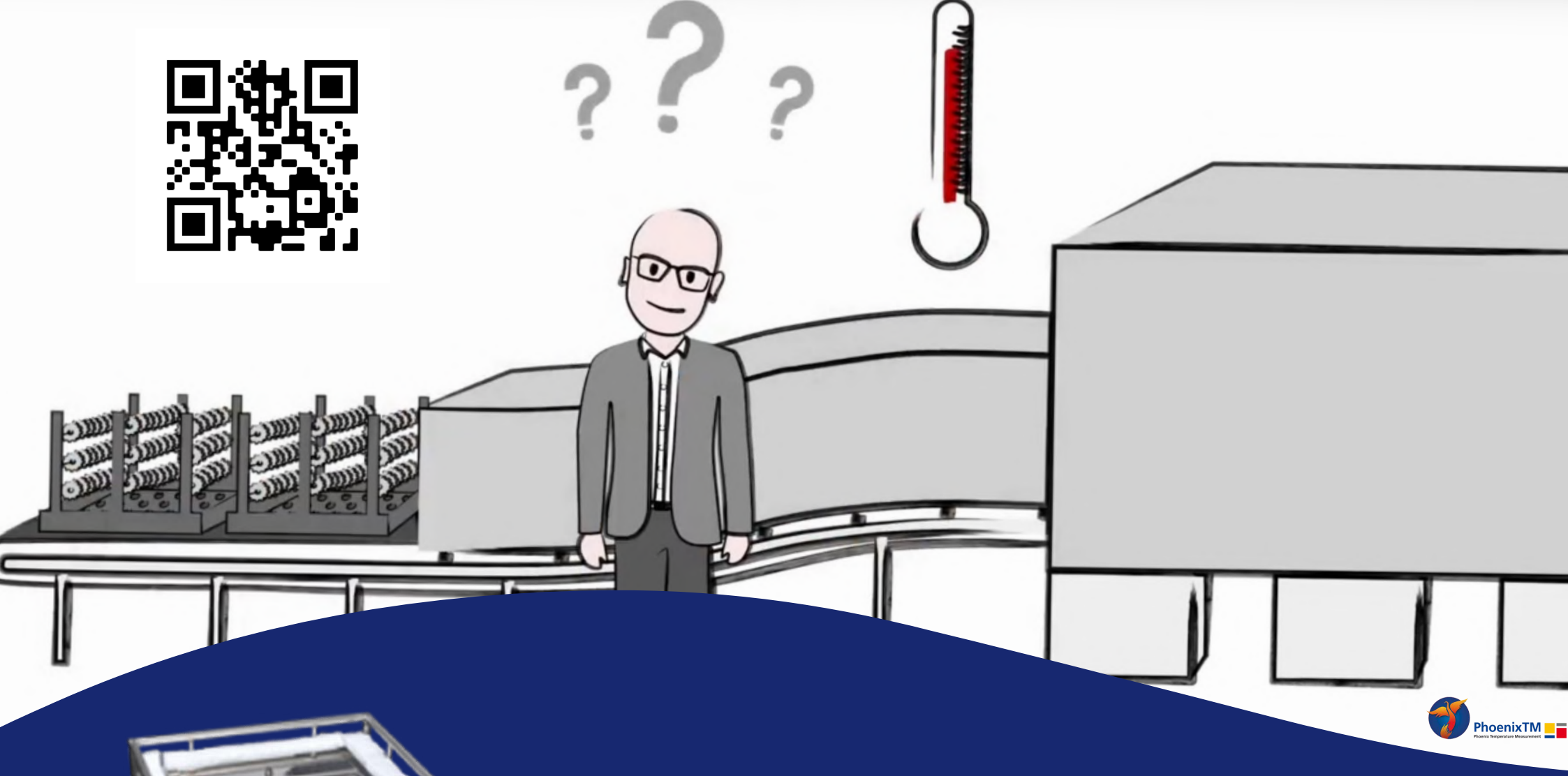
PHOENIXTM

Thermal Profiling System

Heat Treatment of Aluminium Alloys

Presented by Mr.Satit Pumphruk I 30 January 2020



Thru-process Temperature Profile System

เทคโนโลยีบันทึกอุณภูมิแบบติดตามสินค้า

คืออะไร ??

PhoenixTM
Phoenix Temperature Measurement

PSystems

ทำไมถึงต้องวัดโพรไฟลล์อุณหภูมิ

PSystems

หัวหน้าสั่งให้วัด ?

ถูกบังคับให้วัด ?

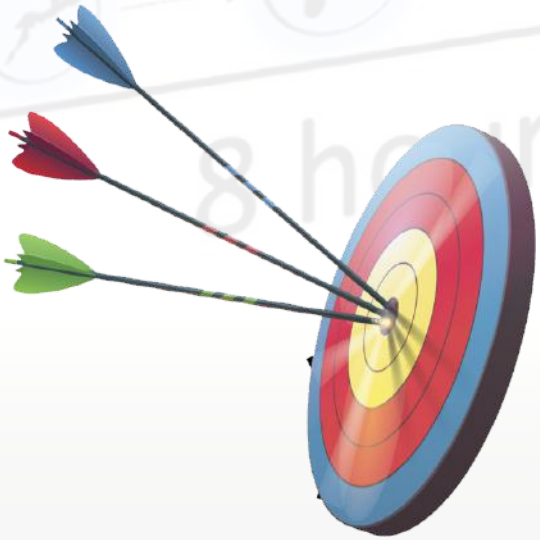
ลูกค้าต้องการข้อมูล ?

วัดเพื่อให้รู้จริง !

PSystems

วัดเพื่อให้รู้จริงด้านใด ?

1. รู้จริงว่า กระบวนการผลิตเป็นอย่างไร
2. รู้จริงว่า เถียรภาพของกระบวนการผลิตปกติหรือไม่
3. รู้จริงว่า กระบวนการทางความร้อนมีผลต่อสินค้าอย่างไร
4. รู้จริงว่า สามารถควบคุมคุณภาพ + พัฒนาศักยภาพ ของเตาและสินค้าให้ถึงจุดสูงสุดได้อย่างไร



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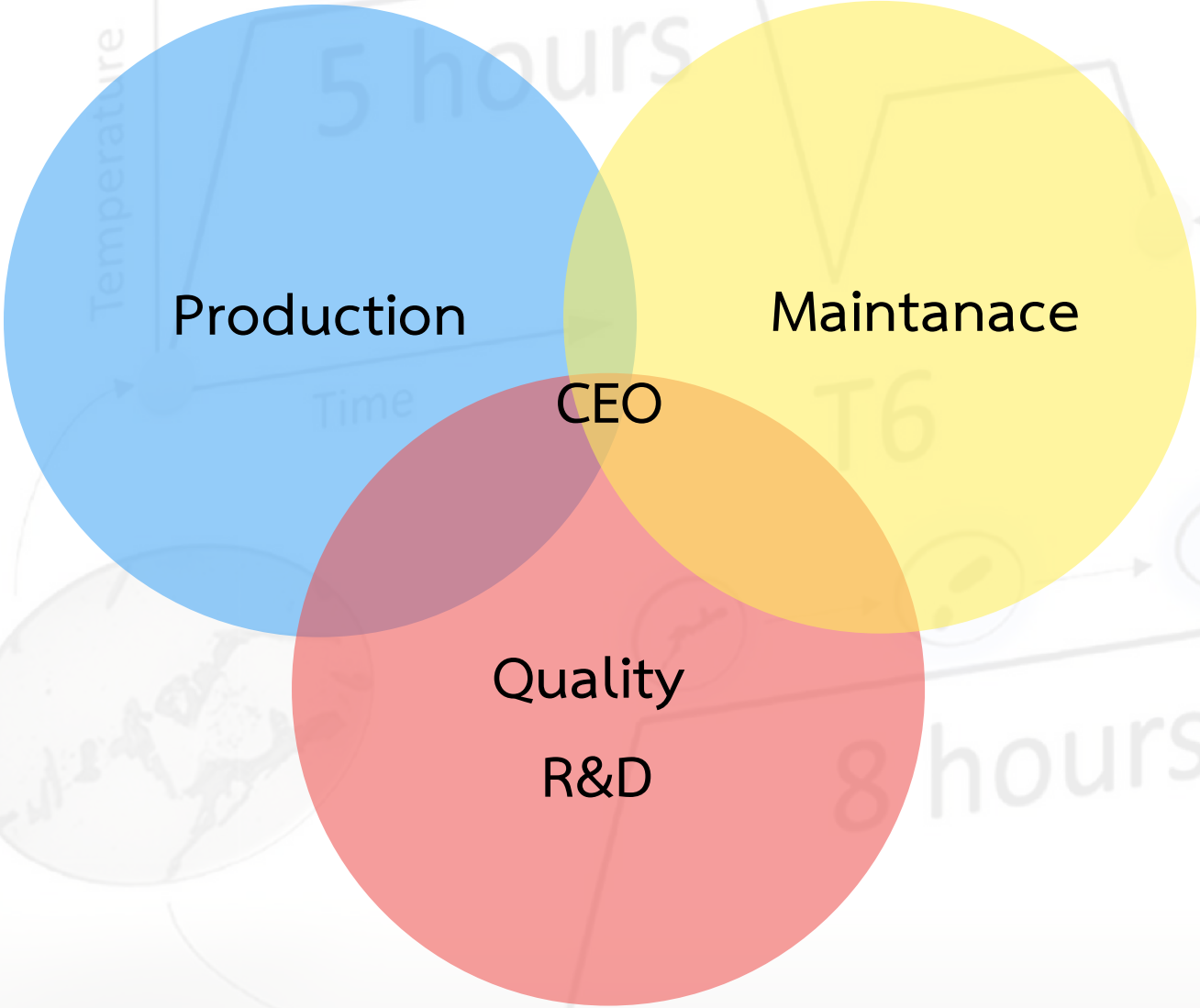
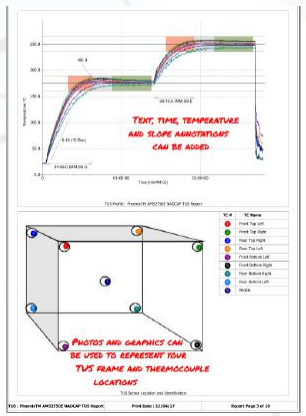
วัดเพื่อให้ใครรู้จริง ?



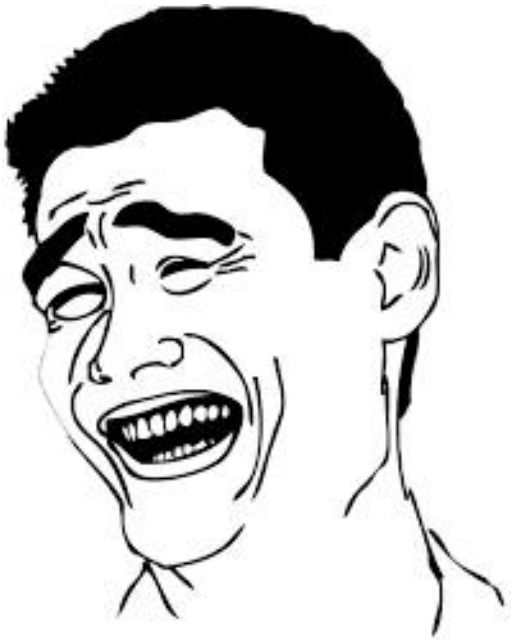


Customer

PSystems

1. No check

- Does not know reliable of equipments.
- Cannot control product quality.
- Most urgent problems, no plan for PM.

