GAS LEAKAGE DETECTION ROBOT

1. Introduction

The day, 2 December 1984: a tragic incident shook the whole nation. Bhopal gas tragedy had been one of the worst industrial disasters in the world. India has been witness to such unfortunate events both at domestic as well as industrial level for number of times but never actively participated on pre-disaster scenarios.

In urban India, there has been an exponential increase in population density, which has resulted in numerous high-rises. In the cities, the complexity of advanced lifestyle has increased the threats that cause Gas Leakage. These threats include: weak implementation of development guidelines, malpractices, haphazard uses, compromised and old electrical infrastructure, and so on. Even minor Gas Leakage in a single apartment or a factory, if not contained in a timely manner, can jeopardize the lives of hundreds of civilians in and around a building. Such extreme demands of leakage detection operations within enclosed spaces stretch the capability of human beings involved in control of Gas Leakage, making the job severe and often lethal.

Automated robotic technology will obviate risking the lives of human beings. Furthermore, robotic Gas Leakage detectors will be better than their human counterparts at enduring the toxic environments caused by Gas Leakage. Due to such reasons, robotic gas detection technology holds great promise in the future.

e-Yantra has designed a theme, "**GAS LEAKAGE DETECTION ROBOT**" to bring awareness to these issues. We have modelled the theme on a factory like scenario consisting of four pipeline areas. The pivotal task of the theme is for an autonomous robot to meticulously detect and stop the leakage of the gas in this factory.

The robot has to navigate through the entire factory. While doing so, it has to detect and stop all the leaking gases, without damaging the arena.

Like in the case of any Gas Leakage, the critical factor is time and the challenge is to complete this task in the shortest time possible. The robot that performs the task best as per the set rules will be declared the **WINNER.**

2. Theme Description

Make an autonomous robot that performs the following tasks:

1. The robot starts from **START/STOP** position of the arena that represents a factory. (Refer to Figure 1).
2. It has to traverse through all the four Pipeline Areas **PA-1, PA-2, PA-3 and PA-4** marked in Figure 1**.**

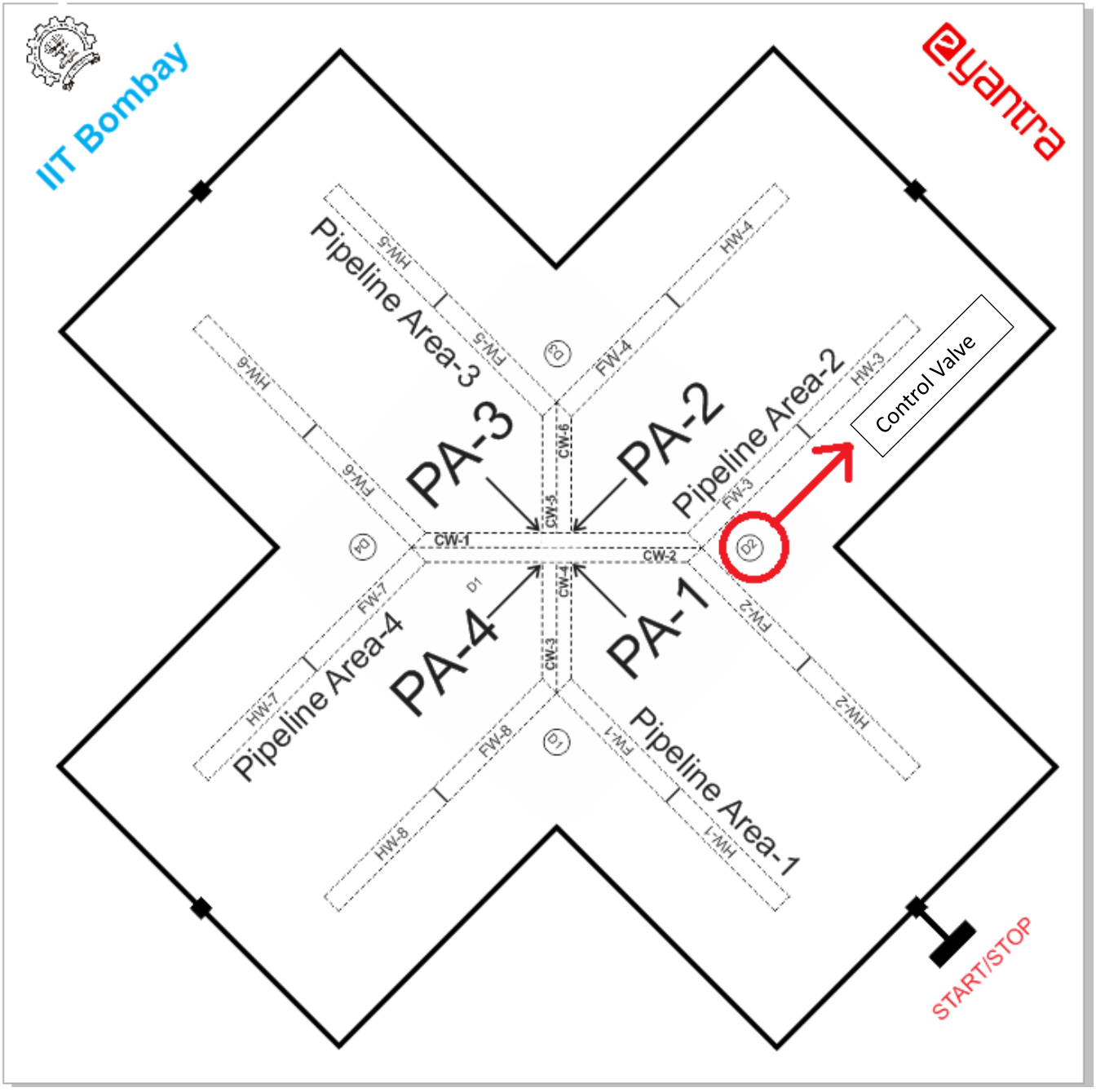


Figure 1: Flex Design

3. The factory can have a **maximum of three Gas Leakages**, happening in any three of the four Pipeline Areas. **A Pipeline Area may or may not contain a Gas Leakage.**

- **Gas Leakage**: To represent the Gas Leakage, we have used 2 Red, 2 Green and 2 Blue LEDs in three of the four Pipeline Areas. These LEDs are part of the LED Array (Refer to Section 3.3). Figure 2 depicts one such example of a Gas Leakage in one of the Pipeline Areas.

  The robot has to detect the Gas Leakage and light a **RGB LED** (either Red, Green or Blue depending on the respective Gas Leakage color) and sound a buzzer for 1 second to indicate detection.

