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MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF WATER MANAGEMENT



Water Efficiency Guidance Documents Series

MOTOR VEHICLE BODYWORK; TRAILER AND SEMI-TRAILER MANUFACTURING

NACE CODE: 29.20

ANKARA 2023

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Abbreviations

WWTP	Wastewater Treatment Plant
EU	European Union
SSM	Suspended Solid Matter
BREF	Best Available Techniques Reference Document
EMS	Environmental Management System
MoECC	Republic of Turkey Ministry of Environment, Urbanisation and Climate Change
NOM	Natural Organic Matter
EMAS	Eco-Management and Audit Programme Directive
EPA	United States Environmental Protection Agency
IPPC	Industrial Pollution Prevention and Control
ISO	International Standards Organisation
BAT	Best Available Techniques
NACE	Statistical Classification of Economic Activities
GDWM	General Directorate of Water Management
RO	Reverse Osmosis
MoAF	Republic of Turkey Ministry of Agriculture and Forestry
TSI	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 to be 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 per cent in the next hundred years.

For the year 2022, the annual amount of water available per capita in Turkey is 1,313 m³ and it is expected that the annual amount of water available per capita will fall below 1,000 cubic metres after 2030 due to human pressures and the effects of climate change. If the necessary measures are not taken, it is obvious that 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 *"using the least amount of water in the production of a product or service"*. The water efficiency approach is based on the rational, sharing, equitable, efficient and effective use of water in all sectors, especially in drinking water, agriculture, industry and household use, in a way that protects water in terms of quantity and quality and takes into account not only the needs of humans but also the needs of all living things with ecosystem sensitivity.

With the increasing demand for water resources, the change in precipitation and temperature regimes as a result of climate change, the increase in population, urbanisation and pollution, the fair and balanced distribution of usable water resources among users is becoming more and more important every day. For this reason, it has become a necessity to create a road map based on efficiency and optimisation in order to protect and use limited water resources through sustainable management practices.

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

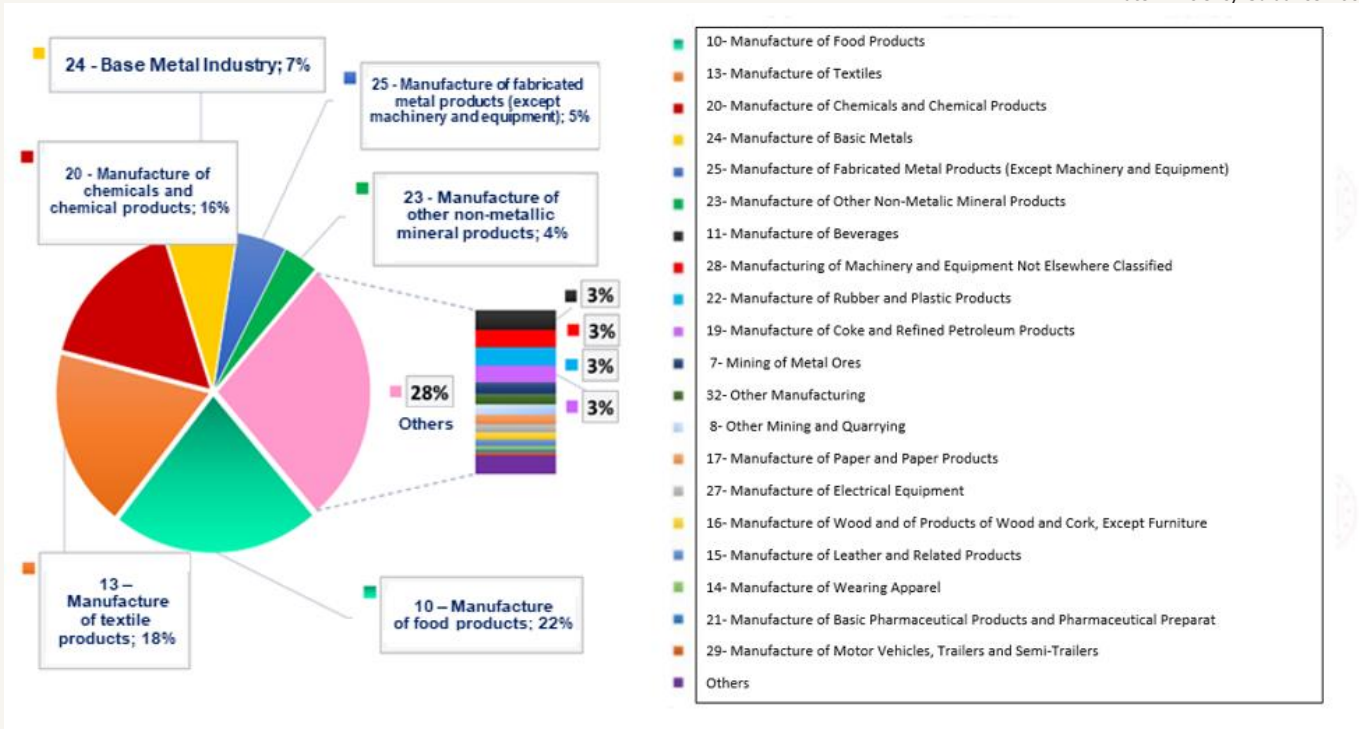
In the European Green Deal Action Plan prepared by our country within the scope of the European Green Deal Action Plan, in which member countries agreed on the objectives such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing environmental impacts, actions emphasising water and resource efficiency in production and consumption in various fields, especially in industry, 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 measures to be taken for the control, prevention or reduction of 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 systematise the applicability of cleaner production processes and to ~~over~~ **mitigate** difficulties in implementation. BATs are the most effective implementation techniques for a high level of environmental protection, taking into account their costs and benefits. In accordance with the Directive, Reference Documents (BAT-BREF) have been prepared for each sector in which BATs are explained in detail. In BREF documents, BATs are presented in a general framework such as good management practices, techniques as general measures, 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 activities aimed at disseminating efficient practices in urban, agricultural, industrial and individual water use and raising social awareness. Water efficiency action plans addressing all sectors and stakeholders were prepared within the scope of **the "Water Efficiency Strategy Document and Action Plan (2023-2033) within the Framework of Adaptation to a Changing Climate"**, which entered into force with the Presidential Circular No. 2023/9. 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 assigned for these actions. Within the scope of the Action Plan, the General Directorate of Water Management is responsible for carrying out studies to determine specific water use ranges and quality requirements on the basis of sub-sectors in industry, organising technical training programmes and workshops on sectoral basis and preparing water efficiency guidance documents.

