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Quality Control Factors of CIPP Construction Management for Water Main Rehabilitation

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- INTRODUCTION
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INTRODUCTION

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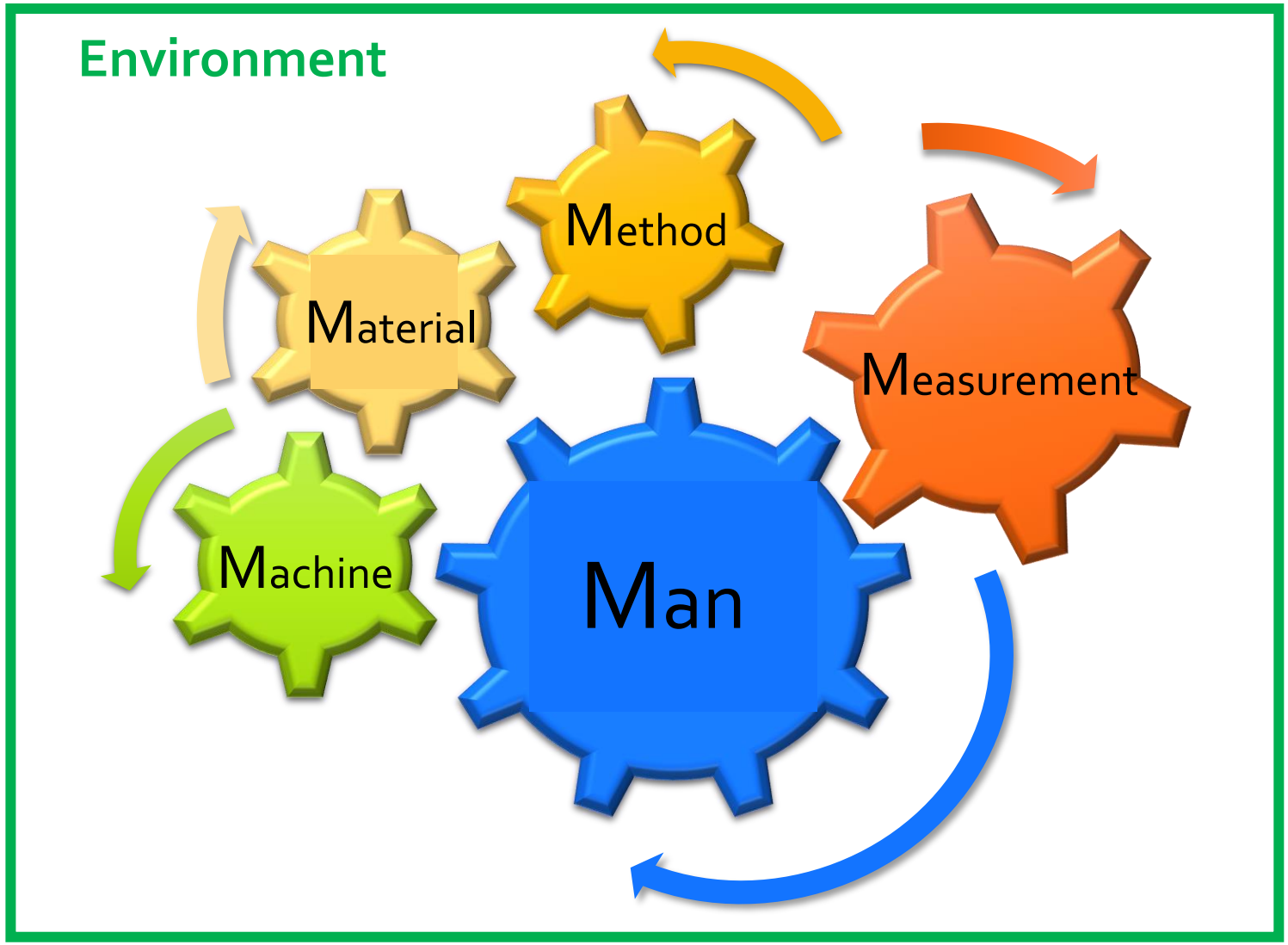
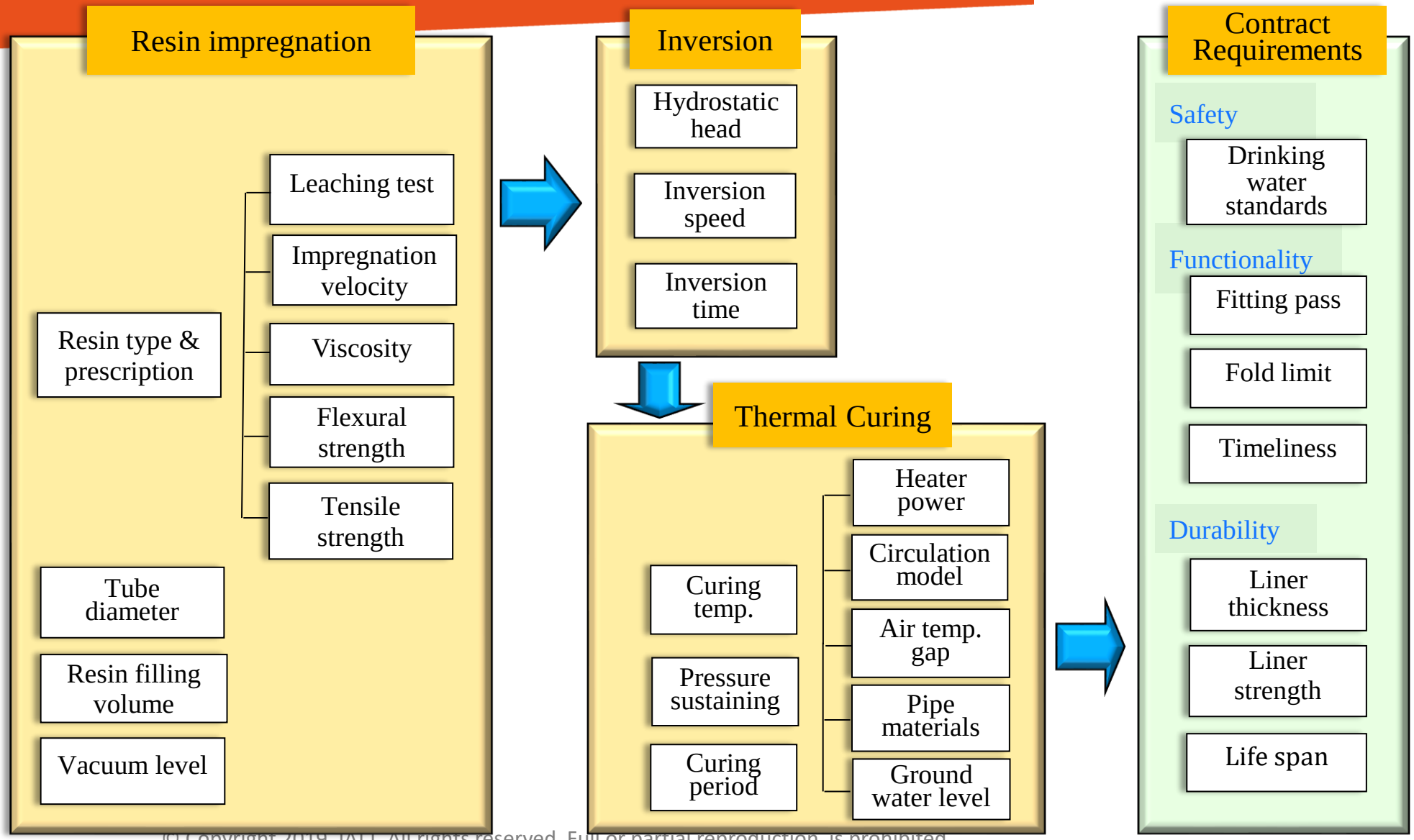
Management Elements



