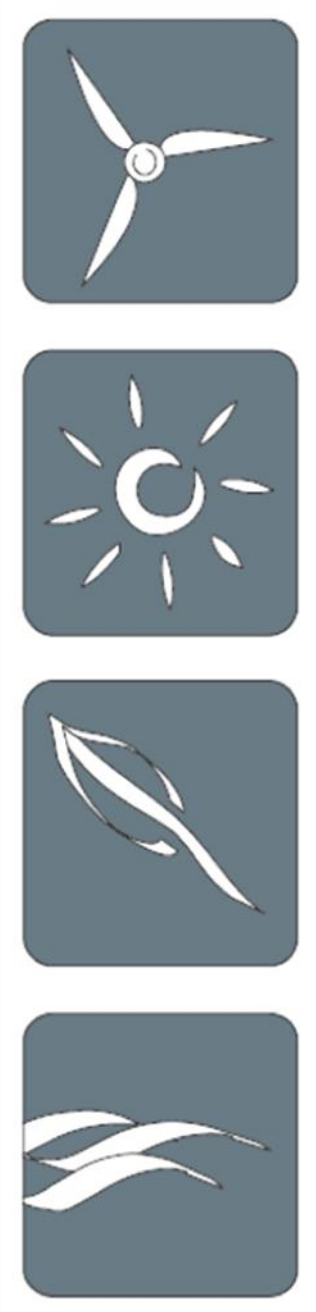
Technical Guidelines

for Power Generating Units



Part 7:

Maintenance of power plants for renewable energy

Category D2:

State-Event-Cause code for
power generating units (ZEUS)

Terms, classification and structuring
of states, events, causes and measures
for future assessments and improvements
in operation and maintenance

Revision 1
01.10.2013

FGW
renewable energies

Published by:

FGW e.V. -
Fördergesellschaft Windenergie
und andere Erneuerbare Energien

Maintenance
of power plants for renewable energy

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'State-Event-Cause code' (ZEUS)

Terms, classification and structuring of states, events, causes and measures for future assessments and improvements in operation and maintenance

Revision 1, dated 01.10.13

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The focus of the FGW Technical guidelines for power generating units Part 7 (TG7) "Maintenance of renewable energy power plants" lies in the description of the processes and the necessary documents and data. Furthermore, a clear and standardised identification of components, standard description of states and events and classification of malfunctions are required for all participants to enable later evaluation and analysis.

The present Part 7 of the Technical Guidelines (TG7) was compiled jointly by operative management - companies, service providers, manufacturers, research institutes, specialist companies, certification bodies and insurance companies. The aim is to define terms, describe essential processes and documentation in the area of maintenance of regenerative power generating units including the associated infrastructure, as well as to create standardised communication interfaces for the exchange of maintenance -relevant data.

Part 1: Determination of Noise Emission Values

Part 2: Determination of Power Curves and Standardized Energy Yields

Part 3: Determination of Electrical Characteristics of Power Generating Units connected to MV, HV and EHV Grids

Part 4: Requirements for Modelling and Validating Simulation Models of Electrical Characteristics of Power Generating Units and Systems (starting from Rev. 3)

Part 5: Determination and Application of Reference Yield

Part 6: Determination of Wind Potential and Energy Yields

Part 7: Operation and maintenance of power plants for renewable energy

- **Category A:** Miscellaneous section
- **Category B3:** Specialist application notes for monitoring and testing foundations and supporting structures for wind turbines
- **Category D2:** State-Event-Cause code
- **Category D3:** Global Service Protocol (GSP)

Part 8: Certification of the Electrical Characteristics of Power Generating Units and Systems in the Medium-, High- and Highest-voltage Grids

Part 9: Electromagnetic Compatibility

Notes on TG7:

- *Existing energy industry standards were combined with experience from the renewable energy sector to produce these guidelines.*
- *Additional categories in TG7 are in preparation at the time of publication of Category D2 in TG7. References to other as yet unpublished categories are therefore provisional and purely for information.*
- *TG7 category D2 Rev. 0 does not take into account the actual state description (damages). This will be included in the next revision of category D2.*

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1. Introduction

In accordance with Section 6 of the Energy Industry Act (Energiewirtschaftsgesetz, EnWG), "Security and reliability of the energy supply", Para. 49 Requirements for Energy Plants, the following applies: Energy systems must be set up and operated in such a way as to ensure the technical safety is guaranteed. Generally recognised rules of technology are to be taken into account subject to other relevant legal provisions.

In accordance with DIN EN 13306 and DIN 31051, the term maintenance comprises all technical and administrative measures, as well as the management of measures, required to establish the actual state, to maintain a functional state, to return to this state and to increase functional reliability during the life cycle of a unit. A proper approach to maintenance aims to secure the value of the invested capital and the required availability as well as protecting public safety.

Every operator or a system is responsible for its safe and economical operation. The operator is liable for any harm to the environment or to persons caused directly by the generating units operated by him or the associated infrastructure. It is therefore necessary to seamlessly and adequately document operations for the authorities, insurance companies and banks, not only for economic considerations, as far as possible.

