Thermal expansion meter for rapid quenching
(Full Automatic Transformation Measuring Apparatus)

formastor - F

(Model: FTF-260)

Specifications

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<u>**CONTENTS**</u>

1. INTRODUCTION

This apparatus measures all kinds of transformations of metallic materials as temperature vs. time graph and transformation (thermal dilation) vs. time graph and plots both graphs on the same chart (recording paper and display).

Specimen is heated at an arbitrary (selectable) and accurate heating rate in a wide temperature range from room temperature to high temperature (about 1400℃) and on completion of heating, the specimen can be maintained at specified temperature for an arbitrary (selectable) period of time. Moreover, in cooling from the high temperature to room temperature also, many cooling rates can be selected in a wide range (C.C.T.). For an example in the case of steel, the specimen can be quickly cooled from the high temperature to a desired temperature in the range from the transformation point A_1 to the point MS and can be immediately maintained at a preset temperature within this range for a desired period of time (T.T.T.).

This apparatus subjects the specimen to above mentioned thermal history and at the same time measures and records the transformations (changes of dilation) taking place in the specimen during this process against temperature.

This Apparatus mainly consists of a high frequency generator unit, a program pattern generator and data logger, an automatic temperature controller unit, a dilation detecting and measuring unit, a 2-pen automatic recorder, a specimen heating and cooling unit and a vacuum unit.

Arrangements or adjustments of heating atmospheric conditions, operational program-heating / cooling pattern, making of data logging method and operation / control based on the method, and data logging are all carried out through the computer installed. Temperature during operation and thermal dilation history are indicated on display and pen-recorder.

Accommodated data after completion of operation is filed in Excel form are used for「detection of transformation point」and also for making「CCT」and「TTT」diagram (drawings) by use of the computer installed and or any other computer available.

1.1 Main measurement items:

(1) 「Ac_1, Ac_3 transformation point」 measurement during heat rising process.

(2) 「Continuous cooling transformation point」 measurement during cooling process and 「CCT diagram」 making.

(3) 「Time-Temperature-Transformation point」 measurement during holding temperature process and 「TTT diagram」 making.

(4) Heat dilation (coefficient) measurement during heating/cooling process.

1.2 Features

(1) This apparatus is incorporated with a high frequency induction heating and a gas cooling systems, which simultaneously control adjustment both of heating power and cooling gas volume. Hence, wide range of temperature (RT ～1400℃) can be controlled at optional rates for rapid heating/cooling and also gradual heating/cooling to enable reproduction of heating history corresponding to various heating treatments.

(2) Detection mechanism for dilation changes occurring from transformation is composed of low dilation material like quartz, super invar alloy, and so on to avoid affects from surrounding temperatures.

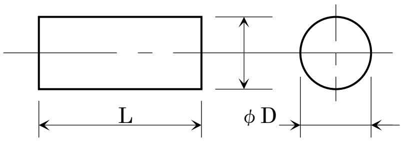
(3) This computer system is designed under our basic conception of HMI (Human – Machine – Interface). The system is integrated with use of relating hardware and also software enabling performance control, data collection and data processing of measurement results (automatic detection of transformation point, CCT and TTT diagram making, etc.) during operation process ranging from pattern generation.

(4) In order to prevent materials from being deteriorated by oxidation, de-carbonization and so on, it is possible to do tests under vacuum or inert gas atmosphere.

2. MAIN PERFORMANCES

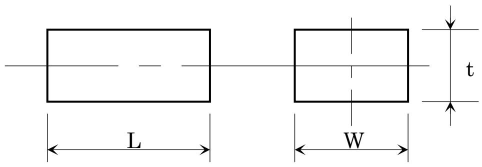
2.1 Dimension of Specimen

(1) Cylindrical type



No	ϕD	L
1	3±0.2	10
2	2±0.2	10

(2) Rectangular type



No	L	t	W
3	10	3±0.2	3
4	10	2±0.2	3
5	10	1.2±0.2	3

2.2 Heating System

High Frequency Induction Heating System

2.3 Cooling System

Gas spray system through double coiled nozzles
(automatic flow control by Gas flow control valve)

2.4 General Temperature Range Test Performance

<u>**Objective specimen： ϕ3×10mm**</u>

(1) Temperature detection : R thermocouple

(2) Temperature range : RT～1400℃

(3) Heating rate

<No controlled heating> : Max 135℃/sec (RT～1350℃averaged rate)

< Controlled heating > : Min.1℃/hour (RT~1350℃ linear control)

: Max 100℃/sec (RT～1350℃linear control)

(4) Temperature control : ±1℃ (RT～1350℃ stationary state)

(5) Temperature control accuracy

<Dynamic control> : RT~400℃ 5℃ or less

: 400~1350℃ 10℃ or less

<Stationary state> : RT~1350℃ ±1℃

(6) Cooling medium gas : N_2, He, and Ar

(7) Cooling rate and accuracy

Cooling range 900~300℃, excluding latent heat transformation affect.

<No controlled cooling> : He Gas 250℃/sec 900~300℃
N_2 Gas 80℃/sec 900~300℃

<Controlled cooling> : Min 1℃/hour 900℃~RT
(Linear control) Max. 50℃/sec 900~300℃ (He gas)

2.5 Dilation Measurement

1) Detection system : Differential transformation system
2) Detection method : Expansion length direction of specimen
3) Measuring range : 4 ranges of 0.5, 0.2, 0.1, 0.05mm
4) Accuracy : ±1.0% / each range
: Min. 0.08 μm
(not specification but target valve)
5) Nonlinear value : Max. 0.1%
(not specification but target valve)
6) Stability : 2 μ / hour (RT change within 1℃)
7) Output voltage : ±5V / each range

2.6 Vacuum/Exhaust System

1) Rotary pump : 162 (50Hz) / 197 (60 Hz) ℓ/min.
2) Diffusion pump : 360 L /sec (Dia. 3 inches)
3) Vacuuming rate : Max. 1.3 x 10^{-2} Pa / 15 min.
4) Attainable vacuum : Order of 10^{-3} Pa
5) Valve drive : Air drive system (pneumatic valve)

3. COMPUTER SYSTEM

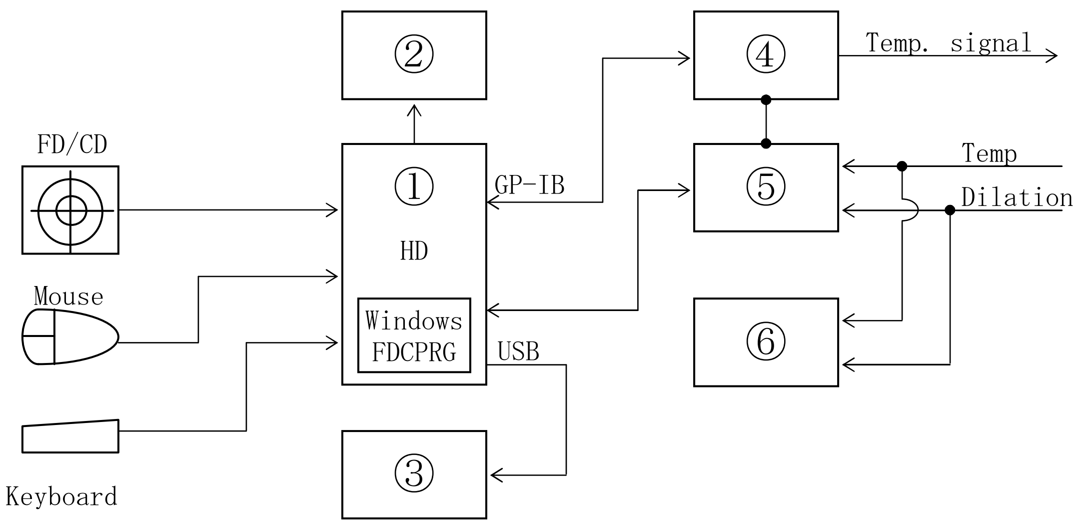
This system carries out the following;

- Program pattern generation and data logging/cooling/other commands.
- Test program making and control of behavior in testing process according to the test program.
- Data accumulation obtained in the testing process and data processing of operation/analysis/diagram making/etc. based on the test results.

