

Recommended symbols in forming technology

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RECOMMENDED SYMBOLS IN FORMING TECHNOLOGY

for use within Scientific Technical Committee "F" of C.I.R.P.

compiled by J.A.G. Kals
Techn. Secr. S.T.C. "F"

PT 373

C.I.R.P.

INTERNATIONAL INSTITUTION FOR PRODUCTION ENGINEERING RESEARCH.
INTERNATIONALE FORSCHUNGSGEMEINSCHAFT FÜR MECHANISCHE PRODUKTIONSTECHNIK.
COLLEGE INTERNATIONAL POUR L'ETUDE SCIENTIFIQUE DES TECHNIQUES DE PRODUCTION MECHANIQUE.

Scientific Technical Committee "F" (Forming)

RECOMMENDED

SYMBOLS IN FORMING TECHNOLOGY

(international recommendation for use within S.T.C. "F")

compiled by J.A.G. Kals, Techn. Secr. S.T.C. "F"

Approved by the meeting of S.T.C. "F" on the 30th of January 1976 in Paris.

- Explanation: - Numbers in column 3 refer to terms and texts in C.I.R.P. dictionary (part 5) in which the symbol of column 1 is used in a meaning which conforms to that in column 4;
- different symbols and meanings (not only from the C.I.R.P. dictionary) are commented in the last column;
 - + behind number of term: no symbol mentioned in dictionary;
 - (d) behind number of term: definition;
 - E = English text only; G = German text only; F = French text only.
 - references to symbols used in Japanese literature are based on the Japanese Industrial Standard JIS Z - 8202 - 1974.

SYMBOL		C.I.R.P. dictionary	RECOMMENDED MEANING	COMMENTS
pref.	alt.	vol. 5		
a	ä etc.		<ul style="list-style-type: none"> - acceleration - Beschleunigung - accélération 	5445 G : a_k = Kerbschlagzähigkeit.
A		5302 EG	<ul style="list-style-type: none"> - area, cross-section - Fläche, Querschnitt - aire, section 	<ul style="list-style-type: none"> - 5302 F, 5307 F etc: S = aire - 5331 F: A = allongement conventionnel - 5470 EF: $\sigma = A\epsilon^n$ - sometimes A is used for work
α			<ul style="list-style-type: none"> - angle - Winkel - angle 	<ul style="list-style-type: none"> - α and β also for family of orthogonal characteristics known as slip or shear lines (5369 +) - 5713: 2α = cone angle, Öffnungswinkel, angle au sommet du cône de filage. - coefficient of linear thermal expansion. - heat transfer coefficient.

b	B		<ul style="list-style-type: none"> - width - Breite - largeur 	
β			<ul style="list-style-type: none"> - angle - Winkel - angle 	<ul style="list-style-type: none"> - α and β also for family of orthogonal characteristics known as slip or shear lines (5369 +) - <u>Recommendation</u>: β for geometrical dimensionless number indicating the broad formability in any forming process (β large if formability is good) for example limiting drawing ratio. - coefficient of volumetric thermal expansion.
c			<ul style="list-style-type: none"> - specific heat - spezifische Wärme - capacité calorifique spécifique 	<ul style="list-style-type: none"> - also used for elastic stiffnesses, c_{ij} - capital letter C is probably more widely used in U.S.A. for specific heat.
C	K		<ul style="list-style-type: none"> - constant - Konstante - constante 	<ul style="list-style-type: none"> - $\sigma = Ce^n$ (Ludwik's relationship) for example - also in Japan C = heat capacity
d	D		<ul style="list-style-type: none"> - diameter - Durchmesser - diamètre 	<ul style="list-style-type: none"> - d and δ used for differentials or increments - Japan : d = thickness
δ				<ul style="list-style-type: none"> - 5442 G: δ = Bruchdehnung (also VDI 3137 a.o.) - often used for differentials, increments or differences - VDI 3137: δ_g = Gleichmaszdehnung - in Japan δ^g = thickness

