International Telecommunication Union (ITU-R) Radio Regulations and Rules of Procedure
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Table 3.10 American Petroleum Institute (API)

API RP 2MOP: Marine Operations

API RP 2FPS: Recommended Practice for Planning, Designing and Constructing Floating Production Systems
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Table 3.11 Civil Aviation Authority (CAA)

CAP437 Offshore Helicopter Landing Areas – Guidance on Standards
--

Paper 2008/03 Helideck Design Considerations
--

Table 3.12 International Electro-Technical Commission (IEC)

IEC 60034 - Rotating Electrical Machines
--

IEC 60076 - Power Transformers

IEC 60079 - Explosive Atmospheres

IEC 60092 - Electrical Installation in Ships
--

IEC 60146 – Semiconductor Converters

IEC 60529 - Degrees of protection provided by enclosures (IP code)
--

IEC 60533 - Electrical and Electronic Equipment in Ships – Electromagnetic compatibility
--

IEC 60331 - Tests for Electric Cables under Fire Conditions – Circuit Integrity

IEC 60332 - Tests on Electric and Optical Fibre Cables under Fire Conditions
--

IEC 60623 - Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes - Vented Nickel-Cadmium Prismatic Rechargeable Single Cells
--

IEC 60754 - Test on gases evolved during combustion of materials from cables
--

IEC 60794 - Optical fibre cables

IEC 60812 - Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)

IEC 60896 - Stationary Lead-Acid Batteries
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IEC 60947 - Low-voltage switchgear and controlgear
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IEC 61034 - Measurement of smoke density of cables burning under defined conditions

IEC 61363-1 - Electrical Installations of Ships and Mobile and Fixed offshore Units - Part 1:

Procedures for Calculating Short-Circuit Currents in Three-Phase a.c.
IEC 61439 - Low voltage switchgear and control gear assemblies
IEC 61508 - Functional Safety of Electrical/Electronic/Programmable Electronic Safety Related Systems
IEC 61511 - Functional Safety - Safety instrumented systems for the process industry sector
IEC/TR 61641 - Enclosed low-voltage switchgear and controlgear assemblies – Guide for testing under conditions of arcing due to internal fault
IEC 61800 - Adjustable Speed Electrical Power Drive Systems
IEC 61892 - Mobile and fixed offshore units — Electrical installations
IEC 62040 - Uninterruptible power systems (UPS)
IEC 62259 - Secondary cells and batteries containing alkaline or other non-acid electrolytes Nickel-cadmium prismatic secondary single cells with partial gas recombination
IEC 62271 - High-voltage switchgear and control gear

Table 3.13 Energy Institute

Model Code of Safe Practice - Part-15 Area Classification Code for Installations Handling Flammable Fluids
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Table 3.14 International Labour Organisation (ILO)

Maritime Labour Convention 2006

Table 3.15 UK Health and Safety Executive

A Guide to the Offshore Installations (Safety Case) Regulations
Guide to Lifting Operations and Lifting Equipment Regulations (LOLER)
UK HSE Offshore Helideck Design Guidelines
The Offshore Installations (Prevention of Fire and Explosion, Emergency Response Regulations) (PFEER)
Offshore Information Sheet No. 12/2008 Big Persons in Lifeboats

Table 3.16 Society of International Gas Tanker and Terminal Operators (SIGTTO)

Guidelines for the Alleviation of Excessive Surge Pressures on ESD
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Table 3.17 GL Noble Denton Guidelines

0013/ND Guidelines for Load outs
0021/ND Guidelines for the Approval of Towing Vessels
0027/ND Guidelines for Marine Lifting Operations

0030/ND Guidelines for Marine Transportations

Table 3.18 International Marine Contractors Association (IMCA)

SEL 017 Introduction to the International Ship & Port Facility Security Code
M204 Vessel Assurance
M205 Guidance on Operational Communications
M220 Guidance on Operational Activity Planning

Table 3.19 International Association of Lighthouse Authorities (IALA)

Recommendations 0-139 on the Marking of Man-Made Offshore Structures 2008

Table 3.20 International Association of Oil and Gas Producers

HSE Guidelines for metocean surveys - Report No: 348 -December 2003;
Helicopter guidelines for land seismic and helirig operations - report Number OGP420 - June 2009.

