The University of Texas at Austin
Department of Physics
College of Natural Sciences

Cryogenic Material Library – An Overview

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CMB-S4 Technical Meeting

Goals and Motivation

- **Data:** Compile and house a repository of cryogenic material data (beginning with thermal conductivity and eventually expanding to other desired properties)
- **Fitting:** Develop a method of fitting data to produce high quality, adaptable fits which can be used for calculations. And store fits created by others for materials for which raw data is not available.
- **Transparency:** Produce a transparent database that saves references to data and clearly shows and explains how fits are procured.
- **Tools:** Provide example tools demonstrating the operation of the pipeline output in scientific applications.
- **Versatility:** Develop a pipeline that can be easily updated by users as new data is added, or changed depending on specific scientific goals.

What does this repo have?

Cryogenic_Material_Properties / tc_generic_20240722.csv

henry-e-n Updated Full Run 0722

Preview | Code | B... loc) · 7.57 KB

Material Name

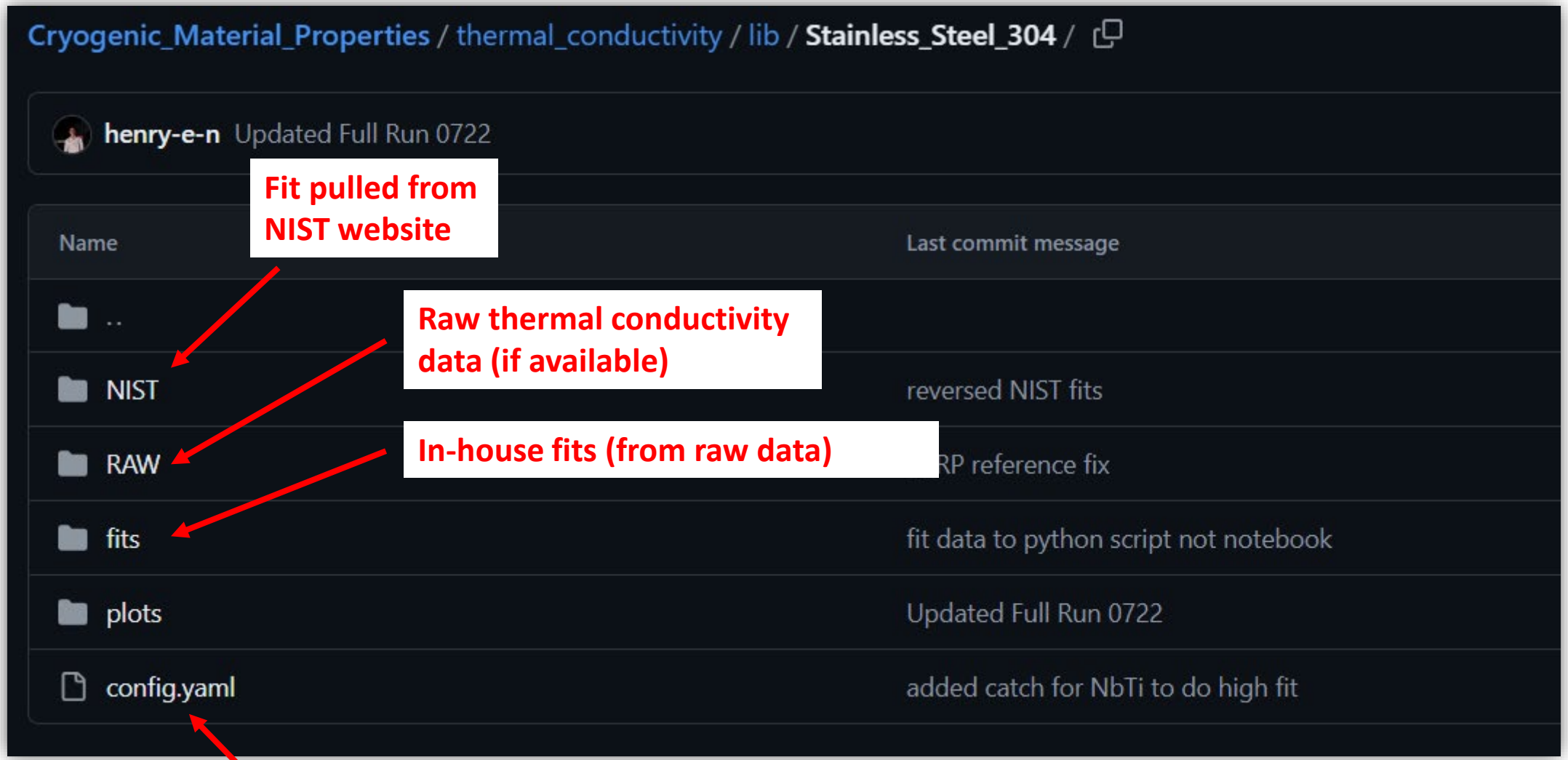
Range of Fit

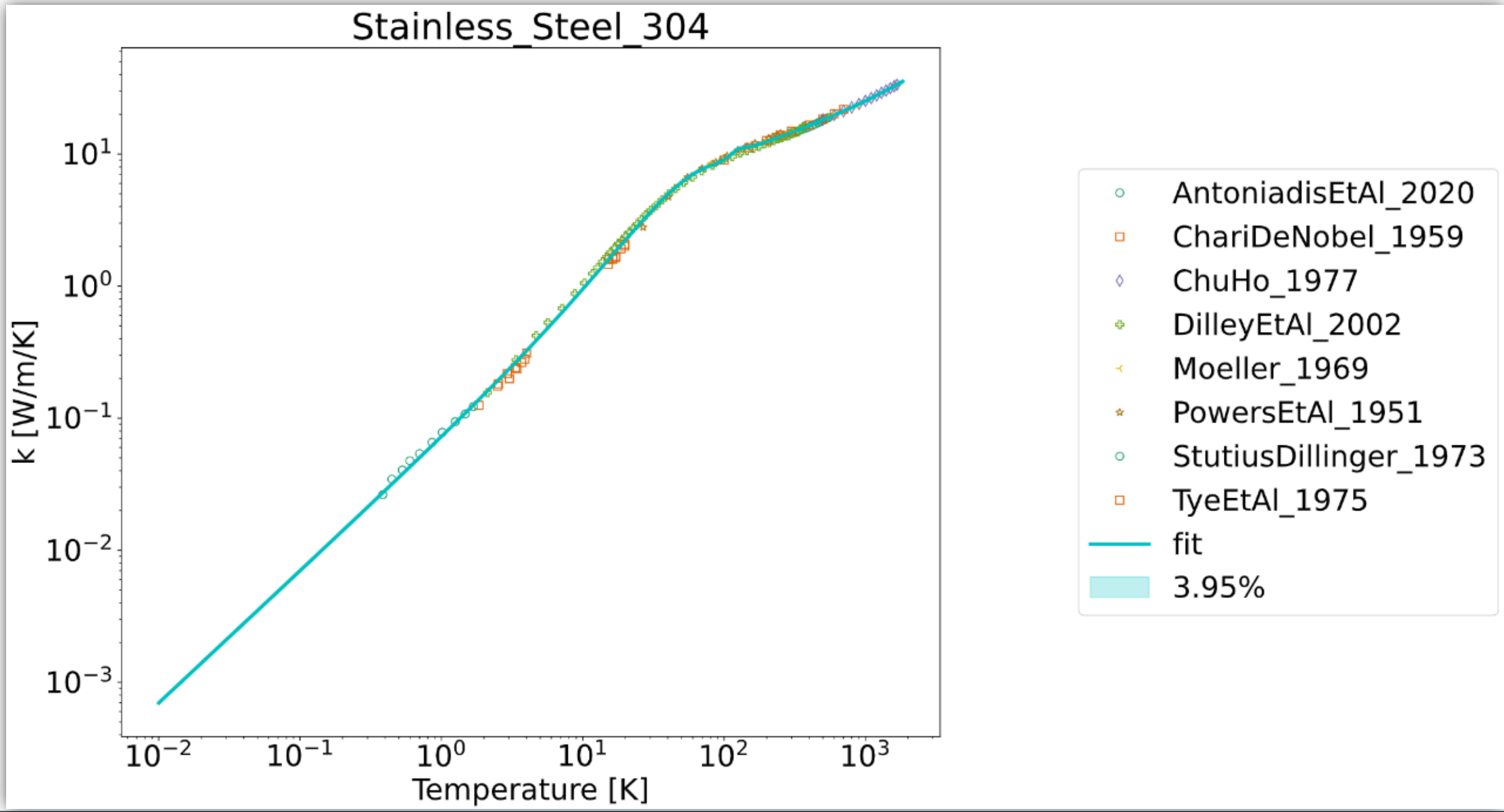
Fit Parameters (between 3 and 10+)

