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Fine bubble technology — Guideline for indicating benefits —

Part 1: Requirements for systematic classification of effective functions of fine bubbles

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Foreword

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

A list of all parts in the ISO 24217 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

Fine bubble technologies have been developed and introduced from the early 20th century. Especially, microbubbles have been actually introduced in various application areas such as the froth flotation, ultrasonic imaging, purification of contaminated water and the enhancement of growth of living things in the ocean. One reason of microbubble application is due to the visible character of microbubbles. Fine bubble technologies has been investigated academically since the late 20th century. As for the application of the ultrafine bubbles, investigation into their many usages has made great advances since the year 2000.

There have been various kinds of application technology of fine bubbles recently. The application fields include engineering application, environmental application, agro-aqua and food application and medical, living and cosmetic application.

From the viewpoints of effective functions of fine bubble technology, there are various kinds of effective functions. They include cleaning effect, water treatment effect, sterilizing promotion effect, growth promotion effect, lubrication effect, control of chemical reaction, improvement in food quality and control of material processing.

If the systematic classification of fine bubble technology from the viewpoints of the application fields and the effective functions has been established, the identification of each fine bubble technology is possible to be made, and be classified in the matrix and furthermore, the extension of the other application are imagined.

Therefore, the International Standards are made for the systematic classification of fine bubble technology from the viewpoints of application fields and the effective functions.

This document provides a path for fine bubble suppliers to contribute properly to the various application fields. Furthermore, by showing to fine bubble users and potential customers, it will be able to help them to bring the effective functions to the other important applications.

In addition, this document bears a guideline for standards developers to judge when expressing the contents of application fields and the effective functions of fine bubble technology and is not subject to the conformity assessment.

Fine bubble technology — Guideline for indicating benefits —

Part 1: Requirements for systematic classification of effective functions of fine bubbles

1 Scope

This document provides in detail how the standards of fine bubble technologies can contribute to establish the systematic classification of fine bubble technologies including the effective functions and the application fields of fine bubbles, which is useful for the users and the potential customers to optimize the application of fine bubble technologies..

This document also specifies the clauses required for fine bubble standards, including a description relating application fields and effective functions of fine bubble technologies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 20480-1, *Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 1: Terminology*

ISO 20480-2, *Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 2: Categorization of the attributes of fine bubbles*

ISO 20480-3, *Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 3: Methods for generating fine bubbles*

ISO 20480-4, *Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 4: Terminology related to microbubble beds*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20480-1, ISO 20480-2, ISO 20480-3, ISO 20480-4, and the following apply.

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

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

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

3.1
systematic classification
tables and figures where fine bubble technologies are identified and explained from various kinds of viewpoints, such as application fields , effective functions

3.2
application fields
applied areas and fields of industry where fine bubble technologies are effectively used, demonstrated and commercialized

3.3
effective function
useful and characterized phenomena obtained successfully by the fine bubble technologies, which are used in the actual industrial applications

4 Effective functions of fine bubble technology

There are several effective functions of fine bubble technology demonstrated in the literature and described in Table 1 and Table 2. Since the fine bubble has been determined to be composed of microbubbles, which have the diameter between 1 μm and 100 μm, and ultrafine bubbles, which have the diameter less than 1 μm, the description of the effective functions would be discussed separately.

Microbubble applications: As for the effective functions of using micro bubbles, effective functions would be related to the froth floatation, ultrasonic imaging, purification of contaminated water and the enhancement of living things in the ocean as explained in the Annex A.

Froth floatation: The froth floatation would belong to one kind of control of chemical reaction by the separation of some kinds of metallic element. This floating method used micro bubbles and surface surfactants based on the mechanism that the bubble surfaces would attract the hydrophobic metallic element more than the hydrophilic rock element[1].

Fine Bubbles for Ultrasonic Imaging inside Body: The generation of ultrasonic contrast agent to the medical application has been established from the viewpoints of fine bubble formation and microcapsule generation[2][3].

Purification of Contaminated Water: Cleaning and purification of contaminated water in the lakes, ponds and dams with oil contamination and with the lack of oxygen have been used from about 1995.[4]

Enhancement of Growth of Oysters, Scallop and Pearls: These application technologies have been established for getting rid of the damages of HABs (Harmful Algal Blooms) around 1999.[5] These harmful algal blooms had made the red coloured sea water and the lack of oxygen for fishes and oysters. The injection of microbubbles included water has made the significant effects for decreasing the damages. Various application areas have been developed such as effective bathing, drag reduction of ships by using the microbubbles.

There were several challenges independently for clarifying the characteristics of ultrafine bubbles and investigating the applications of ultrafine bubbles from about 2000 to 2008. Then, many challenges have been made continuously in many application fields, as shown in Annex B.

The effective functions generated by ultrafine bubbles are explained in Table 1 as follows:

a) Cleaning effect.

b) Water treatment.

c) Sterilizing promotion effect.

d) Growth promotion.

e) Lubrication effect.

f) Control of chemical reaction.

g) Improvement in food quality.

h) Material processing.