3.3 NAVAL ARCHITECTURE AND MARINE STRUCTURES

3.3.1 Dimensions and arrangements

1. Dimensions and arrangements of the hull shall provide storage capacity, topside area and topside weight carrying capacity to meet the client specified cargo storage and consumables capacities.
2. The cargo storage region of the hull shall be protected by double sides.
 - a. The size of ballast spaces shall be determined by required ballast capacity, structural and damage protection criteria stated in MARPOL Annex I Reg 19.
3. All disconnectable FPSO shall have a double hull arrangement to meet IMO requirements.

A double hull arrangement has double sides and a double bottom and is the legal requirement for all trading tankers.

A double bottom is not required for the cargo storage region of a permanently moored FPSO.

4. The dimensions and arrangements shall ensure stability and strength criteria based on Classification Society rules are met, while allowing flexibility in tank selection for operations involving continuous loading, offloading concurrent with loading, and access to any tank for inspection and maintenance/repair while production continues.

3.3.2 Hull form and arrangements

1. The hull shall be designed to minimise restrictions on individual cargo tank levels as follows:
 - a. Combinations of tank filling levels shall be possible to the maximum extent practicable.
 - b. The distribution and capacity of operational ballast tanks shall be sufficient to allow the hull to be operated within allowable limits of shear force and bending moments.
 - c. The resulting number of slack cargo and ballast tanks shall not result in the operational roll heel limits being exceeded (which includes habitability criteria) as specified in the Project Specific Parameters document.
2. Dedicated, segregated water ballast tanks, including the fore and aft peak tanks, may be used for trim and strength correction purposes.

3.3.3 General construction

1. Cofferdam access, lighting, and ventilation arrangements shall be provided.
 - a. Where freestanding tanks are placed inside designated spaces, cofferdams are not required.
 - b. Spaces designated for the storage of methanol and chemicals shall be fully coated internally for the product being stored.
2. Spaces/voids within the cargo region that are not cargo, ballast, methanol, or other chemical tanks shall be fully coated in line with the requirements of the hull coating manual as specified in the project specific design document.
3. All fuel oil tanks shall meet the requirements of MARPOL 12A.
4. To enable cargo oil tank inspection and maintenance without recourse to numerous tanks being taken out of service, cofferdam voids should be arranged between transverse sets of cargo oil tanks.

3.3.4 Deadweight capacities

1. Required storage capacity shall be based on offloading parcel size plus a contingency for four days production.
 - a. The required storage capacity shall be achieved, with cargo at minimum specific gravity and tanks 98 % full, throughout normal operational conditions.
2. To enable cargo oil tank inspection and maintenance without recourse to numerous tanks being taken out of service, cofferdam voids should be arranged between transverse sets of cargo oil tanks.
3. The design Summer Load Water Line draft shall not be exceeded at the full load and maximum consumables condition, considering final installation weights and mooring arrangements.
4. The cargo and ballast capacity of the FPSO shall allow the offload of a parcel in the following condition:
 - a. Minimum consumables and chemicals condition.
 - b. Within the operating trim and heel limitations of the process facility.
 - c. Maintaining a draft not less than the lightest design operating conditions.
 - d. Without any seasonal restriction.
 - e. Process facility not operating (empty).

5. The cargo and ballast capacity of the FPSO shall allow the offload of a parcel in the following conditions:
 - a. Maximum consumables and chemicals condition.
 - i. Within the operating trim and heel limitations of the process facility.
 - ii. Maintaining a draft not exceeding the deepest design operating conditions.
 - iii. Without any seasonal restriction.
 - iv. Process facility operational.

3.3.5 Weight and centre of gravity management

1. The weight control and monitoring system shall include the development of centre of gravity in three planes (longitudinal, transverse, and vertical).
2. Weight control report shall be capable of update at least every two-weeks.

