Computational Fluid Dynamics (CFD) Modelling Report

Revision: R0
Date: 11 May 2022

Project:

Oakdale South
Loading Dock Ventilation

Prepared for:

Eastwood Air Conditioning Pty Ltd
Unit 3
6 Bonz Place
Seven Hills NSW 2147
☎Tel: +61 2 9674 9944
Fax: +61 2 9838 4743

Prepared By: Dr C B Allison
Simultude, Thermal Fluid Modelling
PO Box 400
Torrensville
SA, 5031

Table of Contents

AMENDMENTS **2**
1 INTRODUCTION **3**
2 LOADING DOCK DEPOT DESCRIPTION **3**
3 MECHANICAL VENTILATION SYSTEM **5**
4 EXPOSURE STANDARDS **7**
5 CFD MODELLING SOFTWARE **7**
6 MODELLING METHODOLOGY AND ASSUMPTIONS **7**
6.1 METHODOLOGY 7
6.2 ASSUMPTIONS 8
7 CFD SIMULATION RESULTS **9**
7.1 NO VENTILATION 9
7.2 DEEMED TO SATISFY SOLUTION 11
7.3 PERFORMANCE BASED SOLUTION 13
8 CONCLUSION **14**
9 REFERENCES **14**

AMENDMENTS

Revision	Description	Date
R0	Draft	11/05/2022

1 INTRODUCTION

This study has been undertaken to compare CO concentrations for a loading dock facility where the length inside the building exceeds 10m, hence not complying with a deemed to satisfy condition. Several simulations have been performed which compare the case of no ventilation, a deemed to satisfy version, and a performance-based solution. These scenarios assumed still air conditions which is obviously the most hazardous breathing condition. It was found that a performance-based solution consisting of using destratification fans discharging almost horizontally, swept high level CO away from the entrance to the LD bays, and maintained a very low concentration of CO in the vicinity of the loading docks.

2 LOADING DOCK DEPOT DESCRIPTION

The entire depot consists of several large warehouses which may have various loading dock facilities. In each case the loading dock internal length is 12m in order to accommodate the B-Double trucks backed into the LD platform. The model under consideration simulates a 2-bay and a 4-bay LD on either side of a driveway between to warehouses. From each LD entrance, there is a ramp down to the LD platform to facilitate loading/unloading. The trucks typically reverse down the ramp, and since the exhaust is behind the driver's cab, the CO is generated outside the entrance discharging vertically upwards. Since the entrance is protected from the elements by a large high-level awning, the CO accumulates under the awning, and may bleed into the building via the entrance.

Figure 1 is a 3D image of the warehouse geometry showing the loading docks.

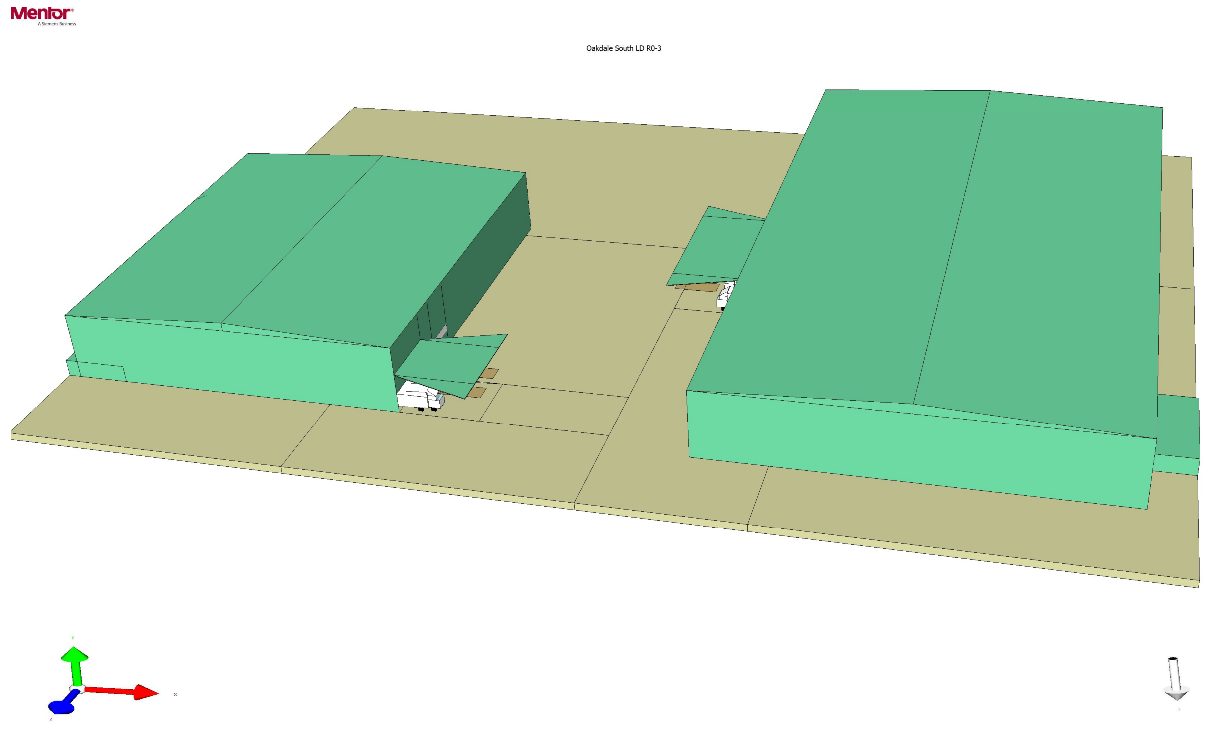

Figure 1 3D model of the 2-bay and 4-bay loading docks

Figure 2 shows the geometry without the roof indicating the warehouse internal layout, racks etc. The CO sources are located above each LD entrance at a height of 3500mm and underneath each awning.

