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

Water Efficiency
Campaign

Water Efficiency Directory Documents Series

Manufacture of Tubes, Pipes, Hollow Profiles and Related Fittings, of Steel

NACE CODE: 24.2

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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

Türkiye is located in the Mediterranean basin where the effects of global climate change are felt intensely. and is among the regions that will be most affected by the negative effects of climate change.acceptance is being done. In our basins This our existence climate to the change connected aspect in the futureProjections on how our water resources will be affected by the next hundred yearsTo 25 Arriving in proportions may decrease shows.

2022 year for In our country person per falling available annual This amount 1,313 m³ is, human pressuresand the annual amount of usable water per capita, together with the effects of climate change, by 2030 It is expected to fall below 1,000 cubic meters after 2010. If necessary precautions are not taken in A lot close in the future Turkey's This scarcity attracting One country to the situation the future, socialand it is obvious that it will bring many negative economic consequences. The next period Projections from the results in It will be understood as follows our country waiting drought And This scarcity riskavailable This our resources productive And sustainable in this way to be used compulsory is performing.

This efficiency concept *"One the product or your service in production -most little in quantity This “use”* aspectdefinable. This efficiency approach; of water, amount And quality in terms of protected Onlypeople's not, ecosystem sensitivity with all of living things requirements Consideration will take in this wayfirst drinking water, agriculture, industry And digit The people of uses to be as follows all in sectors rational,Sharer, fair, productive And effective in this way to be used basis is taking.

Increasing demand for water resources, precipitation and heat regimes change, population, urbanization And contamination increase with availableThis of resources users between fair And balanced One in this way distribution each last daymore in importance is gaining. This For this reason, limited the one which... This of resources sustainable management A roadmap based on efficiency and optimization for the protection and use of applications Creation of difficulty into has arrived.

In the sustainable development vision set by the United Nations, the Millennium Development Target 7: Sustainable Development by *Ensuring Environmental Sustainability* Among its goals *are Goal 9: Industry, Innovation and Infrastructure* and *Goal 12: Responsible Production and Consumption.* in the scope of This first to be as follows resources productive, fair And sustainable usage, environment friendlyproduction And future generations anxiety bearing consumption like to the matters place is given.

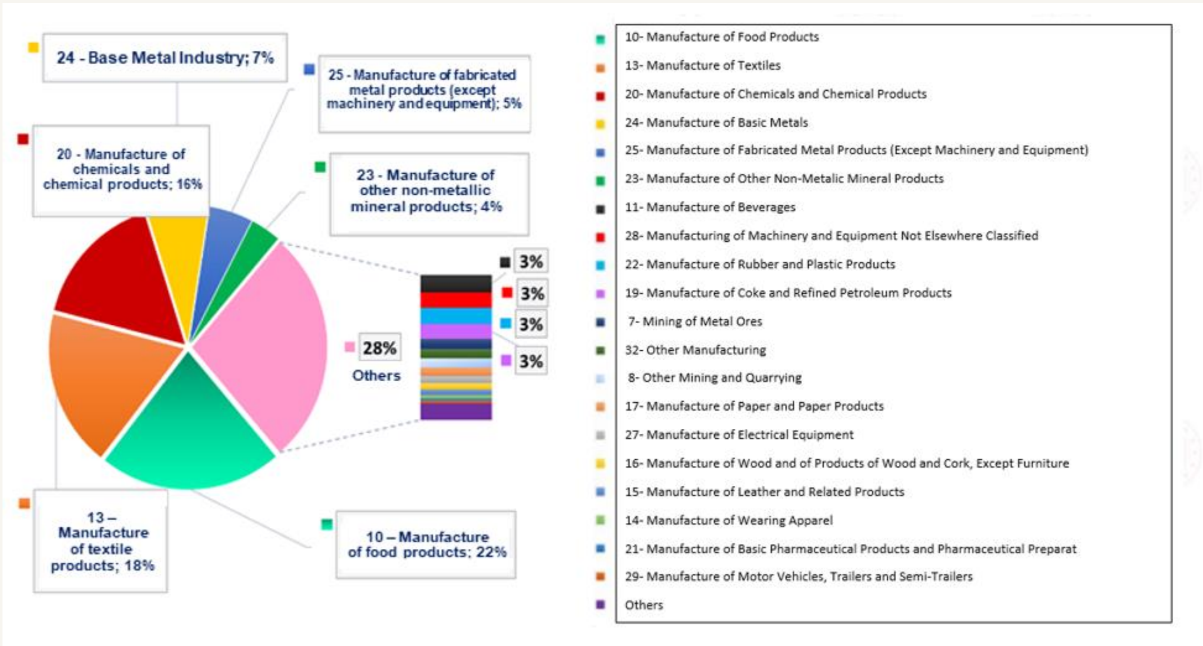
Carbon neutral with the aim of clean, cyclical One economy model to life spend, resources productive use of popularize And environmental effects to reduce like targets on member countriesagreed upon Europe Green The agreement in the scope of our country prepared is Europe Green The agreementIn the Action Plan, water and resources are used in various fields, especially in industry, production and consumption. efficiency Emphasizing actions has been determined.

“Industrial Environmental Legislation” is one of the most important components of the European Union environmental legislation in terms of industry. Emissions The directive (EED)” industry from activities originating from And weather, This And soil to be as followsbuyer to the environment done discharges/emissions integrated One with approach control And Preventionor to be reduced oriented to be taken required precautions contains. In the directive, clean productionprocesses applicability systematic halo to bring And in practice happened difficultiesIn order to eliminate Best Available Techniques (MET) (BAT/ (MET) has been presented. METs cost and benefits eyelash in front when kept, the environmenthigh at level to be protected oriented -most effective APPLICATION techniques. Directive in accordance with, each onesector for METs detailed aspect as described Reference Documents (BAT-BREF) has been prepared. BREF in their documents METs, Good management applications, general measures in the nature of techniques,chemical usage and management, various production processes for techniques, wastewater management, emission management and waste management like general One in the frame is presented.