Search this file

1	Material Name	Fit Type	Low Temp	High Temp	Perc Err	erf param	a	b	c	d
2	Aluminum_1100	Nppoly	0.264	1.061	6.458	0.00e+00	-2.22005e+00	2.07719e+00	2.92536e+01	-1.85
3	Beryllium_Copper	polylog	2.000	80.000	2.0	0.00e+00	-5.00150e-01	1.93190e+00	-1.69540e+00	7.121
4	CFRP	Nppoly	0.134	4.842	14.228	0.00e+00	3.99669e-03	5.20942e-03	-2.17074e-03	2.498
5	Cu_OFHC_RRR50	copperfit	4.000	300.000	2.0	0.00e+00	1.87430e+00	-4.15380e-01	-6.01800e-01	1.329
6	G10_FR4	Nppoly	0.304	2.971	4.296	0.00e+00	-2.55459e-03	1.94298e-02	-7.63211e-03	1.090
7	Glass_FabricPolyester_He_warp	polylog	38.000	300.000	1.0	0.00e+00	6.89532e+02	-2.54363e+03	3.96707e+03	-3.40
8	Graphite	lowTextrapolate	0.150	1.000	??	0.00e+00	3.00000e+02	1.00000e-02	1.76000e+00	5.100
9	Inconel_718	polylog	6.000	275.000	2.0	0.00e+00	-8.28921e+00	3.94470e+01	-8.34353e+01	9.816

Fit Type Flag


Cryogenic_Material_Properties / thermal_conductivity / lib / Stainless_Steel_304 /
henry-e-n Updated Full Run 0722
Fit pulled from NIST website
Name
Last commit message
..
NIST
reversed NIST fits
Raw thermal conductivity data (if available)
RAW
RP reference fix
In-house fits (from raw data)
fits
fit data to python script not notebook
plots
Updated Full Run 0722
config.yaml
added catch for NbTi to do high fit
A config file with some necessary info like 'parent' materials, and data flags.


Stainless_Steel_304
k [W/m/K]
Temperature [K]
AntoniadisEtAl_2020
ChariDeNobel_1959
ChuHo_1977
DilleyEtAl_2002
Moeller_1969
PowersEtAl_1951
StutiusDillinger_1973
TyeEtAl_1975
fit
3.95%

Cryogenic_Material_Properties / thermal_conductivity / lib / Stainless_Steel_304 / RAW / **references.txt**