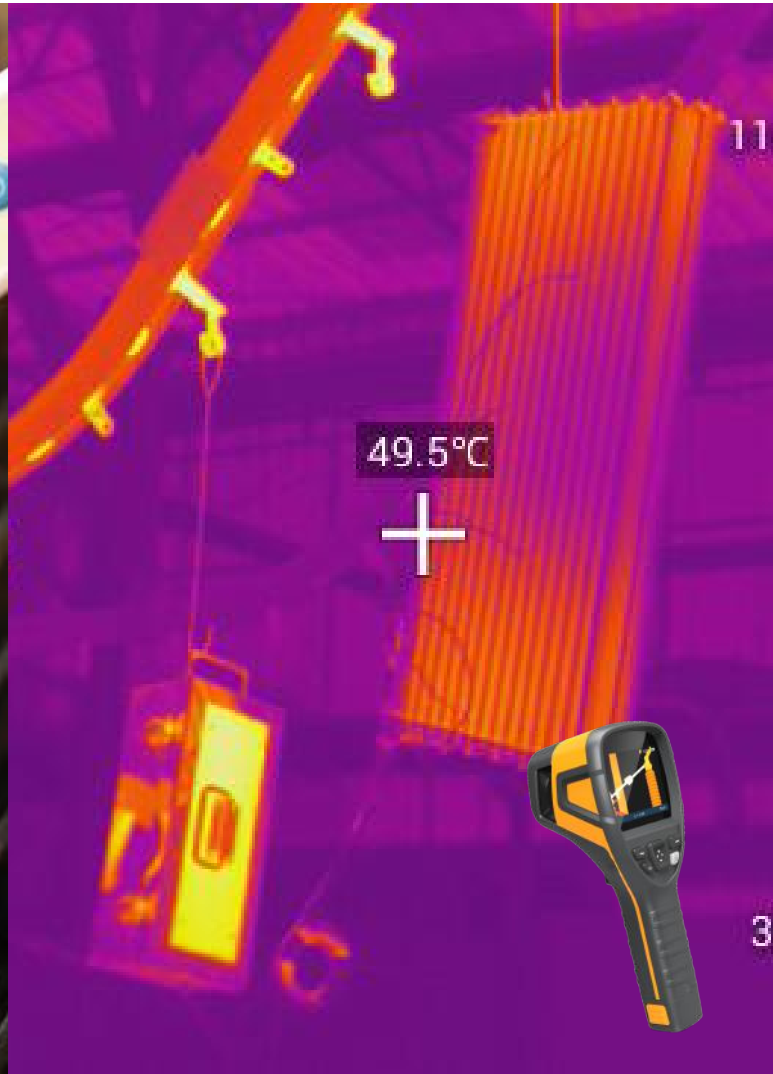


2. Thermometer

- Know just only final temperature, just some points.
- How to estimate heat up rate, max temp, time above ?

3. Non-contact Thermometer

- Does not know core temp.
- Know just surface temperature which error by surface emissivity, not accurate as wire thermocouple.



4. Install Oven Recorder

ติดตั้งเซ็นเซอร์วัดอุณหภูมิอากาศ ไว้ที่ผนังเตา ตลอดความยาวเตาอบ

อุณหภูมิอากาศในแต่ละตำแหน่งของเตาส่งผลต่ออุณหภูมิชิ้นงาน วิธีที่ 4 จะไม่ทราบใช้ปรับตั้งเตาได้ให้มีอุณหภูมิที่ใกล้เคียงได้ จะใช้เพื่อดูเถียรภาพของเตาเท่านั้น นอกจากนี้ ยังไม่ทราบอุณหภูมิของชิ้นงาน

5. Triling Lead

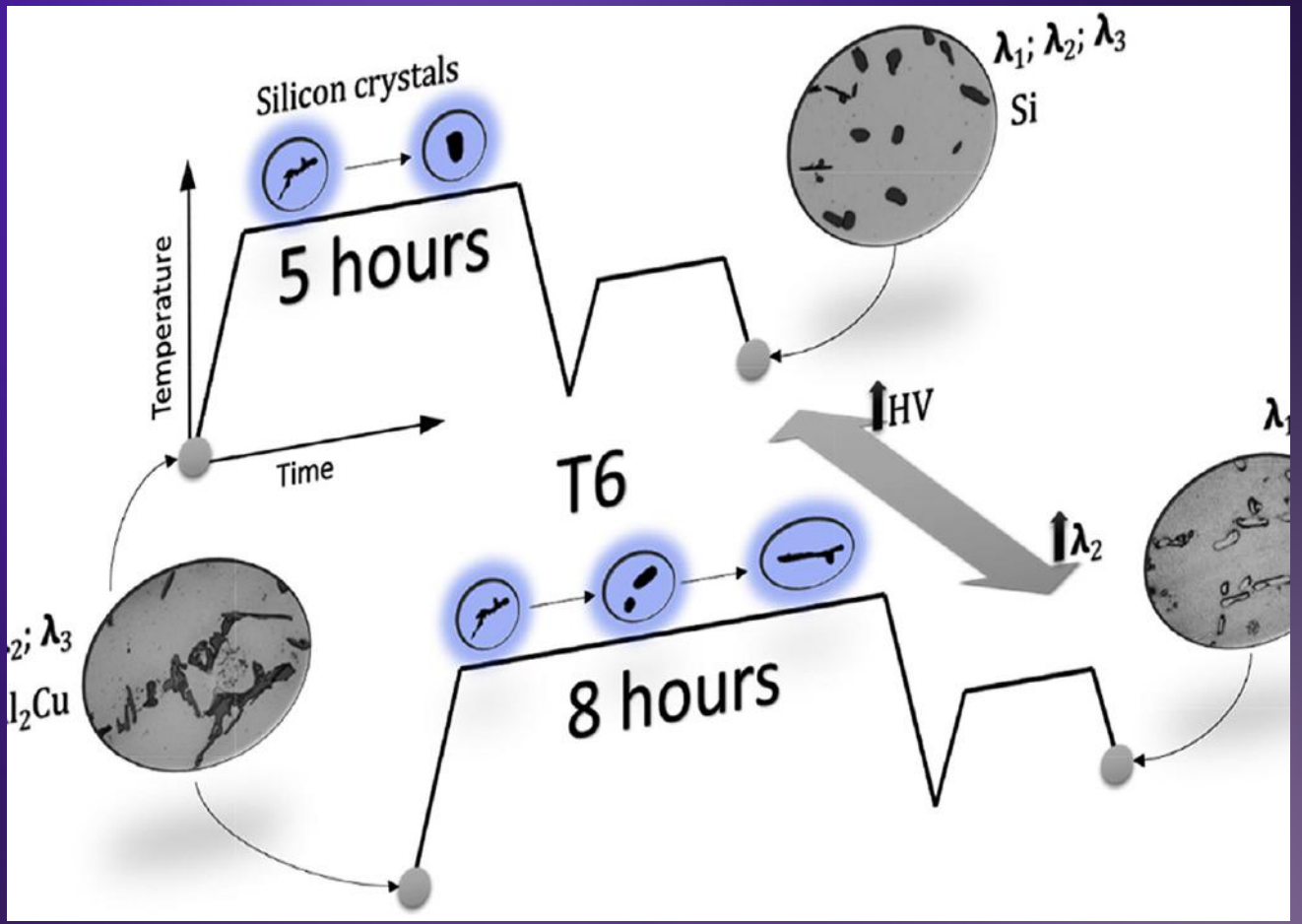
ติดตั้งเซ็นเซอร์วัดอุณหภูมิไว้กับชิ้นงาน หรือ Jig และปล่อยเข้าเตาอบ เมื่อชิ้นงานออกจากเตาแล้วปลดสายและดึงสายกลับ

- สายจะชำรุดง่ายเมื่อดึงกลับ
- สายอาจจะหลุดจากชิ้นงานได้หากปล่อยสายไม่สัมพันธ์กับความเร็วสายพาน
- มีข้อจำกัดหากไม่ใช่เตา Batch หรือ Strength Continious จะทำได้ยาก
- สายมีโอกาสติดพันสายพาน
- ต้องแง้มประตูเตาเอาไว้ เพื่อให้สายเข้าอาจส่งผลให้ค่าที่วัดได้ต่ำกว่าจริง

6. Thru-process Temperature Profile System

การบ่มแข็งอะลูมิเนียมคืออะไร ?

เป้าหมายของการบ่มแข็งคือ การควบคุมการตกตะกอนของอนุภาคของธาตุเจือในสภาวะของแข็งภายในอะลูมิเนียม ซึ่งความแข็งแรงที่เพิ่มขึ้นจากกระบวนการนี้ขึ้นอยู่กับขนาดและการกระจายตัวของอนุภาคของธาตุเจือที่เกิดขึ้น ถ้ามีขนาดเล็กเกินไปจะไม่ช่วยเพิ่มความแข็งแรงของวัสดุ (under aging) ส่วนอนุภาคที่มีขนาดใหญ่เกินไปจะเสียรูปได้ง่ายเป็นเหตุให้ความแข็งแรงลดลง (over aging) บางครั้งก่อนการบ่มแข็งเราจึงจำเป็นต้องให้ความร้อนแก่อะลูมิเนียมเพื่อให้อนุภาคที่มีขนาดและการกระจายตัวไม่เหมาะสมละลายกลับเข้าไปเป็นเนื้อเดียวกับอะลูมิเนียม หรือการอบให้เป็นสารละลายของแข็ง (solution annealing)