By The Ministry of Agriculture And Forestry, General Directorate of Water Management urban, agricultural, industrialand individual water use productive applications dissemination and social awareness to be increased targeting studies is being carried out. 2023/9 numbered Presidency With the circular come into force Entering ***“Water Efficiency Strategy Document within the Framework of Adaptation to the Changing Climate”*** Water efficiency that appeals to all sectors and stakeholders within the scope of ***the “Action Plan (2023-2033)”***Action plans have been prepared. In the Industrial Water Efficiency Action Plan for the period 2023-2033A total of 12 actions have been determined and responsible and relevant institutions have been appointed for these actions. Within the scope of the said Action Plan; specific water sub-sectors in the industry Conducting studies to determine usage intervals and quality requirements,Organizing technical training programs and workshops on a sectoral basis and water efficiency guides documents preparation actions This Management General Directorate of responsibility has been defined.

On the other hand, the General Directorate of Water Management of the Ministry of Agriculture and Forestry ***"NACE To their codes According to Industrial This Use Efficiency "Project"*** with in industry This efficiency ofto be improved oriented studies in the scope of to our country specific sectoral -most Good techniques As a result of the study, high water consumption companies operating in our country NACE codes containing recommended measures for improving water use efficiency in sectors with classified sectoral directory documents And action plans has been prepared.

As in the world, the sectors with the highest share in water consumption in our country are food, textile, chemical 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, primarily food, textile, chemical, and basic metal industries, representing production areas of different capacities and varieties within the scope of NACE Codes operating in our country and with high water consumption, and data on water supply, sectoral water use, wastewater generation, and recovery were obtained, and information was provided on the best available techniques (MET) and sectoral reference documents (BREF) published by the European Union, water efficiency, cleaner production, water footprint, etc.



Distribution of water usage in industry sector in Türkiye

As a result of the studies, businesses with high water consumption have been identified for 152 different 4-digit NACE codes.to their processes oriented specific This consumption And potential saving rates set, EU available Water efficiency guidelines, taking into account best practices (BAT) and other cleaner production techniques documents has been prepared. Guides in This to its efficiency oriented 500 piece technical (MET);
(i) Good Management Applications, (ii) General Measures In the nature of Measures, (iii) Helper To the processesRelated Measures And (iv) To the sector Unique Measures to be as follows 4 main group under has been examined.

During the determination of METs for each sector within the scope of the project carried out; environmentalbenefits, operational data, technical specifications-requirements and applicability criteria are taken into account. The determination of METs was not limited to BREF documents only. up-to-date literature data on a global scale, real case studies, innovative applications, industryDifferent data sources such as reports of sectoral representatives are examined in detail.MET lists have been created. The created MET lists are designed to be effective on the local industrial infrastructure of our country.and specifically for each NACE code to assess its suitability for capacity MET lists prepared by businesses; water saving, economic saving, environmental benefit, prioritized by scoring on the criteria of applicability, cross-media impact and scoring Results by using final MET Lists has been determined. Project in the scope of visit saidfacilities This And wastewater data with sectoral stakeholders by what's that issued And to our country specificlocal dynamics Consideration by taking determined final MET Lists over NACE code on the basis ofsectoral This efficiency Guides has been created.

2 The 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)

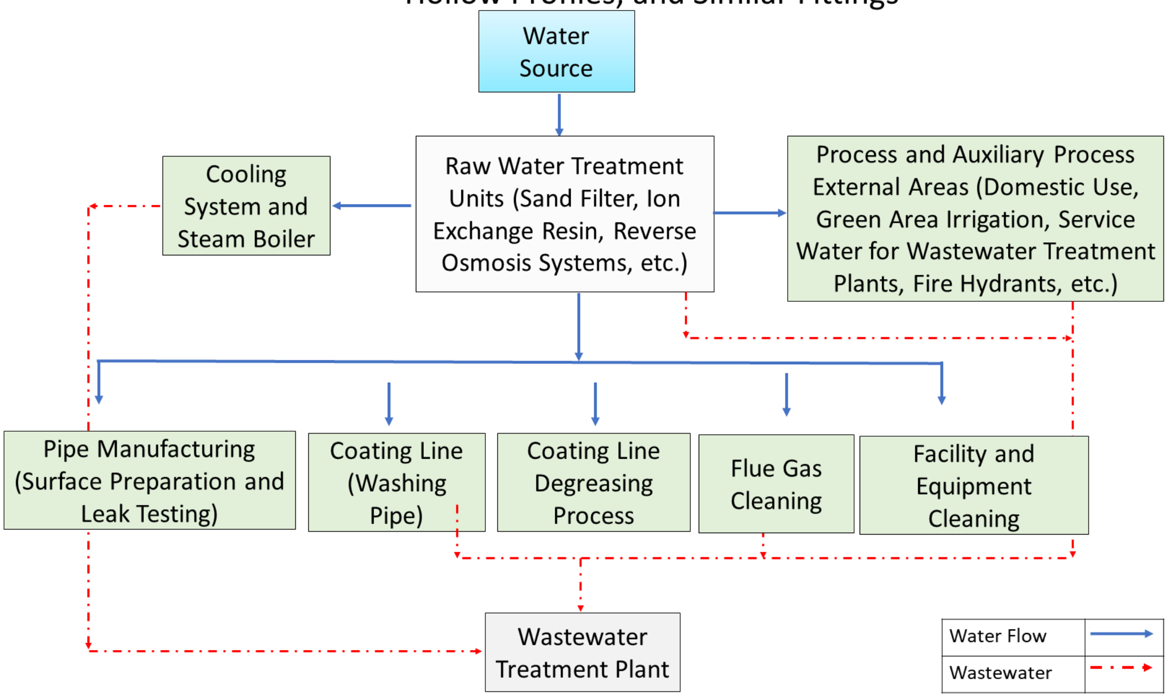
"Main metal industry" And "Fabrication metal products manufacturing (machine and equipment not including)"

