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MAR 2 5 1982

Docket Nos. 50-387/388

APPLICANT: Pennsylvania Power & Light Company

FACILITY: Susquehanna Steam Electric Station, Units 1 and 2

SUBJECT: SUMMARY OF MARCH 17, 1982 GAS PIPELINE MEETING

On March 17, 1982, representatives of the Pennsylvania Power & Light Company and their consultant from Gilbert Associates met with members of the NRC staff to discuss the analysis used by PP&L to evaluate the consequences of a gas pipeline break and its effect on the Susquehanna facility. A list of attendees is provided in Attachment 1.

The applicant utilized an adiabatic, constant enthalpy model in analyzing the consequences of a gas pipeline break. The applicant also provided a letter from an outside source to confirm their use of this model was correct (Attachment 2). Based on this model, the applicant felt that overall changes in gas temperatures would be less than 20° F, limiting the absorption of moisture, and therefore have minimal effect on the rise of the gas above control room air intakes.

The staff had previously performed an independent analysis which showed the applicant's analysis to be non-conservative, particularly in the areas of initial gas expansion with a resulting cooldown and reduced buoyancy, as well as the considerable uncertainty associated with the predicted heights of rise given by the plume rise formulae and the complex topography represented by the pipeline and plant configuration. The information provided by the applicant at this meeting did not alter the staff position. The current staff position is the pipeline, in absence of a conservative analysis which addresses and satisfactorily resolves the staff concerns, needs to be relocated to a distance where a rupture will have no adverse effects upon the plant.

Robert L. Perch, Project Manager
Licensing Branch No. 2
Division of Licensing

Attachments:
As stated

cc: See next page

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Attachment 1

List of Attendees

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L. Soffer

PP&L

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D. Kohn
A. Male
R. Sgarro
J. Ellis (Gilbert Assoc.)

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March 10, 1982

Mr. Donald J. Kohn
Fire Protection Engineer
Nuclear Plant Engineering
Pennsylvania Power & Light Company
Two North Ninth Street
Allentown, Pennsylvania 18101

Dear Mr. Kohn:

This is a summary of my thoughts with respect to the technical questions discussed below.

What density must be assumed for natural gas escaping a pipeline at 310 psig and 60°F (288°K)? This value was needed for the estimation of the buoyancy F ($F = (\rho-\rho_o)gQ/\pi\rho$) for the plume calculations described in the attached report. The calculations described in the report had been made assuming an isoenthalpic expansion from the pipeline conditions to the atmospheric pressure. The question raised, however, was the following: Is it possible to have any other type of expansion that would give a lower temperature, and consequently a higher density and lower or negative buoyancy?

The most dramatic case would correspond to a isoentropic expansion, since a rough estimation gives a temperature as low as 140°K. Clearly this worst case condition would only occur in a well-designed nozzle. The enthalpy change (a decrease in this case) would appear as kinetic energy of the gas.

The key point is that far enough from the gas exit this kinetic energy will dissipate into internal energy of the gas leaving the pipe and the air entrained by the jet. The condition of the plume at that point will be the same as if the gas had originally expanded along a constant enthalpy line. The plume buoyancy is shown below (for the conditions prescribed, methane at 280°K expands into air at 280°K, 1 atm) to be essentially independent of the amount of air entrained and equal to that obtained assuming an isoenthalpic expansion.

The conclusion is then that the calculation of the buoyancy based in an isoenthalpic expansion is a correct one independently of the small scale process taking place in the neighborhood of the pipe.

Mr. Donald J. Kohn
March 10, 1982
Page 2

If I could be of additional help, please do not hesitate in contacting me.