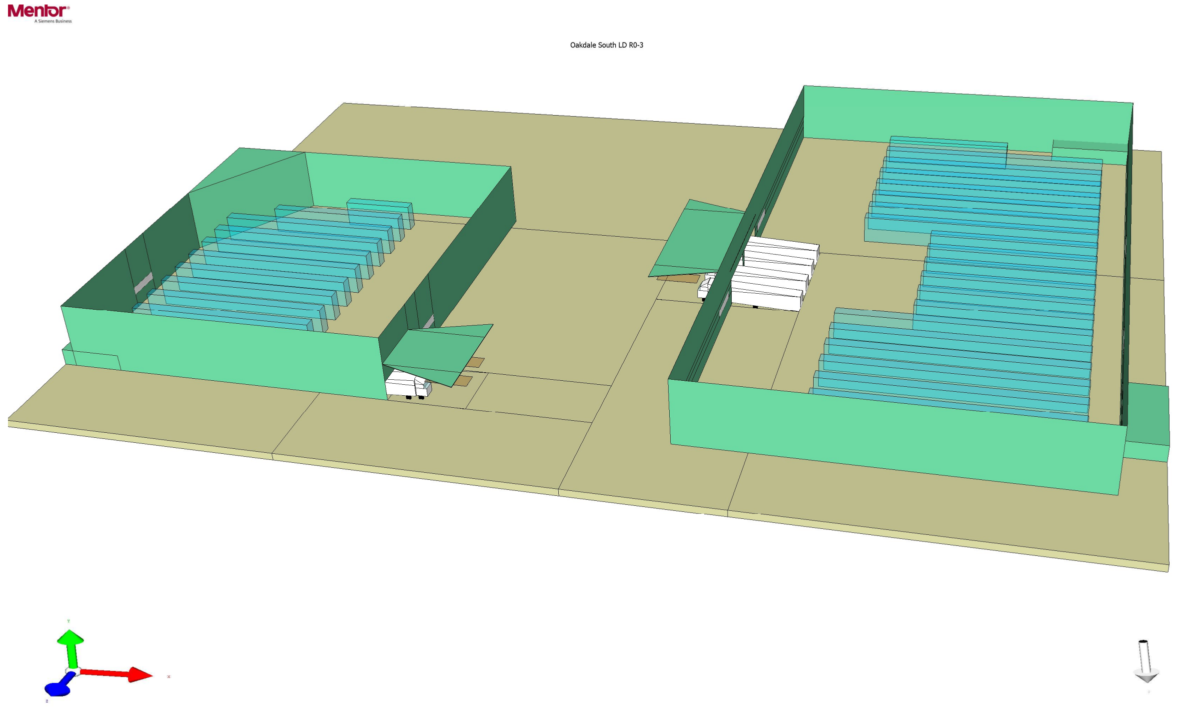

Figure 2 3D model of the LD’s with roof removed, indicating the CO sources

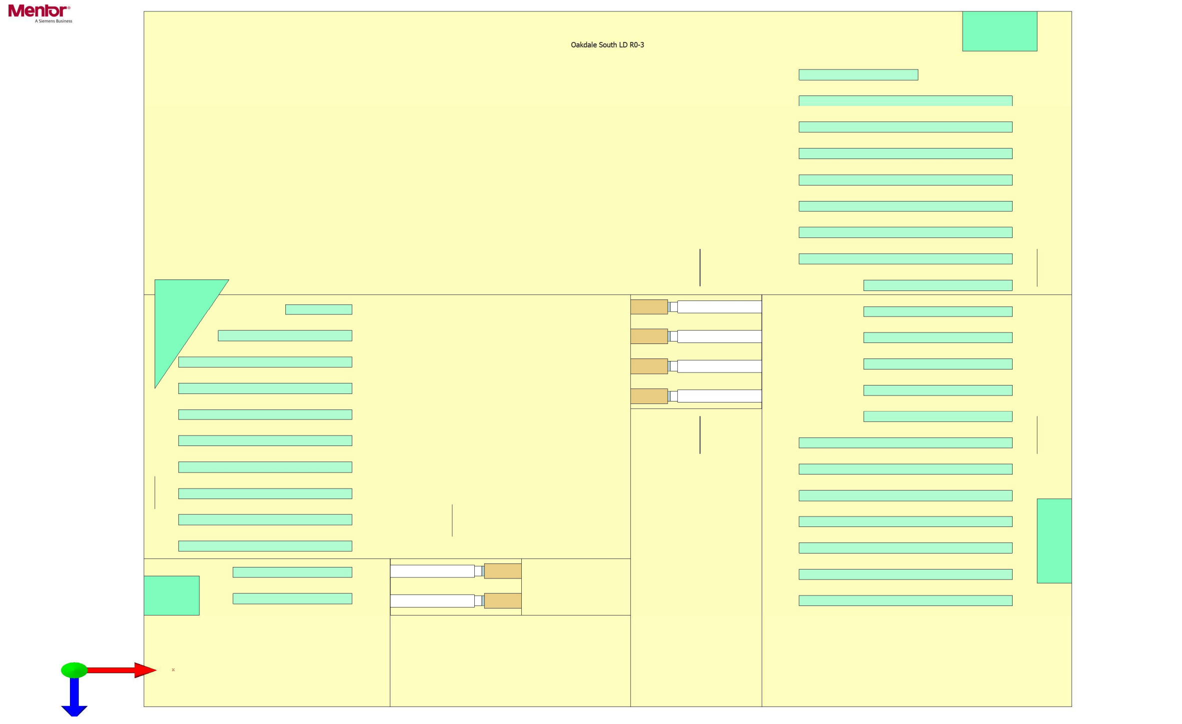

Figure 3 Plan view with roof removed, indicating the location of CO sources

3 MECHANICAL VENTILATION SYSTEM

The warehouses have natural ventilation louvres located in the warehouse walls, adjacent to each loading dock, however these rely on wind movement to provide cross flow ventilation.

A mechanical ventilation system that would satisfy the deemed to satisfy conditions consisted of exhaust grilles mounted at low level in the LD platforms as shown in Figure 4 and Figure 5. Each exhaust grille exhausts 1500l/s as specified by AS1668.2 of 2012.

