# TECHNICAL SPECIFICATION

# ISO/TS 21256-4

First edition
2023-05

# Fine bubble technology — Cleaning applications —

## Part 4:
## Test method for oil removal from polyester-based textile

*Technologie des fines bulles — Applications de nettoyage —*

*Partie 4: Méthode d'essai pour l'élimination de l'huile sur un tissu en polyester*



Reference number
ISO/TS 21256-4:2023(E)

# Contents

# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 281, *Fine bubble technology*.

A list of all parts in the ISO 21256 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.



# Introduction

In recent years, the market has witnessed a proliferation of new products using fine bubble technology. In the field of textile industry, the introduction of fine bubbles can bring many interesting effects. Using fine bubbles can increase the cleaning efficiency by removal of the residual surface oil of textile in large-scale manufacturing in order to improve the quality of dyeing and finishing process. Especially, polyester-based textile takes very important role in the textile industry since its outstanding features. In addition, fine bubble washing is a physical cleaning method which can reduce the pollution of detergent to the water environment. So, it is needed to design a general test method, for textile manufacturers and related researchers, to evaluate the cleaning efficiency by removal of fine bubble water on polyester-based textile.

In order to adapt to complex usage scenarios in large-scale textile manufacturing, the proposed method uses the mass fraction of oil on polyester-based textile after and before washing to characterize the cleaning effect, and uses ISO brightness (R457)[1] to assist in expressing the degree of cleanliness. To demonstrate, a lubricant, whose main composition is high molecular hydrocarbon, is used as an identical contaminant in production, and an edible oil, whose main composition is fatty acid, is used as an identical contaminant in daily washing. The method is simple, reproducible and highly versatile.

With this method, the oil removal ability of fine bubble water with different bubble sizes and concentrations can be compared. Furthermore, it will further promote the civil and industrial application of oil removal from textile of fine bubbles, for example, washing during fabric recycling process or cleaning with less detergent.

# Fine bubble technology — Cleaning applications —

# Part 4:
# Test method for oil removal from polyester-based textile

## 1 Scope

This document specifies a test method to evaluate the oil removal performance from polyester-based textile with fine bubbles.

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

## 4 Principle

In the textile industry, various types of manufacturing machines use different kinds of oils, surfactants and detergents. During the production either the oils are coated over the whole surface of the strings uniformly or the whole surface of the textile in different processes. To test the removal ability, identical samples should be used, e.g. always to use polyester-based textile, for better comparative consistency in the method.

The test method consists in determining the mass fraction of oil on a textile sample before and after cleaning. A weighed polluted sample is soaked in the circulated bubble water. To evaluate the degree of cleanliness, the mass fraction of residual oil on the sample is determined, and the brightness according to ISO[1],[2] is also evaluated.

## 5 Test methods

### 5.1 Equipment and material

#### 5.1.1 Drying Oven

Figure 1 shows the drying oven's appearance. The power is 4 kW, and the working temperature range is approximately +10 °C to 250 °C with ±1 °C accuracy.

**Figure 1 — Drying oven**

### 5.1.2 Digital electronic scale

Figure 2 shows the digital electronic scale used in this test, whose maximum range is 220 g and resolution is 0,001 g.

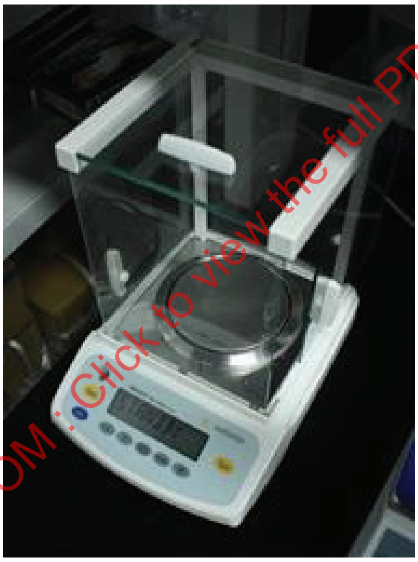


**Figure 2 — Digital electronic scale**

### 5.1.3 Dye

Sudan Red III ($C_{22}H_{16}N_4O$), AR.

### 5.1.4 Oil

Lubricant, whose main composition is high molecular hydrocarbon, and edible oil, whose main composition is fatty acid. The two typical kinds of oils are described in Annex A.

