

THE COOLING WATER SYSTEM FOR THE DELESTO 2 CO-GENERATION PLANT

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1. Introduction HBW

Hollandsche Beton- en Waterbouw [HBW], a HBG group company, is a civil engineering contractor, based in The Netherlands and working in Western Europe. HBW is strong in the area of non standard projects, in which the in house design and construction knowledge and capabilities can be combined to achieve clever and economical solutions. The cooling water system for the Delesto 2 co-generation plant is a typical example of such a project.

2. Background

AKZO Nobel operates a chemical plant near Delfzijl in the province of Groningen in the far North east of The Netherlands [fig. 1] The plant is located along a channel [Zeehavenkanaal] connecting the harbour of Delfzijl with the Eems. The Eems is the wide estuary of the German River Ems [fig. 2]. The channel runs parallel to the coast line and is in fact a former part of the Eems, now separated by a long dike [Schermdijk]. The dike between the channel and the AKZO Nobel plant is the actual sea defence [Zeedijk]. Characteristic for this area, as for the rest of the North Netherlands coast, are the vast flats [Wadden] in the Eems, outside the Schermdijk, which are dry during low water and wet during high water. This is where the Dutch practice 'wadlopen'.



Figure 1: Location

The AKZO Nobel plant was founded in the 1950's after the discovery of a large underground reservoir of mineral salt in the area and still most activities on the plant are salt-related. Yet gradually other activities have developed, one of those being power generation. This power generation is in hand of the Joint Venture Delesto, formed by AKZO Nobel [50%] and EDON [50%]. EDON is the energy distribution company for the Eastern and Northern Netherlands. Since 1983 a small co-generation power plant is operational at the Delfzijl location. In the co-generation power plant electricity and steam are produced and both are used directly on the AKZO Nobel plant. Part of the electricity is sold to the electricity companies and put in the national network.



Figure 2 Detailed location plan

At present an additional larger co-generation plant is under construction. The capacity of this so called Delesto 2 co-generation plant is 350 MW electricity and 750 tonnes steam per hour. The plant will be operational in 1999.

The cooling water system of this Delesto 2 plant has been designed and built by HBW. The coastal aspects of this cooling water system are the subject of this paper.

3. Project introduction

The tender for the cooling water system Delesto 2 took place in the autumn of 1995. AKZO Nobel Engineering acted as the formal client. The tender package included a basic design, by consultant Hasko, however, alternatives were allowed and detailed design was to be in the contractors scope. HBW's price was significantly below those of the competitors, roughly 20 million Dutch Guilders versus 27 million. The price difference was caused by some clever alternatives brought in by HBW; these will be explained further on. After some clarifications and negotiations the contract was awarded to HBW in December 1995.

Design work by WOB/DMC, the engineering department of HBW, started in January 1996. Construction works at the site started in April 1996 and the works were completed in December 1997.

The main components of the cooling water system are indicated in figure 3 and 4 and briefly explained below:

1. water intake with protective barrier etc. in the Zeehavenkanaal;
2. pump station [reinforced concrete] situated at the land-water transition area;
3. pipe and access bridge [reinforced concrete] from the pump station to the dike
4. two cooling water intake lines \varnothing 1500 [concrete pipe with steel plate core] running from the pump station via the bridge and subsequently underground to the power plant;
5. buffer tower connected to the intake lines, which functions as pressure equaliser;
6. one water return line \varnothing 2000 [concrete pipe with steel plate core] which is mainly parallel to the intake lines for the onshore part, then splits off at the crown of the dike, subsequently runs underneath the Zeehavenkanaal and ends in the outfall structure;
7. outfall structure on the flats in the Eems, outside the Schermdijk;
8. earth work and sheet piling at the dike crossing of the pipes.

