Titolo

INSTRUMENTATION UPGRADE AND COMMISSIONING TESTS IN THE HLM FACILITY

Descrittori

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Argomenti trattati: Generation IV reactors, Tecnologia dei metalli liquidi

Sommario

This report is focused on the experimental tests of new absolute pressure transducer (GEFRAN KE2, 0-20 bar) for heavy liquid metals to be used in the HLM (Heavy Liquid Metal) loop HELENA. The tests were performed using a small vessel filled with LBE, but with a proper flanged connection in the bottom part to install the transducer. A new strategy to minimize the instrument error was tested avoiding the temperature drift by controlling the sensor temperature independently from the vessel HLM process temperature. This strategy was successful and it allowed to fix all the technical solutions both for LBE and for Lead in terms of temperature control and to reduce the maximum instrument error to 100 mbar (0.5% of the range).
This result will allow to install and operate the transducers in the HELENA loop and in other loops at the ENEA Brasimone R.C.
It is an important technological development for pressure measuring in liquid metals.

Note

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Copia n. **In carico a:I. Di Piazza**

REV.	DESCRIZIONE	DATA		REDAZIONE	CONVALIDA	APPROVAZIONE
2			NOME			
			FIRMA			
1			NOME			
			FIRMA			
0	EMISSIONE	19/09/2016	NOME	I.Di Piazza	A. Del Nevo	M. Tarantino
			FIRMA	[signature]	[signature]	[signature]

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1. Introduction

Absolute pressure is an important quantity to know to operate HLM facilities. Due to the fact that the HLM (lead or LBE) density is around 10^4 kg/s, a column of 1 m of HLM brings 1 bar at the bottom of the column itself. Therefore, from the operational point of view, it is important to know the absolute pressure in a loop especially during the filling and drain operations to have a better understanding of the loop behavior.

Up to know, the so-called 'bubble tubes' were used with a small (6-8 mm) pipe entering the main pipe of the loop (or facility) with a continuous gas injection at a small flow rate through the small pipe. By measuring gas pressure in equilibrium with HLM, an indirect measure of the HLM pressure in the penetration point can be achieved. This technique was successfully largely used in the main experimental HLM facilities at the Brasimone R.C., both for loops (Di Piazza et al., 2016) and for pool (Tarantino et al., 2015). Although the bubble tube technique allows pressure measure, the measuring error can be too high according to the specific application. Moreover the facility design is complicated by the presence of this penetrations with small pipes with long heating cables to manage, and from an operational point of view these long small pipes can have HLM freezing if gas flow is stopped.
For these and other reasons, it is desirable to develop and test sensors to measure pressure directly in HLM without any gas injection.

Sensors for liquid metals at high temperatures are not commercially available in the market. The sensors 'KE2' developed prototypically by GEFRAN were mounted and tested to study the behavior, the accuracy (error) and the repeatability (precision) of the measure. There sensors were developed specifically for liquid metals in collaboration with ENEA and the datasheet is reported in APPENDIX A. After the testing, the sensors will be procured and installed in the HELENA facility.

2. Experimental set-up and test matrix

A picture of the experimental setup used for the tests is shown in Figure 1. It consists of a small main vessel S100 filled with liquid LBE with a cover gas (Ar) and a Barksdale gas pressure transducer in the range 0-10 bar. The data sheet of the gas transducer is reported in APPENDIX B, and the declared accuracy is 0.5% of the range, i.e. 50 mbar.

In the bottom part of the vessel, a 1'' penetration with a coupling flange is welded to locate the flanged GEFRAN KE2 pressure sensor. Figure 2 shows a zoom of the GEFRAN KE2 sensor with the coupling flanges and the electrical connections.

A fill and drain system with an auxiliary vessel is also present to dismount and operate the test rig. Pipes, vessel and penetrations are traced with heating cables in order to heat up the facility and test the instrument in different conditions.

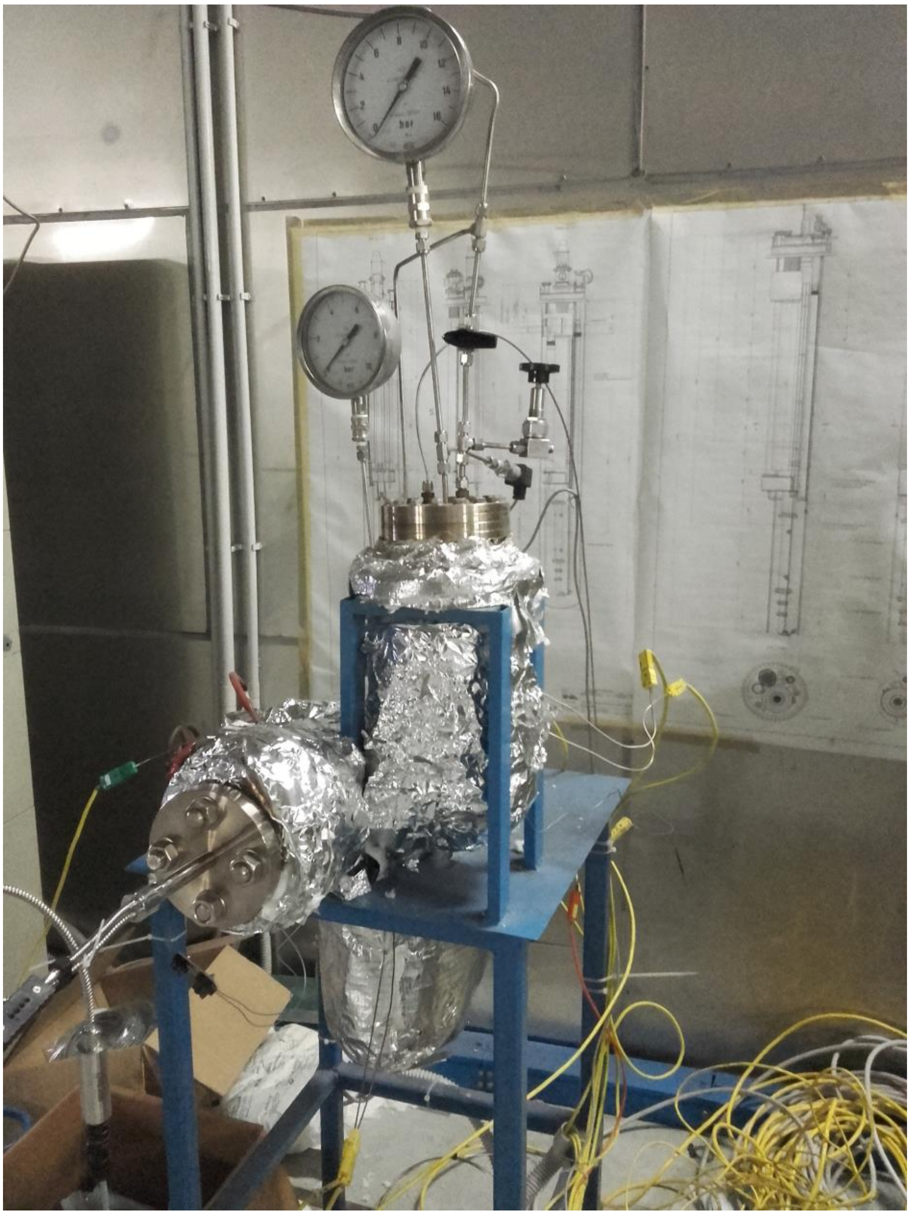


Figure 1 Experimental setup used to test the sensor.

