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Introduction

Duty holders must be able to demonstrate that there is a management system is in place to ensure structural integrity is maintained throughout the lifecycle of the installation. This document summarises the requirements for the structural integrity management (SIM) of offshore structures. It has been developed from the regulatory requirements for offshore installations on the UKCS, industry standards and good practice and technology developments. The emphasis of the document is on defining a framework for good structural integrity management practice to provide a benchmark against which a duty holder's management system can be assessed.

Background

The UKCS has been developed for oil and gas production for over 40 years and a significant body of good practice has developed for the maintenance of structural integrity. The replacement of the prescriptive certification system with the risk-based, goal-setting safety case regime which is focused on the management of safety and environmental critical elements (SECEs), the failure of which could cause or contribute substantially to a major accident. These changes have necessitated the requirement for a managed approach to structural integrity.

With many installations now reaching or exceeding their original anticipated design life, there is a particular need to evaluate approaches to structural integrity management by duty holders to ensure their adequacy in managing ageing structures. In addition to this, a significant proportion of ageing structures are now operated by a different duty holder to the original one, some of whom are new to the UKCS and its regulatory regime, and information on the structural integrity history of the structure may no longer be available. A significant additional consideration is the development of structural integrity standards to reflect improved knowledge of the performance of offshore structures, requiring reassessment of the structural integrity.

Legal requirements

Compliance with the following regulations needs to be achieved:

(a) Offshore Installations and Wells (Design and Construction, etc) Regulations 1996 (DCR), Regulations 4, 5(1)(a) and (e), 6, 7, 8 and 9.

(b) Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015 16(1)(d) and 9.

(c) The Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995 (PFEER), Regulations 4 and 5.

(d) Management of Health and Safety at Work Regulations 1999, Regulation 5.

Standards and guidance

The most comprehensive modern standards for structures are those of the International Standards Organisation (ISO) which contain worldwide, harmonised practice.

Relevant standards include

- ISO 19900:2013 Offshore Structures - General requirements
- ISO 19901-9, Petroleum and natural gas industries -- Specific requirements for offshore structures - Part 9: Structural integrity management (Under development)
- ISO 19902:2007 Fixed Steel Offshore Structures
- ISO 19903:2006 Fixed Offshore Concrete Structures
- ISO 19904-1:2006 Floating Offshore Structures -- Part 1: Monohulls, semi-submersibles and spars
- ISO 19905-1:2016 Site-specific assessment of mobile offshore units -- Part 1: Jack-ups

Guidance includes

- Guidance on management of ageing and thorough reviews of ageing installations. HSE Offshore Information Sheet 4/2009
- Managing for Health and Safety (HSG65) HSE 2013

Complying with the legal requirements

The SIM Process

The application of the HSG65 model to the SIM process is set out below and depicted in Figure 1. It is compatible with the requirements of the ISO standards for offshore installations.

