

(INCH-POUND)

MIL-S-19500/623
5 April 1993

MILITARY SPECIFICATION
SEMICONDUCTOR DEVICE, DARLINGTON TRANSISTOR, PNP, SILICON, HIGH-POWER
TYPE 2N7371 JANTX, JANTXV, AND JANS

This Specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the detail requirements for PNP silicon, high-power darlington transistor. Three levels of product assurance are provided as specified in MIL-S-19500.

1.2 Physical dimensions. See figure 1.

1.3 Maximum ratings.

	P_T $T_C = +25^\circ\text{C}$	V_{CBO}	V_{CEO}	V_{EBO}	I_B	I_C	T_J and T_{STG}	$R_{\theta JC}$
	W	V dc	V dc	V dc	A dc	A dc	$^\circ\text{C}$	$\frac{^\circ\text{C}}{\text{W}}$ Max
2N7371	100	100	100	5.0	0.2	12	-65 to +175	1.5

1/ Derate linearly 0.667 W/ $^\circ\text{C}$ above $T_C = +25^\circ\text{C}$.

1.4 Primary electrical characteristics.

	h_{FE2} 1/	$V_{BE(SAT)1}$ 1/	$V_{CE(SAT)1}$ 1/	$ h_{fe} $
	$V_{CE} = 3.0 \text{ V dc}$ $I_C = 6.0 \text{ A dc}$	$I_C = 12.0 \text{ A dc}$ $I_B = 120 \text{ mA dc}$	$I_C = 12.0 \text{ A dc}$ $I_B = 120 \text{ mA dc}$	$V_{CE} = 3.0 \text{ V dc}$ $I_C = 5.0 \text{ A dc}$ $f_C = 1 \text{ MHz}$
Min	1000	V dc	V dc	10
Max	18000	4.0	3.0	250

1/ Pulsed (see 4.5.1).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Defense Electronics Supply Center, ATTN: DESC-ECT, 1507 Wilmington Pike, Dayton, OH 45444-5270, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 5961

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards and handbooks. The following specifications, standards and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DCDISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATION

MILITARY

MIL-S-19500 - Semiconductor Devices, General Specification for.

STANDARD

MILITARY

MIL-STD-750 - Test Methods for Semiconductor Devices.

(Copies of the specification and standard required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity)

2.2 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Associated detail specification. The individual item requirements shall be in accordance with MIL-S-19500, and as specified herein.

3.2 Abbreviations, symbols, and definitions. Abbreviations, symbols, and definitions used herein shall be as specified in MIL-S-19500.

3.3 Design, construction, and physical dimensions. The design, construction, and physical dimensions shall be as specified in MIL-S-19500, and on figure 1 herein. Methods used for electrical isolation of the terminal feedthroughs shall employ materials that contain a minimum of 90% Al_2O_3 (ceramic). Examples of such construction techniques are metallized ceramic eyelets or ceramic walled packages. The preferred measurements used herein are the metric units. However, this transistor was designed using inch-pound units of measurement. In case of conflicts between the metric and inch-pound units, the inch-pound units shall be rule.

3.3.1 Lead finish and formation. Lead finish shall be solderable in accordance with MIL-STD-750, MIL-S-19500, and herein. Where a choice of lead finish or formation is desired, it shall be specified in the acquisition requirements (see 6.2). When lead formation is performed, as a minimum, the vendor shall perform 100 percent hermetic seal in accordance with screen 14, of MIL-S-19500.

3.4 Marking. Marking shall be in accordance with MIL-S-19500.

4. QUALITY ASSURANCE PROVISIONS

4.1 Sampling and inspection. Sampling and inspection shall be in accordance with MIL-S-19500, and as specified herein.

4.2 Qualification inspection. Qualification inspection shall be in accordance with MIL-S-19500, and as specified herein (see 4.3.1.1).

4.3 Screening (JANTX, JANTXV, and JANS levels). Screening shall be in accordance with MIL-S-19500 (table II), and as specified herein. The following measurements shall be made in accordance with table I herein. Devices that exceed the limits of table I herein shall not be acceptable.

