T.R.
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF WATER MANAGEMENT

Water Efficiency
Campaign

Water Efficiency
Directory Documents Series

BARS COLD WITHDRAWAL

NACE KODU: 24.31

ANKARA 2023

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Abbreviations

WTP	Wastewater Treatment Plant
EU	Europe Union
SSM	Suspended Solid Matter
BREF	Best Available Techniques Reference Document
EMS	Environment Management The system
MoEUCC	Republic of Turkey Ministry of Environment, Urbanization and Climate Change
NOM	Natural Organic Article
EMAS	Eco Management and Audit Program Directive
EPA	United States Environmental Protection Agency
IPPC	Industrial Pollution Prevention And Control
ISO	International Standardization for Organization
BAT	Best Available Techniques
NACE	Statistical Classification of Economic Activities
GSWM	General Directorate of Water Management
RO	Reverse Osmosis
MAF	Ministry of Agriculture and Forestry of the Republic of Turkey
TurkStat	Turkish Statistical Institute
NF	Nanofiltration
MF	Microfiltration
UF	Ultrafiltration
GW	Ground Water
SW	Surface Water

1 Introduction

Our country is located in the Mediterranean basin, where the effects of global climate change are intensely felt, and is considered one of the regions that will be most adversely affected by climate change. Projections regarding how the water resources in our basins will be affected in the future due to climate change indicate that our water resources may decrease by up to 25% over the next century.

For the year 2022, the per capita annual available water amount in our country is 1,313 m³. However, due to human pressures and the effects of climate change, it is expected that the per capita annual available water amount will fall below 1,000 cubic meters after 2030. If necessary measures are not taken, it is evident that Turkey will become a water-scarce country in the near future, bringing many social and economic negative consequences. As can be understood from the results of future projections, the risk of drought and water scarcity awaiting our country necessitates the efficient and sustainable use of our existing water resources.

The concept of water efficiency can be defined as "the use of the least amount of water in the production of a product or service." The approach to water efficiency emphasizes the rational, equitable, efficient, and effective use of water across all sectors, including drinking water, agriculture, industry, and household uses, while considering the needs of not only humans but also the sensitivity of ecosystems and all living beings, and conserving water in terms of both quantity and quality.

The increasing demand for water resources, changes in precipitation and temperature regimes as a result of climate change, and the growing population, urbanization, and pollution make the fair and balanced distribution of available water resources among users increasingly important. Therefore, it has become essential to create a roadmap based on efficiency and optimization for the sustainable management and protection of our limited water resources.

In the sustainable development vision defined by the United Nations, Goal 7 of the Millennium Development Goals: Ensuring Environmental Sustainability, along with Goals 9: Industry, Innovation, and Infrastructure, and 12: Responsible Consumption and Production of the Sustainable Development Goals, emphasizes the efficient, fair, and sustainable use of resources, primarily water, environmentally friendly production, and consumption that considers the concerns of future generations.

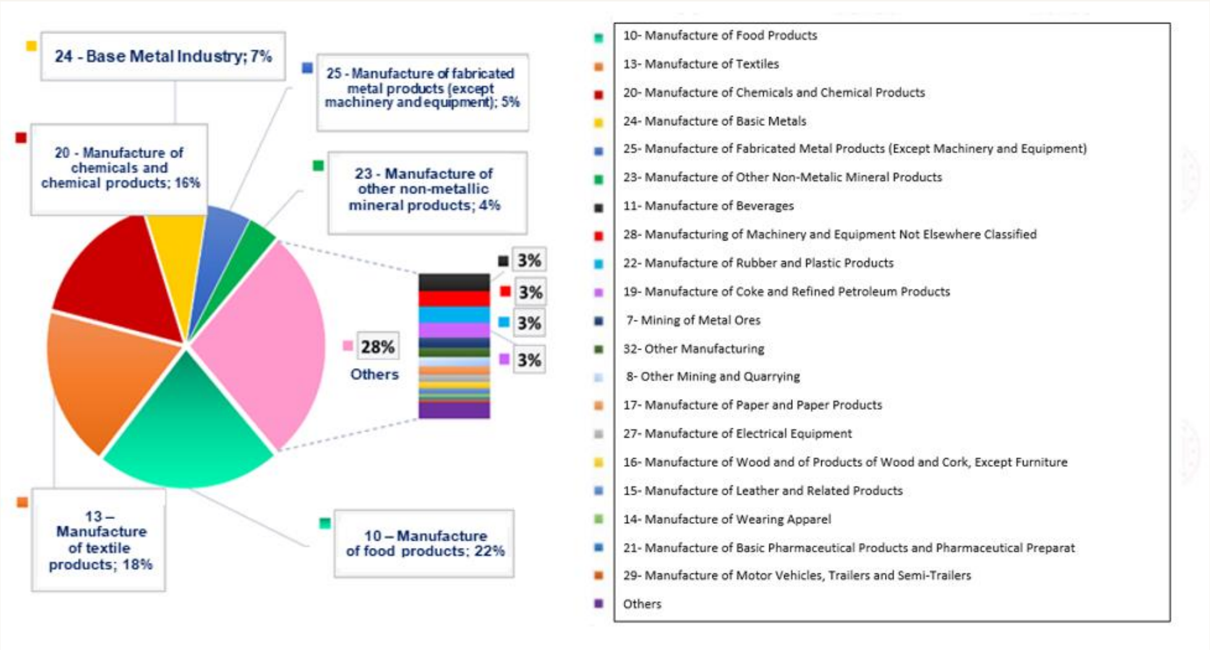
Within the framework of the European Green Deal, which aims to implement a clean, circular economy model with a carbon-neutral target, promote the efficient use of resources, and reduce environmental impacts, Turkey has outlined actions emphasizing water and resource efficiency in production and consumption across various fields, primarily industry, in its European Green Deal Action Plan.

The "Industrial Emissions Directive (EED)", which is one of the most important components of the European Union's environmental legislation from an industrial perspective, includes measures that must be taken for the control and prevention or reduction of discharges/emissions from industrial activities into air, water, and soil. The directive presents Best Available Techniques (BAT/MET) to systematically implement clean production processes and eliminate difficulties encountered in practice. When considering costs and benefits, BATs are the most effective implementation techniques for the high-level protection of the environment. Under the directive, Reference Documents (BAT-BREF) detailing the BATs for each sector have been prepared. The BREF documents present BATs, good management practices, technical measures of a general nature, chemical use and management, techniques for various production processes, wastewater management, emission management, and waste management within a general framework.

The Ministry of Agriculture and Forestry, through the General Directorate of Water Management, conducts studies aimed at promoting efficient practices in urban, agricultural, industrial, and individual water use and increasing public awareness. Under the "Water Efficiency Strategy Document and Action Plan (2023-2033)", which came into effect with Presidential Circular No. 2023/9, action plans for water efficiency addressing all sectors and stakeholders have been prepared. The Industrial Water Efficiency Action Plan has identified a total of 12 actions for the 2023-2033 period, and responsible and relevant institutions have been designated for these actions. Within the scope of this Action Plan, tasks have been defined for the General Directorate of Water Management to determine specific water usage ranges and quality requirements by sub-sector in industry, organize technical training programs and workshops on a sectoral basis, and prepare water efficiency guideline documents.

