Asia-Pacific
Economic Cooperation

Capacity Building on Testing and Conformity Assessment of Fine Bubble Technologies for Use in Agro-/Aqua-Culture and Water Treatment in APEC Region

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APEC Sub-Committee on Standards and Conformance

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1 Background and Objectives

The small size, high stability and high surface area of Fine Bubbles (FBs) give water unique features, which can be applied to enhance productivity in agro-/aqua- culture and water treatment fields. But in order to achieve maximum performance, FBs generated by appropriate methods must be used in appropriate ways. In this project, two remote workshops were held with the aim to;

- harmonize the basic usage and measurements of Fine Bubbles (FBs) using ISO standards
- introduce various applications being developed in APEC economies
- share the practices on testing and evaluations being conducted in each application
- introduce the certification system of Fine Bubble Technology (FBT) in Japan as a method to guarantee the quality of FBs.

In addition to the workshops, test data on various applications of FBs was shared in order to accelerate the development and standardization activities of FBT.

2 Project Summary

General explanation on current standardization for fine bubble technology and conformity assessment of testing results was presented both with international level and domestic level. Throughout the workshops, it was emphasized that internationally agreed conformity assessment on testing both for ultrafine bubble characteristics and functional performance of application of fine bubble to agro- and aqua- farming and water treatment is essential; therefore, needs to be achieved in the near future in the APEC region tying the regional market and suppliers of solution using fine bubble technology.

For application performance, speakers from 8 economies explained a variety of application with their experience on testing the performance. The characteristics of ultrafine bubble is measurable by using specific technology. The measurement experts were invited to show their procedure visually in order to disseminate the technology. In order to study the level of the learning an international comparison for the measurement of ultrafine bubble was proposed and 4 economies agreed to their participation.

The application area for Workshop 1 was focused in agro- and aqua- farming and then the subjects of Workshop 2 was water treatment area. Total of 14 documents were explained in the workshop, out of 18 published documents from ISO/TC 281. Please see ANNEX for the list of ISO standards introduced by the Workshops.

The contribution of fine bubble technology to SDGs were discussed also according to the ISO standards for identifying the goal and target benefitting from the application.

As for the measurement technology, advanced technique of ultrafine bubble elimination was visually presented.

The result of international comparison was presented in order to demonstrate the efficiency of the learning and convince the participants of the availability of one stop testing.

The progress of the Workshop is in line with the planned scope of the project reading,
- To explain general principles for usage and measurement of FBs based on ISO standards.
- To introduce applications in the field of agro-/aqua- culture, water treatment.
- To share testing methods and data to accelerate the development and standardization activities of FBT.

2.1 Dates and Activities

Remote meeting 1 hosted by Japan (at Head quarte of Fine bubble industries association.)
January 19 (Tue) 2021 18:00-20:00, 21(Thu) 18:00-20:45
Theme: Application in agro- and aqua- farming
Remote meeting 2 hosted by Japan (at Head quarter of Fine bubble industries association)
September 16(Thu) 2021 19:00-21:45
Theme: Introduction of international standards
International comparison of measurement of Ultrafine bubble water. (at Sydney, Tokyo and Shanghai)
April 5(Mon) -26(Mon) 2021

Note: Original plan was to hold meetings in Tokyo and Singapore. Due to the pandemic, they were changed to remote meeting based on detailed consultation to the Japanese and Singaporean partners. Similarly, the transport of the samples for the international comparison was made using air cargo.

2.2 **Participants**

<Workshop 1>

・The total number of participants was 51, including 19 females (37%)

・13 economies have participated :Australia, Chile, China, , Indonesia, Japan,
Korea, Malaysia, Peru, Philippines, Singapore, Chinese Taipei, Thailand, Viet Nam

<Workshop 2>

・The total number of participants was 56 including 18 females (32%)

・13 economies have participated: Chile, China, Indonesia, Japan,
Korea, Peru, Singapore, Chinese Taipei, Thailand, Viet Nam

3 Summary of Testing Procedures

In order to confirm the basis for sound application of fine bubble technology, the measurement of basic characteristics of fine bubble characteristics (size and number concentration of fine bubbles in water) was studied and international comparison of testing for UFB water was planned.

The followings are the agreed comparison procedure for testing UFB water. The result of comparison is summarized in the next section 4. As for the detail of the test comparison, please see the presentation media for the presentation 2f) “Inter Laboratory Comparison of Ultra Fine Bubble Measurement” in Supplementary Annex SA 3.

/Condition
Measuring Instrument: Nanosight (PTA method)
Sample A：UFB water、B:Blank water
Container：25 mL Glass bottle (Duran)

/Preparation and measurement
1. Unpack the parcel carefully, take the bottles out and check if bottles are not damaged and wrapped in their necks with plastic film. Record also if you find visible bubbles (>1 mm) in the bottle and if large amount of sample leaks out.
2. Put the bottles on table and keep at room temperature (5-35 ° C) until the measurement start.
Do not give hard mechanical shock to them. Be careful not to freeze it, in case toput into refrigerator.

3. Un-wrap the film and open the lid by careful and gentle unscrewing with hand.
4. Discard about 10 ml of sample to prepare for homogenization.
5. Homogenize the sample by using hands or a motor-driven drum roller, rotating a bottle at approximately 10 rpm to 20 rpm with seesaw motion.
6. You can transfer the sample to another clean glass container as your convenience.
7. Inject the sample into sample chamber by using syringe or tube, etc..
Before injection, syringe, tube, sample chamber must be cleaned the surface of them by rinsing several times with UFB sample or Blank water.
8. Set the parameters such as Camera Level to appropriate values for capturing the light scattered by UFBs and measure UFBs in UFB water. Repeat the same process with Blank water. If you are not sure about the appropriate Camera Level, measure under multiple conditions (Camera Level: 13,14,15,16, etc.) and record them just in case.
9. Measure 5 times. Set an appropriate measurement time (60 seconds per measurement, for example). Replace the entire sample for each measurement.
5 measurements must be completed in a day.
10. Once the bottle is opened and air space is made in the bottle, the sample in the bottle cannot be used after the next day again since the number concentration may be reduced.
11. After the measurement, it is analyzed by using appropriate parameter such as Threshold, etc.

/Reporting
A: Date and time of measurement, room temperature, humidity
B: Name of Measuring instrument, its type, software version, wavelength of laser
C: Parameters (Camera level, Threshold ,..)
D: Name of operator
E: The following data
Peak diameter (nm) over the range 1 nm -1000 nm for each of 5 measurement
Average diameter (nm) over the range 1 nm -1000 nm for each of 5 measurement
Accumulated number concentration over the range 1 nm -1000 nm for each of 5 measurement

/Reporting address
E-mail the reporting excel file to:
*****@*******

4 Summary of Test Data

Summary of Test Data for Comparison Test for UFB water

1.UFB water samples should have been prepared once, distributed, and measured within a few days.
But due to the availability of measurement instruments, UFB water samples were generated twice. (Sample 1 and Sample 2)

2. During transportation some reduction of UFB sample are likely happened.
Number concentration distributes over laboratories giving the disagreement more than +/- 30 %.
The sample giving the least value for number concentration was measured around 2 weeks after the generation.
For other samples the terms were less than around 1 week.
The statistics over the latter three results shows the agreement within +/- 30%, although small elimination of UFB due to the term is suspected. The level of agreement is almost consistent with that of domestic comparison using surface transportation.

3. While type of Measuring instruments were identical, software version and wavelength of laser sources were different.
Since both versions were available on the hardware of instrument and sample, indirect comparison between measurement result from different versions of software was made over all four laboratories.

Conclusion:
Four laboratories participated international comparison exercise for ultra fine bubble measurement.

It consisted of three bi-lateral comparisons and allowed to compare average diameter measurements and number concentration measurements.

Agreement in +/- 30% were found among the number concentration of three labs on the samples with short transportations in a week.
However, it is to be noted that by some unidentified reason some elimination or transformation of UFB may have happened reducing number concentration of UFB. The exposure to long and hard environment for transportation before measurement looks to give significant influence to UFB.

The similar agreements were achieved for average diameter.

As far as report on the measurement procedures are concerned each laboratory performed sufficiently as specified in agreed procedure.

5. List of Application of Fine bubble technology to agro- and aqua-farming and water treatment area

Details of the application are found in Supplementary Annex SA 3 “Presentations”.
The abstract of the presentation on application and the biography of speakers are found in Supplementary Annex SA 2 and SA 1 respectively.

The applications presented were summarized under a format specifying essential characteristics, which was introduced in the workshop. The list is intended to allow quick look over the variety of application and identifying the economy engaged in the research and development and testing.

Since each participants are willing to contact more to the presenter for deepen the technology and learn on the market and technology transfer through research, testing and certification activity the list will facilitate the work-sharing and cooperation internationally and in each economy.