4. After detection the robot has to **stop the Gas Leakage/s.**

- **Control Valve:** A Control Valve is a conical funnel sitting over a **Switching Mechanism** (Refer to Section 3.3) to stop the Gas Leakage which can be placed at D1, D2, D3 or D4 positions as shown in Figure 1. Every Gas Leakage (lit LED Array) has its own Control Valve placed at one of the D1, D2, D3 and D4 positions with a color corresponding to that of the respective Gas Leakage. In case there are any pipeline areas which do not have a Gas Leakage, a corresponding number of black colored dummy Control Valves will be placed in arena.

- **Stopping a Gas Leakage:** The robot has to drop a **magnet** into the Control Valve to stop the corresponding Gas Leakage. Henceforth in this document, this action is referred to as **"Closing the Control Valve".**

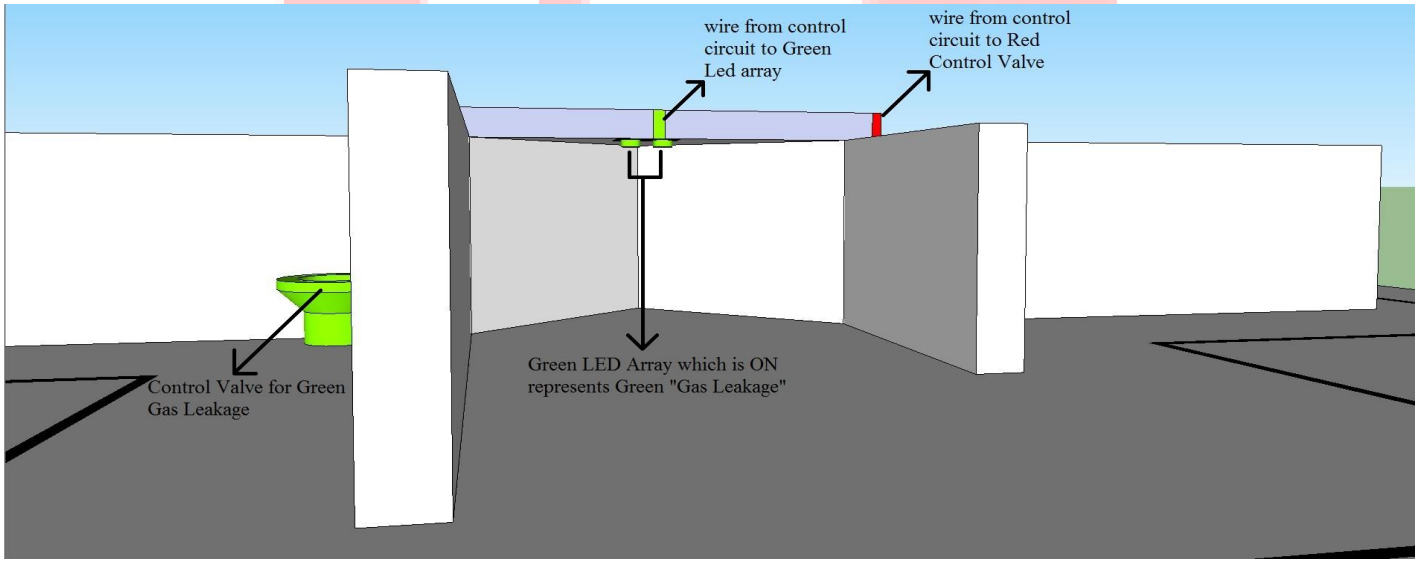


Figure 2: The LED Array and their Control Valves attached through wires

5. After checking all the Pipeline Areas and closing all the required Control Valves, the robot should return to the **STOP** position and sound a continuous buzzer of more than 5 seconds to indicate the end of the task.

   In this competition, teams are free to design the mechanism for detecting the presence of Gas Leakage and closing the corresponding Control Valves.

