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MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF WATER MANAGEMENT

Water Efficiency Guide Documents Series

N.E.C. MANUFACTURE OF OTHER TEXTILES

NACE CODE: 13.99

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Abbreviations

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

1 Introduction

Our country is located in the Mediterranean basin, where the effects of global climate change are felt intensely, and is considered among the regions that will be most affected by the negative effects of climate change. Projections on how our water resources in our basins will be affected in the future due to climate change show that our water resources may decrease by up to 25 percent in the next hundred years.

For 2022, the annual amount of usable water per capita in our country is 1,313 m^3, and it is expected that the annual amount of usable water per capita will fall below 1,000 cubic meters after 2030 due to human pressures and the effects of climate change. It is obvious that if the necessary measures are not taken, Turkey will become a country suffering from water scarcity in the very near future and will bring many negative social and economic 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". Water efficiency approach; It is based on the rational, sharing, equitable, efficient and effective use of water in all sectors, especially drinking water, agriculture, industry and household uses, taking into account the needs of not only people but also ecosystem sensitivity and all living things by protecting it in terms of quantity and quality.

With the increasing demand for water resources, the change in precipitation and temperature regimes as a result of climate change, the increase in population, urbanization and pollution, it is becoming more and more important to share the usable water resources among the users in a fair and balanced way. For this reason, it has become a necessity to create a roadmap based on efficiency and optimization in order to protect and use limited water resources with sustainable management practices.

In the sustainable development vision determined by the United Nations, Goal 7 from the Millennium Development Goals: *Ensuring Environmental Sustainability* and Goal 9 from the Sustainable Development Goals: *Industry, Innovation and Infrastructure* and *Goal 12: Responsible Production and Consumption goals* Issues such as efficient, fair and sustainable use of resources, especially water, environmentally friendly production and consumption that is the concern of future generations are included.

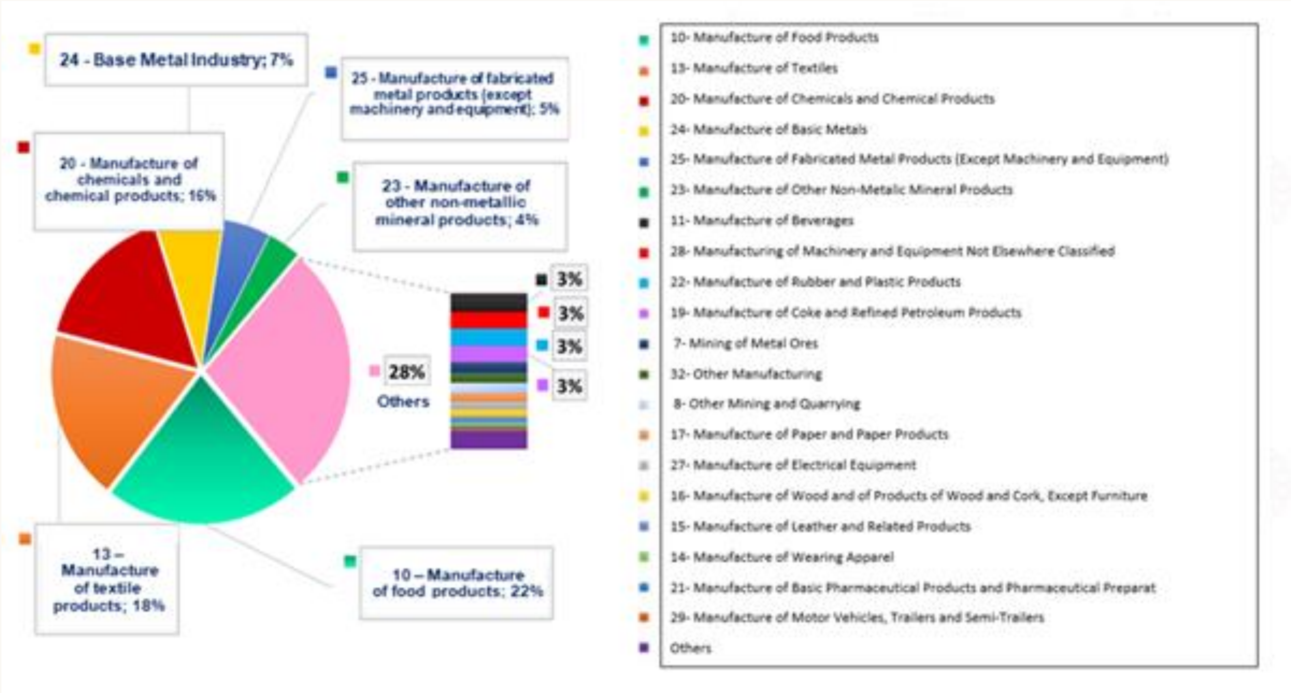
In the European Green Deal Action Plan prepared by our country within the scope of the European Green Deal, where member countries agree on goals such as implementing a clean, circular economy model with the goal of carbon neutrality, expanding the efficient use of resources and reducing environmental impacts, actions emphasizing water and resource efficiency in various fields, especially in industry, production and consumption have been determined.

The "Industrial Emissions Directive (EED)", which is one of the most important components of the European Union environmental legislation in terms of industry, includes the measures to be taken to control, prevent or reduce the discharges/emissions from industrial activities to the receiving environment, including air, water and soil, with an integrated approach. In the Directive, Best Available Techniques (BAT) are presented in order to systematize the applicability of cleaner production processes and to eliminate the difficulties experienced in practice. Considering the costs and benefits, BATs are the most effective implementation techniques for a high level of environmental protection. In accordance with the Directive, Reference Documents (BAT-BREF) have been prepared for each sector, in which the BATs are explained in detail. In BREF documents, BATs are presented in a general framework such as good management practices, general precautionary techniques, chemical use and management, techniques for various production processes, wastewater management, emission management and waste management.

The Ministry of Agriculture and Forestry, General Directorate of Water Management carries out studies aimed at disseminating efficient practices in urban, agricultural, industrial and individual water use and increasing social awareness. "Water Efficiency Strategy Document and Action Plan within the Framework of Adaptation to the Changing Climate (2023-2033)" entered into force with the Presidential Circular No. 2023/9Water efficiency action plans addressing all sectors and stakeholders have been prepared. In the Industrial Water Efficiency Action Plan, a total of 12 actions have been determined for the period 2023-2033 and responsible and relevant institutions have been appointed for these actions. Within the scope of the said Action Plan; Carrying out studies to determine specific water usage ranges and quality requirements on the basis of sub-sectors in the industry, organizing technical training programs and workshops on a sectoral basis, and preparing water efficiency guidance documents are defined as the responsibility of the General Directorate of Water Management.

