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ReDAPT - DNV GL - The New Standard for Tidal Turbines

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Topics

- The background on the standard
- The challenges
- Standard scope
- Risk and Technology Qualification
- The risk based method for the generic tidal turbine
- Table of contents
- Main features
- The Service Specification for Certification of Tidal Turbine and Arrays
- Conclusions and future developments

The background

- The application of Technology Qualification (risk based) process as described in DNV-RP-A203 has been adapted to marine renewables for the first time in the Guideline for Design and Operation of WEC, 2005 (commissioned by the Carbon Trust to DNV during the Marine Energy Challenge)
- Certification of wave and tidal energy converters have been carried out by DNV having the Technology Qualification as the core of the process since 2008 when the DNV-OSS-312 was issued
- The ETI ReDAPT Work Package No.8 (MC8) was established to deliver a draft certification standard as the industry perceived the need to specific requirements to be derived for the tidal industry to lower costs bringing a harmonised approach to the industry.
- After almost 3 years of work, in December 2014, the draft certification standard for HATT was delivered after consultation with ReDAPT partners and main stakeholders.
- Since then, the scope of the standard was expanded and the contents were divided into a Service Specification (DNVGL-SE-0163), with the certification requirements and procedures, and the Standard (DNVGL-ST-0164) with all technical content.
- External hearing has been concluded and work has been complete to address the comments (~200) and to conclude both documents.

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The challenges

The standard for tidal turbines has to face some difficult challenges

- How to address the novelties and uncertainties?
- How to define success criteria?
- How to communicate the tidal turbine features to all stakeholders?
- How to provide requirements for design, manufacturing, etc covering different technologies?
- What is the minimum content for an useful standard?
- And finally, to be able to produce the standard itself...

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DOCUMENT INFORMATION (Author to fill in all fields)

Title of document: Service Specification for the Certification of Tidal Turbines and Arrays

All other parts/documents affected by this proposal: DNVGL-ST-0164 Tidal Turbines

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Author: Benson Waldron et al

DNV GL SERVICE SPECIFICATION

DNVGL-SE-0163
Certification of tidal turbines and arrays

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STANDARD

DNVGL-ST-0164
Tidal turbines

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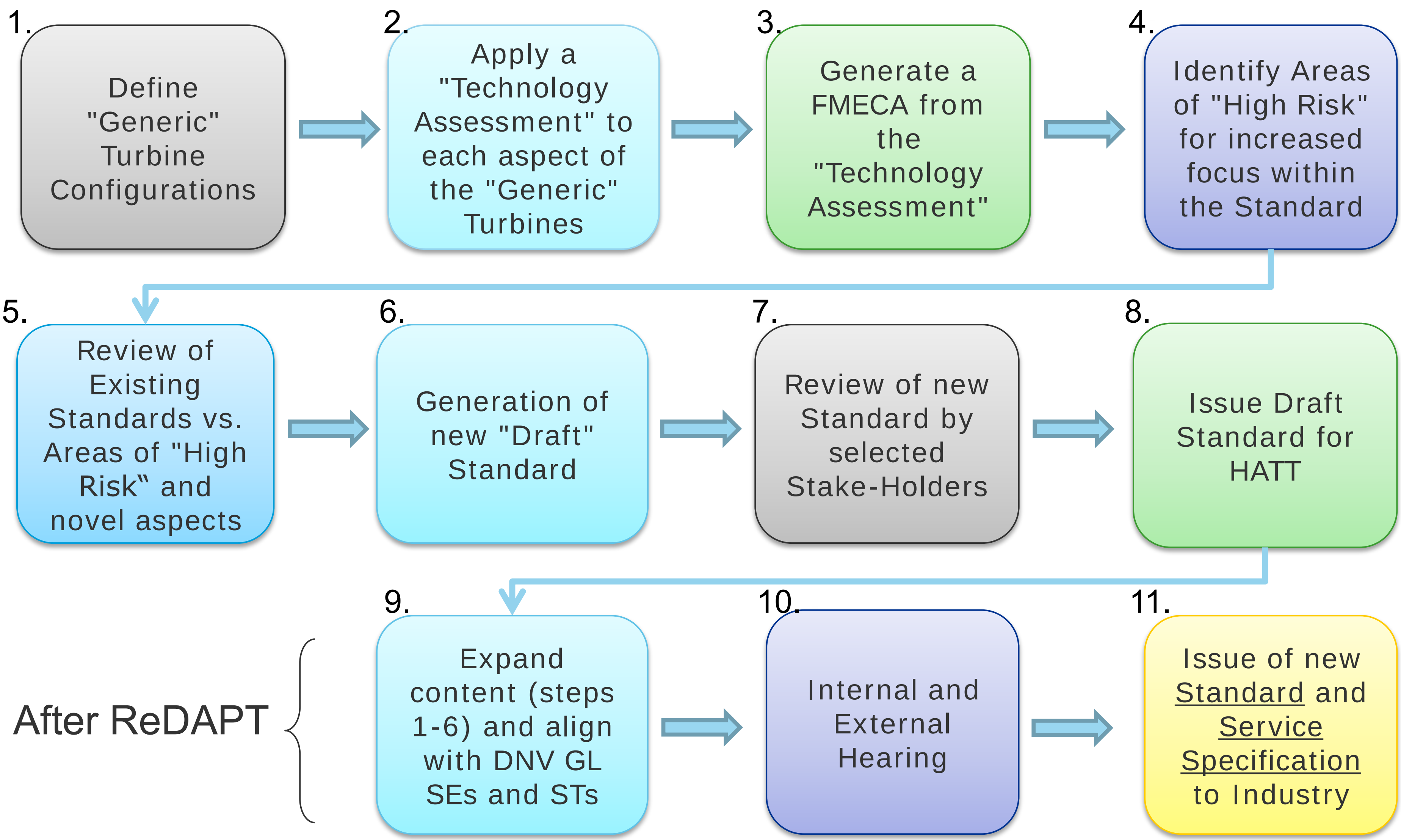
The Development Process