3. Arena

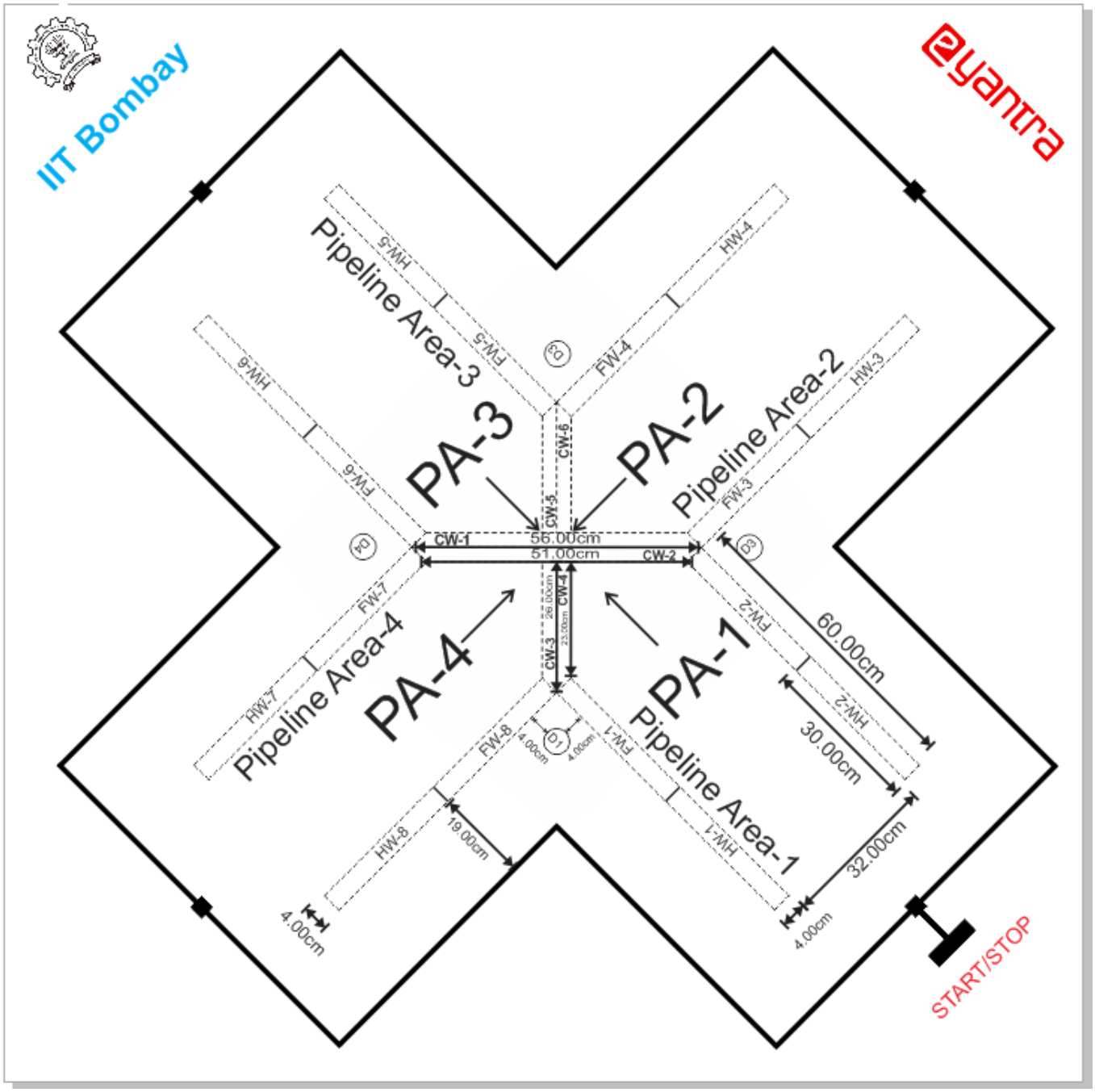


Figure 3: Arena Design with dimensions.

Preparing the arena:

Each team has to prepare the arena. Preparing the arena consists of four major steps.

1. Printing the arena design on flex sheet.
2. Preparing and placing the walls.
3. Assembling the LED Array circuits and their Control Valves.

4. Placing the LED Array circuits and their respective Control Valves.

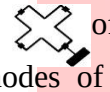
NOTE: Teams are not allowed to make any changes in the arena design. Any team making unauthorized modifications will be disqualified from the competition.

3.1. Printing the arena design on flex sheet:

A Corel Draw (.cdr) file containing the flex design will be provided to the teams. Each team prints the flex design according to the direction given in the .cdr file.

WARNING: Please be careful while handling the flex sheet – avoid folding it like a bed-sheet since the resultant folds will cause problems while the robot moves. One way of "flattening" flex if it has been compromised is to hang it for a few hours in the sun -- it tends to straighten out. Never attempt ironing it or applying heat of any kind -- it may be a fire hazard.

Details of arena design:

- Dimension of the flex sheet is 210 cm x 210 cm.
- The Path  of black Line enclosing the Pipeline Areas is of 1 cm thickness.
- Square nodes of 3cm x 3cm dimension have been provided along the black lines at entrance to each Pipeline Area.
- **Walls**: Every pipeline area is surrounded by walls with opening at the entrance and a **Ceiling** as shown in Figure 4. The length of these walls can vary according to their placement in the arena. The preparation and the placement of these walls and Ceiling are explained below in Section 3.2.

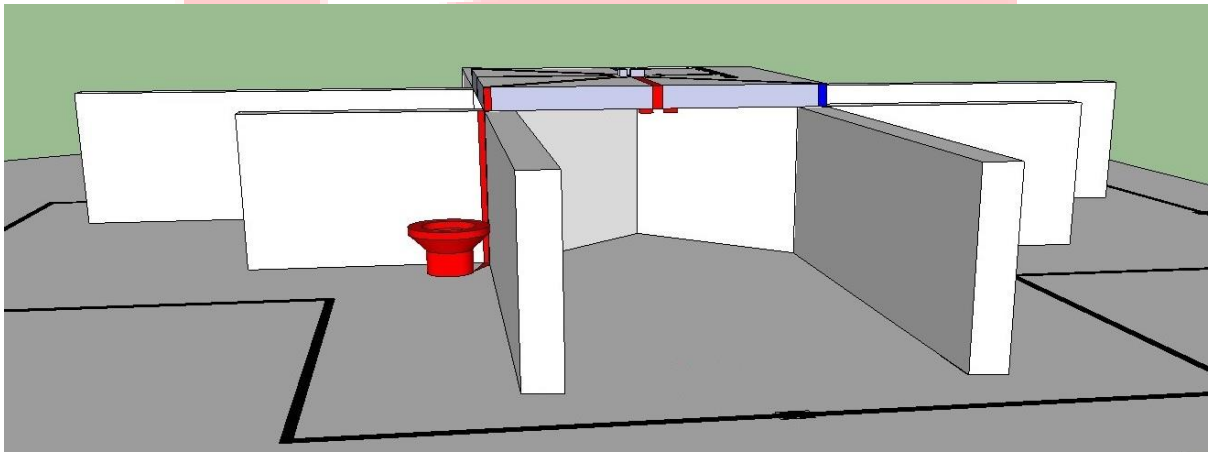


Figure 4: Entrance to the Pipeline Areas

- **Gas Leakage Zone:** Four inner ends of a Pipeline Area where a LED Array can be placed are referred to as **GL1, GL2, GL3** and **GL4** which are attached to the Ceiling of the Central Walls. An example of **GL2** is shown in Figure 5.

- **No Leakage Zone:** The inner end of the Pipeline Area where there is no Gas Leakage is called **No Leakage Zone**. Figure 6 represents one such Pipeline Area where "**No Leakage Zone**" is present. How to prepare and place the No Leakage Zone is discussed below.