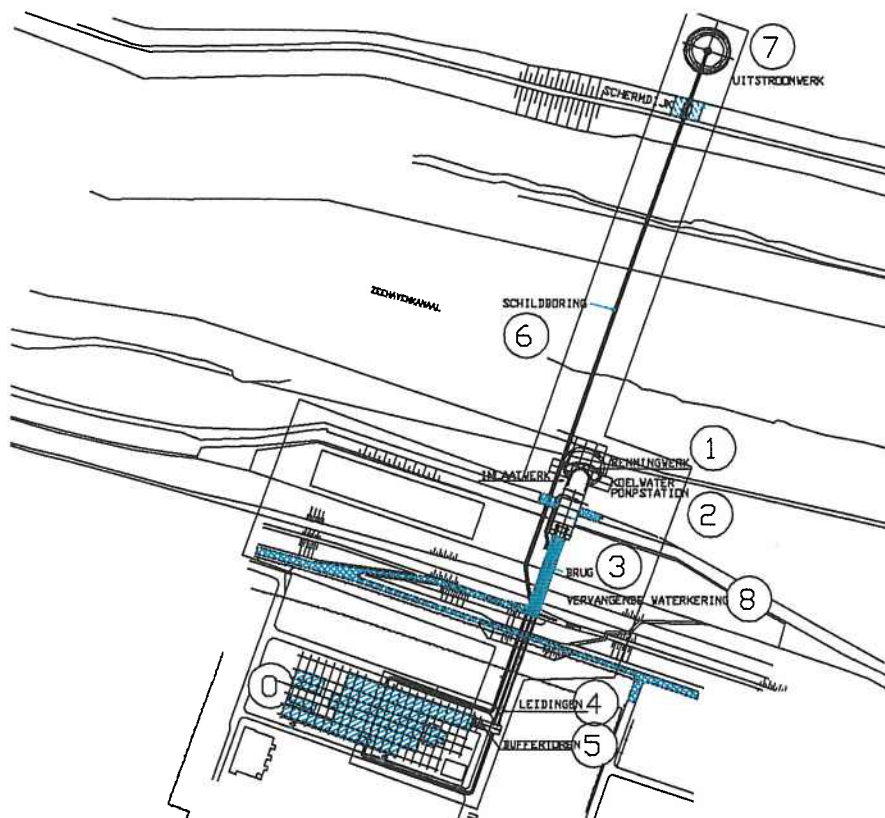


Figure 3 General layout, showing main components



Figure 4 Overview construction activities

4. Alternatives by HBW

The main alternatives to the basic design, brought in by HBW in the tender phase refer to:

1. the cooling water return line underneath the channel
2. the outfall structure at the flats.

4.1 Alternative for return line under channel.

The basic design for this part consisted of an immersed tube which required a deep trench in the channel bottom. The alternative proposed was to drill the pipeline \varnothing 2000 mm underneath the channel starting at the Zeedijk and ending directly at the location of the outfall structure.

Main benefits of this alternative were:

- important cost saving because trenching of [partly] polluted soil could be omitted;
- far less temporary works in the two dikes because [complex] connections of the immersed and on land parts could be avoided.

Drilling of these kind of tubes is a specialism of sister company HWZ. They were involved in the tender phase, developed the alternative together with HBW and carried out the drilling works as subcontractor to HBW [figure 5]. A good example of HBG synergy!

