



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS STR 106

Assessment of existing fixed offshore steel platforms
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1. Scope

This document defines the codes, standards, reference documents, the procedures and the acceptance criteria to be applied for the assessment of existing fixed offshore steel platforms, including the jacket, the foundations and the superstructures.

The text of this document is based on [ISO 19902](#) Section 25 'Assessment of existing structures' not yet published. It amends, supplements and replaces various clauses/sections of [API RP 2A](#) and [ISO 19902](#) for the studies and works to be performed for platform re-assessment

The assessment shall be performed according to [API RP 2A WSD](#) or [API RP 2A LFRD](#), which is subject to COMPANY approval, unless otherwise indicated in the present specification.

In all cases, the design principle (i.e. WSD or LRFD) shall be the same for all parts of the platform (jacket, deck, etc.), and for all conditions.

Materials for procurement, welding and associated inspections are covered by specifications [GS STR 201](#), [GS STR 301](#) and [GS STR 304](#).

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

The assessment of existing fixed offshore steel platforms shall be conducted in accordance to the reference documents including codes and standards defined hereafter.

Where national regulations exist, their provisions and those of the standards and codes to which they refer shall apply, supplementing or amending the provisions of this document, subject to prior COMPANY approval.

If there are no national regulations covering all or part of the subject of this document, the reference documents shall be strictly applied, as supplemented by the provisions of this specification and the project documents.

In case the re-assessment of a particular structure or part of a structure is not covered by any of the listed reference documents, CONTRACTOR shall propose the use of a reputed and fit for purpose international code or regulation, subject to COMPANY approval.

Only the main reference documents are mentioned; the CONTRACTOR shall be responsible for complying with all secondary reference documents dealing with the subject of this document.

Standards

Reference	Title
ISO 19900 Series	Offshore structures
API RP 2A LRFD (ISO 13819-2)	Recommended Practice for Planning and Constructing Fixed Offshore Platforms Load and Resistance Factor Design
API RP 2A WSD	Recommended Practice for Planning and Constructing Fixed Offshore platforms, Working Stress Design
API Bulletin 2V	Bulletin on design of flat plate structures
API Bulletin 2U	Bulletin on stability design of cylindrical shells
ISO 1000	International system of units
AISC LRFD	Manual of steel construction - Load and resistance factor design latest edition (subject to COMPANY approval)
AISC ASD	Manual of steel construction. Allowable Stress Design
DNV classification notes n° 30.5	Environmental Conditions and Environmental Loads
DNV Rules	Rules for the design, construction and inspection of offshore structures. Appendix B, Loads, 1977
NF P 22-255 or equivalent	Metal construction. Hollow section welded assemblies on type I and H sections. Design and verification

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
AWS D 1.1	Structural Welding Code - Steel

Other documents

Reference	Title
Not applicable	

Total General Specifications

The provisions of this document shall be applied in the light of the project documents supplied by COMPANY, including:

- Country specificity appendices
- Particular specification
- Data sheets
- Articles and conditions; list of tasks
- Quality assurance provisions.

Reference	Title
GS COR 100	Design of cathodic protection of offshore structures
GS COR 240	Fusion bonded epoxy based coatings works for conductor pipes of drilling platforms
GS COR 350	External protection of offshore and related structures and equipment by painting
GS GEO 702	Requirements for design and installation of skirted foundations and suction anchors
GS STR 001	Weight monitoring and weighing of offshore units
GS STR 100	Fixed offshore steel platforms - General
GS STR 102	Design of offshore topsides structures
GS STR 105	Design of Boat landings, bumpers and protections for offshore installations
GS STR 201	Materials for offshore steel structures
GS STR 301	Fabrication of offshore steel structures
GS STR 304	Fabrication of welded plate girders
GS STR 401	Load out, sea-fastening, transportation and installation of offshore structures
GS STR 431	Installation of piles for steel structures. Driven piles
GS STR 432	Installation of piles for offshore steel structures – Drilled and grouted piles
GS STR 901	Design rules and construction standards for ancillary structures of offshore installations

3. General

This document gives procedures for the assessment of existing fixed steel offshore structures to demonstrate their fitness-for-purpose. The aims and procedures are also applicable to topsides structures. The assessment process has a number of stages and where a numerical

assessment is required there are five levels of complexity, as per [ISO 19902](#). It is recommended that an assessment follows the levels sequentially although some may be skipped.

An assessment shall be undertaken if any of the initiators specified in section 6 are triggered, with the objective to demonstrate the fitness-for-purpose of the structure for its specific site conditions and operational requirements, based on the principles given in this document.