On the other hand, the "Industrial Water Use Efficiency Project According to NACE Codes" conducted by the General Directorate of Water Management aims to improve water efficiency in the industry by identifying sector-specific best techniques unique to our country. As a result of this study, sectoral guideline documents and action plans classified by NACE codes have been prepared, containing recommended measures for improving water use efficiency in sectors with high water consumption operating in our country.

As in the rest of the world, the sectors with the highest share of water consumption in our country are food, textiles, chemicals, and primary metals. In the course of the studies, field visits were conducted to businesses representing 152 sub-sectors across 35 major sectors, including food, textiles, chemicals, and primary metal industries, which operate under NACE Codes and have high water consumption. Data was collected regarding water supply, sectoral water use, wastewater generation, and recovery. Information was also provided on existing best available techniques (BAT) published by the European Union, as well as topics such as water efficiency, clean production, and water footprint.



Distribution of water usage in industry sector in Türkiye

As a result of the studies, specific water consumption and potential savings rates for processes in businesses with high water consumption have been determined for 152 different four-digit NACE codes. Water efficiency guideline documents have been prepared, taking into account the EU's Best Available Techniques (BAT) and other clean production techniques. Within these guidelines, a total of 500 techniques related to water efficiency have been categorized into four main groups: (i) Good Management Practices, (ii) General Measures, (iii) Measures Related to Auxiliary Processes, and (iv) Sector-Specific Measures.

Executed During the phase of identifying BATs for each sector in the project, considerations included environmental benefits, operational data, technical specifications/requirements, and feasibility criteria. The identification of BATs was not limited to BREF documents; various data sources, including current literature on a global scale, real case analyses, innovative practices, and reports from sector representatives, were thoroughly examined to create sectoral BATs lists.

To evaluate the suitability of the created BAT lists for our country’s local industrial infrastructure and capacity, specific BAT lists prepared for each NACE code were prioritized by businesses based on criteria such as water savings, economic savings, environmental benefits, feasibility, and cross-media effects. Using the scoring results, the final BAT lists were determined. Based on the water and wastewater data collected from the visited facilities and the final BAT lists identified considering local dynamics specific to our country, sectoral water efficiency guides have been developed on a NACE code basis.

2 Scope of the Study

The guidance documents prepared within the scope of water efficiency measures in the industry include the following main sectors:

- Crop and animal production, hunting and related service activities (including sub-production areas represented by 6 four-digit NACE Codes)
- Fisheries and aquaculture (including 1 sub-production area represented by a four-digit NACE Code)
- Extraction of coal and lignite (including 2 sub-production areas represented by a four-digit NACE Code)
- Service activities in support of mining (including 1 sub-production area represented by a four-digit NACE Code)
- Metal ore mining (including 2 sub-production areas represented by a four-digit NACE Code)
- Other mining and quarrying (including 2 sub-production areas represented by a four-digit NACE Code)
- Manufacture of food products (including 22 sub-production areas represented by a four-digit NACE Code)
- Manufacture of beverages (including 4 sub-production areas represented by a four-digit NACE Code)
- Manufacture of MAFacco products (including 1 sub-production area represented by a four-digit NACE Code)
- Manufacture of textiles (including 9 sub-production areas represented by a four-digit NACE Code)
- Manufacture of apparel (including 1 sub-production area represented by a four-digit NACE Code)
- Manufacture of leather and related products (including 3 sub-production areas represented by a four-digit NACE Code)
- Manufacture of wood, wood products and cork products (except furniture); manufacture of articles made by knitting from reeds, straw and similar materials (including 5 sub-production areas represented by a four-digit NACE Code)
- Manufacture of paper and paper products (including 3 sub-production areas represented by a four-digit NACE Code)
- Manufacture of coke and refined petroleum products (including 1 sub-production area represented by a four-digit NACE Code)
- Manufacture of chemicals and chemical products (including 13 sub-production areas represented by a four-digit NACE Code)
- Manufacture of basic pharmaceutical products and pharmaceutical materials (including 1 sub-production area represented by a four-digit NACE Code)
- Manufacture of rubber and plastic products (including 6 sub-production areas represented by a four-digit NACE Code)
- Manufacture of other non-metallic mineral products (including 12 sub-production areas represented by a four-digit NACE Code)
- Base metal industry (including 11 sub-production areas represented by a four-digit NACE Code)
- Manufacture of fabricated metal products (excluding machinery and equipment) (including 12 sub-production areas represented by a four-digit NACE Code)
- Manufacture of computers, electronic and optical products (including sub-production area represented by 2 four-digit NACE Codes)
- Manufacture of electrical equipment (including 7 sub-production areas represented by a four-digit NACE Code)
- Manufacture of machinery and equipment, n.e.c. (including 8 sub-production areas represented by a four-digit NACE Code)
- Manufacture of motor vehicles, trailers and semi-trailers (including 3 sub-production areas represented by a four-digit NACE Code)
- Manufacture of other means of transport (including 2 sub-production areas represented by a four-digit NACE Code)
- Other productions (including 2 sub-production areas represented by a four-digit NACE Code)
- Installation and repair of machinery and equipment (including 2 sub-production areas represented by a four-digit NACE Code)
- Electricity, gas, steam and ventilation system production and distribution (including 2 sub-production areas represented by a four-digit NACE Code)
- Waste collection, remediation and disposal activities; recovery of materials (including 1 sub-production area represented by a four-digit NACE Code)
- Construction of non-building structures (including 1 sub-production area represented by a four-digit NACE Code)
- Storage and supporting activities for transportation (including 1 sub-production area represented by a four-digit NACE Code)

- Accommodation (including 1 sub-production area represented by a four-digit NACE Code)
- Educational Activities (Higher Education Campuses) (including 1 sub-production area represented by a four-digit NACE Code)
- Sports, entertainment and recreational activities (including 1 sub-production area represented by a four-digit NACE Code)

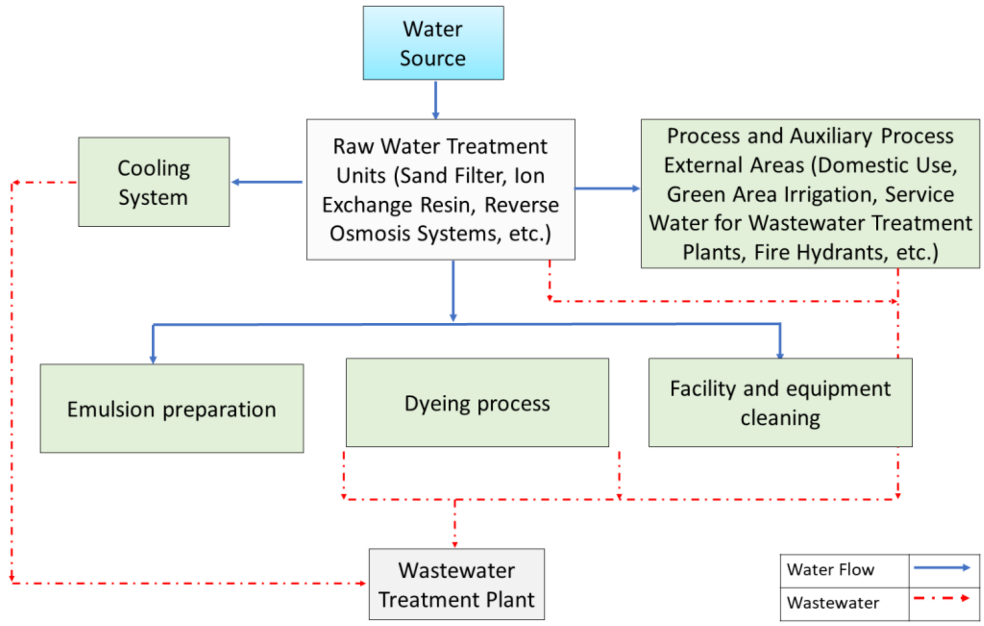
"Main metal industry" And "Fabrication metal products manufacturing (machine and equipment not including)"