3.3.6 Loading conditions

1. In order to determine the environmental loadings on the structure, the design shall allow for relative direction for incoming wind, sea, swell and current and the attitude of the FPSO to these conditions.
2. The design shall consider the loading conditions given in Table 3.21.
3. Loading Cases (1-9) in Table 3.21 shall be assessed for all FPSOs.
 - a. Principal provided Metocean parameters from the Project Specific Parameters document shall be used.

Table 3.21 Loading Conditions

Ref No.	Loading Cases	Facility Condition	Ballast/Cargo Condition	Environment ^[1]
1	Class Requirements	The Classification Society rules for Floating Production, Storage and Offloading Systems, current version at time of the Contract effective date.		
2	In-place Operating	Manned, Operating, Intact, FPSO Connected	Any ^[2]	10-yr
3	In-place Extreme	Manned, Not Operating, FPSO Connected	Any ^[2]	100-yr
4	Survival ^[4]	Manned, Not Operating, FPSO Connected	Any ^[2]	10,000-yr
5	Inspection	Operating, Intact, FPSO Connected	Any single tank empty ^[6]	1-yr
6	In-Transit to Installation Site from Yard	Manned, Not Operating, Intact	As Required for Pre-Service Condition ^[3]	Class ^[5]
7	Pre-Service (Installation, Special Integration)	Manned, Not Operating, Intact	As Required for Pre-Service Condition ^[3]	By Contractor ^[5]
8	Damaged 1	Manned, Not Operating, One mooring line damaged, FPSO Connected	Any ^[2]	1-yr
9	Damaged 2 ^[4]	MARPOL Annex I damaged condition(s), FPSO Connected	Any ^[2]	95% non-exceedance for swell, wave, current and wind

- NOTES:
1. The design shall consider sufficient wave height, period and direction combinations for both swell and locally generated wave conditions to ensure that the maximum site-specific loading shall be identified.
 2. The Ballast/Cargo conditions shall comply with the latest version of the Classification Society's rules at the time specified by the Principal in the Project Specific Parameters document.
 3. The ballast condition for pre-service cases shall be as required for the particular operation.
 4. These load cases shall be analysed to assess the risk of catastrophic damage, specifically addressing the following:
 - a. The FPSO shall remain in a floating upright condition,
 - b. The modules, swivel stack, flare tower, and any other structure shall remain onboard the FPSO,
 - c. There shall be no release of hydrocarbons to environment.
 5. No modifications to the design shall be made based on the results of these analyses. The Contractor shall immediately notify the Principal in the event that these requirements are not met.
 6. The environmental condition for pre-service cases shall be determined by the Contractor.
 7. For transportation operations, a minimum 10-yr return period environmental condition shall be used based on the selected tow route unless the transportation plan justifies a reduced condition based on tow duration, weather routing or other operational procedure.
 8. Analyses shall consider that adjacent tanks to the tank being inspected are empty.
 9. Non-designated ballast tanks should not be used for ballasting in transit or for the installation process.
 10. For appurtenances attached to the hull, the design loads shall be determined by hydrodynamic analysis. Such as overboard lines, casings, riser porches.

3.3.7 Strength

1. The longitudinal, transverse, and local structural strength shall meet the design criteria specified in Table 3.21.

3.3.8 Underwater inspections and sea chest blanking arrangements

1. There shall be provisions for "In-Water" surveys.
2. Blanks for hull penetrations and diver handling arrangements on the blanking pieces shall be provided.
3. Redundant underwater openings shall be sealed off with plating inserts complete with stiffening, transitioned into the existing structure.
4. Enclosed spaces shall be accessible for inspection from within the hull.
5. Lapped connections shall not be used for closing plates.