A structure is fit-for-purpose when the risk of structural failure leading to unacceptable consequences is sufficiently low. The process described in this document shall be followed for the assessment of fitness-for-purpose.

A structure that complies with the requirements given in [GS STR 101](#) and [GS STR 102](#) may be considered fit-for purpose.

Demonstration of adequate fitness-for-purpose may include justified deviation from [GS STR 101](#) and [GS STR 102](#), or modifications to either the structure or its operation (i.e. prevention and mitigation measures). Deviations from [GS STR 101](#) and [GS STR 102](#) shall be reviewed and approved by the regulator, where one exists, and/or personnel with sufficient knowledge and experience of the behaviour of fixed steel offshore structures to understand and assess the implications of the deviations. The rationale for the deviations shall be documented.

For existing structures, it is permissible to accept limited individual component 'failure' (i.e. action effects exceeding the component strength as given in this document), provided that both the reserve against overall system failure and deformations remain acceptable. The assessment process involves detailed review, analysis, testing or calculation of the aspects of the design that do not comply with [GS STR 101](#) and [GS STR 102](#). The current state of scientific and technical knowledge and the best available data should be used in this process. It is recommended that simple techniques be exhausted prior to the use of technically complex analyses.

For structures that do not comply with [GS STR 101](#) and [GS STR 102](#), the risk associated with a failure shall be reduced, as much as is reasonably practicable, by effecting risk prevention and mitigation measures. In determining the reasonable practicability of effecting these measures, the balance between the benefits and the cost, time and difficulty of implementing the measures should be considered. Local conditions and circumstances and the degree of confidence in the data and techniques used in the assessment should also be considered.

Prevention and mitigation measures to reduce the occurrence and the consequences of structural failure should be considered during all stages of the assessment process. If the structure is strengthened because of a failure to pass the assessment, the design of the strengthening should enable the structure to pass subsequent assessments at level 1.

In certain circumstances an assessment of one structure may be taken as an assessment of similar structures in similar conditions if all the requirements of section 9 are met.

4. Assessment process

Figure 1 shows a flow chart of an assessment. As can be seen, there are several points at which an assessment can be completed and it is not always necessary for an assessment to include numerical analysis.