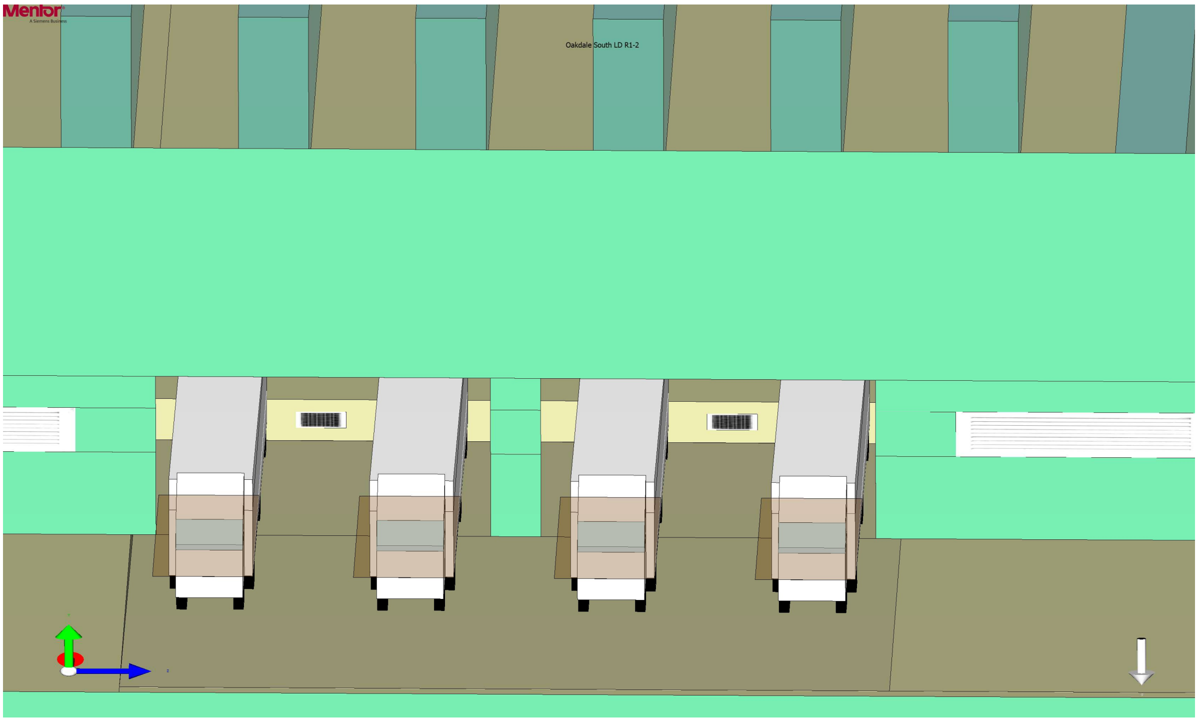

Figure 4 Elevation view of WH2-1 entrance showing loading platform exhaust grilles, and adjacent wall mounted louvres

The performance-based ventilation solution consisted of mounting destratification fans on the warehouse wall at high level blowing outwards towards the street. The fans were orientated downwards at 15 degrees from horizontal as shown in Figure 6.

Note that the destratification fans proposed are the Airius type Air Pear model AP45/PS-2, which does an airflow of 505l/s.

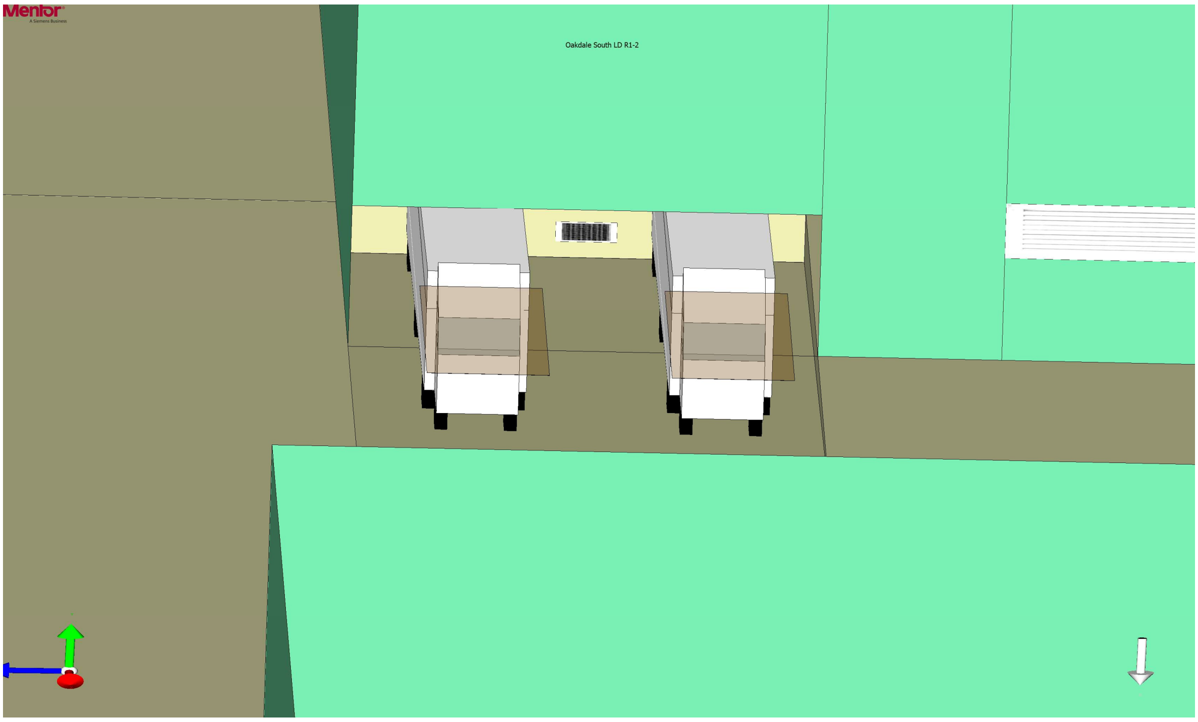

Figure 5 Elevation view of WH2-3 entrance showing loading platform exhaust grilles, and adjacent wall mounted louvre