3.3.9 Towing characteristics

1. The FPSO shall be designed so that it may be towed from the bow or stern dependent upon the consideration of hydrodynamic efficiency, course keeping, structural integrity and equipment safety.
2. Towing chocks shall be provided fore and aft.
3. Additional towing points shall be provided at the aft end of the FPSO for heading control during riser and umbilical pull-in.
4. The transit condition from the yard to the installation site shall include procedures for exchanging water used as ballast during the transit at sea.

3.3.10 Tank access

1. Double hull/side spaces and other similar cellular spaces within the cargo region shall be provided with a permanent arrangement to distribute air for effective gas freeing and the maintenance of a safe environment during inspection.
 - a. Permanent means shall be provided for atmospheric testing.
2. Two manhole openings shall be provided for access to tank spaces within the cargo region, and to ballast, bunker and other large spaces outside of the cargo region.
3. The design shall enable the evacuation of injured personnel from any location throughout the tank and including a direct vertical lift from the bottom of the tank.
4. Manhole openings (dimensions) shall be designed to allow personnel to safely pass through while wearing Breathing Apparatus (BA) sets. Refer to the Project Specific Parameters document for dimensions.
5. The design shall ensure that during hull tank inspection or hot work, adjacent tanks may be empty or bounded by a cofferdam so that continuing operations are not impacted.
6. Cofferdam spaces surrounding hull tanks shall:
 - a. be treated as a tanker pump room, if the space contains equipment;
 - b. have personnel and equipment access equivalent to that of cargo tanks;
 - c. have internal access ways (walkways, ladders etc.) applicable to the inspection regime; and
 - d. have dedicated penetrations and associated distribution systems as necessary, to ensure ventilation of the cofferdam.
7. Within tanks, handrails and grills for openings shall be provided to protect personnel from falling.
8. To facilitate safe entry of confined spaces, tank-piping arrangements shall meet the requirements specified in the DEC.

3.3.11 Tank testing

1. Tank testing shall be in accordance with the more stringent of the following:
 - a. Classification Society requirements;
 - b. IACS UR S14 for a seagoing vessel.

3.3.12 Deck equipment

1. Deck fittings and mooring equipment shall be suitable for berthing the FPSO alongside at a quay, securing harbour tugs, towing (if required) and for tandem offloading.
2. Deck equipment shall be sufficient to meet the emergency towing/mooring requirements of the delivery voyage, taking into account the intended Class Notation specified for the installation site.

3.3.13 Stores

1. Refrigerated storerooms and dry stores shall provide the necessary capacity, subject to the Principal's approval, to cater for the maximum occupancy (including temporary conditions). Refer to the Project Specific Parameters document for necessary capacities.
2. Cold rooms and dry provisions stores shall have high temperature and personnel alarms incorporated into the vessel alarm system.
3. Stores shall be sized in accordance with the LIRA study and maximising operations efficiencies, recognizing synergies with other operating assets in the region of operation.

3.3.14 Helideck

1. The helideck shall comply with all of the following:
 - a. Applicable Local Government and/or Flag State regulatory requirements.
 - b. UKCAA CAP 437.
 - c. CAA Paper 2008/03, Helideck Design Considerations for Environmental Effects.
 - d. Helicopter size, type and number parked as defined in Project Specific Parameters (Design Basis) document.
2. Helicopter operational issues shall comply with NORMAN 1/6 and OGP Report 6.56/322.
3. The helicopter reception/boarding lounge shall be:
 - a. Located on the accommodations upper deck.
 - b. Sized to handle the full personnel capacity for the largest helicopter that will be used.

3.4 HULL MARINE SYSTEMS**3.4.1 General**

The Maritime systems and equipment in the Hull of the FPSO are designed and constructed to meet the requirements of the Marine Codes and Standards as listed in (3.2.3). Many of these systems have an interface with Process Systems; i.e. across the battery limits. A description of marine systems typically found on an FPSO can be found in ISO 19904-1:2006(E) Section 16.2. Guidance on application of standards is available in ISO 19904-1:2006(E) Annex A.16.2 Hull Systems.

1. For battery limits and interface definition, there shall be a joint interface document developed by the Topsides and Maritime Design Engineering team which provides system demarcation so that responsibility and ownership of structures and systems can be clearly communicated.