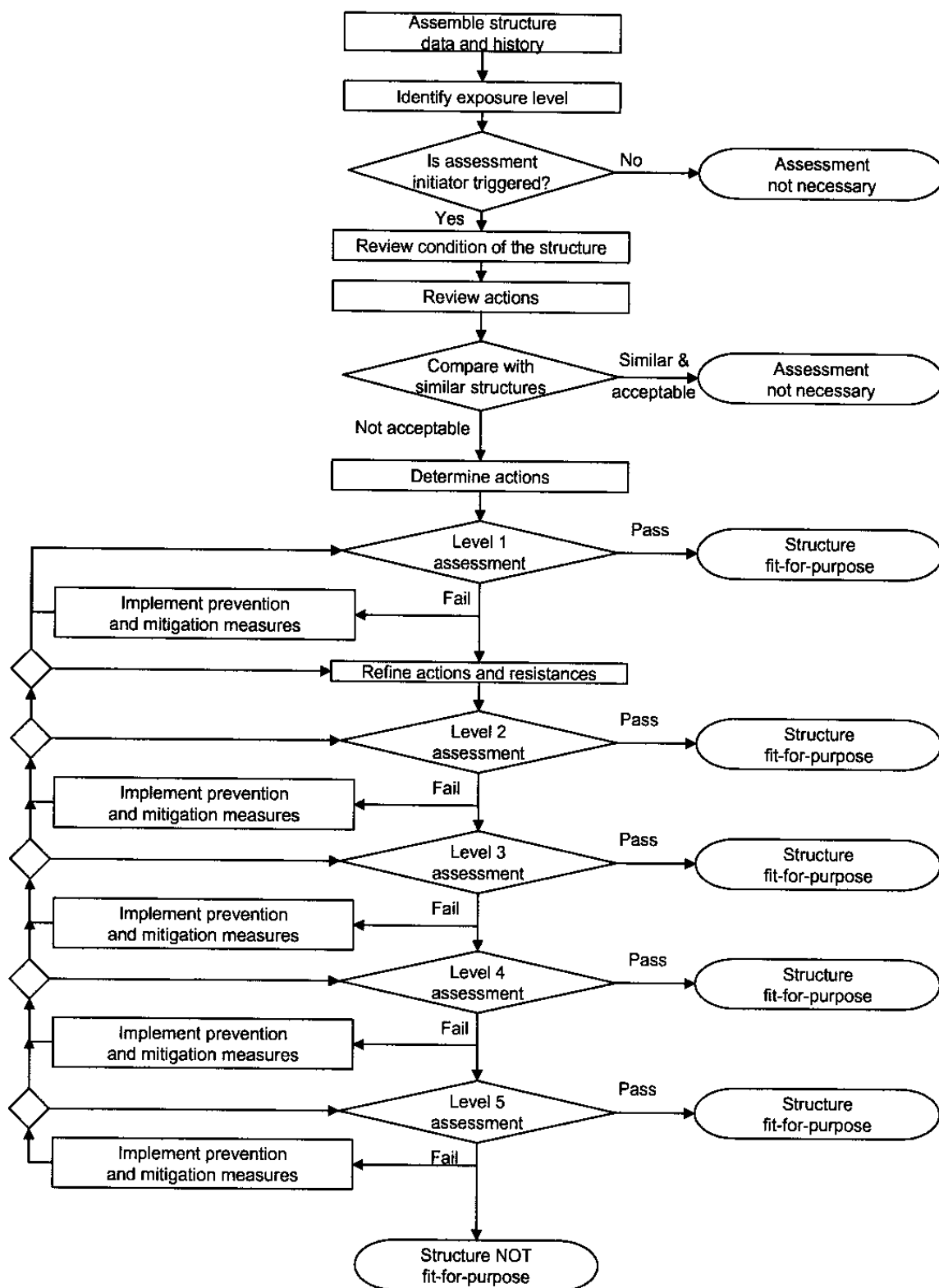


Figure 1 — Flow chart of an assessment

The main elements in the process of initiating and conducting an assessment of a structure are:

- a) Assemble data on structure, its history and exposure level, see section 5;
- b) Determine if assessment initiators is triggered, see section 6;
- c) Review condition of the structure, review actions and compare with similar structures, see sections 7, 8 and 9;
- d) Level 1 assessment in accordance with **GS STR 101** and **GS STR 102**, see section 10.1;
- e) Level 2 assessment, refined actions and resistances, see section 10.2;
- f) Level 3 assessment, linear elastic redundancy analysis, see section 10.3;
- g) Level 4 assessment, system strength analysis, see section 10.4
- h) Level 5 assessment, structural reliability analysis, see section 10.5
- i) Prevention and mitigation see section 12.

All stages of the assessment shall be fully documented and become part of the structure data.

A structure shall be assigned an exposure level for the assessment process, see section 5.2
The exposure level is used to evaluate the assessment triggers and the acceptance criteria for the numerical assessments.

5. Data collection

5.1 Structure data and history

The following data shall, where possible, be reviewed as part of the assessment:

- original design analyses,
- specifications and fabrication records including material certificates and inspection
- records of transportation, installation (including piling) and in-service inspections,
- engineering evaluations,
- modifications and repairs, and
- incidents.

5.2 Exposure level

Acceptance criteria for assessment can depend on the exposure level of the platform. The life safety and consequences categories shall be determined for the conditions for which the platform is being assessed.

The exposure level is defined in [ISO 19902](#) section 6.6 and indicated in Appendix 1.

6. Structural assessment initiators

An existing structure shall be assessed to demonstrate its fitness-for-purpose if one or more of the following conditions a), b) or c) exist:

a) Changes from the original design or previous assessment basis. Such changes include:

- 1) addition of personnel or facilities such that the platform exposure level is changed to a more onerous level;
- 2) modification to the facilities, such that the magnitude or disposition of the permanent, variable or environmental actions on a structure are more onerous;
- 3) more onerous environmental conditions and/or criteria;
- 4) more onerous component or foundation resistance data and /or criteria;
- 5) physical changes to the structure's design basis, e.g. excessive scour or subsidence;
- 6) inadequate deck height, such that waves associated with previous or new criteria will impact the deck, and provided such action was not previously considered. Inadequate deck height may result from one or more of the following events: deck elevation set too low by equipment limitations at the time of installation, deck elevation set to clear a lower design wave height, inadequate wave clearance requirements at time of installation, field installed cellar deck, structure installed in deeper water than designed for;
- 7) subsidence due to reservoir compaction.

b) Damage or deterioration of a primary structural component

Minor structural damage may be accepted on the basis of appropriate local analysis without performing an assessment. However, cumulative effects of multiple damages shall be documented and included in an assessment.

c) Exceedance of the original design service life

Although exceedance of the original design service life is not, in itself, considered as an assessment initiator by [ISO 19902](#), studies and inspection of the structure shall be undertaken to ensure that time dependent degradation (i.e. fatigue and corrosion) has not become significant.

