

Material Properties (MP) Package

Users' Guide

The MELCOR Material Properties (MP) package models the physical properties needed by many of the various physics packages. This is done by using analytical laws, correlations, or linear tables. New materials and their properties may be defined through user input, and properties for default materials may be redefined by user input.

This Users' Guide gives a list of the default materials and the properties defined in the package, describes the user input, and lists some sample input and output.

The default property values and functions used in the MP package along with their references are provided in the MP Package Reference Manual.

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1. Default Material Properties

The MELCOR Material Properties (MP) package models many common properties needed by the various phenomenological packages through the use of analytical laws, correlations, and tabulated values. These properties include thermodynamic state and transport properties needed for structural materials, as well as transport properties for water and noncondensable gases. (Thermodynamic state properties for these fluids are provided separately by the H2O and NCG packages; see the NCG/H2O Reference Manual.)

In a few cases, stand-alone codes that have been wholly integrated into MELCOR still use properties defined within those codes; a notable example is CORCON, which has been integrated into the Cavity (CAV) package. Also, properties unique to a package, such as those for trace species used in the RadioNuclide (RN) package, are generally modeled within that package. The Core (COR), Fuel Dispersal Interactions (FDI), and Heat Structures (HS) packages use principally the structural materials properties, while the Control Volume Hydrodynamics (CVH), Engineered Safety Features (ESF), Containment Sprays (SPR), and RN packages use principally the fluid transport properties.

The following 35 materials, listed with their mnemonic identifiers, are defined in the Material Properties package:

Table 1.1 MP Materials and Mnemonic Identifiers

1.	Water (WATER)	19.	Carbon Dioxide (CO2)
2.	Steam (STEAM)	20.	Carbon Monoxide (CO)
3.	Air (AIR)	21.	Nitrogen (N2)
4.	Hydrogen (H2)	22.	Nitric Oxide (NO)
5.	Helium (HE)	23.	Nitrous Oxide (N2O)
6.	Argon (AR)	24.	Ammonia (NH3)
7.	Deuterium (D2)	25.	Acetylene (C2H2)
8.	Zircaloy (ZR)	26.	Methane (CH4)
9.	Zirconium Oxide (ZRO2)	27.	Ethylene (C2H4)
10.	Uranium Dioxide (UO2)	28.	Uranium Hexafluoride (UF6)
11.	Stainless Steel (SS)	29.	Aluminum (ALUM)
12.	Stainless Steel Oxide (SSOX)	30.	Aluminum Oxide (AL2O3)
13.	Boron Carbide (B4C)	31.	Cadmium (CADM)
14.	Silver-Indium-Cadmium (AGINC)	32.	Stainless Steel 304 (SS304)
15.	Uranium Metal (UMETL)	33.	Lithium Aluminum (LIAL)
16.	Graphite (GRAPH)	34.	Uranium Aluminum (UAL)
17.	Concrete (CON)	35.	Carbon Steel (CS)
18.	Oxygen (O2)		

Material 11, Stainless Steel (SS), is a type 347 stainless steel and is typically used in the Core package, whereas material 32 (SS304) is a type 304 stainless steel.

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The following properties are defined in the package:

Table 1.2 Defined Material Properties (Mnemonic)

1.	Enthalpy as a function of temperature (ENH)	Tabular	J/kg
2.	Temperature as a function of enthalpy (TMP)	Tabular	K
3.	Specific Heat Capacity as a function of temperature (CPS)	Tabular	J/kg-K
4.	Thermal Conductivity as a function of temperature (THC)		
	a. From tables	Tabular	W/m-K
	b. From Eucken correlation and Wassijewa equation	Calculated	W/m-K
5.	Dynamic Viscosity as a function of temperature		
	a. From tables (VIS)	Tabular	kg/m-s
	b. From Chapman-Enskog equations and Lennard-Jones potential parameters (SIG, EPS)	Calculated	kg/m-s
6.	Binary Diffusion Coefficient		
	a. Function of temperature and pressure	Calculated	m ² /s
	b. From Chapman-Enskog equations and Lennard-Jones potential parameters	Calculated	
7.	Density		
	a. Constant (DEN)	Constant	kg/m ³
	b. Function of temperature (RHO)	Tabular	kg/m ³
	c. Function of temperature and pressure (N/A)	Calculated	kg/m ³
8.	Melting Temperature (MLT)	Constant	K
9.	Latent Heat of Fusion (LHF)	Constant	J/kg

Default values are provided for some, but not all, combinations of materials and physical properties.

