#### PRINCETON PLASMA PHYSICS LABORATORY ES&H DIRECTIVES

ES&HD 5008 SECTION 2

ELECTRICAL SAFETY



DATE: 2/1/95

CHAPTER 17, REV. 3

PAGE 1 OF 2

# ATTACHMENT H SAMPLE CALCULATIONS OF ENCLOSED AC ARC OVERPRESSURES

#### INTRODUCTION

Converting copper conductors into a plasma as a consequence of short circuit energy can be approximated using a few assumptions. Calculations which use these assumptions can give an estimated pressure change for a fixed volume.

## CONDITIONS

Initial conditions consist of an electric circuit that has sustained a solid/bolted polyphase fault of 110 kA which is presumed to flow for 5 cycles within an enclosed cubicle. Shock wave effects are neglected in favor of a uniform pressure rise. This event is presumed to occur adiabatically.

### **CHARACTERISTICS OF COPPER**

Melting Point	1085°C
Boiling Point	2567°C
Specific Heat, Solid	0.0923 Calories/gram at 20°C (varies with temperature)
Specific Heat, liquid	0.118 Calories/gram
Latent heat of fusion	49.0 Calories/gram
Latent Heat of Vaporization	1130.3 Calories/gram
Atomic Weight	63.5 grams/mole
Density	8.92 grams/cc <sup>3</sup>

### **EQUIVALENCIES**

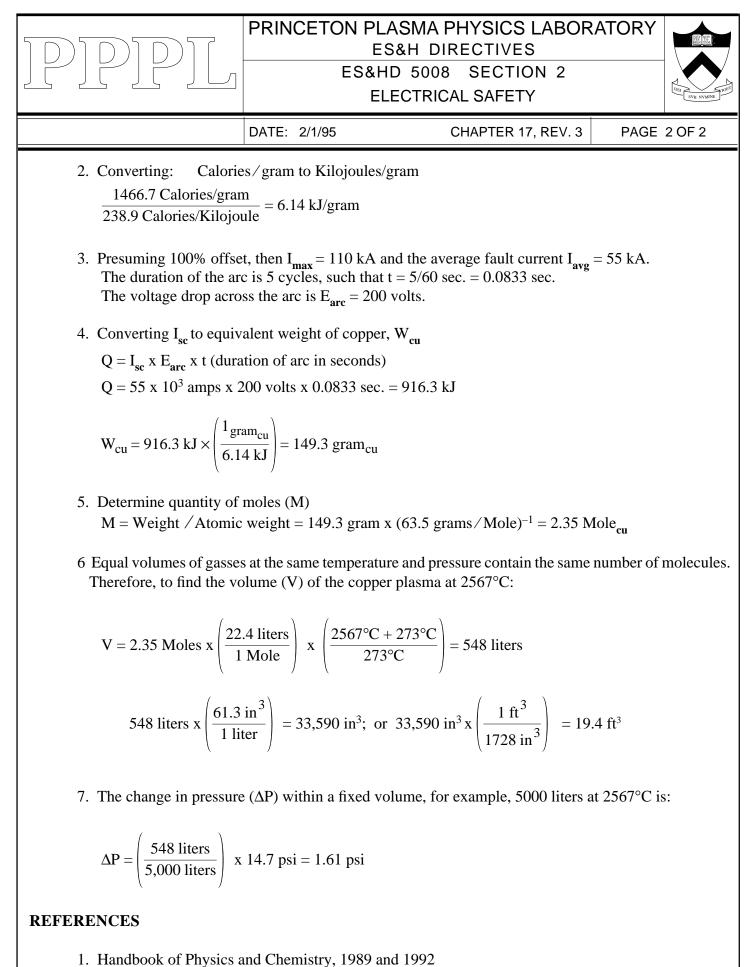
238.9 Calories/gram	. 1.0 kilojoule/gram
61.3 in <sup>3</sup>	ş 6
1 Mole	$6.02 \times 10^{23} \text{ Atoms}_{Cu}$ (Molecules)
1 Mole Volume	Cu

# CALCULATIONS

1. To vaporize 1 gram of Copper from 20°C ( $C_p = 0.0923$ ) to 1085°C ( $C_p = 0.1189$ ); ( $C_{Pavg} = 0.1056$ )  $Q_{total} = Q_1 + Q_2 + Q_3 + Q_4$ 

= 1466.7 Calories/gram

 $\begin{array}{rcl} Q_1 = 0.1056 \ x \ (1085 - 20) &=& 112.5 \ Calories \\ & At \ 1085^\circ C, & Q_2 &=& 49.0 \ Calories \\ From \ 1085^\circ C \ to \ 2567^\circ C \\ Q_3 &=& 0.118 \ x \ (2567 - 1085) &=& 174.9 \ Calories \\ Q_4, \ heat \ of \ vaporization &=& 1130.3 \ Calories \\ \end{array}$ 



2. Metals Reference Handbook, 9th Ed. 1979; American Society of Metals