

Property Library for Nitrogen

LibN2

Prof. Hans-Joachim Kretschmar
Dr. Sebastian Herrmann
Dr. Matthias Kunick
Ines Jaehne
Guido Keuchel

Range of Validity

The calculation of nitrogen is described in detail in the publications by *SPAN et al.* [2] and *LEMMON et al.* [1]. It includes temperatures from 63.151 K (-209.999°C) to 1000 K (726.85°C) and pressures from 0.00001 bar to 22000 bar. Important bulks are given in Table 1.1.

Table 1.1: Range of validity

Bulks	Abbreviations	Values and Units
pressures: minimal at triple point at critical point maximal	P_{\min}	$1 \cdot 10^{-5}$ bar
	P_t	0.12532 bar
	P_c	33.958 bar
	P_{\max}	22000 bar
temperatures: minimal at critical point maximal	$T_{\min} = T_t$	-209.999°C
	T_c	-146.958 °C
	T_{\max}	726.85°C

Figure 1.1 shows the entire range of validity for the equation in a p,t -diagram and Figure 1.2 in a p,v -diagram.

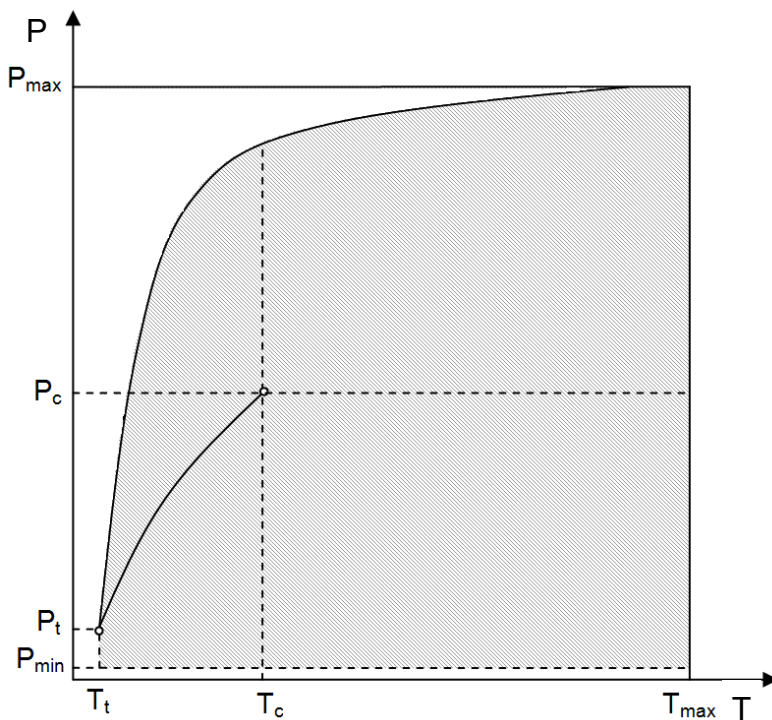


Figure 1.1: Entire range of validity of SPAN in a p,t -diagram

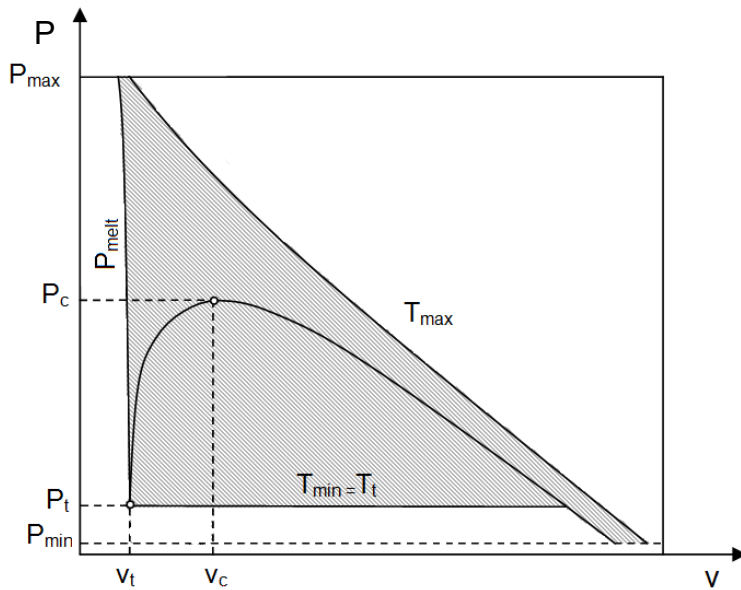


Figure 1.2: Entire range of validity of SPAN in a p, v -diagram

The sub-programs of the LibN2 DLL and the functions of the Add-In FluidEXL *Graphics* for Excel are listed in the following section.