On the other hand, with the "Industrial Water Use Efficiency Project According to NACE Codes" ***carried out by the Ministry of Agriculture and Forestry, General Directorate of Water Management,*** the best sectoral techniques specific to our country have been determined within the scope of studies to improve water efficiency in the industry. As a result of the study, sectoral guidance documents and action plans classified with NACE codes, which include the measures recommended to improve water use efficiency in sectors with high water consumption operating in our country, have been prepared.

As in the world, the sectors with the highest share in water consumption in our country are food, textile, chemistry and basic metal sectors. Within the scope of the studies, field visits were carried out in enterprises representing 152 sub-sectors in 35 main sectors, especially food, textile, chemistry, basic metal industry, which will represent production areas of different capacities and diversity within the scope of NACE Codes, which operate in our country and have high water consumption, and provide data on water supply, sectoral water use, wastewater generation and recycling. and the best available techniques (BAT) and sectoral reference documents (BREF) published by the European Union, water efficiency, cleaner production, water footprint, etc.



Distribution of water use in industry on a sectoral basis in our country

As a result of the studies, specific water consumption and potential savings rates for the processes of the enterprises were determined for 152 different 4-digit NACE codes with high water consumption, and water efficiency guidance documents were prepared by taking into account the EU best available techniques (BAT) and other cleaner production techniques. The guidelines include 500 techniques for water efficiency (BAT);
It has been examined under 4 main groups: (i) Good Management Practices, (ii) General Measures, (iii) Measures Related to Auxiliary Processes and (iv) Sector-Specific Measures.

Within the scope of the project, environmental benefits, operational data, technical specifications-requirements and applicability criteria were taken into account during the determination of BATs for each sector. In the determination of BATs, BREF documents were not limited to the BATs, but also different data sources such as current literature data, real case studies, innovative practices, and reports of sector representatives on a global scale were examined in detail and sectoral BAT lists were created. In order to evaluate the suitability of the BAT lists created for the local industrial infrastructure and capacity of our country, the BAT lists prepared specifically for each NACE code were prioritized by the enterprises by scoring them on the criteria of water saving, economic saving, environmental benefit, applicability, cross-media impact, and the final BAT lists were determined using the scoring results. Sectoral water efficiency guidelines have been created on the basis of the NACE code based on the water and wastewater data of the facilities visited within the scope of the project and the final BAT lists highlighted by the sectoral stakeholders and determined by taking into account the local dynamics specific to our country.

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 MoAFacco 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, eleROonic and optical products (including sub-production area represented by 2 four-digit NACE Codes)
- Manufacture of eleROical 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)
- EleROicity, 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)

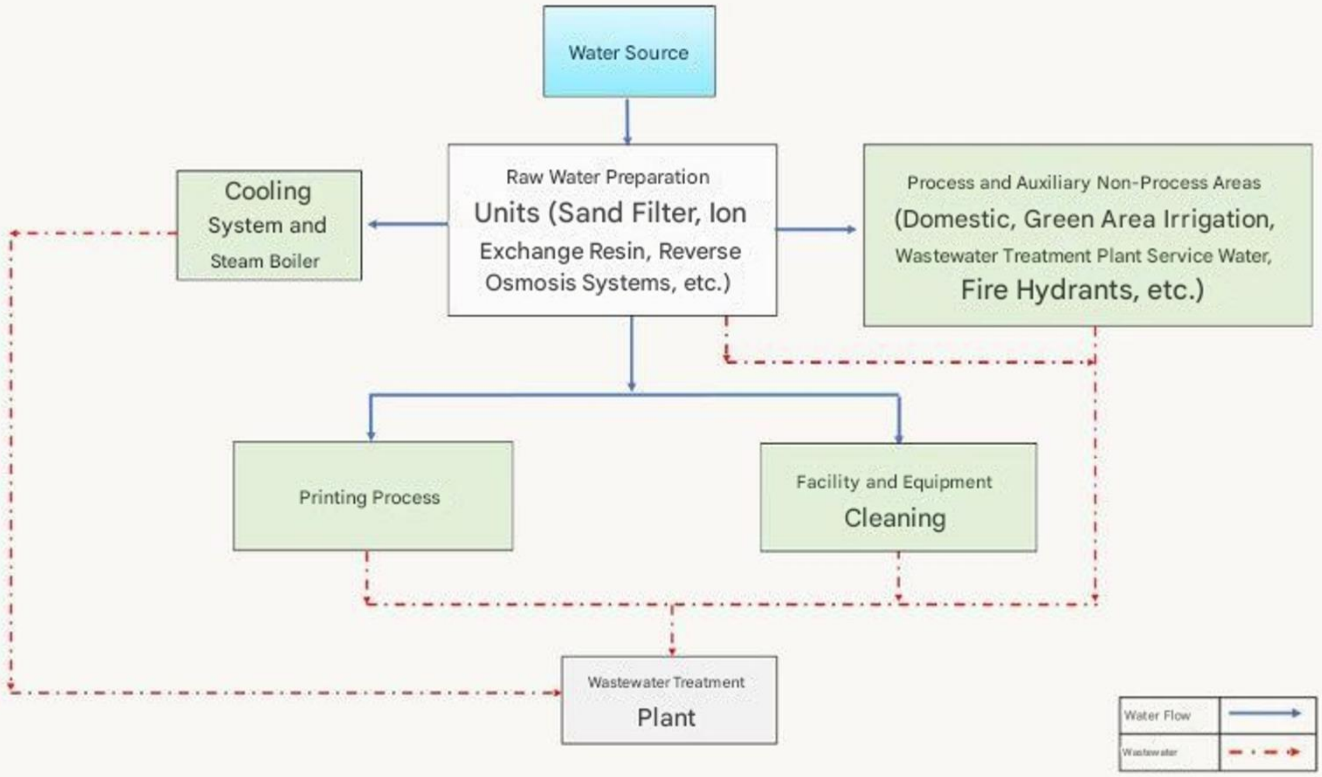
"Manufacture of Textile Products" and "Manufacture of Apparel"

Under the "Manufacture of Textile Products" and "Manufacture of Clothing" sectors, the sub-production branches for which guide documents have been prepared are as follows:

13.10	Preparation and twisting of textile fiber
13.20	Woven
13.30	Finishing of textiles
13.91	Manufacture of knitted (knitwear) or crocheted (crochet) fabrics
13.92	Manufacture of finished textiles other than apparel
13.93	Manufacture of carpets and rugs
13.95	Manufacture of nonwovens and products made from nonwovens, excluding apparel
13.96	Manufacture of other technical and industrial textiles
13.99	Manufacture of other textiles n.e.c.
14.13	Manufacture of other outerwear

