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Remaining Life Assessment of Kotabaru 2x7 MW Coal Fired Power Plant Circulating Water A252 Gr 2 Intake Pipe by Inspection Method

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ABSTRACT: Kotabaru power plant is a power plant that was built in 2010 and currently the construction work is pending. The construction work stopped in 2014 and based on Kotabaru power plant construction final quantity report, Kotabaru construction work progress is 79,61% up to now. Kotabaru power plant uses open cooling system and takes seawater as cooling water resources. The seawater distribute through intake pipeline which use A252 grade 2 material 600 mm and 800 mm diameter pipeline with 3PL coating and rubber lining inside the pipe. The pipeline distribute the water in 3.184.739 kg/hr flow rate and 5 kg/cm^2 G pressure. These pipeline material was on site in 2013 and it was not constructed yet. In 2022 Kotabaru power plant is planned to continue the construction work progress. It was about 9 years of pipeline material on Kotabaru power plant site and these pipeline is exposed to the environment such as sunlight, temperature, oxygen, water, and contaminants and cause a primer failure, especially ultraviolet light (UV) from the sunlight is the main damaging factor. Ultraviolet light from sunlight is high enough to break the coating of pipeline. Inspection and assess the pipeline can help the management to figure out pipeline actual condition. More effective inspections can reduce the risk level by reducing the frequency of future failures, through corrective and preventive action. In general, the purpose of this method is classify all risk level equipment, calculate the risk value of all equipment and it can help to make a decision to the next construction period. The service lifetime of pipeline prediction can be determined by actual pipe condition by use corrosion test and actual thickness dimension of the pipeline. This method will inform the life time prediction of the pipeline that should be meet the 15 years life time required and also inform the risk matrix value of all pipeline equipment on the site.

KEYWORDS: carbon steel pipe, corrosion rate, remining life pipe.

I. INTRODUCTION

Coal fired power plant is one of the biggest resource electricity power in Indonesia, and there are some coal fired power plant in small capacity that in construction progress and has a postpone status project. Kotabaru is one of small city or district in the south borneo or Pulau Laut island has a small coal fired power plant capacity that is a under constructed. This power plant is postpone status because the financial problem. The progress of power plant about 79% which there are several electrical and mechanical equipment installed on site. The power plant design is used open cooling cycle system.

The most equipment installed on the site is mechanical equipment that is partially installed and not installed. Some of the mechanical equipment that has been installed includes Boilers, Auxiliary Boilers, and some equipment that is already on site, namely turbine equipment, auxiliary turbines, auxiliary boiler equipment, several pumps, WTP systems, and mobile equipment. Civil works that have been completed include the Man Power Building, Boiler Foundation and structure, Chimney, WTP Building, Tank Foundation, Coal Storage, Jetty, 20 kV Building, Laboratory Building, Workshop, Warehouse, and some intake water system buildings, some open cooling system building. Some of the electrical equipment and instruments that are already on site are ESP panels, DCS, and some DC motors, All turbine and auxiliary instruments already on site. One of mechanical system on site is, intake piping system. There are intake pipes already on site, and it is not yet installed. There are about 300m pipe total length with elbow and reducer.

The intake pipe material is A252 grade 2 that coated with 3PL materials. The condition of the pipe is different condition, some of the condition is rusted, dan the coat is damage. To continue the construction, the company should asses the materials, one of them is intake pipe materials. Is the pipe condition should be repair, or replace. And is that the pipe still meet the requirement of pipe design. And also the company should know about the remaining life of the pipe.

II. PIPELINE OF CIRCULATING WATER

The pipeline of the Kotabaru Coal Fired Power Plant Circulating Water is still unconstructed. Furthermore, it materials does not in a good handling and expose to the weather which are the sunny and rainy. The condition of all the pipe, reducer, spool are separated in the yard, and the specification of pipe is described bellow :

No	Description	Information
1	Diameter Pipe	500 mm, 600 mm, 800 mm
2	Length Pipe	6 m, 12 m, 48 m
3	Number of pipe	48
4	Number of elbow	16
5	Number of Reducer	13
6	Number of Spool	4

Those pipes, elbows, reducers, and spools will be constructed into pipeline system that distribute water for steam cooling system. The pipe length is about 798.86 meter length pipeline. The pipe line design is shown in Figure 1 below, and the condition of current pipes is shown in Figure 2 below. The pipes and another fitting accessories are steel pipes that coated by epoxy in outer pipe and these are coated by rubber lining inside. The design pipes, spools, reducers, and elbows are shown in the figure 3 below, the pipe uses steel pipe design A252 gr 2 material coated with epoxy outside, and rubber lining inside.

