



WATER
TREATMENT
PLANTS
FOR A
SUSTAINABLE
INDUSTRY

DANIELI ENVIRONMENT & SYSTEMS



- 2 Water treatment plant solutions
- 6 Customized design to meet client's requirements
- 10 Technology advances made by Danieli
 - _ DANfilters: high-filtering-rate and deep-filtration sand filters
 - _ ZLD: Zero Liquid Discharge
 - _ Give Water a Second Life
 - _ ZSP™: Zero Scale Pit
- 20 Energy/Water saving
- 24 Design criteria for metallurgical applications
- 26 Control and automation systems
- 30 Commissioning, training and water management
- 34 Case study installations



Water treatment plant solutions

Targets

- Steel industry;
- Oil and gas fields;
- Chemical and petrochemical plants;
- Thermal or combined cycle power plants;
- Food industry;
- Paper mills;
- Chemical and fertilizer industries.

Today, industrial operations have a greater concern about the environmental impact of their processes, and saving water means saving money as well. Laws and regulations are pushing industrial companies to recycle water, reducing the discharge and make-up amounts usually prepared using river or well water. Using the correct water quality will improve the final product quality too, with fewer impurities, while the equipment life will be extended and the cost of maintenance will be reduced. Another consideration is that each kind of industry needs different water quality for its production. Breweries need decarbonated water, while other drinks processors use demineralized water. Demineralized water for boilers must follow stated norms that depend on the working pressure of the steam boiler itself.

This means a different technology must be applied to achieve the customers' requirements. Condensate treatment is another interesting application, for power stations, and a very important one from the point of view of water savings.

Care has to be shown to the cooling-circuit water in order to avoid corrosion, but also to reduce water usage for make-up. Paper manufacturers need clean, uncolored water for their pulp preparation, to reduce waste in production. Each water quality can be prepared from different water sources, and with discharging that respect local norms and regulations. Following these considerations

industrial companies need a reliable partner to develop together the best solution for their site. Thanks to its expertise in design and engineering, Danieli Plant Engineering, in combination with other divisions of Danieli Group, performs exceptionally well worldwide as a supplier of water treatment systems for:

- Steel manufacturing;
- Oil and gas processing;
- Chemical and petrochemical plants;
- Power plants;
- Food and beverage industry;
- Pulp and paper mills;
- Chemical and fertilizer industries.

Danieli accompanies its customers from the very beginning of a project through to the final realization. Danieli is not a "hardware" supplier, but a technology partner, supporting its customers with:

- Concept and feasibility studies;
- Engineering and process design;
- Hazard and operability studies;
- Procurement of equipment and materials;
- Supply of proprietary equipment packages;
- Supply of complete plants and turnkey solutions;
- Plant commissioning and operator training;
- Technical service and support;
- Spare parts and service.



- 1 Wastewater-treatment system for a petrochemical plant in North Africa.
- 2 Activated sludge basins of a biological system for producing make-up water from municipal wastewater.
- 3 Ion-exchange resins system to produce demineralized water for a power generation plant.
- 4 Reaction and settling tanks of a wastewater-treatment plant installed in a closed bay, in Northern Europe.



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Our tools for designing Water Treatment Plants

With specific application requirements, Danieli Plant Engineering uses advanced software tools and instruments for maximum design quality to meet customer requirements. These tools, mainly, are:

- Aspen software for process optimization;
- Heat and material balance calculation;
- Equipment selection;
- 3D piping design;
- Calculation of conditioning agents;
- Line pressure drop calculation;
- Structural analysis;
- Thermal analysis;
- Seismic analysis.

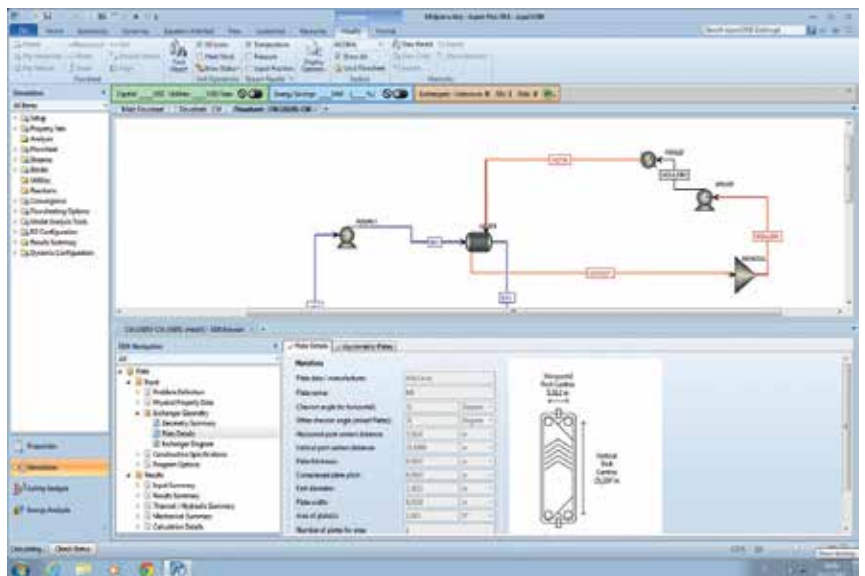
The Danieli Research Center, equipped with a chemical laboratory for water analysis, is where the development and optimization of components and equipment are carried out, also using scale models and prototypes.

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Danieli cares about safety. All Danieli plants are in compliance with the European Community CE mark and all the safety requirements are on rule as standard configuration offered by Danieli. More restrictive safety regulations can be easily implemented to conform with the local laws and regulations, or as per the client's requirements.

- 1 Kickoff meeting for a water-treatment project at Danieli HQ.
- 2-3 Danieli Water Treatment design department developing 3D drawings for piping and equipment layout.
- 4 Example of pressure loss calculation for a plate heat exchanger with Aspen software.



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Customized design to meet clients' requirements

Targets

- Process Hazard Analysis to prevent any safety issues;
- Process/equipment fulfills the most recent worldwide BAT - Best Available Technology prescriptions;
- All equipment is chosen in order to avoid wasting power and water.



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Danieli Water Treatment Dept. is effectively specialized in the treatment of water: primary and waste, civil and industrial, fresh or recycled. Thanks to its vast and multi-field technical experience gained during more than 50 years of activity, and continuous and interdisciplinary research and development work, Danieli maintains extensive know-how, offering innovative process technology solutions to its customers. Danieli's designs are oriented to meet customers' requirements with customized plants and equipment to fulfill specific needs. Special attention is focused on:

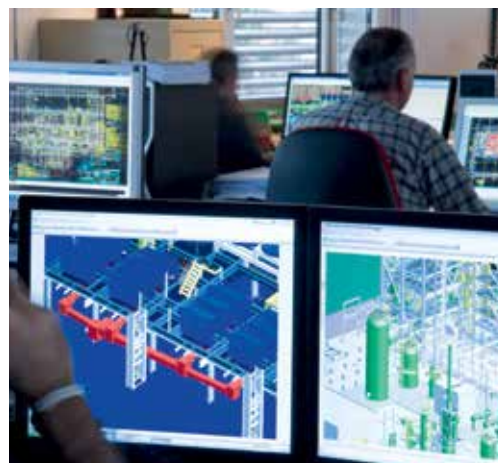
- Process Hazard Analysis to prevent any safety issues.
- Process/equipment to fulfill the most recent worldwide BAT (Best Available Technology) prescriptions.
- Equipment selection to avoid wasting power and water.

This guarantees the best optimization and effectiveness of the process in any condition, and reduces installation costs (CapEx) and management/maintenance costs (OpEx).

As standard, the water treatment plants are designed, built and ready for commissioning within one year from the date of the contract coming to force, thanks to plant engineering and development using the most sophisticated 3D-CAD drawings and modelling systems, and pre-assembled supplies (such as packaged cooling towers, skid-mounted equipment, modular pipe works, etc.) minimizing on-site installation costs and the overall footprint of the plant.



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- 1 Overview of a water treatment plant for a steel mill in Eastern Europe.
- 2 Danieli field-service technician explains to a customer the solutions developed for the erection activities..
- 3 Danieli Water Treatment technical department using advanced engineering tools.
- 4 Pump room of a cooling-water treatment circuit for a steel making plant.



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Danieli Engineering is selected by customers with orders to supply water treatment plants because of its consistent ability to deliver the best technical and economical proposal; this result is backed by smart solutions (i.e., Zero Liquid Discharge, Zero Scale Pit, patented DANfilters, etc.) and by the world's most extensive reference list for plant installations.

Danieli water treatment plants grant the maximum optimization with a relevant reduction of the overall footprint.

In fact, the use of the 3D design layout intelligently minimizes the housing space for complex units where a number of different sections and components have to be connected.

Danieli water-treatment plant solutions and installations abide by prevailing local regulations. (For example: ASME, GOST, BS, EN, BIS, CPCB, GB-150, CSA, UL, FM, AISC, AWWA, API).



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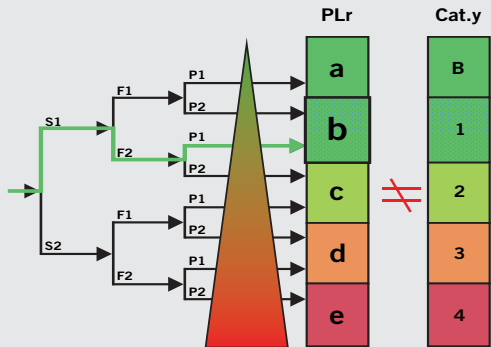
- 1 Patented DANfilters, featuring high filtration rates and deep filtration, installed for a contact circuit of a steel mill in Eastern Europe.
- 2 Water treatment system for a steelmaking plant

using EAF closed circuits with "air cooled" technology (Zero Water Evaporation), located in Middle East.