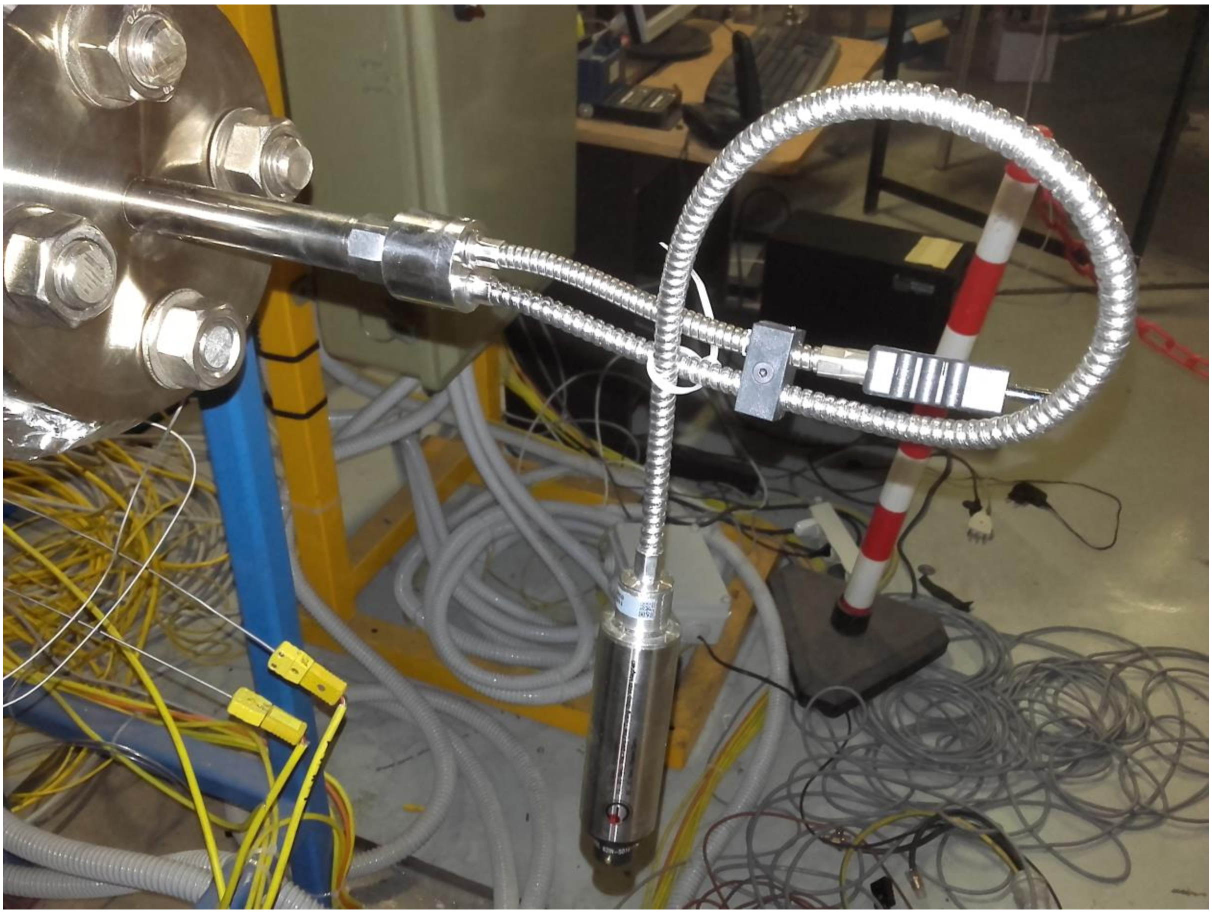


Figure 2 Picture of the GEFRAN sensor with the coupling flange.

By comparing values of the Barksdale gas pressure sensor and of the GEFRAN KE2 sensor, the accuracy of the instrument can be assessed and potential problems can be evidenced.
By previous experience, it is known that there is a significant drift of the signal with the sensor temperature. Therefore the 1’’ penetration and the coupling flange were traced with electrical cable (Thermocoax, 60V, 300W) in order to control the sensor temperature independently from the LBE temperature. The temperature of the sensor is known by a thermocouple installed by the manufacturer.
A Data Acquisition and Control System (DACS Labview NI) allows the control of all the parameters independently: S100 LBE temperature T_{HLM}, sensor temperature T_s, pressure in the cover gas p_0. The measured pressure by GEFRAN KE2 (4-20 mA signal) is called p_G.

A <u>complete test matrix</u> was planned on the following parameters:
T_{HLM}[°C]=180, 200, 250, 300, 350, 400, 450, 500
p_0[bar]=0, 1, 2.5, 5, 7.5, 10
T_s[°C]=230, 380

The sensor temperature was controlled and fixed at 230 °C or 380°C to simulate LBE and Lead real conditions and to develop an applicable solution both for LBE and Lead loops.

Practically, tests were made by fixing T_{HLM} and by varying the cover gas pressure in steps.
The offset error was computed and corrected by empty vessel tests and zero pressure.
The original calibration curve (straight line) of the sensor (Current 4-20 mA vs. pressure 0-20 bar) was taken as first guess, but the slope was corrected by data analysis of the experimental tests.

The test matrix, with the tests assembled together for the different pressures, is given in Table 1. Within each test the whole pressure range was explored. Tests 9-15 are specular with respect to tests 1-8 and are made for repeatability. Tests 101-106 are performed with the sensor temperature T_s at 380°C.

Table 1 Experimental test matrix for the calibration of the HLM pressure sensor GEFRAN KE2.

TEST	T_s [°C]	p_0 [bar]	T_{HLM} [°C]
1	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	180
2	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	200
3	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	250
4	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	300
5	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	350
6	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	400
7	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	450
8	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	500
9	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	450
10	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	400
11	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	350
12	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	300
13	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	250
14	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	200
15	230	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	180
101	380	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	350
102	380	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	400
103	380	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	450
104	380	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	500
105	380	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	450
106	380	0, 1, 2.5, 5, 7.5, 10, 7.5, 5, 2.5, 1, 0	400

3. Experimental tests

The measurement results of all the experimental tests are reported in tabular form in APPENDIX C, where ‘PT-REF’ is the reference gas pressure p_0, ‘GEFRAN’ is the instrument value without corrections with the original calibration curve and ‘DIFF’ (or DIFF-ABS, absolute value) represent the difference in [bar] between GEFRAN KE and gas pressure sensor after the offset and slope calibration correction, in formulas p_s-p_0. The value GEFRAN-OFFSET represents the GEFRAN KE pressure p_s after all corrections.
The original calibration curve (straight line) of the sensor (Current 4-20 mA vs. pressure 0-20 bar) was taken as first guess, but the slope was corrected by statistical data analysis of the experimental tests. ‘GEFRAN’ and ‘PT-REF’ values were compared and the best slope was computed by minimizing the Mean Squared Error. The slope correction with respect to the slope provided by the manufacturer is around 1.4%.

Figure 3 shows the error in terms of absolute value of p_s-p_0 [mbar] in the experimental tests with the sensor temperature T_s kept at 230 °C. The main remark is that the error is always less than 100 mbar in any condition (<0.5% range). Moreover the error is higher at higher HLM temperature (450, 550 °C), while it is generally less than 50 mbar for temperatures below 400 °C. Considering that the error of the gas Barksdale pressure probe is around 50 mbar, the GEFRAN has a comparable accuracy for process temperatures below 400 °C. This is a very good indication for the facility operation.
Similar results are obtained for the case T_s=380 °C, shown in Figure 4, and similar considerations yields.

Regarding the repeatability of the measure, a more deep analysis of the data must be still carried out. Figure 5 shows a comparison of the error in a single condition (T_{HLM} 450 °C, T_s 230°C) taken in two different instants. The difference between the 2 measures is maximum 30 mbar, i.e. of the same order or lower than the instrument error. From these data, the repeatability of the measure seems to be good.

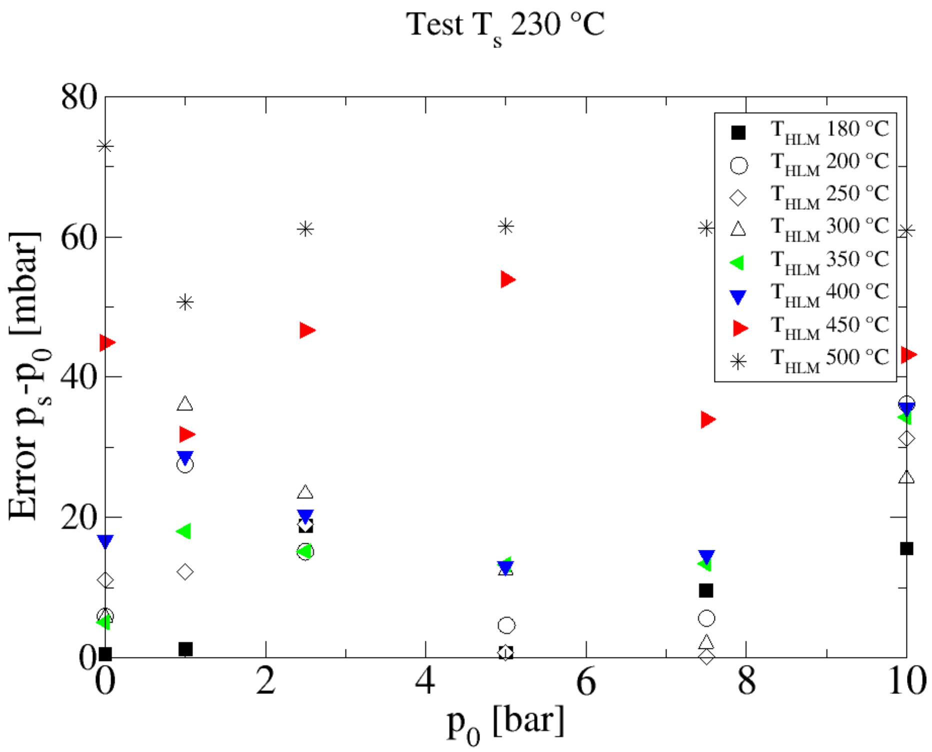


Figure 3 Error abs(p_s-p_0) [mbar] with the sensor temperature kept at 230 °C.

