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Session B2: Certification of 'Fish-Friendliness': Looking Through a Glass Darkly

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ENERGY

Certification of 'fish-friendliness'

Looking Through a Glass Darkly

Maarten Bruijs
June 2015





Fish Passage 2015

International conference on river connectivity best practices and innovations

June 22-24, 2015 – Groningen, The Netherlands

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"Through a glass darkly"...

.... is to have an obscure or imperfect vision of reality

*The expression comes from the writings of the Apostle Paul,
who explains that we do not now see clearly, but at the end of time, we will do so...*

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'Certification of fish friendliness'...

- A hydropower station must use procedures to prove its operations (of the entire project) are managed and its facilities are designed in such a way that they safeguard basic features of the ecological integrity of the water system it uses.
- A certification for electricity produced in an environmentally responsible way needs to rely on credible and objective assessment criteria. This also applies to "green hydropower".
- Similarly, turbine developers/producers need procedures to 'prove' their turbine system is indeed achieving significant fish mortality reduction.
- When (novel) turbine designs are to be applied for reducing fish mortality, there is a strong need for a scientific, uniform and technical certification protocol

...is a prerequisite for large-scale application by end-users

Technical definitions relevant to certification of 'new technology'

- | | |
|------------------------------|--|
| ▪ Certification Basis | ▪ Technology - Degrees of Novelty |
| ▪ Certification | ▪ New technology |
| ▪ Standard | ▪ Technology with limited field history |
| ▪ Witnessing | ▪ Proven technology |
| ▪ Certification Plan | ▪ Technology qualification |
| ▪ Guidance | ▪ Fit-for-service |
| ▪ Guidance note | |

...what are the definitions for 'fish friendliness'?

Some definitions (1)

- **Certification Basis:** Requirements for the system's specifications, operating conditions, performance and reliability targets. The basis to which the system will be assessed during certification.
- **Certification:** Action by a certification body, providing written assurance that adequate confidence is provided that a duly identified product is demonstrably in conformity with a specific standard or other normative document.
- **Standard:** Means a document that provides guidance for the design, construction, deployment and in-service life of a product together with principles and technical requirements which must be observed in order to achieve specified levels of safety and reliability. A Standard provides the minimum basis for certification.
- **Witnessing:** Means the attendance of tests or measurements where the surveyor verifies compliance with agreed test and / or measurement procedures.

Some definitions (2)

- **Certification Plan:** Created at the conclusion of the Definition Phase. This will include the standards and certification levels agreed upon for the components and sub-systems, and the testing plan as defined by the Qualification Methods. The document contains the plan for all actions to be carried out during the certification process.
- **Guidance:** Means advice that is not mandatory but with which, in light of general experience, recommends compliance.
- **Guidance note:** Information in the standards in order to increase the understanding of the requirements.

Some definitions (3)

- **Technology - Degrees of Novelty:** The level of novelty and maturity are normally classified as New or Unproven, Limited history and Proven. The degree of technology novelty combined where / how the technology is applied (Application Area) will be classified in categories to be used as input to a risk assessment.

Some definitions (4)

- **New technology:** Technology that is not proven, no track record. The failure modes and mechanisms of failure are not known or there is limited understanding on how the technology can fail and the safety margins to failures. The technology has large uncertainties.
- **Technology with limited field history:** Technology that has been used to a limited range of applications and conditions. The technology has limited statistical basis and track record to clearly conclude that there is no new technical uncertainties to be identified. It is unlikely that standards and procedures have already been consolidated or are available to address the technology.
- **Proven technology:** In the field, proven technology has a documented track record for a defined environment. Such documentation shall provide confidence in the technology from practical operations, with respect to the ability of the technology to meet the specified requirements. Technology has been used in the industry for many years with modes of failure and failure mechanisms identified and controlled by design, fabrication, testing and maintenance requirements provided in standards or industry practice.

Some definitions (5)

- **Technology qualification:** A confirmation by examination and provision of evidence that the new technology meets the specified requirements for the intended use. Hence, qualification is a documented set of activities to prove that the technology is fit for service.
- **Fit for service:** A technology is considered fit for service when the failure modes that have been identified through the systematic process outlined in the Service Specifications have been properly addressed, and the supporting evidence substantiates that the technology fulfils all stated functional requirements and meets the stated reliability target. Although a technology has been stated fit for service, the technology has not necessarily an in-service record that eliminates the possibility for failures due to unidentified or misjudged failure modes. Consequently, there will be a possibility that the technology, contrary to expectations, will fail in-service.

