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INTERNAL DOCUMENT No. 331

Evaluation report on a FSI Temperature Module at IOSDL

T J P Gwilliam, S B Keene & B A King

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Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES
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ABSTRACT

Laboratory tests and sea going trials have been carried out with a temperature module type OTM-D-112 to evaluate its potential for use at IOSDL.

Tables and plots have been produced to show stability changes over a 708 day period.

KEYWORDS

CALIBRATION ACCURACY
LONG TERM STABILITY
MK3 CTD
OTM-D-112

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DIAGRAMS AND TABLES

Evaluation Report on a FSI Temperature Module at IOSDL.

T. J. P. Gwilliam, S. B. Keene, B.A. King (IOSDL Wormley)

1.0. Introduction.

This report is based on a series of tests and studies carried out on a Falmouth Scientific Instruments Introduction (FSI) Temperature module type OTM - D - 112., serial number 1333 and received at the Institute of Oceanographic Sciences in April 1992. The purpose of these tests was to evaluate the instrument in terms of accuracy, long term stability and general operational handling in an attempt to assess the suitability of this sensor for use at IOSDL for the collection of accurate and reliable temperature data.

The evaluation involved both laboratory and sea going exercises, the former covering calibrations at intervals over a near 2 year period, while the latter include a series of data comparative deployments with the CTD system on Discovery Cruise 199.

2.0. OTM General Information.

A brief outline of the manufacturers specification for the OTM is shown in Table 1 below.

During the laboratory tests, the instrument was directly connected to a desk top computer system and a power supply using the cable configuration shown in figure 1. Using the Procomm communications software package a two way RS232 communications procedure was set up so that data could be acquired, and commands to operate the module in its different modes could be transmitted. Details of these procedures are explained in the manual. The temperature information received was displayed on the monitor and also saved for further analysis. The calibration polynomial equations were evaluated using the IOSDL 'POLFIT' calibration software.

For the sea going deployments the temperature data from the module was coupled into the CTD MK3 data stream using the interface kit provided by FSI.

Table 1

OTM type OTM - D - 112. Serial number 1333

Range	-2°C. to + 32 °C.
Accuracy	± 0.003°C.
Stability	± 0.0005 °C./mnth...
Resolution	0.0001 °C.
Response	500 m.secs@ 1m/sec flow
Sensor	Platinum Resistance
Supply Voltage	12 volts dc ± 20%
Current	75 m.Amps.
Data Output	Temperature in °C. to ITS90
Data Format	RS-232- C
	9600 Baud
	8 data bits , 1 stop bit, no par.
	ASC II
Connector	Sea - Con VSGn - 4 -BCL

3.0. Laboratory Evaluation.

3.1. Accuracy and stability.

To determine the accuracy and stability of the OTM, a series of calibrations were carried out at intervals, over a two year period, using the IOSDL Automatic Systems Laboratory (ASL) F17 and Neil Brown CT - 2 temperature transfer standard thermometers. In all, eight calibrations were completed, and the results are tabulated in Tables 4 to 11 inclusive. Apart from one, all the calibrations were carried out at IOSDL to ITS90, using procedures to meet the WOCE temperature specification(Gwilliam and Keene, 1993) . The remaining calibration, Table 9, was carried out at the National Physical Laboratory, NPL, in an attempt to use the OTM in an inter comparison calibration exercise.

From the calibration data, the differences between the OTM output and the absolute temperature, at intervals of 5°C. over the range 0°C. to 30°C., were calculated and the results tabulated in Table 12. From the information in Table 12, two graphs were plotted of temperature difference against time illustrating the total drift over 708 days,(figure 2), and showing the drift over the latter 84 days, (figure 3)

3.2. Results

The calibration provided by FSI for this instrument is shown in Table 2. As shown in the table, a third order polynomial is used to calibrate the instrument but inspection of the 'differences' (col.4) of a linear fit show that these residuals are less than ±1m°C. and would therefore satisfy the manufactures accuracy specification of ±3m°C. Further perusal of Table 2 show that a "clerical" error by FSI has occurred, columns 1 and 2 should be interchanged. We have corrected this mistake, recalculated a linear and third order polynomial and include the results in table 3.

Comparing the FSI corrected calibration (Table 3) with the first calibration of the instrument at IOSDL (Table 4) 8 days later, immediately highlights a change in the offset of 65.2m°C.at 0°C. Further communication with the manufacture indicated that there were problems at the time of the calibration and that this original calibration is incorrect.

The large time gap between our first calibration on 30.3.92 and the next on 24.9.93 covers the period when the OTM was being evaluated on the RRS Discovery WOCE cruises 199, 200 and 201 in the Southern Oceans. A study of Fig 2 over this period show that the stability of the sensor at 0°C. was of the order 0.5°mC./mnth. which is within specification, again during the latter 5months the difference amounted to 2m°C. which produces a 0.4m°C. /mnth. long term stability figure.

However there was an unusual discontinuity in the temperature difference during a 12 day period between the calibrations of 28.1.94 and 9.2.94 when the difference was 4m°C, a stability of 10m°C./mnth. This appears the more unusual in that the immediate period after this event the gradient of the drift returned to <0.4m°C./mnth. Mechanical damage to the platinum element of the prt, over the period between 21-1-94 and 4-2-94, could possibly cause the offset increase. However, the offset again increased between the 4-2-94 and 9-2-94 calibrations, when it would be highly unlikely to be due to mishandling. At the next calibration, 21-2-94, the rate of change of offset had returned to the pre 28-1-94 calibration value which introduces a doubt on the theory of prt damage. It was over this period that the sensor was at NPL for calibration, and a possible explanation could be that with the increased handling , an intermittent electronic fault occured within the instrument.

From the information in Table 12 it is possible to evaluate the temperature change as a result of sensitivity changes within the OTM between calibrations. Neglecting the initial FSI calibration, over the period from 30.3.92 to 24.9.93 the effect of sensitivity change at 30 °C., were it would be most evident, was 0.3m°C/mnth., and from 24.9.93 to 21.2.94 was 0.2m°C/mnth.. When added to the worst case 0°C offset stability error of 0.4m°C/mnth. the total error at 30°C. is 0.7m°C/mnth., which is just outside the manufacturers specification.