This system consists of the following hardware and also software described hereunder.

Furthermore this system's program can be used by other computers and with friendly HMI.

3.1 Hardware



1	Computer O.S.	Windows O.S.
2	Display	17 inch. color
3	Printer	A4 size, ink jet
4	Pattern generator	Model PSG-104, 1CH, 16 bit
5	Data logger	Model NR-1000, 4CH, 16 bit, 2MB
6	Pen recorder	Model 3712-21(YEW), 2 pens

Fig. 1 Computer system - Hardware constitution

3.2 「FDCPRG」Software

「FDCPRG」software is operated under「Windows」O.S. and uses “C language”.

「FDCPRG」 consists of the following files;

「FDCPRG」 System for formastor-F		
Program		Description
Main menu		Program selection
Pattern generation/making		Program generation pattern making and filing
Operation/Data logging		Pattern generation/data logging (accumulation) and filing
Data analysis menu		Selection of the following data analysis program.
	TDDP	「Temperature-Dilation」 diagram →CCT transformation temperature detection
		「Temperature-Dilation curves : overwriting up to 24 curves
		「Time-Temperature/Dilation」diagram*1 →TTT transformation temperature detection
		「Coefficient of dilation」 operation
		Data filing to CCT/TTT*2
	CCT	CCT diagram drawing (up to 24 curves)
		CCT diagram filing
	TTT	TTT diagram drawing (up to 12 curves)
		TTT diagram filing
	TIMEDP	Data analysis for equally divided time
Data check		For logging data check
Disk utility		Path setting of pattern data
		Path setting of accumulated data
		Read-out of disk manager soft

*1 Time axis is in logarithm graduation.

*2 It is possible to select either “binary” or “ASCII (Excel)” filing.

*3 Logging data is displayed on display monitor on “ON – LINE”.

3.3 Data Processing

3.3.1 TDDP

1) Operation/ Display/Drawing

① This reads out the accumulated actual data and then by moving averaging these data , 「Time -Temperature・Dilation」 or 「Temperature – Dilation」 is operated and displayed.

② Above curve is displayed and also output to printer.

Note: Both of temperature scale and dilation range can be freely changed.

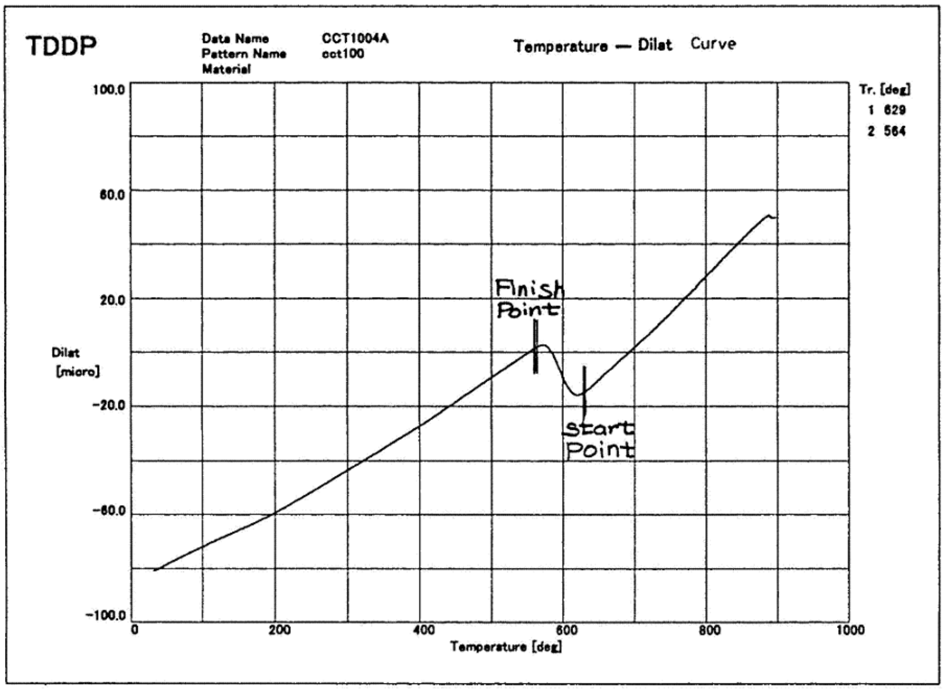


Fig 2. 「Temperature – Dilation」(CCT) curve and

<u>Transformation temperature detection on CCT curve</u>

2) Transformation Temperature Detection

Transformation temperature is detected on the curve drawn on the item 1) in 3.3.1.

＜ Detection on 「Temperature - Dilation」(CCT) curve ＞… Fig.2

① When “Automatic Detection” is selected, cursor is indicated. It comes down on the curve from higher temperature side, operating gradient and so on.

② When the transformation temperature is detected, the point is acknowledged as the starting point of transformation. Cursor stops at the point, which is the 「transformation temperature」.

③ “Automatic Detection” starts again, cursor simultaneously moves and stops at the different point on the curve, which is the second transformation point and finishing point.

④ Simultaneously, detection and registration of transformation temperature shall be repeatedly done.

< Detection on 「Time – Temperature・Dilation」 Curve＞… Fig. 3

Transformation temperature is detected on dilation curve and starting/finishing time is detected on temperature curve.

① Automatic detection of transformation temperature starts with data starting point on time axis. Same operation as stated in the above shall be done for detection of transformation and registration.

② The point when the temperature falls to constant temperature shall be the starting point (“ 0 “ second) for the time determination. It is the time standard.

Note 1: When “automatic detection” is impossible, when manual detection is desired or when detection point is desired to be corrected/added, cursor manually.

Note 2: It is possible to detect transformation temperature by enlarging a specific part of the curve.

