

BIO-HAZARD CLEANING INTELLIGENT AGENT - TEST CASE DOCUMENTATION

Project: AI Agent Simulation System
Created: February 16, 2026
Total Test Cases: 173
Framework: Python unittest + pytest

Executive Summary

This document provides comprehensive documentation of all 173 test cases covering the Bio-Hazard Cleaning Intelligent Agent system. The test suite ensures robust validation of four core modules: Environment, Agent, Movement, and Action.

Test Coverage Overview

Module	Test Count	Status
Environment	43	<input checked="" type="checkbox"/> PASSING
Agent	46	<input checked="" type="checkbox"/> PASSING
Movement	34	<input checked="" type="checkbox"/> PASSING
Action	50	<input checked="" type="checkbox"/> PASSING
TOTAL	173	<input checked="" type="checkbox"/> ALL PASSING

1. ENVIRONMENT MODULE TESTS (43 tests)

Purpose

Validates grid environment functionality, bio-hazard placement, accessibility checks, and cell querying operations.

Test Categories

1.1 Initialization Tests (3 tests)

#	Test Name	Description
1	test_environment_initialization_size_20	Verify environment creates correct 20x20 grid
2	test_environment_initialization_size_50	Verify environment creates correct 50x50 grid
3	test_environment_initialization_size_100	Verify environment creates correct 100x100 grid

1.2 Inaccessible Areas Tests (4 tests)

#	Test Name	Description
4	test_border_inaccessible	Verify grid borders are marked inaccessible
5	test_guest_house_inaccessible	Verify building areas are inaccessible
6	test_pond_inaccessible	Verify pond area is inaccessible
7	test_size_100_has_buildings	Verify 100x100 grid has internal buildings

1.3 is_inside_grid() Tests (5 tests)

#	Test Name	Description
8	test_is_inside_grid_valid_positions	Test boundary positions return True
9	test_is_inside_grid_outside_right	Test position outside right boundary returns False
10	test_is_inside_grid_outside_bottom	Test position outside bottom boundary returns False
11	test_is_inside_grid_negative_indices	Test negative indices return False
12	test_is_inside_grid_boundary_positions	Test boundary edge positions

1.4 is_accessible() Tests (3 tests)

#	Test Name	Description
13	test_is_accessible_clean_area	Test accessible clean cells return True
14	test_is_accessible_building_area	Test inaccessible building areas return False
15	test_is_accessible_inaccessible_border	Test inaccessible borders return False

1.5 is_bio_hazard() Tests (2 tests)

#	Test Name	Description
16	test_is_bio_hazard_true	Test bio-hazard detection returns True
17	test_is_bio_hazard_false_clean_area	Test clean area returns False

1.6 is_clean() Tests (2 tests)

#	Test Name	Description
18	test_is_clean_empty_position	Test accessible clean area returns True
19	test_is_clean_after_cleaning	Test cleaned cell returns True

1.7 Bio-Hazard Placement Tests (6 tests)

#	Test Name	Description
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#	Test Name	Description
20	test_place_bio_hazards_count	Verify specified hazard count is placed
21	test_place_bio_hazards_zero_hazards	Verify zero hazards handled safely
22	test_place_bio_hazards_no_duplicates	Verify hazards are placed at unique positions
23	test_place_bio_hazards_in_accessible_areas_only	Verify hazards placed only in accessible cells
24	test_place_maximum_hazards	Verify maximum possible hazards can be placed
25	test_bio_hazard_return_zero_unavailable	Verify return value correct when no space

1.8 count_bio_hazards() Tests (2 tests)

#	Test Name	Description
26	test_count_bio_hazards_zero	Verify zero count before placement
27	test_count_bio_hazards_matches_placed	Verify count matches placed hazards

1.9 count_clean_areas() Tests (2 tests)

#	Test Name	Description
28	test_count_clean_areas_initial	Verify initial clean areas calculation
29	test_count_clean_areas_after_hazard_placement	Verify count decreases after hazard placement

1.10 count_inaccessible_areas() Tests (2 tests)

#	Test Name	Description
30	test_count_inaccessible_areas_consistent	Verify inaccessible count is consistent
31	test_count_inaccessible_areas_borders_included	Verify borders counted as inaccessible

1.11 count_accessible_areas() Tests (2 tests)

#	Test Name	Description
32	test_count_accessible_areas_calculation	Verify accessible area calculation
33	test_count_accessible_areas_vs_inaccessible	Verify accessible + inaccessible = total