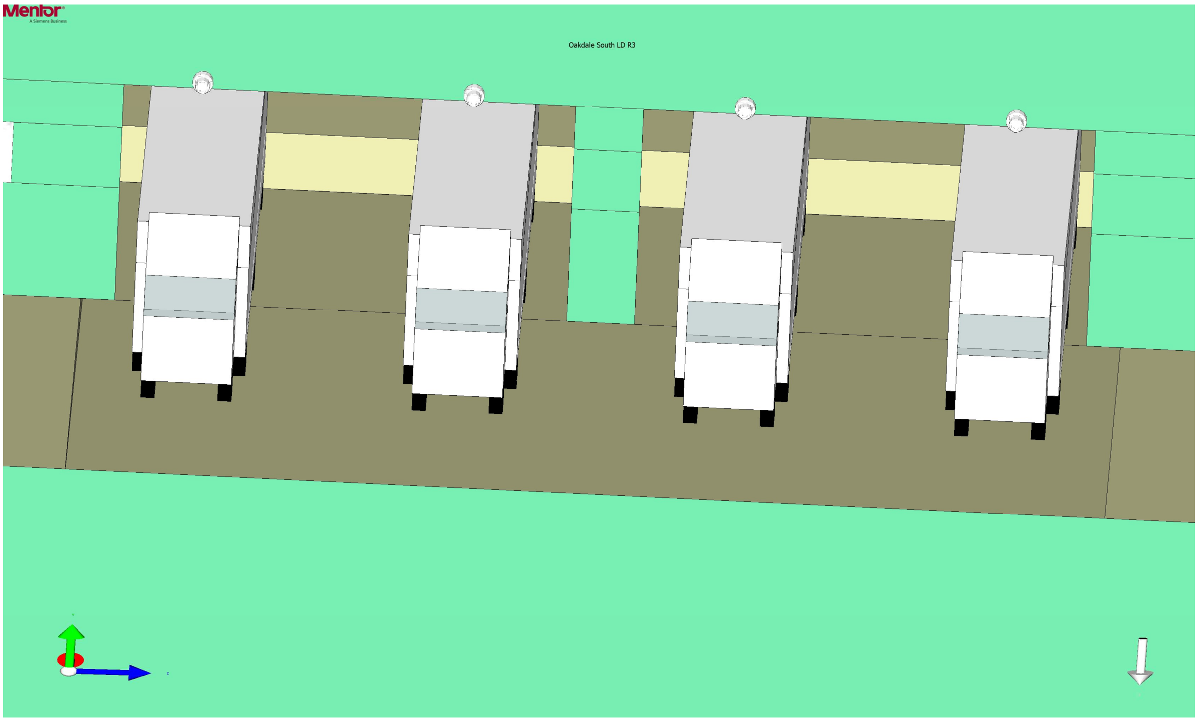

Figure 6 Elevation view of WH2-1 entrance showing the destratification fans at high level, one for each loading bay, typical

4 EXPOSURE STANDARDS

AS1668.2:2012 clause 4.5.2 specifies the provision of exhaust air quantities for loading docks.

4.5.2 Loading docks

Loading docks, in which the rear of the docked vehicle may be located at a distance greater than 10 m from the vehicle entrance opening in an external wall, shall be ventilated by an exhaust system. The airflow rate while the dock is in use shall be not less than 1500 L/s per vehicle docking space with a minimum of 3000 L/s.

Hence in the simulation the CO sources were sized to emit an amount of CO which would result in a 51ppm concentration rise when provide with the equivalent amount of dilution air.

5 CFD MODELLING SOFTWARE

The FloVENT CFD code is an HVAC specific flow simulation software package which predicts numerically the heat transfer and fluid flow phenomenon occurring within a particular computational domain. FloVENT is retailed by Mentor Graphics, and validation examples can be obtained from the Mentor Graphics website www.mentor.com.

6 MODELLING METHODOLOGY AND ASSUMPTIONS

6.1 Methodology

Initially a 3D model of the warehouse was constructed from the Architectural drawings. Then the internal geometry including offices, warehouse storage racks, and vehicles were inserted. The ramps leading down to the loading platforms and the loading bay area was constructed.

The CO sources were inserted as strips along the vehicle reversing route, located 3500mm off the ground. The CO concentrations were calculated according to the methodology below. Hence the case of no ventilation and still air conditions provided a benchmark CO concentration level for comparison purposes.

Any proposed ventilation system was constructed for the applicable simulation, such as exhaust grilles or Air Pear fans.

Then the model was meshed with a Cartesian grid throughout the computational domain. The mesh was refined at flow sensitive locations such as fan exhaust capture zones or supply air discharges, to account for the high velocity and pressure gradients occurring there. Finally, appropriate boundary conditions, flow rates etc were specified before the model could be run. A steady state simulation using the k-e turbulence model was then computed to a convergence residual level of less than 5%.

6.2 Assumptions

Boundary Conditions

– **Truck Size:** B double.

– **Average CO Emission Rate**

From AS1668.2 of 2012

$$CO = \frac{\dot{Q}}{0.872} \times \frac{51ppm}{10^{-6}} \times 60$$

$CO = 9.16 \times 10^{-6}$ kg/s per loading bay

7 CFD SIMULATION RESULTS

7.1 No ventilation

The resulting CO concentration contours at a height of 1200mm affl are shown in Figure 7.