### 5.1.5 Substrate

The polyester-based textiles, such as Polyethylene terephthalate (PET), Polybutylene terephthalate (PBT) and Polytrimethylene terephthalate (PTT) are used as substrates. The ability of oil removing depends on all of their characteristics, i.e. weaving types of manufacturing, the diameter of thread. Therefore, the specification of the textile characteristics should be clarified in detail for cleaning applications to obtain the repeatability of the experiments. Annex A describes an example of oil removal performance comparison between tap water and fine bubble water, in which the substrate is clearly described.

### 5.1.6 Micropipette

Figure 3 shows the micropipette used in this test, whose resolution is 0,01 ml.

**Figure 3 — Micropipette**

### 5.1.7 Beaker

250 ml and 2 000 ml.

### 5.1.8 Tripod stand

Load polyester-based textile pieces at the tripod stand presented in Figure 4.

**Figure 4 — Tripod stand**

### 5.1.9 Portable brightness meter

The portable brightness meter used in this test is shown in Figure 5, which resolution is 0,1 %.



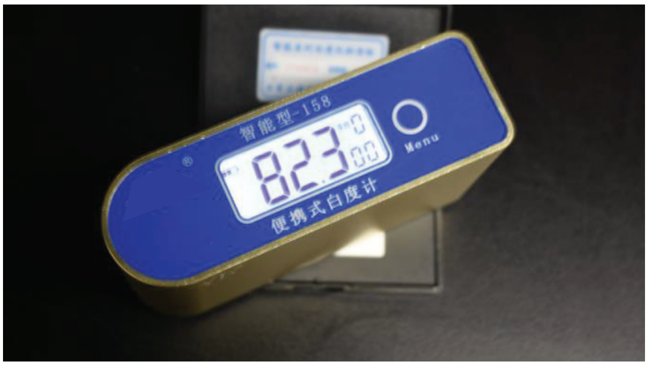



**Figure 5 — Portable brightness meter**

### 5.1.10 Suspended stirring bar

The suspended stirring bar as shown in Figure 6 is used to reduce the influence of uneven flow on the performance of oil removal.

**Figure 6 — Suspended stirring bar**

The test method allows to use other equipment or materials different from those specified in 5.1, provided their technical characteristics are satisfying and not inferior to those described and specified in 5.1.

## 5.2 Procedure

— Fully dry the sample to minimize the moisture content.

— Weigh the dried sample within 30 s to avoid the influence of environmental humidity as the initial mass of textile.

— Dye the oil with Sudan Red III.

— Contaminate the sample with specific amount of coloured oil and weigh out the net weight of oil.

— Allow the coloured oil to spread for better stability.

— Test the ISO brightness (R457)[1] as the initial brightness of textile.

— Preset a water flow rate to 2 l/min, allow the test water to overflow out of a 2 000 ml container.

— Soak the sample. The sample is fixed at the centre of the water diffuser in a container. The duration of soaking is 5 min.

— Fully dry the sample to minimize the moisture content.

— Weigh the dried sample within 30 s as the weight of the textile sample after soaking and drying.

— Test the ISO brightness (R457) as the brightness of the textile sample after soaking and drying.

### 5.3 Oil removal determination

The oil removal rate, $R$ is calculated by Formula (1):

$$R = \frac{m_t + m_o - m_w}{m_o} \quad (1)$$

where

$m_t$ is the initial mass of textile sample after drying;

$m_o$ is the net weight of polluted oil;

$m_w$ is the weight of the textile sample after soaking and drying.

## 6 Test report

The test report should include at least the following information:

a) the sample;

b) a reference to this document, i.e. ISO 21256-4:2023;

c) the test date;

d) the ambient temperature and humidity of the test facility;

e) fine bubble property;

f) the test conditions:

    1) the flow rate of cleaning liquid;

    2) dyeing ratio;

g) the test result:

    1) number of repetitions;

    2) initial mass of textile sample before soiling after drying;

    3) mass of oil;

    4) mass of the textile sample after soaking and drying;

    5) oil stain removal rate;

    6) brightness;

