MIL-S-19500/219A(EL)
2 APRIL 1963
SUPERSEDING
MIL-S-19500/219(SigC)
21 NOVEMBER 1961

MILITARY SPECIFICATION

TRANSISTOR, PNP, GERMANIUM, POWER, SWITCHING TYPES 2N1651, 2N1652, 2N1653

1. SCOPE

1.1 Scope. This specification covers the detail requirements for germanium, PNP, power, switching transistors having the following particular characteristics at $T_A = +25°$ C. (See 3.2 herein.):

	h_{FE}		h_{fe}	V_{BE}(sat)	V_{CE}(sat)	Switching		
	(at: I_C=—10 Adc V_{CE}=—2 Vdc)	(at: I_C=25 A c V_{CE}=—1.5Vdc	(at: f=30 kc I_C=0.5 Adc V_{CE}=—6Vdc	(at: I_C=—25 Adc I_B=—2.5Adc)	(at: I_C=—25 Adc I_B=—2.5Adc	t_r	t_s	t_f
				Vdc	*Vdc*	*usec*	*usec*	*usec*
Minimum	35	20	20					
Maximum	105	.....	.....	0.9	0.65	10	6	5

1.2 Ratings (absolute maximum):

	I_C	P_C[1]	V_{BEO}	V_{CES}	V_{CEO}	V_{CBO}	T_{STG}	Altitude
Type	*Adc*	*W*	*Vdc*	*Vdc*	*Vdc*	*Vdc*	°C	*ft*
2N1651	—25	100	—1.5	—60	—60	—30	—65 to +110	85,000
2N1652	—25	100	—1.5	—100	—100	—60	—65 to +110	85,000
2N1653	—25	100	—1.5	—120	—120	—80	—65 to +110	85,000

[1] At a mounting-base temperature of +25°±3° C. For collector power ratings at higher mounting-base temperatures, see Figure 1 herein.

2. APPLICABLE DOCUMENTS

2.1. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

SPECIFICATIONS

MILITARY

MIL-S-19500—Semiconductor Devices, General Specification For

STANDARDS

MILITARY

MIL-STD-202—Test Methods For Electronic And Electrical Components Parts

MIL-STD-750—Test Methods For Semiconductor Devices

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by

FSC 5960

the contracting officer. Both the title and number or symbol should be stipulated when requesting copies.)

3. REQUIREMENTS

3.1 Requirements. Requirements for the transistors shall be in accordance with Specification MIL–S–19500, and as specified herein.

3.2 Abbreviations and symbols. The abbreviations and symbols used herein are defined in Specification MIL–S–19500 and as follows:

V_{CC} .....Collector supply voltage.
V_{CEO} ....Collector–to–emitter voltage (dc), open base.
V_{CES} ....Collector–to–emitter voltage (dc), base short-circuited to emitter.

3.3 Design and construction. The transistors shall be of the design, construction, and physical dimensions specified on Figure 2 herein.

3.3.1 *Pin arrangement.* The pin arrangement shall be specified on figure 2 herein.

3.3.2. *Operating position.* The transistors shall be capable of proper operation in any position.

3.4 Performance characteristics. The transistor performance characteristics shall be as specified in Tables I, II, and III herein. Except where specifically differentiated for respective transistor types (see 1.1, 1.2, and Tables I, II, and III herein), the performance requirements, including characteristics, ratings, and test conditions, apply equally to all transistor types covered herein.

3.5 Marking. The transistors shall be marked in accordance with Specification MIL–S–19500 and as follows. When the diminutive size or lack of suitable surface area prevents routine marking, on the device, of all items required by Specification MIL–S–19500, the following items may be omitted in the following preferred order: color-band type identification (if specified for the device), country of origin, manufacturer's identification. Where only a minimum of items can suitably be marked on the device, first consideration shall be given to marking the complete type designation (see 3.5.1 herein), and then to inclusion of the acceptance date and inspection lot identification. However, all required marking shall be placed on the unit package.