Note: Estimation of the significance of a change from the original design may be assessed from [API RP2A WSD](#) section 17.2.6: Changes from the design premises are considered to be significant if greater than 10%.

7. Review of condition

7.1 General

Sufficient information shall be collected to allow an engineering assessment of the structure's overall structural integrity, which shall include a current inventory of the structure's structural condition and facilities at the time of the assessment. Additional details can be found in [API RP 2A WSD](#) section C17.4.1.

7.2 Topsides surveys

Data relating to the current state of the topsides structure shall be considered. Where data are not available, are ambiguous or thought to be inaccurate, additional walk-around surveys of the topsides structure and facilities shall collect the necessary information.

7.3 Underwater and splash zone surveys

In the absence of inspection data, a Level II inspection shall as a minimum be performed, to determine the general condition of the structure. In some instances, additional detailed inspection can be necessary to verify suspected damage, deterioration due to age, lack of joint cans, major modifications, lack of structural drawings, drawings whose accuracy is suspect, poor inspection records, or analytical findings.

7.4 Foundation data

Available on-site or near-site soil borings shall be reviewed and used to develop an improved foundation model.

8. Review of actions

8.1 Metocean parameters and environmental actions

The metocean data required for an assessment are the same as for design, as are environmental design situations and actions. In some cases a reduced return period is considered for assessment, see section 10.2.1.

8.2 Deck elevation and additional environmental actions

The existing deck height, with an allowance for any future subsidence within the design service life, shall be determined. The deck height shall be checked for potential inundation. If the deck is inundated the additional environmental action shall be considered. A method for calculating this additional action is given in [API RP 2A WSD](#) section C17.6.2, which may be used in lieu of more advanced techniques.

9. Comparison with similar structures

A structure to be assessed may be compared with similar nearby structures, and where sufficient similarity can be demonstrated the structure to be assessed may be assumed to be fit-for-purpose if the following requirements are all met, unless notified otherwise:

- The exposure level of the structure to be assessed shall not be L1.
- If the structure to be assessed has exposure level L2, the nearby structure that has been assessed shall have an exposure level of L2 or L1.
- The distance between the two structures is no more than 25 km.
- The structures are in the same water depth to within 2,5 m.
- The environmental and seismic conditions at the site of the structure to be assessed shall not exceed those at the site of the structure that has been assessed.

- The topsides arrangements of the two structures shall be similar and the topsides weights on the structure to be assessed shall not exceed those on the structure that has been assessed.
- The structures are of the same configuration, i.e. same number of legs and same bracing pattern.
- The foundation arrangements are the same, i.e. same number, diameter and penetration of piles.
- The structure to be assessed has not suffered any accidental damage.
- The materials and welding strengths and ductility on the structure to be assessed shall be greater than or equal to those on the structure that has been assessed. Where for any component the strength is less than that of the equivalent component on the structure that has been assessed, a specific check of the component shall be undertaken.
- The component dimensions (diameters, thicknesses and lengths) on the structure to be assessed shall be equal to those on the structure that has been assessed, except that thicknesses may be greater on the structure to be assessed. Where for any component the dimensions are different to the equivalent component on the structure that has been assessed, a specific check of the component shall be undertaken.
- The soil conditions at the site of the structure to be assessed shall be no less competent than those at the site of the structure that has been assessed.
- The ages of the structures are within 5 years of each other.

In no circumstances may a structure be considered as fit-for-purpose by comparison to a similar structure which itself has been determined to be fit-for-purpose by comparison to another structure.

10. Resistance assessment – Ultimate limit state

10.1 Assessment level 1 – Linear analysis and component checks

10.1.1 Method

Assessment level 1 is a check of the structure following the same requirements as for a new design and is sometimes called the design level check.

The assessment of structural component resistance shall be performed in accordance with **GS STR 101** and **GS STR 102** with exceptions, modifications, and additions as noted below. This procedure may be by-passed by using the non-linear ultimate strength procedure described in 10.4.

A structure shall be evaluated based on its current condition or future intended condition, accounting for any damage, repair, scour, modifications, or other factors which can affect its performance or integrity as given in section 7.

A structural analysis of the complete structural system, shall be performed on a three dimensional model that is of sufficient detail to accurately represent the stiffness of and actions on the structure and foundation. The stiffness and strength of the topsides shall also be adequately modelled.

Special attention should be given to a rational representation of the actual stiffness of damaged or corroded members and joints.

The use of increased pile capacities due to ageing effects is allowed, if this can be justified at the specific structure location. For assessment purposes individual pile failure is acceptable if the total foundation system can be demonstrated to have adequate reserve against failure.