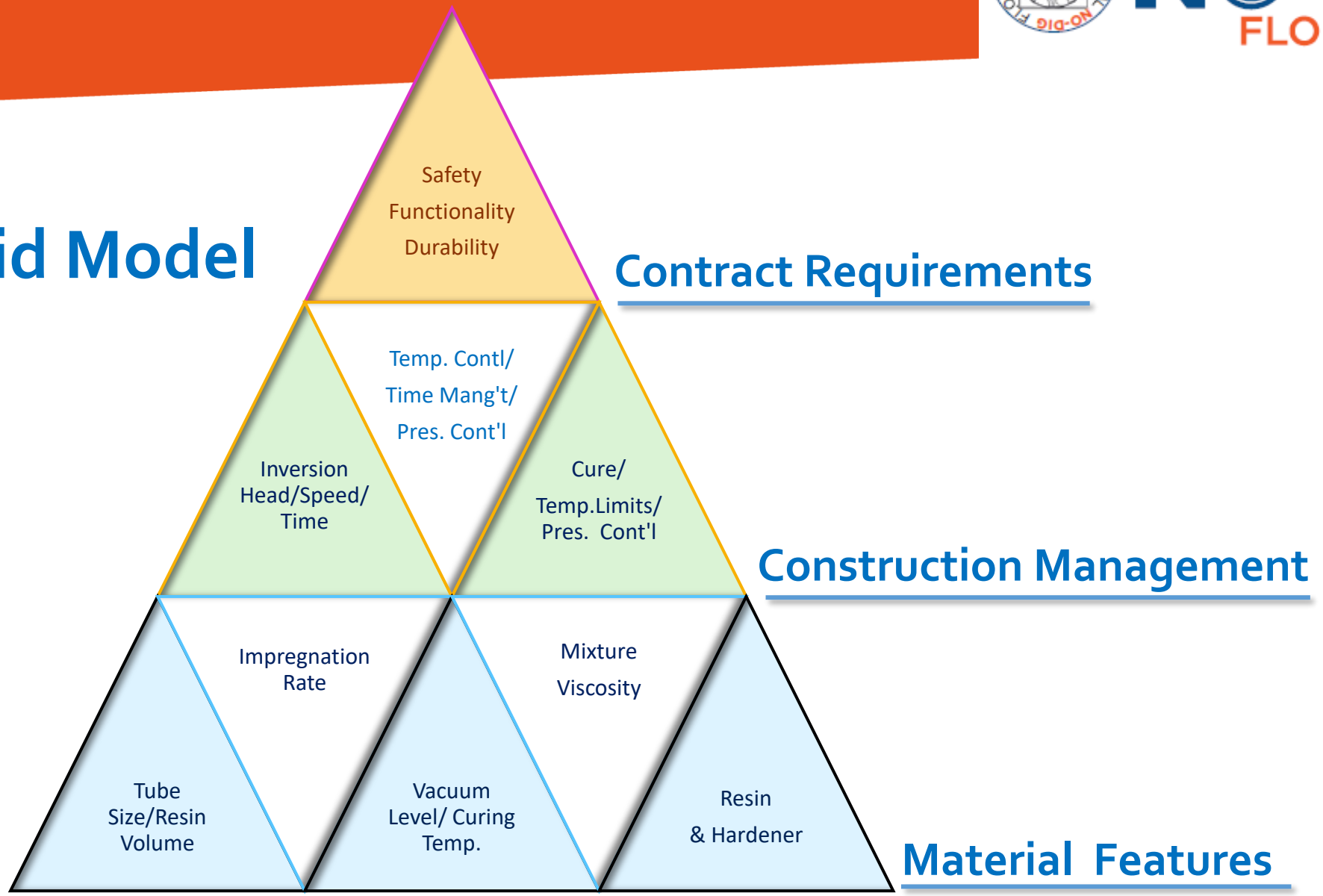
CIPP of Water Transmission in Taipei

Quality Management Framework



Superposition Effect of CIPP Quality Factors

Pyramid Model



Major Quality Control Factors of CIPP Construstion

Operation	Control Factors	Quality Parameters	Operation Required & Standards
Resin Impregnation Operation	Flexible felt size	● Length ● Axial folds criteria(Diameter oversize)	● Sampling bare tube at terminal ● Elastic coefficient of the lining tube (tensile strength)
	Prescription of resin & hardener	● Leaching test ● Compatibility tests (viscosity, permeability, impregnation rate, reaction rate) ● Flexural strength test ● Tensile strength test ● Gravity Deformation Rate of Bare Tube	● Drinking water standards ● Porosity of woven fabric and glass fiber layer ● Structural strength of bare tube
	Volume of resin filled	● Thickness	● Cost of resin
	Vacuum level	● Impregnation velocity ● Thickness of the cured tube ● Structural strength of cured tube	● Viscosity ● Structural strength of the cured tube
Inversion Operation	Inversion hydrostatic head	● Inversion driving force	● Features of existing pipe (material ,diameter, length, fitting Types & number) ● Limitation of operating space ● Viscosity of resin mixture
	Inversion speed	● Design thickness ● Pass the bends ● Circumferential folds	● Tube feeding capability (forward) ● Control cable operations (brake) ● Allowable operating Time for inversion
	Inversion time	● Strength of cured tube	● Resin & hardener features
Curing Operation	Curing temperature	● Curing time ● Temperature uniformity	● Heater power ● Heater and circulation system
		● Deformation of Plastic Layer(water-contacted)	● Upper limit of temperature
		● Total curing time	● Lower limit of temperature
	Required pressure	● Flexible tube tight against existing pipe wall	● Inversion water head
	Curing time	● Strength of the cured tube (hardness test at terminal)	● Textures of existing pipeline, air temperature, underground water level, etc.

The Fuxing Project

- DN 1000mm MJP transmission built in 1971
- Total length 812m and depth 4.2m.
- 6 work pits and 5 sections.

The Xinsheng Project

- DN 800mm CIP pipeline, 1963
- Total length 771m
- Layout 7 work pits and 6 sections.

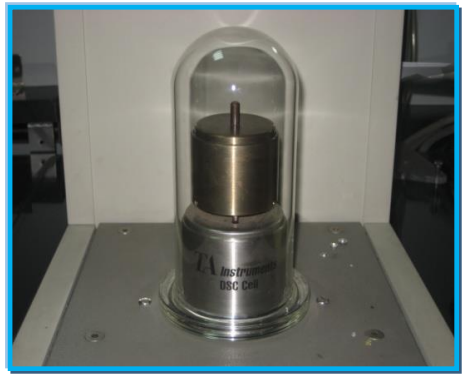
The Specifications and Tests of Materials in Contract

- **Water Safety** - Leaching test(Turbidity, Color, Odor, Residual chlorine reduction , TOC, Phenols, Cyanide, Formaldehyde, Styrene etc.
- **Pipe Structure** - Vertical Curvature and inner Pressure tests (bare pipe), Thickness, Hardness, Tensile strength and Flexural strength tests (slide sample)
- **Construction Required** - Compatibility tests(viscosity, permeability, impregnation rate, reaction rate) and Curing test(room temperature & heating)