3.5.1 *Complete type-designation marking.* Complete type-designated marking of transistors procured on Department of Army contracts, and which have passed Government inspection and comply with all requirements of this specification, shall consist of: "USA-manufacturer's qualification code letters-transistor designation (including any assigned reliability indicator)." The letters "JAN" or any abbreviation thereof shall not be used. If any specification waiver has been granted, the combination "USA-manufacturer's qualification code letters" shall not be used to complete the type-designation marking.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. Except as otherwise specified herein, the responsibility for inspection, general procedures for acceptance, classification of inspection, and inspection conditions and methods of test shall be in accordance with Specification MIL–S–19500, Quality Assurance Provisions.

4.1.1 *Responsibility for inspection.* Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Qualification and acceptance inspection. Qualification and acceptance inspection shall be in accordance with requirements in Specification MIL–S–19500, Quality Assurance Provisions, and as otherwise specified herein. Groups A, B, and C inspection shall consist of the examinations and tests speci-

fied in Tables I, II, and III, respectively, herein. Acceptance inspection shall include inspection of Preparation For Delivery (see 5.1 herein).

4.2.1 *Specified LTPD for subgroups.* The LTPD specified for a subgroup in Tables I, II and III herein shall apply for all of the tests, combined, in the subgroup.

4.2.2 *Mechanical damage resulting from tests.* Except for inherently deforming, mutilating, or dismembering mechanical-stress tests to which samples are subjected,

TABLE I. *Group A inspection*

Test Method per MIL-STD-750	Examination or test	Conditions[1]	LTPD	Symbol	Limits Min.	Limits Max.	Unit
	Subgroup 1		10				
2071	Visual and mechanical examination.						
	Subgroup 2		10				
3036	Collector-to-base cutoff current.	Bias Cond. D V_{CB}=—2 Vdc I_E=0	.....	I_{CBO}	.....	—300	uAdc
3036	Collector-to-base cutoff current:	Bias Cond. D I_E=0					
	2N1651	V_{CB}=—60 Vdc	.....	I_{CBO}	.....	—5	mAdc
	2N1652	V_{CB}=—100 Vdc	.....	I_{CBO}	.....	—5	mAdc
	2N1653	V_{CB}=—120 Vdc	.....	I_{CBO}	.....	—5	mAdc
3041	Collector-to-emitter cut-off current:	Bias Cond. D I_B=0					
	2N1651	V_{CE}=—30 Vdc	.....	I_{CEO}	.....	—500	mAdc
	2N1652	V_{CE}=—60 Vdc	.....	I_{CEO}	.....	—500	mAdc
	2N1653	V_{CE}=—80 Vdc	.....	I_{CEO}	.....	—500	mAdc
3041	Collector-to-emitter cut-of current.	Bias Cond. C					
	2N1651	V_{CE}=—60 Vdc	.....	I_{CES}	.....	—50	mAdc
	2N1652	V_{CE}=—100 Vdc	.....	I_{CES}	.....	—50	mAdc
	2N1653	V_{CE}=—120 Vdc	.....	I_{CES}	.....	—50	mAdc
3061	Emitter-to-base cutoff current.	Bias Cond. D V_{EB}=—1.5 Vdc I_C=0	.....	I_{EBO}	.....	—50	mAdc
3076	Static forward-current transfer ratio.	I_C=—10 Adc V_{CE}=—2 Vdc	.....	h_{FE}	35	105	
3071	Collector-to-emitter saturation voltage.	I_C=—25 Adc I_B=—2.5 Adc	.....	$V_{CE(sat)}$	.....	0.65	Vdc
3066	Base-to-emitter saturation voltage.	I_C=—25 Adc I_B=—2.5 Adc	.....	$V_{BE(sat)}$	.....	0.9	Vdc
	Subgroup 3		10				
3306	Small-signal short-circuit forward-current transfer ratio.	V_{CE}=—6 Vdc I_C=—0.5 Adc f=30 kc	.....	h_{fe}	20		
3076	Static forward-current transfer ratio.	I_C=—25 Vdc V_{CE}=—1.5 Vdc	.....	h_{FE}	20		
	Subgroup 4		10				
3251	Switching tests (pulse response):	Test Cond. A V_{CC}=—28 Vdc I_C=—25 Vdc					
	Pulse rise time	I_B(on)=—2.5 Adc	.....	t_r	.....	10	usec
	Pulse storage time	I_B(on)=—2.5 Adc	.....	t_s	.....	6	usec
	Pulse fall time	I_B(off)=—2.5 Adc	.....	t_f	.....	5	usec

[1] See 3.4 herein.