Current List of activity for R &D for Application of Fine Bubble Technology and Related testing, going on in each APEC economy. (Introduced in the Workshops) related to Agro- and Aqua- Farming and Water treatment areas.

No	Area	Data Format (AG,AQ,WT)	correspondent, Organization, Economy	/Specific R&D (now, planned) & Generalization for IS (future)	/Fine Bubble Enhanced Performance	/Parameter representing Performance (ex, Growth of Product)	/Parameter measurement method (ex. Weighing)	/Tested Object (ex. Fine Bubble Water)	/Characteristic of Tested Object	/Product (Vegetable, Fish, Water in A pond)	/Environments for Test Process
1~A3:L6	AG	Case Leaf Lettuce	Japan	Now: Leaf Lettuce, Future: Leaf Vegetable	Growth of Lettuce	Mass increase of Lettuce	Weighing	Fine Bubble Water	Size &Number Concentration of Fine Bubbles	Leaf Lettuce	Hydroponic Bed,Temperature, Light, Fertilizer,···
2	AG	Case Germination of Barley Seed	Japan	Now: Barley, Future: Cereal or Root Vegetable	Acceleration in Germination	Time until Germination	Day & hour, Calendar	Fine Bubble Water	Size &Number Concentration of Fine Bubbles	Barley seed	Bottled Pure Water with seed immersed, Temperature
3	AG	Case Leaf Vegetable	Chile	Now:Lettuce Growing Monitor: Oxygen transfer efficiency	Reduce cycle times, Increase yield, Oxygen transfer efficiency -Zeta Potential (Radica formation)	Duration (10 days reduction), Mass(166 % increase)	Weighing, Zeta Potential	Ultrafine Bubble Water	Size, NC and Zeta potential	Lettuce (green house)	
4	AG	Case Orange	Chile	Now:Oranges post-harvest disinfection	Increase the shelf-life of the product	Disinfection	Shape inspection, Duration (shelf life, 8 weeks increase) of the product	UFB water	Size, NC , Zeta potential (radical formation), Surface tension		Reduction of Chlorine use
5	AQ	Case Seabed	Chile	Now:Healthy Seabed (FONSA)	Restore on seabed to aerobic condition	Oxygen transfer efficiency		Fine bubble water	Size, NC, Dissolved oxygen (neutral buoyancy = UFB size)	Healthy seabed	Biofilm eradicated, Sludge decomposed, DO increased, and Biodiversity revived

6	AQ	Case Salmon	Chile	Now:Flow ice (Ecofriendly sanitization of fresh Salmon) Plan:Other Fishes	Sanitization of fresh salmon (reduction of use of peracetic acid)	Improved shelf-life	Disinfection of fresh Salmon, Oxidization reduction potential (ORP, +735 mV à+576 mV)	Ultrafine bubbles generating system	Size, NC, Zeta potential, radicals formation, surface tension	Fresh salmon in aqua culturing	Increase in shelf-life & improved certification
7	WT	Case Dissolved Air Floatatin	Chie	Now:Improvement on Dissolved Air Floatation	Reduction of coagulant	Coagulant maintaining efficiency (50 % decrease)	Size distribution of coagulant	Ultrafine bubble generating system	Size, NC, Size distribution, Zeta potential	Clean used water	
8	WT	Case Urban Water	China	Now: Improvement of quality of urban water	Reduction of dissolved oxygen, pollutant and reproduction of anaerobic bacteria	Decrease in chemical oxide demand (COD), concentration of NH3-N and phosphor	Chemical analysis	Fine bubble generating system	Size, NC	Urban water sewage	
9	WT	Case Industrial Sewage Water	China	Now: Improvement of quality of industrial sewage water	Reduction of dissolved oxygen, pollutant of reproduction of anaerobic bacteria and ozone use	Decrease in chemical oxide demand (COD) and phosphor	Chemical analysis	Fine bubble generating system	Size, NC	Industrial water sewage (pharmaceutical industry)	Weather
10	WT	Case Rice Field Improvement	China	Now:Improvement of yield of rice	Reduction of dissolved oxygen, pollutant of reproduction of anaerobic bacteria and ozone use	Decrease in chemical oxide demand (COD) and phosphor	Chemical analysis	Fine bubble generating system	Size, NC and COD (faster & cheaper)	Industrial water sewage (Papermaking industry)	Weather

11	AG	Case Rice Field Salinity Improvement	China	Now: Improvement of salinity-alkaline enriched rice field	Reduction of salinity (0.5 % à 0.2%) in 5 months by application of FB generating system	Salinity of sampled rice field+G10E14G12:G13	Salinity meter and pH meter	Fine bubble generating system	Size, NC, salinity reduction, enabled rice growth (6,120 kg/ha)	Rice	Weather
12	AG	Case Production Agricultural Foods	China	Now:Improvement of production of Rice, tomato, cucumber, water melon	Increase in food production and improve nutritional quality	Increase in mass per specified area of rice field	Weighing, sugar content meter , lycopene content meter	Fine bubble generating system	Size, NC, (Oxygen transfer enhanced) & higher production	Rice, Tomato, Cucumber, Water melon	Weather
13	AQ	Case Fish Culturing	China	Now : Improvement of Tawarat (mad barb) aqua-culturing	1. Increase in growth of hatching, hatching rate, shape of hatching and their healthiness, 2. Faster mass gain, less water exchange, less feed	Increase in mass per specified area of rice field.					
14	AG	Case Promoing Germination of Plants	Indonesia	Now:Promotion of germination of seeds,Rice, Soybean, Gmelina arborea Roxb wood (furniture, seed), Garlic	Faster germination	Duration, visual recognition of germination	Observation	UFB water	Size, NC	Rice, Soy beans, Gmelina arborea tree and leaves.	
15	AG	Case Breaking Dormacy of Garlic Bulb	Indonesia	Now:Promotion of breaking dormancy of garlic bulb (plumure)	dormancy for 5-6 months control takes 2-3 months for fine bubble application	Germination by plumula length	Observation (length measurement)	UFB water	Size, NC, DO, immersion duration	Garlic	

16	AQ	Case Productivity Shrimp Pond	Indonesia	New:Promotion of Productivity of Shrimp Pond	Increase the density of fish/ shrimp in fresh water	Duration, surviving rate	Observation	UFB generating system	Size, NC	Fish and shrimp	
17	WT	Case Dissolved Air Floatatin	Korea	New:Promotion of removal of floc	Improved effectiveness of separation	Depth of separation layer	Microbabble bed depth	Dissolved Air Floatation Plant	Size, NC	Industrial waste water	
19	AG	Case Washing Vegetable	Korea	New:Decrease of surface Micro-organism in washing leaf vegetable	Long shelf life and quality of leaves	Storage period	Observation in color	FB water	Size, NC	Long storage period and anti-browning (Quality) of lettuce	
20	AQ	Case Fish Cultering	Korea	New:Reduction of mortality of fishes		Mortality vs size of aquaculture farm	Increase in DO and temperature controllability	FB water	Size, NC	Fishes	
21	AG	Case Promotion of Growth	Korea	New:Hydroponic s for Ginseng and Water Cress	Growth of seedling in Ginseng & Contents of pharmaceutical ingredient of Watercress	Change in height of seedling by FB and Increase in contents of Glucosinolate by MB	Length measurement and Chemical analysis	FB water	Size, NC	Ginseng, Watercress	
22	WT	Case Water Ozonation	Singapore	New:Combined Microbubble-Catalytic Ozonation Process For High Shreagth Petrochemical Wastewater Treatment	High shreagth petrochemical wastewater treatment by MB ozonation & MB-catalytic ozonation	Reduction of COD, Removal effect on Phenol and Increase in BOD5/COD ratio	Chemical analysis	Micro Bubble generating system	Size, NC	Waste water from petrochemical industry	
23	AQ	Case Waterless Shipping Shrimp	Singapore	New: Waterless Shipping of Live Shrimps with Fine Babble Techeology	Higher survival rate after waterless condition of shrimps	Survival rate	Observation	Fine bubble generating and application method before shipping	Size, NC	Shrimp	