'Certification of fish friendliness': not only to protect fish...

- **Safe** product design
- **Trustable** quality – important for the strong growing market of novel turbines
- Conformity to **state-of-the-art**
- Ensuring hydropower turbines to be **fit-for-purpose**
- **Reliable** prediction of turbine life-time
- Increasing client's (end-user) **confidence**
- Minimizing environmental damages and financial risks
- **Assistance** to make technology choice by end-user: application of criteria/specifications in scope and tender documents
- **Clarity** by producers in sales/marketing

...also required for technical acceptance and marketing

'fish friendly' turbines...

- Improvement of fish survival at hydropower dams
 - focus shift: fish guidance systems → 'fish-friendly' turbines
 - technical features of turbines altered to reduce turbine passage mortality of fish
- 'Improved' (novel) turbine types must be tested thoroughly before any conclusion can be drawn for full-scale project(s) and long term application
- How to test fish-friendliness of turbines, such that water authorities/regulators, permitting authorities, etc, will accept a 'minimum' (?) of fish mortality?
 - small-scale flume test
 - real-time field conditions
- How to translate test results for a single turbine to an entire installation/project?
- How to develop confidence in technology by the end-user without field history?

...a novel approach to reduce mortality?

The variety of different approaches...

- Service providers use self-developed 'protocols' in a controlled environment
 - are the test procedures 'uniform'?
 - are the results 'reliable', 'applicable', but foremost 'comparable'?
- There is lack of
 - scientific basis (best practices) for protocols, facilities and evaluation procedures
 - alignment / harmonization of applied test procedures
 - references to evaluate 'improvement'
 - independent witnessing during tests
- End-users need to comply to (strict) permit conditions: require confidence
- **Need: standardization of test protocols for fish survival**
 - protocols/test-rigs must be designed to provide best possible representativeness
 - protocols should allow independent testing of 'fish friendliness' of a turbine type
 - protocol must allow assessment impact of total project

...is undesired: all stakeholders need 1 accepted protocol

'Certification of fish-friendliness'...

- 'Fish-friendliness' itself can (likely) not be certified...
- Certification will be:
 - a statement of fulfilment of the test protocol
- but should also be:
 - a statement of 'best practice' / 'proven technology' / 'fit-for-purpose'?
 - a ranking criteria among different turbine types?
- Eventually, not just the turbine, but the '*entire project*' must comply to....
 - ... to what?
 - (inter)national criteria: WFD, etc
 - governmental statement (and permit requirement) of maximum fish mortality of the total project (not just per turbine) on fish population level?
 - maximum achievable fish mortality reduction, compared to 'standard technology'?

...must be based on clear definitions, protocols and criteria

Turbine passage mortality...

- Data on mortality rates at traditional, currently applied turbine types, shows great variation between fish species and life stages
 - is mortality rate a 'technical feature' of each specific turbine type and design? what about:
 - characteristics environment of deployment (e.g., river, tidal, or ocean)
 - hydrometric principles
- Direct impacts (blade strike + hydraulic conditions)
- Indirect impacts (disruptions in local movements and migrations)
- Cumulative effects
 - *river situations* with diadromous fish populations and passage multiple projects
 - *tidal situations* with multiple passage of single project

...is not only determined by the applied turbine type itself, but variable among different operating conditions, species/life stages and characteristics local environment

Test fish and procedures...

- Ethics: compliance to regulations: EU Guideline 2010/63/EU
 - Central Authority for Scientific Procedures on Animals (CCD)
 - Animal ethics committee (DEC)
- Choice of test species based on
 - similarity to a variety of species and life stages that are likely to encounter the turbines
 - length range must be sufficient to test for differences in survival associated with fish length
- River situations (fresh water)
- Tidal situation (sea water)

**...must be ethical, and...
...should be attuned/representative
to the conditions of future applications**

Testing fish survival...