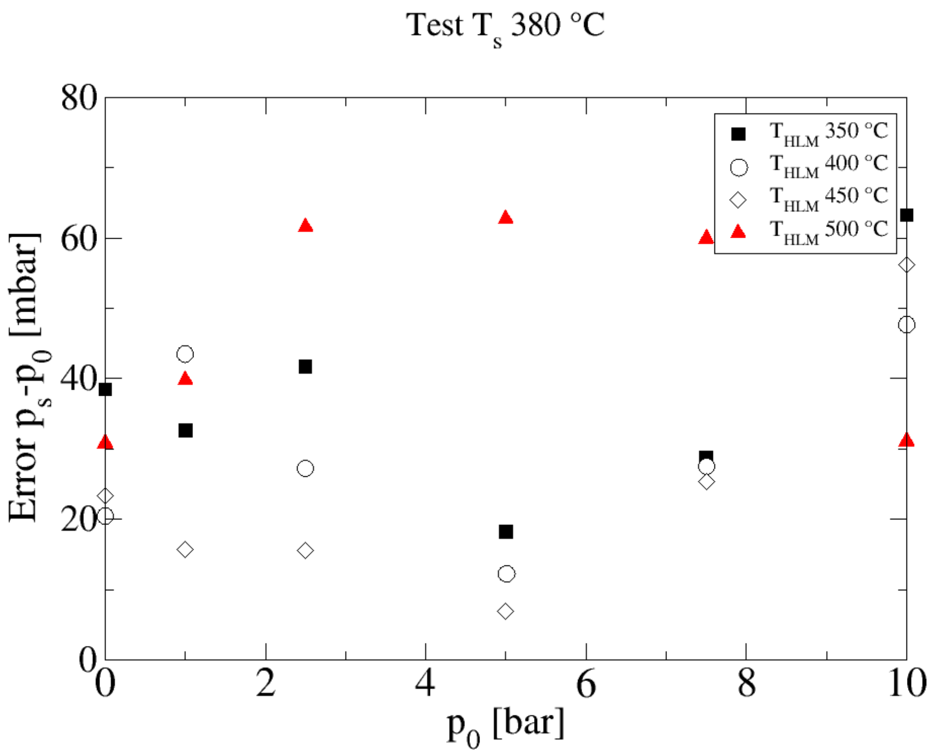


Figure 4 Error abs(p_s-p_0)[mbar] with the sensor temperature kept at 380 °C.

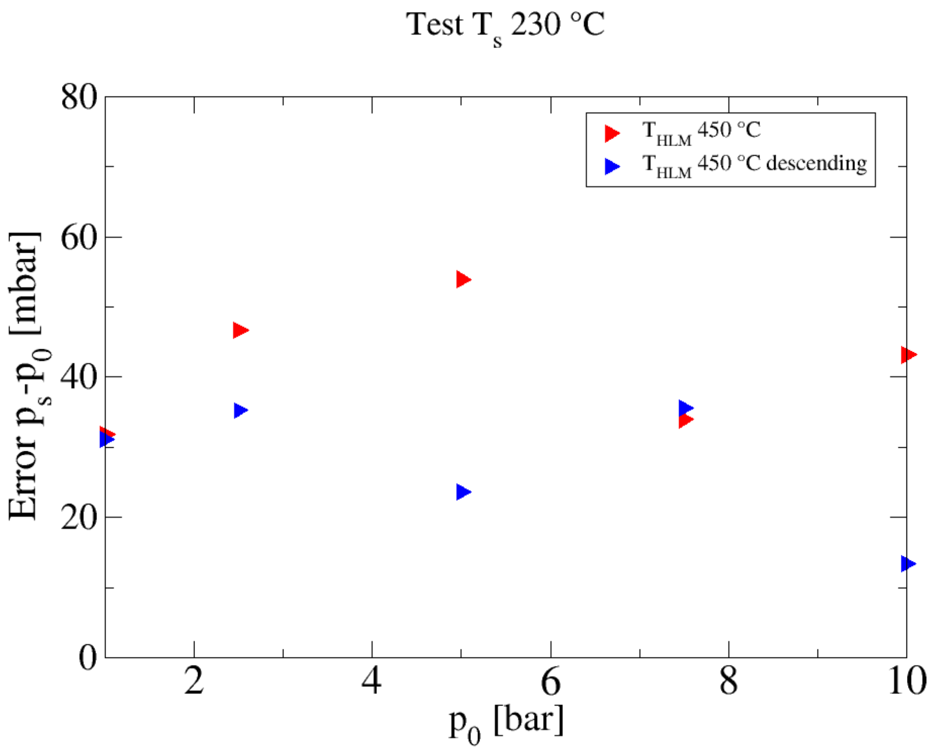


Figure 5 Repeatability of the measure by a comparison between the same condition (T_{HLM} 450°C) taken in two different instants.

4. Conclusions

This report is focused on the experimental tests of new absolute pressure transducer (GEFRAN KE2, 0-20 bar) for heavy liquid metals to be used in the HLM (Heavy Liquid Metal) loop HELENA. The tests were performed using a small vessel filled with LBE, but with a proper flanged connection in the bottom part to install the transducer. A new strategy to minimize the instrument error was tested avoiding the temperature drift by controlling the sensor temperature independently from the vessel HLM process temperature. This strategy was successful and it allowed to fix all the technical solutions both for LBE and for Lead in terms of temperature control and to reduce the maximum instrument error to 100 mbar (0.5% of the range). The error is even lower than 50 mbar for process (HLM) temperature below 400 °C (0.25% of the range).
Regarding the repeatability, a first analysis of the results shows a good repeatability with differences among measures taken in similar conditions lower than the typical error in that condition.
This result will allow to install and operate the transducers in the HELENA loop and in other loops at the ENEA Brasimone R.C.
Most of the technological issues related to the installation, operation, managing and calibration of this new sensor where basically solved.
It is an important technological development for pressure measuring in liquid metals.

5. References

I. Di Piazza, M. Angelucci, R. Marinari, M. Tarantino, N. Forgione, "**Heat Transfer On Hlm Cooled Wire-Spaced Fuel Pin Bundle Simulator In The Nacie-Up Facility**", Nucl. Eng. Des., Vol.300, pg.256-267, 2016.

M. Tarantino, D. Martelli, G. Barone, I. Di Piazza, N. Forgione, "**Mixed Convection and Stratification Phenomena in a Heavy Liquid Metal Pool**", *Journal of Nuclear Engineering and Design, vol.286, pp. 261-277, 2015.*

APPENDIX A: GEFRAN KE2 DATA SHEET

GEFRAN

TRASMETTITORI DI PRESSIONE DI MELT A RIEMPIMENTO NaK
PER IL SOLARE TERMODINAMICO A CONCENTRAZIONE
KE SERIE CSP XMD05 *uscita 4...20mA*

La serie KE CSP è specificatamente studiata per la tecnologia del solare termodinamico a concentrazione (CSP), nelle quali le temperature di processo possono raggiungere valori molto elevati (600°C).
Il principio costruttivo della serie KE CSP si basa sulla trasmissione idraulica della pressione; il trasferimento della sollecitazione meccanica avviene tramite un liquido di trasmissione incomprimibile (lega Sodio Potassio - NaK).
La tecnologia estensimetrica della serie KE CSP consente di trasdurre la grandezza fisica pressione in segnale elettrico.

CARATTERISTICHE PRINCIPALI

- Campi di pressione compresi tra 0-20 e 0-100 bar / 0-300 e 0-1500 psi
- Accuratezza: < ±1.0% FSO (L)
- Sistema di trasmissione idraulica del segnale di pressione per garantire stabilità alla temperatura di esercizio
- Il fluido NaK è conforme alla Direttiva RoHS
- Il fluido NaK è definito una sostanza sicura (GRAS) dalla FDA
- Quantità di NaK contenuta: 40mm³ (0.00244 in³)
- Filettatura standard : M18x1.5
- Funzione Autozero integrata/ opzione esterna
- Membrana corrugata Inconel 718
- Materiale dello stelo: Inconel 718

FUNZIONE DI AUTOZERO

In assenza di pressione, tutte le variazioni di segnale possono essere eliminate tramite la funzione di Autozero.
Questa funzione viene attivata chiudendo un contatto magnetico posto sulla custodia del trasmettitore.
La procedura è consentita solo in condizioni di "pressione zero" del sensore.

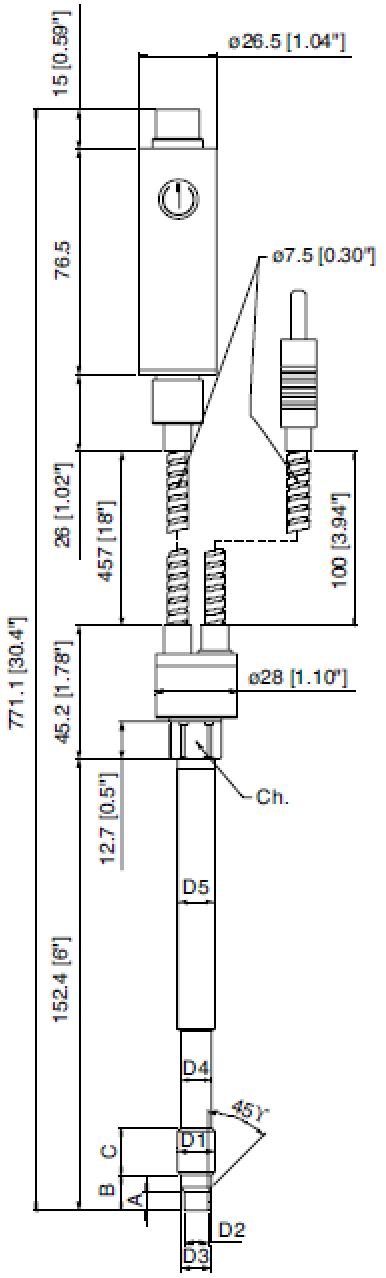
CARATTERISTICHE TECNICHE

Accuratezza (1)	L <±1.0%FSO @ >250°C (20...100bar)
Risoluzione	Infinita
Campo di misura	0..20 to 0..100bar 0..300 to 0..1500psi
Sovrapressione massima (senza degrado delle prestazioni)	2 x FS
Alimentazione elettrica	10...30Vdc
Assorbimento massimo di corrente	32mA
Resistenza di isolamento (a 50Vdc)	>1000 MOhm
Segnale di uscita a fondo scala (FSO)	20mA
Segnale di zero (tolleranza ± 0.25% FSO)	4mA
Regolazione dei segnali di zero (tolleranza ± 0.25% FSO)	funzione "Autozero"
Regolazione Span entro ± 5% FSO	vedi manuale Melt
Carico massimo consentito	vedi schema
Tempo di reazione elettronica (10...90% FSO)	~ 1ms
Disturbo in uscita (RMS 10-400Hz)	< 0.025% FSO
Segnale di calibrazione	80% FSO
Protezione contro cortocircuito in uscita e inversione di polarità	SI
Campo di temperatura compensato housing	0...+85°C
Temperatura massima membrana	600°C/1112°F
Deriva zero temperatura	< 0.5bar/100°C < 7.5psi/100°F
Termocoppia	STD : type "J" (giunzione isolata)
Grado di protezione (connettore femmina a 6-poli)	IP65

FSO = Uscita a fondo scala
(1) Metodo BFSL (Best Fit Straight Line): comprende effetti combinati di Non-Linearità, Isteresi e Ripetibilità.