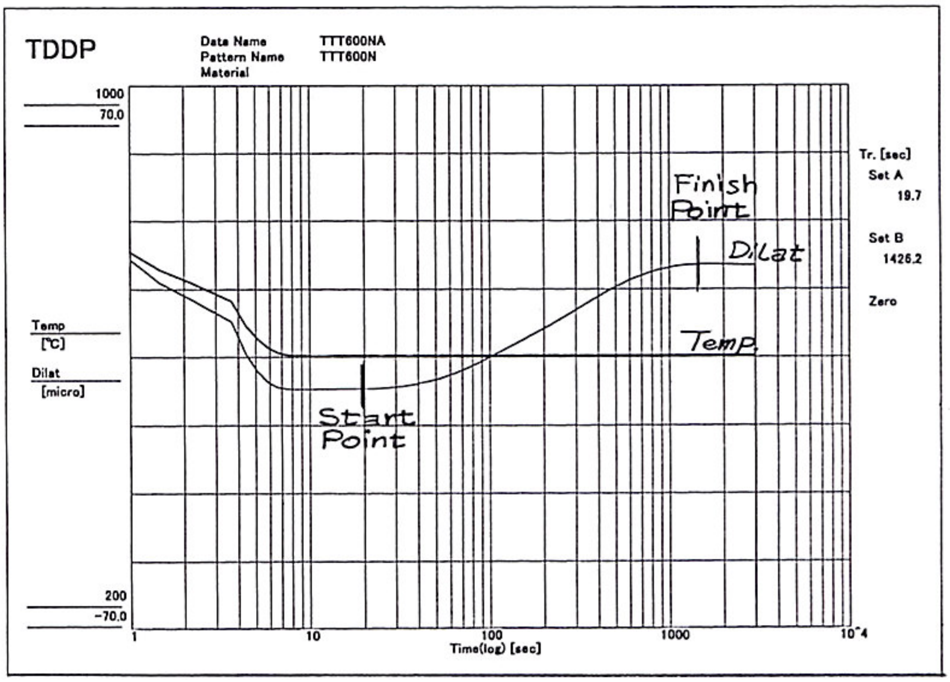


Fig. 3.「Time –Temperature・Dilation」(TTT) curve and

<u>Transformation temperature detection on TTT curve</u>

3) 「CCT」 and 「TTT」 file making

① Data that the transformation temperature is detected and registered on「Temperature – Dilation」curve shall be saved in 「CCT」 file for making 「CCT diagram」.

② Data that the transformation point is detected and registered on「Time – Temperature・Dilation」curve shall be saved in 「TTT」file for making 「TTT diagram」.

4) Operation of coefficient of linear thermal expansion Dilation coefficient can be operated from 「Temperature – Dilation」(CCT) curve.
For this, data during heat rise process is necessary.
By inputting temperature range and step temperature, dilation coefficient is output accordingly.

3.3.2 「CCT」 and 「TTT」

1) 「CCT」diagram … Fig. 4

① Read out maximum 24 curves of CCT data from 「CCT」file made under the item 3) in 3.3.1 and output 「Time – Temperature」curve on display screen.

② Make CCT diagram on display by inputting necessary comments and boundary line by using mouse and key.

③ After outputting to printer, save whole CCT drawing in 「CCT」file.

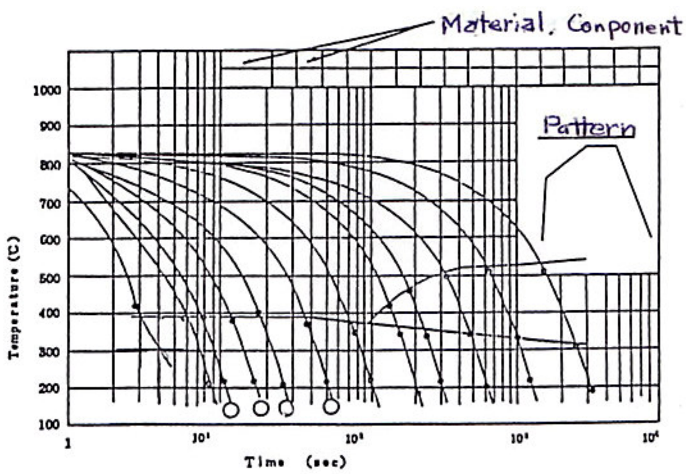


Fig. 4 CCT diagram

2) 「TTT」 diagram … Fig. 5

① Read out maximum 12 curves of TTT data from 「TTT」 file made under the item 3) in 3.3.1 and output, on display screen, transformation temperature on「Time – Temperature」co-ordinate.

② Make TTT diagram by similar operation to the item 1). After outputting to printer, save whole TTT diagram in 「TTT」 file.

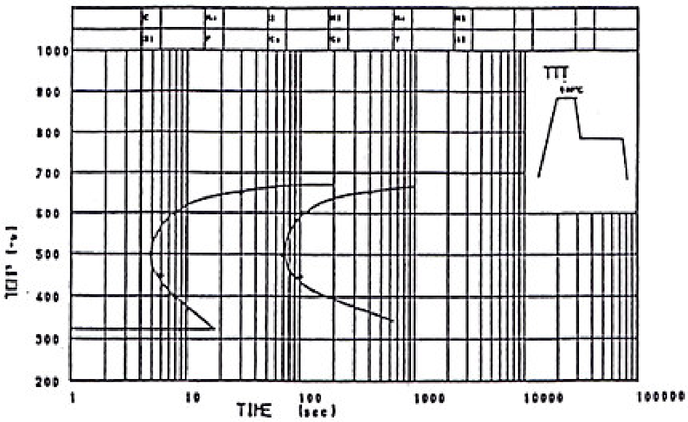


Fig. 5 TTT diagram

3.3.3 「PRESENT」

This is to make sheets for presentation. This can output the following diagram analyzed;

① Actual data	: Diagram processed by 「TIMEDP」
② 「Temperature – Dilation」data	: Diagram processed by 「TDDP」
③ 「Time – Temperature ・ Dilation」data	: Diagram processed by 「TDDP」
④ CCT diagram	: Diagram processed and made by 「CCT」
⑤ TTT diagram	: Diagram processed and made by 「TTT」