Leaching test

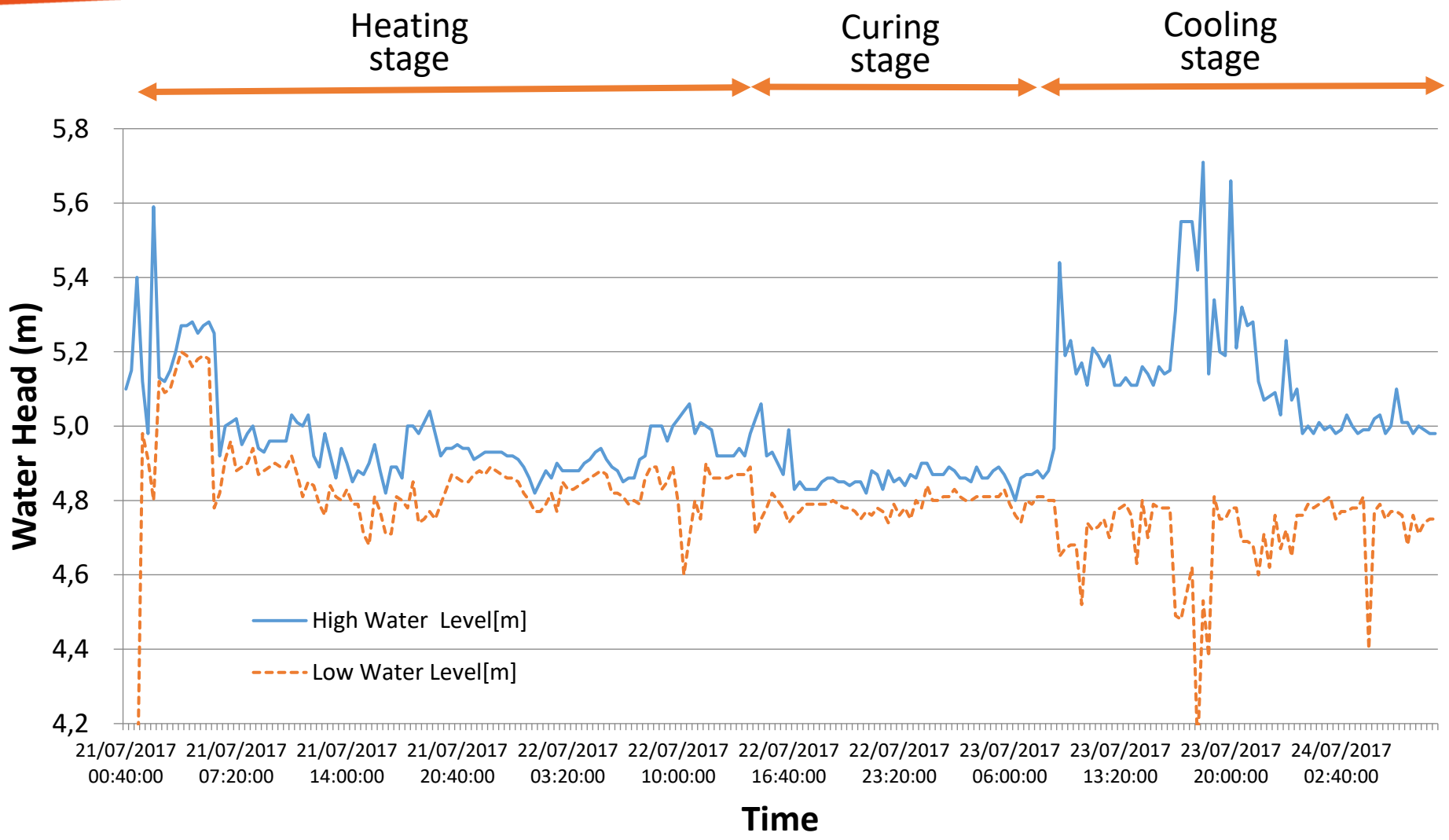
inner Pressure test
(≦ ID 4% under 0.3 Mpa)