"Base metal industry" And "Fabrication metal products manufacturing (machine And equipment not including)"sectors under directory documents prepared lower production arms This It is as follows:

24.10	Manufacturing of basic iron and steel products and ferro alloys
24.20	Manufacturing of steel tubes, pipes, hollow profiles, and similar fittings
24.31	Cold drawing of bars
24.32	Cold rolling of narrow strips
24.34	Cold drawing of wires
24.41	Production of precious metals
24.42	Production of aluminum
24.51	Iron casting
24.52	Steel casting
24.53	Casting of light metals
24.54	Casting of other non-ferrous metals
25.12	Manufacturing of metal doors and windows
25.21	Manufacturing of central heating radiators (excluding electric radiators) and hot water boilers (calorifiers)
25.30	Manufacturing of steam generators, excluding central heating hot water boilers (calorifiers)
25.50	Forging, pressing, stamping, and rolling of metals; powder metallurgy
25.61	Processing and coating of metals
25.62	Machining and shaping of metals
25.71	Manufacturing of cutlery and other cutting tools
25.73	Manufacturing of hand tools, machine tool parts, saw blades, etc.
25.92	Manufacturing of lightweight packaging materials from metal
25.93	Manufacturing of wire products, chains, and springs
25.94	Manufacturing of fastening materials and products for screw machines
25.99	Manufacturing of other fabricated metal products not elsewhere classified

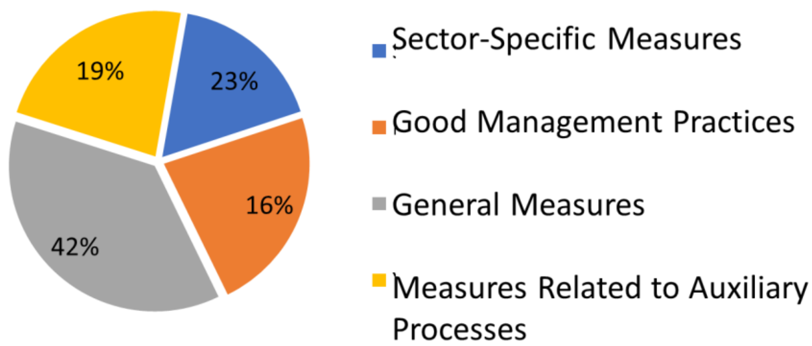
2.1 The bars Cold Withdrawal (NACE 24.31)

Water Flow Diagram for the Cold Drawing of Bars Industry



	Minimum	Maximum
Specific Water Consumption of Facilities Visited in the Project (L/unit of product)	0,3	0,4
Reference Specific Water Consumption (L/kg of product)	3	5

Percentage Distribution of Water Efficiency Practices



Rolling is the process of shaping metallic materials by passing them between rollers, known as rollers, which rotate around their axes. The cross-section of the material is continuously reduced while its length is increased. Rolling processes are classified as hot or cold based on temperature. Steel bars produced through cold rolling are initially subjected to hot rolling. The hot-rolled bars are then processed through a die using the drawing method to produce cold-rolled bars. Cold-drawn bars have higher tensile and yield strengths compared to hot-rolled bars. Steel producers operating under the NACE code for cold drawing of bars purchase hot-rolled steel to obtain cold-rolled steel.

Water is used in the coloring and emulsion preparation processes for cold drawing of bars. Significant water consumption also occurs in raw water preparation units such as sand filters, ion exchange resins, and reverse osmosis systems for processes like filter washing, resin regeneration, and membrane cleaning. Additionally, water is consumed in auxiliary processes such as cooling systems.

The reference specific water consumption in the cold drawing sector of bars ranges from 3 to 5 L/kg. The specific water consumption analyzed for the production branch in this study is between 0.3 and 0.4 L/kg. By implementing sector-specific techniques, good management practices, general preventive measures, and precautions related to auxiliary processes, water savings of 32% to 65% can be achieved in the sector.

https://www.steelwarehouse.com/assets/images/content/coldmill_2.jpg

Cold Rolling The process

24.31 The bars Cold Withdrawal NACE code in the scope of the recommended priority water efficiency application techniques are presented in the table below

NACE Code	NACE Code Description		Sector-Specific Priority Best Available Techniques
24.31	Sector-Specific Priority Best Available Techniques for Cold Drawing of Bars		**Sector-Specific Measures**
		1.	**Recovery Systems:** The recovery of rinsing water can significantly reduce water consumption through the use of ion exchangers, reverse osmosis, membrane technologies, and electrolytes.
		2.	**Chemical Compatibility:** Using compatible chemicals in sequential tanks to reduce the effluent water transported in baths.
		3.	**Surfactants:** The use of surfactants to decrease the volume of effluent water
		4.	**Reuse:** Reusing wash water as makeup water in acid baths
		5.	**Low-Speed Extraction:** Extracting materials from tanks at low speeds to minimize effluent water.
		6.	**Efficient Processes:** Increasing the efficiency of mechanical pre-treatments and flue gas treatment systems to reduce water consumption.
		7.	**Material Placement:** Arranging coated materials so that the widest surface is vertical and the longest surface is horizontal to minimize water loss.
		8.	**Dry Extinguishing:** Using dry extinguishing methods instead of water for extinguishing coal to save water.
		9.	**In-Mold Cooling:** Implementing cooling applications within molds.
			Best Management Practices
		1.	**Integrated Waste Management:** Utilizing an integrated wastewater management and treatment strategy to reduce effluent quantity and pollutant load.
		2.	**Environmental Management Systems:** Establishing an environmental management system.
		3.	**Water Flow Diagrams:** Preparing water flow diagrams and mass balance calculations for water use.
		4.	**Action Plans:** Developing water efficiency action plans to reduce water consumption and prevent water pollution.
		5.	**Training Programs:** Providing technical training to staff to reduce and optimize water usage.
		6.	**Production Planning:** Conducting effective production planning to optimize water consumption.
		7.	**Target Setting:** Establishing water efficiency targets.
		8.	**Monitoring:** Monitoring the quantity and quality of water used in production processes and auxiliary processes, and integrating this information into the environmental management system.
			General Preventive Measures
		1.	• **Leak Control:** Minimizing spills and leaks.
		2.	• **Recovery Practices:** Recovering water from rinsing solutions and reusing the recovered water in suitable processes.
		3.	• **Automatic Systems:** Utilizing automatic devices and equipment that conserve water at usage points (sensors, smart handwashing systems, etc.).
		4.	• **Pressurized Washing Systems:** Using pressurized washing systems for equipment cleaning and general cleaning operations.
		5.	**Filtration and Cleaning Systems:** Reusing filter wash water in filtration processes, reusing relatively clean cleaning water in production processes, and reducing water consumption by using cleaning-in-place systems (CIP).