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Table 1.3 summarizes the properties for which default values are available. A 'T' indicates that the default function can be changed through user-defined tabular functions (see the Tabular Function Package Users' Guide) and an MPMATnnnmm input record. A 'C' indicates that the default function can be changed through user-defined constant values input on an MPMATnnnmm record. An 'X' indicates that the default function cannot be changed through user input. A blank space indicates that no default is provided, but may be supplied by the user, although in some cases that property for that material may not be used by MELCOR.

Also shown are the mnemonic identifiers used to add new values or alter the default values through user input for those properties which can be changed.

Two materials, AIR and UF6, are not currently defined in the NCG package and, as such, should not be used.

In those cases where both tabular data and correlational data exists for a given material, the tabular data are the default. For example, H2 viscosity data exists in tabular form and as Chapman-Enskog input parameters. The code will use the tabular form unless the user specifies the use of Chapman-Enskog parameters.

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Table 1.3 Default material properties, property mnemonics, and user input capabilities

Property*:	1	2	3	4a	4b	5a	5b	6a	6b	7a	7b	7c	8	9
Mnemonic:	ENH	TMP	CPS	THC	SIG	VIS	SIG	n/a	SIG	DEN	RHO	n/a	MLT	LHF
WATER			T		T									
STEAM			T	C	T	C		C			X			
AIR			T	C	T	C		C			X			
H2				C	T	C		C						
HE				C		C		C						
AR				C		C		C						
D2				C	T	C		C						
ZR	T	T	T	T					C	T		C	C	
ZRO2	T	T	T	T					C	T		C	C	
UO2	T	T	T	T					C	T		C	C	
SS	T	T	T	T					C	T		C	C	
SSOX	T	T	T	T					C	T		C	C	
B4C	T	T	T	T					C	T		C	C	
AGINC	T	T	T	T					C	T		C	C	
UMETL	T	T	T	T					C	T		C	C	
GRAPH	T	T	T	T					C	T		C		
CON			T	T							T			
O2				C		C		C						
CO2				C		C		C						
CO				C		C		C						
N2				C		C		C						
NO				C		C		C						
N2O				C		C		C						
NH3				C		C		C						
C2H2				C		C		C						
CH4				C		C		C						
C2H4				C		C		C						
UF6				C		C		C						
STEAM + AIR								X						
STEAM + H2								X						
ALUM	T	T	T	T					C	T		C	C	
AL2O3	T	T	T	T					C	T		C	C	
CADM	T	T	T	T					C	T		C	C	
SS304	T	T	T	T					C	T		C	C	
LIAL	T	T	T	T					C	T		C	C	
UAL	T	T	T	T					C	T		C	C	
CS	T	T	T	T					C	T		C	C	

T - The default function can be changed using tabular functions and an MPMATnnnnm input record.

C - The default function can be changed using constant values input on an MPMATnnnnm record.

X - The default function cannot be changed through user input.

* - See page 5 for a full description of these properties.

2. User Input

2.1 MELGEN Input

The user may define new materials for the material properties package. This is done by naming the material and defining the properties for that material through a tabular function or a constant value input. If the input material name matches the name of one of the 34 default materials, the input properties are used instead of the default properties for that material. One set of the following records is required for each new material or for each redefinition of a pre-defined material.

MPMATnnn00 - Material Name

0 ≤ nnn ≤ 999, nnn is the user-defined material id number

Required

This record defines the name of the material. The name may be a default material name or a newly defined name. Any name containing spaces must be enclosed in single quotes. Alternatively, a dash (-) can be used in place of a space. Upper and lower case letters are considered equivalent.