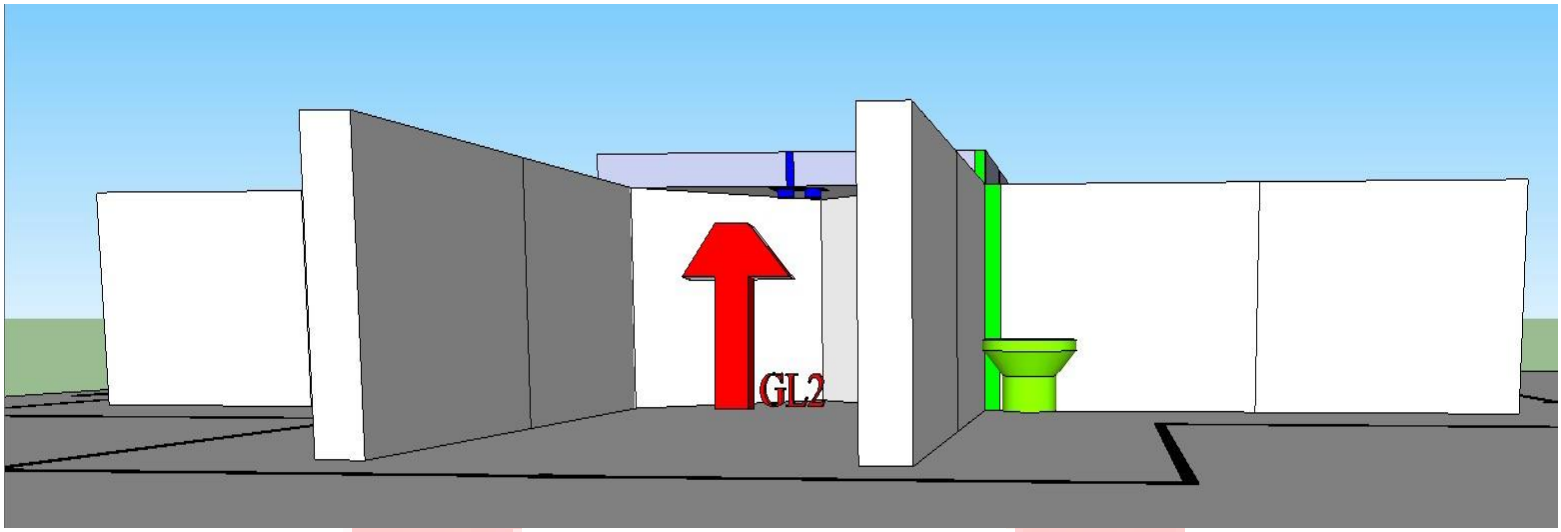


Figure 5: Gas Leakage zone (GL2) present in the Pipeline Area.

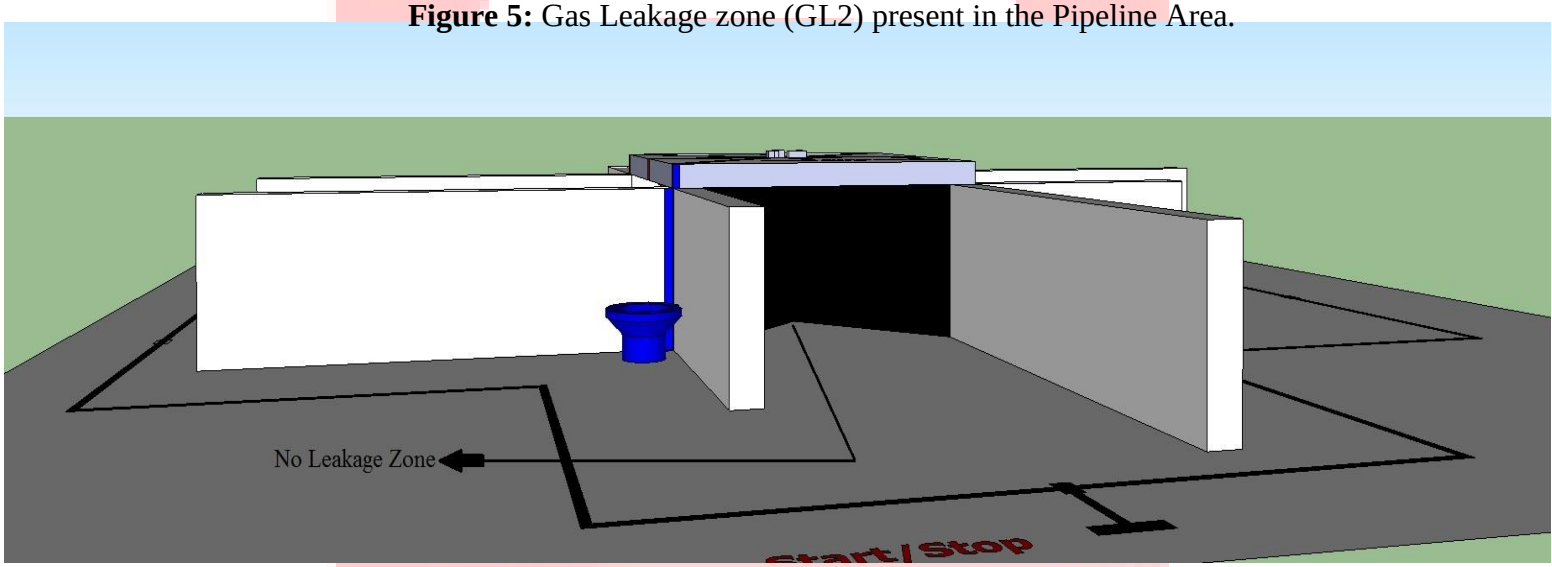


Figure 6: Black color depicting "No leakage Zone"

3.2. Preparing and placing the walls:

Materials required for preparing walls:

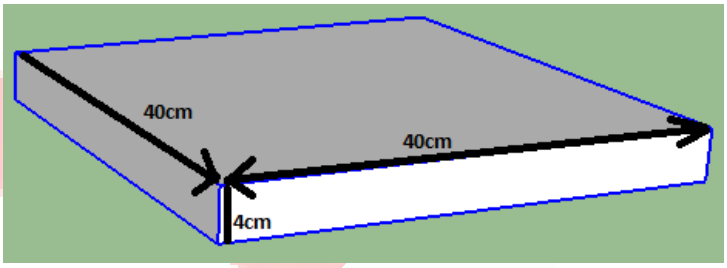
- Thermocol sheets.
- Black color chart paper.

Preparing Walls:

There are different types of walls being displayed in Figure 7. The descriptions related to the dimensions of these walls are given in Table 1 below:

Table 1: Wall Description Table

Serial Number	Name	Dimension(L x B x H)	Number of Walls
1	Fixed Wall (FW-1 to 8)	30cm x 4cm x 20cm	8
2	Half Wall(HW-1 to 8)	30cm x 4cm x 20cm	8
3	Central Walls(CW-1 & CW-2)	56cm x 2.5cm x 51cm	2
4	Central Walls(CW-3, CW-4, CW-5 & CW-6)	26cm x 2.5cm x 23cm	4
5	Ceiling	40cm x 4cm x 40cm	1



