November 27, 1998

Federal Communications Commission
Equipment Approval Services
P.O.Box 358315
Pittsburgh, PA 15251-5315
U.S.A.

Subject : Certification Application for Part 15 Equipment Authorization

Applicant : Toshiba Corporation, Control & Instrumentation Div.
Product : Density Meter
Model No. : LQ300
FCC ID : M8D62378Y06

Dear Sir/Madame:

We are submitting application documents through electronic filing for Certification of FCC Part 15 Equipment Authorization for the above-mentioned product.
This electronic filing application is the first our experience so that we have had many problems. However, we hope the problems will be solved gradually.

We shall appreciate your helpful cooperation to this application and awaiting your approval.

Sincerely,

K.O.
Kyozo Ouchi
Application Service Div.
Product Safety Center
Japan Quality Assurance Organization

FCC ID : M8D62378Y06

# LIST of SUBMITTED DOCUMENTS

1. Name and address of the Applicant :

   Toshiba Corporation, Product Marketing Dept.,
   Control & Instrumentation Div.
   1-1, Shibaura 1-chome, Minato-ku, Tokyo, 105-8001 Japan

2. Name and address of the manufacturer :

   The same as 1

3. FCC ID : M8D62378Y06

4. EXHIBITS

   (1) Exhibit A : FCC ID Label Drawing
   (2) Exhibit B : Operation Manual
   (3) Exhibit C : Equipment Description and brief description of the circuit functions
   (4) Exhibit D : Circuit Diagrams & Block Diagram
   (5) Exhibit E : Report of Measurements
   (6) Exhibit F : Photographs

# Requests for confidentiality

## 1. The portions to be requested for confidentiality

The Circuit diagrams of this equipment are requested for confidentiality .

Circuit diagrams

page to : LQ300 Converter RF Unit(1/13) - (13/13)

page to : LQ300 Converter Main board(1/12) - (12/12)

## 2. Reason for confidentiality

This equipment measures a solid density of the liquid by unique microwave technology. Refer to the attached document ,`Density meter through Application of Microwave Technology`. And it has a lot of know-how. If the data is opened to the public, a lot of know-how also becomes opening to the public and gives the other companies the chance of the imitation easily. Because the circuit diagrams have a lot of know-how, they are requested to be confidential especially .

FCC ID : M8D62378Y06

**TOSHIBA**

# Density meter through Application of Microwave Technology

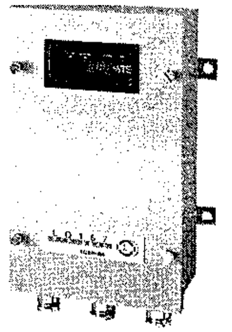
**TOSHIBA CORPORATION**

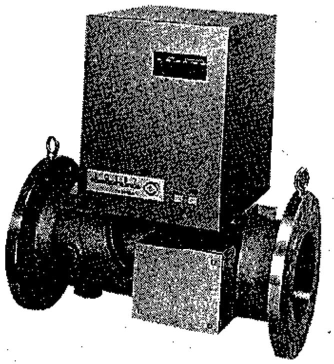
## 1. Preface

Density is an important index for monitoring and control in enhancing the efficiency of various processes and the quality of products, as well as in production management.

Toshiba has developed and (since April, 1993) marketed an entirely new type of instrument for measuring the density of fluids flowing inside pipes through the use of microwaves. It overcomes the influence of fouling and bubbles -- problems which plagued previous densitometric methods -- to achieve highly reliable measurements and outstanding maintenance characteristics.

This paper introduces the metric principle, basic construction and salient characteristics of this density meter using microwave technology, and also introduces characteristic data and points to bear in mind concerning use of this density meter in polluted sludge and pulp applications.





## 2. Metric principle

Microwave propagation speed varies according to the physical properties (dielectric constant, conductivity, magnetic permeability) of the medium. Because the dielectric constant of fluids varies according to their density, it is possible to find the density of a fluid by measuring the microwave propagation speed change.