4. OPERATION FLOW CHART

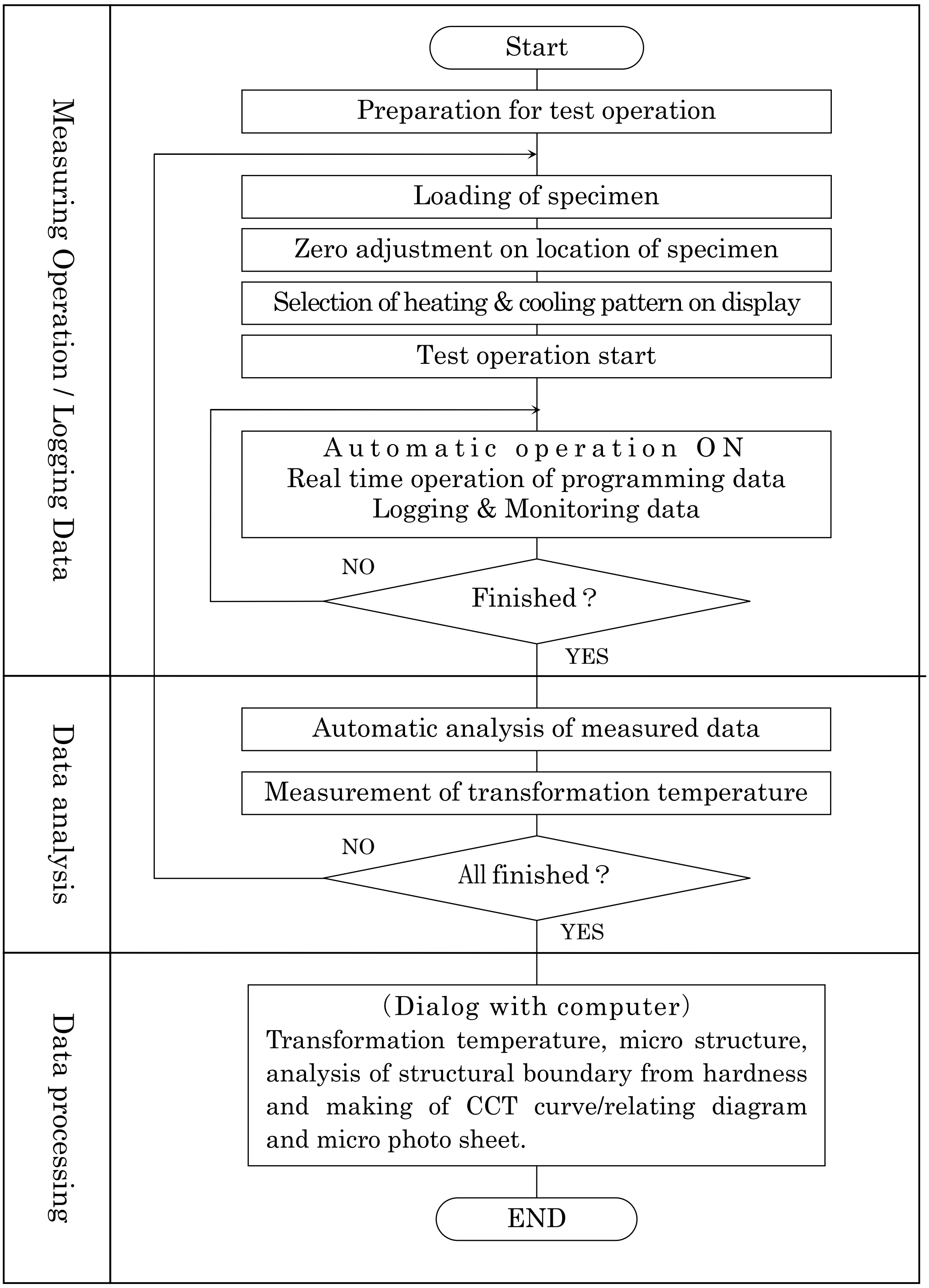
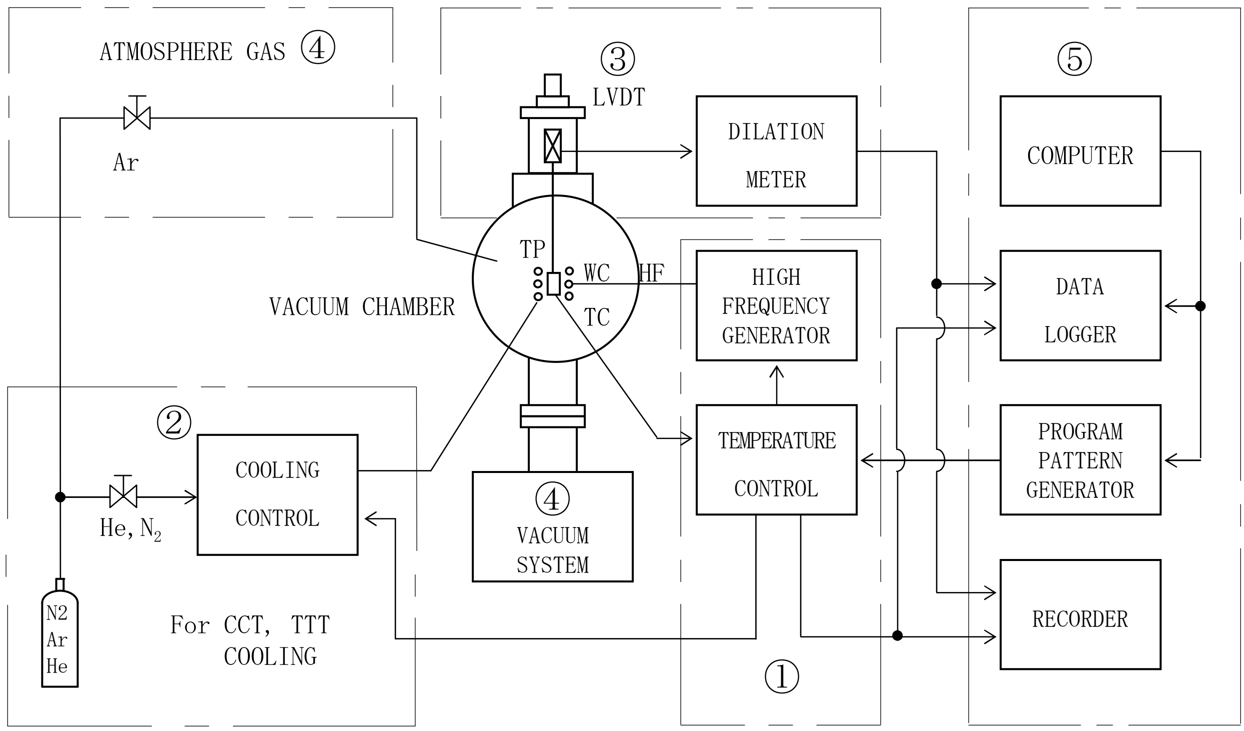


Fig. 6 Test operation flow chart

5. SYSTEM CONSTITUTION AND SPECIFICATIONS

Constitution of formastor－F is hereunder described. This system consists of Vacuum・Atmosphere Chamber (within Heating・Cooling System included) as the main constitution, Atmosphere adjustment system, Dilation measurement system, Heating control system, Cooling control system and Computer system.



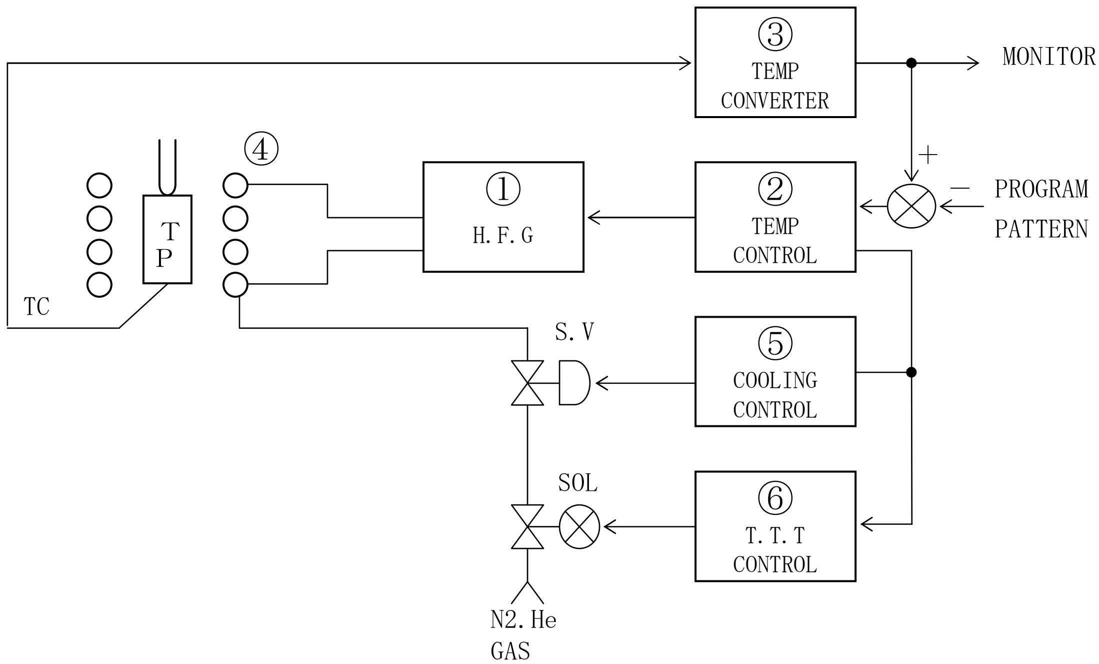
①	Heating control system	Heating control of specimen
②	Cooling control system	Cooling control of specimen
③	Dilation measurement system	Thermal dilation measurement
④	Atmosphere adjustment system	Vacuum or atmospheric gas adjustment
⑤	Computer system	Operation control・measured data treatment

Fig. 7 System constitution

5.1 Heating/Cooling Control System

High frequency induction heating system and cooling gas spraying system are incorporated with the machine, enabling highly precise heating and cooling control of wide range of temperature. By using of differential signals from thermocouple welded onto specimen and also from pattern generator, heating and cooling control can be done in two controlling ways; high frequency power output control and cooling gas spraying volume control either independently or in combination thereof.