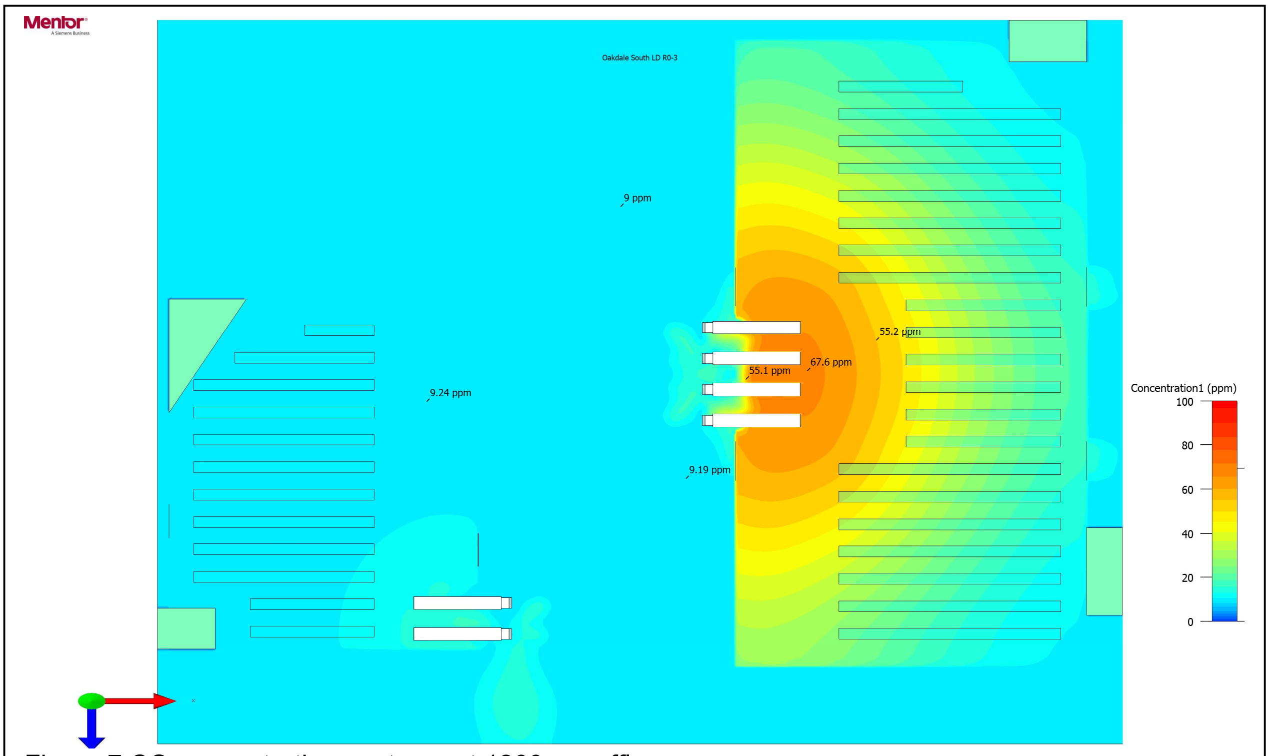

Figure 7 CO concentration contours at 1200mm affl

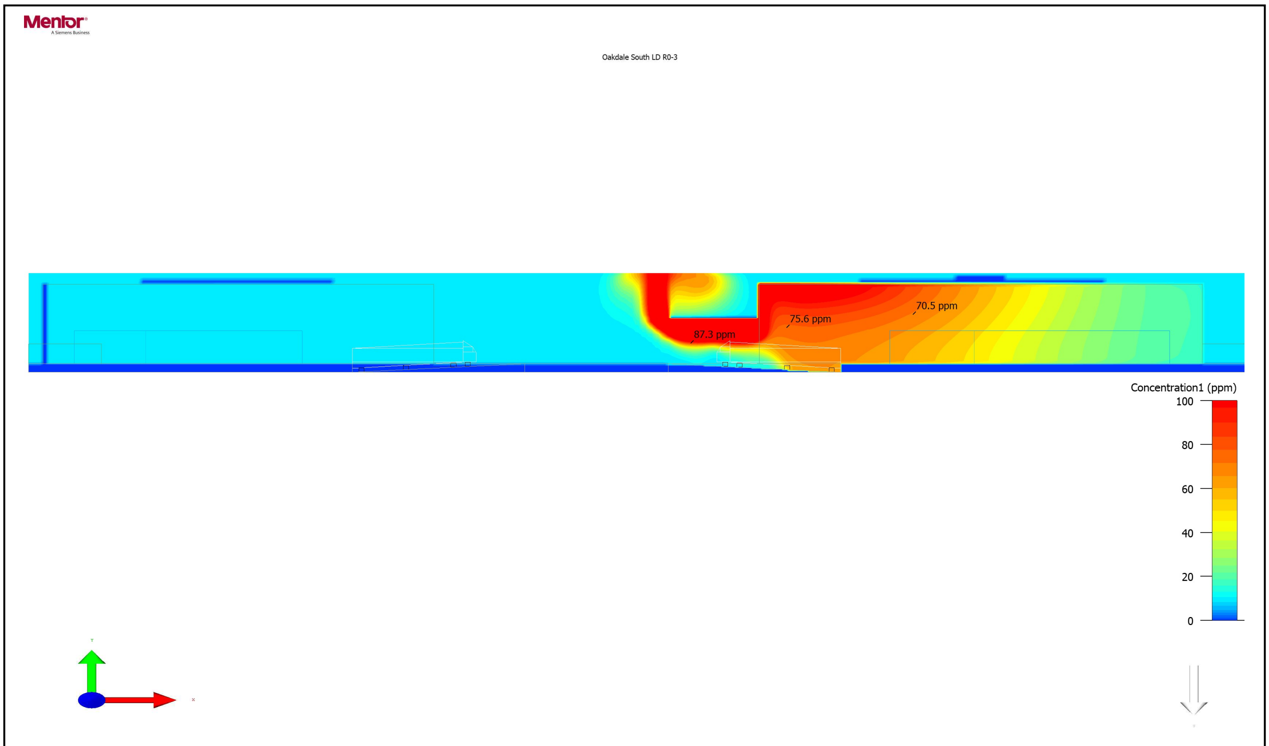

Figure 8 Section view of CO concentration contours through entrance WH2-1

Figure 8 and Figure 9 show the CO concentrations in section through the entrance of WH2-1 and WH2-3 respectively.

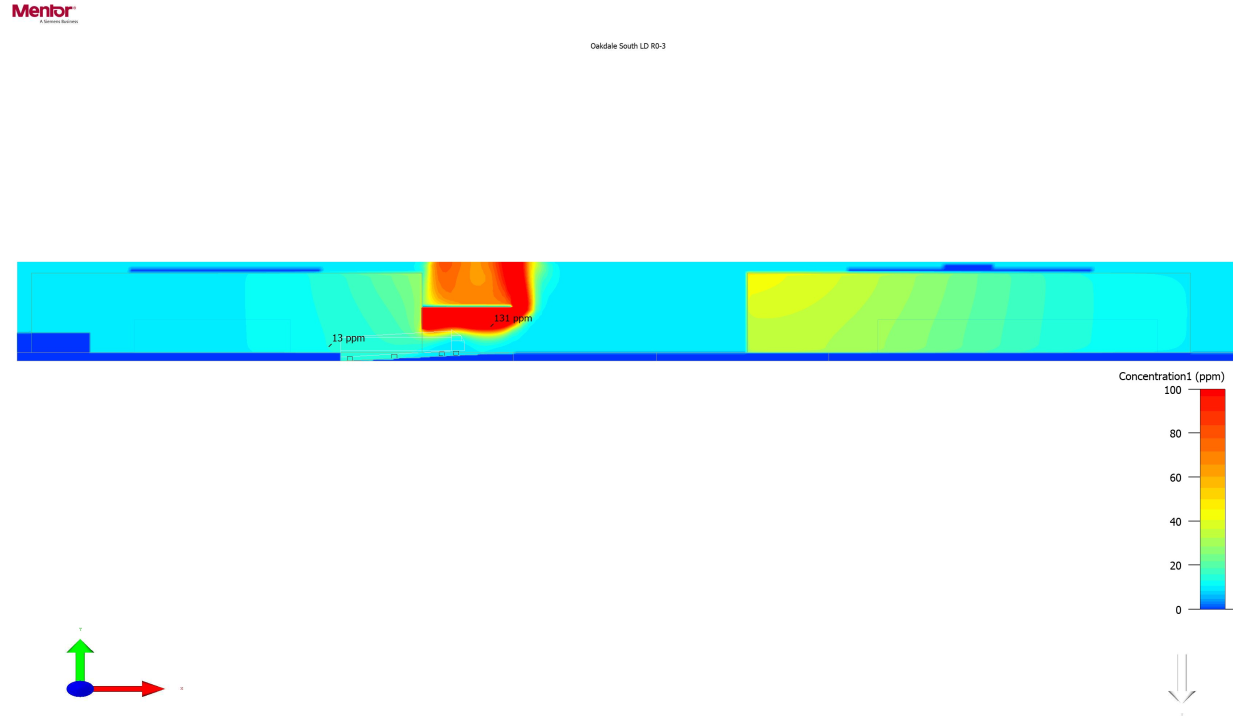

Figure 9 Section view of CO concentration contours through entrance WH2-3

In the case of no ventilation the CO generated under each awning accumulates and then travels underside the awning both into the warehouse and outwards from underneath the awning ie all directions. Quite an extensive amount of CO diffuses into the warehouse resulting in CO concentrations reaching 67 to 75ppm which is above the hourly permissible rate of 60ppm.

7.2 Deemed to Satisfy Solution

The resulting CO concentration contours at a height of 1200mm affl are shown in Figure 7.