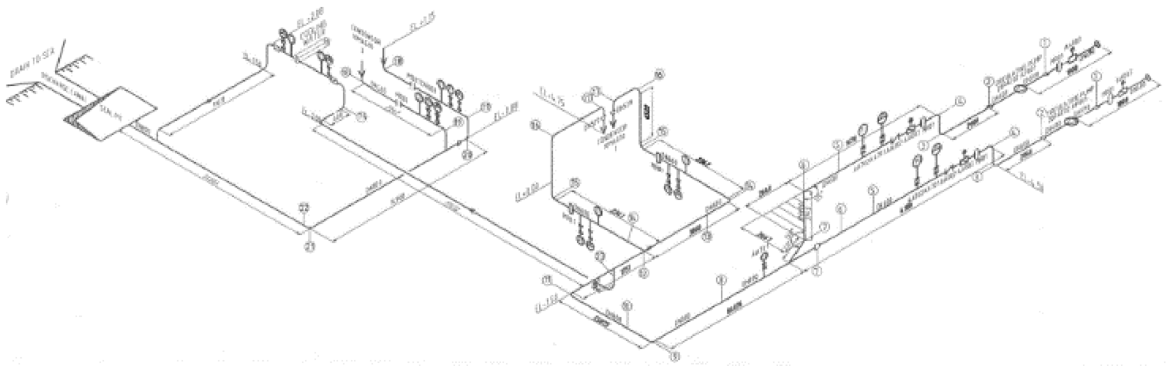

Figure 1

Figure 2

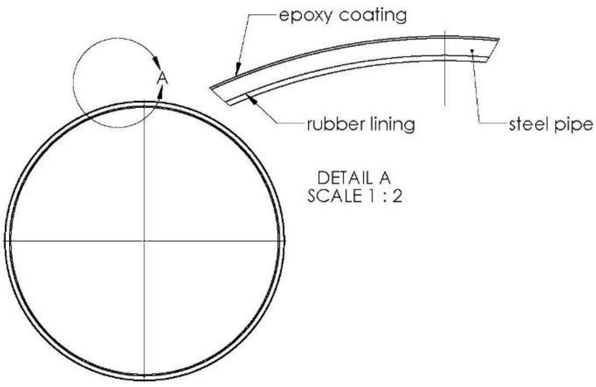

Figure 3

III. ASSESSMENT METHOD

A. Steps of Assessment

This assessment is aim to getting life time prediction of the pipeline. The pipeline is one of essential system on coal fired power plants. The process of assessment is described in Figure

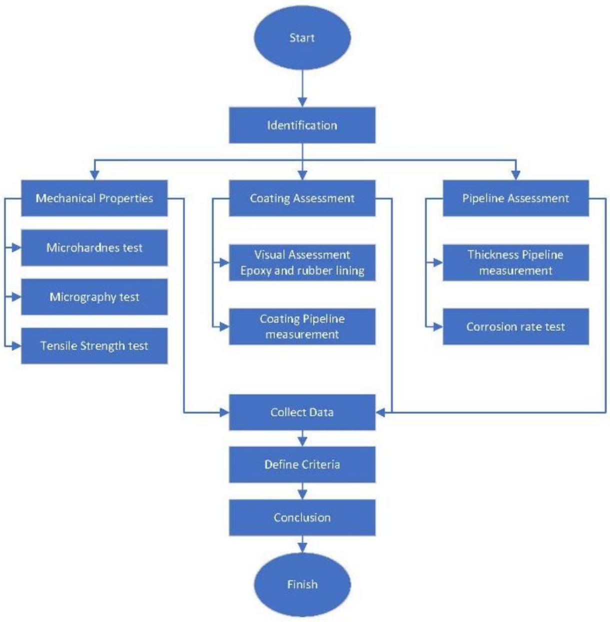

Figure 4

The process is divided into 3 parts that shown in Figure 4, the first one is determining about material properties and the type of steel pipe. To confirm about material properties, can be determined by microhardness test, micrography test, and tensile strength test. Assessment work is carried out to determine the condition of the outer pipeline and the inner pipeline. It is because the outer pipeline is coated by epoxy and the inner pipeline is coated by rubber lining.

