

Standard Operation Procedure – Thermal Conductivity Testing

1. Scope and Application

- This document provides instructions on testing minimal volumes of powder, liquids, faeces, pit latrine (VIP) samples using TCi small volume test kit (SVTK).
- Testing with the C-Therm TCi can directly measure thermal conductivity and thermal effusivity.
- It can indirectly measure diffusivity, heat capacity, the R-value or depth of penetration.

2. Summary

- The SVTK was developed for testing minimal volumes of liquid volumes of fluid material.
- Reducing the volume of sample material required for an effective thermal conductivity measurement is extremely important in the testing of energetic materials whereby larger samples pose a significant safety concern.
- The use of the accessory has also been applied widely in the testing of various materials that are doped with extremely expensive filters (gold, diamonds etc.) that are in limited supply.

3. Apparatus

SVTK P/N:

- Weight
- Test Cell, Allen screws,
- TCi sensor
- Sensor Base
- Measuring spoons(1/8 and ¼)



Figure 1: TCi sensor

4. Reagents

No reagents are used.

5. Interferences

- If any cell is red, the measurement is not valid. Repeat the measurement.
- Check the R2 value for each measurement. If the R2 value is less than 0.995, the measurement is not valid.
- An orange cell means that the thermal conductivity or thermal effusivity value is outside of the calibration range of that material group.
- To enter density: Click on material, add, density value, save.

6. Collection, Preservation and Storage

- Collect samples in 1L plastic buckets.
- Preferably, analyse samples immediately after sampling.
- Store samples at 4 °C or freeze dry samples.
- Preserve wastewater samples by acidifying with concentrated sulphuric acid to pH 2 and faecal samples by freeze drying or freezing.
- Determine COD on well- homogenised samples.

7. Safety Precautions

- Always use safety goggles, gloves and laboratory coat while working in laboratory
- Wear gloves suitable for withstanding high temperatures when removing crucibles from the oven.
- After the analysis clean bottles and beakers with clear water keep it for drying

- Dispose the used gloves after completion of analysis
- Clean the hands using antiseptic soap
- Disinfect hands after washing with soap
- Avoid spillage and contact

8. Calibration

- Sensor is factory calibrated. Calibration data is stored on the sensor chip.
 - USER ID: Admin
 - Password: no password

9. Procedure

DENSITY:

- Weigh out X3 $^{1}/_{8}$ teaspoon of sample and divide by the total volume (1.8ml).
- Enter density value in table.
- Go to Test details/ material I (...) enter density value. Press + for addition of density for another test.
- Save and close.

SOLID TESTING:

- Fill the 1/8 teaspoon (0.63ml) with the sample to be investigated.
- Level off the excess sample by scraping off the excess with a spatula by making a horizontal movement.
- Care must be taken to prevent compaction of the sample in the teaspoon (e.g. Vibrations, rearranging sample with spatula, and tapping on the teaspoon).
- The sample remaining in the teaspoon is the specimen.
- Transfer the sample to a weighing dish.
- Repeat the above steps 3 times for a total volume of specimen of approximately $^{3}/_{8}$ teaspoon or 1.8ml.
- Place the weight onto the sample so that it seats on the rim of the test cell. NB: If the sample to be measured weighs more than 150g, omit the weight.
- Monitor the sensor temperature via the TCi software until it is stable and the sensor, sample and environment have all reached a state of thermal equilibrium.
- Initiate the test sequence within the TCi software.
- Alter test measurements to enter the number of measurements required (usually 5 measurements are required).



CLEANING:

- Pour out the contents of the sample from the test cell or remove it with a paper towel.
- Place sensor upside down and remove the test cell by gradually unfastening the three screws in a sequenced manner. Use a $^{3}/_{32}$ Allen wrench.
- Remove the sensor test and clean with either soap and water, water or propyl alcohol.
- To test again place the test cell on the sensor and place upside down in order to have easy access to the screws.
- Tighten gradually and in sequence until the test cell seats perfectly flat against the sensor-housing surface.