Ceiling used to cover Central Walls

Figure 7: Different types of Walls

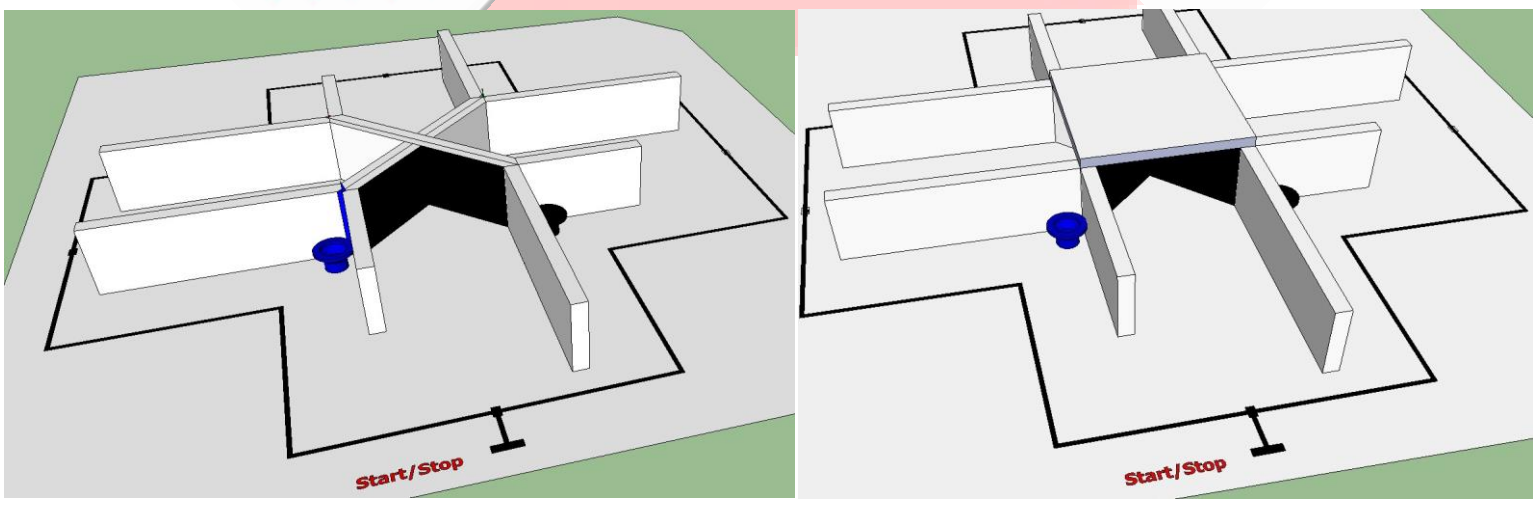


Figure 8: Central Walls without Ceiling and with Ceiling

- A **Fixed Wall (FW)** is made up of 2 **Half Walls (HW).**
- There are **14 fixed** walls:
    - **Central Walls CW - 1 to 6 -** are fixed walls which are placed exactly at the center of the arena. The Ceiling of the Central Walls as shown in Figure 9 holds the LED Array and also its control circuit.
    - **FW- 1 to 8** are permanently fixed to Central Walls **CW - 1 to 6** as shown in Figure 7.
- **Ceiling:** This is a slab which is fixed on top of the Central Walls. All the LED Arrays representing Gas Leakages are attached to the bottom of the Ceiling with one of the LED Array being a part of each Pipeline Area. Control circuits for these LED Arrays is attached to the roof of the Ceiling. Figure 8 displays the Ceiling of the Central Walls.
- The other walls **HW (1 to 8)** are temporary and can be attached to the Fixed Walls. They are placed based on the given **wall configuration table.**
- Cut the thermocol sheets to prepare walls of dimensions given in Table 1.

Note: **a) Edges of all the Central Walls should be cut at an angle of 45 degrees as shown in Figure 7.**

b) If a single sheet of required length is not available, then two or more small pieces can be joined to form a single wall of required size.

Placing walls:

Stick all the 14 fixed walls and the Ceiling permanently to the arena using double-sided tape or any other suitable adhesive. After this step the arena should look like that in Figure 9. (Note that on the flex design walls are marked on the appropriate wall section for each Pipeline Area.)

- There are 8 slots for temporary wall placement in the Arena.
- These slots are used to fix **HW (1 to 8)** walls as per the Wall Configuration.
- An example configuration is shown in the Table 2 below.

Table 2: Wall Configuration Table

Sl.no	Pipeline Area	Wall Present	Wall Absent
1	PA-1	HW-2	HW-2
2	PA-2	HW-3 & HW-4	----
3	PA-3	HW-5	HW-6
4	PA-4	----	HW-7 & HW-8

- Figure 9 maps the above Wall Configuration table.

