THE EMPIRICAL RELATION BETWEEN TIME AND INTENSITY OF
APPLIED THERMAL ENERGY IN PRODUCTION OF 2+ BURNS IN PIGS

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ABSTRACT

The combined experience of several investigators in this laboratory is cited to show that within the limitations of experimental conditions the 50% effective radiant exposure required to produce a 2+ burn on Chester White pigs may be given by the alternative expressions

$$Q_c = 4.39 t^{0.224}$$

or

$$Q_c = 6.73 H^{-0.289}$$

where Q_c = critical energy of 50% effective radiant exposure for 2+ burn (cal/cm²)

H = irradiance (cal/cm²/sec)

t = time of exposure (sec), (*auth*)

METHODS

This report summarizes the experience of this laboratory, both published and unpublished, of the 2+ burn thresholds of Chester White pig skin to "square-wave pulses" of radiant energy from a carbon arc source (1). Though the burns have been assessed by five investigators over a four year period in the course of various types of experiment, the basic technics and criteria have been uniform, as defined in detail in earlier publications (2, 3).

RESULTS

Tables 1 - 3 give the dose-response data previously unreported. This information was obtained in the course of several different experiments in this laboratory, which are to be reported in fuller detail.

The synthesis of these data with those previously reported is presented in table 4. The thresholds for 2+ burns are expressed as the 50% effective radiant exposures with their 95% confidence intervals, as calculated by the graphical probit method of Litchfield and Wilcoxon (4).

These figures are plotted on a double logarithmic scale in Fig. 1. It will be seen that within the limits of observation these points approximate a straight line. The linear fit of these points, as obtained by the method of least squares, yields the equation

$$Q_c = 4.39 t^{0.224}$$

The solid line of Fig. 1 is the graphic expression of this statement.

Since $Q = tH$, where $H =$ irradiance in cal/cm²/sec, the time dependency of radiant energy dosage may be expressed alternatively as irradiance dependency, i. e.

$$Q_c = 6.73 H^{-.289}$$

and these two expressions are completely equivalent and interchangeable.

DISCUSSION

It will be noted that this empiric statement is approximately true within the range of exposures from 0.1 to 30 sec and of irradiances from 0.3 to 37 cal/cm²/sec. No theoretic significance, either explicit or implicit, is attached to the equations just stated above. Thus, there

is no justification for extending the application of either of these formulae beyond the limits experimentally explored. It is also to be understood that the foregoing analysis is based upon the superficial gross appearance at 24 hours, and does not take into account such important features as depth of damage, edema production or healing time.

It is felt that the simple mathematical expression of the data given in table 14, representing as it does 1593 burns in over 200 pigs, has practical utility as well as measurable statistical validity.

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Table I

T Sec	H (Cal/cm ² /sec)	Q (cal/cm ²)	0	1+		2+			3+
				Mild	Sev	Mild	Mod	Sev	
1.0	3.6	3.6		15	4	1			
	4.0	4.0		4	13	3	1		
	4.4	4.4		1	8	9	2		
	4.8	4.8			5	7	7	1	
	5.2	5.2				5	8	7	

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Table II

T Sec	H (Cal/cm ² /sec)	Q (Cal/cm ²)	0	1+		2+			3+
				Mild	Sev	Mild	Mod	Sev	
1.5	2.8	4.2		6	4	2			
	3.0	4.5		4	6	2			
	3.2	4.8		1	5	5	1		
	3.5	5.2			2	8	2		
	3.8	5.7				8	2	2	
2.0	2.2	4.4		7	4	1			
	2.4	4.8		5	5	2			
	2.6	5.2		4	2	5	1		
	2.8	5.6			3	3	4	2	
	3.0	6.0			2	4	5	1	
3.0	1.6	4.8		6	4	2			
	1.8	5.4		3	5	4			
	2.0	6.0			4	7	1		
	2.2	6.6			1	3	6	2	
	2.4	7.2			2	1	7	2	

Table III

t Sec	H (Cal/cm ² /sec)	Q (Cal/cm ²)	0	1+		2+			3+
				Mild	Sev	Mild	Mod	Sev	
4	1.3	5.2	1	5					
	1.65	6.6		2	3	1			
	1.84	7.36			3	3			
	2.1	8.4				2	1	2	1
7	.71	5.0	6						
	.86	6.0		4	2				
	1.08	7.6	1	0	4	1			
	1.3	9.1				3	2	1	
	1.65	11.6							1
10	.60	6.0		5	1				
	.71	7.1			5	0	0	1	
	.86	8.6		1	0	4	0	1	
	1.08	10.8					1	4	1
	1.3	13.0							1
12	.41	4.9	1	2	1				
	.51	6.1		2	4				
	.60	7.2			1	2	3		

	.71 .86 1.08	8.5 10.3 13.0		8		4	2 3	3 1	1
15	.41 .51 .60 .71 .86	6.2 7.7 9.0 10.7 12.9	1	2 2	1 4 1	2	3 3	2 2	1
20	.36 .41 .51 .60	7.2 8.2 10.2 12.0		5	1 3	3 3	2	1 4	2
25	.35 .36 .41 .51	8.8 9.0 10.0 12.5		1	3 3 1	1 2 2 1	1 1 1 2	2 3	
30	.24 .31 .35 .36 .41	7.2 9.3 10.5 10.8 12.3		3	1 5	1 3 3	3 3 1	1	

Table IV

t (sec)	Q (cal/cm ²)	95% Confidence Interval	Number of Burns	Source
0.1	3.0	2.7 - 3.2	108	Ref. 2
0.3	3.2	3.0 - 3.4	192	Ref. 2
0.5	3.2	2.9 - 3.5	120	Ref. 3
0.5	3.5	3.3 - 3.7	120	*
0.5	3.9	3.6 - 4.2	120	*
1.0	4.45	4.26 - 4.6	100	Table I
1.0	4.3	3.9 - 4.8	191	Ref. 2
1.5	4.8	4.6 - 5.0	60	Table II
2.0	5.27	5.0 - 5.6	60	Table II
3.0	5.6	5.3 - 6.0	60	Table II
4.0	7.2	6.4 - 8.1	24	Table III
5.0	5.4	5.1 - 5.7	183	Ref. 2
7.0	8.0	6.9 - 9.2	30	Table III
9.0	7.0	6.6 - 7.4	69	Ref. 2
10.0	7.8	7.1 - 8.5	30	Table III
12.0	6.6	6.0 - 7.3	30	Table III
15.0	8.5	7.9 - 9.2	24	Table III
20.0	8.2	7.6 - 8.8	24	Table III
25.0	9.0	8.1 - 10.0	24	Table III
30.0	9.7	9.1 - 10.3	24	Table III
			<u>1593</u>	

* Data of K. M. Berkley, 1953 to be published.

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CUTANEOUS BURN AS A FUNCTION OF EXPOSURE TIME:
50% EFFECTIVE DOSE OF RADIANT ENERGY REQUIRED
TO PRODUCE 2+ BURN IN CHESTER WHITE PIGS.

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