- 3 Field erected cooling towers.
- 4 Plant risk analysis.



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A typical Job Safety Concept (JSC) made by Danieli for each unit of equipment installed in a water treatment plant. JSC is one of the risk-assessment tools used to identify and control

workplace hazards. A JSC is a second-tier risk assessment with the aim of preventing injury to a person, or their colleagues and any other person passing or working adjacent.

RISK ESTIMATION

Category value (EN954-1)	Performance Level (PL)	Average probability of dangerous failure per hour 1/h		Safety Integrity Level (SIL) as per EN 62061
B	a	$\geq 10^{-5}$	to $< 10^{-4}$	n.a.
1	b	$\geq 3 \times 10^{-6}$	to $< 10^{-5}$	1
2	c	$\geq 10^{-6}$	to $< 3 \times 10^{-6}$	1
3	d	$\geq 10^{-7}$	to $< 10^{-6}$	2
4	e	$\geq 10^{-8}$	to $< 10^{-7}$	3

NOTE: besides the average probability of dangerous failure per hour other measures are also necessary to archive the PL;

Severity of Injury	S	S1	Slight injury (normally reversible)
		S2	Serious (normally irreversible injury, including death)
Frequency and/or exposure time to Hazard	F	F1	Rarely to more often or short exposure duration
		F2	Frequent to continuously exposed duration to the hazard
Possibility of avoiding Hazard	P	P1	Realistic chance of avoiding all accident or
		P2	Almost no chance to avoid the hazard

4

Technology advances made by Danieli

Targets

Danieli is always improving the applied technologies in its plant designs. The latest examples are:

- **DANfilters: high-filtering-rate and deep-filtration sand filters;**
- **ZLD-Zero Liquid Discharge;**
- **Give Water second life;**
- **ZSP-Zero Scale Pit for steel industry.**



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DANfilters: high-filtering-rate and deep-filtration sand filters

DANfilter (patented) is the result of the Danieli commitment to develop an improved sand filtering system.

This proven technology, previously tested in a pilot plant to confirm its effectiveness, has been installed already in several plants, confirming optimal performances.

The Danieli special filter sets new limits in filtration rates and optimizes filtering efficiency: optimal water quality at low investment cost. Danieli know-how can properly design customized filters with filtration rates up to $60 \text{ m}^3/\text{m}^2\text{h}$, maintaining final water quality with less than 10 ppm of suspended solids.

It is possible to design filters with long filtration times and high specific solid loads.

Therefore, Danieli know-how can optimize all process requests, always minimizing investment and running costs, saving space in the layout design.

These are the particular characteristics of the DANfilters:

- Monolayer type;
- High-rate filtering;
- Certified selection of sand granularity;
- Very deep filtering bed, with increased working time;
- Very accurate distribution of the backwashing air, avoiding formation of conglomerate balloons;
- Final co-current washing before to put into operation.

The invention (No. PCT/EP2007/061336 - No. WO 2008/049833) is essentially dedicated to uphold construction parameters, as well as the conditions for high-rate filtration and relevant backwashing design.

ZLD – Zero Liquid Discharge

In recent decades, the focus on the water cycle has been limited to ensuring quality suitable to its use in industrial processes, assuming unlimited availability of primary waters and at low cost. So, due to the above approach to the cycle of water, every year several hundred tons of chemical residues dissolved in the treated wastewaters are discharged in the rivers and in the sea.

In reality the availability of water resources is linked to the control of two key factors:

- Consumption must not reach values higher than the resource reconstitution;
- Deterioration may not exceed the capacity of self-healing of the resource.

As a consequence, not only ethical and environmental considerations, but also economic targets, require a critical review of current water uses, adopting where possible, the technologies that involve “zero liquid discharge”, or that minimize the discharge of wastewater.

Danieli achieves optimal management of the water cycle by implementing the reduction/zeroing of the primary water needs through the reuse of treated wastewater.

Depending on the economic return and/or lack of availability of primary water, we can perform the recovery of 60 - 90% of wastewater, or carry out the total wastewater reuse with “Zero Liquid Discharge”.

In the first case, the technologies used must allow the discharge of small quantities of treated effluent with characteristics in accord with the “emission limits of discharges into surface water or public sewer systems”; in the second case (“Zero Liquid Discharge”), the result waste consists only of solids. At a superficial analysis, to obtain a lower consumption of water, less pollution and a lower

cost of management seems to be a dream. Instead, in many cases, we can prove that the rational and smart application of available innovative technologies can achieve these goals simultaneously.

In order that the industrial development and environmental protection may grow in a correct way at the same time, it is important first to optimize the industrial production processes. To do this, the objectives can be summarized as follows:

- Maximum efficiency of industrial production processes;
- High-quality raw materials used to prevent the transferring of the pollutants from the production process to waste;
- Streamlining production processes to reduce duplication, complications and waste of energy;
- Raw materials at low salt content to reduce or eliminate the increasing of saline wastewater;
- Minimizing water demand in manufacturing processes;
- Minimizing of energy consumption.

Regarding the reduction of water demand, it is important to critically review the various water treatment processes in order to adopt technologies that integrate production processes with solutions that minimize the water requirements, or reduce water-discharge volumes to zero.



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- 1 3.8-m-dia. DANfilter battery treating 4,000 m³/h of direct cooling circuits for a 1.0-Mtpy minimill for long products in Southeast Asia.
- 2 Ultrafiltration plant for sea water treatment.
- 3 3.8-m-dia. DANfilter battery for the treatment of contact circuit in a rolling mill, up to 600 m³/h capacity for each filter.
- 4 Reverse-osmosis desalination section to recover 60 m³/h of blowdown, at a ZLD project in North Africa (NPSS).

In most cases it is sufficient to use and integrate appropriate technologies already established in many applications. For example:

— Softening: this is a cold and hot chemical process with the addition of lime and soda. It may look obsolete, but is to be reassessed as it allows the reduction of the hardness and alkalinity, coupled with the reduction of salinity, silica, organics and turbidity. It excludes or replaces ion-exchange softening in sodium cycle, which raises saline levels in the regeneration wastewater.

— Reverse osmosis: this is a physical process that by the use of appropriate membranes leads to recovery of specific salts, reuse of salty water and production of water with low salinity. In demineralized water production systems it is preferable to ion exchange processes, which cause high salt increases in the regeneration wastewater.

— Evaporation: the concentration/crystallization systems by evaporation, used as the final stage in the process of waste treatment. This system allows recovery of the brine resulting from reverse osmosis. This solution allows for the further recovery of wastewater and obtains crystallized salts.

Recently, Danieli has realized many successful installations that achieve the ZLD target. Whereas in each cooling tower system there is the necessity to discharge water as blow-down, so as to maintain the proper concentration factor and relevant water quality, the total blow-down water is treated in the supplied ZLD plant.

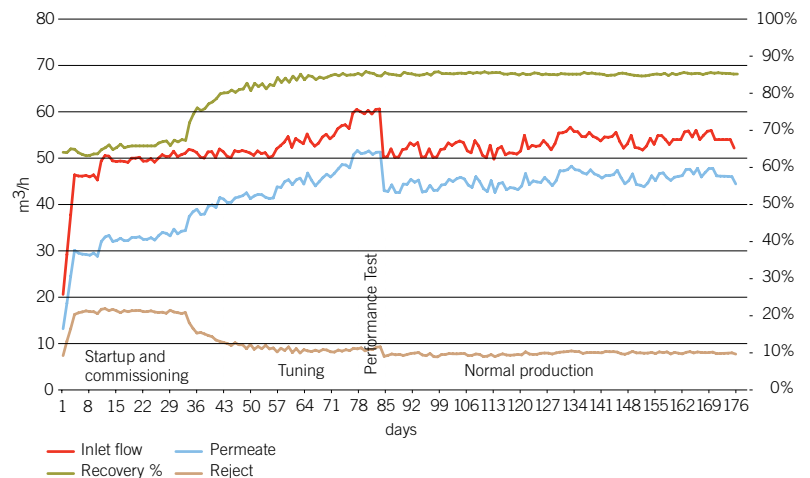
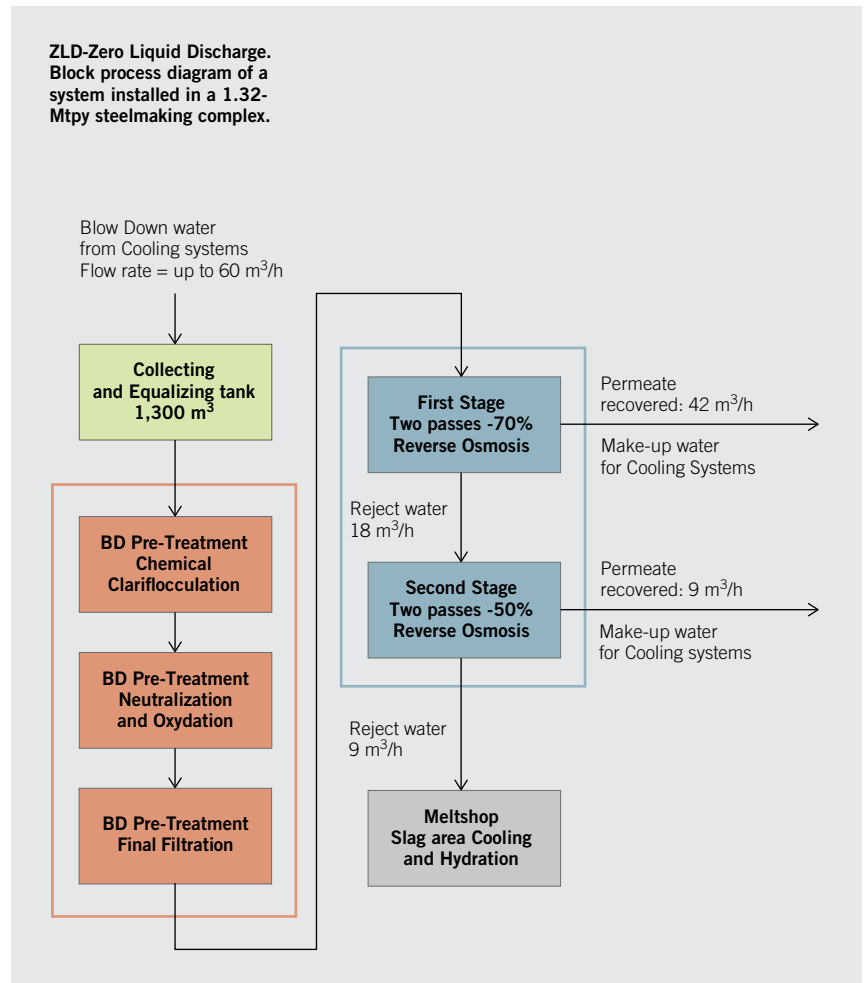
A typical block process diagram shows that, after a collecting and equalizing phase, the water is sent to pre-treatment, consisting of clari-flocculation with suitable chemicals, followed by neutralization and oxidation, and a final filtration.