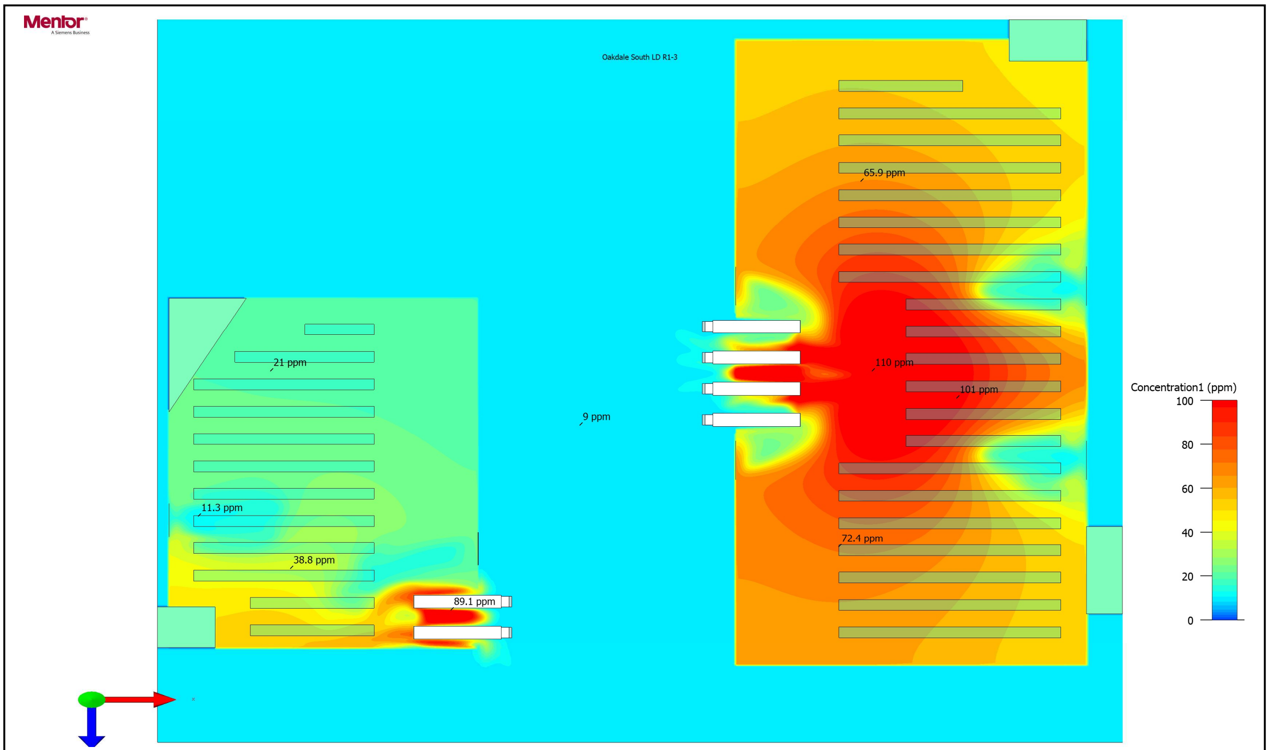

Figure 10 CO concentration contours at 1200mm affl

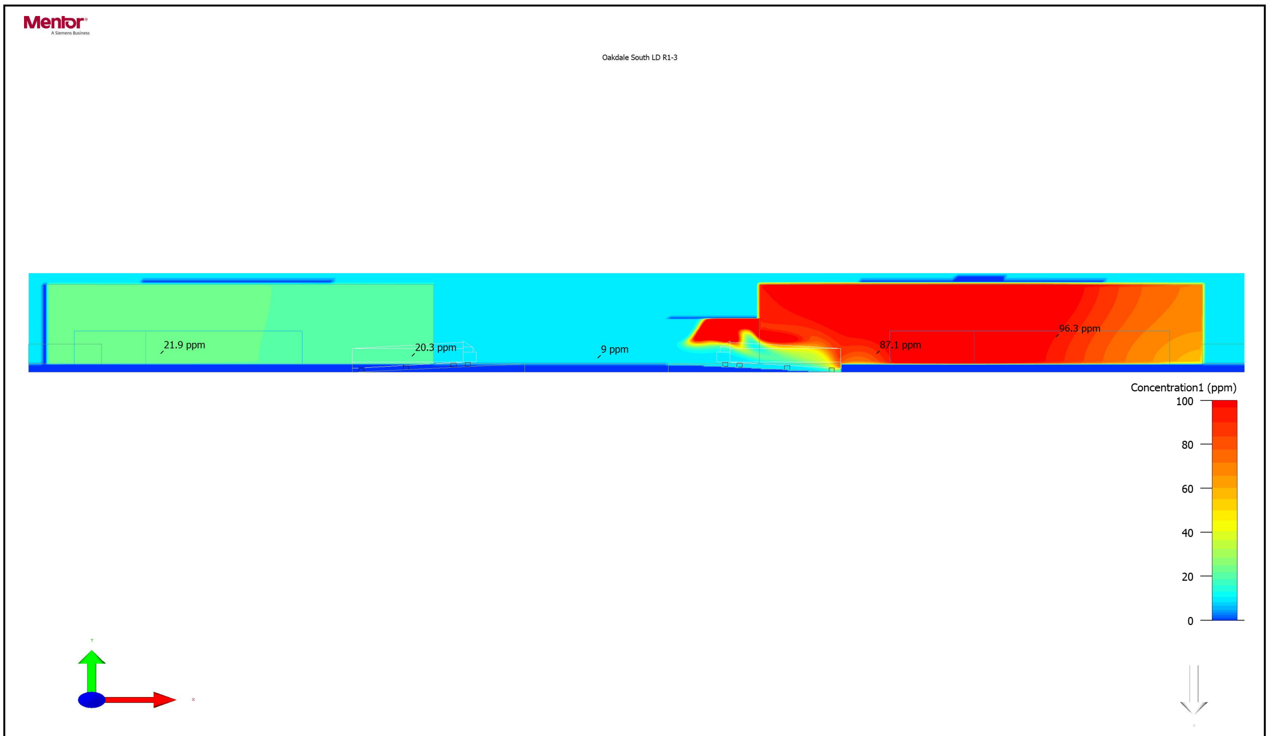

Figure 11 Section view of CO concentration contours through entrance WH2-1

Figure 8 and Figure 9 show the CO concentrations in section through the entrance of WH2-1 and WH2-3 respectively.