In general, everything above deck is the topside/process domain, and everything below this battery limit from the main deck is defined as being in the Hull domain where Shell Maritime Safety requirements for Design Engineering Construction and Operation apply. This includes deck level piping in support of marine functions (e.g., oil offloading, tank venting systems).

3.4.2 Marine hull system with topside interface

As the hull is typically built in a shipyard, experience has shown that deviation from marine codes and standards can have a disproportionate impact on cost due to disruption to their production line philosophy and the utilisation of supply chain, which could lead to schedule slip and additional cost penalty.

Typical marine hull systems that interface with topside systems include but are not limited to the following:

- Diesel Oil System
 - Cargo Oil and Slop System
 - Inert Gas & HC blanketing
 - Cargo Slop Tanks Heating
 - Fire Water (Topsides & Domestic)
 - Fire Fighting & Foam System
 - Nitrogen System
 - Compressed Air System
 - Chemical Injection System
 - Essential generators, Transformers and Switchgear
 - Emergency Generators, Transformers, and Switchgear
 - Cabling and Cable Support Systems
 - Earthing and bonding of marine electrical systems and equipment
 - Fire and gas detection system
 - Stability monitoring (loading) system
 - Offloading monitoring system
 - Mooring monitoring system
 - Metocean monitoring system
 - Advisory hull monitoring System
 - Tank monitoring system including overfill instrumentation
 - Oil discharge control and monitoring system
 - Propulsion control system
 - Control systems for marine packaged equipment
 - Instrumentation for marine equipment
 - PAGA system
1. The hull systems that interface with the Topside/Hydrocarbon Process Systems may require topside system specifications to be continued and used in the Hull/Substructure; as such, assessment and management shall be carried out by both topsides and marine engineering responsible engineers.
 2. The Shell Maritime Safety requirements shall be the basis of design applied for the Design, Engineering and Construction of the Marine Hull Systems.

3. When considering altering the specification of marine hull systems located in the hull to match Topside Process specifications, the Principal's Maritime Design and Engineering team lead shall be consulted for assessment and approvals of this part of the design.
4. The selected topside codes and standards to be applied to the marine hull system interface shall be communicated to the hull design contractor.

3.4.3 Cargo oil and slop system

The Cargo Oil system is typically designed and manufactured to marine standards and by the hull Contractor in the shipyard. It connects the output of the process train(s) to the cargo tanks and as such, the codes and standards applied need to be checked for compatibility with the duty in normal operation and because of process upsets.

1. Should process-engineering standards need to be applied to components of the cargo system then the components shall be clearly defined and communicated.
2. The interfaces between the marine cargo system, the process system, and the offloading system should be clearly defined, including the required flow rates and pressures at various stages in the system.
3. In new build FPSOs, configurations shall not require cargo pump rooms.
4. In the case where an SPM buoy is to be used for offloading, then the output from the cargo pumps and associated piping system shall deliver the oil at a pressure and flow rate to the inlet of the SPM booster pump(s) as specified in the Project Specific Parameters document.
5. The system side resistance curves will be unknown, and will likely not be known until the detailed design phase. The initial required flow rate and pressures shall allow for this uncertainty.
6. Flow rates and discharge pressures shall be specified at points of interest in the system (e.g. tandem offloading reel, SPM booster pump inlets) and not specified as discharge pressures and flow rates for cargo pumps.

3.4.4 Inert gas, hydrocarbon blanketing and venting system

Gas freeing of cargo tanks is required when human entry for maintenance or cleaning of the tanks is required.

Safety implications of gas freeing hydrocarbon blanketing in operation compared to inert gas blanketing is more time consuming and more difficult because the hydrocarbon gas must first be displaced with inert gas before air can be introduced.

The Inert Gas and Venting system is a standard marine system found on all crude oil tankers. Marine codes and standards cover the design and operations of such systems. For normal operation, these rules are appropriate; however, the venting system will need to be able to deal with a blow-by scenario where a process upset results in process gas flowing through a valve(s) designed to regulate flow of liquid.