Generic Turbine

The generic tidal turbine can be divided into 15 subsystems:

- FOUNDATION FIXINGS
- SUB-STRUCTURE
- STATION KEEPING
- NACELLE
- BLADES
- HUB
- PITCH SYSTEM
- YAW SYSTEM
- DRIVETRAIN
- SEALS
- BEARINGS
- AUXILARY SYSTEM
- ELECTRICAL SYSTEM
- PROTECTION AND CONTROL SYSTEM
- CORROSION PROTECTION

A further breakdown was performed defining the content and boundaries of main sub-systems and components in order to perform the risk assessment (to a reasonable level of detail considering the generic nature of tidal turbine) and to support the derivation of a complete set of requirements.

DRIVETRAIN

Gearbox

Gearing
Input bearing
Output bearing
Inner bearings
Inner shafts
Lubrication system
Oil cooling system

Scope of the Standard DNVGL-ST-0164

- Tidal Turbines fixed to seabed and floating
- All phases and stages that are required to achieve a successful product.
- Principles, technical requirements and guidance for the design, construction and in-service inspection of tidal turbines
- The technical basis for certification activities covering structures (including blades, rotor, nacelle, supporting structure and foundations), machinery, safety, controls & instrumentation and electrical systems.
- Transportation, deployment, commissioning, retrieval and in-service inspection are taken into account to the extent necessary in the context of overall certification and risk to the success of the technology.

RISK AND TECHNOLOGY QUALIFICATION

TABLE I
TECHNOLOGY STATUS

Application area	Technology status		
	Proven	Limited field history	New or unproven
Known	1	2	3
New	2	3	4

Notes:
1: No new technical challenges 2: New technical uncertainties
3: New technical challenges 4: Demanding new challenges

Class	Name	Description	Indicative Annual Failure Rate (up to)
1	Very Low	Negligible event frequency	10^{-4}
2	Low	Event unlikely to occur	10^{-3}
3	Medium	Event rarely expected to occur	10^{-2}
4	High	Event expected to occur once or several times during a lifetime	10^{-1}
5	Very High	Event expected to occur once or several times each year	1

Consequence Classes

Class	Description of consequences (impact on)				
	Safety	Environment	Operation	Assets	GBP
1	Negligible injury, effect on health	Negligible pollution or no effect on environment	Negligible effect on production (hours)	Negligible	1k
2	Minor injuries, health effects	Minor pollution / slight effect on environment (minimum disruption on marine life)	Partial loss of performance (retrieval not required outside maintenance interval)	Repairable within maintenance interval	10k
3	Moderate injuries and/or health effects	Limited levels of pollution, manageable / moderate effect on environment	Loss of performance requiring retrieval outside maintenance interval	Repairable outside maintenance interval	100k
4	Significant injuries	Moderate pollution, with some clean-up costs / Serious effect on environment	Total loss of production up to 1 month	Significant but repairable outside maintenance interval	1m
5	A fatality	Major pollution event, with significant clean-up costs / disastrous effects on the environment	Total loss of production greater than 1 month	Loss of device, major repair needed by removal of device and exchange of major components	10m