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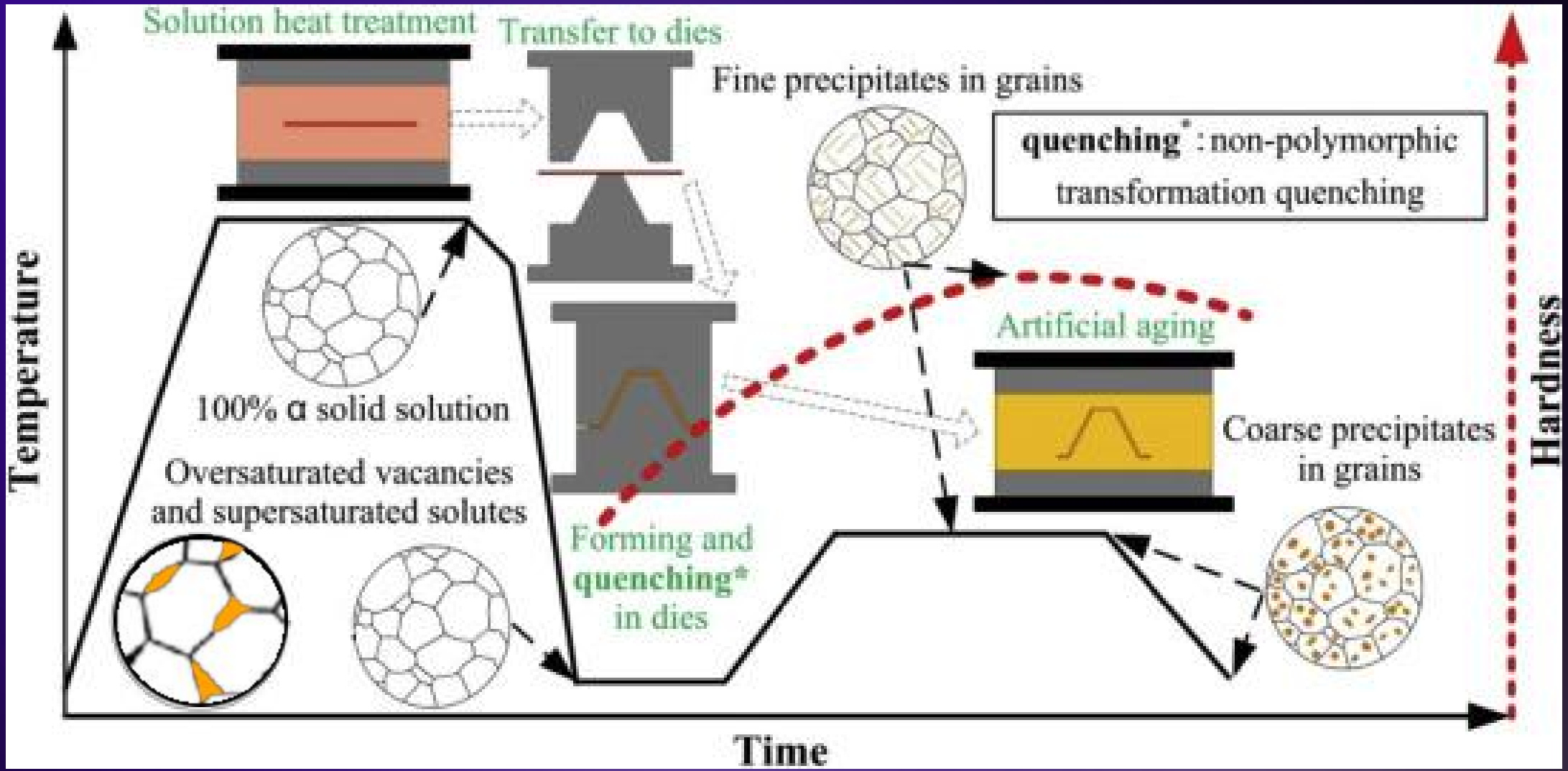
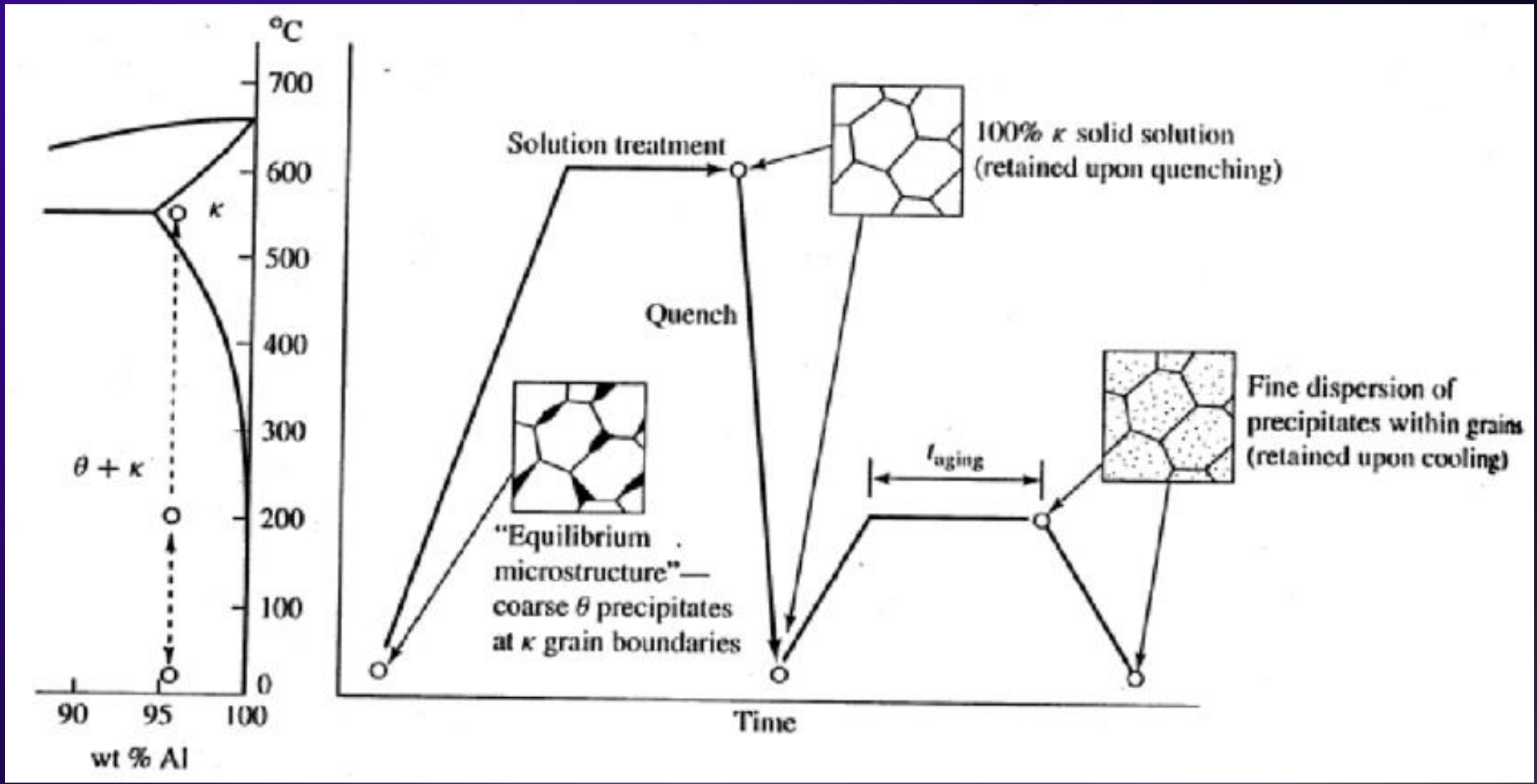
Aluminium Heat Treated Understanding



https://www.sciencedirect.com/science/article/pii/S2588840419301271

Aluminium Heat Treated Understanding



https://www.researchgate.net/figure/Figure-2-5-Steps-of-precipitation-hardening-47-2-14-1-Solution-heat-treatment_fig4_289672797

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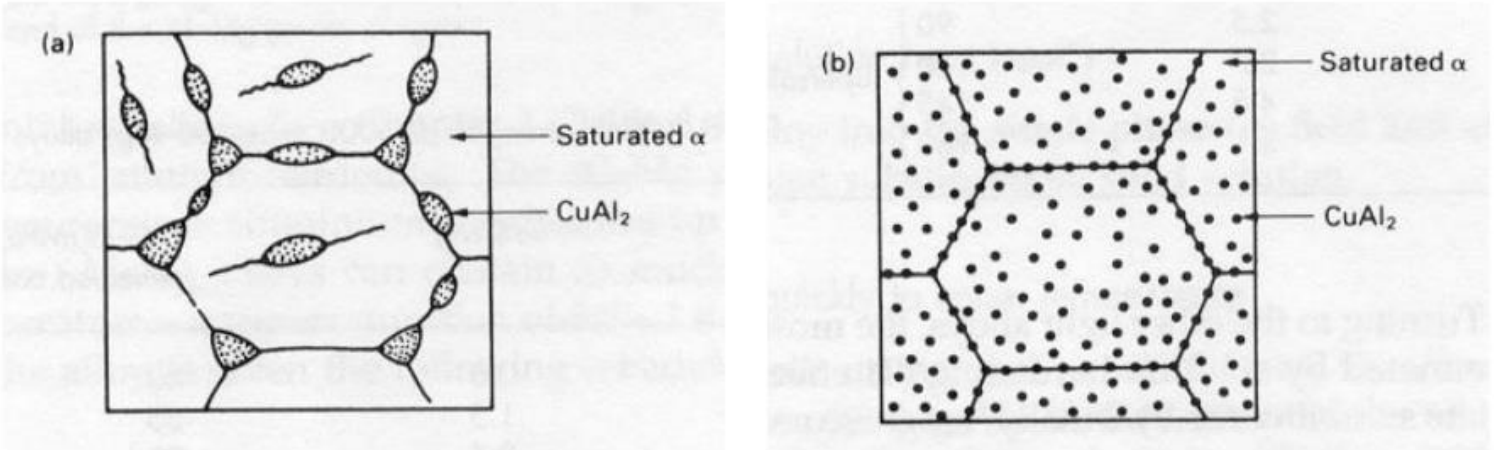
Aluminium Heat Treated Understanding

West Virginia University

Age (Precipitation) Hardening



https://www.slideserve.com/menefer/dispersion-and-solution-hardening

Room temperature microstructures in Al-4%Cu alloy.
(a) slow cooling; (b) moderately fast cooling

Mechanical & Aerospace Engineering

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Aluminium Heat Treated Understanding

สถานะการบ่มแข็งอะลูมิเนียมตามมาตฐาน EN515

Temper	Definition
T1	Cooled from an elevated temperature shaping process and naturally aged
T2	Cooled from an elevated temperature-shaping process, cold worked, and naturally aged
T3	Solution heat treated, cold worked, and naturally aged
T4	Solution heat treated and naturally aged
T5	Cooled from an elevated temperature-shaping process and artificially aged
T6	Solution heat treated and artificially aged
T7	Solution heat treated and artificially overaged
T8	Solution heat treated, cold worked, and artificially aged
T9	Solution heat treated, artificially aged, and cold worked
T10*	Cooled from an elevated temperature shaping process, cold worked, and artificially aged

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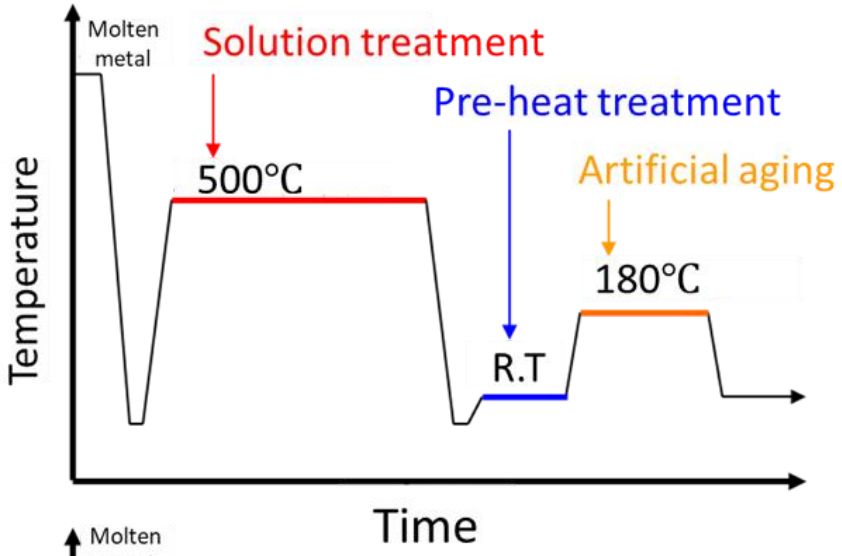
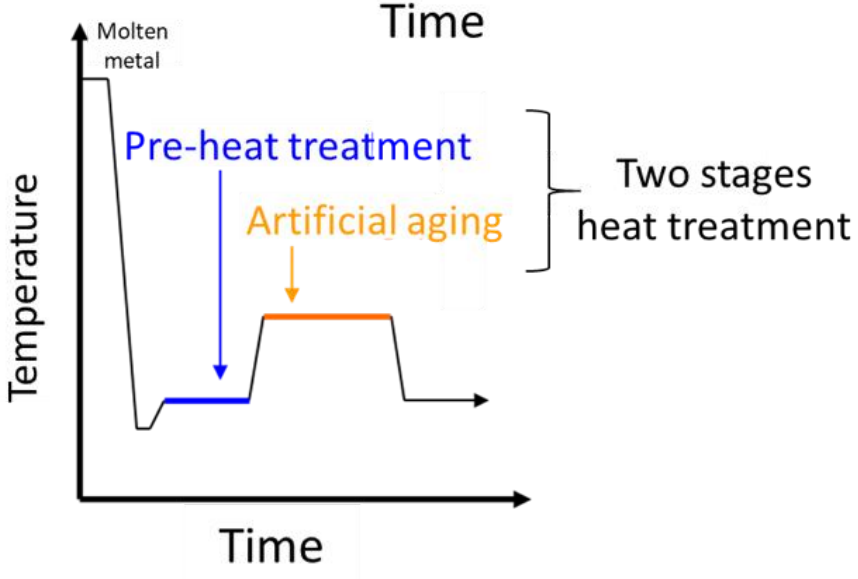
Aluminium Heat Treated Understanding

T6 Treatment



T5 Treatment



- Solution heat treating, quenching and ageing are basic heat treatments for Al alloys.
- The proper selection of these heat treatments can achieve optimum combination of strength and ductility of the material.
- **Solution treatment** is the heating of an alloy to a suitable temperature, holding it at that temperature long enough to cause one or more constituents to enter into a solid solution and then cooling it rapidly enough to hold these constituents in solution.
- The **purpose of solution heat treatment** is to put the maximum practical amount of hardening solutes such as Cu, Mg and Si into solid solution of Al – matrix
- The **purpose of quenching** is to preserve the solid solution formed at the solution heat treating temperature by rapidly cooling to some lower temperature, usually near room temperature
- The **purpose of ageing** is to increase strength and resistance to corrosion by forming Guinier-Preston (GP) zones and precipitating second-phase particles from solid solution obtained from quenching

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Aluminium Heat Treated Understanding

อะไรคือหัวใจของกระบวนการบ่มแข็งอลูมิเนียม ?