e		5331 E(d)	<ul style="list-style-type: none"> - engineering strain - Dehnung (bezogen auf Ausgangslänge) - allongement brut (conventionnel) 	<ul style="list-style-type: none"> - 5331 F: A = allongement conventionnel - e is also error, eccentricity and e = base of natural logs 2.7182818 - VDI 3137: ϵ instead of e, this is never used in English literature (see ϵ below)
E			<ul style="list-style-type: none"> - Young's modulus - Elastizitätsmodul - module d'Young 	<ul style="list-style-type: none"> - sometimes used for energy (see W)
ϵ		5331 EF(d)	<ul style="list-style-type: none"> - natural strain (true strain) - Umformgrad (log. Formänderungsverh.) - déformation vraie (déf. rationelle) 	<ul style="list-style-type: none"> - 5331 G : φ = Umformgrad - Germany a.o.: ϵ = engineering strain - the recommended meaning is always used in English literature, G notation inconsistent (see 5338 G, 5435 G and 5309)
$\dot{\epsilon}$		5334 EF(d)	<ul style="list-style-type: none"> - natural strain rate - Formänderungsgeschwindigkeit - vitesse de déformation 	<ul style="list-style-type: none"> - see aboven for ϵ - $(\dot{\epsilon}_{ij})$ = strain rate tensor (i,j = 1, 2, 3, or x, y, z) - 5334 G: $\dot{\phi}$ = zeitliche Änderung der Formänderung
$\bar{\epsilon}$		5338 EF(d)	<ul style="list-style-type: none"> - equivalent (effective, generalized) strain - Vergleichsformänderung - déformation équivalente 	<ul style="list-style-type: none"> - 5338 G: $d\epsilon_v$ = Vergleichsformänderungszuwachs (etc). - subscript eff. could have a more general meaning - bar is sometimes used as mean or average but this is not recommended here (see subscript m)
$\dot{\bar{\epsilon}}$			<ul style="list-style-type: none"> - equivalent strain rate - Vergleichsformänderungsgeschwindigkeit - vitesse de déformation équivalente 	
η		5330	<ul style="list-style-type: none"> - efficiency factor, work ratio factor - Wirkungsgrad - coefficient de rendement 	<ul style="list-style-type: none"> - 5330 (d) : η_F = efficiency of deformation, Umformwirkungsgrad rapport de formage - η often used as viscosity

$\delta \epsilon_{ij}^1$			<ul style="list-style-type: none"> - components of deviatoric strain increment tensor - Komponenten des infinitesimalen deviatorischen Formänderungs-tensors - composantes du tenseur déviatorique des déformations infinitésimales 	<ul style="list-style-type: none"> - one subscript (1,2,3); principal stress - double subscript (11,22,33) or (xx,yy,zz): general normal stress - double subscript (12,23,31) or (xy,yz, zx): general shear stress.
f			<ul style="list-style-type: none"> - frequency - Frequenz - fréquence 	<ul style="list-style-type: none"> - often used as Coulomb's friction coefficient for the past few years f is connected with another frictional concept in the U.S.A. - VDI 3137: f = Federweg
F	L	5301 GF(d)	<ul style="list-style-type: none"> - force (load) - Kraft (Belastung) - force (effort) 	5301 E, 5302 E, 5305 E: L = load
φ			<ul style="list-style-type: none"> - average value of natural strain - mittlerer Umformgrad - valeur moyenne de la déformation vraie 	<ul style="list-style-type: none"> - 5363 (Mohr figure): φ = angle - φ is often used for (spherical) coordinate - 5331 G : $\varphi_1 = \ln \frac{l_i}{l_0}$ - often used for orientation of slip lines
$\dot{\varphi}$			<ul style="list-style-type: none"> - average natural strain rate - mittlere (logarithmische) Formänderungsgeschwindigkeit - valeur moyenne de la vitesse de déformation 	- 5334 G : $\dot{\varphi}$ = Formänderungsgeschwindigkeit
$\bar{\epsilon}_I$			<ul style="list-style-type: none"> - average total equivalent strain - mittlere Vergleichsformänderung - valeur moyenne de la déformation totale équivalente 	
$\dot{\bar{\epsilon}}_I$			<ul style="list-style-type: none"> - average equivalent strain rate - mittlere Vergleichsformänderungsgeschwindigkeit - valeur moyenne de la vitesse de déformation équivalente 	