"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

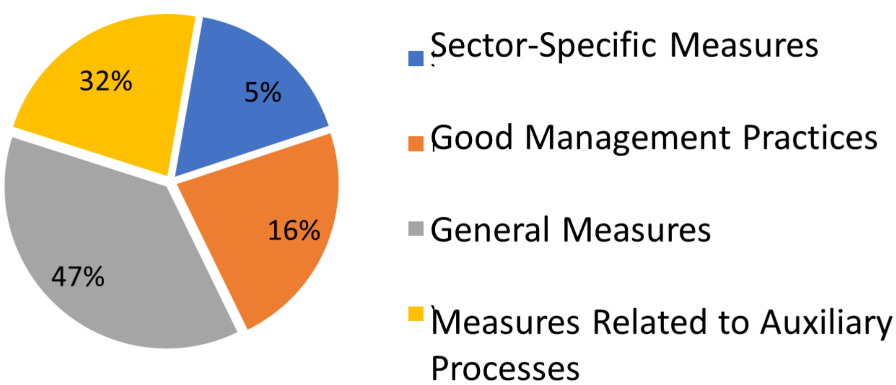
2.1 Made of steel Tubes, Piping, Intra Empty Profiles And SimilarConnection Parts of Manufacturing (NACE 24.20)

Water Flow Diagram for the Manufacturing Sector of Steel Tubes, Pipes, Hollow Profiles, and Similar Fittings



	Minimum	Maximum
Specific Water Consumption of Facilities Visited in the Project (L/unit of product)	0,03	7,5
Reference Specific Water Consumption (L/kg of product)	3	5

Percentage Distribution of Water Efficiency Practices



In facilities where steel tubes, pipes, hollow profiles and similar fittings are manufactured, the steel roll is added to the sheet metal that continues to be processed on the line. For this process, first the joints of both steel sheets are cut with high heat. The weld mouth is opened on the flattened steel. The steel sheet is rolled by rollers. When flat steel is bent and rolled, it takes the form of a spiral pipe. The steel that reaches the desired pipe length is cut with the spiral plasma cutting method. When the production and controls of the steel pipe are completed, the insulation process is started according to the area where it will be used. The steel pipes to be insulated are sent to the sandblasting unit. Here, any rust that may occur on the inner and outer surfaces is cleaned with sprayed metal particles. In this way, the material to be used for insulation adheres better to the surface. After the painting process, hot glue is poured on the pipe on one side and polyurethane on the other side and the entire surface of the pipe is covered. Cooling water is used to harden the coating. Finally, the produced and insulated steel pipes are sent to the area where they will be used. In the production of steel tubes, pipes, hollow profiles and similar fittings, water is used in the coating line washing bath and degreasing processes, as well as surface preparation, leakage testing and flue gas cleaning. In addition, machine and product cooling water is consumed. The water used in product cooling is used as a recirculating water and is added to as it decreases as a result of evaporation. In order to produce soft water for use in production processes in the sector, significant amounts of water are consumed for filter washing, resin regeneration and membrane cleaning processes in raw water preparation units such as sand filters, ion exchange resins and reverse osmosis.

In the production of steel tubes, pipes, hollow profiles and similar fittings, the reference specific water consumption is between 3 - 5 L/kg. The specific water consumption of the production branch analyzed within the scope of the study remains between 0.03 - 7.5 L/kg. With the implementation of sector-specific measures, good management practices, general measures and measures related to auxiliary processes, it is possible to achieve 36 - 69% water recovery in the sector.

24.20 Made of steel Tubes, Piping, Intra Empty Profiles and Similar Connection Parts of Manufacturing NACE code in the scope of recommended priority This efficiency APPLICATION techniques the following in the table is presented.

NACE Code	NACE Code Description		Sector-Specific Priority Best Available Techniques
24.20	Manufacturing of steel tubes, pipes, hollow profiles, and similar fittings		**Sector-Specific Measures**
		1.	Reusing acidification and rinsing/washing water by filtering it to reduce water consumption required for acid neutralization
		2.	Reducing water consumption by increasing the efficiency of mechanical pretreatment and flue gas treatment systems
			Good Management Practices
		1.	Preparing water flow diagrams and mass balances for water
		2.	Developing a water efficiency action plan to reduce water usage and prevent water pollution
		3.	Providing technical training to staff for reducing and optimizing water use
		4.	Ensuring good production planning for optimizing waterconsumption
		5.	Setting water efficiency targets
		6.	Monitoring the quantity and quality of water used in production processes and auxiliary processes, and integrating this information into the environmental management system
			General Measures
		1.	Minimizing spills and leaks
		2.	Recovering water from rinsing solutions and reusing it in processes suitable for the quality of the recovered water
		3.	Using automatic devices and equipment (sensors, smart handwashing systems, etc.) that save water at water usage points such as showers/toilets
		4.	Utilizing pressure washing systems for equipment cleaning, general cleaning, etc.
		5.	Reusing filter washing water in filtration processes, reusing relatively clean cleaning water in production processes, and reducing water consumption through on-site cleaning systems (CIP)
		6.	Avoiding the use of drinking water in production lines
		7.	Using cooling water as process water in other processes
		8.	Detecting and reducing water losses
		9.	Using automatic control shut-off valves to optimize water use
		1	Su ve enerji israfını engellemek için üretim prosedürlerinin dokümante edilmiş halde bulundurulması ve çalışanlar tarafından kullanılması