Table 1 — Effective functions related to the application of fine bubble technologies

No.	Effective function see ISO 20480-2, ISO 20480-3, ISO 24261-1, ISO 24261-2	Description of each effective function
A	Cleaning effect, see ISO 21256-3, ISO 20480-2 and ISO 20480-3	— Toilet cleaning — Removal of salt from the bridges, see ISO/TS 21256-1 — Cleaning of vegetables — Removal of contaminants on the semiconductor wafers — Cleaning inside of mouth — Cleaning of ceramic membrane — Detergent free cleaning
B	Water treatment effect, see ISO 20480-4	— Dissolution of oxygen lack of ponds and lakes — Floatation mining of minerals — Water treatment of disposed and contaminated water (minimizing the total amount of disposal in isolated area, promoting the growth of bacterium for disposal treatment), see ISO 24261-2, ISO 20304-1, ISO 21255, ISO 21910-1 — Removal of radioactive substances from the soil — Soil treatment
C	Sterilizing promotion effect	— Minimize the total usage amount of ozone — Maximize the effect of sterilizing liquid by changing the PH
D	Growth promotion effect	— Growth promotion of vegetables (leaves such as lettuce, increase of total harvest and quality of tomato) — Germination promotion — Application of cell cultivation — Growth promotion of fishes — Prevention of oxygen lack of fishes in aquaculture
E	Lubrication effect	— Lubrication of semiconductor wafer transportation
F	Control of chemical reaction	— Control the limiting transport phenomena
G	Improvement in food quality	— Control of calorie of mayonnaise — Freshness keeping of fishes — Transportation, anestesi of fishes (aquaculture use) — Fragrance addition
H	Material processing	— Size controlled synthesis — Froth flotation

5 Application fields of fine bubble technology

The application fields are categorized in Table 2 as follows:

— Engineering field.

— Environmental field.

— Agri-aquacultural and food field.

— Medical, living and cosmetic field.

Table 2 — Application fields of fine bubble technologies

No.	Application fields see ISO 20480-1, ISO/TR 24217-2	Description of each application fields
1	Engineering applications see ISO 21256-2, ISO/TR 23015	— Removal of contaminants on the semiconductor wafers (see A in Table 1) — Cleaning of ceramic membrane (see A in Table 1) — Floatation mining of minerals (see B in Table 1) — Minimize the total usage amount of ozone (see C in Table 1) — Maximize the effect of sterilizing liquid by changing the PH (see C in Table 1) — Lubrication of semiconductor wafer transportation (see E in Table 1) — Control the limiting transport phenomena (see F in Table 1) — Dtergent free cleaning (see A in Table 1)
2	Environmental applications	— Toilet cleaning (see A in Table 1) — Removal of salt from the bridges (see A in Table 1) — Dissolution of Oxygen lack of ponds and lakes (see B in Table 1) — Water treatment of disposed and contaminated water (see B in Table 1) — Removal of radioactive substances from the soil (see B in Table 1) — Minimize the total usage amount of ozone (see C in Table 1) — Application of cell cultivation (see D in Table 1) — Detergent free cleaning (see A in Table 1)

Table 2 *(continued)*

No.	Application fields see ISO 20480-1, ISO/TR 24217-2	Description of each application fields
3	Agro-aqua and food applications	— Cleaning of vegetables (see A in Table 1) — Water treatment of disposed and contaminated water (see B in Table 1) — Minimize the total usage amount of ozone (see C in Table 1) — Growth promotion of vegetables (see D in Table 1), see ISO/TS 23016-1 — Germination promotion (see D in Table 1), see ISO 23016-2, ISO/TR 23016-3 — Application of cell cultivation (see D in Table 1) — Growth promotion of fishes (see D in Table 1) — Prevention of oxygen lack of fishes in aquaculture (see D in Table 1) — Control of calorie of mayonnaise (see G in Table 1) — Freshness keeping of fishes (see G in Table 1) — Transportation, anestesi of fishes (see G in Table 1) — Fragrance addition (see G in Table 1)
4	Medical, living and cosmetic applications	— Cleaning inside of mouth (see A in Table 1) — Minimize the total usage amount of ozone (see C in Table 1) — Sterilizing medical equipment (medical grade use) (see C in Table 1) — Oxygenated water, cancer treatment (medical treatment) (see C in Table 1)

6 Systematic classification of fine bubble technology from the viewpoints of application fields and the effective functions

Fine bubble technologies have been systematically classified from the viewpoints of application fields and the effective functions in Table 3.

Existing application technology are symbolled by the circle in Table 3. They would have been meant to be already researched, developed, actually used or commercialized. Some typical literatures are shown in the table also as the reference. As the typical and successful challenges of applications, the following several kinds of ultrafine bubble technology have been researched and developed so far. The application to the higher performance of grinding has been researched[23] for the manufacturing application. The cleaning of the manufacturing tools has been developed[24]. The sterilizing equipment has been researched and developed for the medical applications[25]. As for the washing machine for the living application, the first commercial equipment has been developed using ultrafine bubbles[26]. For realizing the higher quality of living, the bath and shower have been developed and widely commercialized. For bathing using ultrafine bubbles and microbubbles the effect of the temperature rise of the body surface would have been observed[27]. For the shower in the living applications, the moisture content of the homy layer would have been observed to increase about 20 %[28]. For the environmental applications, the water treatment would have the large amount of application targets with the simple ultrafine bubble generators[29].