HINKLEY POINT C PERMIT VARIATION

EPR/HP3228XT/V004

Technical Brief: TB007

Low Velocity Side Entry Intake Design; effect of intake velocity cap.

Operations Catchment Services, Environment Agency.

2020 (DRAFT-03)

EXECUTIVE SUMMARY

This Technical Brief reviews aspects of the fish impingement estimates in section 5 of TR456 Ed2 (2019), which scales the observed impingement from Hinkley Point B (HPB) to Hinkley Point C (HPC).

This Technical Brief focuses on the capped intake ratio applied for pelagic species within TR456 Ed2 due to the design of the Low Velocity Side Entry (LVSE) intake design.

Vertical velocities at the intake are expected to affect pelagic species in particular, and the capped design should mitigate this.

This Technical Brief provides additional data relevant to the discussion and outlines an alternative approach. The factors calculated here are used in the impingement and biomass calculations described in EA 2019b.

INTRODUCTION

TR456 Ed2 estimates impingement for HPC by scaling observed values from HPB. The approach uses several assumptions, which are not clearly described, and introduce uncertainty.

This note discusses the allowance applied to represent the velocity cap at HPC's intake. The cap is intended to suppress any vertical components of velocity at the intake, so that water flows approach the intake screens horizontally. This design should reduce the impingent of pelagic fish swimming over the intake, which are more able to swim against horizontal currents than vertical ones. TR456 Ed2 derives a scale factor using data from Sizewell A (uncapped) and Sizewell B (capped) but this analysis is complicated by other differences between the stations. (See 'Comparison' below for a brief discussion.)

This note reviews the approach, and suggests an alternative based purely on geometry. Both discussions refer to tidal levels at Hinkley Point, which are shown in Table 1 below.

mODN	tide level
7.12	Highest Astronomical Tide HAT
5.64	Mean High Water Springs MHWS
2.5	Mean High Water Neaps MHWN
0.1	Mean Sea Level MSL
-2.3	Mean Low Water Neaps MLWN
-5.1	Mean Low Water Springs MLWS
-6.1	Lowest Astronomical Tide LAT

Table 1. Tide levels at Hinkley Point (TR456 Ed2, p31)

HPB intake design

To give a crude description of the intake at HPB: the intake structure is essentially a doughnut shape, resting on the seabed, and tall enough to stick out above the sea surface for much of the time. The vertical faces are protected by bar screens, while the horizontal face has radial spokes that occupy half the total area.

In more detail, TR456 Ed2 says (p33):

> *The HPB sector faces approximately south east (Figure 2). Each sector has 2 intake surfaces; a vertical face that rises from just above the seabed to a height of 5.8 m with a surface area 118.4 m^2 and a horizontal surface extending approximately 5.3 m towards the centre of the caisson with a surface area of 93.5 m^2 (Source EDF Energy).*
> *… At and above low water neaps both the HPB vertical and horizontal intake surfaces are submerged and the cooling water flow is abstracted through a surface area of approximately 212 m^2. At low water on springs the seawater level drops below the horizontal screen (at which point the intake surface area is 118.4 m^2) and the intake surface area then falls to a minimum of approximately 77 m^2 at low water slack.*

TR456 Ed2 Figure 1 indicates that seabed level at the HPB intake is about -8 mODN. (The design drawing mentioned later states -9 mODN, but this difference is not important to this discussion.)

Table 2 below summarises the intake structure levels, and shows how they relate to the tidal levels. It may be seen that the intake is partially exposed at all low water levels, but covered at MSL and above. Two sketches (based on a design drawing) illustrate this further (Fig.1).

intake structure	mODN	tide level
	7.12	Highest Astronomical Tide HAT
	5.64	Mean High Water Springs MHWS
	2.5	Mean High Water Neaps MHWN
	0.1	Mean Sea Level MSL
top of opening	-2.2	
	-2.3	Mean Low Water Neaps MLWN
	-5.1	Mean Low Water Springs MLWS
	-6.1	Lowest Astronomical Tide LAT
bottom of opening	-8	
seabed level	-8	

Table 2. Key levels for HPB intake design (approximate)

Figure 1. Vertical (radial) section through HPB intake. Left: based on design drawing; Right: schematic showing water level around MLWS.

The top face (horizontal screen) is only 50% open. Taken together with the partial exposure, this makes it very difficult to infer what effect a full cap might produce.

At Low Water on any tide, the top of the intake is exposed. So any type of cap would have no effect on the drawdown (it would be in the air). The quoted intake speeds – 0.16-0.44 m/s – should limit surface draw down even for relatively shallow submergence. (For comparison, the HPC LVSE intake target velocity is 0.3 m/s, so HPB is in the same range when submerged.)

