In the Board staff verification process and as a check of the Board staffs calculation of evaporation rate presented above, this rate was summed over all constituents of a typical hazardous waste fuel and then converted to units of grams per second. The result was an average evaporation rate of about 242 grams per second, which is also about 1/40th of the bum rate presented by Applicant. This confirms the Board staffs calculation above which showed underestimation of the total air emissions from the fire by at least a factor of 40.

The validity of staffs conclusion that Applicant has underestimated air emissions by at least a factor of 40 might be questioned if the chemical constituents listed in Table 1.1-3, CD .97 at I-15, were only a subset of the constituents of a typical hazardous waste fuel. Therefore, it is important to compare the constituents of a typical hazardous waste fuel as identified in Table 4.1-1 , CD .97 at 4-3, with the chemical constituents found in Table I. l-3, CD .97 at I-15. Each table contains the same list of 32 organic chemicals which add up to 87% of the mass. Table 4. l-l identifies the remainder of the mass as 11% water and 2 % inerts. In conclusion, the chemical constituents listed in Table I. l-3 do represent the total organic composition of a typical hazardous waste fuel rather then a subset of possible organic constituents in a hazardous waste fuel and the validity of Board staffs calculation is sustained.

Underestimation of possible air emissions must raise serious doubts regarding the competency and credibility of the Applicant's evidence in support of its application. In this case it is especially distressing that Applicant did not consider Applicant's reference Ndubizu's statements

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regarding the relationship between evaporation rate and heat generation in the fire. Due consideration of Applicant's reference Ndubizu should have suggested to Applicant the need for Applicant to ***verify*** its air emission estimates in the manner as was done by Board staff.

Finally, the validity of the equation Applicant selected for the calculation of evaporation rates from a pool under a fire condition is questioned. Applicant's reference, MacKay and Matsubu at 424, make the following statement regarding the applicability of their equation:

> The problem considered here is that of determining the rate of evaporation of a given oil spill as a function of temperature, wind-speed, atmospheric conditions, *solar radiation,* ground or sea conditions, (i.e. roughness), the dimensions of the oil spill and the volatility and diffusion characteristics of the oil. (Emphasis added.)

No mention was found in MacKay and Matsubu regarding the determination of evaporation rates from pools of burning fuels. As emphasized above, the variable considered was solar radiation. For a fire scenario, radiation from the flame would be expected to be the dominant influence rather then solar radiation. While Applicant announced that some modifications to the MacKay and Matsubu equation were employed before calculating emission rate, a demonstration that said modifications would yield *accurate* estimates of evaporation rates in a fire scenario was not provided.

Again, the manner in which Applicant uses the information of Applicant's references raises very serious doubts regarding the competency and credibility of the Applicant's evidence in support of its application. It is not credible to simply take an equation from a paper, make unsupported

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modifications on inputs to the equation and then assume that the calculated outputs are related to the problem at hand. At a minimum, Applicant should have conducted some test to confirm that the modified equation is giving reasonable outputs.

9. Inconsistency Between Applicant's DRE and Ndubizu's Combustion Efficiency

In CD .97 at Table I. *l-3, the* DRE values for organic components of a typical hazardous waste fuel vary from 0.93956 to 1 for all but three components, and varies from 0.45412 to 0.68994 for the remaining components which were trichloroethylene, tetrachloroethylene, and 1,2-dichloroethane. It is also observed that these three chlorinated components only make up about 0.5 percent of the mass of organic materials in a typical hazardous waste fuel. Thus, the DRE for the greatest portion of a typical hazardous waste fuel in Applicant's fire scenario is between 0.93956 and 1.

In CD .97 at I-10, Applicant states that a theoretical value for DRE of an individual chemical compound can be calculated based upon the assumption that its combustion is a first order kinetic process. Also in CD .97 at I-5, Applicant presents combustion as a reaction where the fuel combines with oxygen producing CO_2 and H_2O. These statements show that in Applicant's calculations, DRE and combustion efficiency are the same. That is, if the combustion efficiency of xylene is 99 percent, then its DRE is also 99 percent. It then follows from the preceding paragraph that in Applicant's fire scenario, the overall combustion efficiency of components of

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a typical hazardous waste fuel would be between 93.956 and 100 percent.

In Applicant's reference Ndubizu combustion efficiency is presented as a fraction of the heat of combustion which is actually released in the fire. This implies one of two situations. First, it could mean that a portion of fuel is consumed in the fire to produce CO_2 and H_2O and a portion of the fuel passes through the fire without an alternation of its chemical form. In this situation, the Ndubizu's combustion efficiency and Applicant's DRE values are equivalent. Second, combustion efficiency could mean that fuel is altered in chemical form by the fire but not converted to CO_2 and H_2O and as a result only a portion of the heat content of the fuel is released to the fire. In this case, products of incomplete combustion would be forming, a smaller portion of the fuel carbon is converted to CO_2, and therefore, the total carbon emissions would be greater than in the first case. In the discussion to be presented it is assumed that Ndubizu's combustion efficiency is equivalent to Applicant's DRE to obtain a first approximation of possible air emissions from a fire. However, it is seen here that emissions would even be higher if consideration were given to products of incomplete combustion forming in the fire.