The pre-treated water is sent to the osmosis phase, consisting in a First RO Pass with two stages, equipped with low fouling membranes, for a total permeate recovery of 70%, and a Second RO Pass with two stages, equipped with the same type of membranes, for a further recovery of 50%.

The remaining 15% of concentrate reject is sent as make-up to the spray circulation system provided for the slag area for its cooling and hydrating. Therefore, the entire quantity of water supplied to the plant is used in internal systems, and no liquid discharge outside is required. Zero Liquid Discharge (ZLD) is reached.

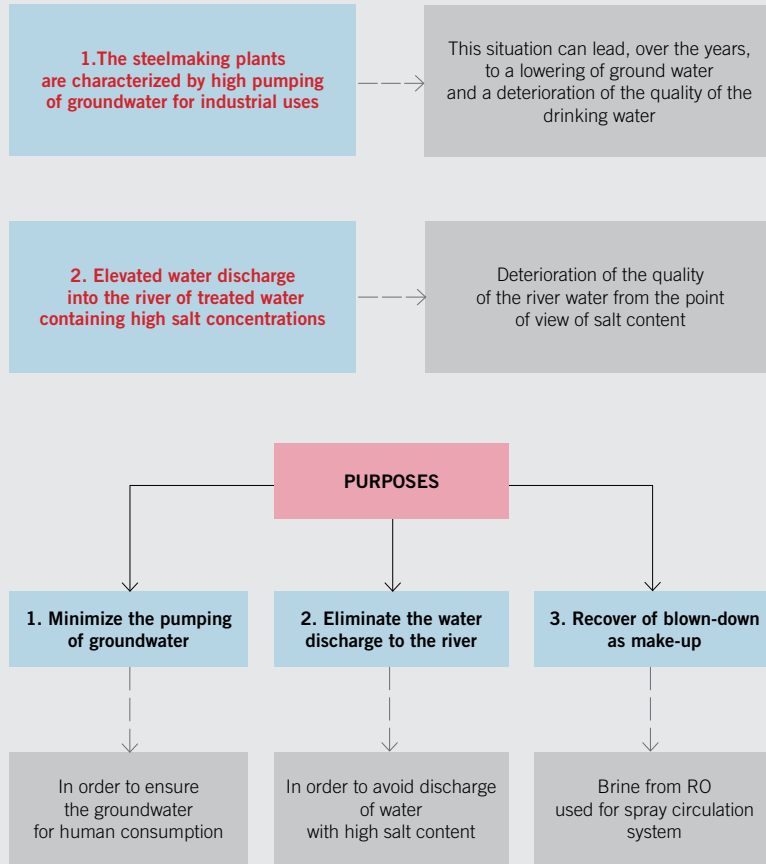
Looking at the working parameters of the same ZLD plant from the startup to three months of normal operation, it can be seen that the plant achieved stable and reliable performances, and the total quantity of water is always less than the required quantity by the slag cooling/hydrating process.

ZLD-Zero Liquid Discharge.
Block process diagram of a
system installed in a 1.32-
Mtpy steelmaking complex.



ZLD plant working parameters from the startup up to three months of normal operation. It can be seen that the plant reached stable and reliable performances.

Problem definition and purposes of the ZLD project



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Main highlights of the ZLD plants

The first and more evident advantage of this kind of plant is its “environmentally friendliness”. It uses the most recent BAT-Best Available Technology in the steel industry, and drives the customer to achieve further advantages:

- OpEx savings. The recovered water is used to blend the make-up, thus increasing the quality of the cooling water and reaching a consistent saving in the relevant costs.
- A consequence of this is the possibility to get very profitable rates in financing.

- 1 Danieli specialist supervising the startup of a ZLD plant.
- 2 Application of an Under Vacuum Evaporation system as the final stage to achieve ZLD target, at a 250-Ktpy Cold Strip Mill complex, located in Middle East.

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Case study:
Zero Liquid Discharge Technology for the
500-Ktpy Cold Mill Complex at Toshkent
Metallurgiya Zavodi (TMZ).

The order for new water-treatment plant will complete the cold mill complex for TMZ and Metprom in Tashkent, Uzbekistan.

The new Water-Treatment Plant will incorporate the most advanced Zero Liquid Discharge (ZLD) technology in order to reduce the environmental footprint and improve sustainability.

The new plant will be designed to purify and recycle all the polluted cold complex wastewaters using an advanced treatment method that includes:

— **Fenton Oxidation:** dosing hydrogen peroxide and ferrous sulphate to obtain radical oxygen able to oxidize the organic content, converting it to inorganic salts, water and carbon dioxide.

The radical oxygen is the most effective oxidant agent to attack and destroy the large organic molecules of color and surfactants.

— **Ultrafiltration and Reverse Osmosis:** the use of membrane technologies must be designed accurately, estimating the necessary pre-treatment for membrane protection and the most efficient washing system, obtaining the maximum recovery rate.

— **Evaporation and Crystallization:** water evaporation will be done under vacuum conditions.

The concentrate solution is fed into the evaporator and passes across a heat source. The applied heat converts the water in the solution into vapor.

The vapor is removed from the rest of the solution and is condensed while the now-concentrated solution is fed into a second evaporator, and so on.

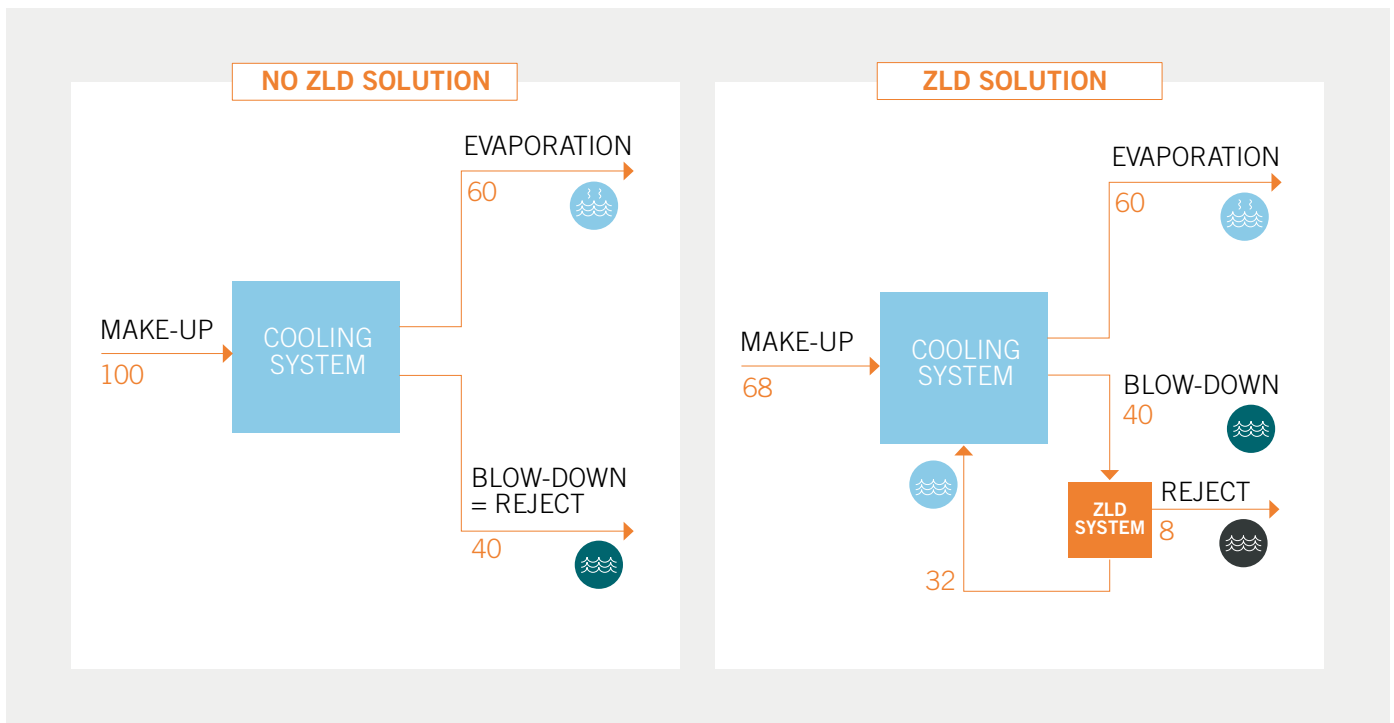
The multistage evaporator consists of three or four sections, minimizing the steam consumption.