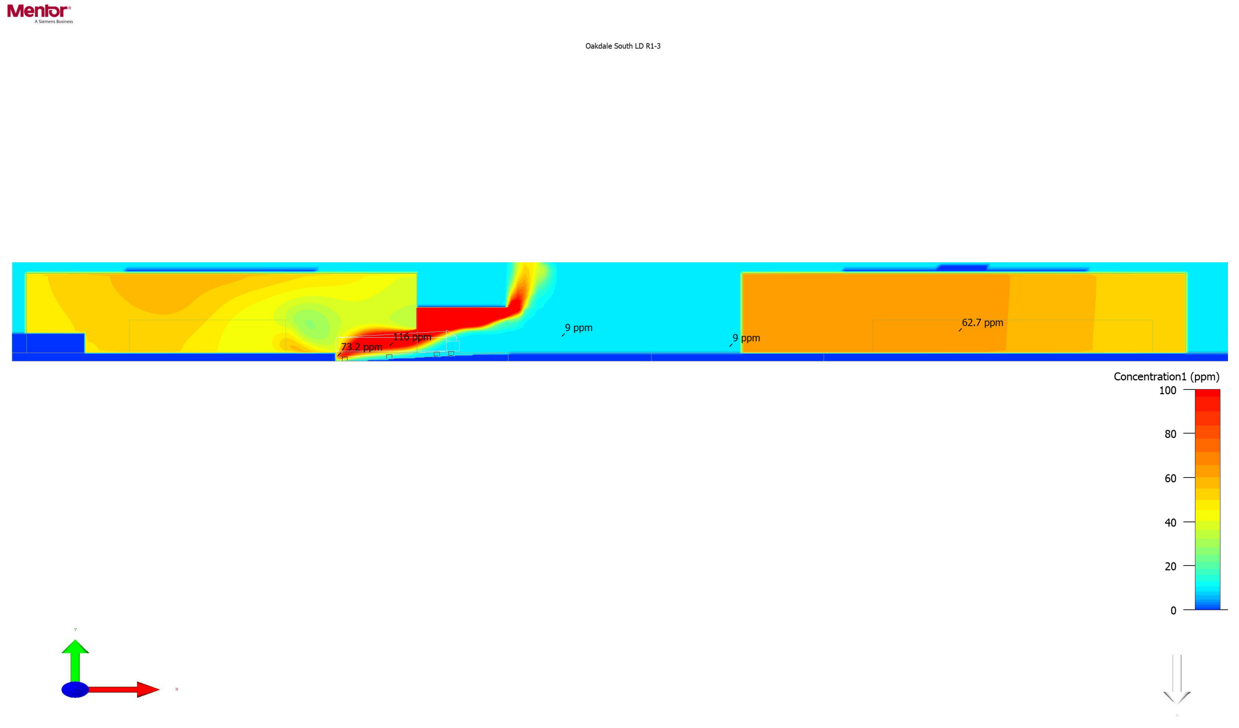

Figure 12 Section view of CO concentration contours through entrance WH2-3

In the case of a local low-level exhaust, make up air is drawn into the loading dock area from outside. Unfortunately, it also draws in the emitted CO concentrations. This results in CO concentrations of 70 to 110ppm which far exceeds the hourly permissible rate of 60ppm.

7.3 Performance based solution

The resulting CO concentration contours at a height of 1200mm affl are shown in Figure 7.