This method measures the received wave's phase lag -- the change in propagation speed -- after it has passed through the fluid to be measured, and thereby is able to measure the density. If, as in Fig. 1, the phase lag of fresh water (density 0%) is taken as $\theta_1$ and the phase lag of a fluid of a certain density is taken as $\theta_2$, the difference $\Delta\theta$ $(= \theta_2 - \theta_1)$ is in a linear relationship with the density. The density can be found from this relationship. Also, since the phase shift varies depending on the temperature of the measured fluid, the density meter is designed to compensate for the temperature.

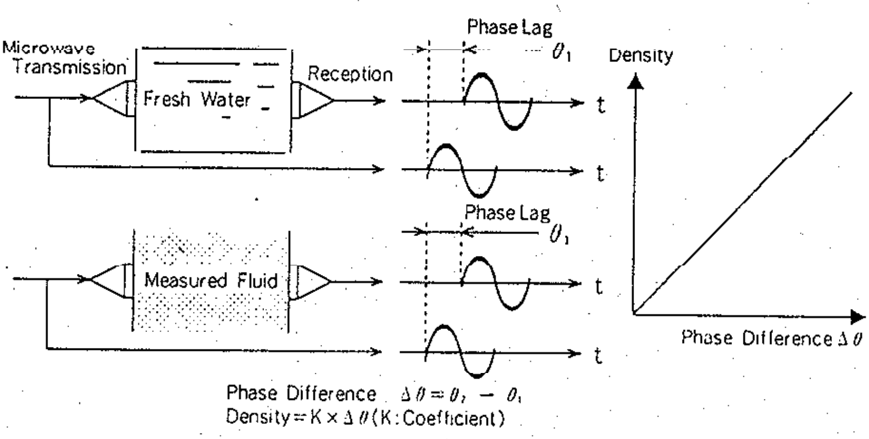



**Fig. 1 Microwave phase difference metric principle**

### 3. Detector construction

Fig. 2 shows the basic construction of the detector applicator section. Note its simplicity: in addition to having no moving parts, it has no projections into the main pipe.

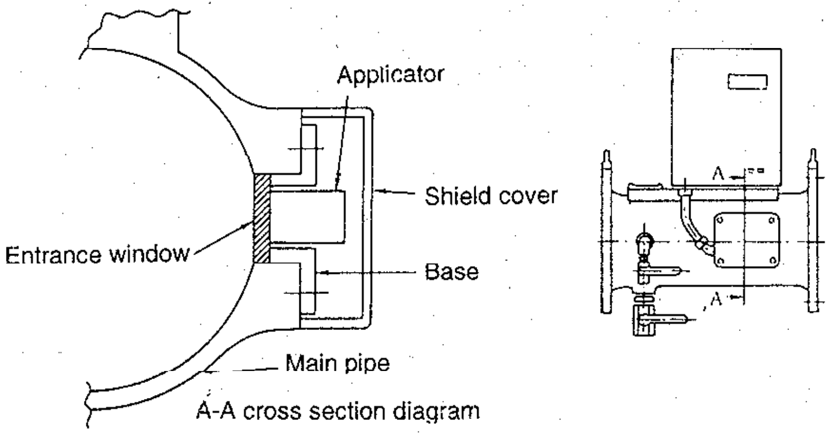



**Fig. 2 Basic construction of the applicator section**

### 4. Main specifications

This density meter's main specifications are as follows.

Pipe diameter: 150mm (standard): 100/200mm(optional)

Measurement range: 0-1% TS ~ 0-10% TS TS:total solids

Repeatability: ±2% FS (however ±4%FS at range of 0-1% TS)

Linearity: ±2% FS (however ±4%FS at range of 0-1% TS)

Resolution: density 0.05%

Measurement cycle: 0.05 seconds (every 5 seconds, the average value of one hundred 0.05-second measurements is output as the measurement value)

Fluid temperature: 0~50°C

Conductivity: 7mS/cm or less (when pipe diameter is 150mm)

### 5. Salient characteristics

Let's examine the salient characteristics of this density meter through comparisons with previously used density meters, such as optical, ultrasonic, and blade/rotating mechanical pulp density meters.