On the other hand, with the **"Industrial Water Use Efficiency Project by NACE Codes"** carried out by the General Directorate of Water Management of the Ministry of Agriculture and Forestry, the best sectoral techniques specific to our country were determined within the scope of studies on improving water efficiency in industry. As a result of the study, sectoral guidance documents and action plans categorised by NACE codes, including the measures recommended for improving water use efficiency in sectors with high water consumption operating in our country, were 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, especially food, textile, chemical, basic metal industry, which represent production areas with different capacities and diversity 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, recycling were obtained and information was provided on the best available techniques (BAT) and sectoral reference documents (BREF) published by the European Union, water efficiency, clean production, water footprint, etc.



Sectoral distribution of water use in industry in Turkey

As a result of the studies, specific water consumption and potential saving rates for the processes of enterprises for 152 different 4-digit NACE codes with high water consumption were determined, and water efficiency guidance documents were prepared by taking into account the EU best available techniques (BAT) and other cleaner production techniques. Within the guidelines, 500 techniques (BAT) for water efficiency;

(i) Good Management Practices, (ii) General Water Efficiency BATs, (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 consideration during the determination of BATs for each sector. In the determination of BATs, not only BREF documents were not limited, but also different data sources such as current literature data on a global scale, real case analyses, innovative practices, reports of sector representatives 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 prioritised by the enterprises by scoring them on the criteria of water saving, economic savings, environmental benefit, applicability, cross-media impact and the final BAT lists were determined using the scoring results. Water and wastewater data of the facilities visited within the scope of the project and the final BAT lists, which were prioritised by sectoral stakeholders and determined by taking into account the local dynamics specific to our country, were used to create sectoral water efficiency guides on the basis of NACE code.

2 Scope of the Study

Guidance documents prepared within the scope of water efficiency measures in industry cover the following main sectors:

- Crop and animal production and hunting and related service activities (including sub-production area represented by 6 four-digit NACE codes)
- Fisheries and aquaculture (including sub-production area represented by 1 four-digit NACE Code)
- Coal and lignite extraction (including sub-production area represented by 2 four-digit NACE codes)
- Service activities in support of mining (including sub-production area represented by 1 four-digit NACE Code)
- Metal ores mining (including the sub-production area represented by 2 four-digit NACE codes)
- Other mining and quarrying (including the sub-production area represented by 2 four-digit NACE codes)
- Manufacture of food products (including 22 sub-production areas represented by four-digit NACE codes)
- Manufacture of beverages (including the sub-production area represented by 4 four-digit NACE codes)
- Manufacture of tobacco products (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of textile products (including 9 sub-production areas represented by four-digit NACE codes)
- Manufacture of articles of clothing (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of leather and related products (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of wood, wood products and cork products (except furniture); manufacture of articles made of thatch, straw and similar materials (including sub-production area represented by 5 four-digit NACE Codes)
- Manufacture of paper and paper products (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of coke and refined petroleum products (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of chemicals and chemical products (including 13 sub-production areas represented by four-digit NACE codes)
- Manufacture of basic pharmaceutical products and pharmaceutical ingredients (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of rubber and plastic products (including sub-production area represented by 6 four-digit NACE codes)
- Manufacture of other non-metallic mineral products (including 12 sub-production areas represented by four-digit NACE codes)
- Basic metal industry (including 11 sub-production areas represented by four-digit NACE codes)
- Manufacture of fabricated metal products (except machinery and equipment) (including 12 sub-production areas represented by four-digit NACE codes)
- Manufacture of computers, electronic and optical products (including sub-production area represented by 2 four-digit NACE codes)
- Manufacture of electrical equipment (including sub-production area represented by 7 four-digit NACE codes)
- Manufacture of machinery and equipment not elsewhere classified (including sub-production area represented by 8 four-digit NACE codes)
- Manufacture of motor vehicles, trailers (trailers) and semi-trailers (semi-trailers) (3 four-digit

- Including the sub-production area represented by NACE Code)
- Manufacture of other transport equipment (including sub-production area represented by 2 four-digit NACE codes)
 - Other manufacturing (including 2 sub-production areas represented by four-digit NACE codes)
 - Installation and repair of machinery and equipment (including sub-production area represented by 2 four-digit NACE codes)
 - Electricity, gas, steam and ventilation system production and distribution (including sub-production area represented by 2 four-digit NACE codes)
 - Waste collection, reclamation and disposal activities; recovery of materials (including sub-production area represented by 1 four-digit NACE Code)
 - Construction of non-building structures (including sub-production area represented by 1 four-digit NACE Code)
 - Warehousing and supporting activities for transport (including sub-production area represented by 1 four-digit NACE Code)
 - Accommodation (including sub-production area represented by 1 four-digit NACE Code)
 - Educational Activities (Higher Education Campuses) (including sub-production area represented by 1 four-digit NACE Code)
 - Sporting activities, leisure and recreation activities (including sub-production area represented by 1 four-digit NACE Code)

Manufacture of motor vehicles, trailers and semi-trailers

Under the motor vehicle, trailer (trailer) and semi-trailer (semi-trailer) manufacturing sector, the sub-production branches for which guidance documents were prepared are as follows:

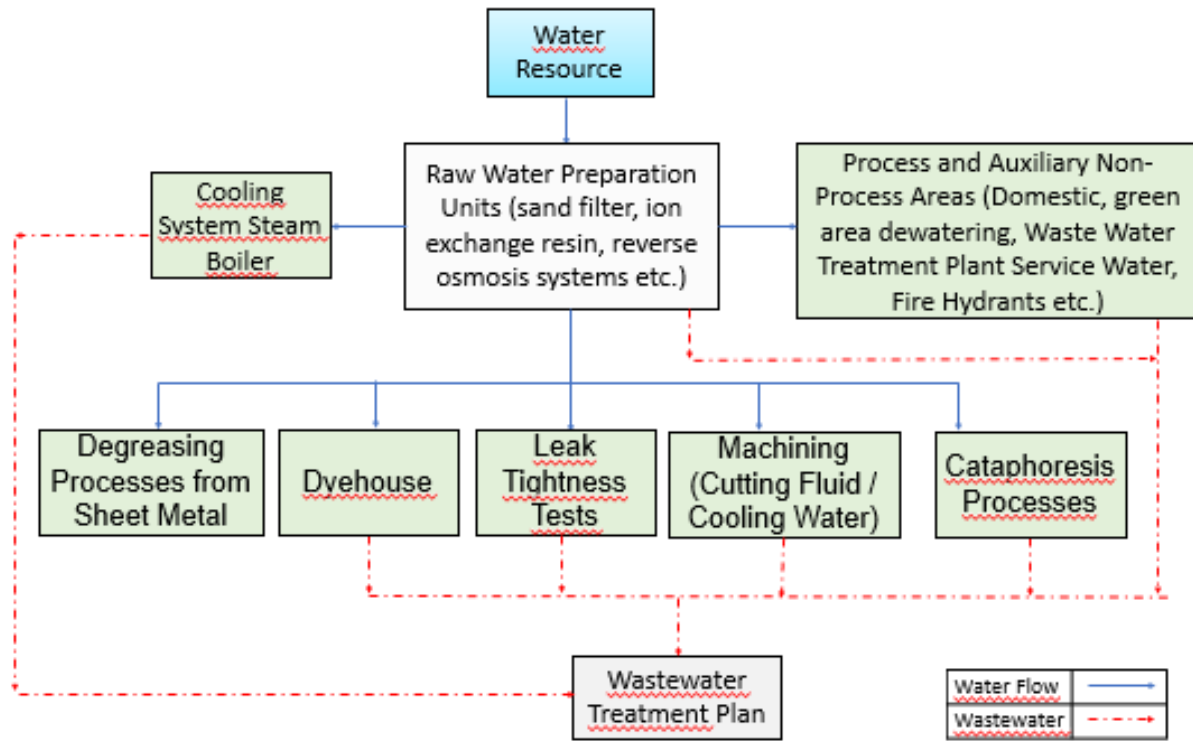
29.10 Manufacture of motor vehicles

29.20 Motor vehicle bodywork; trailer and semi-trailer manufacturing
(semi-trailer) manufacturing

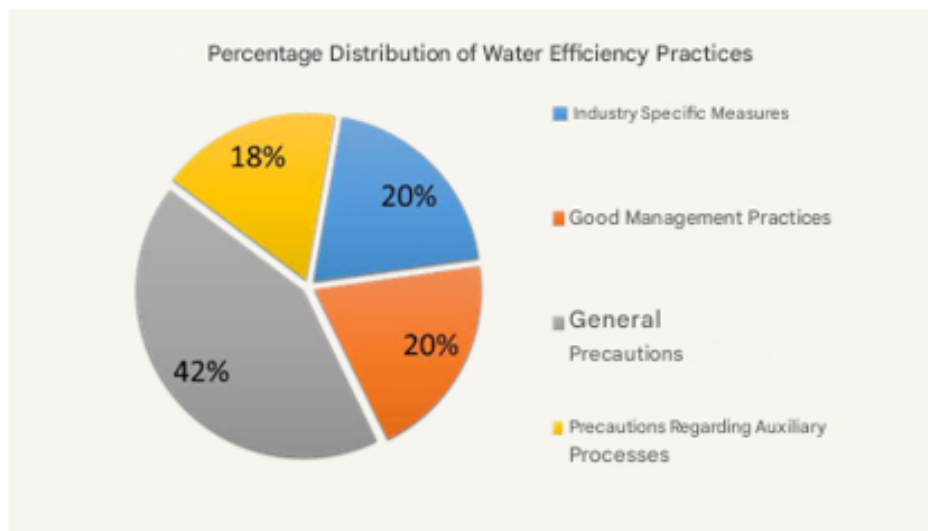
29.32 Manufacture of other parts and accessories for motor vehicles

2.1 Manufacture of bodywork of motor vehicles; manufacture of trailers (trailers) and semi-trailers (semi-trailers) (NACE 29.20)

Motorized Land Vehicle, Trailer (trailer) and Semi-Trailer (semi-trailer) Manufacturing Sector Water Flow Diagram



	Minimum	Maksimum
Specific Water Consumption of Facilities Visited within the Scope of the Project (L/kg product)	823,6	10,231
Reference Specific Water Consumption (L/kg product)	1.250	4.300



Within the scope of the manufacture of motor vehicle bodies and trailers, body, bonnet and trailer are formed by pressing, welding and assembly processes from sheet metal materials. In addition, coating processes are carried out to prevent damage to vehicle paints. In addition to the production of motor vehicle bodies and trailers with cathodolysis, sheet coating, paint shop and final assembly processes, the production of cabins and skeletons of construction machinery such as tractors and excavators is also carried out.

Water consumption occurs in degreasing baths, vehicle paint shops, sealing tests of vehicles and cathodolysis processes. Cooling water is used in processes expressed as machining production in lathes where cutting, drilling and shaping processes are carried out. Cutting fluid containing boron oil is used both to prevent heat increase during the processes and to facilitate cutting processes. In the raw water preparation units such as activated carbon filter, ion exchange resin, reverse osmosis, which are used to produce soft water to be used in production processes in the sector, significant water consumption is also realised for filter washing, resin regeneration and membrane cleaning processes. Water consumption also occurs in auxiliary units such as cooling tower and steam boilers.

The reference specific water consumption in the manufacture of motor vehicle bodywork; trailer (trailer) and semi-trailer (semi-trailer) manufacturing is in the range of 1,250 - 4,300 L/piece. The specific water consumption of the production line analysed within the scope of the study is 823.6 - 10,231 L/piece. With the application of sector-specific techniques, good management practices, general water efficiency BATs and measures related to auxiliary processes, it is possible to achieve water savings of 41 - 63% in the sector.

29.20 Manufacture of bodywork for motor vehicles; manufacture of trailers and semi-trailers The priority water efficiency implementation techniques recommended within the scope of the NACE code are presented in the table below.