henry-e-n Stainless_Steel Rename

Code | Blame | 38 lines (30 loc) · 1.66 KB

```
1   AntoniadisEtAl_2020.csv
2   ['Reference correlations for the thermal conductivity of solid BK7 - PMMA - Pyrex 7740 - Pyroceram 9606 and SS304'
3    'K.D. Antoniadis - A. Tyrou - M.J. Assael - X. Li - J. Wu - and H.P. Ebert'
4    'International Journal of Thermophysics 41:98 (2020) 35 pages ']
5
6   ChariDeNobel_1959.csv
7   ['Thermal conductivity of some steels at low temperature'
8    'M.S.R. Chari and J. De Nobel' 'Physica 25 (1959) pp. 73-83']
9
10  ChuHo_1977.csv
11  ['Thermal conductivity and electrical resistivity of eight selected AISI stainless steels'
12   'T.K. Chu and C.Y. Ho'
13   '"Proc. 15th Thermal Conductivity Conf. Plenum Press New York (1977) pp. 79-104"']
14
15  DilleyEtAl_2002.csv
16  ['Commercial apparatus for measuring transport properties from 1.9 to 390 K'
17   '"N.R. Dilley - R.C. Black - L. Montes - A. Wilson - and M.B. Simmonds"'
18   'Mat. Res. Soc. Symp. Proc. 691 (2002) pp. G3.5.1 to G3.5.6']
19
20  Moeller_1969.csv
21  ['Guarded double-cylinder apparatus for determining thermal conductivities from 80 to 860 K'
```

How can you use this repository?

Bluefors LD-400 Thermal Model

	Room	PTC1	PTC2	Still	MC			
Global Variables	300 K	40 K	3 K	1 K	0.1 K			**Constants**

Between Room Temperature and Stage 1

Support Cylinder		**Housekeeping Cable**		**Radiation**	
Material	Stainless_Steel_316_hi	Material	Manganin		
OD	10 mm	Diameter of wire	0.1007 mm	top SA (Surface Area)	0.166 m^2
ID	9 mm			top CSA (Curved Surface Area)	0.679 m^2
Thickness	0.5 mm			bottom CSA	1.218 m^2
Area	14.9225651 mm^2	Area	0.0079643 mm^2	bottom SA	0.135 m^2
Length	176 mm	Length	320 mm		
A/L for 1 leg	8.47873E-05 m	A/L for 1 leg	2.48885E-08 m	Total SA	2.198 m^2
ConInt	2217.638925 W/m	ConInt	4309.523647 W/m		
Power per Part	0.188027621 W	Power per Part	0.000107258 W	Emissivity of Al - Outer	0.05
Number of Parts	4	Number of Parts	50	Emissivity of Al - Inner	0.05
Power Total (W)	7.52E-01	Power Total (W)	5.36E-03	Power Total (W)	2.59E+01

Total
2.66E+01

Cryogenic_Material_Properties / **ThermalModelTools** /

henry-e-n BlueforsThermalModel

Name

..