2.1 Manufacture of Other Textiles n.e.c. (NACE 13.99)

Other Textiles Manufacturing Sector Not Elsewhere Classified Water Flow Diagram



	Minimum	Maximum
Specific Water Consumption of Facilities Visited within the Scope of the Project (L/kg product)	1	8.5
Reference Specific Water Consumption (L/kg product)	0.5	40

Percentage Distribution of Water Efficiency Practices

Within the scope of the production of other textiles not classified elsewhere, products such as needlework, lace, felt, gipe and chenille yarn are manufactured. Although the production processes vary greatly depending on the raw materials used in the facilities, the techniques/technologies applied and the features expected from the product, the sector generally covers pre-treatment, dyeing-printing and finish-finishing (finishing) processes. In pre-treatment processes such as bleaching, bleaching, hydrophilizing, mercerization, textile materials are prepared for the dyeing-printing process. In addition, technical properties such as strength, dyestuff affinity, gloss are also given to the material to be used. Dyeing-printing processes, on the other hand, aim to color textile materials with various dyeing-printing methods and recipes . In the final finishing processes, technical properties such as non-flammability, water-oil repellency, wrinkle resistance are gained in accordance with the use of the final product.

Within the scope of the manufacture of other textiles not classified elsewhere, water consumption is generally realized in dyeing-printing processes. Significant water consumption is also realized for filter washing, resin regeneration and membrane cleaning processes in raw water preparation units such as activated carbon filters, ion exchange resins, reverse osmosis, which are used to produce soft water for use in production processes in the sector. In addition, water consumption occurs in auxiliary units such as cooling towers and steam boilers.

In the manufacturing sector of other textiles not elsewhere classified, the reference specific water consumption is in the range of 0.5 – 40 L/kg. The specific water consumption of the production branch analyzed within the scope of the study is 1 – 8.5 L/kg. It is possible to achieve 24-60% water recovery in the sector with the implementation of sector-specific techniques, good management practices, measures in the nature of general measures and measures related to auxiliary processes.

13.99 Manufacture of Other Textiles Not Elsewhere Classified
The priority water efficiency implementation techniques recommended under the NACE code are presented in the table below.

NACE Code	NACE Code Description		Prioritized Sectoral Water Efficiency Techniques
13.99	Manufacture of Other Textiles n.e.c.		**Industry-Specific Measures**
		1.	Reduction of print paste losses on rotary printers
		2.	Reuse of finishing wastewater in other processes
		3.	Use of polyfunctional reactive dyestuffs instead of conventional reactive dyes
		4.	Treatment and reuse of wastewater containing pigment printing paste
			Good Management Practices
		1.	Preparation of water BAT diagrams and mass balances for water
		2.	Preparation of a water efficiency action plan to reduce water use and prevent water pollution
		3.	Providing technical training to personnel for the reduction and optimization of water use
		4.	Good production planning to optimize water consumption
		5.	Setting water efficiency targets
		6.	The water used in production processes and auxiliary processes and the formed Monitoring wastewater in terms of quantity and quality and adapting this information to the environmental management system
			General Precautionary Measures
		1.	Minimization of spills and leaks
		2.	Recovery of water from rinsing solutions and reuse of recovered water in processes appropriate to its quality
		3.	Use of automatic equipment and equipment (sensors, smart hand washing systems, etc.) that will save water at water usage points such as showers/toilets, etc.
		4.	Avoiding the use of drinking water in production lines
		5.	Detection and reduction of water losses
		6.	Use of automatic check-off valves to optimise water use
		7.	Documentation of production procedures and use by employees to prevent waste of water and energy
		8.	Construction of closed storage and impermeable waste/scrap yard to prevent the transportation of toxic or hazardous chemicals for the aquatic environment
		9.	Substances that pose a risk in the aquatic environment (oils, emulsions, binders storage, storage and prevention of mixing with wastewater after use.
		10.	Prevention of mixing of clean water streams with polluted water streams Wastewater quantities and qualities at all wastewater formation points
		11.	which can be reused with or without treatment by characterization Determination of wastewater BATs

NACE Code	NACE Code Description	Prioritized Sectoral Water Efficiency Techniques
13.99	Manufacture of Other Textiles n.e.c.	12. Use of closed-loop water cycles in appropriate processes
		13. Use of computer-aided control systems in production processes
		14. Untreated reuse of relatively clean wastewater from washing, rinsing and equipment cleaning in production processes
		15. Determining the scope of reuse of washing and rinsing waters
		16. Separate collection and treatment of gray water in the facility and use it in areas that do not require high water quality (green area irrigation, floor, floor washing, etc.)
		17. Implementation of time optimization in production and arrangement of all processes to be completed as soon as possible
		18. Collecting rainwater and evaluating it as an alternative water source in facility cleaning or in appropriate areas
		19. Avoiding the need for rinsing between activities by using compatible chemicals in successive processes
		Precautions for Ancillary Processes
		1. Saving water by reusing steam boiler condensate Saving water by insulating steam and water lines (hot and cold),
		2. Prevention of water and steam losses at pipes, valves and connection points in the lines and monitoring them with a computer system Based on the principle of reverse osmosis of old equipment in the ventilation system
		3. replacement with ion exchange resins (systems that produce demineralized water) and reuse of water
		4. Reuse of the liquid formed by condensation from the ventilation system
		5. Avoiding unnecessary cooling processes by identifying processes that need wet cooling
		6. Reduction of water consumption in closed-loop cooling systems by increasing the number of cycles and improving the quality of the catch-up water
		7. Increasing the number of cycles by using anti-corrosion and anti-scale inhibitors in systems with a closed water loop
		8. Prevention of flash steam losses due to boiler draining
		9. The use of hot water produced in the cogeneration system in heating processes

NACE Code	NACE Code Description	Prioritized Sectoral Water Efficiency Techniques
13.99	Manufacture of Other Uniform Styles Not	1. Use of cold water produced in the cogeneration system in cooling processes 2. Use of a closed-loop refrigeration system to reduce water use 3. Reducing the amount of blowdown by using deaerators in steam boilers 4. Minimizing boiler discharge water (blowdown) in steam boilers 5. Reuse of energy generated from the steam condenser A

total of 43 techniques have been proposed in this sector.

Manufacture of Other Textiles Not Elsewhere Classified NACE Code;

(i) Sector-Specific Measures,
(ii) Good Management Practices,
(iii) General Precautions and
(iv) Precautions Regarding Auxiliary Processes are given under separate headings.