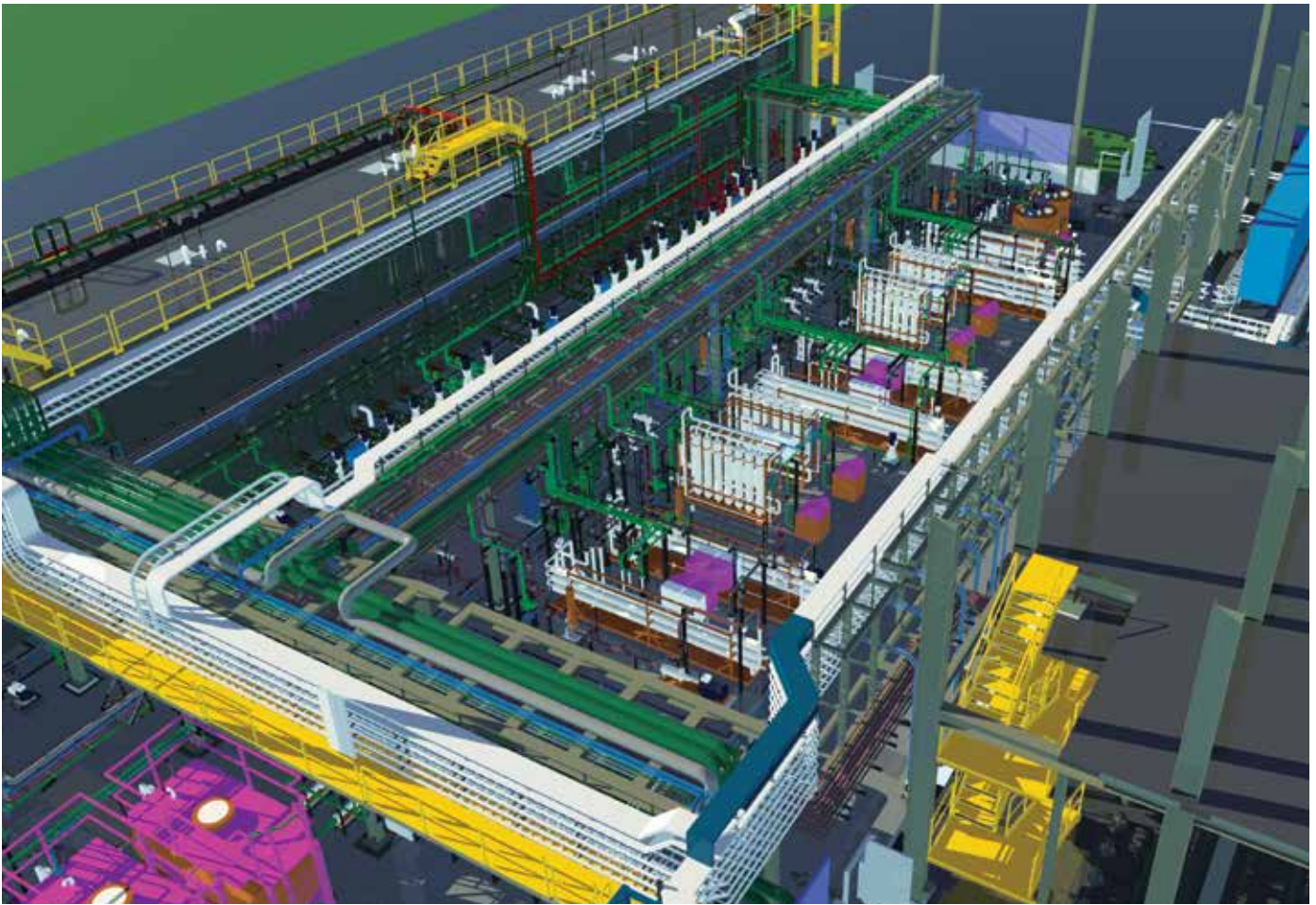
The condensate vapor is recovered and blended with the permeates from RO.

The concentrate solution from the last evaporator stage is delivered to the crystallization unit where, at the end of the process, a sludge of a very low moisture content is obtained.

All the water will be fully reused within the process, as industrial water for the cold complex production and demineralized water for process and steam boilers. Thanks to Danieli technology, TMZ will save about 320,000 m³/year of fresh water with a consistent reduction in plant OpEx, and without any liquid discharge to the external environment, as the plant is designed to treat as well the internal liquid waste generated by the process itself.

Below, cooling circuit with and without ZLD technology. By using ZLD, make-up decrease by 30%.





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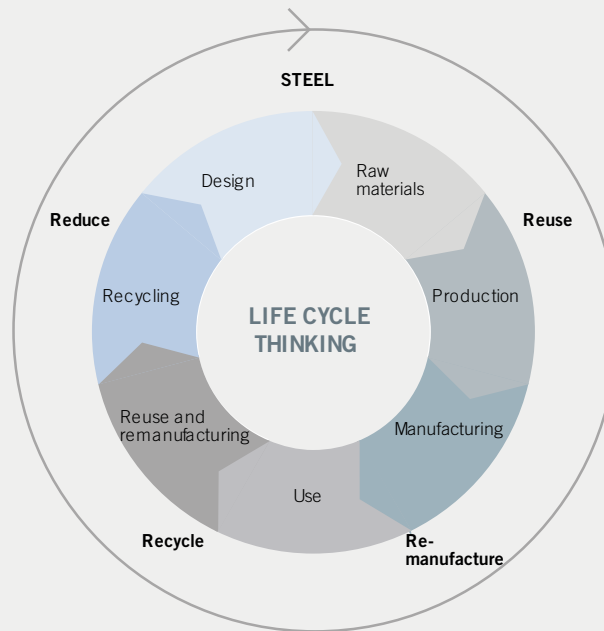
1 3D design of the new ZLD Water Treatment Plant for the Toshkent Metallurgiya Zavodi cold mill complex.

2 Cold Mill Complex Waste Water Treatment Chrome reduction: oil separation, fenton reaction, clarification and flocculation.

3 Demi and Industrial Water: Ultra filtration Reverse Osmosis.

4 Pumping station for cooled water distribution.

> Give Water Second Life



Water and Circular Economy in Steel Industry

In the last few years a new appreciation of the natural resources has been adopted by the industrial sector. Things that had been supposed to be unlimited, renewable and available at low cost - as water is today - now are considered to have a value to be preserved.

A critical review of current uses of water on ethical, environmental and economic bases must be made in order to be a step ahead toward sustainability requirements. This way of thinking drives the initiative to apply technologies that aim for Zero Liquid Discharge. Nowadays, the available technology for water treatment allows us to fully recover the process water and to reuse it, thus reducing fresh-water consumption.

An alternative source of water

In an urban setting it's possible to convey the sewage wastewaters to the industrial area, to be treated and reused for production.

The sewage transfer infrastructure is more sustainable than transferring the city tap waters directly for industrial purpose.

Common benefits

There may be economic benefits for the municipalities selling waters, creating additional revenues. Reusing treated water instead of discharges will

eliminated environmental monitoring of effluent quality. The industrial production gets stable quantity and quality water from the most stable source to ensure stable long-term industrial production. The fresh water made available can be provided for primary human usages. In some countries reuse water is regarded as green solution and it's encouraged by preferential interest rates in financing.

Danieli promotes and realizes commercial partnerships considering the wide experiences as EPC contractor for large investments in the steel industries, strong relationships with the local government, stakeholders, decision makers and lenders, as well as the technological expertise that covers all the water reuse issues.

