

downwind, then the burn rate is equal to the rate of evaporation. If volatilized chemicals are carried downwind, then the rate of evaporation must exceed the burn rate.

Again Applicant has ignored basic concepts of combustion which were clearly discussed in Applicant's reference. For Applicant to simply ignore such basic concepts when they are in conflict with Applicant's analysis, again raises doubts regarding the competency and credibility of the Applicant's evidence in support of its application.

*4. Applicant's Response to Questions on the Relationship Between Radiant Heat Transfer
from the Flame and Evaporation Rate of Waste Fuel*

Finally, Applicant responds to the question as to why its method of estimation of evaporation from a burning pool of hazardous waste fuel did not include a consideration of radiant heat transferred from the flame to the pool surface.

Due to the high volatility of the mixture, the incorporation of radiant heat would have resulted in an instantaneous release of the entire content of the pool. This is contrary to experience and intuition and would not be compatible with our philosophy of using conservative assumptions in light of uncertainties.

Id.

On page 145 of Peters, Applicant's reference on elementary chemical engineering, the following is written:

Radiant energy is emitted in all directions by a body. If this energy can contact a receiver, some of the energy will be absorbed by this receiver. The flow of heat from a hot body to a cold body in this manner is known as heat transfer by thermal radiation.

If radiant heat is emitted by a body in all directions, why does Applicant conclude that radiant heat would not strike and warm the surface of a pool of liquid hazardous waste fuel?

Applicant's cited reference Ndubizu observed that radiant heat is a factor in heat flow to the surface of pools of liquid fuels. In Table 4 of Ndubizu, terms for both radiant heat ($q_{r,net}$) and convection heat ($A_s h_c (T_f - T_a)$) transfer to the surface of pools are reported. It can be observed that as the diameter of the fire increases from 15 to 130 cm, the ratio of radiant heat to convective heat transfer to the pool surface increases from about 2 to about 12 for gasoline and kerosene fires.

Again Applicant's statements raise serious doubts regarding the competency and credibility of the Applicant's evidence in support of its application. Once again Applicant has ignored basic concepts of Applicant's references Peters and Ndubizu. This time Applicant's arguments are in violation of the law of radiant heat transfer which is defined in the reference Peters. Also, Applicant's statements are in direct contradiction to the data of Applicant's reference Ndubizu.

*K. REVIEW OF THE TECHNICAL ARGUMENTS IN CD 2.35, APPLICANT'S REQUEST
FOR RECONSIDERATION*

In CD 2.35 Applicant requests that the Board reconsider its decision of March 23 to deny Applicant's permit application. Applicant claims that errors were made by Mr. Brown in his presentation to the Board at the March Board meeting. A review of Applicant's technical arguments is now presented here in section *K* of this Opinion and Final Order.

The first question to be considered is whether or not CD 2.35 contains additional fundamental errors and also attempts by the applicant to mislead the Board regarding the facts already presented in the record. If CD 2.35 is free of such errors and misrepresentations, then consideration could be given to whether or not CD 2.35 contains any new information which would inspire new confidence in the competency and credibility of Applicant's evidence in support of its application.

In CD 2.35 at 1 Applicant states:

given adequate opportunity and time to respond, the Applicant and its consultant feel confident that they can adequately respond to all of the Board's questions and comments. A discussion addressing several of the topics raised at the hearing illustrates this point.

It is noted that Applicant has now had five months since the March Board meeting to prepare CD 2.35. This should have been more than enough time and opportunity for Applicant and its consultant's most able staff to prepare an error free document. Therefore, it is fair to say that CD **2.35** should be representative of Applicant's best technical skills and a true test of Applicant's competency and credibility in the presentation of evidence in support of its application.

1. Applicant Claims the First Law of Thermodynamics Was Not Violated by Applicant's Model

In CD 2.35 at 3 Applicant states:

We disagree that we have stated that heat transfer coefficients are equal in the flame and in the surrounding region. Intuitively speaking, we would expect flame and environment heat transfer coefficients to be different.

It is noted that this is a dramatic departure from Applicant's arguments in CD .97 at I-9 through I-10 where Applicant equates the gas film coefficient of heat transfer for the turbulent flow of fluids inside a circular pipe with the coefficient of heat transfer due to natural convection of gases. Now in CD 2.35, Applicant no longer uses Peter's equation for the coefficient of heat transfer due to natural convection.

It was the equating of the gas film coefficient of heat transfer for the turbulent flow of fluids inside a circular pipe with the coefficient of heat transfer due to natural convection of gases which lead to Dr. Pinto's conclusion that Applicant's arguments violated the **first** law of thermodynamics. These changes in Applicant's arguments-are recognized as a positive step and they indicate that Applicant is no longer insisting that Applicant's equation ten can be equated with Applicant's equation eleven as was presented by Applicant in CD .97 at I-9 through I-10 and again defended by Applicant in CD **2. 30** at **5-6**.