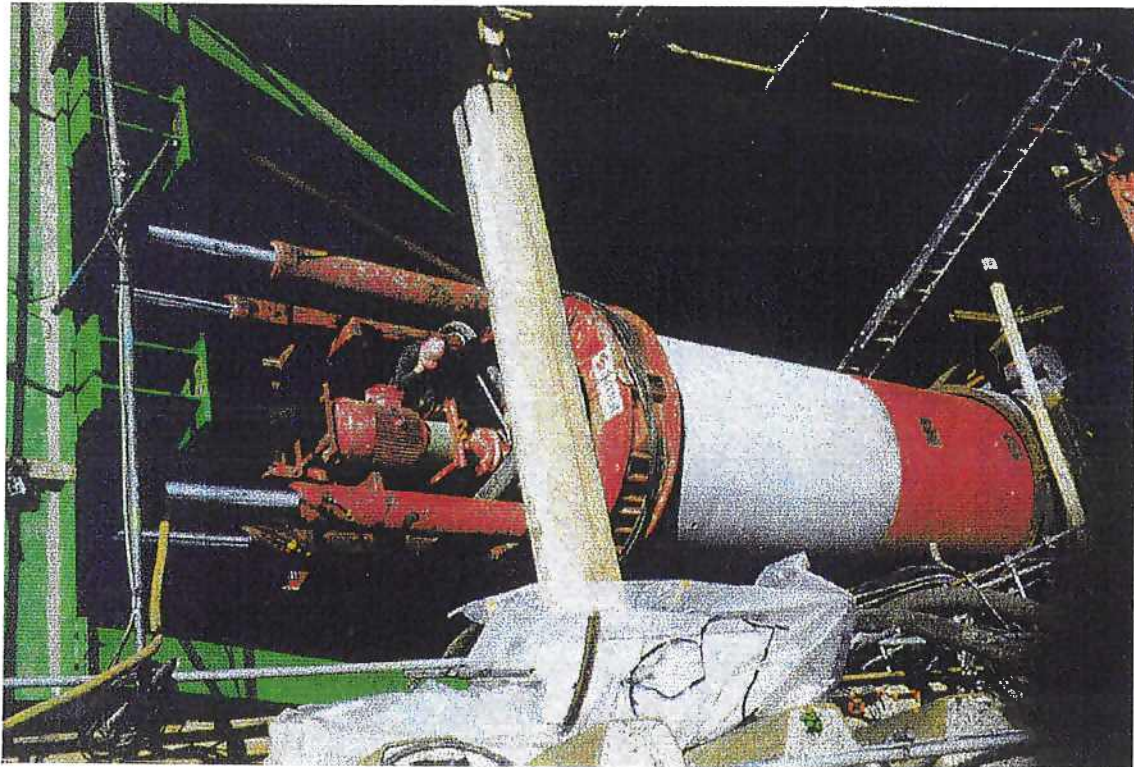


Figure 5 Drilling of first pipe section

4.2 Outfall structure

Instead of a rather large and heavy piled concrete outfall structure given in the basic design, HBW has designed a very small and simple circular outlet structure which could be put directly on the water pipeline.

Main benefits of this alternative were:

- far less weather dependent construction works on the flats;
- direct saving in piles, concrete etc.

This alternative will be further elaborated under the coastal aspects in the next chapter. Also this alternative results more or less from HBG synergy; it was initiated because of knowledge and experience gained by DMC in designing similar structures for sister company Interbeton.

5. **Coastal aspects of the project**

Interesting coastal aspects of the Delesto 2 project are:

1. construction methodology of the pump station situated on the transition of land and water
2. the alternative outfall structure indicated earlier.

5.1 Construction methodology pump station

The pump station itself is of more or less standard construction [fig. 6]; it has a concrete substructure with dimensions in plan of approximately 30 m x 15 m and a height of approximately 18 m, reaching from NAP - 8,65 m to NAP + 9.30 m. The service 'building' on top comprises a steel structure with precast concrete façads. The pump station accommodates two pumps with a total capacity of 30.500 m³/hr.

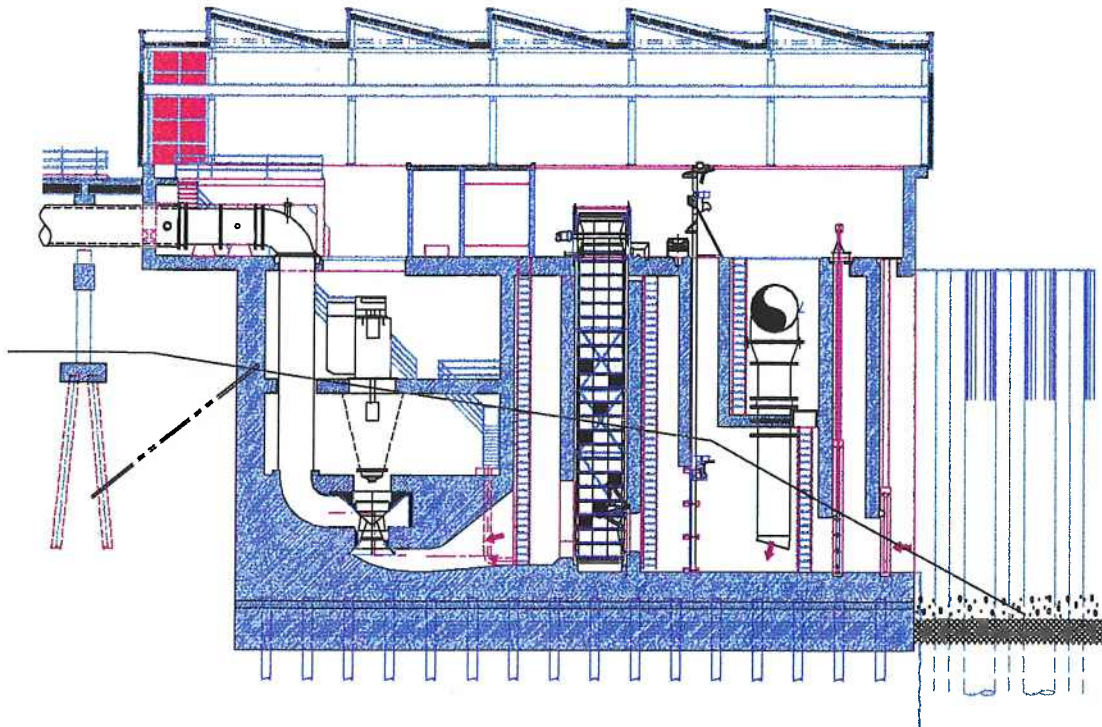


Figure 6 Section pump station

The pump station is located at the outer side of the Zeedijk [the actual sea defense] in the slope running from a relatively flat berm at NAP + 2.00 m to the bottom of the channel.