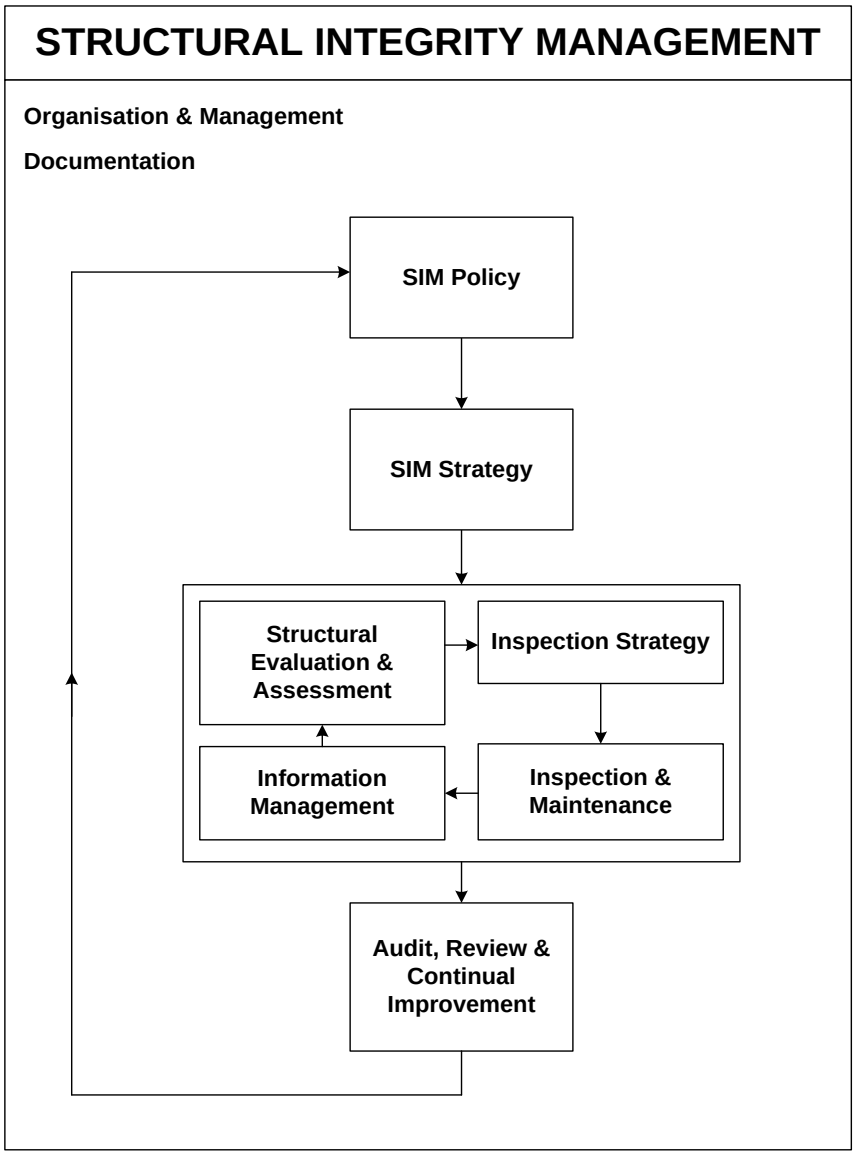

Figure 1: The SIM process

A number of key processes that constitute good practice, together with an appropriate management and documentation structure, and are as follows:

(1) **SIM Policy:** The SIM policy sets out the overall intention and direction of the duty holder with respect to SIM and the framework for control of the SIM related processes and activities. These should be aligned with the duty holder's strategic plan and other corporate policies.

(2) **SIM Strategy:** The SIM strategy sets out the duty holder's process for delivering the integrity management of its assets in line with the SIM Policy and sets acceptance criteria.

(3) **Organisation and management:** An appropriate organisational structure with defined management processes defining the roles and responsibilities of individuals

(4) **Inspection Strategy:** A systematic approach to the development of a plan for the in-service inspection of a structure.

(5) **Inspection Programme:** The inspection programme provides the detailed scope of work for the offshore execution of the inspection activities to determine the current condition of the structure. It is developed from the inspection strategy.

(6) **Structural Evaluation:** Review of current condition of the structure compared to that when it was last assessed and other parameters that affect the integrity and risk levels to confirm or otherwise that the acceptance criteria for structural integrity are met. This process identifies any repair or maintenance requirements to meet the acceptance criteria for structural integrity.

(7) **Maintenance:** The upkeep of the required condition of the structure by proactive intervention based on output from the structural evaluation.

(8) **Information Management:** The process by which all relevant historical and operational documents, data and information are collected, communicated and stored.

(9) **Audit and Review:** Audit is the process to confirm that SIM is carried out in conformity with the procedures set out in the SIM policy and strategy, and legislation. The review process assesses how the SIM processes can be improved on the basis of in house and external experience and good industry practice.

(10) **Life Extension Evaluation:** Evaluation of structural integrity for operations beyond the design life of the installation.

The requirements for each process are set out below, together with guidance on how to achieve good practice.

Structural integrity management policy and strategy

SIM policy and strategy generally cover all aspects of structural integrity management for a fleet of assets operated by the duty holder. This would typically include but not be limited to

- subsea inspection
- topsides inspection
- appurtenance inspection
- weight control
- air gap and settlement monitoring

SIM Policy

The duty holder should have a SIM policy endorsed at senior management level which

- defines the overall intentions and direction of the organisation with respect to SIM
- integrates and aligns SIM with the overall business plan and other corporate policies
- sets out a framework for SIM

The policy should:

(a) include a commitment to comply with current applicable legislation, regulatory and statutory requirements and to other relevant industrial and national standards and practices.