Excel_Notebooks

PythonThermalModel

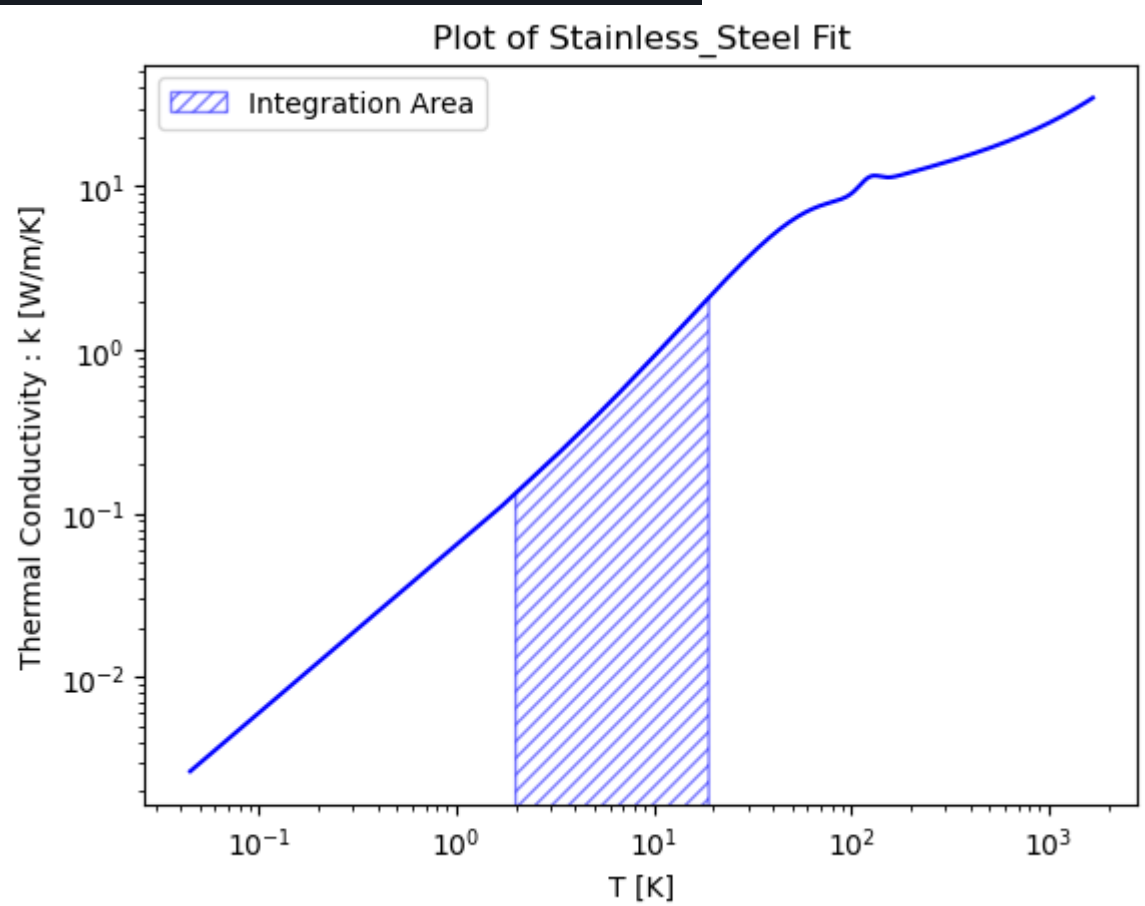
DataTable.xlsx

RepositoryTutorial.ipynb

data_table.csv

Old Fashioned Data Table

Tutorial Jupyter Notebook



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	Temperature	Aluminum_11	Aluminum_30	Aluminum_50	Aluminum_606	Aluminum_606	Beryllium_Co	Brass	CFRP	CFRP_Clear	CFRP_I	CFRP_Grap	Constanta	Constanta	Cu_OF	Cu
2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0.15	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0	
4	0.2	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0	
5	0.25	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0	
6	0.3	0.161	0	0	0	0	0	0	0.002	0.002	0	0	0	0	0	
7	0.35	0.454	0	0	0	0	0	0	0.002	0.002	0	0.002	0	0	0	
8	0.4	0.843	0	0	0	0	0	0	0.002	0.002	0	0.002	0	0	0	
9	0.45	1.328	0	0	0	0	0	0	0.003	0.003	0	0.003	0	0	0	
10	0.5	1.909	0	0	0	0	0	0	0.003	0.003	0	0.003	0	0	0	
11	0.55	2.581	0	0	0	0	0	471452	0.003	0.004	0	0.004	0	0	0	
12	0.6	3.336	0	0	0	0	0	41641.9	0.004	0.004	0	0.004	0	0	0	
13	0.65	4.164	0	0	0	0	0	5286.73	0.004	0.004	0	0.005	0	0	0	
14	0.7	5.053	0	0	0	0	0	898.763	0.005	0.005	0.002	0.005	0	0	0	
15	0.75	5.988	0	0	0	0	0	193.929	0.005	0.005	0.003	0.006	0	0	0	
16	0.8	6.949	0	0	0	0	0	50.963	0.006	0.006	0.003	0.007	0	0	0	
17	0.85	7.917	0	0	0	0	0	15.791	0.006	0.006	0.003	0.007	0	0	0	
18	0.9	8.866	0	0	0	0	0	5.623	0.006	0.007	0.004	0.008	0	0	0	
19	0.95	9.77	0	0	0	0	0	2.254	0.007	0.007	0.004	0.008	0	0	0	
20	1	10.6	0	0	0	0	0	1	0.007	0.008	0.004	0.009	0	0	1	
21	1.5	0	0	0	0	0	0	0.009	0.012	0.013	0.008	0.014	0	0	0	
22	2	0	0	0	0	0	0.9	0.001	0.015	0.018	0.011	0.018	0	0	0	
23	2.5	0	0	0	0	0	1.158	0.001	0.018	0.022	0.014	0.021	0	0	0	
24	3	0	0	0	0	0	1.402	0.001	0.02	0.025	0.016	0.022	0	0	0	
25	3.5	0	0	0	0	0	1.641	0.001	0.022	0.027	0.017	0.023	0.091	0	0	
26	4	0	10.805	3.295	5.347	34.379	1.879	0.001	0.024	0.028	0.017	0.027	0.103	0	0	
27	4.5	0	12.293	3.722	6.07	37.763	2.117	0.001	0.028	0.031	0	0	0.115	0	0	
28	5	0	13.782	4.143	6.798	42.15	2.358	0.001	0	0	0	0	0.126	0	0	
29	5.5	0	15.274	4.562	7.531	46.893	2.602	0.001	0	0	0	0	0.137	0	0	
30	6	0	16.769	4.982	8.268	51.688	2.85	0.002	0	0	0	0	0.147	0	0	
31	6.5	0	18.27	5.404	9.007	56.402	3.101	0.002	0	0	0	0	0.158	0	0	