	Consequence				
Probability	1	2	3	4	5
5	Low	Med	High	High	High
4	Low	Med	Med	High	High
3	Low	Low	Med	Med	High
2	Low	Low	Low	Med	Med
1	Low	Low	Low	Low	Med

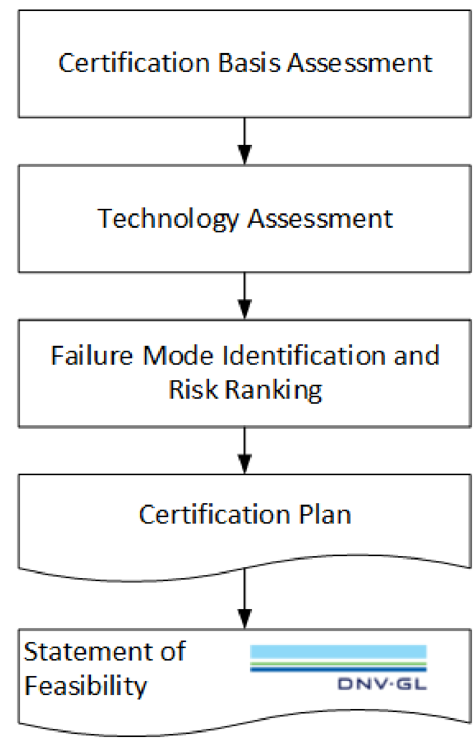


Table of Contents

DNVGL-ST-0164

Standard's Main Features

A. Safety Philosophy

DEFINITION OF SAFETY LEVELS

Safety Level	Definition	Probability of failure
High	Operating conditions where failure implies high risk of human injury, significant environmental pollution or very high economic or political consequences	$< 10^{-5}$ per annum (p.a.)
Normal	For temporary or operating conditions where failure implies: risk of human injury, significant environmental pollution or high economic or political consequences This level normally aims for a risk of less than 10^{-4} per year of a major single accident. It corresponds to a major incident happening on average less than once every 10,000 installation years. This level equates to the experience level from major representative industries and activities.	$<10^{-4}$ p.a.
Low	Failure implies low risk of human injury and minor environmental and economic consequences	$<10^{-3}$ p.a.

B. Site Characterisation

Limitations on the data characterising the site with the objective to obtain design parameters is, for now, the norm in the tidal sector. A combination of minimum period of investigation and limitation of the instrumentation normally used to collect site information makes the level of uncertainty very high and, as such influencing the overall confidence on the design parameters used.

UNCERTAINTY SITE FACTOR

Characterization	γ_s
Statistically derived with several years' data from the location.	1.00
1 month measurements at site	1.05
Incomplete measurements at site	1.25

C. Loading and Calibration of Load Factors

LOAD FACTORS FOR ULTIMATE LIMIT STATE

Load factor set	Limit state	Load categories					
		G	Q	E			D
				Risk / Safety class			
				Low	Normal	High	
(a)	ULS	1.25	1.25	0.70 (1)			1.0
(b)	ULS	1.00 (2)	1.00 (2)	1.10 (3)	1.35 (3)	1.60 (3)	1.0
(c)	ULSa	1.00 (2)	1.00 (2)	1.10			1.0
(d)	ALS	1.00 (2)	1.00 (2)	0.90	1.00	1.15	

Load categories are:
G = permanent load
Q = variable functional load, normally relevant only for design against ship impacts and for local design of platforms

A 50-year return period for environmental loading is considered.

REQUIREMENTS FOR DESIGN FATIGUE FACTORS (DFF)

Structural element accessible	Structural element repairable	Risk Low	Risk Medium	Risk High
✓	✓	1	2	3
✓	✗	2	3	6
✗	✗	3	6	10

Standard's Main Features

D. Station Keeping

LOAD FACTORS FOR MOORING LINES

Limit state	Load factor	Risk	
		Normal	High
ULS	γ_{mean}	1.30	1.50
ULS	γ_{dyn}	1.75	2.20
ALS	γ_{mean}	1.00	1.00
ALS	γ_{dyn}	1.10	1.25

The design tension T_d in a mooring line is the sum of two factored characteristic tension components $T_{c,mean}$ and $T_{c,dyn}$,

$$T_d = \gamma_{mean} \cdot T_{c,mean} + \gamma_{dyn} \cdot T_{c,dyn}$$

In which $T_{c,mean}$ is the characteristic mean tension, $T_{c,dyn}$ is the characteristic dynamic tension and T_d is the design tension.

