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Hydrometry — Fishpasses at flow measurement structures

Hydrométrie — Échelles à poissons auprès des structures mesurant le débit

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Foreword

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ISO 26906 was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 2, *Flow measurement structures*.

Introduction

Flow gauging structures are commonly used for the measurement of open channel flows. To operate satisfactorily, these structures require a head difference to be generated between the upstream and downstream water levels. At structures designed to operate in the modular flow range, an upstream head measurement is used to interpret flow rates. At structures designed to operate in both the modular and drowned flow ranges, the upstream head measurement is augmented by a second measurement which senses tailwater conditions. The former type tends to require higher head losses over the structure.

In recent years, greater emphasis has been placed on environmental issues, including the free migration of fish in watercourses. It is acknowledged that flow measurement structures, with their requirement for a head loss between upstream and downstream conditions, may inhibit the movement of fish. It has become important, therefore, to consider ways of aiding fish migration without seriously affecting flow measurement accuracy.

Hydrometry — Fishpasses at flow measurement structures

1 Scope

This International Standard specifies requirements for the integration of fishpasses with flow measurement structures. It identifies those fishpasses which have satisfactory hydrometric calibration data and gives methods for computing combined flows and uncertainties.

NOTE Measurement structures and fishpasses have inherently different hydraulic performance criteria. Water measurement structures perform better with uniform flow patterns; conversely, fish passage performance is improved by the variability of the flow conditions that allow fish and other aquatic inhabitants to select the passage conditions that best meet their mode of movement. This International Standard does not suggest that the fishpasses discussed are the preferred methods of passage or that they are good enough that passage performance can be sacrificed to obtain a single structure that does both.

2 Normative references

The following references are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 772, *Hydrometry — Vocabulary and symbols*

ISO 14139, *Hydrometric determinations — Flow measurements in open channels using structures — Compound gauging structures*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 772 apply.

4 Symbols

Where a symbol applies to a particular type of fishpass, it is indicated as follows.

[L] indicates applicable to the Larinier super-active baffle fishpass (see 7.2)

[PT] indicates applicable to the pool type fishpass with V-shaped overfalls (see 7.3)

[PO] indicates applicable to the Dutch pool and orifice fishpass (see 7.4)

Symbol	Term	Unit
a	height of baffle [L]	m
b	orifice width [PO]	m
b	crest breadth measured at transverse section of upstream baffle [L]	m
B	width of fishpass [L]	m
B	pool width [PT and PO]	m
B_2	width of the non-aerated nappe [PT]	m
C	characteristic discharge coefficient [PO]	
C_{de}	dimensionless coefficient of discharge [L]	
C_{D}	characteristic discharge coefficient [PT]	
C_{V}	coefficient for the approach velocity [PT]	
D	longitudinal spacing of transverse baffles [L]	m
D	pipe diameter [PO]	m
g	acceleration due to gravity [All]	$\mathrm{m/s^2}$
h_{max}	maximum head	m
h_{V}	orifice height [PO]	m
h_1	upstream gauged head relative to transverse section of upstream baffle [L]	m
h_1	upstream head [PT]	m
h_2	downstream head [PT]	m
H_1	upstream total head relative to transverse section of upstream baffle [L]	m
H_1	upstream total head [PT]	m
$H_{1\mathrm{e}}$	effective upstream total head relative to transverse section of upstream baffle [L]	m
k_{h}	head correction factor taking into account fluid property effects [L]	m
l	pool length [PT]	m
L	crest length [PT]	m
L	pool length [PO]	m
n	number of partitions [PO]	
n_{l}	length scale factor [PO]	
n_{V}	flow velocity scale [PO]	
n_{Q}	discharge scale [PO]	
n_{ℓ}	scale factor for length dimensions [PT]	
P	height of the top baffle [L]	m
P	pool depth [PT]	m
Q	discharge [All]	$\mathrm{m^3/s}$
Q_{d}	design discharge [PT and PO]	$\mathrm{m^3/s}$
S	bed slope of fishpass [PO and L]	
U	burst velocity of fish [PO]	m/s
v	flow velocity [PT and PO]	m/s
v_1	velocity of approach at tapping location [L]	m/s
$\bar{V}$	mean flow velocity [PO]	m/s
W_{L1}	upstream water level [PO]	m
W_{L2}	downstream water level [PO]	m
X	distance to h_1 measurement section [PT]	m
X_{C}	uncertainty in C_{D} [PT]	%
X_{Q}	uncertainty in measured or calculated discharge [PT and PO]	%
Y_{d}	downstream water depth, related to upstream bed level [PO]	m
Y_0	upstream water depth, related to upstream bed level [PO]	m

α	angle of V-shape [PT]	deg
δ_h	error in measurement of h_1 [PT]	m
Δh	drop over the fishpass for modular flow [PT]	m
$\overline{\Delta h}$	head drop per pool [PO]	m
$\overline{\Delta h_d}$	design head drop per pool [PO]	m
Δt	pool drop [PT]	m

5 Principle

The discharge over a flow measurement structure is a function of the upstream head (plus a measure of the downstream head in the case of those structures designed to operate in the drowned flow range). When a fishpass is placed alongside a flow gauging structure, an additional flow path is created. In certain circumstances, where the fishpass has a well-defined hydrometric calibration, total flows and uncertainties may be calculated. Thus the fishpass becomes an integral part of the flow measurement system. This document provides the necessary design and performance information for this type of arrangement.