Screen (see table II of MIL-S-19500)	Measurement	
	JANS level	JANTX and JANTXV levels
1/	Thermal Impedance (see 4.3.2)	Thermal Impedance (see 4.3.2)
9	I_{CEX1} & h_{FE2}	Not applicable
11	Subgroup 2 of table I herein; I_{CEX1} and h_{FE2} ; $\Delta I_{CEX1} = 100\%$ of initial value or $100 \mu A$ dc whichever is greater. $\Delta h_{FE2} = \pm 40\%$ of initial value.	I_{CEX1} and h_{FE2}
12	$t = 160$ hours	$t = 80$ hours
13	Subgroup 2 and 3 of table I herein; I_{CEX1} and h_{FE2} ; $\Delta I_{CEX1} = 100\%$ of initial value or $100 \mu A$ dc whichever is greater. $\Delta h_{FE2} = \pm 40\%$ of initial value.	Subgroup 2 of table I herein; I_{CEX1} and h_{FE2} ; $\Delta I_{CEX1} = 100\%$ of initial value or $100 \mu A$ dc whichever is greater. $\Delta h_{FE2} = \pm 40\%$ of initial value.

1/ May be performed anytime before screen 9.

4.3.1 Power burn-in conditions. Power burn-in conditions are as follows:

$$T_J = 162.5 \pm 12.5^\circ C, V_{CE} \geq 10 \text{ V dc}, t_A = 30 \pm 5^\circ C.$$

4.3.2 Thermal impedance $Z_{\theta JX}$ measurements for screening. The $Z_{\theta JX}$ measurements shall be performed in accordance with MIL-STD-750, method 3131. The maximum limit and conditions for $Z_{\theta JX}$ in screening (table II of MIL-S-19500) shall be derived by each vendor by means of process control of actual measurements which characterizes the die attach process. When three lot date codes have exhibited control, the data from these three lots will be used to establish a fixed screening limit (not to exceed the end point limit). Once a fixed limit has been established, monitor all future sealing lots using a sample from each lot to be plotted on the applicable X and R chart.

4.3.2.1 Thermal impedance ($Z_{\theta JX}$ measurements) for initial qualification or requalification. The $Z_{\theta JX}$ measurements shall be performed in accordance with MIL-STD-750. Method 3131 (read and record date $Z_{\theta JX}$) derived conditions limits and thermal response curve shall be supplied to the qualifying activity on the qualification lot prior to qualification approval.

4.4 Quality conformance inspection. Quality conformance inspection shall be in accordance with MIL-S-19500, and as specified herein.

4.4.1 Group A inspection. Group A inspection shall be conducted in accordance with MIL-S-19500, and table I herein.

4.4.2 Group B inspection. Group B inspection shall be conducted in accordance with the conditions specified for subgroup testing in table IVb of MIL-S-19500. Electrical measurements (end-points) and delta requirements shall be in accordance with the applicable steps of table III herein.

4.4.2.1 Group B inspection, table IVa (JANS) of MIL-S-19500. Subgroup 4: Condition for intermittent operation life are as follows: $V_{CB} \geq 10$ V dc. ΔT_J between cycles $\geq +100^\circ\text{C}$, 2000 cycles.

4.4.2.2 Group B inspection, table IVb (JANTX and JANTXV) of MIL-S-19500. Subgroup 3: Condition for intermittent operation life are as follows: $V_{CB} \geq 10$ V dc. ΔT_J between cycles $\geq +100^\circ\text{C}$, 2000 cycles.

4.4.3 Group C inspection. Group C inspection shall be conducted in accordance with the conditions specified for subgroup testing in table V of MIL-S-19500. Electrical measurements (end points) and delta requirements shall be in accordance with the applicable steps of table III herein.

4.4.3.1 Group C inspection, table V of MIL-S-19500.

- a. Subgroup 2: Condition for terminal strength (tension) is method 2036, condition A, weight = 4.5 kg, $t = 10$ seconds.
- b. Subgroup 6: Condition for intermittent operation life are as follows: $V_{CB} \geq 10$ V dc. ΔT_J between cycles $\geq +100^\circ\text{C}$, 6000 cycles.

