Open Surface Tanks Ventilation: Some Design Criteria

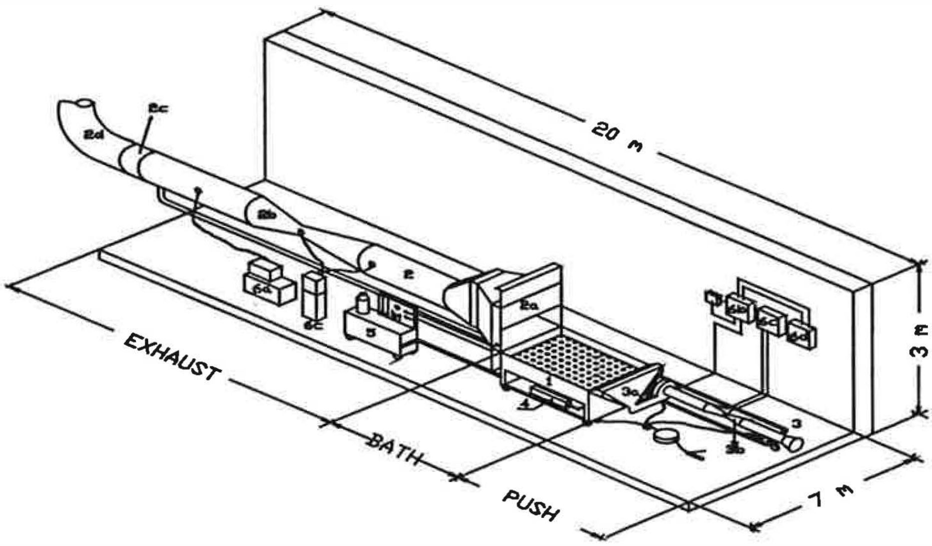
Marzal F.[1], *Baeza A.*[2], *G Duperón E*[2], *G Ferradás E*[2], *Miñana A*[2]
[1]Departamento de Ingeniería Térmica y de Fluidos, Universidad Politécnica de Cartagena, Murcia, Spain
[2]Departamento de Ingeniería Química, Universidad de Murcia, Murcia, Spain

Introduction

The control of emissions from open surface tanks is usually perfomed using simple exhaust systems or combined with push (1). In the first case the exhaust entries generate omnidirectional speed fields within the tank, which rapidly reduce efficiency as the distance increased and are recommended for tanks of less them 1 metre in length. In the push-pull systems, a curtain of air sweeps over the surface of the tank and drags emission towards the exhaust causing a jet wall which (2), when well formed, permits high capture efficiency (3). Random drafts coming from outside distor these push flows to a lesser extent. The description of flow involved in the push-pull system is not simple and even less so whem seeking to explain quantitative aspects, given the high number of variables involved. This paper present the experimental equipment designed for visualising flows and for determining their efficiency as well as the results of the improvement of the geometrical variables for both ventilation system.

Pilot Installation

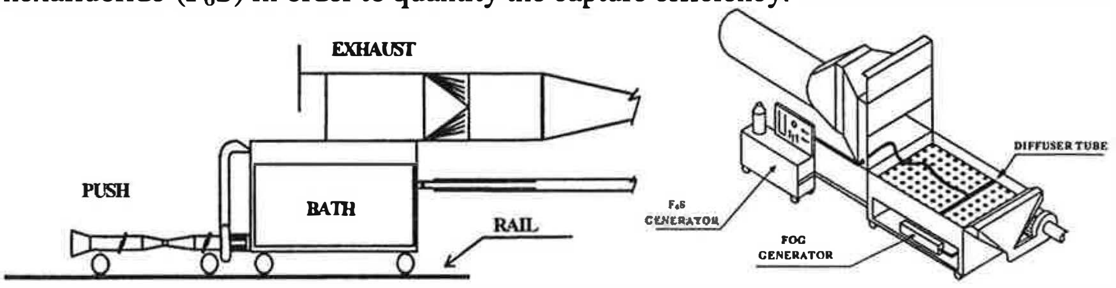
Figure 1 schematically represents the whole installation.



1. Bah. 2. Exhaust system. **2.a. Exhaust hood. 2.b. Venturi. 2.c. Fan. 2.d. Chimney.** 3. Push system. **3.a. Air scooping push. 3.b. Venturi.** 4. Smoke generator. 5. Equipment F_6S generator. 6. Controls systems. **6.a. Infrared spectrophotometer. 6.b. Hiccough fans. 6.c. Flow meter. 6.d. Temperature bath control.**