All sub-programs and functions can be applied in the entire range of validity of the LibN2. The call of the necessary equation of state for each calculation region will be realized within the program.

Property Functions

Functional Dependence	Function Name	Call from DLL LibN2, Result as Parameter	Property or Function	Unit of the Result
$a = f(p, t, x)$	a_ptx_N2	= APTXN2(P, T, X)	Thermal diffusivity	m ² /s
$\alpha_P = f(p, t, x)$	alphap_ptx_N2	= ALPHAPPTXN2(P, T, X)	Relative pressure coefficient	1/K
$\alpha_V = f(p, t, x)$	alphav_ptx_N2	= ALPHAAPTXN2(P, T, X)	Isobaric cubic expansion coefficient	1/K
$\beta_P = f(p, t, x)$	betap_ptx_N2	= BETAPPTXN2(P, T, X)	Isothermal stress coefficient	kg/m ³
$c_p = f(p, t, x)$	cp_ptx_N2	= CPPTXN2(P, T, X)	Specific isobaric heat capacity	kJ/(kg · K)
$c_v = f(p, t, x)$	cv_ptx_N2	= CVPTXN2(P, T, X)	Specific isochoric heat capacity	kJ/(kg · K)
$\eta = f(p, t, x)$	eta_ptx_N2	= ETAPTXN2(P, T, X)	Dynamic viscosity	Pa · s = kg/(m · s)
$h = f(p, t, x)$	h_ptx_N2	= HPTXN2(P, T, X)	Specific enthalpy	kJ/kg
$\kappa = f(p, t, x)$	kappa_ptx_N2	= KAPPAPTXN2(P, T, X)	Isentropic exponent	-
$\kappa_T = f(p, t, x)$	kappat_ptx_N2	= KAPPATPTXN2(P, T, X)	Isothermal compressibility	1/kPa
$\lambda = f(p, t, x)$	lambda_ptx_N2	= LAMPTXN2(P, T, X)	Thermal conductivity	W/(m · K)
$\nu = f(p, t, x)$	ny_ptx_N2	= NYPTXN2(P, T, X)	Kinematic viscosity	m ² /s
$p_{mel} = f(t)$	p_mel_t_N2	= PMELTN2(T)	Melting pressure	bar
$Pr = f(p, t, x)$	Pr_ptx_N2	= PRPTXN2(P, T, X)	Prandtl number	-
$p_s = f(t)$	ps_t_N2	= PSTN2(T)	Vapor pressure	bar
$\rho = f(p, t, x)$	rho_ptx_N2	= RHOPTXN2(P, T, X)	Density	kg / m ³
$s = f(p, t, x)$	s_ptx_N2	= SPTXN2(P, T, X)	Specific entropy	kJ/(kg · K)
$t_{mel} = f(p)$	t_mel_p_N2	= TMELPN2(P)	Melting temperature	°C

Functional Dependence	Function Name	Call from DLL LibN2, Result as Parameter	Property or Function	Unit of the Result
$t = f(p, h)$	t_ph_N2	= TPHN2(P,H)	Backward function: Temperature from pressure and enthalpy	°C
$t_s = f(p)$	ts_p_N2	= TSPN2(P)	Saturation temperature	°C
$t = f(p, s)$	t_ps_N2	= TPSN2(P,S)	Backward function: Temperature from pressure and entropy	°C
$u = f(p, t, x)$	u_ptx_N2	= UPTXN2(P,T,X)	Specific internal energy	kJ/kg
$v = f(p, t, x)$	v_ptx_N2	= VPTXN2(P,T,X)	Specific volume	m ³ /kg
$w = f(p, t, x)$	w_ptx_N2	= WPTXN2(P,T,X)	Speed of sound	m/s
$x = f(p, h)$	x_ph_N2	= XPHN2(P,H)	Backward function: Vapor fraction from pressure and enthalpy	kg/kg
$x = f(p, s)$	x_ps_N2	= XPSN2(P,S)	Backward function: Vapor fraction from pressure and entropy	kg/kg
$z = f(p, t, x)$	z_ptx_N2	= zPTXN2(P,T,X)	Compression factor	-

Units: t in °C
 p in bar
 x in kg saturated steam/kg wet steam

Range of validity of the LibN2

Temperature: from 63.151 K (-209.999°C) to 1000 K (726.85°C)
Pressure: from 0.00001 bar to 22000 bar