24	WT	Case Washing Manufactured Parts	Singapore	New: A New Fine Bubble Cleaning Method on Aerospace Parts	Improved efficiency in removing contamination		Observation	Fine bubble modifying system to accelerate interaction of FB to contamination	Size, NC	Aerospace parts	
25	AG	Case Promotion of Growth	Chinese Taipei	Ozonated Fine Bubble promoting growths of Strawberry, Leaf Vegetable and Potato	Antibacterial, Oxygenation efficiency, Decrease in pesticide and sterilization on bacterial by spraying	Yield and quality	Observation, Analysis	O3-FB water supplying system	Size, NC	Strawberry, Leaf Vegetable, Potato	
26	AQ	Case Improve Aqua farming	Chinese Taipei	New Enhancement of productivity in aqua farming	Antibacterial, Oxygenation efficiency, Decrease in NH3-H and anti-biotics use, Increase in DO and stocking density	Chemical component, mortality	Chemical analysis	O3-FB water supplying system	Size, NC	Fishes	
27	AG	Case Production of Chinese Medicine	Chinese Taipei	New:Productivit y of Ginseng, Improvement of quality of medicine	Increase oxygenation at Ginseng root and Sterilization and bleaching of Chinese medicine by O3-FB			O3-FB water supplying system		Chinese Medicine	
28	WT	Case Ozone Decolorization	Japan	New:Accelerate water treatment	Facilitation of oxydization of chemicals in water	Decolorization	Optical turbidity in color	Ozone chemical process system	Size, NC	Chemical Plant	
29	WT	Case Salt Washing in Steel Structure Surface	Japan	New:Efficient removal of surface salt	Faster removal of salt	Removal of salt	Salinity meter and pH meter	Ultra fine bubble	Size, NC	Building, Bridge	

6. Summary of Q&A

There were more than 57 questions during workshops and few of them were responded immediately in aural. Most of questions were requested to submit through “chat” channel. They were collected after the meeting is over and circulated to all participants with answer from each presenter through e-mail. Most of the questions concern to technological subjects, while some, to general.
The following lists the general and typical questions. For total Q &As, please see Annex A 4

Q1:I have a question about p. 25.
On the right-hand side, why do u put the Testing Designation outside of the box?
A:In internationally agreed scheme, the role of designation cannot be undertaken solely by FBIA but also by other bodies, while in current scheme, it is conducted only by FBIA. The shifting of box has such meaning

Q2 For the future marking system to be applied in the international community, how long is the “future”?
Approximately.
A:FBIA marking system like certification or registration system I explained are already open to foreign countries. That means foreign companies or organizations can apply certification or registration to FBIA now. (Inspection works will be conducted through internet mostly in current situation) The answer "It takes a few years" , replied at workshop occasion, meant preparation term for complying FBIA
system to internationally (including APEC region) agreed conformity assessment as mentioned in the last slide.

Q3: Do you have tentative list of possible applications of FB for
aquaculture?Thank you. Would appreciate to have copies of the results on aquaculture.
A:I am sorry I cannot answer to the subject. The presentations
c), f), g), h), i), j), k) will show you the examples.

Q4: For International standardization, what is the key issue which each country has to contribute ?

A:Current number of the member of ISO TC 281 “Fine bubble
technology” does not deserve to the broad scope of FB application in the world. Non member economies is expected to join it.
Since FB technology concerns to improvement of application of “water” and, eventually, application fields are enormous and quite dependent to the individual economic situation, market, food, climate etc. (le’ts say “environment” of each economy of APEC area. In order to develop sound standard taking care of such position of FB technology, the
knowledge, insights, test results and case studies from as many different “environment” will significantly contribute to improve the productivity of the technical committee. Especially, Agro-, Aqua- farming and water treatment application of fine bubble are significantly dependent on the “environment” specific to each economy of APEC region. Participation to join the information sharing of case studies is encouraged.

Q5: Are there any standardization for freshness keeping of fishes?
A:There are several methods reported so far for freshness
keeping of fishes. However, there has been no trial of making international standardization.

Q6: With tremendously broad applications of UFB, I believe
education for general people in each country would be an important task. What is the direction of FBIA to coordinate with this issue.
A:This APEC symposium will be the important chance of

information exchange and the education of UFB. As the activities of ISO TC281, we have been organizing the international workshop to introduce the tremendously broad application of UFB.

Q7:For making the price of UFB application achievable for people in some countries, Do you have any strategic movement ?
A:We have been making the SDGs reports for the UFB applications. This means that the UFB application will be applicable for many countries without much amount of cost. UFB would be one of the most suitable technology for many countries with the usage of only water and air.

Q8: we are interested in application of NB in water treatment and agriculture. How FBIA support other member countries on application of NB technique on field scale? I hope we can share the achievements and establish joint projects to enhance application of NB technique.
A:There are two methods for supporting the application of UFB to agricultural fields. One is to show the experimental results of our actual fields tests, which would be helpful for the challenge of agricultural fields test. The second one is to make the collaboration project at the international scale.
Both would be useful for the promotion of UFB application to agricultural fields.

Q9:How can you distinguish bubbles from particles?
A:The methods are described in ISO standard 24261-2 under development. I hope I will introduce it next time after published.

Q10:Is this technology suitable for vertical farming?
A:Yes, it is.
Q:hydroponic?
A:Yes, it is.

Q11:Regarding KFBIA activities, do you have a plan to start certification of FB products or service?
A:For now, it has certified size and density of microbubbles.

Q12:Congrats for your excellent research. Have you conducted the research on the mechanism of MB degradation? Which species are responsible for MB degradation? Thank you.
A:Un-saturated chemical bond of methylene blue colorizing blue, will decomposed by ozone. Then, FB promotes the oxidization power of ozone.

Q13:May I have QR Code of NITE
A:From here you can acces NITE's official web site and the You Tube video.
NITE's official website: https://www.nite.go.jp/en/gcet/index.html You Tube video: https://www.youtube.com/watch?v=Scu2OdYvJSk&list=PLWxWKUOj3xAJk8ID51IWTFighPmgU0FOI&index=6

Q14:Is the application of cleaning salt on surface of iron structure ready for commercial use?
A:It is of commercial one.

Q15:Does pure water need to compare with each other as control? During the generation of nanobubbles, may also produce some contamination.

A:Ideally, I think three types of samples: pure water, water containiing ultrafine bubbles and water after elimination process should be evalutated.
4-2:<Practical output in terms of Key objectives of Workshop>

7. Summary of Evaluation Survey

Survey was conducted after workshops and the results were analyzed in order to learn how the participants evaluate the project. The result of analysis is summarized as followings.

The participants understand the role of the project and were able to acquire a lot of information in the application of the fine bubble technology and their area, understand the role of the penetration of the product of application to the society by R&D, standardization and certification for the market.

7.1 Result of Project Evaluation Survey for Workshop

The evaluation on the workshop activity was responded by answering and commenting to the circulated questing format and the results were collected and analyzed as follows.

Each question item has rating score 1 out of 5 levels.

The results of evaluation survey are collected together with their analysis in Annex A3 Survey Results. The questions for the participants are also found in the Annex.

The “questions 0” is subdivided into 8 questions and holds sub-marking such as 0-1, 0-2, …

Besides them the format has 7 questions with rating score 2.

Brief summary of analysis indicates the following findings

/Definition of objective of WS were well understood.

/Achievement to objective were agreed.

/The Contents of WS were very interesting.

/The presented materials were arranged for good understanding.

/The time schedules were tight for some participants.

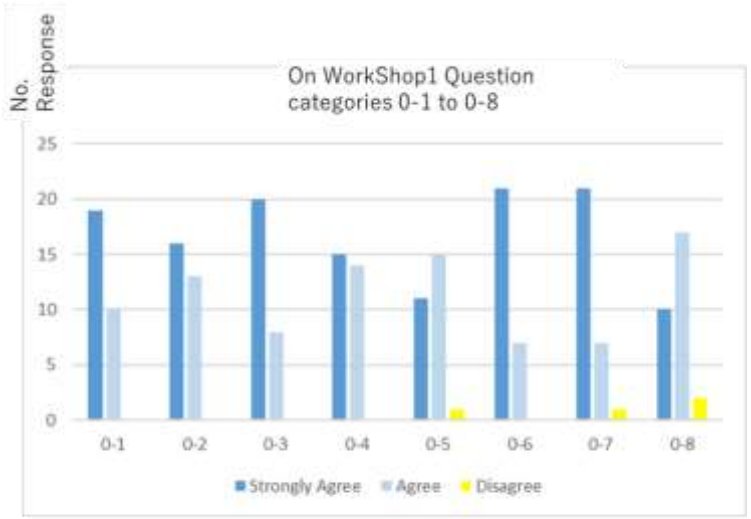
/The subjects of WS were very relevant to each economy.

/Various outcomes of WS useful for each economy were predicted and pointed out. Facilitation of standardization, dissemination of the information to domestic players, collaboration with experts of foreign economies and setting regulation for laboratory level.

