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Äspö Hard Rock Laboratory

Canister Retrieval test

Sensor data report (Period: 001026 - 010201) Report No: 1

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February 2001

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Abstract

This report presents data from the measurements in the Canister Retrieval Test from 001026 to 010201.

The following measurements are made in the bentonite: Temperature is measured in 32 points, total pressure in 27 points, pore water pressure in 14 points and relative humidity in 55 points. Temperature is also measured by in all relative humidity gauges. The positions of the measuring points in the bentonite are related to a coordinate system in the deposition hole.

The following measurements are made in the rock: Temperature is measured in 40 points, stresses are measured in 8 points and strain is measured in 9 points. Results from the two latter measurements are not shown in this report.

The following measurements are made in the canister: Temperature is measured every meter along two fiber optic cables and strain is measured in 75 points on the surface of the copper envelop. Temperature is measured in the steel insert in 18 points.

Results from the two latter measurements are not shown in this report

The following measurements are made on the plug: Force is measured in 3 of the 9 anchors and vertical displacement is measured in three points.

The water inflow to the filter mats on the rock surface is also measured.

The general conclusion is that the measuring systems and transducers seem to work well but the following problems have been noted: There has been a delay of the evaluation of stress and strain measurements in the canister and in the rock and those results are not included. There have been problems with the data collection system for the fiber optical cables, which yielded a period with no data. A few Vaisala relative humidity transducers, located in the high temperature region, have failed.

Sammanfattning

I denna rapport presenteras data från mätningar i Återtag under perioden 001026-010201.

Följande mätningar görs i bentoniten: Temperaturen mäts i 32 punkter, totaltryck i 27 punkter, porvattentryck i 14 punkter och relativa fuktigheten i 55 punkter. Temperaturen mäts även i alla relativa fuktighetsmätare. Varje mätpunkt relateras till ett koordinatsystem i deponeringshålet.

Följande mätningar görs i berget: Temperaturen mäts i 40 punkter, spänning mäts i 8 punkter och töjning mäts i 9 punkter. Resultat från de två senare visas inte i denna rapport.

Följande mätningar görs på ytan i kapselns kopparhölje: Temperaturen mäts varje meter längs två fiberoptiska kablar och töjning mäts i 75 punkter. Temperaturen mäts i stålinsatsen i kanistern i 18 punkter.

Resultat från de två senare mätningarna redovisas inte i denna rapport.

Följande mätningar görs på pluggen: Kraften mäts i 3 av de 9 stagen och vertikala förskjutningen mäts i tre punkter.

Vatteninflödet till filtermattorna mäts också.

En generell slutsats är att mätsystemen och givarna tycks fungera bra, men följande problem har noterats: Utvärderingen av spännings- och töjningsmätarna i berget och kapseln har försenats och dessa resultat är inte redovisade. Problem med datainsamlingssystemet till de fiberoptiska kablarna har medfört att det saknas data under en period. Några av Visalas relativa fuktighetsmätare, belägna nära kapseln, har slutat fungera.

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1 Introduction

The installation of the Canister Retieval Test was made during autumn 2000. In general the data in this report are presented in diagrams covering the time period 2000-10-26 to 2001-02-01. The time axis in the diagrams represents days from 2000-10-26. The diagrams are attached.

A test overview with the positions of the measuring points and a brief description of the instruments is also presented in this report (chapters 3 and 4).

General comments concerning the collection of the data are given in chapter 2.

2 Comments

2 General

In this chapter short comments on general trends in the measurements are given. Sensors that are not delivering reliable data or no data at all are noted and comments on the data collection in general are given.

The slot between rock and bentonite block was filled with bentonite pellets and water at 001026. This date is also marked as start date.

The saturation of the bentonite started by applying 1 m water head in the water supply tank connected to the filters on 001102.

The heating of the canister started with an initially applied constant power of 700 W at 001027 that is one day after test start. The power was raised to 1700 W on 001113.

2.2 Total pressure, Geokon (pages 19-21)

The measured pressure range is from 0 to 2.6 MPa. The highest pressure is indicated from P105, P107, P109 and P114. The three first are placed in cylinder 1 and all of them are placed at the same distance from the canister and near the bentonite block periphery. P114 is placed in Ring5 in the slot at the bentonite block periphery.

Sensor P104 was not installed

U106 was originally intended to be a pore pressure sensor but was replaced by a total pressure sensor.

2.3 Total Pressure, Kulite (page 22)

Six total pressure transducers are installed in the bentonite blocks. P224 and P222 indicate high pressure corresponding to 2 MPa and 1 MPa. These sensors are placed in the bentonite block periphery in Ring10. P224 did not work properly until after 60 days

P221 yields unreliable reading and it is not plotted in this report.

2.4 Suction, Wescore Psychrometers (page 23)

The three transducer W141, W147 and W124 have started to yield values that can be interpreted, which means that they are very close to water saturation.

W141 and W147 placed near the periphery surface in Ring10.

W124 placed near the periphery surface in the bentonite block Ring5.

2.5 Relative humidity, Vaisala (pages 24-27)

W112 was not installed. W102 and W125 were out of order from start and they are not plotted in this report.

W103 and W101 have stopped working during this period.

The measured water ratio range is from 70% till 100% .

W106, W111, W118 in Cylinder1, W121, W127 in Ring 5 and W150, W138, and W144 in Ring10 indicate high relative humidity. All these transducers are placed near the periphery of the bentonite blocks.

2.6 Pore water pressure, Geokon (pages 28-29)

U108 and U110 yield a water pressure of 100 kPa. They are placed in the periphery of Ring 5. U107 and U105 yield 70 kPa and 50 kPa. These sensors are placed in Ring5 but not near the periphery of the bentonite block.

U106 is replaced by a total pressure sensor.

The remaining sensors of this type yield zero pressure .

2.7 Pore water pressure, Kulite (page 30)

There are only one sensor of this type in Ring 10 and one in Cylinder 4. Both indicate zero pressure.

2.8 Water flow into the filters (page 31)

Measurement of water inflow into the filters started on 001102. The total inflow to the filter during the actual period has been 174 liter. There seems to be close to a steady flow of about 0.5 l/day.

2.9 Forces on the plug (page 32)

The forces on the plug have been measured since 001106.The total force is about 2500 kN at 010201.

During the first about 50 days the plug was only fixed with 3 rods. When the total force exceeded 1500 kN the rest of the 9 rods were fixed in a prescribed manner. This procedure took place 12-14 December that is 46-48 days after test start. From that time only every third anchor is measured and the results should thus be multiplied with 3. The diagram shows both the actual measurements and after multiplication with 3.

2.10 Displacement of the plug (page 33)

The three displacement gauges were placed and started to measure displacements from 001101. The results show that two of the transducers have about the same displacement but the third has yielded a much lower displacement. The plug thus seems to tilt.

2.11 Canister power (page 34)

The measurement of the power of the canister was erroneous during the first 20 days, which was the reason for that only 700 W were applied from start.

2.12 Temperature in the buffer (pages 35-39)

The temperature ranges from no increase at all (in the periphery of the upper bentonite cylinder C4) to a total temperature of 59 degrees in the center close to the canister. The highest temperature gradient is 0.55 degrees/cm (ring 5).

2.13 Temperature in the rock (pages 40-43)

The maximum temperature in the rock (44 degrees) is measured in the central section on the surface of the deposition hole. Almost complete axial symmetry can be observed.

2.14 Temperature on the canister surface, Optical fiber cables (pages 44-45)

The first diagram shows the maximum temperature plotted as a function of time. The maximum temperature on the canister surface is 65 degrees. The second diagram shows the distribution of the temperature along the cables. The length of the cable on the canister surface is only about 20 m and close to the entrances the temperature is affected by the lower surrounding temperatures.

2.15 Temperature inside the canister (pages 46-47)

The highest temperature (75 degrees) is measured in the center of the canister (P15). In the same central section the temperature on the surface of the steel insert (P5) is about 5 degrees lower, which can be compared to the corresponding temperature on the copper surface, which is still 5 degrees lower.

2.16 Strain in the canister

Continuous measurements have been made but so far no results have been produced due to evaluation problems.

2.16 Rock stresses and strain

Continuous measurements have been made but so far no results have been produced due to evaluation problems.

3 Geometry

The test installation consists of a full scale deposition hole, a copper canister equipped with electrical heaters and bentonite blocks (cylindrical and ring shaped). A plug of concrete and steel is anchored to the rock on top of the bentonite.

The saturation of the bentonite is attained artificially by vertical filter stripes. 16 stripes with a width of 0.1 meters and a length of 5.5 meters are applied on the surrounding rock.

Measurements are made in four vertical sections A, B, C and D according to Figure 3-1. Direction A-B is parallel to the tunnels axial with A headed almost against north.

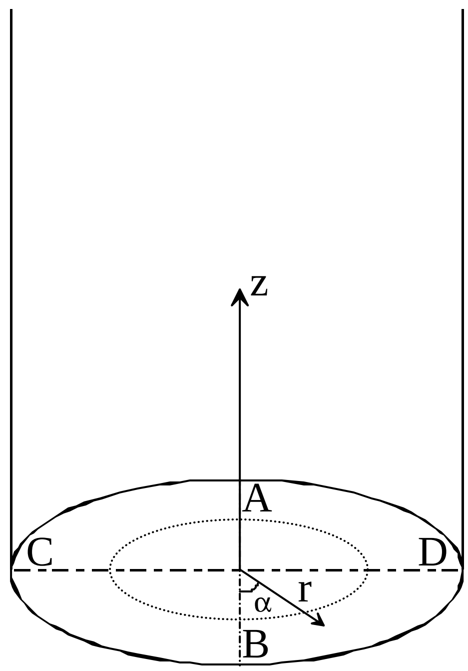


Figure 3-1. Figure describing the instrument planes (A-D) and the coordinate system used when describing the instrument positions.

4 Location of instruments

4.1 Brief description of the instruments

The different instruments that are used in the experiment are briefly described in this chapter.

Measurements of temperature

Buffer

Thermocouples from BICC have been installed for measuring temperature in the buffer. Measurements are done in 32 points in the test hole. In addition, temperature gauges are built in into the capacitive relative humidity sensors (29 sensors) as well as in the pressure gauges of vibrating wire type (13 gauges). Temperature is also measured in the psychrometers.

Canister

Temperature is measured inside the canister (on the insert) in 19 points with PT-100 gauges. In addition temperature is measured on the surface of the canister with optical fiber cables. An optical measuring system called FTR (Fiber Temperature Laser Radar) from BICC is used.

Rock

Temperature in the rock and on the rock surface of the hole is measured in 40 points with thermocouples from BICC.

Measurement of total pressure in the buffer

Total pressure is the sum of the swelling pressure and the pore water pressure. It is measured with the following instrument types:

- Geocon total pressure cells with vibrating wire transducers. 15 cells of this type have been installed.
- Kulite total pressure cells with piezo resistive transducers. 6 cells of this type have been installed.

Measurement of pore water pressure in the buffer

Pore water pressure is measured with the following instrument types:

- Geocon pore pressure cells with vibrating wire transducer. 13 cells of this type have been installed.
- Kulite pore pressure cells with piezo resistive transducer. 2 cells of this type have been installed.

Measurement of the water saturation process

The water saturation process is recorded by measuring the relative humidity in the pore system, which can be converted into water ratio or total suction (negative water pressure). The following techniques and devices are used:

- Vaisala relative humidity sensor of capacitive type. 29 cells of this type have been installed. The measuring range is 0-100 % RH.

- Wescor psychrometers model PST-55. The devices measure the relative humidity in the pore system, The measuring range is 95.5-99.6 % RH corresponding to the pore water pressure -0.5 to -6MPa. 26 cells of this type have been installed.

Measurements of stresses and strain in the rock

These are not reported.

Measurements of forces on the plug

The force on the plug caused by the swelling pressure of the bentonite is measured in 3 of the 9 anchors. The force transducers are of the type GLÖTZL.

Measurements of plug displacement

Due to straining of the anchors the swelling pressure of the bentonite will cause not only a force on the plug but also displacement of the plug. The displacement is measured in three points with transducers of the type LVDT with the range 0 – 50 mm.

Measurement of water flow into the permeable mats

Water is supplied to the bentonite with filter strips attached to the rock surface. The water flow into these mats is measured by measuring the water volume in the supply tank with a differential pressure transmitter that measures the difference in pressure between the nitrogen in the top of the tank and the water in the bottom of the tank.

4.2 Strategy for describing the position of each device

Every instrument is named with a short unique name consisting of 1-2 letters describing the type of measurement and 3 figures numbering the device. Every instrument position in the buffer and rock is described with three coordinates according to Figure 3-1.

The r-coordinate is the horizontal distance from the center of the hole and the z-coordinate is the height from the bottom of the hole (the block height is set to 500 mm). The $\alpha-$coordinate is the angle from the vertical direction B (almost south).

The short description of the positions in the diagrams differs between the buffer and the rock.

Buffer: Three positions with the following meaning: (bentonite block or cylinder number counted from the bottom \ direction A, B, C, or D \ radius in mm from center line)

Rock: Three positions with the following meaning: (distance in meters from the bottom \ α according to Fig 3-1 \ distance in meters from the hole surface)

The bentonite blocks are called cylinders and rings. The cylinders are numbered C1-C4 and the rings R1-R10 respectively (Figure 4-1).

4.3 Position of each instrument in the bentonite

Measurements are done in four vertical sections A, B, C and D according to Figure 3-1. Direction A and B are placed in the tunnels axial direction.

An overview of the positions of the instruments is shown in Fig 4-1. Exact positions are described in Tables 4-1 to 4-4.

The instruments are located in two main levels in the blocks, 50 mm and 160 mm, from the upper surface. The thermocouples have mostly placed in the 50mm level and the other gauges in the 160 mm level.

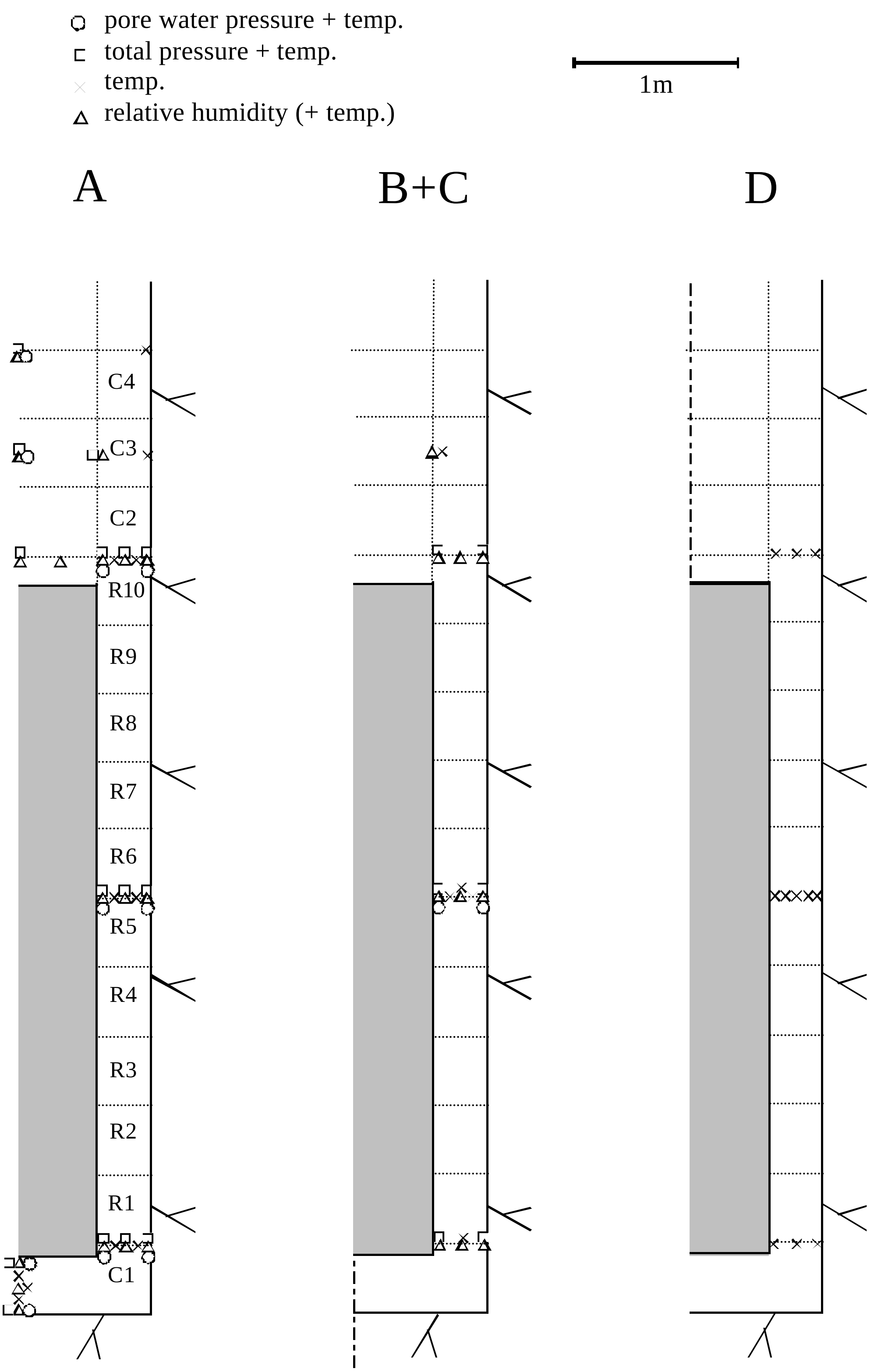


Figure 4-1 *Schematic view over the instruments in four vertical sections and the block designation.*

Table 4-1 Numbering and position of instruments for measuring temperature (T)

		Instrument position in block				Cable pos.		
Type and number	Block	Direction	α	r	Z	α	Fabricate	Remark
T101	Cyl. 1	Center	90	50	50	242	BICC	
T102	Cyl. 1	Center	90	50	250	238	BICC	
T103	Cyl. 1	Center	90	50	450	230	BICC	
T104	Cyl. 1	A	180	635	450	206	BICC	
T105	Cyl. 1	A	180	735	450	202	BICC	
T106	Cyl. 1	B	365	685	450	38	BICC	
T107	Cyl. 1	C	275	685	450	274	BICC	
T108	Cyl. 1	D	90	585	450	96	BICC	
T109	Cyl. 1	D	90	685	450	94	BICC	
T110	Cyl. 1	D	90	785	450	92	BICC	
T111	Ring 5	A	180	635	2950	224	BICC	
T112	Ring 5	A	180	735	2950	218	BICC	
T113	Ring 5	B	360	610	2950	318	BICC	
T114	Ring 5	B	360	685	2950	322	BICC	
T115	Ring 5	B	360	735	2950	324	BICC	
T116	Ring 5	C	270	610	2950	258	BICC	
T117	Ring 5	C	270	685	2950	260	BICC	
T118	Ring 5	C	270	735	2950	262	BICC	
T119	Ring 5	D	90	585	2950	44	BICC	
T120	Ring 5	D	90	635	2950	46	BICC	
T121	Ring 5	D	90	685	2950	48	BICC	
T122	Ring 5	D	90	735	2950	50	BICC	
T123	Ring 5	D	90	785	2950	52	BICC	
T124	Ring 10	A	180	635	5450	200	BICC	
T125	Ring 10	A	180	735	5450	194	BICC	
T126	Ring 10	D	90	585	5450	54	BICC	
T127	Ring 10	D	90	685	5450	56	BICC	
T128	Ring 10	D	90	785	5450	58	BICC	
T129	Cyl. 3	A	180	785	6250	166	BICC	
T130	Cyl. 3	B	365	585	6250	358	BICC	
T131	Cyl. 3	C	275	585	6250	280	BICC	
T132	Cyl. 4	A	180	785	6950	66	BICC	

Table 4-2 Numbering and position of instruments for measuring total pressure (P)