DIMENSIONI MECCANICHE

KE2



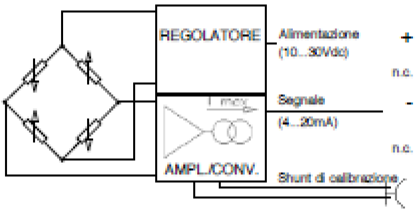
D1	**M18x1.5**
D2	ø10 -0.05 [ø0.394" -0.002]
D3	ø16 -0.08 [ø0.63" -0.003]
D4	ø16 -0.4 [ø0.63" -0.016]
D5	ø18 [ø0.71"]
A	6 -0.25 [0.24" -0.01]
B	14.8 -0.4 [0.58" -0.016]
C	19 [0.75"]
Ch [Hex]	19 [3/4"]

NOTE: Le dimensioni si riferiscono all'opzione stelo rigido con lunghezza "4" (153mm - 6")

AVVERTENZA: Per il montaggio, utilizzare una coppia di serraggio massima di 56 Nm (500 in-lb)

CONNESSIONI ELETTRICHE

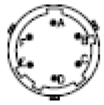
USCITA IN CORRENTE (4...20mA, 2 fili)



	AUTOZERO MAGNETICO 6-pin	AUTOZERO MAGNETICO 8-pin		AUTOZERO ESTERNO 6-pin	AUTOZERO ESTERNO 8-pin
Alimentazione (10...30Vdc) +	A	B	Alimentazione (10...30Vdc) +	A	B
n.c.	C	A	n.c.	C	A
Segnale (4...20mA) -	B	D	Segnale (4...20mA) -	B	D
n.c.	D	C	n.c.	D	C
Shunt di calibrazione	E - F	E - F	Autozero	E - F	E - F
n.c.		G - H	n.c.		G - H

Collegare la calza del cavo sul lato dello strumento

Connettore 6-pin VPT07RA10-6PT2 (PT02A-10-6P



Connettore 8-pin PC02E-12-8P Bendix

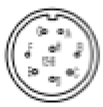
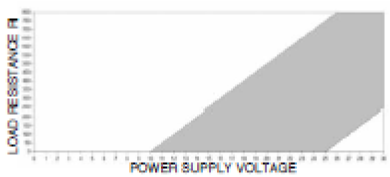
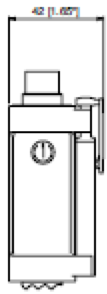


DIAGRAMMA DI CARICO



Il diagramma riporta il rapporto ottimale tra il carico e l'alimentazione per i trasmettitori con uscita 4...20mA.
Per il corretto funzionamento, utilizzare una combinazione di resistenza di carico e tensione che rientri nell'area ombreggiata.

FUNZIONE AUTOZERO



La funzione Autozero è attivata mediante un contatto magnetico (magnete esterno fornito con il sensore).
Per l'illustrazione completa della funzione Autozero, consultare il manuale utente.

ACCESSORI

Connettori

Connettore femmina a 6 poli (grado di protezione IP65)	**CON300**
Connettore femmina a 8 poli	**CON307**

Cavi di estensione

Connettore 6 poli con 8m (25 ft) di cavo	**C08WLS**
Connettore 6 poli con 15m (50 ft) di cavo	**C15WLS**
Connettore 6 poli con 25m (75 ft) di cavo	**C25WLS**
Connettore 6 poli con 30m (100 ft) di cavo	**C30WLS**
Connettore 8 poli con 8m (50 ft) di cavo	**E15WLS**
Connettore 8 poli con 25m (75 ft) di cavo	**E25WLS**
Connettore 8 poli con 30m (100 ft) di cavo	**E30WLS**
Altre lunghezze	**su richiesta**

Accessori

Staffa di fissaggio	**SF18**
Tappo di protezione per M18x1,5	**SC18**
Kit di perforazione per M18 x 1,5	**KF18**
Kit di pulizia per M18x1,5	**CT18**
Clip di fissaggio penna	**PKIT309**
Penna Autozero	**PKIT312**

Termocoppia per modello KE2

Tipo "J" (stelo rigido 153mm - 6")	**TTER601**

Adattatori

Particolare lavorato su misura, in base alle esigenze del cliente

Cable color code

Conn.	Wire
A	Red
B	Black
C	White
D	Green
E	Blue
F	Orange

LA COMPETENZA GEFRAN: LE NOSTRE SOLUZIONI PER LE APPLICAZIONI CSP

La pressione di processo viene trasmessa alla membrana di misura tramite un tubo capillare riempito di fluido NaK.
La membrana a contatto funge da separatore tra il fluido di processo (Sali Fusi) e il fluido di riempimento (NaK).
In base alla temperatura del "lato caldo" del sensore, l'espansione del fluido di riempimento produce una deriva di zero del sensore stesso.
Questo effetto è stato ottimizzato e minimizzato a < 0,5bar/100°C per soddisfare i requisiti delle applicazioni CSP.

INCIDENZA DELLA TEMPERATURA AMBIENTE *(Ciclo Giorno-Notte)*

Un contributo secondario alla deriva di zero proviene dall'incidenza della temperatura sul "lato freddo" del sensore.
Anche questo effetto è stato minimizzato.
Il ciclo Giorno-Notte può essere generalmente responsabile di una deriva di zero pari a ± 100 mbar (1,5 psi).

Suggerimenti per ridurre al minimo l'incidenza delle condizioni ambientali esterne sulla deriva di zero:

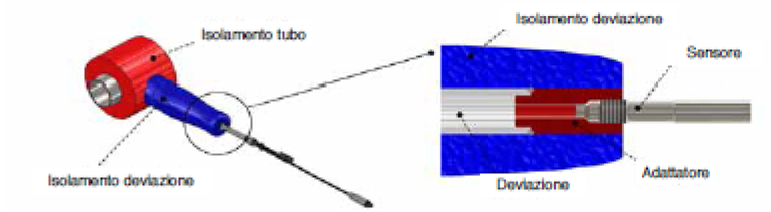
- Non esporre il sensore all'irraggiamento solare diretto, ma tenerlo all'ombra.
- Se possibile, montare il sensore orizzontalmente, affinché non vi siano elementi riscaldati al di sotto di esso.

ISTRUZIONI DI MONTAGGIO

Il sensore deve essere montato in una sede adeguata e pulita.
Una sede adeguata può essere ottenuta con l'ausilio del Kit di perforazione *KF18*. Utilizzare il Kit di pulizia Gefran *CT18* per eliminare le tracce residue di sale dalla sede, fino a potere fare ruotare l'attrezzo liberamente.
Se l'attrezzo *CT18* non ruota liberamente, significa che la sede non è pulita o che non è stata correttamente lavorata.
Occorre tassativamente applicare grasso per alte temperature sulle filettature.
La rimozione del sensore deve avvenire quando la temperatura della sede è > 250°C, affinché il sale sia liquido.
L'interfaccia tra il sensore e il processo può essere un adattatore da saldare all'estremità della deviazione.

CONSIGLI DI INSTALLAZIONE

Non collocare la punta del sensore direttamente sul tubo principale, all'interno del flusso di sale. Utilizzare una deviazione piezometrica (come illustrato nella figura sotto):



L'isolamento della deviazione piezometrica non deve avvolgere lo stelo del sensore. Mantenere la deviazione ad una temperatura > 250°C (ad esempio 300°C). Questo può facilitare l'installazione e la taratura del sensore.
Più la deviazione è lunga e meno elevata sarà la temperatura di esercizio del sensore.
Può essere utile prevedere una valvola di intercettazione sulla deviazione per isolare il sensore dal tubo pressurizzato.

LINEE GUIDA DELLA PROCEDURA DI TARATURA

1. Collocare il sensore nella sua sede senza avvitarlo (affinché misuri la pressione ambiente).
2. Riscaldare la sede fino a 300°C.
3. Lasciare riscaldare il sensore per 30 minuti dopo avere raggiunto una temperatura stabile.
4. Annotare la temperatura indicata dalla termocoppia (To) del sensore e il segnale di uscita (mAo) del sensore.