Part 1 the goal assessment is to determine and confirm about material properties of steel pipe material. It will be defined by the result of some tests, they are microhardness test, micrography test, and tensile strength test. And Part 2 the goal assessment is to determine the coating condition by measuring the thickness and visual inspection. And Part 3 we measure about the thickness of pipeline and calculate the lifetime of pipeline.

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B. Microhardness Test, Micrography Test, and Tensile Strength Test

Microhardness test is done by *Rockwell Hardness Test* according to ASTM E10 standard. And then micrography test to define the microstructure steel characteristic and the magnification about 50x, 100x, 200x, 500x. Another test is tensile strength test to determine the strength of material it self by using Universal Tensile Machine and ASTM E8 Standard. The tensile strength test can be defined the yield strength and ultimate tensile strength. The graphic of tensile test result is shown below on Figure 5.

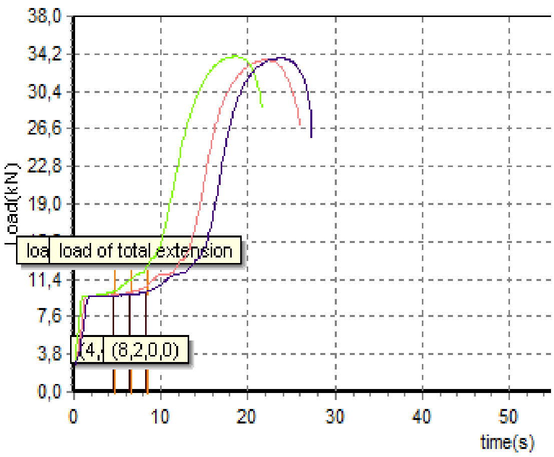

Figure 5

C. Visual Inspection and Coating Thickness Measurement

Visual inspection is method to determine material condition physically, the pipeline is inspected by visual either the inside as rubber lining and outer pipeline as epoxy. The coating thickness can be measured by Non Ferrous Metal Thickness Gauge. Only outer coating that is measured by the thickness gauge, and the inside pipe is not measured caused the difficulties of measurement area.

Coating thickness test is carried out by the coating tester shown in figure below. The probe is pointed to surface pipe, and the actual thickness will be shown on the display.

Figure 6

D. Life Time of Pipeline

Calculation the pipeline life time is determine by the actual thickness of steel pipe and the corrosion rate that carried out by testing on the laboratory. The corrosion rate testing is carried out by ASTM G102 standard. To determine the remining life of pipe, the thickness calculation should be defined by this formula below :

$$T_{rc} = \frac{P.R}{S.E - 0.6P} + C$$

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According to ASME VIII div.1 UG-16 (b) (4) the minimum thickness for pipeline is :

$$T_{min} = 2.5mm + C = 2.5 + 3 = 5.5\ mm$$

Thus the remining life of pipe can be determined by this equiation below :

$$R_{life} = \frac{T_{actual} - T_{min}}{Corrosion\ Rate}$$

IV. TESTING AND ANALYSIS

E. Microhardness Test, Micrography Test, and Tensile Strength Test Result

From the Rockwell A test result, the hardness of the pipeline is described below :

No	Sample 1 (HRA)	Sample 2 (HRA)	Sample 3 (HRA)
1	42.5	46.0	45.5
2	44.0	45.5	46.5
3	44.5	45.5	43.0
4	44.0	43.5	44.0
5	46.5	47.5	44.0
AVG	44,83		

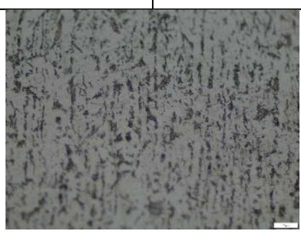
The sample of hardness test is taken form 3 part, and that is for determining the similarity of material characteristic. The hardness test informs that the result is about 42.5 HRA to 47.5 HRA. And the average result is about 44,83 that is relatively no changed by the exposure of weather. And furthermore evidence to confirm about the weather exposure impact is the micrographic structure of the materials. The microstructure of the materials are shown In the figure below :