G			<ul style="list-style-type: none"> - shear modulus - Schubmodul - module de cisaillement 	- also used for force of gravity
γ		5331 5338	<ul style="list-style-type: none"> - shear angle, engineering shear strain - Schiebung(s winkel), Gleitungswinkel - angle de glissement, déformation de cisaillement 	<ul style="list-style-type: none"> - 5331 EGF, 5338 EGF, shear strain - different meanings in Japan.
$\dot{\gamma}$			<ul style="list-style-type: none"> - engineering shear strain rate - Schiebungsgeschwindigkeit - vitesse de déformation de cisaillement 	
h	H		<ul style="list-style-type: none"> - height - Höhe - hauteur 	<ul style="list-style-type: none"> - VDI 3137: h = Kraftweg etc. - in U.S.A.: h or H = enthalpy - in Japan: heat transfer coefficient
H	h	5304 (d) + 5651 (d) + 5654 +	<ul style="list-style-type: none"> - stroke - Hub - course 	<ul style="list-style-type: none"> - 5305: s = Stroke, Stößelweg, déplacement - \dot{H} = stroke speed (also \dot{h}) - VDI 3137 : h_A = Auswerferhub H = Hub (Maximalwert)
I_1 I_2 I_3			<ul style="list-style-type: none"> - tensor invariants - Tensorinvarianten - invariants du tenseur 	<ul style="list-style-type: none"> - usually for strain tensors - by way of exception the suffixes do not indicate a direction; cannot introduce any misunderstanding. - In Japan: I = mechanical energy

J_1 J_2 J_3			<ul style="list-style-type: none"> - tensor invariants - Tensorinvarianten - invariants du tenseur 	<ul style="list-style-type: none"> - usually for stress tensors - by way of exception the suffixes do not indicate a direction; cannot introduce any misunderstanding.
k		5348 (d) 5349 (d)	<ul style="list-style-type: none"> - yield stress in shear - Schubfließspannung - limite d'élasticité au cisaillement 	<ul style="list-style-type: none"> - 5470 G: $k_f = k_{f_0} \cdot \varphi^n$ - 5349 G: $k \sqrt{3} = k_f =$ Fließgrenze ($k_f = 2k$, Tresca) - 5349 EF: $k \sqrt{3} = Y =$ yield stress in tension = limite d'élasticité au tension - VDI 3137 : $k_f =$ Fließspannung
K	C		<ul style="list-style-type: none"> - constant - Konstante - constante 	<ul style="list-style-type: none"> - K is used for stiffness matrix and heat conductivity - very often used for stress intensity factor in fracture mechanics - compression modulus, bulk modulus
l	L	5331 5736 etc.	<ul style="list-style-type: none"> - length - Länge - longueur 	<ul style="list-style-type: none"> - see F also
λ (or $d\lambda$)			<ul style="list-style-type: none"> - factor of proportionality in incremental stress-strain relations. - Proportionalitätsfaktor der konstitutiven Gleichungen. - coefficient de proportionnalité entre la déformation infinitésimale et les contraintes. 	<ul style="list-style-type: none"> - λ often used for wavelength and for first Lamé constant - In Japan a.o. $\lambda =$ heat conductivity

m			<ul style="list-style-type: none"> - mass - Masse - masse 	<ul style="list-style-type: none"> - constant friction factor (Tresca) - Reibungsbeiwert - coefficient de friction 	<ul style="list-style-type: none"> - "friction factor" = shear stress/yield shear stress - m often used as strain rate sensitivity exponent $\text{in } \bar{\sigma} = C \dot{\epsilon}^m$ <ul style="list-style-type: none"> - m is used as the Weibull flow density constant to determine the probability of failure of brittle materials
M			<ul style="list-style-type: none"> - moment - Moment - moment 		<ul style="list-style-type: none"> - bending moment M_B, torsion moment M_T
μ	v	5381 (d)	<ul style="list-style-type: none"> - Coulomb's coefficient of friction - Reibungsbeiwert (Reibwert) - coefficient de frottement 		<ul style="list-style-type: none"> - μ is used for Lode's parameter too - μ is the 2nd Lamé's constant and is convenient to use were G is taken as the Gibbs free energy - also μ = viscosity
n		5470 (d)	<ul style="list-style-type: none"> - strain hardening exponent - Verfestigungsexponent - coefficient d'écrouissage 		<ul style="list-style-type: none"> - n, m, l often used as direction cosines of the normal to a plane - defining relation $\sigma = C\epsilon^n$ attributed to Ludwik - VDI 3137: n = Verfestigungsexponent + Hubzahl
ν			<ul style="list-style-type: none"> - Poisson ratio - Poissonzahl - coefficient de Poisson 		<ul style="list-style-type: none"> - ν often used for frequency and kinematic viscosity - Lode's parameter
ω			<ul style="list-style-type: none"> - angular velocity - Winkelgeschwindigkeit - vitesse angulaire 		
p		5302	<ul style="list-style-type: none"> - pressure - Flächenpressung (Druck) - pression 		<ul style="list-style-type: none"> - in Japan p is used for moment - also to be used for hydrostatic pressure - often used as primary principal stress
P	\dot{W}		<ul style="list-style-type: none"> - power (work per unit time) - Leistung - puissance 		<ul style="list-style-type: none"> - in Japan: P = pressure
q					<ul style="list-style-type: none"> - often used for secondary principal stress

