

Santa Rita Jail  
AGV System Replacement Project  
Magnetic Spot Installation Specifications  
MTM Project **17018-17026.0**



# AUTOMATIC GUIDED VEHICLE SYSTEMS



Santa Rita Jail – Project 17018-17026.0 – Navigation Spot Installation Specification v1.0

November 1, 2017

## Revision History

Revision	Date	Change Summary	Author
0.10	10.31.2017	New Document	DCE
1.00	11.1.2017	Final review and comments	DCE

## 1 Automatic Guided Vehicle (AGV) Spot Navigation

### 1.1 General

The current automatic guided vehicles (AGVs) at Santa Rita Jail use wire navigation for guidance. The wire navigation system includes a continuous wire embedded in the floor. This wire is electrically energized by a frequency generator. Antennas located on the bottom of the AGV detect the signal emitted from the wire, enabling the AGV to follow the wire.

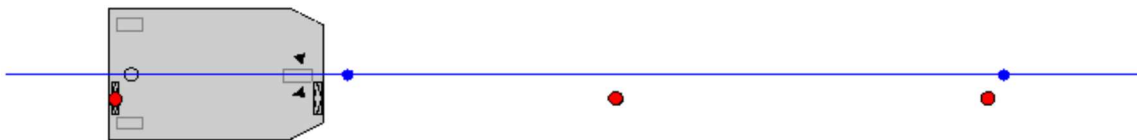
In intersections, the use of different frequencies in the wires enable the AGVs to switch to alternate travel paths based on their programmed destination.

The embedded wire defines the travel paths of the AGVs. The AGVs cannot travel where this is no wire. For this project, the new AGVs will use spot navigation, but will follow the exact same travel paths as the current system. For this reason, the existing navigation wire can be used as a very accurate guide for the placement of magnetic spots.

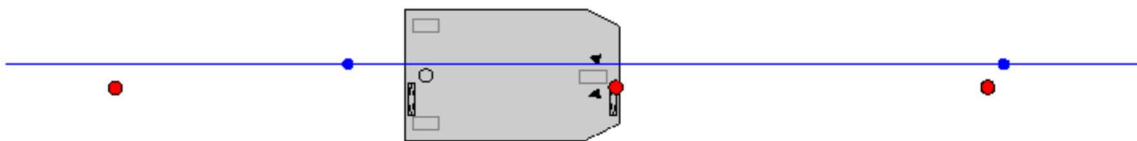
### 1.2 Spot Navigation

Spots are small magnetic cylinders embedded in the floor along the AGV travel paths. They are used by the AGV to update position as it navigates on the paths. Between spots, AGVs navigate using a dead-reckoning method. This method uses information from drive and steer encoders plus an onboard gyro to continuously update the vehicle's position.

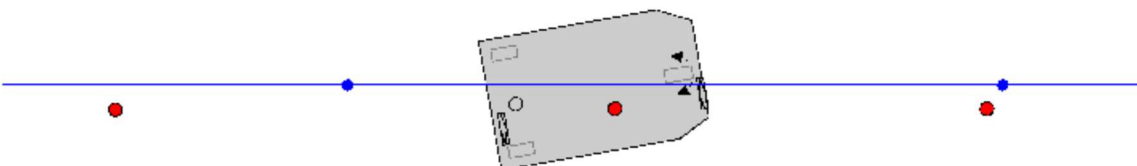
Dead-reckoning is not perfect, spots are used by the AGV to correct for the accumulated navigation error. Spots are detected by inductive sensors located on the bottom of the AGV. When a sensor detects a spot, it reports the position of the magnet relative to the vehicle. The vehicle controller has a map of all spot positions. If there is a deviation between the measured position and expected position the AGV controller will automatically steer the vehicle back onto the correct path.