This wide range of control adjustment mechanism and high speed response enables test of specimen in wide temperature range from low temperature range to melting point temperature range and make it possible to do long time test for more than one week.



1	High frequency generator	Output 1.5kW, 1.7MHz
2	Temperature controller	PID control
3	Temperature converter	For R type thermocouple
4	Heating coil	Double coiled with cooling gas pipe with nozzles
5	Cooling gas flow control mechanism	Servo valve controller (cooling controller)
6	Cooling gas automatic stop・automatic reset mechanism	Solenoid valve, integral time adjustment mechanism

Fig. 8 Heating/Cooling control system

5.1.1.1 High Frequency Generator

1) Oscillation method	: Colpitts method
2) Output	: 1.5 kW
3) Frequency	: 1.7MHz ± 10%
4) Output control	: Duty control (PWM)
5) Output range	: 0～100% / 0～5V
6) Oscillation bulb	: 6T58RA
7) Power supply	: 1 φ 200V 3.5kVA
8) Cooling water	: 8 ℓ/min. 0.25～0.35MPa (2.5～3.5kgf/cm^2)
	Back pressure 0.05MPa (0.5kgf / cm^2)
9) Protection circuit	: ① Over current relay
	: ② Water shut-off relay

5.1.2 Temperature Controller

1) Control method	: PID operation method
2) Setting input	: ① 0～4V / 0～1600℃ (R thermocouple)
3) Thermocouple input	: ① 0～16mV / 0～1600℃ (R thermocouple)
4) Output signal	: ① 0～5V / 0～100% (heating signal)
	: ② ±10V / ±100% (cooling signal)
5) Control accuracy	
<Dynamic control>	: RT ~ 400℃ 5℃ or less
	: 400 ~ 1350℃ 10℃ or less
<Stationary state>	: RT ~ 1350℃ ±1℃
6) Temperature indication	: 3-1/2 figures Digital indication
	(actual/differential measurement)
7) Protection circuit	: Temperature deviation limit (±100℃)

< Temperature converter (conditioner) >

1) Model : MS-3201-R
2) Input signal : 0～18.74mV / 0～1600℃
3) Output signal : 0～16mV / 0～1600℃ (linear)
4) Accuracy : ±(0.1%FS + 0.3℃ linearize accuracy)
5) Response Speed : 100Hz
6) Protection Circuit : UP Burnout

5.1.4 Cooling Controller

2 different kinds of cooling control circuits are prepared in 2 series; one for controlled cooling and the other for rapid cooling (quenching) .

< Common >

1) Cooling method : Gas spray from nozzles on inner coil
2) Cooling signal : Time signal ON/OFF signal from pattern generator
3) Cooling gas : Kinds N_2, He
: Quantity Max. 0.7MPa, 200 ℓ/min.

< Controlled Cooling Circuit >

1) Control method : PID operation method
2) Control object : Gas flow 0～ 70 ℓ/min.
3) Input signal : Temperature differential signal ±10V / ±200℃
4) Output signal : Signal to servo valve ±100mA /±100%
5) Monitor : ±100mA Analog Meter
6) Valve : Servo valve 58A

< Rapid Cooling Circuit >

1) Control method : 2 position (ON/OFF) control
2) Valve : Solenoid valve AC200V

< Cooling Stop Mechanism >

Cooling valve should be turned to “CLOSE” at the temperature set for a target temperature.

1) Cooling stop setting method : Temperature differential setting method by dial

2) Temperature differential setting range: 0～200℃ for target temperature

< Auto Reset Mechanism >

This is a mechanism rapidly to attain the target temperature, decreasing unnecessary time by altering integrating time.

1) Reset setting method: Time differential setting method by dial

2) Temperature differential setting range: 0～100℃ for target

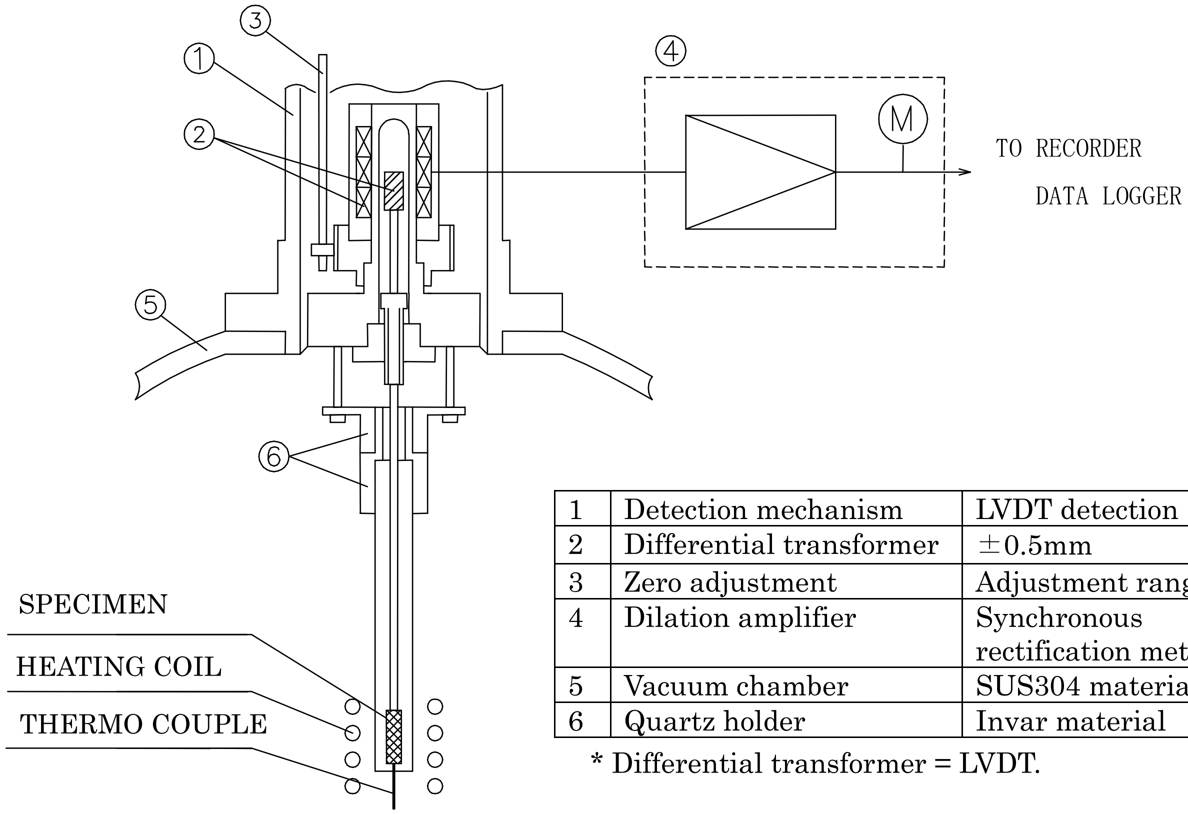
The above 2 – kinds mechanism operate for making T.T.T curves.