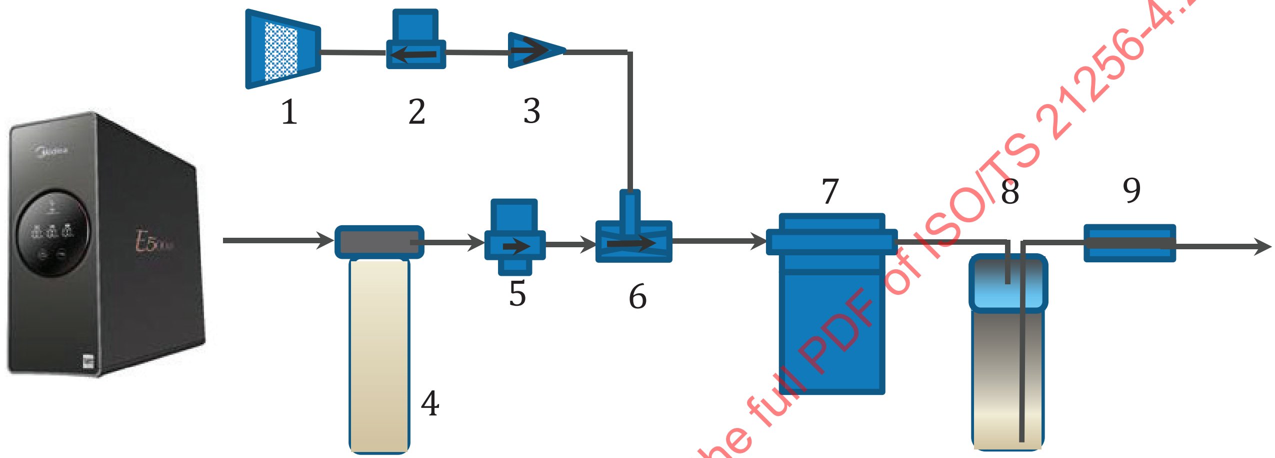
h) any deviations from the procedure;

i) any unusual features observed.

# Annex A
(informative)

# Oil removal performance comparison between tap water and fine bubble water

## A.1 Fine bubble generating system




**Key**

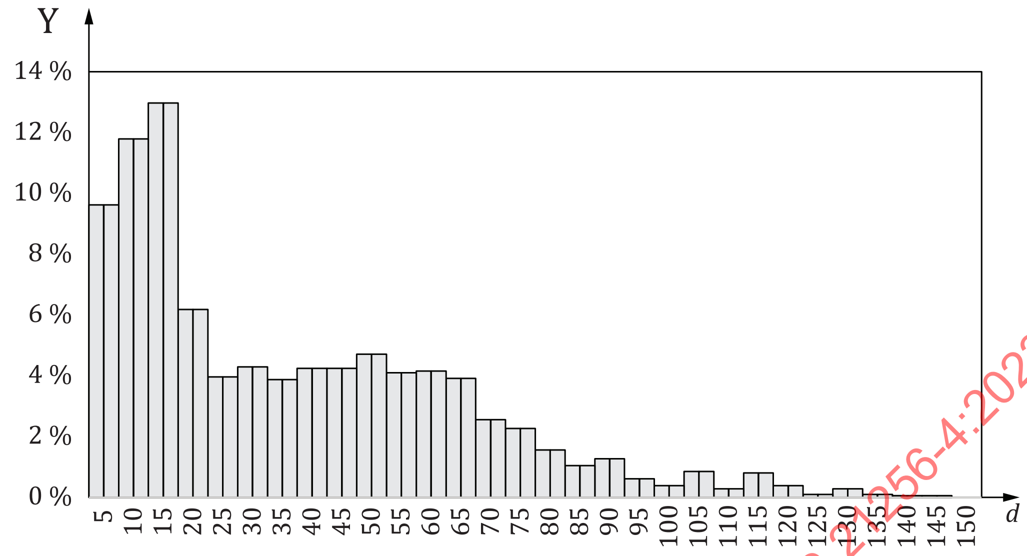
1 filter
2 intake valve
3 check valve
4 pre-filter
5 pressure limiting valves
6 venturi tube
7 diaphragm pump
8 mixing tank
9 bubble

**Figure A.1 — Fine bubble system**

In this example, the fine bubble generating system is a water purifier. The system adopts the principle of pressurized dissolved air and reduced pressure to generate fine bubbles (see Figure A.1). The pressure in the mixing tank is 0,5 MPa to 0,7 MPa.