*The red dots are spots, the blue line is the AGV travel path. In this diagram the AGV antenna is centered over the spot, no correction is required.*



*The AGV has drifted slightly and not directly over the spot*



*The AGV automatically corrects its position based on spot information.*

## 2 Spot Installation

### 2.1 General

The refurbished AGVs with spot navigation, will follow the same travel paths as the existing AGVs. This greatly simplifies the spot installation. The spots will be installed along the existing navigation wire, offset by a fixed distance from the wire and spaced a fixed distance along the wire. There is no need for a detailed spot location drawing.

### 2.2 Location of Spots

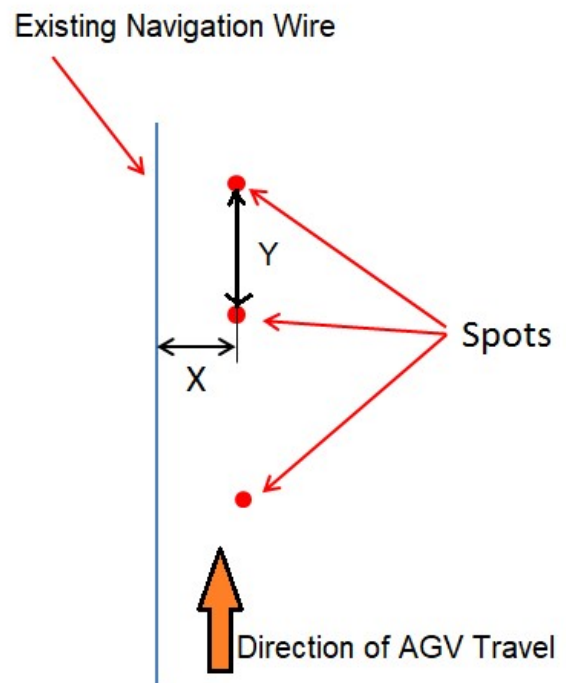
Install the spots along the existing navigation wire for all AGV travel paths. It might be necessary for an SRJ AGV engineer to assist in locating the main navigation wire in some areas. There is also embedded wire used for other AGV control functions that could be confusing for the spot installation team.

**Spots are only installed along the straight sections of the AGV travel paths. In curves and turns the AGV use dead-reckoning for navigation.**

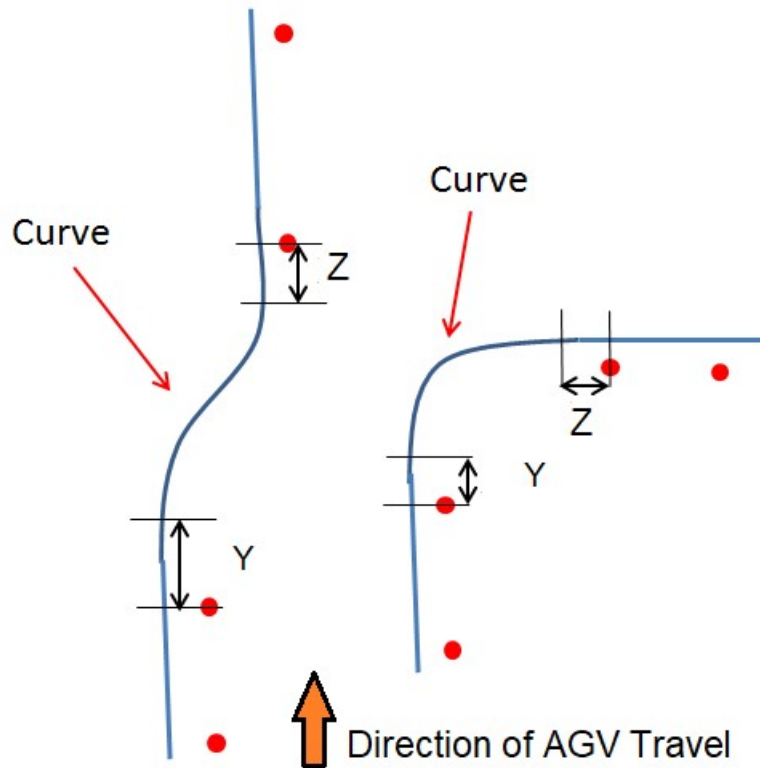
#### 2.2.1 Straight Sections of AGV Travel Path

Along the straight runs, install the spots approximately every 5 meters  $\pm 25\text{cm}$  and offset from the wire 10cm to the right in the direction of AGV travel.