LIQUID TESTING:

- Measure 1.25ml $(^{1}/_{4}$ tsp) of total liquid volume of specimen.
- Transfer this volume directly to the test cell.
- Place the quick clamp cap on the test cell.
- Use of the cap is optional, but will prevent any undesirable evaporation of the liquid from the cell.
- Monitor the sensor temperature via the TCi software until it is stable and the sensor, sample and environment have all reached a state of equilibrium.
- Initiate the test sequence within the TCi software.



REPORTS:

• Click on Reports/test report/enter test number or additional details /search/export report/open folder/save.

Example of a report

Test Instrument: Test Project		TCIUSER-P TH89-05-002 Liquids and FBR	C-380 227 Powders Defat	ult	Software Test sta Perfor	Version: 2.3.3 Inted on: 05-Au med by: Merlie User ID: REDI	2.3.3954 05-Aug-2013 Merlien Reddy REDDYM5		
N Mater	Materia ial Lot:	feces 001015							
#	Repea	Sensor ID	Start Time	<u>_W*∿</u> Effusivit ^{(m} *	(s) 2)*K Conductivit (W/mK)	Ambient T	DeltaT (°C)	V0	
1	1	T298	21:16:26	489	0.180	19.39	0.96	2 496.14	
2	1	T298	21:17:32	490	0.180	19.82	0.94	2 497.61	
3	1	T298	21:18:37	507	0.190	19.94	0.93	2 497.97	
4	1	T298	21:19:43	517	0.190	19.84	0.92	2 499.20	
•									

Exporting Data

Shift copy/paste onto excel/send to USB

Example of Results sheet

#	Sensor	Valid	Effusivity (Ws½/m²K)	k (W/mK)	Diffusivity (m ² /s)	k (Computed)	Heat Capacity (J/kg/K)	Depth of Penetration (m)
1.0000	T298	TRUE	488.5823	0.1816	0.0000		1205649.2736	0.0007
2.0000	T298	TRUE	489.8089	0.1821	0.0000		1208939.7528	0.0007
3.0000	T298	TRUE	507.2582	0.1880	0.0000		1255668.4148	0.0007
4.0000	T298	TRUE	517.4153	0.1915	0.0000		1282799.1077	0.0007
5.0000	T298	TRUE	523.5440	0.1936	0.0000		1299144.0643	0.0007

R-Value ((m ² K)/W)	1/m	R2	Start	V0 (mV)	VMax (mV)	DeltaV (mV)	Ambient (°C)	T0 (°C)	DeltaT (°C)
0.0037	73.1471	0.9990	41491.8864	2496.1410	2504.2780	8.1375	19.3916	19.8414	0.9554
0.0037	73.2738	0.9988	41491.8872	2497.6150	2505.6190	8.0047	19.8219	20.1683	0.9403
0.0035	74.2658	0.9985	41491.8879	2497.9670	2505.8550	7.8883	19.9435	20.2428	0.9267
0.0035	74.8194	0.9986	41491.8887	2499.1960	2507.0400	7.8435	19.8373	20.3567	0.9214
0.0034	75.0554	0.9986	41491.8895	2500.9440	2508.7670	7.8230	19.0486	20.2899	0.9181