P Systems

อะไรคือหัวใจของกระบวนการบ่มแข็งอลูมิเนียม ?

ตัวอย่าง T6 Aluminium Heat Treating

solution & aging temperature ?

solution & aging time ?

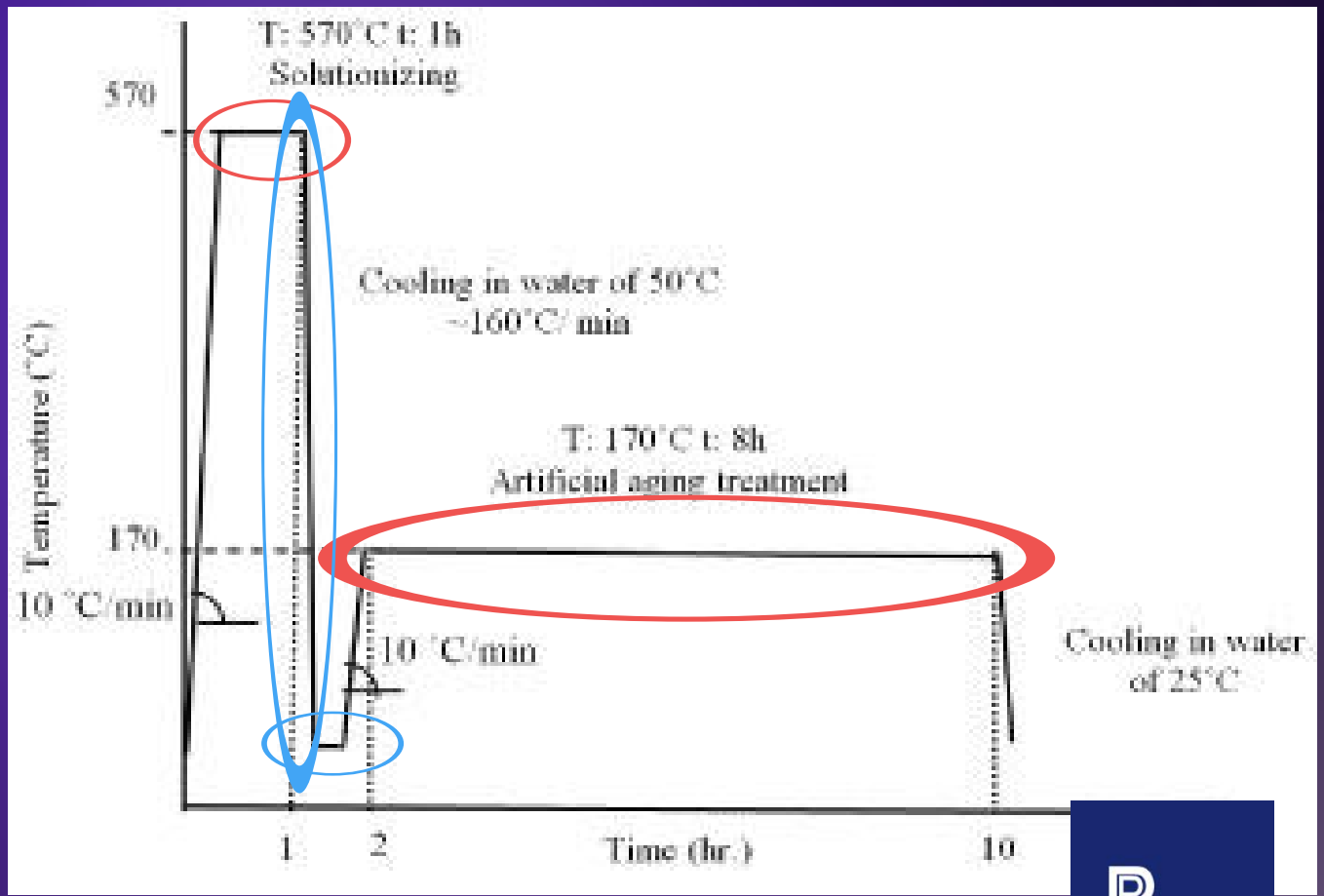
water temperature ?

cooling time ?

cooling rate of product ?

furnace air temperature

around working space ?

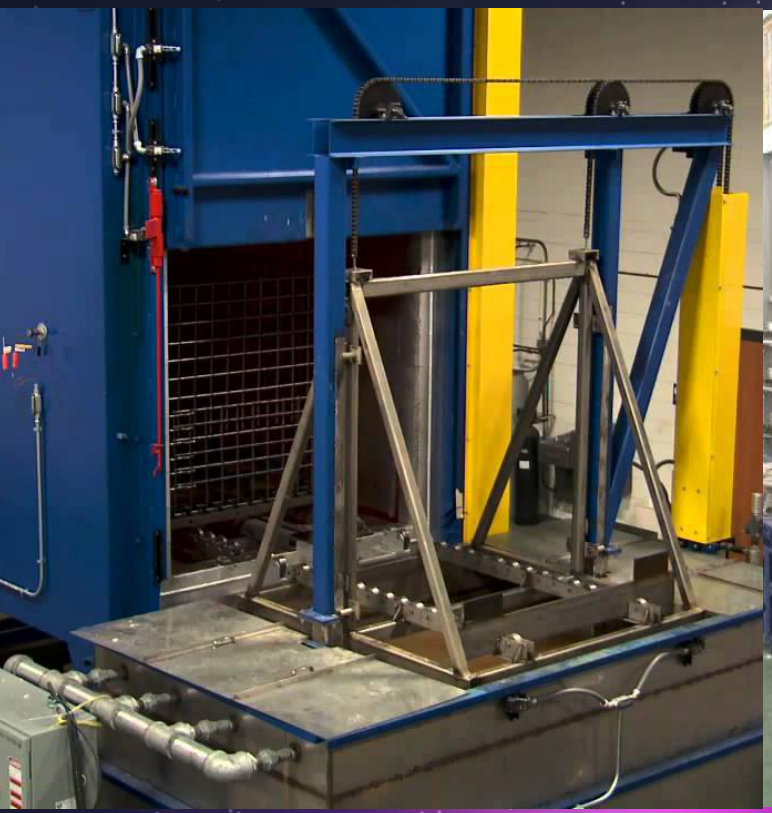


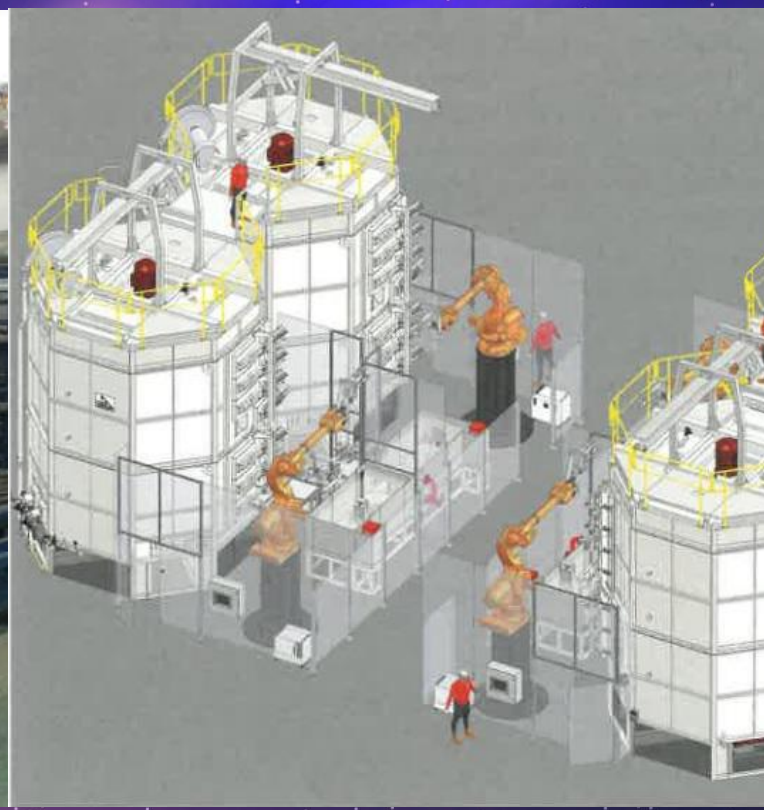
Systems

Batch Type

Strength Continuous

Rotary Continuous



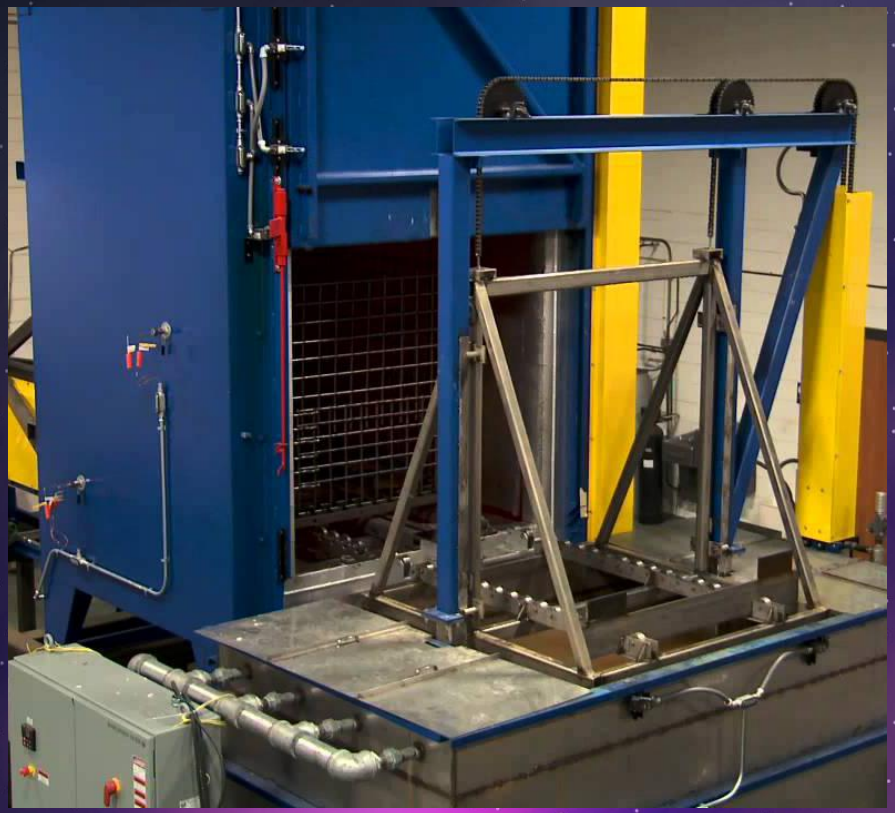


Aluminium Heat Treatment Furnace Type I T6

P Systems

Batch Furnace (Small Parts)

Solution -> Quench -> Aging



Aluminium Heat Treatment Furnace Type I T6

PSystems

Batch Furnace (Large Parts)

Aluminium Heat Treatment Furnace Type I T6

PSystems

Strength Continuous (Large Parts)