Hydrocarbon blanketing systems are often required to be fitted to comply with rules covering the emission of Volatile Organic Compounds. These systems can be incorporated into the Inert Gas and Venting system.

1. The venting system and the wider cargo system design shall be suitably designed to deal with process upset scenarios (blow-by).
2. The design should evaluate and address blow-by scenarios that result in large volumes of gas entering the cargo tanks, to ensure that the system is adequately sized, and marine standard pressure/vacuum (P/V) valves can accommodate the flow.

3. Where P/V breakers are fitted, the design must ensure attention must be given to that the intervals between the activation pressures of the P/V valves and the P/V breaker(s), and the peak transient pressures encountered to avoid the premature operation of the P/V breaker(s).

3.4.5 Compressed air system

It is common practice for the compressed air supply for the entire FPSO to be supplied from compressors located in the hull.

Clear communication between the hull and process engineers is vital in order to accurately estimate the compressed air demand, quality and demand profile.

1. If the air compressors are to be located in the hull, standard marine air compressors should be specified.
2. Compressed air demand, quality and demand profile estimation should include sizing of reservoirs so that in the event of multiple compressor failure the supply to critical systems as defined in the project specific document, (e.g., instrument air) is maintained for the specified duration.
3. The required reliability of the air compressors shall be communicated to the marine engineers.

3.4.6 Marine hull systems – low interface with topsides

The typical marine systems without strong topside interface/application are listed as follows:

Items marked with () may have interfaces with topsides or other systems due to location and layout.*

- *Crude Oil Washing*
- *Seawater Systems*
- *Ballast System*
- *Water Mist System*
- *Hydraulic Oil System for marine equipment*
- *Bilge and Oily Drains System**
- *SW Deck Wash System*
- *Lube Oil System for marine equipment*
- *Heli Fuel Transfer System**
- *Air and Sounds System*
- *Propulsion motors (inc. thrusters), if there*
- *Variable speed drives for propulsion motors*
- *Motors for marine equipment*
- *Variable speed drives for marine equipment*
- *UPS (inc. batteries) for marine equipment*
- *Accommodation and Bridge Related:*
- *Hull and Accommodation Lighting and Small Power*
- *Refrigeration System*
- *Chilled Water System*
- *Freshwater Systems*
- *Sewage System*
- *Navigation Lights and Navigational Aids**
- *Navigation Equipment*
- *Security CCTV system**
- *Data cabling and server racks*
- *Accommodation Entertainment and Audio Visual Equipment*

3.4.7 Helicopter refuelling

1. Where helicopter refuelling is required, as indicated in the Project Specific Parameters (Design Basis) document, the refuelling system shall be in accordance with UKCAA CAP 748 and capable of refuelling aircraft as specified in the Project Specific Parameters document.

3.4.8 Accommodation

Marine accommodation requirements are included in the Design Engineering and Construction database.

The DEC requirements assume the following DEPs apply

- DEP 37.17.10.10-Gen.

3.4.9 Heating, ventilation and air conditioning

1. The HVAC system shall be designed in accordance with DEP 37.76.10.10-Gen.

3.4.10 Laboratory

1. Laboratories shall be designed in accordance with DEP 34.17.10.31-Gen.

3.4.11 Temporary refuge (TR)

1. The TR shall be designed in accordance with DEP 37.17.10.11-Gen.

3.4.12 Offloading hoses for secondary (tandem) offloading system

1. The offloading hose connection point shall contain necessary features to connect and disconnect the hose.
2. Provision shall be included to flush the offloading hose and put flush fluids into the FPSO dirty slop tank, including the ability to flush to and from the offload tanker.
3. The type of offloading hose arrangement shall be as described in Project Specific Parameters (Design basis).
 - a. The offloading hose may be either reel mounted or free floating.
 - b. Where the offloading hose remains floating in water between offloads, arrangements shall be made to prevent hose chafing and to secure the free end of the floating hose when not connected to an offtake tanker.