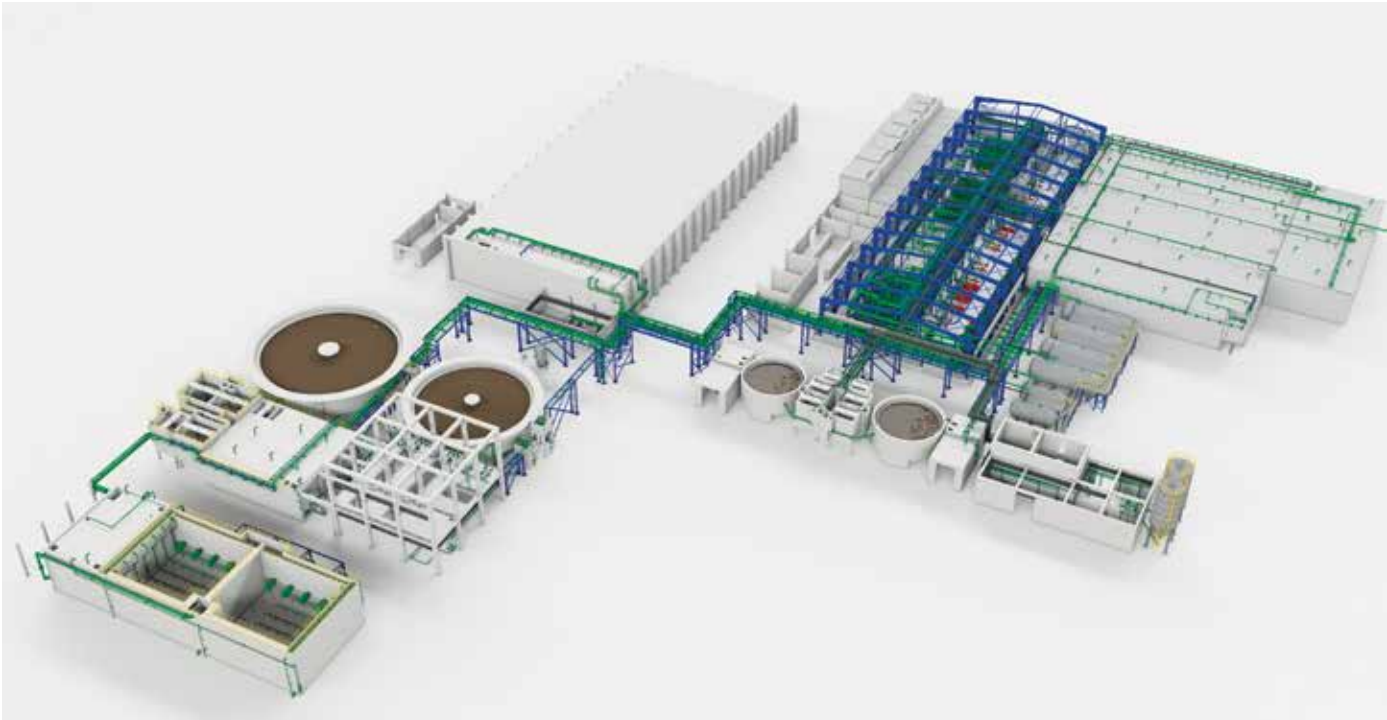
The main target is to reuse civil sewage discharge for industrial water production.

Case History

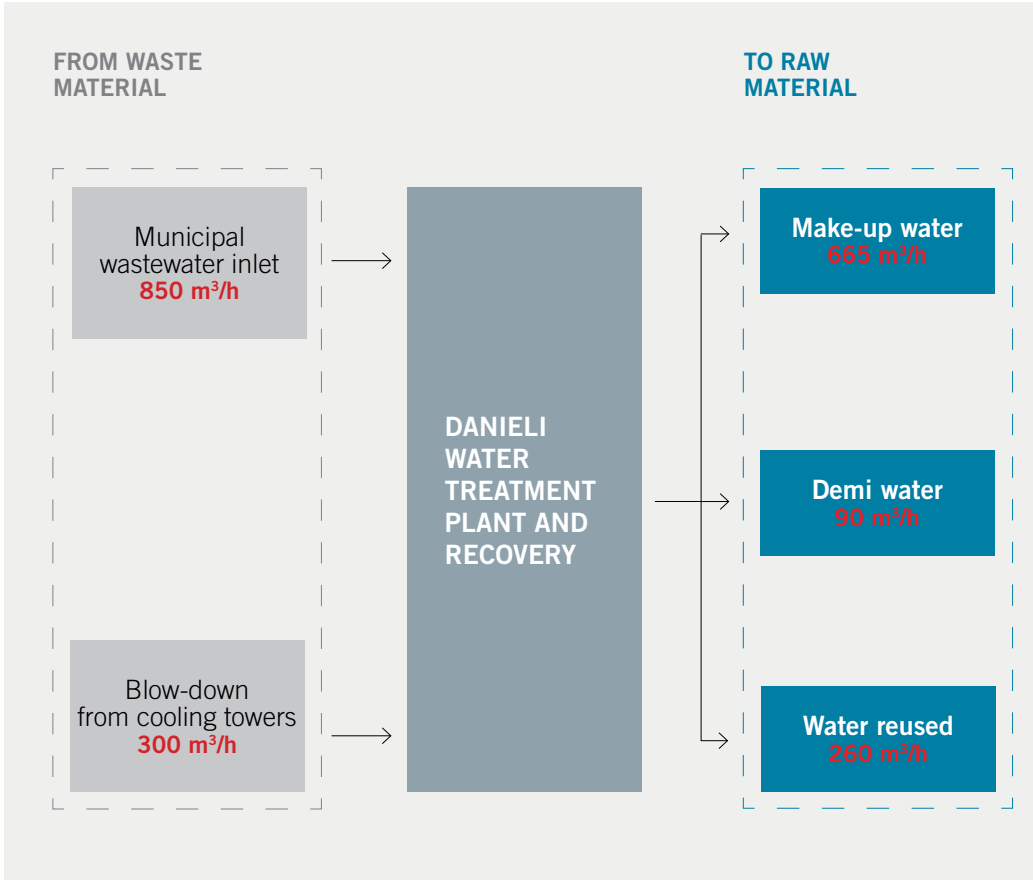
The industrial area described is a semi-arid zone located 300 km far from the sea, where the local water resources are totally absent, neither from rivers, lakes, nor from the ground.

The direct outtake from the city water network was considered to detrimental and too expensive. Sewage collected from the city represented the only water source for steel production.

The make-up water required for steel production is about 650 m³/h (with peak about 870 m³/h), where the users are a power plant, an iron ore pelletizing plant, a steel melting shop and a direct reduction plant.



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1 Overall view of the plant.
2 Block scheme of the plant indicating the main sections capacity.

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Danieli ZSP™ - Zero Scale Pit

Danieli has improved the common standard approach to contact cooling systems for conticasters and rolling mills, in order to reach the same good results in water cleaning, but allowing significant CapEx saving in the overall application.

This new Danieli know-how is based on a proper partition of the overall rolling mill discharge. The first part collects the water discharged from the descaler and the first roughing stands, and contains most of the released scale (the larger and heaviest parts). The second part of flushing collects most of the overall water, containing little quantity of very fine scale, which is not a problem for pumps and relevant delivery pipes. Based on above situation, the Danieli solution is to use, in the collection of the first part, a specially designed equipment (DAN-DREDGE™) that allows quick sedimentation of the larger, heavier and more dangerous scale particles, and their continuous extraction, drainage and discharging into a proper skip or directly into a dedicated truck. Then, the overflow water, now devoid of the dangerous scale, is pumped to the water treatment plant for its final cleaning in a longitudinal clarifier, where medium-sized particles are removed by sedimentation and oil and grease are removed by an oil skimmer. The second part of the rolling mill flushing is collected separately in a small circular pit, especially designed to avoid any matter deposit, from where submersible pumps provide the

delivery to the same water treatment plant final cleaning. The conticaster spray system has almost the same characteristics of the above-mentioned first part of water from the rolling mill. Indeed, the scale is even heavier.

Therefore, the solution is quite similar: the equipment is the same, but, as the water has a better quality and is almost free of oil, it is sent directly to the clarifier overflow collecting pit for its final filtration.

- 1 **DAN-DREDGE™** scraper conveyor installed for a 1-Mtpy rolling mill in Central America.
- 2 **DAN-DREDGE™** in operation, Mexico.

DAN-DREDGE™ is the core equipment of the ZSP design philosophy.



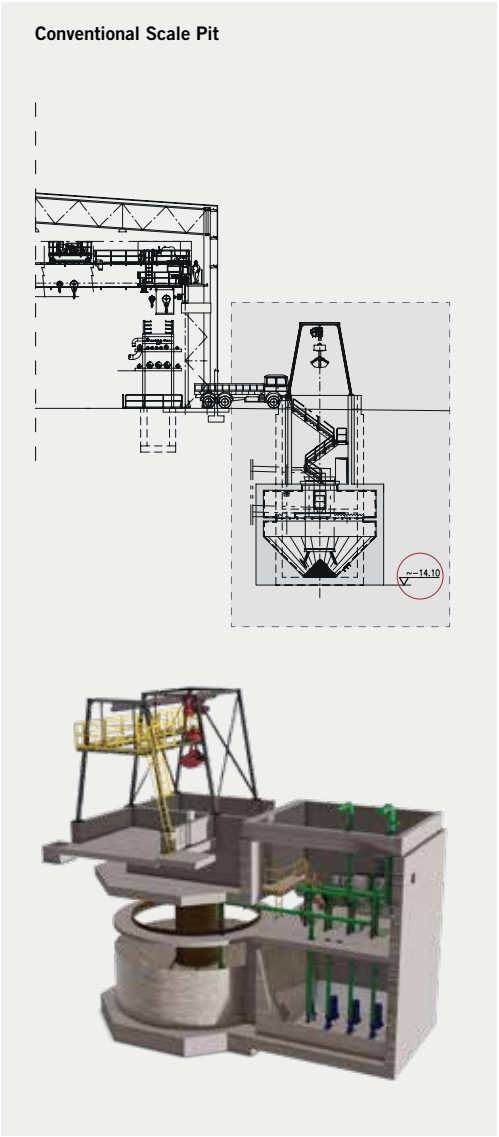
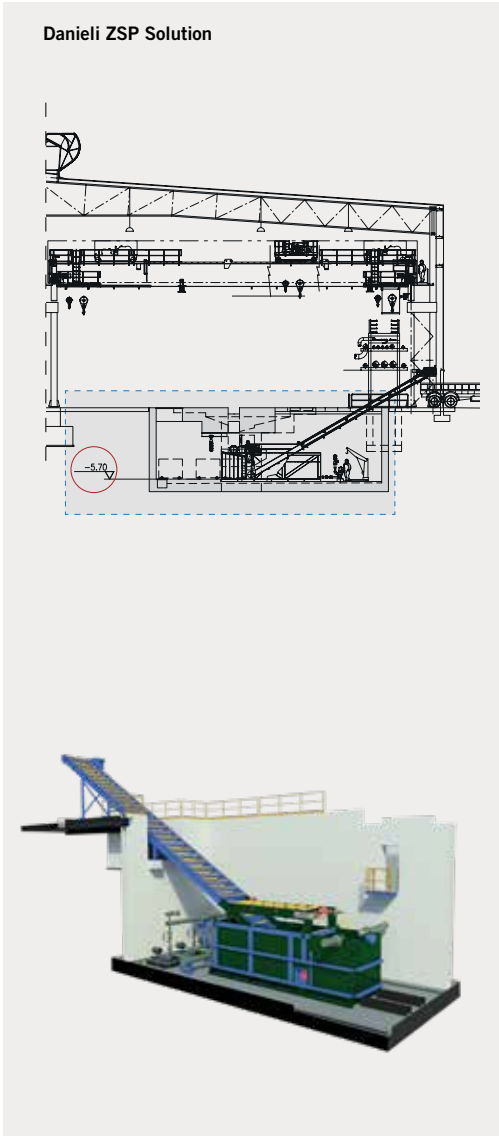
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Comparison of the ZSP™ solution versus conventional scale pit system.

