



The Role of the Teacher in the 21st Century



The role of the teacher in the 21st century is changing. Teachers are no longer just providers of knowledge. They are now facilitators of learning. They are helping students to develop critical thinking skills, problem-solving skills, and communication skills. They are also helping students to become lifelong learners.

Teachers are also responsible for creating a safe and supportive learning environment. They are helping students to feel confident and motivated. They are also helping students to develop a positive attitude towards learning.

Teachers are also responsible for assessing student learning. They are using a variety of assessment tools to measure student progress. They are also using assessment data to inform their instruction.

Teachers are also responsible for collaborating with other professionals. They are working with parents, administrators, and other teachers to ensure the best possible outcomes for their students.

The role of the teacher in the 21st century is a challenging one. Teachers must be able to adapt to change and to meet the needs of their students. They must also be able to stay current in their field.

Despite the challenges, the role of the teacher remains an important one. Teachers are the ones who are helping to shape the future. They are the ones who are helping to create a better world for all of us.

The role of the teacher in the 21st century is a challenging one. Teachers must be able to adapt to change and to meet the needs of their students. They must also be able to stay current in their field.

Despite the challenges, the role of the teacher remains an important one. Teachers are the ones who are helping to shape the future. They are the ones who are helping to create a better world for all of us.

IGBT, Wechselrichter / IGBT, Inverter

Höchstzulässige Werte / Maximum Rated Values

Kollektor-Emitter-Sperrspannung Collector-emitter voltage	$T_{vj} = 25^{\circ}\text{C}$	V_{CES}	1200	V
Kollektor-Dauerleistungsstrom Continuous DC collector current	$T_C = 100^{\circ}\text{C}, T_{vj} = 175^{\circ}\text{C}$	$I_{C, \text{nom}}$	600	A
Periodischer Kollektor-Spitzenstrom Repetitive peak collector current	$t_p = 1 \text{ ms}$	$I_{C, \text{RM}}$	1200	A
Gesamt-Verlustleistung Total power dissipation	$T_C = 25^{\circ}\text{C}, T_{vj} = 175^{\circ}\text{C}$	P_{tot}	3,35	kW
Gate-Emitter-Spitzenspannung Gate-emitter peak voltage		V_{GES}	+/-20	V