HPC intake design

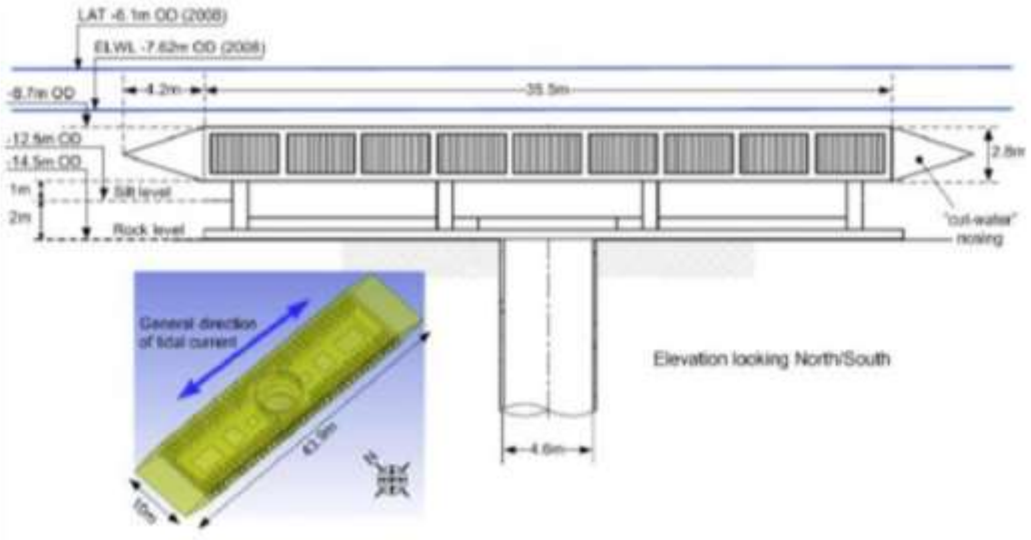


Figure 2. This figure is Figure 6.1 from HRW 2013, Numerical & Physical modelling of the Hinkley Point C Intake & Outfall Structures: Task 1 – Physical modelling of flows at intake heads (TN10).

intake structure	mODN	tide level
	7.12	Highest Astronomical Tide HAT
	5.64	Mean High Water Springs MHWS
	2.5	Mean High Water Neaps MHWN
	0.1	Mean Sea Level MSL
	-2.3	Mean Low Water Neaps MLWN
	-5.1	Mean Low Water Springs MLWS
	-6.1	Lowest Astronomical Tide LAT
top of opening	-8.7	
bottom of opening	-11.5	
silt level	-12.5	

Table 3. Key levels for HPC intake design

The HPC intake will be fully submerged at all stages of the tide. Capping is therefore an important design feature, and combined with low intake velocity, it should limit the risk of drawdown. Even at LAT, the cover depth is 2.6m which is moderately, if not 'deeply' submerged as the opening height is 2.8m. At MLWS the cover is 3.6m which can be considered 'deeply submerged'.

Comparison

Because the design and operation of the two intakes are significantly different, it is very difficult to establish an expectation of their relative behaviour. HPB intake will likely draw from all or most of the water column, for tidal elevations below MSL. However, above MSL the intake is partially capped.

At higher tidal levels, the intake velocity drops below 0.3 m/s and the main draw will be from the side face. This does not seem strikingly different from the anticipated HPC performance. However it is reassuring that analysis of pelagic species impingement at HPB through the tide, does not indicate any significant difference between tidal states (EA 2019a). This suggests that the exposure/submergence of the HPB intake does not significantly influence pelagic species entrapment, and supports the use of HPB as an uncapped reference.

Alternative approach

We have carried out some further analysis to understand better the uncertainties and sensitivities in the drawdown factor. We made various assumptions about the drawdown at HPB and at HPC, and allowed for tidal variation in water depth (using BODC tide gauge for 2018). We then compared the *fraction* of the water column that each intake draws. (Note that this approach is wholly different from that adopted in TR456 Ed2.)

In particular, we assumed that the HPB intake could draw either:

- the full water depth at all states of the tide (completely uncapped – this is probably unrealistic close to high water) - 100%.
- only from its own height (allowing for exposure – this corresponds to a perfectly capped design) - 72% of the water depth as annual average.

We consider that these two conditions present extremes of the possible HPB performance, and that reality probably lies between them.

For HPC we first assumed perfectly capped behaviour (drawing horizontally from 2m only) and then relaxed this assumption to represent some limited drawdown.

This approach assumes that pelagic fish are as likely to be present at one depth as any other depth (i.e. they are evenly distributed through the water depth). This is considered to be a reasonable assumption, as they are mobile species and active swimmers, and can move through the water column during foraging. For example, European sprat and Atlantic herring have been found to show vertical migrations when foraging to follow zooplankton movements through the day, and to feed on the nektobenthos at the bed (Cardinale et al., 2003). Furthermore, species such as Atlantic salmon and sea trout will generally occupy the upper parts of the water column during their marine migrations (Renkawitz et al., 2012; Godfrey et al., 2014) and therefore assuming an equal probability of being present at any depth is likely to be a precautionary situation for their potential interaction with the HPC intake.

This approach also assumes that the design of the intake offers no benefit at reducing the impingement of benthic or demersal species. As the intake is raised off the seabed, there may be some benefit whilst individuals are resting on the seabed (i.e. they are unlikely to be drawn in when resting on the seabed near the intake). However, to reach the area of the seabed they will have had to actively swim in the water column. Many benthic and demersal species conduct sporadic, or regular periodic, incursions into the water column, influenced by diurnal or tidal patterns. These movements will put the fish at risk of impingement. Therefore, assuming no benefit is considered to be a reasonable assumption.