NACE Code	NACE Code Description	Sectoral Prioritisation Best Available Techniques
29.20	Manufacture of motor vehicle bodywork; manufacture of trailers (trailers) and semi-trailers (semi-trailers)	<p>Sector Specific Measures</p> <ol style="list-style-type: none"> 1. Use of compatible chemicals in consecutive tanks to reduce the filtrate carried in the baths 2. Removal of material from the tanks at low speed to minimise the filtrate carried in the baths 3. In order to reduce the filtrate water carried in the bathrooms, the widest surface of the coated material should be placed vertically and the longest surface should be placed horizontally. 4. Ensuring that the solutions are transferred back to the tank with inclined drainage plates placed between the tanks in order to minimise the filtrate water carried in the baths 5. Recovery of rinse water using ion exchangers, reverse osmosis, membrane technologies and electrolytes to make the rinsing process more efficient 6. Optimising the bath discharge frequency 7. In order to make the rinsing process more efficient, water usage can be reduced by immersing more than one part at a time in the rinsing tank, using the smallest possible size rinsing tanks, placing the water inlets and outlets in opposite directions, placing curtains, diffusers or diffusers at the water inlets, rinsing with the countercurrent principle. <p>Good Management Practices</p> <ol style="list-style-type: none"> 1. Use integrated wastewater management and treatment strategy to reduce wastewater quantity and pollutant load 2. Establishment of environmental management system 3. Preparation of water flow diagrams and mass balances for water 4. Preparing a water efficiency action plan to reduce water use and prevent water pollution 5. Providing technical trainings to personnel for the reduction and optimisation of water use 6. Good production planning to optimise water consumption 7. Determination of water efficiency targets 8. Monitoring the water used in production processes and auxiliary processes and the wastewater generated in terms of quantity and quality and monitoring this information in terms of environment adaptation to the management system

NACE Code	NACE Code Description	Sectoral Prioritisation Best Available Techniques
29.20	Motor vehicle bodywork; trailer and semi-trailer manufacturing Manufacture	<p>General Water Efficiency BATs</p> <ol style="list-style-type: none"> 1. Minimising spillages and leakages 2. Use of automatic hardware and equipment (sensors, smart hand washing systems, etc.) that will save water at water usage points such as showers/toilets etc. 3. Use of pressure washing systems for equipment cleaning, general cleaning, etc. 4. Avoiding the use of drinking water in production lines 5. Identification and minimisation of water losses 6. Use of automatic control-close valves to optimise water use 7. Documented production procedures are kept and used by employees to prevent water and energy wastage 8. Reuse of pressurised filtration backwash water prior to water softening at appropriate points 9. Optimising the frequency and duration of regeneration (including rinses) in water softening systems 10. Construction of closed storage and impermeable waste/scrap sites to prevent the transport of toxic or hazardous chemicals for the aquatic environment 11. Storage and storage of substances (such as oils, emulsions, binders) that pose a risk in the aquatic environment and prevention of their mixing with wastewater after use 12. Prevention of mixing of clean water flows with polluted water flows 13. Determination of wastewater flows that can be reused with or without treatment by characterising the wastewater quantities and qualities at all wastewater generation points 14. Use of closed loop water cycles in appropriate processes 15. Use of computer aided control systems in production processes 16. Separate collection and treatment of grey water in the facility and its use in areas that do not require high water quality (green area irrigation, floor washing, etc.) utilisation

NACE Code	NACE Code Descriptio	Sectoral Prioritisation Best Available
29.20	Motor vehicle body (bodywork) manufacturing; trailer (trailer) and semi-trailer (semi-trailer) manufacturing	<p>17. Implementation of time optimisation in production and arrangement of all processes to be completed as soon as possible</p> <hr/> <p>18. Collecting rainwater and utilising it as an alternative water source in facility cleaning or in suitable areas</p> <hr/> <p>19. Nanofiltration (NF) or reverse osmosis (RO) concentrates reuse with or without treatment depending on the characterisation</p> <p>Precautions for Auxiliary Processes</p> <hr/> <p>Old equipment in the ventilation system should be converted to the reverse osmosis principle</p> <p>1. replacement with ion exchange resins based on ion exchange resins (systems producing demineralised water) and water reuse</p> <hr/> <p>2. Re-use of the liquid formed by condensation from the ventilation system</p> <hr/> <p>3. Avoiding unnecessary cooling processes by identifying processes that need wet cooling</p> <hr/> <p>4. Reducing water consumption by increasing the number of cycles in closed loop cooling systems and improving the quality of make-up water</p> <hr/> <p>5. Reduction of evaporation losses in closed loop cooling water</p> <hr/> <p>6. Increasing the number of cycles by using corrosion and scale inhibitors in systems with closed water cycle</p> <hr/> <p>7. Use of a closed-loop cooling system to minimise water use</p>

A total of 41 techniques have been proposed in this sector.

Motor vehicle bodywork; trailer and semi-trailer manufacturing
For NACE Code;

- (i) Sector Specific Measures,
- (ii) Good Management Practices,
- (iii) General Precautions and
- (iv) Measures for auxiliary processes are given under separate headings.

2.1.1 Sector Specific Measures

- ***Optimising the bath discharge frequency***

In water-based surface treatment processes, the bath drain frequency can be regulated by applying reverse flow and multiple cascade rinsing and regular conductivity control in the final rinse tank. By regularly checking the conductivity, unnecessary bath draining operations can be prevented and water savings can be achieved.

- ***Removal of material from the tanks at low speed to minimise the filtrate carried in the baths***

The slow removal of the materials placed in the tanks ensures that the chemicals and rinse water drip back into the tanks and prevent unwanted filtration out of the tank (MoEnvUIDU, 2013).

- ***Ensuring that the solutions are transferred back to the tank with inclined drainage plates placed between the tanks in order to minimise the filtrate water carried in the baths***

By using sloping drainage boards between non-sequential tanks, solutions and filtrate can be transferred back to the tank (MoEnvU, 2013).

- ***Use of compatible chemicals in consecutive tanks to reduce the filtrate carried in the baths***

It is important that filtrate is kept to the lowest possible level. In the absence of good rinsing between processes, chemicals carried on parts may contaminate the process solutions. By using compatible chemicals in consecutive tanks, the transport of chemicals can be reduced (MoEU, 2013).