Questi valori possono essere utilizzati (se necessario) per la compensazione della deriva di zero rispetto alla temperatura di processo, in base al seguente algoritmo:

$$\textbf{Pressione} = (mA - mAo) \times FS/16 - k\,(T - To)/1000$$

dove:

- "*T*" e "*To*" sono valori di temperatura espressi in °C
- "*mA*" e "*mAo*" sono valori di uscita espressi in mA
- "*k*" è il coefficiente di deriva della pressione, espresso in mbar/°C (questo coefficiente è fornito per ogni singolo sensore)
- "*FS*" è il campo di pressione (cioè Fondo Scala) del sensore espresso in bar (o psi)

5. Avvitare il sensore nella sua sede

CODICE DI ORDINAZIONE

K - □ - □ - □ - □ - □□□□ - □ - □ - □ - □ - □ - XMD05

SEGNALE DI USCITA	
4 .. 20mA	E

VERSIONE	
Con termocoppia	2

CONNETTORE	
Standard	
6 pin	6
8 pin	8

CLASSE DI PRECISIONE	
1.0% FSO	L

CAMPO DI MISURA			
bar		psi	
20	B02D	300	P03C
35	B35U	500	P05C
50	B05D	750	P75D
70	B07D	1000	P01M
100	B01C	1500	P15C

E	Autozero esterno
-	Autozero magnetico

MEMBRANA DI CONTATTO	
I	Inconel 718

LUNGHEZZA STELO FLESSIBILE (mm / inches) (*)		
Standard		
D	457mm	18"
E	610mm	24"
F	760mm	30"
Disponibile su richiesta		
A	76mm	3"
B	152mm	6"
C	300mm	12"

LUNGHEZZA STELO RIGIDO (mm / inches) (*)		
Standard		
4	153mm	6"
5	318mm	12.5"
Disponibile su richiesta		
1	38mm	1.5"
2	50mm	2"
3	76mm	3"
6	350mm	14"
7	400mm	16"
8	456mm	18"

(*) La lunghezza massima combinata dello stelo rigido/flessibile è di 1000 mm - 39"

FILETTATURA	
Standard	
4	M18 x 1.5

Esempio

KE2-6-M-B05D-4-4-D-I-XMD05

Trasduttore della pressione di Melt con termocoppia di tipo "J", uscita 4...20mA , connettore 6 poli, filettatura M18X1,5 , campo di pressione 50 bar, classe di precisione 1,0 %, stelo rigido da 153 mm (6"), stelo flessibile da 457 mm (18"), membrana Inconel 718

I sensori sono realizzati conformemente a:

- Direttiva per la Compatibilità Elettromagnetica EMC 2004/108/CE
- Direttiva RoHS 2002/95/CE

Requisiti di installazione elettrica e certificato di Conformità sono disponibili sul nostro sito internet: www.gefran.com

GEFRAN

GEFRAN spa
via Sebina, 74
25050 PROVAGLIO D'ISEO (BS) - ITALIA
tel. 0309888.1 - fax. 0309839063
Internet: http://www.gefran.com

APPENDIX B: BARKSDALE PRESSURE GAS SENSOR DATA SHEET

Electronic Pressure Transducers *Type UPA 5*

Electronic pressure transducer for OEM applications, with internal ceramic sensor, linearity accuracy 0.5 % f. s.

Features

Very compact design,
space-saving,
High shock and vibration stability

Measuring ranges

-1...0 bar to 0...400 bar gauge
0...1 bar 0...16 bar absolute pressure

Applications

OEM applications,
hydraulic and pneumatic systems

Index: A

Technical Data

Sensor element:	Ceramic sensor
Materials: Pressure connection: Housing: Wetted parts: Sensor seal:	 Stainless steel, mat. no. 1.4305 Stainless steel, mat. no. 1.4305 Ceramics Al_2O_3 O ring FKM
System of protection:	IP65
Protection class:	III
Process connection:	G1/4 M
Dimensions:	Ø27 x approx. 58 mm (without plug connector)
Weight:	approx. 145 g

Measuring ranges [bar]:	-1...0	1	1.6	2.5	4	
Proof pressure [bar]:	4	4	4.0	4.0	10	
Measuring ranges [bar]:	6	10	16	25	40	60
Proof pressure [bar]:	10	20	40	40	100	100
Measuring ranges [bar]:	100	160	250	400		
Proof pressure [bar]:	200	400	400	600		

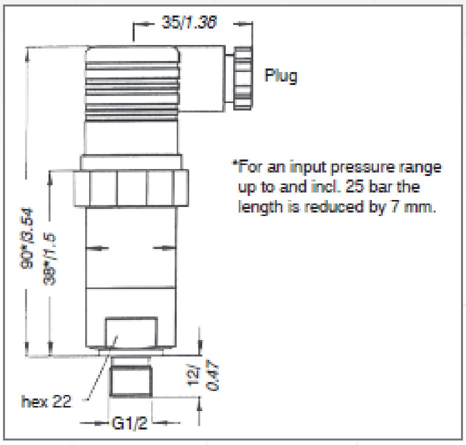
Linearity error:	≤ ±0.5 % v. f. s.
Electrical connection:	Plug reversed polarity protected, DIN EN 175 301-803-A (prev. DIN 43650) (Optional: PG7/2 m cable)
Temperature influence:	< ±0.3 % v. f. s./10K
Compensation range:	0 °C... +70 °C
Temperature range: Medium: Electronics: Storage:	 -25 °C... +125 °C -25 °C... +85 °C -40 °C... +125 °C
Output signals:	4... 20 mA/2-wire (Optional: 0... 10 V/3-wire)
Power supply:	12... 36 V DC, reversed polarity protected (SELV, PELV)
Permissible load (Ohm): Current 2-wire: Voltage 3-wire:	 ≤ (Ub-12 V)/20 mA >1 MOhm
Vibration:	10 g/20... 2000 Hz
Shock:	100 g/11 ms

Pressure

Electronic Pressure Transducers *Type UPA 5*

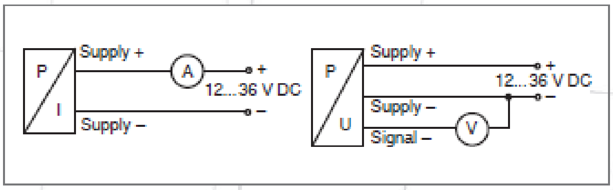
Dimensions (in mm / *inch*)

Index: A



Wiring diagrams

2 wire: 4... 20 mA **3 wire: 0... 10 V**



Electrical Connection

	Current output 4...20 mA (2-wire)		Voltage output 0...10 V (3-wire)	
Connection	**Plug (DIN 43650)**	**Cable (DIN 47100)**	**Plug (DIN 43650)**	**Cable (DIN 47100)**
+ Supply	1	white	1	white
- Supply	2	brown	2	brown
+ Signal	---	---	3	green
- Signal	---	---	---	---

Order Numbers

Pressure ranges [bar] relative pressure	Output signal 4...20 mA Plug DIN 43650	Output signal 0...10 V Plug DIN 43650	Output signal 4...20 mA PG7 / 2 m cable	Output signal 0...10 V PG7 / 2 m cable
-1...0	0434-002	0434-037	0434-046	0434-061
1	0434-006	0434-027	0434-047	0434-062
1.6	0434-007	0434-028	0434-048	0434-063
2.5	0434-008	0434-029	0434-049	0434-064
4	0434-009	0434-030	0434-050	0434-065
6	0434-010	0434-031	0434-051	0434-066
10	0434-011	0434-032	0434-052	0434-067
16	0434-012	0434-026	0434-053	0434-068
25	0434-024	0434-022	0434-054	0434-069
40	0434-014	0434-033	0434-055	0434-070
60	0434-015	0434-034	0434-056	0434-071
100	0434-003	0434-035	0434-057	0434-072
160	0434-004	0434-023	0434-058	0434-073
250	0434-018	0434-005	0434-059	0434-074
400	0434-001	0434-036	0434-060	0434-075
[bar] absolute pressure				
1	0434-041			
2	0434-040			
4	0434-042			
16	0434-043			

APPENDIX C: EXPERIMENTAL TESTS (TABULAR DATA)

TEST 1 in PbBi - PbBi a 180° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
25/08/2016	20:27:01	0.914693	-0.0255078	180	229	-0.025003316	0.00050448	0.000504484
25/08/2016	20:27:40	1.89469	0.944492	179	231	0.94323372	-0.0012583	0.00125828
25/08/2016	20:28:52	3.35469	2.40449	179	230	2.38571372	-0.0187763	0.01877628
25/08/2016	20:29:44	5.89469	4.89449	179	231	4.89523372	0.00074372	0.00074372
25/08/2016	20:30:27	8.42469	7.40449	179	231	7.39487372	-0.0096163	0.00961628
25/08/2016	20:31:51	11.0199	9.97449	180	231	9.9589412	-0.0155488	0.0155488
25/08/2016	20:32:55	8.66994	7.62873	180	230	7.63718072	0.00845072	0.00845072
25/08/2016	20:34:09	6.25994	5.22873	179	230	5.25610072	0.02737072	0.02737072
25/08/2016	20:34:54	3.57994	2.58873	179	231	2.60826072	0.01953072	0.01953072
25/08/2016	20:35:40	1.91994	0.948727	180	232	0.96818072	0.01945372	0.01945372
25/08/2016	20:35:59	0.999943	0.0387265	179	231	0.059223684	0.02049718	0.020497184