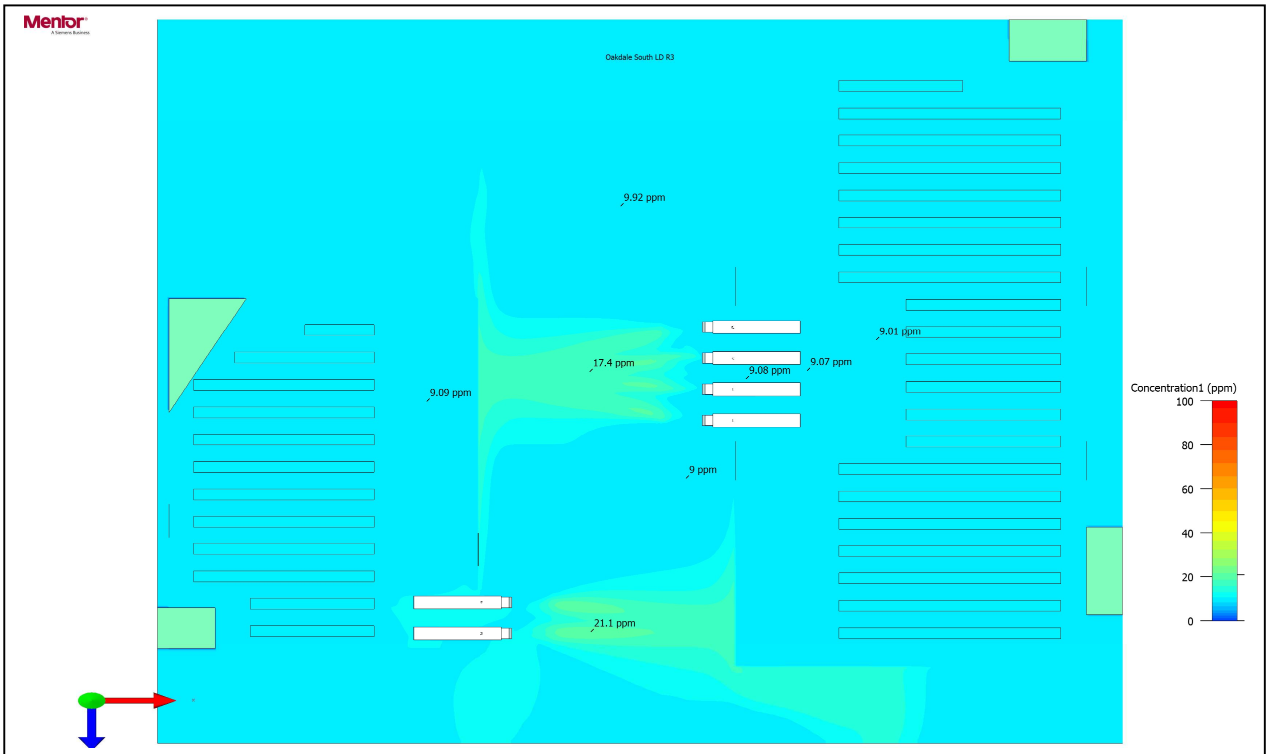

Figure 13 CO concentration contours at 1200mm affl

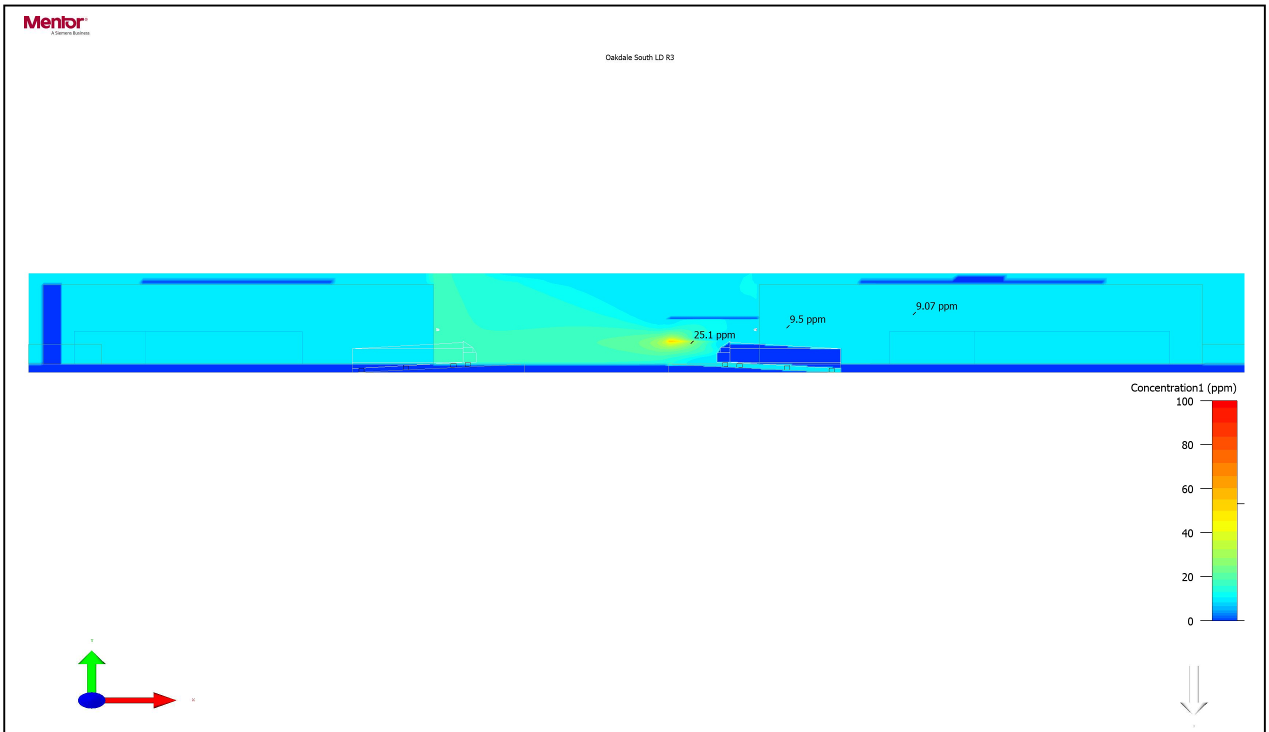

Figure 14 Section view of CO concentration contours through entrance WH2-1

Figure 8 and Figure 9 show the CO concentrations in section through the entrance of WH2-1 and WH2-3 respectively.

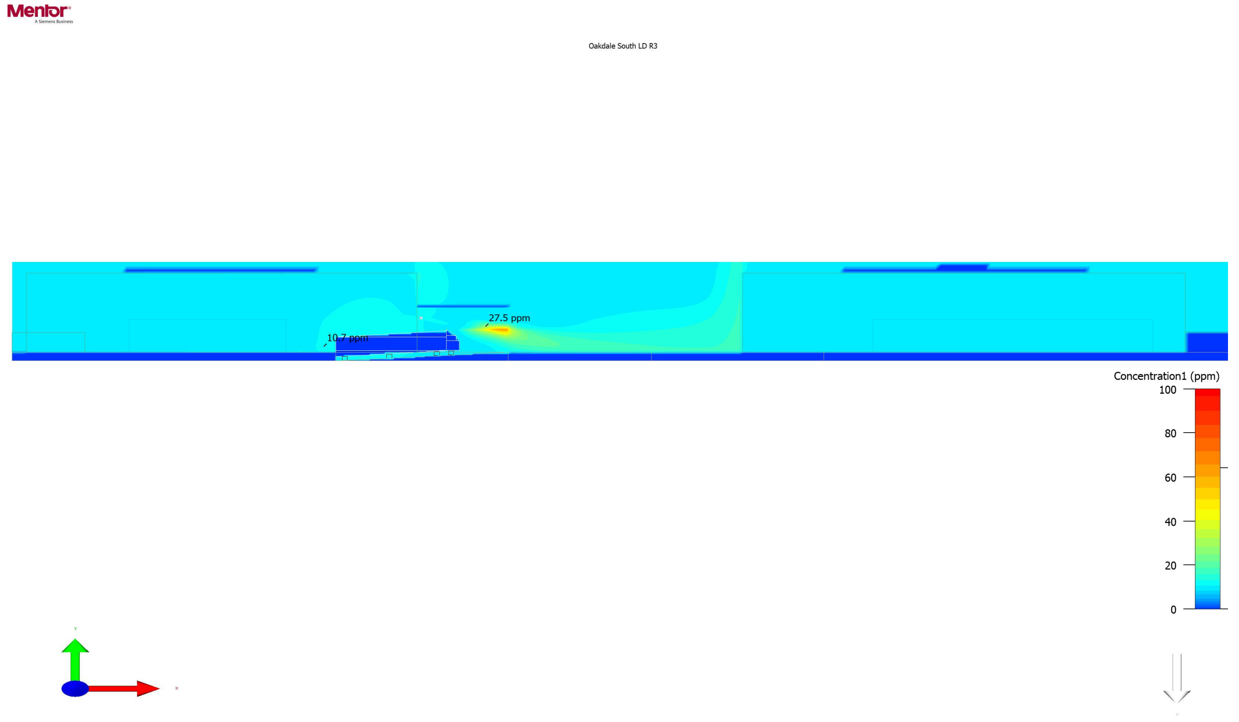

Figure 15 Section view of CO concentration contours through entrance WH2-3

In the case of having the Air Pear destratification fans discharging horizontally at 15 degrees, most of the CO is blown away from the entrance and into the street. This results in CO concentrations equivalent to ambient conditions of 9ppm. Outside in the street, the CO concentrations only reach about 17 to 30ppm.

8 CONCLUSION

The CFD simulations demonstrated that in the absence of any ventilation, with still air conditions there were high levels of CO which diffused into the LD entrance.

A DTS solution actually resulted in worse conditions because the CO was drawn into the building by virtue of the makeup air.

Reversing this incoming air flow by providing high level de stratification fans discharging almost horizontally, dispersed the CO outwards into the street resulting in very low concentrations inside the LD area.

9 REFERENCES

– AS 1668.2:2012 The use of ventilation and air conditioning in buildings, Part 2: Ventilation design for indoor air contaminant control.