(1) Resistant to influence of fouling/bubbles

Optical and ultrasonic density meters measure density based on the amount of attenuation which occurs on passage through the measured medium. Attenuation can also be caused by scale/fouling of the window (optical method) and by bubbles (ultrasonic method), in which case measurement error results. With severe fouling, optical measurement may not even be possible. The microwave phase difference method, however, is in principle highly resistant to the influence of fouling and bubbles, enabling reliable measurements.

(2) Absence of moving parts and internal projections assures high reliability and ease of maintenance

One approach of the ultrasonic method toward solving the influence of bubbles is to eliminate the bubbles through pressurization. In this method, a sample of the fluid to be measured is taken from the pipe in which it flows, into a cylinder, which is then closed off and pressurized with a piston to force the bubbles to dissolve into the fluid, the density of which is then measured. One problem with this approach is that the piston sealing ring wears out and needs to be replaced at appropriate intervals, which necessitates a partial disassembly and reassembly of the system by a skilled technician. The likelihood of a malfunction is greater due to the presence of moving parts. The same drawbacks also apply to blade/rotating methods, because of their moving parts.

On the other hand, as shown in Fig. 2, this new method uses a simple design with no moving parts and no projections

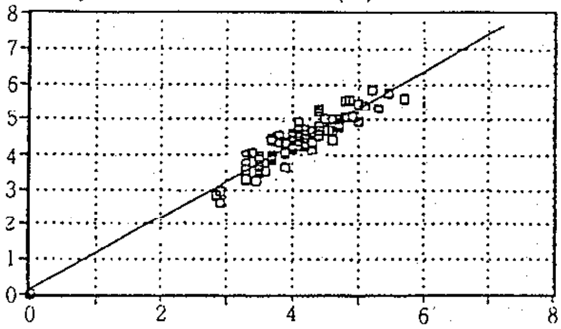



**Fig. 3 Unprocessed (raw) polluted sludge density measurement example**

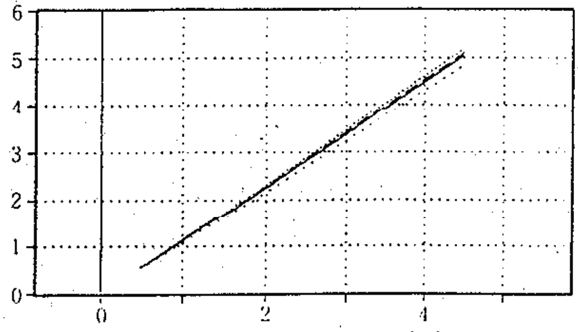



**Fig.5 Comparison of different types of pulp**

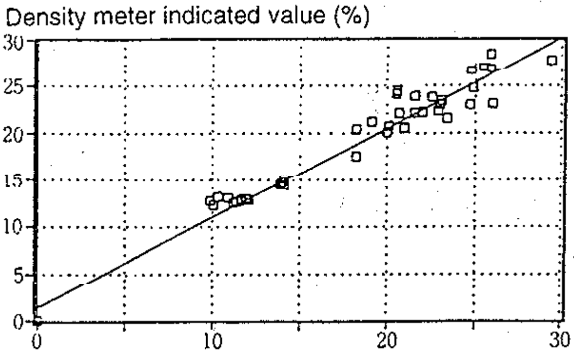



**Fig. 4 High-density polluted sludge density measurement example**

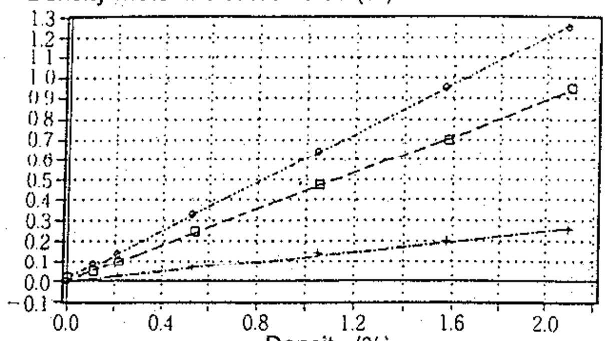



**Fig. 6 Various pulp additive density measurements example**

into the pipe, thus eliminating any possibility of objects hanging or getting stuck and ensuring that highly reliable measurements will be able to be conducted without interruption. Maintenance is also easier because there are no consumable parts to replace.

