DEGASSING OF STORAGE TANKS

DISCUSSION OF LIMITATIONS OF TECHNOLOGIES

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INTRODUCTION

Degassing of large stationary storage tanks that contain volatile organic compounds is of great significance in industrial areas because of the potential for large emissions of the vapors in the tanks. The process has been regulated by TCEQ under 30 TAC Chapter 115 Subchapter F Division 3: Degassing or Cleaning of Stationary, Marine, or Transport Vessels. TCEQ is now considering comments relevant to these regulations. The purpose of this paper is to explore some of the limitations to the technologies being used in the degassing process.

LIMITATIONS OF TECHNOLOGIES

Limitations in tank degassing operations include the flow rate of the technology, the inherent limiting removal rate of the technology, and the mixing of the tank contents.

It is tempting to consider a storage tank being degassed as an ideally mixed Continuous Stirred Reactor (CSTR). However, the geometry of the tank volume, the layout of nozzles and vapor-relief valves, and the low velocities and energy generally applied to the tank contents make achievement of ideal mixing difficult. The parameters indicate that stratification of the contents and channelization of flow from vapor-relief valves to degassing nozzles will easily occur.

In addition to mixing limitations, each technology must be considered for its inherent processing limitation. For combustion devices, the limitation is the maximum heat release in the furnace. For condensers, the limitation is the maximum heat transfer capacity.

ILLUSTRATIVE EXAMPLES

The following example cases were used:

SUMMARY OF CASES CONSIDERED

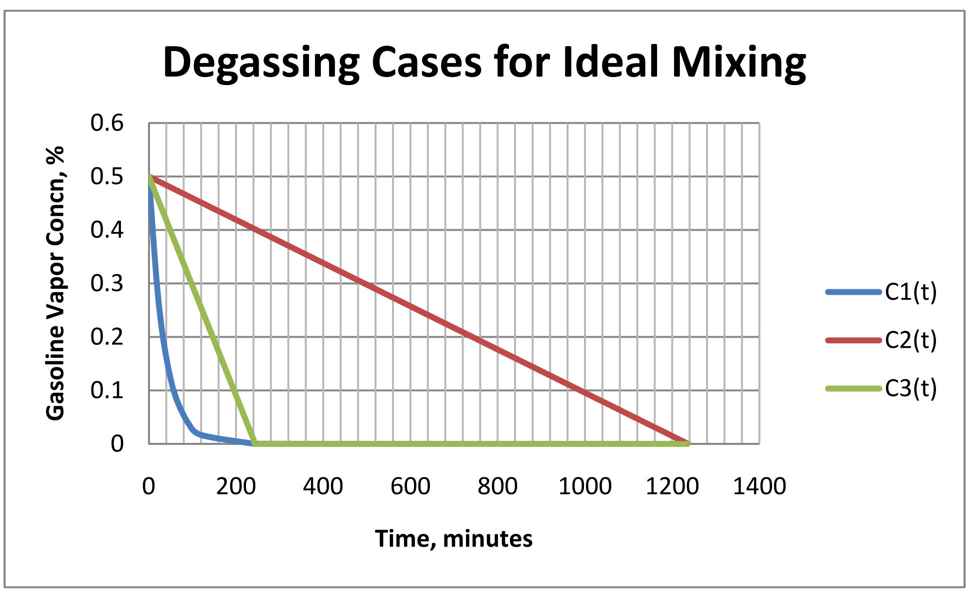
Case	Description
Cases with Ideal Mixing	
1	Dilution ventilation at 1000 cfm
2	degassing limited by combustion at 2.4 million Btu/hr
3	degassing limited by condensation at 98,562 Btu/hr
Cases with Non-Ideal Mixing	
4	Dilution ventilation at 1000 cfm - Non-Ideal Mixing
5	degassing limited by combustion at 2.4 million Btu/hr - Non-Ideal Mixing

The results of simple models for each of these cases is shown below for a 100-ft diameter gasoline storage tank with the floating roof sitting 4.5-feet above the tank bottom and with the initial gasoline content in the vapor phase of 50%.

The models are simple and are not intended to be mechanistic. They are intended to be conceptual and preliminary and to illustrate basic concepts that apply to the real world. They do not include considerations of such factors as regeneration of vapors from residual liquid pools or liquid trapped in scale at the bottom of the tank. They also do not consider the detailed hydraulics of inlet and outlet flow regimes.

Ideal Mixing

These cases consider three examples with the assumption of ideal mixing in CSTRs.