Charakteristische Werte / Characteristic Values

			min.	typ.	max.
Kollektor-Emitter-Sättigungsspannung Collector-emitter saturation voltage	$I_C = 600 \text{ A}, V_{GE} = 15 \text{ V}$ $I_C = 600 \text{ A}, V_{GE} = 15 \text{ V}$ $I_C = 600 \text{ A}, V_{GE} = 15 \text{ V}$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	$V_{CE, \text{sat}}$	1,75 2,05 2,10	2,05 V V
Gate-Schwellenspannung Gate threshold voltage	$I_C = 23,0 \text{ mA}, V_{CE} = V_{GE}, T_{vj} = 25^{\circ}\text{C}$		$V_{GE, \text{th}}$	5,2	5,8 6,4
Gateladung Gate charge	$V_{GE} = -15 \text{ V} \dots +15 \text{ V}$		Q_G	4,40	μC
Interner Gatewiderstand Internal gate resistor	$T_{vj} = 25^{\circ}\text{C}$		R_{Gint}	1,8	Ω
Eingangskapazität Input capacitance	$f = 1 \text{ MHz}, T_{vj} = 25^{\circ}\text{C}, V_{CE} = 25 \text{ V}, V_{GE} = 0 \text{ V}$		C_{in}	37,0	nF
Rückwirkungskapazität Reverse transfer capacitance	$f = 1 \text{ MHz}, T_{vj} = 25^{\circ}\text{C}, V_{CE} = 25 \text{ V}, V_{GE} = 0 \text{ V}$		C_{res}	2,05	nF
Kollektor-Emitter-Reststrom Collector-emitter cut-off current	$V_{CE} = 1200 \text{ V}, V_{GE} = 0 \text{ V}, T_{vj} = 25^{\circ}\text{C}$		I_{CES}		5,0
Gate-Emitter-Reststrom Gate-emitter leakage current	$V_{CE} = 0 \text{ V}, V_{GE} = 20 \text{ V}, T_{vj} = 25^{\circ}\text{C}$		I_{GES}		400
Einschaltverzögerungszeit, induktive Last Turn-on delay time, inductive load	$I_C = 600 \text{ A}, V_{CE} = 600 \text{ V}$ $V_{GE} = \pm 15 \text{ V}$ $R_{\text{Gon}} = 1,8 \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_{don}	0,24 0,29 0,31	μs μs μs
Anstiegszeit, induktive Last Rise time, inductive load	$I_C = 600 \text{ A}, V_{CE} = 600 \text{ V}$ $V_{GE} = \pm 15 \text{ V}$ $R_{\text{Gon}} = 1,8 \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_r	0,09 0,10 0,10	μs μs μs
Abschaltverzögerungszeit, induktive Last Turn-off delay time, inductive load	$I_C = 600 \text{ A}, V_{CE} = 600 \text{ V}$ $V_{GE} = \pm 15 \text{ V}$ $R_{\text{Goff}} = 2,2 \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_{doff}	0,70 0,80 0,85	μs μs μs
Fallzeit, induktive Last Fall time, inductive load	$I_C = 600 \text{ A}, V_{CE} = 600 \text{ V}$ $V_{GE} = \pm 15 \text{ V}$ $R_{\text{Goff}} = 2,2 \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	t_f	0,15 0,16 0,17	μs μs μs
Einschaltverlustenergie pro Puls Turn-on energy loss per pulse	$I_C = 600 \text{ A}, V_{CE} = 600 \text{ V}, L_G = 45 \text{ nH}$ $V_{GE} = \pm 15 \text{ V}, di/dt = 4800 \text{ A}/\mu\text{s} (T_{vj}=150^{\circ}\text{C})$ $R_{\text{Gon}} = 1,8 \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	E_{on}	49,0 61,0 65,0	mJ mJ mJ
Abschaltverlustenergie pro Puls Turn-off energy loss per pulse	$I_C = 600 \text{ A}, V_{CE} = 600 \text{ V}, L_G = 45 \text{ nH}$ $V_{GE} = \pm 15 \text{ V}, di/dt = 3100 \text{ V}/\mu\text{s} (T_{vj}=150^{\circ}\text{C})$ $R_{\text{Goff}} = 2,2 \Omega$	$T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	E_{off}	53,0 73,0 82,0	mJ mJ mJ
Kurzschlußverhalten SC data	$V_{GE} \leq 15 \text{ V}, V_{CC} = 800 \text{ V}$ $V_{\text{CEmax}} = V_{CES} \cdot L_{\text{GE}} \cdot di/dt$	$t_p \leq 10 \mu\text{s}, T_{vj} = 150^{\circ}\text{C}$	I_{SC}	2400	A
Wärmewiderstand, Chip bis Gehäuse Thermal resistance, junction to case	pro IGBT / per IGBT		R_{thJC}		45,0
Wärmewiderstand, Gehäuse bis Kühlkörper Thermal resistance, case to heatsink	pro IGBT / per IGBT $\lambda_{\text{Kupfer}} = 1 \text{ W}/(\text{m} \cdot \text{K}) / \lambda_{\text{Gehäuse}} = 1 \text{ W}/(\text{m} \cdot \text{K})$		R_{thCH}	14,0	K/kW

Vorläufige Daten
Preliminary Data

Diode, Wechselrichter / Diode, Inverter

Höchstzulässige Werte / Maximum Rated Values

Periodische Spitzenspannung Repetitive peak reverse voltage	$T_{vj} = 25^{\circ}\text{C}$	V_{RRM}	1200	V
Dauergleichstrom Continuous DC forward current		I_F	600	A
Periodischer Spitzenstrom Repetitive peak forward current	$t_b = 1\text{ ms}$	I_{FRM}	1200	A
Grenzlastintegral PT - value	$V_{CE} = 0\text{ V}, t_b = 10\text{ ms}, T_{vj} = 125^{\circ}\text{C}$ $V_{CE} = 0\text{ V}, t_b = 10\text{ ms}, T_{vj} = 150^{\circ}\text{C}$	PT	51,0 49,0	kA's kA's