Thermal response time for the sensor was also evaluated in the laboratory by first allowing the instrument to stabilise at room temperature, 20°C. , then completely immersing it into the temperature controlled water bath at 0.3°C. The OTM data was sampled at 2.95hz and the plot using this information is show in figure 4. With the circulating water flow approximately 20cm/sec. the time taken to reach 63% of its final value is approximately 1.36 seconds.

4.0. Operation at Sea.

The WOCE cruise 199 on RRS Discovery during December 1993 to February 1994 provided an opportunity to compare the performance of the OTM with the MK3 CTD under operational conditions. The OTM was mounted on the multisampler frame such that the prts were in close proximity, ~20 cms, and used on several deployments down to 5500 metres. The OTM output data was integrated into the MK3 data stream and processed on board without difficulty.

4.1. Results.

Problems with starting the OTM in the correct RUN mode caused a loss of OTM data for some of the deployments due to the lack of a resetting pulse which normally occurs on the step function of the supply voltage on initial switch on. The cause appeared to be the slow rise time of the compliance voltage on initial power switch on due to the delay time in charging the capacitors of the acoustic altimeter. To overcome this problem , it was necessary to disconnect the OTM from the system until the capacitors were fully charged.

Figures 5 and 6 are data collected from deployment CTD 12297. The upper trace of figure 5 is an example of a filtered MK3 prt down and up profile over the range 0 - 10 °C . The lower plots of figure 5 show the temperature difference (MK3 - OTM) for the down and up casts against depth (0 - 2000 dbar). If the MK3 and the OTM had the same accuracy and thermal response then the plots would be two overlapping horizontal lines from 0°C. However, for this example it indicates that the OTM has a thermal response time lag, with respect to the MK3 prt temperature sensor. Near the surface, where there are high rates of change in temperature, the difference is most obvious, while in the deeper waters, the plots tend to coincide much more.

To ascertain the degree of time lag that the OTM has with respect to the MK3 prt, a scatter plot of difference (MK3 - OTM) data against the rate of change of temperature was produced, figure 6 for the pressure range 400 - 800 dbars. The concentration of points highlight the areas around the low temperature gradients, while the scatter for the negative and positive higher gradients illustrate the degree of time advancement the MK3 has over the OTM. The mean slope of the points is an indication of the time lag of the OTM. From the plot:

Time = (MK3 - OTM)/(dTEMP/dtime) Secs

$\approx$ 26/40

$\approx$ 0.7 Secs.

The MK3 data is already accelerated by 0.2 Secs , therefore the response time of the OTM with respect to the mk3 is 0.7 - 0.2

= 0.5 Secs.

The mean difference between the curves indicate an overall offset of near 7 m°C.

5.0. Conclusions

Both the laboratory and the seagoing trials show that there are small problems , but overall the instrument does come very close to the manufactures specification with no overall inherent design problems. However, because of the slower thermal response time with respect to the MK3 CTD instruments, it would be difficult to recommend its use for SeaSoar work or for WOCE type profiling deployments were a higher stability is desirable. Discussions with the manufactures indicate that the later OTM models do have a faster response prt and it is hoped to evaluate a sample in the future.

6.0. References.

Gwilliam,T.J.P.,Keene,S.B., Calibration of Temperature and Pressure Sensors for the World Ocean Circulation Experiment., International WOCE Newsletter, Number 15, February 1994.

Order of Polynomial = 3 . Number of terms = 4

ATB-1250	OTM 1333	Calc OTM 1333	Difference
0.64237	0.64240	0.64235	-0.00005
7.05356	7.05420	7.05437	0.00017
14.95264	14.95270	14.95246	-0.00024
22.57622	22.57510	22.57529	0.00019
27.98922	27.98930	27.98923	-0.00007

TA = -2.433556E-04
TB = 1.000373
TC = -3.80579E-05
TD = 8.953358E-07

PRESS ANY KEY TO CONTINUE

CALIBRATION DATA OTM SERIAL NUMBER 1333
CALIBRATION DIFERENCES FROM ATB-1250
WOODS HOLE OCEANOGRAPHIC CTD CALIBRATION LABORATORY

DATE: 15 MAR 92 TECH: ____________

Table 2. - Initial FSI Calibration

DATA FILE: SWP1333 DATE: 15-3-92.

TERM COEFFICIENT

A= -3.2496825E-4
B= 1.0000264E0

Y(cal)= B(x)+A

(x) FSI	STD NB	Y(cal)	DIFF
0.6424	0.6424	0.6421	0.0003
7.0542	7.0536	7.0541	-0.0005
14.9527	14.9526	14.9528	-0.0001
22.5751	22.5762	22.5754	0.0008
27.9893	27.9892	27.9897	-0.0005

STD ERROR OF ESTIMATE FOR Y=0.0007

DATA FILE: SWP1333 DATE: 15-3-92

TERM COEFFICIENT

A= 2.4471709E-4
B= 9.9962634E-1
C= 3.8150400E-5
D= -8.9775542E-7

Y(cal)= D(x^3)+C(x^2)+B(x)+A

(x) FSI	STD NB	Y(cal)	DIFF
0.6424	0.6424	0.6424	-0.0001
7.0542	7.0536	7.0534	0.0002
14.9527	14.9526	14.9529	-0.0002
22.5751	22.5762	22.5760	0.0002
27.9893	27.9892	27.9893	-0.0001

STD ERROR OF ESTIMATE FOR Y=0.0004

Table 3. - Corrected FSI Calibration

DATA FILE: FSIVNB DATE: 30/3/92

TERM COEFFICIENT

A= -6.4586833E-2
B= 9.9956406E-1

Y(cal)= B(x)+A

(x) FSIdegC	STD NBTSdegC	Y(cal)	DIFF
0.7264	0.6613	0.6615	-0.0002
0.7266	0.6615	0.6617	-0.0002
5.4485	5.3822	5.3815	0.0007
8.6872	8.6187	8.6188	-0.0001
11.9511	11.8816	11.8813	0.0003
15.4460	15.3746	15.3747	-0.0001
19.3120	19.2384	19.2390	-0.0006
22.7566	22.6817	22.6821	-0.0004
25.3237	25.2487	25.2481	0.0006