2.1.1 Industry-Specific Measures

- ***Reduction of print paste losses on rotary printers***

  In order to ensure water efficiency in printing and dyeing processes, it is necessary to reduce the printing paste losses in rotary printing by minimizing the volume of printing paste supply systems in rotary printing machines, recovery of the printing paste, two-step reactive printing method, etc. Printing paste losses are also reduced by optimizing the size of feeding equipment/tanks and reusing printing pastes (black ink production, etc.). Thus, the wastewater pollution load is reduced and the recovery potential of wastewater increases.

- ***Treatment and reuse of wastewater containing pigment printing paste***

  Pigment printing paste wastewater containing organic paint pigments, organic thickeners, organic binders, fixants, catalysts and softeners can be reused after treatment with appropriate membrane techniques. Process steps generally include microfiltration/ultrafiltration application after the pre-treatment stage such as coagulation and precipitation . Then, the suspended solids in the concentrated waste are removed by adding flocculant . The resulting sludge is separated from the system for physicochemical treatment. It is stated that with the application of this technique, 90% of the wastewater generated in the process can be recovered and reused in washing (IPPC BREF, 2003).

- ***Use of polyfunctional reactive dyestuffs instead of conventional reactive dyes The*** fixation of reactive dyes to cellulose fibers is expressed either as a percentage of the total amount of dye appliquéd (fixation rate) or as a percentage of the amount of dye extracted (shrinkage rate)

  Is. In monofunctional paints, the fixation rate is 60% and the shrinkage rate is about 70% is around. In other words, 40% of the appliquéd paint is lost in wastewater. In bifunctional reactive paints, shrinkage rates of over 90% can be achieved with fixation rates of approximately 80%. With the use of bifunctional reactive dyes, the amount of unused dyestuff given to wastewater is significantly reduced. This reduction is advantageous in cases where advanced oxidation techniques are used for the treatment of dyes in wastewater. Compared to conventional reactive dyes, the use of polyfunctional reactive dyestuffs provides high fixation efficiency and reduces the use of salt, energy and water.

- ***Reuse of finishing wastewater in other processes***

  The reuse of finishing wastewater in other processes is one of the effective practices that reduce water use in the sector . With this application, water savings can be achieved at varying rates in various industrial facilities.

2.1.2 Good Management Practices

- ***Preparation of water BAT diagrams and mass balances for water***

  Determination of water use and wastewater generation points in industrial facilities, creation of water wastewater balances in production processes and auxiliary processes other than production processes are the basis of many good management practices in general. Creation of process profiles throughout the plant and on the basis of production processes; It facilitates the identification of unnecessary water usage points and high water use points, the evaluation of water recovery opportunities, process modifications and the determination of water losses (MoAF, 2021).
- ***Preparation of a water efficiency action plan in order to reduce water use and prevent water pollution Preparation*** of an action plan that includes what to do in the short, medium and long term in order to reduce the amount of water-wastewater in industrial facilities and to prevent water pollution in terms of water efficiency

  Important. At this point, determining the water needs throughout the facility and in the production processes, water

  quality requirements should be determined at the points of use, wastewater formation points and wastewater characterization should be done (MoAF, 2021). At the same time, it is necessary to determine the measures to be implemented to reduce water consumption, wastewater generation and pollution loads, to make feasibility and to prepare action plans for the short-medium-long term. In this way, water efficiency and sustainable water use are ensured in facilities (MoAF, 2021).
- ***Providing technical training to personnel for the reduction and optimization of water use***

  With this measure, water saving and water recovery can be achieved by increasing the training and awareness of the personnel, and water efficiency can be achieved by reducing water consumption and costs. Due to the fact that the personnel do not have the necessary technical knowledge in industrial facilities, problems may arise with the use of high amounts of water and wastewater formation. For example, it is important that cooling tower operators, who represent a significant proportion of water consumption in industrial operations, are properly trained and have technical knowledge. In applications such as determining water quality requirements in production processes, measuring water and wastewater amounts, etc., it is necessary for the relevant personnel to have sufficient technical knowledge (MoAF, 2021). For this reason, it is important to provide training to staff on water use reduction, optimization and water saving policies. Practices such as involving personnel in water conservation studies, creating regular reports on water usage amounts before and after water efficiency initiatives, and sharing these reports with personnel support participation and motivation in the process. The technical, economic and environmental benefits to be obtained through personnel training give results in the medium or long term (TUBITAK MAM, 2016; MOAF, 2021).
- ***Good production planning to optimize water consumption***

  In industrial production processes, planning a raw material until it turns into a product by using the least process is an effective practice to reduce labor costs, resource use costs and environmental impacts and to ensure efficiency (TUBITAK MAM, 2016; MoAF, 2021). Production planning in industrial facilities by considering the water efficiency factor reduces water consumption and wastewater. Modifying production processes or combining some processes in industrial facilities provides significant benefits in terms of water efficiency and time planning (MoAF, 2021).

- ***Setting water efficiency targets***

  The first step in achieving water efficiency in industrial facilities is to set targets (MoAF, 2021). For this, first of all, a detailed water efficiency analysis should be carried out on the basis of processes. Thus, unnecessary water use, water losses, wrong practices affecting water efficiency, process losses, reusable water-wastewater resources with or without treatment can be determined. It is also extremely important to set water saving potential and water efficiency targets for each production process and the plant as a whole (MoAF, 2021).

2.1.3 General Precautionary Measures

- ***Detection and reduction of water losses***

In industrial production processes, water losses can occur in equipment, pumps and pipelines. In order to prevent water losses, it must be detected first. It should be ensured that equipment, pumps and pipelines are regularly maintained and kept in good condition, and leakage should be prevented. Therefore, regular maintenance procedures should be established (IPPC BREF, 2003).

Particular attention should be paid to the following areas:

- Adding pumps, valves, level switches, pressure and BAT regulators to the maintenance checklist
- Carrying out inspections not only for the water system, but also especially for heat transfer and chemical distribution systems, broken and leaking pipes, drums, pumps and valves
- Regular cleaning of filters and pipelines
- Calibrating, routinely checking and monitoring measuring equipment such as chemical measuring and dispensing instruments, thermometers, etc. (IPPC BREF, 2003).

With effective maintenance-repair, cleaning and loss control practices, savings ranging from 1-6% in water consumption can be achieved (Öztürk E., 2014).

