ATLAS Central Solenoid
Report of Chimney-Extension Test

held at Toshiba

June 19 - 30, 2001

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Test of Chimney Extension

Objectives

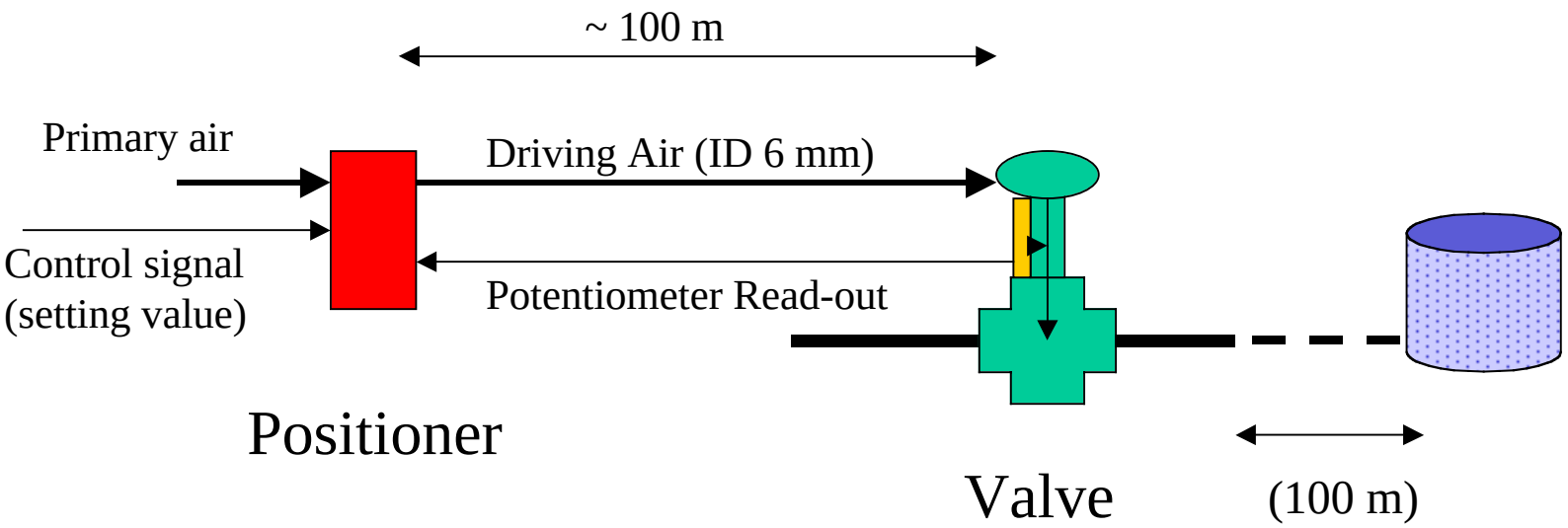
- Cryogenics:
  - Valve functioning with a distance of 100 m away from positioners,
  - Thermo-syphon cooling functioning @ heat load of > 200 W ,
  - Confirmation of cryogenics functions,

- Excitation:
  - Safe operation up to I = 10 kA
  - Current-leads characteristics @ I ≤ 8 kA
  - Superconductor joint resistance @ I ≤ 8 kA,
  - Heater quench to measure minimum quench energy and propagation,
  - Mass-flow stop test and Tc measurment @ I ≤ 8 kA
  - Thermoshphon cooling capacity and stability limit with Joule Heating.

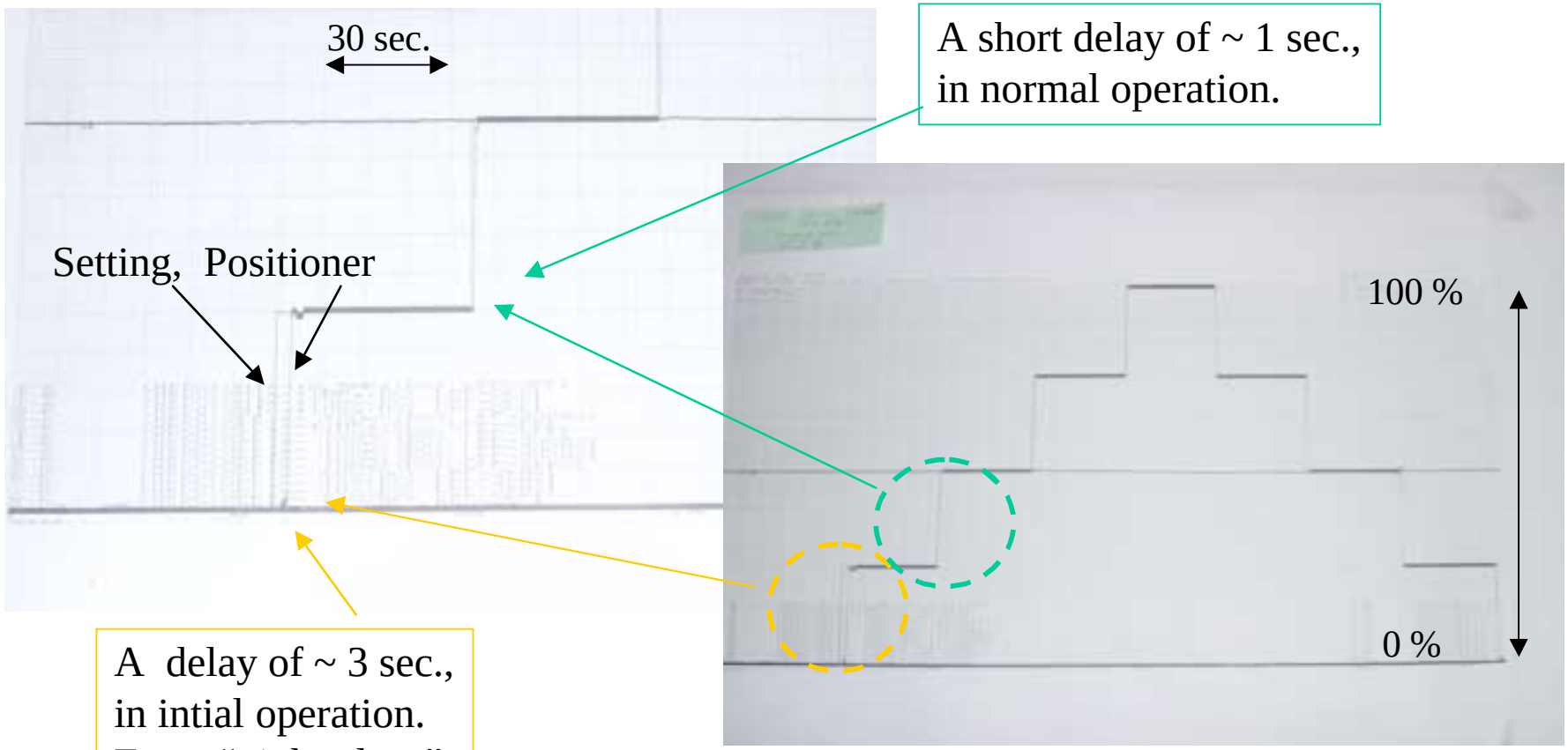
Progress

June	19 - 25	Preparation of test at Toshiba, and warm leak tight test,
	26	Valve functioning test with 100 m long lines at Room temp.
	27	Pre-cooling, cold leak-tight test
	28	Excitation up to 10 kA, and
		CLs & R-Joint meas. at ≤ 8 kA
	29	Heater quench tests at 8, 6, & 4 kA and
		Tc quench at 8 kA
	30	Tc quench at 6, & 4 kA, and
		Thermo-syphon test,
		General and final check at 8 kA,
July	3	Cold leak tight test
	6	Warm leak tight test

