## Q&A

**21Q2: Could you tell me quality analysis method of solid PAC?**
**I would like to know checking method of quality of PAC. We don't have experience for it. And we are planning to use PAC instead of Aluminum Sulfate. (Mr. H, Mr. T, Ms. S, Cambodia)**

**A:** Waterworks bureaus in Japan use liquid PAC. Quality of liquid PAC and the check method are regulated by "Japan Waterworks Association Standard –JWWA K 154 Polyaluminum chloride". This Japanese standard cannot be applied to solid PAC. Mr. Sasayama modified it for analytical method of solid PAC. Mr. Kudo checked it. Mr. Sasayama's analytical method is written in Annex-1. And also Quality of PAC (liquid) regulated by JWWA K154 is written in Annex-2

➢ *We considered how you check solid PAC quality firstly, as following.*

**1. What is the quality check of PAC?**

1) Verify the sufficient coagulation result
2) Verify that the content (by percentage) of aluminum oxide written on the purchased PAC is constant anytime.
3) Verify that harmful substances are below acceptable value of drinking water quality standard.
4) When PAC is dissolved in water, verify there are no impurities which cause the clogging of the pipe.

Through the periodic check above 1)~4), judge whether the purchased PAC has stable quality or whether some changes happened in the manufacturing process.

**2. Check method**

***1) Verify the sufficient coagulation result***

Dissolve a fixed amount of PAC into water and make fixed concentration of PAC solution. Change the dosing rate of the PAC solution and verify whether to be able to find most effective dosing rate (see turbidity of treated water) by jar-test.

∗ **At first, how much should PAC concentration be as fixed concentration ?**

Since it is supposed that a fixed concentration of PAC is written in standard directions for use to solid PAC which purchased, just follow it. If the standard direction is not written, basically, take 2~10g of solid PAC and dilute it by water as check sample. Solid PAC is hard to dissolve in water, therefore concentration of aluminum oxide of the

sample solution will be about 1~2%. Comparing with Japanese case, concentration of aluminum oxide will be 1/10 ~ 1/5 times. Because the result of coagulation effect depends on amount of dosing of aluminum oxide, the dosing rate of PAC solution will be 5 to 10 times higher than Japanese case. It may be easy for small water treatment plant to control dosing of PAC.

**＊ PAC has excellent characteristic which the range of optimum dosing rate is wider than aluminum sulfate.**

It means that even if turbidity of raw water changes widely, it is easy to deal with it. It will become easy to manage turbidity of treated water at the WTP. It is important to do Jar-test periodically, to verify optimum dosing rate and to check quality of PAC products.

***2) Verify that the content (by percentage) of aluminum oxide written on the purchased PAC is constant anytime.***

＊There are several verification methods. Here, three of them are explained.

(1) Carry out the jar-test by using same concentration's aluminum oxide solution, same dosing rate and same sample water. Then verify to result the same coagulation effect. If the result is not same, content of aluminum oxide in the purchased solid PAC has variation. It means the quality of PAC has problem.

(2) Make a solution of fixed concentration of aluminum oxide. Then analyze amount of aluminum oxide. There are several analytical methods. Titration method which was modified based on JWWA K154 by Mr. Sasayama in Annex-1. In this case, it is assumed to use high quality reagents (reagent of JIS (Japanese Industrial Standards are used in Japan).

(3) As easy analysis, check aluminum concentration by Hach's spectrophotometer. First, ample is digested with acid as same as titration method and adjusted pH to recommended range in the Hach's instruction. Aluminum oxide content is calculated with the result of aluminum concentration. Then verify whether same amount of aluminum oxide contains anytime.

***3) Verify that harmful substances** are below acceptable value of drinking water quality standard.***

Even if the maximum possible dosing rate is used, treated water has to meet the drinking water quality standards.

***4) When PAC is dissolved in water, verify there are no impurities which cause the clogging of the pipe.***

Check the appearance and insoluble matters

***5) Judge whether products are stable or some changes happened in the manufacturing process.***

Big difference compared to normal pH is considered something happened in materials or manufacturing process.

** As harmful substances, followings are written in Japanese Standard.
Cadmium, Mercury, Selenium, Zinc, Arsenic,
Hexavalent chromium

## Annex-1

*Following analytical method is modified by Mr. Sasayama for solid PAC and confirmed by Mr. Kudo.

**Analytical Method: Aluminum Oxide in Poly Aluminum Chloride**

**1. Principle**

Polymerized aluminum is decomposed to aluminum ion with acid. Excess of disodium ethylene tetraacetate is added and aluminum chelate is produced completely. Then surplus of ethylene tetraacetate is obtained by titration of zinc solution with xylenol orange as the indicator.

**2. Reagent**

All reagents should be analytical grade.