(1)MATNAM - Default or user-defined material name.
(type = character * 24)

Table 2.1 Default Material Names

1.	WATER	19.	CARBON DIOXIDE
2.	STEAM	20.	CARBON MONOXIDE
3.	AIR	21.	NITROGEN
4.	HYDROGEN	22.	NITRIC OXIDE
5.	HELIUM	23.	NITROUS OXIDE
6.	ARGON	24.	AMMONIA
7.	DEUTERIUM	25.	ACETYLENE
8.	ZIRCALOY	26.	METHANE
9.	ZIRCONIUM OXIDE	27.	ETHYLENE
10.	URANIUM DIOXIDE	28.	URANIUM HEXAFLUORIDE
11.	STAINLESS STEEL	29.	ALUMINUM
12.	STAINLESS STEEL OXIDE	30.	ALUMINUM OXIDE
13.	BORON CARBIDE	31.	CADMIUM
14.	SILVER-INDIUM-CADMIUM	32.	STAINLESS STEEL 304
15.	URANIUM METAL	33.	LITHIUM ALUMINUM
16.	GRAPHITE	34.	URANIUM ALUMINUM
17.	CONCRETE	35.	CARBON STEEL

18.	OXYGEN	
-----	--------	--

MPMATnnnmm - Property, Tabular Function Pairs

$0 \leq nnn \leq 999$, nnn is the user-defined material id number

$01 \leq mm \leq 49$, mm is used for ordering the input

Required

These records define the properties by data pairs. The first field in a pair is a property mnemonic, and the second field is the number of the tabular function to be used for that property. There may be an arbitrary number of pairs on a record, but a pair may not be split across a record. If a property for a material is given more than once, the last definition is used.

- (1) PROP - Property mnemonic.
(type = character * 3)

Must be one of the following property mnemonics:

ENH	- enthalpy vs temperature
TMP	- temperature vs enthalpy
CPS	- specific heat vs temperature
THC	- thermal conductivity vs temperature
VIS	- viscosity vs temperature
RHO	- density vs temperature

- (2) ITBPRP - Number of the tabular function for property, PROP. See the Tabular Function (TF) Package Users' Guide.
(type = integer, default = none, units = dimensionless)

or

Character string 'C-E' to specify the use of Chapman-Enskog relationships for THC or VIS properties (see PROP above). If Chapman-Enskog relationships are specified, the Lennard-Jones potential parameters SIG and EPS may be defined by the user or changed from the defaults provided, as described in the next section.

(type = character *3)

MPMATnnnmm - Property, Constant Value Pairs

$0 \leq nnn \leq 999$, nnn is the user-defined material id number

$50 \leq mm \leq 98$, mm is used for ordering the input

Required

These records define the constant properties by data pairs. The first field in a pair is a property mnemonic, and the second field is the constant value to be used for that property. There may be an arbitrary number of pairs on a record, but a pair may not be split across a record. If a property for a material is given more than once, the last definition is used.

- (1) PROP - Mnemonic for a constant property.
(type = character * 3)

Must be one of the following property mnemonics:

DEN	- constant density
MLT	- melting temperature
LHF	- latent heat of fusion
SIG	- Lennard-Jones potential parameter, σ
EPS	- Lennard-Jones potential parameter, ε/k

- (2) CPROPV - Constant property value to be used for property, PROP.
(type = real, defaults = see MP Reference Manual, units = kg/m**3
for 'DEN', K for 'MLT', J/kg for 'LHF', Å (10⁻¹⁰m) for 'SIG', K for
'EPS')

MPMATnnn99 - Steel Composition

0 ≤ nnn ≤ 999, nnn is the user-defined material id number for stainless steel (SS)
Optional

This record allows the user to override the default stainless steel composition (74% iron, 18% chromium, 8% nickel, 0% carbon) used by the Core package. The values will be normalized if required to ensure that the sum of the material fractions equals 1.0.

- (1) XFE - Relative mass fraction of iron (must be greater than 0.0).
(type = real, default = 0.74, units = dimensionless)
- (2) XCR - Relative mass fraction of chromium.
(type = real, default = 0.18, units = dimensionless)
- (3) XNI - Relative mass fraction of nickel.
(type = real, default = 0.08, units = dimensionless)
- (3) XCAR - Relative mass fraction of carbon.
(type = real, default = 0.0, units = dimensionless)

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2.2 MELCOR Input

There is at present no MELCOR input to the material properties package.

3. Sensitivity Coefficients

There are no sensitivity coefficients currently used in the material properties package.

4. Plot Variables and Control Function Arguments

There are no plot variables or control function arguments currently available in the material properties package.