TABLE II. *Group B inspection*

Test Method per MIL-STD-750	Examination or test	Conditions[1]	LTPD	Symbol	Limits Min.	Limits Max.	Unit
	Subgroup 1		20				
2066	Physical dimensions						
	Subgroup 2		15				
2026	Solderability						
1052	Temperature cycling.....	2; Cond. C except: $T_{(high)} = +110° +3° -0°$ C					
1021	Moisture resistance.....	No initial conditioning					
	End-point tests:						
3036	Collector-to-base cutoff current:	Bias Cond. D $I_E = 0$					
	2N1651.....	$V_{CB} = -60$ Vdc	.....	I_{CBO}	.....	—7.5	mAdc
	2N1652.....	$V_{CB} = -100$ Vdc	.....	I_{CBO}	.....	—7.5	mAdc
	2N1653.....	$V_{CB} = -120$ Vdc	.....	I_{CBO}	.....	—7.5	mAdc
3061	Emitter-to-base cutoff current.	Bias Cond. D $V_{EB} = -1.5$ Vdc $I_C = 0$	.....	I_{EBO}	.....	—75	mAdc
3076	Static forward-current transfer ratio.	$I_C = -25$ Adc $V_{CE} = -1.5$ Vdc	.....	h_{FE}	15		
	Subgroup 3		15				
2016	Shock.....	Non-operating G = 1500 5 blows of 0.5 msec ea. in orientations X1, Y1, Y2, Z1 (total = 20 blows)					
2006	Constant acceleration (centrifuge).	G = 5,000 Orientations X1, Y1, Y2, Z1					
2046	Vibration fatigue.....	Non-operating G = 10					
2056	Vibration, variable frequency.	f = 100 to 1000 cps					
	End-point tests:						
	Same as listed under Subgroup 2, above.						
	Subgroup 4		15				
[3]	High-temperature operation:	$T_A = +100°C$, min.					
3036	Collector-to-base cutoff current:	Bias Cond. D $I_E = 0$					
	2N1651.....	$V_{CB} = -60$ Vdc	.....	I_{CBO}	.....	—35	mAdc
	2N1652.....	$V_{CB} = -100$ Vdc	.....	I_{CBO}	.....	—35	mAdc
	2N1653.....	$V_{CB} = -120$ Vdc	.....	I_{CBO}	.....	—35	mAdc
1046	Salt spray (corrosion.						
	End-point tests:						
	Same as listed under Subgroup 2, above.						
	Subgroup 5		20				
2036	Tension.....	Test Cond. A Fixed position = axis of unit vertical Weight (force) = 10 lbs ± 10 oz. t = 30 sec.					

TABLE II. *Group B inspection*—Continued

Test Method per MIL-STD-750	Examination or test	Conditions[1]	LTPD	Symbol	Limits Min.	Limits Max.	Unit
	Subgroup 5—(Cont'd)						
2036	Bolting torque	Test Cond. D Torque = 20 lb./in. t = 30 sec.					
2036	Terminal torque	Test Cond. D Torque = 8±2 oz./in. applied to flat of each terminal t = 30 sec.					
	End-point tests: Same as listed under Subgroup 2, above.						
	Subgroup 6		λ = 10				
1031	High-temperature life (non-operating).	T_{stg} = +110°C. min.					
	End-point tests:						
3036	Collector-to-base cutoff current:	Bias Cond. D $I_E = 0$					
	2N1651	V_{CB} = −60 Adc		I_{CBO}		−7.5	mAdc
	2N1652	V_{CB} = −100 Vdc		I_{CBO}		−7.5	mAdc
	2N1653	V_{CB} = −120 Vdc		I_{CBO}		−7.5	mAdc
3061	Emitter-to-base cutoff current.	Bias Cond. D V_{EB} = −1.5 Vdc $I_C = 0$		I_{EBO}		75	mAdc
3076	Static forward-current transfer ratio.	I_C = −10 Adc V_{CE} = −2 Vdc		h_{FE}	20		
3041	Collector-to-emitter cutoff current:	Bias Cond. D $I_B = 0$					
	2N1651	V_{CE} = −30 Vdc		I_{CEO}		750	mAdc
	2N1652	V_{CE} = −60 Vdc		I_{CEO}		750	mAdc
	2N1653	V_{CE} = −80 Vdc		I_{CEO}		750	mAdc
	Subgroup 7		λ = 10				
1026	Steady state operation life.	T_C = +85°C, min. P_C = 25 W					
	End-point tests: Same as listed under Subgroup 6, above.						