		Instrument position in block				Cable pos.		
Type and number	Block	Direction	α	r	Z	α	Fabricate	Remark
P101	Cyl. 1	Center	180	50	50	244	Geocon	
P102	Cyl. 1	Center	180	50	250	232	Geocon	
P103	Cyl. 1	A	185	585	250	208	Geocon	
P104	Cyl. 1	A	185	685	250	204	Geocon	
P105	Cyl. 1	A	185	785	250	186	Geocon	
P106	Cyl. 1	B	365	585	250	40	Geocon	
P107	Cyl. 1	B	365	785	250	2	Geocon	
P108	Cyl. 1	C	275	585	250	278	Geocon	
P109	Cyl. 1	C	275	785	250	270	Geocon	
P110	Ring 5	A	185	585	2750	228	Geocon	
P111	Ring 5	A	185	685	2750	222	Geocon	
P112	Ring 5	A	185	785	2750	188	Geocon	
P113	Ring 5	B	365	535	2750	36	Geocon	
P114	Ring 5	B	365	825	2750	16	Geocon	
P115	Ring 5	C	275	585	2750	296	Geocon	
P116	Ring 5	C	275	785	2750	290	Geocon	
P117	Ring 10	Center	180	50	5250	24	Kulite	
P118	Ring 10	A	180	585	5250	216	Geocon	
P119	Ring 10	A	180	685	5250	198	Geocon	
P120	Ring 10	A	180	785	5250	192	Geocon	
P121	Ring 10	B	365	585	5250	20	Kulite	
P122	Ring 10	B	365	785	5250	18	Kulite	
P123	Ring 10	C	275	585	5250	286	Kulite	
P124	Ring 10	C	275	785	5250	284	Kulite	
P125	Cyl. 3	Center	180	50	6250	158	Geocon	
P126	Cyl. 3	A	180	585	6250	162	Geocon	
P127	Cyl. 4	Center	180	50	6750	64	Kulite	

Table 4-3 Numbering and position of instruments for measuring pore water pressure (U)

		Instrument position in block				Cable pos.		
Type and number	Block	Direction	α	r	Z	α	Fabricate	Remark
U101	Cyl. 1	Center	270	50	50	246	Geocon	
U102	Cyl. 1	Center	270	50	250	236	Geocon	Horizontal
U103	Cyl. 1	A	175	585	250	126	Geocon	
U104	Cyl. 1	A	175	785	250	178	Geocon	
U105	Ring 5	A	175	585	2750	138	Geocon	
U106	Ring 5	A	175	785	2750	180	Geocon	
U107	Ring 5	B	355	535	2750	314	Geocon	
U108	Ring 5	B	355	825	2750	348	Geocon	
U109	Ring 5	C	265	585	2750	256	Geocon	In the slot
U110	Ring 5	C	265	825	2750	264	Geocon	In the slot
U111	Ring 10	A	175	585	5250	146	Geocon	
U112	Ring 10	A	175	785	5250	152	Geocon	
U113	Cyl. 3	Center	270	50	6250	156	Geocon	
U114	Cyl. 4	Center	270	50	6950	62	Kulite	

Table 4-4 Numbering and position of instruments for measuring water content (W)

		Instrument position in block				Cable pos.		
Type and number	Block	Direction	α	r	Z	α	Fabricate	Remark
W101	Cyl. 1	Center	360	50	50	248	Vaisala	
W102	Cyl. 1	Center	360	400	160	240	Vaisala	
W103	Cyl. 1	Center	360	50	450	234	Vaisala	Horizontal
W104	Cyl. 1	A	180	585	340	128	Vaisala	
W105	Cyl. 1	A	180	685	340	132	Vaisala	
W106	Cyl. 1	A	180	785	340	184	Vaisala	
W107	Cyl. 1	A	170	585	340	124	Wescor	
W108	Cyl. 1	A	170	685	340	130	Wescor	
W109	Cyl. 1	A	170	785	340	134	Wescor	
W110	Cyl. 1	B	360	585	340	304	Vaisala	
W111	Cyl. 1	B	360	785	340	360	Vaisala	
W112	Cyl. 1	B	360	685	340	308	Vaisala	
W113	Cyl. 1	B	355	585	340	302	Wescor	
W114	Cyl. 1	B	355	685	340	306	Wescor	
W115	Cyl. 1	B	355	785	340	310	Wescor	
W116	Cyl. 1	C	270	585	340	250	Wescor	
W117	Cyl. 1	C	270	685	340	252	Wescor	
W118	Cyl. 1	C	270	785	340	254	Vaisala	
W119	Ring 5	A	180	585	2840	226	Vaisala	
W120	Ring 5	A	180	685	2840	220	Vaisala	
W121	Ring 5	A	180	785	2840	182	Vaisala	
W122	Ring 5	A	170	585	2840	136	Wescor	
W123	Ring 5	A	170	685	2840	140	Wescor	
W124	Ring 5	A	170	785	2840	142	Wescor	
W125	Ring 5	B	360	535	2840	316	Vaisala	In the slot
W126	Ring 5	B	360	685	2840	34	Vaisala	
W127	Ring 5	B	360	785	2840	350	Vaisala	
W128	Ring 5	B	350	535	2840	312	Wescor	In the slot
W129	Ring 5	B	350	685	2840	320	Wescor	
W130	Ring 5	B	350	785	2840	346	Wescor	
W131	Ring 5	C	270	585	2840	294	Wescor	In the slot
W132	Ring 5	C	275	685	2840	292	Wescor	
W133	Ring 5	C	270	785	2840	288	Wescor	
W134	Ring 10	Center	360	50	5340	22	Vaisala	
W135	Ring 10	A	180	262	5340	26	Vaisala	
W136	Ring 10	A	180	585	5340	214	Vaisala	
W137	Ring 10	A	180	685	5340	196	Vaisala	
W138	Ring 10	A	180	785	5340	190	Vaisala	
W139	Ring 10	A	170	585	5340	144	Wescor	
W140	Ring 10	A	170	685	5340	148	Wescor	
W141	Ring 10	A	170	785	5340	150	Wescor	
W142	Ring 10	B	360	585	5340	328	Vaisala	
W143	Ring 10	B	360	685	5340	332	Vaisala	
W144	Ring 10	B	360	785	5340	336	Vaisala	
W145	Ring 10	B	355	585	5340	326	Wescor	
W146	Ring 10	B	355	685	5340	330	Wescor	
W147	Ring 10	B	355	785	5340	334	Wescor	
W148	Ring 10	C	270	585	5340	266	Wescor	
W149	Ring 10	C	270	685	5340	268	Wescor	
W150	Ring 10	C	270	785	5340	272	Vaisala	
W151	Cyl. 3	Center	360	50	6250	154	Vaisala	
W152	Cyl. 3	A	180	585	6250	160	Vaisala	
W153	Cyl. 3	B	360	585	6250	356	Vaisala	
W154	Cyl. 3	C	270	585	6250	276	Wescor	
W155	Cyl. 4	Center	360	50	6840	60	Vaisala	

4.4 Instruments in the rock

Temperature measurements

40 thermocouples are placed in the rock and on the rock surface of the deposition hole. Holes have been bored in three directions on three levels and one additional hole has been bored in the bottom of the deposition hole i.e. totally 10 holes. They are led from the rock, over the gap between rock and bentonite and up along the bentonite block periphery. The position of the thermocouples in the rock is shown in Table 4-5.

Table 4-5 Numbering and positions of thermocouples in the rock

Type and number	Level	Direction	Distance from rock surface	Cable pos. α	Fabricate	Remark
TR101	0	Center	0.000	70°-90°	BICC	
TR102	0	Center	0.375	70°-90°	BICC	
TR103	0	Center	0.750	70°-90°	BICC	
TR104	0	Center	1.500	70°-90°	BICC	
TR105	0.61	10°	0.000	4°-14°	BICC	
TR106	0.61	10°	0.375	4°-14°	BICC	
TR107	0.61	10°	0.750	4°-14°	BICC	
TR108	0.61	10°	1.500	4°-14°	BICC	
TR109	0.61	80°	0.000	70°-90°	BICC	
TR110	0.61	80°	0.375	70°-90°	BICC	
TR111	0.61	80°	0.750	70°-90°	BICC	
TR112	0.61	80°	1.500	70°-90°	BICC	
TR113	0.61	170°	0.000	168°-176°	BICC	
TR114	0.61	170°	0.375	168°-176°	BICC	
TR115	0.61	170°	0.750	168°-176°	BICC	
TR116	0.61	170°	1.500	168°-176°	BICC	
TR117	3.01	10°	0.000	4°-14°	BICC	
TR118	3.01	10°	0.375	4°-14°	BICC	
TR119	3.01	10°	0.750	4°-14°	BICC	
TR120	3.01	10°	1.500	4°-14°	BICC	
TR121	3.01	80°	0.000	70°-90°	BICC	
TR122	3.01	80°	0.375	70°-90°	BICC	
TR123	3.01	80°	0.750	70°-90°	BICC	
TR124	3.01	80°	1.500	70°-90°	BICC	
TR125	3.01	170°	0.000	168°-176°	BICC	
TR126	3.01	170°	0.375	168°-176°	BICC	
TR127	3.01	170°	0.750	168°-176°	BICC	
TR128	3.01	170°	1.500	168°-176°	BICC	
TR129	5.41	10°	0.000	4°-14°	BICC	
TR130	5.41	10°	0.375	4°-14°	BICC	
TR131	5.41	10°	0.750	4°-14°	BICC	
TR132	5.41	10°	1.500	4°-14°	BICC	
TR133	5.41	80°	0.000	70°-90°	BICC	
TR134	5.41	80°	0.375	70°-90°	BICC	
TR135	5.41	80°	0.750	70°-90°	BICC	
TR136	5.41	80°	1.500	70°-90°	BICC	
TR137	5.41	170°	0.000	168°-176°	BICC	
TR138	5.41	170°	0.375	168°-176°	BICC	
TR139	5.41	170°	0.750	168°-176°	BICC	
TR140	5.41	170°	1.500	168°-176°	BICC	

Stress and strain measurements

These are not reported

4.5 Instruments in the canister

The canister is instrumented with optical fiber cables on the copper surface, thermocouples in the steel insert and strain gauges on the copper surface. Only the fiber cables and the thermocouples and the resulting temperature measurements are described in this report.

Figure 4-2 shows how the two optical fiber cables are placed on the canister surface. Both ends of a cable are used for measurements. This means that the two cables are used as four measuring channels as described in Table 4-6.

With this laying the cable will enter and exit the surface at almost the same position. Curvatures are shaped as a quarter circle with a radius of 20 cm. The cable is placed in a milled out channel on the surface. The channel has a width and a depth of just above 2 mm

Table 4-6. Combination of cables and channels

Channel 1	Outlet of cable 1
Channel 2	Inlet of cable 1
Channel 3	Outlet of cable 2
Channel 4	Inlet of cable 2

Figure 4-3 shows the location of the thermocouples on the steel insert inside the canister.

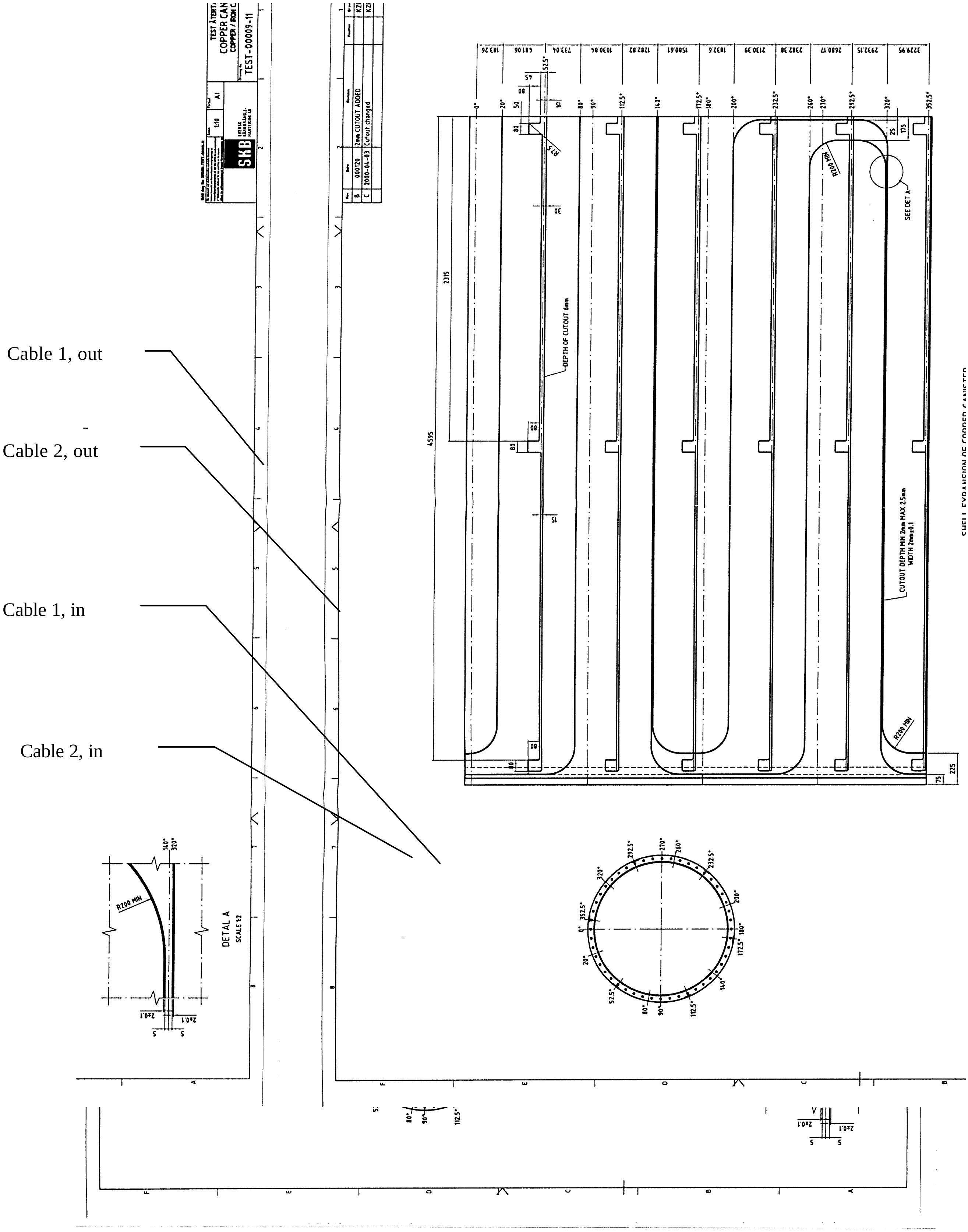
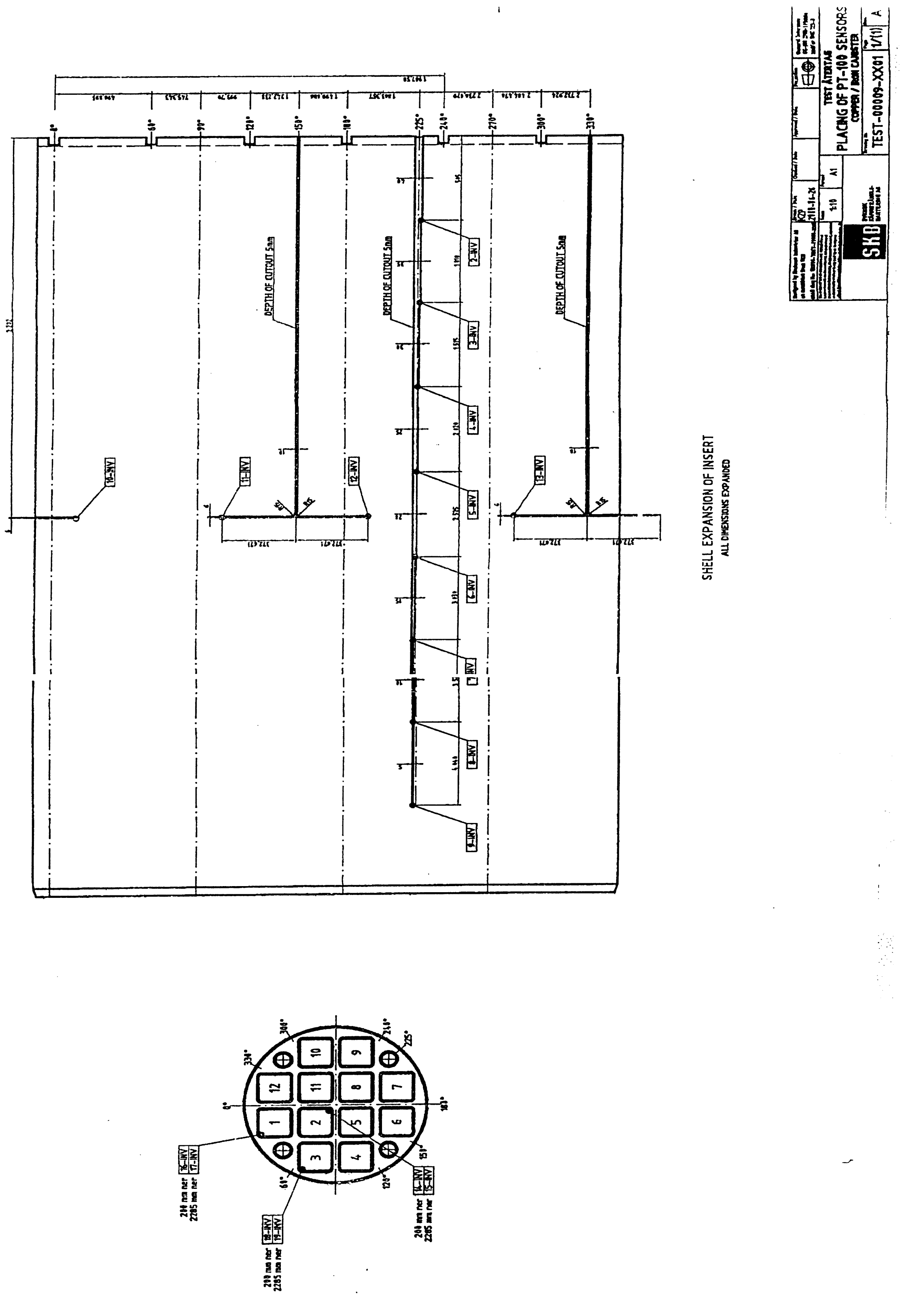


Figure 4-2. *Laying of two optical fibre cables with protection tube of Inconel 625 (outer diameter 2 mm) for measurement of the canister surface temperature (surface unfolded).*



Figur 4-3. *Location of thermocouples inside the canister*

4.6 Instruments at the plug

Three force transducers and three displacement transducers have been placed on the plug to measure the force of the anchors and the displacement of the plug. The location of these transducers can be described in relation to Fig 4-4, which shows a schematic view of the plug with the slots, rods and cables.

The rods are numbered 1-9 anti-clockwise and number 1 is assumed to be the northern rod in direction A. The force transducers are placed on rods 3, 6, and 9. The displacement transducers are placed between the rods 5 cm from the rock surface of the hole and according to Table 4-6. They are fixed on the rock surface and measure thus the displacement relative the rock.