impregnation rate

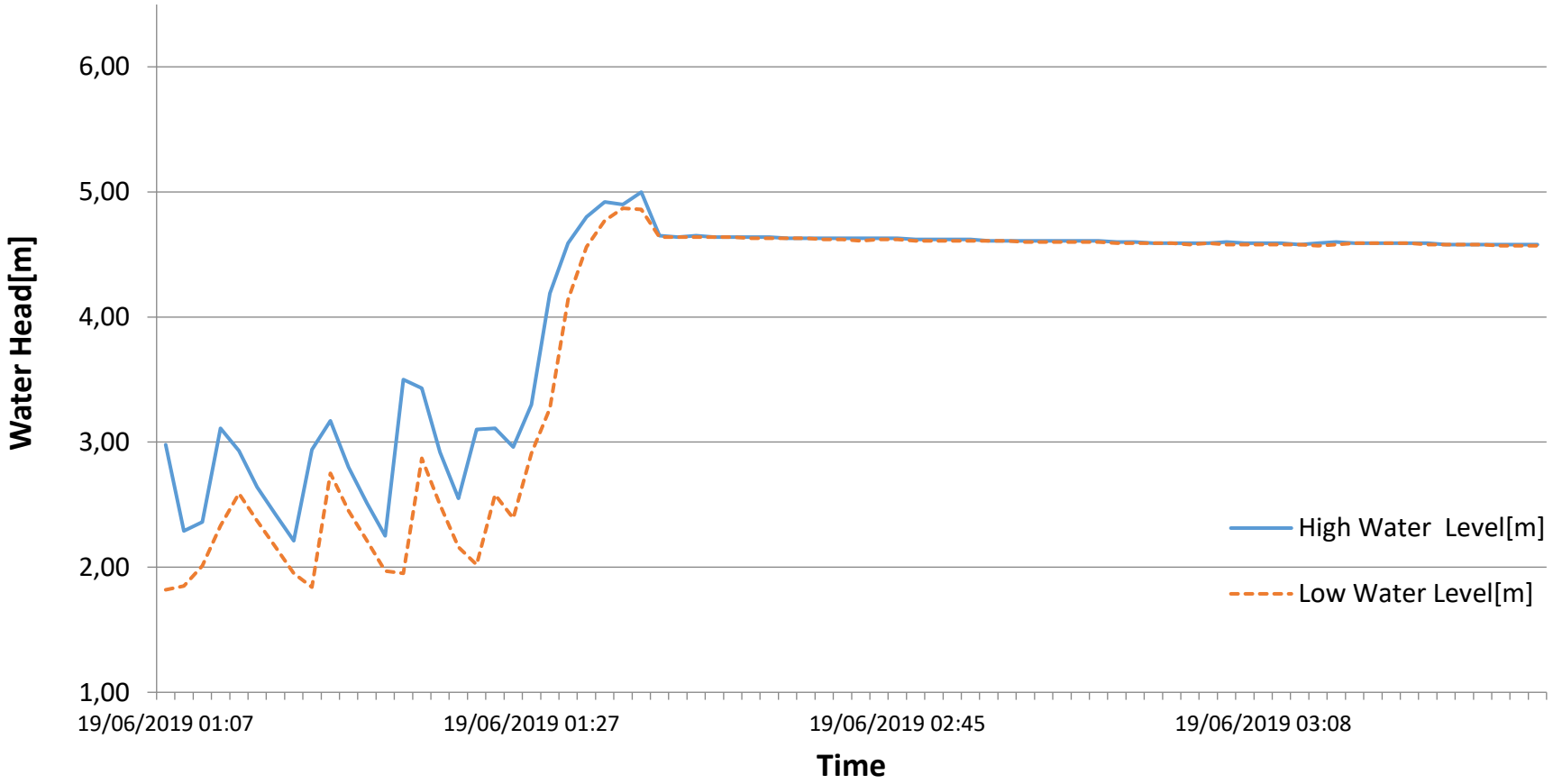


reaction rate