6 Installation

NOTE General requirements of combined flow measurement structure/fishpass installations are given in the following clauses.

6.1 Requirements for gauging structure/fishpass installations

NOTE Requirements for the installation of gauging structures are given in the appropriate International Standard (see Clause 2 and the Bibliography). There is much in common between the different structures and the requirements, which can also be applied to flow measurement structure/fishpass installations, and are summarized in the following clauses.

6.1.1 Selection of site

6.1.1.1 A preliminary survey shall be made of the physical and hydraulic features of the proposed site, to check that it conforms (or may be made to conform) to the requirements necessary for measurement by a weir.

6.1.1.2 Particular attention shall be paid to the following features in selecting the site:

— availability of an adequate length of channel of regular cross-section;

— the existing velocity distribution;

— the avoidance of a steep channel, if possible;

— the effects of any increased upstream water level due to the measuring structure;

— conditions downstream, including such influences as tides, confluences with other streams, sluice gates, mill dams and other controlling features which might cause submerged flow;

— the impermeability of the ground on which the structure is to be founded, and the necessity for piling, grouting or other sealing, in river installations;

— the necessity for the use of flood banks to confine the maximum discharge to the channel;

— the stability of the banks and the necessity for trimming and/or revetment in natural channels;

— the clearance of rocks or boulders from the bed of the approach channel;

— the effect of wind; wind can have a considerable effect on the flow in a river or over a weir, especially when these are wide and the head is small and when the prevailing wind is in a transverse direction.

6.1.1.3 If the site does not possess the characteristics necessary for satisfactory measurement, the site shall be rejected unless suitable improvements are practicable.

6.1.1.4 If an inspection of the stream shows that the existing velocity distribution is regular, then it may be assumed that the velocity distribution will remain satisfactory after the construction of a weir.

6.1.1.5 If the existing velocity distribution is irregular and no other site for a gauge is feasible, due consideration shall be given to checking the distribution after the installation of the weir and to improving it if necessary.

6.1.1.6 Several methods are available for obtaining a more precise indication of irregular velocity distribution. Velocity rods, floats or concentrations of dye can be used in small channels, the latter being useful in checking conditions at the bottom of the channel. A complete and quantitative assessment of velocity distribution may be made by means of a current metre or acoustic Doppler profiler.

6.1.2 Installation conditions

6.1.2.1 The complete installation consists of an approach channel, the flow measurement/fishpass structures and a downstream channel. The conditions of each of these three components affect the overall accuracy of the measurements.

6.1.2.2 Installation requirements include such features as the quality of the structures, the cross-sectional shape of channel, channel roughness and the influence of control devices upstream or downstream of the structures.

6.1.2.3 The distribution and direction of velocity, determined by the features outlined in 6.1.1, have an important influence on the performance of the flow measurement structure and the fishpass.

6.1.2.4 Once an installation has been constructed, the user shall prevent any change which could affect the flow characteristics.

6.1.3 Upstream channel

6.1.3.1 At all installations the flow in the upstream channel shall be smooth, free from disturbance and shall have a velocity distribution as normal as possible over the cross-sectional area. This can usually be verified by inspection or measurement. In the case of natural streams or rivers this can only be attained by having a long, straight upstream channel free from projections either at the side or on the bottom. Unless otherwise specified in the appropriate clauses, the following general requirements shall be complied with.

6.1.3.2 The altered flow-conditions due to the construction of the structure(s) might have the effect of building up shoals of debris upstream of the structure, which in time might affect the flow conditions. The likely consequential changes in the water level shall be taken into account in the design of the structures.

6.1.3.3 In an artificial channel the cross-section shall be uniform and the channel shall be straight for a length equal to at least five times its breadth.

6.1.3.4 In a natural stream or river the cross-section shall be reasonably uniform and the channel shall be straight for such a length as to ensure regular velocity distribution.

6.1.3.5 If the entry to the upstream channel is through a bend or if the flow is discharged into the channel through a conduit of a smaller cross-section, or at an angle, then a longer length of straight approach channel may be required to achieve a regular velocity distribution.

6.1.3.6 There shall be no baffles in the upstream channel, which are nearer than five times the maximum head to the point of head measurement.