- Pre-selected operating conditions
- Survival estimate:
 - release test fish directly upstream / control fish downstream operating units
 - direct injury and mortality, indirect sub-lethal injuries
- Handling and release of *treatment* and *control* groups
 - injury and mortality associated with handling / test procedures
- Behavioral observations
- Samples size to achieve 95% CI within $\pm 5\%$ of survival estimates:
 - 100 treatment / 100 control per replicate, 5 replicate trials per test condition (species, size class, velocity)
- 48-hr post-test observation: operation holding tank + monitoring water parameters and fish behavior/physiology
- Etc.....

**...requires a thorough preparation and proper logistics and...
...is not just about counting dead fish!**

Estimation turbine survival in controlled set-ups...

- Application of theoretical predictions of blade strike probability and mortality
- **Outcome:** predicted turbine passage survival
- Theoretical estimates of turbine passage survival and the survival estimates calculated from flume data cannot be directly applied to the river/tidal environments, because of
 - seasonal variations
 - fish behavior (avoidance)
 - other impacts on fish populations

**...still is an estimated prediction, not based on reality
(future conditions)**

Certifying fish-friendliness...

- So, after testing turbine, and a 'survival rate' is specified... **WHAT DO WE KNOW?**
 - mortality as 'technical feature' of a specific turbine type,
 - under selected (pre-set) operating conditions,
 - for a selected fish species and size classes
- **Is this representative for future application of the total project?**
 - The environmental impact of the total project must be evaluated in relation to relevant fish populations
 - differences in technologies will determine impact of a total project
 - number of turbines
 - size of turbines
 - location of project within the environment
 - environmental characteristics
 - relevant species and size classes

**...protocol should also include
impact assessment of the total project**

'Certification of fish-friendliness'...

- **Aim:** to enable a representative view on the impact of a future project
- The tested survival rate for a specific turbine is NOT subject to 'certification', what must be done is providing a

Statement of Conformity

... to certify that ...

the environmental performance of a specific turbine type

(being the fish survival rate itself, and subsequent assessment of the impact of the total project on relevant fish populations)

has been correctly evaluated according to the principles in the "Protocol"

(using the method statement based on the protocol for testing fish survival and evaluation of environmental impact, both yet to be developed)

...is not a %-figure, but matter of compliance

Stakeholders...

- The "protocol" applies to
 - turbines tests in laboratory flume and field test facilities
 - assessment of the impact of the total project
- Stakeholders should be (at least):
 - governmental water regulator
 - turbine manufacturers
 - biologists
 - operators test facilities
 - end-users
 - accredited certifying body (independent)
- Press-release Dutch standardisation institute:
 - NEN-initiative to develop Dutch Technical Arrangement (NTA)

...are jointly responsible to develop and apply the "protocol"

Discussion is needed...

- What is fish-friendliness?: 100% survival? / <10% mortality?
 - What level of fish passage survival /mortality reduction compared to the 'reference' should be achieved by of (novel) turbines?
 - How should this be tested?
 - What is the reference / reference criteria?
 - And, in the light of new turbine types under development, *with lack of any track record of fish survival and technical performance under real-time field conditions*,
 - should there be a comparison between turbine technologies?
- or...
- should the impact of the entire project with application of each specific turbine technology be evaluated?
- What should be the scientific basis of an independent certification process?

**...for developing a basis for the protocol....
...to obtain a clear view on fish-friendliness and total impact**

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Relevant references

- Fish Passage Through Turbines: Applicability of Conventional Hydropower Data to Hydrokinetic Technologies. EPRI, Palo Alto, CA: 2011. 1024638.
- Evaluation of Fish Injury and Mortality Associated with Hydrokinetic Turbines. EPRI, Palo Alto, CA: 2011. 1024569.
- DNV GL 2014. Design of tidal turbines. DNV GL – Energy, Renewables Certification – Wave and Tidal. 15-12-2014.
- ISO 26906 Hydrometry - Fishpasses at flow measurement structures *(currently under revision)*
- ISO/TR 19234 Low cost baffle solution to aid fish passage at crump weir flow measurement structures *(intention to develop this Technical Report to a Norm)*
- New Work Item Proposal (2015) Water quality - Monitoring the performance of fish passes *(recently launched by the UK Environmental Agency, applies the two ISO/TR on hydrometry)*
- NEN-EN 14962 Water quality - Guidance on the scope and selection of fish sampling methods *(seems applicable to the projects)*
- NEN press release, May 6 2015: call for development of working group to prepare an Netherlands Technical Agreement (NTA) for studying fish-friendliness of pumps

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