The load factors for loads with 50-year return period are presented below.

E. Blades

Requirements for materials, design and construction and testing of blades is provided with specific aspects for tidal environment. The target safety level is set to normal (annual probability of failure of 10-4) that is consistent with the risk assessment for the blade for the generic turbine.

F. Protection and Safeguarding

The philosophy and requirements regarding protection and safeguarding is to be aligned with the results of risk assessment in order to identify the functions of the protection, control and safety systems for efficient and safe operations, The requirements contributes essentially towards reducing risks as through:

- ensuring that tidal turbine and its components are always kept within their design limits,
- preventing damage of the tidal turbine components due to internal faults (e.g. leakage, short circuit) , and
- control of hazards i.e. potential sources of physical injury or damage to the health of persons, of damage to investments or of damage to the environment, or reduction of the risks related to these hazards.

Certification of Tidal Turbines and Array – DNVGL-SE-0163

Main Principles

- The certification process and its requirements and procedures are defined in the Service Specification (SE-0163)
- The technical requirements for certification are defined in the Standard (ST-0164)
- Similar deliverables and terminology used in the Wind Industry (there are similar stakeholder across renewables)
- Certification process in agreement with the practices in the Tidal Sector
- Risk-based approach

Scope

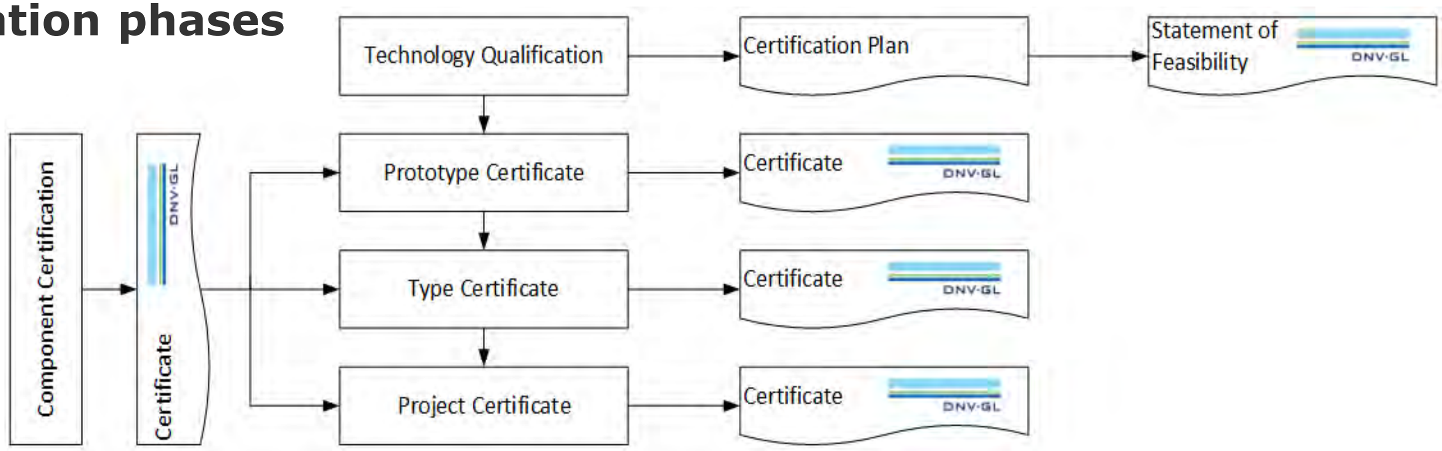
- prototype, type, project and component certification of tidal turbines or tidal turbine arrays;
- all types of turbines and their support structures, fixed or floating;
- all types of substation(s) including support structure(s), power cables and subsea connectors; and
- onshore balance of plant.