(3) In-line continuous measurement possible

With ultrasonic units that eliminate bubbles through pressurization, measurement can only be done at intermittently. This new method, however, enables continuous in-line measurement, able to keep close track of density changes in the measured medium.

(4) Measurements unaffected by flow speed

With blade methods, the characteristics are easily affected by flow speed. The same is true for rotating methods, albeit to a lesser degree. With this new method, however, the flow speed is irrelevant. This is further discussed in section 6. (8) below.

## 6. Polluted sludge and pulp density measurement examples

The following actual measurement examples give an enhanced appreciation of this new method's salient characteristics.

(1) Unprocessed (raw) polluted sludge measurement

We attached this new density meter to various polluted sludge lines in a sewage treatment facility and compared the measurements with those obtained through Manual analysis (dry weight method). Close linearity and correlationality were demonstrated with various types of polluted sludge. Fig. 3 shows an example of unprocessed (raw) polluted sludge density measurement.

(2) High-density polluted sludge density measurement example

Fig. 4 shows an example of high-density polluted sludge density measurement, such as when the polluted sludge has been dehydrated. At present, the maximum density measurement range is 0~10%, but it has been confirmed that use with

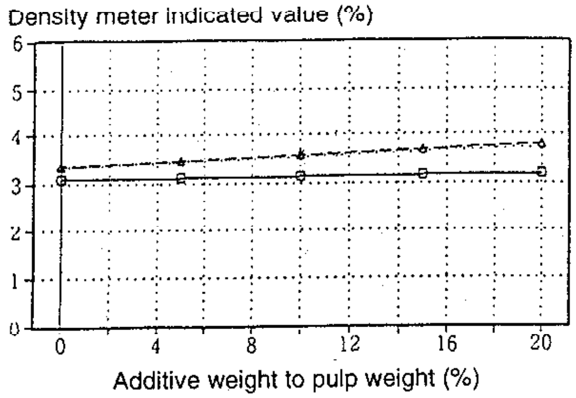



**Fig.7 Influence of various additives in pulp density measurement**

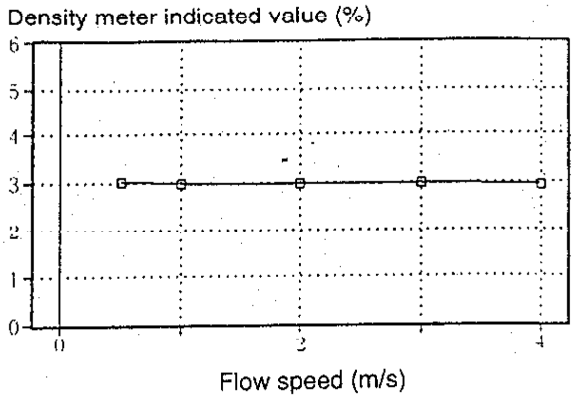



**Fig. 8 Indicated value characteristics versus flow speed**

high-density measurements of 10~30% is possible.

(3) Long-term measurement in sewage treatment facilities

We gathered data through the course of one year at a sewage treatment facility. A wide variety of objects flow through the facility on occasion, and during summer in particular there is a tendency for lots of bubbles to form. Even so, excellent measurements were obtained at all times.