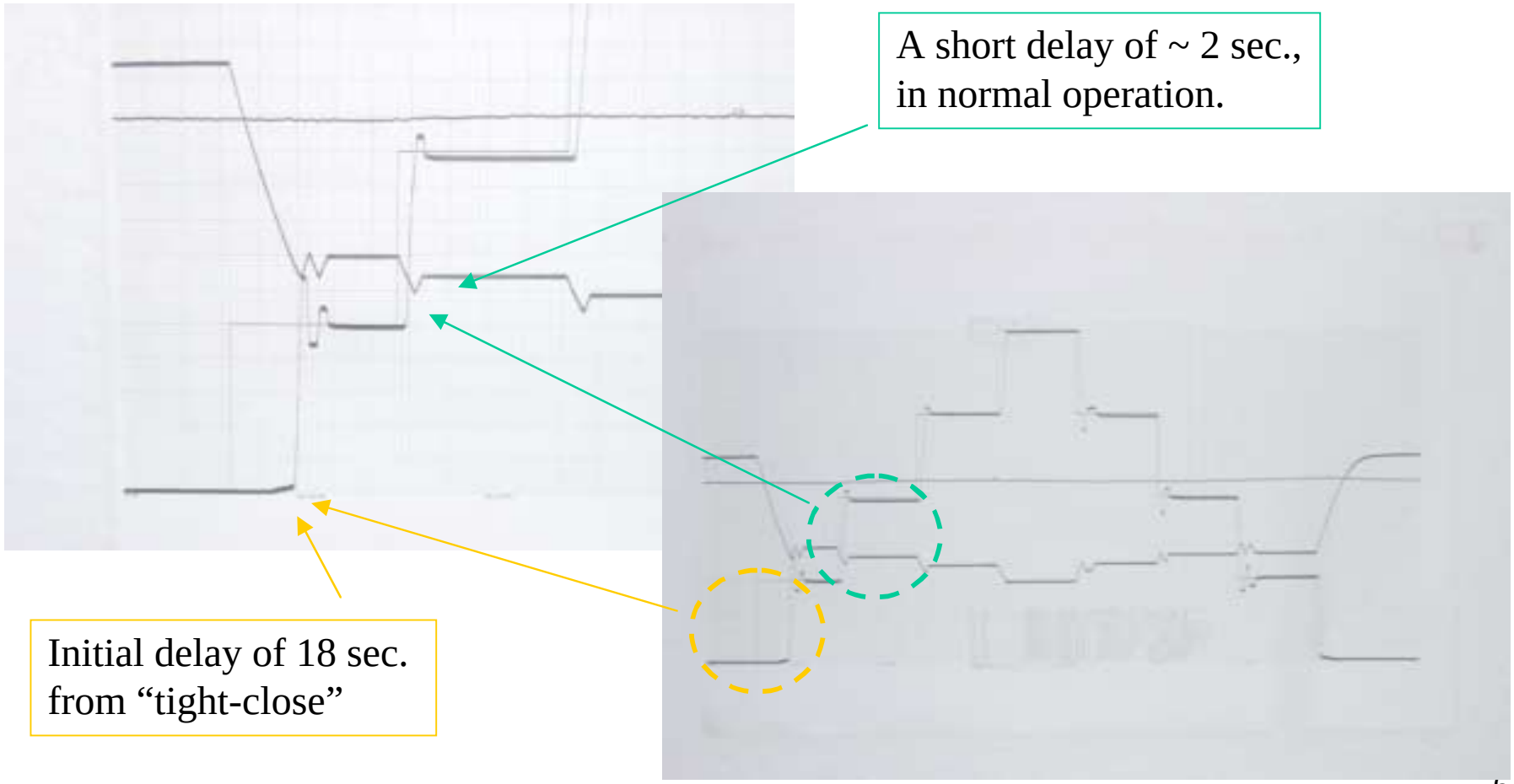
Valves and Poisitoners
Bench Test Configuraiton



Standard Configuration with a short distance (2~3 m)



Valve functioning
with a positioner distance of 100 m



A short delay of ~ 2 sec.,
in normal operation.

Initial delay of 18 sec.
from “tight-close”