- ***Prevention of mixing of clean water streams with dirty water streams***

By determining the wastewater formation points and characterizing the wastewater in industrial facilities, wastewater with high pollution load and relatively clean wastewater can be collected in separate lines (TUBITAK MAM, 2016; MoAF, 2021). In this way, wastewater streams of appropriate quality can be reused with or without treatment. By separating wastewater streams, water pollution is reduced, treatment performances are increased, energy consumption can be reduced in relation to reducing treatment needs, and emissions are reduced by ensuring wastewater recovery and recovery of valuable materials . In addition, heat recovery from separated hot wastewater streams is also possible (TUBITAK MAM, 2016; MoAF, 2021)Separation of wastewater streams often requires high investment costs, and costs can be reduced when it is possible to recover large amounts of wastewater and energy (IPPC BREF, 2006).

- ***Avoiding the use of drinking water in production lines***

In different sub-sectors of the manufacturing industry, water with different water quality can be used in accordance with production purposes. In industrial facilities, raw water obtained from underground water sources is used in production processes after being treated. However, in some cases, although it is costly in production processes, drinking water can be used directly or raw water is disinfected with chlorinated compounds and evaluated in production processes. These waters, which contain residual chlorine, can react with organic compounds (natural organic substances (NOM)) in the water in the production processes and form disinfectant by-products harmful to living metabolisms (Özdemir & Toröz, 2010; Oğur et al.; MOAF, 2021). The use of drinking water containing residual chlorine compounds or raw water disinfected with chlorinated compounds should be avoided as much as possible. In the disinfection of raw water, disinfection methods with high oxidation ability such as ultraviolet (UV), ultrasound (US) or ozone can be used instead of chlorine disinfection. In order to increase the technical, economic and environmental benefits to be provided by the application, determining and using the water quality parameters required in each production process helps to reduce unnecessary water supply and treatment costs. With this application, it is possible to reduce water, energy and chemical costs (TUBITAK MAM, 2016).

- ***Use of closed-loop water cycles in appropriate processes***

In general, refrigerants are chemical compounds with certain thermodynamic properties that affect the performance of the cooling process, taking heat from the substances to be cooled and cooling them (Kuprasertwong et al., 2021).

Water is used as a refrigerant in manufacturing industry processes and in many processes led by product cooling. While this cooling process is carried out, the water can be reused through the cooling tower or central cooling systems. If unwanted microbial growth occurs in the cooling water, it can be controlled by adding chemicals to the recirculation water (TUBITAK MAM, 2016).

By reusing cooling water in processes such as cleaning, water consumption and the amount of wastewater generated are reduced. However, the need for energy for cooling and recirculation of cooling water emerges as a side interaction.

Heat recovery is also provided by the use of heat exchangers in cooling waters. Generally , closed loop systems are used in facilities where water cooling systems are used. However, the cooling system blowdowns are removed by giving them directly into the wastewater treatment plant channel. These removed blowdown waters can be reused in suitable production processes.

- ***Use of computer-aided control systems in production processes***

Since inefficient resource use and environmental problems in industrial facilities are directly related to input-output BATs, process inputs-outputs should be defined in the best way specific to production processes (TUBITAK MAM, 2016). Thus, it becomes possible to develop measures to increase resource efficiency, economic and environmental performance. Organizing input-output inventories is considered a prerequisite for continuous improvement. While such management practices require the participation of technical staff and senior management, they pay for themselves in a short time with the work of various experts (IPPC BREF, 2003). It is necessary to use measurement equipment on the basis of application processes and to perform some routine analyzes/measurements specific to the processes. In order to obtain the highest level of efficiency from the application, using computerized monitoring systems as much as possible ensures that the technical, economic and environmental benefits to be obtained are increased (TUBITAK MAM, 2016).

- ***Storage, storage and prevention of substances that pose a risk in the aquatic environment (such as oils, emulsions, binders) and mixing with wastewater after use as much as possible***

In industrial facilities, dry cleaning techniques can be used to prevent chemicals that pose a risk to the aquatic environment, such as oils, emulsions and binders, from mixing with wastewater streams and leaks can be prevented. In this way, the protection of water resources can be ensured (TUBITAK MAM, 2016).

- ***Construction of closed storage and impermeable waste/scrap yard to prevent the transportation of toxic or hazardous chemicals for the aquatic environment***

In industrial facilities, closed and impermeable waste/scrap storage areas can be built to prevent the transport of toxic or dangerous chemicals to the receiving environments for the aquatic environment. This practice is already being implemented within the scope of the current environmental regulations in our country. Within the scope of the field studies carried out, a separate collection channel can be built in the toxic or hazardous substance storage areas in industrial facilities to prevent the separate collection of the leachate in question and its mixing with the natural water environments.

Computer Aided Control System

https://sayachizmet.com/wp-content/uploads/2020/01/SCADA-nedir-1280x720-1.jpg.webp

- ***Avoiding the need for rinsing between activities by using compatible chemicals in successive processes***

  Chemical compatibility is a measure of how stable a substance is when mixed with another substance. If two substances mix with each other and undergo a chemical reaction, they are considered incompatible.

  Various chemicals are used in industrial facilities to increase washing and rinsing efficiency. The fact that these chemicals are compatible and act as solvents shows a positive course in increasing efficiency. Therefore, dirt on the material can be removed in a shorter time and more effectively, and the amount of water used in washing processes can be significantly reduced. In this case, even if the amount of wastewater can be reduced, there may be an increase in the chemical loads carried by the wastewater. These negative effects can be minimized by ensuring that the washing water containing solvents used in the washing and rinsing processes is reused.

  It is possible to save 25-50% of water by reusing washing water. Reserved tanks and new pipelines may be needed for the application. In alternative cases, the washing solution is kept directly in the system and can be used many times until it loses its properties.

- ***Minimization of spills and leaks***

  Both raw material and water losses can be experienced due to spills and leaks in enterprises. In addition, if wet cleaning methods are used to clean the spilled areas, there may be increases in water consumption, wastewater amounts and pollution loads of wastewater (MOAF, 2021). In order to reduce raw material and product losses, spillage and splash losses are reduced by using anti-splashes, fins, drip trays, sieves (IPPC BREF, 2019).

- ***Recovery of water from rinsing solutions and reuse of recovered water in processes appropriate to its quality***

  Rinsing wastewater in industrial facilities can be reused without treatment in relatively clean wastewater, floor washing and garden irrigation processes that do not require high water quality (Öztürk, 2014). In raw water consumption with the recovery of rinse water Savings of 1-5% can be achieved.

- ***Use of automatic check-off valves to optimise water use***

  Monitoring and controlling water consumption using BAT control devices, meters and computer-aided monitoring systems provides significant technical, environmental and economic advantages (Öztürk, 2014). Monitoring the amount of water consumed within the facility and in various processes prevents water losses (TUBITAK MAM, 2016). It is necessary to use BAT meters and meters in the facility and production processes, to use automatic shut-off valves and valves in continuously operating machines, to develop monitoring-control mechanisms according to water consumption and some determined quality parameters using computer-aided systems (TUBITAK MAM, 2016). With this application, it is possible to save up to 20-30% in water consumption on a process basis (DEPA, 2002; LCPC, 2010; IPPC BREF, 2003). By monitoring and controlling water consumption on a process basis , 3-5% savings can be achieved in process water consumption (Öztürk, 2014).