(b) be reviewed periodically and be committed to continual improvement of the SIM process.

(c) be documented and effectively communicated to all relevant parties including employees and contractors.

SIM Strategy

The duty holder should develop a SIM strategy to enable the implementation of the SIM policy. Guidance on setting a SIM strategy is given in ISO 19902 and API RP 2SIM.

The strategy should:

(a) include a description of the assets included in the strategy, including their function(s) and performance and condition requirements. This should include health, safety and environmental performance requirements.

(b) identify roles and responsibilities in delivering SIM.

(c) include reference to all SECEs and their performance standards

(d) define the process and rationale involved in delivering SIM, ensuring best use is made of all relevant information, e.g.

- subsea inspection specification
- anomaly evaluation and management
- inspection data management and reporting
- weight control
- structural analysis models and assessments
- metocean data and air gap measurement
- management of change with respect to structural integrity
- systems, tools and processes for managing data and information about the structure and its appurtenance including inspection results, assessment results, work performed, backlog of work, costs, etc.

(e) include reference to the emergency response strategy.

(f) include processes for monitoring the performance of the structures and of the management systems used, benchmarking, management review and corrective actions.

(g) include arrangements to capture lessons from in-service performance of structures and feed this back into the management arrangements to seek continual improvement.

(h) include references to processes for audit and assurance arrangements, including independent verification of SECEs.

(i) be reviewed and revised periodically to ensure current best practice and emerging technologies are utilised.

Organisation and management

SIM requires the duty holder to put in place an appropriate organisational structure and have defined management processes. The objective of these is to define responsibilities of individuals and to clearly set out their activities, interactions, lines of communication and interfaces. Typically, these would be recorded in the duty holder's SIM strategy. The following aspects should be considered

- management structure
- roles and responsibilities
- competency management
- emergency response

Management structure

The duty holder should have in place a transparent and effective management structure for the SIM system. The management systems should

- clearly identify the procedure for risk assessment and acceptance
- identify technical and budgetary responsibilities. This should be an integral part of the SIM strategy and be clearly communicated so that all personnel are aware of, their responsibilities and reporting structure
- identify reporting lines for all personnel
- cover the role of, and management of, external suppliers
- be reviewed following mergers and acquisition of any additional assets to confirm its continued suitability

Roles and responsibilities

The SIM system should include the following key personnel

- integrity manager (IM)
- structural technical authority (STA)
- inspection contractor (IC)
- independent verification body (IVB)

Integrity manager (IM)

The IM is responsible for ensuring performance standards in safety cases relating to structural integrity are met. This is typically achieved by

- setting the SIM policy
- approving a SIM strategy in line with the SIM policy

Structural technical authority (STA)

The STA is responsible for developing the SIM strategy to define the processes by which the SIM objectives set-out in the SIM policy are achieved. The role of STA is sometimes given to an appropriately qualified third party. The responsibilities of the STA would be expected to typically include

- assessment of integrity issues and ensuring visibility of these issues and associated risks to the integrity manager
- development and maintenance of SIM strategies around SECEs and performance standards (PSs)
- development and maintenance of structural inspection strategies
- development of weight control procedures and maintain a weight database
- maintenance of analysis models of structure and performance of structural assessments, as require
- provision of advice to the IM on planned modifications
- development and maintenance of environmental load (airgap, tilt and metocean data) strategy
- production of the annual summary report of integrity issuesreview of inspection and maintenance workscopes
- assessment of inspection findings and make recommendations
- evaluation and provision of recommendations for change management
- provision of structural input to any situation requiring an emergency response

Inspection contractor (IC)

The IC supplies personnel and resources to carry out routine survey and inspection of the structure. The IC is typically a specialist contractor, with their own inspection and quality procedures, which will need to be reviewed for consistency with SIM documentation. The responsibilities of the IC are expected to typically include

- generation of detailed inspection workscopes in line with the requirements set out in the structural inspection strategy
- ensuring competency and qualifications of inspection personnel
- carrying out inspections in line with the work scopes
- providing detailed reporting on inspection findings

Independent verification body (IVB)

The IVB should provide feedback to the duty holder on the adequacy of the SIM system. IVB activities include

- review of any impairments or maintenance issues with respect to SECEs
- verification of any significant structural modifications
- verification of the SIM processes

The IVB should be involved with general SIM related activities such as analysis reviews and modification reviews and have free access to any relevant information and the remit and resources to carry out their duties as required by DCR. The IVB should be informed of any significant structural issues and should be given the opportunity to provide a response.