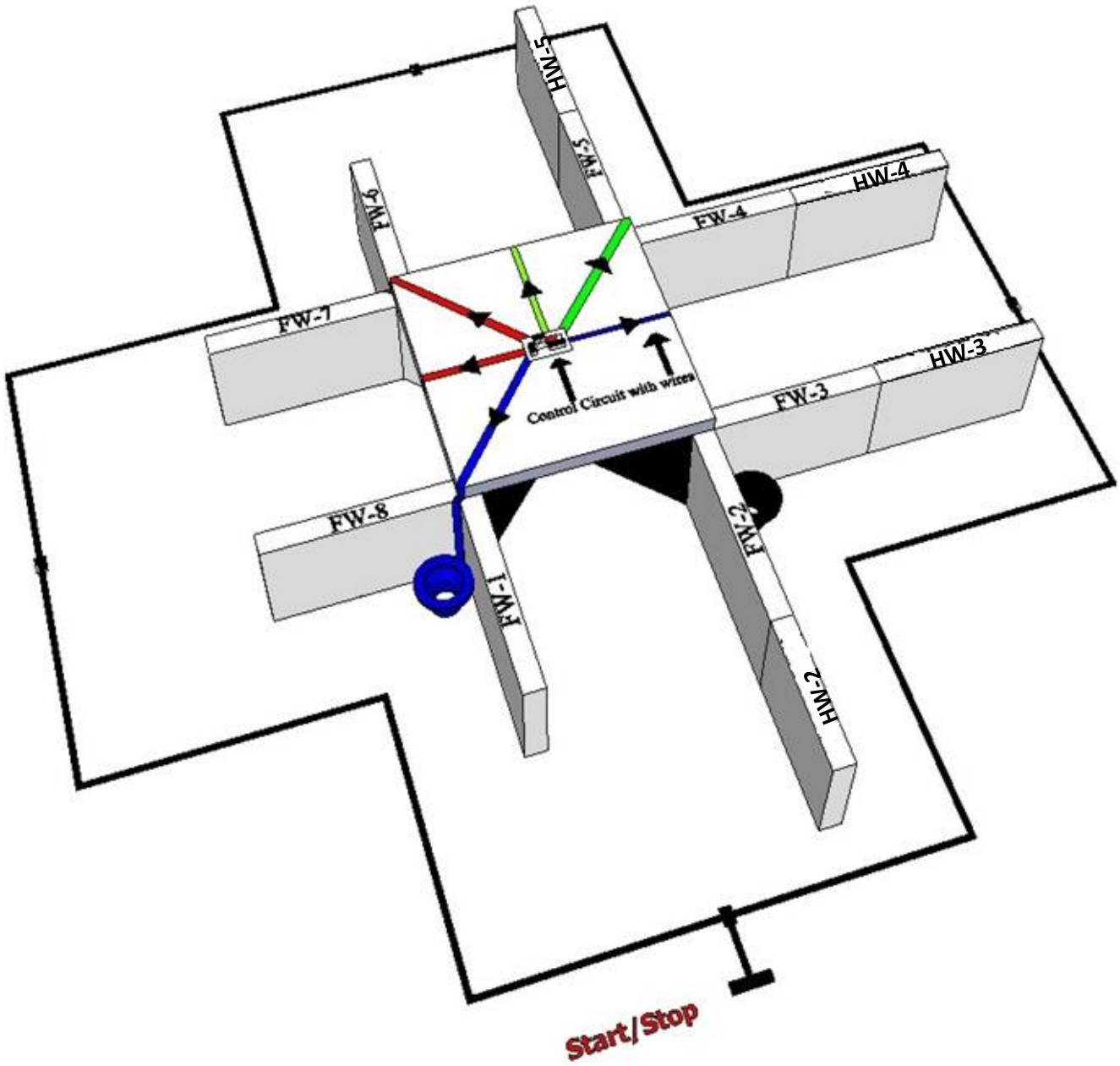


Figure 9: Wall Configuration According to Table 2.

Representing a No Leakage Zone:

- Only in the No Leakage Zone, where there is no Gas Leakage, the Central Walls should be covered with black chart paper (shown in Figure 10).

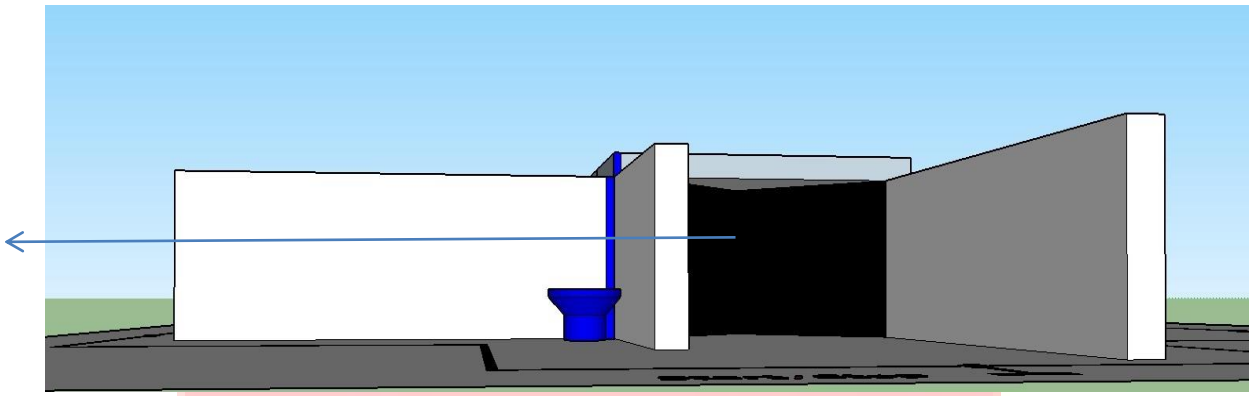


Figure 10: No leakage Zone depicted by walls covered with black chart paper.

Note: Faces of all other walls placed in the Pipeline Areas should be left uncovered.

3.3. Assembling the LED Array circuits and their Control Valves:

- A Control Circuit packet (mentioned in the component list) has been provided in the kit which will be used to make the LED Array and the Control Circuit.
    1. **Control Circuit:** This part will be constructed by the participants using the components provided in the kit. This part will be used to control the LED Array such that the switching mechanism beneath the Control Valves will turn off the corresponding LED Array when magnet is dropped over it.
    2. **Switching Mechanism:** This part will be constructed by the participants using the components provided in the kit. This part will be used to transfer signal to the Control Circuit to turn off the LED Array.
    3. **LED Array:** This part will be constructed by the participants using the components provided in the kit. This part will be connected to Control Circuit to light different colored Gas Leakages.
- Assemble all the LED Array circuits as per the steps presented in the tutorial called 'Assembling the LED Array circuits and their Control Valves'. This will be available in the Resources tab in the portal along with Task 2.This tutorial explains: how to solder the parts and assemble the Control Circuit, LED Array and Switching Mechanism.

3.4. Placing the LED Array Circuits and their Respective Control Valves:

- In each Pipeline Area in the Gas Leakage Zone an LED Array of a given color will be attached (if there is a Gas Leakage) to the Ceiling using double-sided tape as shown in the Figure 11.
- The distance of the LED Arrays is 5cm from the midpoint of the side of the Ceiling. One Example is shown in Figure 11.
- Control Valves for stopping the Gas Leakage are placed at D1, D2, D3 and D4 positions.
- Note that the Red, Green and Blue Control Valves control the Gas Leakage and the Black Colored Control Valve is a dummy. Your robot should not drop any magnet in the Black Control Valve.
- The number of black colored Control Valves will depend on the number of No

Leakage Zones. You don't have to drop any magnet into this Control Valve.
For Example: If there are 2 "**No Leakage zones**", two Black colored dummy **Control Valves** having no switching mechanism, are placed at the corresponding positions.

- The pattern of placement of Control Valves in these four positions is completely based on Table 3.
- There can't be two Control Valves of same color except the Black colored Control Valves.
- Table 3 represents the placement of Gas Leakages and Control Valves with their corresponding LED Array.