4.5 Method of inspection. Methods of inspection shall be as specified in the appropriate tables and as follows:

4.5.1 Pulse measurements. Conditions for pulse measurement shall be as specified in section 4 of MIL-STD-750.

4.5.2 Thermal resistance. Thermal resistance measurements shall be conducted in accordance with test method 3131 of MIL-STD-750. The following details shall apply:

- a. Collector current magnitude during power application shall be 1.0 A dc.
- b. Collector to emitter voltage magnitude shall be ≥ 10 V dc.
- c. Reference temperature measuring point shall be the case.
- d. Reference point temperature shall be $+25^\circ\text{C} \leq T_R \leq +75^\circ\text{C}$ and recorded before the test is started.
- e. Mounting arrangement shall be with heat sink to header.
- f. Maximum limit of $R_{\theta JC}$ shall be 1.5°C/W .

4.5.3 Thermal Impedance $Z_{\theta JX}$ limit for end point measurements.

The following test conditions shall be used for $Z_{\theta JX}$, end point measurements: $Z_{\theta JX} = 1.4^\circ\text{C/W}$

- a. I_H - - - - - 10 mA.
- b. V_{CE} measurement voltage - - - - - 20 V (same as V_H).
- c. I_H collector heating current - - - - - 4 A (minimum).
- d. V_H collector-emitter heating voltage - - - - - 20 V (minimum).
- e. t_H heating time - - - - - 100 ms.
- f. t_{MD} measurement delay time - - - - - 50 μ s to 80 μ s.
- g. t_{sw} sample window time - - - - - 10 μ s (maximum).

TABLE 1. Group A inspection.

Inspection 1/	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 1</u>						
Visual and mechanical examination	2071					
<u>Subgroup 2</u>						
Collector - emitter breakdown voltage	3011	Bias condition D; $I_C = 100$ mA dc; Pulsed (see. 4.5.1)	$V_{CE0(sus)}$	100		V dc
Collector - emitter cutoff current	3036	Bias condition D; $V_{CE} = 50$ V dc	I_{CEO}		1.0	mA dc
Emitter - base cutoff current	3061	Bias condition D; $V_{EB} = 5$ V dc	I_{EBO}		2.0	mA dc
Collector - emitter cutoff current	3041	Bias condition A; $V_{BE} = 1.5$ V dc; $V_{CE} = 100$ V dc	I_{CEX1}		0.5	mA dc
Base - emitter saturated voltage	3066	Test condition A; $I_C = 12$ A dc; $I_B = 120$ mA dc; Pulsed (see 4.5.1)	$V_{BE(sat)}$		4.0	V dc
Collector - emitter saturated voltage	3071	$I_C = 12$ A dc; $I_B = 120$ mA dc; Pulsed (see 4.5.1)	$V_{CE(sat)}$		3.0	V dc
Forward - current transfer ratio	3076	$V_{CE} = 3.0$ V dc; $I_C = 6.0$ A dc; Pulsed (see 4.5.1)	h_{FE1}	1000	18000	
Forward - current transfer ratio	3076	$V_{CE} = 3.0$ V dc; $I_C = 12$ A dc; Pulsed (see 4.5.1)	h_{FE2}	150		
<u>Subgroup 3</u>						
High - temperature operation		$T_A = +150^\circ\text{C}$				
Collector to emitter cutoff current	3041	Bias condition C; $V_{CE} = 100$ V dc; $V_{BE} = 1.5$ V dc	I_{CEX2}		5.0	mA dc
Low - temperature operation		$T_A = -55^\circ\text{C}$				
Forward - current transfer ratio	3076	$V_{CE} = 3.0$ V dc; $I_C = 6.0$ A dc; Pulsed (see 4.5.1)	h_{FE3}	300		

See footnote at end of table.

TABLE I. Group A inspection - Continued.