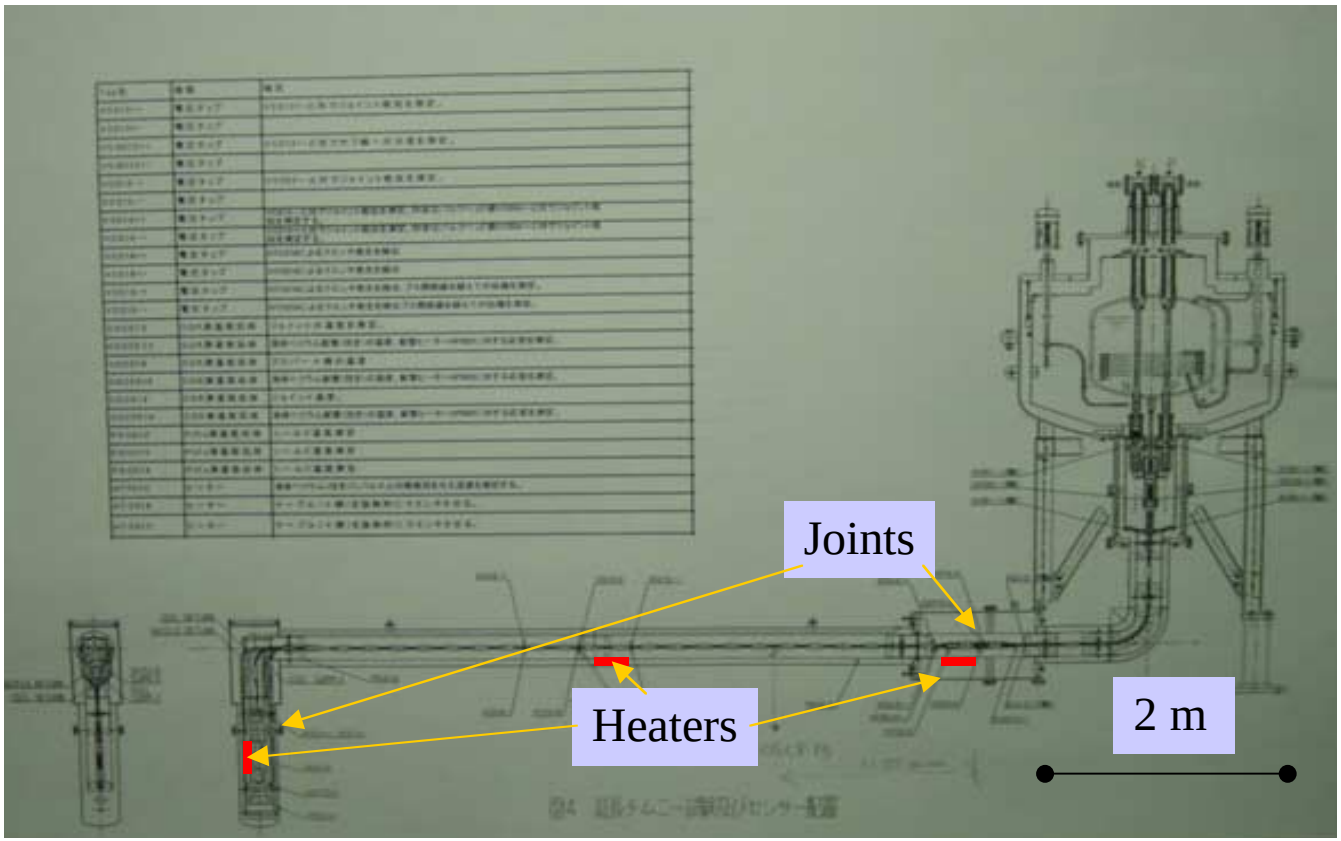
Results of Bench Tests

- Valves may be controlled with positioners with a distance of 100 m away from the valves,

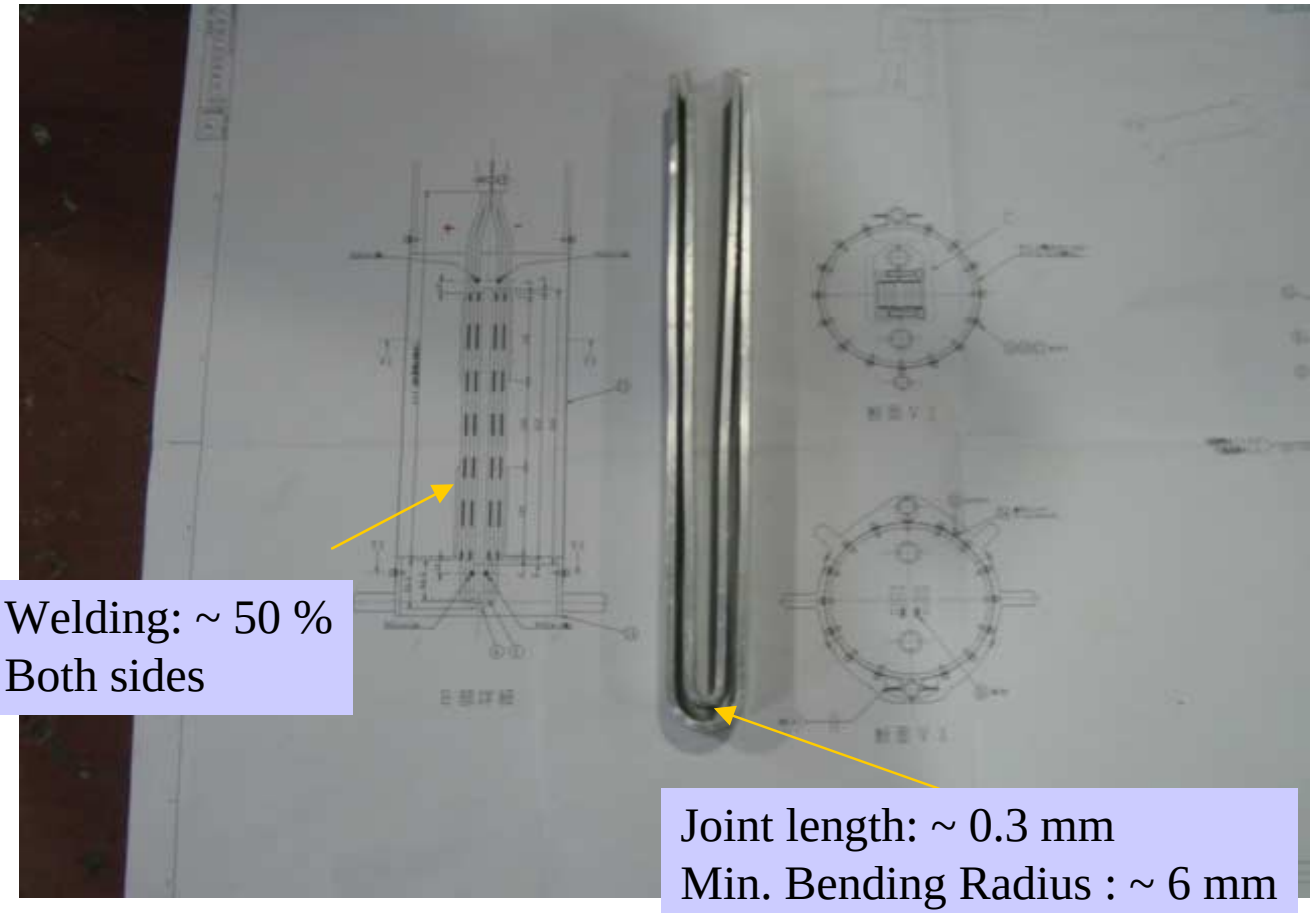
- A remaining problem of very slow initial action from “tight-close; (<< 4 mA)” to practical action still to be solved,

- It will be hopefully to be investigated after devlivery of the system to CERN, and in cooperation with experts at CERN for those valves to be harmonized with other system.