Danieli ZSP solution	Conventional scale pit system
Water coming from the direct cooling of rolling mill line is separated as different fluxes: flux containing large/heavy scale are sent to scraper conveyor packages while flux containing only small/light scale is collected in a separate pit and pumped directly to the longitudinal clarifier.	All water coming from the direct cooling of rolling mill line is sent to the scale pit to allow the large/ heavy scale separation.
The scraper conveyor packages and the pumping pit are located under/next to the rolling mill, consequently the excavation works are not so deep (-5 / -7 m).	The scale pit unit collecting all water from contact circuits is located outside the building, because of the depth required (-10 / -15 m).
The scale is removed continuously by the chain scrapers of the Dan-Dredge™.	The scale accumulated in the pit is removed periodically by an automated bucket.
Time required for the execution of civil works is limited (about one month).	Time required for the execution of civil works is considerable (about six months).

ZSP™-Zero Scale Pit cross section compared with the traditional one and related 3D sections of ZSP and conventional.

ZSP™ solution permits to reduce costs of civil works, to reduce execution time and to simplify access and maintenance.



Energy / Water saving

Targets

- Efficient wastewater treatment
- Customized chemical conditioning systems
- Tailor-made automation programs
- Special water treatment plant cooling system design
- High-efficiency equipment
- Power monitoring tools
- Water quality improvement and control
- Reuse of blow-down and flushing water
- Zero Liquid Discharge



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Savings can be reached by adopting improvements in all the aspects involved: design of machinery, materials and components, control and automation. Even if the individual modifications generally have a small impact, considering them as a whole, day-by-day they can show continuous improvement.

Power supply and system distribution

A proper electrical distribution system design drives energy savings. Reducing cable distances by properly locating electrical cabinets and distribution switchboards can reduce energy dissipated during distribution process. Furthermore, locally compensating the power factor will improve the efficiency of the distribution network, because with such a technical solution only active power will be transferred. Power monitoring tools and power demand control systems also can be adopted, especially when power availability is limited, in order to select preferred loads and to establish switch-off criteria for unused equipment. High-efficiency transformers and motors are selected in order to reduce electric power losses. Other energy saving methods include using of variable speed motors, to be adopted when loads are discontinuous and depending on the process sequences.

Water treatment and system design

Water is a fundamental requirement in the steel industry, mainly for cooling machinery and quenching the product, but it is also used in

the process, for instance in beneficiation of raw material from mines; as a transfer media for delivering the iron ore; or as solvent in the chemical processes of cold treatment of strips.

The cooling systems can be designed following different philosophies. In fact, the cooling process is commonly performed in evaporative cooling towers, because this is the easier, the most efficient and the less expensive way. This process also has the smaller power requirement. In order to save more energy, special automation programs provide modulation for the fan rotation, with start-stop or in continuous mode with an inverter, following the heat dissipation requirement of the system. Great care is taken with the cooling tower type and in its selection. The cooling water temperature is designed for the maximum temperature acceptable to the system, in order to avoid wasting power that is not strictly necessary to the process.

The long, wide experience of the Danieli Water Treatment Plants Department guarantees in the most effective process for any condition and lower costs for installation (CapEx) and management-maintenance (OpEx). In all the above uses, considerable quantities of water are lost, by evaporation (direct or for cooling purposes), by losses (drift or mechanical), and by contamination with products or substances that make it a waste stream. To provide savings in these applications, many routes can be followed, as explained in the following points.

Make-up water quality improvement

As the most common cooling process is performed with evaporative cooling towers, the circulating

media lose some water by evaporation. In this process the dissolved salts are continuously concentrated, and other fresh water (= make-up) is added. In order to avoid problems in machinery and piping, it is necessary to maintain a maximum value in the salt concentration (TDS - Total Dissolved Solids), and therefore it is essential to discharge part of the circulating water (= blow-down). The ratio between the TDS in blow down and TDS in makeup is called concentration factor. From these principles it is clear that the best quality has the starting available water as make-up, the higher concentration factor will be reached before water has the maximum permissible TDS. Danieli has long experience in recommending the best and most convenient treatment of available water, in order to conserve water volumes and to ensure the best cooling conditions without problems in the circuits. The processes that can be applied vary from a simple filtration, to sedimentation, to clari-flocculation; up to more sophisticated treatments, such as lime/soda softening, ion-exchange systems (softening, de-alkalization, demineralization), UF (ultrafiltration), RO (reverse osmosis), etc.

Increasing circulating-water quality control

As a corollary to the previous discussion, the mentioned philosophy acts as a guide to improve

water quality control. The circulating water quality continuously changes in its concentration by the succeeding evaporation, make-up and blow-down events. An effective water quality control makes it possible to reach and maintain the upper design limit of concentration factor, ensuring the integrity of machinery and piping.

But, not only automation is involved in this scope: chemical analysis control carries the same importance and is duly executed with frequency according to Danieli prescriptions.

Implementation of circulating water conditioning

Another approach for increasing the concentration factor of the circuits is to improve the efficiency of the chemical conditioning. If the scaling and/or aggressiveness effect of the circulating water is more efficient, it is possible to accept a higher value in the concentration factor. Consequently, the blow-down and make-up water quantities are lower, thus resulting in water savings. This principle must be implemented together with requirements listed to the above point; otherwise it can be ineffective and dangerous. Danieli helps customers to define the best conditioning program in accordance with the local chemical supplier, which will support the customer in the future production stages.



2

- 1 Pump room with high-efficiency motors installed in a 1.1-Mtpy steelmaking plant with 12,000 m³/h indirect cooling circuits and 1,500 m³/h direct cooling circuits in Eastern Europe.
- 2 Ultrafiltration pre-treatment section for 1,600 m³/h of seawater to produce high quality make-up water.
- 3 Reverse osmosis desalination section for a 1.4-Mtpy DRI-based minimill complex in the Middle East.



3

Reuse of blow-down

The blow-down must be discharged, but this does not mean that it is a pollutant discharge. On the contrary, it is simple circulating water, of the same quality involved in the process. Therefore, this water can be reused for other secondary purposes, such as slag quenching, fume cooling, pavement cleaning / rinsing, or irrigation.

Reuse of flushing water after a dedicated treatment

A further implementation of the previous point is represented by the recent Danieli establishment of a “Transferable Wastewater Treatment Plant”. This containerized unit, a Danieli property, is temporarily installed at sites where no waste treatment is available, and makes it possible to efficiently clean the resulting dirty wastewater from flushing and cleaning and passivation operations. Cleaned water is conveniently reused in other operation or for first filling of the circuits. This represents a profound commitment by Danieli to water savings and respect for the environment.

1



Recovery of blow-down

Another Danieli contribution is the “zero discharge system”. All blowdowns and wastewater discharged are chemically treated and then passed through reverse osmosis treatments until the non-recovered water is reduced to a value compatible with the slag quenching at the site. The small, final fraction of water, with its high TDS content, is then used and evaporated for that purpose. If we consider the external environment of the steelmaking facility, the effect is “zero discharge”, because all the withdrawn water is completely used “within” the system. No water is discharged outside.

Use of closed circuits with zero evaporation

In some few cases, for the indirect cooling circuits it is possible to use the “closed type” together with an “air-cooler” system. No water is evaporated, and water consumption is limited to the mechanical losses. A limitation to this solution is in the temperature of the cooled water, which cannot practically reach less than 10 °C above the ambient air temperature. Therefore, this solution is applicable in cold climates or for applications where hot water is acceptable for cooling purposes.