STD ERROR OF ESTIMATE FOR Y=0.0005

DATA FILE: FSIVNB DATE: 30/3/92

TERM COEFFICIENT

A= -6.4998952E-2
B= 9.9988759E-1
C= -3.4916421E-5
D= 9.2957646E-7

Y(cal)= D(x^3)+C(x^2)+B(x)+A

(x) FSIdegC	STD NBTSdegC	Y(cal)	DIFF
0.7264	0.6613	0.6613	-0.0000
0.7266	0.6615	0.6615	-0.0000
5.4485	5.3822	5.3820	0.0002
8.6872	8.6187	8.6192	-0.0005
11.9511	11.8816	11.8814	0.0002
15.4460	15.3746	15.3744	0.0002
19.3120	19.2384	19.2385	-0.0001
22.7566	22.6817	22.6819	-0.0002
25.3237	25.2487	25.2486	0.0001

STD ERROR OF ESTIMATE FOR Y=0.0003

Table 4. - OTM Calibration. 30-3-92.

DATA FILE: F17OTM DATE: 24/9/93

TERM COEFFICIENT

A= -7.3948953E-2
B= 9.9949670E-1

Y(cal)= B(x)+A

(x) OTM1333	STD 708'371	Y(cal)	DIFF
-0.6857	-0.7594	-0.7593	-0.0001
-0.4705	-0.5445	-0.5442	-0.0003
-0.2675	-0.3415	-0.3413	-0.0002
-0.0664	-0.1406	-0.1403	-0.0003
-0.0161	-0.0902	-0.0900	-0.0001
0.0346	-0.0396	-0.0393	-0.0003
0.0849	0.0106	0.0109	-0.0003
0.2878	0.2135	0.2137	-0.0002
0.5914	0.5171	0.5171	-0.0000
2.8549	2.7797	2.7796	0.0001
5.0146	4.9388	4.9382	0.0007
7.5805	7.5037	7.5027	0.0010
10.0600	9.9817	9.9810	0.0007
12.6566	12.5768	12.5763	0.0006
15.1006	15.0190	15.0191	-0.0001
17.6577	17.5746	17.5749	-0.0003
20.0197	19.9353	19.9357	-0.0004
22.5050	22.4193	22.4197	-0.0004
25.1063	25.0196	25.0197	-0.0001

STD ERROR OF ESTIMATE FOR Y=0.0004

Table 5. - OTM Calibration. 24-9-93.

DATA FILE: F17OTM   DATE: 24/9/93

TERM COEFFICIENT

A= -7.4136785E-2
B= 9.9980740E-1
C= -3.0130501E-5
D= 7.0917682E-7

Y(cal)= D(x^3)+C(x^2)+B(x)+A

(x) OTM1333	STD 708'371	Y(cal)	DIFF
-0.6857	-0.7594	-0.7597	0.0003
-0.4705	-0.5445	-0.5445	0.0000
-0.2675	-0.3415	-0.3416	0.0001
-0.0664	-0.1406	-0.1405	-0.0001
-0.0161	-0.0902	-0.0902	0.0000
0.0346	-0.0396	-0.0395	-0.0001
0.0849	0.0106	0.0107	-0.0001
0.2878	0.2135	0.2136	-0.0001
0.5914	0.5171	0.5171	-0.0000
2.8549	2.7797	2.7800	-0.0003
5.0146	4.9388	4.9389	-0.0000
7.5805	7.5037	7.5035	0.0003
10.0600	9.9817	9.9816	0.0000
12.6566	12.5768	12.5766	0.0002
15.1006	15.0190	15.0191	-0.0002
17.6577	17.5746	17.5747	-0.0001
20.0197	19.9353	19.9353	-0.0000
22.5050	22.4193	22.4193	-0.0000
25.1063	25.0196	25.0195	0.0001

STD ERROR OF ESTIMATE FOR Y=0.0002

Table 5. - OTM Calibration. 24-9-93.

DATA FILE: OTMF17A DATE: 29/11/93

TERM COEFFICIENT

A= -7.5934235E-2
B= 9.9944588E-1

Y(cal)= B(x)+A

(x) OTM1333	STD '700'371	Y(cal)	DIFF
-0.6779	-0.7544	-0.7535	-0.0009
1.2080	1.1312	1.1314	-0.0002
5.1236	5.0457	5.0449	0.0008
9.1761	9.0958	9.0951	0.0008
14.1024	14.0189	14.0187	0.0003
17.1249	17.0393	17.0395	-0.0001
21.1271	21.0389	21.0394	-0.0005
25.0449	24.9551	24.9551	-0.0001

STD ERROR OF ESTIMATE FOR Y=0.0007

DATA FILE: OTMF17A DATE: 29/11/93

TERM COEFFICIENT

A= -7.6559694E-2
B= 9.9991532E-1
C= -4.3336279E-5
D= 1.0164065E-6

Y(cal)= D(x^3)+C(x^2)+B(x)+A

(x) OTM1333	STD '700'371	Y(cal)	DIFF
-0.6779	-0.7544	-0.7544	0.0000
1.2080	1.1312	1.1313	-0.0001
5.1236	5.0457	5.0456	0.0000
9.1761	9.0958	9.0959	-0.0000
14.1024	14.0189	14.0189	0.0000
17.1249	17.0393	17.0393	0.0000
21.1271	21.0389	21.0390	-0.0001
25.0449	24.9551	24.9550	0.0000

STD ERROR OF ESTIMATE FOR Y=0.0001

Table 6. - OTM Calibration 29-11-93.

