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## **A Reference Guide for Cryogenic Properties of Materials\***

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### **Abstract**

A thorough knowledge of the behavior of materials at cryogenic temperatures is critical for the design of successful cryogenic systems. Over the past 50 years, a tremendous amount of material properties at cryogenic temperatures have been measured and published. This guide lists resources for finding these properties. It covers online databases, computer codes, conference proceedings, journals, handbooks, overviews and monographs. It includes references for finding reports issued by government laboratories and agencies. Most common solids and fluids used in cryogenics are covered.

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## Introduction

This is a guide to finding properties of materials at cryogenic temperatures. Over the last 50 years, a large amount of material properties at cryogenic temperatures have been measured and published. For the working engineer or scientist, the problem is frequently not that the desired material property is unknown at cryogenic temperatures but that it is unclear where to find the published data. The goal of this document is to make the properties easier to find. There are 2 caveats to this guide. The first is that it is not meant to be completely exhaustive. The second is that this is simply a guide to the scientific literature and inclusion in this list does not mean the data is somehow “better” or more accurate than other sources.

## Databases

### 1. Cryogenic Information Center

This a commercial database issued on CD-ROM that contains references to more than 146,000 papers, books and technical reports specifically concerning cryogenics. The database includes the cryogenic database formally maintained by the US National Bureau of Standards. The citations go back as far as 1829. Many useful references for cryogenic material properties may be found in this database. The database permits searches by keyword, title, author and year among others. The citation listing is updated on a regular basis. Information regarding the Cryogenic Information Center may be found at: <http://www.cryoinfo.org/>

### 2. SPIRES

This is a free online database listing more than 500,000 papers, books, laboratory reports and preprints associated with high energy physics. The database permits searches by keyword, title, author and year among others. Properties of cryogenic materials are not an emphasis of this database. However, references to those properties measured during the development of high energy physics experiments and accelerators are frequently found here. Of particular value are the large number of reports from high energy physics laboratories worldwide that are referenced here. The SPIRES website may be found at: <http://www.slac.stanford.edu/spires/hep/>

### 3. DOE Energy Citations Database

This is a free online database of all energy related research funded by the US Department of Energy and its predecessors from 1948 to the present. The

database contains references to technical reports, papers, thesis and books.

The database may be found at <http://www.osti.gov/energycitations/>

A related database, the DOE Information Bridge, contains full text versions of DOE funded work dating back to 1995. This database may be found at:

<http://www.osti.gov/bridge/>

Both these databases permit searches by keyword, title, author and year among others. Both are regularly updated.

Since these databases deal with much more than the properties of cryogenic materials, the careful use of search terms is required to avoid drowning in irrelevant citations.

#### 4. Defense Technical Information Center

This is a free online database that contains citations to technical papers and reports dating back to 1974. This database allows searches by keyword, title, author and year among others and is regularly updated. The database includes but is not limited to reports from Department of Defense contractors. The database contains references to cryogenic material properties but also to many other topics so careful searching is needed. The database may be found at: <http://stinet.dtic.mil/>

#### 5. NIST Data Gateway

This is a free online database created by the National Institute of Standards and Technology (NIST). It provides links to online NIST property databases. The database allows searching by keyword, material or property. Both cryogenic and room temperature material properties are covered. The database may be found at: <http://srdata.nist.gov/gateway/gateway>

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These are the proceedings of the Cryogenic Engineering Conference / International Cryogenic Materials Conference which is held biannually (odd years) in North America. As roughly 50 % of this conference concerns cryogenic materials, these proceedings can be quite useful.

2. Proceedings of the International Cryogenic Engineering Conference

These are the proceedings of the International Cryogenic Engineering Conference which is held biannually (even years) in Europe or Asia.

3. Applied Superconductivity Conference, IEEE Transactions on Magnetics
4. Proceedings of the Magnet Technology Conference

## Journals

1. *Cryogenics*, Elsevier Science – Monthly refereed journal covering all aspects of cryogenic engineering and science

## Properties of Fluids

### I. Computational Codes

1. HEPAK

This is a commercial product that calculates the thermophysical properties (both state and transport properties) of Helium. The program is valid for a wide range

of helium temperatures and pressures including the superfluid regime. More details about this program may be found at <http://www.cryodata.com/>

## 2. GASPAK

A commercial product very similar to HEPAK except that it calculates state and transport properties for a 33 different fluids including Helium, Hydrogen, Oxygen, Neon, Carbon Dioxide, Nitrogen and various refrigerants. More details about this program may be found at <http://www.cryodata.com/>

## 3. NIST 12 (NIST Thermodynamic and Transport Properties of Pure Fluids Database)

A commercial program created by the National Institute of Standards & Technology very similar in nature to GASPAK. More details about this program may be found at <http://www.nist.gov/srd/nist12.htm>

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## Properties of Solids

### I. Computational Codes

#### 1. Cryogenic Material Properties Program (CMP)

This is a commercial product that allows the calculation of material properties for 35 different materials including G-10, aluminum alloys, stainless steel alloys and titanium. The properties available include: yield strength, thermal conductivity, electrical resistivity and thermal expansion. The valid temperature range is generally between less than 4 K up to the melting point. Information about this program may be found at: <http://www.cryoinfo.org/>

#### 2. CRYOCOMP and METALPAK

These are commercial software packages that permit that calculation of material properties for a number of solids. CRYOCOMP will produce properties for 60 different solids including copper, stainless steels, and aluminum. Properties include: specific heat, thermal conductivity, and electrical resistivity. Mechanical properties are not covered. The properties are generally calculated between 1 K and 300 K. METALPAK is similar to CRYOCOMP except that it calculates properties for 14 metals. More details about these program may be found at <http://www.cryodata.com/>

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