These mechanism prevent overshoot (undershoot) at the time of abrupt temperature change to stationary state in T.T.T. program and allow to reach desired temperature (constant temperature) in a short time.

5.2 Dilation Measurement System

formastor-F detects transformation start and finish points through dilation change to the length direction of specimen .

In order to increase detection accuracy, high sensitivity and high accuracy linear variable differential transformer (LVDT) is used and in order to remove as much affects like changes in room temperature as possible, low dilation material such as quartz, super invar, etc. are used.



1	Detection mechanism	LVDT detection
2	Differential transformer	±0.5mm
3	Zero adjustment	Adjustment range 5mm
4	Dilation amplifier	Synchronous rectification method
5	Vacuum chamber	SUS304 material
6	Quartz holder	Invar material

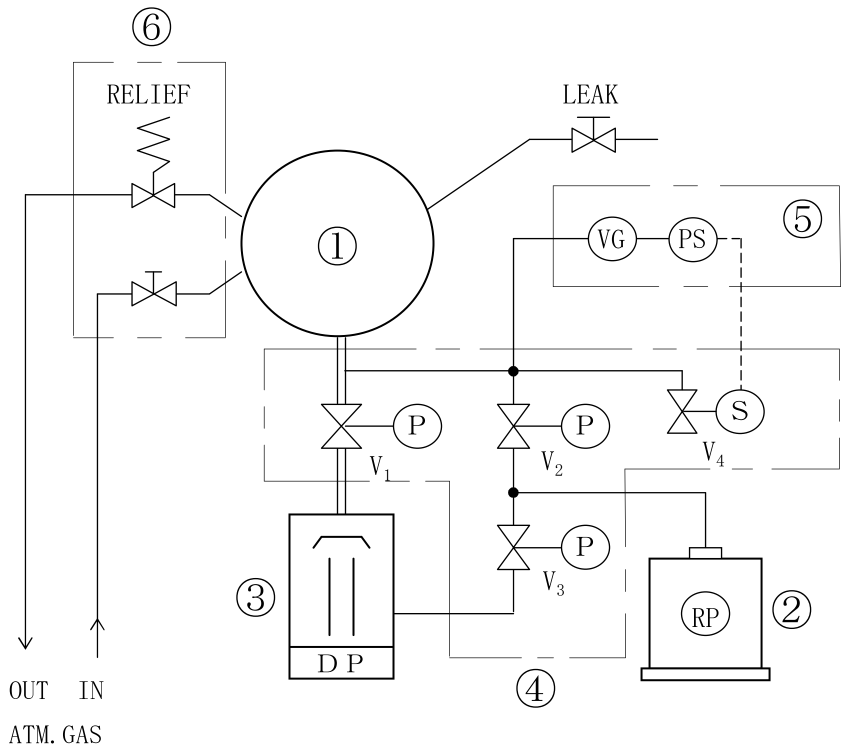
* Differential transformer = LVDT.

Fig. 9　Dilation detection system constitution

1) Measuring range　:0.5mm, 0.2mm, 0.1mm and 0.05mm
2) Detection accuracy　:±1.0% / each range
3) Initial drift time　:Approx. 30 min.
4) Stability　:2 μm / hour
5) Output signal　:±5V / each range
6) Indication　:Digital indication　±100.0% / each range

5.3 Test Atmosphere Adjustment System

In order to prevent specimen under heating process from degeneration of being oxidized, de-carbonized and so on, heating/cooling system and a part of dilation detection system are put in the vacuum chamber. This system has the structure allowing atmosphere adjustment by vacuum or inert gas.



PS : Pressure Switch	VG : Vacuum Gauge	V_1 : Main Valve
P : Pneumatic Valve	S : Solenoid Valve	V_2 : Roughing Valve
RP : Rotary Pump	DP : Diffusion Pump	V_3 : Fore Valve
		V_4 : Leak Valve

Fig.10 Atmosphere adjustment system structure

1	Vacuum chamber	Approx. 14 ℓ
2	Rotary pump	Exhaust Volume 162 (50Hz) /197 (60Hz) ℓ/min.
3	Diffusion pump	Exhaust Volume 360 ℓ/ sec
4	Vacuum valve	Main valve, roughing valve and fore valve
5	Pressure gauge (Vacuum gauge)	Pirani and Penning gauges
6	Atmospheric gas	Gas flow valve, gas pressure control (relief) valve

5.3.1 Vacuum Chamber

1) Material	: SUS304
2) Size	: ϕ 300 x D200
3) Port	: ① Cooling and atmospheric gas port
	: ② Leak gas exhaust port
	: ③ Gauge port
	: ④ Thermocouple port
	: ⑤ High frequency induction lead-through port
	: ⑥ Dilation detection port
4) Observation window	: ϕ 50

5.3.2 Rotary Pump

1) Model	: RV8
2) Exhaust rate	: 162 (50Hz) / 197 (60Hz) ℓ/min.
3) Attainable pressure	: 1.3 x 10^{-1}Pa order
4) Oil volume	: 750 cc
5) Motor	: 1 ϕ 200V 450W (50Hz) / 550W (60Hz)
6) Protection Circuit	: Auto-leak

5.3.3 Diffusion Pump

1) Model	: DSS-321 (DPF-3Z 3 inch)
2) Exhaust rate	: 360 ℓ/ sec
3) Attainable pressure	: 1.3 x 10^{-4}Pa order
4) Oil volume	: 100 cc
5) Heater	: 1 ϕ 200V 500W
6) Cooling water	: 2 ℓ/min. 0.25Mpa (2.5kgf / cm^2)
7) Protection Circuit	: ① Flow switch
	: ② Over-heat

5.3.4 Valve

1) Driving method : Pneumatic method

2) Air pressure : 0.4MPa (4kg/cm^2)

3) Main valve : 3 inch flapper valve

4) Roughing/Back valve : 1 inch 3 way valve

5) Leak valve : 1/4" inch solenoid valve

6) Protection circuit : ① Air pressure detection

: ② Main valve open/close LS

5.3.5 Vacuum Gauge

<Pressure switch – Digital Indication>

1) Model : PIS-PO1K

2) Measuring pressure : 0～ 0.1 MPa

3) Contact switch : 0.01MPa (ON)

<Pirani gauge>

1) Model : ① Sensor P-3

: ② Amplifier VS-10P

2) Measuring pressure : 10^2 ～10^{-1}Pa

3) Contact switch : 10Pa (ON)

<Penning gauge>

1) Model : ① Sensor C-1

: ② Amplifier VS-5P

2) Measuring pressure : 10^{-1} ～10^{-4} Pa

3) Contact switch : 1.3 x 10^{-2}Pa (ON)

5.3.6 Atmospheric Gas Relations

1) Atmospheric gas : Inert gas (Ar, N_2)

2) Gas flow-through valve : 1/4 inch solenoid valve

3) Gas exhaust valve : 1/4 inch solenoid valve

5.4 Computer System

This system consists of DOS/V and the "Windows" OS type computer as the main items, Display, Printer, Pattern generator and controlled by GP-IB and Data logger.