Solution -> Quench -> Aging

Aluminium Heat Treatment Furnace Type I T6

PSystems

Drop Bottom Batch Furnace

Solution -> Quench

Aluminium Heat Treatment Furnace Type I T6

PSystems

Strength Continuous

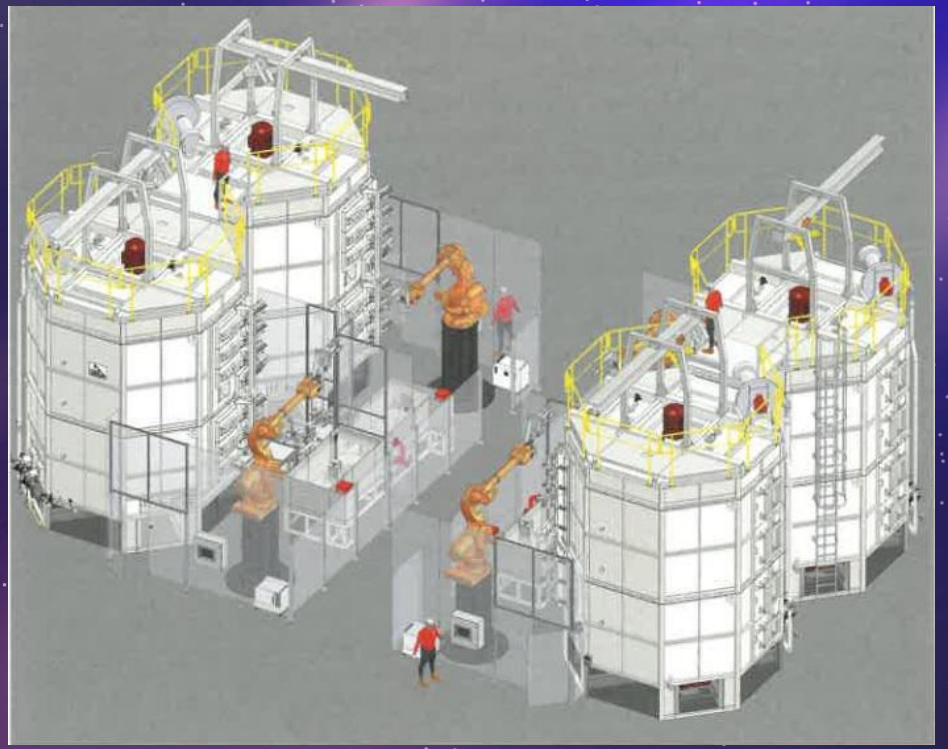
Solution -> Quench -> Aging

Aluminium Heat Treatment Furnace Type I T6

PSystems

Rotary Continuous

Solution -> Quench -> Aging



Aluminium Heat Treatment Furnace Type I T6

PSystems

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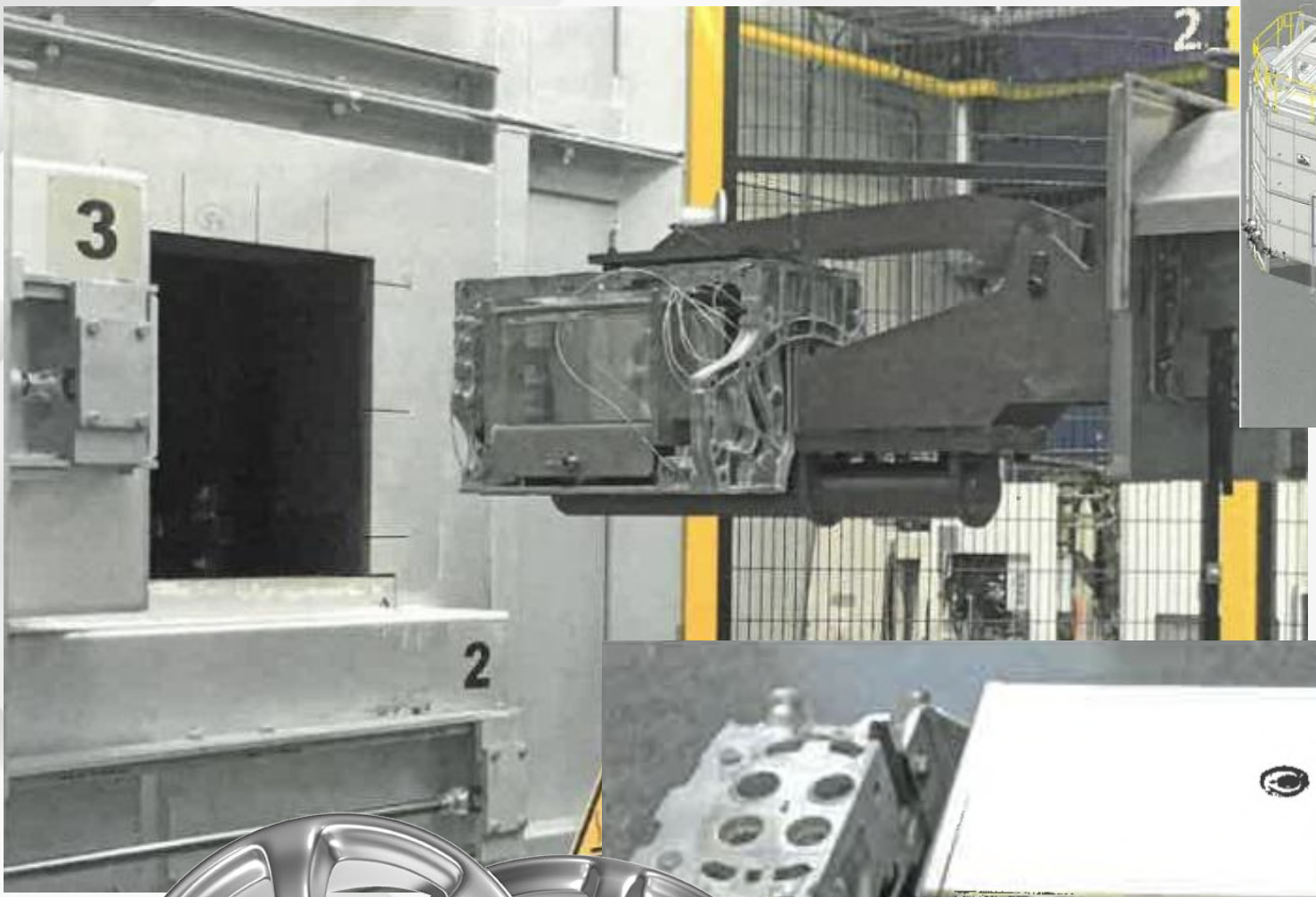
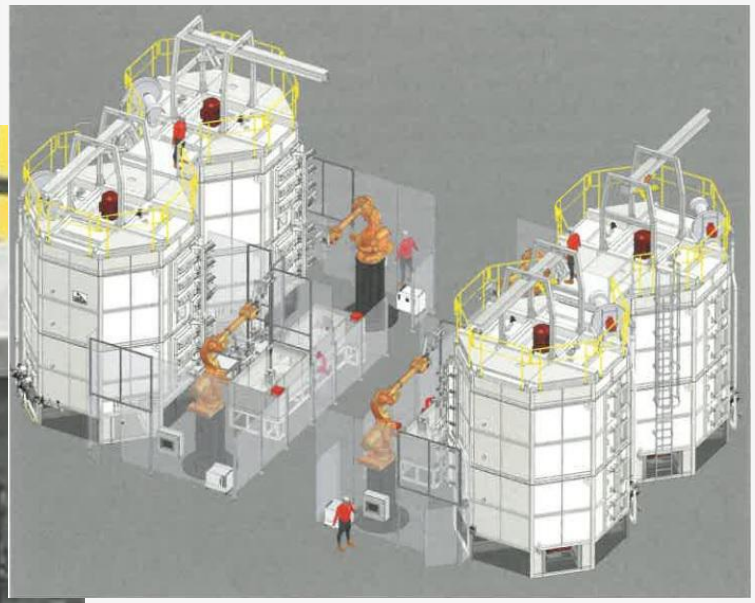
Phoenix Temperature Measurement





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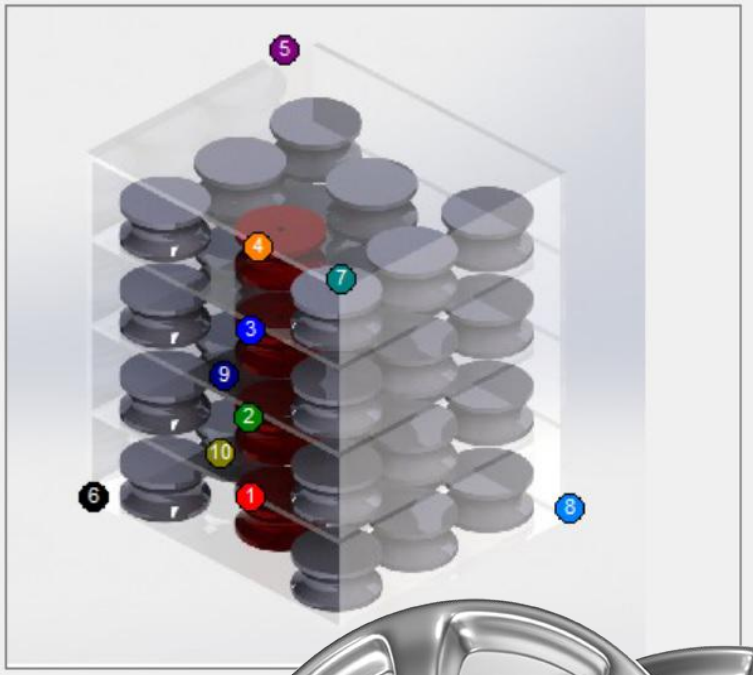
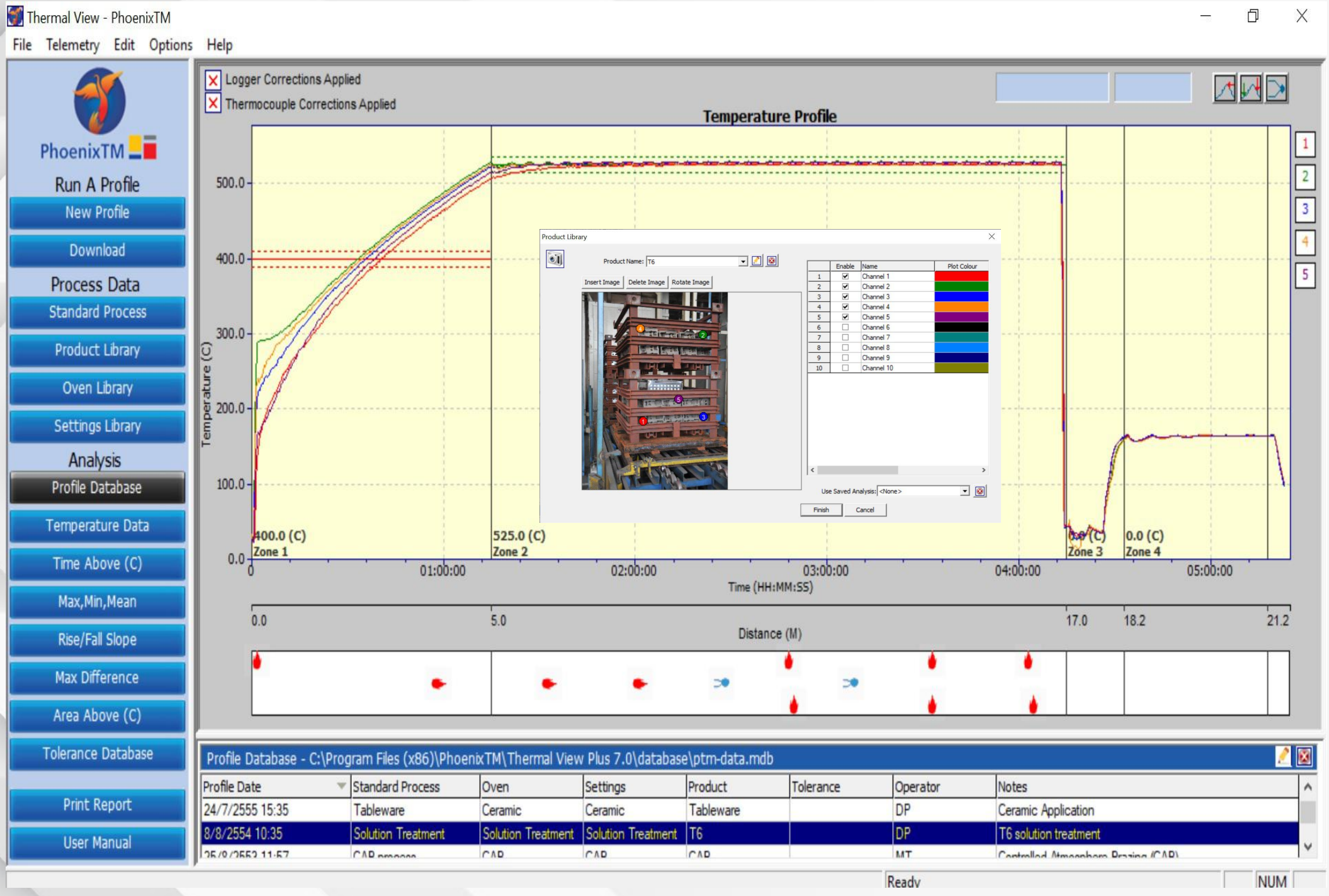
Phoenix Temperature Measurement