Competency management

The duty holder's responsibility for SIM includes ensuring the competency of its own personnel, and a duty of care with respect to the competency of external contractors, to carry out the relevant roles within the SIM process. In many instances, competency management extends to external suppliers who may have a direct effect on SIM. Guidance is provided in ISO 19902, Section 24.8 and in API RP 2SIM on the topic of competence management for SIM.

Emergency response

Any SIM process should consider preparedness for emergencies and this should be documented as part of the SIM strategy. The process should closely interface with operator's primary evacuation, escape and rescue (EER) plan. The emergency response process should set out the means in which relevant parties are alerted in the case of an emergency situation. This should include out-of-office hours contacts. Typically, the following personnel should be included as a minimum

- integrity manager
- offshore installation manager
- structural technical authority

The emergency response process should demonstrate that rapid access to all integrity information, assessment software, resources is available to the named personnel.

Structural inspection strategy

The duty holder is required to develop and maintain a structural inspection strategy. The objectives of a structural inspection strategy are to

- ensure that structural integrity is maintained
- ensure that safety of offshore personnel is safeguarded
- ensure the environment is not impaired

The inspection strategy should:

(a) be consistent with the structural integrity strategy and SIM processes including structural evaluation, assessment, maintenance and information management requirements;

(b) as a minimum determine with reasonable level of confidence the existence and extent of deterioration, defects and damage;

(c) address the motives for inspection listed by ISO 19902;

(d) be developed and maintained by a competent person, using appropriate experience, data and where required analysis;

(e) specify the tools and techniques to be used;

(f) be documented.

Structural inspection programme

Guidance on development of the inspection programme is given in ISO 19902, Section 24.5 and API RP 2SIM, Section 5. The inspection programme is developed from the inspection strategy and should specify

(1) *Inspection requirements*
The inspection requirements should take account of

- component condition
- component criticality
- potential failure modes
- operating experience and historic failure rates
- available analysis / assessment results

(2) *Review and improvement*
The subsea inspection strategy should take into consideration structural modifications, changes in the platform condition or consequence of failure. It should also consider failure trends and the development of inspection and monitoring methods.

Structural evaluation

Structural evaluation is an ongoing process and requirement within the SIM process to ensure that structural integrity is maintained. The structural evaluation process should include the following stages:

(1) review and evaluation of the latest inspection data to identify any significant changes, degradation or damage. Sufficient extent and quality of information should be gathered to allow an appropriate engineering assessment to be completed in line with the chosen assessment route. This could range from general visual inspection to detailed NDT measurements.

(2) structural (re)assessment, if required, in accordance with ISO 19902 to demonstrate fitness-for-purpose, taking account of;

(a) available data, including
- relevant information from previous assessments
- design, fabrication and installation data
- operating experience
- remedial works

(b) changes from the original design or previous assessment basis, e.g. due to the addition of personnel or facilities such that the platform exposure level is changed to a more onerous level; more onerous environmental conditions, more onerous component or foundation resistance data and / or criteria, physical changes to the structure's design basis (such as excessive scour or subsidence), inadequate deck height or extending the original design service life.

(c) damage or deterioration of a primary structural component, including the cumulative effects of multiple damage.

(d) relevant failure modes which may include
- static strength and overload
- fatigue and fracture
- buckling
- bolt loosening
- grout deterioration
- foundation failure
- negative air gap

The structural analysis should be appropriate to the risk associated with the component under consideration and the relevant failure mode(s), e.g. non-linear (pushover) analysis to determine ultimate strength and detailed analysis on particular failure modes, using shell models, fatigue calculations, local buckling calculations, soil structure interaction calculation etc. The analysis may be based on deterministic or probabilistic calculations or a combination thereof.

The interpretation of the analysis results should take into account acceptable margins and risk levels. This should include interaction with any other failure modes which may not have been considered in the analysis. An example would be the interaction between local corrosion and bucking strength of a compression member.