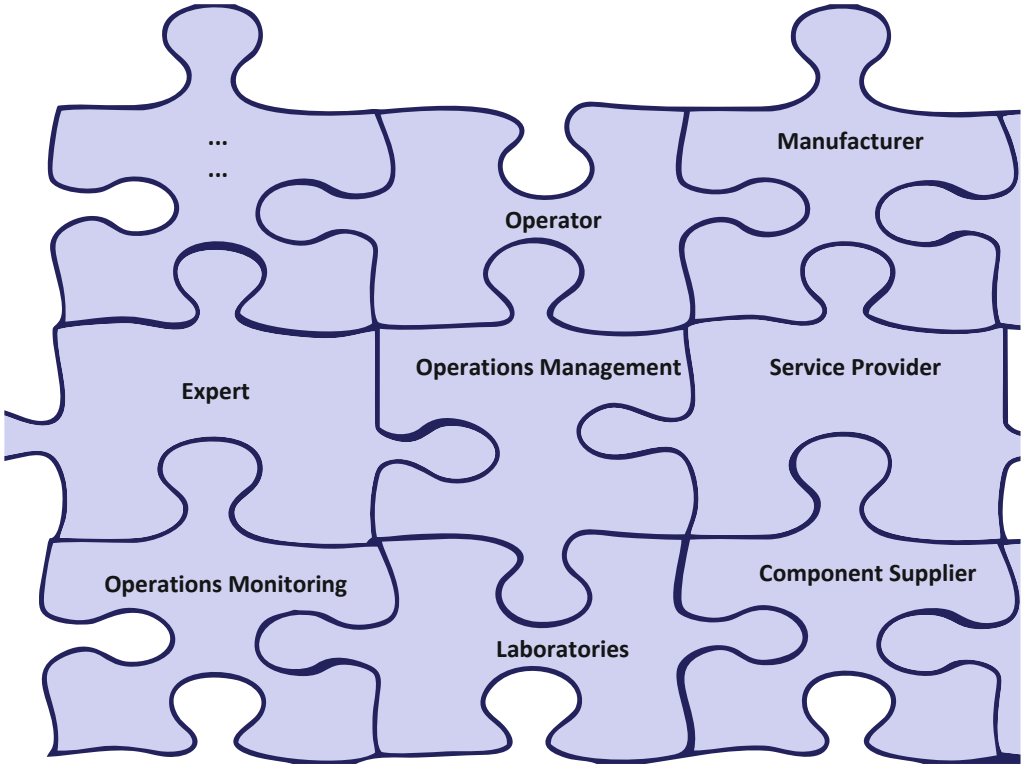

Fig. 1: Parties involved in the process who generate or receive maintenance-relevant information using the example of wind energy

Fig. 1 illustrates the complexity of communication between the participants in the maintenance processes and thereby indirectly the requirement for a standardisation of identification and descriptions for the purpose of simplification.

In addition to safety aspects, this documentation serves the purpose of prioritisation, planning and controlling maintenance measures as well as the analysis of operational and maintenance data relating to the updating of ongoing maintenance planning, the optimisation of the named processes as well as improving the systems. The operator also needs all the required technical documents in accordance with DIN EN 13460. A standardised design of documentation and data interfaces facilitates co-operation of all the parties involved in the process.

1.1. Category D2 “State-Event-Cause code”

Condition-based maintenance stems from the monitoring of the operating process and/or the state of the relevant maintenance object from representative measurements, while predictive or reliability-oriented maintenance predicts this based on parameters that indicate the deterioration of the maintenance object.

Both types of maintenance are aimed at using a wear-prediction to predict the wear response of a maintenance object and determine the limit of wear. Only an exact prediction of the limit of wear makes it possible to use the relevant maintenance object as long as possible and to avoid unnecessary consequential costs due to failures as well as downtime.

ZEUS is aimed at achieving a standardised description of states, events and causes in combination with a standardised identification system that can use these for the analysis to provide technical data for the state-oriented and predictive/reliability-oriented maintenance.

An important aim of TG7 is to determine probable limits of wear for maintenance objects in advance, based on undertaking standardisation and developing a cost effective maintenance strategy for the relevant types of maintenance object (see also TG.7/A section 4.2 "Maintenance concept and framework").

