MANAGING THE INTEGRITY OF WIND FARM STRUCTURES

From development, through operation to decommissioning

Offshore wind farm life-cycle phases

An offshore wind farm requires systems that safeguard life, protect the environment, and preserve the asset and its functionality over the whole of its life-cycle. Asset owners need to identify structural risk and to focus resources on providing mitigations where they are most needed. Principal wind farm components that would benefit from such systems include:
- Sub-structures, secondary structures and appurtenances of wind turbines and offshore substations and meteorological masts
- Wind turbine towers
- Topside structures of offshore substations
- Power cables.

The application of an integrity management system is of immense value to an offshore wind farm throughout its life-cycle. Through the development, application and continuous improvement of a documented, procedure-based, integrity management system, integrated with and through the use of structural assessment services, integrity can be assured throughout the lifecycle of an asset.

In-service inspection and maintenance are fundamental requirements within the design, certification and operation of offshore wind farm assets, as set out in various standards and recommended practices such as: IEC 61400-3, DNVGL-ST-0126, DNVGL-ST-0145, DNVGLST-0359 and DNVGL-SE-0190.

DNV GL advocates engaging structural integrity management expertise early during the concept development and design phases to facilitate the transition to operations. Early engagement will benefit the operations and maintenance strategy.

During the operation and maintenance phase, systematic application of structural integrity management principles provides benefits for wind turbine components, offshore substations and power cables by:
- Establishing and maintaining a criticality/risk-based asset management system or long-term inspection and monitoring programme; covering scope, frequencies and methods
- Producing periodic detailed inspection/monitoring specifications and scopes of work; assessing and acting on the results from inspections, and dealing with deviations/non-conformities/anomalies
- Fully documenting all activities; providing stewardship of data through systems of storing, retaining and allowing easy access to information
- Continuously reviewing and updating programmes, specifications and scopes in response to change: deterioration, change of use, or modification
- Allowing optimisation of the inspection and maintenance programme, through prioritising items to be inspected, thereby managing risks whilst reducing costs.

Additionally, application of structural integrity management principles can assist due diligence in asset sales by providing clear records of best practice operational management and maintenance

In the final stages of a wind farm’s life, a structural integrity management system:
- Provides assurance when considering lifetime extension
- Affords a sound basis for decommissioning.
The SIM and structures unit is one of a number of groups of specialists serving the global market within asset Structural Integrity: United Kingdom, Norway, US, Brazil, Middle East, Singapore and Malaysia. These experts engage in a global network sharing expertise and best practice. The unit is UK-based and part of Noble Denton marine services.

With a long and successful track record in providing the full range of SIM services in the offshore oil and gas and renewables sector. Our team develops and applies SIM systems, and performs advanced structural assessment for fixed and floating structures. Team members are selected for their innovative ability in providing rapid response problem solving, engineering and expert advice.

We can offer services to windfarm operators in support of in-service inspection and maintenance that encompass, integrity management systems, structural and stress analysis, and verification and emergency response.

Structural Integrity Management

Integrity Management Systems
Documented integrity management systems, incorporating written schemes of examination (WSE), strategies and procedures that cover: safety and environmentally critical element (SECE) identification, qualitative and quantitative risk based inspection planning and support during inspections; anomaly management, assessment and mitigation; integrated approaches to weight and structural model management. Bespoke systems can be supplied to suit clients’ particular needs.
Structural & Stress Analysis
Structural assessment services offered as part of an overall integrity management system, in support of an existing system, or on a stand-alone basis independent of a structural integrity management system; these include the following:

- Assessment of structures subject to gravity and environmental loads, under operating or extreme conditions; integrated analysis for wind and hydrodynamic forces.
- Topside; multi-piled jacket; monopile and minimum fixed-structures; jack-up structures.
- Semi-submersible, FPSO and spar floating structures.
- Global and local analyses: in-place, transportation, launch, lift and decommissioning; detailed FEA of components and connections – superelement and submodel use.
- Core linear assessments, including: strength and dynamic spectral fatigue to code specifications.
- Advanced non-linear assessments, including: static ultimate strength, redundancy, pushover, ship impact and fire; dynamic response and seismic assessments; post incident damage assessments.