(3) Definition of mitigating actions to ensure short term and long term fitness-for-purpose. This could include
- damage repair
- member strengthening (e.g. clamped sleeve, grouting, welded reinforcements)
- provision of alternative load path (e.g. structural clamp)
- revision of inspection / monitoring requirements

(4) change of consequence, e.g. by stipulating platform de-manning and emergency response procedure

(5) Update of the structural risk assessment following any findings. The risk assessment should include
- vessel (ship) collisions
- change of use
- corrosion and materials degradation
- extreme environmental conditions
- dropped objects
- geotechnical hazards
- fires and explosions
- interaction with other risks and the cumulative risk associated with a number of smaller risks should be considered as part of this process

The results of these assessments and the effects of the subsequent control measures should be considered and where appropriate provide input into
- the SIM strategy
- inspection and maintenance regimes

- the determination of requirements for the design, specification, procurement, construction, installation, commissioning, monitoring, refurbishment, replacement, decommissioning and disposal risks of structural elements
- identification of adequate resources including staffing levels, training needs and skills
- development of operational controls
- the duty holder's overall risk management framework

Maintenance

Common maintenance activities include

- weld repair: welding and / or grinding to repair or remove reported cracksclamp installation: to reinstate structural strength where welded repairs are not appropriate or practical
- retrofitting of sacrificial anodes: to reinstate and prolong the life of the CP system
- marine growth cleaning: carried out to reduce local and global load on the structure due to increased drag. This helps improve fatigue lives and in extreme cases also reduces the risk of overload of the structure
- rock dumping: prevention and backfill of scour around structure, typically around platform legs. It may be used to improve support of subsea pipelines
- electrical continuity bonding: to include isolated steel piles, conductors or caissons in the CP protection envelope
- debris removal: typically required for safety reasons when dive operations are carried out

Accelerated corrosion rates and exposure to impact damage of structures in the splash zone requires that planned inspection and maintenance activities are undertaken. Maintenance activities that HSE would expect to be included are

- coating repair and reinstatement. It is difficult to achieve good coating in the splash zone, but paint systems are continually improving and this option is now more practicable than some years ago
- conductor, caisson clamp and guide maintenance
- minor repairs due to impact damage. These could include grouting or installation of clamps
- reinstatement of splash zone access walkways, ladders and stairways

Information management

Effective SIM requires the retention and availability of information. The duty holder should ensure that:

(1) information is established and maintained in a suitable form which describes the key elements of the SIM system. The following should be documented
   - platform specific safety case (a regulatory requirement)
   - platform specific performance standards
   - SIM policy
   - SIM strategy

- inspection strategy
- inspection programme
- weight control documentation
- inspection summary report
- annual summary report
- structural assessment models
- structural drawings
- performance monitoring reports

(2) records of the following items are retained for the duration of the platform life and transferred to new duty holders as necessary

- general platform characteristic data, e.g. original or subsequent owners, original or subsequent function, location and orientation, water depth, corrosion protection systems etc.
- original design analyses, e.g. design contractor, date of design, design drawings, material specifications, design codes used, environmental criteria etc.
- structural assessments, including computerised numerical models of the structure
- fabrication details, including as-built drawings
- transportation details
- installation reports
- in-service maintenance
- engineering evaluations
- in-service inspection condition monitoring including current condition and presence of anomalies including photographic records
- repairs and structural modifications
- mitigating actions
- records of accidents and incidents

(3) historical information is retained and any relevant information not directly held by the duty holder, such as that held by the certifying authority under the certification regime, retrieved.

(4) databases are kept of

- as-built drawings
- current and historic inspection results
- maintenance activities and modifications
- drawing register (not required if the drawing database is suitably searchable)
- environmental data
- anomalies register, including criticality rating
- damage register
- completed and outstanding inspections

(5) control procedures are in place to ensure that documents, data and information are easily locatable and accessible to authorised personnel

- are periodically revised to incorporate any changes

- are available at all sites where asset related tasks are performed
- if obsolete, are promptly removed from all points of use, and substituted by their replacement document
- if obsolete, are removed, archived or flagged as 'obsolete' to avoid cluttering the database.

(6) inspection and maintenance data are stored in a way which readily allows collation of information on any backlog of inspection / maintenance activities.