32	7	0	19.776	5.828	9.749	60.988	3.356	0.003	0	0	0	0	0.168	0	0	
33	7.5	0	21.289	6.255	10.491	65.445	3.615	0.003	0	0	0	0	0.178	0	0	
34	8	0	22.808	6.685	11.235	69.794	3.877	0.003	0	0	0	0	0.187	0	0	
35	8.5	0	24.333	7.117	11.978	74.064	4.142	0.004	0	0	0	0	0.197	0	0	
36	9	0	25.865	7.552	12.721	78.284	4.41	0.004	0	0	0	0	0.206	0	0	
37	9.5	0	27.403	7.988	13.463	82.48	4.681	0.005	0	0	0	0	0.214	0	0	
38	10	0	28.945	8.427	14.204	86.674	4.955	0.005	0	0	0	0	0.223	0	0	
39	15	0	44.432	12.85	21.487	130.567	7.781	0.005	0	0	0	0	0.293	0	0	
40	20												0.341	0	0	
41	25												0.367	0	0	
42	30												0.376	0	0	
43	35												0.369	0	0	
44	40												0.349	0	0	
45	45												0.32	0	0	
46	50	0	118.695	39.663	62.048	284.983	26.204	0	0	0	0	0	0.283	0	0	
47	55	0	124.063	42.826	66.529	280.819	28.377	0	0	0	0	0	0.242	0	0	
48	60	0	128.573	45.854	70.759	274.825	30.416	0	0	0	0	0	0.2	0	0	
49	65	0	132.37	48.759	74.759	267.992	32.317	0	0	0	0	0	0.158	0	0	
50	70	0	135.58	51.549	78.548	260.981	34.076	0	0	0	0	0	0.12	0	0	
51	75	0	138.309	54.232	82.144	254.21	35.687	0	0	0	0	0	0.089	0	0	
52	80	0	140.646	56.815	85.561	247.924	37.146	0	0	0	0	0	0.067	0	0	

Notice all the red: Red means the repository is missing data (or has insufficient data) within that temperature range.

Next Steps

1. More data – fill in some of the gaps in data by tracking down other references and taking additional data (UT currently taking CFRP data). Perhaps even eventually add other properties.
2. More tools – long-term goals may include connecting the code to existing load calculators and more
3. Feedback – we need people to use the repository and give feedback on what works and what they would like changed or added.
4. Collaborative developers – we would be more than happy to work with others to further develop this repository so please get in contact if you (or a student) are interested in

Summary

- Current development includes thermal conductivity fits, raw data, plots, and basic thermal model tools and examples.
- Looking for more thermal conductivity data and feedback on existing repository features.
- For code related problems/requests use the GitHub Issues tab.

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