10.1.2 Acceptance criteria

If all components within the structure and foundation are assessed to have utilizations less than or equal to unity, the structure shall be considered to be fit-for-purpose, and no further analysis is required.

The assessment of structural connections shall comply with the requirements of [API RP 2A](#), with the following exceptions:

- There is no requirement for an existing structure that a joint strength exceeds its brace member strengths, i.e. the criteria listed in section 4.1 of [API RP 2A WSD](#), which require that joints be able to carry at least 50 percent of the buckling load for compression members and at least 50 percent of the yield stress for members loaded primarily in tension, need not to be met.
- The strength of ungrouted and grouted joints may be based on experimental or analytical studies, provided that these results make due provision for the statistical uncertainties used in the development of the formulae.

Structures which do not pass assessment level 1 may be assessed at a higher level or shall have prevention and mitigation measures implemented, see section 12.

10.1.3 Specific case of foundations low safety factor – Redistribution analysis

When the foundations safety factors are below the limits requested by [API RP2A WSD](#), a redistribution analysis may be performed on request of COMPANY or regulator and/or Certification Authority where one exists.

The redistribution analysis consists in setting the pile safety factor to the ultimate limit (2.00 for operating case and 1.50 for extreme case) when the capacity is exceeded and to recalculate the safety factor in the other piles. To set the pile safety factor to the ultimate limit, an ad hoc axial force shall be applied at the bottom of the concerned pile. The recalculated safety factors in the other piles shall respect the limits of [API RP2A WSD](#).

10.2 Assessment level 2 – Refined actions and resistances

10.2.1 Method

The values of actions may be refined if there is sufficient information available to justify such refinement. Examples of refinement of actions include the following:

- More detailed review and application of permanent and variable actions, in particular in identifying variable actions that cannot occur simultaneously (such as maximum rig set-back and maximum rig hook load), or that can be controlled by operating practice (e.g. controls on lay-down area use).
- Exploitation of directionality of environmental conditions where this has not been taken into account previously.
- Reduced environmental parameters for L2 and L3 structures.

The strength of a member can be refined by considering:

- effective length factors (K)
- moment amplification reduction factors (Cm)
- use of face to face lengths
- moment relief due to joint flexibility.

Because of availability and other non-structural reasons, members and joints can be made from steel with yield stress higher than the specified minimum yield stress. If no reliable data exist, tests may be used to determine the material grades used so that appropriate yield stresses can be used.

Such effects may be utilized in assessment when properly justified and documented.

10.2.2 Acceptance criteria

If all components within the structure and foundation are assessed to have utilizations less than or equal to unity, when using refined actions and resistances, the structure shall be considered to be fit-for-purpose, and no further analysis is required.

Structures which do not pass assessment level 2 may be assessed at a higher level or shall have prevention and mitigation measures implemented, see section 12.

10.3 Assessment level 3 – Linear elastic redundancy analysis

10.3.1 Method

A traditionally framed fixed steel offshore structure generally contains a degree of redundancy in that there are components that can suffer overstress and allow internal forces to be redistributed within the remainder of the structure, such that the structure still retains adequate safety.

In a linear elastic redundancy analysis the structure is analysed using quasi-static linear analysis. Components that have utilizations that exceed unity are then disabled, normally by removing their elements from the analysis model and transferring actions applied to them to adjacent nodes (i.e. the internal resisting forces and moments associated with full utilization of the component should be applied at the end nodes). The structure is then reanalysed using the same methods. This cycle is repeated until either all remaining components have utilizations of less than 1 or until it becomes obvious that the structure cannot withstand the applied actions.

The process is repeated for each storm direction, however components that are disabled due to a storm in one direction may be assumed to be intact when considering storms from another direction.

It must be noted that this type of analysis is not recommended where there are multiple failures of individual components, multiple failure paths, or where design analysis component utilization exceeds 1,10 (i.e. 10 % over utilized), as the linear elastic assumptions, implicit within the analysis, can become invalid.

10.3.2 Acceptance criteria

If it can be demonstrated that the structure can remain standing, with the remaining components having utilizations of less than or equal to unity, the structure may be considered to be fit-for-purpose and no further analysis is required.

Structures which do not pass assessment level 3 may be assessed at a higher level or shall have prevention and mitigation measures implemented, see section 12.

10.4 Assessment level 4 – Non-linear analysis and component checks

10.4.1 Method

An ultimate strength analysis is intended to demonstrate that a structure has adequate strength and stability to withstand a significant overload. Local overstress and potential local damage is accepted, but total collapse or excessive/damaging deformations shall be avoided.