NACE Code	NACE Code Description		Sector-Specific Priority Best Available
24.31	Cold drawing of bars	6.	Drinking of water production on the lines from the use of to be avoided
		7.	Cooling water other in processes process water aspect to be used
		8.	This their losses detection to be done And reduction
		9.	Use of automatic control-shutoff valves to optimize water usage
		10.	To prevent water and energy waste, production procedures must be documented and used by employees.
		11.	Aquatic environment for toxic either in dangerous chemicals of being transported to prevent closed storage And impermeable waste/scrap field to be done
		12.	Aquatic in the environment risk constituent substances (oils, emulsions, binders to prevent mixing with wastewater after storage, preservation and use.
		13.	Preventing the mixing of clean water streams with dirty water streams wastewater formation at points wastewater the amounts of And Qualifications
		14.	Characterized by being made by purification either in without purification back usage determination of possible wastewater streams
		15.	Suitable in processes closed loop This cycles of to be used
		16.	Production in their processes computer supported control systems to be used
		17.	Grey water is collected and purified separately in the facility and in areas that do not require high water quality. (green area irrigation, place, ground washing etc.) to be used
		18.	Collecting rainwater and using it as an alternative water source for facility cleaning or in suitable areas.
		19.	Nanofiltration (NF) or opposite osmosis (TO) concentrates reuse with or without purification depending on characterization
			Helper To the processes Related Measures
		1.	Ventilation in the system old equipments opposite osmosis principle of based on replacement with ion exchange resins (systems producing demineralized water) and reuse of water
		2.	Reuse of condensate from the ventilation system
		3.	Reducing water consumption by increasing the number of cycles in closed loop cooling systems and improving the quality of makeup water
		4.	Increasing the number of cycles by using corrosion and scale inhibitors in systems with closed water loops
		5.	Using air cooling systems instead of water cooling in cooling systems
		6.	Cooling water back gain systems healthy can work for installation of water softening systems
		7.	Use of a closed loop cooling system to reduce water usage
		8.	Collecting the water formed by surface runoff with a separate collection system and using it for purposes such as cooling water, process water, etc.

This in the sector total 44 piece technical has been suggested.

The bars Cold Withdrawal NACE Code Oriented;

(i) To the sector Unique Measures,
(ii) Good Management Applications,
(iii) General Measures And
(iv) Helper to processes related measures separate Titles is given in the form of .

2.1.1 Sector-Specific Measures

- ***Using compatible chemicals in sequential tanks to reduce rinsate water transported in baths:***

  It is important to keep the rinsate water at the lowest possible level. If proper rinsing cannot be performed between processes, the chemicals carried on the parts can contaminate the process solutions. By using compatible chemicals in sequential tanks, the transportation of these chemicals can be reduced (CSIDB, 2013).

- ***Placing coated materials so that the widest surface is vertical and the longest surface is horizontal to reduce rinsate water transport in baths:***

  When placing coated materials in rinsing tanks, positioning them so that the widest surface is vertical and the longest surface is horizontal can reduce the transfer of rinsate water from the rinsing bath (CSIDB, 2013).

- ***Removing materials from tanks at a low speed to reduce rinsate water transported in baths:***

  Slowly removing materials from the tanks helps prevent chemicals and rinsing water from backflowing into the tanks and avoids unwanted rinsate outside the tanks (CSIDB, 2013).

- ***Using surfactants to reduce rinsate water transported in baths:***

  Surfactants help reduce surface tension, thereby decreasing the transfer of chemicals and rinsate water (CSIDB, 2013).

- ***Recovering rinsing water using ion exchangers, reverse osmosis, membrane technologies, and electrolytes to make the rinsing process more efficient:***

  Cationic and anionic ion exchangers can help return rinsing water back to the process. Reverse osmosis can be used to recover both rinsing water and the chemicals in the water. Membrane processes like ultrafiltration and nanofiltration can also be used for rinsing water recovery (CSIDB, 2013).

- ***Using dry extinguishing instead of wet extinguishing in the coke extinguishing process to save water:***

  Coke production generates 0.66 m³ of wastewater per ton of raw steel. On average, 8-15% of this wastewater arises from the moisture content of the coal. By opting for dry extinguishing alternatives instead of wet extinguishing methods during the extinguishing process, water consumption can be prevented (Avinal & Tosun, 2019).

- ***Reusing used washing water as make-up water in the pickling bath:***

  Used washing water can be reused by mounting squeezing rollers and wiping rollers after the pickling baths and before and after the rinsing baths.

- ***Increasing the efficiency of mechanical pre-treatment and flue gas purification systems to reduce water consumption:***

  In cold rolling mills, the amount of water consumed during surface cleaning (pickling) can be reduced by employing techniques such as using spray processes instead of immersion processes or utilizing compressive rollers (STB, 2019a).

- ***In-mold cooling application:***

  Lubrication of molds and pistons in high-pressure die casting machines is crucial for the success of high-pressure casting. Lubrication improves casting quality and facilitates the removal of the casting from the mold. Lubricants (or release agents) are mostly water-based and applied by spraying onto open molds. The "in-mold cooling" application is an alternative method to applying release agents as a water-based solution on an open mold. In this application, the release agent is applied in vaporized form to a closed mold casting. This method reduces the use of both water and release agents (IPPC BREF, 2005a).

2.1.2 Good Management Applications

- ***Establishment of an Environmental Management System (EMS):***

Environmental Management Systems (EMS) encompass the organizational structure, responsibilities, procedures, and resources necessary for industrial establishments to develop, implement, and monitor their environmental policies. The establishment of an EMS improves decision-making processes among raw materials, water-wastewater infrastructure, planned production processes, and various treatment techniques. Environmental management organizes how to manage the demands for resource supply and waste discharge with the highest economic efficiency, without compromising product quality and with minimal impact on the environment.

The most commonly used Environmental Management Standard is ISO 14001, with alternatives including the Eco-Management and Audit Scheme (EMAS) (761/2001). It has been developed for the evaluation, improvement, and reporting of businesses' environmental performance. It is among the leading practices in EU legislation on eco-efficiency (clean production) and participation is voluntary (TUBİTAK MAM, 2016; TOB, 2021). The benefits of establishing and implementing an EMS include:

- Improved operational performance leading to economic benefits (Christopher, 1998).
- Increased compliance with global legal and regulatory requirements through the adoption of International Organization for Standardization (ISO) standards (Christopher, 1998).
- Minimization of penalty risks related to environmental responsibilities while reducing waste amounts, resource consumption, and operational costs (Delmas, 2009).
- The use of internationally recognized environmental standards eliminates the need for multiple registrations and certifications for businesses operating in different locations around the world (Hutchens Jr., 2017).
- Particularly in recent years, the improvement of companies' internal control processes has gained importance among consumers. The implementation of environmental management systems provides a competitive advantage over companies that do not adopt the standard and also contributes to better positioning in international markets (Potoski & Prakash, 2005).