50x mag. Sample 1

100x mag. Sample 1

200x mag. Sample 2

200x mag. Sample 1



500x mag. Sample 2

Figure 7

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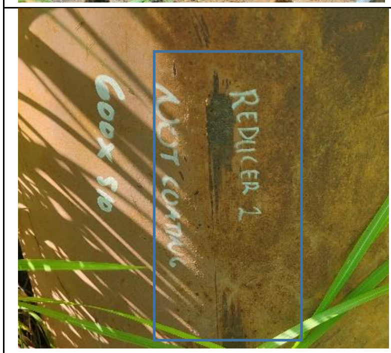
F. Visual Inspection and Coating Thickness Measurement result

From visual inspection, there are some types of coating defects inner and outer pipeline. The typical of coating defects are described below:

Photo	Information
 	Those defects are some types, such as cracking cause the decreasing flexibility of coating and increase the brittle of its characteristic. Also there are some rust staining, and undercutting caused of corroded substrate.
	Abrasive coat, this defect is removal of a portion of the surface. It caused by the surface contact with another object. This defect is found in some pipes and reducer. It can be exist caused by the handling material.
	Bloom (Blush), this coating happened by the film exposed to temperature and weather. It happen in some high humidity area, for example under a tree, or in an area that is flooded with rainwater.

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	Rust Staining, this defect caused by the exposure of ferrous oxide to the steel. It is also common defects that happen in the pipeline surface.
	Cracking of rubber line, the rubber exposes the weather, temperature and water of rain. The flexibility decreasing and make the rubber becomes brittle.
	Pelling defects cause of the adhesive of rubber and steel decreasing and also expose to the weather make the rubber becomes brittle.

The thickness of epoxy coating is shown in the table below :

Pipe numb	Diameter (mm)	Coating Thickness (µm)		
		Min	Max	Avg
1	600	60.0	78.4	69.20
2	600	56.0	86.6	71.30
3	600	158.0	191.0	174.50
4	600	114.0	171.0	142.50
5	600	230	271.0	250.50
6	600	95.3	155	125.15
7	600	229	269	249.00
8	600	47.4	64.6	56.00
9	600	176	385	280.50
10	600	34.3	48.4	41.35
11	600	61.7	83.7	72.70
12	800	355	371	363.00

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It shows that the coating of epoxy is exposed by the weather, and there is decreasing of epoxy thickness. From the design approval, the coating thickness is about 250 µm or above. It will be more attention to get best performance in steel pipe protection.

G. Life Time of Pipeline Calculation

The method to measure the thickness of the 48 pipes is measuring the steel pipe thickness use Ultrasonic Thickness Gauge. In every section pipe, there are 4 points to measure, they are 0˚, 90˚, 180˚, 270˚. And in one pipe is divided into 4 section, they are 50cm each end pipe, and 2 point in the middle pipe. The result of steel pipe thickness is shown on the table below :

Pipe numb	Thickness of steel pipe (mm)				
	0˚	90˚	180˚	270˚	Avg
1	7.92	7.91	7.92	7.68	7.86
2	7.89	7.86	7.86	7.83	7.86
3	8.16	8.24	8.24	8.28	8.23
4	7.75	7.82	7.80	7.74	7.78
5	7.61	7.86	7.80	7.81	7.77
6	7.54	7.86	7.80	7.58	7.70
7	6.75	6.89	6.84	6.80	6.82
8	7.80	7.87	6.84	7.87	7.60
9	7.80	7.80	7.74	7.74	7.77
10	7.00	6.84	6.88	6.89	6.90
11	7.90	7.85	7.85	7.91	7.88
12	6.67	6.72	6.72	6.69	6.70
13	7.86	7.87	7.97	8.01	7.93
14	8.04	7.97	8.01	8.01	8.01
15	7.88	7.87	7.80	7.80	7.84
16	7.96	7.95	7.74	7.87	7.88
17	7.87	7.87	7.74	7.87	7.84
18	7.65	7.74	7.65	7.84	7.72
19	8.87	8.87	8.87	8.93	8.89
20	7.98	8.01	7.98	7.98	7.99
21	7.87	7.75	7.98	7.86	7.87
22	7.70	7.90	8.03	7.91	7.89
23	7.90	7.86	7.86	7.84	7.87
24	7.75	7.74	7.86	7.79	7.79
25	7.80	7.79	7.86	7.84	7.82
26	7.82	7.96	7.99	7.91	7.92
27	7.82	7.93	7.93	7.87	7.89
28	7.10	7.23	7.30	7.17	7.20
29	7.50	7.63	7.93	7.59	7.66
30	7.34	7.30	6.95	7.31	7.23
31	9.03	9.08	8.03	9.08	8.81
32	7.23	7.11	7.40	6.80	7.14
33	8.60	8.75	8.72	8.75	8.71
34	8.72	8.75	8.60	8.72	8.70
35	9.34	9.31	9.31	9.34	9.33