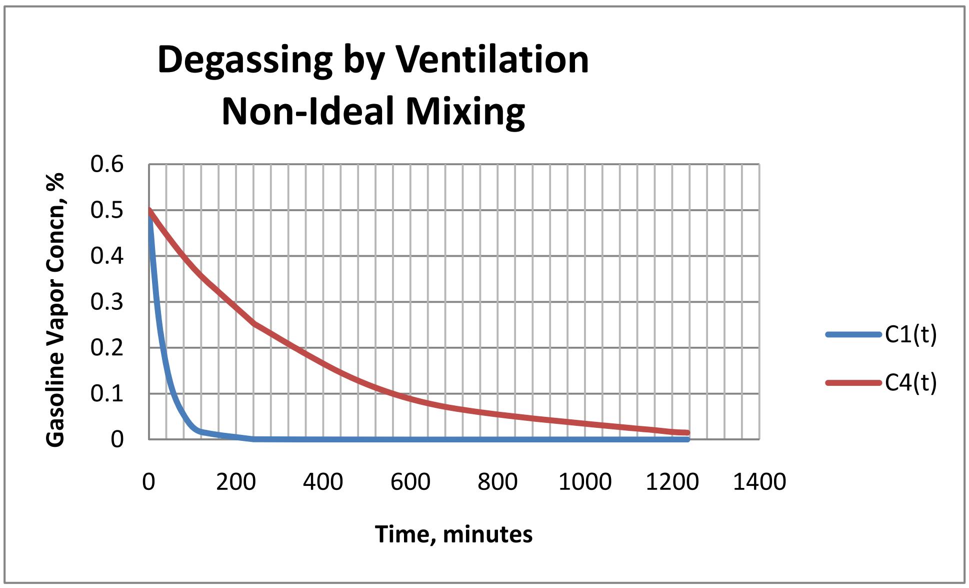


Where:

C1(t) is the concentration vs. time for Case 1, dilution ventilation at 1000 cfm
C2(t) is the concentration vs. time for Case 2, combustion at 2.4 MMBtu/hr
C3(t) is the concentration vs. time for Case 3, condensation at 98,562 Btu/hr.

Non-Ideal Mixing

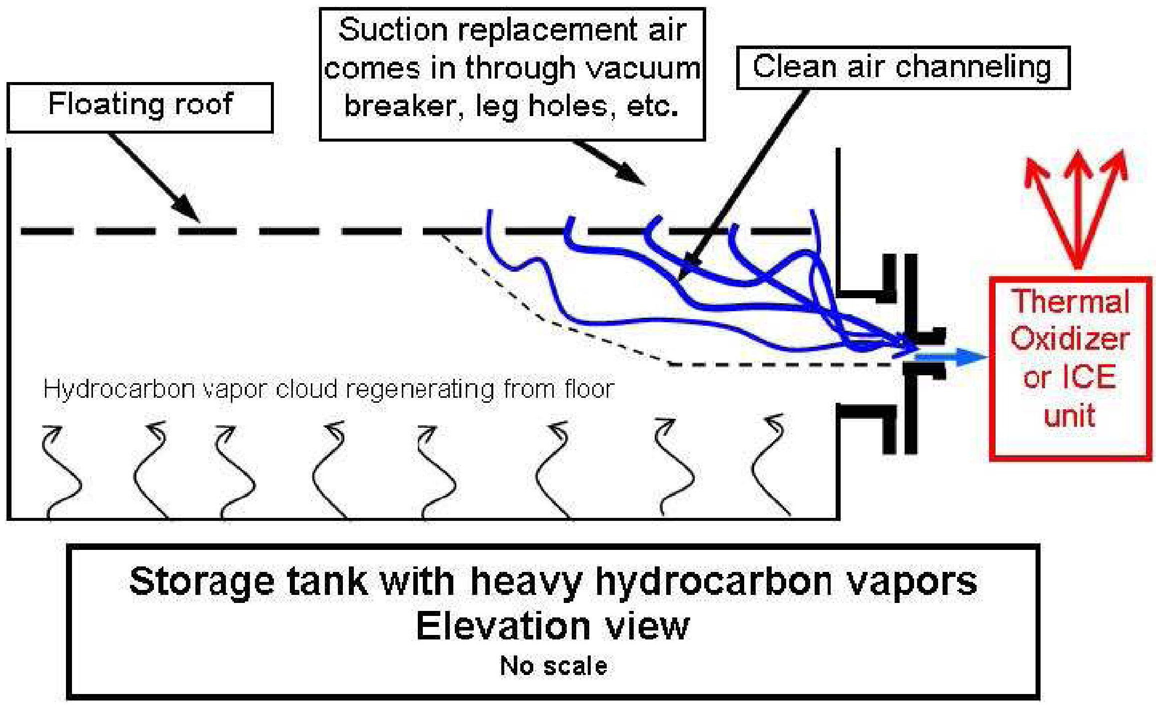
Two example cases assume non-ideal mixing, first for simple dilution ventilation and then for the more complex case of degassing with destruction of gasoline vapors by combustion with distinct stratification and channeling of flow.