r			<ul style="list-style-type: none"> - radius (polar coordinate) - Radius (Polkoordinate) - rayon (coordonée polaire) 	- sometimes strain ratio in deep drawing (I.D.D.R.G.)
		5309 EF(d)	<ul style="list-style-type: none"> - area reduction ratio - bezogene Querschnittsänderung - variation relative de la section transversale 	
R			<ul style="list-style-type: none"> - anisotropy parameter - Kennwert für Anisotropie - coefficient d'anisotropie 	
		5308 EF(d)	<ul style="list-style-type: none"> - extrusion ratio - Querschnittsverhältnis bei Fliespressen - rapport de filage 	
ρ			<ul style="list-style-type: none"> - radius (of curvature, bending radius) - (Krümmungs)radius, Biegeradius - rayon (de courbure, rayon de pliage) 	- often ρ = density
s	t		<ul style="list-style-type: none"> - thickness - Dicke, Blechstärke - épaisseur 	<ul style="list-style-type: none"> - 5305 : s = Stößelweg, stroke, déplacement - s is used as engineering stress i.e. load divided by original cross-section - VDI 3137 : s = Stauchverhältnis s = Wanddicke
S			<ul style="list-style-type: none"> - area, cross-section - Fläche, Querschnitt - aire, section 	<ul style="list-style-type: none"> - 5302 F, 5307 F, 5308 F : section transversale - S often used for entropy.
σ_{ij}		5339 (d) 5341 (d)	<ul style="list-style-type: none"> - components of stress tensor - Komponenten des Spannungstensors - composantes du tenseur des contraintes 	<ul style="list-style-type: none"> - one subscript (1,2,3) → principal stress - double subscript (11,22,33) or (xx,yy,zz) → general normal stress - double subscript (12,23,31) or (xy,yz,zx) → general shear stress

σ_{ij}^I		5344 (d)	<ul style="list-style-type: none"> - components of deviatoric (reduced) stress tensor - Komponenten des deviatorischen (reduzierten) Spannungstensors - composantes du tenseur déviatorique (reduit) des contraintes 	<ul style="list-style-type: none"> - one subscript (1,2,3) → principal stress - double subscript (11,22,33) or (xx,yy,zz) → general normal stress - double subscript (12,23,31) or (xy,yz,zx) → general shear stress 	
σ_m			<ul style="list-style-type: none"> - hydrostatic or mean stress - hydrostatischer Spannungszustand - contrainte hydrostatique 	<ul style="list-style-type: none"> - 5343 (d) σ = hydrost. Spannungszustand, hydrostatic stress, contrainte hydrostatique 	
$\bar{\sigma}$	σ_{eff}	5345 E(d)	<ul style="list-style-type: none"> - effective (generalized, equivalent) stress - Vergleichsspannung - contrainte équivalente (effective, généralisée) 	<ul style="list-style-type: none"> - 5345 G : σ_v = Vergleichsspannung - 5345 F : σ = contrainte équivalente 	
τ		5342 (d)	<ul style="list-style-type: none"> - shear stress - Schubspannung - contrainte de cisaillement 	τ_{ij} ($i \neq j$) for shear stress components of stress tensor	
t			<ul style="list-style-type: none"> - time - Zeit - temps 	<ul style="list-style-type: none"> - thickness - Dicke - épaisseur 	<ul style="list-style-type: none"> - sometimes used for resulting stress or stress-components (t_{ij}).
T			<ul style="list-style-type: none"> - temperature ($^{\circ}\text{C}$, $^{\circ}\text{K}$, $^{\circ}\text{F}$, $^{\circ}\text{R}$) - Temperatur - température 	<ul style="list-style-type: none"> - period - torque 	
θ			<ul style="list-style-type: none"> - angle - Winkel - angle 	<ul style="list-style-type: none"> - also used for (Kelvin) temperature and volumetric strain (Japan) 	