EA 2019b discusses the application of pelagic and non-pelagic factors in calculating impingement. (Including the factors applied to each species.)

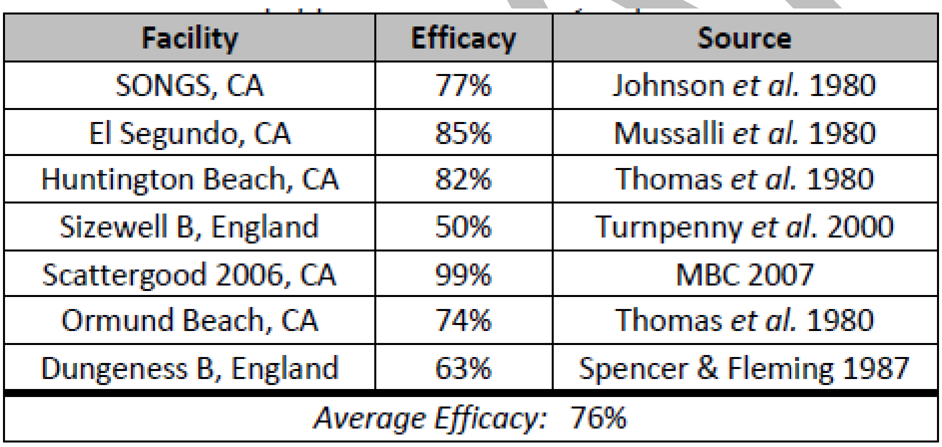
RESULTS

Table 4 below summarises the results and scale factors. EA 2019b applies the factor 0.23 (average of the two methods, at 2.5m draw depth) to calculate impingement of pelagic and non-pelagic species. It also shows the factors applied to each species. This factor was included in the Technical Brief: Uncertainty Analysis (EA2019c).

HPB assumption	**HPC assumed draw depth (m)**		
	2	**2.5**	**3**
draws from the full water depth, all of the time	0.15	0.19	0.23
draws perfectly horizontally: maximum height 6.8m	0.21	0.27	0.32
average	*0.18*	*0.23*	*0.28*

Table 4. 'Scale factor' ratio of depth affected by HPC vs HPB

For comparison, Nieder *et al*. (2018) undertook a review of reported efficacies of offshore velocity cap intakes and determined an average efficacy of 76%. This confirms that our value is plausible.



Facility	Efficacy	Source
SONGS, CA	77%	Johnson *et al.* 1980
El Segundo, CA	85%	Mussalli *et al.* 1980
Huntington Beach, CA	82%	Thomas *et al.* 1980
Sizewell B, England	50%	Turnpenny *et al.* 2000
Scattergood 2006, CA	99%	MBC 2007
Ormund Beach, CA	74%	Thomas *et al.* 1980
Dungeness B, England	63%	Spencer & Fleming 1987
Average Efficacy: 76%		

Table 5. Efficacies reported from several facilities with an offshore intake velocity cap (taken from Nieder et al., 2018)

Table 6. Conclusion results

	Used in Applicant's assessment	**Used in Environment Agency's assessment**	
		Predicted	Uncertainty Range
Intake velocity cap factor for pelagic species	0.38	0.23	0.18 – 0.28

REFERENCES

Cardinale, M., Casini, M., Arrhenius, F. and Hakansson, N. (2003) Diel spatial distribution and feeding activity of herring (Clupea harengus) and sprat (Sprattus sprattus) in the Baltic Sea. Aquatic Living Resources 16 (2003) 283–292

Environment Agency (2019a) Technical Brief: Low Velocity Side Entry Intake Design; effect of intake intercept area. Operations Catchment Services, Environment Agency.

Environment Agency (2019b) Technical Brief: Biomass Weight and Mortality Report. Operations Catchment Services, Environment Agency.

Environment Agency (2019c) Technical Brief: Uncertainty Analysis. APEM and Operations Catchment Services, Environment Agency.

Godfrey, J. D., Stewart, D. C., Middlemas, S. J. and Armstrong, J. D. (2015) Depth use and migratory behaviour of homing Atlantic salmon (Salmo salar) in Scottish coastal waters. ICES Journal of Marine Science 72: 568–575

HRW (2013) Numerical & Physical Modelling of the Hinkley Point C Intake & Outfall Structures. Task 1 – Physical Modelling of Flows at Intake Heads (TN-10). HR Wallingford Ltd. May 2013.

Renkawitz, M. D., Sheehan, T. F. and Goulette, G. S. (2012) Swimming Depth, Behavior, and Survival of Atlantic Salmon Postsmolts in Penobscot Bay, Maine. Transactions of the American Fisheries Society 141 Issue 5

TR456 Ed2 (2019) Revised Predictions of Impingement Effects at Hinkley Point C - 2018. BEEMS Technical Report TR456 Edition 2, Revision 10. Cefas, Lowestoft.