NACE Code	Description		Sector-Specific Priority Best Available
24.20	Manufacturing of steel tubes, pipes, hollow profiles and similar fittings	13.	Preventing clean water streams from mixing with dirty water streams All wastewater formation at points wastewater the amounts of And Qualifications
		14.	Characterized by being made by purification either in without purification back usage possiblethe one which... wastewater currents Determination
		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.	Production in their processes washing, rinse And equipment from cleanliness originating from relatively clean wastewater without purification again usage
		18.	In the facility gray of waters separate gathered together purification and high This quality not requiringin the fields (green area irrigation, place, ground washing etc.) to be used
		19.	In production time optimization implementation and all transactions -most shortin time will end in this way arrangement
		20.	Rain of waters by gathering facility in its cleanliness or suitable in the fields alternative water source aspect evaluation
			Helper To the processes Related Measures
		1.	Ventilation in the system old equipments opposite osmosis principle of based on ion change resins (demineralized This producing systems) with to be changed Andof water again to be used
		2.	Ventilation from the system incoming condensation with consisting of of liquid again to be used
		3.	Wet cooling need the one which... processes by determining unnecessary coolingfrom the transactions to be avoided
		4.	Closed loop cooling in their systems loop number of by increasing and completionof water quality by improving This consumption reduction
		5.	Closed loop cooling in the water evaporation their losses reduction
		6.	Closed loop owner non- in systems tower cooling application with water back gain
		7.	Closed This to the cycle owner in systems corrosion And lime inhibitor inhibitors by using cycle the number of increase
		8.	Cooling in their systems with water cooling in its place by air cooling systemsto be used
		9.	Cooling water back gain systems healthy can work for water softening systems Establishment
		10.	This of use reduction for closed loop cooling systemto be used
		11.	Of the year some in the periods cooling your need little is in cases local dry weather with cooling to be done
		12.	Superficial flow with consisting of of waters separate One collection with the system by gatheringcooling water, process water etc. with purposes to be used

This in the sector total 40 piece technical has been suggested. Made of steel tubes, piping, intra- empty Profiles and similar connection of parts manufacturing NACE to your codeoriented;

(i) To the sector Unique Measures, (ii) Good Management Applications, (iii) General Measures And

(iv) Helper to processes related measures separate Titles in is given.

2.1.1 Sector-Specific Measures

- ***Mechanical front process, flue gas purification systems efficiency by increasing water consumption reduction***

  Cold in rolling mills surface cleaning (pickling) process during consumed This amount of use of closed tanks, application of spray processes instead of immersion processes, Compressed of rollers to be used or consecutive flowing pickling systems And ImprovedIt is possible to reduce it with techniques such as using acid and rinse equipment.(STB, 2019a).

- ***Acid Neutralization for required water consumption drop for pickling And rinse/washof water from filters by passing again to be used***

  The reuse of wastewater and rinse/wash water generated during the acidification process by purifying them through a filter in the acid neutralization process provides water efficiency and water savings (IPPC BREF, 2001a).

https://www.metalsupermarkets.com/wp-content/uploads/2021/11/steel-pickling.png

Steel Pickling Line

2.1.2 Good Management Applications

- ***Providing technical training to personnel to reduce and optimize water usage.***
  With this measure, water saving and water recovery can be achieved by increasing the training and awareness of personnel, and water efficiency can be achieved by reducing water consumption and costs. In industrial facilities, problems related to high amounts of water use and wastewater generation can occur due to the lack of necessary technical knowledge of personnel. For example, it is important for cooling tower operators, who represent a significant proportion of water consumption in industrial operations, to be properly trained and have technical knowledge. The relevant personnel must also have sufficient technical knowledge in applications such as determining water quality requirements in production processes, measuring water and wastewater quantities, etc. (TOB, 2021). Therefore, it is important to provide training to personnel on water use reduction, optimization, and water saving policies. Practices such as including personnel in water saving 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 with personnel training yield results in the medium or long term. (TUBITAK MAM, 2016; TOB, 2021).

- ***Monitoring the quantity and quality of water used in production processes and auxiliary processes and the wastewater generated, and adapting this information to the environmental management system.***
  There are resource uses in industrial facilities, and the inefficiency and environmental problems that occur as a result of resource use can be caused by input-output flows. For this reason, it is necessary to monitor the amount and quality of water and wastewater used in production processes and auxiliary processes (TUBITAK MAM, 2016; TOB, 2021). Process-based quantity and quality monitoring, together with other good management practices (personnel training, establishment of an environmental management system, etc.), can provide a reduction of 6-10% in energy consumption and up to 25% in water consumption and wastewater amounts (Ozturk, 2014).

  The water And wastewater amount And qualification In terms of to be monitored oriented main stages are as follows:
  - The main stages for monitoring water and wastewater in terms of quantity and quality are as follows:
  - • Using monitoring equipment (such as meters) to monitor water, energy, etc. consumption on a process basis,
  - • Establishing monitoring procedures,
  - • Determining the usage/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 quantity and quality,
  - • Monitoring raw material losses in production processes where raw materials are transformed into products and taking precautions against raw material losses (CSIDB, 2020e).

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

- ***Preparing a water efficiency action plan to reduce water use and prevent water pollution***
  Preparing an action plan that includes short, medium and long-term actions to reduce water-wastewater amounts and prevent water pollution in industrial facilities is important for water efficiency. At this point, water needs should be determined throughout the facility and in production processes, quality requirements should be determined at water usage points, wastewater generation points and wastewater characterization should be done (TOB, 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 their 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 (TOB, 2021).

- ***Determining water efficiency targets***
  The first step in achieving water efficiency in industrial facilities is to determine targets (TOB, 2021). For this, a detailed water efficiency analysis must be carried out on a process basis. In this way, unnecessary water use, water losses, incorrect practices affecting water efficiency, process losses, water-wastewater resources that can be reused with or without treatment, etc. can be determined. It is also extremely important to determine water saving potential and water efficiency targets for each production process and the facility in general (TOB, 2021).

- ***Preparation of water flow diagrams and mass balances for water***
  Determination of water usage and wastewater generation points in industrial facilities, creation of water-wastewater balances in production processes and auxiliary processes outside of production processes generally constitute the basis of many good management practices.
  Creation of process profiles throughout the facility and on the basis of production processes; It facilitates the determination of unnecessary water usage points and high water usage points, evaluation of water recovery opportunities, process modifications and determination of water losses (TOB, 2021).