Charakteristische Werte / Characteristic Values

			min.	typ.	max.
Durchlassspannung Forward voltage	$I_F = 600\text{ A}, V_{CE} = 0\text{ V}$ $T_{vj} = 25^{\circ}\text{C}$ $I_F = 600\text{ A}, V_{CE} = 0\text{ V}$ $T_{vj} = 125^{\circ}\text{C}$ $I_F = 600\text{ A}, V_{CE} = 0\text{ V}$ $T_{vj} = 150^{\circ}\text{C}$	V_F	1,80 1,75 1,70	2,20	V V V
Rückstromspitze Peak reverse recovery current	$I_F = 600\text{ A}, -di/dt = 4800\text{ A}/\mu\text{s} (T_{vj}=150^{\circ}\text{C})$ $V_{CE} = 600\text{ V}$ $V_{CE} = -15\text{ V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	I_{RRM}	395 450 495		A A A
Sperrverzögerungsladung Recovered charge	$I_F = 600\text{ A}, -di/dt = 4800\text{ A}/\mu\text{s} (T_{vj}=150^{\circ}\text{C})$ $V_{CE} = 600\text{ V}$ $V_{CE} = -15\text{ V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	Q_r	60,0 110 125		μC μC μC
Abschaltenergie pro Puls Reverse recovery energy	$I_F = 600\text{ A}, -di/dt = 4800\text{ A}/\mu\text{s} (T_{vj}=150^{\circ}\text{C})$ $V_{CE} = 600\text{ V}$ $V_{CE} = -15\text{ V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$	E_{RR}	31,0 45,0 57,0		mJ mJ mJ
Wärmewiderstand, Chip bis Gehäuse Thermal resistance, junction to case	pro Diode / per diode	$R_{\theta JC}$			75,0 K/kW
Wärmewiderstand, Gehäuse bis Kühlkörper Thermal resistance, case to heatsink	pro Diode / per diode $\lambda_{plate} = 1\text{ W}/(\text{m}\cdot\text{K}) \quad / \quad \lambda_{grate} = 1\text{ W}/(\text{m}\cdot\text{K})$	$R_{\theta CH}$	24,0		K/kW

NTC-Widerstand / NTC-Thermistor

Charakteristische Werte / Characteristic Values

			min.	typ.	max.
Nennwiderstand Rated resistance	$T_C = 25^{\circ}\text{C}$	R_{25}		5,00	k Ω
Abweichung von R100 Deviation of R100	$T_C = 100^{\circ}\text{C}, R_{100} = 493\text{ }\Omega$	$\Delta R/R$	-5		5 %
Verlustleistung Power dissipation	$T_C = 25^{\circ}\text{C}$	P_{25}			20,0 mW
B-Wert B-value	$R_2 = R_{25} \exp [B_{25/50} (1/T_2 - 1/(298,15\text{ K}))]$	$B_{25/50}$		3375	K
B-Wert B-value	$R_2 = R_{25} \exp [B_{25/100} (1/T_2 - 1/(298,15\text{ K}))]$	$B_{25/100}$		3411	K
B-Wert B-value	$R_2 = R_{25} \exp [B_{25/100} (1/T_2 - 1/(298,15\text{ K}))]$	$B_{25/100}$		3433	K

Angaben gemäß gültiger Application Note.

Specification according to the valid application note.