Cross Sectional View of Chimney-extension with Control-dewar



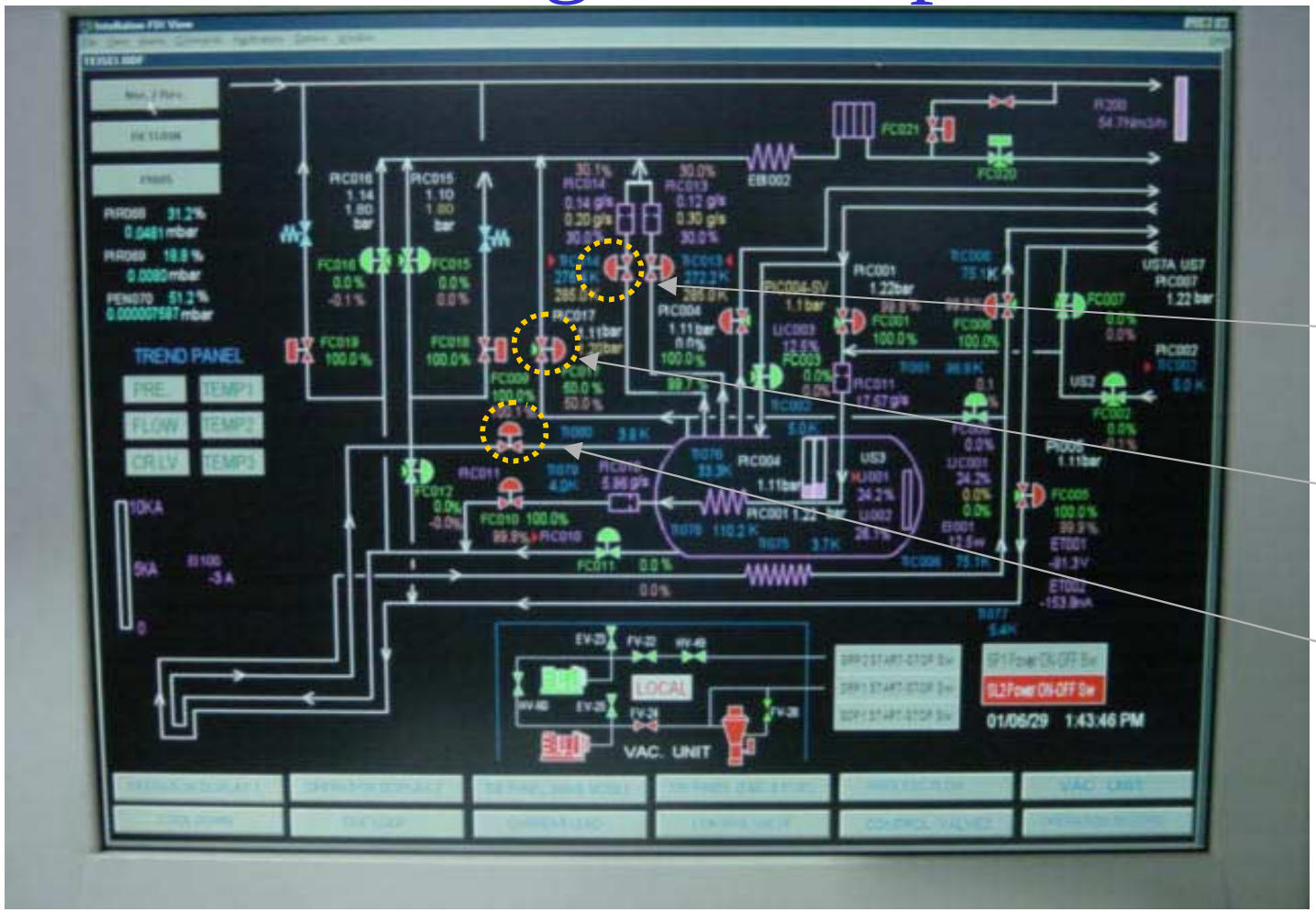
By-pass Joints at the bottom-end of Chimney-extension