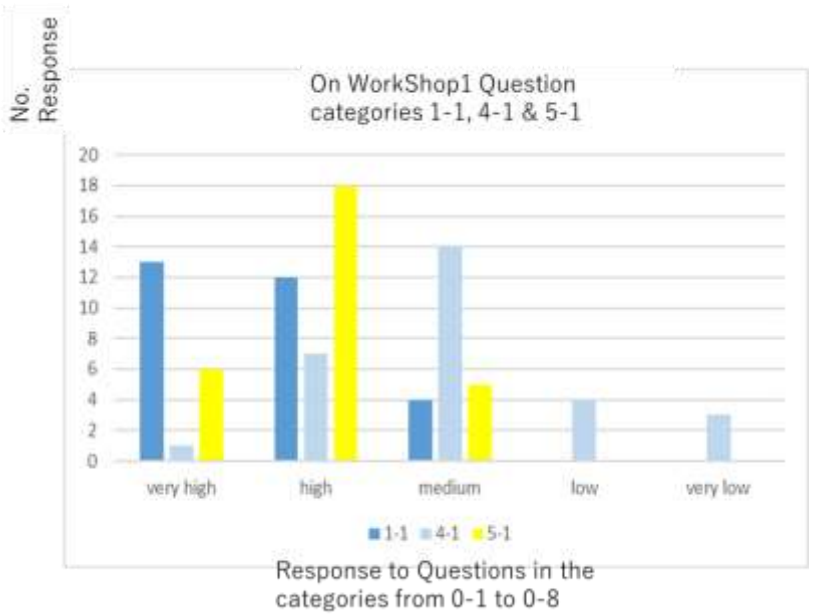
/The information acquired at WS improved the knowledge of each participants.

The following graphs show the number distribution of scores by responding participants.

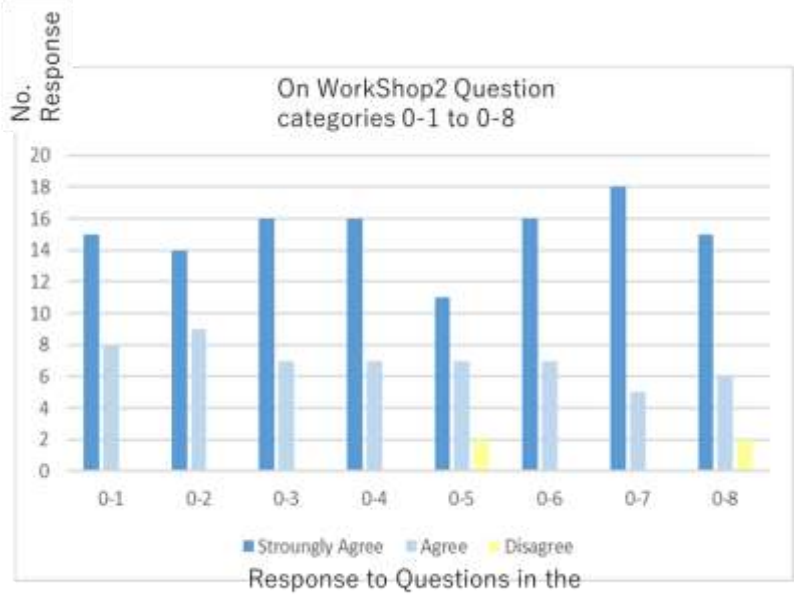
(For “questions”, please see the Annex A3.)



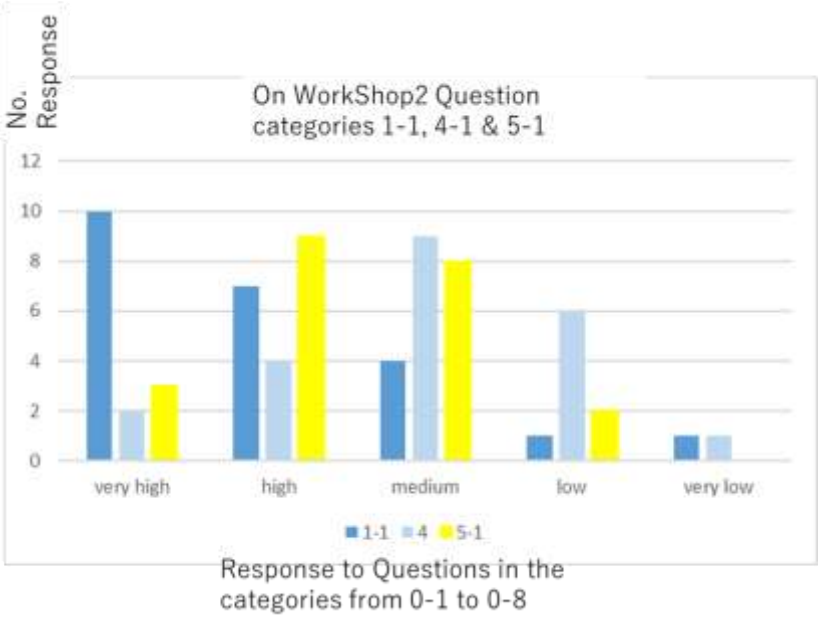
Response to Questions in the categories from 0-1 to 0-8



Response to Questions in the categories from 0-1 to 0-8



Response to Questions in the categories from 0-1 to 0-8



<Key outcomes>
Record of Q&A for each presentation is available at A 4_"Q&AWorkshop1&2" of Supplement Documents.

1)

The participants responded to the presenter by using Q &A and evaluation survey and looks intending to apply the information to their researched and testing activities intensively. Many comments express the requirement of cooperation on the information share. See in QC1, in QC2, in QC6, in QC7, OC13, OC15, OC21,

The study report "Summarized List of Application of Fine bubble technology to agro- and aqua-farming and water treatment" classifies each presented application according to the key-words and provide common wording shared by potential stakeholders.

The broad information share is confirmed and improve effectiveness and versatility of FBT testing, in economy and internationally.

2)

On already published ISO standards for evaluation of the fine bubble performance and fine bubble characteristic measurement, the presentation, the response of the participant seen in the Q &A and evaluation survey looks their further domestic approach for the confidence in the quality of FBT. It is also confirmed from some comments such as in QC1, in QC3, in QC6

3)

As the presentation 2c) related to TR 24217-2 shows the Fine bubble technology is influential and contributing to many targets and goals of "Sustainable Development Goals", the participants are aware of the above-mentioned feature of the fine bubble technology. The technology transfer near future in related fine bubble technology is confirmed to be approached according to comments of participants as

Q7 and Q13, OC22, OC24,

4)

As the presentation 1b) shows the importance and benefit of the standardization and conformity related to ISO TC 281 deliverable for sound international market and introduces the

current example of domestic certification activities, the participants are sufficiently aware of the above-mentioned outcome and confirms their contribution establishing certification infrastructure in each economy and internationally, as seen.
In QC1, in QC2, in QC3, in QC6, OC1 and OC3.

8. Overall Impact and Future Perspectives

<Overall Impact>
The participants are well impressed with a variety of subjects related to the fine bubble technology, from standardization to market and technology transfer, from agriculture to water treatment, from market product to measurement technology, from written standards to the video learning of the measurement procedure. In order to install and implement the benefit of fine bubble technology into domestic and international society as rapid and efficient as possible, the simultaneous activation in such broad area is necessary and it is the impact of the workshop to initiate the activations. The outputs, presentation media, evaluation survey and Q&A, evidence the result of initiation and confirm the activation.

The workshops introduced 14 ISO standards for fine bubble technology and 7 standards related to certification activity with 2 practical procedures and 1 inter laboratory comparison. They also introduced application R &Ds from 7 economies.

Although the applications were limited to agro-, aqua- farming and water treatment this time, most of the participants are acquired many essential information to expand their scope related to the fine bubble technology over a variety of domestic activities.

<Lessons Learning>

Since in the season right after the WS 1, it was difficult to start the international comparison,the technical conduction of comparison was obliged to place in April in order to avoid the freezing of UFB water sample eliminates UFB totally. Never the less the careful treatment of the sample was given, one of the samples was deteriorated, which maybe is caused by long transportation time. The shorter transportation measure should have been taken, but limitation on the air transportation caused by the regulation due to anti-pandemic policy did not allowed it.

As seen in some comments, further opportunity to obtain deepening understanding on the detail of subjects is demanded. Since there are some limitation in time and space with online workshops, we believe that such opportunity needs to be facilitated with longer time scale with more Q &A session, and importantly with face-to face meeting.

A lot of development of fine bubble technology and testing for it are in APEC economies and the participants can help each other technically and in management for creating sound market in APEC region.