1.12 Grid Coordinate Methods Tests (6 tests)

#	Test Name	Description
34	test_get_grid_returns_copy	Verify get_grid() returns copy
35	test_get_grid_same_size	Verify returned grid has same size

#	Test Name	Description
36	test_get_bio_hazard_coordinates	Verify bio-hazard coordinate retrieval
37	test_get_bio_hazard_coordinates_empty	Verify empty list when no hazards
38	test_get_inaccessible_coordinates	Verify inaccessible coordinate retrieval
39	test_get_inaccessible_coordinates_count_matches	Verify count matches returned coordinates

1.13 Grid Size Tests (4 tests)

#	Test Name	Description
40	test_minimum_grid_size	Verify minimum grid size handling
41	test_large_grid_size	Verify large grid size (100x100) handling
42	test_get_clean_area_coordinates	Verify clean area coordinate retrieval
43	test_count_clean_areas_calculation	Verify clean areas sum correctly

2. AGENT MODULE TESTS (46 tests)

Purpose

Validates agent initialization, movement tracking, waste collection, termination handling, and state management.

Test Categories

2.1 Initialization Tests (4 tests)

#	Test Name	Description
1	test_agent_initialization_position	Verify agent starts at correct position
2	test_agent_initialization_active_state	Verify agent initializes as active=True
3	test_agent_initialization_stop_reason	Verify stop_reason initializes as None
4	test_agent_initialization_empty_visited	Verify visited_positions initialized

2.2 Position Update Tests (6 tests)

#	Test Name	Description
5	test_update_position_changes_current_position	Verify position updated correctly
6	test_update_position_increments_steps	Verify steps_taken incremented
7	test_update_position_adds_to_visited	Verify position added to visited set
8	test_update_position_adds_to_path	Verify position added to path list

#	Test Name	Description
9	test_update_position_maintains_path_order	Verify path maintains chronological order
10	test_update_position_multiple_increments	Verify multiple updates handled correctly

2.3 Waste Collection Tests (4 tests)

#	Test Name	Description
11	test_collect_waste_increments_counter	Verify waste counter incremented
12	test_collect_waste_multiple_times	Verify multiple collection events
13	test_collect_waste_returns_none	Verify collect_waste() returns None
14	test_collect_waste_statistics	Verify waste count in statistics

2.4 Termination/Stop Tests (4 tests)

#	Test Name	Description
15	test_stop_changes_active_state	Verify active set to False on stop
16	test_stop_sets_stop_reason	Verify stop_reason set correctly
17	test_stop_different_reasons	Verify different stop reasons handled
18	test_stop_once_set_remains	Verify stop_reason preserved once set

2.5 Visited Positions Tests (4 tests)

#	Test Name	Description
19	test_has_visited_starting_position	Verify starting position marked visited
20	test_has_visited_after_movement	Verify positions marked visited after move
21	test_has_visited_multiple_positions	Verify multiple positions tracked
22	test_has_visited_unvisited_position	Verify non-visited positions return False

2.6 Path Tracking Tests (5 tests)

#	Test Name	Description
23	test_get_path_correct_length	Verify path length equals movements
24	test_get_path_maintains_order	Verify path order chronological
25	test_get_path_returns_copy	Verify get_path() returns copy
26	test_steps_equals_path_length_minus_one	Verify steps = path_length - 1
27	test_visited_positions_represents_path_uniqueness	Verify visited = unique path positions

2.7 Rapid Movement Tests (2 tests)

#	Test Name	Description
28	test_rapid_movements	Verify rapid sequential movements
29	test_same_position_multiple_times	Verify same position visited multiple times

2.8 Statistics Tests (9 tests)

#	Test Name	Description
30	test_get_statistics_returns_dict	Verify statistics returns dictionary
31	test_get_statistics_has_required_keys	Verify statistics has all required keys
32	test_get_statistics_initial_values	Verify initial statistics values
33	test_get_statistics_after_movement	Verify statistics after movement
34	test_get_statistics_after_collection	Verify statistics after waste collection
35	test_get_statistics_after_stop	Verify statistics after agent stop
36	test_get_statistics_combined	Verify statistics after multiple operations
37	test_get_current_position	Verify current position getter
38	test_get_path_copy_independence	Verify path copy is independent

2.9 Edge Case Tests (8 tests)

#	Test Name	Description
39	test_large_number_of_steps	Verify agent handles many movements
40	test_large_number_of_collections	Verify agent handles many collections
41	test_position_tuple_vs_list	Verify position handling flexibility
42	test_zero_position_valid	Verify zero coordinates valid
43	test_negative_steps_not_allowed	Verify steps not decremented
44	test_concurrent_visited_tracking	Verify visited positions consistent
45	test_state_consistency	Verify state consistency across operations
46	test_path_starting_position	Verify starting position in path

3. MOVEMENT MODULE TESTS (34 tests)

Purpose

Validates movement validation logic, boundary checking, visited position tracking, and state preservation.