Materia Type	l Minimum Thickness	Sample Preparation	on	Contact Agent	
Liquids	1 mm	Fill 50 mL beaker to 35 n mark. Place sensor in be	nL eaker.		
Powders	1 mm	Fill 50 mL beaker to 30 mL mark. Place sensor in beaker.		None	
Foams	2 mm	Place sample on sensor. Place weight on sample.			
Polymers	5 mm	Place contact agent on s	ensor.	-20°C to 5°C: 3 drops of glycol 5°C to 70°C: 3 drops of water 70°C to 200°C: Wakefield 120 Thermal Joint Compound ting Tips Wear gloves while handling samples to avoid thermal contamination. When using a thermal chamber, allow samples and sensor to equilibrate to emperature for 2 hours prior to testing and for 10 minutes every time the door is	
Ceramics	5 mm	Place sample on sensor.	sample on sensor. Place t on sample. Testin be tested. amage. the sensor. e. Whe sample of the sensor.		
Metals	5-12 mm	weight on sample.			
Step 2	Inspect surface for Position the mate Place weight if a	or dirt/damage. erial on the sensor. oplicable.			
Step 3	Click the New Te toolbar.	est button on the	tem		
Step 4	Select the project	t.	ope	ened.	
Step 5	Click the Next bu	itton.	Importing Files		
Step 6	Select the test m	ethod to be used.	Sten 1	Select the type of record to	
Step 7 Select the materia		al group and	import	from the Tools menu.	
Step 7	obioot the matori		~ ~	O de statue file te imment	
Step 7	material to be us	ed. If no suitable	Step 2	Select the file to import.	
Step 7	material to be us record exists, clic enter the name of material, and clic	ed. If no suitable sk the New button, if the group or sk the Save button.	Step 2 Step 3 are dis	All records contained in the file played.	
Step 7 Step 8	material to be us record exists, clic enter the name c material, and clic Click the Next bu	ed. If no suitable ck the New button, of the group or k the Save button. ttton.	Step 2 Step 3 are disp Step 4	All records contained in the file played. Click the Import button.	
Step 7 Step 8 Step 9	material to be us record exists, clic enter the name c material, and clic Click the Next bu Select the instrur	ed. If no suitable ck the New button, of the group or .k the Save button. tton. ment.	Step 2 Step 3 are dis Step 4	All records contained in the file played. Click the Import button.	

Step 11 Select the contact agent.

Step 12 Click the Start Test button.



Exporting Files

Test results, user calibration results, calibration methods, and test methods can be exported and imported. All records with the exception of notes are exported and imported with the test results, user calibration results, calibration methods, or test methods.

- Step 1 Select the type of file to export from the Tools menu.
- Step 2 Enter keywords in the parameter fields.
- Step 3 Click the Search button or press the Enter key.
- Step 4 Select the records to export from the displayed list.
- Step 5 Click the Next button.
- Step 6 Select a destination for the export file.
- Step 7 Click the Export button.

Creating a Test Method

- Step 1 Open the test method table.
- Step 2 Click the Add button.
- Step 3 Enter a name for the test method.
- Step 4 Select a project.
- Step 5 Select a calibration method.
- Step 6 Enter the delay before the first measurement (optional).
- Step 7 Enter the minimum measurement period (optional).
- Step 8 Enter the number of measurements to be taken. If zero is entered, measurements will be taken until the test is stopped by the user.
- Step 9 Enter the number of sensors to be used. If zero is entered, any number of sensors can be selected when beginning a test.
- Step 10 Enter the number of samples per sensor per measurement. This is the number of times the sensor fires during a single measurement interval.

- Step 11 Select the prompts to be displayed.
- Step 12 Click the Save button.

Changing Units

- Step 1 Select Change Units of Measure from the Tools menu.
- Step 2 Select the units.
- Step 3 Click the OK button.

Step 4 Logout and restart the software.

Reference Material Tests

Calib	oration Material Group	Reference Material				
Liquids	and Powders	Distilled Water				
Foams		LAF 6720*				
Polyme	ſS	Pyrex				
Ceramic	S	Pyroceram				
Metals		Phosphor Bronze*				
Step 1	Prepare the referen sensor.	ce material and				
Step 2	Click Reference Ma Tools menu.	terial Test from the				
Step 3	Click the Next butto	n.				
Step 4	Select an Instrumer	nt.				
Step 5	Select the calibratio	on method.				
Step 6	Select the sensor(s)) to be used.				
Step 7	Click the Next butto	'n.				
Step 8	Select the reference (Foam and Metal)	e material bin				
Step 9	Confirm the ambient temperature.					
Step 10	Click the Update button (if temperature was incorrect).					
Step 11	Click the Get Sample button. All results should be within 5% of the displayed predicted value.					
Step 12	Click the Finish butt	on.				

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