5. Example MELGEN Input

```
*****
*          MELGEN INPUT FOR USER'S GUIDE      *
*****
*
TITLE      'USERS GUIDE'
*
*****
* FILES *
*****
*
OUTPUTF    MPUSERS.GOUT
DIAGF      MPUSERS.GDIA
RESTARTF   MPUSERS.RST
*
CRTOUT
*
*****
* CHANGE NH3 THERMAL CONDUCTIVITY AND VISCOSITY THROUGH *
* LENNARD-JONES POTENTIAL PARAMETERS, SIG AND EPS        *
*****
*
MPMAT00200  'AMMONIA'
MPMAT00250  SIG      3.000           * CONSTANT SIG (ANGSTROMS)
MPMAT00251  EPS      600.0           * CONSTANT EPS (K)
*
*
*****
* CHANGE B4C MELTING TEMPERATURE *
*****
```

```

*
MPMAT00300    'BORON CARBIDE'
MPMAT00350    MLT        2750.0                                * CONSTANT MLT (K)
*
*
*****
* ADD LENNARD-JONES POTENTIAL PARAMETERS FOR A NEW GAS, HELIUM *
*****
*
MPMAT00400    'GASA'     * MUST USE NAME COMPATIBLE WITH NCG PACKAGE
MPMAT00450    SIG        2.551      * CONSTANT SIG (ANGSTROMS)
MPMAT00451    EPS        10.22     * CONSTANT EPS (K)
*
*                               * NOTE: GASA (HELIUM) PARAMETERS MUST
*                               * BE DEFINED USING NCG CARDS

```

6. Example MELGEN Output (Partial Listing)

```

TOTAL NUMBER OF PROPERTIES =      7
TOTAL NUMBER OF MATERIALS =      35
TOTAL NUMBER OF PROPERTIES FOR ALL MATERIALS = 245

```

USING	FOR
DEFAULT TABLE	29 WATER thermal conductivity vs temperature
DEFAULT TABLE	32 WATER viscosity vs temperature
DEFAULT TABLE	30 STEAM thermal conductivity vs temperature
DEFAULT TABLE	33 STEAM viscosity vs temperature
DEFAULT TABLE	31 AIR thermal conductivity vs temperature
DEFAULT TABLE	34 AIR viscosity vs temperature
CHAPMAN-ENSKOG 2000	HYDROGEN thermal conductivity vs temperature
DEFAULT TABLE	42 HYDROGEN viscosity vs temperature
CHAPMAN-ENSKOG 2000	HELIUM thermal conductivity vs temperature
CHAPMAN-ENSKOG 2000	HELIUM viscosity vs temperature
CHAPMAN-ENSKOG 2000	ARGON thermal conductivity vs temperature
CHAPMAN-ENSKOG 2000	ARGON viscosity vs temperature
CHAPMAN-ENSKOG 2000	DEUTERIUM thermal conductivity vs temperature
DEFAULT TABLE	83 DEUTERIUM viscosity vs temperature
DEFAULT TABLE	1 ZIRCALOY enthalpy vs temperature
DEFAULT TABLE	8 ZIRCALOY temperature vs enthalpy
DEFAULT TABLE	15 ZIRCALOY specific heat vs temperature
DEFAULT TABLE	22 ZIRCALOY thermal conductivity vs temperature
DEFAULT TABLE	35 ZIRCALOY density vs temperature
DEFAULT TABLE	2 ZIRCONIUM-OXIDE enthalpy vs temperature
DEFAULT TABLE	9 ZIRCONIUM-OXIDE temperature vs enthalpy
DEFAULT TABLE	16 ZIRCONIUM-OXIDE specific heat vs temperature
DEFAULT TABLE	23 ZIRCONIUM-OXIDE thermal conductivity vs