Test Categories

3.1 Initialization Tests (2 tests)

#	Test Name	Description
1	test_movement_initialization_environment	Verify movement has environment
2	test_movement_initialization_agent	Verify movement has agent

3.2 Valid Move Tests (5 tests)

#	Test Name	Description
3	test_is_move_valid_right_direction	Verify rightward movement valid
4	test_is_move_valid_left_direction	Verify leftward movement valid
5	test_is_move_valid_up_direction	Verify upward movement valid
6	test_is_move_valid_down_direction	Verify downward movement valid
7	test_is_move_valid_accessible_unvisited	Verify valid move to accessible cell

3.3 Boundary Tests (4 tests)

#	Test Name	Description
8	test_is_move_valid_outside_right_boundary	Verify move past right boundary fails
9	test_is_move_valid_outside_left_boundary	Verify move past left boundary fails
10	test_is_move_valid_outside_top_boundary	Verify move past top boundary fails
11	test_is_move_valid_outside_bottom_boundary	Verify move below bottom boundary fails

3.4 Inaccessible Area Tests (3 tests)

#	Test Name	Description
12	test_is_move_valid_to_building_area	Verify move to building blocked
13	test_is_move_valid_to_pond	Verify move to pond blocked
14	test_is_move_valid_to_border	Verify move to border blocked

3.5 Visited Position Tests (4 tests)

#	Test Name	Description
15	test_is_move_valid_to_visited_position	Verify revisit blocked
16	test_is_move_valid_revisit_after_movement	Verify re-visit after other moves blocked

#	Test Name	Description
17	test_is_move_valid_multiple_visits_blocked	Verify multiple revisit attempts blocked
18	test_movement_with_circular_path	Verify circular path prevention

3.6 Border Hit Detection Tests (5 tests)

#	Test Name	Description
19	test_agent_stops_on_border_hit_right	Verify border detection right edge
20	test_agent_stops_on_border_hit_left	Verify border detection left edge
21	test_agent_stops_on_border_hit_top	Verify border detection top edge
22	test_agent_stops_on_border_hit_bottom	Verify border detection bottom edge
23	test_border_hit_only_once	Verify border hit stops agent once

3.7 Combination/Advanced Tests (7 tests)

#	Test Name	Description
24	test_move_validation_all_conditions	Verify all validation conditions work
25	test_move_fails_any_condition	Verify move fails if any condition fails
26	test_move_to_corner_inside	Verify corner positions inside grid
27	test_move_to_corner_at_border	Verify corner positions at border
28	test_move_at_maximum_grid_position	Verify maximum grid position
29	test_is_move_valid_diagonal_not_standard	Verify diagonal movement
30	test_move_fails_any_condition	Verify combined condition failures

3.8 State Preservation Tests (3 tests)

#	Test Name	Description
31	test_failed_move_doesnt_change_agent_position	Verify invalid move doesn't update position
32	test_movement_validation_consistency	Verify same input same result
33	test_valid_move_still_requires_manual_update	Verify valid move doesn't auto-update

3.9 Edge Cases Tests (1 test)

#	Test Name	Description
34	test_is_move_valid_far_outside_grid	Verify far out-of-bounds handling

4. ACTION MODULE TESTS (50 tests)

Purpose

Validates action definitions, delta calculations, and movement direction handling.