**Key**

X diameter (μm)

Y particle distribution (%)

**Figure A.2 — Bubble size distribution**

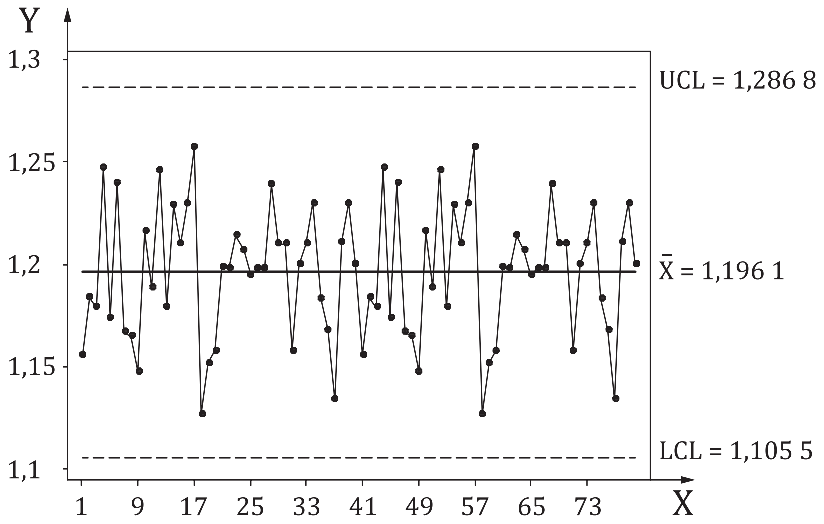
Figure A.2 shows the bubble size distribution, the average fine bubble concentration and mean size are 1,94 × $10^5$/ml and 35,18 μm respectively.

## A.2 Substrate

The specification of the textile characteristics is shown in Table A.1 (measured at (20 ± 2) °C, (65 ± 5) % relative humidity).

**Table A.1 — The specification of the textile characteristics**

| Textile characteristics | | Specification |
|---|---|---|
| Substrate | | (65 ± 3) % polyester<br>(35 ± 3) % cotton |
| Yarn | | Ring spun |
| Weave | | Plain 1/1 |
| Yarn count (tex) | warp | 150 ± 4 |
| | weft | 150 ± 4 |
| Pick count (pick/cm) | warp | 47 ± 2 |
| | weft | 31 ± 2 |
| Mass per unit area (g/m$^2$) | | 125 ± 10 |
| Finish | | Desizing, washing, bleaching, thermofixation |




**Key**

X test round

Y textile weight (g)

**Figure A.3 — Stability analysis of polyester-based textile weight**

The weight of polyester-based textile samples is evaluated in Figure A.3. The mean weight is 1,196 13 g and the standard deviation ($\sigma_T$) is 0,030 52 g, which shows good consistency. Defective samples which are outside the control limits (±3σ) would be removed.

## A.3 Operation steps

a) Put a sample in a dying oven at a preset temperature of 60 °C for 20 min, and fully dry the sample to minimum moisture content.

b) Place a 250 ml beaker on the scale used as the stand and tare the scale.

c) Place the dried sample at the centre of the beaker and weigh within 30 s to avoid the influence of environmental humidity. The sample quality after drying is recorded as $m_t$.

d) Dye the oil used for contamination with Sudan RedIII (reference ratio: 150 g edible oil + 0,067 g Sudan red, 100 g lubricant + 0,1 g Sudan red) to form coloured oil.

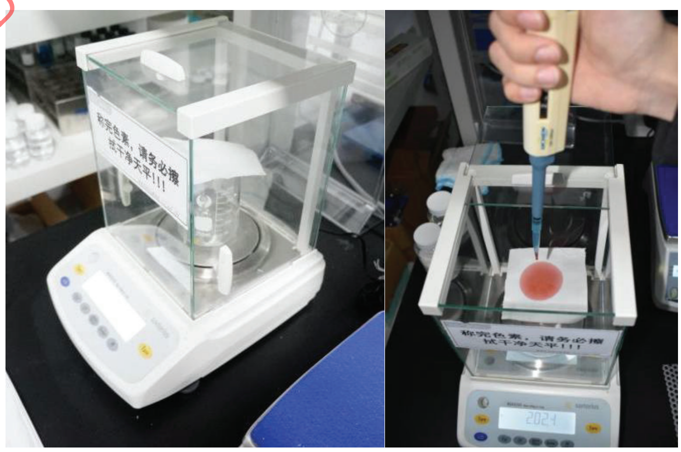


**Figure A.4 — Sample weighting and soiling**

e) Tare the scale and titrate 0,15 g coloured oil recorded as $m_0$ in the centre of the sample, which is shown in Figure A.4.