<b>X</b> distance from wire	10cm to the right of the wire, in the direction of travel
<b>Y</b> spacing between spots	5m $\pm 25\text{cm}$



## 2.2.2 Curved Sections

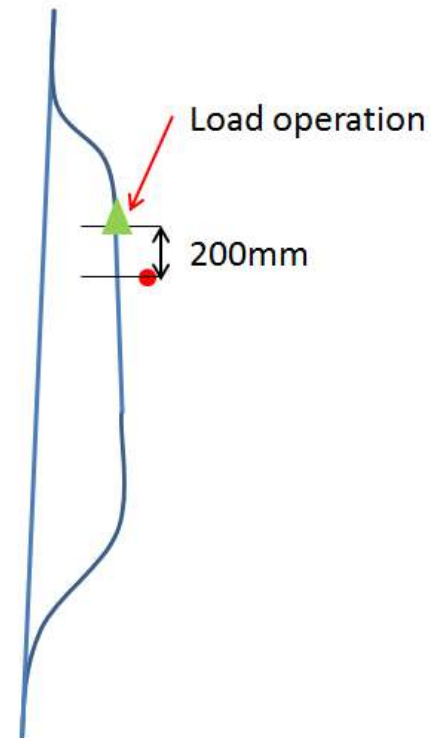


Spots should not be installed in the curves. There should be 1 spot installed **Ycm** from the beginning of the curve and 1 spot installed **Zcm** from the end of each curve. The offset from the wire is the same, **10cm** to the right of the wire, in the direction of AGV travel.

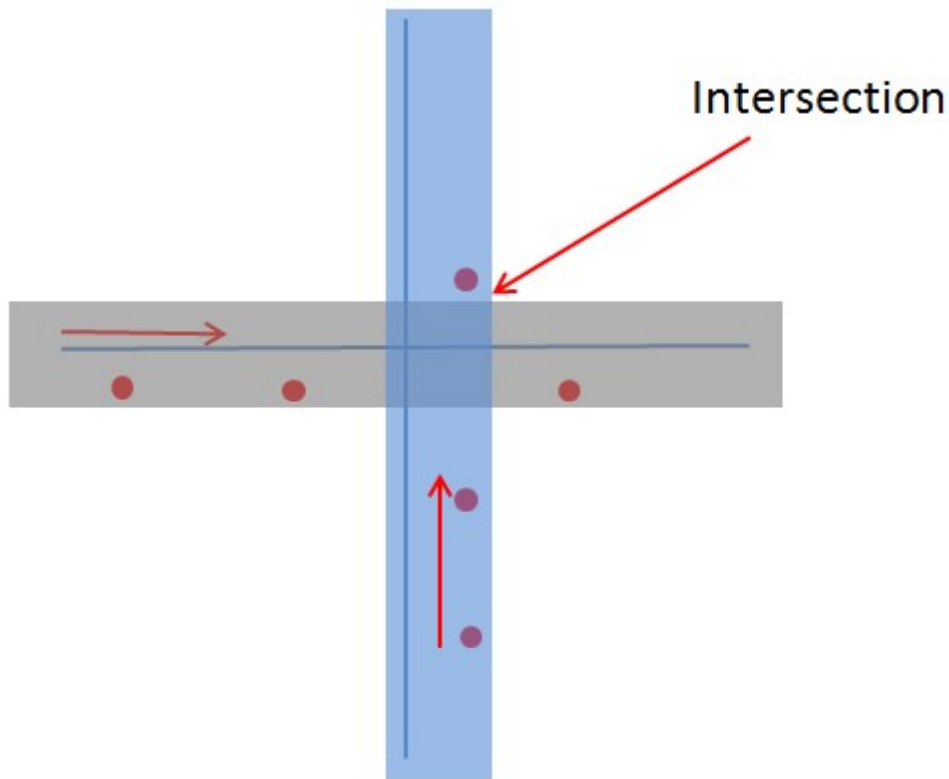
<b>X</b> distance from wire	<b>10cm to the right of the wire, in the direction of travel</b>
<b>Y</b> spacing before curve	<b>200 cm</b>
<b>Z</b> spacing after curve	<b>200 cm</b>

## 2.2.3 Load, Unload and Battery Charge Stations

At load, unload and charge stations, a spot should be installed 20 cm before the actual stop position. This insures that the AGV will have maximum accuracy for positioning the AGV on the station.