Thermocouple Locations



#	Name
1	Wheel 1
2	Wheel 2
3	Wheel 3
4	Wheel 4
5	Air Left Top
6	Air Left Bottom
7	Air Right Top
8	Air Right Bottom
9	Air Mid
10	Air Mid Bottom

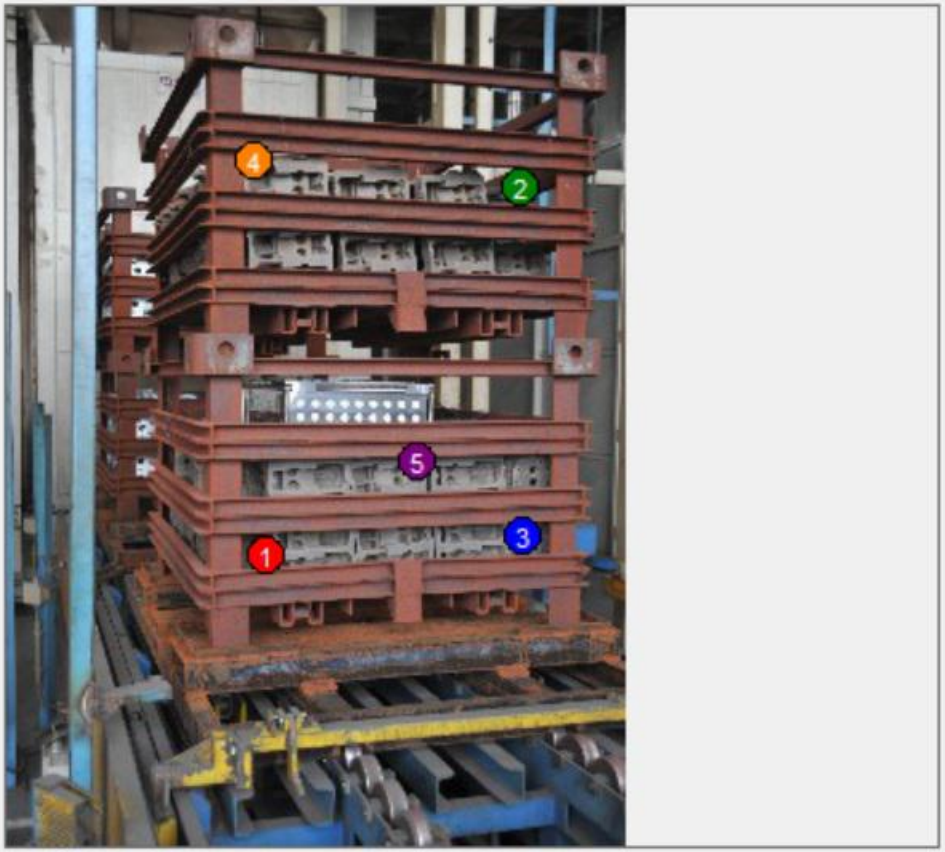
PhoenixTM
Phoenix Temperature Measurement


Thermal View - PhoenixTM
File Telemetry Edit Options Help
PhoenixTM
Run A Profile
New Profile
Download
Process Data
Standard Process
Product Library
Oven Library
Settings Library
Analysis
Profile Database
Temperature Data
Time Above (C)
Max,Min,Mean
Rise/Fall Slope
Max Difference
Area Above (C)
Tolerance Database
Print Report
User Manual
Logger Corrections Applied
Thermocouple Corrections Applied
Temperature Profile
Temperature (C)
Time (HH:MM:SS)
Distance (M)
400.0 (C)
Zone 1
525.0 (C)
Zone 2
0.0 (C)
Zone 4
Product Library
Product Name: T6
Insert Image
Delete Image
Rotate Image
Use Saved Analysis: <None>
Finish
Cancel
Profile Database - C:\Program Files (x86)\PhoenixTM\Thermal View Plus 7.0\database\ptm-data.mdb
Profile Date
Standard Process
Oven
Settings
Product
Tolerance
Operator
Notes
24/7/2555 15:35
Tableware
Ceramic
Ceramic
Tableware
DP
Ceramic Application
8/8/2554 10:35
Solution Treatment
Solution Treatment
Solution Treatment
T6
DP
T6 solution treatment
Ready
NUM

Product Library

Product Name: T6

Insert Image | Delete Image | Rotate Image



	Enable	Name	Plot Colour
1	☑	Channel 1	
2	☑	Channel 2	
3	☑	Channel 3	
4	☑	Channel 4	
5	☑	Channel 5	
6	☐	Channel 6	
7	☐	Channel 7	
8	☐	Channel 8	
9	☐	Channel 9	
10	☐	Channel 10	

Use Saved Analysis: <None>

Finish | Cancel

1

SOLUTION
FURNACE 10Ch

2

SOLUTION
FURNACE 10Ch RF

3

SOLUTION
FURNACE 20Ch RF

PhoenixTM
Phoenix Temperature Measurement

HTS01 I Non-Quench Profiling System

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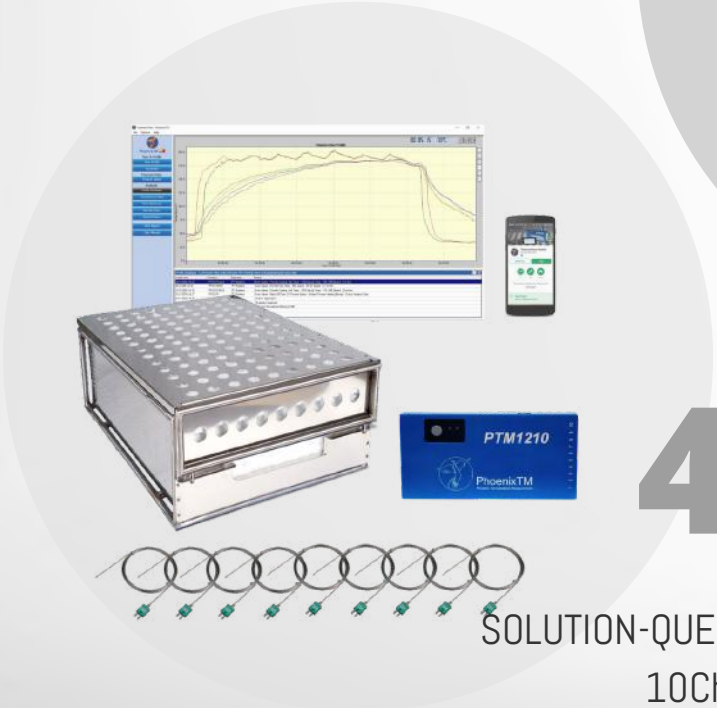

4

SOLUTION-QUENCH-AGING
10Ch

5

SOLUTION-QUENCH-AGING
10Ch RF

6

SOLUTION-QUENCH-AGING
20Ch RF

HTS06 I Water Quench Profiling System

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Phoenix Temperature Measurement

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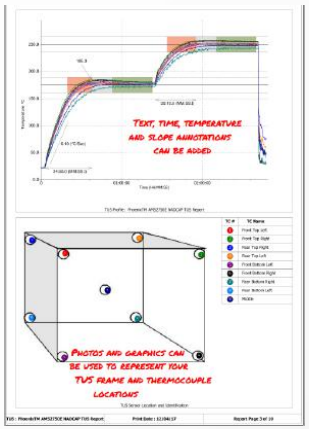
1. TEST INSTRUMENT

2. TEST SENSOR

3. SURVEY SOFTWARE

4. TUS REPORT



CQI-9 & AMS2750E Compliance

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Phoenix Temperature Measurement

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[P38] TABLE 3 - INSTRUMENTS AND INSTRUMENT CALIBRATION

CQI-9 and AMS2750E require an instrument calibration accuracy of **±0.6 °C or ±0.1%** of the reading whichever is the greater.

PhoenixTM data logger accuracy +/- 0.3°C

Maximum Calibration Period : 3 Months

CQI-9 & AMS2750E Compliance

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Phoenix Temperature Measurement

Systems

2.2.2 BASE METAL THERMOCOUPLE : Thermocouple whose thermoelements are composed primarily of base metals and their alloys. Example of base metal include E, J, K, N, T.

3.1.2.6 Thermocouples made from rolls calibrated in accordance with the paragraph may be used in leu of individually calibrated thermocouples.

3.1.2.6.1 The maximum amout of wire/cable in roll at the time of calibration. All base metal sensor 5000 feet (1525 m)

3.1.2.5.1 Calibration intervals shall not exceed 150°C (AMS2750E) and 140°C (CQI-9) for all thermocouple

4.2.1 TABLE 1 - SENSOR AND SENSOR CALIBRATION

Temperature Uniformity Survey Sensor +/- 2.2°C or 0.75%
Calibration every 6 months - Type B, R, S
Calibration every 3 months - Base metal Type J, N, T.

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CQI-9 & AMS2750E Compliance

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Accuracy for thermocouples in accordance with IEC-EN 60584-2 and ASTM E230-ANSI MC96.1

IEC Tolerance class EN60584-2

TC type	Class 1	Tolerance	Class 2	Tolerance
J	-40 to 375°C	+/-1.5°C	-40 to +333°C	+/- 2.5°C
	375 to 750°C	0.4% of reading	333 to 750°C	0.75% of reading
K-N	-40 to 375°C	+/-1.5°C	-40 to +333°C	+/- 2.5°C
	375 to 1200°C	0.4% of reading	333 to 1200°C	0.75% of reading
T	-40 to 125°C		-40 to +133°C	
	125 to 350°C		133 to 350°C	
E	-40 to 375°C		-40 to +333°C	
	375 to 800°C		333 to 800°C	
R-S	0 to 1100°C		-0 to 600°C	
	1100 to 1600°C		333 to 800°C	
B	Not applicable		-0 to 600°C	EMK to small
			600 to 1700°C	0.25% of reading

OTHERS

OTHERS

Limits of Error ASTM E230-ANSI MC96.1

TC type	Special limits	Tolerance	Standard limits	Tolerance
J	0 to 750°C	+/-1.1°C-or 0.4% of reading	0-750	+/- 2.2°C or 0.75% of reading
			-200 to 0°C	+/- 2.2°C or 2% of reading
K	0 to 750°C	+/-1.1°C-or 0.4% of reading	0-750	+/- 2.2°C or 0.75% of reading
T	0 to 350°C		0 to 350°C	+/- 1°C or 0.75% of reading
			-200 to 0°C	+/- 1.°C or 1.5% of reading
E	0 to 900°C		0 to 900°C	+/- 1.7°C or 0.5% of reading
			-200 to 0°C	+/- 1.7°C or 1 % of reading

PhoenixTM

All PhoenixTM thermocouples are manufactured using ANSCI MC96.1 thermocouple wire which has an accuracy of +/-1.1C or +/-0.4% of the range