[1] See 3.4 herein.
[2] Per Method 102 in Standard MIL-STD-202.
[3] Measurement shall be made after thermal equilibrium has been reached at the temperature specified.

there shall be no evidence of mechanical damage to any sample as a result of any of the Groups A, B, or C tests.

4.2.3 *Destructive tests.* The Group B, Subgroups 2, 3, and 4 tests are considered destructive. However, the tests of Subgroups 2 and 3 can be considered non-destructive if sufficient evidence is presented to the inspection authority to that effect. Acceptable evidence, for example, would be repeating of all Subgroup 2 and 3 tests, ten times, without significant device degradation. This test repetition procedure need be done only once at inception of acceptance inspection, provided no change in design, or of production techniques, has been effected.

4.2.4 *Disposition of sample units.* Sample units subjected to Group B, Subgroup 4 tests shall not be delivered on the contract or order. Sample units that have been subjected

TABLE III. *Group C inspection*[1]

Test Method per MIL-STD-750	Examination or test	Conditions	LTPD	Symbol	Limits Min.	Limits Max.	Unit
	Subgroup 1		15				
3126	Thermal resistance (junction-to-case).	.....	.....	θ_{J-C}	.....	0.8	°C/W
1001	Barometric pressure, reduced (altitude operation):	Pressure: 15 mmHg t=1 min.					
3036	Collector-to-base cutoff current:	Bias Cond. D $I_E=0$					
	2N1651.....	$V_{CB}=-60$ Vdc	.....	I_{CBO}	.....	—7.5	mAdc
	2N1652.....	$V_{CB}=-100$ Vdc	.....	I_{CBO}	.....	—7.5	mAdc
	2N1653.....	$V_{CB}=-120$ Vdc	.....	I_{CBO}	.....	—7.5	mAdc

[1] Periodicity for Group C inspection=Initial lot, and thereafter on a lot every 90 days or every 5th lot, whichever occurs first.
[2] See 3.4 herein.

to and have passed Group B, Subgroup 2 and 3 tests not determined to be destructive tests may be delivered on the contract or order provided that, after Group B inspection is terminated, those sample units are subjected to and pass Group A inspection. Defective units from any sample group that may have passed group inspection shall not be delivered on the contract or order until the defect(s) has been remedied to the satisfaction of the Government.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery. Preparation for delivery shall be in accordance with Specification MIL-S-19500.

6. NOTES

6.1 Notes. The notes included in Specification MIL-S-19500, with the following exceptions, are applicable to this specification.

6.2 Re-evaluation or verification inspection. The LTPD method is exceptionally well suited for inspection at source, since it provides a high degree of assurance (90 percent confidence) that the lot represented has a proportion defective less than the specified LTPD value. However, the LTPD method is not suitable for inspection performed subsequent to source inspection since it provides, at most, a 10 percent confidence that the lot represented by a failed sample actually contains a proportion defective in excess of the specified LTPD value. As a result, whenever the quality of a lot is re-evaluated or verified by sampling inspection subsequent to the supplier's satisfactory demonstrations of compliance with the quality requirements, lot disposition should be based on a sampling plan which provides reasonable assurance that any lot rejected contains a proportion defective greater than the specified LTPD or λ value for any individual subgroup. When deemed necessary, the purchase order should specify the detailed criteria for lot disposition.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in Qualified Products List (QPL)-19500, supplement (Army), whether or not such products have actually been so listed by that date. Information pertaining to qualification of products covered by this specification should be requested from the Chief, Standardization Engineering Division, U. S. Army Electronics Materiel Support Agency, Fort Monmouth, N. J., attention: SELMS-PSM-3.