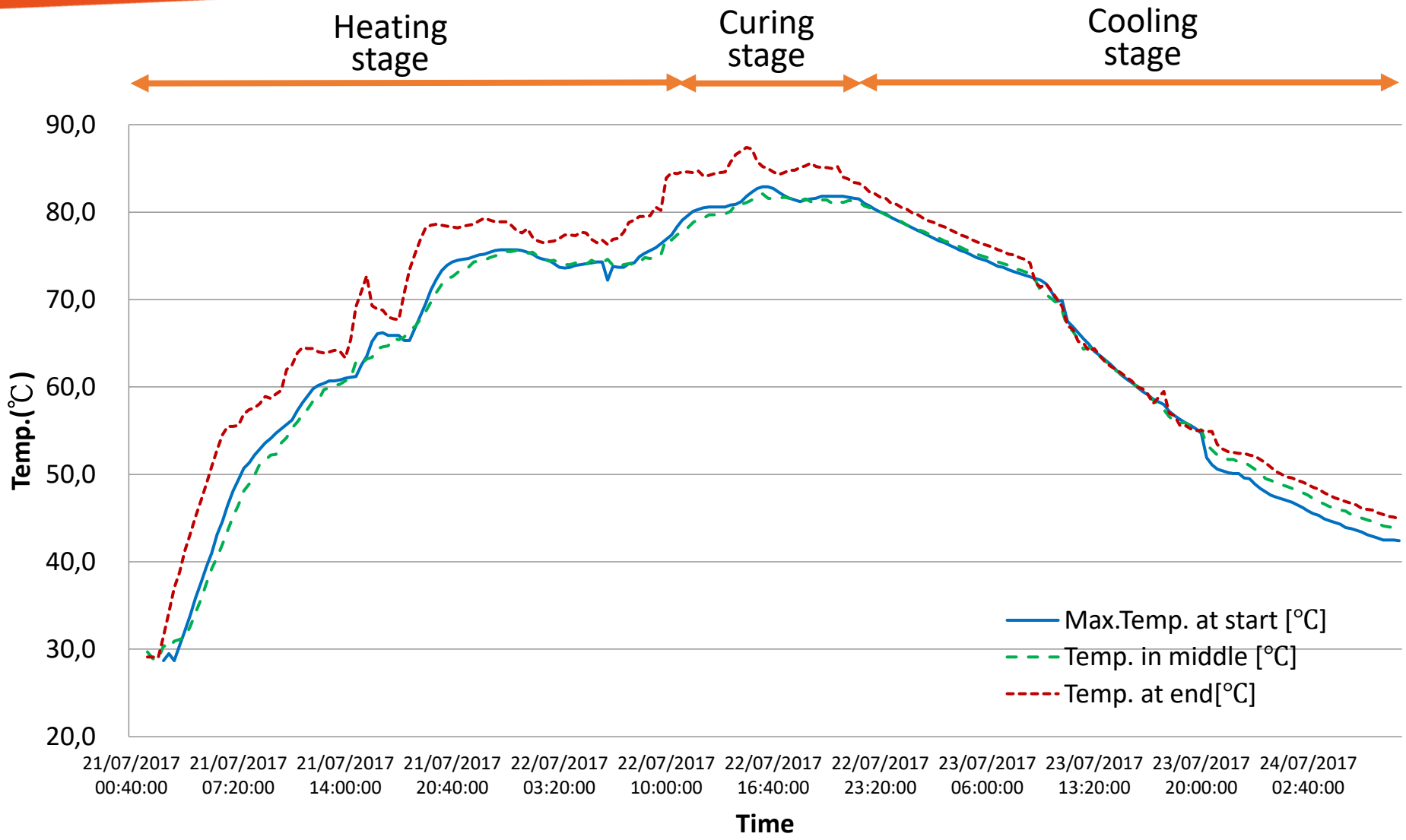
Control of Inversion Water Level in the Fuxing Project