(1) Nitric acid (1+12)
5mL of nitric acid (>62%) is diluted with 60mL of distilled water.

(2) 0.05mol/L EDTA solution
18.61g of disodium ethylenediamine tetraacetate dihydrate is dissolved in 1000mL of distilled water.

(3) Sodium acetate buffer solution
272g of sodium acetate trihydrate is dissolved in distilled water and its volume is adjusted to 1000mL.

(4) Xylenol orange solution (1g/L)
0.1g of xylenol orange is dissolved in distilled water and its volume is adjusted to 100mL.

(5) Standard solution of aluminum (1mg Al/mL)

1.000g of aluminum (>99.99%) is put into 100mL glass beaker. Small portion of nitric acid (1+1) is added. Then beaker is covered with a watch glass soon. The beaker is heated to react aluminum with acid completely. After cooled the beaker, the solution is moved into 1000mL volumetric flask and diluted to 1000mL with nitric acid (1+30).

(6) 0.02mol/L zinc solution

1.308g of zinc powder is put into 100mL glass beaker. 6 to 7mL of hydrochloric acid and small portion of distilled water are added. The beaker is heated to react zinc with acid completely. Then the beaker is heated more on water bath to evaporate water of the solution. After the solution nearly become solid, it is dissolved with distilled water. Then it is put into 1000mL volumetric flask and diluted to 1000mL with distilled water. 20mL of 0.05mol/L EDTA solution is taken in 200mL glass beaker. 2mL of nitric acid (1+12) is added Then steps 3. (3) to (5) is operated. Titrated volume of zinc solution is a1. 20mL of aluminum standard solution (1mg Al/mL) and 20mL of 0.05mol/L EDTA solution is taken in another 200mL glass beaker. 2mL of nitric acid (1+12) is added. Then the beaker is covered with a watch glass and boiled for 1 minute. The beaker is cooled down to room temperature and steps 3. (3) to (5) is operated. When titrated volume of zinc solution is a2, aluminum amount corresponding to 1mL of 0.02mol/L zinc solution is obtained with the following equation.

$$f_1 = \frac{0.001 \times 20}{a_1 - a_2}$$

where,

$f_1$: aluminum amount corresponding to 1mL of 0.02mol/L zinc solution

**3. Analytical procedure**

(1) About 3g of solid poly aluminum chloride is weighed with the digit of mg. It is dissolved with distilled water. The solution is put into 500mL volumetric flask and diluted to 500mL with distilled water.

(2) 20mL of sample solution is put into 200mL Erlenmeyer flask. 2mL of nitric acid (1+12) is added to make pH 1 to 2. The beaker is covered with a watch glass and heated. The solution is boiled for 1

minute then cooled. 20mL of 0.05mol/L EDTA solution is added.

(3) Sodium acetate buffer solution is added till pH of the solution, measured with thymol blue pH indicator paper, reach to 3. Then the solution is boiled for 2 minutes.

(4) After the solution is cooled, about 10mL of sodium acetate buffer solution is added to change pH 5 to 6. 2 to 5 drops of xylenol orange solution is added.
(5) The solution is titrated with 0.02mol/L zinc solution until the color is turned to light red.
(6) 20mL of 0.05mol/L EDTA solution is put into 200mL Erlenmeyer flask. 20mL of distilled water and 2mL of nitric acid (1+12) are added. Then steps (3) to (5) is operated.

**4. Calculation**

Aluminum oxide (%) in the sample is obtained with the following equation.

$$A = \frac{1.8895 \times (b_2 - b_1) \times f_1}{S \times \frac{20}{500}} \times 100$$

where,

A (%): aluminum oxide content in the sample

1.8895: coefficient of aluminum oxide corresponding to aluminum

$f_1$ (g): amount of aluminum corresponding to 1mL of 0.02mol/L zinc solution

$b_1$ (mL): titrated volume of 0.02mol/L zinc solution for the sample solution

$b_2$ (mL): titrated volume of 0.02mol/L zinc solution in the step **3**. (6)

$S$ (g): weight of sample

## Annex-2

*Reference*

**Table 1 Quality of PAC　JWWA K 154**

| | |
|---|---|
| Type | Liquid type* |
| Appearance | Transparent or yellow tinted pale brown liquid |
| Specific gravity (20℃) | 1.19 or more |
| Aluminum oxide (AL2O3) (wt%) | 10-11 |
| pH (10g/L solution) | 3.5-5.0 |
| Sulfate ion (So42-) (wt%) | 3.5 or less |
| Basicity (wt%) | 45-65 |

This is a Japanese standard. The standards are intended for the products manufactured according to JIS (Japanese Industrial Standards.)

Since the products obtained by each country differ, we cannot say whether it is applicable as it is.

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