Test Categories

4.1 Initialization Tests (2 tests)

#	Test Name	Description
1	test_action_initialization_right	Verify RIGHT action initialization
2	test_action_initialization_up	Verify UP action initialization

4.2 Action Values Tests (4 tests)

#	Test Name	Description
3	test_action_right_value	Verify RIGHT action has correct value
4	test_action_left_value	Verify LEFT action has correct value
5	test_action_up_value	Verify UP action has correct value
6	test_action_down_value	Verify DOWN action has correct value

4.3 Delta Calculation Tests (8 tests)

#	Test Name	Description
7	test_get_row_delta_up	Verify UP row delta = -1
8	test_get_row_delta_down	Verify DOWN row delta = +1
9	test_get_row_delta_left_right	Verify LEFT/RIGHT row delta = 0
10	test_get_col_delta_right	Verify RIGHT col delta = +1
11	test_get_col_delta_left	Verify LEFT col delta = -1
12	test_get_col_delta_up_down	Verify UP/DOWN col delta = 0
13	test_delta_calculation_all_directions	Verify deltas for all 4 directions
14	test_delta_sum_zero	Verify delta sum = 0 for all actions

4.4 get_all_actions() Tests (2 tests)

#	Test Name	Description
15	test_get_all_actions_count	Verify 4 actions returned

#	Test Name	Description
16	test_get_all_actions_contains_all	Verify all action types included

4.5 Action Validation Tests (4 tests)

#	Test Name	Description
17	test_is_valid_action_right	Verify RIGHT valid
18	test_is_valid_action_invalid	Verify invalid action returns False
19	test_is_valid_action_all_valid	Verify all 4 actions valid
20	test_is_valid_action_none	Verify None invalid

4.6 Action Limits Tests (2 tests)

#	Test Name	Description
21	test_action_boundary_values	Verify action boundary values
22	test_action_invalid_values	Verify invalid action values

4.7 Opposite Actions Tests (4 tests)

#	Test Name	Description
23	test_get_opposite_action_right	Verify RIGHT opposite = LEFT
24	test_get_opposite_action_up	Verify UP opposite = DOWN
25	test_get_opposite_action_consistency	Verify opposite(opposite(a)) = a
26	test_opposite_action_all_directions	Verify opposites for all 4 directions

4.8 Action Movement Tests (6 tests)

#	Test Name	Description
27	test_action_moves_correctly_right	Verify RIGHT moves to (r, c+1)
28	test_action_moves_correctly_left	Verify LEFT moves to (r, c-1)
29	test_action_moves_correctly_up	Verify UP moves to (r-1, c)
30	test_action_moves_correctly_down	Verify DOWN moves to (r+1, c)
31	test_apply_action_to_position	Verify action applied correctly
32	test_sequential_actions	Verify sequential action application

4.9 Action Consistency Tests (8 tests)

#	Test Name	Description
33	test_action_right_value_constant	Verify RIGHT value doesn't change
34	test_action_left_value_constant	Verify LEFT value doesn't change
35	test_action_up_value_constant	Verify UP value doesn't change
36	test_action_down_value_constant	Verify DOWN value doesn't change
37	test_delta_consistency	Verify deltas consistent
38	test_action_names_consistency	Verify action names consistent
39	test_all_actions_have_unique_names	Verify unique action names
40	test_all_actions_have_unique_values	Verify unique action values

4.10 Edge Cases Tests (10 tests)

#	Test Name	Description
41	test_action_on_zero_position	Verify action on (0,0)
42	test_multiple_actions_same_direction	Verify repeated same action
43	test_four_actions_return_to_start	Verify 4 opposite actions = original
44	test_action_coordinates_boundary	Verify boundary positions
45	test_action_negative_deltas	Verify negative movement handling
46	test_action_comparison	Verify action comparison works
47	test_action_string_representation	Verify action string format
48	test_all_actions_iteration	Verify can iterate all actions
49	test_action_with_large_position	Verify large position handling
50	test_get_all_actions_returns_list	Verify get_all_actions returns list

Test Execution Instructions

Running All Tests

```
python -m pytest tests/ -v
```

Running Specific Module Tests

```
# Environment tests
python -m pytest tests/test_environment.py -v
```

```
# Agent tests
python -m pytest tests/test_agent.py -v

# Movement tests
python -m pytest tests/test_movement.py -v

# Action tests
python -m pytest tests/test_action.py -v
```

Running with Coverage

```
python -m pytest tests/ --cov=. --cov-report=html
```

Running Specific Test

```
python -m pytest tests/test_module.py::TestClass::test_method -v
```

Test Results Summary

All 173 tests PASSING ☒

- Environment Module: 43/43 ☒
- Agent Module: 46/46 ☒
- Movement Module: 34/34 ☒
- Action Module: 50/50 ☒

Execution Time: < 1 second
Coverage: Comprehensive across all modules
Quality: Production-ready