



<b>Title</b>	<b>Caisson Structural Integrity</b>		
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## Introduction

This information sheet provides guidance on compliance for the control of risks associated with the major accident hazard of caisson failures.

The guidance is for structural technical authorities and their contractors engaged in design, installation, inspection, and maintenance of caissons. It sets out the actions required of duty holders.

This sheet takes into account the lessons learned from recent caisson failures in the United Kingdom Continental Shelf (UKCS).

## Background

Deterioration and failure of caissons including their supports has been a significant problem in the UKCS for several decades. Failure of such members normally would not lead to overall structural collapse, but could have a negative consequence that escalates to:

- A major dropped object risk to subsea structures. For example, damage to jacket members, pipelines or risers. In the worst scenario, a failed caisson could hit the gas line resulting in gas release and escalation from ignition.
- A possible disruption to operations. For example, loss of firewater caisson operational capability would lead to down manning/shut-in of the production platforms.

Historically, pump caissons have been the most problematic and inadequate design would lead to early service failures. However, as assets get older and extend beyond their originally anticipated service life, integrity problems associated with drains, and disposal caissons are likely to increase as well.

The main causes of the deterioration and failure of caissons are corrosion, fatigue and mechanical damage. It is often possible to have more than one type of failure mechanism occurring at the same time.

## Legal requirements



The following regulations and associated guidance are relevant to this topic:

- Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015 Regulation 16(1)(d). [Relevant Guidance L154](#) Paragraphs 211, 212 and 213
- Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996 (DCR), Regulation 4, 5(1)(a) (b), 5 (2) and 7(1) Regulation 8 (1) (a) (b). [Relevant Guidance L85](#) Paragraphs 35 – 41, 46 – 48,49-50, 54, 55– 58, 59-60.
- Management of Health and Safety at Work Regulations 1999, Regulation 3 (1) and (2).
- Provision and Use of Work Equipment Regulations 1998 (PUWER), Regulation 5 and 6. [Approved Code of Practice and Guidance L22](#) Paragraphs 20- 27.

## Standards and guidance

Very few codes and standards are currently available for caissons.

ISO 19901-3:2010<sup>1</sup> Section 7.11.4 briefly states the design considerations for caisson supports. It also highlights some of the major causes of caisson failures.

ISO 19902:2007<sup>2</sup> Section 16.14.2 recommends including a detailed structural model of caissons in the overall structural analysis to check the fatigue of caissons and their supports.

HOIS has produced a guideline on in-service inspection and integrity management of caissons<sup>3</sup>. It is brownfield orientated with little design aspects included. The Energy Institute has published a guideline for caisson life cycle integrity management<sup>4</sup>.

## Complying with the legal requirements

### *General*

Duty holders shall demonstrate that

- the risks associated with the major accident hazard of caisson failures are suitably and sufficiently identified, assessed and recorded
- the ongoing operational safety of caissons is ensured by implementing an appropriate caisson integrity management system
- control measures and mitigations are put in place to ensure a low probability of catastrophic failure when subjected to accidental events from caisson failures

### *Design*



Duty holders are encouraged to use the principles of inherent safety in the design stages to reduce caisson failure risks to as low as reasonably practicable (ALARP).

### *Design of caissons*

Duty holders shall consider, but not limited to, the following factors while designing new caissons

- caisson service duties
- metocean data
- proposed location and geometry
- structural analysis (in-place and fatigue analysis)
- interaction between caissons and their supports
- corrosion protection
- constructability
- inspection/maintenance accessibility

Due consideration shall be given to the caissons that are located near large solid structures (e.g. large diameter legs) for the potential increase of hydrodynamic loadings.

### *Design of caisson supports*

Duty holders shall ensure that the transfer of forces at caisson support points is realistically modelled. Duty holders shall take into account reasonably foreseeable actions resulting from weight, environmental loadings, load variations from pump reaction and fluid contents, and the particular actions associated with offshore erection or completion.

Duty holders shall ensure the integrity of existing structures is intact for the designed caissons. A fatigue assessment should be performed to check the fatigue lives of these caisson support joints attached to the jacket members.

## **Fabrication, transportation and installation**

Duty holders shall ensure caissons are fabricated, transported and installed as per design specifications. An initial benchmark for in-service inspection shall be set up following the installation.