The reserve strength ratio (RSR) shall be determined in accordance with equation (10.4-1) here below, using the analysis methods described in Appendix 2 to determine the best estimate of the system strength. The RSR shall be determined for all wave directions and the lowest value obtained shall be the structure's RSR.

$$R_{RS} = F_{collapse} / F_{100} \quad (10.4-1)$$

where

$F_{collapse}$ is the unfactored global environmental action which, when co-existing unfactored permanent and variable actions are added, causes collapse of the structure,

F_{100} is the unfactored 100 year global environmental action.

Preferred software to perform non-linear analysis is USFOS.

10.4.2 Acceptance criteria

The acceptance criterion when an ultimate strength analysis has been undertaken is that the calculated RSR value (R_{RS}) shall exceed a minimum value. The appropriate acceptable RSR depends on both the environmental conditions and the exposure level of the platform. Except noted otherwise, a default value of $R_{RS} = 1,85$ shall be used.

Structures which do not pass assessment level 4 may be assessed at level 5 on COMPANY request or shall have prevention and mitigation measures implemented, see section 12.

10.5 Assessment level 5 – Structural reliability analysis

10.5.1 Method

The final level of assessment is the structural reliability analysis (SRA). SRA depends on the accuracy of statistics associated with many parameters, including the wave climate and the actions resulting from that environment, as well as with the resistances of components and structural systems.

Although permitted by [ISO 19902](#), the use of SRA requires extreme care and shall be undertaken only on COMPANY request.

10.5.2 Acceptance criteria

As the reliability determined by an SRA is highly dependent on the knowledge and skill of the analyst and the data upon which the analysis is based, it is not possible to provide acceptance criteria in this document.

It is recommended that thorough validation of the techniques and application of those techniques is undertaken, that acceptance criteria are agreed between the regulator and/or Certification Authority, where one exists, and the COMPANY.

11. Resistance assessment - Fatigue limit state

11.1 Method

As part of the assessment process for future service life, consideration shall be given to the accumulated degradation effects of fatigue and the future accumulation of fatigue damage during the remaining service life. The inspection history may be used to demonstrate adequate future fatigue durability, giving consideration to both the reliability of inspection results and crack growth behaviour, in lieu of the analytical procedures described in Clause 16 of [ISO 19902](#). Future inspection requirements shall comply with the principles given in Clause 24 of [ISO 19902](#).

11.2 Acceptance criteria

The assessment shows adequate fatigue durability if one of the following criteria is met:

- The results of a fatigue assessment in accordance with [GS STR 101](#) and [GS STR 102](#) shows that the fatigue lives of all members and joints are at least equal to the total design service life, and the inspection history shows no fatigue cracks or unexplained damage.
- A fatigue assessment in accordance with [GS STR 101](#) and [GS STR 102](#) has identified the joints with the lowest fatigue lives and periodic inspection of these joints finds no fatigue cracks or unexplained damage.
- Where fatigue lives of any members and joints are calculated to be less than the total design service life of the structure and fatigue damage has been identified, the structure may be assumed to be fit-for-purpose providing conservative fracture mechanics predictions of fatigue crack growth demonstrate adequate future life and periodic inspection monitors crack growth of the members or joints concerned.

12. Prevention and mitigation

Prevention and mitigation of risk using appropriate measures should be considered at all levels of assessment for structures that do not comply with [GS STR 101](#) and [GS STR 102](#). These measures should consider all aspects of the platform operations.

Possible prevention measures include structural strengthening and reduction of actions on the structure. Mitigation includes such measures as de-manning and hydrocarbon inventory reduction that will reduce the consequences of a failure of the structure. Consideration of prevention and mitigation measures should involve all engineering disciplines to ensure comprehensive consideration of any prevention and mitigation measures.

13. Appendix 1 – Definition of Exposure Levels

13.1 General

Structures can be categorized by various levels of exposure to determine criteria that are appropriate for the intended service of the structure. This applies to the design of new structures and to the assessment of existing structures. The levels are determined by consideration of life-safety and of environmental and economic consequences.

The life-safety category addresses personnel on the platform and the likelihood of successful evacuation before a design environmental event occurs.

The consequence category considers the potential risk to life of personnel brought in to react to any incident, the potential risk of environmental damage and the potential risk of economic losses.

13.2 Life-safety categories

The category for life-safety shall be determined from:

a) S1 Manned non-evacuated

The manned non-evacuated category refers to a platform that is continuously (or nearly continuously) occupied by persons accommodated and living thereon, and from which personnel evacuation prior to the design environmental event is either not intended or impractical.