[P44] TABLE 11 - NUMEBR OF TUS SURVEY SENSORS

Workspace Volume Less Than	3 cubic feet (0.085 m3)	225 cubic feet (6.4 m3)	300 cubic feet (8.5 m3)	400 cubic feet (11 m3)	600 cubic feet (17 m3)	800 cubic feet (23 m3)	1000 cubic feet (28 m3)	2000 cubic feet (57 m3)	3000 cubic feet (85 m3)	4000 cubic feet (113 m3)
Number of Sensors (1) Classes 1 and 2	5	9	14	16	19	21	23	30	35	40
Number of Sensors (1) Classes 3 thru 6	5	9	12	13	14	15	16	20	23	25
Cubic feet per Sensor Classes 1 and 2	<1	25	21	25	32	38	43	67	86	100
Cubic feet per Sensor Classes 3,4,5 and 6	<1	25	25	31	43	53	63	100	130	160

PhoenixTM Thermal View Survey Software allow to generate TUS report with up to 60 thermocouples

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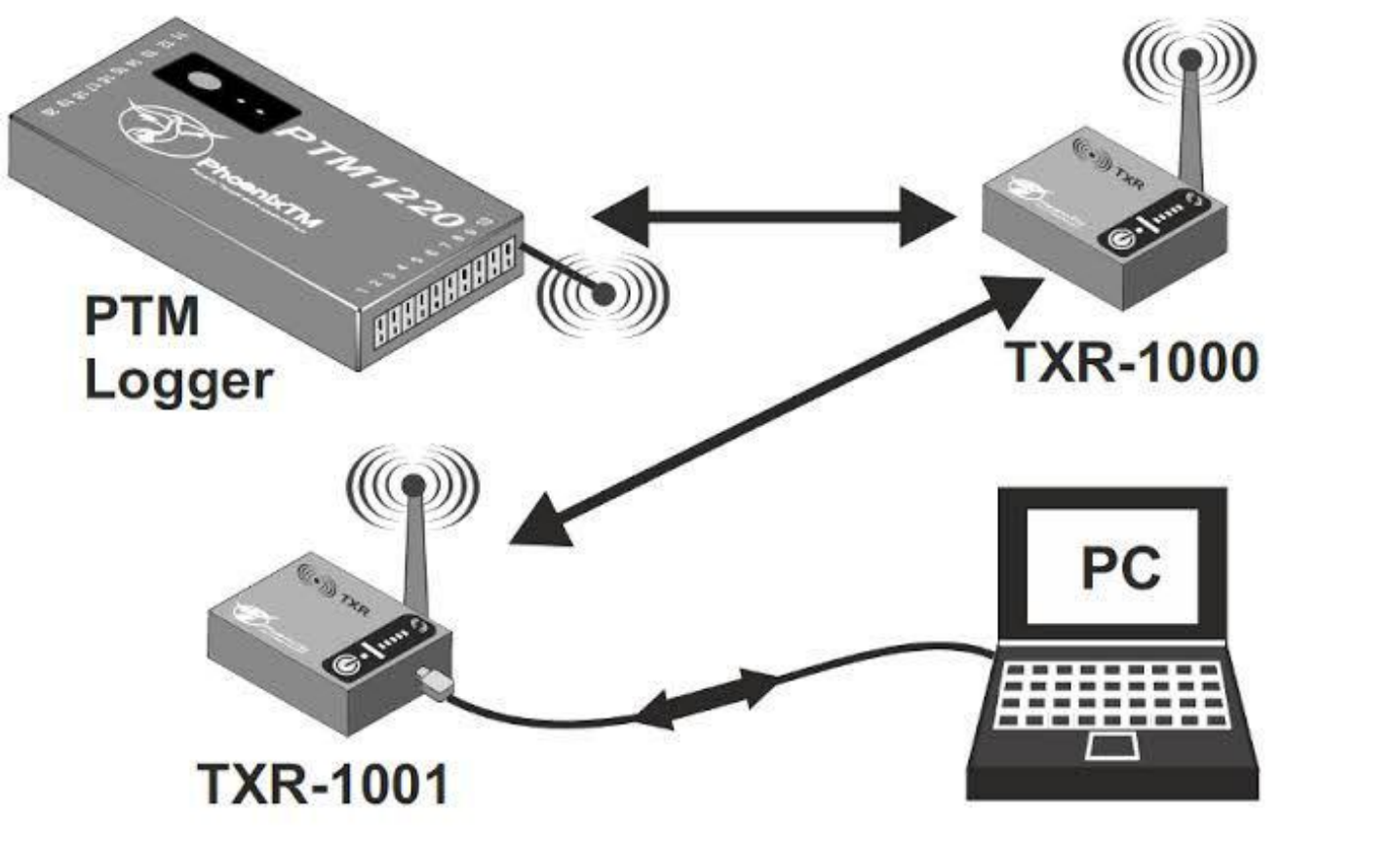
CQI-9 & AMS2750E Compliance

PSystems



RF Telemetry

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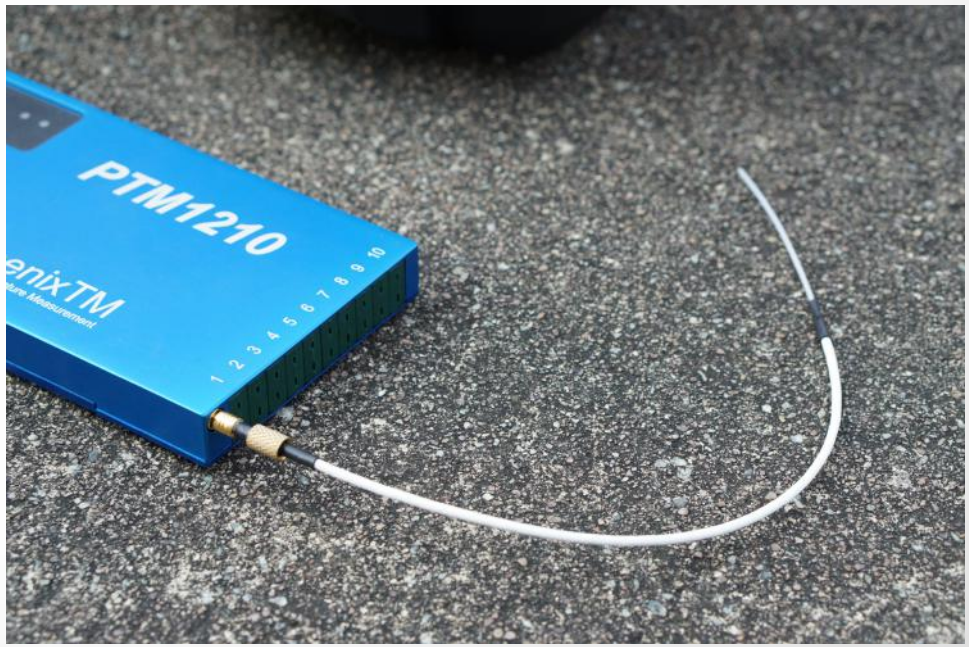

RF Telemetry

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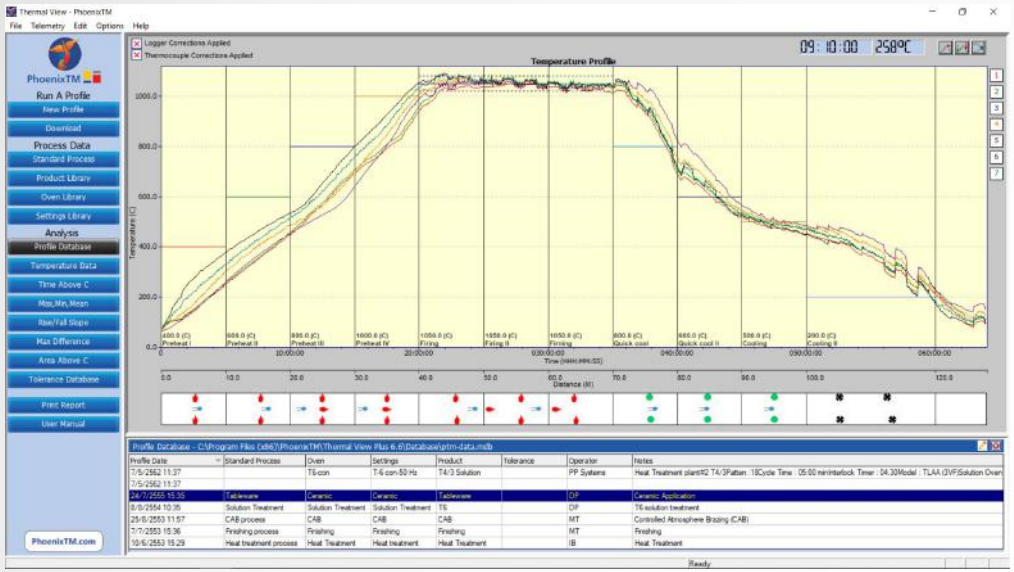
SW15 - Thermal View Plus Software



SW25 - Thermal View Survey Software

ThermalView Mobile | Android

Software & Appliaction

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[P32] 3.5.21 Temperature Uniformity Survey Report

3.5.2.1 The following items shall be included in the temperature uniformity survey report.

a. Furnace identification name or number
b. Survey temperatures
c. TUS sensor and location identification including a detailed diagram, description or photograph(s) of any load or rack used
d. Time and temperature data from all recorded sensors required for furnace instrumentation type for all zones tested (3.5.13.3.2)
e. Correction factors for TUS sensors at each survey temperature.
f. As found and as left TUS offsets (if used in production)
g. Corrected or uncorrected readings of all TUS sensors at each survey temperature. Readings shall be identified as corrected or uncorrected.
h. Testing company identification (if not performed in-house)
i. Signature for the testing company (if not performed in-house)
j. Identification of technician performing survey
k. Survey start date and time
l. Survey end date and time
m. Survey test instrument identification number
n. Indication of test pass or test fail
o. When required, documentation of furnace survey sensor failures (See 3.5.16)
p. Summary of corrected plus and minus TUS readings at each test temperature after stabilization.
q. Quality Organization approval.

3.5.21.2 Although not a required part of the uniformity survey report, the following shall be accessible on site:

a. Control instrument tuning parameters
b. TUS sensor calibration report
c. Control and recording sensor calibration report
d. Diagrams of control and recording sensors, load and TUS sensor locations in three dimensional space.