Technische Information / Technical Information

IGBT-Module
IGBT-modules

FF600R12IE4



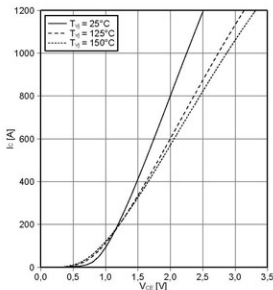
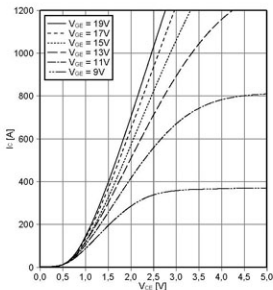
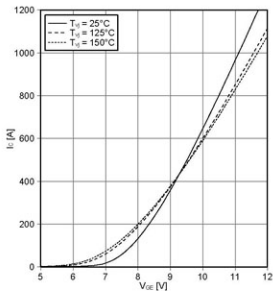
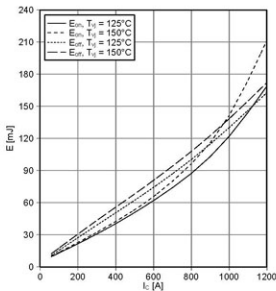
Vorläufige Daten Preliminary Data

Modul / Module

Isolations-Prüfspannung Isolation test voltage	RMS, f = 50 Hz, t = 1 min.	V _{ISOL}	4,0	kV
Material Modulgrundplatte Material of module baseplate			Cu	
Innere Isolation Internal isolation	Basisisolierung (Schutzklasse 1, EN61140) basic insulation (class 1, IEC 61140)		Al ₂ O ₃	
Kriechstreck Creepage distance	Kontakt - Kühlkörper / terminal to heatsink Kontakt - Kontakt / terminal to terminal		33,0 33,0	mm
Luftstrecke Clearance	Kontakt - Kühlkörper / terminal to heatsink Kontakt - Kontakt / terminal to terminal		19,0 19,0	mm
Vergleichszahl der Kriechwegbildung Comparative tracking index		CTI	> 400	
			min.	typ.
Wärmewiderstand, Gehäuse bis Kühlkörper Thermal resistance, case to heatsink	pro Modul / per module $\lambda_{plate} = 1 \text{ W/(m}^2\text{K)}$ / $\lambda_{groove} = 1 \text{ W/(m}^2\text{K)}$	R _{DSCH}	4,50	K/kW
Modulstreulinduktivität Stray inductance module		L _{SC}	18	nH
Modulleitungs-widerstand, Anschlüsse - Chip Module lead resistance, terminals - chip	T _C = 25°C, pro Schalter / per switch	R _{DS(on)}	0,30	mΩ
Höchstzulässige Sperrschichttemperatur Maximum junction temperature	Wechselrichter, Brems-Chopper / inverter, brake-chopper	T _{qjmax}	175	°C
Temperatur im Schaltbetrieb Temperature under switching conditions	Wechselrichter, Brems-Chopper / inverter, brake-chopper	T _{qj}	-40	150 °C
Lagertemperatur Storage temperature		T _{stg}	-40	150 °C
Anzugsdrehmoment f. Modulmontage Mounting torque for modul mounting	Schraube M5 - Montage gem. gültiger Applikationsschrift Screw M5 - Mounting according to valid application note	M	3,00	- 6,00 Nm
Anzugsdrehmoment f. elektr. Anschlüsse Terminal connection torque	Schraube M8 - Montage gem. gültiger Applikationsschrift Screw M8 - Mounting according to valid application note	M	1,8 8,0	- 2,1 10 Nm
Gewicht Weight		G	825	g

prepared by: AC
approved by: MS

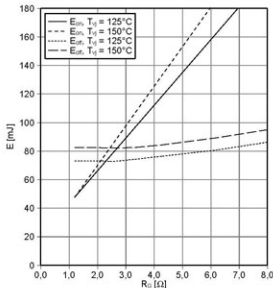
date of publication: 2013-03-05
revision: 2.4