Verification
Independent structural design verification as part of a developed integrity management system, or as a precursor to the development of a system; provision of structural technical authority services.

Complementary Services
As well as those listed above the unit can call upon complementary expertise from the whole of the DNV GL organisation across a wide range of areas, including: maritime operations, metocean, geotechnical, materials, corrosion and fracture mechanics. In addition, DNV GL can provide instrumentation and inspection services.

DNV GL can offer software solutions for the asset integrity and SIM processes through its Synergi asset integrity management software portfolio.
**Instrumentation Services**

Some regulatory regimes require that, because of the lack of long-term experience of the effects of environmental loads on the sub-structures of offshore windfarms, a proportion of the wind turbine generators in a windfarm must have a continuous condition monitoring system installed. Condition monitoring can be used to verify design assumptions against actual performance.

Condition monitoring can also bring benefits as a complement to a structural integrity management system. Structural status can be examined remotely, observational inspections can be reduced, allowing optimisation of the inspection and maintenance programme, thereby managing risks whilst potentially reducing costs.

The instrumentation services DNV GL can provide to windfarm operators include devising the required observational methods, along with the associated necessary monitoring system.

- Conceptual design of the monitoring system tailored to projects individual requirements
- Support to windfarm operators
  - Determination of structural behaviour limits
  - Preparation of an Action-Plan to manage if limits are exceeded
- Development of a measurement concept and provision of a monitoring system:
  - Selection of suitable sensors: strain gauges, anenometers, accelerometers, displacement transducers, current velocity sensors, wave radar, marine growth sensors, scour sensors, corrosion sensors,
- Installation of the measurement system
  - Maintenance/Repair
  - Data recording and analysis
  - Periodic reporting
- Early notification and alert in case of exceeding structural behaviour limits
- Through-life and final reporting of the monitoring results.

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**WTG Controller**
- Nacelle position
- Rated power
- Wind speed
- Status

**Tower Bottom Inclination**

**Tower Bottom Torsion**

**Tower Bottom Bending**

**Wave Radar**
- Wave height
- Wave direction

**Distance Monopile <-> TP**

**Horizontal ADCP**
- Direction of flow
- Speed of flow

**Strain of the Monopile**
- Corrosion
- Pressure
- Oxygen
- Temperature
- pH...

**Scour Detection/Measurement**
- 120°/240°/360°
DNV GL can provide inspection services covering the whole of an offshore windfarm’s lifecycle, carried out by our own staff. Surveillance and inspection can be offered for: manufacturing and testing, and transport and storage of main components; construction and commissioning; end of warranty; periodic monitoring; decommissioning and life extension.

- **Commissioning inspections**: reviewing the quality of the work undertaken during construction and commissioning; setting comprehensive punch lists to ensure a seamless hand-over to the operators.

- **End of warranty inspections**: assessing the condition of the asset and identifying defects allow operators/owners to better manage warranty issues and optimize post warranty O&M costs.

- **Periodic monitoring**: regular monitoring of main components ensures repair actions are undertaken at an early stage, hence reducing O&M costs and downtime. Includes above-water and underwater inspections.

- **Vendor/Buyer Inspections**: a quick turn over and detailed inspections on main components to support acquisition and investment, and due diligence mechanisms by identifying hidden costs related to technical issues.

Services can include visual inspections of the turbine towers, nacelles and hubs; internal and external blade inspections via rope access or drones; mechanical component inspection, including gearboxes and main bearings, lubricant analysis, thermal imaging of electrical cabinets, switchgear and cable terminations, testing and resistance measurement of generator insulation and high voltage inspection.
Setting the standard

We have contributed significantly to developing guidelines, standards rules and global best practice in marine operations. But, we believe that the benchmark can always be higher.

Every year, we invest 5% of our revenue back into research and development to keep us at the forefront of our customers’ challenges. That results in more robust standards and, when you combine those with the deep technical expertise we bring to the complete asset lifecycle, you get true risk reduction.