36	7.24	7.25	6.97	6.97	7.11
37	8.94	9.01	9.01	9.15	9.03
38	7.84	7.79	7.79	7.79	7.80
39	7.84	8.00	8.00	7.92	7.94
40	7.84	7.77	7.77	7.90	7.82
41	7.66	7.69	7.77	7.78	7.73
42	7.85	8.09	8.09	7.87	7.98
43	7.90	7.98	7.98	7.87	7.93
44	7.69	7.75	7.75	7.84	7.76
45	7.69	7.99	7.99	7.95	7.91
46	7.82	7.84	7.84	7.87	7.84
47	7.80	7.81	7.81	7.86	7.82
48	7.69	7.75	7.75	7.84	7.76

From those data we can calculate the remaining life through corrosion rate test result. Corrosion rate is carried out by sea water media as an actual fluid that expose to the pipeline. The contain of Kotabaru sea water is informed below :

No	Parameter	Result
1	Salinity	29,500 mg/L
2	Cl	16,329.02 mg/L
3	pH	7.01

The high salinity and chloride is informing that the Kotabaru sea water can be easy to make the steel corroded. From the corrosion rate test, the result is shown in the table below :

No	Parameter	Result
1	Potential	566.78 mV
2	Current	13.368 µA/cm^2
3	Corrosion rate	0.15525 mmpy

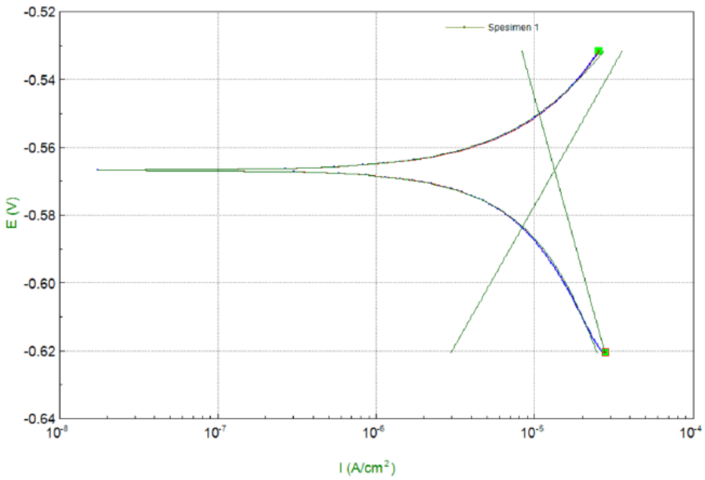

Figure 8. the result of corrosion rate.

The microstructure of the steel pipe before and after testing is shown in the Figure 9 below :

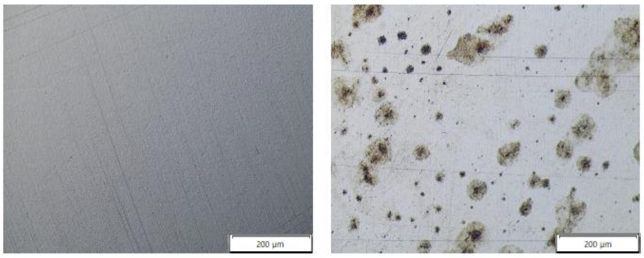

Figure 9. The microstructure magnification 50x, before corrosion rate testing on the left, and after corrosion rate testing on the right picture.