2.1.3 General Precautions

- ***Detection and Reduction of Water Losses***
  - In industrial production processes, water losses occur in equipment, pumps, and pipelines. First, water losses should be identified, and regular maintenance of equipment, pumps, and pipelines should be performed to keep them in good condition, preventing leaks (IPPC BREF, 2003). Regular maintenance procedures should pay particular attention to the following points:
  - Including pumps, valves, level switches, pressure, and flow regulators in the maintenance checklist.
  - Conducting inspections not only in the water system but also especially in heat transfer and chemical distribution systems, broken and leaking pipes, barrels, pumps, and valves.
  - Regularly cleaning filters and pipelines.
  - Calibrating measurement equipment such as chemical measurement and distribution devices, thermometers, etc., and routinely checking and monitoring them at designated intervals (IPPC BREF, 2003).

  Effective maintenance, cleaning, and loss control practices can achieve water savings ranging from 1% to 6% in consumption (Ozturk, 2014).

- ***Minimizing Spills and Leaks***

  In businesses, spills and leaks can lead to losses of both raw materials and water. Additionally, when wet cleaning methods are used to clean spill areas, there can be increases in water consumption, wastewater quantities, and the pollution loads of wastewater (TOB, 2021). To reduce raw material and product losses, measures such as splash guards, trays, and sieves are used to minimize spills and splashes (IPPC BREF, 2019).

- ***Reuse of Relatively Clean Wastewaters from Washing, Rinsing, and Equipment Cleaning Processes without Treatment***

  In industrial facilities, relatively clean wastewater, such as washing-final rinsing wastewater and filter backwash wastewater, can be reused without treatment for ground washing and garden irrigation processes that do not require high water quality, resulting in savings of 1% to 5% in raw water consumption. The initial investment costs for this application consist of the installation of new pipelines and the creation of reserve tanks (Ozturk, 2014).

- ***Prevention of Clean Water Flows Mixing with Contaminated Water Flows***

In industrial facilities, by identifying wastewater generation points and characterizing the wastewaters, it is possible to collect wastewater streams with high pollution loads separately from relatively clean wastewaters (TUBİTAK MAM, 2016; TOB, 2021). This allows for the treatment or non-treatment of appropriately characterized wastewater flows for reuse. Separating wastewater flows reduces water pollution, enhances treatment performance, decreases energy consumption associated with reduced treatment needs, and facilitates the recovery of wastewater and valuable materials, thus reducing emissions. Additionally, heat recovery from separated hot wastewater streams is also possible (TUBİTAK MAM, 2016; TOB, 2021). Separating wastewater flows usually requires high investment costs, but cost reductions can be achieved in situations where large amounts of wastewater and energy recovery are feasible (IPPC BREF, 2006).

- ***Identification of Wastewater Streams Possible for Reuse through Characterization of Quantities and Qualities at All Wastewater Generation Points***

In industrial facilities, identifying and characterizing wastewater generation points allows for the reuse of various wastewater streams either through treatment or without treatment (Öztürk, 2014; TUBİTAK MAM, 2016; TOB, 2021). In this context, filter backwash waters, total dissolved solids concentrates, blowdown waters, condensate waters, 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). Furthermore, wastewater streams that cannot be reused directly can be treated using appropriate treatment technologies before being 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 NF or RO processes (Singh et al., 2014).

- ***Use of Cooling Water as Process Water in Other Processes***

Water cooling systems are commonly used in processes where thermal energy is heavily utilized and cooling is required. By employing heat exchangers in the return of cooling water, heat recovery can be achieved, preventing the contamination of cooling water and increasing the return rates of cooling water, thereby saving water and energy (TUBİTAK MAM, 2016; TOB, 2021). Additionally, when cooling waters are collected separately, it is often possible to use the collected water for cooling purposes or to reevaluate it in suitable processes (EC, 2009). The reuse of cooling waters can result in savings of 2-9% in total water consumption (Greer et al., 2013). In terms of energy consumption, savings of up to 10% can be achieved (Öztürk, 2014; TOB, 2021).

- ***Use of Pressure Washing Systems for Equipment Cleaning and General Cleaning***

  Water nozzles are commonly used in cleaning industrial facilities. Effective results can be achieved in reducing water consumption and wastewater pollution loads through the use of properly placed and suitable nozzles. The use of active sensors and nozzles in areas with high water consumption is crucial for the efficient use of water. By replacing mechanical equipment with pressure nozzles, significant water savings can be realized (TUBİTAK MAM, 2016). In technically suitable processes, using optimized nozzles can reduce water consumption, wastewater generation, and wastewater pollution loads, providing significant environmental benefits in practice.

- ***Use of Automatic Control-Shutoff Valves to Optimize Water Use***

  Monitoring and controlling water consumption through flow control devices, meters, and computer-assisted monitoring systems offers significant technical, environmental, and economic advantages (Öztürk, 2014). Monitoring the amount of water consumed within the facility and across various processes helps prevent water losses (TUBİTAK MAM, 2016). The use of flow meters and counters for the entire facility and specific production processes, along with automatic shutoff valves for continuously operating machines, is necessary. Additionally, developing monitoring-control mechanisms based on water consumption and certain quality parameters using computer-assisted systems is essential (TUBİTAK MAM, 2016). With this application, water consumption savings of up to 20-30% on a process basis are possible (DEPA, 2002; LCPC, 2010; IPPC BREF, 2003). Monitoring and controlling water consumption in processes can lead to savings of 3-5% in process water consumption (Ozturk, 2014).

- ***Use of Automatic Equipment and Devices for Water Saving at Water Usage Points (Sensors, Smart Handwashing Systems, etc.)***

  Water is vital in many sectors of the manufacturing industry, both for production processes and for ensuring personnel meet necessary hygiene standards. Water consumption in industrial facilities can be achieved through various methods, including the use of equipment such as sensor taps and smart handwashing systems in personnel water usage areas, which can lead to water savings. Smart handwashing systems adjust the water, soap, and air mixture in the correct proportions, providing not only water savings but also resource efficiency.