9 Annex

ANNEX A1: Agenda

<AGENDA for APEC-WS 1>
Date and time①
Tuesday, January 19, 2021 18:00-20:40 (Japanese Local Time) (a)-e))
1a) 18:00-18:10 "Greeting" from SCSC Japan
Mr. Mitsuo MATSUMOTO, Principal Advisor for International Standardization Policy, Ministry of Economy, Trade and Industry, Japan
"Greeting" from Fine Bubble Industries Association (FBIA)
Dr. Hiroshi KASAI, Executive Director, FBIA, Japan
1b) 18:10-18:40 "Standardization and certification as technical platform of fine bubble technology"
Mr. Takeyuki FUSE, General Manager, FBIA, Japan
Dr. Mitsuru TANAKA, Certification Coordinator, FBIA, Japan
1c) 18:40-19:10 "Current status of fine bubble technology"
Dr. Akira YABE, Special Advisor & Researcher Emeritus, National Institute of Advanced Industrial Science and Technology (AIST), Japan
1d) 19:10-20:10 "Standards for basic principle and measurement of fine bubbles"
Ms. Seika OHUCHI, Manager, National Institute of Technology and Evaluation (NITE), Japan
Ms. Hirona KOBAYASHI, Chief, National Institute of Technology and Evaluation (NITE), Japan
1e) 20:10-20:40 "Role of inter-laboratory comparison"
Dr. Seiichi OSHITA, Project Professor, The University of Tokyo
Dr. MitsuruTANAKA, Certification Coordinator, FBIA, Japan

Date and time②
Thursday, January 21, 2021 18:00-20:15 (JLT) (f)-m))

(18:00-19:45 Introduction of technical activities related fine bubble technology in APEC economies)

1f) 18:00-18:15 "Activities in Chile" Mr. Manuel VIAL, Head of R&D, KRAN

1g) 18:15-18:30 "Fine Bubble Technology in China-Application and Standardization“
Dr. Zhaojun LI, Professor, Institute of Process Engineering
1h) 18:30-18:45 "Activities in Indonesia“
Dr. Y. Aris PURWANTO, Lecturer, Department of Mechanical and Biosystem Engineering, IPB University
1i) 18:45-19:00 "Activities in Korea"
Dr. Chang Gyun KIM, Dean, Inha University
1j) 19:00-19:15 "Activities in Singapore"
Dr. Chee Wee LEE, Technology Advisor, Temasek Polytechnic
1k) 19:15-19:30 "Activities in Chinese Taipei"
Dr. Jong-Shinn WU, Distinguished Professor, National Chiao Tung University
1l) 19:30-19:45 "Activities in Japan“
Dr. Seiichi. OSHITA, Project Professor, The University of Tokyo
1m) 19:45-20:15 "Development of Application Standards and cooperation by data sharing"
Dr. Akira YABE, Special Advisor & Researcher Emeritus, AIST, Japan
Dr. Mitsuru TANAKA, Certification Coordinator, FBIA, Japan

<AGENDA for APEC-WS 2>

Greeting from SCSC of Japan

Mr. Mitsuo MATSUMOTO,
Principal Advisor for International Standardization Policy, Ministry of Economy, Trade and Industry,Japan and the Project Overseer APEC –WS 2 (SCSC 03 2019T)
Dr. Hiroshi KASAI
Executive Director for Fine bubble Industries Association (FBIA), Japan, Organizing Secretariat APEC-WS 2(SCSC 03 2010T)

2a) Decolorization of Water by Ozone Fine Bubbles -Water Treatment
Dr. A.YABE
Special Advisor & Researcher Emeritus of National Institute of Advanced Industrial Science and Technology (AIST), Japan
IS 20304-1: Test Method for Decolorization and Examples of application of Ozone Fine Bubble are introduced. (20 min)

2b) Introduction to dissolved air flotation (DAF) process and DAF bubble bed
Dr. CG.KIM, professor at INHA University, Incheon, Korea
and Dr.HJ KIM IrehEnvit Corp., Tanhyeon-myeon, Paju-si, Gyeonggi-do, Republic of Korea
IS 20480-4: Terminology for DAF application of Fine Bubble and Examples of application to DAF technology are introduced. (30 min)

2c) Fine Bubble Technology for Sustainable Development Goals
Ms. S. NISHIMURA , Staff, Fine Bubble Technology Office, Global Center for Evaluation Technology, National Institute of Technology and Evaluation (NITE), Japan
TR 24217-2: Methods Assigning Fine Bubble Technology to Sustainable Development Goals (SDGS) are introduced. (20 min)

2d) Cleaning of Salt on Surface of Iron Structure by Using Ultrafine Bubbles
Dr. A. YABE, Special Advisor & Researcher Emeritus of National Institute of Advanced Industrial Science and Technology (AIST), Japan
TS_ 21256-1: Test Method for Cleaning Performance and practical example of application to maintaining Steel bridge structure are introduced (20 min)

2e) The standards for elimination method of fine bubble
Ms. H. KOBAYASHI, Chief, Fine Bubble Technology Office, Global Center for Evaluation Technology, National Institute of Technology and Evaluation (NITE), Japan
IS 24261-1&2: Elimination specifically for Ultrafine Bubbles enables to identify bubbles from particles assuring reliable measurement of Ultrafine Bubbles (35 min)

2f) Inter Laboratory Comparison of Ultra Fine Bubble Measurement .
Dr. M. TANAKA , Certification Coordinator, Fine Bubble Industries Association, Japan
A comparison of measurements for ultrafine bubble water was planned and conducted and its results will be presented. (20 min)
Closing

ANNEX A 2: List of ISO standards introduced by the Workshops

14 documents were explained in the workshop, out of 18 published documents from ISO/TC 281 product.

ISO 20298-1:2018
Fine bubble technology — Sampling and sample preparation for measurement — Part 1: Ultrafine bubble dispersion in water

ISO 20304-1:2020
Fine bubble technology — Water treatment applications — Part 1: Test method for evaluating ozone fine bubble water generating systems by the decolorization of methylene blue

ISO 20480-1:2017
Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 1: Terminology

ISO 20480-2:2018
Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 2: Categorization of the attributes of fine bubbles

ISO 20480-3:2021
Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 3: Methods for generating fine bubbles

ISO 20480-4:2021
Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 4: Terminology related to microbubble beds

ISO 21255:2018
Fine bubble technology — Storage and transportation of ultrafine bubble dispersion in water

ISO/TS 21256-1:2020
Fine bubble technology — Cleaning applications — Part 1: Test method for cleaning salt (NaCl)-stained surfaces

ISO 21910-1:2020
Fine bubble technology — Characterization of microbubbles — Part 1: Off-line evaluation of size index

ISO/TS 23016-1:2019
Fine bubble technology — Agricultural applications — Part 1: Test method for evaluating the growth promotion of hydroponically grown lettuce

ISO 23016-2:2019
Fine bubble technology — Agricultural applications — Part 2: Test method for evaluating the promotion of the germination of barley seeds

ISO/TR 24217-2:2021
Fine bubble technology – Guideline for indicating benefits — Part 2: Assignment of Sustainable Development Goals (SDGs) to applications of fine bubble technologies

ISO 24261-1:2020

Fine bubble technology — Elimination method for sample characterization — Part 1: Evaluation procedure

ISO 24261-2:2021
Fine bubble technology — Elimination method for sample characterization — Part 2: Fine bubble elimination techniques

ANNEX A 3: Survey Results

Question Format
Project Evaluation Survey has the following questions to the participants of Workshops.
APEC Project Name/Number: Capacity Building on Testing and Conformity Assessment of Fine Bubble Technologies for use in Agro-/Aqua- Culture and Water Treatment in the APEC Region (SCSC 03 2019T)
Date: 19 & 21 Jan 2021

Instructions: Please indicate your level of agreement with the statements listed in the table below.
0: Please Choose from “Strongly agree “, “Agree” and “Disagree”
0-1:The objectives of the training were clearly defined?
0-2:The project achieved its intended objectives?
0-3:The agenda items and topics covered were relevant?
0-4:The content was well organized and easy to follow?
0-5:Gender issues were sufficiently addressed during implementation?
0-6:The trainers/experts or facilitators were well prepared and knowledgeable about the topic?
0-7:The materials distributed were useful?
0-8:The time allotted for the training was sufficient.?

1: How relevant was this project to you and your economy?
1-1:Rate and Explain
2:In your view what were the project’s results/achievements?
Explain
3:What new skills and knowledge did you gain from this event?
Explain
4:Rate your level of knowledge of and skills in the topic prior to participating in the event:
5:Rate your level of knowledge of and skills in the topic after participating in the event
6:How will you apply the project’s content and knowledge gained at your workplace? Please provide examples (e.g. develop new policy initiatives, organise trainings, develop work plans/strategies, draft regulations, develop new procedures/tools etc.).
Explain:___
7:What needs to be done next by APEC? Are there plans to link the project’s outcomes to subsequent collective actions by fora or individual actions by economies?
8:How could this project have been improved? Please provide comments on how to improve the project, if relevant.

6.3 Answers and brief estimation of the Workshops
For WS 1, 29 participants responded with answer and 23, for WS2 making 52 in total.

0-1:The objectives of the training were clearly defined?
About 2/3 of all answers scores “Strongly Agree” and 1/3, “Agree”.
The objectives of the training are clearly understood.

0-2:The project achieved its intended objectives?
More than half of all answers scores “Strongly Agree” and the rest, “Agree”.
The objectives of the training are thought achieved..