Inspection <u>1/</u>	MIL-STD-750		Symbol	Limit		Unit
	Method	Conditions		Min	Max	
<u>Subgroup 4</u>						
Switching parameters						
Turn-on		See figure 2	t_{on}		2.0	μs
Turn-off		See figure 2	t_{off}		10	μs
Magnitude of small-signal short-circuit forward-current transfer ratio	3306	$V_{CE} = 3.0$ V dc; $I_C = 5.0$ A dc; $f = 1$ MHz	$ h_{fe} $	10	250	
<u>Subgroup 5</u>						
Safe operating area (continuous dc)	3051	$T_C = 25^\circ C$; $t \geq 1$ s; 1 cycle; (See figure 3)				
<u>Test 1</u>		$V_{CE} = 8.3$ V dc; $I_C = 12.0$ A dc				
<u>Test 2</u>		$V_{CE} = 30$ V dc; $I_C = 3.3$ A dc				
<u>Test 3</u>		$V_{CE} = 90$ V dc; $I_C = 150$ mA dc				
Safe operating area (clamped inductive)	3053	Load condition B (clamped inductive load); $T_A = +25^\circ C$; $t_r + t_f \leq 1.0$ μs ; duty cycle $\leq 2\%$; $t_p = 1$ ms; (vary to obtain I_C); $R_s = 0.10$ ohms; $R_{BB1} = 80$ ohms; $V_{BB1} = 16$ V dc; $R_{BB2} = 100$ ohms; $V_{BB2} = 1.5$ V dc; $I_C = 12$ A dc; $V_{CC} = 20$ V dc; $R_L \leq 2$ ohms; $L = 10$ mH; (Stancor C-2688 or equivalent) clamp voltage = 100 +0, -5 V dc; Device fails if clamp voltage not reached.				
Electrical measurements		See table III Steps 1 & 2				
<u>Subgroups 6 & 7</u>						
N/A						

1/ For sampling plan see MIL-S 19500.

TABLE II. Group E inspection (all quality levels) for qualification only.

Inspection	MIL-STD-750		Qualification conformance inspection
	Method	Conditions	
<u>Subgroup 1</u>			22 devices, c = 0
Temperature cycling	1051	500 cycles	
Hermetic seal	1071		
Electrical measurements		See table III, steps 1 & 2	
<u>Subgroup 2</u>			22 devices, c = 0
High Temperature Reverse bias	1039	Condition A; 1000 hours	
Electrical measurements		See table III, steps 1 & 2	
<u>Subgroup 3</u>			
Not applicable			
<u>Subgroup 4</u>			10 devices, c = 0
Thermal resistance	3131	$R_{\theta JC} = 1.5^{\circ}\text{C/W}$ maximum. See 4.5.2	
<u>Subgroup 5</u>			
Not applicable			

TABLE III. Group B, C, and E electrical measurements.

Step.	Inspection	Method	MIL-STD-750 Conditions	Symbol	Limit		Unit
					Min	Max	
1.	Collector - emitter cutoff current	3041	Bias condition C; $V_{CE} = 100$ V dc $V_{BE} = 1.5$ V dc	I_{CEX1}		0.5	mA dc
2.	Forward - current transfer ratio	3076	$V_{CE} = 3.0$ V dc; $I_C = 6.0$ A dc; Pulsed (see 4.5.1)	h_{FE1}	1000	18000	
3.	Collector - emitter cutoff current	3041	Bias condition C; $V_{CE} = 100$ V dc $V_{BE} = 1.5$ V dc	ΔI_{CEX1}	100% of initial value or 100 μ A dc; whichever is greater		
4.	Forward - current transfer ratio	3076	$V_{CE} = 3.0$ V dc; $I_C = 6.0$ A dc; Pulsed (see 4.5.1)	Δh_{FE1}	$\pm 40\%$ change from initial value		
5.	Thermal impedance	3131	See 4.5.3	$Z_{\theta JX}$		1.4	$^{\circ}$ C/W

1/ The electrical measurements for table IVa (JANS) of MIL-S-19500 are as follow:

- a. Subgroup 2, see table II herein, steps 1 and 2.
- b. Subgroup 3, see table II herein, steps 3, 4, and 5.
- c. Subgroup 6, see table II herein, steps 3, 4, and 5.

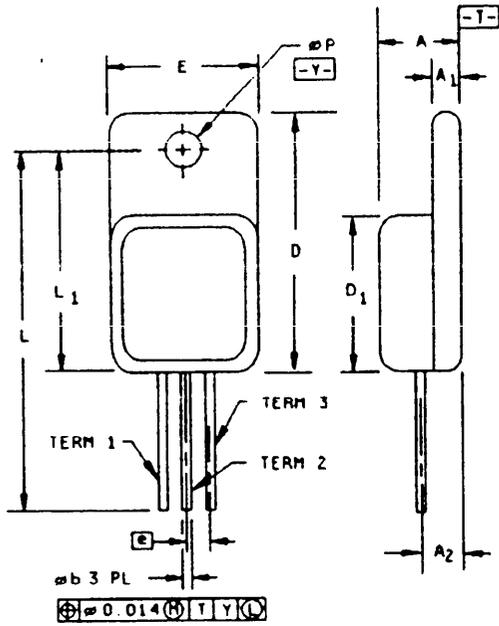
2/ The electrical measurements for table IVb (JANTX and JANTXV) of MIL-S-19500 are as follow:

- a. Subgroup 2, see table II herein, steps 1 and 2.
- b. Subgroup 3, see table II herein, steps 1, 2, and 5.
- c. Subgroup 6, see table II herein, steps 1, 2, and 5.