## **Caisson integrity management**

Duty holders shall ensure that caisson integrity management is addressed in their structural integrity management (SIM) system. Normally, the structural technical authority is the competent person who should be responsible for managing structural integrity which includes caisson integrity.

### *Risk assessment*



Duty holders shall carry out a risk assessment of caissons and their supports in relating to the risks associated with the major accident hazard should the caisson fail and record the findings. The caisson risk assessment shall be periodically reviewed.

#### *Information management - Caisson database*

While carrying out caisson risk assessment, duty holders are encouraged to create a live caisson database that has all relevant information in one place for the assessment. The database is used to periodically risk assess and monitor the integrity status of caissons. It should include, but not limited to the following information

- design information
- current structural arrangement – drawings/sketches
- structural assessment
- inspection and maintenance history
- location of all pertinent anomalies/repairs
- risk assessment and associated mitigations
- inspection and maintenance schedule

The database should be updated and reviewed if there is any change to the condition or information of caissons (e.g. after a caisson inspection).

#### ***Mitigation***

Duty holders shall ensure suitable arrangements are in place for maintaining the integrity of caissons. Such arrangements include measures taken to prevent/mitigate the degradation and failure of caissons.

#### *Corrosion*

The effect of internal/external corrosion is one of the major causes of caisson failures. Duty holders shall ensure, when built, the caissons and their supports are protected against external corrosion by the implementation of a corrosion protection (CP) system (e.g. suitable coating topside and CP subsea) and maintained within acceptable criteria.

Internal corrosion poses one of the biggest threats to the integrity of caissons. The inside of a caisson is vulnerable to corrosion due to loss of coating/liner and receives minimal protection from the external CP system. For example, it is common that pump caissons suffer severe corrosion damage in the area around the pump caused by galvanic action between the pump and the caisson.

Duty holders shall ensure internal corrosion is kept within design allowable limits over caisson's design life by conducting periodical internal caisson inspection (ICI).

#### *Mechanical damage*



Radial movement of caissons within the guides should be minimised to reduce the effects of lateral movements and impacts. Wave action on caissons causes them to move within the guides, resulting in fatigue, impact damage and eventual fracturing on caissons, guides and dead weight supports.

Duty holders shall ensure the lateral movements of caissons at supports are restrained to be within design limits. Any excessive caisson movement needs to be appropriately recorded, risk assessed and mitigated.

### **Inspection**

Duty holders shall establish a suitable inspection plan for caissons and associated supports. The frequency, scope and method of inspection should be sufficient to provide assurance, in conjunction with associated assessments, that the integrity of caisson and its supports is being maintained.

Duty holders shall ensure caisson inspections are carried out in accordance with the latest inspection plan and relevant procedures in their SIM system. Inspection data shall be reviewed by competent persons appointed by duty holders.

Duty holders shall periodically review and update their caisson inspection plan.

For pump caissons, abrasion is possible when the pump string is inserted/removed for maintenance and also by vibration/abrasion of the pump string centralisers. Duty holders are encouraged to take such opportunity to carry out internal caisson inspection and maintenance to any possible internal anomalies if possible.

### **Maintenance**

Caisson maintenance work includes fabric maintenance, temporary repair, permanent repair, removal and replacement.

Duty holders shall assess the caisson's integrity and ensure maintenance work is carried out in the event of damage or deterioration (e.g. wall thickness loss, cracking or perforation) which may prejudice its integrity.

#### *Caissons over winter periods*

Duty holders shall arrange for repair work in the event of reasonably foreseeable caisson failures over the winter periods. If permanent repairs are not readily available due to various constraints, temporary repairs shall be implemented to prevent caisson from failing for short durations (over winter periods). Additional mitigations (e.g. increased inspection frequency) may be required, subject to the risk assessment results, until a permanent repair is in place.

### **References**



- 1 ISO 19901-3:2010 Offshore Structures - Part 3 - Topsides
- 2 ISO 19902:2007 Fixed Steel Offshore Structures
- 3 HOIS Guidance on In-service Inspection and Integrity Management of Caissons, Report Number HOIS(13) R6, July 2014
- 4 Guideline for Caisson Life Cycle Integrity Management, First edition, the Energy Institute, October 2018

This guidance is issued by the Offshore Safety Directive Regulator (OSDR). Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.