TEST 2 in PbBi - PbBi a 200° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
25/08/2016	21:00:01	0.973224	0.0387265	200	229	0.032825312	-0.005901188	0.005901188
25/08/2016	21:01:06	1.94322	1.01873	200	229	0.99118136	-0.02754864	0.02754864
25/08/2016	21:01:34	3.41322	2.45873	199	230	2.44354136	-0.01518864	0.01518864
25/08/2016	21:02:05	5.86322	4.86873	199	228	4.86414136	-0.00458864	0.00458864
25/08/2016	21:02:41	8.3809	7.35722	200	230	7.3516092	-0.0056108	0.0056108
25/08/2016	21:03:10	10.9309	9.90722	198	229	9.8710092	-0.0362108	0.0362108
25/08/2016	21:03:54	8.6709	7.62722	198	229	7.6381292	0.0109092	0.0109092
25/08/2016	21:04:31	6.3109	5.27722	198	230	5.3064492	0.0292292	0.0292292
25/08/2016	21:05:03	3.5509	2.57722	197	228	2.5795692	0.0023492	0.0023492
25/08/2016	20:35:38	1.91994	0.948727	180	232	0.96818072	0.01945372	0.01945372
25/08/2016	21:05:58	0.9809	0.0272205	197	229	0.0404092	0.0131887	0.0131887

TEST 3 in PbBi - PbBi a 250° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
25/08/2016	21:25:16	0.928148	-0.02278	252	231	-0.011709776	0.011069724	0.011069724
25/08/2016	21:25:32	1.95815	1.01816	252	231	1.0059322	-0.0122278	0.0122278
25/08/2016	21:26:01	3.35815	2.40816	253	229	2.3891322	-0.0190278	0.0190278
25/08/2016	21:26:33	5.99815	4.99816	254	231	4.9974522	-0.0007078	0.0007078
25/08/2016	21:27:03	8.44815	7.41816	254	229	7.4180522	-0.0001078	0.0001078
25/08/2016	21:27:22	11.0381	10.0082	254	230	9.9769228	-0.0312772	0.0312772
25/08/2016	21:27:53	8.81815	7.76816	255	231	7.7836122	0.0154522	0.0154522
25/08/2016	21:28:28	6.30815	5.27816	255	230	5.3037322	0.0255722	0.0255722
25/08/2016	21:28:58	3.50346	2.51816	256	231	2.53269848	0.01453848	0.01453848
25/08/2016	21:29:26	1.86346	0.91816	256	230	0.91237848	-0.00578152	0.00578152
25/08/2016	21:29:51	0.963457	0.00816	256	231	0.023175516	0.015015066	0.015015066

TEST 4 in PbBi - PbBi a 300° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
25/08/2016	21:43:10	0.923457	-0.02209	299	230	-0.016344484	0.005744616	0.005744616
25/08/2016	21:43:34	1.90346	0.987911	300	229	0.95189848	-0.03601252	0.03601252
25/08/2016	21:43:49	3.35346	2.40791	301	228	2.38449848	-0.02341152	0.02341152
25/08/2016	21:44:07	5.77346	4.78791	300	228	4.77545848	-0.01245152	0.01245152
25/08/2016	21:44:29	8.23346	7.20791	301	230	7.20593848	-0.00197152	0.00197152
25/08/2016	21:44:50	11.0335	9.99791	301	230	9.972378	-0.025532	0.025532
25/08/2016	21:45:18	8.84017	7.78791	301	228	7.80536796	0.01745796	0.01745796
25/08/2016	21:45:46	5.81017	4.78791	301	230	4.81172796	0.02381796	0.02381796
25/08/2016	21:46:16	3.17017	2.19791	302	230	2.20340796	0.00549796	0.00549796
25/08/2016	21:46:42	1.93017	0.995232	302	228	0.97828796	-0.01694404	0.01694404
25/08/2016	21:47:00	0.980166	0.025232	302	228	0.039684008	0.014452408	0.014452408

TEST 5 in PbBi - PbBi a 350° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
25/08/2016	22:05:58	0.930166	-0.01477	349	230	-0.009715992	0.005052408	0.005052408
25/08/2016	22:06:14	2.02017	1.08523	350	230	1.06720796	-0.01802204	0.01802204
25/08/2016	22:06:34	3.45017	2.49523	350	229	2.48004796	-0.01518204	0.01518204
25/08/2016	22:06:53	5.79017	4.80523	350	228	4.79196796	-0.01326204	0.01326204
25/08/2016	22:07:14	8.30017	7.28523	351	228	7.27184796	-0.01338204	0.01338204
25/08/2016	22:07:34	11.032	10.0052	351	227	9.970896	-0.034304	0.034304
25/08/2016	22:08:05	8.84203	7.78523	351	231	7.80720564	0.02197564	0.02197564
25/08/2016	22:08:32	5.99203	4.96433	351	230	4.99140564	0.02707564	0.02707564
25/08/2016	22:09:02	3.46203	2.47433	351	229	2.49176564	0.01743564	0.01743564
25/08/2016	22:09:25	1.86203	0.914327	352	228	0.91096564	-0.00336136	0.00336136
25/08/2016	22:10:00	0.962032	0.024328	351	228	0.021767616	-0.002559884	0.002559884

TEST 6 in PbBi - PbBi a 400° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
25/08/2016	22:40:27	0.937506	0.014328	401	228	-0.002464072	-0.016791572	0.016791572
25/08/2016	22:40:49	1.92751	1.00433	400	228	0.97565988	-0.02867012	0.02867012
25/08/2016	22:41:20	3.50472	2.55433	400	227	2.53394336	-0.02038664	0.02038664
25/08/2016	22:41:42	5.78472	4.79959	400	227	4.78658336	-0.01300664	0.01300664
25/08/2016	22:41:59	8.41472	7.39959	400	227	7.38502336	-0.01456664	0.01456664
25/08/2016	22:42:19	11.0047	9.97959	400	227	9.9439236	-0.0356664	0.0356664
25/08/2016	22:43:03	8.61472	7.56959	399	227	7.58262336	0.01303336	0.01303336
25/08/2016	22:43:26	6.15472	5.12959	399	227	5.15214336	0.02255336	0.02255336
25/08/2016	22:43:48	3.40472	2.42959	399	227	2.43514336	0.00555336	0.00555336
25/08/2016	22:44:11	1.87472	0.92959	399	226	0.92350336	-0.00608664	0.00608664
25/08/2016	22:45:01	0.974717	0.03959	398	226	0.034300396	-0.005289204	0.005289204

TEST 7 in PbBi - PbBi a 450° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
26/08/2016	16:00:11	0.983072	-0.00237	450	230	0.042555136	0.044923376	0.044923376
26/08/2016	16:00:28	2.07307	1.08763	450	230	1.11947316	0.03184316	0.03184316
26/08/2016	16:00:50	3.33307	2.31763	449	231	2.36435316	0.04672316	0.04672316
26/08/2016	16:01:03	6.06307	5.00763	449	231	5.06159316	0.05396316	0.05396316
26/08/2016	16:01:32	8.56307	7.49763	449	230	7.53159316	0.03396316	0.03396316
26/08/2016	16:02:06	11.1331	10.0276	449	232	10.0707828	0.0431828	0.0431828
26/08/2016	16:02:31	8.83307	7.71763	450	232	7.79835316	0.08072316	0.08072316
26/08/2016	16:03:04	6.27307	5.18763	450	231	5.26907316	0.08144316	0.08144316
26/08/2016	16:03:36	3.59307	2.53763	449	233	2.62123316	0.08360316	0.08360316
26/08/2016	16:03:53	2.01307	0.993527	449	233	1.06019316	0.06666616	0.06666616
26/08/2016	16:03:59	1.05767	0.033527	449	233	0.11625796	0.08273086	0.08273086

TEST 8 in PbBi - PbBi a 500° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
26/08/2016	16:25:21	0.997669	-0.01599	492	234	0.056976972	0.072963172	0.072963172
26/08/2016	16:25:33	2.01767	1.01401	492	234	1.06473796	0.05072796	0.05072796
26/08/2016	16:25:53	3.64767	2.61401	492	234	2.67517796	0.06116796	0.06116796
26/08/2016	16:26:10	6.11767	5.05401	492	234	5.11553796	0.06152796	0.06152796
26/08/2016	16:26:26	8.63767	7.54401	493	234	7.60529796	0.06128796	0.06128796
26/08/2016	16:27:06	11.1677	10.044	494	235	10.1049676	0.0609676	0.0609676
26/08/2016	16:27:24	9.00767	7.87401	494	235	7.97085796	0.09684796	0.09684796
26/08/2016	16:27:46	6.03239	4.91401	493	235	5.03128132	0.11727132	0.11727132
26/08/2016	16:28:09	3.60239	2.5279	493	235	2.63044132	0.10254132	0.10254132
26/08/2016	16:28:28	2.04239	1.0079	493	235	1.08916132	0.08126132	0.08126132
26/08/2016	16:28:57	1.10239	0.057899	493	235	0.16044132	0.10254262	0.10254262