- ***Avoiding the Use of Drinking Water in Production Lines***

In different sub-sectors of the manufacturing industry, waters with varying qualities can be used according to production needs. In industrial facilities, raw waters typically sourced from groundwater are treated before being used in production processes. However, in some cases, despite the high costs, drinking water may be directly used in production processes, or raw waters may be disinfected with chlorine compounds and then utilized in production. Waters containing residual chlorine can react with organic compounds present in the water (such as dissolved organic matter (DOM)), potentially forming harmful disinfectant by-products for living organisms (Özdemir & Toröz, 2010; Oğur et al.; TOB, 2021). The use of drinking water containing residual chlorine or raw waters disinfected with chlorine compounds should be avoided as much as possible. Instead of chlorine for disinfection, methods with high oxidation capabilities, such as ultraviolet (UV), ultrasound (US), or ozone, can be used. To increase the technical, economic, and environmental benefits of the application, it is essential to determine and use the necessary water quality parameters for each production process, which helps reduce unnecessary water procurement and treatment costs. This approach can lead to reductions in water, energy, and chemical costs (TUBITAK MAM, 2016).

- ***Collecting Rainwater to Use as an Alternative Water Source for Facility Cleaning or Suitable Areas***

This In today's world, where water resources are diminishing, rainwater harvesting is increasingly preferred, especially in areas with low rainfall. Various technologies and systems are available for rainwater collection and distribution. Systems include cisterns, infiltration into the ground, surface collection, and filtration systems. If the rainwater collected through special drainage systems meets the required quality standards, it can be used for production processes, garden irrigation, tank and equipment cleaning, surface cleaning, etc. (Tanık et al., 2015).

In various examples, rainwater collected from industrial facility roofs has been stored and used within the building and in landscaping, resulting in a 50% water savings in landscape irrigation (Yaman, 2009). To increase ground permeability and facilitate the infiltration and absorption of rainwater, perforated stones and green areas can be preferred (Yaman, 2009). Rainwater collected from building roofs can be used for vehicle washing and garden irrigation. The collected water can be biologically treated to achieve a recovery rate of 95% for reuse (Şahin, 2010).

- ***Use of Closed-Loop Water Circulation in Suitable Processes***

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

  Water is commonly used as a refrigerant in many manufacturing processes, especially in product cooling operations. 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 recirculating water (TUBITAK MAM, 2016).

  Reusing cooling water for processes such as cleaning reduces water consumption and the volume of wastewater generated. However, the need for energy to cool and recirculate cooling waters presents a side effect. Heat recovery is also achieved through the use of heat exchangers in cooling waters. Typically, closed-loop systems are used in facilities that employ water cooling systems. However, cooling system blowdown is directly discharged into the wastewater treatment plant's channel. This discharged blowdown water can be reused in suitable production processes.

- ***Prevention of Contamination of Wastewater Streams by Hazardous Substances in Aquatic Environments (such as Oils, Emulsions, Binders)***

  In industrial facilities, the use of dry cleaning techniques and the prevention of leaks help recover water by preventing chemicals such as oils, emulsions, and binders, which pose risks to aquatic environments, from mixing with wastewater streams (TUBITAK MAM, 2016).

- ***Construction of Enclosed Storage and Impermeable Waste/Scrap Areas to Prevent the Transport of Toxic or Hazardous Chemicals in Aquatic Environments***

  Industrial facilities, enclosed and impermeable waste/scrap storage areas can be constructed to prevent the transport of toxic or hazardous chemicals to receiving environments. This practice is already implemented under current environmental regulations in our country. Through field studies, separate collection channels can be constructed for toxic or hazardous material storage areas in industrial facilities to prevent the collection of leakage waters and their mixing with natural water environments.

- ***Recovery of Water from Rinsing Solutions and Reuse of Recovered Water in Suitable Processes***

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

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

  In industrial facilities, inefficient resource use and environmental problems are directly related to input-output flows; therefore, the inputs and outputs of production processes need to be well-defined (TUBİTAK MAM, 2016). This allows for the development of measures to improve resource efficiency, economic performance, and environmental performance. Organizing input-output inventories is considered a prerequisite for continuous improvement. While such management practices require the participation of technical personnel and upper management, they can quickly pay off through the efforts of various experts (IPPC BREF, 2003). It is necessary to use measurement equipment on a process basis and to perform routine analyses/measures specific to the processes. To maximize the benefits of the application, utilizing computer monitoring systems as much as possible enhances the technical, economic, and environmental benefits that can be achieved (TUBITAK MAM, 2016).

- ***Separate Collection and Treatment of Greywater in Facilities for Use in Areas That Do Not Require High Water Quality (such as Irrigating Green Spaces, Floor Washing, etc.)***

  The wastewater generated in industrial facilities is not only from industrial processes but also includes wastewater from areas such as showers, sinks, and kitchens. Wastewater from showers, sinks, kitchens, etc., is referred to as greywater. By treating this greywater through various treatment processes, it can be reused in areas that do not require high water quality, thereby conserving water.

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Computer Supported Control The system

- ***Reusing Backwash Water in Filtration Processes, Reusing Relatively Clean Cleaning Water in Production Processes, and Reducing Water Consumption with On-Site Cleaning Systems (CIP)***

  Wastewater generated from backwashing activated carbon filters and softeners primarily contains a high concentration of suspended solids (SS). Backwash water, one of the easiest types of wastewater to recover, can be filtered through ultrafiltration systems. This can lead to water savings of up to 15% (URL - 1, 2021).

  Regeneration wastewater produced after the regeneration process is soft water with high salt content, constituting approximately 5-10% of total water consumption. These regeneration wastewaters can be collected in a separate tank for use in processes requiring high salt, facility cleaning, and domestic applications. This requires a reserve tank, plumbing, and pumps. Reusing regeneration wastewater can reduce water consumption, energy consumption, wastewater amounts, and the salt content of wastewater by about 5-10% (Öztürk, 2014). The payback period varies depending on the use of regeneration water in production processes, facility cleaning, and domestic uses. In production processes requiring high salt, the potential payback period is estimated to be less than a year due to the recovery of both water and salt. However, for facility and equipment cleaning and domestic uses, the payback period is expected to exceed one year (TOB, 2021).