The aforementioned benefits depend on numerous factors such as the production process, management practices, resource use, and potential environmental impacts (TOB, 2021). Implementing practices such as preparing annual inventory reports with similar content to the EMS and monitoring the quantity and quality of inputs and outputs in production processes can result in water savings of 3-5% (Öztürk, 2014). The total duration for the development and implementation stages of the EMS is estimated to take 8-12 months (ISO 14001 User Manual, 2015).

Industrial establishments also conduct studies under the ISO 14046 Water Footprint Standard, which defines the requirements and guidelines for assessing and reporting water footprints. The application of this standard aims to reduce the freshwater usage necessary for production and its environmental impacts. Additionally, the ISO 46001 Water Efficiency Management Systems Standard assists industrial establishments in achieving water savings and reducing operational costs by facilitating the development of water efficiency policies through monitoring, benchmarking, and review processes.

- ***Use of Integrated Wastewater Management and Treatment Strategies to Reduce Wastewater Volume and Pollutant Load***

Wastewater management should adopt a holistic approach from the generation of wastewater to its final disposal, encompassing functional elements such as composition, collection, treatment including sludge disposal, and reuse. The selection of appropriate treatment technologies for industrial wastewater depends on integrated factors such as land availability, desired quality of treated water, and compliance with national and local regulations (Abbassi & Al Baz, 2008).

The reuse of treated wastewater not only improves the quality of water bodies but also reduces the demand for freshwater. Therefore, identifying suitable treatment strategies for different reuse objectives is crucial.

In integrated industrial wastewater treatment, various aspects such as the wastewater collection system, treatment process, and reuse objectives are evaluated together (Naghedi et al., 2020). Methods like SWOT analysis (Strengths, Weaknesses, Opportunities, Threats), PESTEL analysis (Political, Economic, Social, Technological, Environmental, Legal factors), and decision trees can be combined with expert opinions to establish an integrated wastewater management framework (Naghedi et al., 2020). The integration of Analytical Hierarchy Process (AHP) and Combined Compromise Solution (CoCoSo) techniques can be utilized to determine priorities based on multiple criteria for industrial wastewater management processes (Adar et al., 2021).

The implementation of integrated wastewater management strategies can lead to an average reduction of up to 25% in water consumption, wastewater volume, and pollutant loads in wastewater. The potential payback period for such implementations ranges from 1 to 10 years (TOB, 2021).

http://www.asw-eg.com/en/images/products/116567Water-Sewage-Treatment-System-With-Plant-And-Facility.jpg

Industrial Wastewater Purification The facility

- ***Providing Technical Training to Personnel to Reduce and Optimize Water Use:***

  This measure increases personnel training and awareness, enabling water conservation and recovery, while reducing water consumption and costs, thereby enhancing water efficiency. In industrial facilities, a lack of necessary technical knowledge among staff can lead to excessive water use and wastewater generation. For example, it is crucial to properly train cooling tower operators, who represent a significant portion of water consumption in industrial operations, to ensure they possess the necessary technical knowledge. Adequate technical expertise is also required for determining water quality requirements in production processes and measuring water and wastewater quantities (TOB, 2021). Therefore, educating personnel on reducing water use, optimizing it, and implementing water conservation policies is essential. Involving staff in water-saving initiatives, creating regular reports on water usage before and after such initiatives, and sharing these reports with the personnel help support participation and motivation. The technical, economic, and environmental benefits gained from personnel training yield results in the medium to long term (TUBİTAK MAM, 2016; TOB, 2021).

- ***Preparing a Water Efficiency Action Plan to Reduce Water Use and Prevent Water Pollution:***

  t is important to prepare an action plan that includes short, medium, and long-term measures to reduce water and wastewater volumes and prevent water pollution in industrial facilities. This involves determining water needs across the facility and production processes, establishing quality requirements at water usage points, and characterizing wastewater generation points (TOB, 2021). Additionally, it is necessary to identify, assess the feasibility of, and prepare action plans for measures aimed at reducing water consumption, wastewater generation, and pollution loads in the short, medium, and long term. This ensures water efficiency and sustainable water use in facilities (TOB, 2021).

- ***Preparing Water Flow Diagrams and Mass Balances for Water:***

  Identifying water usage and wastewater generation points in industrial facilities and creating water-wastewater balances for production processes and auxiliary processes form the basis of many good management practices. Creating process profiles based on the entire facility and production processes facilitates the identification of unnecessary water usage points, high water usage areas, evaluation of water recovery opportunities, process modifications, and identification of water losses (TOB, 2021).

- ***Optimizing Water Consumption through Effective Production Planning:***

  In industrial production processes, planning the transformation of a raw material into a product with minimal process use is an effective practice for reducing labor costs, resource utilization costs, environmental impacts, and achieving efficiency (TUBİTAK MAM, 2016; TOB, 2021). When water efficiency factors are considered in production planning in industrial facilities, it reduces water consumption and wastewater amounts. Modifying production processes or combining certain processes in industrial facilities provides significant benefits in terms of water efficiency and scheduling (TOB, 2021).

- ***Determining Water Efficiency Targets:***

The first step to achieving water efficiency in industrial facilities is setting targets (TOB, 2021). This requires a detailed water efficiency analysis on a process-by-process basis. By doing so, unnecessary water uses, water losses, improper practices affecting water efficiency, process losses, and potential reusable water and wastewater sources (either treated or untreated) can be identified. It is also crucial to determine the water conservation potential and water efficiency targets for each production process as well as for the facility as a whole (TOB, 2021).

2.1.3 General Preventive Measures

- ***Detection and Reduction of Water Losses:***

  Water losses occur in equipment, pumps, and pipelines during industrial production processes. First, water losses should be identified, and regular maintenance should be conducted to keep equipment, pumps, and pipelines in good condition to prevent leaks (IPPC BREF, 2003). Regular maintenance procedures should particularly focus on the following:

  - Including pumps, valves, level switches, pressure, and flow regulators in the maintenance checklist.
- Conducting inspections not only on the water system but also on heat transfer and chemical distribution systems, as well as on broken and leaking pipes, barrels, pumps, and valves.
- Regular cleaning of filters and pipelines.
- Calibrating measurement equipment such as chemical measurement and distribution devices, thermometers, etc., and routinely checking and monitoring them at specified intervals (IPPC BREF, 2003). Effective maintenance, repair, cleaning, and loss control practices can result in water savings ranging from 1% to 6% (Öztürk, 2014).
- ***Minimizing Spills and Leaks:***

  Spills and leaks in businesses can lead to both raw material and water losses. Additionally, using wet cleaning methods to clean areas where spills occur can increase water consumption, wastewater amounts, and pollutant loads in the wastewater (TOB, 2021). To reduce raw material and product losses, anti-splash devices, trays, and screens are used to minimize spills and splashes (IPPC BREF, 2019).