Danieli CHR®- Clean Heat Recovery

In the fume treatment plant gas and fumes are cooled with water in a closed loop. In the electric arc furnace approximately 20 -30 % of the total

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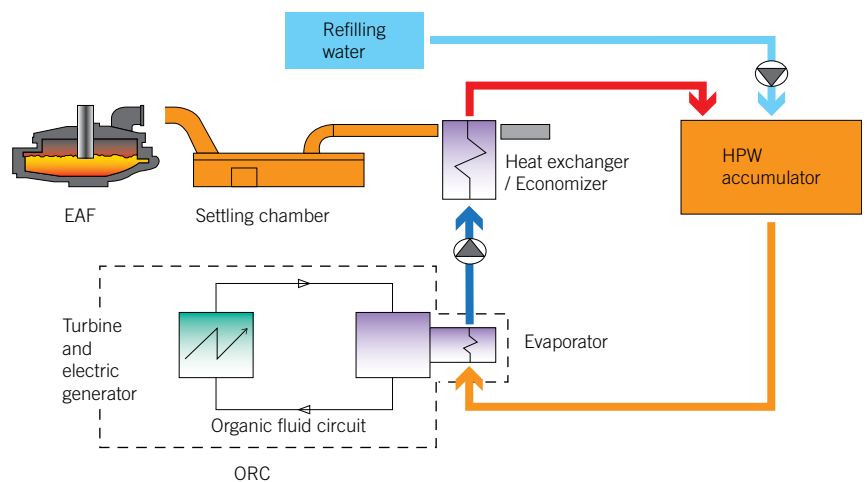
input energy is lost through the primary fumes. To recover such energy Danieli developed the CHR® plant to produce electric energy, with consequent fuel savings and reduction of greenhouse gas emissions. In a closed loop water acts as a vehicle of energy, so the hot water coming out from heat exchanger (hot fumes heat water up to 200 °C) is sent to an accumulator, then to the ORC closed loop. The ORC-Organic Rankine Cycle technology is a cycle that converts heat into energy using an organic fluid with a boiling point occurring at lower temperature than the water-steam phase change. In field plants, energy recovered can reach values of 15-20 kWh/t of produced steel. Recovering part of the waste heat offers the opportunity to access public financing, which varies from country to country.

4



- 1 Clari-flocculation units in steel structure to treat make-up water and blow-down for a 1.1-Mtpy steelmaking plant.
- 2 Air coolers for an EAF closed circuits with Zero Water Evaporation, in the Middle East.
- 3 Overview of a water treatment plant for a 2-Mtpy, DR-based steelmaking plant, located in North Africa.
- 4 Danieli transferable wastewater treatment plant to clean water to reuse during plant commissioning.
- 5 CHR® process scheme.

5



Design criteria for metallurgical applications

Targets

- Systems that properly treat and cool process and effluent water to ensure a successful production process and protect the plant itself, as well as the surrounding environment
- Reducing the amount of make-up water
- Drastically reducing wastewater to meet the ever-increasing demands of lower environmental impact

Steelmaking is one of the industrial processes that has the greatest consumption ratio between water usage and tons of material produced.

The goal of developing a sustainable and environmentally friendly steel industry is reducing the huge water demand, therefore increasing the water recirculation in the cooling and treatments processes. Continuous research aimed at increasing production quality and capacity has led to the development of sophisticated machinery, which works under extreme conditions. The call for environmental sustainability of the total steel production system has inspired us to highlight two development targets related to water use:

- A need for best quality cooling water at all times, to promote longer recirculation and avoid scaling and/or corrosion of the machinery;
- Respect for the environment linked to water discharge, with low levels of polluting agents accumulated in the continuous recirculation.

Aware of these fundamental principles, Danieli Plant Engineering aims to achieve a dual target, namely:

- To reduce the amount of make-up water; and
- To reduce wastewater volumes significantly, to meet the ever-increasing demands of lower environmental impact.

Danieli Plant Engineering Systems adopted this philosophy of water management, right from the outset of its activity. It represents the central nucleus around which the water treatment planning and project research develops.

The use of closed cooling circuits, in-line cleaning of the water contaminated during the production cycle and the purification of the effluent water, represent considerable progress in safeguarding the external environment, and therefore have contributed significantly to the creation of production plants that have little impact on the environment.

Danieli Plant Engineering Systems gained wide experience in the auxiliary utilities of the steelmaking plants and other processes. Therefore, it is able to manage all the various and complex problems concerning the process and effluent water treatment and cooling systems.

Technical Data

The water treatment plant is the main auxiliary plant for the steelmaking industry. For this reason technical data such as thermal load, cooling water flow-rate and inlet pressure must be taken into consideration.

The above parameters are required from the technical departments in order to design the water treatment plants for:

- Primary plants: ore treatment facilities, pelletizing plants, coke-oven units, and by-product facilities;
- Melting shops: blast furnaces, Direct Reduction plants, BOFs and EAFs;
- Secondary treatment: ladle metallurgy furnaces, VD and VOD units;
- Continuous casting machines: for billets, blooms, thick and thin slabs;
- Rolling mills: long product mills (bars, wire rod and sections), hot strip mills and cold strip mills;
- Finishing lines: pickling, galvanizing, tinning, painting lines.

- 1 Water treatment plant located in Middle East for a 1.4 Mtpy DR-based minimill with indirect cooling circuit for 22,000 m³/h and direct cooling circuit for 5,000 m³/h.
- 2 50-m-dia settling units serving an iron ore pelletizing plant in the Middle East.
- 3 Set of package cooling towers for a rolling mill contact circuit in Vietnam.
- 4 Water treatment system for the galvanizing line of a 100,000-tpy cold mill complex for stainless steels, located in Northern Europe.
- 5 800-m³/h lamellar clarifiers to treat water from reheating furnace in a cold mill complex for stainless steel in the Middle East.



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Site conditions

The environmental conditions are fundamental data for a correct dimensioning of the Water Treatment Plant as well as for the definition and application of the cooling systems, which thus will guarantee the maximum operating capacity for the plant, even under the most extreme working conditions.

The most important elements to be considered in designing a water treatment plant are as follows:

- Available water quality on site;
- Dry bulb temperature;
- Wet bulb temperature;
- Wind speed and direction;
- Seismicity;
- Geotechnical survey;
- Local environmental regulations.

Danieli Engineering's water treatment plant technology uses:

- Closed circuits (pressurized or not);
- Open no-contact circuits;
- Contact circuits;
- Induced draft, cross-flow, forced and closed cooling towers;
- Plate exchangers;
- Air coolers;
- Chiller systems.

Treatment of dirty water in contact circuits is carried out according to various schemes, often multiphase, consisting of separation by gravity, centrifugal force, and coagulation. Specialized sand filtration is done with our special high-rate DANfilters.



1 Longitudinal clarifier of a direct cooling water treatment system for a 1.1-Mtpy bar and rod mill in the Middle East.

2 Circular clarifier of a water treatment plant for a 4.7-Mtpy mining, beneficiation and pelletizing plant located in the Middle East.

3 Overview of a water treatment plant for a 1.0-Mtpy minimill (meltshop + rolling mill) for long products in Southeast Asia.



Control and automation systems

Most significant products:

- Engineering for logic development and graphics pages
- Control systems architecture for PLC and DCS
- Digital / analogic control logics for process control
- Engineering and manufacturing of control panels and electrical switchboards
- Inverter panels, MCC panels, PCC panels, Local control boxes, etc.
- Integrate automation together with technological line



1

As standard practice, the automation system of a water treatment plant consists of:

- PLC system (Programmable Logic Controller) for basic automation;
- HMI system (Human Machine Interface) for supervision activities or synoptic mimic diagram;
- Communication network;
- Sets of pushbuttons, instruments and local components.

In particular, for all the plant areas under control, including pumping stations, cooling systems, filtering batteries, purification plant, etc., the PLC is responsible for:

- Executing automation sequences in automatic, manual and local manual mode;
- Acquiring of data from the field.

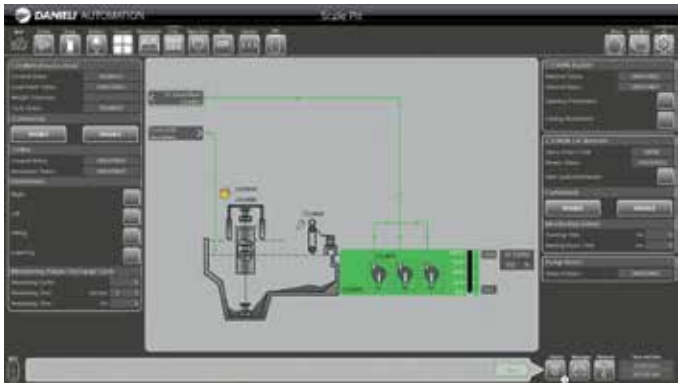
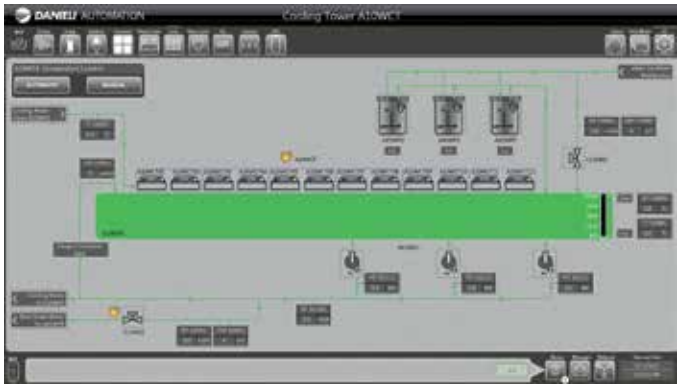
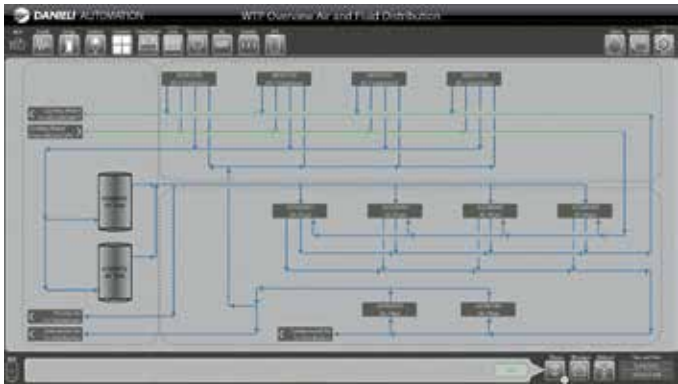
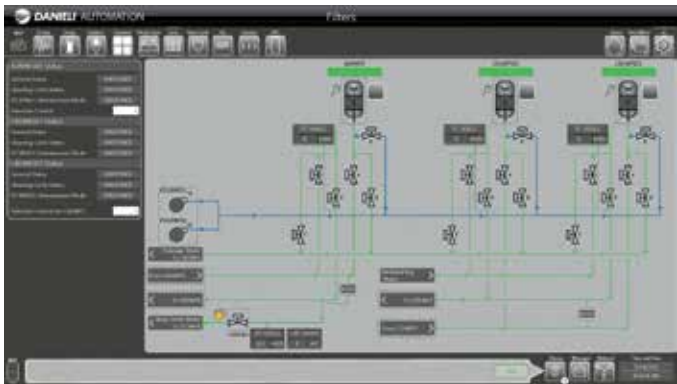
The HMI system, which consists of a networked PC or an operator terminal directly connected to the PLC, is dedicated to the other functions, including diagnostics, device testing, setting of operational parameters, manual controls, real-time and historical trends, and displaying of plant mimic diagram panels for dynamic monitoring of processes. Thanks to the color graphics and real-time updating, the supervisor has immediate and continuous information on plant status.