TUS Report Requirement

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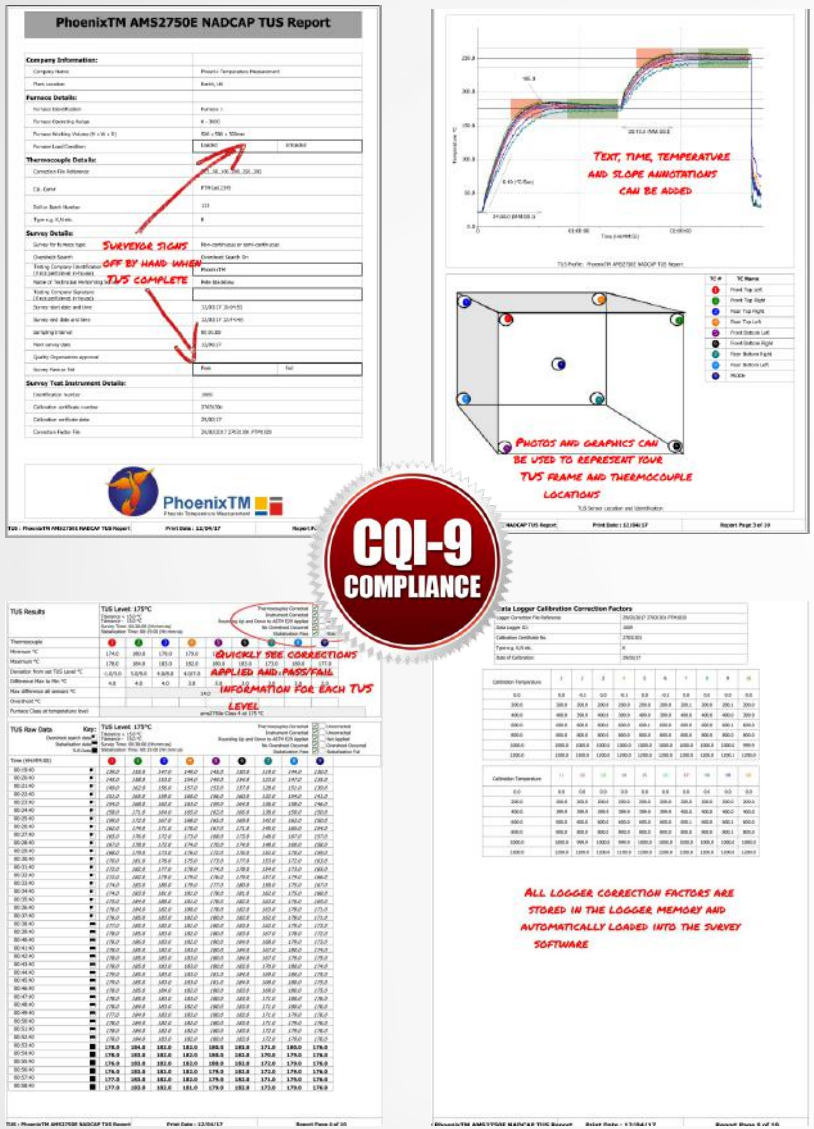
Systems



PhoenixTM Thermal View Survey Report can generate reprot accorance CQI-9 and AMS2750E standard :

- Thermocouple and Instrument Correction Factors
- Full temperature data at TUS levels
- TUS temperature level library
- TUS frame library & on-screen view
- Temperature overshoot warnings
- Password protection
- Furnace class result at each level
- Rounding Up/Down to ASTM E29
- On screen notes
- Printed report to ASM2750E etc
- Export to CSV file
- RF & USB real time analysis
- On screen help
- Database storage
- Audit trail
- TUS with up to 60 thermocouples

PhoenixTM TUS Report

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For aluminium heat treating :

Thermocouple and calibration of thermocouple shall conform AMS2750.

Instrument calibration per AMS2750 shall be quartely at a minimum.

Temperature uniformity tolerance for solution treating and aging furnace shall be **+/- 6°C**.

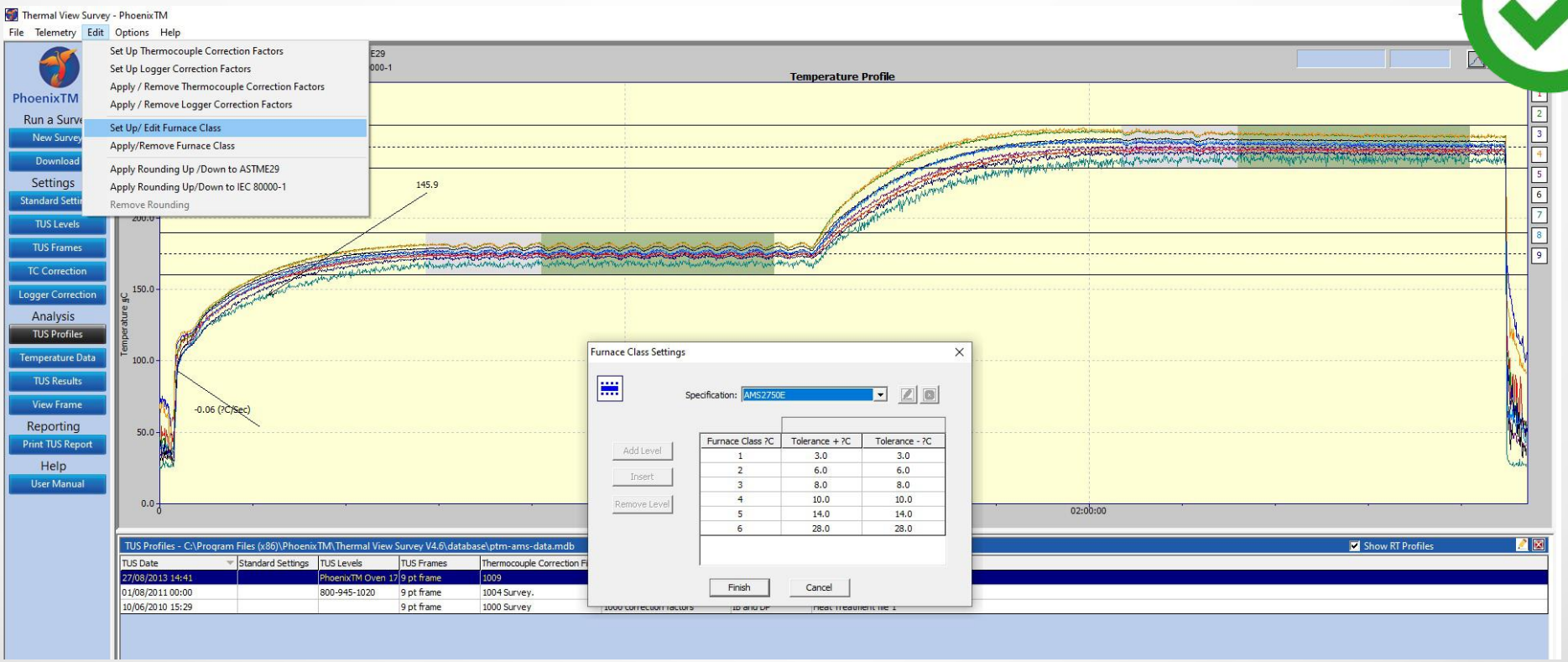
Quenchability check e.g. cooling curve of quench media, viscosity or tritration must be perform semianual.

Aluminium Heat Treating Requirement

Furnace Class	Temperature Uniformity	
	Range (Degrees F)	Range (Degrees C)
1	±5	±3
2	±10	±6
3	±15	±8
4	±20	±10
5	±25	±14
6	±50	±28

[P14] 3.3.1 FURNACE CLASS UNIFORMITY RANGE

PhoenixTM Thermal View Software provide automatically estimate furnace class calculated from TUS level to meet CQI-9 and AMS2750E standard.



Furnace Class Estimation

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Oven Customers

Distrubution period 2012 - 2019 I Thailand

Low temperature profile system is one of the most popular model. More than hundred Thai customers have proofed that thru-process temperature profile data of air and products combined PhoenixTM engineered analysis software make huge changes such as confirm paint curing, oven cold-sport surveying, preventive maintanance program, oven fault finding, production planing, researches and ect.

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TOYOTA
TOYOTA
GM
TRIUMPH
YAMAHA
VOLVO
UD TRUCKS
DENSO
LENSO
Minebea
FASCO
REGAL
SANKO GOSEI
Sodick
Vandapac
TOYODA GOSEI
THAI PARKERIZING
CHITA
AISIN
SCMP
PJW
MHG
KYB
JFILTER
HICOM AUTOMOTIVE
ABLE
CHAISERI
COMPACT BRAKE
Calsonic Kansei
NWP
AAG
MMI
COMPART
MATTEL
majorette
Titleist
DAIKIN
SANDEN
MIC
Tefcoat Professional Coating
MEYER
TOSHIBA
SHARP
Electrolux
FUNAI
WHETRON
Fuji Electric
GPV
AICHI
APEX
D.N.S. ENGINEERING
ISSES
7STARS Engineering Co., Ltd.
NEW CHOICE
TOYOINK
TOA
RICH POWDER COATINGS
PPG
OKITSUMO
JOTUN
GPC Green Powder Coatings
BCM
Henkel
MAHAPHANT
SHERA

PSystems | Temperature Monitoring Solutions

Furnace Customers

Distrubution period 2012 - 2019 I Thailand

High temperature profile system allows customer to measure process temperature up to 1,200°C particularly in aluminium and heat treatment industries. The process such as Controlled Atmosphere Brazing (CAB), Anneling fuance, T6 solution treatment, Intergrated quench caburizing fuance, vacumm furnace, AMS2750E & CQI-9 Temperature Uniformity Surveys (TUS) and System Accuracy Tests (SAT).

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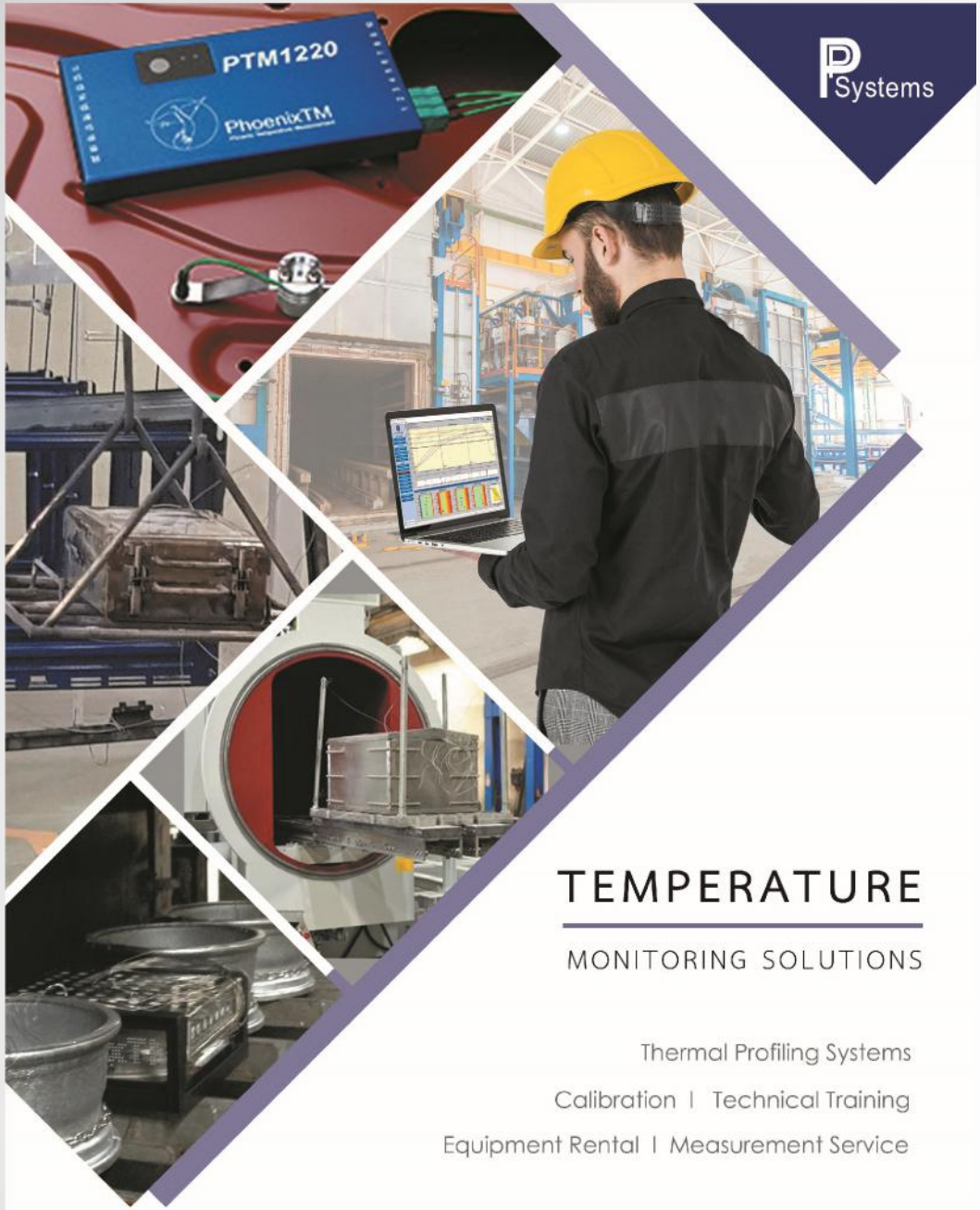

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