- ***Preventing the Mixing of Clean and Dirty Water Flows:***

  In industrial facilities, identifying wastewater generation points and characterizing the wastewater allows for the separation of highly polluted wastewater from relatively clean wastewater, enabling them to be collected in different lines (TUBİTAK MAM, 2016; TOB, 2021). This allows for the reuse of wastewater streams with suitable quality, either treated or untreated. By separating wastewater streams, water pollution is reduced, treatment performance is enhanced, energy consumption related to reduced treatment needs is decreased, and emissions are lowered through wastewater recovery and the recovery of valuable materials. Additionally, heat recovery from separated hot wastewater streams is also possible (TUBİTAK MAM, 2016; TOB, 2021). The separation of wastewater streams generally requires high investment costs; however, costs can be reduced when significant amounts of wastewater and energy recovery are feasible (IPPC BREF, 2006).

- ***Using Cooling Water as Process Water in Other Processes:***

  In processes where thermal energy is heavily used and cooling is necessary, water cooling systems are commonly employed. By utilizing heat exchangers in the return of cooling water, it is possible to recover heat, prevent contamination of cooling water, and increase the return rates of cooling water, leading to water and energy savings (TUBİTAK MAM, 2016; TOB, 2021). Additionally, when cooling waters are collected separately, it is generally possible to reuse the collected water for cooling purposes or in suitable processes (EC, 2009). The reuse of cooling water can result in water savings of 2-9% (Greer et al., 2013), while energy consumption can be reduced by up to 10% (Öztürk, 2014; TOB, 2021).

- ***Using Pressure Washing Systems for Equipment Cleaning and General Cleaning***

  Water nozzles are widely used in equipment and facility cleaning. Effective results can be achieved in reducing water consumption and wastewater pollution loads by using appropriately placed nozzles. The use of active sensors and nozzles at points of high water consumption is crucial for efficient water use. Significant water savings can be achieved by replacing mechanical equipment with pressure nozzles (TUBİTAK MAM, 2016). In technically suitable processes, the use of optimized nozzles can reduce water consumption, wastewater generation, and wastewater pollution loads, providing major environmental benefits.

- ***Using Automatic Control-Shutoff Valves to Optimize Water Use:***

  Monitoring and controlling water consumption through flow control devices, meters, and computer-assisted monitoring systems provide significant technical, environmental, and economic advantages (Ozturk, 2014). Monitoring the amount of water consumed within the facility and various processes helps prevent water losses (TUBİTAK MAM, 2016). The use of flow meters and counters across the facility and specific production processes, along with automatic shutoff valves and control mechanisms developed through computer-assisted systems based on water consumption and specific quality parameters, is essential (TUBİTAK MAM, 2016). This application can lead to water savings of 20-30% on a process basis (DEPA, 2002; LCPC, 2010; IPPC BREF, 2003). Monitoring and controlling water consumption at the process level can achieve savings of 3-5% in process water consumption (Ozturk, 2014).

- ***Creating Enclosed Storage and Impermeable Waste/ Scrap Areas to Prevent the Transport of Toxic or Hazardous Chemicals:***

  In industrial facilities, closed and impermeable waste/scrap storage areas can be established to prevent the transport of toxic or hazardous chemicals to aquatic environments. This practice is already implemented under existing environmental regulations in our country. Through ongoing fieldwork, separate collection channels can be created for toxic or hazardous material storage areas in industrial facilities to collect these leakage waters separately and prevent them from mixing with natural water environments.

- ***Avoiding the Use of Drinking Water on Production Lines:***

In different subsectors of manufacturing, water with varying qualities can be utilized according to production needs. Typically, raw water sourced from underground resources is treated and used in production processes at industrial facilities. However, in some cases, despite being costly, drinking water may be used directly in production processes, or raw water may be disinfected with chlorinated compounds before being utilized. These chlorinated waters can react with organic compounds present in the water (such as dissolved organic matter (DOM)), producing harmful disinfection byproducts for living organisms (Özdemir & Toröz, 2010; Oğur et al.; TOB, 2021). Therefore, the use of drinking water containing residual chlorine or raw water disinfected with chlorinated compounds should be avoided whenever possible. Instead of chlorination, high oxidation disinfecting methods such as ultraviolet (UV), ultrasound (US), or ozone can be employed. By determining and using the necessary water quality parameters for each production process, unnecessary water procurement and treatment costs can be reduced, leading to savings in water, energy, and chemical costs (TUBİTAK MAM, 2016).

- ***Collecting Rainwater for Use as an Alternative Water Source in Facility Cleaning or Other Appropriate Areas:***

In today's context of diminishing water resources, rainwater harvesting is increasingly preferred, especially in areas with low rainfall. Various technologies and systems are available for rainwater collection and distribution, including cistern systems, ground infiltration, surface collection, and filtration systems. If collected rainwater meets the required quality standards, it can be used for production processes, garden irrigation, tank and equipment cleaning, surface cleaning, and similar purposes (Tanik et al., 2015).

In various cases, rainwater collected from industrial facility rooftops has been stored and used for landscaping, achieving up to 50% water savings in irrigation (Yaman, 2009). To increase soil permeability and facilitate the infiltration and absorption of rainwater, porous stones and green areas can be utilized (Yaman, 2009). Rainwater collected from building rooftops can also be used for vehicle washing and garden irrigation. After use, collected water can be biologically treated and recovered for reuse at a rate of up to 95% (Şahin, 2010).

- ***Reuse of Nanofiltration (NF) or Reverse Osmosis (RO) Concentrates Based on Characterization***

  Based on the characterization of wastewater and appropriate usage points, the reuse potential of other wastewater resulting from membrane processes should be evaluated (e.g., backwashing without chemicals, chemical-assisted backwashing, CIP cleaning, module cleaning, cleaning of chemical tanks, etc.).

  Nanofiltration is a membrane-based liquid separation technique suitable for treating well water and surface water, characterized by low energy consumption and low operating pressures. Reverse osmosis is also a membrane-based liquid separation technique but can separate smaller particles than nanofiltration (Akgül, 2016).

  By reusing nanofiltration or reverse osmosis concentrates, either after treatment or without treatment, savings can be achieved. In filtration processes, measures should be taken to reuse backwash waters in production processes and to reduce water consumption by utilizing cleaning systems (TOB, 2021).

https://genesiswatertech.com/wp-content/uploads/2019/08/RO-waste-water-recycling-1.jpg

Opposite Osmosis The system

- ***Use of Closed-Circuit Water Loops in Suitable Processes***

Refrigerants are chemical compounds that absorb heat from the materials to be cooled, affecting the performance of the cooling process through specific thermodynamic properties (Kuprasertwong et al., 2021).

In manufacturing processes, water is commonly used as a refrigerant for product cooling. During this cooling process, water can be reused through cooling towers or central cooling systems. If undesirable microbial growth occurs in the cooling water, it can be controlled by adding chemicals to the recirculation water (TUBİTAK MAM, 2016).

By reusing cooling water in processes such as cleaning, water consumption and the resulting wastewater volume are reduced. However, the need for energy to cool and recirculate the cooling water presents a trade-off. Heat recovery is also achieved through heat exchangers in cooling water systems. Closed-loop systems are generally used in facilities that utilize water cooling systems. However, cooling system blowdown is directly discharged into the wastewater treatment facility's channel. This discharged blowdown water can be reused in suitable production processes.