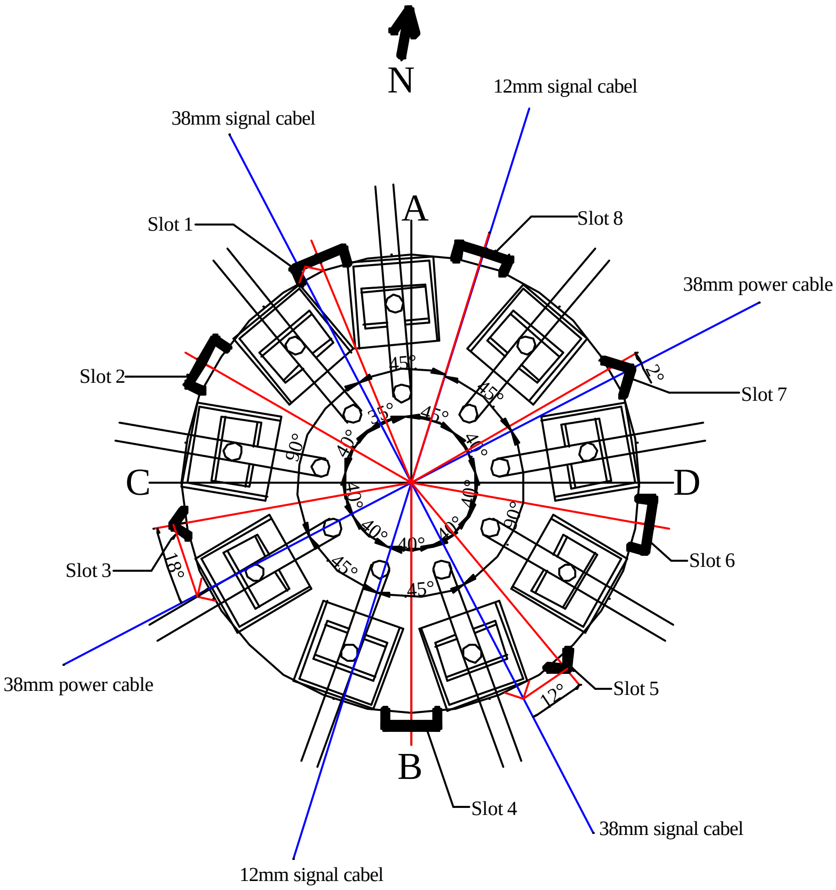


Figure 4-4. *Schematic view of the deposition hole, showing the position of the slots, the rods and the cables from the canister.*

Table 4-6. Location of displacement transducers

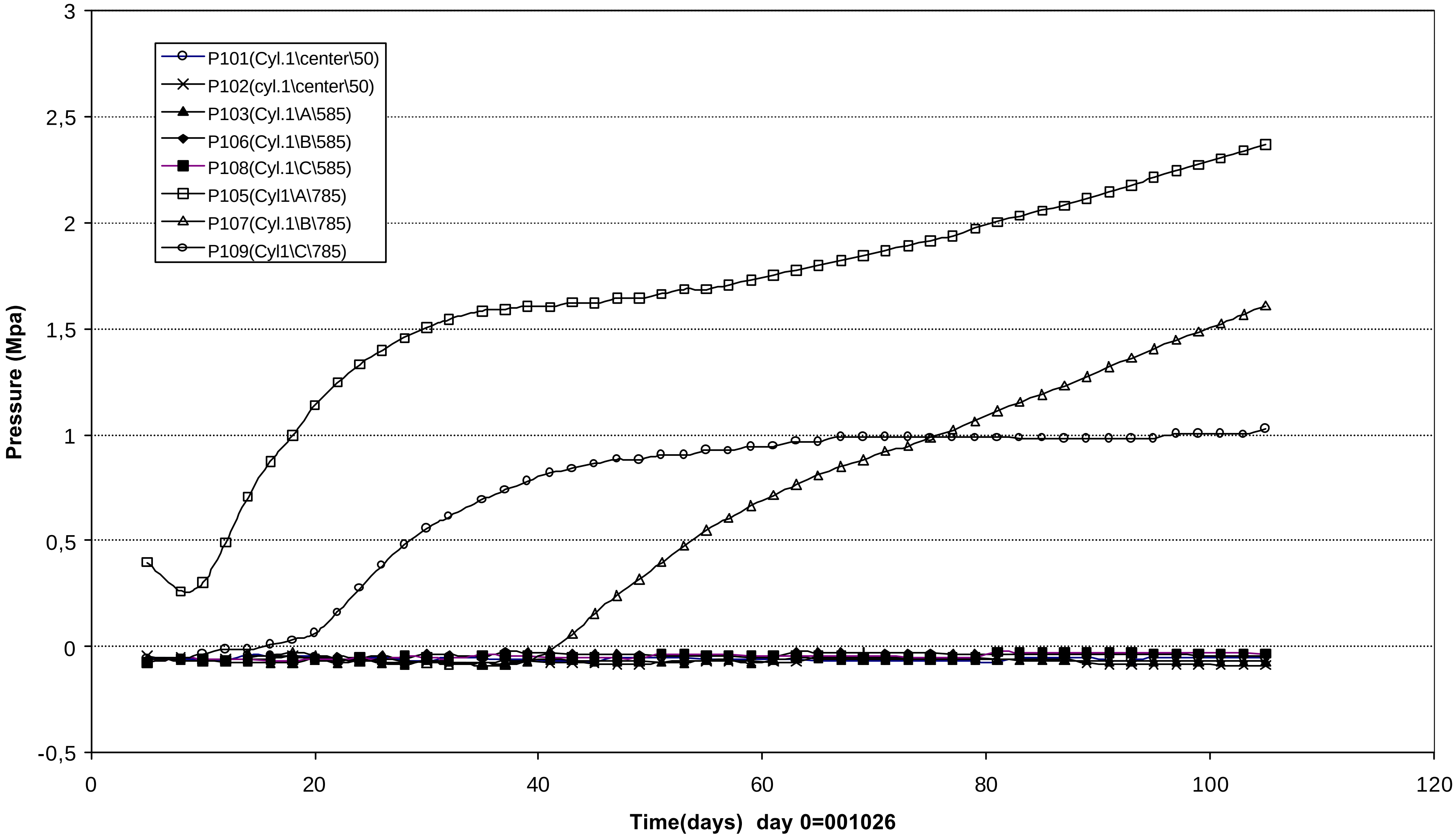
Transducer No.	Located between rods No.
1	4 and 5
2	7 and 8
3	1 and 2

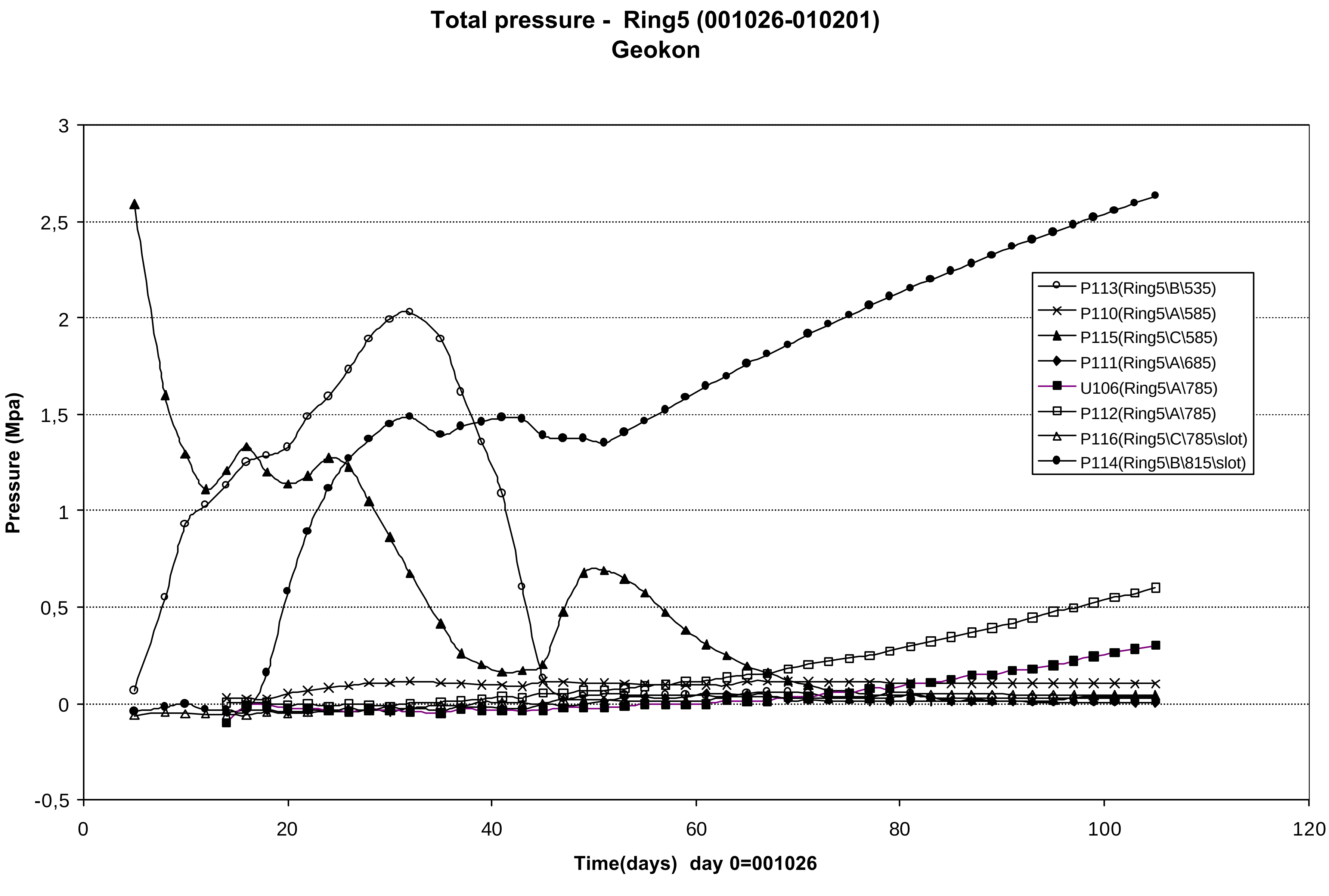
References

/1-1/ Sanden T, Börgesson L. Report on instrument positions and preparation of bentonite blocks for instruments and cables May 2000

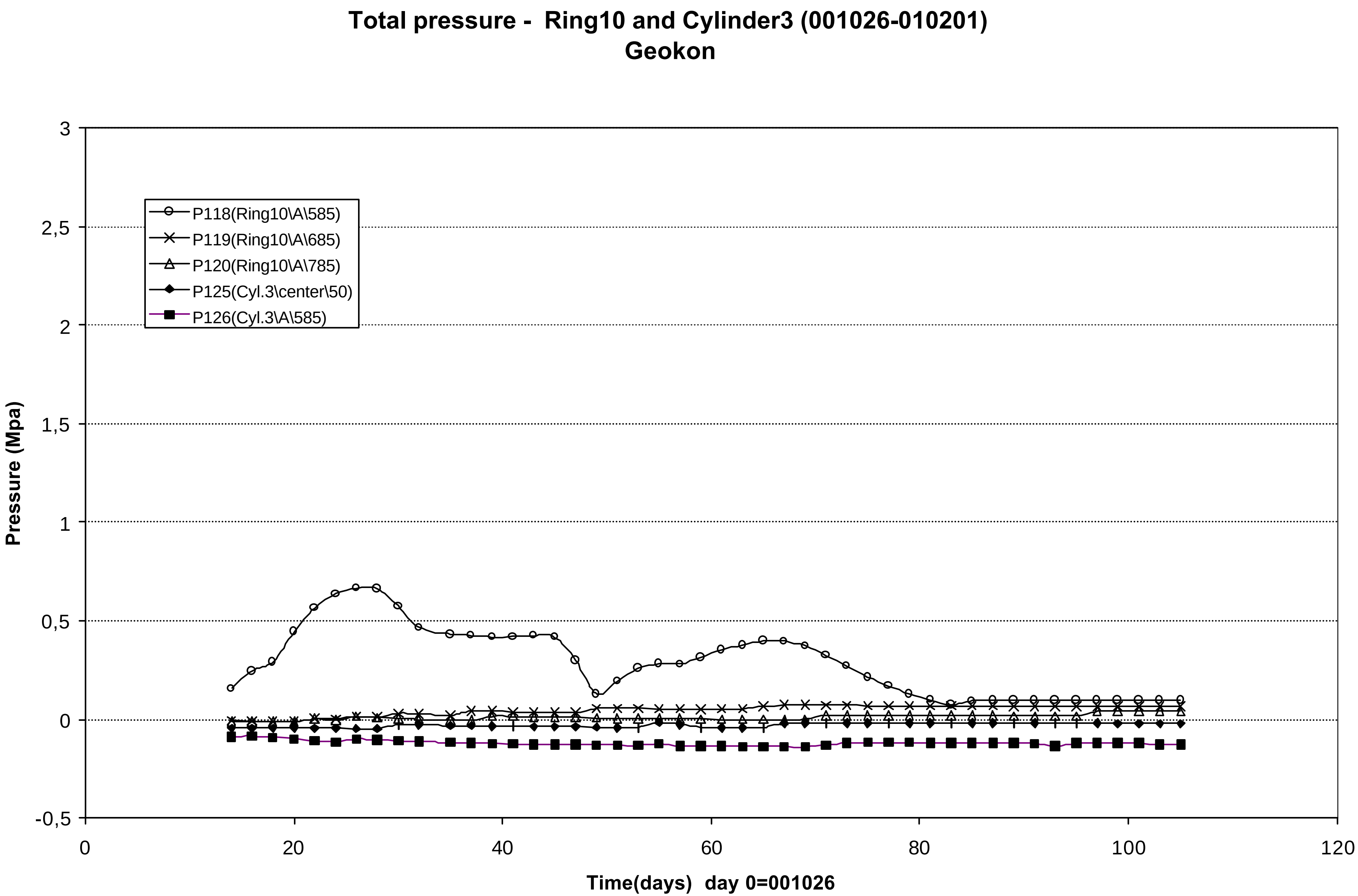
Appendix 1

Total pressure - Cylinder1 (001026-010201)
Geokon



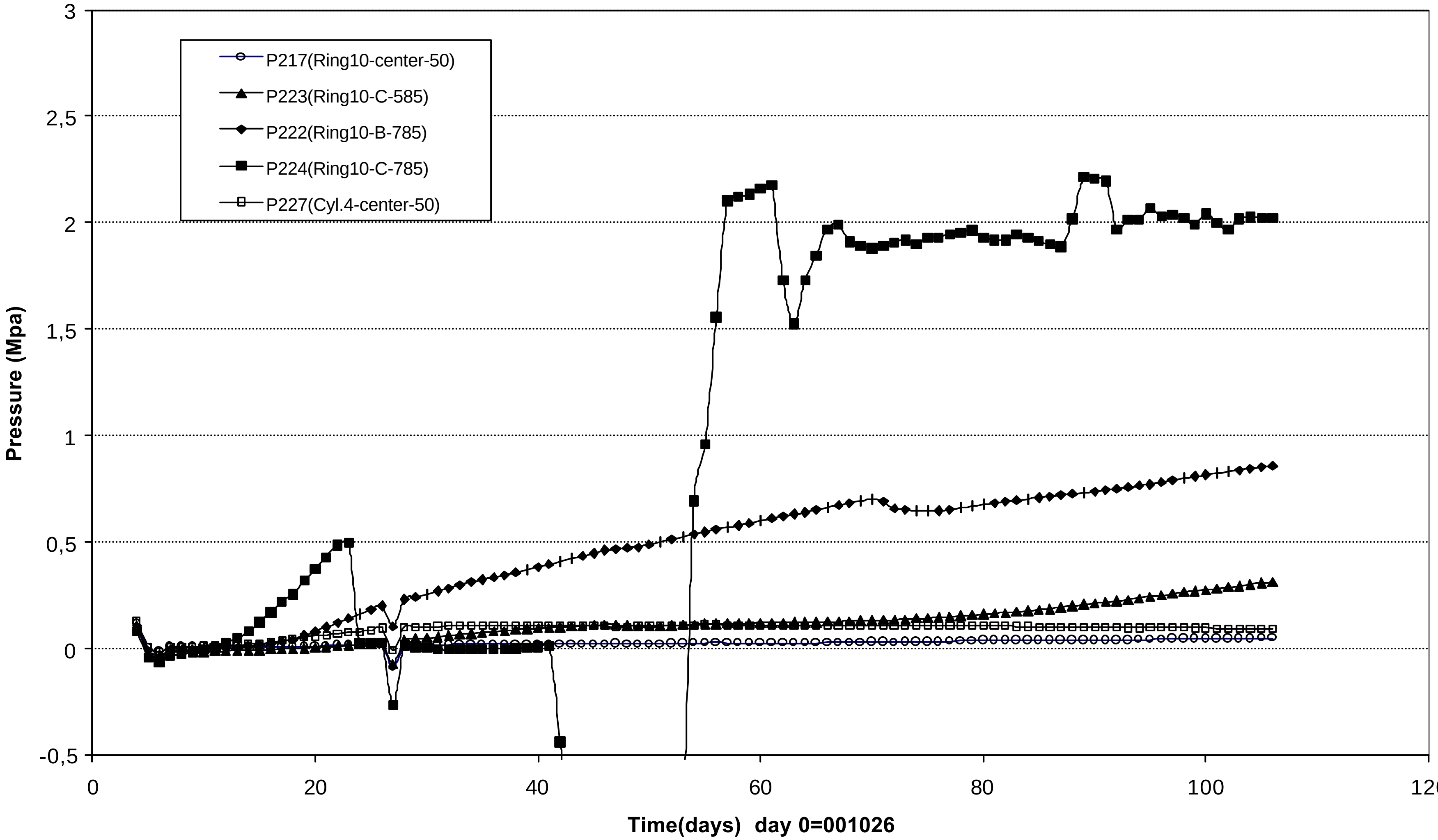


Total pressure - Ring5 (001026-010201)
Geokon
Pressure (Mpa)
3
2,5
2
1,5
1
0,5
0
-0,5
0
20
40
60
80
100
120
Time(days) day 0=001026
P113(Ring5\B\535)
P110(Ring5\A\585)
P115(Ring5\C\585)
P111(Ring5\A\685)
U106(Ring5\A\785)
P112(Ring5\A\785)
P116(Ring5\C\785\slot)
P114(Ring5\B\815\slot)