  In Turkey, reverse osmosis (RO) concentrates are combined with other wastewater streams and directed to the wastewater treatment facility. The concentrates formed in RO systems used for additional hardness removal can be utilized in garden irrigation, facility cleaning, and tank-equipment cleaning (TUBİTAK MAM, 2016; TOB, 2021). Moreover, it is possible to return and mix RO concentrates with raw water reservoirs for reassessment through proper monitoring of raw water quality (TOB, 2021).

- ***Implementing Time Optimization in Production and Organizing All Processes to Conclude in the Shortest Time Possible***

  In industrial production processes, planning the transformation of raw materials into products using the least number of processes is an effective practice for reducing labor costs, resource usage costs, and environmental impacts while enhancing efficiency. In this context, it may be necessary to revise production processes to minimize the number of process steps used (TUBİTAK MAM, 2016). When some deficiencies, inefficiencies, and design flaws in the fundamental production processes prevent the desired product quality, it may be necessary to renew those processes. As a result, the resource usage required for manufacturing a unit quantity of product, as well as the generated waste, emissions, and solid waste amounts, increase. Time optimization in production processes is an effective practice (TUBİTAK MAM, 2016).

- ***Documenting Production Procedures to Prevent Water and Energy Waste and Ensuring Their Use by Employees***

  To achieve efficient production within a facility, effective procedures must be implemented to identify, evaluate, and control potential problems and resources during the production stages (Ayan, 2010). Establishing and applying appropriate procedures in production processes ensures more efficient use of resources (such as raw materials, water, energy, chemicals, personnel, and time) while guaranteeing reliability and quality in the production processes (Ayan, 2010). Having documented production procedures contributes to evaluating business performance and enhancing the capability for rapid response in solving issues (TUBİTAK MAM, 2016; TOB, 2021).

  Effectively applying and monitoring the procedures established for specific production processes is one of the most effective ways to ensure product quality, obtain feedback, and develop solutions (Ayan, 2010). Documenting production procedures and ensuring their effective application and monitoring is a good management practice and serves as an effective tool in structuring and sustaining a clean production approach and an environmental management system. While potential benefits are significant, the costs and economic gains of the application may vary from sector to sector or depend on the structure of the facility (TUBİTAK MAM, 2016; TOB, 2021). Although the creation and monitoring of production procedures are not costly, considering the savings and benefits they provide, the payback period can be short (TUBITAK MAM, 2016; TOB, 2021).

2.1.4 Measures Related to Auxiliary Processes

Measures Related to Cooling Systems METs

- ***Use of Closed-Circuit Cooling Systems to Reduce Water Usage***

  Closed-circuit cooling systems significantly reduce water consumption compared to open-loop systems that have higher water usage. In closed-circuit systems, water is recirculated within the same system, and typically, only the amount of water evaporated needs to be replaced. Optimizing cooling systems can also reduce evaporation losses.

- ***Increasing the Number of Cycles in Closed-Circuit Cooling Systems to Improve the Quality of Make-Up Water and Reduce Water Consumption***

  Water is used as a cooling fluid in many processes, such as production processes in the manufacturing industry and cooling of products. Cooling is achieved by recirculating water 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 recirculated water (TUBİTAK MAM, 2016). By ensuring good chemical conditioning during the recirculation process, the number of cycles can be increased. This reduces the amount of fresh water fed into the system, leading to water savings. Additionally, properly conditioning the cooling make-up water can also increase the number of cycles (TOB, 2021).

- ***Using Local Dry Air Cooling When Cooling Needs Are Low During Certain Periods of the Year***

  When the cooling demand is low, using dry air for cooling can provide water savings.

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

  Industrial cooling systems are used to cool heated products, processes, and equipment. Both closed and open-loop cooling systems can be used, as well as industrial cooling systems that utilize 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 have different operating principles. In industrial air-cooling systems, heated water is cooled with air in closed-loop cooling condensers and heat exchangers (IPPC BREF, 2001b; TOB, 2021). In water-cooled systems, heated water is sent to a cooling tower, where it is cooled using a spray system. However, despite operating in a closed circuit, significant evaporation occurs in water-cooled systems. Additionally, a certain amount of water is lost as blowdown in cooling systems, resulting in further water loss (IPPC BREF, 2001b; TOB, 2021). Using air-cooling systems instead of water in cooling systems can reduce evaporation losses and also lower the risk of cooling water contamination (IPPC BREF, 2001b; TOB, 2021).

- ***Water Recovery through Cooling Tower Application in Systems without Closed Circuits***

Cooling towers are classified into two types based on their operating principles: counterflow and crossflow. In counterflow cooling towers, water flows downward while the air flow moves upward; in crossflow cooling towers, water also flows downward, but the air moves horizontally. The water exposed to fresh air cools down until it reaches the cold water basin, where it collects and is sent to the facility. During these processes, a portion of the water evaporates. The air, which gains moisture from evaporation, is expelled into the atmosphere through the fan stack located at the top of the tower. The evaporation losses in cooling towers must be effectively managed.

To prevent the growth of bacteria and parasites and to control scale deposits in cooling towers, various chemicals are used. These chemicals concentrate as water evaporates, leading to unwanted sediment and deposits inside the tower. To maintain this concentration at a certain level, a blowdown system is used. Blowdown water can be treated and recovered through membrane filtration systems or ion exchange resins. Recovering blowdown wastewater is important for water efficiency.