- ***Documentation of production procedures and use by employees to prevent waste of water and energy***

  In order to make efficient production in an enterprise, effective procedures should be applied in order to identify and evaluate potential problems and their sources and to control the production stages (Ayan, 2010). Determining and implementing appropriate procedures in production processes ensures more efficient use of resources (such as raw materials, water, energy, chemicals, personnel and time) and assurance of reliability and quality in production processes (Ayan, 2010). The presence of documented production procedures in production processes contributes to the development of the ability to develop sudden reflexes for the evaluation of operational performance and the solution of problems (TUBITAK MAM, 2016; MoAF, 2021). Effective implementation and monitoring of procedures created specifically for production processes is one of the most effective ways to ensure product quality, to receive feedback and to develop solution proposals (Ayan, 2010). Documenting, effectively implementing and monitoring production procedures is a good management practice and is an effective tool in structuring and ensuring the continuity of the cleaner production approach and environmental management system. In addition to the potential benefits, there may be changes in the cost and economic gains of the application depending on the sector or facility structure (TUBITAK MAM, 2016; MoAF, 2021). Although the establishment and monitoring of production procedures is not costly, the payback period may be short considering the savings and benefits it will provide (TUBITAK MAM, 2016; MoAF, 2021).

- ***Characterizing the amount and quality of wastewater at all wastewater formation points and determining the wastewater BATs that can be reused with or without treatment,***

  Determining and characterizing wastewater formation points in industrial facilities,
  It is possible to reuse various wastewater streams with or without treatment (Öztürk, 2014; TUBITAK MAM, 2016; MoAF, 2021). In this context, filter backwash water, RO concentrates, blowdown water, condensate water, relatively clean washing and rinsing water can be reused without treatment in the same/different processes and in areas that do not require high water quality (such as plant and equipment cleaning). Apart from this, it is possible to reuse wastewater streams that cannot be reused directly in production processes after they are treated using appropriate treatment technologies.

  Membrane filtration processes are an integral part of many wastewater reuse systems. Nanofiltration (NF) and Reverse osmosis (RO) filtration systems are used for industrial wastewater recovery. Microfiltration (MF) and ultrafiltration (UF) are often used for the pretreatment of water before it goes to the NF or RO process (Singh et al., 2014).

  In the textile industry, water savings of 30-70% can be achieved by reusing washing and rinsing water without treatment (USEPA, 2008; LCPC, 2010; MoAF, 2021). In addition, in a clean production study carried out in the textile industry, it has been reported that a reduction in total water consumption in the range of 29-55% and in the pollution loads of composite wastewater in the range of 42-53% will be achieved with the recovery applications of appropriate wastewater streams by treatment/untreated (Öztürk, 2014). In another textile mill engaged in textile finishing-dyeing, it has been determined that 46-50% reduction in water consumption, 48-56% reduction in wastewater amounts and 16-20% reduction in wastewater load can be achieved by reusing wastewater with or without treatment (Öztürk, 2014).

- ***Monitoring the water used in production processes and auxiliary processes and the wastewater generated in terms of quantity and quality and adapting this information to the environmental management system*,** There are resource uses in industrial facilities, and as a result of resource use,

  Inefficiency and environmental problems can be caused by input-output BATs. For this reason, it is necessary to monitor the water and wastewater used in production processes and auxiliary processes in terms of their quantity and quality (TUBITAK MAM, 2016; MoAF, 2021). Process-based quantity and quality monitoring, together with other good management practices (personnel training, establishment of an environmental management system, etc.), can be used to reduce energy consumption by 6-10%, water consumption and wastewater amounts. It can provide a reduction of up to 25% (Öztürk, 2014).

  The main stages for monitoring water and wastewater in terms of quantity and quality are:

  - Use of monitoring equipment (such as meters) to monitor consumption of water, energy, etc. on the basis of processes,
  - Establishment of monitoring procedures,
  - Determining the use/exit points of all inputs and outputs (raw materials, chemicals, water, products, wastewater, sludge, solid waste, hazardous waste and by-products) related to the production process, monitoring, documenting, comparatively evaluating and reporting in terms of their quantity and quality,
  - Monitoring raw material losses in production processes where raw materials are transformed into products and taking measures against raw material losses (MoEUCC, 2020e).

- ***Untreated reuse of relatively clean wastewater from washing, rinsing and equipment cleaning in production processes***

  In industrial facilities, relatively clean wastewater, especially washing-final rinsing wastewater and filter backwash wastewater, can be recycled without treatment in floor washing and garden irrigation processes that do not require high water quality, saving between 1-5% in raw water consumption . The initial investment costs required for the application consist of the establishment of new pipelines and reserved tanks (Öztürk, 2014).

- ***Implementation of time optimization in production and arrangement of all processes to be completed as soon as possible***

  In industrial production processes, planning the process from raw material to product transformation using the least process is an effective practice to reduce labor costs, resource use costs and environmental impacts and to ensure efficiency. In this context, it may be necessary to review the production processes and revise them to use the least number of process steps (TUBITAK MAM, 2016). In cases where the desired product quality cannot be achieved due to some inadequacies, inefficiency and design errors in basic production processes, production processes may need to be renewed. Therefore, in this case, the use of resources required in the manufacture of the unit amount of product and the amount of waste, emissions and solid waste generated increase. Time optimization in production processes is an effective practice (TUBITAK MAM, 2016).

- ***Collecting rainwater and evaluating it as an alternative water source in facility cleaning or in appropriate areas***

  In today's world where water resources are decreasing, rainwater harvesting is frequently preferred especially in regions with low rainfall. There are different technologies and systems for rainwater collection and distribution systems. Cistern systems, infiltration into the ground, collection from the surface and filter systems are used. Rainwater collected by special drainage systems can be used for production processes, garden irrigation, tank and equipment cleaning, surface cleaning, etc., if it meets the required quality requirements (Witness et al., 2015).

  In various examples, 50% water savings were achieved in landscape irrigation by using roof rainwater collected in industrial facilities and using it in buildings and landscaping areas after storing it (Yaman, 2009). Perforated stones and green areas can be preferred in order to increase the permeability of the ground and to ensure that rainwater passes and is absorbed into the soil in the field (Yaman, 2009). Rainwater collected on the roofs of buildings can be used for car washing and garden irrigation. It is possible to reuse the collected water by recovering 95% of it with biological treatment after use (Şahin, 2010).