(4) Pulp (LBKP) density measurement

We used this new density meter to measure pulp (LBKP) of densities ranging from 0 to 4.5% and compared the values obtained with bone dry density values (dry weight analysis). The results are shown in Fig. 5. Overall close linearity and correlationality were confirmed. Excellent characteristics were also obtained at low density levels of 0~0.5%.

Note: Tests (4) ~ (8) were done to confirm the linearity and sensitivity with various measurement media; the span has not been adjusted.

(5) Measurements of various types of pulp

Fig. 6 shows graphs confirming the linear relationship between similar measurement values and bone dry weight density values with LBKP, NBKP, TMP and L-broke. The characteristics were almost exactly the same for each type of pulp, indicating that reliable pulp measurements can be obtained regardless of type.

(6) Measurements of various types of pulp additives

We used fresh water to dilute calcium carbonate, titanium oxide and talc (all commonly used as additives in pulp) and flowed various concentrations of these compounds through the pipe to investigate the relationship between this new density meter's measurement values and the bone dry density values (the relative weights of the additives in the fluid overall). The results are shown in Fig.5.

The results confirm that excellent linearity and correlationality are obtained with each of these inorganic compounds. Depending on their differing physical properties, the sensitivity (density meter indicated value versus bone dry density) is lower than with pulp, and the sensitivity varies according to additive. However, it is clear that with calibration for each additive, the density meter is highly effective.

(7) The influence of additives in pulp density measurement

Fig. 7 shows the change in indicated values with calcium carbonate, titanium oxide and talc added to pulp (NBKP) of 3% density. Additive density is the weight density versus pulp weight. It is clear that the influence is small even when the additive density changes.

(8) Indicated value characteristics versus flow speed

For pulp (LBKP) of about 3% density, we varied the flow speed within the pipe and measured how the indicated values change. The results are shown in Fig. 8. As mentioned in section 5. (4) above, the irrelevance of flow speed is clear from these test results.

## 7. Points to keep in mind in application

The following points should be kept in mind in applications for this new density meter.

(1) Dielectric constant conditions

Because this method measures density according to changes in dielectric constant, it is necessary that there be a difference in the relative dielectric constant of the solvent medium (e.g., water) and the fluid with dissolved polluted sludge/pulp/ other material that you intend to measure.

(2) Conductivity upper limit

If the conductivity of the fluid is too high, the transmitted microwave will become too greatly attenuated for normal signal processing to be possible, so that measurement will not be possible. In the case of a pipe of 150mm diameter, the conductivity needs to be 7mS/cm or less. This means that highly conductive fluids, such as those based on alkaline or acidic compounds, may not be appropriate for measurement with this density meter.

(3) Influence of conductivity changes

Microwave propagation speeds also vary according to conductivity. Accordingly, on lines where conductivity changes, measurement deviation may occur. There is a conductivity compensation function which allows connection of a conductivity meter signal to the density meter. We generally recommend that measurement be done under conditions free from changes in conductivity.

(4) Influence of magnetic permeability

Microwave propagation speeds also vary according to magnetic permeability. Accordingly, measurement deviation can occur on lines where magnetic permeability changes. Care must be exercised when measuring fluids containing significant amounts of magnetic materials such as iron filings.

(5) Compound fluids

Overall density measurements are possible when the composition of compound fluids comprised by two or more components with different physical properties (sewage polluted sludge is an example) provided the component structural ratio remains constant. It is not possible to measure the density of each component separately.

(6) Flow conditions

This density meter is spliced into the piping in order to measure the density of fluids flowing within. Thus the medium to be measured must be capable of flowing smoothly through the piping. Furthermore, for proper measurement the density meter needs to be entirely filled by the medium, so please bear this in mind when planning the piping layout and density meter installation. Also, if the medium should stop flowing, particulate matter suspended within may settle out. If this happens, the resulting irregular distribution of particulates may prevent accurate measurements. It is important that such media be properly agitated to ensure sufficiently even distribution of particulates therein.

(7) Others

This applies to all sensors, but it is important to take note of the materials which will contact the media to be measured, and to operate within the specified temperature and pressure ranges and other such constraints.