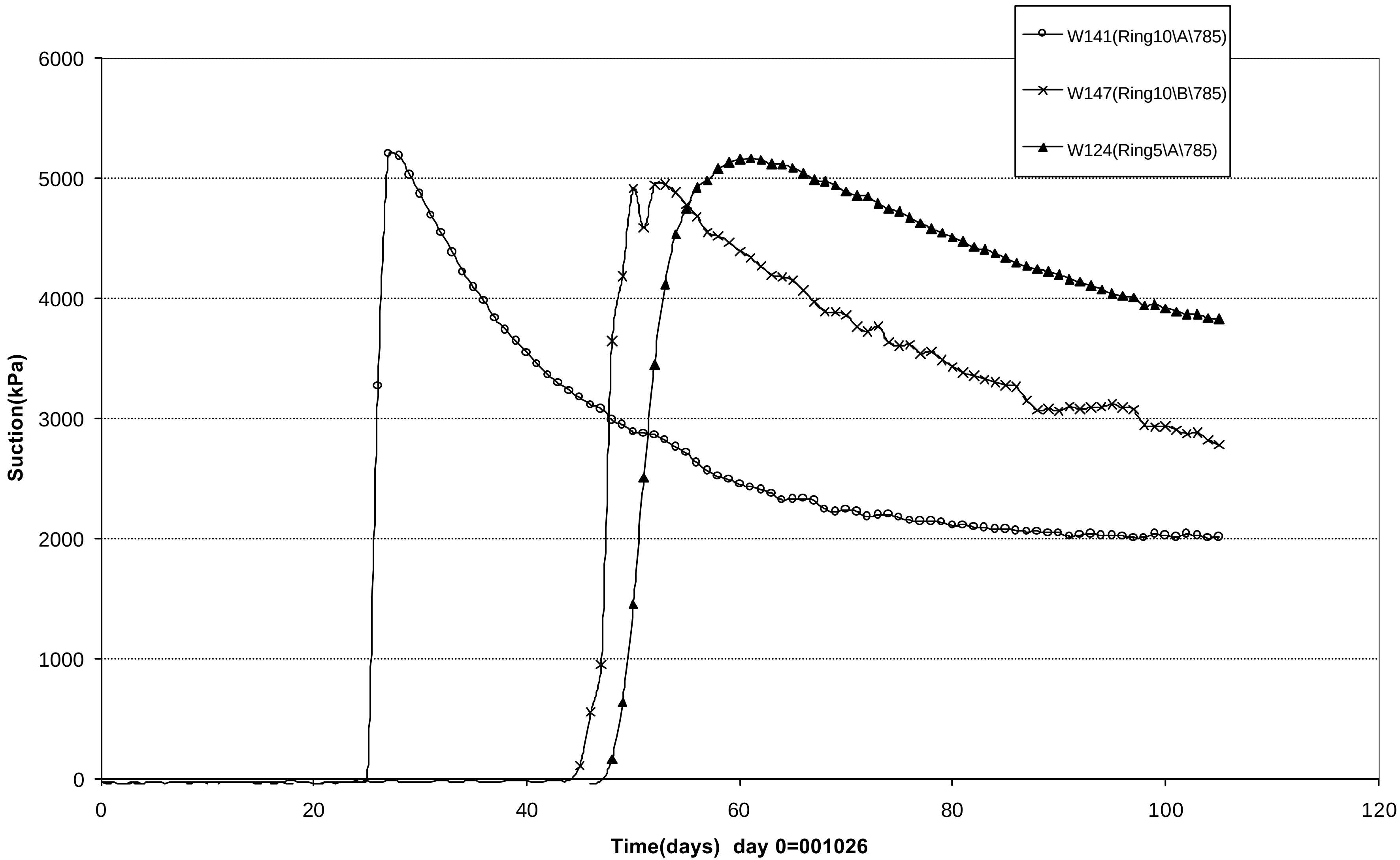


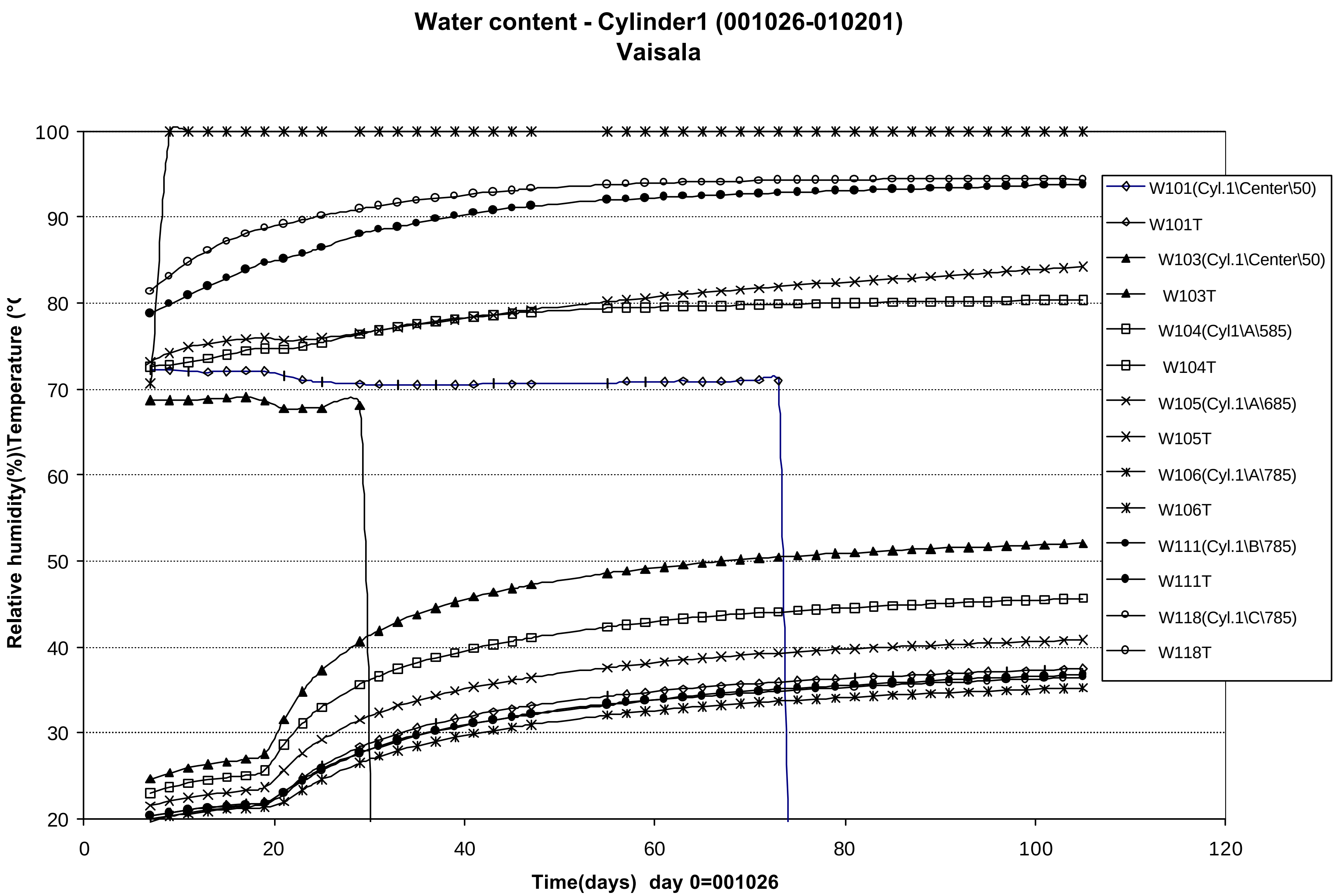
Total pressure - Ring10 and Cylinder3 (001026-010201)
Geokon
P118(Ring10\A\585)
P119(Ring10\A\685)
P120(Ring10\A\785)
P125(Cyl.3\center\50)
P126(Cyl.3\A\585)
Pressure (Mpa)
3
2,5
2
1,5
1
0,5
0
-0,5
0
20
40
60
80
100
120
Time(days) day 0=001026

Total pressure - Ring10 (001026-010201)
Kulite

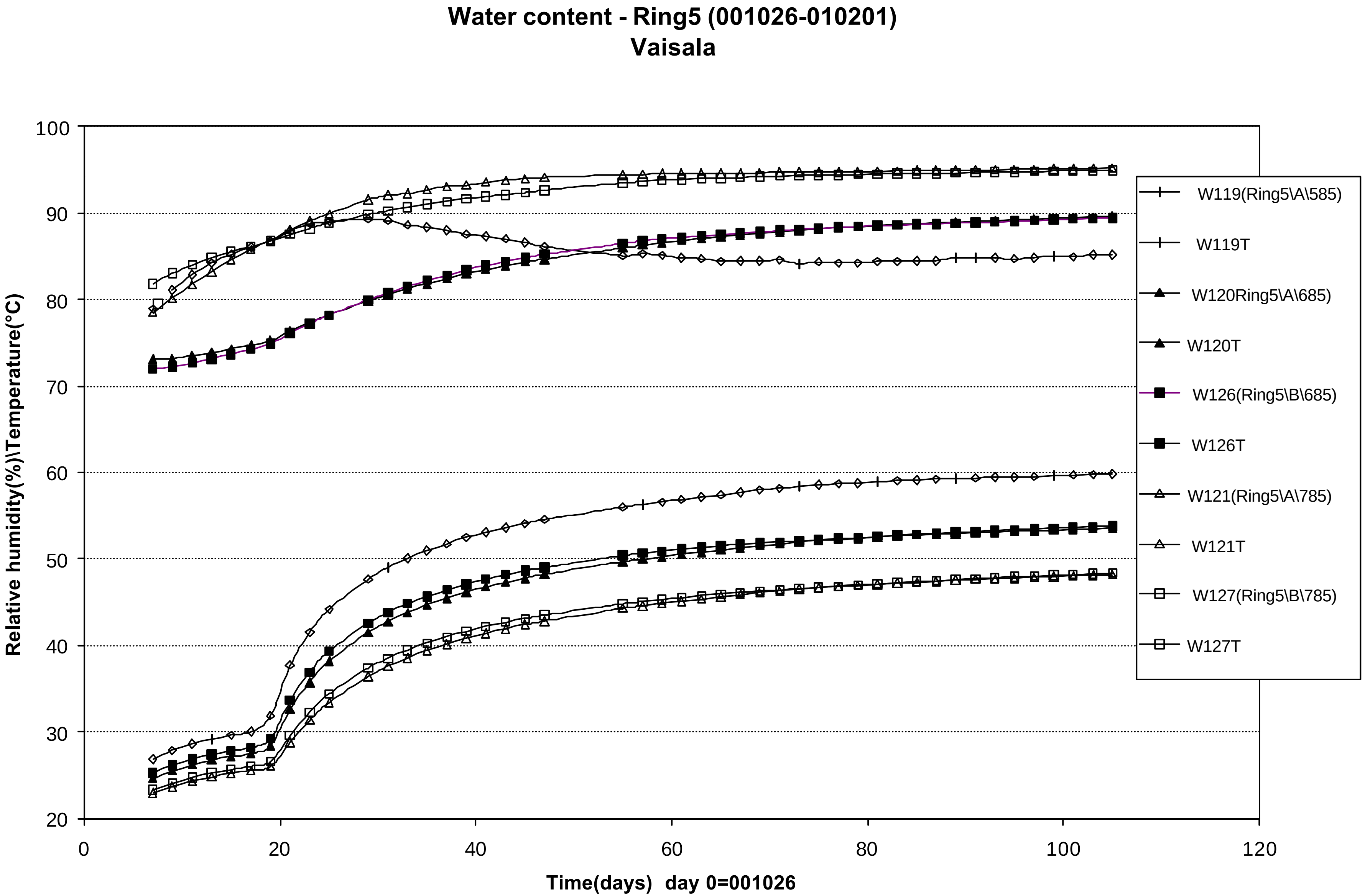


Suction in the buffer (001026-010201)

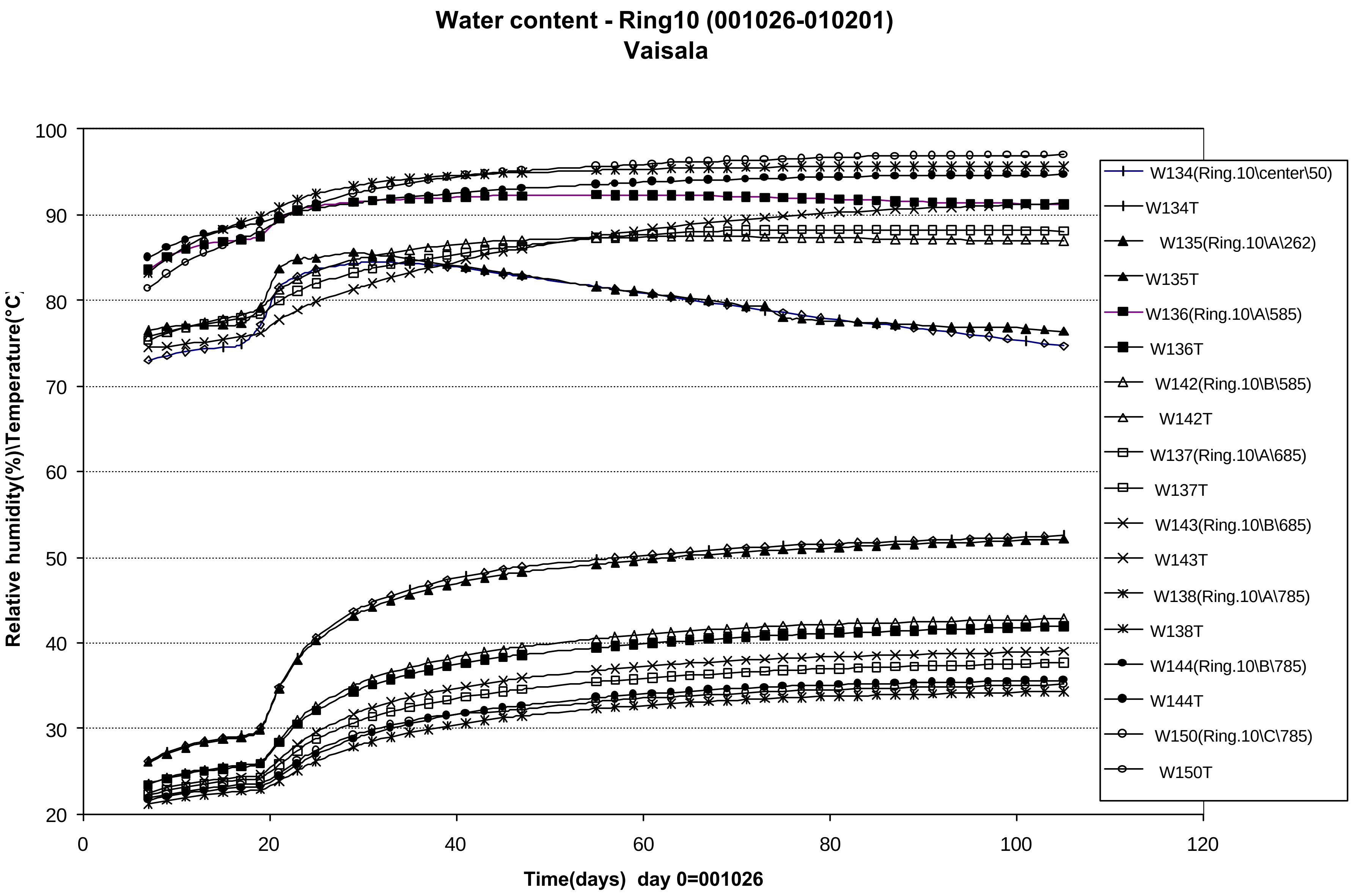




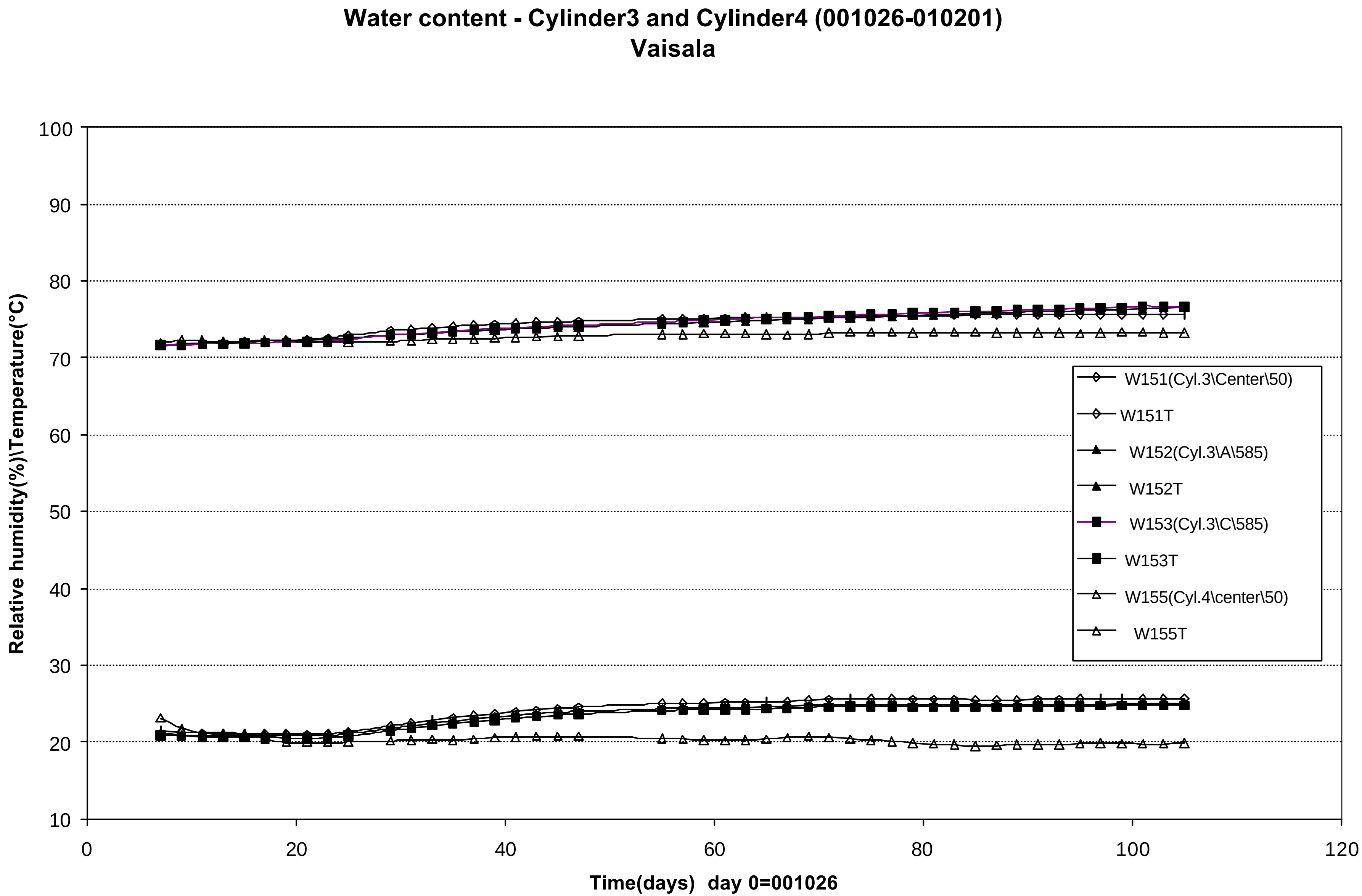
Water content - Cylinder1 (001026-010201)
Vaisala
Relative humidity(%)\Temperature (°C
Time(days) day 0=001026
100
90
80
70
60
50
40
30
20
0
20
40
60
80
100
120
W101(Cyl.1\Center\50)
W101T
W103(Cyl.1\Center\50)
W103T
W104(Cyl1\A\585)
W104T
W105(Cyl.1\A\685)
W105T
W106(Cyl.1\A\785)
W106T
W111(Cyl.1\B\785)
W111T
W118(Cyl.1\C\785)
W118T



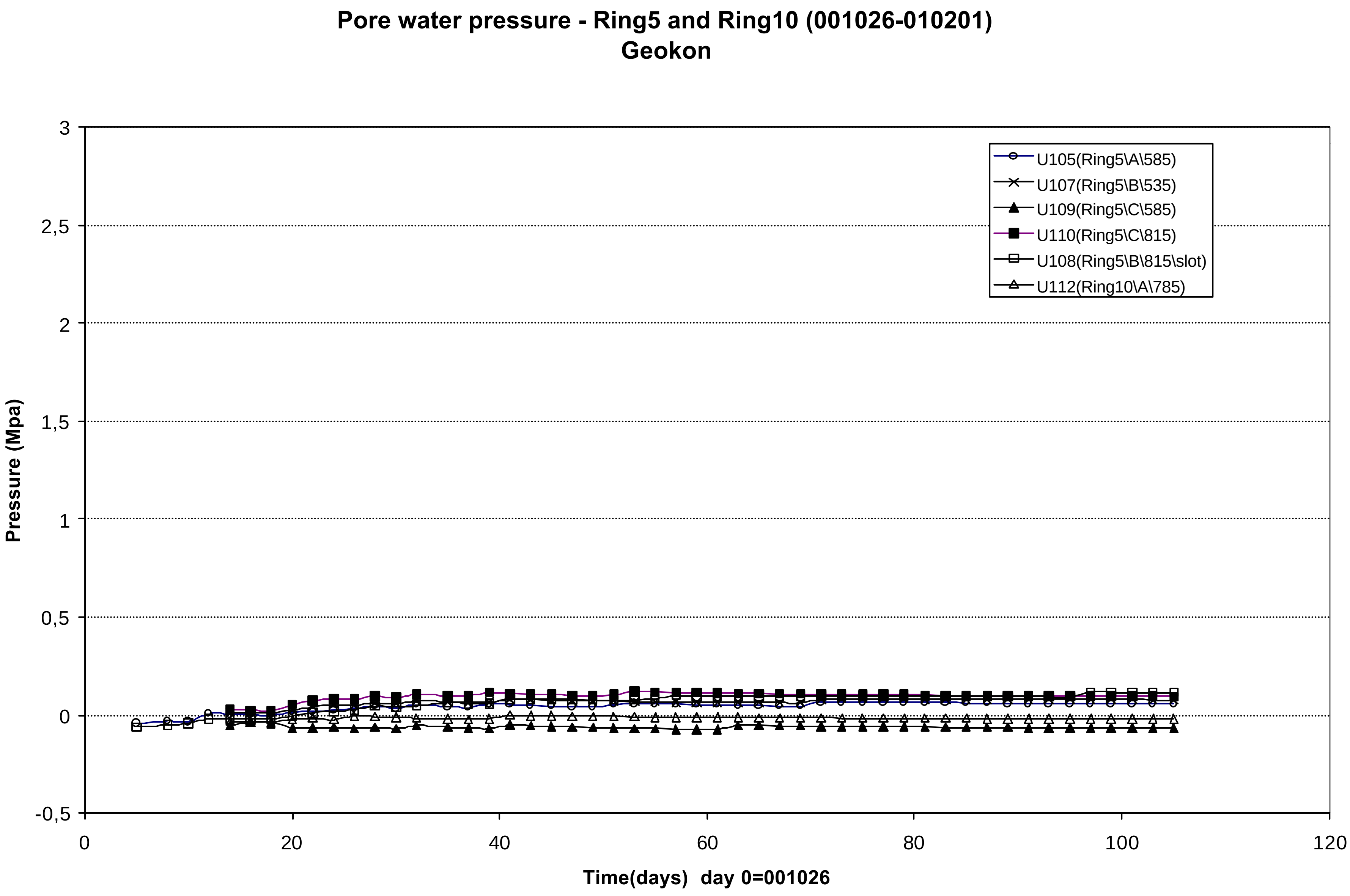
Water content - Ring5 (001026-010201)
Vaisala
100
90
80
70
60
50
40
30
20
Relative humidity(%)\Temperature(°C)
0
20
40
60
80
100
120
Time(days) day 0=001026
W119(Ring5\A\585)
W119T
W120Ring5\A\685)
W120T
W126(Ring5\B\685)
W126T
W121(Ring5\A\785)
W121T
W127(Ring5\B\785)
W127T