A platform shall be categorized as S1 manned-non-evacuated unless the particular requirements for S2 or S3 apply throughout the design service life of the platform.

b) S2 Manned evacuated

The manned evacuated category refers to a platform that is normally manned except during a forecast design environmental event. For categorization purposes, a platform shall not be categorized as a manned evacuated platform unless:

- 1) reliable forecast of a design environmental event is technically and operationally feasible, and the weather between any such forecast and the occurrence of the design environmental event is not likely to inhibit an evacuation;
- 2) prior to a design environmental event, evacuation is planned;
- 3) sufficient time and resources exist to safely evacuate all personnel from the platform and all other platforms likely to require evacuation for the same storm.

c) S3 Unmanned

The unmanned category refers to a platform that is only manned for occasional inspection, maintenance and modification visits. For categorization purposes a platform shall not be categorized as unmanned unless:

- 1) visits to the platform are undertaken for specific planned inspection, maintenance or modification operations on the platform itself;
- 2) visits are not expected to last more than 24 hours during seasons when severe weather can be expected to occur;
- 3) the evacuation criteria 1) to 3) for S2 manned evacuated platforms are also met.

A platform in this category may also be described as not normally manned.

It is recognized that life-safety category definitions include a degree of judgement. The category that applies to a structure shall be determined by the owner of the structure prior to the design of a new structure and shall be agreed by the regulator where applicable.

13.3 Consequence categories

Factors that should be considered in determining the consequence category include:

- life-safety of personnel on, or near to, the platform brought in to react to any consequence of failure, but not personnel that are part of the normal complement of the platform;
- damage to the environment;
- anticipated losses to the owner, to other installation owners, to industry and/or to other third parties as well as to society in general.

The consequence category shall be determined from:

a) C1 High consequence category

The high consequence category refers to platforms with high production rates or large processing capability and/or those platforms that have the potential for well flow of either oil or sour gas in the event of platform failure. In addition, it includes platforms where the shut-in of the oil or sour gas production is not planned, or not practical, prior to the occurrence of the design event (such as areas with high seismic activity). Platforms that support trunk oil transport lines and/or storage facilities for intermittent oil shipment are also considered to be in the high consequence category.

A platform shall be categorized as C1, high consequence unless the particular requirements for C2 or C3 apply throughout the design service life of the platform.

b) C2 Medium consequence category

The medium consequence category refers to platforms where production can be shut-in during the design event. For categorization purposes a platform shall not be categorized as medium consequence unless:

- 1) all wells that can flow on their own in the event of platform failure shall contain fully-functional subsurface safety valves, which are manufactured and tested in accordance with applicable specifications;
- 2) oil storage is limited to process inventory and “surge” tanks for pipeline transfer;
- 3) pipelines shall be limited in their ability to release hydrocarbons, either by virtue of inventory and pressure regime, or by check valves or seabed safety valves.

c) C3 Low consequence category

The low consequence category refers to minimal platforms where production can be shut-in during the design event. These platforms may support production departing from the platform and low volume in-field pipelines. For categorization purposes a platform shall not be categorized as low consequence unless:

- 1) all wells that can flow on their own in the event of platform failure shall contain fully-functional subsurface safety valves, which are manufactured and tested in accordance with applicable specifications;
- 2) oil storage is limited to process inventory;

- 3) pipelines shall be limited in their ability to release hydrocarbons, either by virtue of inventory and pressure regime, or by check valves or seabed safety valves.

It is recognized that consequence category definitions include a degree of judgement. The category that applies to a structure shall be determined by the owner of the structure prior to the design of a new structure and shall be agreed by the regulator where applicable.

13.4 Determination of exposure level

The 3 categories for each of life-safety and consequence can, in principle, be combined into 9 exposure levels.

However, the level to be used for structure categorization is the more restrictive level for either life-safety or consequence.

This results in three exposure levels as illustrated in Table 6.6-1:

Table 6.6-1 — Determination of exposure level

Life-safety category	Consequence category		
	C1 High consequence	C2 Medium consequence	C3 Low consequence
S1 Manned non-evacuated	L1	L1	L1
S2 Manned evacuated	L1	L2	L2
S3 Unmanned	L1	L2	L3

The exposure level applicable to a structure shall be determined by the owner prior to the design of a new structure or the assessment of an existing structure, and be agreed by the regulator where applicable.

Platform categorization may be revised over the design service life of the structure as a result of changes in factors affecting life-safety or consequence category.

14. Appendix 2 – Non-linear Push-over analysis

Reference [1] and [2] provide information on conducting non-linear ultimate strength analysis.

The collapse strength of a space frame structure is usually expressed as the ratio of the global environmental action at collapse, measured in terms of base shear or overturning moment, to the global environmental action used for design.