3/ The electrical measurements for table V of MIL-S-19500 are as follows:

- a. Subgroup 2, see table II herein, steps 1 and 2.
- b. Subgroup 3, see table II herein, steps 1 and 2.
- c. Subgroup 6, see table II herein, steps 1, 2, and 5.

4/ Devices which exceed the group A limits for this test shall not be shippable but are not considered failures for the test.

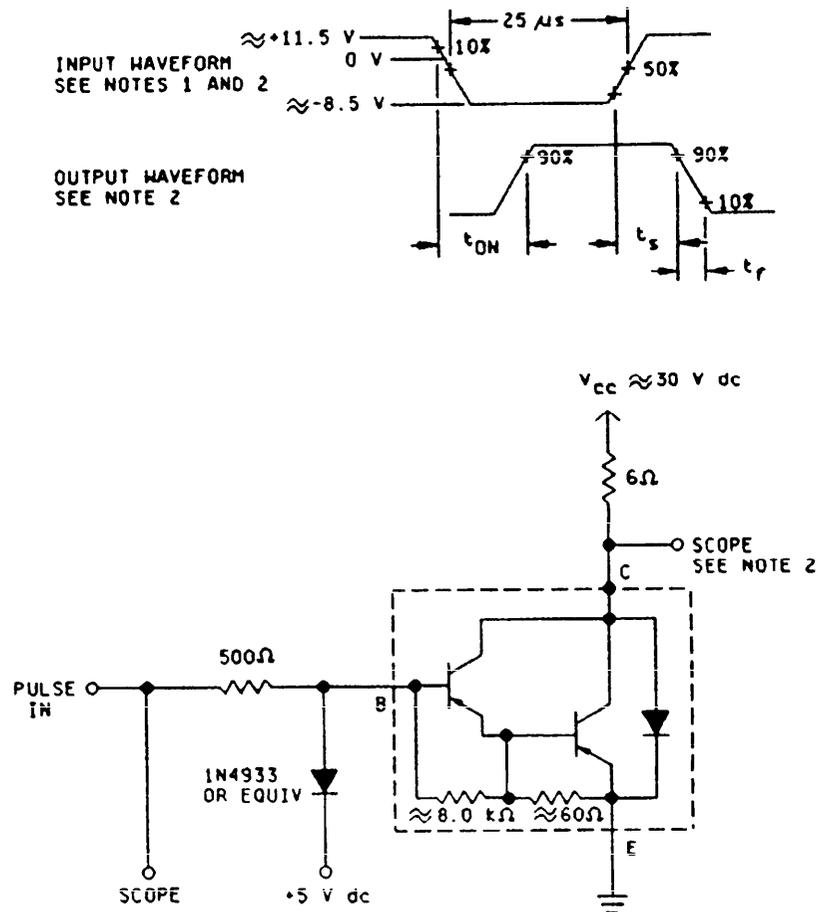


Ltr	Dimensions			
	Millimeters		Inches	
	Min	Max	Min	Max
A	6.32	6.60	.249	.260
A ₁	1.02	1.27	.040	.050
A ₂	3.81 BSC		.150 BSC	
D	20.07	20.32	.790	.800
D ₁	13.59	13.89	.535	.545
e	3.81 BSC		.150 BSC	
E	13.59	13.89	.535	.545
L	30.35	31.37	1.195	1.235
L ₁	16.89	17.40	.665	.685
φP	3.53	3.78	.139	.149
φb	0.89	1.43	.035	.045
Term 1	Base			
Term 2	Collector			
Term 3	Emitter			

NOTES:

1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. All terminals are isolated from case.

FIGURE 1. Dimensions and configuration (TO-254AA).