Inversion Speed Controlled by Water Head in the Xinsheng Project



Thermal Curing Curve of the Fuxing Project



CONCLUSION

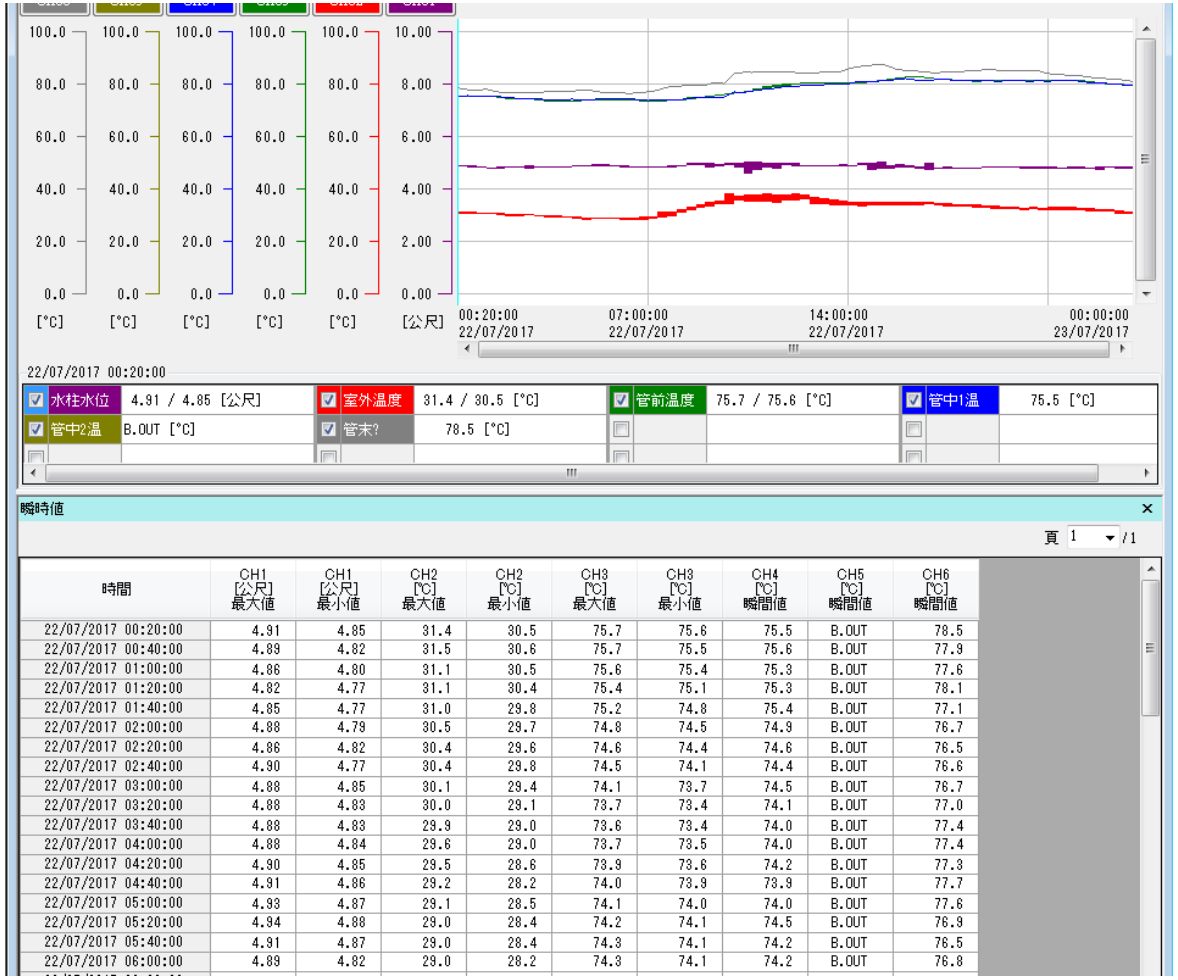
1. The quality management framework of CIPP projects consist of resin impregnation, tube inversion, and lining curing, which shall be managed as a whole in construction.
2. The key operational factors of quality control are mutually influenced by each other and have a superposition effect. The features of tube materials are regarded as highly relative factors with operations of construction on-site.
3. It is recommended that civil engineers manage CIPP projects in a full process perspective and comprehend the characteristics of resin and flexible felts in cases, which will ensure the lifespan of cured pipeline.