Test Set-up

Test Set-up

Valve Functioning Tests with long air and process lines



Tested with
100 m
Extension

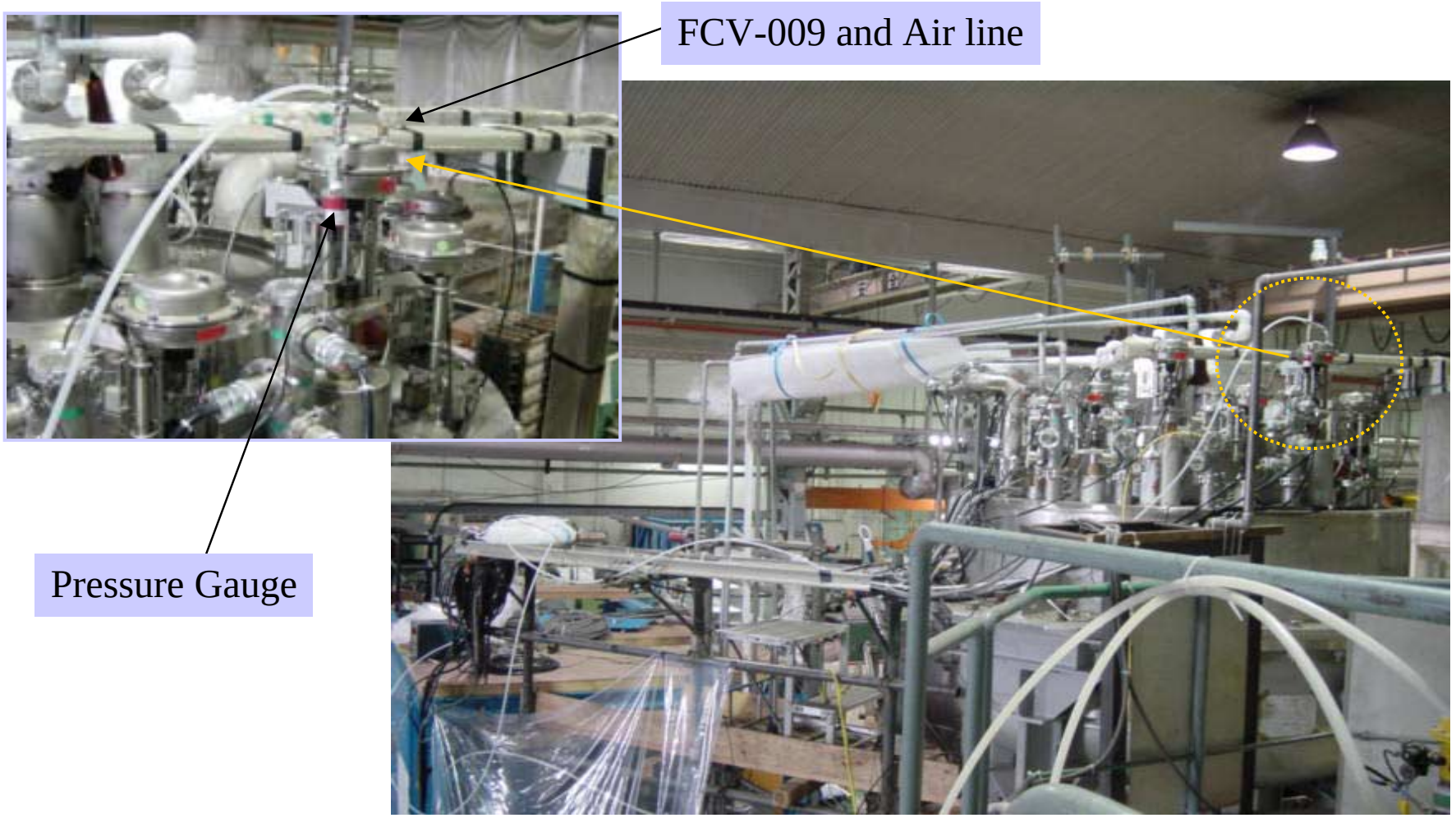
FCV-014
- Current Leads+

FCV-017
- Pressure of CD

FCV-009
- LHe return

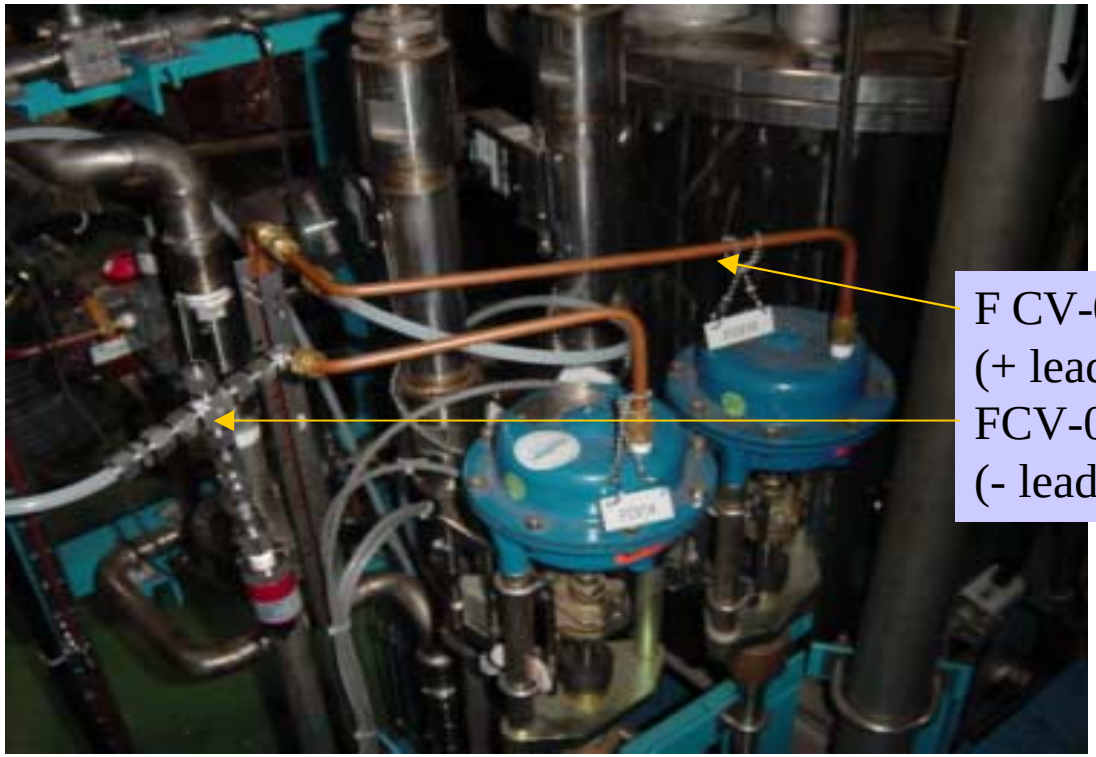
FCV-009 (LHe return line from chimney) Air-line extended