From the measurement results, and calculation the remining life is shown in the table below :

Pipe numb	Thickness of steel pipe (mm)	years	Result
	Avg		
1	7,86	15,19	Accepted
2	7,86	15,18	Accepted
3	8,23	17,59	Accepted
4	7,78	14,67	rejected
5	7,77	14,62	rejected
6	7,70	14,14	rejected
7	6,82	8,50	rejected
8	7,60	13,49	rejected
9	7,77	14,62	rejected
10	6,90	9,03	rejected
11	7,88	15,31	Accepted
12	6,70	7,73	rejected
13	7,93	15,64	Accepted
14	8,01	16,15	Accepted
15	7,84	15,06	Accepted
16	7,88	15,33	Accepted
17	7,84	15,06	Accepted
18	7,72	14,30	rejected
19	8,89	21,80	Accepted
20	7,99	16,02	Accepted
21	7,87	15,23	Accepted
22	7,89	15,36	Accepted
23	7,87	15,23	Accepted
24	7,79	14,72	rejected
25	7,82	14,96	rejected

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26	7,92	15,59	Accepted
27	7,89	15,38	Accepted
28	7,20	10,95	rejected
29	7,66	13,93	rejected
30	7,23	11,11	rejected
31	8,81	21,29	Accepted
32	7,14	10,53	rejected
33	8,71	20,64	Accepted
34	8,70	20,60	Accepted
35	9,33	24,64	Accepted
36	7,11	10,35	rejected
37	9,03	22,72	Accepted
38	7,80	14,83	rejected
39	7,94	15,72	Accepted
40	7,82	14,94	rejected
41	7,73	14,33	rejected
42	7,98	15,94	Accepted
43	7,93	15,67	Accepted
44	7,76	14,54	rejected
45	7,91	15,49	Accepted
46	7,84	15,09	Accepted
47	7,82	14,94	rejected
48	7,76	14,54	rejected

From those can be determined whether acceptable or not acceptable. The requirement of durability is about 15 years operations. Cause the coal fired power plant is going to operate about 15 years minimum.
In some variation size pipe, the data below shows life remaining of sample pipe. The pipe as object to be calculated is pipe number 13 as shown graphic below.

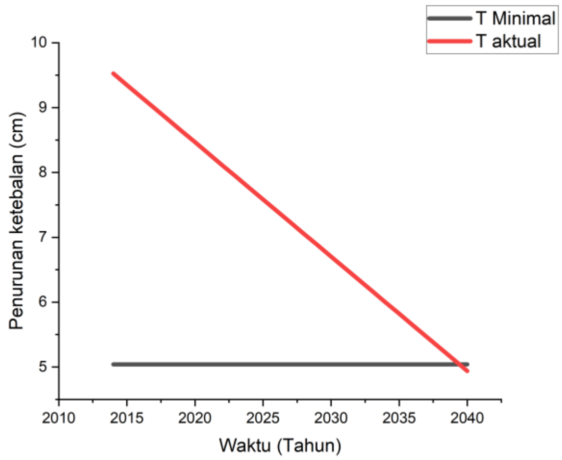

Figure 9. ***remaining lifetime*** **pipe number 13**

For the pipe number 13 thickness would be 4,9 mm in 2040 and still 16 years left for operation.

V. CONCLUSION

Based on this study above, the conclusion of assessment of Circulating Water Pipeline of Kotabaru Coal Fired Power Plants is :

1. Based on the material physical testing, the steel pipe is A252 grade 2 or include the low carbon steel material.
2. Expose from the weather about 9 years is not change the microstructure of the steel pipe material.
3. The common coating defect of the rubber line is peel and cracking.
4. The exposure of weather also cause the coating defect, such as cracking, bloom, and rust staining.
5. The calculation of steel pipe remaining life, there are 22 pipe should be replace cause the remaining life under 15 years and there are 26 accepted pipe cause the remaining life more than 15 years.
6. Pipe number 13 has 16 years remaining life based on the actual thickness.
7. Should be found the method to repair the rubber defect and epoxy defect.

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