Vorläufige Daten
Preliminary DataAusgangskennlinie IGBT, Wechselrichter (typisch)
output characteristic IGBT, inverter (typical) $I_C = f(V_{CE})$
 $V_{GE} = 15\text{ V}$ Ausgangskennlinienfeld IGBT, Wechselrichter (typisch)
output characteristic IGBT, inverter (typical) $I_C = f(V_{CE})$
 $T_J = 150^\circ\text{C}$ Übertragungscharakteristik IGBT, Wechselrichter (typisch)
transfer characteristic IGBT, inverter (typical) $I_C = f(V_{GE})$
 $V_{CE} = 20\text{ V}$ Schaltverluste IGBT, Wechselrichter (typisch)
switching losses IGBT, inverter (typical) $E_{on} = f(I_C), E_{off} = f(I_C)$
 $V_{GE} = \pm 15\text{ V}, R_{DS(on)} = 1.8\ \Omega, R_{\theta JA} = 2.2\ \text{K/W}, V_{CE} = 600\text{ V}$ 

Schaltverluste IGBT, Wechselrichter (typisch)
switching losses IGBT, inverter (typical)

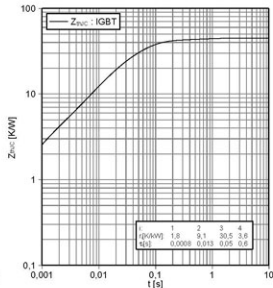
$E_{on} = f(R_{DS(on)})$, $E_{off} = f(R_{DS(on)})$

$V_{GE} = \pm 15 \text{ V}$, $I_C = 600 \text{ A}$, $V_{CE} = 600 \text{ V}$



Transienter Wärmewiderstand IGBT, Wechselrichter
transient thermal impedance IGBT, inverter

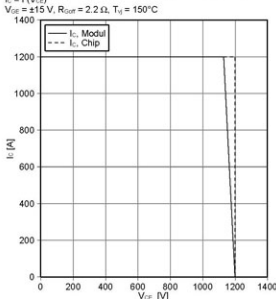
$Z_{thJC} = f(t)$



Sicherer Rückwärts-Arbeitsbereich IGBT, Wechselrichter
(RBSOA)
reverse bias safe operating area IGBT, inverter (RBSOA)

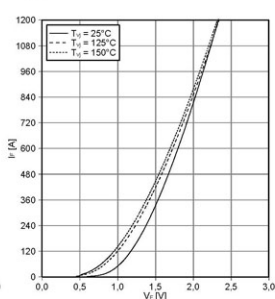
$I_C = f(V_{CE})$

$V_{GE} = \pm 15 \text{ V}$, $R_{DS(on)} = 2.2 \text{ m}\Omega$, $T_J = 150^\circ\text{C}$



Durchlasskennlinie der Diode, Wechselrichter (typisch)
forward characteristic of Diode, inverter (typical)

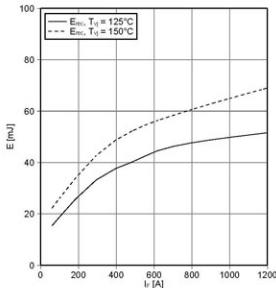
$I_F = f(V_F)$



Schaltverluste Diode, Wechselrichter (typisch)
switching losses Diode, Inverter (typical)

$E_{rec} = f(I_r)$

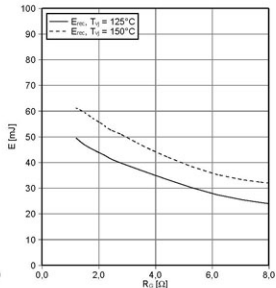
$R_{DS(on)} = 1.8 \Omega$, $V_{CE} = 600 \text{ V}$



Schaltverluste Diode, Wechselrichter (typisch)
switching losses Diode, Inverter (typical)

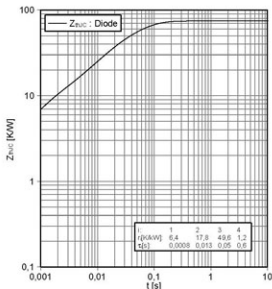
$E_{rec} = f(R_{\theta})$

$I_r = 600 \text{ A}$, $V_{CE} = 600 \text{ V}$



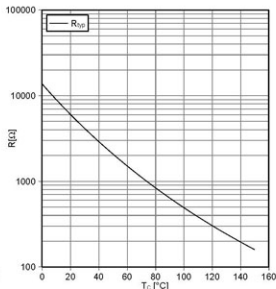
Transienter Wärmewiderstand Diode, Wechselrichter
transient thermal impedance Diode, Inverter