5.4.1 Computer

1) Model	: *Opti Plex GX280	
2) C P U	: *Pentium 4 (more than 2.0GHz)	
3) Memory	: 256 MB	
4) Medium equipment	: ① Floppy Disk 3.5 inch	
	: ② Hard Disk *40 GB	
	: ③ CD R/W	
5) O. S.	: Windows * XP Prof. Edition	
6) Interface	: USB, RS-232C, GP-IB	

5.4.2 Display (Separate Setting)

1) Model	: *E172EPb
2) Size	: 17 inch Color
3) Control	: Brightness/contrast/size/position

5.4.3 Printer (Separate Setting)

1) Model	:*PIXUS ip3100
2) Printing method	: Ink Jet Method
3) Size	: A4
4) Resolution	: 4800 x 1200 dot/inch *
5) Printing rate	: 15 sheets / min: color *

Note: * Items with * mark for model No., function, etc. may change to those available at the time of discussion and/or contract.

5.4.4 Pattern Generator

1) Model	: PSG-104 (1 channel Pattern generator)
2) Programming method	: Program transfer from computer
3) Channel	: 1 ch. (Temperature)
4) Address	: 99 points
5) Time setting	: (1～9999 sec) x 1/100, 1/10, 1 and 10
6) Temperature setting	: -200～1600℃ 1℃ step
7) Controlled signal	: 8 series (RT1～RT8)
8) Controlled signal setting	: 1 / series / each address
9) Output voltage	: 1 ch. –0.5～4v
10) Output voltage accuracy	: ±0.1% (16 bits)
11) Output time accuracy	: ±0.1 sec at " x 1 " magnification
12) Interface	: GP-IB

5.4.5 Data Logger

1) Model	: NR-1000 (4 channel data logger)
2) Channel	: ① 1 ch (Temperature)
	: ② 2 ch (Dilation)

Note : 3 and 4 ch are for spare use.

3) Memory	: 2MB
4) Resolution	: 16 bits
5) Input signal	: ① 1ch (Temperature) 0~5V / 0~1600℃
	: ② 2 ch (Dilation) ±5V/±100%
6) Sampling time	: 0.1sec ~ 24hr
7) Accuracy	: DC volt ±0.08% of F.S.
8) Interface	: USB (Ver 1.0)
9) Accessory	: AC adapter, USB cable

5.5 Recorder

1) Model	: 3712-21 (YEW)
2) Pen	: 2 pens (red and green)
& signal	Temperature and dilation
3) Recording paper width	: 250mm
4) Accuracy	: ±0.25% / recording paper width
5) Pen rate	: 1600mm/sec
6) measuring range	: Direct current (DCV) 10mV～200V F.S.
7) Recording paper	: Folding type approx. 20m (DIN chart)
8) Chart speed	: 10～1200mm/min and mm/hour
9) Remote function	: Pen up・down
	Chart start, stop
	Chart speed 2 kinds

5.6 PLC (Sequencer)

1) Model	: FX2N (MITSUBISHI)
2) CPU	: Specific LSI
3) Control	: Repeated computation system
4) Processing speed	: 0.08 μ sec (basic instruction)
5) Input/output points	: 128 points
6) Memory Capacity	: 16k step
7) Input relay	: DC24V 7mA photo coupler insulation (7)
8) Output relay	: AC250V/DC30V 2A

5.7 Cooling Water Supply Unit

1)	Circulation method	: Closed loop method
2)	Temperature adjustment	: −20 ~ 30℃
3)	Cooling capacity	: 1.2kW (1030 kcal/h) at 10℃
4)	Water flow rate	: Max. 15ℓ/min. at 0.1MPa (50Hz)
5)	Outlet water temp control	: ±2℃ or less
6)	Setting / Monitoring temp	: Key input / 1℃ step
7)	Cooling method / media	: Air cooling / R22
8)	Water tank capacity	: 16.5ℓ (SUS304)
9)	Power up pump	: Turbine pump (KLD01S) Capacity 8ℓ/min. at 0.1MPa AC POWER 1φ AC100V 100W
10)	Protection mechanism	: Breaker & Fuse Over current High pressure (Refrigerant) Thermal (Pump)
11)	AC POWER	: 1φ AC100V 50Hz 1.5kVA
12)	Dimension / weight	: W354 x D384 x H1000 43kg

5.8 Cooling Gas Bomb & Regulator

This bomb is used for cooling.

1)	Capacity	$1m^3$
2)	Pressure	25MPa
3)	Diameter	φ7 horse joint
4)	Regulator	Primary : Max. 25MPa Secondary : Max. 2.5MPa

6. Safety Protection Mechanism

In order to secure safety and protection of the system during operation, following safety/protection mechanism are incorporated.

6.1 Countermeasure for Electricity Service Interruption

1) Oscillation, heating and cooling stoppage
2) Exhausting system shut down
3) Prevention of rotary pump oil from adverse flow

6.2 Countermeasure for Cooling Water Failure

1) Oscillation・heating stoppage
2) Diffusion pump shut down

6.3 Countermeasure for Pressure Rise in Chamber

When pressure in chamber should rise over specified setting point during cooling, safety valve (pressure control valve) opens to discharge gas and prevents abnormal pressure rise.

6.4 Countermeasure for Oscillation・Heating Problems

Alarm indications are on for problems during oscillating heating.　When the followings should happen, heating immediately stops.

1) Chamber door opens.
2) Current is over rated current.
3) Either cooling water supply stops or is less than specified requirement.
4) Abnormal situation happens with vacuum/exhaust relations.
5) Temperature differential limit starts working.
6) Operation finishes as programmed.

6.5 Countermeasures Vacuum/Exhaust Relations.

6.5.1 Countermeasures for Opening/ Closing of Valves

1) As pneumatic method is adopted for this apparatus, alarm lamp is on when compressed air is not supplied.
2) Limit SW is incorporated with valve for main valve opening and closing. Upon definite confirmation of detection of opening/closing, sequences works.
3) Interlocks allows to open/close valves when the following conditions are met.
   ① Leak valve : Main and roughing valves are "”closed”
   ② Roughing valve : Main and fore valves are “closed”
   ③ Fore valve : Roughing valve is “closed”
   ④ Main valve : Roughing valve is “closed” and fore valve is “open”
4) Start of cooling makes roughing or main valve “closed”
5) When vacuum does not reach less than 1.33 x 10^{-2}Pa within 30 min. after start with main valve “open” , main valve will be “closed”
6) During electricity service interruption, all valves are “closed”

6.5.2 Countermeasures for Rotary Pump

1) When Magnet Contactor thermal relay starts working, pump stops.
2) When electricity service is interrupted, pump stops.
3) When rotary pump stops, mechanism to prevent operation oil from adverse flow starts working.