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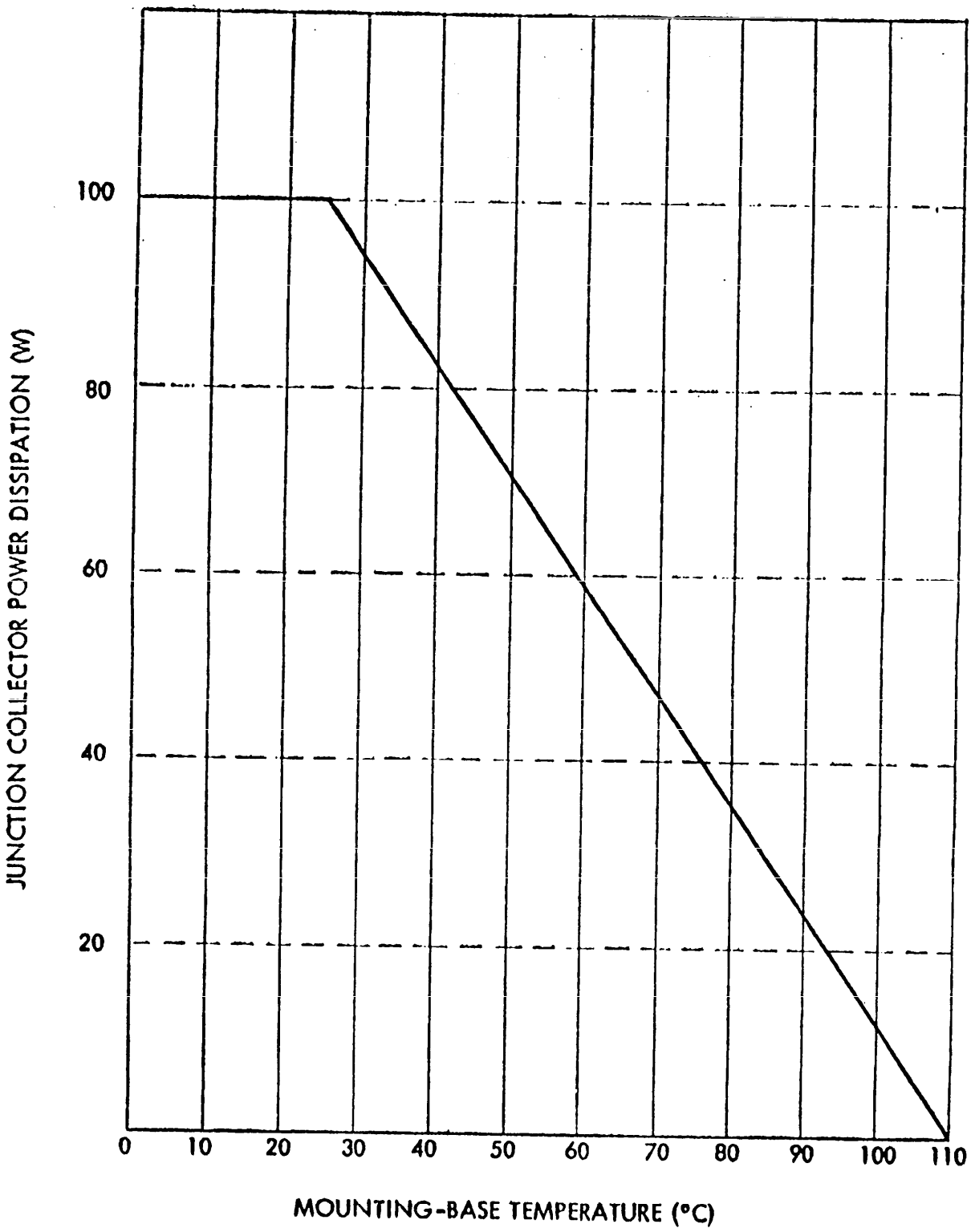
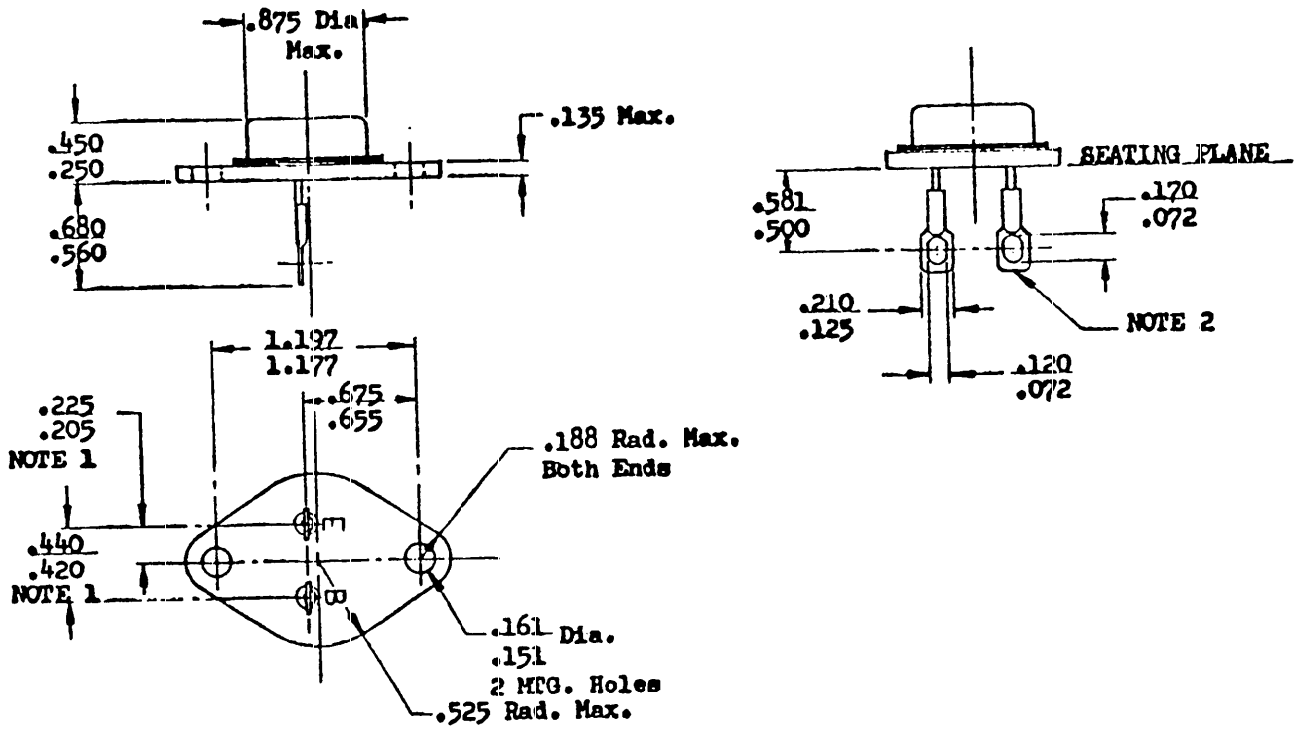


FIGURE 1. *Power dissipation curve.*



NOTES:

1. THESE DIMENSIONS SHOULD BE MEASURED AT POINTS .050 TO .055 BELOW SEATING PLANE. WHEN GAGE IS NOT USED, MEASUREMENT WILL BE MADE AT SEATING PLANE.
2. SQUARE OR RADIUS ON END OF TERMINAL AND/OR HOLE OPTIONAL.
3. ALL DIMENSIONS IN INCHES.
4. COLLECTOR SHALL BE INTERNALLY CONNECTED TO MOUNTING BASE.

FIGURE 2. *Outline and dimensions.*

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