FCV-009 Air -line extended



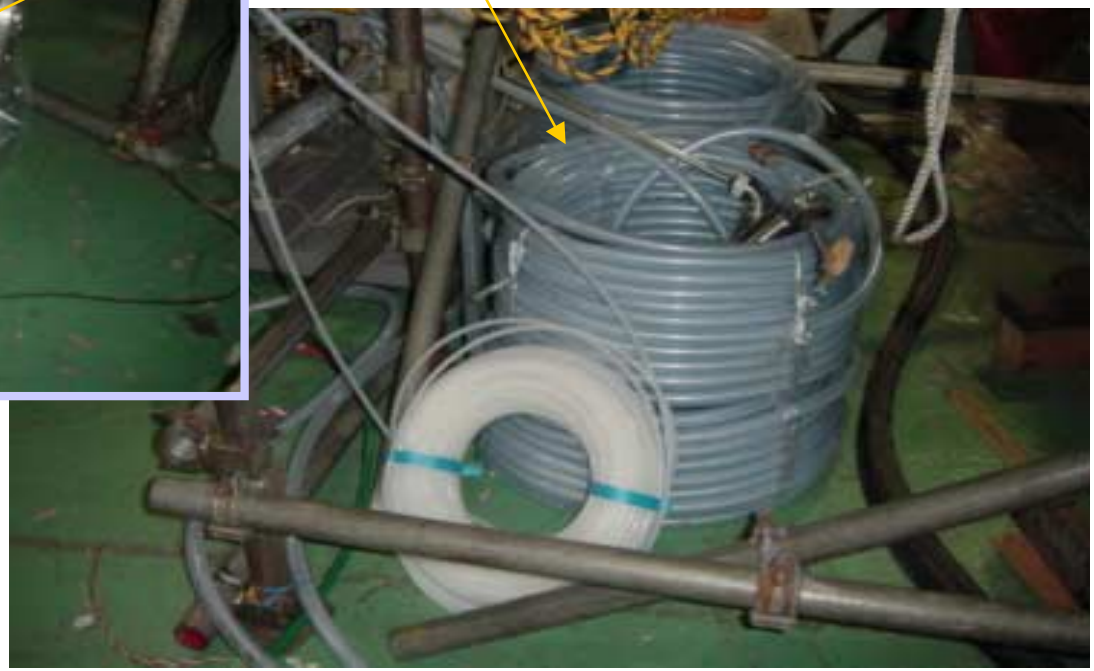
Positoner of FCV-009

FCV-014 (Currnet-lead flow line)
Air line extended

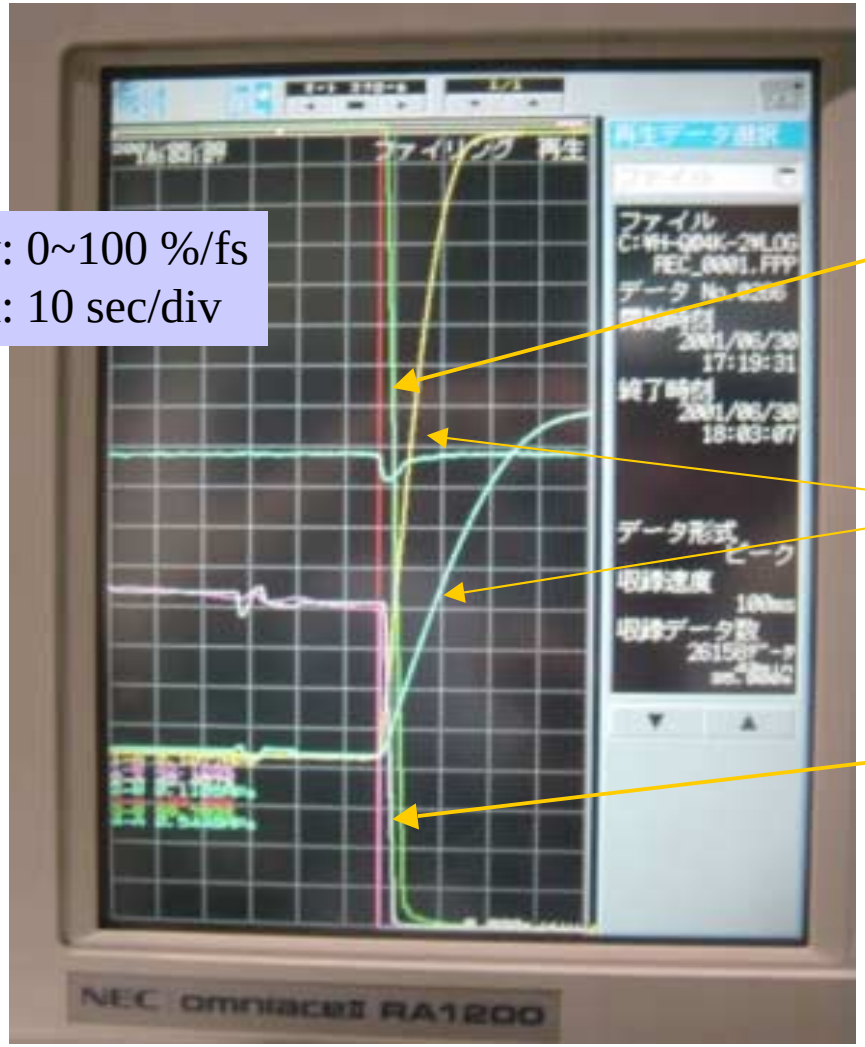


FCV-014
Gas process line also extended

Process line extended
With 19 mm ID Tube



FCV(PCV)-009, FCV-014
Appropriate Functioning at Emergency Shut-off



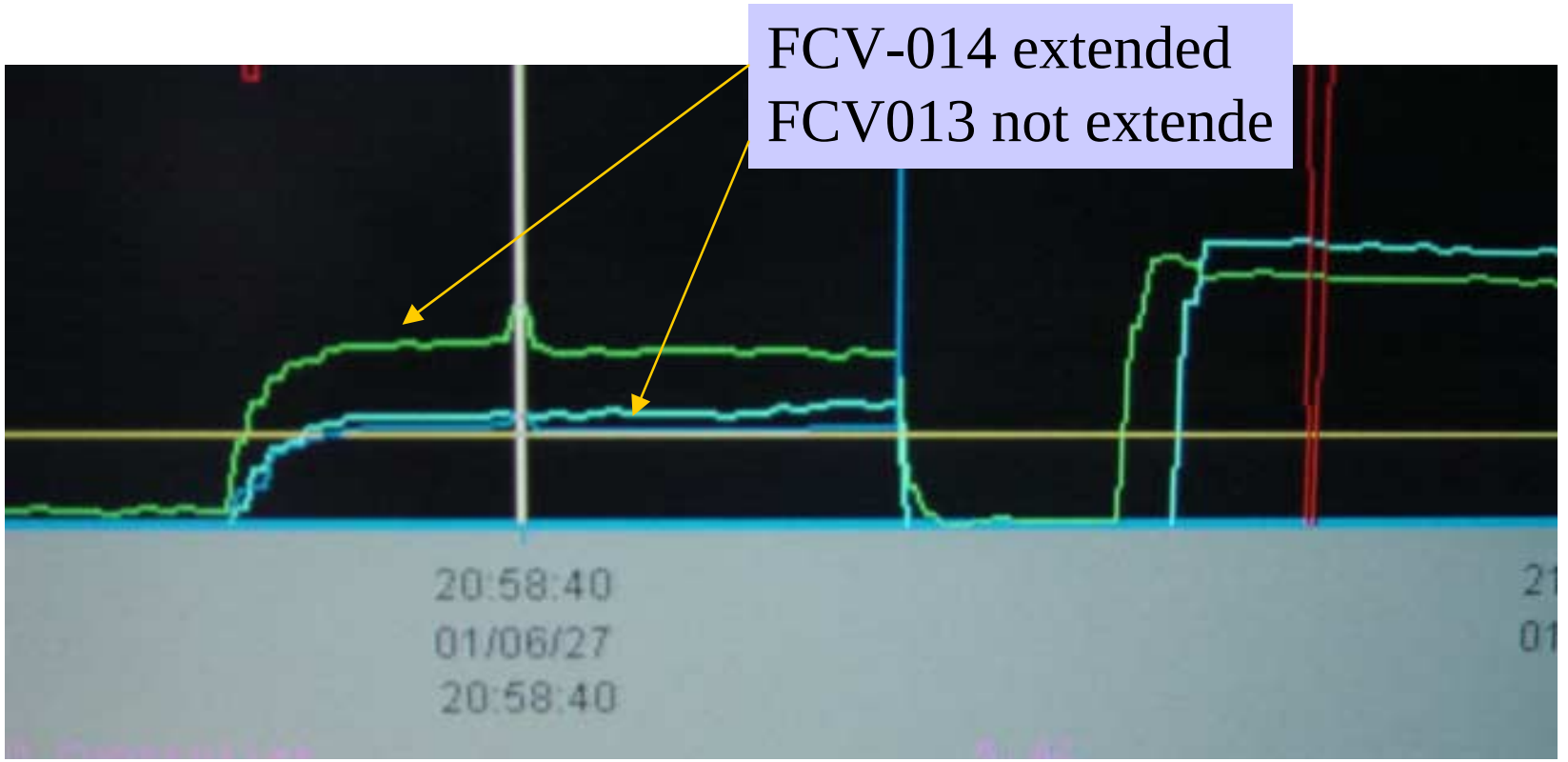
y: 0~100 %/fs
x: 10 sec/div

FCV-009
Shut off time: 2~3 sec

Control air pressure
measured at valve

FCV-014:
Shut-off time: ~ 2 sec

Current Leads Flow Control
No measure change observed



" I could feel no-difference of function of FV CV-014 from -013" said Doi-san.

Results of Dynamic Tests of the Positioners 100 m away

- Current lead line (FCV-014) may be operated without problems
- CD pressure control valve (PCV-017) may be operated without problems.
- Ghe return line from the coil/chimney may be controled and shut-off practically without problems, but further quick action for the “tight close” to be investigated.

