Georgia Public Service Commission
244 Washington Street, S.W.
Atlanta, Georgia 30334

January 23, 1986

Mr. Douglas Chisholm
Chief, Research Unit
DPS 20
Office of Pipeline Safety
400 - 7th Street, S.W.
Room 8409
Washington DC 20590

Dear Mr. Chisholm:

The Georgia Public Service Commission is charged with auditing LNG facility construction in the State of Georgia to assure conformance to the Federal Regulation 49 CFR 193. In reviewing the regulation, we found that it is not clear what amount of vapor hold-up is allowed within the LNG storage tank dike. Because the amount of vapor hold-up allowed can be an important factor in determining the downwind travel of a flammable gas cloud, we feel that this point needs to be clarified. We would like your interpretation as to what fraction of the LNG storage tank dike free volume (dike volume less storage tank volume up to the dike wall height less any liquid accumulation) is allowed for LNG vapor accumulation.

Naturally, a reply at your earliest convenience would be greatly appreciated.

Sincerely,

Glynn Blanton
Section Chief
Utilities Engineer

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March 3, 1986

Mr. Glynn Blanton
Section Chief
Utilities Engineer
Georgia Public Service Commission
244 Washington Street, S.W.
Atlanta, Georgia 30334

Dear Mr. Blanton:

This responds to your letter of January 23, 1986, to Dr. Douglas Chisholm requesting clarification of the fraction of storage tank impoundment space allocable to vapor detention under 49 CFR Part 193.

Part 193 does not limit the space for “vapor hold-up” in impounding system design. The minimum capacity requirements of §193.2181 are designed to assure that some minimum space is available for vapor, but the operator may increase this capacity.

I have enclosed a brief Technical Note by Mr. Walter Dennis providing some of his observations and commentary on impounding system capacity and our current LNG research program.

In addition, I have enclosed copies of two Office of Pipeline Safety documents dealing with closely related issues.

Sincerely,

(J.C. Thomas for)
Robert L. Paullin
Director
Office of Pipeline Safety

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A TECHNICAL NOTE ON VAPOR DETENTION CAPACITY AND ITS EFFECTS ON VAPOR DISPERSION DISTANCE

by
Mr. Walter Dennis

As you currently note, the vapor detention capacity can significantly affect the downwind travel of flammable LNG vapor (vapor dispersion distance). This is due to the potential for change in the proportionate detention capacity (the capacity relative to other spill conditions) to change the duration of LNG contact with heat transfer surfaces, the consequent degree of cooling, and the related rate of heat transfer from those surfaces before initial vapor overflow occurs.

Under the prescribed model in §193.2059(c), a constant rate spill is presumed to continue at least until vapor overflows the diking (continuous spill). For this purpose, the term diking applies to either diking for the impoundment of spilled LNG, or as appropriate, to an extended or additional barrier (if any) designed to increase holding volume for detention of evolving LNG vapor, as provided in §193.2059(d)(1)(iv). In applying the model, initial vapor overflow is assumed to occur when the combined volume of evolved vapor, and the impounded volume of unvaporized spilled liquid equals all space outside the component served that is provided for liquid impoundment and vapor detention. Thus, occurrence of initial vapor overflow is assumed at the moment of overflow due to overfill without consideration of scooping by wind entrainment or ejection by vapor velocity.

Vaporization rate at the moment of initial overflow defines source strength in determining uniform unit source strength under the model, the primary parameter that directly influences dispersion distance. The strength at this moment is considered to be at its highest, thereby predicting the maximum dispersion distance, since thereafter, vaporization rate is assumed to be diminishing as heat transfer surfaces in contact with liquid will be cooling.

From the foregoing, it is seen that with an increase in proportionate detention capacity, the time needed to fill the impoundment-detention space and reach maximum source strength will increase. With a reduction in the proportionate capacity, this time delay will diminish. It is evident, thereby, that both contact duration of the liquid and consequent cooling of heat transfer surface in contact will vary directly with proportionate detention capacity.

Conversely, the rate of heat transfer along with the vaporization rate, and related source strength will vary inversely with proportionate detention capacity. It follows that, under the prescribed model, the predicted dispersion distance will vary inversely with the proportionate detention capacity—the former diminishing as the latter increases and vice versa.

Thus, in §193.2059, there is no specified fraction of impoundment-detention space arbitrarily dedicated to vapor detention. Rather, as defined in §193.2059(d)(1)(iv), the space dedicative to vapor detention is the total space available for liquid impoundment and vapor detention minus the volumetric space occupied by impounded liquid at the moment of initial overflow due to overfill.

This definition is necessary, since for a given total impoundment-detention capacity, the latter fraction will vary with spill volume, spill rate, differential enthalpy in spillage, and similar design specific variables. For example, under a given design, an increase in overall detention-impoundment volume provided by increasing the height or perimeter of vapor detention fencing would be allocable only in part to vapor detention, since the increase in time for initial overflow from overfill would result in an additional liquid spill volume which must be accommodated.

Of course, in spite of this increase in spill volume, time duration to initial overflow would still be increased with a consequent reduction in source strength and predicted dispersion distance. Solution of respective liquid-vapor volumes would be relatively simple, once cumulative vaporization and liquid accumulation is established either as a volume-time function or simply by iterative convergence. Although you refer only to storage tank impoundment, the foregoing applies to all impounding-detention systems.

The prescribed model under §193.2059 was developed only with conventional low remote diking in mind. Therefore, it may be important also for you to be aware of certain limitations. For conventional designs and clear field dispersion, predictions are generally thought to be overly conservative. But this has never been conclusively evaluated, and some comparisons give rise to uncertainties. Certain design conditions, however, could result in hazardous nonconservatism.

One (which the model cannot address) is channeling or diversion of the vapor by large downwind structures or other topography. Very large detention capacity, where source strength based on initial overflow could be significantly less than actual source strength due to wind entrainment, is another. A third problem is envisaged with multiple diking.

High close-in diking, a more recently proposed design, presents a fourth and potentially more serious problem. This problem results from the potential for actual source strength to continue increasing (if actual LNG spillage continues) after initial vapor overflow, thereby exceeding the theoretical maximum source strength. It is seen that this would occur where the heat transfer rate continues to increase, despite cooling, as the contact area continues to increase with the rising level of LNG from continuing spillage into the narrow impoundment annulous [sic].

Because of limitations in predictive capability of the current model, costs for protection distance at new plants could be economically burdensome. Preclusion of expansion at most existing plants would be likely. Yet unsafe conditions could prevail with certain designs. OPS recognized this problem even at the writing of current standards, but available options were limited.

Accordingly, in 1983, OPS initiated a six phase research program, and subsequently was joined in co-sponsorship by the Gas Research Institute, to resolve this problem. The program is intended to develop definitive and verified methodologies and procedures for regulatory application of wind tunnel simulation independently or conjunctively with a select mathematical model to predict dispersion distance where diffusion is influenced by: (a) eddy entrainment from excess capacity LNG vapor detention systems, (b) wake turbulence from on site structures and natural obstacles, and (c) topographically induced diversion or meander. Independent physical simulation will be dependent on scale. With such methodologies, protective distance for dispersion may be safety reduced by as much as one order of magnitude with tank top transfer and designs to provide the conditions described in (a), (b), and (c) above. Although results of this effort will not be in place until after 1988, it may be useful for you and operators under your jurisdiction to be aware of this potential development in planning for expansion.