The tidal variations are relatively high in this area:

- Extreme High Water [1 : 50 year] NAP + 4.80 m
- Mean High Water NAP + 1.50 m
- Mean Low Water NAP - 1.50 m
- Extreme Low Water [1 : 50 year] NAP - 3.00 m.

The design High Water Level during the construction phase has been set at NAP + 4.00 m.

Note: NAP = reference level [Nieuw Amsterdams Peil].

The basic construction method used for the Delesto 2 pump station is quite common in The Netherlands; a building pit is formed by braced sheet piling at the sides and an under water concrete floor with tension piles, to resist upward water pressures, at the bottom; subsequently the structure is built in the dry in this pit, after which the sheet piling can [partly] be removed.

The difficulty in a land-water transition area as in this case is how to construct the building pit, because access both from land and water is difficult. The solution selected for this project was to install a temporary bridge from the dike area above the slope towards the channel. This bridge was supported by temporarily extended steel tension piles. From this bridge all parts of the building pit could be installed. This method proved to be reliable and effective.

In more detail the construction phasing can be described as follows [figure 7]

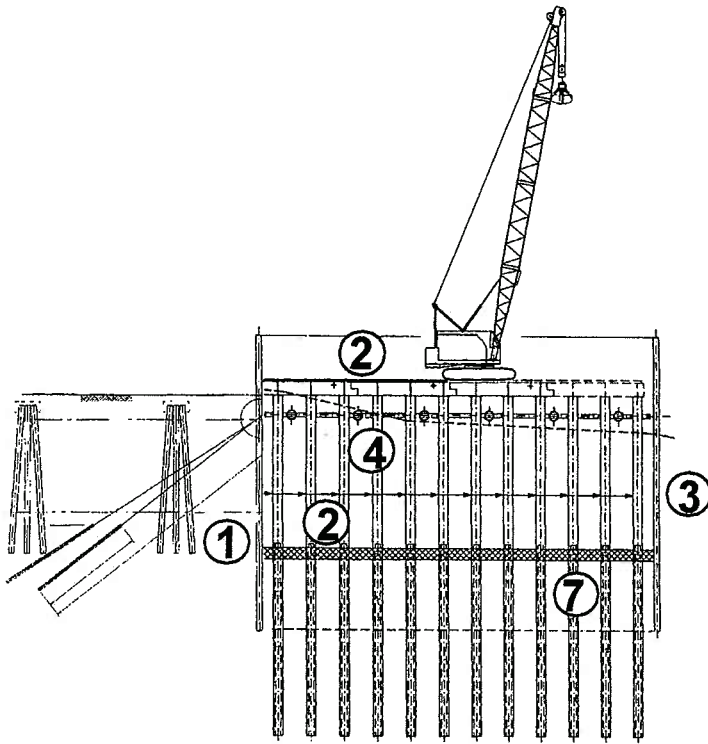


Figure 7 Construction method building pit

1. installation of sheet piling and grout anchors at land side
2. driving of extended steel tension piles for temporary bridge/installation of bridge
3. driving sheet pile walls
4. installation of bracings and struts
5. wet excavation
6. driving of rest of tension piles, using an underwater hammer
7. pouring underwater concrete
8. breakdown temporary bridge/cut off extended piles/filling of these piles with concrete plugs
9. dewatering of building pit after sufficient hardening of underwater floor and plugs.

Above constructed sequence is further illustrated in figures 8 to 10.



Figure 8 Pile driving from temporary bridge



Figure 9 Design condition for cofferdam



Figure 10 Construction works pump station

5.2 Outfall structure

Originally a weir type outfall structure was designed by Haskoning for the Delesto powerplant, as shown in figure 11. The main characteristic of this outfall structure was the weir level at + 1.0 m NAP. This level was required to have sufficient back pressure in the pipeline. However, to reduce the flow resistance, the weir had been smoothed by adding non structural concrete filling. Because of the total weight of the outfall structure it had to be founded on concrete piles. As the area of the Wadden sea at which the outfall is located is dry at low tide, a quite large scour protection was provided to keep the expected scour hole at some distance from the concrete structure. To prevent undermining also a sheet pile wall was provided all around the concrete structure. To reduce the flow velocity of the outflowing water when reaching the scour protection a spillway with concrete blocks for flow resistance was provided. The original outfall design did also have sliding doors to be able to close the pipeline from the sea at the outfall location.