- ***Prevention of Risky Substances from Entering Aquatic Environments***

In industrial facilities, techniques such as dry cleaning can be used to prevent the mixing of chemicals that pose risks to aquatic environments, such as oils, emulsions, and binders, into wastewater flows. This helps protect water resources (TUBİTAK MAM, 2016).

- ***Recovery of Water from Rinsing Solutions for Reuse***

In industrial facilities, rinsing wastewater, which has a relatively clean character, can be reused without treatment in ground washing and garden irrigation processes that do not require high water quality (Öztürk, 2014). Recovery of rinsing water can lead to savings of 1-5% in raw water consumption.

- ***Use of Automatic Equipment for Water Conservation at Points of Use (e.g., Showers/Toilets)***

Water is vital in many sectors of the manufacturing industry, both for production processes and for personnel to meet necessary hygiene standards. Water consumption in industrial facilities can be managed in various ways, including the use of sensor taps and smart handwashing systems to save water. Smart handwashing systems not only conserve water but also enhance resource efficiency by properly adjusting the mixture of water, soap, and air.

- ***Reuse of Filter Wash Water and Cleaning Water in Production Processes***

The wastewater generated from the backwashing of activated carbon filters and softening devices primarily contains a high concentration of suspended solids (TSS). Backwash water, one of the easiest types of wastewater to recover, can be filtered using ultrafiltration facilities, resulting in water savings of up to 15% (URL - 1, 2021).

Regeneration wastewater produced after the regeneration process is soft water with high salt content, accounting for approximately 5-10% of total water consumption. This wastewater can be collected in a separate tank and used in processes that require high salt, for facility cleaning, and for domestic uses. A reserve tank, plumbing, and a pump are necessary for this. The reuse of regeneration wastewater can lead to reductions of about 5-10% in water consumption, energy usage, wastewater volume, and salt content in wastewater (Öztürk, 2014). The payback period for the reuse of regeneration water varies based on its application in production processes, facility cleaning, or domestic uses. In high-salt production processes, the payback period for the reuse of regeneration water (as both water and salt are recovered) is estimated to be less than one year. For facility and equipment cleaning or domestic uses, the payback period is expected to exceed one year (TOB, 2021).

In Turkey, reverse osmosis (RO) concentrates are typically combined with other wastewater flows and directed to the wastewater treatment facility. The concentrates produced in RO systems, which are used for additional hardness removal, can be utilized for garden irrigation and for cleaning within the facility and equipment (TUBİTAK MAM, 2016; TOB, 2021). Furthermore, by structuring monitoring related to raw water quality, it is possible to feed RO concentrates back into raw water reservoirs for mixing and reuse (TOB, 2021).

- ***Collection and Treatment of Gray Water in Facilities***

Wastewater In industrial facilities, the wastewater generated includes not only industrial wastewater from production processes but also gray water from showers, sinks, kitchens, etc. Wastewater from these sources is referred to as gray water. By treating this gray water through various treatment processes, it can be reused in areas that do not require high water quality, contributing to water savings.

- ***Documentation of Production Procedures to Prevent Water and Energy Waste***

  To ensure efficient production in a facility, it is essential to identify and evaluate potential issues and resources, and to implement effective procedures for controlling production stages (Ayan, 2010). Establishing and applying appropriate procedures in production processes ensures the more efficient use of resources (such as raw materials, water, energy, chemicals, personnel, and time) and guarantees reliability and quality in production (Ayan, 2010). Documented production procedures contribute to the assessment of operational performance and the development of rapid responses to problem-solving (TUBİTAK MAM, 2016; TOB, 2021). Effectively implementing and monitoring the procedures specific to production processes is one of the most effective ways to ensure product quality, receive feedback, and develop solutions (Ayan, 2010). Documenting and efficiently applying and monitoring production procedures is a good management practice and serves as an effective tool in structuring and maintaining a clean production approach and environmental management system. The costs and economic gains of implementing such practices may vary by sector or facility structure (TUBİTAK MAM, 2016; TOB, 2021). While the establishment and monitoring of production procedures may not be costly, the potential savings and benefits can lead to a short payback period (TUBİTAK MAM, 2016; TOB, 2021).

- ***Use of Computer-Aided Control Systems in Production Processes***

  In industrial facilities, inefficient resource use and environmental issues are directly related to input-output flows, necessitating the accurate definition of process inputs and outputs (TUBİTAK MAM, 2016). This allows for the development of measures aimed at enhancing resource efficiency, economic performance, and environmental performance. Organizing input-output inventories is considered a prerequisite for continuous improvement. Such management practices require the involvement of technical staff and upper management, and they can pay for themselves quickly through the efforts of various specialists (IPPC BREF, 2003). It is necessary to utilize measurement equipment and conduct routine analyses/measures specific to processes to maximize efficiency. Leveraging computerized monitoring systems enhances the technical, economic, and environmental benefits that can be achieved (TUBİTAK MAM, 2016).

- ***Characterization of Wastewater Volumes and Qualities for Reuse***

  Identifying and characterizing the points of wastewater generation in industrial facilities allows for the potential reuse of various wastewater streams, either treated or untreated (Öztürk, 2014; TUBİTAK MAM, 2016; TOB, 2021). In this context, backwash waters, RO concentrates, blowdown waters, condensate, and relatively clean washing and rinsing waters can be reused without treatment in the same or different processes and in areas that do not require high water quality (such as facility and equipment cleaning).

In addition, wastewater streams that cannot be reused directly can be treated using appropriate treatment technologies and then reused in production processes.

Membrane filtration processes are an integral part of many wastewater reuse systems. Nanofiltration (NF) and Reverse Osmosis (RO) filtration systems are utilized for industrial wastewater recovery. Microfiltration (MF) and ultrafiltration (UF) are generally used for pre-treatment of water before it undergoes NF or RO processes (Singh et al., 2014).

- ***Monitoring Water and Wastewater in Production Processes***

In industrial facilities, resource use can lead to inefficiencies and environmental problems stemming from input-output flows. Therefore, it is essential to monitor the quantity and quality of water used and wastewater generated in production and auxiliary processes (TUBİTAK MAM, 2016; TOB, 2021). Monitoring quantity and quality on a process basis, in conjunction with other good management practices (such as personnel training and establishment of an environmental management system), can reduce energy consumption by 6-10% and water use and wastewater volumes by up to 25% (Ozturk, 2014).

The main steps for monitoring the quantity and quality of water and wastewater include:

- Use of monitoring equipment (such as meters) to track water, energy, etc., consumption on a process basis,
- Development of monitoring procedures,
- Identification, monitoring, documentation, comparative evaluation, and reporting of all inputs and outputs related to the production process (raw materials, chemicals, water, products, wastewater, sludge, solid waste, hazardous waste, and by-products),
- Monitoring raw material losses in production processes where raw materials are converted to products and taking measures against those losses (ÇŞİDB, 2020e).

2.1.4 Measures Related to Auxiliary Processes

Cooling System Measures

- ***Use of Closed-Circuit Cooling Systems to Reduce Water Usage***
  Closed-circuit cooling systems significantly reduce water consumption compared to open-circuit systems, which typically use more water. In closed-circuit systems, the same water is recirculated, while typically only the amount of evaporated water needs to be replaced. Optimizing cooling systems can also reduce evaporation losses.