In Applicant's reference Ndubizu's at 239 in Table II, the combustion efficiency for pools less than 100 cm diameter was estimated to be about 95 percent for methanol fires and 73 percent for kerosene fires. Ndubizu at 240 estimated that for pools greater than 100 cm diameter, as the diameter increases, combustion efficiency should decrease. In models of fires for pools greater

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than 100 cm diameter, a combustion efficiency of 64 percent was recommended as a **likely** value.

The possible air emissions from a fire based upon Ndubizu's lowest combustion efficiency value, rather than Applicant's DRE values, are summarized below.

1. In general form: emissions = (1-DRE)*bum rate

2. Based upon the Applicant's DRE values of 0.93956 to 1 for most hazardous waste constituents:

   Emissions c (1 - 0.93956)*(burn rate) or < 0.06044*(burn rate)

3. Based upon Ndubizu's lowest combustion efficiency estimate 0.64 for fires exceeding 100 cm in diameter:

   emissions are about (1 - 0.64)*(evaporation rate) or 0.36*(evaporation rate)

4. Therefore, emissions based upon Ndubizu's combustion efficiency would be about *six* times greater than emissions based upon the Applicant's DRE values.

In conclusion, if Applicant's cited reference Ndubizu's combustion efficiency of 0.64 had been used in the air emission calculations instead of Applicant's DRE values, the air emissions from an open fire would have been approximately 6 times[22] greater than Applicant's estimate. When this factor of 6 is included with the previous factor of 1/40, it is possible that the Applicant's air emission estimate is only 1/240th actual air emissions.

[22]In Mr. Brown's presentation at the March 23rd meeting, he stated that air emissions would have been nine times greater if Applicant used the bum efficiency of 0.64, as the DRE value. As shown *infra,* the correct factor is six times air emissions.

Again, the manner in which Applicant uses the information of Applicant's references raises very serious doubts regarding the competency and credibility of the Applicant's evidence in support of its application. As no discussion is provided, it is difficult to understand how the Applicant could have ignored the great difference between Applicant's_estimate of DRE and the Applicant's reference's estimate of combustion efficiency. This difference dramatically brings into question the credibility of the Applicant's calculations.

I. SCENARIO OF SPILL INTO BEAVER CREEK

Applicant presents an assessment of the impact of the hypothetical spill of a truck load of hazardous waste fuel into Beaver Creek resulting from a highway accident on the I-675 bridge. As a worse case scenario, it is assumed that the entire contents of the truck were released into the creek. CD .97 at J-l.

The resulting concentrations of pollutants entering the creek at position "x" downstream from the spill at time "t" were calculated as:

$$C(x,t) = \frac{M}{2A*(\pi*E_x*t)^{0.5}} * \exp\left\{\frac{-(x - U*t)^2}{4E_x*t}\right\}$$

where the units of the parameters were defined by the Applicant as:

term	units
C(x,t)	mg/L
M	kg
t	sec
x	m
A	m^2
E_x	m^2/sec
U	m/sec

CD .97 at *J-2*

Substitution of units into the exponential portion of the equation yields a dimensionless fraction, as would be expected. Substitution of units into the non exponential portion of the equation is presented as:

$$C(x,t) = mg/L = \frac{kg}{m^2 * ((m^2/sec) * sec)^{0.5}}$$

$$= kg/m^3 = kg/1000L = g/L$$

On the left side are units in mg/L, which are specified by the Applicant. However, on the right side of the equation are units in g/L. It would appear that Applicant has underestimated possible pollutant concentrations in the creek by a factor of 1000.

Again, this error raises very serious doubts regarding the competency and credibility of the Applicant's evidence in support of its application. In this case, the credibility of quality assurance and quality control procedures comes into question. In engineering or scientific calculations, the initial step in any calculation is to verify that the units of all parameters are consistent. Likewise, the first factor a reviewer checks when verifying a calculation is, also, that the units of the parameters are consistent. While such errors may appear in early drafts of a plan or a report, they should *not* appear in a final document presented for approval.

J. RESPONSE OF APPLICANT TO BOARD STAFF INQUIRY

In CD 2.24, the Board staff informed the parties that:

> Staff has reviewed the documents in the record. In particular, our review of the Siting Criteria Document (CD .97) indicated several calculations and/or assumptions that are unclear. Staff is of the opinion that there is a duty upon the State, as a permit decision making authority, to take a rigorous examination, including verification, of submitted information.

The responses of Applicant, set forth in CD 2.30, does not satisfactorily resolve the questions raised by the Board staff in CD 2.24 as per Dr. Pinto's statement:

> I have read your document 230, I believe it is, which contains your explanation, and I do not find the explanations to be adequate in a lot of instances,
>
> Tr. at 95.[23]

[23] Dr. Pinto has miss-cited the document. The correct citation is CD 2.30.