4. STATION KEEPING SYSTEM AND RISER SUPPORT**4.1 GENERAL**

1. The following specifications shall apply in the station keeping design:
 - a. API RP 2SK;
 - b. API RP 2FPS;
 - c. API RP 2SM;
 - d. DEP 37.81.10.13-Gen.;
 - e. DEP 37.81.21.35-Gen.

4.2 STRENGTH ANALYSIS

1. Strength analysis of moorings shall be in accordance with API RP 2SK Recommended Practice for Design and Analysis of Station keeping Systems for Floating Structure, Third Edition, October 2005.

4.3 FATIGUE ANALYSIS

1. Fatigue analysis shall be in accordance with API RP 2SK.
2. The out of plane bending (OPB) fatigue shall be added to the overall fatigue damage
3. Out-of-plane bending (OPB) fatigue of the mooring chain shall be addressed in the design of the mooring system.
 - a. The methodology as described in BV Guidance Note Ni 604 and/or Chain OPB JIP (OTC 25779) may be used.
 - b. A stress concentration factor shall not be applied to the chain tension (as described in DNV-OS-E301).
4. The overall fatigue design shall meet the minimum required Factor of Safety (FOS).

4.4 CORROSION CONTROL

4.4.1 Corrosion allowance

1. A minimum corrosion allowance of 0.2 mm/yr (8 mils/yr) and 0.4 mm/yr (16 mils/yr) for ground and platform chain respectively shall be used unless otherwise stated in the project specification.

The above minimum allowance is based on API RP 2SK. This may be different for other projects due to factors such as ocean temperature.

4.4.2 Anodes

1. For the anode design and selection, refer to DEP 37.19.30.30-Gen. and DEP 30.10.73.32-Gen.
2. The submerged mooring components, except chains, shall be cathodically protected by anodes.
 - a. The cathodic protected components shall include, but not limited to the following:
 - i. wire rope sockets;
 - ii. fairleads;
 - iii. supports and foundations.
 - b. All cathodic protected components shall be electrically isolated from chain segments.

4.4.3 Coating

1. Anchor piles and ground chain length shall be uncoated.
 - a. Thermally sprayed aluminum (TSA) may be applied to platform chain in the splash zone to provide corrosion protection.
 - b. The decision to use TSA or additional corrosion allowance should be made based on the project specific corrosion management strategy.
 - c. Chain TSA coating practice and qualification process shall comply with DEP 30.48.40.31-Gen.

4.5 MOORING SYSTEM OFF VESSEL

4.5.1 General

1. All elements of the off-vessel mooring equipment shall be designed to have a fatigue FoS no less than 10.
 - a. The FoS of 10 shall also apply to the on-vessel equipment that is positioned in the splash zone or may be submerged during the service life.
2. For mooring system components which are completely dry during service, the FoS shall be the more stringent of:
 - a. class requirements;
 - b. a minimum FoS of 2.

4.5.2 Chain

1. For permanently moored FPSOs, chains shall be studless.

4.5.3 Wire rope

1. Wire rope shall be manufactured and certified in accordance with DEP 37.81.21.31-Gen.

4.5.4 Polyester rope

1. Polyester rope shall be manufactured and certified in accordance DEP 40.10.01.12-Gen.

The provision from ABS guidance note cited above is based on the "mean – 2 x std dev" polyester T-N curve in API RP 2SM, July 2014. ABS guidance note allows this to be replaced with a T-N curve from actual test data.

4.5.5 Connectors

1. Connectors, sockets pins and connectors shall be manufactured and tested in accordance with DEP 37.81.21.31-Gen.

Both of these standards apply to wire rope. If the connectors are chain to chain, chain to synthetic rope, the same standards apply to the connectors.

4.5.6 Foundation anchors

1. Mooring foundation anchors shall be in accordance with DEP 37.81.10.12-Gen.
2. Anchor design and installation analysis shall be based on site-specific soil data.