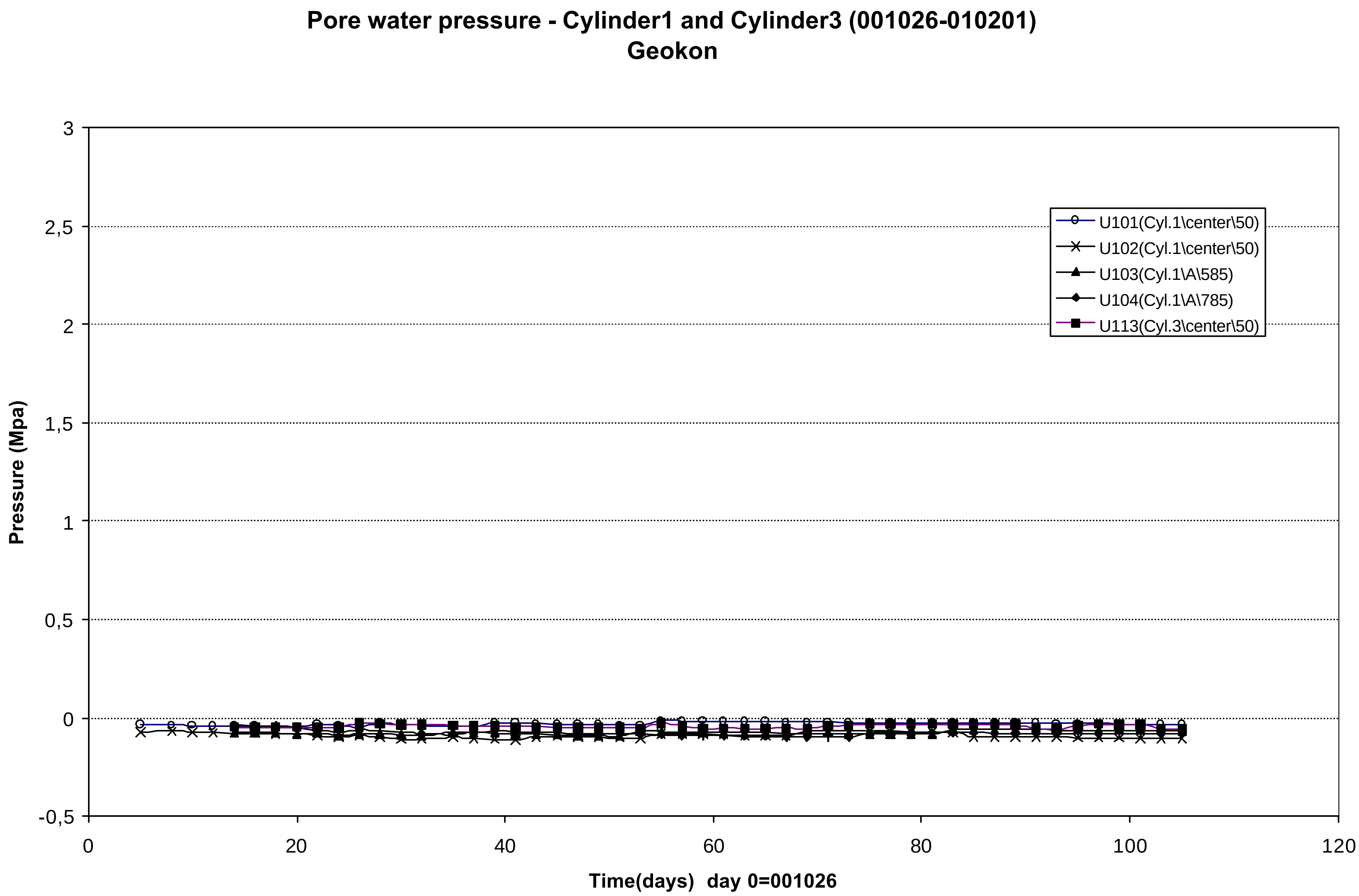
Water content - Ring10 (001026-010201)
Vaisala
Relative humidity(%)\Temperature(°C)
100
90
80
70
60
50
40
30
20
0
20
40
60
80
100
120
Time(days) day 0=001026
W134(Ring.10\center\50)
W134T
W135(Ring.10\A\262)
W135T
W136(Ring.10\A\585)
W136T
W142(Ring.10\B\585)
W142T
W137(Ring.10\A\685)
W137T
W143(Ring.10\B\685)
W143T
W138(Ring.10\A\785)
W138T
W144(Ring.10\B\785)
W144T
W150(Ring.10\C\785)
W150T



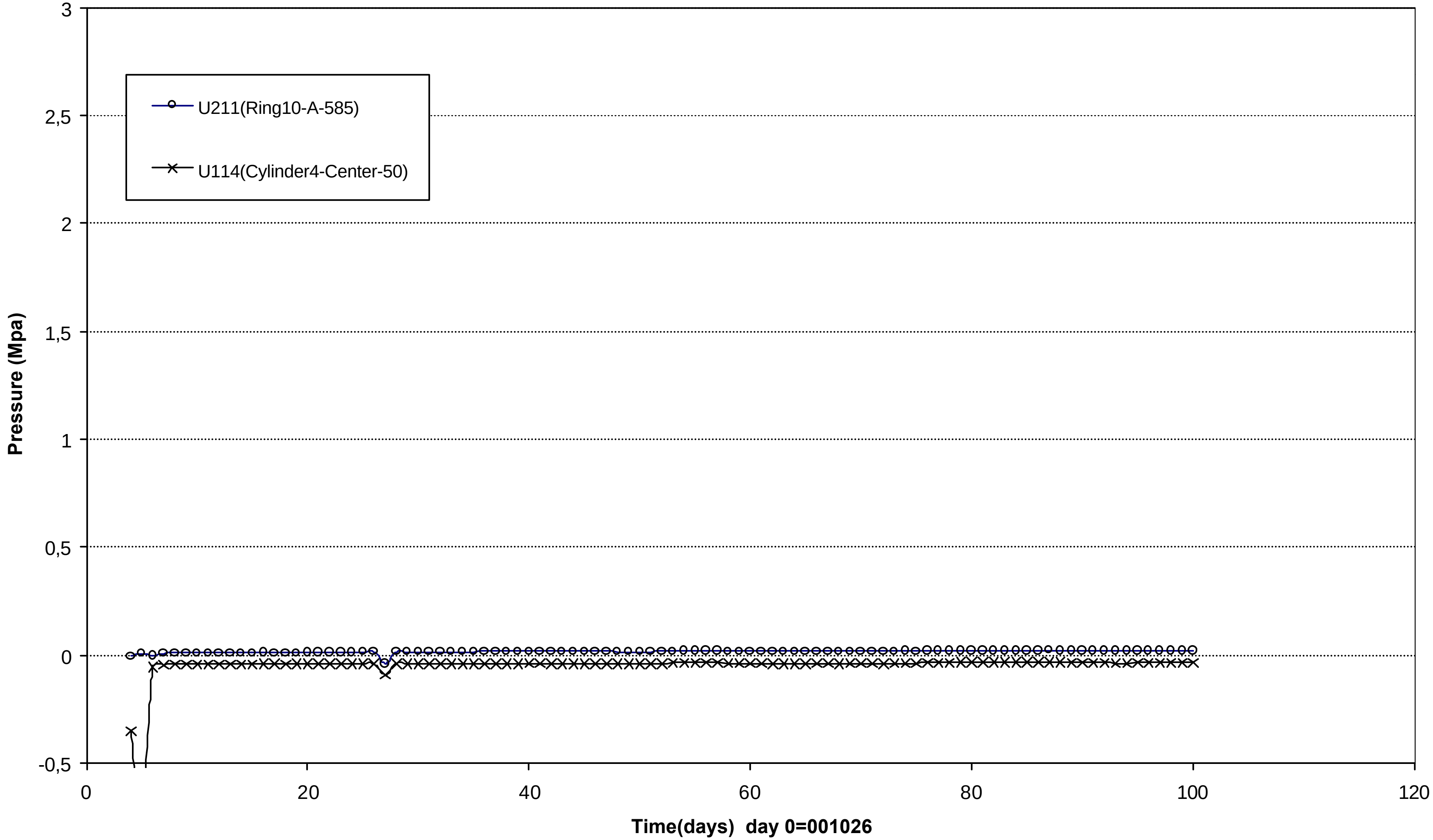
Water content - Cylinder3 and Cylinder4 (001026-010201)
Vaisala
Relative humidity(%)\Temperature(°C)
Time(days)   day 0=001026
100
90
80
70
60
50
40
30
20
10
0
20
40
60
80
100
120
W151(Cyl.3\Center\50)
W151T
W152(Cyl.3\A\585)
W152T
W153(Cyl.3\C\585)
W153T
W155(Cyl.4\center\50)
W155T

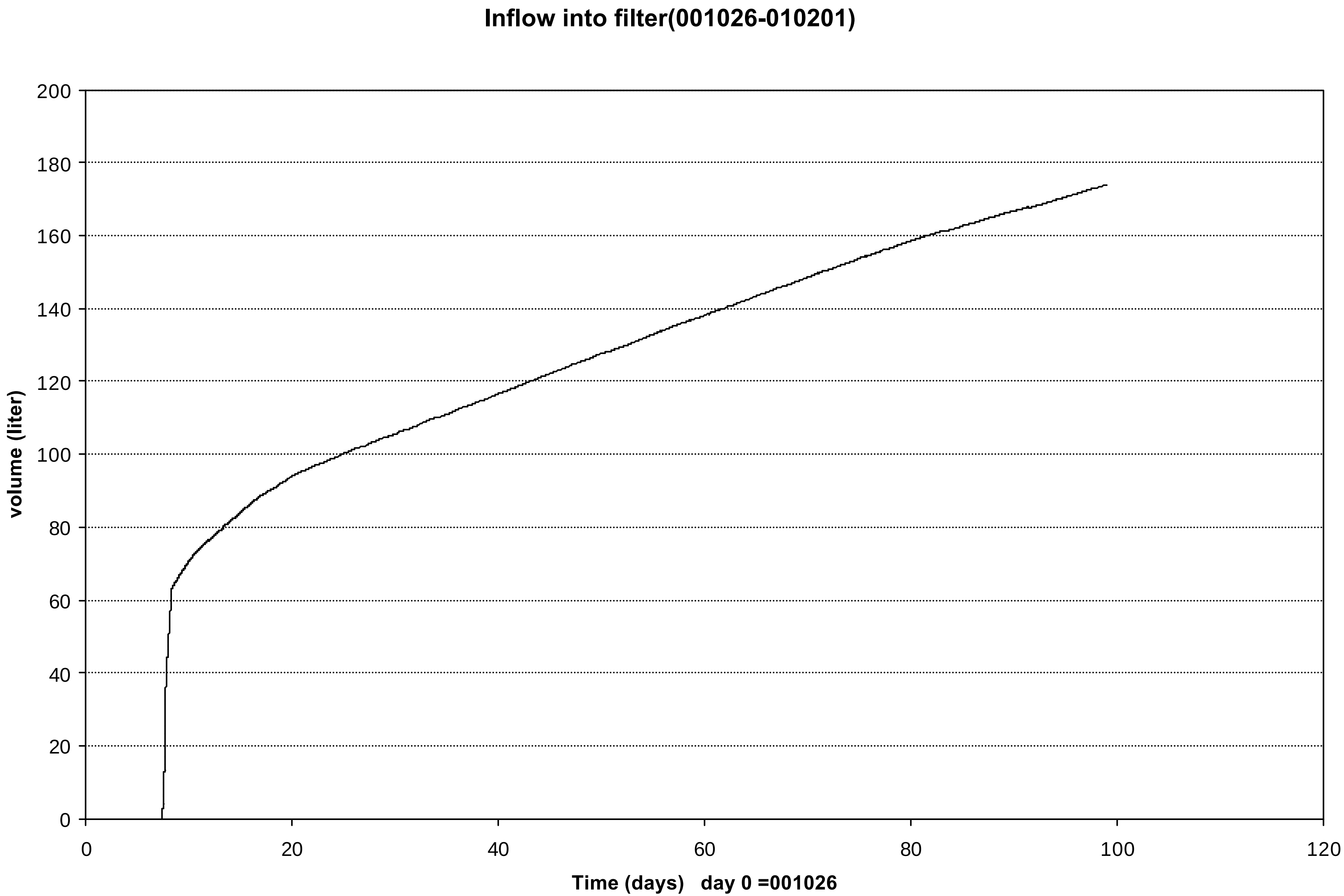


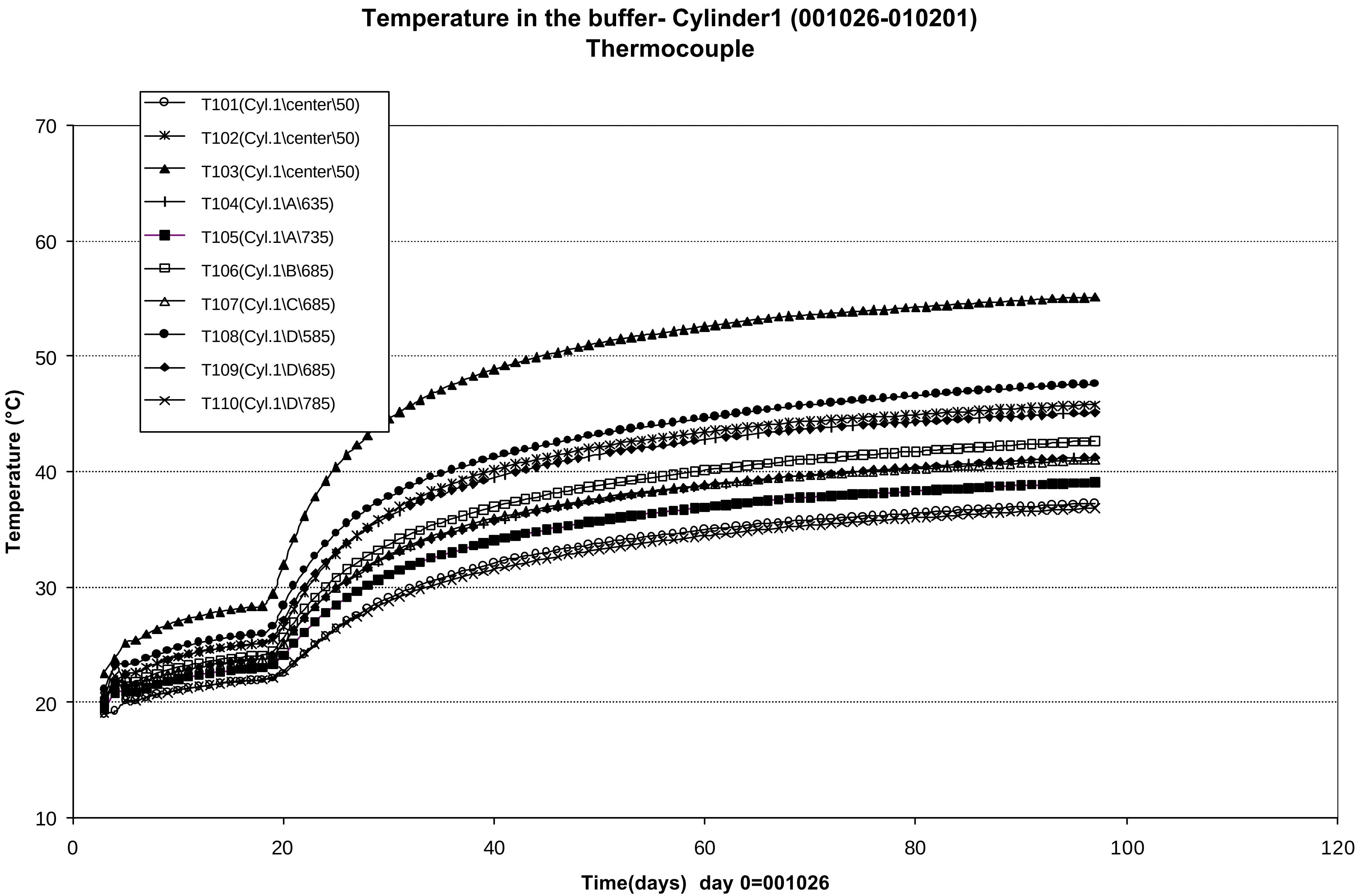
Pore water pressure - Ring5 and Ring10 (001026-010201)
Geokon
Pressure (Mpa)
3
2,5
2
1,5
1
0,5
0
-0,5
0
20
40
60
80
100
120
Time(days) day 0=001026
U105(Ring5\A\585)
U107(Ring5\B\535)
U109(Ring5\C\585)
U110(Ring5\C\815)
U108(Ring5\B\815\slot)
U112(Ring10\A\785)


Pore water pressure - Cylinder1 and Cylinder3 (001026-010201)
Geokon
Pressure (Mpa)
3
2,5
2
1,5
1
0,5
0
-0,5
0
20
40
60
80
100
120
Time(days) day 0=001026
U101(Cyl.1\center\50)
U102(Cyl.1\center\50)
U103(Cyl.1\A\585)
U104(Cyl.1\A\785)
U113(Cyl.3\center\50)

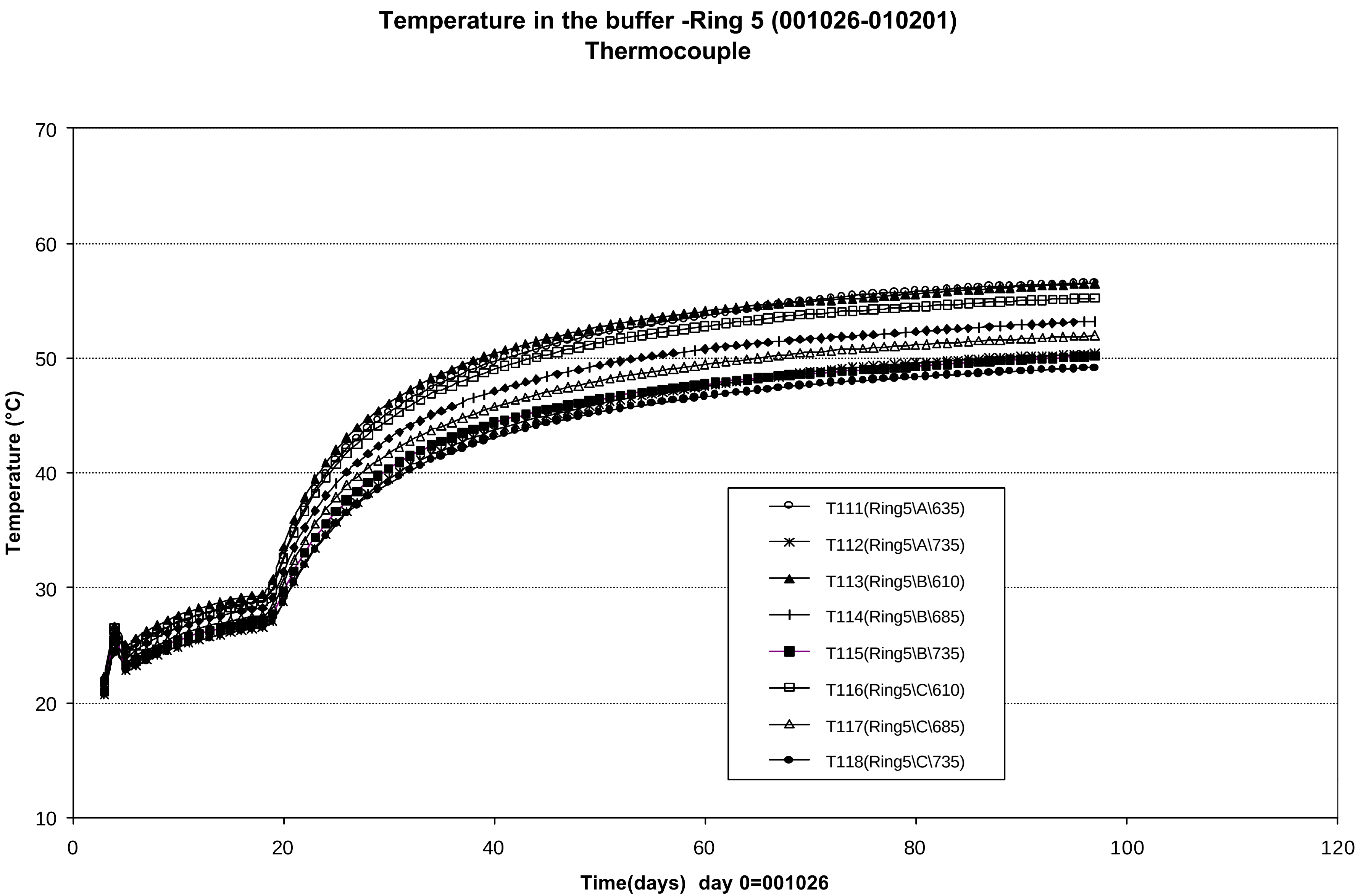
Pore water pressure - Ring10 and Cylinder4 (001026-010201)
Kulite