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	temperature
DEFAULT TABLE	36 ZIRCONIUM-OXIDE density vs temperature
DEFAULT TABLE	3 URANIUM-DIOXIDE enthalpy vs temperature
DEFAULT TABLE	10 URANIUM-DIOXIDE temperature vs enthalpy
DEFAULT TABLE	17 URANIUM-DIOXIDE specific heat vs temperature
DEFAULT TABLE	24 URANIUM-DIOXIDE thermal conductivity vs temperature
DEFAULT TABLE	37 URANIUM-DIOXIDE density vs temperature
DEFAULT TABLE	4 STAINLESS-STEEL enthalpy vs temperature
DEFAULT TABLE	11 STAINLESS-STEEL temperature vs enthalpy
DEFAULT TABLE	18 STAINLESS-STEEL specific heat vs temperature
DEFAULT TABLE	25 STAINLESS-STEEL thermal conductivity vs temperature
DEFAULT TABLE	38 STAINLESS-STEEL density vs temperature
DEFAULT TABLE	5 STAINLESS-STEEL-OXIDE enthalpy vs temperature
DEFAULT TABLE	12 STAINLESS-STEEL-OXIDE temperature vs enthalpy
DEFAULT TABLE	19 STAINLESS-STEEL-OXIDE specific heat vs temperature
DEFAULT TABLE	26 STAINLESS-STEEL-OXIDE thermal conductivity vs temperature
DEFAULT TABLE	39 STAINLESS-STEEL-OXIDE density vs temperature
DEFAULT TABLE	6 BORON-CARBIDE enthalpy vs temperature
DEFAULT TABLE	13 BORON-CARBIDE temperature vs enthalpy
DEFAULT TABLE	20 BORON-CARBIDE specific heat vs temperature
DEFAULT TABLE	27 BORON-CARBIDE thermal conductivity vs temperature
DEFAULT TABLE	40 BORON-CARBIDE density vs temperature
DEFAULT TABLE	7 SILVER-INDIUM-CADMIUM enthalpy vs temperature
DEFAULT TABLE	14 SILVER-INDIUM-CADMIUM temperature vs enthalpy
DEFAULT TABLE	21 SILVER-INDIUM-CADMIUM specific heat vs temperature
DEFAULT TABLE	28 SILVER-INDIUM-CADMIUM thermal conductivity vs temperature
DEFAULT TABLE	41 SILVER-INDIUM-CADMIUM density vs temperature
DEFAULT TABLE	51 URANIUM-METAL enthalpy vs temperature
DEFAULT TABLE	52 URANIUM-METAL temperature vs enthalpy
DEFAULT TABLE	50 URANIUM-METAL specific heat vs temperature
DEFAULT TABLE	49 URANIUM-METAL thermal conductivity vs temperature
DEFAULT TABLE	48 URANIUM-METAL density vs temperature
DEFAULT TABLE	56 GRAPHITE enthalpy vs temperature
DEFAULT TABLE	57 GRAPHITE temperature vs enthalpy
DEFAULT TABLE	55 GRAPHITE specific heat vs temperature
DEFAULT TABLE	54 GRAPHITE thermal conductivity vs temperature
DEFAULT TABLE	53 GRAPHITE density vs temperature
DEFAULT TABLE	45 CONCRETE specific heat vs temperature
DEFAULT TABLE	46 CONCRETE thermal conductivity vs temperature