f) As shown in Figure A.5, allow the coloured oil to spread for 15 min for more stability.

g) Test the ISO brightness (R457) as the initial brightness of textile.

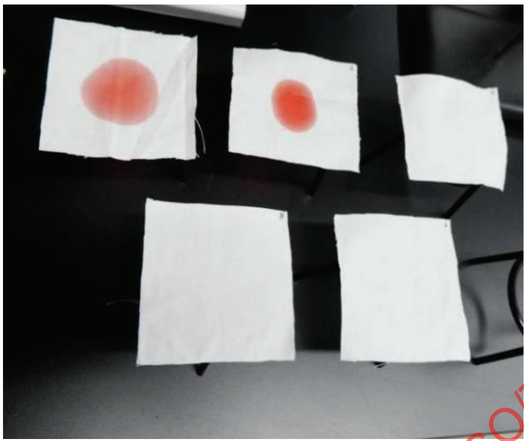


**Figure A.5 — Oil spreading**

h) Preset the water flow rate to 2 l/min and allow the test water to overflow out of the container.

i) Fix the sample at the centre of the water diffuser with two magnets in the 2 000 ml beaker. Allow the test water to overflow out of the beaker. The duration of soaking is 5 min. Figure A.6 shows the procedure of soaking.

**Figure A.6 — Soaking**



j) Put the washed sample into the drying oven at a preset temperature of 60 °C for 20 min, and fully dry the sample to minimum moisture content.

k) As shown in Figure A.7, weigh the sample within 30 s. The sample mass after drying is recorded as $m_w$.

l) Test the ISO brightness (R457) as the brightness of the textile sample after soaking and drying.

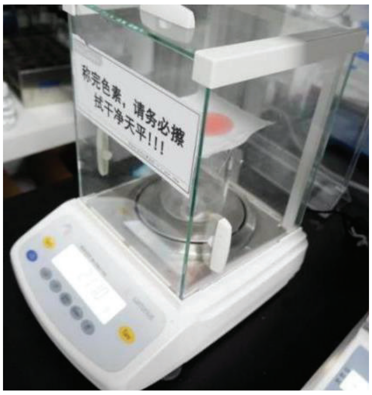



**Figure A.7 — Sample weighting**

## A.4 Test report

### A.4.1 Lubricant washing

a) the sample;

1) oil type: lubricant;

2) textile type: polyester-based textile;

b) a reference to this document, i.e. ISO 21256-4:2023;

c) the test date: approximately 2-26-2021 to 6-20-2021;

d) the ambient temperature and humidity of the test facility;

1) room temperature: 25 ± 2 °C;

2) room humidity: 62 ± 5 %;

3) water temperature: 20 ± 2 °C;

e) fine bubble property;

1) liquid property: tap water;

2) air property: indoor air;

3) additives: N/A;

4) average fine bubble concentration and size: 1, 94 × $10^5$/ml, 35,18 µm;

f) test conditions:

1) the flow rate: 2 l/min;

2) dyeing ratio: 100 g lubricant + 0,1 g Sudan red;

g) test results (listed in Table A.2).