Current-lead Performance

- The operational parameters at 8 kA are very close to an ideal condition instructed with M. Wilson,
- The stability and safety confirmed up to 10 kA (> 25 % above the operation condition),
- The safety in case of mass-flow stop was already confirmed in the test in last year. (@ full current of 8 kA with no flow for 10 min. >> no problems)

Current Leads Performance

Current	[kA]	10	8	6	4	2	0
Voltage+	[mV]	(102)	68	52	36	18	-
Voltage-		(96)	64	50	33	17	-
T-gas+	[K]	(283)	284	284	283	283	281
T-gas-		(285)	285	286	283	283	281
T-bus+	[K]	(287)	296	294	288	286	283
T-bus-		(296)	303	300	291	287	283
He-flow+	[g/s]	(0.56*)	0.47*	0.33	0.15	0.09	0.09
He-flow-		(0.59*)	0.50*	0.35	0.20	0.11	0.11
		(*average at last two meas.)					

Heater Quench Characteristics

- Necessary heat-pulse to generate normal zone is suffiently large enough, and the cable design is stable enough.
- Temperature threshold of > 7.5 K is sufficiently high enough for safe operation.
- Quench may propagate first enough with in chimney (within a few second at the full cureent),
- A sufficient time margin of > 30 sec to allow the coil to be discharged with full energy dump before the current lead temperature to reach < 40 K (<< 80 K).

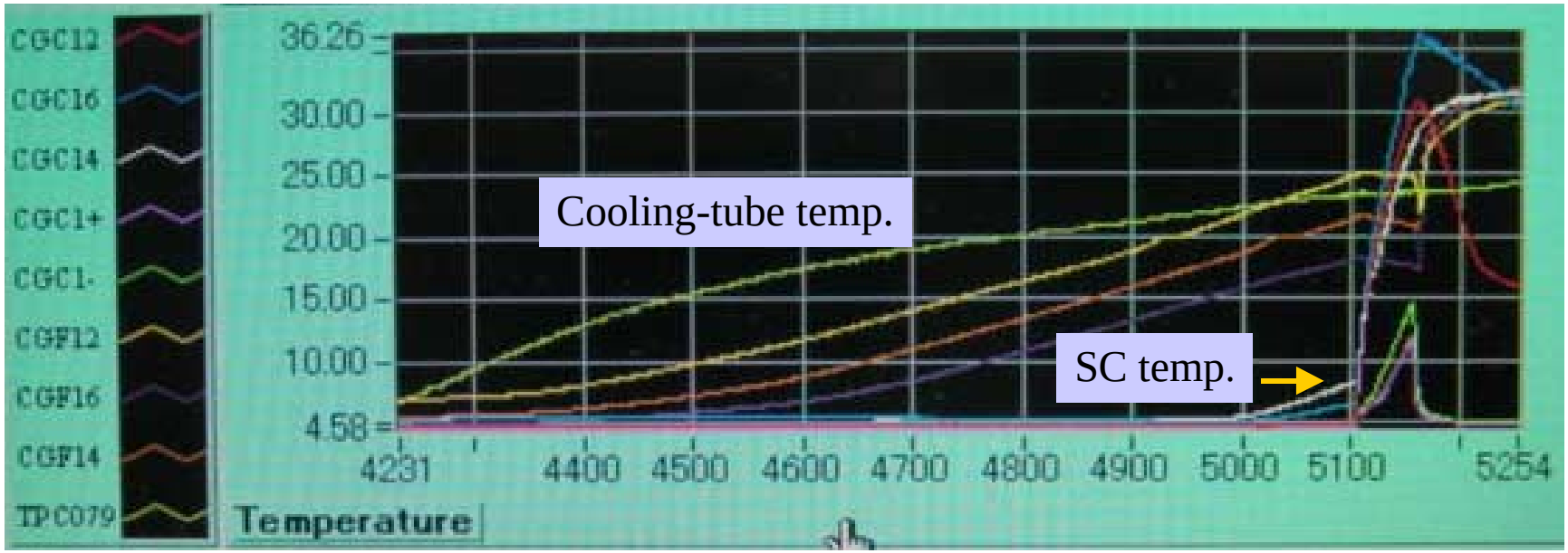
Heater Quench Tests

Current	[kA]	4	6	8
P-ht12 w/o quench	[W]	60	65	55
P-ht12 w/ quench (t-pulse: 1 sec)	[W]	65/70	70	60
T-propagation	[s]	10~12	2~3	≤ 1
V-propagation	[m/s]	~0.5	~2	~5
T-waiting aft. prop.	[sec]	>> 30	> 30	> 30
V-total aft. prop.	[mV]	25	40	60
V-total bef. P/S off	[mV]	25	48	140
Temp-final	[K]	13	15	34

Tc Quench Test

Current	[kA]	4	6	8
t-q w/ zero-flow	[min.]	~ 35	20	~ 30
Tc-cgc14	[K]	> 9	8.2	7.5
t-propagation	[sec]	≤ 1	≤ 1	≤ 1
t-holding	[sec]	30	30	30
T-cg14 aft. holding	[K]	TBD	TBD	TBD

Mass-flow stop and Tc-quench test



Mass flow stop >> (> 20 min.) >> Tc-Quench

Thermo-syphon Cooling Characteristics

- Thermo-syphon cooling capacity of > 200 W was confirmed under stable operation of the chimney conductor under the normal state (Joule heating) condition after normal zone propagated in the full chimney and thermally balanced with keeping temperature and voltage drops, up to 5.5 kA,