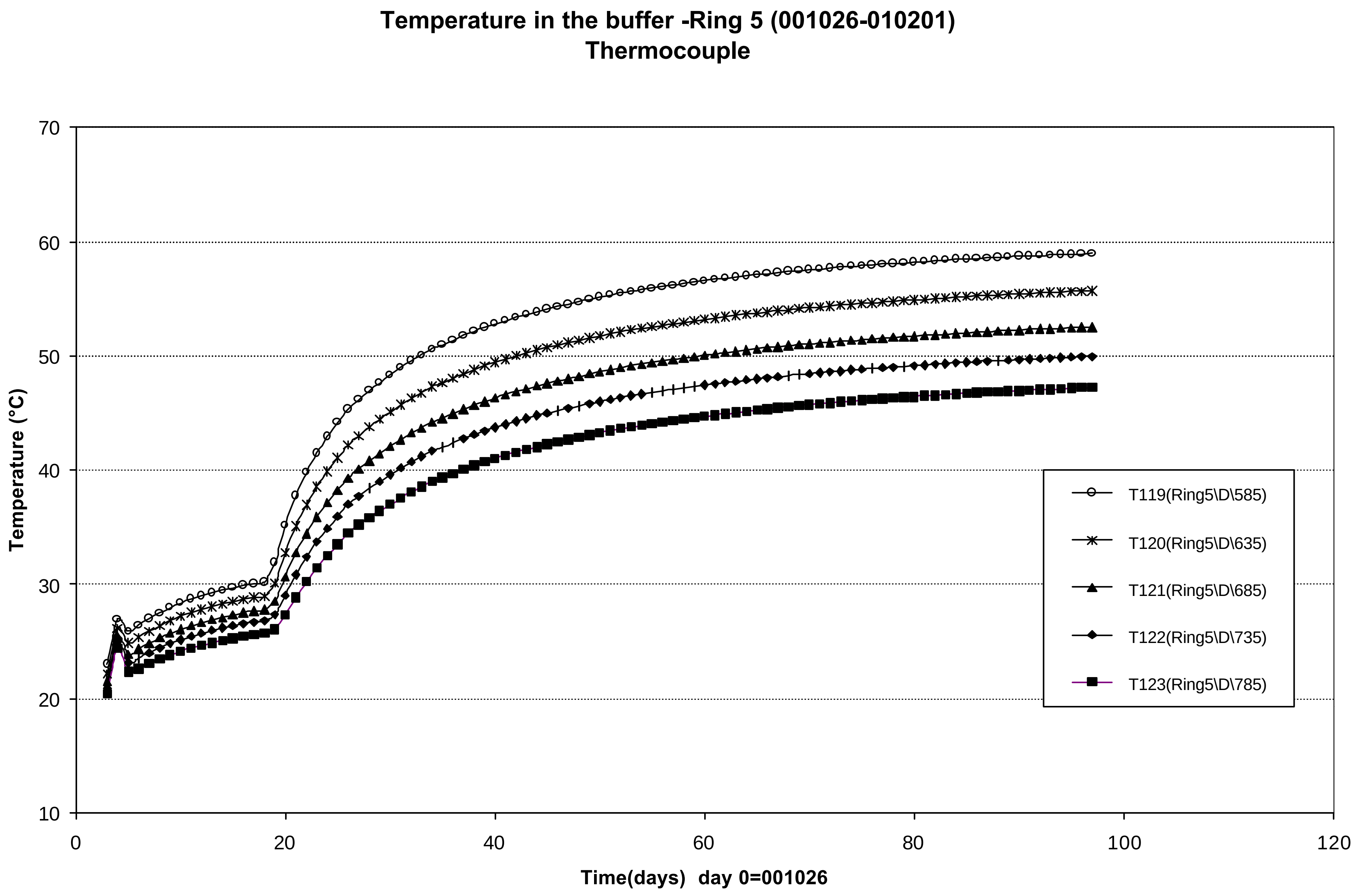

Inflow into filter(001026-010201)
volume (liter)
0
20
40
60
80
100
120
140
160
180
200
0
20
40
60
80
100
120
Time (days)   day 0 =001026



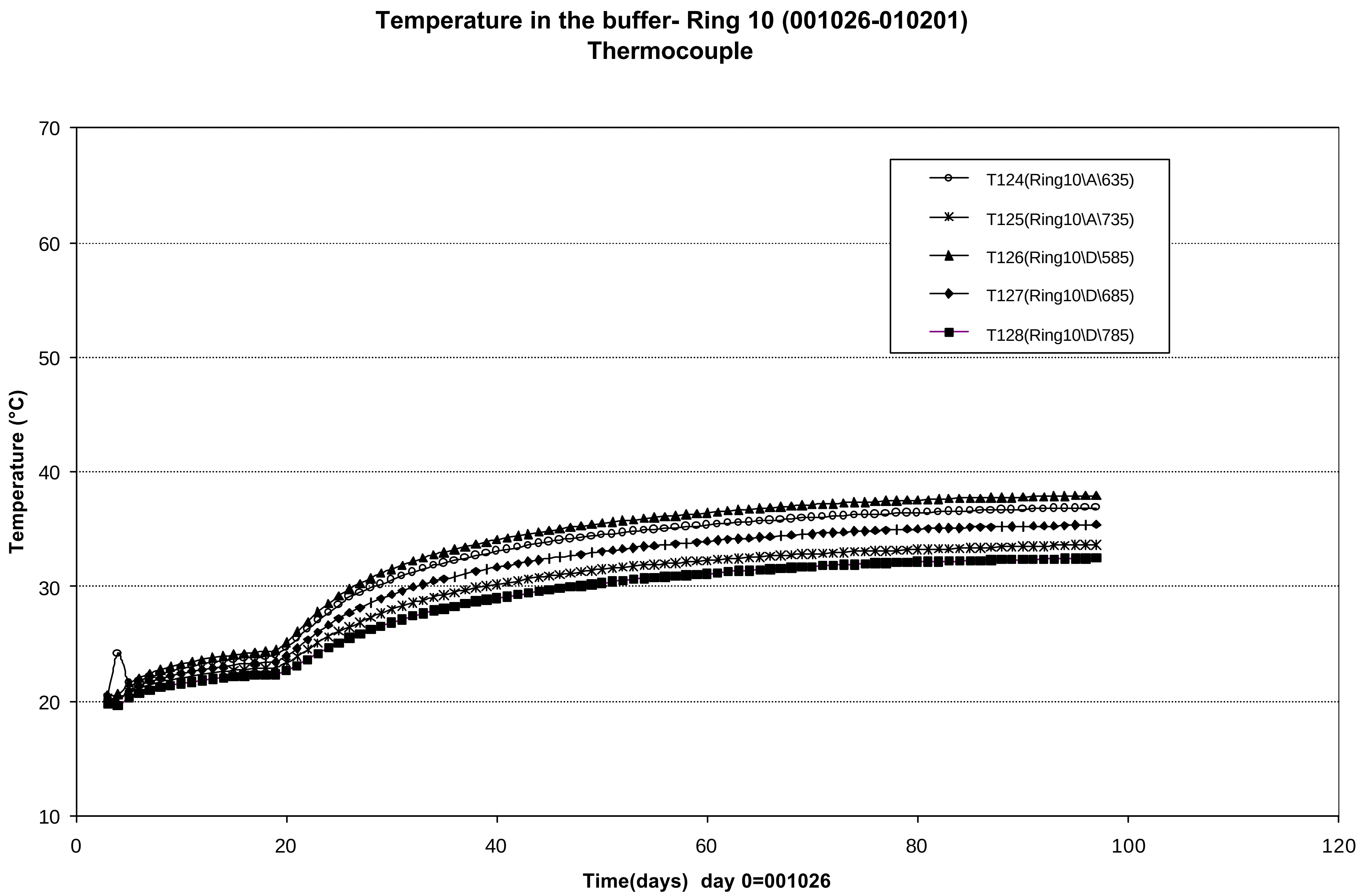
Temperature in the buffer- Cylinder1 (001026-010201)
Thermocouple
T101(Cyl.1\center\50)
T102(Cyl.1\center\50)
T103(Cyl.1\center\50)
T104(Cyl.1\A\635)
T105(Cyl.1\A\735)
T106(Cyl.1\B\685)
T107(Cyl.1\C\685)
T108(Cyl.1\D\585)
T109(Cyl.1\D\685)
T110(Cyl.1\D\785)
Temperature (°C)
Time(days) day 0=001026
0
20
40
60
80
100
120
10
20
30
40
50
60
70



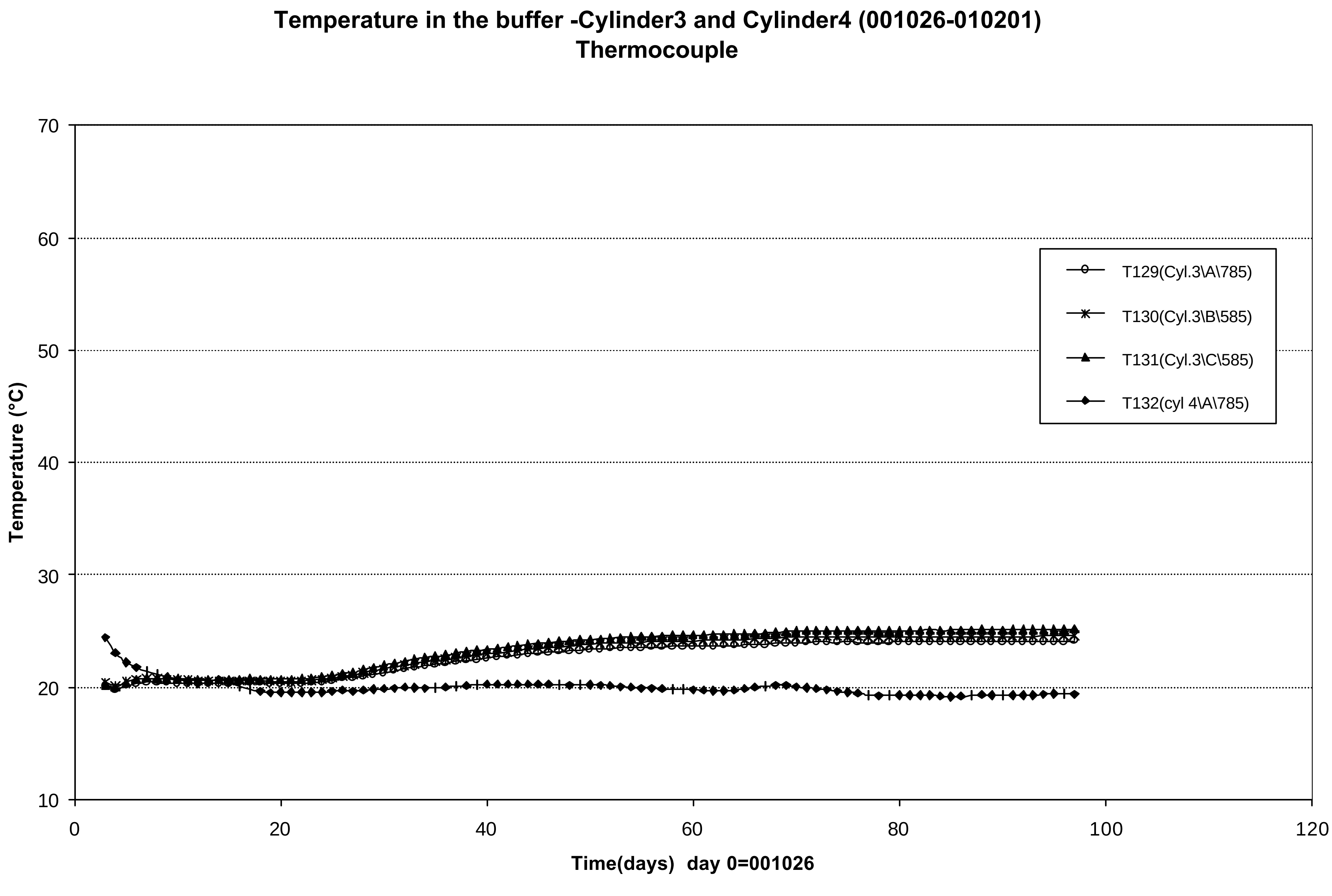
Temperature in the buffer -Ring 5 (001026-010201)
Thermocouple
Temperature (°C)
70
60
50
40
30
20
10
0
20
40
60
80
100
120
Time(days) day 0=001026
T111(Ring5\A\635)
T112(Ring5\A\735)
T113(Ring5\B\610)
T114(Ring5\B\685)
T115(Ring5\B\735)
T116(Ring5\C\610)
T117(Ring5\C\685)
T118(Ring5\C\735)



Temperature in the buffer -Ring 5 (001026-010201)
Thermocouple
Temperature (°C)
Time(days) day 0=001026
70
60
50
40
30
20
10
0
20
40
60
80
100
120
T119(Ring5\D\585)
T120(Ring5\D\635)
T121(Ring5\D\685)
T122(Ring5\D\735)
T123(Ring5\D\785)

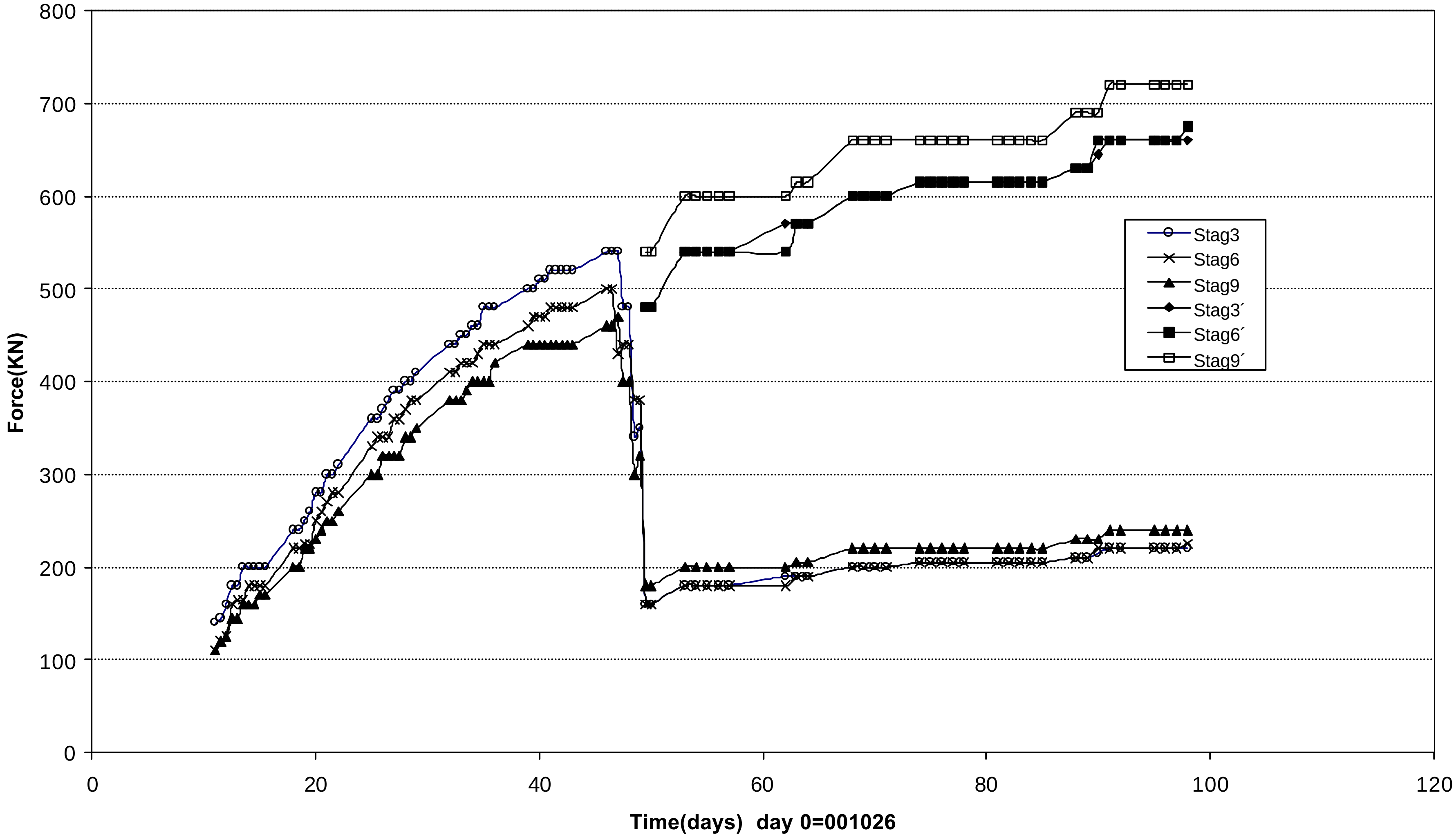


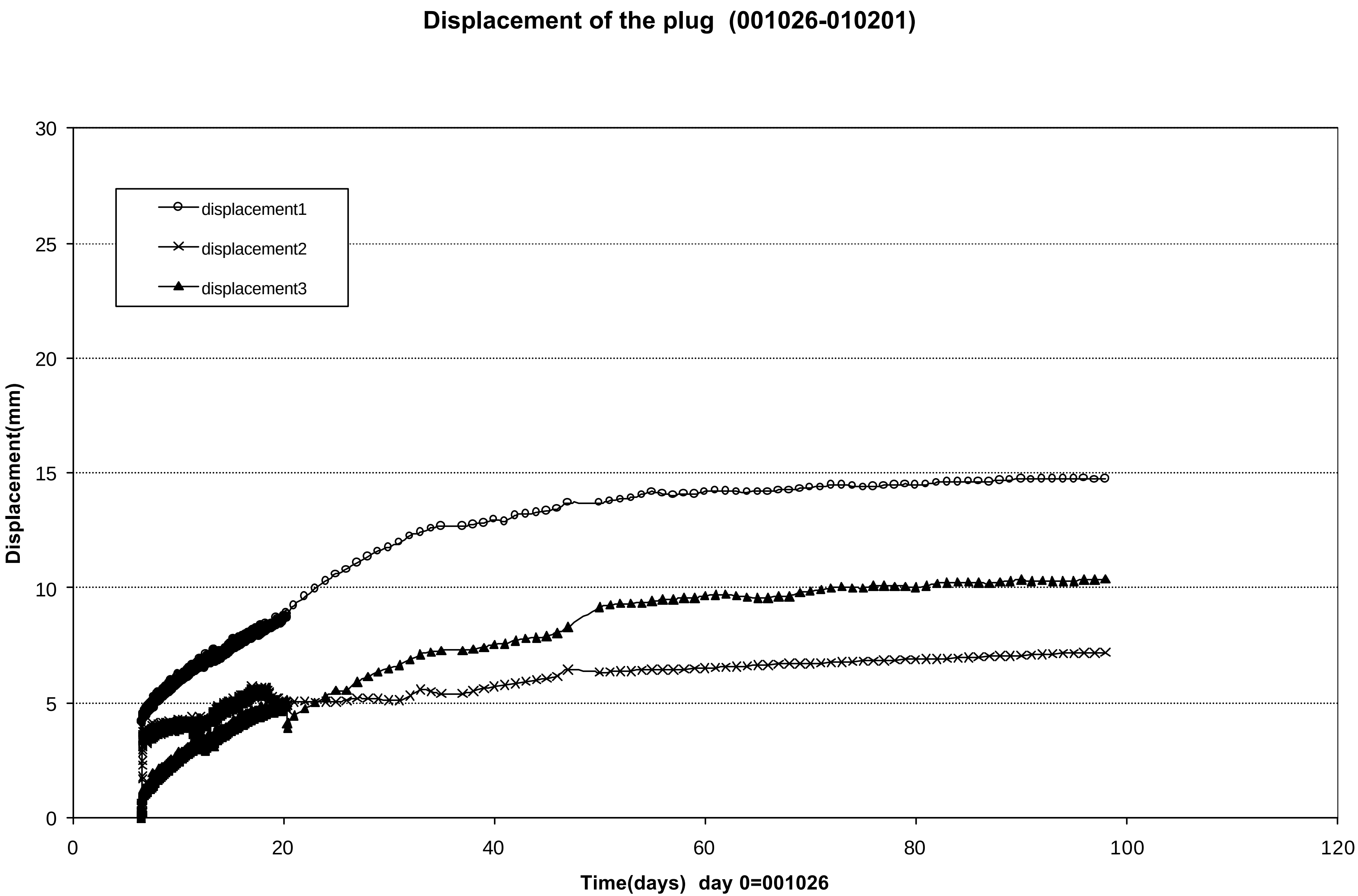
Temperature in the buffer- Ring 10 (001026-010201)
Thermocouple
T124(Ring10\A\635)
T125(Ring10\A\735)
T126(Ring10\D\585)
T127(Ring10\D\685)
T128(Ring10\D\785)
Temperature (°C)
Time(days) day 0=001026
70
60
50
40
30
20
10
0
20
40
60
80
100
120