DATA FILE: OTM1794 DATE: 4/1/94

TERM COEFFICIENT

A= -7.5067844E-2
B= 9.9945611E-1

Y(cal)= B(x)+A

(x) OTM1333	STD '700'371	Y(cal)	DIFF
0.5129	0.4372	0.4375	-0.0003
7.6036	7.5252	7.5244	0.0008
15.1428	15.0593	15.0595	-0.0002
22.6181	22.5299	22.5308	-0.0009
28.2035	28.1137	28.1131	0.0006

STD ERROR OF ESTIMATE FOR Y=0.0008

DATA FILE: OTM1794 DATE: 4/1/94

TERM COEFFICIENT

A= -7.5621849E-2
B= 9.9991420E-1
C= -4.4890729E-5
D= 1.0656991E-6

Y(cal)= D(x^3)+C(x^2)+B(x)+A

(x) OTM1333	STD '700'371	Y(cal)	DIFF
0.5129	0.4372	0.4372	0.0000
7.6036	7.5252	7.5252	-0.0000
15.1428	15.0593	15.0593	0.0000
22.6181	22.5299	22.5299	-0.0000
28.2035	28.1137	28.1137	0.0000

STD ERROR OF ESTIMATE FOR Y=0.0001

Table 7. - OTM Calibration 4-1-94

DATA FILE: F133394 DATE: 28/1/94

TERM COEFFICIENT

A= -7.4689340E-2
B= 9.9945120E-1

Y(cal)= B(x)+A

(x) OTM1333	STD '700'371	Y(cal)	DIFF
0.4553	0.3799	0.3803	-0.0004
7.8146	7.7364	7.7357	0.0007
14.1409	14.0584	14.0585	-0.0001
21.6703	21.5831	21.5838	-0.0006
28.7016	28.6115	28.6112	0.0003

STD ERROR OF ESTIMATE FOR Y=0.0006

DATA FILE: F133394 DATE: 28/1/94

TERM COEFFICIENT

A= -7.5204987E-2
B= 9.9982629E-1
C= -3.4899756E-5
D= 7.9552416E-7

Y(cal)= D(x^3)+C(x^2)+B(x)+A

(x) OTM1333	STD '700'371	Y(cal)	DIFF
0.4553	0.3799	0.3800	-0.0000
7.8146	7.7364	7.7363	0.0001
14.1409	14.0584	14.0585	-0.0001
21.6703	21.5831	21.5831	0.0001
28.7016	28.6115	28.6115	-0.0000

STD ERROR OF ESTIMATE FOR Y=0.0002

Table 8. - OTM Calibration 28-1-94.

DATA FILE: NPLOTM DATE: 4/2/94

TERM COEFFICIENT

A= -7.6060347E-2
B= 9.9944665E-1

Y(cal)= B(x)+A

(x) OTM1333	STD NPL DegC	Y(cal)	DIFF
0.0763	0.0000	0.0002	-0.0002
4.9620	4.8840	4.8832	0.0008
9.9320	9.8510	9.8504	0.0006
14.9110	14.8260	14.8267	-0.0007
19.9070	19.8190	19.8199	-0.0009
24.9090	24.8180	24.8192	-0.0012
29.8970	29.8060	29.8044	0.0016

STD ERROR OF ESTIMATE FOR Y=0.0011

DATA FILE: NPLOTM DATE: 4/2/94

TERM COEFFICIENT

A= -7.6315552E-2
B= 9.9988096E-1
C= -4.7938240E-5
D= 1.1841578E-6

Y(cal)= D(x^3)+C(x^2)+B(x)+A

(x) OTM1333	STD NPL DegC	Y(cal)	DIFF
0.0763	0.0000	-0.0000	0.0000
4.9620	4.8840	4.8841	-0.0001
9.9320	9.8510	9.8509	0.0001
14.9110	14.8260	14.8262	-0.0002
19.9070	19.8190	19.8187	0.0003
24.9090	24.8180	24.8183	-0.0003
29.8970	29.8060	29.8059	0.0001

STD ERROR OF ESTIMATE FOR Y=0.0003

Table 9. - OTM NPL Calibration 4-2-94.

DATA FILE: AFTRF17 DATE: 9/2/94

TERM COEFFICIENT

A= -7.8561384E-2
B= 9.9945884E-1

Y(cal)= B(x)+A

(x) OTM1333	STD '700'371	Y(cal)	DIFF
0.4311	0.3517	0.3523	-0.0006
5.0982	5.0177	5.0169	0.0008
10.0828	9.9994	9.9987	0.0006
15.0830	14.9960	14.9963	-0.0003
20.0822	19.9918	19.9928	-0.0010
25.0966	25.0038	25.0045	-0.0007
29.1053	29.0120	29.0109	0.0011

STD ERROR OF ESTIMATE FOR Y=0.0009

DATA FILE: AFTRF17 DATE: 9/2/94

TERM COEFFICIENT

A= -7.9343929E-2
B= 1.0000065E0
C= -5.2776674E-5
D= 1.2413022E-6

Y(cal)= D(x^3)+C(x^2)+B(x)+A

(x) OTM1333	STD '700'371	Y(cal)	DIFF
0.4311	0.3517	0.3517	0.0000
5.0982	5.0177	5.0177	0.0000
10.0828	9.9994	9.9994	-0.0000
15.0830	14.9960	14.9960	0.0000
20.0822	19.9918	19.9918	0.0000
25.0966	25.0038	25.0038	-0.0000
29.1053	29.0120	29.0120	0.0000

STD ERROR OF ESTIMATE FOR Y=0.0000

Table 10. - OTM Calibration 9-2-94.

DATA FILE: NBOTM94 DATE: 21/2/94

TERM COEFFICIENT

A= -7.8710843E-2
B= 9.9945106E-1

Y(cal)= B(x)+A

(x) OTM1333	STD NBTS	Y(cal)	DIFF
0.2176	0.1384	0.1388	-0.0004
5.1121	5.0310	5.0305	0.0005
10.1937	10.1099	10.1094	0.0005
15.1183	15.0310	15.0313	-0.0003
20.0950	20.0048	20.0052	-0.0005
25.4289	25.3365	25.3363	0.0003

STD ERROR OF ESTIMATE FOR Y=0.0005

DATA FILE: NBOTM94 DATE: 21/2/94

TERM COEFFICIENT

A= -7.9241355E-2
B= 9.9982223E-1
C= -3.7379835E-5
D= 9.4449137E-7

Y(cal)= D(x^3)+C(x^2)+B(x)+A

(x) OTM1333	STD NBTS	Y(cal)	DIFF
0.2176	0.1384	0.1384	0.0000
5.1121	5.0310	5.0310	-0.0000
10.1937	10.1099	10.1098	0.0001
15.1183	15.0310	15.0311	-0.0001
20.0950	20.0048	20.0047	0.0000
25.4289	25.3365	25.3365	-0.0000

STD ERROR OF ESTIMATE FOR Y=0.0001

Table 11. - OTM Calibration 21-2-94.