Better Water Better Life

Digital Thermocouple Sensors and Monitoring Panel Record

Start Point

End Point



時間	CH1 [公尺] 最大値	CH1 [公尺] 最小値	CH2 [°C] 最大値	CH2 [°C] 最小値	CH3 [°C] 最大値	CH3 [°C] 最小値	CH4 [°C] 瞬間値	CH5 [°C] 瞬間値	CH6 [°C] 瞬間値
22/07/2017 00:20:00	4.91	4.85	31.4	30.5	75.7	75.6	75.5	B.OUT	78.5
22/07/2017 00:40:00	4.89	4.82	31.5	30.6	75.7	75.5	75.6	B.OUT	77.9
22/07/2017 01:00:00	4.86	4.80	31.1	30.5	75.6	75.4	75.3	B.OUT	77.6
22/07/2017 01:20:00	4.82	4.77	31.1	30.4	75.4	75.1	75.3	B.OUT	78.1
22/07/2017 01:40:00	4.85	4.77	31.0	29.8	75.2	74.8	75.4	B.OUT	77.1
22/07/2017 02:00:00	4.88	4.79	30.5	29.7	74.8	74.5	74.9	B.OUT	76.7
22/07/2017 02:20:00	4.86	4.82	30.4	29.6	74.6	74.4	74.6	B.OUT	76.5
22/07/2017 02:40:00	4.90	4.77	30.4	29.8	74.5	74.1	74.4	B.OUT	76.6
22/07/2017 03:00:00	4.88	4.85	30.1	29.4	74.1	73.7	74.5	B.OUT	76.7
22/07/2017 03:20:00	4.88	4.83	30.0	29.1	73.7	73.4	74.1	B.OUT	77.0
22/07/2017 03:40:00	4.88	4.83	29.9	29.0	73.6	73.4	74.0	B.OUT	77.4
22/07/2017 04:00:00	4.88	4.84	29.6	29.0	73.7	73.5	74.0	B.OUT	77.4
22/07/2017 04:20:00	4.90	4.85	29.5	28.6	73.9	73.6	74.2	B.OUT	77.3
22/07/2017 04:40:00	4.91	4.86	29.2	28.2	74.0	73.9	73.9	B.OUT	77.7
22/07/2017 05:00:00	4.93	4.87	29.1	28.5	74.1	74.0	74.0	B.OUT	77.6
22/07/2017 05:20:00	4.94	4.88	29.0	28.4	74.2	74.1	74.5	B.OUT	76.9
22/07/2017 05:40:00	4.91	4.87	29.0	28.4	74.3	74.1	74.2	B.OUT	76.5
22/07/2017 06:00:00	4.89	4.82	29.0	28.2	74.3	74.1	74.2	B.OUT	76.8