- ***In order to reduce the filtrate water carried in the baths, the widest surface of the coated material should be placed vertically and the longest surface should be placed horizontally.***

When placing the coated material in the rinsing tanks, positioning it in such a way that the widest surface is vertical and the vertical surface is horizontal reduces the filtrate water transport from the rinsing bath (MoECC, 2013).

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

With the help of cationic and anionic ion exchangers, rinse water can be returned to the process. Reverse osmosis can be used to recover both rinse water and the chemicals in the water. Membrane processes such as ultrafiltration and nanofiltration can also be used for rinse water recovery (MoECC, 2013).

- ***To make the rinsing process more efficient, it is recommended to immerse more than one piece at a time in the rinsing tank, to use the smallest possible size rinsing tanks, to place the water inlets and outlets opposite each other, to place screens, diffusers or diffusers at the water inlets placement, reduction by the principle water utilisation by rinsing techniques of reverse current***

To reduce the amount of rinse water, immersing the parts in the rinsing tank more than once is a more effective method than immersing and shaking the parts in the tank. Immersing the coated materials in the rinsing tank twice is 6 times more effective than immersing them once in preventing leachate (MoEUDB, 2013). In reverse flow rinsing, the coated part and rinse water flow in opposite directions. The material enters the first tank in contact with the dirtiest rinse water instead of the cleanest rinse water and enters cleaner baths as it progresses. In this way, the clean water is less contaminated in the first tank compared to parallel flow because it does not come into contact with the dirtiest material. It is reported that water savings of more than 90% can be achieved with this method (MoECC, 2013).



<https://www.remorquerolland.com/wp-content/uploads/2019/05/Image2.jpg>

Trailer Production Cataphoresis Baths

2.1.2 Good Management Practices

• **Establishment of environmental management system**

Environmental Management Systems (EMS) include the organisational structure, responsibilities, procedures and resources required to develop, implement and monitor the environmental policies of industrial organisations. The establishment of an environmental management system improves the decision-making processes between raw materials, water and wastewater infrastructure, planned production process and different treatment techniques. Environmental management organises how resource supply and waste discharge demands can be managed with the highest economic efficiency, without compromising product quality and with the least possible impact on the environment.

The most widely used Environmental Management Standard is ISO 14001. Alternatives include the Eco Management and Audit Scheme Directive (EMAS) (761/2001). It has been developed for the assessment, improvement and reporting of the environmental performance of enterprises. It is one of the leading practices within the scope of eco-efficiency (cleaner production) in EU legislation and voluntary participation is provided (TUBITAK MRC, 2016; T, 2021). The benefits of establishing and implementing an Environmental Management System are as follows:

- Economic benefits can be obtained by improving business performance (Christopher, 1998).
- International Standards Organisation (ISO) standards are adopted to ensure greater compliance with global legal and regulatory requirements (Christopher, 1998).
- While the risks of penalties related to environmental responsibilities are minimised, the amount of waste, resource consumption and operating costs are reduced (Delmas, 2009).
- The use of internationally recognised environmental standards eliminates the need for multiple registrations and certificates for businesses operating in different locations around the world (Hutchens Jr., 2017).
- Especially in recent years, the improvement of the internal control processes of companies is also considered important by consumers. The implementation of environmental management systems provides a competitive advantage against companies that do not adopt the standard. It also contributes to the better position of organisations in international areas / markets (Potoski & Prakash, 2005).

The above-mentioned benefits depend on many factors such as the production process, management practices, resource utilisation and potential environmental impacts (MoAF, 2021). Practices such as preparing annual inventory reports with similar content to the environmental management system and monitoring inputs and outputs in terms of quantity and quality in production processes can save 3-5% of water consumption (Öztürk, 2014). The total duration of the development and implementation phases of the EMS takes an estimated 8-12 months (ISO 14001 User Manual, 2015).

Industrial organisations also carry out studies within the scope of ISO 14046 Water Footprint Standard, an international standard that defines the requirements and guidelines for assessing and reporting water footprint. With the implementation of the relevant standard, it is aimed to reduce the use of fresh water required for production and environmental impacts. In addition, ISO 46001 Water Efficiency Management Systems Standard, which helps industrial organisations to save water and reduce operating costs, helps organisations to develop water efficiency policies by conducting monitoring, benchmarking and review studies.

- **Use integrated wastewater management and treatment strategy to reduce wastewater quantity and pollutant load**

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

On-site reuse of treated wastewater not only improves the quality of water bodies, but also reduces the demand for freshwater. It is therefore very important to identify appropriate treatment strategies for different reuse objectives.

In integrated industrial wastewater treatment, different aspects such as wastewater collection system, treatment process and reuse target are evaluated together (Naghedi et al., 2020). For industrial wastewater recovery, methods such as SWOT method (strengths, weaknesses, opportunities and threats), PESTEL method (political, economic, social, technological, environmental and legal factors), decision tree can be combined with expert opinions to determine the integrated wastewater management framework (Naghedi et al., 2020). The integration of Analytic Hierarchy Process (AHP) and CoCoSo techniques can be used to determine priorities based on multiple criteria for industrial wastewater management processes (Adar et al., 2021).

The implementation of integrated wastewater management strategies can lead to an average reduction of up to 25% in water consumption, wastewater quantity and pollution loads of wastewater. The potential payback period of the implementation varies between 1-10 years (MoAF, 2021).



- **Providing technical trainings to the staff for the reduction and optimisation 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. In industrial facilities, problems related to high water consumption and wastewater generation may arise due to the lack of necessary technical knowledge of the personnel. For example, it is important that cooling tower operators, which represent a significant proportion of water consumption in industrial operations, are properly trained and have technical knowledge. Determination of water quality requirements in production processes, measurement of water and wastewater quantities, etc. It is also necessary for the relevant personnel to have sufficient technical knowledge (MoAF, 2021). Therefore, it is important to provide training to staff on water use reduction, optimisation and water saving policies. Practices such as involving the staff in water saving studies, creating regular reports on the amount of water use before and after water efficiency initiatives, and sharing these reports with the staff support participation and motivation in the process. The technical, economic and environmental benefits to be obtained through staff training yield results in the medium or long term (TUBITAK MRC, 2016; MoAF, 2021).