6.5.3 Countermeasures for Diffusion Pump

Pump stops in the following case ;

1) When cooling water supply stops or is less than specified requirement
2) When thermal relay for prevention of over heating starts working
3) When rotary pump stops
4) When electricity service is interrupted
5) When vacuum does not reach less than1.33 x 10^{-2}Pa within 20 minutes after start

6.5.4 Countermeasures for Vacuum Gauge

For protection of sensor in vacuuming gauge, power will be output when the gauges indicate the following vacuum attained:

1) Pirani gauge : Compound gauge indicates "-0.1Mpa"

2) Penning gauge : Pirani gauge indicates "1.33 x 10Pa"

6.6 Power Supply Relations

1) Earth leakage breaker	(ELB)	: For main electricity supply switch.		
			Cut-off	: over 100mA
2) Over-current relay	(NFB)	: For control relatives.	Cut-off	: over 10A
3) Over-current relay	(NFB)	: For rotary pump.	Cut-0ff	: over 10A
4) Over-current relay	(NFB)	: For diffusion pump.	Cut-off	: over 10A

7. STANDARD ACCCESSORIES

1	Temperature Detection Parts			
	1	Thermocouple welder	APW AC100V 1kVA	1 unit
	2	Thermocouple	R ϕ 0.2 x 1 m	2 pairs
	3	Insulation tube	Single tube OD 1.2 x L 100	100 pcs
			Double Tube OD 1.6 x L 25	30 pcs
	4	Temp. keeping tube	SUS ϕ 2.0 x L 25	10 pcs
	5	Adhesive	Aronceramic C	1 pc
	6	Vinyl tube	Red, Black ϕ 1.0 x L 3m	1 pair
2	Recording Parts			
	1	Recorder	Chart paper B9619AM 10 rolls	1 box
			Cartridge pen B9586 (red, green)	3 sets
			Ink ribbon	1 pc
	2	Printer	Print paper A4 500 sheets	1 vol
			Ink cartridge (Black, Color)	1 set
	3	Media	CD 10 sheets	1 box
3	Heating and cooling parts			
	1	Heating Coil	For ϕ 3	1 pc
	2	Specimen holder	Quartz tube & rod for ϕ 3, ϕ 2	5 pairs
			Quartz tube & rod for $^t3$, $^t2$	5 pairs
			Quartz tube & rod for $^t1.2$	5 pairs
	3	Cooling tube	Urethane 1/4" x 5m	1 vol
4	Vacuuming Parts			
	1	Vacuum grease	H1-VAC	1 pc
	2	O - ring		1 set
	3	Gauze		1 pack
5	Utility Parts			
	1	Elec. power cord	4 core 3.5sq 5m	1 pc
	2	Cooling water hose	Vinyl ID9 x 10m	1 pc
	3	Air hose	Rubber ID6 x 10m	1 pc
6	Others			
	1	Check Cord	BNC 1.5m	2 pcs
	2	Fuse	1A 3A	1 set
	3	Grounding rod		1 pc
	4	Tools	Packed in tool box	1 set
7	Documents			
	1	Software	FDCPRG (CD)	1 pc
	2	Operation Manual	formastor – F	3 copies
	3	Test Report	formastor – F	3 copies
	4	Packing List	formastor – F	2 copies
8	First Filling parts			
	1	Specimen	ϕ 3, ϕ 2, $^t3$, $^t2$, $^t1.2$	1 set
	2	Specimen holder	For ϕ 3, 2 , for $^t3$, 2 , for $^t1.2$	1 set
	3	Thermocouple	R ϕ 0.2 x ℓ 300	3 vol
	4	Insulation tube	Single tube, Double tube	1 set

SPARE ACCCESSORIES FOR 1 YEAR

1	Temperature Detection Parts			
	1	Thermocouple	R ϕ 0.2 x 1 m	10 pairs
	2	Insulation tube	Single tube OD 1.2 x L 100	200 pcs
			Double Tube OD 1.6 x L 25	100 pcs
	3	Temp. keeping tube	SUS ϕ 2.0 x L 25	30 pcs
	4	Adhesive	Aronceramic C	2 pc
	5	Vinyl tube	Red, Black ϕ 1.0 x L 3m	3 pair
2	Recording Parts			
	1	Recorder	Chart paper B9619AM 10 rols	10 box
			Cartridge pen B9586 (red, green)	6 sets
			Ink ribbon	3 pc
3	Heating and cooling parts			
	1	Heating Coil	For ϕ 3	1 pc
	2	Specimen holder	Quartz tube & rod for ϕ 3, ϕ 2	20 pairs
			Quartz tube & rod for ^{t}3, 2	10 pairs
			Quartz tube & rod for ^{t}1.2	5 pairs
	3	Cooling tube	Urethane 1/4” x 5m	1 vol
4	Vacuuming Parts			
	1	Vacuum grease	H1-VAC	1 pc
	2	O - ring		1 set

8. CONSTRUCTION WORKS (UTILITY)

Following facilities are necessary for operation of this apparatus.

8.1 Scope of works to be carried out by customer

1) Preparation and arrangement of accommodation room and installation basement.

2) Delivery of the apparatus to the user's accommodation room and installation works.
   Please install in accordance with the details as per the drawing (No. EE02019E) – System Arrangement Drawing hereto attached.

3) Cooling water for Cooling water supply unit.
   Required cooling water : 15 ℓ
   Note: Please refer to the attached sheet of "Standard Requirements" for water quality.

4) Power supply
   ① Required power : 1 phase 200V 50/60Hz 6kVA
   ② Grounding construction : less than 10Ω Cable size: 8 sq
   Independent power distribution board shall be provided on primary power supply side, install switch in conforming to receiving power and connect to the apparatus.
   Note: Power voltage fluctuation shall be within ±10%.

5) Cooling gas and atmosphere adjustment gas facility
   ① Kind : N_2, He, Ar
   ② Pressure : 0～0.7MPa (0～7kgf /cm^2)
   ③ Flow : Max. 200Nℓ/min
   ④ Diameter : φ7 connection end shape : hose joint
   Note: Follow legal and also company's own rules for handling of high pressure gas.
   Note: An empty gas bomb is supplied for user's charging desired cooling gas.

6) Compressed air facility
   ① Pressure : Max. 0.5MPa (5.0kg/cm^2)
   ② Flow : Max. 20Nℓ/min
   ③ Diameter : φ7 connection end shape : hose joint

7) Exhaust pipe facility
   Facility for discharging exhausting gas from rotary pump and chamber is suggested.
   Note: In case that much cooling gas is used and gas ducting facility is not enough, there might be possibility of serious danger to death due to lack of oxygen occurring from repletion of exhausting gas

9. GENERAL MATTERS

9.1 Warranty

1) All material and workmanship of the apparatus are guaranteed for 12 months from the date of user's acceptance of test at the user's operation site, provided that the apparatus is operated under normal operational conditions and handling. The manufacturer will remedy all defects in the delivered apparatus due to faulty design, inferior materials or workmanship, the manufacturer will, at its option, repair or replace all parts in which defects have been arisen within the warranty period due to faulty construction or inferior materials . All spare parts and supplements are not the items for warranty.
2) The maintenance during the warranty period shall be replied within one week upon receipt of the fault report. The maintenance personnel shall come to the Customer's site within 3 weeks.

9.2 Dispatch of engineer(s) to the user

The manufacturer will dispatch engineer(s) to the user's premises at the time of apparatus delivery to the user for instructions for delivery to the operating premises and installation as well as instructions for setting/commissioning, test operation, training of user's operation including handling of the apparatus and maintenance during the warranty period, if agreed upon.

9.3 Documents to be submitted to the user

Following documents (English) will be submitted to the user;

1) Test report ：3 copies
2) Operation manual ：3 copies
3) Packing list ：2 copies

9.4 Environment conditions for operation

As the apparatus is precision machine, the user shall pay attention to the following environmental conditions.

1) Installation site ：In a building room, clean and no dust place. Exposure direct to the sun shall be avoided.
2) Environmental temperature ：10℃～40℃

Note：In order to assure stability of dilation detector, ambient temperature changes in the operation site are suggested hold within 5℃.

3) Environmental moisture ：less than 75% RH, no dew drop.
4) Sea level height ：lower than 1000m

9.5 Noise

Smaller than 65 decibel (db).

9.6 Paint Color

Following paint colors will be used unless specific colors are specified by the user.

13)Machine (outside)	: ACM3-720 (metallic black)
14)Operation Panel	: ACM4-2928 (metallic silver)
15)Machine (inside)	2.5Y8/2 (ivory)