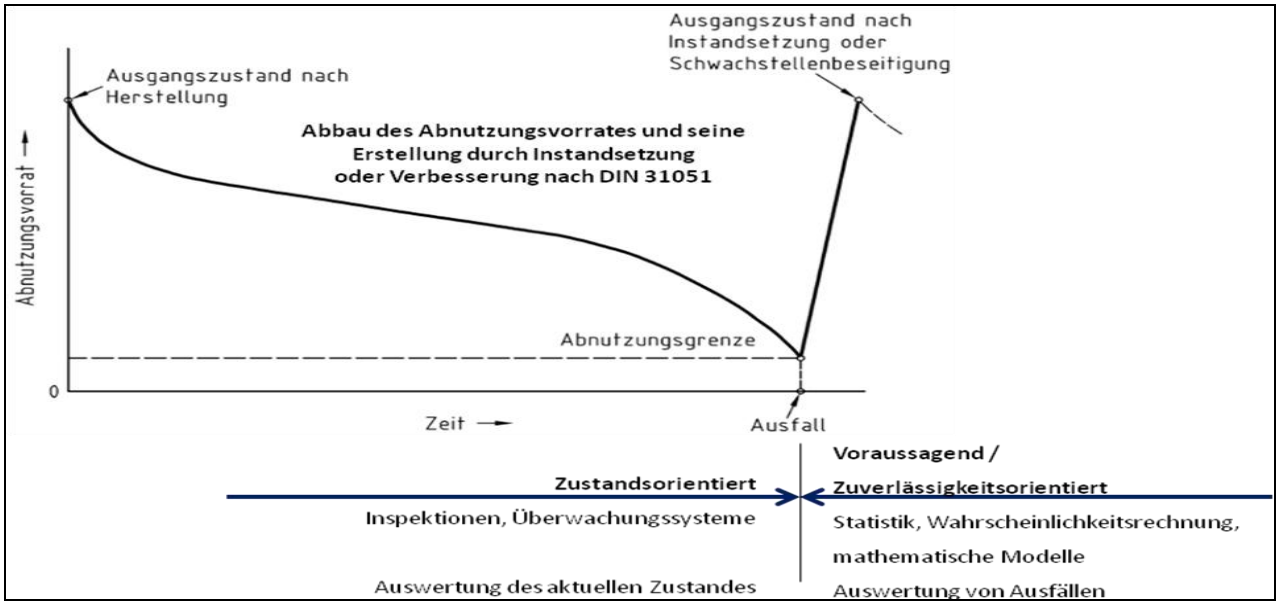

Fig. 2: Area of application of ZEUS for recording and describing the current state and current failures

Abnutzungsvorrat	Wear margin
Ausgangszustand nach Herstellung	Initial condition after manufacture
Abbau des Abnutzungsvorrates und seine Erstellung durch Instandsetzung oder Verbesserung nach DIN 31051	Degradation of the wear margin and its creation through repair or improvements according to DIN 31051
Ausgangszustand nach Instandsetzung oder Schwachstellenbeseitigung	Initial condition after repair or correction of weakness
Abnutzungsgrenze	Limit of wear
Zeit	Time
Ausfall	Failure
Zustandsorientiert	Condition-based
Inspektionen, Überwachungssysteme	Inspections, monitoring systems
Auswertung des aktuellen Zustandes	Evaluation of the current state
Voraussagend / Zuverlässigkeitsorientert	Predicitve / reliability-oriented
Statistik, Wahrscheinlichkeitsrechnung, mathematische Modelle	Statistics, probability calculations, mathematical models
Auswertung von Ausfällen	Evaluation of failures

In accordance with Fig.2, ZEUS describes the current states derived from the operational monitoring or from inspections as well as failures, events and causes. This information is assigned to the relevant originator within a function-oriented structure as per RDS-PP (Reference Designation System for Power Plants).

For additional analysis for operative and strategic evaluation (see also TG7/A section 4.7 "Operative evaluation" and section 4.8 "Strategic evaluation") individual sub-units whose effects and possible subsequent errors in the unit under consideration are significant for the assessment of deviations from the target state. The following information can be used for the description and assessment of deviations from the target state and the associated prioritisation of improvements:

- Information on the influence on the primary function of the unit under consideration:
  An error that causes, for example, a limited functional state of a unit under consideration is not as critical as one that causes a fault or even a hazardous condition:
  - A redundant system drops out and the secondary system takes over the function. This does not influence the primary function of the unit under consideration.
  - Is the introduction of a redundant system based on evaluations from field data useful?

- Information on the probability of detecting a fault:
  Accordingly, a fault that is not easily detected via operational monitoring or planned periodic maintenance is not as critical as a hidden fault that can, under certain circumstances, only be localised through secondary faults:
    - Is it worth installing an additional monitoring unit?
    - Are there any additional detection methods?
- Information on the frequency of the fault: The consequences of the fault have to be taken into account:
    - Fault that occurs frequently → Improvement high priority
    - Fault that seldom occurs → Improvement low priority

In combination with ZEUS it is therefore also necessary to introduce a standardised identification system for the energy plant such as DIN EN IEC 81346 "Industrial systems, installations and equipment and industrial products– structuring principles and reference designations" and the internationally valid reference system for power plants RDS-PP of the VGB.
Identification systems and analyses themselves are not part of the Technical Guidelines Part 7 Category D2 and are handled in separate categories of TG7.

1.2. Fundamental structure of ZEUS

ZEUS essentially differentiates between two blocks:

- Block 01 energy system: State description of an energy system via the description on three conditions/states
- Block 02 element: Naming of the originator of a limited functional state or faults due to the system, detection of deviations from the target state, faults, causes and necessary maintenance measures.