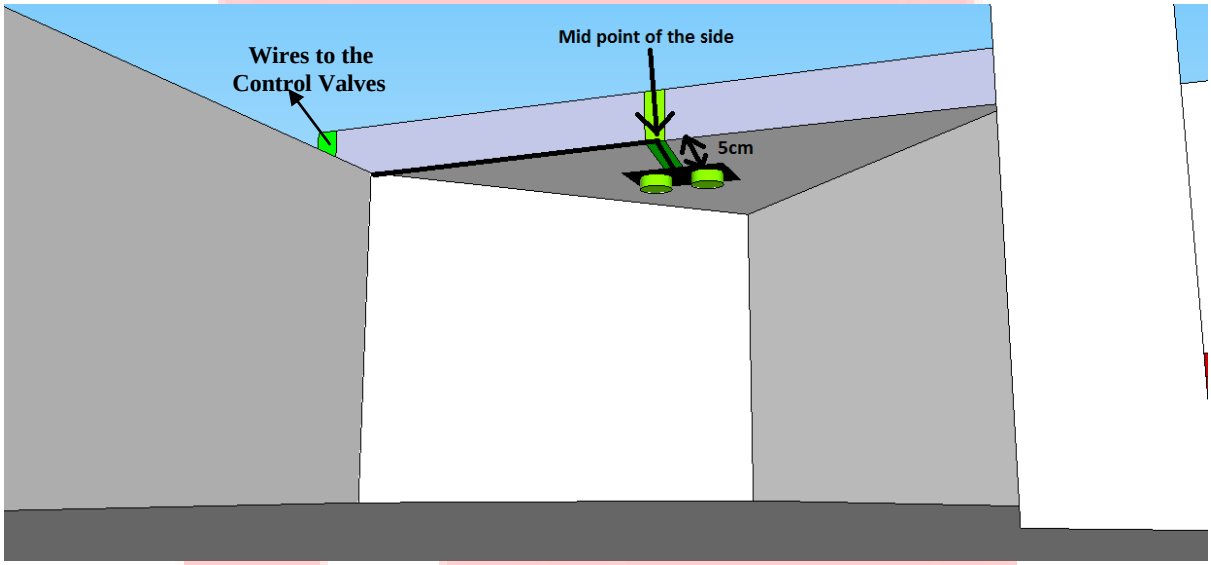


Figure 11: Placement of LED Array

Table 3: Placement of Gas Leakages and Control Valves

Color	Control Valve	Pipeline Area/Gas Leakage Zone	Switching Mechanism
Red	D4	PA-4(GL-4)	Yes
Green	D3	PA-3(GL-3)	Yes
Blue	D1	PA-2(GL-2)	Yes
Black	D2	PA-1(GL-1)	No

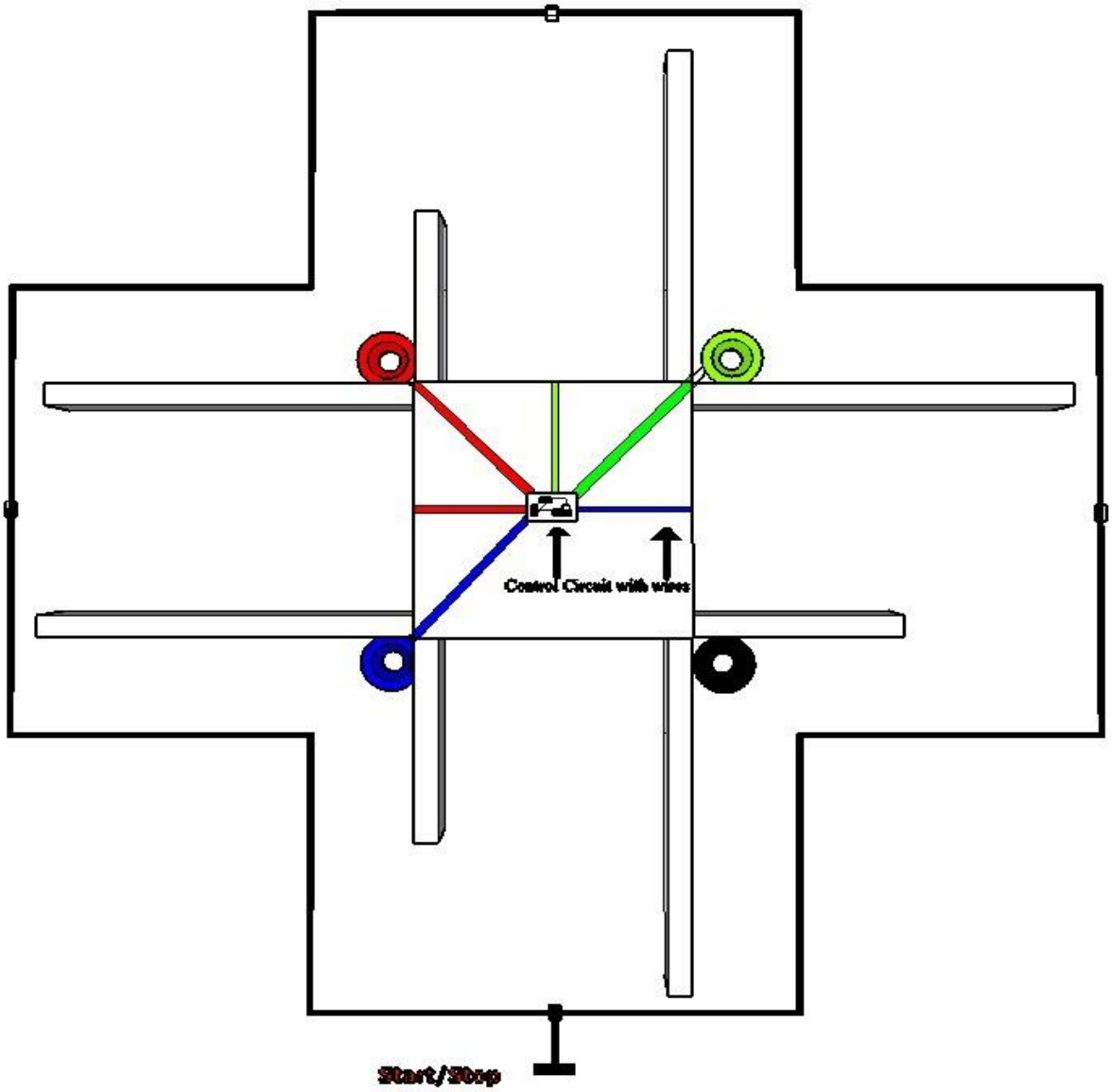


Figure 12: Table 3 Configuration is Shown in This arena

- This is an example used to illustrate the positioning of LED Array and placement of Control Valves. At the time of video submissions, you will be given two configuration tables with "wall Configuration" and "LED Array and their respective Control Valve positions"

NOTE: a) Please accurately calibrate sensors since this is typically the cause of errors. You should make the sensing as robust as possible under different lighting conditions. Also take care in the fabrication of the walls since the proper sizing; positioning and positional stability of the walls might make the difference between failure and success.
b) If the arena is found damaged or in a condition that makes evaluation difficult, e-

Yantra has the right to disqualify a team. The final decision is at the discretion of the reviewer.

4. Hardware Specifications

4.1 Use of Firebird V:

- All participating teams must use only the Firebird V robot sent to them in the kit.
- Team shall not dismantle the robot.
- The robot should be completely autonomous. The team is not allowed to use any wireless remote or any other communication protocol or devices such as a camera while the robot is performing the task.

4.2 Use of additional components not provided in the kit:

- No other microcontroller-based board shall be attached to the Firebird-V robot.
- Teams may connect external actuators along with their driver circuits to the Firebird V robot only on the condition that the actuators must be controlled through the Firebird V robot.
- The team is not allowed to use any other sensors apart from those provided in the kit.