$Z_{th(jc)} = f(t)$



NTC-Widerstand-Temperaturkennlinie (typisch)
NTC-Thermistor-temperature characteristic (typical)

$R = f(T)$



Nutzungsbedingungen

Die in diesem Produktdatenblatt enthaltenen Daten sind ausschließlich für technisch geschultes Fachpersonal bestimmt. Die Beurteilung der Eignung dieses Produktes für Ihre Anwendung sowie die Beurteilung der Vollständigkeit der bereitgestellten Produktdaten für diese Anwendung obliegt Ihnen bzw. Ihren technischen Abteilungen.

In diesem Produktdatenblatt werden diejenigen Merkmale beschrieben, für die wir eine liefervertragliche Gewährleistung übernehmen. Eine solche Gewährleistung richtet sich ausschließlich nach Maßgabe der im jeweiligen Liefervertrag enthaltenen Bestimmungen. Garantien jeglicher Art werden für das Produkt und dessen Eigenschaften keinesfalls übernommen. Die Angaben in den gültigen Anwendungs- und Montagehinweisen des Moduls sind zu beachten.

Sollten Sie von uns Produktinformationen benötigen, die über den Inhalt dieses Produktdatenblatts hinausgehen und insbesondere eine spezifische Verwendung und den Einsatz dieses Produktes betreffen, setzen Sie sich bitte mit dem für Sie zuständigen Vertriebsbüro in Verbindung (siehe www.infineon.com, Vertrieb&Kontakt). Für Interessenten halten wir Application Notes bereit.

Aufgrund der technischen Anforderungen könnte unser Produkt gesundheitsgefährdende Substanzen enthalten. Bei Rückfragen zu den in diesem Produkt jeweils enthaltenen Substanzen setzen Sie sich bitte ebenfalls mit dem für Sie zuständigen Vertriebsbüro in Verbindung.

Sollten Sie beabsichtigen, das Produkt in Anwendungen der Luftfahrt, in gesundheits- oder lebensgefährdenden oder lebenserhaltenden Anwendungsbereichen einzusetzen, bitten wir um Mitteilung. Wir weisen darauf hin, dass wir für diese Fälle

- die gemeinsame Durchführung eines Risiko- und Qualitätsassessments;
- den Abschluss von speziellen Qualitätssicherungsvereinbarungen;
- die gemeinsame Einführung von Maßnahmen zu einer laufenden Produktbeobachtung dringend empfehlen und gegebenenfalls die Belieferung von der Umsetzung solcher Maßnahmen abhängig machen.

Soweit erforderlich, bitten wir Sie, entsprechende Hinweise an Ihre Kunden zu geben.

Inhaltliche Änderungen dieses Produktdatenblatts bleiben vorbehalten.

Terms & Conditions of usage

The data contained in this product data sheet is exclusively intended for technically trained staff. You and your technical departments will have to evaluate the suitability of the product for the intended application and the completeness of the product data with respect to such application.

This product data sheet is describing the characteristics of this product for which a warranty is granted. Any such warranty is granted exclusively pursuant to the terms and conditions of the supply agreement. There will be no guarantee of any kind for the product and its characteristics. The information in the valid application- and assembly notes of the module must be considered.

Should you require product information in excess of the data given in this product data sheet or which concerns the specific application of our product, please contact the sales office, which is responsible for you (see www.infineon.com). For those that are specifically interested we may provide application notes.

Due to technical requirements our product may contain dangerous substances. For information on the types in question please contact the sales office, which is responsible for you.

Should you intend to use the Product in aviation applications, in health or life endangering or life support applications, please notify. Please note, that for any such applications we urgently recommend

- to perform joint Risk and Quality Assessments;
- the conclusion of Quality Agreements;
- to establish joint measures of an ongoing product survey, and that we may make delivery depended on the realization of any such measures.

If and to the extent necessary, please forward equivalent notices to your customers.

Changes of this product data sheet are reserved.