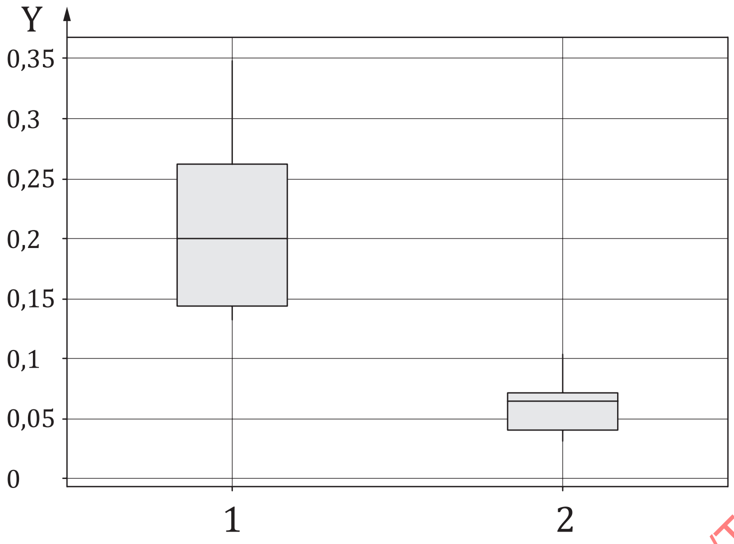


**Table A.2 — The cleaning efficiency by removal of lubricant**

| | No. | $m_t$ /g | $m_o$ /g | $m_w$ /g | $w$/% | $R$/% |
|---|---|---|---|---|---|---|
| Bubble water | 1 | 1,156 | 0,161 | 1,274 | 29,78 | 26,71 |
| | 2 | 1,184 | 0,155 | 1,285 | 31,20 | 34,84 |
| | 3 | 1,179 | 0,145 | 1,296 | 24,98 | 19,31 |
| | 4 | 1,247 | 0,148 | 1,358 | 34,03 | 25,00 |
| | 5 | 1,174 | 0,157 | 1,310 | 31,98 | 13,18 |
| | 6 | 1,240 | 0,156 | 1,344 | 30,17 | 33,33 |
| | 7 | 1,167 | 0,145 | 1,274 | 33,70 | 26,21 |
| | 8 | 1,165 | 0,146 | 1,273 | 34,27 | 26,03 |
| | 9 | 1,148 | 0,149 | 1,260 | 31,43 | 24,83 |
| | 10 | 1,216 | 0,153 | 1,347 | 28,42 | 14,38 |
| | 11 | 1,189 | 0,146 | 1,302 | 31,28 | 22,60 |
| | 12 | 1,246 | 0,146 | 1,371 | 30,40 | 14,38 |
| | 13 | 1,179 | 0,152 | 1,310 | 30,62 | 13,82 |
| | 14 | 1,229 | 0,148 | 1,354 | 29,60 | 15,54 |
| | 15 | 1,210 | 0,150 | 1,330 | 31,53 | 20,67 |
| | 16 | 1,230 | 0,150 | 1,350 | 30,98 | 26,80 |
| | 17 | 1,257 | 0,152 | 1,380 | 29,88 | 19,08 |
| | 18 | 1,127 | 0,153 | 1,258 | 28,82 | 14,38 |
| | 19 | 1,152 | 0,152 | 1,281 | 28,52 | 15,13 |
| | 20 | 1,158 | 0,142 | 1,280 | 29,40 | 14,08 |
| Tap water | 1 | 1,199 | 0,142 | 1,335 | 27,6 | 4,22 |
| | 2 | 1,198 | 0,153 | 1,346 | 28,2 | 3,27 |
| | 3 | 1,214 | 0,149 | 1,355 | 28,15 | 5,37 |
| | 4 | 1,207 | 0,148 | 1,343 | 27,85 | 8,11 |
| | 5 | 1,195 | 0,143 | 1,328 | 28,22 | 6,99 |
| | 6 | 1,198 | 0,147 | 1,337 | 27,65 | 5,44 |
| | 7 | 1,198 | 0,145 | 1,333 | 27,98 | 6,90 |
| | 8 | 1,239 | 0,157 | 1,390 | 28,85 | 3,82 |
| | 9 | 1,210 | 0,164 | 1,369 | 27,25 | 3,05 |
| | 10 | 1,210 | 0,154 | 1,353 | 27,87 | 7,14 |
| | 11 | 1,158 | 0,148 | 1,298 | 27,62 | 5,41 |
| | 12 | 1,200 | 0,150 | 1,350 | 28,65 | 3,92 |
| | 13 | 1,210 | 0,160 | 1,360 | 27,80 | 3,85 |
| | 14 | 1,230 | 0,150 | 1,370 | 26,88 | 6,62 |
| | 15 | 1,183 | 0,142 | 1,312 | 29,38 | 9,15 |
| | 16 | 1,168 | 0,155 | 1,307 | 28,30 | 10,32 |
| | 17 | 1,134 | 0,153 | 1,277 | 28,70 | 6,54 |
| | 18 | 1,211 | 0,147 | 1,346 | 27,42 | 8,16 |
| | 19 | 1,230 | 0,141 | 1,362 | 27,77 | 6,38 |
| | 20 | 1,200 | 0,162 | 1,351 | 27,07 | 6,79 |