Date	15.3.92	30.3.92	24.9.93	29.1193	4.1.94	28.1.94	4.2.94	9.2.94	21.2.94
Day No.	1 FSI	15 IOSDL	557 IOSDL	624 IOSDL	662 IOSDL	684 IOSDL	689 NPL	696 IOSDL	708 IOSDL
Temp. Deg.C.	Difference between OTM and Temperature in m°C.								
0	0.24	65	74	76	75	75	76	79	79
5	-0.78	66	77	79	78	77	79	81	82
10	0.06	69	79	81	81	80	82	84	84
15	-0.02	71	82	84	83	83	84	87	87
20	-0.08	74	84	87	86	86	87	89	90
25	-0.07	75	87	89	88	88	90	92	92
30	0.02	75	89	93	91	91	93	95	95

Table. 12. - Differences between OTM and absolute Temperature

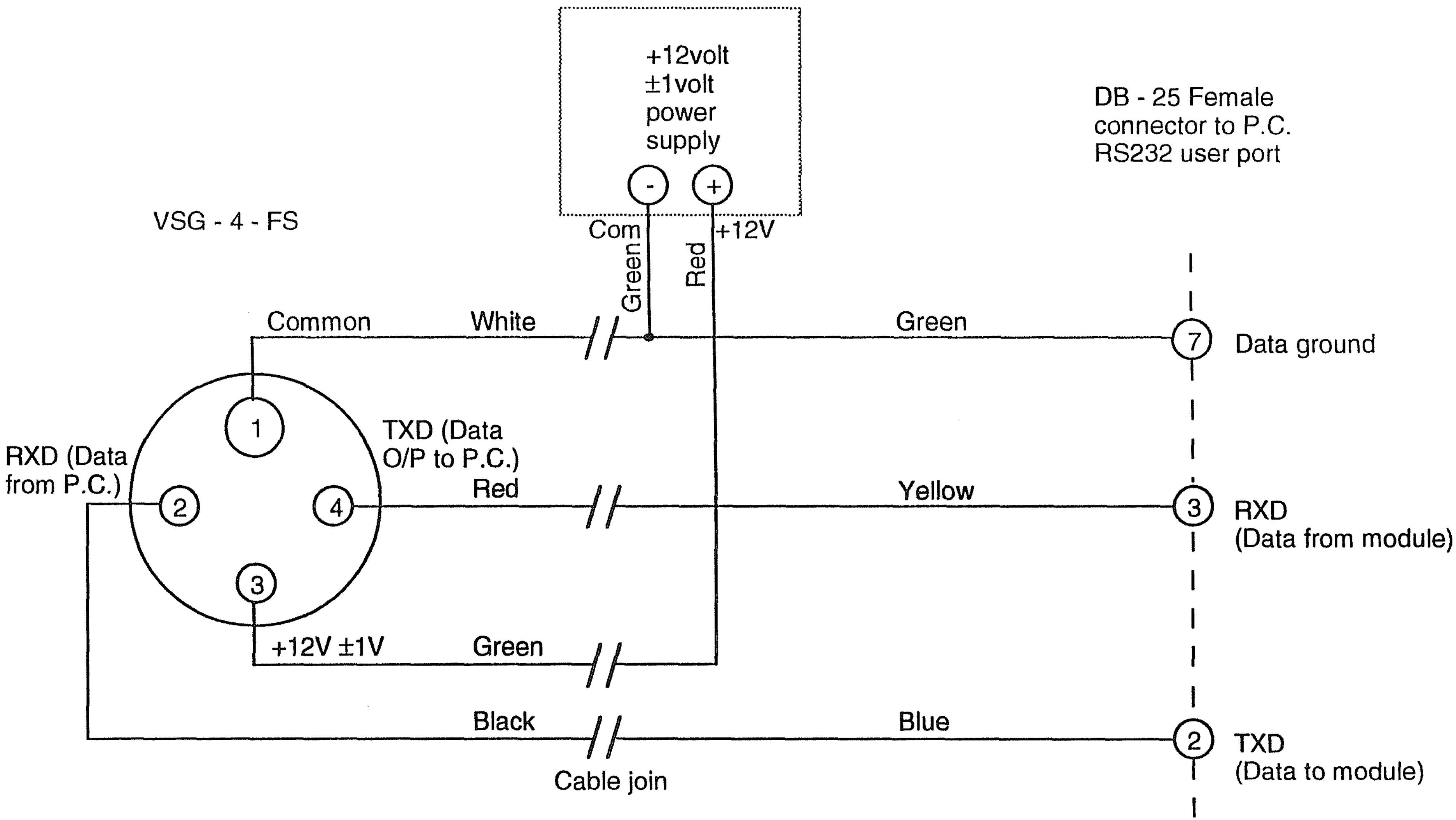