Audit, review and continual improvement

The duty holder should have in place and maintain a SIM audit programme. The audit programme should:

(a) determine whether the SIM process is
- effective in meeting the SIM policy and strategy objectives
- effective in meeting the duty holder's legal obligations with respect to SIM
- effectively managing structural integrity risks
- has been properly implemented, maintained and recorded.

(b) review the results of previous audits and the action taken to rectify non-conformances.

(c) Identify improvements that may be required to the SIM system.

(d) provide information on the results of the audits to senior management.

Implementation of integrity management framework

It is the responsibility of the duty holder to identify any gaps in SIM practice and implement improvements, as illustrated in Figure 2, via the following activities:

(1) **Identification of current practice:** Current practice should be identified and documented to enable a gap analysis to be performed.

(2) **Identification of good SIM practice:** Good SIM practice is provided in the relevant ISO standard.

(3) **Gap analysis:** A gap analysis is performed to identify discrepancies between current practice and good practice and to prioritise where improvements are required.

(4) **Development of implementation plan:** The implementation plan should be based on the gap analysis, taking into consideration realistic budgets, timescales, resources and time constraints. The implementation plan should include the following:
   (a) programme
   (b) fully documented gap analysis
   (c) identification of resources
   (d) budget requirements

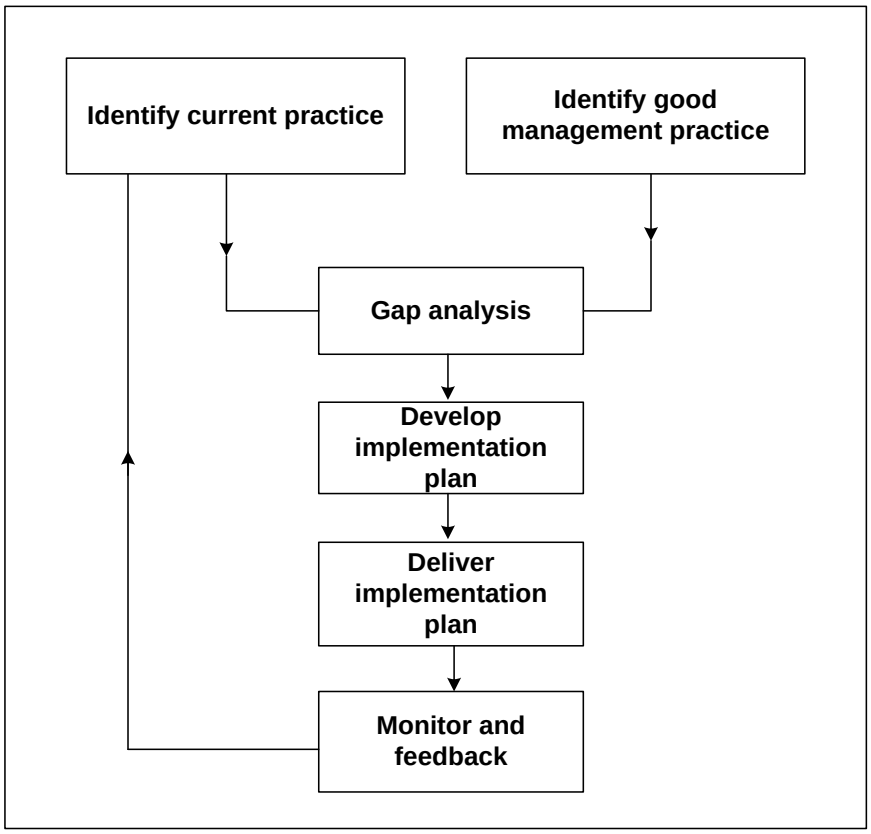

Figure 2: Best practice implementation flowchart

The implementation plan should provide the rationale for any departures from good practice.

(5) **Delivery of implementation plan:** The implementation plan should be delivered as a formal project.

(6) **Monitoring and feedback:** The effectiveness of the implementation plan should be reviewed periodically and the implementation plan adjusted when required.

Life extension

With many platforms now approaching or exceeding their intended design life, life extension has become a prominent part of maintaining good practice in SIM activities. Further guidance is available in HSE Offshore Information Sheet 4/2009 and the references below.

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