0-3:The agenda items and topics covered were relevant?
More than 2/3 of all answers scores “Strongly Agree” and the rest , “Agree”.
For most of participants, the subjects are relevant their business.

0-4:The content was well organized and easy to follow?

More than half of all answers scores “Strongly Agree” and the rest, “Agree”.
The content of the presentations is understandable and making sense to the participants.

0-5:Gender issues were sufficiently addressed during implementation?
Around half of all answers scores “Strongly Agree” and 6%, “Disagree” without clear explanation and the rest, around 44%, “Agree”.
Most of addressing of gender issue are supported by the participant, while a few do not support, The improvement of the way of addressing is hard to learn.
Since the portion of female gender were around 1/3 of all participants in WS 1, the invitation for WS 2 put a sentence encouraging female participants.

0-6:The trainers/experts or facilitators were well prepared and knowledgeable about the topic?
More than 2/3 of all answers scores “Strongly Agree” and the rest , “Agree”.
Most of participants evaluate the WSs and the administration as well prepared.

0-7:The materials distributed were useful?
More than 3/4 of all answers scores “Strongly Agree” and the rest , “Agree” but one, “Disagree”.
Distributed media are in pdf, while a few presentations are in video, on which the answer is claiming. However, some typical shots from the video have been converted to pdf and circulated, too.

0-8:The time allotted for the training was sufficient.?
More than half of all answers scores “Strongly Agree” and 8%, “Disagree” and the rest , “Agree”
The Question of Q &A are collected by using “chat” channel after the presentation is over. The questions are all recorded and circulated with answer from the presenters later, by e-mail. The live Q&A does not allow to estimate the time schedule and the “chat” method is taken in order to present all subject within the scheduled time.

1: How relevant was this project to you and your economy?
According to the rating results, “very high”, “high” and “medium” are 96 %.
The participant-targeting looks work well.
Each participant explained its role in research, testing, standardization and also in the variety of application area of fine bubble technology, emphasizing the impact of the technology. Some pointed the domestic work sharing among the different role players will be necessary

2:In your view what were the project’s results/achievements?
Disseminating the measurement technology and process of Standardization
Raising and deepening knowledges of a variety of application of fine bubble technology.
Finding possible partners of cooperation and its information.

3:What new skills and knowledge did you gain from this event?
Understanding the certification system for fine bubble technology.
Learning measurement technology and handling of fine bubbles.
Understanding on the UFB industry and application of fine bubble technology

4:Rate your level of knowledge of and skills in the topic prior to participating in the event:
According to the rating results, around 50 % have had medium level of knowledge and and skill.
5:Rate your level of knowledge of and skills in the topic after participating in the event
According to the rating results, around 96 % score to “very high”, “high” or “medium”.

The improvement in knowledge and skill is major in the score “high” but not “very high”, which has been ambitious.
However, many comments point out concrete improvement in detailed measurement procedure and handling especially by video presentation.

6:How will you apply the project’s content and knowledge gained at your workplace? Please provide examples (e.g. develop new policy initiatives, organise trainings, develop work plans/strategies, draft regulations, develop new procedures/tools etc.).

To disseminate to domestic role players including students
To facilitate the domestic players to application of fine bubble technology
To facilitate the standardization
To collaborate with experts from other economies
To facilitate setting regulation in laboratory level

7:What needs to be done next by APEC? Are there plans to link the project’s outcomes to subsequent collective actions by fora or individual actions by economies?

To develop to joint project with fine bubble technology industries
To exchange the knowledges for standardization and broad application of fine bubble Technology
To further deepening seminar

8: How could this project have been improved? Please provide comments on how to improve the project, if relevant.

More time for mutual understanding among the participants and for live Q&A time
More program for training and more capacity for the participation

Data: Typical Comments
WS 1

QC1: How relevant was this project to you and your economy?
Comments:
The economy is new to this FB Technology . I will discuss more with the Standardisation Division in the economy .
Our organization is promoting FB technology and we are focusing activities related to creditability issue of FB technology.
It is an important gathering to share different achievements and cooperate worldwide.
Agriculture is very important in the economy. In government policy, high-tech agriculture becomes an edge. As the UFB technology was very promising in application in agro- and aqua-culture, this workshop is extremely a good chance to approach more and more
Very helpful to understand where other FB business are working on. We can share experience and results
We are developing national standards (SNI) of fine bubble technology
The economy is currently developing national standards that harmonize ISO/TC 281 standards.
Useful to promote the International Standards proposal

QC 2: In your view what were the project’s results/achievements?
Comments:
How to measured and standardized fine bubble generator
Importance of FB measurement was shared by all participants.
The WS provides convincing evidence in industry applications of fine bubble technology through sharing of diverse examples implemented at different locations among APEC members.
Knowing each other activities, and be a starting point to start working together.

The project obtained significant results on providing standardization and certification platform of FB and introducing many successful case studies on application of FB in various fields.
Some applications of FB technology different from countries lead to find the necessity of inter-collaboration.

QC 3: What new skills and knowledge did you gain from this event?
Comments:
We clearly understood certification systems applied to FB technology
For sample preparation in characterization of FB water, videos used in the presentation are useful – seeing is believing. Examples of applications and positive results presented by participants across the regions reinforced the economic benefits and industry-scale practicality of FBT
Practical procedure to handle ultrafine bubbles and microbubble.
Increased understanding of the scale of UFB industry and applications; better understanding of handling and transport issues.

QC 5: Rate your level of knowledge of and skills in the topic after participating in the event
Comments:
Needing face-to-face interaction and sharing in order to achieve deep learning and understanding from fellow experts.
The video clips of fine bubbles generation, sample preparation and transportation really helped understanding of the relevant ISO standards. The application cases presented by various economies also helped understanding the potential of fine bubble technology.
Visual presentation on the procedure was well arranged and make easy understanding
The work shop give us very careful description of how to measure the ultrafine bubble

QC 6: How will you apply the project's content and knowledge gained at your workplace? Please provide examples (e.g. develop new policy initiatives, organise trainings, develop work plans/strategies, draft regulations, develop new procedures/tools etc.).
Comments:
This project help me to train other colleague for my nanobubble related project
We decided to develop educational documents for developing economies'' students or such people
Developing new procedures/ tools.
Develop new testing methods for fine bubbles
I will try to connect with experts from other countries and call their technician supports to establish joint research projects in order to accelerate application of FB technique in agriculture and environment in the country.
Set up discussion with national expert to look at the way forward/benefits/possibility on the economy's participation in FBT technical working group at national or ISO level
We get a plan to develop a joint program with a foreign partner in subject of application of UFB in water treatment.
Draft some regulations applicable of laboratory scale results to practical scale.
To organize the cooperation platform of each R&D under strategic information sharing.
Participate in the international comparisons to verify the comparability of our capabilities, and share results within my organisation and use them to more broadly inform National discussions/work on UFB in which I am involved.
Share information with colleges in relative area, and promote development of standards

QC 7:What needs to be done next by APEC? Are there plans to link the project's outcomes to subsequent collective actions by fora or individual actions by economies?
Comments:
I think the next step is to really develop joint projects between scientists-universities-companies participating in the FBIA.

I think knowledge and experiences on new FB standardization and new application case studies need to be exchanged. The companies working on FB technique should be also introduced.
More sessions like this and a more in-depth seminar on the use and benefits of FBT. Sharing sessions with other economies/organisations would be very helpful, too.
I think it needs to be held the next workshops on standardization and conformity assessment related fine bubble technologies and their implementation in various countries

QC8: How could this project have been improved? Please provide comments on how to improve the project, if relevant.
Comments:
It is necessary to provide opportunities for presenters to answer questions in the forum, so that other participants also understand about the matters.
Enough discussion time is needed after each presentation in order to get mutual better understanding that can give new ideas to improve this project.
More time for questions and communication. Share participants' contact information (such as email).
More program for training and more capacity for the participation

Other Comments

OC1:Testing and assessment capability and standards are very important to support fines bubbles technologies in the economy.
OC2:Different testing method and standards in different countries.
fines bubbles technologies is a new area for me before the event. This event helped me to understand the new technology.
OC3:As a testing laboratory, we will plan to develop new procedures/method for fines bubbles.
OC4:Implementation plan for individual countries.
develop website or media platforms to promote and share experience and knowledge

OC5:I cant see how it can be applied commercially in aquaculture industry. Need to look into equipment power consumption, price and lifespan of equipment.
OC6:Supply more information on ultrafine bubble
Measurement of ultrafine bubble, more function of UFB
OC7:Find more fund for researches

OC8:As agro- and aqua-economic of our country is a very important, the application of UFB technology can help much while keeping stable development goals.
OC9:This project is an occasion to approach new technology and its potential in argo-/aqua- culture application. It's also an good occasion for us to find
OC10:I personally gain some knowledge about new application of UFB in DAF technic. Event
OC11:DAF was a tradition technic, the use of UFB in DAF can increase its performance.
OC12:What we learned is also a good experience to build our own standard for
OC13:UFB technology conforming to international standard. some research partnership institution.
OC14:From what I learned from the workshop, I can develop a new research plan in create, characterize and using nitrogen UFB, not oxygen UFB, in field of agro-culture and food-safety. For characterization part, the knowledge learned from workshop was extremely useful, and it can help us to evade some errors in sample preparation and measurement.
OC15:The new knowledge I learned from this training session can help with my current ultrafine bubble project.