6.1.3.7 Under certain conditions, a standing wave may occur upstream of the installation, for example if the approach channel is steep. Provided this wave is at a distance of not less than 30 times the maximum head upstream, flow measurement will be feasible, subject to confirmation that a regular velocity distribution exists at the structure.

6.1.4 Downstream channel

6.1.4.1 The channel downstream of the structure is of no importance to flow measurement if the gauging structure or gauging structure/fishpass installation has been so designed that the flow is modular under all operating conditions. A downstream gauge shall be provided to measure tailwater levels to determine if and when submerged flow occurs.

6.1.4.2 In the event of the possibility of scouring downstream, which may lead to the instability of the structure, particular measures to prevent this happening may be necessary.

6.1.4.3 A separate head gauge to indicate downstream conditions and a second stilling well shall be fitted if the flow measurement structure is designed to operate in the drowned condition or if there is a possibility that the structure may drown in the future.

6.1.4.4 The circumstances described in 6.1.4.3 may arise if the altered flow conditions, due to the construction of the structure, have the effect of building up shoals of debris immediately downstream of the structure or if river works are carried out downstream at a later date.

6.1.4.5 For optimum fishpass performance the jet of water issuing into the downstream channel shall be discernable to the fish amongst all the other competing flows and from as far away as possible. Care shall be taken to avoid the jet being masked by cross-flows or turbulence in the receiving water. Further details, which specifically relate to the fishpass, are given in 6.2.3.

6.1.5 Flow measurement and fishpass structures

6.1.5.1 The flow measurement structure should comply with the requirements given in the appropriate International Standard (see Bibliography).

6.1.5.2 The fishpass shall comply with the requirements of Clause 7. The quality of construction, particularly at the upstream entry, should match that of the flow measurement structure (see Bibliography).

6.1.6 Maintenance

6.1.6.1 Maintenance of the flow measurement structure, the fishpass and the approach channel is important to secure accurate continuous measurements of discharge.

6.1.6.2 It is essential that the approach channel to flow measurement structure/fishpass installations be kept clean and free from silt and vegetation. The float well and the entry from the upstream channel shall also be kept clean and free from deposits.

6.1.6.3 The flow measurement structure and the fishpass shall be kept clean and free from clinging debris and care shall be taken in the process of cleaning to avoid damage to the weir or fishpass.

6.1.7 Measurement of head

6.1.7.1 When a fishpass is set alongside a flow measurement structure, an additional flow path is created and the fishpass flow needs to be evaluated with a similar precision to that of the gauging structure itself. The following are the two ways of doing this.

- Head gauges are placed at both the fishpass and the gauging structure, and the two flows are determined separately and then combined to give the total river flow. This method requires more computing and telemetry but is reliable, particularly where the upstream entry to the fishpass is remote from the gauging structure.

- Head gauges are placed only at the gauging structure and the flow at the fishpass is determined by transferring the single measured head to the fishpass using the established principles which apply to compound weirs. This method is more economical and is particularly useful where the upstream entry to the fishpass is close to the gauging structure.

6.1.7.2 Head gauges shall be designed and installed in accordance with the relevant International Standard (see Bibliography for gauging structures and this International Standard for fishpasses).

6.1.7.3 Head gauges shall be zeroed to the crest of flow measurement weirs or to the invert level of flumes. Accuracy in zeroing gauges is very important at low flows.

6.2 Requirements specific to the fishpass

6.2.1 General

The swimming performance of fish depends on many factors, including:

— species;

— individual size and ability;

— water temperature;

— water depth;

— water velocity;

— water quality;

— turbulence;

— motivation;

— migration period.

It is thus a complex subject with many variations. The data available are variable in both quantity and quality, and are complex to interpret. Furthermore, the effectiveness of a fishpass in terms of ease of passage depends on a suitable match between the type of fishpass, the specific hydraulic conditions within the fishpass and the particular species of fish wishing to migrate. It is not within the scope of this International Standard to cover this complex subject in detail. Instead, basic requirements which apply to a range of species of fish and a range of types of fishpass are identified to help those designing flow measurement structure/fishpass installations.

6.2.2 Guidelines for basic parameters of fishpasses

Guidelines for maximum water velocities within, head drops across and lengths of fishpasses are given in Table 1.

Table 1 — Guidelines for maximum water velocities within, head drops across and lengths of fishpasses

Pass parameters		Species			
		Coarse fish	Brown trout	Sea trout	Salmon
Pool pass	Max. velocity (m/s)	1,4 to 2,0	1,7 to 2,4	2,4 to 3,0	3,0 to 3,4
	Max. head drop (m)	0,1 to 0,2	0,15 to 0,3	0,3 to 0,45	0,45 to 0,6
Baffled pass	Max. velocity (m/s)	1,1 to 1,3	1,2 to 1,6	1,3 to 2,0	1,3 to 2,0
	Length of pass (m)	8 to 10	8 to 10	10 to 12	10 to 12