u			<ul style="list-style-type: none"> - displacement - Verschiebung - déplacement 	<ul style="list-style-type: none"> - velocity - Geschwindigkeit - vitesse 	<ul style="list-style-type: none"> - u_x, u_y, u_z - often u, v, w, instead of u_x, u_y, u_z - often U - often used for velocity in x-direction - see below for v
k_f		5438 EF(d)	<ul style="list-style-type: none"> - instantaneous yield stress (in tension) - Fließspannung (Augenblickswert im Zugversuch) - limite élastique (contrainte d'écoulement) 		<ul style="list-style-type: none"> - 5438 G: k_f = Fließspannung - Y.S. = yield stress in U.S.A. - Y = yield stress in U.K.
v		5306 G	<ul style="list-style-type: none"> - déplacement - Verschiebung - déplacement 	<ul style="list-style-type: none"> - velocity - Geschwindigkeit - vitesse 	<ul style="list-style-type: none"> - 5306 EF: V = velocity, vitesse - often used for velocity in y-direction - see above for u
V			<ul style="list-style-type: none"> - volume - Volumen, Rauminhalt - volume 		<ul style="list-style-type: none"> - 5306 EF: V = velocity, vitesse (see also 5348, 5349, 5470)
w			<ul style="list-style-type: none"> - displacement - Verschiebung - déplacement 	<ul style="list-style-type: none"> - velocity - Geschwindigkeit - vitesse 	<ul style="list-style-type: none"> - sometimes deformation work per unit volume - often used for velocity in z-direction - see u and v
W			<ul style="list-style-type: none"> - work, energy - Arbeit, Energie - travail, énergie 		<ul style="list-style-type: none"> - weight in Japanese literature - often work per unit volume

GENERAL SUBSCRIPTSALLGEMEINE INDIZESSYMBOLES INDICES

Pref.	meaning - Bedeutung - signification		Pref.	meaning - Bedeutung - signification
a	- axial - Axial - axial		opt.	- optimal - Optimalwert - optimal
b	- width - Breite - largeur			
B	- bending - Biegung - pliage		pl	- plastic - plastisch - plastique
c	- critical - kritisch - critique	c sometimes used for "compressive"	r	- radial - Radial - radial
def	- deformation - Umform - déformation	ex: T_{def}	rel	- relative - Relativ - relatif
eff	- effective - Effektivwert - effectif			
el	- elastic - elastisch - élastique		T	- torsion - Torsion - torsion - tangential - Tangential - tangential

e	<ul style="list-style-type: none"> - final - Endwert - final 	max	<ul style="list-style-type: none"> - maximum - Maximalwert, Grenzwert - maximum 	
f	<ul style="list-style-type: none"> - friction - Reibung - frottement 	<ul style="list-style-type: none"> - see 5349 G } k_f 5470 G } - VDI 3137: Fliesz (also F) 	min	<ul style="list-style-type: none"> - minimum - Minimalwert, Grenzwert - minimum
h	<ul style="list-style-type: none"> - height - Höhe - hauteur 	n	<ul style="list-style-type: none"> - normal - Normal - normal 	ex: normal Force = F_n
i, j	<ul style="list-style-type: none"> - denoting components of a tensor - Bezeichnung für Tensorkomponente - indices des composants d'un tenseur 	o	<ul style="list-style-type: none"> - initial - Anfangswert - initial 	
id	<ul style="list-style-type: none"> - ideal - ideell - idéal 	x	- in direction x etc.	
		y	- in x-Richtung usw.	
		z	- en direction x etc.	
		1	- principal	- 5340 : 1,2,3
		2	- Haupt	- VDI 3137: 1,2,3
		3	- principal	
l	<ul style="list-style-type: none"> - length - Länge (Längskomponente) - longueur 			
m	<ul style="list-style-type: none"> - average - Mittelwert - moyenne 			