OC16:More sessions of such training and allow more people to attend

Oc17:Through the workshop, I am more aware about the various application of FB technology
OC18:The workshop is very successful. The minor suggestion is below
OC19:Q&A can be arranged right after the speakers to catch the attention of audience.

OC20:The presentation on the standards were good to provide the accepted protocols
e.g. in the elimination of fine bubbles
OC21:Good to keep to bite-size sharing like this 2nd workshop

OC22:This project is very relevant to my economy, as Fine Bubble technology
will be considered as an option to improve water quality by reducing
pollution and minimizing the discharge of chemicals and hazardous materials;
reduce environmental impact; and prevent and reduce all kinds of
marine pollution. Furthermore, the project is also very relevant to me, because the
project has provided information, knowledge and understanding of standards related
to Fine Bubble technology, such as ISO 20304-1:2020; ISO/DIS 20480-3;
ISO/TR 24217-2:2021; ISO/TS 21256-1:2020(E); ISO/DIS 24261-2;ISO 24261-1:2020.
OC23:In my opinion, the result/achievement of this project is that the project has succeeded in
providing information, knowledge and understanding of standards related to
Fine Bubble technology,

OC24:The economy has been promoting sustainable aquaculture. In that line, this course
has given us a scope about FBT and its different uses related to water quality management.
For example, there are lakes in the economy with poor water quality
where aquaculture is developed, it would be interesting to evaluate the
application of this technology to assess its impact on the development of species
such as trout.

ANNEX A 4: Q&A

No.	questioner	Answer
Q1	I have a question about p. 25. On the right-hand side, why do u put the Testing Designation outside of the box?	In internationally agreed scheme, the role of designation cannot be undertaken solely by FBIA but also by other bodies, while in current scheme, it is conducted only by FBIA. The shifting of box has such meaning.
Q2	I would like to know the potential of FB in water reuse area. Thank u!	Being I not aware of the difference of “water treatment” and “reuse”, there are significant number of application of MB to water treatment so far. May be it will be true for UFB. DAF application, De-colourization application using Ozone FB.
Q3	For the future marking system to be applied in the international community, how long is the “future”? Approximately.	FBIA marking system like certification or registration system I explained are already open to foreign countries. That means foreign companies or organizations can apply certification or registration to FBIA now. (Inspection works will be conducted through internet mostly in current situation) The answer "It takes a few years" , replied at workshop occasion, meant preparation term for complying FBIA system to internationally (including APEC region) agreed conformity assessment as mentioned in the last slide.
Q4	Do you have tentative list of possible applications of FB for aquaculture? Thank you. Would appreciate to have	I am sorry I cannot answer to the subject. The presentations c), f), g), h), i), j), k) will show you the examples.
Q5	what is your opinion in order to apply FBIA marking internationally, since so many limitation in current measurement equipment in	As explained, the example of marking system is currently run only by FBIA, Japan, and manufacturers of FB product in other economies can apply to the system and put the mark on their products,

Q6	For International standardization, what is the key issue which each country has to contribute ?	Current number of the member of ISO TC 281 “Fine bubble technology” does not deserve to the broad scope of FB application in the world. Non member economies is expected to join it. Since FB technology concerns to improvement of application of “water” and, eventually, application fields are enormous and quite dependent to the individual economic situation, market, food, climate etc. (le’ts say “environment” of each economy of APEC area. In order to develop sound standard taking care of such position of FB technology, the knowledge, insights, test results and case studies from as many different “environment” will significantly contribute to improve the productivity of the technical committee. Especially, Agro-, Aqua- farming and water treatment application of fine bubble are significantly dependent on the “environment” specific to each economy of APEC region. Participation to join the information sharing of case studies is encouraged.

Q1	when we produce MB in the water itself , will the MB remove like minerals , colorine etc	The froth flotation method of producing various kinds of metals has been established over hundred years ago. This floating method utilized micro bubbles and surface surfactants based on the mechanism that the bubble surfaces would attract the hydrophobic mettalic element more than the hydrophilic element.
Q2	Are there any standardization for freshness keeping of fishes?	There are several methods reported so far for freshness keeping of fishes. However, there has been no trial of making international standardization.
Q3	since UFB does not move up , is this good for cleaning veg , meat etc ?	UFB will move along the water streamline and move away from the targets. Some amount will remain near the targets. However, UFB have not been reported to be hazardous for the plants and the living things.
Q4	I am very interested in knowing more about the contents on p. 17.	Please examine the reports and scientific papers.

Q5	With tremendously broad applications of UFB, I believe education for general people in each country would be an important task. What is the direction of FBIA to coordinate with this issue.	This APEC symposium will be the important chance of information exchange and the education of UFB. As the activities of ISO TC281, we have been organizing the international workshop to introduce the tremendously broad application of UFB.
Q6	For oil removal from the tools, what kind of the reaction conditions was used? Or just soaking in the liquid with fine bubble ?	As for the ISO documents of oil removal, the method described is just soaking in the liquid with UFB.
Q7	For making the price of UFB application achievable for people in some countries, Do you have any strategic movement ?	We have been making the SDGs reports for the UFB applications. This means that the UFB application will be applicable for many countries without much amount of cost. UFB would be one of the most suitable technology for many countries with the usage of only water and air.
Q8	we are interested in application of NB in water treatment and agriculture. How FBIA support other member countries on application of NB technique on field scale? I hope we can share the achievements and establish joint projects to enhance application of NB technique.	There are two methods for supporting the application of UFB to agricultural fields. One is to show the experimental results of our actual fields tests, which would be helpful for the challenge of agricultural fields test. The second one is to make the collaboration project at the international scale. Both would be useful for the promotion of UFB application to agricultural fields.

Q1	If I understand correctly, for the bubble standard, the standardization will be focused only on bubble size. In fact, you can produce the FB with various kinds of gasses i.e. pure oxygen, ozone, nitrogen, CO2 etc. What will be the guideline using the different kinds of gasses for the international standard? Should be included or it does not necessary for?	Oral answer was made at WS.
Q2	Are there any technical explanation on the reason why at a higher temperature the number concentration of UFBs is lower?	Oral answer was made at WS.
Q3	On page 20, what is ufb-m and what is ufb-g? On page 24, what is the brand of the generator? What the mixer speed for the rotational propeller?	Oral answer was made at WS.

Q4	It is not convincing for me that UFBs are different from solid fine particles. With the negligible effect of buoyancy and with strong effect of surface tension, UFBs should behave like solid particles. Do you have any evidences showing that UFBs behave differently when compared to ultrafine particles.	Oral answer was made at WS.
Q5	How does the homogenization process effect the time life and size of UFB?	If you homogenize following the international standard, the possibility of affecting the time and size of UFB is low.
Q6	We are interested in production of micro-emulsion (water in oil in water). Do you have any comments or recommendation in using UFB Technology.	I'm sorry. I don't have the knowledge of micro-emulsion.
Q7	How can you distinguish bubbles from particles?	The methods are described in ISO standard 24261-2 under development. I hope I will introduce it next time after published.
Q8	I would like to know the optimal storage duration of sample before conducting particle tracking analysis?	Size and concentration of ultrafine bubbles are not stable just after generation. I recommend you measuring after the next day.
Q9	May we get the original presentation file. So many interesting video.	I am afraid we cannot distribute the file. Instead, you can refer the same information in the International standard.
Q10	I saw a Shimadzu SALD-7500 in the last video, how you compare it's performance to a Nanosight? There will be a distribution of the video of the entire APEC Workshop?	Particle tracking analysis method (incl. Nanosight) applies in the range to 1000 nm. On the other hand, I introduced here the evaluation method for microbubbles, which are larger than 1000 nm, using flow cell with Laser diffraction method (incl. SALD-7500). Those cannot be compared. If you can use the batch cell with Laser diffraction method, you can compare the results of ultrafine bubbles between Particle tracking analysis method and Laser diffraction method. In different techniques, that results may demonstrate differences in value but they will show trend and/or correlate. I am afraid we cannot distribute the video.
Q11	when MB rise up , will there be any UFB found in the water ?	It depends on a type and conditions of fine bubble generation system. For examples, there are high concentrate ultrafine bubbles found in the generation system as introduced in the video. Some fine bubble generation systems generate only microbubbles.