NOTES:

1. The input waveform is supplied by a pulse generator with the following characteristics:
 $t_r \leq 20$ ns, $t_f \leq 20$ ns, $Z_{OUT} = 50 \Omega$, $PW = 25 \mu s$, duty cycle $\leq 2\%$.
2. Output waveforms are monitored on an oscilloscope with the following characteristics:
 $t_r \leq 20$ ns, $Z_{IN} \geq 20$ k Ω , $C_{IN} \leq 11.5$ pf.
3. Resistors shall be noninductive types.
4. The dc power supplies may require additional by-passing in order to minimize ringing.

FIGURE 2. Pulse response test circuit.

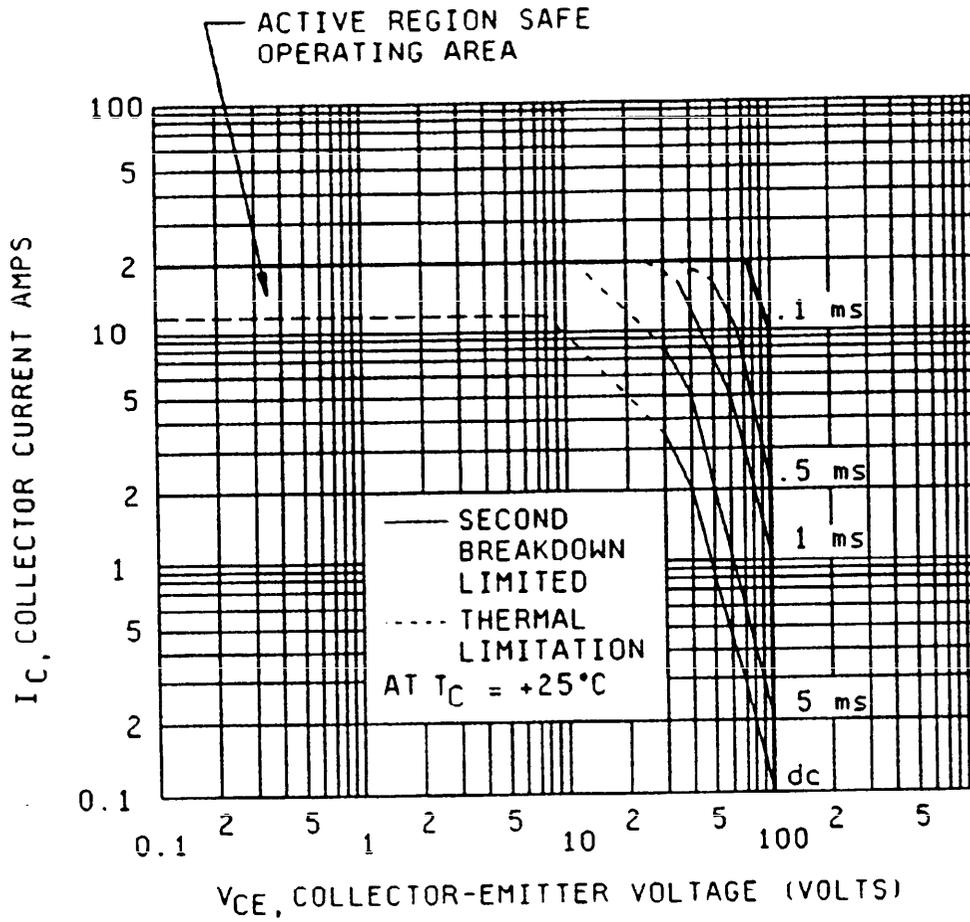


FIGURE 3. Safe operating area.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-S-19500.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Notes. The notes specified in MIL-S-19500 are applicable to this specification.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Lead finish or formation as specified.
- b. Product assurance level and type designation.
- c. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1).

6.3 Interchangeability information. MIL-S-19500/623 is a TO-254 package version of MIL-S-19500/501, which is a TO-3 package version. The military 2N7371 contains the same die as the military 2N6052. The MIL-S-19500/623 is preferred in present designs over the MIL-S-19500/501 whenever interchangeability is not a problem. The 2N7371 should be used in new designs. The 2N6052 is inactive for new design.

CONCLUDING MATERIAL

Custodians:

Army - ER
Navy - EC
Air Force - 17
NASA - NA

Preparing activity:

Navy - EC

Agent:

DLA - ES

Review activities:

Army - AR, MI
Air Force - 19, 85, 99

(Project 5961-1511-02)

User activities:

Army - SM
Navy - AS, CG, MC, OS
Air Force - 13