4.3 Power Supply:

- The robot can be charged through battery or auxiliary power supply. These are shipped with the robot.
- The team cannot use any other power source for powering the robot.
- The team can use auxiliary power during practice but the final demonstration should only be made using only battery powered robot.

5. Software Specifications:

- e-Yantra has provided all teams with ATMEL STUDIO 6, a free software for programming AVR microcontroller. Participating teams are free to use any other open source Integrated Development Environment (IDE) for programming AVR microcontroller.
- As per e-Yantra policy, all your code and documents are open-source and maybe published on the e-Yantra website.

6. Theme Rules:

- The maximum time given for completing all the tasks is 10 minutes. A maximum of two runs will be given to a team (the better score from the two runs will be considered as team's final score). A maximum of two Reposition (explained below) are allowed in each run.
- If robot is found to be displacing any wall or Control Valve, or damaging the arena, it will be considered as the end of the run.

- Participants are not allowed to keep anything inside the arena other than the robot.
- The time measured by the reviewer will be final and will be used for scoring the teams. Time measured by any participant by any other means is not acceptable for scoring.
- The team should Switch ON the robot when asked by the reviewer. This is the start of a run. The timer will start the same time.
- Two configuration tables, one that defines the wall positions and the other that defines the placement of the Gas Leakages and Control Valves, will be given before the start of the run.
- The maximum number of magnets that the robot can carry is equal to the total number of Gas Leakages in the arena. There will be a maximum of three Gas Leakages, with no Pipeline Area containing more than one Gas Leakage.
- The configuration table will remain the same for the two runs.
- Robot should be kept at the START/STOP position with the castor wheel of the robot positioned on the Black Strip.
- Once the robot is switched on, human intervention is NOT allowed.
- After each Gas Leakage is detected, the robot has to sound a buzzer of 1 second and light the **RGB LED** of same color as that of the Gas Leakage.
- Robot should drop a magnet in to the Control Valve to STOP the Gas Leakage.
- A Gas Leakage is considered STOPPED when the magnet has been dropped in the corresponding Control Valve.
- A run ends and the timer is stopped when:
    - The robot stops and sounds continuous buzzer or
    - If the maximum time limit for completing the task is reached or
    - If the team needs repositioning but has used both reposition options for that run.
- Buzzer sound for more than 5 seconds will be considered as continuous buzzer.
- The second run will start once again with resetting the score, timer. The score of both runs will be recorded and best of two runs will be considered as the team's final score.
- The robot is not allowed to make any marks while traversing the arena. Any robot found damaging the arena will be immediately stopped; repositioning will be allowed as per the rules. The final decision is at the discretion of the e-Yantra team.

Repositioning of robot:

- Repositioning is allowed under following circumstances:
    - If the robot gets stuck in the arena or goes off the arena, teams can ask for reposition or can go for next run.
- Participants monitoring the task will Reposition the robot close to the point of deflection (10cm in the radius of robot), you are not allowed to touch the arena in any case.
- Each team will be allowed a maximum of two repositions in each run. All repositions require the approval of the reviewer.
- During repositions, a participant must not feed any information to the robot. A participant shall not alter a robot in a manner that alters its weight or mechanism.
- The reviewer's decision is final.
- Note that during reposition, any Gas Leakage which is not been previously

stopped will remain as it is.

- After reposition the robot has to complete the remainder of the task; the part of the tasks completed previously will be counted in the score.

Note:

- **You will be given the configuration tables just before the submission of Task 3: Video submission along with instructions to complete this task.**
- **After completion of all tasks, teams will be selected as finalists based on their cumulative scores across all the tasks. Complete rules and instructions for the finals at IIT Bombay will be sent to those teams that qualify for the finals.**
- **In case of any disputes/discrepancies, e-Yantra's decision is final and binding. e-Yantra reserves the rights to change any or all of the rules as we deem fit. Any change in rules will be highlighted on the website and notified to the participating teams.**

7. Judging and Scoring System:

- The competition time for a team starts from the moment the robot is switched ON. The timer will stop as soon as the robot finishes the task.
- The better score of the two runs for a team will be considered as the final score of the team.
- The team's total score is calculated by the following formula:

  Total Score = (600 - T) + (D * 50) + (CCCV *50) – (iD*50) – (iCCV *50) + OB – (P*20) – (RP*30)

Where:

✓ **Total time (T):**

T is the total time in seconds taken to complete the task.

✓ **Correct Detection (D):**

D is the total number of correctly detected Gas Leakages and their Control Valves. Detection of Gas Leakages is considered correct, if the robot sounds a buzzer for 1 second and lights the **RGB LED** with same color as that of the Gas Leakage. The Detection of Control Valves will be considered correct if the **RGB LED** lit is of same color as that of Control Valve.

✓ **Correct Closing of Control Valve(CCCV):**

CCCV is the total number of correctly Closed Control Valve. Closing is considered correct when a magnet is dropped inside the Control Valve. No points will be

awarded when robot drops the magnet before detecting the Gas Leakage of same color as that of Control Valves.

Incorrect Detection (iD):

✓ **iD** is the total number of Gas Leakages and their control vales being incorrectly detected. It is considered incorrect detection when the robot sounds a buzzer without presence of any Gas Leakage or when the robot doesn't beep in the presence of a Gas Leakage or it glows the **RGB LED** of different color irrespective of the Gas Leakage and the Control Valves.

Incorrect Closing of Control Valves (iCCV):

✓ **iCCV** is the total number of Control Valves incorrectly Closed. It is deemed incorrect Closing of Control Valves when:

1. The robot drops the magnet anywhere in the arena instead of dropping it in the correct Control Valve.
2. The robot drops the magnet before detecting the Gas Leakage of same color as that of Control Valves.
3. Black Control Valves are dummies, dropping the magnet in these Control Valves will be considered incorrect.

Penalty (P):

✓ **P** is penalty where twenty points are deducted each time the robot dashes against the walls or displaces any part of the arena during the run.

Reposition Penalty(RP):

✓ **RP** is the penalty where thirty points will be deducted when the team will ask for reposition.

Overall Bonus Points (OB):

✓ 100 Bonus points will be awarded, if the robot does ALL of the following:

- Detects all Gas Leakages correctly.
- Closing all the Control Valves correctly.
- Completes task before 10 minutes.
- Doesn't need any Reposition.
- Doesn't incur any penalties.
- Returns to START/STOP position and sounds a continuous buzzer of more than 5 seconds.

ALL THE BEST!!!