Figure 1 Cable connection - P.C. to OTM

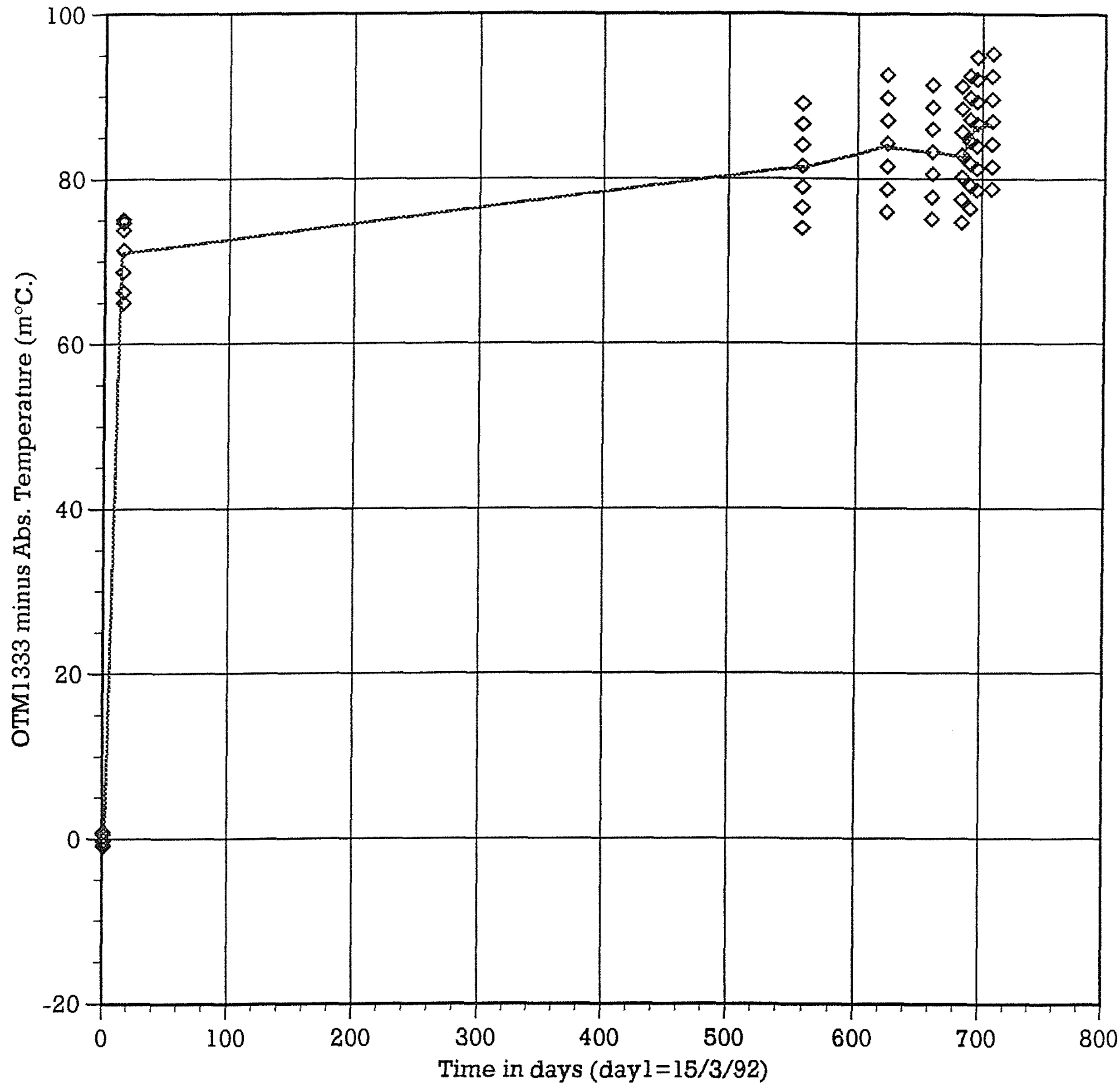

Fig. 2 - 708 Day Temperature difference with Time

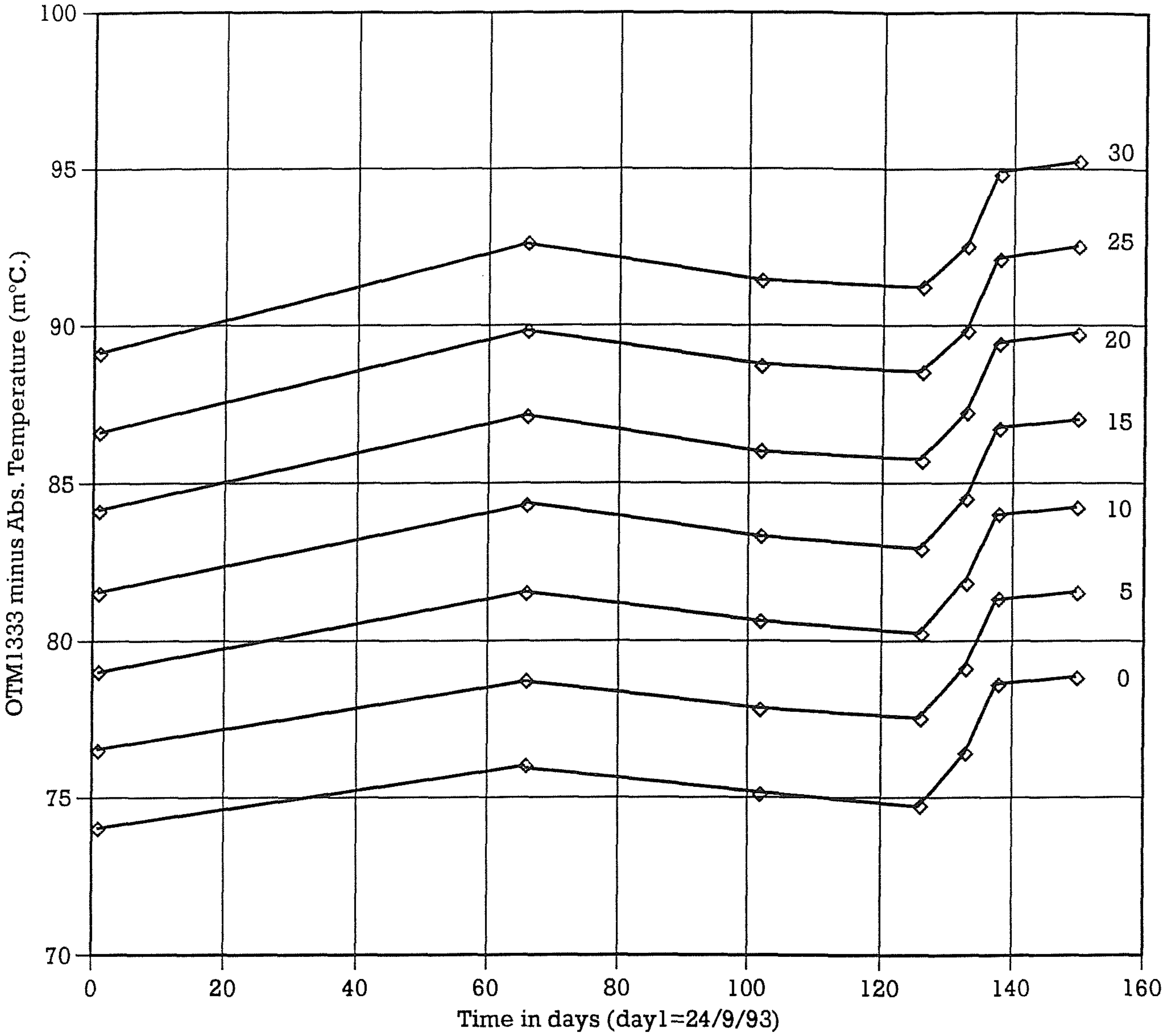

Fig. 3 - 84 Day Temperature difference with Time

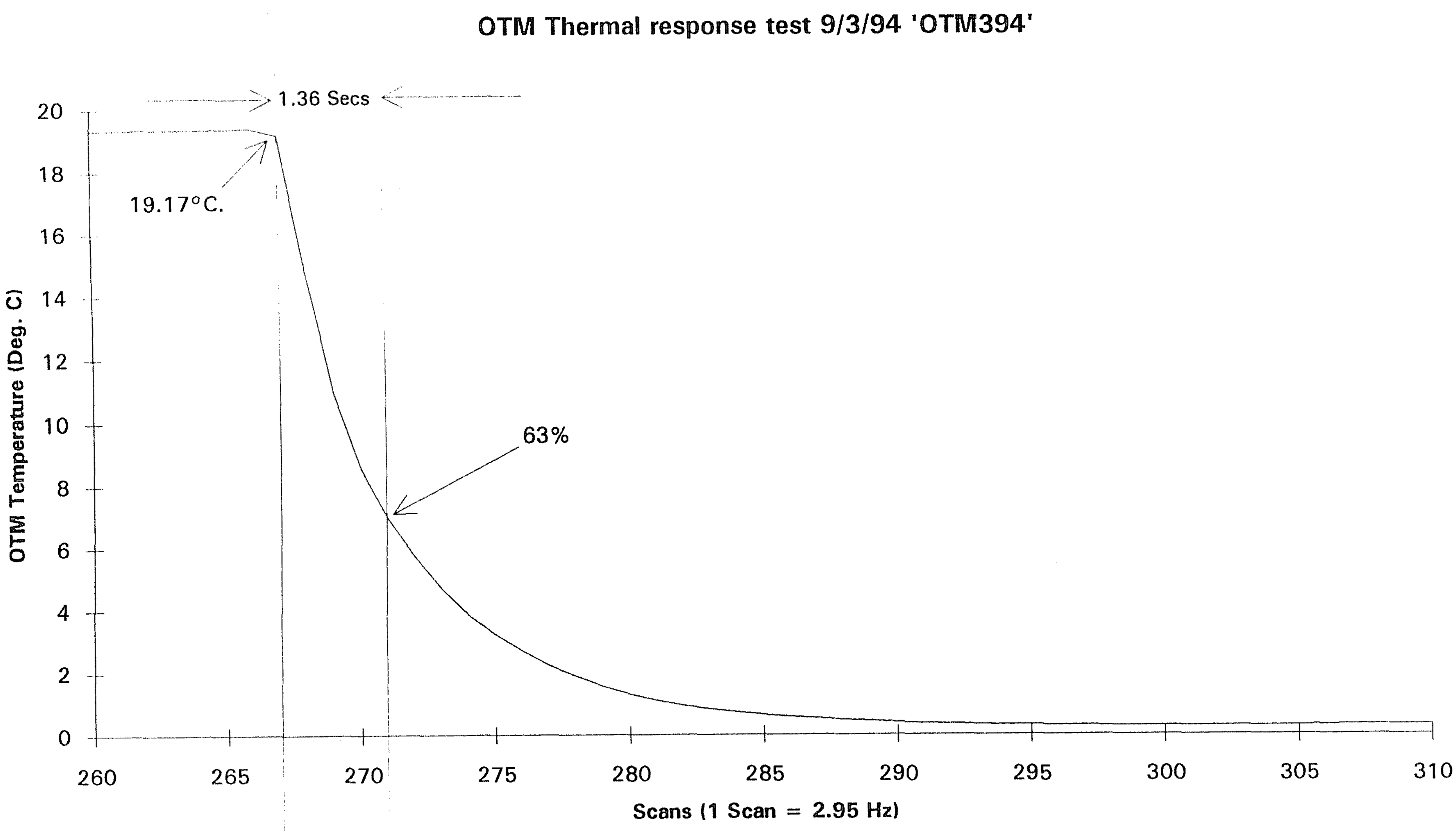

Figure 4 - Thermal Response Plot.