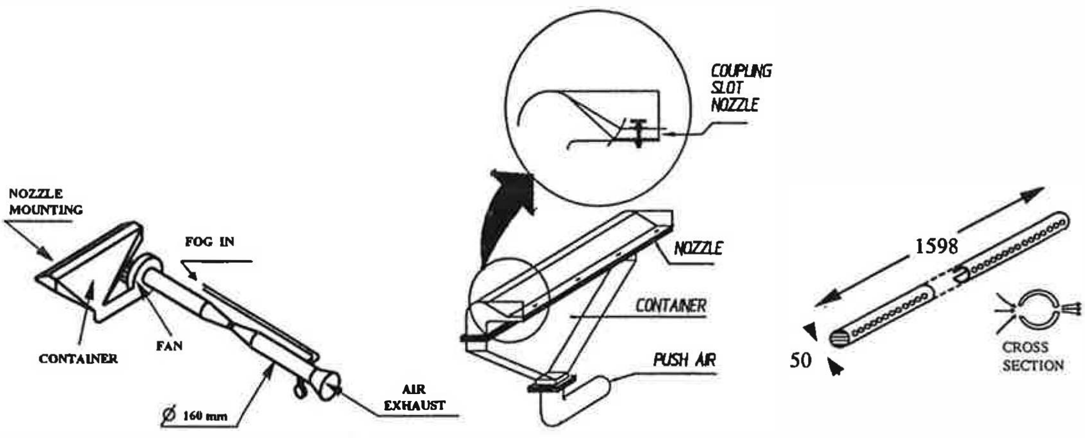
Figure 1. Overview of the pilot installation

In the tank of 1.6 m with (Figure 2), the emission generating process is simulated. By movements of the tank under the exhaust hood, threee different lengths can be studied (1.20 m, 1.53 m and 1.80 m). The surface can be heated up to 100 °C. A digital regulator controlled the selected temperature. A gas grid with 460 tubular outlets set under the surface was fed with tracer gas. The primary exhaust element, equipped with a baffle, allows the height (H) of entrance to be varied between 15 cm and 60 cm. The exhaust air (Q_{pull} from 0.08 m^3/s to 2.5 m^3/s) is evacuated through a chimney. The air curtain which sweeps along the surface of the tank (Q_{push} = 0.5 m^3/s maximum), is generated in the push system (Figure 3). This is made up of tubular nozzles with holes of different diameters (D, betwen 5 and 20 mm), of a variable number (N), whose height can be regulated (between 0.01 and 0.02 m) as can the slope angle (between 0° and 45°). The tracer gases used are smoke, in order to visualise the flows (Figure 4) and sulphur hexafluoride (F_6S) in order to quantity the capture efficiency.



A B

Figure 2. (A) Bath one way movement under the exhaust hood. (B) Tracer gas difusser tube



A B C

Figure 3. (A) Push system. (B) Detail container (C) Nozzle

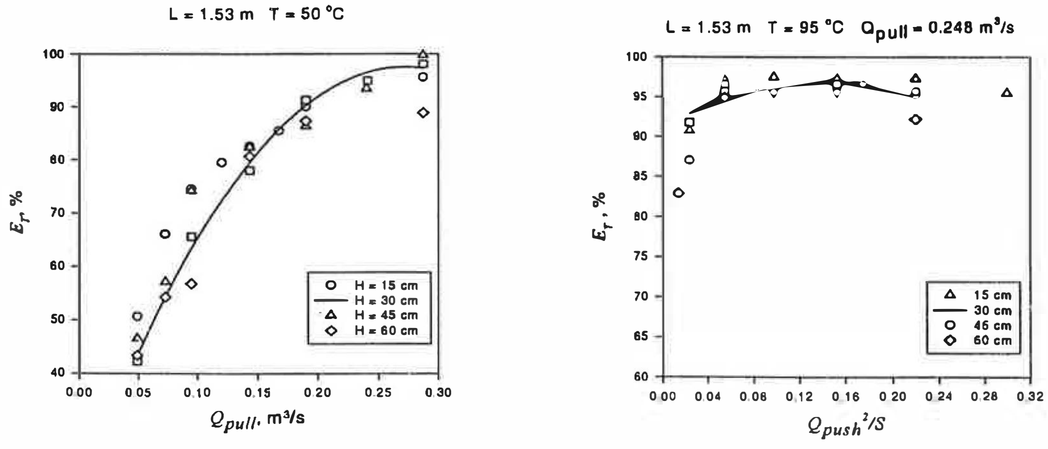
The tracer gases can be injected from the tank surface and the smoke from the push system. The sulphur hexafluoride can also be introduced at the exhaust or through a diffusor whic can travel aver the surface (Figure 2). The capture efficiency is obtained from the ratio between the sulphur hexafluoride concentration emitted from the tank (E_T) or from the diffusor tube (E_l, longitudinal transversal), both in relation to the total concentration injected at the exhaust.