The following analysis procedure is suggested. Unfactored permanent and variable actions are applied followed by the environmental actions due to wind, wave and current. The environmental action is gradually increased until structural collapse occurs, as illustrated on figure 14.1. Note that forces due to buoyancy shall not be simultaneous increased, to avoid generation of unphysical vertical forces.

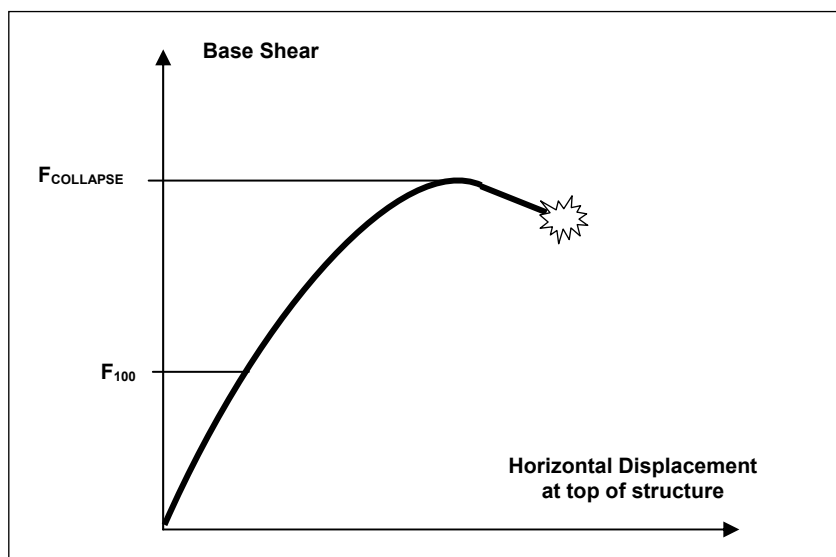


Fig. 14.1 – Illustration of RSR assessment with non linear analysis

14.1 Geometry modelling

When creating models for a non-linear analysis, due consideration shall be given to the types of elements and size of mesh required to predict non-linear structural behaviour. For example, sufficient or specific elements shall be employed along the length of a member to simulate elasto-plastic buckling involving yielding at the ends and middle of the member

The models for describing the ultimate strength and the subsequent post-collapse behaviour of members in a space frame structure shall be able to describe the following failure modes:

- tensile and compressive material yielding of a member's cross-section, this may be achieved by adopting a plastic hinge formulation or by monitoring the stresses and strains in the member;
- buckling of a member and the post-buckling redistribution of internal forces that can involve local buckling,
- local buckling.

The models should allow for the effects of initial geometric imperfections and hydrostatic pressure.

14.2 Ductility criteria

The model for member tensile failure shall include a ductility criterion that will disconnect a member end when the plastic strains have reached the tensile fracture strain. In lieu of more advanced analysis, the member end shall be conservatively assumed to disconnect when the tensile strains in the extreme fibres of a steel member exceed 5 %.

14.3 Yield stress of structural steel

If the mean yield stress of the steel for a part can reliably be determined, this mean yield stress may be used for the part under consideration instead of the specified minimum yield stress (SMYS) of the material. The SMYS is the representative value of the yield stress and should be used in all other cases.

14.4 Models for foundation strength

The foundation shall be included in the overall model and shall be analysed as a fully integrated part of the structural system using non-linear soil $p - y$, $t - z$ and $Q - z$ curves. These curves shall be generated from site specific data, when available. The model shall include the non-linear geometric and material behaviour of the piles.

Simplified models for foundation failure may be used when modelling collapse mechanisms which involve part of the framework and when structural failure occurs before foundation failure.

14.5 Investigating non-linear behaviour

Having performed a non-linear analysis of a structural system or one of its components, the magnitude of the stresses, particularly the equivalent von Mises stresses, shall be examined. The plastic strains shall also be examined to ensure that the ductility limit (fracture strain) has not been exceeded and to confirm areas of yield.

The structural deflections shall also be checked to ensure that serviceability requirements are satisfied with regard to appurtenances such as risers and caissons, failure of which can necessitate platform shutdown or impair the platform's safety systems.

The above checks shall be carried out for various stages of the non-linear analysis to gain an understanding of the history of the structure's behaviour, in particular the sequence of component failures and internal force redistribution.

14.6 References

- [1] DNV/SINTEF/BOMEL *Ultiguide – Best Practice guidance for use of non-linear analysis methods in documentation of ultimate limit states for jacket type offshore structure*, DNV, April 1999
- [2] *Nonlinear Analysis of Offshore Structures*, Bjørn Skallerud and Jørgen Amdahl, Research Study Press Ltd., January 2002