In CD **2. 35** at **3-5**, Applicant presents new arguments regarding flame heat balances and states:

The mathematical formula for heat transfer under this type of flow is:

$$q_2 = h_2 * A_2 * 0.0144C_p G^{0.8}/D^{0.2}$$

where C_p = heat capacity of air at constant pressure,
 G = mass flow rate of gas, and
 D = equivalent diameter of spill.

Id. at 4.

Now from CD. 97 at **I-8**, Applicant's equation 10 is:

$$h = 0.0144C_p G^{0.8}/D^{0.2} \text{ where:}$$

h = the gas film coefficient of heat transfer for turbulent flow inside a circular pipe and the units are defined in Peters at 140 as Btu/(hour)(ft²)(°F) and C_p , G , and D are defined as above.

Applicant does not define the units of h_2 in CD 2.35. However, since it is a heat transfer coefficient, in a consistent system of units, its units would also be $\text{Btu}/(\text{hour})(\text{ft}^2)(^\circ\text{F})$.

It follows by substitution that Applicant's equation becomes:

$$q_2 = h_2 * A_2 * 0.0144C_p G^{0.8}/D^{0.2} = h_2 * A_2 * h$$

In a consistent units system, the units in the equation would be Btu/hour on the left side and $\text{Btu}^2/(\text{hour}^2)(\text{ft}^2)(^\circ\text{F}^2)$ on the right side which is not possible in a valid equation.

Again, as in the spill scenario into a stream discussed under I. above, Applicant ignores the necessity of verifying the consistency of units in Applicant's equations. This time the error was not simply in regard to the magnitude of a parameter, but rather, the error totally invalidates Applicant's argument. Applicant's repetition of such a grave error can only reaffirm the Board's doubts regarding the competency and credibility of Applicant's evidence in support of its Application.

Again, the verification of units is such a fundamental test and also such an easy test to perform, that it does not seem possible that CD 2.35 had been reviewed by Applicant's quality control group. It is especially difficult to understand how this error could have been made when the Applicant knows that the Board has checked the units in Applicant's equations in previous

reviews of Applicant's documents. Such errors can only cause doubts in every calculation and argument presented by the Applicant.

Applicant concludes its arguments on the violation of the first law of thermodynamics as follows:

Since the area has not changed and none of the factors that make up the heat transfer coefficients have changed, then $A_1 = A_2$ and $h_1 = h_2$. Thus both the A and h terms may be cancelled out. *This is the form of the equation that was used in the risk assessment. (Emphasis added.)*

When this cancellation of terms is completed, Applicant's equation becomes:

$dt = 0.0144 C_p G^{0.8} / D^{0.2} = h$, where h is Peter's coefficient for heat transfer for turbulent flow in a pipe, CD .97 at I-9, and where dt is the difference in temperature inside and outside the cylinder (t in - t out), CD 2.35 at 4.

Now an equation were $dt = h$ would have the units of °F on the left and Btu/(hour)(ft²)(°F) on the right. This is another invalid equation where Applicant has failed to verify Applicant's own work by a test of the units of the equation.

It is also noted that this equation does not exist in CD .97, which is contra to the sentence emphasized above in Applicant's statement.

In conclusion, Applicant's arguments regarding the violation of the first law of thermodynamics

contain two equations with errors in units and at least one sentence which is an attempt by Applicant to mislead the Board. These actions of Applicant can only **reaffirm** the Board's doubts of the competency and credibility of Applicant's evidence in support of its application.

2. *Applicant Claims Mr. Brown Erred When He Asserted that the Evaporation Rate Must at Least Equal the Bum Rate*

In CD 2.35 at 2, Applicant states:

We disagree with this assertion. The analysis of Ndubizu et al.(1983) consistently predicts bum rates that exceed volatilization rates by large factors. *The physical reason for this is that the bum rate (or mass flow rate out of the combustion zone) is assumed to include entrained air and mass added by combustion chemical reactions.* (Emphasis added.)

It should be noted that Applicant fails to cite the page in Ndubizu et al. (1983) where the bum rate is defined in the manner as emphasized in the above statement. Nor does Applicant provide a cite to CD .97 or CD 2.30 where bum rate is defined as emphasized in the above quote.

In Applicant's model of the fire, the bum rate is the rate of flow of organic fuels into the fire, not the total mass flow out of the combustion zone as stated above. In CD .97 at I-2 and I-3, Applicant calculated the bum rate to be 9.97 kg/s. In the table at page I-6, *Id.*, Applicant indicated that the mass flow of xylene and isopropyl benzene into the fire were 18,028 and 17,864 kg/hour, respectively. The sum of the rates of mass flow of these to organic fuels into the flame is 35,892 kg/hour which is equivalent to the bum rate of 9.97 kg/sec. This result negates Applicant's definition of the bum rate as emphasized in the above quote.