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DEFAULT TABLE 47 CONCRETE density vs temperature
CHAPMAN-ENSKOG 2000 OXYGEN thermal conductivity vs temperature
CHAPMAN-ENSKOG 2000 OXYGEN viscosity vs temperature
CHAPMAN-ENSKOG 2000 CARBON-DIOXIDE thermal conductivity vs
temperature
CHAPMAN-ENSKOG 2000 CARBON-DIOXIDE viscosity vs temperature
CHAPMAN-ENSKOG 2000 CARBON-MONOXIDE thermal conductivity vs
temperature
CHAPMAN-ENSKOG 2000 CARBON-MONOXIDE viscosity vs temperature
CHAPMAN-ENSKOG 2000 NITROGEN thermal conductivity vs temperature
CHAPMAN-ENSKOG 2000 NITROGEN viscosity vs temperature
CHAPMAN-ENSKOG 2000 NITRIC-OXIDE thermal conductivity vs
temperature
CHAPMAN-ENSKOG 2000 NITRIC-OXIDE viscosity vs temperature
CHAPMAN-ENSKOG 2000 NITROUS-OXIDE thermal conductivity vs
temperature
CHAPMAN-ENSKOG 2000 NITROUS-OXIDE viscosity vs temperature
CHAPMAN-ENSKOG 2000 AMMONIA thermal conductivity vs temperature
CHAPMAN-ENSKOG 2000 AMMONIA viscosity vs temperature
CHAPMAN-ENSKOG 2000 ACETYLENE thermal conductivity vs temperature
CHAPMAN-ENSKOG 2000 ACETYLENE viscosity vs temperature
CHAPMAN-ENSKOG 2000 METHANE thermal conductivity vs temperature
CHAPMAN-ENSKOG 2000 METHANE viscosity vs temperature
CHAPMAN-ENSKOG 2000 ETHYLENE thermal conductivity vs temperature
CHAPMAN-ENSKOG 2000 ETHYLENE viscosity vs temperature
CHAPMAN-ENSKOG 2000 URANIUM-HEXAFLUORIDE viscosity vs temperature
DEFAULT TABLE 58 ALUMINUM enthalpy vs temperature
DEFAULT TABLE 59 ALUMINUM temperature vs enthalpy
DEFAULT TABLE 60 ALUMINUM specific heat vs temperature
DEFAULT TABLE 61 ALUMINUM thermal conductivity vs temperature
DEFAULT TABLE 62 ALUMINUM density vs temperature
DEFAULT TABLE 84 ALUMINUM-OXIDE enthalpy vs temperature
DEFAULT TABLE 85 ALUMINUM-OXIDE temperature vs enthalpy
DEFAULT TABLE 86 ALUMINUM-OXIDE specific heat vs temperature
DEFAULT TABLE 87 ALUMINUM-OXIDE thermal conductivity vs
temperature
DEFAULT TABLE 88 ALUMINUM-OXIDE density vs temperature
DEFAULT TABLE 63 CADMIUM enthalpy vs temperature
DEFAULT TABLE 64 CADMIUM temperature vs enthalpy
DEFAULT TABLE 65 CADMIUM specific heat vs temperature
DEFAULT TABLE 66 CADMIUM thermal conductivity vs temperature
DEFAULT TABLE 67 CADMIUM density vs temperature
DEFAULT TABLE 68 STAINLESS-STEEL-304 enthalpy vs temperature
DEFAULT TABLE 69 STAINLESS-STEEL-304 temperature vs enthalpy
DEFAULT TABLE 70 STAINLESS-STEEL-304 specific heat vs
temperature
DEFAULT TABLE 71 STAINLESS-STEEL-304 thermal conductivity vs

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	temperature
DEFAULT TABLE	72 STAINLESS-STEEL-304 density vs temperature
DEFAULT TABLE	73 LITHIUM-ALUMINUM enthalpy vs temperature
DEFAULT TABLE	74 LITHIUM-ALUMINUM temperature vs enthalpy
DEFAULT TABLE	75 LITHIUM-ALUMINUM specific heat vs temperature
DEFAULT TABLE	76 LITHIUM-ALUMINUM thermal conductivity vs temperature
DEFAULT TABLE	77 LITHIUM-ALUMINUM density vs temperature
DEFAULT TABLE	78 URANIUM-ALUMINUM enthalpy vs temperature
DEFAULT TABLE	79 URANIUM-ALUMINUM temperature vs enthalpy
DEFAULT TABLE	80 URANIUM-ALUMINUM specific heat vs temperature
DEFAULT TABLE	81 URANIUM-ALUMINUM thermal conductivity vs temperature
DEFAULT TABLE	82 URANIUM-ALUMINUM density vs temperature
DEFAULT TABLE	89 CARBON-STEEL enthalpy vs temperature
DEFAULT TABLE	90 CARBON-STEEL temperature vs enthalpy
DEFAULT TABLE	91 CARBON-STEEL specific heat vs temperature
DEFAULT TABLE	92 CARBON-STEEL thermal conductivity vs temperature
DEFAULT TABLE	93 CARBON-STEEL density vs

The following constant properties table is available. If negative, then that property for that material is undefined.