With its high performance standards, the Ethernet provides the internal PC-PLC connections and it is the means for integrating with the other technical areas of the plant with the higher automation level. The objective of maximum efficiency is pursued by integrating the areas not directly involved in the production process.

Due to the fact that the PLC does not work during black-out periods, for safety reasons all emergency systems and devices are “hard-wired”.

In order to ensure the real-time assistance and to perform the required feedback actions due to alarms from the monitored plants, Danieli can supply the Tele Assistance Control System by remote connection. From Danieli offices the qualified operators can act directly to solve the plant troubles. As integration of the Tele Assistance, SCADA is the most sophisticated tool for the real-time data acquisition and supervisory control system.

- 1 Operator working in a control room.
- 2 Power switchboard room.
- 3 Sample of Human Machine Interface: Filters.
- 4 Sample of Human Machine Interface: Overview of air and fluid distribution.
- 5 Sample of Human Machine Interface: Cooling tower.
- 6 Sample of Human Machine Interface: Scale pit.



Commissioning, training and water management

Targets

- Provide skilled personnel to follow erection/commissioning activities of Danieli water treatment plant products in a professional way
- Ensure a smooth transition of all projects, from the build phase through to the operating maintenance and service phases
- Satisfactorily hand over water treatment projects to our customers

Danieli can supply a full set of services on site, through its Erection & Commissioning Department and Danieli Service Department:

- Erection and commissioning of plants;
- Advisory services;
- Training to operators;
- After-sales service.

The full spectrum of services, such as erection, commissioning and startup assistance for new plants, supervising to refurbishment and upgrades of existing plants, retrofitting and revamping projects, can be provided all over the world. The aim of the department, through its internal resources, is to:

- Provide skilled personnel to follow erection/commissioning activities of Danieli water treatment plant products in a professional way;
- Ensure a smooth transition of all projects from the build phase through to the operating/maintenance and service phase;
- Satisfactorily hand over water treatment plant projects to our customers.

Danieli Erection & Commissioning Department developed and established a quality management system based on the ISO 9001 standard, therefore our supervisors follow an internal QA/QC process to ensure that the complete installation is inspected, pre-commissioned (or 'set to work'), adjusted, tested and regulated to respect both environmental conditions and design specifications. Usually the following steps are considered:

- Construction: during the erection phase Danieli supervisors guarantee the accurate following of installation phases through the application of a mechanical completion system;
- Pre-commissioning: this involves carrying out a sequence of checks to ensure the system is complete, correctly installed in accordance with design requirements and then preparing the system for commissioning. DIMAC has developed its own cold test check-lists that normally are shared with the customer;
- Commissioning: starting up and testing all equipment individually, and then the whole plant. Then, the key factor is the process of adjusting fluid flow within the specified tolerances of the project;
- Testing: evaluating the plant performances, which may be temperatures, pressures, flows, water analysis.

These guarantee that, at the hand-over, our customers receive a plant with all the services fully operational. The test results will be documented, witnessed and issued complete with a full set of operating and maintenance manuals for the maintenance staff. This allows for any subsequent defects or modifications to be identified and

appropriate remedial action carried out. After commissioning/hand over of a new plant, Danieli Service can provide a range of one-time and ongoing support to ensure that it remains well-maintained and operates at optimal levels. Whether our customers need training to do the work on their own, or want to rely on Danieli's experts to take care of it, Danieli Service can ensure that the plant continues to offer long-term, reliable, and safe water treatment services.

Danieli Service can offer the following support services:

- Operator training;
- On-call assistance and troubleshooting;
- Routine inspections;
- Full operation and maintenance services;
- Remote monitoring.

Danieli's goal is to achieve the customer's satisfaction, ensuring a safe work place on site. Danieli personnel operating during erection and commissioning phases apply the company standards for the prevention and protection of the health and safety for the workers involved. Danieli applies procedures and instructions that are periodically certified by external corporations in compliance with the OHSAS 18001/07 British standard. Danieli staff are trained periodically, taking into consideration the risk assessment carried out in compliance with the Safety European Regulations and their specific tasks.



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- 1 Meeting room provided for worksite.
- 2 Site technical office for erection activities.
- 3 Welding pipes on site.
- 4 Cooling-water pump testing.
- 5 Piping test activities.
- 6 Piping insulation work.
- 7 One of Danieli's Teleservice stations.

Water Management

Danieli Engineering Systems also facilitates supply of specialty services, as construction and management in global service (BOOT - build-own-operate-transfer) where Danieli receives a concession from a customer to finance, design, construct and operate a WTP, as stated in the concession contract.

The customers have only to pay the quantity of inlet water used (or discharged outlet water) without any issue about project, investment, operating and maintenance expenses.







Case study installations



Nucor Gallatin, USA

WTP upgrading for SMP and QSP (TSC & 3-Mtpy hot strip mill)

Plant location	Ghent Kentucky, USA
Plant type	Water Treatment Plant
Indirect cooling	26,860 m ³ /h
Direct cooling	19,950 m ³ /h
Make-up water	980 m ³ /h



Emirates Steel, UAE

1.4-Mtpy DRI-based minimill #1 for bars and wire rod

1.4-Mtpy DRI-based minimill #2 for heavy sections

1.9-Mtpy Direct Reduction Plant

Plant location:	Abu Dhabi, UAE
Plant type	Water Treatment Plant
Indirect cooling	11,400 m ³ /h
Direct cooling	1,275 m ³ /h
Make-up water	1,400 m ³ /h (minimill #1)
Make-up water	1,600 m ³ /h (minimill #2)
Make-up water	450 m ³ /h (DRI)



Saudi Iron & Steel Co. - Hadeed, KSA

1.0-Mtpy steel meltshop and wire rod mill

Plant location:	Jubail, Kingdom of Saudi Arabia
Plant type:	Water Treatment Plant cooled in sea water system
Indirect cooling	7,920 m ³ /h
Direct cooling	2,820 m ³ /h
Make-up water	480 m ³ /h



JESCO-Jubail Energy Services Corp.

400,000-tpy seamless pipe plant

Plant location	Jubail, Kingdom of Saudi Arabia
Plant type	Water Treatment Plant
Indirect cooling	1,715 m ³ /h
Direct cooling	2,700 m ³ /h
Make-up water	50 m ³ /h



TMZ TASHKENT, Uzbekistan

500-Ktpy WTP for cold complex including ZLD

Plant location	Taskent, Uzbekistan
Plant type	Water Treatment Plant ZLD-Zero Liquid Discharge
Indirect cooling	3,100 m ³ /h
Make-up water	90 m ³ /h
ZLD	52 m ³ /h



Dneprosteel, Ukraine

1.32-Mtpy steelmaking plant

Location	Dnepropetrovsk, Ukraine
Plant type	ZLD-Zero Liquid Discharge Water Treatment Plant
Indirect cooling	11,681 m ³ /h
Direct cooling	1,330 m ³ /h
Make-up water	165 m ³ /h
ZLD	60 m ³ /h



AQS, Algeria

2.0-Mtpy rolling mill (Wire Rod & Rebars)

2.1-Mtpy steelmaking plant

Location	Algeria
Plant type	Water Treatment Plant
Indirect cooling	3,120 m ³ /h; 14,270 m ³ /h
Direct cooling	5,300 m ³ /h; 1,060 m ³ /h
Make-up water	110 m ³ /h; 280 m ³ /h

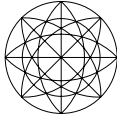


NMDC - Nagarnar, India

2.9-Mtpy Thin Slab Caster and Hot Strip Mill complex

Plant location:	Nagarnar, Chhattisgarh, India
Plant type:	ZLD-Zero Liquid Discharge Water Treatment Plant
Raw water	400 m ³ /h
Indirect cooling	3,426 m ³ /h (TSC); 3,064 m ³ /h (HSM)
Direct cooling	10,181 m ³ /h; 5,600 m ³ /h strip cooling
ZLD	135 m ³ /h

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