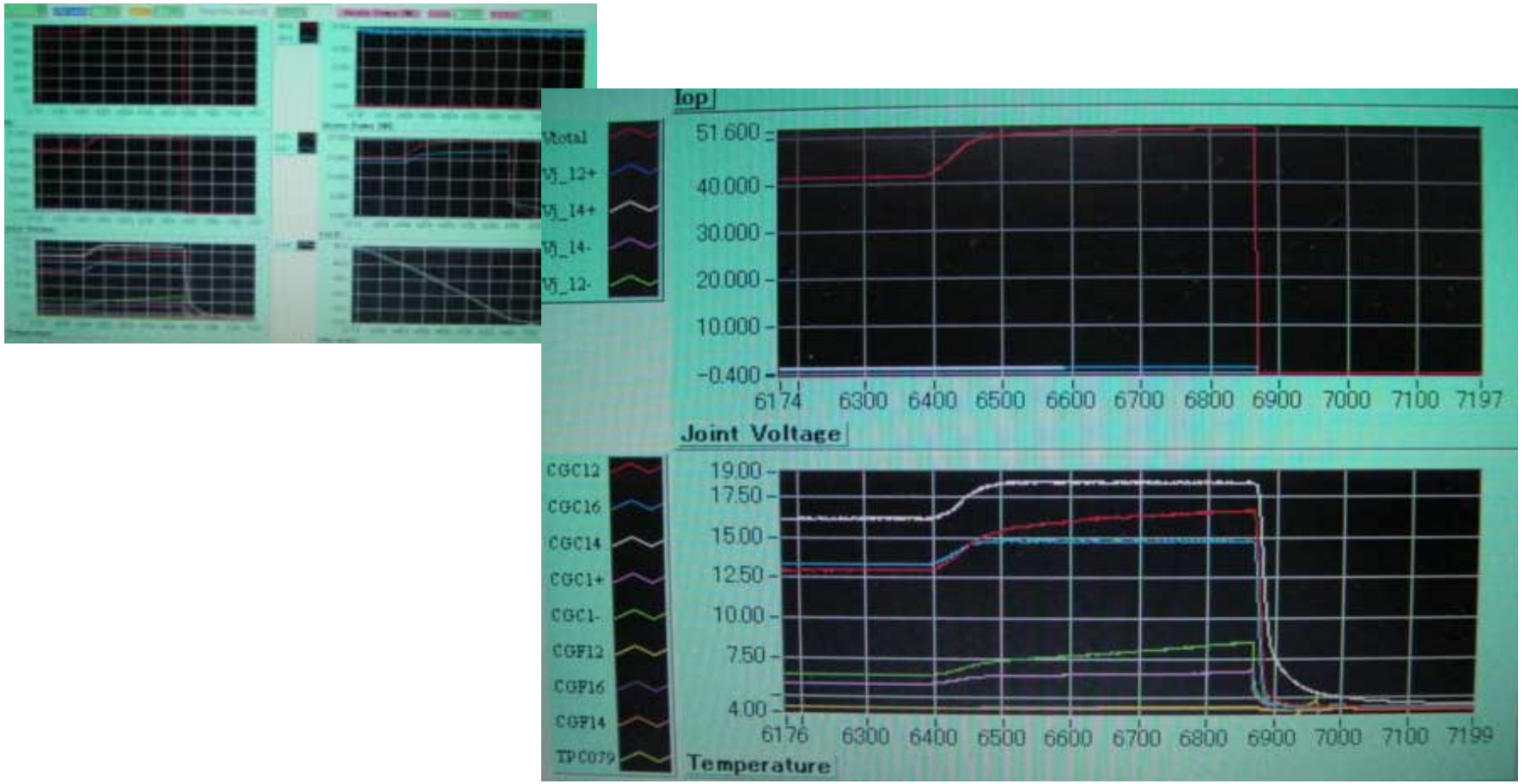
- The balance was slightly missed at 6 kA with a Joule heating load of ≥ 300 W, at the top of the chimney (close to the Control Dewar where the sufficient cooling was physically difficult.

- The result is very positive for the thermo-syphon to be applicable and promising to be used in the long operation at CERN.

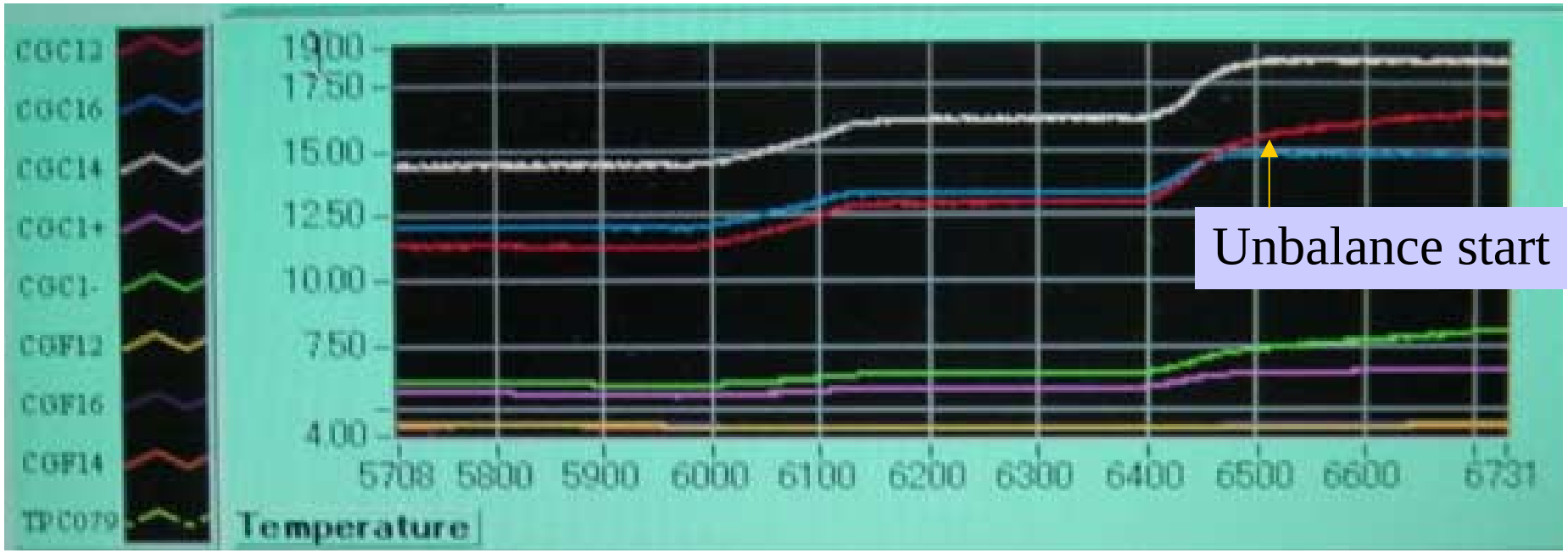
Thermo-syphon
Cooling capacity measurement

Current		[kA]	0	4	5	5.5	6
V-total		[mV]	-	25.0	35.6	41.7	50.4 >> 51.5
Joule heating		[W]	-	100	178	229	302 >> 327
T-sc/bus	CG12	[K]	4.5	8.3	11.3	12.9	15.2 >> 16.5
	CG16		4.6	9.4	12.1	13.4	14.8 >> 14.8
	CG14		4.7	11.3	14.4	16.1	18.3 >> 18.6
T-pipe	CGCF12		4.4	4.4	4.4	4.4	4.4 >> 4.4
	CGVF16		4.4	4.4	4.4	4.4	4.4 >> 4.4
	CGCF14		4.3	4.4	4.3	4.3	4.3 >> 4.4
LHe level		[%]	69	65	61	44	35 ~ 24
Cryogenics loss		[W]	(43)	80	250	228	333

Thermosyphon cooling unbalance start at > 300 W



Thermosyphon
Cooling capacity tests



5 kA → 5.5 kA → 6 kA

with Completing the Tests

General Summary

- Valve with a positioner of a distance of ~ 100 m away from the valve may be acceptable, and further investigation shall be made in close cooperation with CERN experts, under the site conditions at CERN .

- The chimney extension test has been very successful,
  - Sufficient stability, temperature margin and
  - Fast enough quench propagation once it happen and safe enough for a sufficient time duration.

- Thermo-syphon cooling scheme has worked. The nearly 300 W cooling capacity has been confirmed.

- The sytem should be ready to be shipped to CERN.