TEST 9 in PbBi - PbBi a 450° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
26/08/2016	17:23:37	1.01258	0.017899	451	229	0.07170904	0.05381034	0.05381034
26/08/2016	17:23:58	2.07258	1.0879	451	229	1.11898904	0.03108904	0.03108904
26/08/2016	17:24:14	3.39258	2.3879	451	229	2.42314904	0.03524904	0.03524904
26/08/2016	17:24:28	6.02258	4.9979	451	228	5.02158904	0.02368904	0.02368904
26/08/2016	17:24:52	8.36258	7.2979	450	228	7.33350904	0.03560904	0.03560904
26/08/2016	17:25:13	11.0526	9.9779	450	228	9.9912488	0.0133488	0.0133488
26/08/2016	17:25:35	8.83258	7.7295	450	228	7.79786904	0.06836904	0.06836904
26/08/2016	17:25:53	6.53258	5.4295	450	230	5.52546904	0.09596904	0.09596904
26/08/2016	17:26:15	3.6057	2.5595	451	231	2.6337116	0.0742116	0.0742116
26/08/2016	17:26:36	1.9257	0.909496	451	230	0.9738716	0.0643756	0.0643756
26/08/2016	17:26:55	1.0157	0.009496	450	230	0.0747916	0.06529605	0.06529605

TEST 10 in PbBi - PbBi a 400° - Gefran a 230°							
Date	**Time**	**GEFRAN**	**PT-REF**	**TC PbBi**	**TC GEFRAN**	**GEFRAN-OFFSET**	**DIFF**	**DIFF-ABS**
26/08/2016	17:42:19	0.985703	-0.0105	401	230	0.045154564	0.055659064	0.055659064
26/08/2016	17:42:35	2.0757	1.0895	400	230	1.1220716	0.0325716	0.0325716
26/08/2016	17:42:44	3.4457	2.4495	400	230	2.4756316	0.0261316	0.0261316
26/08/2016	17:43:01	5.8757	4.8395	400	229	4.8764716	0.0369716	0.0369716
26/08/2016	17:43:28	8.3657	7.28531	399	230	7.3365916	0.0512816	0.0512816
26/08/2016	17:43:42	11.1257	10.0453	399	230	10.0634716	0.0181716	0.0181716
26/08/2016	17:43:58	8.74266	7.63531	399	230	7.70902808	0.07371808	0.07371808
26/08/2016	17:44:22	6.17266	5.09531	399	229	5.16986808	0.07455808	0.07455808
26/08/2016	17:44:44	3.43266	2.40531	398	230	2.46274808	0.05743808	0.05743808
26/08/2016	17:45:01	1.92266	0.915307	398	230	0.97086808	0.05556108	0.05556108
26/08/2016	17:45:55	1.02266	0.035307	396	230	0.08166808	0.04636158	0.04636158

TEST 11 in PbBi - PbBi a 350° - Gefran a 230°								
Date	**Time**	**GEFRAN**	**PT-REF**	**TC PbBi**	**TC GEFRAN**	**GEFRAN-OFFSET**	**DIFF**	**DIFF-ABS**
26/08/2016	18:02:19	0.982661	0.005307	352	231	0.042149068	0.036842538	0.036842538
26/08/2016	18:02:55	0.982661	-0.01469	351	231	0.042149068	0.056842568	0.056842568
26/08/2016	18:03:25	3.86266	2.86531	351	230	2.88758808	0.02227808	0.02227808
26/08/2016	18:03:44	5.92266	4.86617	351	231	4.92286808	0.05669808	0.05669808
26/08/2016	18:04:03	8.44803	7.36617	350	231	7.41793364	0.05176364	0.05176364
26/08/2016	18:04:13	11.088	10.0162	350	231	10.026224	0.010024	0.010024
26/08/2016	18:04:46	9.00803	7.90617	349	231	7.97121364	0.06504364	0.06504364
26/08/2016	18:05:17	5.95803	4.88617	349	231	4.95781364	0.07164364	0.07164364
26/08/2016	18:05:42	3.75803	2.72617	349	231	2.78421364	0.05804364	0.05804364
26/08/2016	18:06:08	1.93803	0.93617	349	232	0.98605364	0.04988364	0.04988364
26/08/2016	18:06:28	1.01803	0.01617	348	232	0.07709364	0.06092334	0.06092334

TEST 12 in PbBi - PbBi a 300° - Gefran a 230°								
Date	**Time**	**GEFRAN**	**PT-REF**	**TC PbBi**	**TC GEFRAN**	**GEFRAN-OFFSET**	**DIFF**	**DIFF-ABS**
26/08/2016	19:15:23	0.915301	-0.05383	298	231	-0.024402612	0.029427088	0.029427088
26/08/2016	19:15:48	1.9353	0.97617	298	230	0.9833564	0.0071864	0.0071864
26/08/2016	19:16:03	3.3453	2.36402	298	229	2.3764364	0.0124164	0.0124164
26/08/2016	19:16:18	5.9653	4.94402	298	230	4.9649964	0.0209764	0.0209764
26/08/2016	19:16:37	8.4153	7.36402	298	230	7.3855964	0.0215764	0.0215764
26/08/2016	19:16:57	11.0153	9.94402	299	230	9.9543964	0.0103764	0.0103764
26/08/2016	19:17:25	8.74085	7.65402	299	230	7.7072398	0.0532198	0.0532198
26/08/2016	19:17:51	6.17085	5.10402	298	230	5.1680798	0.0640598	0.0640598
26/08/2016	19:18:17	3.57085	2.56402	298	229	2.5992798	0.0352598	0.0352598
26/08/2016	19:18:34	1.93085	0.944024	298	229	0.9789598	0.0349358	0.0349358
26/08/2016	19:18:56	1.01085	0.024024	298	230	0.0699998	0.0459755	0.0459755

TEST 13 in PbBi - PbBi a 250° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
26/08/2016	19:50:05	0.980854	-0.00598	251	231	0.040363752	0.046339492	0.046339492
26/08/2016	19:50:21	1.94238	0.974024	251	230	0.99035144	0.01632744	0.01632744
26/08/2016	19:50:35	3.41238	2.41132	251	231	2.44271144	0.03139144	0.03139144
26/08/2016	19:50:51	5.95238	4.90132	250	231	4.95223144	0.05091144	0.05091144
26/08/2016	19:51:05	8.28238	7.22132	251	231	7.25427144	0.03295144	0.03295144
26/08/2016	19:51:26	11.0624	9.99132	250	231	10.0009312	0.0096112	0.0096112
26/08/2016	19:51:50	8.63238	7.55132	250	232	7.60007144	0.04875144	0.04875144
26/08/2016	19:52:11	6.24238	5.17132	249	231	5.23875144	0.06743144	0.06743144
26/08/2016	19:52:40	3.71238	2.68132	248	231	2.73911144	0.05779144	0.05779144
26/08/2016	19:53:00	1.95238	0.961318	249	232	1.00023144	0.03891344	0.03891344
26/08/2016	19:53:35	1.03238	0.031318	249	231	0.09127144	0.05995374	0.05995374

TEST 14 in PbBi - PbBi a 200° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
26/08/2016	21:00:48	0.978942	-0.00629	200	229	0.038474696	0.044764436	0.044764436
26/08/2016	21:01:06	2.00894	1.04371	200	230	1.05611272	0.01240272	0.01240272
26/08/2016	21:01:35	3.39894	2.41371	200	229	2.42943272	0.01572272	0.01572272
26/08/2016	21:01:58	5.84894	4.79371	202	230	4.85003272	0.05632272	0.05632272
26/08/2016	21:02:23	8.24894	7.19371	201	230	7.22123272	0.02752272	0.02752272
26/08/2016	21:02:49	11.0389	9.95371	200	230	9.9777132	0.0240032	0.0240032
26/08/2016	21:03:23	8.70894	7.61371	201	231	7.67571272	0.06200272	0.06200272
26/08/2016	21:03:57	6.24894	5.17371	200	231	5.24523272	0.07152272	0.07152272
26/08/2016	21:04:28	3.54075	2.50371	200	231	2.569541	0.065831	0.065831
26/08/2016	21:04:50	1.96075	0.962593	200	231	1.008501	0.045908	0.045908
26/08/2016	21:04:59	1.06075	0.062593	200	232	0.119301	0.0567078	0.0567078

TEST 15 in PbBi - PbBi a 180° - Gefran a 230°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
26/08/2016	21:48:57	0.984305	0.002593	186	229	-0.00562666	-0.0082199	0.0082199
26/08/2016	21:49:15	1.9743	0.992593	189	228	0.9724884	-0.0201046	0.0201046
26/08/2016	21:49:35	3.3943	2.388	187	228	2.3754484	-0.0125516	0.0125516
26/08/2016	21:49:59	5.9143	4.848	187	230	4.8652084	0.0172084	0.0172084
26/08/2016	21:50:22	8.30234	7.208	186	231	7.22459192	0.01659192	0.01659192
26/08/2016	21:50:49	10.9723	9.888	187	231	9.8625124	-0.0254876	0.0254876
26/08/2016	21:51:15	8.89234	7.788	187	230	7.80751192	0.01951192	0.01951192
26/08/2016	21:51:45	6.04234	4.948	187	231	4.99171192	0.04371192	0.04371192
26/08/2016	21:52:14	3.58234	2.528	188	233	2.56123192	0.03323192	0.03323192
26/08/2016	21:52:41	1.89234	0.888003	188	232	0.89151192	0.00350892	0.00350892
26/08/2016	21:52:54	1.05234	0.028003	188	232	0.06159192	0.03358902	0.03358902