Figure 4. Visualisation of flows with smoke in the push-pull system

Results

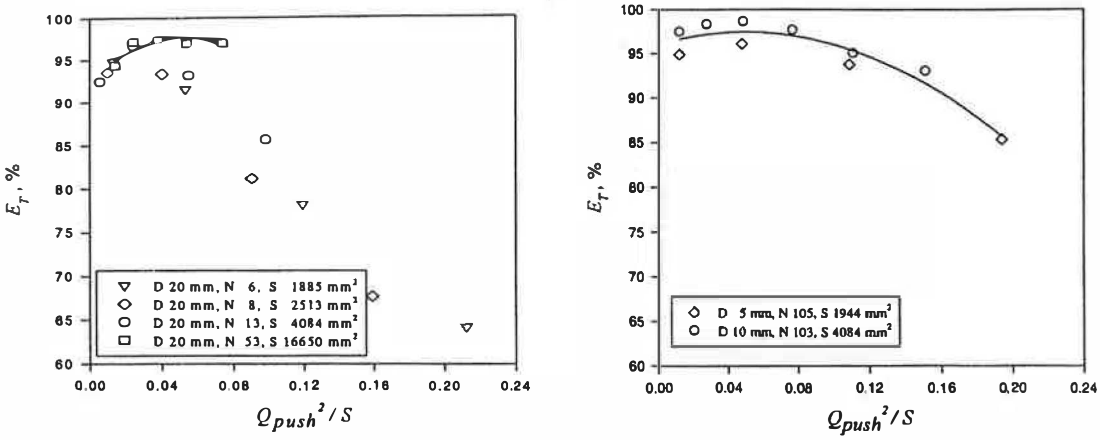
The results are expresed relating the capture efficiency, E_T, to the pull flow (in lateral exhaust) or to the flow momentum in the push-pull system or the parameter Q_{push}^2/S, where S is the total surface area of the nozzle holes.

The height of the exhaust slot is not a determining factor (ANOVA) for capture efficiency greater than 90% (Figure 5). The nozzle, with the sufficient number of holes, should form a continuous curtain of air, although the diameter of the holes is not a determinining factor (Figure 6). The analysis of the longitudinal traverse efficiencies, in which the areas over the respective profile are proportional to the losses of pollutant (Figure 7A), demostrates that the raising of the push elements not desirable since the contribution of the lover air current displaces the impact area towards the exhaust. Here the concentrations of the pollutant which have ben dragged along the tank are greater. The same reason as above (the approximation of the zone of impact towars the push) explains the slight increase in the capture efficiency for slope angles push nozzle between 22 and 45° (Figure 7B).



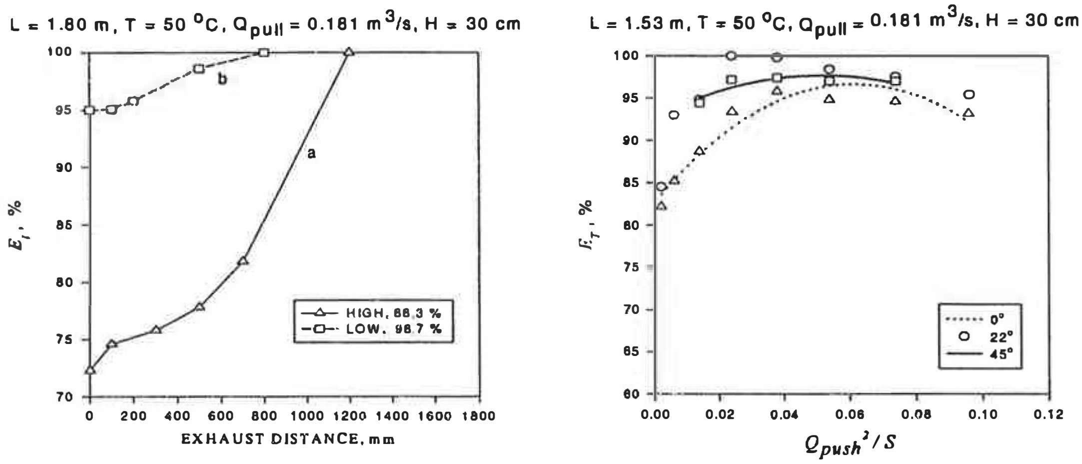
A B

Figure 5. Influence 0f the slot height on capture efficiency: (A) Lateral exhaust (B) Push-pull



A B

Figure 6. Push-pull system. Influence of the geometry of the push element. A: number of holes. B: diameter of hole. L = 1.53 m; T = 50 °C; Q_{pull} = 0.175 m³/s, H = 30 cm



A B

Figure 7. A) Longitudinal tranverse efficieciencies (E_l) obtained with a push element in two positions: resting on the tank –LOW, b- and positioned above the tank at a distance of 100 mm from the edge of the same -HIGH, a-. B) Influence of the angle slope of the push on the capture efficiency (E_T) of the ventilation system.

References

1. INRS, Institut National de Recherche et de Sécurité. Guide Practique de ventilation: Ventilation des cuves et bains de traitement de surface. ED. 651, 30, rue Olivier-Noyer, 75680 Paris Cedex 14. 1989
2. Hughes, R.T., An overwiew of push-pull ventilation characteristics, Appl. Occup. Environ. Hyg. 1990; 5 (3):156–161.
3. González Ferradás, E.; Miñana Aznar, A.; Baeza Caracena, A.; Morales Mateo, F. and Marzal Martínez, F.J. Open surface tanks ventilation: influence of the size source in the emissions to the environment. International Conference on Environmental Engineering. Cartagena. MU. SP. 1999: 75–76.