Q12	There are 3 methods introduced by Ohuchi san and 1 method by Kobayashi. Could u recommend which one should be used in a general circumstance?	I do not have a single answer. It depends on the characteristics of bubbles and the objective of evaluation. I recommend that you refer to ISO/TR23015 “Measurement technique matrix for the characterization of fine bubbles”. It shows the merits and limitations of each of the techniques.

Q1	What is the fundamental mechanism for enhancing the germination rate by UFBs?	Very low concentration less than micro Molar of Hydroxyl radical (one of ROS) generated in UFB water will provoke the generation of superoxide anion radical inside seeds which cause to start germination. However, it is still unclear why UFB collapses violently causing the generation of Hydroxyl radical when seeds are submerged.
Q2	What is the definition of high- and low-quality seeds?	The meaning of “Seed quality” is complex as described in the Clause “Seed Quality” in “Seed and Seed Quality” by NC STATE EXTENSION reached through the URL as follows. https://content.ces.ncsu.edu/seed-and-seed-quality# So, I defined in my study as high-quality seeds are the seeds of which final germination ratio is inherently around 100%. In this case, UFB’s promotion effect appears as the increase in germination speed. This can be judged by the relation of T50, UFB<T50, Control as shown in page 19 of the slide file delivered. And low-quality seeds are the seeds whose original germination ratio, in other words, inherent germination ratio, is less than 100%, for example, 70% or so. And a final germination ratio can be increased to a statistically higher germination ratio by applying UFB water as shown in page 4 of the slide file delivered. In this case, UFB’s promotion effect appears clearly as a difference in final germination ratios without comparing T50 values. The definitions above does not concern if seeds are fresh or stored in an inadequate conditions nor too long.

f)	what the size of your ultrafine bubble?	It is between 50 nm to 400 nm depending of the operation of the generator (flow rates, pressure and others).
	In case of lettuce growing, UFB was applied to soil media or liquid solution?	It was applied to the irrigation water.
	With the case of ORP with 735 mV, what is the O3 concentration?	We reached 735 mV of ORP by dissolving oxygen and not ozone. We dissolve 67,2 mg/L of oxygen with our generator (as the ice-water had near 1°C we were able to dissolve that remarkably high number)
i)	How does microbubbles control Temperature in aquaculture?	It becomes cooling down water temperature when liquified oxygen has been gasified into microbubbles.
	Is this technology suitable for vertical farming?	Yes, it is.
	hydroponic?	Yes, it is.
	Regarding KFBIA activities, do you have a plan to start certification of FB products or service?	For now, it has certified size and density of microbubbles.
	Could u explain the role of catalyst in the Microbubble-catalytic ordination?	We recommend microbubble- catalytic ozonation process to treat high strength wastewater that contains recalcitrant organics that are difficult to degrade. Conventional ozonation processes in wastewater treatment have some drawbacks such as high-energy consumption due to poor utilization of gaseous ozone, process selectivity and incomplete oxidation of recalcitrant organics due to unfavorable reaction kinetics. Hence, it becomes more imperative to develop modified ozonation process that could enhance both ozone mass transfer and promote ●OH generation. Therefore, we have adapted combined microbubble- catalytic ozonation technology. Please refer to our recent published work Chemosphere (2021), Volume: 263, page: 127980

j)	What is the fundamental mechanism of keeping higher survival rate of the shrimp using FB technology?	We were shipping live shrimps without water. Hence the beneficial effects of FB during shipment is unlikely. We were looking at could pre-conditioning of animals with FB prior treatment had any positive effect on their survival. The mechanism of action is yet to confirm at this stage.
	Which DO level is used to pre condition those shrimps?	There is no different in DO level in both control and FB water as the FB was generated using atmospheric air.
	Shipping of shrimp is so interesting and practical work. Anyway, may you please give more information on "Waterless". Do it mean that no water was supplied to shrimp when it was placed under a specific condition for a certain time period (24, 36, 48 hrs).	Shrimps were packed in styroform box without water. Wet paper towels were placed in the box to maintain humidity and to keep animals moist.
	I do agree with Dr. Wu, Chinese Taipei that the technical explanation on why FB could help increase survival rate of shrimp would be worth for sharing.	We are looking into it and also trying post-conditioning of animals with FB as well.
k)	Electrical potential for plasma generation would be closely related to the zeta potential of UFBs suspending in water. With such plasma activated water, does particle size and zeta potential distribution of UFBs change?	It is possible, but we have not measured the zeta potential in plasma-activated microbubble, so I cannot give a solid answer right now.
	What is 'RONS' in slide No. 20	It stands for “reactive oxygen/nitrogen species”.
	in slide No. 18, there are 2 exposure times and 2 camera speeds, which one was really used in your analysis.	Both were applied in the analysis. Details can be found in this paper: J. Phys. D: Appl. Phys. 53 (2020) 485201.
l)	Microbubble enhances the ozone mass transfer in the wastewater and catalyst helps to induce more OH radical generation from the transferred ozone.	Your opinion is correct. However, I don’t use microbubble nor ozone in this technique as (i) excessive concentration of OH radical will damage seeds and (ii) ozone is harmful chemical thus ozone doesn’t fit this technique which aims not only the promotion of seed germination but also the chemical free technique realized with UFB.
	which is the ROS safe zone limits in terms of dissolved oxygen?	The concentration of ROS corresponds to UFB number concentration. However, the dissolved oxygen concentration is not determined correctly according to UFB number concentration. This is why ROS safe zone limits cannot be expressed by dissolved oxygen concentration.
	As ROS will affect the DNA, does this technique affect the final product?	As far as UFB leads to ROS concentration within the oxidative window shown in 11th slide delivered, ROS doesn’t damage seeds. In this condition, the final product will not be affected physiologically and the increase in production amount is expected.

No.		
1	: Congrats for your excellent research. Have you conducted the research on the mechanism of MB degradation? Which species are responsible for MB degradation? Thank you.	Un-saturated chemical bond of methylene blue colorizing blue, will decomposed by ozone. Then, FB promotes the oxidization power of ozone.
2	Dr. Yabe, very nice research. I have a questions. Since your research conducted in with comparison between bubble diffuser vs FB in MB oxidation. can you explain the concentration of bubble and concentration of ozone in case of your bubble difuser and FB ?	The UFB concentration is of the order of 10E+8 /mL The measurement of that for diffuser has not been monitored. Ozone concentrations are not clear.
3	How to measure the thickness of DAF bubble bed? Is it very important to evaluate the efficiency of floation? thank you. Thank you for quick answer.	Thank you for your question.Online particle counter can be used to measure the depth of bubble bed.Becasue bubble and bubble bed float particles, the number of particle is decreased at the interface of bubble bed and water, sharply.Therefore, we measure the number of particle according to the depth, there is some range that the number of particle is decreased sharply, then we can know the depth of bubble bed.
4	Dear Dr Yabe, nice presentation. We also develop fine Bubble with AOP system. https://youtu.be/qIvt8ta6t9E. Hope we can collaborate in the future.	AOP advanced oxydation process. Japanese side will welcome, then.
5	May I have QR Code of NITE	From here you can acces NITE's official web site and the You Tube video. NITE's official website: https://www.nite.go.jp/en/gcet/index.html You Tube video: https://www.youtube.com/watch?v=Scu2OdYvJSk&list=PLWxWKUOj3xAJk8ID51IWTFighPmgU0FOI&index=6
6	Dr. Yabe is the application of cleaning salt on surface of iron structureready for commercial use?	It is of commercial one.
7	please type the compamy name	A privaterized company, West Nippon Expressway. They also use FB to clean toilets for more than 100 service areas.

8	The salt removal process using UFB is a mechanical process or radical species play any role in this process?	Small FBs can enter to small gap. It will be Mechanical. Physical properties of crystal are changed. Several mechanism will be working, among which radical mechanism is.
9	what happened to the ultrafine bubbles after the ultrasonic treatment? burst? or dissolved?	Ultrasonication gives both mechanical effects and chemical effects. I don't know the mechanical effects but I can explain chemical effects. The zeta potencial of UFBs around pH7 is around -30mV. Ultrasonication creates NOx and the pH decreases. when pH decreases, the zeta potential of UFBs approches 0mV and UFBs get destabilized. In this way, I guess UFBs are eliminated. The details are described in the paper introduced in my presentation material P37.
10	I am wonder if the contaminants/NBs, NBs/NBs or contaminants/contaminants aggregated, can we still subtract the NBs-eliminated-results from the NBs-existed-results for size measurement?	Depending on the kinds of contaminants, contaminants can aggregate. In that case, volume concentration should be evaluated, not number concentration.
11	Does pure water need to compare with each other as control? During the generation of nanobubbles, may also produce some contamination.	Ideally, I think three types of samples: pure water, water containiing ultrafine bubbles and water after elimination process should be evalutated.