## 2.2.4 Intersections



In intersections where AGVs will pass in different directions, spots should be separated so the AGV heading in the N/S direction (blue) does not read a spot intended for AGVs traveling in the E/W direction (gray).

## 2.3 Installation of the Magnetic Spots

### 2.3.1 Estimated Number of spots

There are approximately 2.0 miles of AGV travel paths. Assuming a spot needs to be installed every 5m of straight travel path, approximately 650 spots are required.

### 2.3.2 Spot Specifications

The spots are small cylindrical permanent magnets. There is a small red dot on the end of each spot identifying the north pole of the magnet. When installing, it's critical that the spot be placed in the hole with the north pole of the magnet facing up.



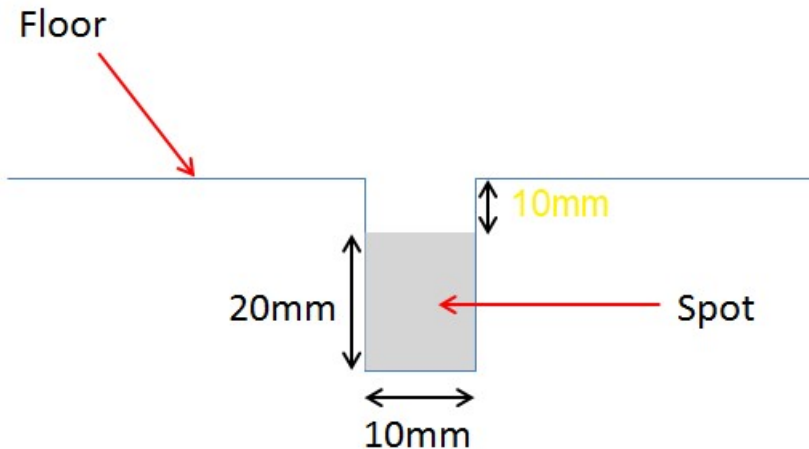
*Two magnetic spots and AGV spot antenna.*

#### Specifications:

Diameter	10 mm
Height	20 mm
Surface Coating	Nickel + Tin
Temperature Range	-40 to 120°C



## 2.3.3 Spot Floor Installation



The spot is a 20mm x 10mm cylindrical magnet. To install:

1. Drill a hole in the concrete slightly larger than 10mm in diameter and **30mm deep**. Use a drill depth control to get the same distance and blow out the concrete dust from the hole.
2. Insert the spot, with the red dot (north pole of the magnet) facing up. *It is critical for AGV navigation that the orientation of the spot is correct.*
3. Fill in the space above the spot **with concrete sealer. Amerden recommends Sikaflex 1cSL.**

## 3 Survey Map of the Spots

Once the navigation spots have been installed, a survey team needs to measure the exact X,Y coordinate of each spot. All spots should have the same reference point (0,0 point). This point can be determined by the survey team, but approved by Amerden. Coordinate accuracy **should be ± 1 mm?**

All spot coordinates need to be in the first quadrant, i.e., all surveyed points need to have a positive value for both X coordinate and Y coordinate. Coordinate data should be provided in an Excel spreadsheet, in the following format.

Target label	X-coord	Y-coord
1	4747.561	4913.034
2	4787.556	4913.116
3	4708.544	4932.866
4	4708.902	4913.491
5	4748.853	4975.164
6	4788.907	4974.349
7	4708.002	4963.96
8	4707.974	4981.979
9	4708.657	5008.664