DENSITY (KG/M**3)	MELT TEMP.(K)	LAT.HT.FUS. (J/KG)	LJ SIGMA (ANG)	LJ EPSILON (K)	MATERIAL
-1.0000E+03	-1.0000E+03	-1.0000E+03	-1.0000E+03	-1.0000E+03	WATER
-1.0000E+03	-1.0000E+03	-1.0000E+03	2.6410E+00	8.0910E+02	STEAM
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.7110E+00	7.8600E+01	AIR
-1.0000E+03	-1.0000E+03	-1.0000E+03	2.8270E+00	5.9700E+01	HYDROGEN
-1.0000E+03	-1.0000E+03	-1.0000E+03	2.5510E+00	1.0220E+01	HELIUM
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.5420E+00	9.3300E+01	ARGON
-1.0000E+03	-1.0000E+03	-1.0000E+03	2.9480E+00	3.9300E+01	DEUTERIUM
6.5000E+03	2.0980E+03	2.2500E+05	-1.0000E+03	-1.0000E+03	ZIRCALOY
5.6000E+03	2.9900E+03	7.0700E+05	-1.0000E+03	-1.0000E+03	ZIRCONIUM-OXIDE
1.0960E+04	3.1130E+03	2.7400E+05	-1.0000E+03	-1.0000E+03	URANIUM-DIOXIDE
7.9300E+03	1.7000E+03	2.6800E+05	-1.0000E+03	-1.0000E+03	STAINLESS-STEEL
5.1800E+03	1.8700E+03	5.9800E+05	-1.0000E+03	-1.0000E+03	STAINLESS-STEEL-OXIDE
2.5200E+03	2.7500E+03	5.0000E+05	-1.0000E+03	-1.0000E+03	BORON-CARBIDE
9.6894D+03	1.0750E+03	9.8000E+04	-1.0000E+03	-1.0000E+03	SILVER-INDIUM-CADMIUM
1.8210E+04	1.4060E+03	5.0250E+04	-1.0000E+03	-1.0000E+03	URANIUM-METAL
1.7300E+03	3.8660E+03	-1.0000E+03	-1.0000E+03	-1.0000E+03	GRAPHITE
-1.0000E+03	-1.0000E+03	-1.0000E+03	-1.0000E+03	-1.0000E+03	CONCRETE
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.4670E+00	1.0670E+02	OXYGEN
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.9410E+00	1.9520E+02	CARBON-DIOXIDE
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.6900E+00	9.1700E+01	CARBON-MONOXIDE
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.7980E+00	7.1400E+01	NITROGEN
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.4920E+00	1.1670E+02	NITRIC-OXIDE
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.8280E+00	2.3240E+02	NITROUS-OXIDE
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.0000E+00	6.0000E+02	AMMONIA

DENSITY (KG/M**3)	MELT TEMP.(K)	LAT.HT.FUS. (J/KG)	LJ SIGMA (ANG)	LJ EPSILON (K)	MATERIAL
-1.0000E+03	-1.0000E+03	-1.0000E+03	4.0330E+00	2.3180E+02	ACETYLENE
-1.0000E+03	-1.0000E+03	-1.0000E+03	3.7580E+00	1.4860E+02	METHANE
-1.0000E+03	-1.0000E+03	-1.0000E+03	4.1630E+00	2.2470E+02	ETHYLENE
-1.0000E+03	-1.0000E+03	-1.0000E+03	5.9670E+00	2.3680E+02	URANIUM-HEXAFLUORIDE
2.3650E+03	9.3300E+02	3.9780E+05	-1.0000E+03	-1.0000E+03	ALUMINUM
4.0000E+03	2.3270E+03	1.0700E+06	-1.0000E+03	-1.0000E+03	ALUMINUM-OXIDE
7.5900E+03	5.9400E+02	5.5000E+04	-1.0000E+03	-1.0000E+03	CADMIUM
7.7006D+03	1.7000E+03	2.6920E+05	-1.0000E+03	-1.0000E+03	STAINLESS-STEEL-304
2.3280E+03	9.1700E+02	3.9845D+05	-1.0000E+03	-1.0000E+03	LITHIUM-ALUMINUM
3.1819D+03	1.3380E+03	2.9000E+05	-1.0000E+03	-1.0000E+03	URANIUM-ALUMINUM
-1.0000E+00	-1.0000E+00	-1.0000E+00	2.5510E+00	1.0220E+01	GASA
7.7529E+03	1.8109E+03	2.7196E+05	-1.0000E+03	-1.0000E+03	CARBON-STEEL

7. Diagnostic and Error Messages

An error message is printed when the range of a property table is exceeded if extrapolation is not allowed. The material name, property name, independent variable value and acceptable range are printed. For example,

```
ERROR IN SUBROUTINE MPDFVL, CALLED FROM COR
ARGUMENT OUT OF RANGE FOR ZIRCALOY SPECIFIC HEAT VS TEMPERATURE
ARGUMENT =      2.70374D+02, RANGE =  2.73150D+02,  5.00000D+03
```

MP Package Users' Guide