- **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 is resource utilisation in industrial facilities and there is resource utilisation as a result of resource utilisation.

Inefficiency and environmental problems may arise from input-output flows. For this reason Water and wastewater used in production processes and auxiliary processes should be monitored in terms of quantity and quality (TUBITAK MRC, 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 reduce energy consumption by 6-10%, water consumption and wastewater quantities by 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 as follows

- Use of monitoring equipment (such as counters) to monitor water, energy, etc. consumption on a process basis,
- Establishment of 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, comparative evaluation and reporting in terms of quantity and quality,
- Monitoring raw material losses in production processes where raw materials are transformed into products and taking measures against raw material losses (MoEU, 2020e).

- **Good production planning to optimise water consumption**

In industrial production processes, planning by using the least process in the process from raw material to product is an effective practice for reducing labour costs, resource use costs and environmental impacts and ensuring efficiency (TUBITAK MRC,2016;MoAF,2021). In industrial plants, production planning in consideration of the water efficiency factor reduces water consumption and wastewater amount. Industrial modification of production processes in plants or combining some processes water It provides significant benefits in terms of efficiency and time planning (MoAF, 2021).

- **Preparing a water efficiency action plan to reduce water use and prevent water pollution**

It is important for water efficiency to prepare an action plan that includes short, medium and long term actions to be taken in order to reduce water-wastewater quantities and prevent water pollution in industrial facilities. At this point, determination of water needs throughout the facility and in production processes, determination of quality requirements at water use points, wastewater generation points and wastewater characterisation should be carried out (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 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 the facilities (MoAF, 2021).

- **Determination of water efficiency targets**

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

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

Determination of water use and wastewater formation points in industrial plants, production processes and auxiliary processes other than production processes, water-wastewater balances

In general, the establishment of good governance is the basis of many good governance practices.

Establishing process profiles on a plant-wide and production process basis facilitates the identification of unnecessary water use points and high water use points, evaluation of water recovery opportunities, process modifications and determination of water losses (MoAF, 2021).

2.1.3 General Water Efficiency BATs

• **Identification and minimisation of water losses**

Water losses occur in equipment, pumps and pipelines in industrial production processes. Firstly, water losses should be identified and leakages should be prevented by regular maintenance of equipment, pumps and pipelines to keep them in good condition (IPPC BREF, 2003). Regular maintenance procedures should be established, paying particular attention to the following points:

- Adding pumps, valves, level switches, pressure and flow regulators to the maintenance checklist,
- Carrying out inspections not only in the water system, but also in particular in the heat transfer and chemical distribution systems, broken and leaking pipes, barrels, pumps and valves,
- Regular cleaning of filters and pipework,
- ~~Can~~ routinely check and monitor measuring equipment such as chemical measuring and dispensing devices, 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, 2014).

• **Minimising spillages and leakages**

Both raw material and water losses can occur due to spills and leaks in enterprises. In addition, if wet cleaning methods are used to clean the areas where spillage occurs, water consumption, wastewater amounts and pollution loads of wastewater may also increase (MoAF, 2021). In order to reduce raw material and product losses, spill and splash losses are reduced by using splash guards, flaps, drip trays, sieves (IPPC BREF, 2019).

• **Prevention of mixing of clean water flows with polluted water flows**

By determining the wastewater generation points in industrial facilities and characterising the wastewater, wastewater with high pollution load and relatively clean wastewater can be collected in separate lines (TUBITAK MRC, 2016; MoAF, 2021). In this way, wastewater streams with appropriate quality can be reused with or without treatment. With the separation of wastewater streams, water pollution is reduced, treatment performances are improved, energy consumption can be reduced in relation to the reduction of treatment needs, and emissions are reduced by providing wastewater recovery and recovery of valuable materials. In addition, heat recovery from separated hot wastewater streams is also possible (TUBITAK MRC, 2016; MoAF, 2021). Separation of wastewater streams usually requires high investment costs, and where it is possible to recover large amounts of wastewater and energy, costs can be reduced (IPPC BREF, 2006).

- ***Determination of wastewater flows that can be reused with or without treatment by characterising wastewater quantities and qualities at all wastewater generation points***

Determination and characterisation of wastewater generation points in industrial facilities
It is possible to reuse various wastewater streams with or without treatment (Öztürk, 2014; TUBITAKMRC,2016;MoAF,2021). In this context, filter backwash waters, TO concentrates, blowdown waters, condensate waters, relatively clean washing and rinsing waters can be reused without treatment in the same/different processes and in areas that do not require high water quality (such as facility and equipment cleaning). In addition, wastewater streams that cannot be directly reused can be reused in production processes after treatment 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 generally used for pre-treatment of water before it goes to NF or TO (Singh et al., 2014).

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

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

- ***Use of automatic hardware 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 meet the necessary hygiene standards. Water consumption in the production processes of industrial facilities can be provided in various ways, as well as water consumption savings can be achieved by using equipment such as sensor faucets and smart hand washing systems in the water usage areas of the personnel. Smart hand washing systems provide resource efficiency in addition to water saving while adjusting the mixture of water, soap and air at the right rate.

- ***Use of pressure washing systems for equipment cleaning, general cleaning, etc.***

Water nozzles are widely used in equipment plant cleaning. Effective results can be achieved by using correctly placed, appropriate nozzles to reduce water consumption and wastewater pollution loads. The use of active sensors and nozzles at points where high water consumption occurs and where possible is very important in terms of efficient use of water. It is possible to achieve significant water savings by replacing mechanical equipment with pressurised nozzles (TUBITAK MRC, 2016). Reducing water consumption, wastewater generation and wastewater pollution load through the use of water pressure optimised nozzles in technically appropriate processes are the main environmental benefits of the application.

- ***Use of automatic control-close valves to optimise water use***

Monitoring and controlling water consumption using flow control devices, meters and computer-aided monitoring systems provide significant technical, environmental and economic advantages (Öztürk, 2014). Monitoring the amount of water consumed in the plant and in various processes prevents water losses (TUBITAK MRC, 2016). It is necessary to use flow meters and counters in the plant in general and in production processes in particular, to use automatic shut-off valves and valves in continuously operating machines, and to develop monitoring-control mechanisms according to water consumption and some determined quality parameters by using computer-aided systems (TUBITAK MRC, 2016). With this application, it is possible to save up to 20-30% of water consumption on 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).