- ***Determination of the scope of reuse of washing and rinsing waters***

  In industrial facilities, relatively clean wastewater such as washing-final rinsing wastewater and filter backwash wastewater can be reused without treatment in floor washing and garden irrigation processes that do not require high water quality (Öztürk, 2014). Thus, it is possible to save between 1-5% in raw water consumption (MoAF, 2021).

- ***Separate collection and treatment of gray water in the facility and use it in areas that do not require high water quality (green area irrigation, floor, floor washing, etc.)***

  Wastewater generated in industrial facilities is not only industrial wastewater originating from production processes, but also includes wastewater originating from showers, sinks, kitchens, etc. Wastewater consisting of showers, sinks, kitchens, etc. is called gray water. Water savings can be achieved by treating these gray waters with various treatment processes and using them in areas that do not require high water quality .

- ***Use of automatic equipment and equipment (sensors, smart hand washing systems, etc.) that will save water at water usage points such as showers/toilets, etc.***

  Water is very important in many sectors of the manufacturing industry, both for production processes and for personnel to provide the necessary hygiene standards. Water consumption can be achieved in various ways in the production processes of industrial facilities, as well as savings in water consumption by using equipment such as sensor taps and smart hand washing systems in the water usage areas of the personnel. Smart hand washing systems adjust the water, soap and air mixture in the right proportion and provide resource efficiency in addition to water savings.

2.1.4 Precautions for Ancillary Processes

METs for steam generation

- ***Saving water by insulating steam and water lines (hot and cold) and preventing water and steam losses in pipes, valves and connection points in the lines and monitoring them with a computer system***

Steam losses may occur if the steam lines are not properly designed in the facilities, routine maintenance and repairs of the steam lines are not carried out, mechanical problems that occur in the lines and the lines are not operated properly, and full insulation of the steam lines and hot surfaces is not made. This affects both the water consumption and energy consumption of the facility. It is necessary to use control systems with automatic control mechanisms in order to make steam insulations and to monitor steam consumption continuously. Due to the reduction of steam losses, similar savings can be achieved in fuel consumption and additional soft water consumption in boilers. Since fuel consumption in steam boilers will decrease, waste gas emissions are expected to decrease at the same rate. Since the use of additional soft water used in steam boilers will be reduced with the application, the amount of regeneration water, the amount of salt used in regeneration and reverse osmosis concentrates are also reduced. Automatic control mechanisms for full vapor insulation application and minimization of steam losses are used in many facilities with heavy steam consumption. With the configuration of the application, 2-4% fuel savings are achieved in steam boilers.

In order to prevent losses in production processes, adding the most important parts of equipment such as pumps, valves, adjustment knobs, pressure, BAT regulators to the maintenance checklist, inspecting not only water systems but also heating and chemical distribution systems, drums, pumps and valves, regular cleaning of filters and pipelines, 1-6% savings in water consumption can be achieved with regular calibration of measuring equipment (thermometers, chemical scales, dispensing/dosing systems, etc.) and routine inspection and cleaning of heat treatment units (including chimneys) at specified periods, effective maintenance-repair, cleaning and loss control practices (Hasanbeigi, 2010; Ozturk, 2014; MoAF, 2021).

Industrial Steam Boilers

https://hohwatertechnology.com/wp-content/uploads/2021/03/boiler_175594851-1024x688.jpeg

- ***Saving water by reusing steam boiler condensate***

When steam indirect heating techniques are used to transmit thermal energy in production processes, the recovery of condensed steam (condensate) is an effective practice in terms of reducing water consumption (IPPC BREF, 2009). By recovering condensate water, an average of 5% reduction in water consumption can be achieved (Greer et al., 2013). In addition, the potential payback period varies between 4-18 months (taking into account energy savings) (Öztürk, 2014; TUBITAK MAM, 2016).

- ***Prevention of frisk steam losses due to boiler draining***

Steam boiler condensate is generally discharged from the system at atmospheric pressure from the equipment outlets and steam traps outlet. In condensate systems, as the pressure decreases, some of the condensate evaporates again and cools down to the boiling point of water at atmospheric pressure. The re-evaporated condensate, called flash steam, is thrown into the atmosphere and disappears. In the case of condensate return lines, which are usually quite long, cooling and therefore evaporation are inevitable. In order to prevent the condensate from evaporating again, savings can be achieved by keeping it in a flash tank under pressure until it returns to the boiler feed tank. As the pressure decreases in the condensate taken into the tank, the steam formed is collected on the tank and feeds the low pressure steam system from there. The remaining hot condensate is taken into the boiler from the bottom of the tank.

- ***Minimizing boiler discharge water (blowdown) in steam boilers***

Boiler blowdown refers to the water consumed from a boiler to prevent the condensation of pollutants during the continuous evaporation of steam. Boiler blowdown can be reduced by 50% with condensate recovery (IPPC BREF, 2009).

In automatic systems, the blowdowns in the boilers are constantly monitored and the system is re-analyzed together with the water taken after the blowdown. In the analysis, data such as dissolved and undissolved particles in the water and water density are processed. If the density for the boiler is above the system limits, the blowdown process is repeated. The system should be automated and the optimum blowdown frequency should be determined. When the frequency of blowdowns is reduced, the amount of wastewater decreases. This saves energy and cooling water used to cool wastewater (IPPC BREF, 2009). By optimizing the steam boiler blowdown process, operating costs are reduced by saving boiler water consumption, waste costs, conditioning and heating.

- ***Reuse of energy generated from the steam condenser***

By applying a simple modification to the piping system, the water that feeds the water resting/decarbonization unit can be obtained from the outlet of the turbine condenser unit. This water has sufficient temperature for the resting/decarbonization unit. Therefore, this water does not need to be heated by means of steam generated by the heat exchanger system. Thanks to this work, significant steam gain can be achieved. In addition, cooling water consumption can be reduced (CPRAC, 2021).

- ***Reducing the amount of blowdown by using deaerators in steam boilers***

Free oxygen dissolved in steam boilers, feed water and hot water boilers, and carbon dioxide formed by the breakdown of carbonates in boilers can cause corrosion in the form of pores and rusting and melting in steam boilers, devices using steam and especially in installations. The effects of these gases increase as the proportion of fresh feed water and the operating pressure of the system increases. If these dissolved gases are not removed from the boiler feed water, the useful life of these systems is shortened, corrosion and various deformations may occur. These gases also cause excessive corrosion in carbon dioxide coils, steam appliances and condensate pipes. Boiler feed water must be purified from dissolved gases such as oxygen and carbon dioxide by passing through the deaerator. Deaeration systems are mechanical systems that allow dissolved gases to be evaporated from the water by giving air to the water with a fan. Dissolved deaeration can be increased by increasing the water and air contact surface in the deaerator system. In this way, corrosion formation is reduced and boiler efficiency is increased (TUBITAK MAM, 2016; MoAF, 2021).