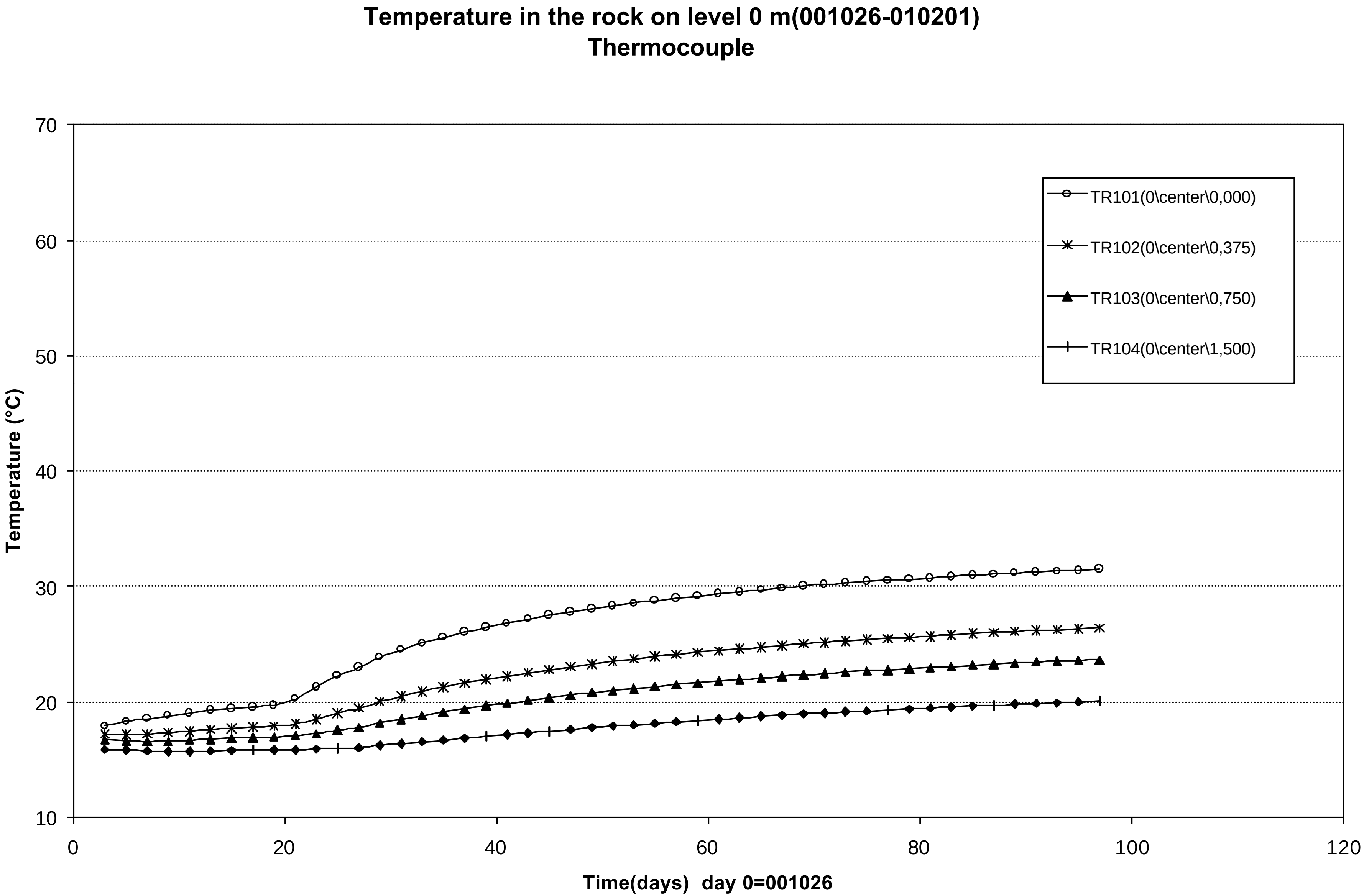
Temperature in the buffer -Cylinder3 and Cylinder4 (001026-010201)
Thermocouple
Temperature (°C)
70
60
50
40
30
20
10
0
20
40
60
80
100
120
Time(days) day 0=001026
T129(Cyl.3\A\785)
T130(Cyl.3\B\585)
T131(Cyl.3\C\585)
T132(cyl 4\A\785)

Forces on plug (001026-010201)

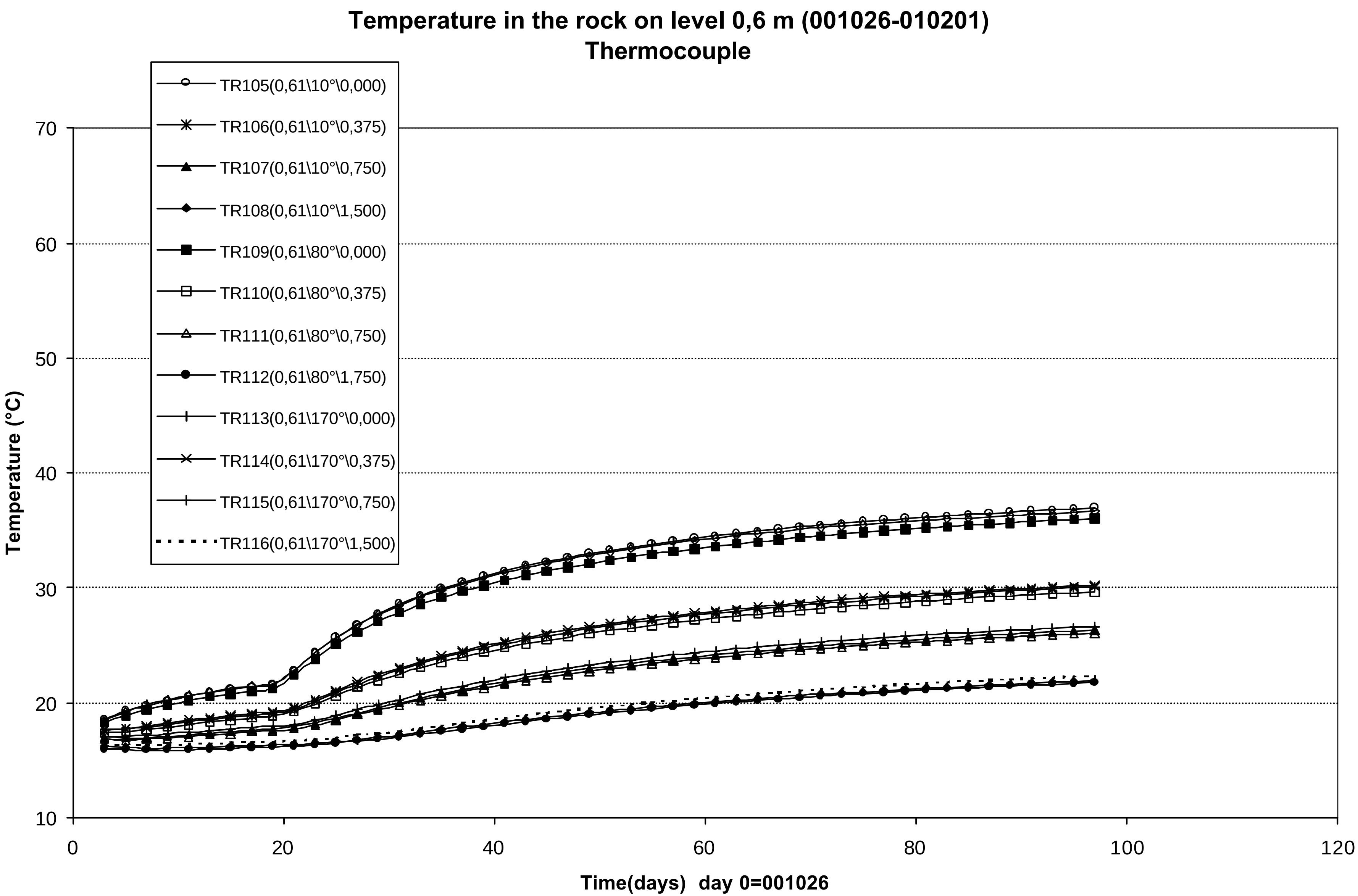


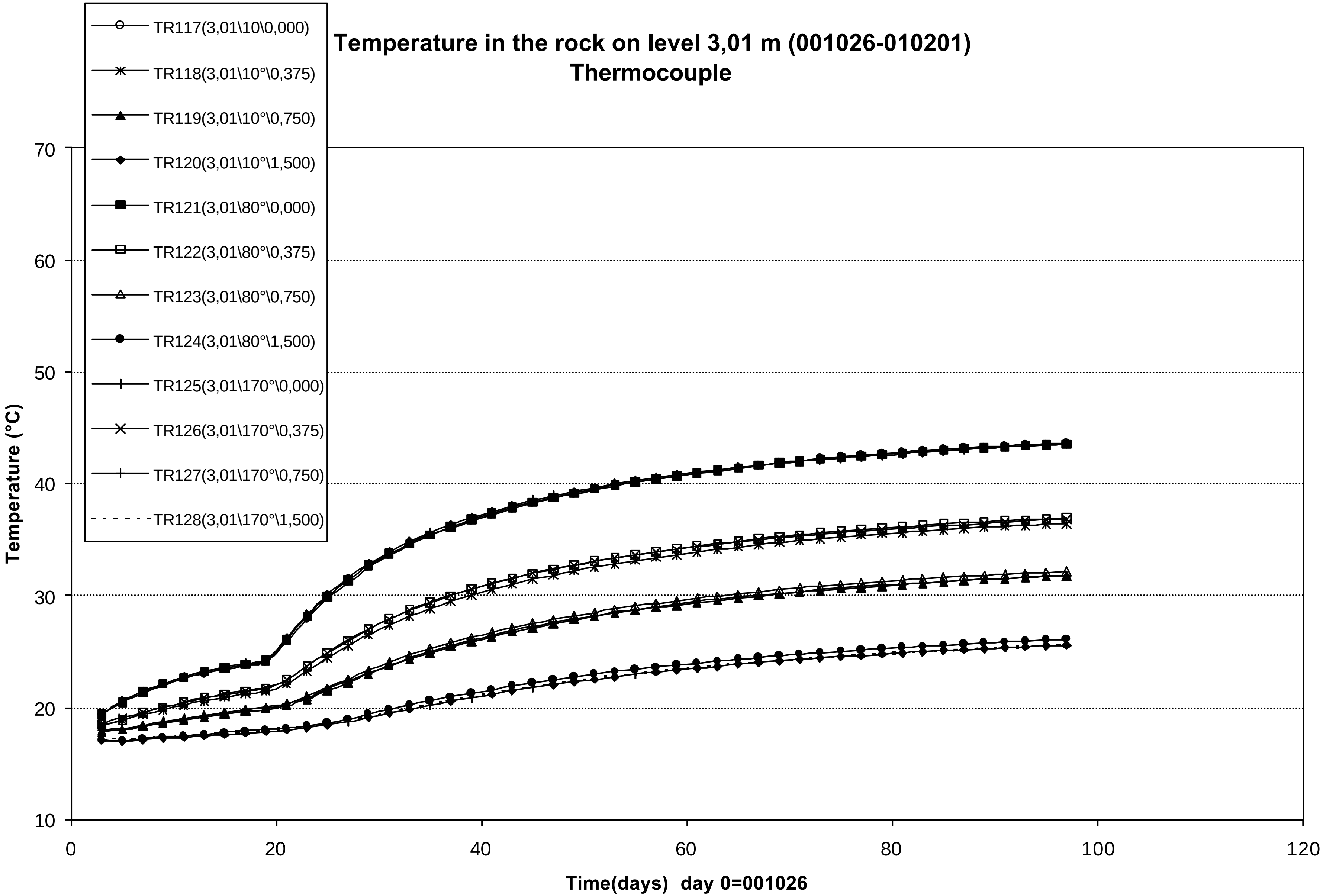


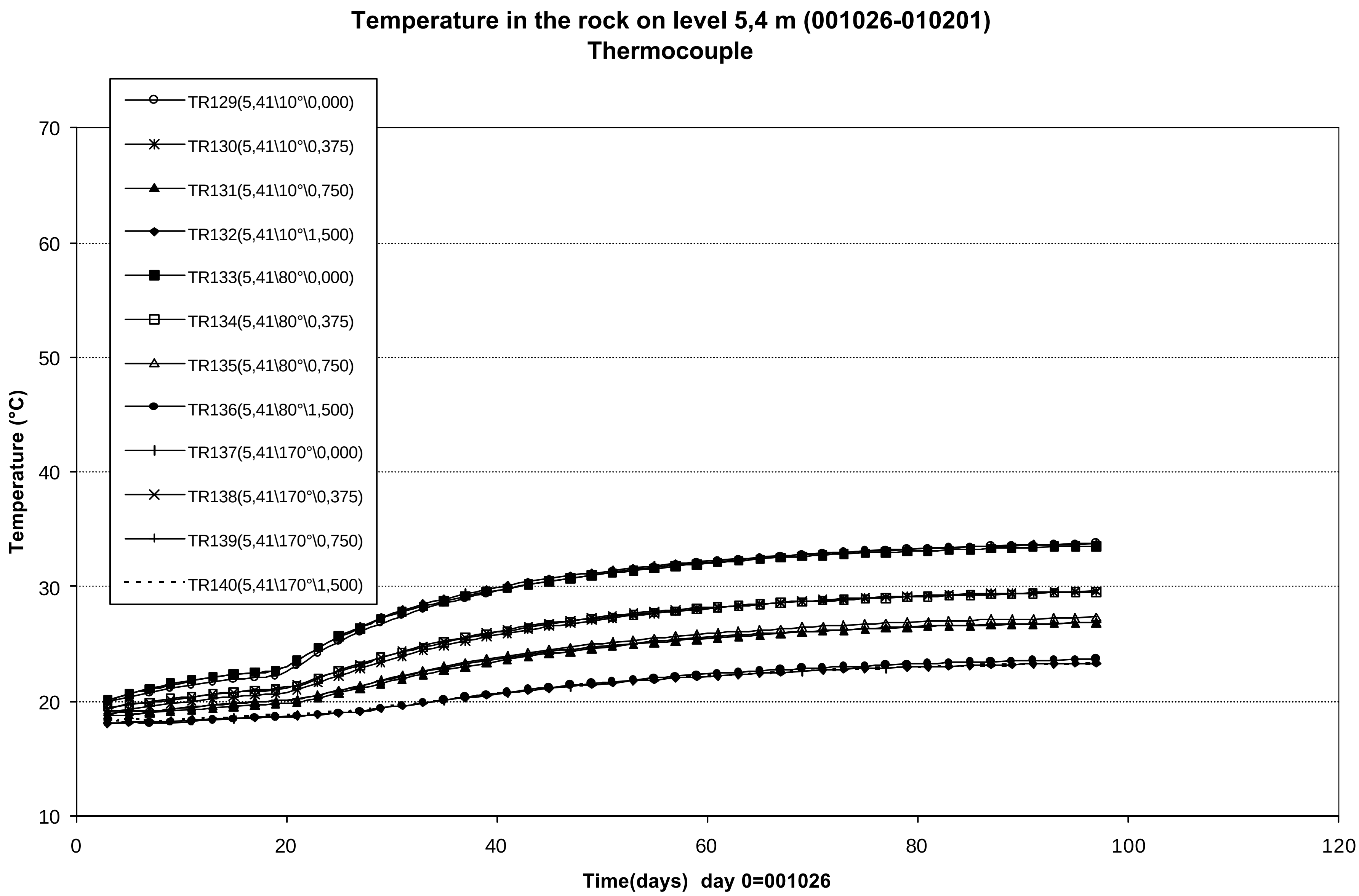
Displacement of the plug (001026-010201)
displacement1
displacement2
displacement3
Displacement(mm)
30
25
20
15
10
5
0
0
20
40
60
80
100
120
Time(days) day 0=001026