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

In different sub-sectors of the manufacturing industry, waters with different water quality can be used for production purposes. In industrial plants, raw water supplied from groundwater sources is generally used in production processes after treatment. 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 then used in production processes. These waters containing residual chlorine can react with organic compounds (natural organic substances (NOM)) in water in production processes and form disinfectant by-products harmful to living metabolisms (Özdemir & Toröz, 2010; Oğur et al.) The use of drinking water containing residual chlorine compounds or raw water disinfected with chlorinated compounds should be avoided as much as possible. Highly oxidising disinfection methods such as ultraviolet (UV), ultrasound (US) or ozone can be used instead of chlorine disinfection for disinfection of raw water. In order to increase the technical, economic and environmental benefits of the application, the determination and use of 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 MRC, 2016).

- ***Reuse of pressurised filtration backwash water prior to water softening at appropriate points***

Softened water with low calcium and magnesium concentrations is required for many industrial processes. With water softening systems, calcium, magnesium and some other metal cations in hard water are removed from the water and soft water is obtained.

Savings are achieved by reusing pressurised filtration backwash water at appropriate points before water softening. This measure is similar in content with practices such as "Reuse of filter backwash water in filtration processes, reuse of relatively clean water in production processes, reduction of water consumption by using on-site cleaning systems".

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

Nowadays, when 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, ground infiltration, surface collection and filter systems are used. Rainwater collected with 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 (Tanık et al., 2015).

In various examples, roof rainwater collected in industrial facilities was stored and used inside the building and in landscape areas, resulting in 50% water saving in landscape irrigation (Yaman, 2009). Perforated stones and green areas can be preferred in order to increase the permeability of the ground and to allow rainwater to pass and absorb into the soil on the site (Yaman, 2009). Rainwater collected on building roofs can be used for car washing and garden irrigation. It is possible to recover and reuse 95% of the collected water by biological treatment after use (Şahin, 2010).

- **Optimising the frequency and duration of regeneration (including rinses) in water softening systems**

Cationic ion exchange resins, which are one of the most frequently used methods for softening raw water in industrial plants, are routinely regenerated. In regeneration, pre-washing of the resin using raw water, regeneration with salt water and final rinsing processes are carried out respectively. Regeneration periods are determined depending on the hardness of the water. If the hardness is high, regeneration should be performed more frequently in water softening systems.

In regeneration processes, washing, regeneration and rinsing wastewaters are generally removed directly. However, if the washing and final rinsing waters are of raw water quality, they can be sent to raw water storage or reused in processes that do not require high water quality such as facility cleaning and green area irrigation (MoAF, 2021).

It is very important to determine the optimum regeneration frequency in regeneration systems. Although regeneration in water softening systems is adjusted according to the frequencies recommended by the supplier or depending on the flow rate and time entering the softening system, this frequency also varies depending on the calcium concentration in the raw water. For this reason, online hardness measurement is applied while determining the regeneration frequency. Thus, regeneration frequencies can be optimised and excessive washing rinsing or backwashing with salt water can be prevented by using online hardness sensors.

- **Reuse of nanofiltration (NF) or reverse osmosis (RO) concentrates with or without treatment depending on their characterisation**

Depending on the wastewater characterisation and the appropriate point of use, the reuse potential of other wastewater from membrane processes (backwashing without or with chemicals, CIP cleaning, module cleaning, cleaning of chemical tanks, etc.) should be assessed.

Nanofiltration is a membrane-based liquid separation technique with low energy consumption and low operating pressures suitable for the treatment of well water and surface water. Reverse osmosis is also a membrane-based liquid separation technique and can separate smaller substances than nanofiltration (Akgül, 2016).

Savings are achieved by reusing nanofiltration or reverse osmosis concentrates with or without treatment depending on their characterisation. Measures should be taken to reduce water consumption by reusing clean water in the production processes of filter backwash water in filtration processes and using cleaning systems (MoAF, 2021).

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

In industrial plants, water recovery is achieved by using dry cleaning techniques and preventing leaks to prevent the mixing of chemicals that pose a risk to the aquatic environment such as oils, emulsions and binders into wastewater streams (TUBITAK MRC, 2016).

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

Closed and impermeable waste/scrap storage sites can be constructed in industrial facilities in order to prevent the transport of toxic or hazardous chemicals for aquatic environment to receiving environments. This practice is already being implemented in our country within the scope of existing environmental regulations. Within the scope of the field studies carried out, a separate collection channel can be constructed in the storage areas of toxic or hazardous substances in industrial facilities and the leachate can be collected separately and prevented from mixing into natural water environments.



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

Reverse Osmosis System

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

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

Water is used as a refrigerant in many processes in the manufacturing industry and in many processes led by the product cooling process. During this cooling process, water can be reused through 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 MRC, 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 is a side interaction.

Heat recovery is also provided by the use of heat exchangers in cooling water. Generally, closed loop systems are used in plants where aqueous cooling systems are used. However, cooling system blowdowns are discharged directly to the wastewater treatment plant channel. These blowdown waters can be reused in appropriate production processes.

- ***Implementation of time optimisation 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 by using the minimum number of processes is an effective practice for reducing labour costs, resource use costs and environmental impacts and ensuring efficiency. In this context, it may be necessary to revise the production processes so that the minimum number of process steps is used (TUBITAK MRC, 2016). In cases where the desired product quality cannot be achieved due to some inefficiencies, inefficiency and design errors in basic production processes, production processes may need to be renewed. Therefore, in this case, the resource utilisation and the amount of waste, emission and solid waste generated in the production of unit amount of product increases. Time optimisation in production processes is an effective application (TUBITAK MRC, 2016).