TEST 101 in PbBi - PbBi a 350° - Gefran a 380°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
31/08/2016	16:02:18	1.73584	0.024505	351	380	-0.01399008	-0.03849528	0.03849528
31/08/2016	16:02:36	2.91584	1.18451	352	381	1.15184992	-0.03266008	0.03266008
31/08/2016	16:02:57	4.50584	2.76451	351	379	2.72276992	-0.04174008	0.04174008
31/08/2016	16:03:20	6.71584	4.92451	349	380	4.90624992	-0.01826008	0.01826008
31/08/2016	16:03:52	9.25584	7.44451	349	381	7.41576992	-0.02874008	0.02874008
31/08/2016	16:04:22	11.8158	10.0083	348	380	9.9450104	-0.0632896	0.0632896
31/08/2016	16:05:06	9.50584	7.66828	348	378	7.66276992	-0.00551008	0.00551008
31/08/2016	16:05:32	6.67947	4.85828	349	380	4.87031636	0.01203636	0.01203636
31/08/2016	16:06:17	4.25947	2.46828	348	382	2.47935636	0.01107636	0.01107636
31/08/2016	16:06:50	2.63947	0.878282	349	383	0.87879636	0.00051436	0.00051436
31/08/2016	16:07:07	1.74947	0.028283	349	381	-0.00052364	-0.02880614	0.02880614

TEST 102 in PbBi - PbBi a 400° - Gefran a 380°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
31/08/2016	20:56:36	1.72003	-0.00908	400	382	-0.02961036	-0.02053197	0.02053197
31/08/2016	20:56:55	2.81003	1.09092	399	381	1.04730964	-0.04361036	0.04361036
31/08/2016	20:57:13	4.06142	2.31092	400	381	2.28368296	-0.02723704	0.02723704
31/08/2016	20:57:27	6.98142	5.18092	399	382	5.16864296	-0.01227704	0.01227704
31/08/2016	20:57:54	9.26142	7.4488	399	380	7.42128296	-0.02751704	0.02751704
31/08/2016	20:58:17	11.7814	9.9588	399	378	9.9110232	-0.0477768	0.0477768
31/08/2016	20:59:15	9.39142	7.5488	398	379	7.54972296	0.00092296	0.00092296
31/08/2016	20:59:51	6.87142	5.0388	396	381	5.05996296	0.02116296	0.02116296
31/08/2016	21:00:26	4.22142	2.4288	395	381	2.44176296	0.01296296	0.01296296
31/08/2016	21:00:59	2.80142	1.0388	395	382	1.03880296	2.96E-06	2.96E-06
31/08/2016	21:01:37	1.75552	0.018797	396	381	0.00545376	-0.01334344	0.01334344

TEST 103 in PbBi - PbBi a 450° - Gefran a 380°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
31/08/2016	21:18:33	1.79552	0.068308	450	381	0.04497376	-0.02333384	0.02333384
31/08/2016	21:19:02	2.82552	1.07831	450	382	1.06261376	-0.01569624	0.01569624
31/08/2016	21:19:32	4.48552	2.71831	451	381	2.70269376	-0.01561624	0.01561624
31/08/2016	21:20:08	6.90329	5.09831	450	382	5.09145052	-0.00685948	0.00685948
31/08/2016	21:20:30	9.28329	7.46831	451	379	7.44289052	-0.02541948	0.02541948
31/08/2016	21:20:51	11.8533	10.0383	451	379	9.9820604	-0.0562396	0.0562396
31/08/2016	21:21:31	9.75329	7.91578	451	379	7.90725052	-0.00852948	0.00852948
31/08/2016	21:21:55	6.75329	4.91578	450	381	4.94325052	0.02747052	0.02747052
31/08/2016	21:22:38	4.26329	2.47578	450	381	2.48313052	0.00735052	0.00735052
31/08/2016	21:23:01	2.66329	0.895785	451	382	0.90233052	0.00654552	0.00654552
31/08/2016	21:23:54	1.72142	-0.00422	451	382	-0.02823704	-0.02402154	0.02402154

TEST 104 in PbBi - PbBi a 500° - Gefran a 380°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
31/08/2016	21:56:50	1.8448	0.062835	501	379	0.0936624	0.0308273	0.0308273
31/08/2016	21:57:09	2.7648	0.962835	501	379	1.0026224	0.0397874	0.0397874
31/08/2016	21:57:29	4.2848	2.44284	501	380	2.5043824	0.0615424	0.0615424
31/08/2016	21:58:07	7.1048	5.22776	501	379	5.2905424	0.0627824	0.0627824
31/08/2016	21:58:31	9.47033	7.56776	500	378	7.62768604	0.05992604	0.05992604
31/08/2016	21:59:01	11.8703	9.96776	500	376	9.9988564	0.0310964	0.0310964
31/08/2016	21:59:26	9.54033	7.61776	499	378	7.69684604	0.07908604	0.07908604
31/08/2016	21:59:58	6.71033	4.80776	499	378	4.90080604	0.09304604	0.09304604
31/08/2016	22:00:39	4.27033	2.39776	500	379	2.49008604	0.09232604	0.09232604
31/08/2016	22:01:10	2.84033	1.01364	500	379	1.07724604	0.06360604	0.06360604
31/08/2016	22:01:56	1.82033	0.023645	499	378	0.06948604	0.04584144	0.04584144

TEST 105 in PbBi - PbBi a 450° - Gefran a 380°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
31/08/2016	22:26:41	1.8367	0.013645	451	378	0.0856596	0.072015	0.072015
31/08/2016	22:27:02	2.8167	0.963645	452	380	1.0538996	0.0902546	0.0902546
31/08/2016	22:27:17	4.41594	2.54364	452	381	2.63394872	0.09030872	0.09030872
31/08/2016	22:27:47	6.91594	5.01364	452	381	5.10394872	0.09030872	0.09030872
31/08/2016	22:28:18	9.53594	7.60364	452	380	7.69250872	0.08886872	0.08886872
31/08/2016	22:29:09	11.8259	9.90501	450	379	9.9549892	0.0499792	0.0499792
31/08/2016	22:29:41	9.60594	7.66501	451	379	7.76166872	0.09665872	0.09665872
31/08/2016	22:30:19	6.78594	4.84501	449	381	4.97550872	0.13049872	0.13049872
31/08/2016	22:30:49	4.15594	2.26501	449	381	2.37706872	0.11205872	0.11205872
31/08/2016	22:31:11	2.72079	0.855015	449	381	0.95914052	0.10412552	0.10412552
31/08/2016	22:31:57	1.88079	0.015015	450	382	0.12922052	0.11420602	0.11420602

TEST 106 in PbBi - PbBi a 400° - Gefran a 380°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
01/09/2016	20:54:07	1.67227	-0.02231	399	381	-0.07679724	-0.05448614	0.05448614
01/09/2016	20:54:23	2.71227	0.997689	400	381	0.95072276	-0.04696624	0.04696624
01/09/2016	20:54:50	4.38227	2.63769	400	382	2.60068276	-0.03700724	0.03700724
01/09/2016	20:55:27	6.72227	4.93769	399	381	4.91260276	-0.02508724	0.02508724
01/09/2016	20:55:44	9.05662	7.24769	399	381	7.21894056	-0.02874944	0.02874944
01/09/2016	20:56:10	11.7266	9.93769	399	378	9.8568808	-0.0808092	0.0808092
01/09/2016	20:56:47	9.46662	7.65049	400	378	7.62402056	-0.02646944	0.02646944
01/09/2016	20:57:28	6.96662	5.16049	399	379	5.15402056	-0.00646944	0.00646944
01/09/2016	20:58:02	4.11662	2.34049	400	379	2.33822056	-0.00226944	0.00226944
01/09/2016	20:58:26	2.83662	1.09049	400	380	1.07358056	-0.01690944	0.01690944
01/09/2016	20:58:49	1.73662	0.010487	400	380	-0.01321944	-0.02370614	0.02370614

TEST 107 in PbBi - PbBi a 350° - Gefran a 380°								
Date	Time	GEFRAN	PT-REF	TC PbBi	TC GEFRAN	GEFRAN-OFFSET	DIFF	DIFF-ABS
01/09/2016	21:37:29	1.68656	-0.00951	349	379	-0.06267872	-0.0531654	0.0531654
01/09/2016	21:37:38	2.67656	0.960487	348	380	0.91544128	-0.04504572	0.04504572
01/09/2016	21:38:16	4.19656	2.44049	348	382	2.41720128	-0.02328872	0.02328872
01/09/2016	21:38:39	6.82656	5.03348	350	382	5.01564128	-0.01783872	0.01783872
01/09/2016	21:39:14	9.19656	7.39348	348	379	7.35720128	-0.03627872	0.03627872
01/09/2016	21:39:38	11.7066	9.90348	348	378	9.8371208	-0.0663592	0.0663592
01/09/2016	21:40:27	9.49656	7.64348	349	379	7.65360128	0.01012128	0.01012128
01/09/2016	21:40:54	6.78656	4.94348	348	380	4.97612128	0.03264128	0.03264128
01/09/2016	21:41:21	4.15656	2.36348	347	381	2.37768128	0.01420128	0.01420128
01/09/2016	21:42:08	2.71459	0.963476	348	380	0.95301492	-0.01046108	0.01046108
01/09/2016	21:43:09	1.74459	0.003476	351	382	-0.00534508	-0.00882106	0.00882106