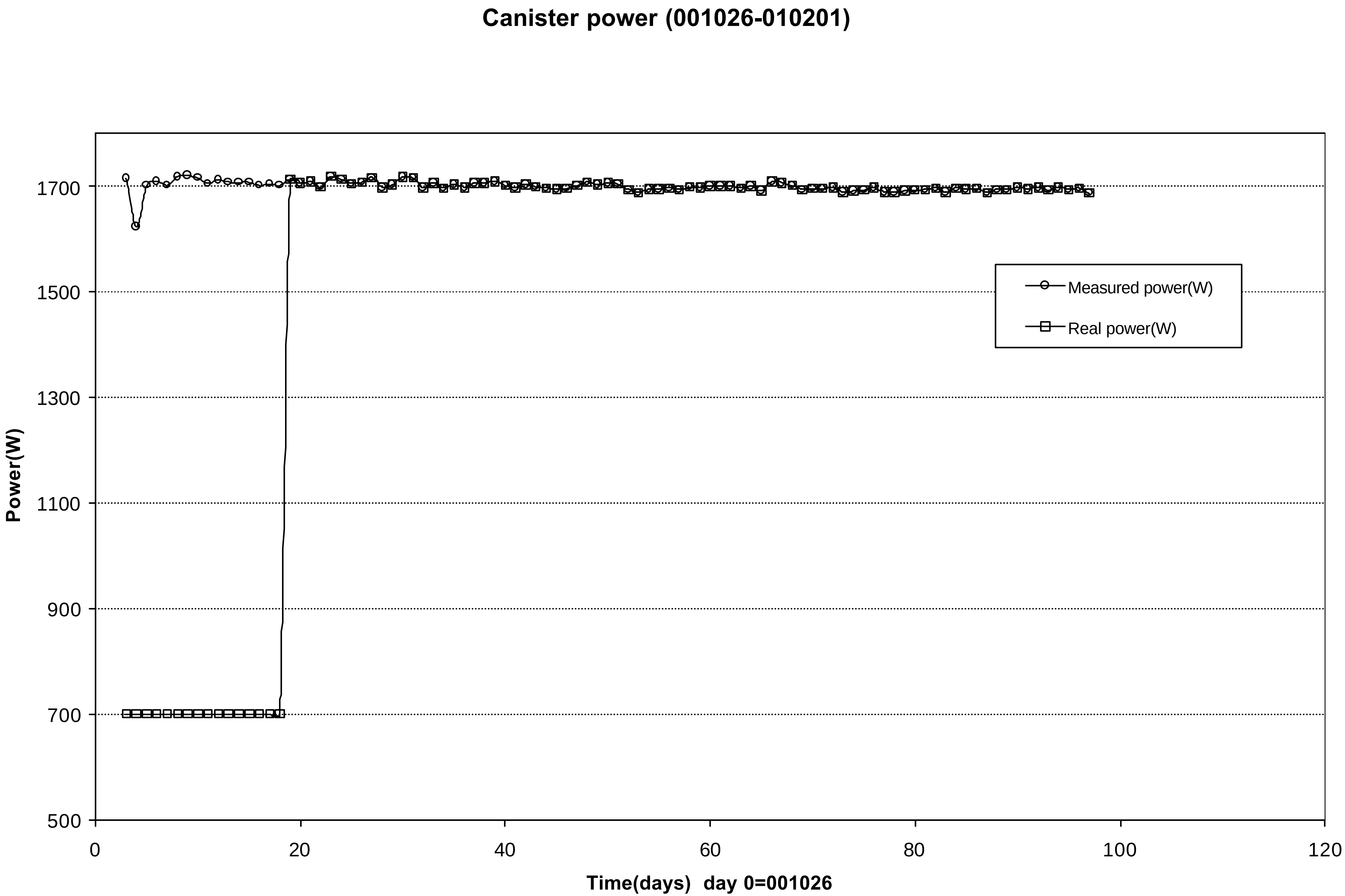
Temperature in the rock on level 0 m(001026-010201)
Thermocouple
Temperature (°C)
70
60
50
40
30
20
10
0
20
40
60
80
100
120
Time(days) day 0=001026
TR101(0\center\0,000)
TR102(0\center\0,375)
TR103(0\center\0,750)
TR104(0\center\1,500)


Temperature in the rock on level 0,6 m (001026-010201)
Thermocouple
TR105(0,61\10°\0,000)
TR106(0,61\10°\0,375)
TR107(0,61\10°\0,750)
TR108(0,61\10°\1,500)
TR109(0,61\80°\0,000)
TR110(0,61\80°\0,375)
TR111(0,61\80°\0,750)
TR112(0,61\80°\1,750)
TR113(0,61\170°\0,000)
TR114(0,61\170°\0,375)
TR115(0,61\170°\0,750)
TR116(0,61\170°\1,500)
Temperature (°C)
70
60
50
40
30
20
10
0
20
40
60
80
100
120
Time(days) day 0=001026


Temperature in the rock on level 3,01 m (001026-010201)
Thermocouple
TR117(3,01\10\0,000)
TR118(3,01\10°\0,375)
TR119(3,01\10°\0,750)
TR120(3,01\10°\1,500)
TR121(3,01\80°\0,000)
TR122(3,01\80°\0,375)
TR123(3,01\80°\0,750)
TR124(3,01\80°\1,500)
TR125(3,01\170°\0,000)
TR126(3,01\170°\0,375)
TR127(3,01\170°\0,750)
TR128(3,01\170°\1,500)
Temperature (°C)
70
60
50
40
30
20
10
0
20
40
60
80
100
120
Time(days) day 0=001026

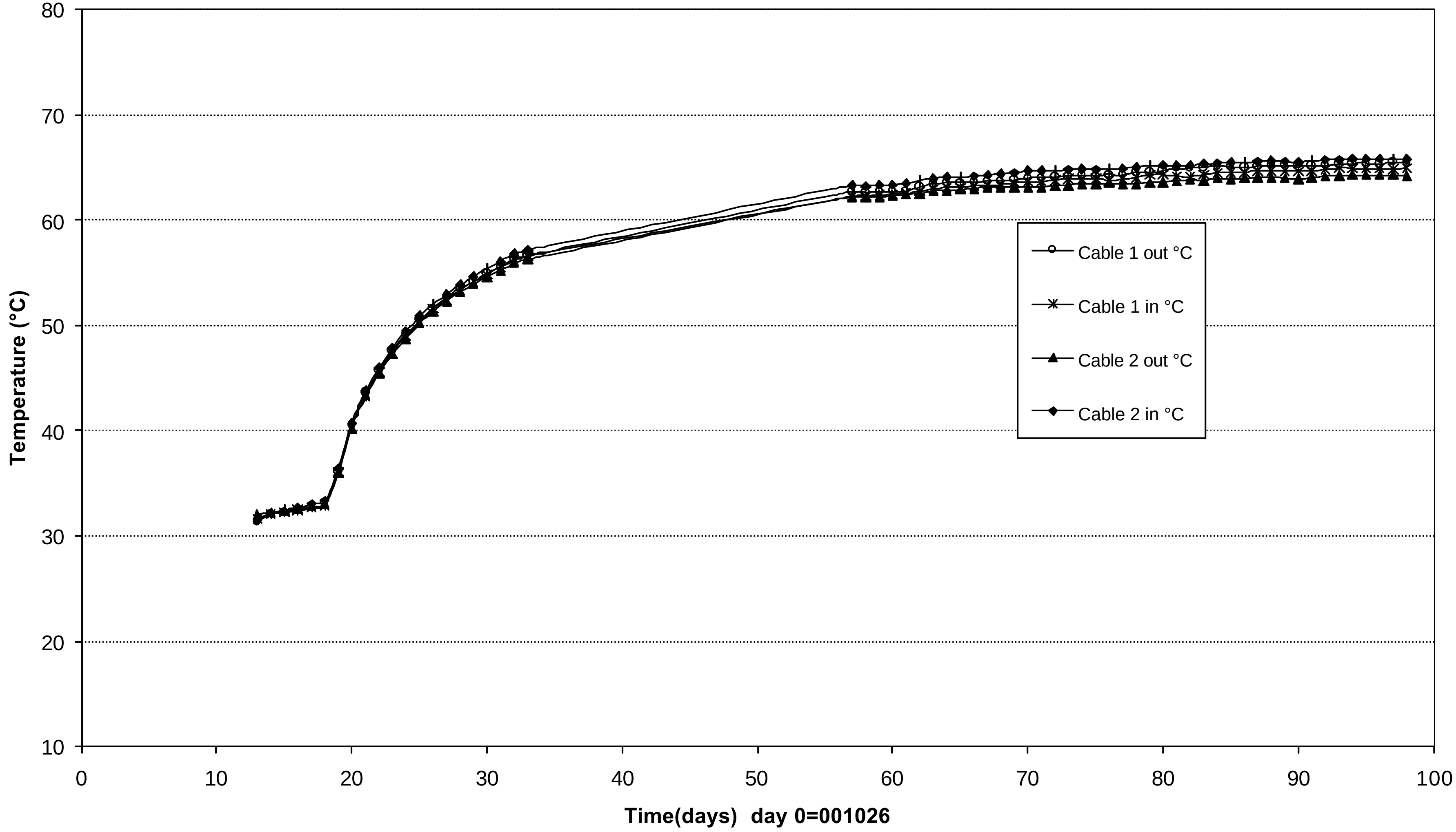


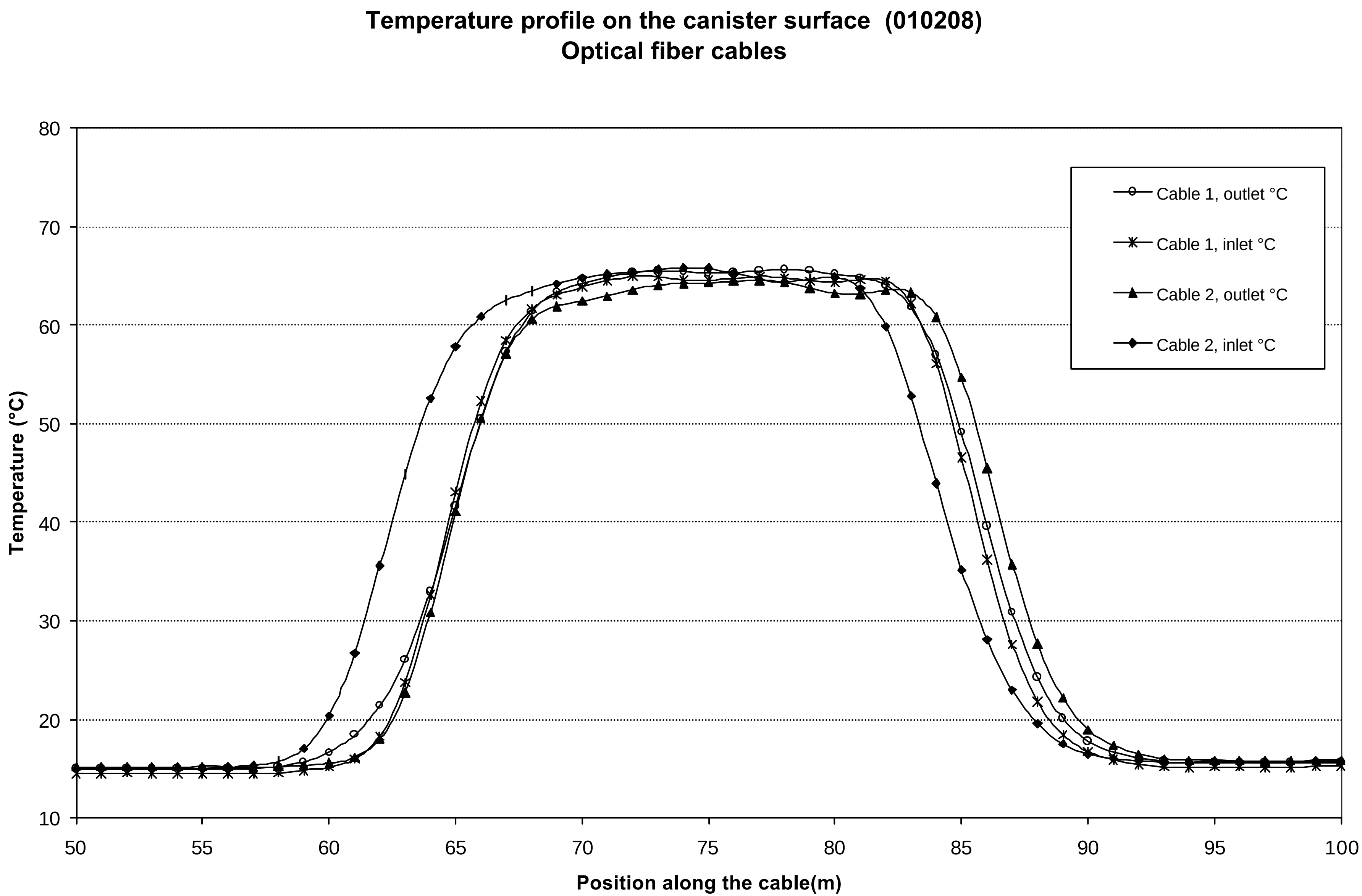
Temperature in the rock on level 5,4 m (001026-010201)
Thermocouple
Temperature (°C)
Time(days) day 0=001026
TR129(5,41\10°\0,000)
TR130(5,41\10°\0,375)
TR131(5,41\10°\0,750)
TR132(5,41\10°\1,500)
TR133(5,41\80°\0,000)
TR134(5,41\80°\0,375)
TR135(5,41\80°\0,750)
TR136(5,41\80°\1,500)
TR137(5,41\170°\0,000)
TR138(5,41\170°\0,375)
TR139(5,41\170°\0,750)
TR140(5,41\170°\1,500)
70
60
50
40
30
20
10
0
20
40
60
80
100
120



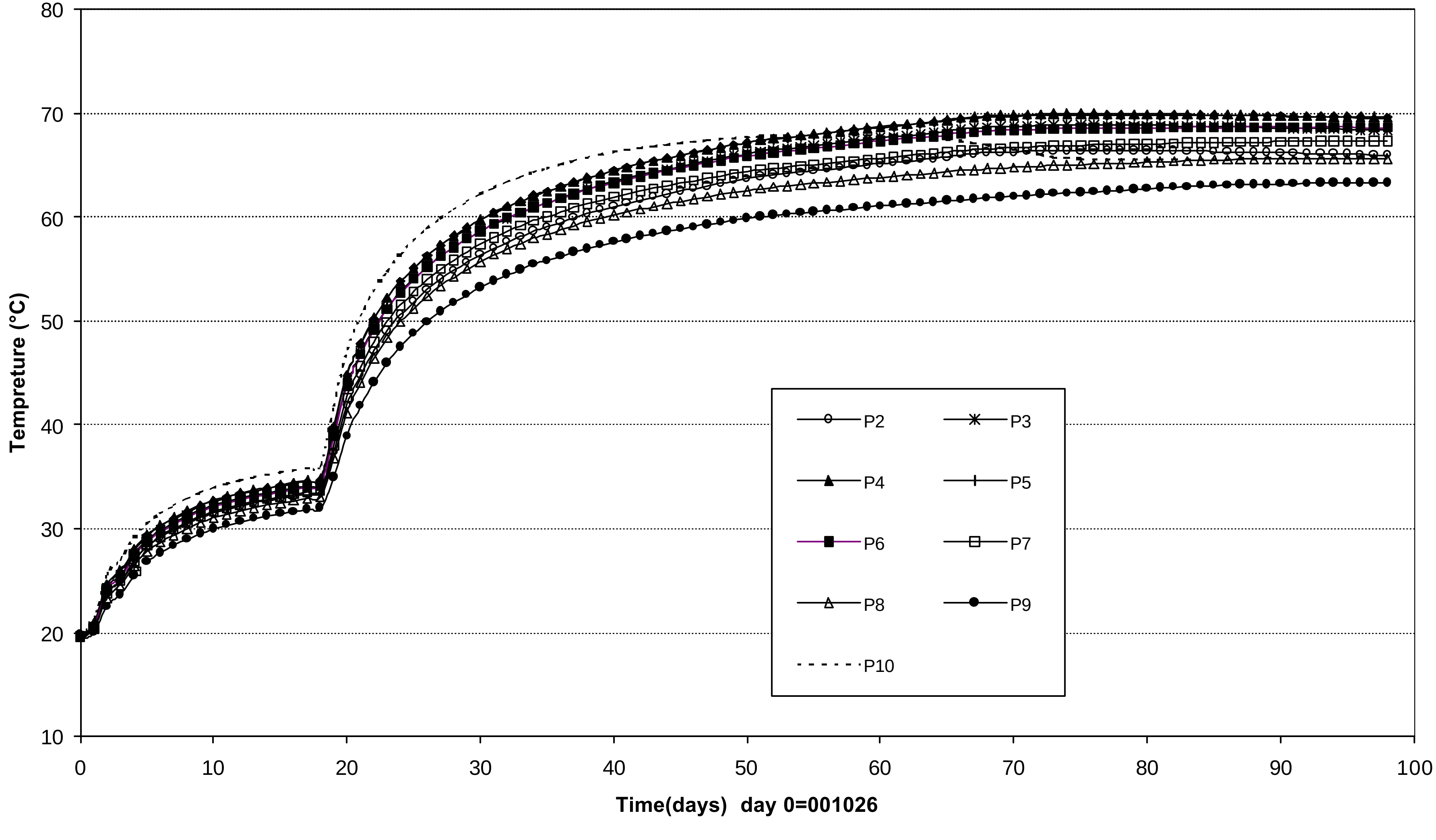
Canister power (001026-010201)
Power(W)
1700
1500
1300
1100
900
700
500
0
20
40
60
80
100
120
Time(days) day 0=001026
Measured power(W)
Real power(W)

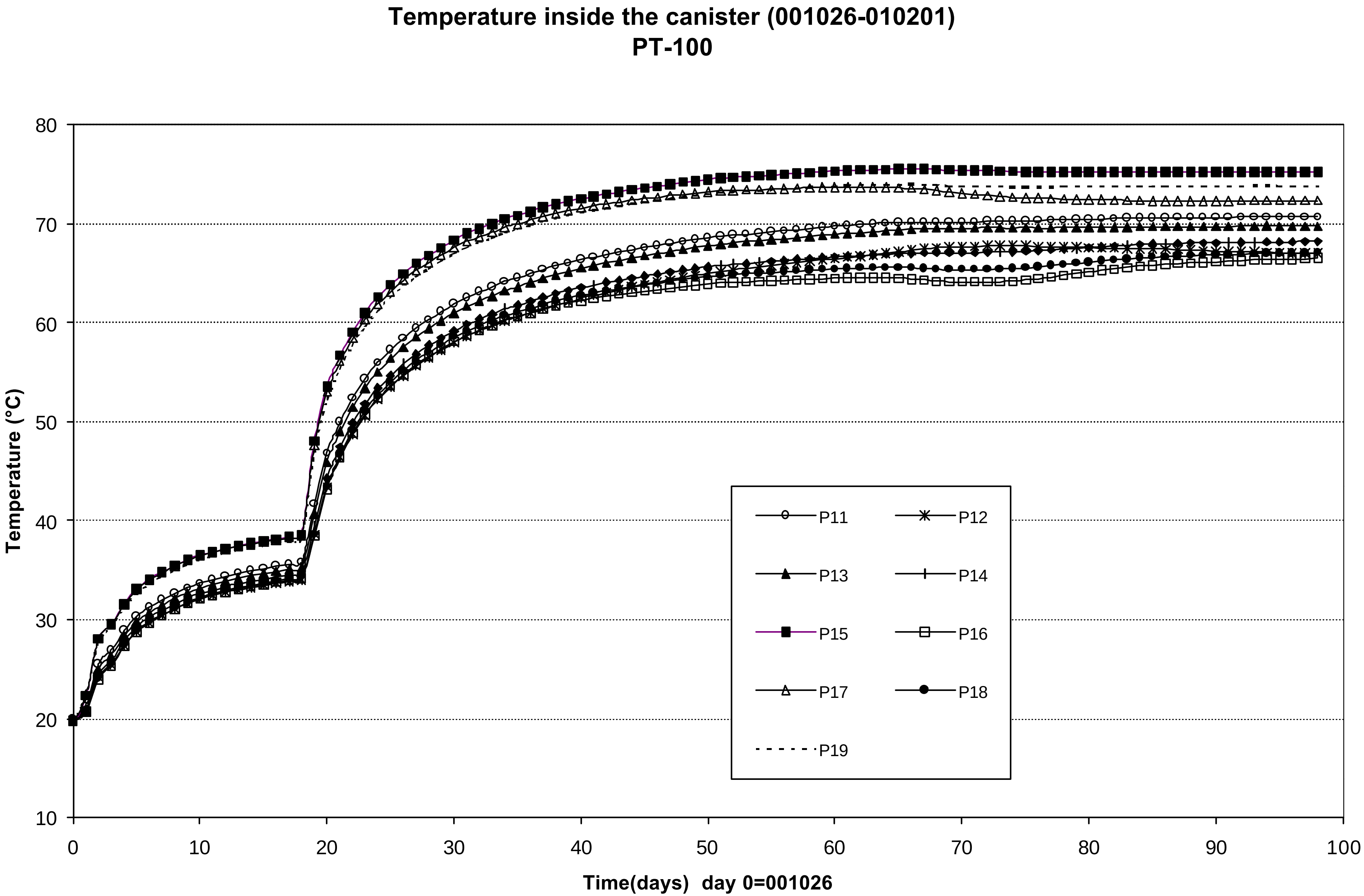
Temperature on the canister surface (001026-010201)
Optical fiber cables




Temperature profile on the canister surface (010208)
Optical fiber cables
Temperature (°C)
Position along the cable(m)
Cable 1, outlet °C
Cable 1, inlet °C
Cable 2, outlet °C
Cable 2, inlet °C
80
70
60
50
40
30
20
10
50
55
60
65
70
75
80
85
90
95
100

Temperature inside the canister (001026-010201)
PT-100





Temperature inside the canister (001026-010201)
PT-100
Temperature (°C)
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
Time(days) day 0=001026
P11
P12
P13
P14
P15
P16
P17
P18
P19