### A.4.2 Cleaning performance evaluation of lubricant stain




**Key**

Y oil removal rate (%)

1 bubble water washing

2 tap water washing

**Figure A.8 — Cleaning performance comparison based on lubricant stain removal rates**

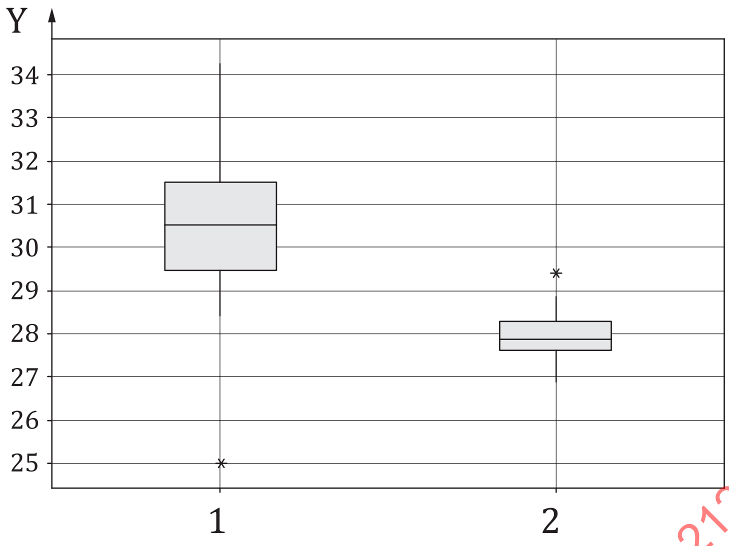
**Table A.3 — Statistics of lubricant removal rates**

| Variable | N | Minimum | Median | Maximum | 95 % median CI |
|---|---|---|---|---|---|
| Bubble water | 20 | 0,131 800 | 0,199 900 | 0,348 400 | (0,145 56, 0,257 88) |
| Tap water | 20 | 0,030 500 | 0,064 600 | 0,103 200 | (0,044 905, 0,069 688) |

Engine oil is used as a typical lubricant contaminate to reveal the advantages of fine bubble water soaking in cleaning process. Cleaning performance of tap water (TW) and fine bubble water (BW) is compared based on lubricant stain removal rates in Figure A.8 and Table A.3. It describes the statistics of lubricant removal rates, the median oil removal rate of BW and TW being 19,99 % and 6,46 % respectively, and the cleaning efficiency by removal of fine bubble water which is 13,43 % better for removing lubricant.






**Key**

Y ISO brightness

1 bubble water washing

2 tap water washing

**Figure A.9 — Cleaning performance comparison based on brightness**

**Table A.4 — Statistics of brightness evaluation**

| Variable | N | Minimum | Median | Maximum | 95 % median CI |
|---|---|---|---|---|---|
| Bubble water | 20 | 24,980 0 | 30,510 0 | 34,270 0 | (29,642 3, 31,394 7) |
| Tap water | 20 | 26,880 0 | 27,860 0 | 29,380 0 | (27,627 1, 28,215 3) |

The cleaning efficiency by removal of tap water (TW) and fine bubble water (BW) is compared based on brightness differences in Figure A.9. Table A.4 shows the statistics of brightness evaluation. For lubricant stain, the median washed sample brightness of BW and TW is 30,51 % and 27,86 % respectively. As statistically higher brightness values relate to better cleaning performance, the cleaning efficiency by removal of fine bubble water soaking is statistically better than tap water soaking for removing lubricant stain.

## A.4.3 Edible oil washing

a) the sample;

   1) oil type: edible oil;

   2) textile type: polyester-based textile;

b) a reference to this document: ISO 21256-4:2023;

c) the test date: approximately 2-26-2021 to 6-20-2021;

d) the ambient temperature and humidity of the test facility;

   1) room temperature: 25 ± 2 °C;

   2) room humidity: 62 ± 5 %;