- ***Identifying Processes Requiring Wet Cooling to Avoid Unnecessary Cooling Operations***

The boundaries of the facility site affect design parameters such as cooling tower height. In cases where reducing tower height is necessary, a hybrid cooling system may be implemented. Hybrid cooling systems combine evaporative and non-evaporative (wet and dry) cooling systems. Depending on the ambient temperature, a hybrid cooling tower can operate entirely as a wet cooling tower or as a combined wet/dry cooling tower (TUBİTAK MAM, 2016). In regions where sufficient cooling water is not available or where water costs are high, evaluating dry cooling systems or hybrid cooling systems can be an effective solution to reduce the amount of cooling make-up water needed (TUBITAK MAM, 2016).

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- ***Increasing the Number of Cycles by Using Corrosion and Scale Inhibitors in Systems with Closed Water Circuits***

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). However, since a portion of the recirculated water evaporates, impurities remain in the recirculating water, leading to an increasing concentration of these impurities with each cycle. Impurities that can enter the cooling system with air may cause contamination in the recirculating waters (TUBİTAK MAM, 2016). If impurities and pollutants are not effectively controlled, they can lead to scale formation (limescale) and corrosion, unwanted biological growth, and sludge accumulation. This situation can become a chronic problem, resulting in decreased efficiency of heat transfer surfaces and increased operational costs. Therefore, the quality of the feed water supplied to the cooling system must be managed through a specially designed water conditioning program, taking into account the materials used in the cooling water system and operating conditions.

In this context, appropriate measures may include blowdown control, biological growth control, corrosion control, avoidance of hard water use, the use of sludge control chemicals, and the use of filtration and screen systems (TUBİTAK MAM, 2016). Additionally, establishing and periodically implementing an effective cleaning procedure and program is a good management practice for maintaining cooling systems. Corrosion is one of the most significant problems in cooling systems. In the tower recirculating water, as the hardness level increases, dissolved solids (such as sulfate, chloride, and carbonate) that cause corrosion will lead to the formation of scale and deposits on the surfaces over time. Furthermore, the accumulation of deposits negatively impacts heat transfer, reducing energy efficiency.

To prevent these issues, it is necessary to implement a chemical conditioning program for scale and corrosion prevention, perform disinfection with a biocide that inhibits biological activity, and conduct chemical and mechanical cleaning of the cooling towers at least twice a year to remove deposits. The hardness and conductivity values of the make-up water should also be kept as low as possible (IPPC BREF, 2001; Kayabek et al., 2005). It may be necessary to use an appropriate treatment system to enhance the quality of the make-up water. Additionally, unwanted microbial growth must be kept under control (IPPC BREF, 2001b; TOB, 2021). Due to micro-impurities and sediments in the cooling water, blowdown occurs in cooling systems similar to that in steam boilers. Intentionally draining the cooling system to balance the increasing concentration of solids is referred to as cooling blowdown. By pre-treating the cooling water using appropriate methods and continuously monitoring the quality of the cooling water, it is possible to reduce the use of biocides and the volume of blowdown (TUBİTAK MAM, 2016). While the investment cost depends on the scale of the application, the expected payback period for investment expenses ranges from 3 to 4 years (IPPC BREF, 2001).

- ***Collecting surface runoff waters through a separate collection system for use as cooling water, process water, etc.***

In most industrial facilities, wastewater is generated from process-related or external areas. The generated wastewater can be treated and reused in appropriate locations. By reusing treated wastewater in the facility, savings can be achieved in varying amounts in different industrial plants. Surface runoff waters can be collected through a separate collection system and used as cooling water (TOB, 2021).

- ***Reducing evaporation losses in closed-loop cooling water systems***

In cooling systems, some water evaporates during the cooling of heated water. Therefore, an equivalent amount of cooling water is added to compensate for the evaporated water in closed-loop cooling systems. By optimizing cooling systems, evaporation losses can be prevented. Additionally, treatment of the makeup water added to the cooling systems and measures to prevent biological growth can reduce the blowdown amount. During field studies, blowdown water generated in the cooling system is generally discharged directly into the wastewater channel. By reusing blowdown water from the cooling system, water consumption in cooling systems can be reduced by up to 50%. Implementing this measure may require the installation of new pipelines and reserve tanks (TOB, 2021).

- ***Establishing water softening systems for the effective operation of cooling water recovery systems***

Cooling waters are collected separately for cooling purposes or reused in appropriate processes (EC, 2009). For this system to operate effectively, a water softening system is necessary. The quality of cooling water is suitable for reuse as cleaning and irrigation water. However, due to its hardness, additional softening is required to prevent corrosion problems that may occur over time when used as cooling water. Before reuse in cooling water or processes, this water should undergo an appropriate disinfection process. Furthermore, these waters can be treated using suitable purification techniques (membrane filtration, advanced oxidation, chemical precipitation, granular activated carbon adsorption, etc.) for reuse not only in cooling processes but also in all production processes (TUBİTAK MAM, 2016). As the hardness level of cooling water increases, the formation of scale and deposits occurs on the walls. The formation of deposits adversely affects heat transfer, reducing energy efficiency and increasing energy costs. With the increase in evaporation within the system, the ion concentration and conductivity of the water also rise. To prevent these adverse effects, the cooling water should be treated with scale and corrosion inhibitors, disinfected with a biocide to inhibit biological activation, and cooling towers should be chemically and mechanically cleaned at least twice a year, including the removal of deposits, while maintaining hardness and conductivity levels as low as possible (TUBITAK MAM, 2016).

Ventilation and Air Conditioning System METs

- ***Reusing liquid formed from condensation in the ventilation system***

  During the ventilation cycle, condensate water of good quality can be produced in the system. For example, in a facility in Spain, condensate with a conductivity of approximately 200 µS 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 the reverse osmosis principle (systems that produce demineralized water) and reusing the water***

  When ion exchange resins are used in the ventilation system, the conductivity of the outlet water reaches a suitable level for equipment cleaning. In a facility in Spain, the equipment in the ventilation system was replaced with ion exchange resins, yielding outlet water with a conductivity value of approximately 1000 µS, which is reused in the system (MedClean, n.d.).

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Tower Type Cooling Systems

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