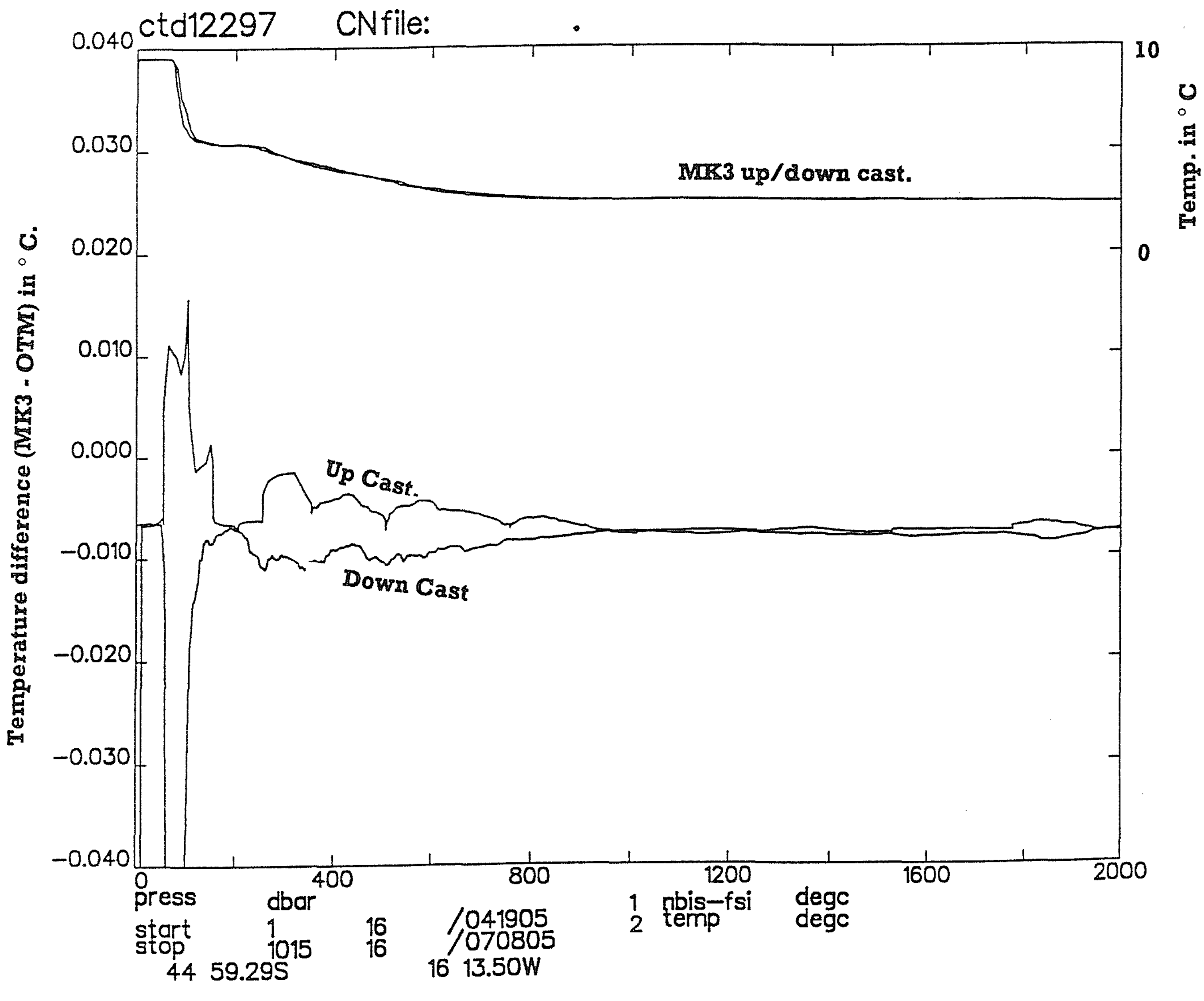

Figure 5. Temperature data from deployment CTD12297.

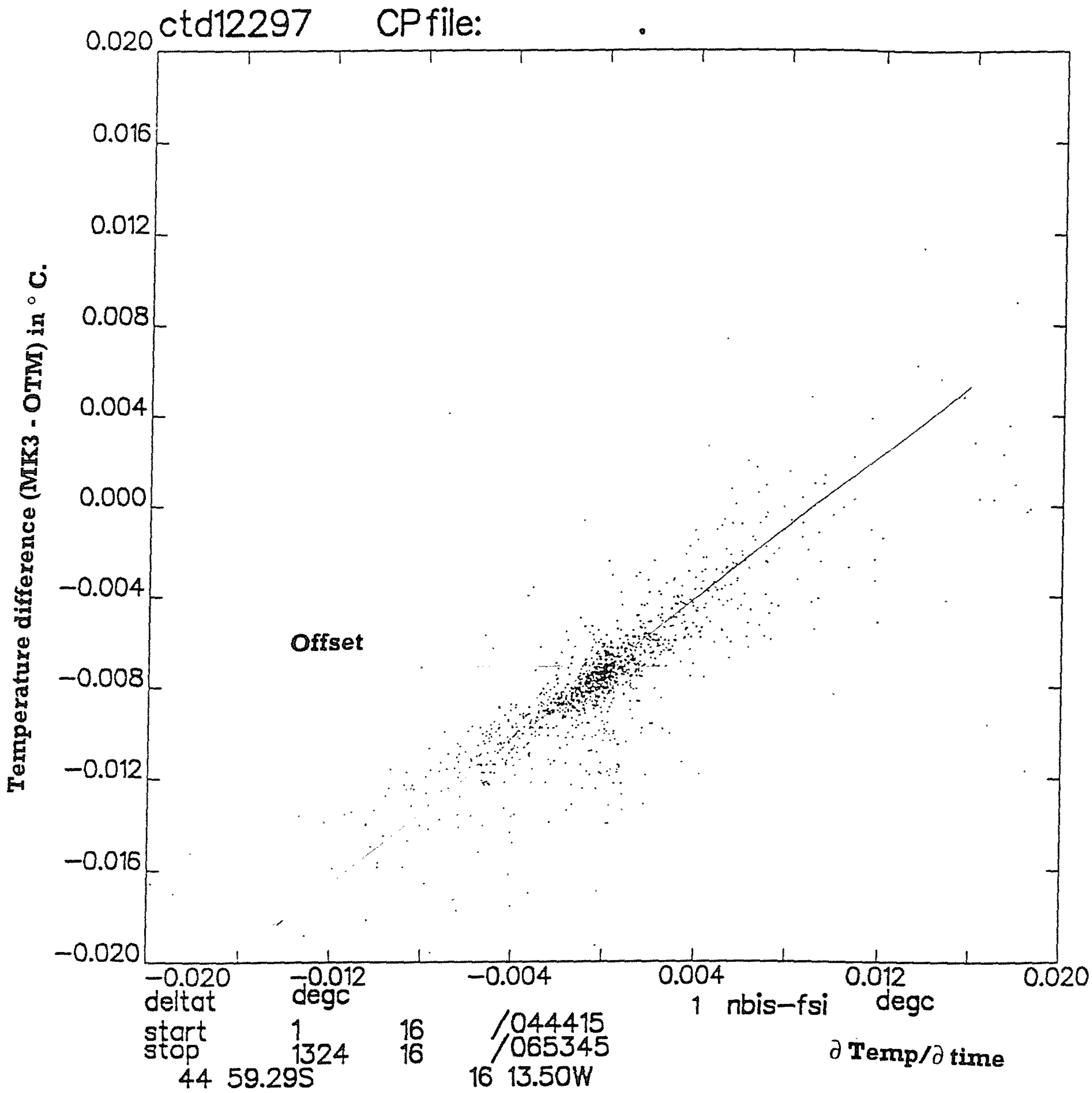

Figure 6. Scatter Plot of MK3 and OTM temperature difference.

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