It replaces the following service specification and guideline:

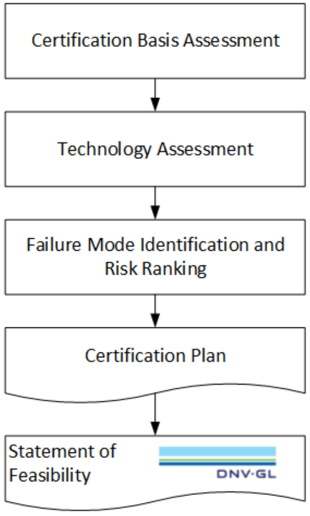
- DNV-OSS-312, Certification of tidal and wave energy converters
- GL IV-14, GL Guideline for the Certification of Ocean Energy Converters, Part 1: Ocean Current Turbines.

DNVGL-SE-0163 Service Overview

Certification phases

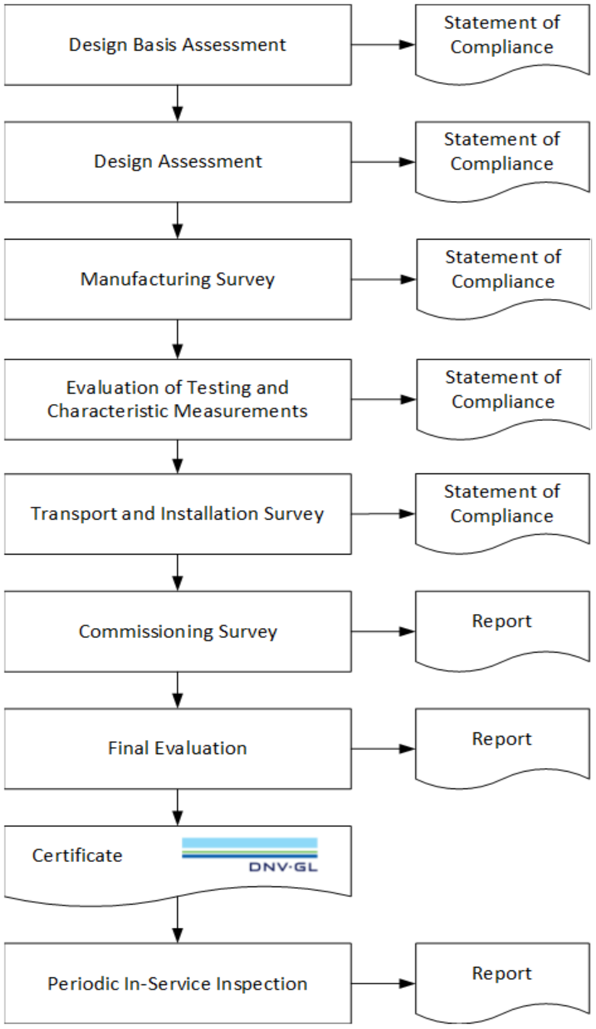


Certification modules for the technology qualification



DNVGL-SE-0163 Service Overview

Certification modules for prototype, type and project certification



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Certification of Tidal Turbines and Array – DNVGL-SE-0163

Main deliverables (Phases)

- Statement of Feasibility
- Prototype Certificate
- Type Certificate
- Component Certificate
- Project Certificate

Statements of compliance and reports (Modules)

- Certification basis
- Certification plan
- Design Basis Assessment
- Design Assessment
- Type testing and characteristic measurements
- Manufacturing survey
- Final evaluation
- Transport and installation survey
- Commissioning survey
- Final evaluation
- Periodic inspection

DNVGL-SE-0163 –Contents

Three main sections.

- SECTION 1 Introduction and description of tidal turbines and arrays
- SECTION 2 Provides the overview and main principles for certification
- SECTION 3 Describes the specific requirements for the different certification modules.

DNVGL-SE-0163 –Contents

SECTION 2 SERVICE OVERVIEW

DNVGL-SE-0163 –Contents

SECTION 3 SERVICE DESCRIPTION

Conclusions

- The capacity to deal with different business models and technologies is an essential feature of the standard.
- The content of the standard is flexible to deal with different risk levels for different technologies, development stages and business models.
- To the experience accumulated by DNV GL through certification process, data from ReDAPT has allowed to better define requirements in critical areas such as site characterisation, loading, simulations, design load cases and calibration of load factors and DFF.
- As a multi-discipline standard, the standard content aims to provide sufficient coverage of all aspects that are essential to the overall survivability, reliability and performance.
- However, it is important to recognise that the tidal sector is at an early stage. The information and experience from the future deployment and in-service life of more tidal turbines will provide the basis for fine-tuning the present requirements.
- Nevertheless, the principles, methodologies and systematics at the core of the standard are a good platform to progress and control the present knowledge limitations and uncertainties and the future development of the technologies.

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