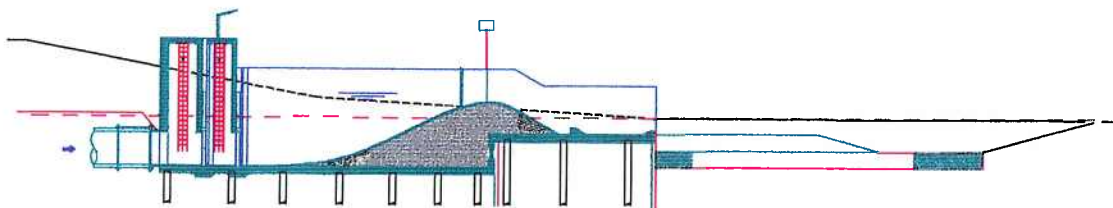


Figure 11 Basic design outfall structure

As the main design requirements were a weir level of + 1.0 m NAP and a low flow resistance at 30500 m³ /hr there was a possibility to design an alternative type of outfall. The idea for the alternative was based on other outfalls, as designed for INTERBETON projects, such as at Melaka. However, the main difference is that the outfall at Delesto would be in the dry at low tide while all earlier designed outfalls of that type were always submerged. The alternative outfall layout is shown in figure 12. The outfall basically consists of a round concrete box which is fitted on top of the pipeline elbow. The floor of the box is located at + 1.0 m NAP, thereby providing the weir level. The box is open all around, and has a cover supported by four radial walls. Therefore the flow resistance is limited. At low tide the water which comes out of the pipeline decelerates vertically due to the influence of gravity, and flows out of the box horizontally, equally distributed over the circumference of the outflow box.

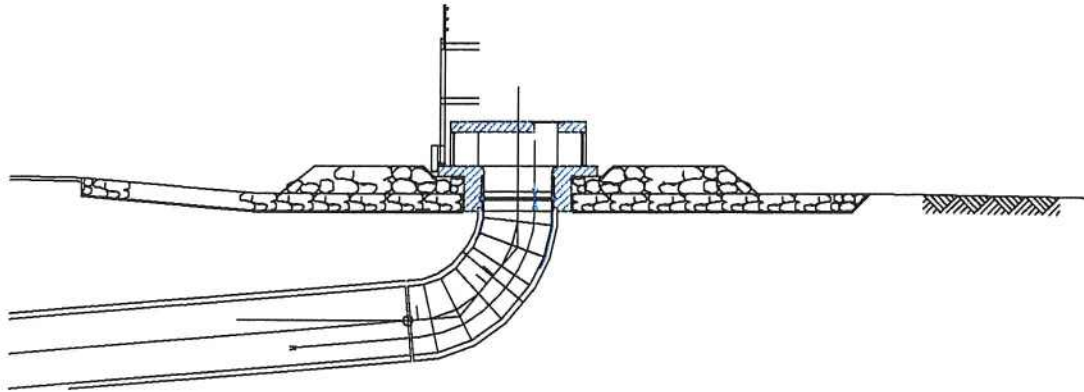


Figure 12 Alternative design

To ensure the geotechnical stability of the outfall structure and pipeline a flexible scour protection has been designed. The scour protection consists of 10-60 kg and 60-300 kg rock on a geotextile equipped with 'wiepen' [bundles of brushwood]. The weight of the rock is mainly determined by extreme wave action during storm surges. For the outflowing water itself 15 kg rock would be sufficient. This scour protection keeps the scour holes, which occur to the dry seabed at low tide, at a safe distance from the structure. Due to the flexibility of the scour protection it is able to follow the upstream slope of the scour holes. The depth of the possible scour holes is limited due to the presence of a stiff clay layer at two meters below the seabed of fine silty sand.

The outfall structures has been built in-situ in a building pit constructed by sheetpiles, which also served as end station for the drilled pipeline.

The outfall structure itself has been in use for a few months now [figure 13] and indeed scour holes have developed. The scour protection has followed the upstream slopes of these scour holes, as expected.

From the figures it can be seen that the alternative outfall structure is much lighter than the original design as provided by the Client. No pile foundation is needed, and the quantity of concrete has been reduced drastically. Instead of the sliding doors, a circular steel/plastic wall has been provided which can be placed over the outfall box to close the opening for maintenance purposes. The alternative has not only reduced the capital costs of the outfall structure, but also the future construction maintenance costs.



Figure 13 Outfall structure in operation

6. Conclusion

The cooling water system for the Delesto-2 co-generation plant was delivered to AKZO Nobel in early 1998. It has been tested thoroughly meanwhile; alternatives and special construction techniques designed and constructed by HBW proved successful.