Details on the vapor fraction x and on the calculation of wet steam

The wet steam region is calculated automatically by the subprograms. For this purpose the following fixed details on the vapor fraction x are to be considered:

Single-phase region

If the state point to be calculated is located in the single-phase region (liquid or superheated steam) $x = -1$ must be entered as a pro-forma value. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value between 0 and 1 ($x = 0$ for saturated liquid, $x = 1$ for saturated steam) must be entered. In this case, the backward functions result in the appropriate value between 0 and 1 for x . It is adequate to enter either the given value for t and $p = -1000$, or the given value for p and $t = -1000$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-pressure curve. If it is not the case the calculation for the property of the chosen function to be calculated results in -1000 .

(Wet steam region of the LibN2: $t_t = 63.151$ K (-209.999°C) ... $p_t = 0.12523$ bar (t – triple point)
 $t_c = 126.192$ K (-146.958°C) ... $p_c = 33.958$ bar (c – critical point))

Note.

If the calculation results in -1000 , the values entered represent a state point beyond the range of validity of SPAN. For further information on each function and its range of validity see Chapter 3. The same information may also be accessed via the online help pages.

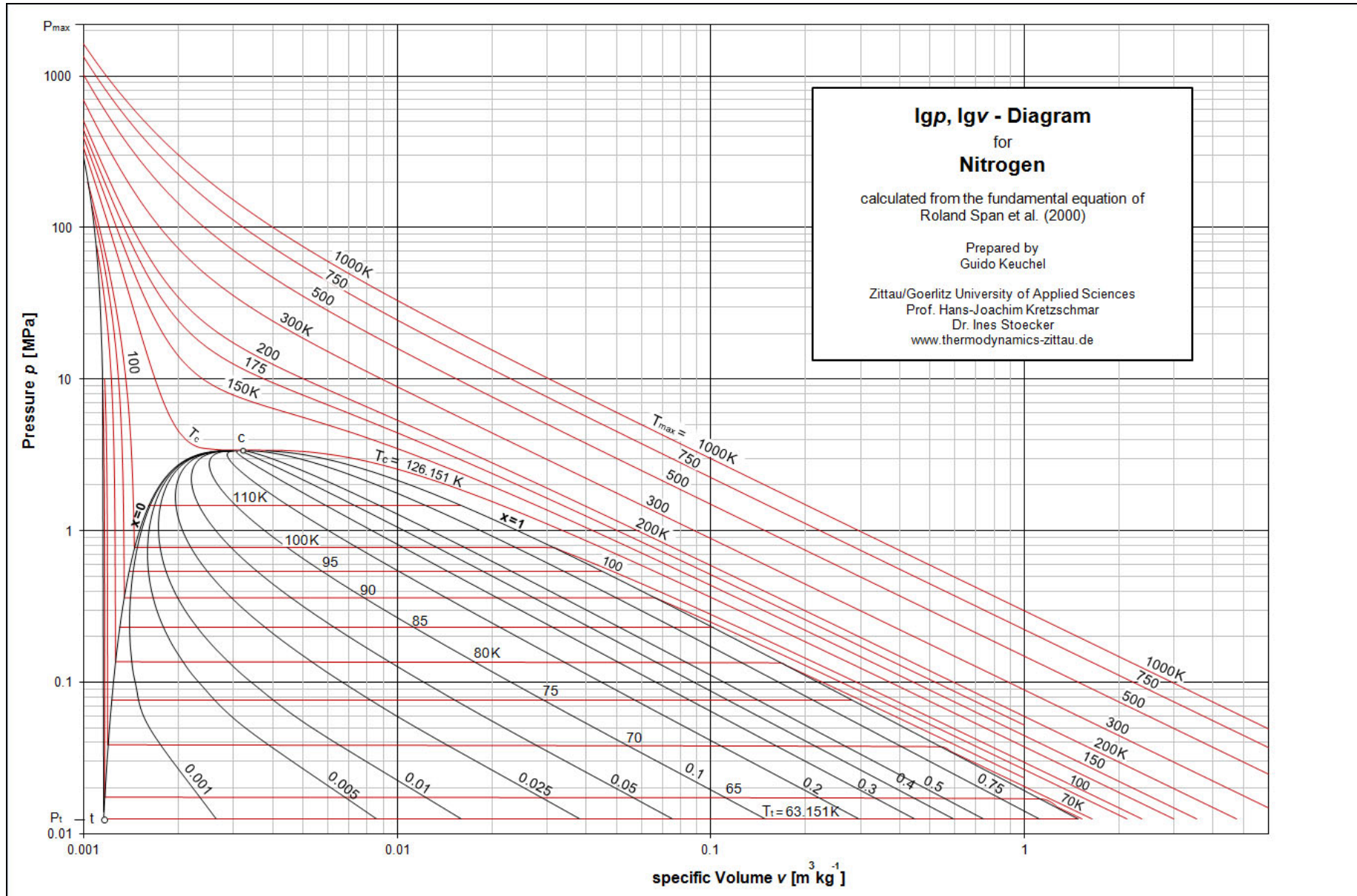
1.3 Thermodynamic Diagrams

The properties of nitrogen are calculated with FluidEXL^{Graphics} including the LibN2 property library. The results are shown in the following thermodynamic diagrams:

- lgp,lgv -diagram Figure 1.3

- lgp,h -diagram Figure 1.4

- T,s -diagram Figure 1.5

Figure 1.3: $lg p$ - $lg v$ diagram

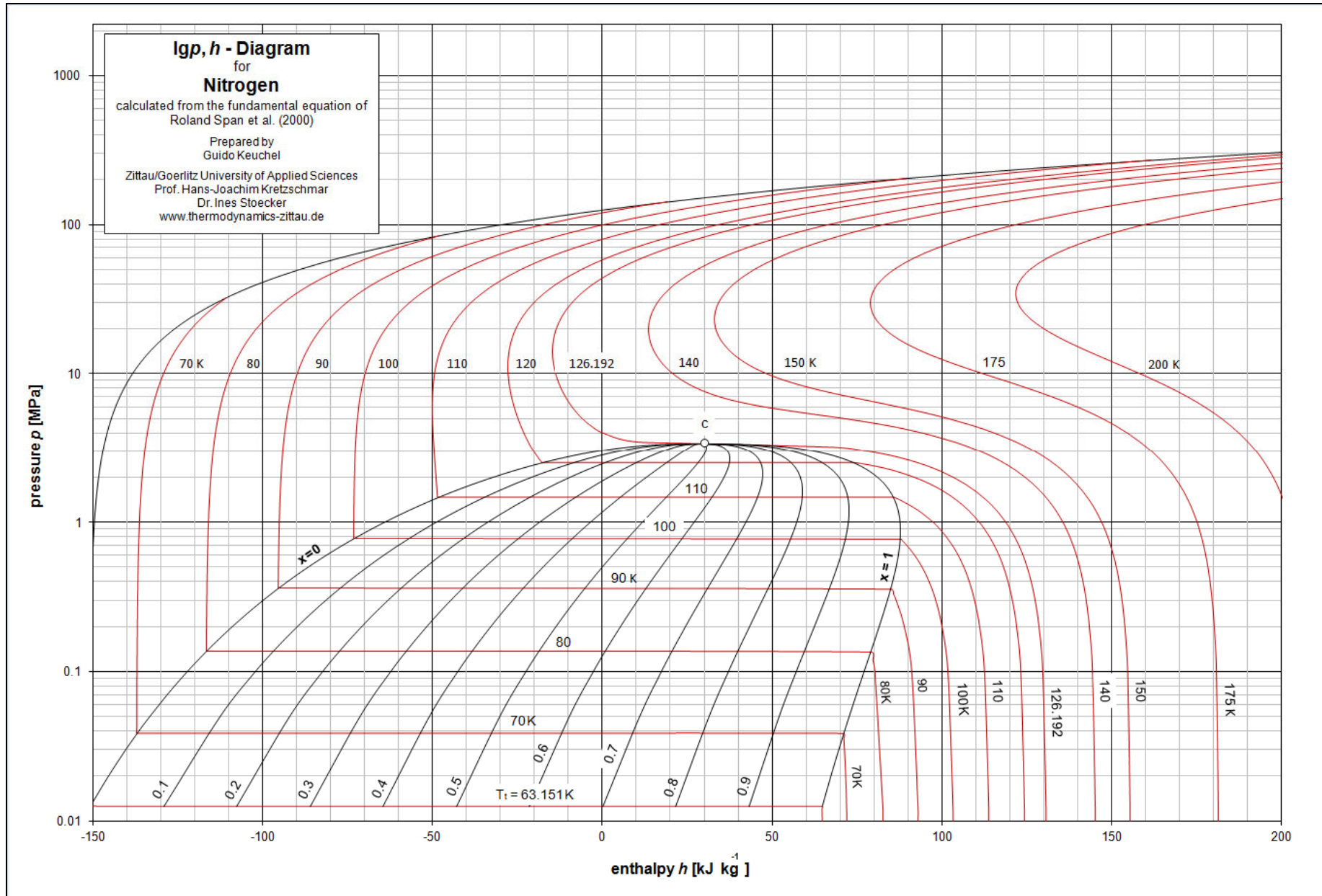


Figure 1.4: lg p-h diagram

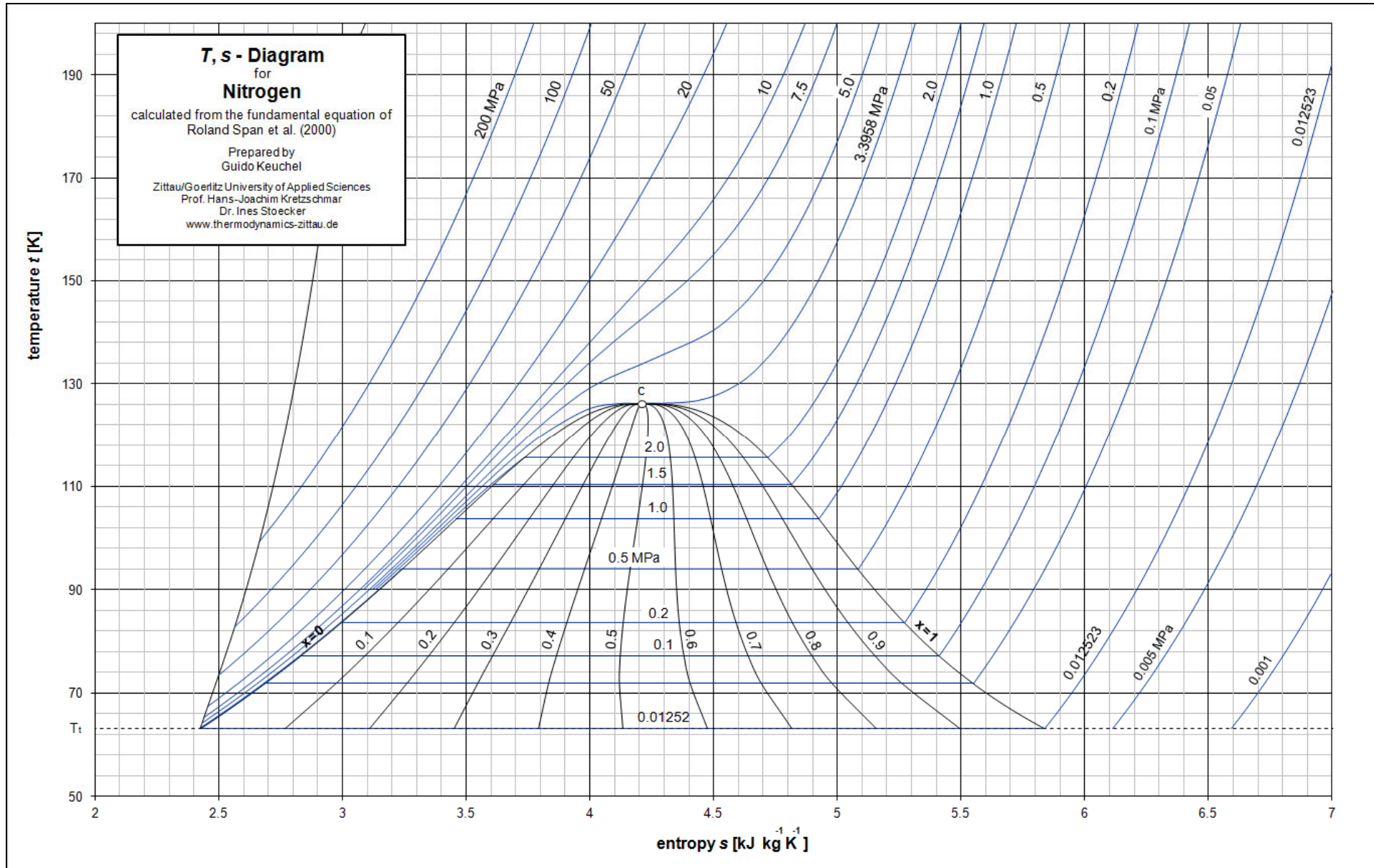


Figure 1.5: T-s diagram