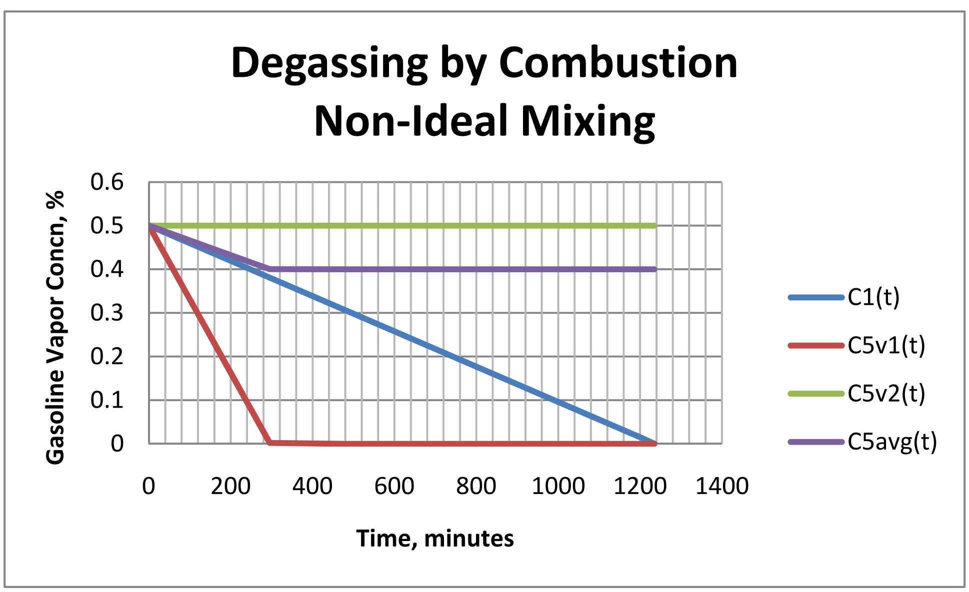
Where:

C1(t) is the concentration vs. time for Case 1, dilution ventilation at 1000 cfm
C4(t) is the concentration vs. time for Case 4, dilution ventilation at 1000 cfm but with non-ideal mixing in the tank.

In this case, C4 refers to the average concentration in the tank, where stratification and channeled flow have created separate volumes with different concentrations, one relatively lean and one relatively rich. This concept is illustrated in a sketch prepared by Hilliard Emission Controls, reproduced below.



This concept draws upon stratification of air and channeling of inlet flow in air-conditioning distribution systems, as illustrated in **Industrial Ventilation**, 23rd edition, ACGIH, 1998 (see Figure 2-1, poor mixing case), and in several industrial hygiene references. In the case of ambient outdoor air entering a vapor space rich in gasoline, the stratification would be much stronger, almost as in two-phase flow systems.



Where:

C2(t) is the concentration vs. time for Case 2, combustion at 2.4 MMBtu/hr

C5v1(t) is the concentration vs. time for the stratified lean volume for Case 5

C5v2(t) is the concentration vs. time for the stratified rich volume for Case 5

C5avg(t) is the concentration vs. time for the volume-weighted average in the tank.

In this case, we considered a tank that develops stratification, with relatively lean vapor near the top and near the degassing nozzle, and relatively rich gasoline vapors near the bottom and in most of the tank. This Two-Volume Model assumed partial mixing, such as in the non-ideal mixing case, with vapor being drawn from the relatively lean vapor volume. Refer to the Hilliard Emission Controls sketch above.

The condenser alternative has a distinct advantage with respect to mixing, because most of the volumetric flow is returned to the tank at a rate, velocity pattern, and location conducive to tank mixing.

CONCLUSIONS & RECOMMENDATIONS

1. Limitations in tank degassing operations include the flow rate of the technology, the inherent limiting removal/destruction rate of the technology, and the mixing of the tank contents.
2. The limitations of the technology used for degassing must be recognized in application of that technology. The application must consider and be consistent with simple mass and energy balances.
3. The limitations of non-ideal mixing must also be recognized. If stratification and channeled flow occur, then the progress of degassing may be difficult to measure.
4. If degassing is terminated prematurely, because of mixing limitations and inaccurate vapor measurements, then the volume of contaminants ultimately flushed to the environment may be much greater than anticipated.
5. The State should consider these limitations, as illustrated in this paper. They may consider incorporation of requirements for mixing and testing that are consistent with the potential limitations discussed.