Sincerely,

Hugo S. Caram
Associate Professor

HSC:mr
Enclosure

The buoyancy force when the pure gas is considered assuming a unit volume of gas is (M_i = molecular weight of gas i, T_i = temperature of ")

$$B_0 = (\rho_1 - \rho_2) g = \frac{p g}{R}\left(\frac{M_1}{T_1} - \frac{M_2}{T_2}\right) = \frac{p g}{R T_1}\left(1 - \frac{\delta}{\gamma}\right) M_1$$

Defining $\longrightarrow$ $\delta = \dfrac{M_2}{M_1}$; $\gamma = \dfrac{T_2}{T_1}$

When a volume β of gas 2 is mixed with the original unit volume of gas 1 the force will be

$$B = V_2 g (\rho - \rho_2) = g \frac{nRT}{p}\left(\frac{p\bar{M}}{RT} - \frac{pM_2}{RT_2}\right)$$

$$= g\left[n\bar{M} - n M_2 \frac{T}{T_2}\right]$$

We need to find n and $\bar{M}$ and T (n = total no. of moles in mixt., $\bar{M}$ = average molecular weight, T = temperature of the mixture)

$$n_1 = \frac{p}{RT_1}, \quad n_2 = \frac{p\beta}{RT_2} \Rightarrow n = \frac{p}{R}\left[\frac{1}{T_1} + \frac{\beta}{T_2}\right] = \frac{p}{RT_1}\left[1 + \frac{\beta}{\gamma}\right]$$

$$M = \frac{M_1 n_1 + M_2 n_2}{n_1 + n_2}$$

$$\bar{M} n = M_1 n_1 + M_2 n_2 = \frac{p}{R}\left[\frac{M_1}{T_1} + \frac{M_2 \beta}{T_2}\right] = \frac{p M_1}{RT_1}\left[1 + \frac{\delta\beta}{\gamma}\right]$$

Finally the temperature of the mixture

$$(n_1 c_{p_1} + n_2 c_{p_2}) T = n_1 c_{p_1} T_1 + n_2 c_{p_2} T_2$$

$$T = \frac{n_1 c_{p_1} T_1 + n_2 c_{p_2} T_2}{n_1 c_{p_1} + n_2 c_{p_2}} = \frac{n_1 c_{p_1} T_1 \left(1 + \frac{n_2}{n_1} \cdot \frac{c_{p_2}}{c_{p_1}} \frac{T_2}{T_1}\right)}{n_1 c_{p_1} \left(1 + \frac{n_2}{n_1} \frac{c_{p_2}}{c_{p_1}}\right)} =$$

$$= T_1 \frac{(1 + \beta\varepsilon)}{\left(1 + \frac{\beta\varepsilon}{\gamma}\right)} ; \quad \text{Where } \varepsilon = \frac{c_{p_2}}{c_{p_1}}$$

The buoyant force acting on the mixture of the two gases would be

$$B = g\left[\frac{pM_1}{RT_1}\left[1 + \frac{\delta\beta}{\gamma}\right] - \frac{pM_2}{RT_1}\left[1 + \frac{\beta}{\gamma}\right] \frac{T_1}{T_2} \frac{(1 + \beta\varepsilon)}{\left(1 + \frac{\beta\varepsilon}{\gamma}\right)}\right]$$

$$= g \frac{pM_1}{RT_1}\left[1 + \frac{\delta\beta}{\gamma} - \frac{\delta}{\gamma}\left[1 + \frac{\beta}{\gamma}\right] \frac{(1 + \beta\varepsilon)}{\left(1 + \frac{\beta\varepsilon}{\gamma}\right)}\right]$$

M_1 16

$$\varepsilon = \frac{c_{p_2}}{c_{p_1}} = \frac{6.97}{8.55} = 0.81$$

Case 1 isoenthalpic expansion 280°K

$p = 20$ atm

$$\gamma = \frac{280}{270} = 1.037$$

β	B
0	0.745
0.1	.744
0.2	.743
0.5	.741
1.0	0.738
2.0	0.736
5.0	0.733
10.0	0.731
20.0	0.731
50.	0.730
100.	0.7303
1000.	0.7302

Case 2

The conclusion is that the flux of buoyancy remains essentially constant along the plume. The only change ~~fluctuation~~ is due to the difference in molar heat capacities. But for that, if $c_{p_1} = c_{p_2} \Rightarrow \varepsilon_1$ it will be

$$B = B_0 = \frac{pg}{RT_1}\left(1 - \frac{\delta}{\gamma}\right)M_1$$

The conclusion is that the mixing does not affect the buoyancy and when the kinetic energy is dissipated we have a process that is equivalent to an isoenthalpic expansion

MEETING SUMMARY DISTRIBUTION

Docket File 50-387/388
NRC PDR
L PDR
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ACRS (16)

LB#2 File
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