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

Since inefficient resource utilisation and environmental problems in industrial facilities are directly related to input-output flows, it is necessary to define the process inputs and outputs in the best way for production processes (TUBITAK MRC, 2016). Thus, it becomes possible to develop measures to improve resource efficiency, economic and environmental performance. The organisation of input-output inventories is considered as 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 carry out some routine analyses/measurements specific to the processes. Utilising computerised monitoring systems as much as possible in order to obtain maximum efficiency from the application increases the technical, economic and environmental benefits to be obtained (TUBITAK MRC, 2016).

- **Documented production procedures are kept and used by employees to prevent water and energy wastage**

In order to ensure efficient production in an enterprise, effective procedures should be implemented to identify and evaluate potential problems and resources and to control 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 ensures reliability and quality in production processes (Ayan, 2010). The existence of documented production procedures in production processes contributes to the evaluation of business performance and the development of the ability to develop immediate reflexes to solve problems (TUBITAK MRC, 2016; MoAF, 2021). Effective implementation and monitoring of the procedures created specifically for production processes is one of the most effective ways to ensure product quality, receive feedback and develop solutions (Ayan, 2010). Documentation, effective implementation and monitoring of production procedures is a good management practice and an effective tool in structuring and ensuring the continuity of the cleaner production approach and environmental management system. In addition to the potential benefits, the cost and economic gains of the application may vary from sector to sector or depending on the facility structure (TUBITAK MRC, 2016; MoAF, 2021). Although establishing and monitoring production procedures is not costly, the payback period may be short considering the savings and benefits it will provide (TUBITAK MRC, 2016; MoAF, 2021).



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

Computer Aided Control System

2.1.4 Precautions for Auxiliary Processes

BATs for cooling systems

- **Use of a closed-loop cooling system to minimise water use**

Closed loop cooling systems significantly reduce water consumption compared to open loop systems with more intensive water use. In closed loop systems, while the same water is recirculated within the system, it is usually necessary to add cooling water equal to the amount of water evaporated. By optimising cooling systems, evaporation losses can also be reduced.

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

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

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

Cooling towers and evaporative condensers are efficient and low-cost systems that remove heat from air conditioning and industrial process cooling systems (IPPC BREF, 2001b; MoAF, 2021). In these systems, more than 95% of the circulating water can be recovered (TUBITAK MRC, 2016). In cooling systems, impurities remain in the recirculated water due to the evaporation of a portion of the recirculated water, and impurity concentrations gradually increase in each cycle. Impurities that can be included in the cooling system together with air can cause contamination in recirculation water (TUBITAK MRC, 2016). If impurities and contaminants are not effectively controlled, they can cause scaling and corrosion, unwanted biological growth and sludge accumulation. This can become a chronic problem leading to reduced efficiency of heat transfer surfaces and increased operating costs. In this case, it is necessary to implement a water treatment programme specifically designed for the quality of the feed water supplied to the cooling system, the cooling water system construction material and operating conditions. In this context; blowdown control, control of biological growth, corrosion control, avoidance of hard water, use of sludge control chemicals, filtration and screening systems may be appropriate (TUBITAK MRC, 2016). The establishment and periodic implementation of an effective cleaning procedure and programme is also a good management practice for the protection of cooling systems. Corrosion is one of the most important problems in cooling systems. In tower recirculation water, dissolved solids (sulphate, chloride, carbonate, etc.) that cause corrosion as a result of the formation of limestone and deposits on the walls as the degree of hardness increases will cause corrosion on the surface over time. In addition, the formation of deposits reduces energy efficiency by adversely affecting heat transfer. In order to prevent these negativities, implementation of a chemical treatment programme to prevent scale and corrosion, disinfection with biological activation inhibitor biocide, disinfection of cooling towers in use at least once a year

The hardness and conductivity values of the reinforcement water should be as low as possible (IPPC BREF, 2001; Kayabek et al., 2005). In order to improve the quality of the makeup water, it may be necessary to treat (condition) it using an appropriate treatment system. In addition, unwanted microbial growth should be kept under control (IPPC BREF, 2001b; MoAF, 2021). Blowdown occurs in cooling systems as well as in steam boilers due to micro-residues and deposits in the cooling water. The deliberate draining of the cooling system to stabilise the increasing concentration of solids in the cooling system is called cooling blowdown. By pre-treatment of cooling water with appropriate methods and continuous monitoring of cooling water quality, biocide usage and blowdown amounts can be reduced (TUBITAK MRC, 2016). Although the investment cost depends on the scale of the application, the payback period for the expected investment costs 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. In cases where it is necessary to reduce the tower height, a hybrid cooling system can be applied. Hybrid cooling systems are a combination of evaporative and non-evaporative (wet and dry) cooling systems. Depending on the ambient temperature, the hybrid cooling tower can be operated as a fully wet cooling tower or as a combined wet/dry cooling tower (TUBITAK MRC, 2016). In regions where there is not enough cooling water or 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 booster water (TUBITAK MRC, 2016).

- ***Reduction of evaporation losses in closed loop cooling water***

Some water evaporates during the cooling of heated water in cooling systems. Therefore, in closed cycle cooling systems, cooling water is added as much as the amount of evaporated water. Evaporation losses can be prevented by optimising cooling systems. In addition, the amount of blowdown can be reduced by applications such as treatment of make-up water added to cooling systems and prevention of biological growth in cooling systems. Within the scope of the field studies carried out, the blowdown water formed in the cooling system is generally discharged directly to the wastewater channel. By reusing the cooling system blowdown water, water consumption of cooling systems can be saved up to 50%. Implementation of this measure may require the installation of new pipelines and reserve tanks (MoAF, 2021).

BATs for ventilation and air conditioning systems

- ***Re-use of the liquid formed by condensation from the ventilation system***

Condensate with good water quality can be produced in the system during the aeration cycle. For example, in a plant in Spain, condensate from the aeration system with a conductivity of about 200 μS is collected in a tank and used to flush an automatic galvanising line (MedClean, n.d.).

- ***Replacement of old equipment in the aeration system with ion exchange resins based on the principle of reverse osmosis (systems producing demineralised water) and water reuse***

By using ion exchange resins in the aeration system, the conductivity of the final effluent is brought to a conductivity level suitable for use in equipment cleaning. For example, in a plant in Spain, by replacing the equipment in the aeration system with ion exchange resins, effluent with a conductivity of approximately 1000 μS is obtained and reused in the system (MedClean, n.d.).

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