- ***Collection of Surface Runoff with a Separate System for Use as Cooling Water or Process Water***
  Most industrial facilities generate wastewater from process-related or external sources. The collected wastewater can be treated and reused in appropriate locations. By treating and reusing the wastewater generated in a facility, various industrial facilities can achieve savings in varying amounts. Water generated from surface runoff can be collected with a separate system and used as cooling water (TOB, 2021).

- ***Increasing the Number of Cycles in Closed-Circuit Cooling Systems to Improve the Quality of Makeup Water and Reduce Water Consumption***
  Water is used as a refrigerant in many processes within the manufacturing industry, including the cooling of products. Water is recirculated via cooling towers or central cooling systems for the cooling process. If unwanted microbial growth occurs in the cooling water, chemical additives can be used to control it (TUBİTAK MAM, 2016). By properly conditioning the recirculation process, the number of cycles can be increased. This approach reduces the amount of fresh water supplied to the system, thus conserving water. Additionally, proper conditioning of the cooling makeup water can also increase the number of cycles (TOB, 2021).

- ***Establishment of Water Softening Systems for Effective Cooling Water Recovery***

  Cooling water is collected separately and can be used for cooling purposes or reevaluated in suitable processes (EC, 2009). For this system to function effectively, a water softening system is necessary. The cooling water has suitable quality for reuse as cleaning and irrigation water. However, due to its hardness, it may cause corrosion problems over time when used as cooling water, necessitating additional softening.

  Before reuse in cooling or process applications, this water must undergo appropriate disinfection processes. Furthermore, these waters can be treated using suitable treatment techniques (such as membrane filtration, advanced oxidation, chemical precipitation, granular activated carbon adsorption, etc.) to allow for their reuse not only in cooling processes but also in all production processes (TUBİTAK MAM, 2016).

  As the hardness level of cooling water increases, scaling and deposits form on the surfaces. This buildup adversely affects heat transfer, reducing energy efficiency and increasing energy costs. With increased evaporation in the system, the ion concentration and conductivity of the water rise. To prevent these issues, the cooling water should undergo chemical conditioning with scale and corrosion inhibitors, disinfection with a biocide to prevent biological activity, and chemical and mechanical cleaning of cooling towers at least twice a year to remove deposits. Additionally, hardness and conductivity values should be maintained at as low levels as possible (TUBİTAK MAM, 2016).

This Softening Systems

Cooling to their systems related METs

- ***Use of Corrosion and Scale Inhibitors to Increase the Number of Cycles in Closed Water Loop Systems***

cooling Cooling towers and evaporative condensers are effective and low-cost systems for removing heat from air conditioning and industrial process cooling systems (IPPC BREF, 2001b; TOB, 2021). In these systems, more than 95% of the circulating water can be recovered (TUBİTAK MAM, 2016). Because some of the recirculation water is evaporated, impurities remain in the recirculation water, leading to increased concentrations of impurities with each cycle. Contaminants that can enter the cooling system with air may cause contamination in the recirculation water (TUBİTAK MAM, 2016). If impurities and pollutants are not effectively controlled, they can lead to scale formation (deposits) and corrosion, unwanted biological growth, and sludge accumulation. This situation can become a chronic problem, leading to decreased efficiency of heat transfer surfaces and increased operating costs. In this case, the quality of the makeup water supplied to the cooling system must be managed through a specifically designed water conditioning program considering the cooling water system's material and operating conditions. This may involve blowdown control, biological growth control, corrosion control, avoidance of hard water usage, use of sludge control chemicals, and filtration and screening systems (TUBİTAK MAM, 2016). Additionally, establishing and periodically implementing an effective cleaning procedure and program is a good management practice for protecting cooling systems. Corrosion is one of the most significant problems in cooling systems. In cooling tower recirculation water, as the hardness level increases, dissolved solids (sulfates, chlorides, carbonates, etc.) that cause corrosion will lead to the formation of scale and deposits on surfaces over time. Furthermore, the accumulation of deposits adversely affects heat transfer, reducing energy efficiency. To prevent these issues, a conditioning program for scale and corrosion inhibitors should be implemented, disinfection with a biocide to prevent biological activation, and cooling towers in use should be chemically and mechanically cleaned at least twice a year to remove deposits. The hardness and conductivity of the makeup water should be kept as low as possible (IPPC BREF, 2001; Kayabek et al., 2005). It may be necessary to use an appropriate treatment system to improve the quality of the makeup water (conditioning). Additionally, unwanted microbial growth must also be kept under control (IPPC BREF, 2001b; TOB, 2021). Due to micro-residues and sediments in cooling water, blowdown occurs in cooling systems, similar to what happens in steam boilers. The deliberate draining of the cooling system to balance the increasing concentration of solids is referred to as cooling blowdown. By pre-treating cooling water using appropriate methods and continuously monitoring the quality of the cooling water, the use of biocides and the amounts of blowdown can be reduced (TUBİTAK MAM, 2016). Although the investment cost depends on the scale of the implementation, the expected payback period for investment expenses ranges from 3 to 4 years (IPPC BREF, 2001).

- ***Use of Air-Cooling Systems Instead of Water-Cooling in Cooling Systems***

  Industrial cooling systems are used for cooling heated products, processes, and equipment. For this purpose, both closed and open circuit cooling systems can be utilized, as well as industrial cooling systems that use a fluid (gas or liquid) or dry air (IPPC BREF, 2001b; TOB, 2021). Air-cooling systems consist of finned tube elements, condensers, and air fans (IPPC BREF, 2001b; TOB, 2021). Air-cooling systems can operate based on different principles. In industrial air-cooling systems, heated water is cooled with air in closed circuit cooling condensers and heat exchangers (IPPC BREF, 2001b; TOB, 2021). In water-cooling systems, heated water is taken to a cooling tower, where cooling is achieved in evaporative systems. However, even though water-cooled systems operate in a closed circuit, significant evaporation occurs. Additionally, some water is lost as blowdown in cooling systems (IPPC BREF, 2001b; TOB, 2021). The use of air-cooling systems instead of water in cooling systems effectively reduces evaporation losses and also decreases the risk of cooling water contamination (IPPC BREF, 2001b; TOB, 2021).

Measures Regarding Ventilation and Air Conditioning Systems METs

- ***Reusing Liquid Generated from Condensation in the Ventilation System***

  During the ventilation cycle, condensation water of good quality can be produced in the system. For example, in a facility in Spain, condensation water with approximately 200 μS conductivity from the ventilation system is collected in a tank and used for washing the automatic galvanizing line (MedClean, n.d.).

- ***Replacing Old Equipment in the Ventilation System with Ion Exchange Resins Based on Reverse Osmosis Principles for Water Reuse***

  In the ventilation system, ion exchange resins are used to bring the conductivity of the final discharge water to a suitable level for equipment cleaning. For instance, in a facility in Spain, replacing the equipment in the ventilation system with ion exchange resins produces output water with a conductivity of approximately 1000 μS, which is reused in the system (MedClean, n.d.).

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