METs for refrigeration systems

- ***Use of a closed-loop refrigeration system to reduce water use***

Closed-loop cooling systems significantly reduce water consumption compared to open-loop systems with more water-intensive use. In closed-loop systems, when the same water is recirculated in the system, cooling water is usually required to be added as much as the amount of evaporated water. Evaporation losses can also be reduced by optimizing cooling systems.

- ***Reducing water consumption by increasing the number of cycles in closed-loop cooling systems and improving the quality of the make-up water***

Water is used as a refrigerant in many processes such as the production processes of the manufacturing industry and the cooling of products. Water is recirculated through a cooling tower or central cooling systems and the cooling process is carried out. If an undesirable microbial growth occurs in the cooling water, it can be controlled by adding chemicals to the recirculation water (TUBITAK MAM, 2016). In the recirculation process, the number of cycles can be increased by good chemical conditioning. In this way, water can be saved by reducing the amount of fresh water fed into the system. In addition, good conditioning of the cooling completion water can also increase the number of cycles (MoAF, 2021).

Cooling Systems (Chiller)

https://www.chiller.com.tr/wp-content/uploads/2018/04/chiller-sogutma-kapasitesi-hesabi.jpg

- ***Increasing the number of cycles by using anti-corrosion and anti-scale inhibitors in systems with a closed water loop***

Cooling towers and evaporative condensers are efficient and cost-effective systems that remove heat from air conditioning and industrial process refrigeration systems (IPPC BREF, 2001b; MoAF, 2021). More than 95% of the circulating water in these systems can be recovered (TUBITAK MAM, 2016). In cooling systems, impurities remain in the recirculation water due to the fact that some of the recirculation water is worked on the basis of evaporation, and the impurity concentrations gradually increase in each cycle. Impurities that can be included in the cooling system together with the air can cause contamination in the recirculation water (TUBITAK MAM, 2016). If impurities and contaminants are not effectively controlled, they can cause the formation of boilerstone and corrosion, unwanted biological growth and sludge accumulation. This can become a chronic problem that leads to a decrease in the efficiency of heat transfer surfaces and an increase in operating costs. In this case, it is necessary to implement a water treatment program specially designed in terms of the quality of the feed water supplied to the cooling system, the cooling water system building material and operating conditions. In this context; blowdown control, biological growth control, corrosion control, avoiding the use of hard water, using sludge control chemicals, using filtration and sieve systems may be appropriate (TUBITAK MAM, 2016). In addition, the establishment and periodic implementation of an effective cleaning procedure and program is a good management practice in terms of protecting cooling systems. Corrosion is one of the most important problems in cooling systems. In the tower recirculation water, as the degree of hardness increases, dissolved solids (sulfate, chloride, carbonate, etc.) that cause corrosion as a result of the formation of limestone and deposits on the walls will cause abrasion on the surface over time. In addition, the formation of deposits negatively affects heat transfer and reduces energy efficiency. In order to prevent these negativities, it is necessary to implement a lime and corrosion preventive chemical conditioning program, to disinfect with biocide that prevents biological activation, to clean the sediments by subjecting the cooling towers in use to chemical and mechanical cleaning at least twice a year, and to keep the hardness and conductivity values of the reinforcement water as low as possible (IPPC BREF, 2001; Kayabek et al., 2005). In order to improve the quality of the supplementary water, it may be necessary to treat (condition) it using an appropriate treatment system. In addition, unwanted microbial growth needs to be kept under control (IPPC BREF, 2001b; MoAF, 2021). Due to micro-residues and deposits in the cooling water, blowdown occurs in cooling systems as well as in steam boilers. Deliberate draining of the cooling system to bring the increased density of solids in the cooling system to balance is called cooling blowdown. It is possible to reduce the use of biocides and blowdown amounts by pre-treating cooling water with appropriate methods and continuous monitoring of cooling water quality (TUBITAK MAM, 2016). Although the investment cost depends on the scale of the application, the payback period in expected investment expenses varies between 3 and 4 years (IPPC BREF, 2001).

- ***Avoiding unnecessary cooling processes by identifying processes that need wet cooling*** : The boundaries of the plant site affect design parameters such as cooling tower height. Hybrid cooling system in cases where it is necessary to reduce the tower height can be applied. Hybrid refrigeration systems with and without evaporation (wet and dry) is a combination of cooling systems. Depending on the ambient temperature, the hybrid cooling tower can be operated as a completely wet cooling tower or as a combined wet/dry cooling tower (TUBITAK MAM, 2016). In regions where there is not enough cooling water or in cases where water costs are high, the evaluation of dry cooling systems or hybrid cooling systems can be an effective solution to reduce the amount of cooling supplement water (TUBITAK MAM, 2016).

METs for ventilation and air conditioning systems

- ***Reuse of the liquid formed by condensation from the ventilation system During the*** ventilation cycle, condensate with good water quality can be produced in the system. For example, in a facility in Spain, the conductivity of about 200 µS in the ventilation system It has condensate water collected in a tank and flushed the automatic galvanizing line (MedClean, n.d.).

- ***Replacement of old equipment in the aeration system with ion exchange resins based on the principle of reverse osmosis (systems that produce demineralized water) and reuse of water*** Conductivity of the final effluent using ion exchange resins in the aeration system It is brought to a conductivity level suitable for use for equipment cleaning. Example In a facility in Spain, effluent with a conductivity value of approximately 1000 µS is obtained by replacing the equipment in the ventilation system with ion exchange resins and reused in the system (MedClean, n.d.).

METs related to the cogeneration system

- ***The use of hot water produced in the cogeneration system in heating processes***
  With the inclusion of cooling systems in cogeneration systems (trigeneration) It is possible to convert yield losses of 10-30% into hot water, water vapor, cold air, hot air and water (for this, it is necessary to use absorption heat exchangers). Thus, it is possible to meet some of the energy required in processes such as cooling and drying in the facility from the waste heat in the cogeneration systems. Energy costs can be reduced by up to 40% in facilities where cogeneration systems are used (TUBITAK MAM, 2016).

- ***The use of cold water produced in the cogeneration system in cooling processes*** It is possible to save water by evaluating the cold water produced in the cogeneration system in cooling processes (TUBITAK MAM, 2016).

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