World Robot Summit 2020
Disaster Robotics Category: Plant Disaster Prevention Challenge
Competition Rules Ver. 0.36

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1. Competition Scenario and Background

The concept of this competition is the routine inspections/checks as well as responding to emergency situations in manufacturing plants, oil refineries, and iron works. Competition tasks and missions dealing with a variety of plants have been set up.

Advantages of the introduction of robots into plant inspections

[Autonomous Routine Inspections] Accidents caused by human error can be avoided through autonomous inspections, and diagnosis of facilities (pumps, tanks, boilers) and constructions in dangerous environments such as off-shore plants, where it can be difficult to dispatch workers.

[Discovering Abnormalities in their Early Stages] Introducing robots would increase the frequency of routine inspections, preventing equipment malfunctions, accidents (explosions from gas leaks or fires caused by toxic gas), or toxic substance leaks due to damage to facilities by human error or deterioration. To carry out inspections and checks of facilities that operate under high temperatures or in dangerous conditions, they need to be turned off. By using robots in these kinds of conditions, checks could be carried out without stopping operations, therefore increasing the plant’s productivity.

[Emergency Response] A pipe, partly damaged from age and deterioration, may leak flammable gas causing an accident such as an explosion or fire. In this situation a robot would be able to both shut off the pipe emitting flammable gas, and turn on the sprinkler and firefighting system in the room affected by the leak, thus ensuring the safety of the workers and containing the accident.

References:
SPRINT Robotics Strategic Roadmap for Inspection and Maintenance Robotics
https://www.sprintrobotics.org/media-downloads/sprint-robotics-strategic-roadmap/
2. The Competition Field

The competition field consists of a 6-storey mock plant tower built as a reproduction of a working plant at Fukushima Robot Test Field, in Fukushima Pref. Minami Souma city. Each floor is 5m in height and is organized in the following way.

1st Floor: Basic facilities (pumps, boilers, small tanks, pipes), 2nd Floor: Pipes, 3rd/4th Floors: medium and large tanks, 5th/6th Floors: Chimney. The competition will use from the 1st to the 4th floor.

![Mock plant tower at Fukushima Robot Test Field](image)

Figure 1: Mock plant tower at Fukushima Robot Test Field

Each task will be carried out according to the inspection instructions, on the facilities and equipment in the mission zones of each floor.

Mission zones:
- P1: 1st Floor (a). Target area - pipes (A), pump x 3, tank (small) x 2
- P2: 1st Floor (b). Target area – pipes (B), pump x 3, boiler
- P3: 2nd Floor. Target area – pipes (C), Duct
- P4: 3rd/4th Floors. Target area – Tank (Medium), Tank (Large)
- P5: 1st Floor (a)(b). Target area – pipes (A), pump x 3, tank (small) x 2, boiler

*1st Floor (a) is on the east side, 1st Floor (b) is on the west side.
*Details concerning the floor layouts, each targets position and other information will be released in summer 2019.
3. Competition Missions

5 missions have been set up in order to assess the plant inspection robot’s abilities.

- P1: Inspection and Maintenance
- P2: Fault Detection and Emergency Response
- P3: Diagnosis: Pipes and Duct
- P4: Diagnosis: Tank
- P5: Overall Performance

Each mission consists of a series of tasks (inspections, surveys, etc.) to be carried out in accordance with the inspection instructions. Each mission is carried out in a specified zone (mission zone), whereby the robot must move from the start area to the end area as it completes each task. Once all tasks have been completed, the robot must return to the start area. In missions P1/P2/P5, the robot will pass through checkpoint areas, where the points gained in the mission thus far will be added to their total points. The order in which tasks are completed is up to the team’s discretion.

After completing the mission, an inspection report must be filled out and submitted before the next competitors start. In the case of digital data, this must be submitted on a USB memory stick. The positions after the preliminary round will be decided based on the total points earned in this round. The competition points are the sum of the mission points, technical points, and time points. Details concerning the points can be found in chapter 6. If the mission is carried out autonomously, the operator must verify each step from movement, inspection (task), to the report.

Below is an outline of each mission and its tasks.
Mission P1: Inspection and Maintenance

Competition Mission:
Daily inspections of plants are carried out several times a day by a number of employees. The objective of this mission is to save labour by performing these inspections through remotely controlled or autonomous robots. Therefore, in mission P1, the robot shall carry out daily inspections and surveys of the facilities.

Target area: pipes (A), pump x 3, pank (small) x 2

Task details and points:
Daily inspection of each of the target facilities should be carried out in accordance with the inspection instructions. Make a round of the facilities and machinery in operation, read the meters at the specified points and report these readings. However, using a photograph of the measuring device to report the readings is not allowed. In addition, equipment and machinery must also be adjusted to a specified setting.
Pipes (A)

(1) Verification of the Pressure Gauge Reading

Take a reading of pressure gauges placed in horizontal and vertical positions, and report these readings in accordance with the inspection instructions. After completing the mission, submit the processed images of meters used to confirm the readings: 10 points/place (points may vary depending on the target’s placement.)

(2) Opening and Closing Valves

Adjust the handles of both horizontally and vertically placed valves to positions specified in the inspection instructions: 10 points/place (points may vary depending on the target’s placement.)

(3) Adjusting Valves

Turn the handles of both horizontally and vertically placed valves to angles specified in the inspection instructions: 10 points/place (points may vary depending on the target’s placement.)

Pump x 3

(1) Confirmation of Operation

Check the LED control panel and report which pumps are in operation: 10 points

(2) Pressure Gauge Reading

Take readings of the scale, check if these readings match those indicated in the inspection instructions, and report findings. After completing the mission, submit the processed images of meters used to confirm the readings: 10 points/pump

(3) Opening and Closing Valves

Shut (turn 90 degrees) the valves of the pumps not in operation: 10 points/pump

Tank (small) x 2

(1) Confirm Water Level Reading

Read the water level meters, check if these readings match those indicated in the inspection instructions, and report findings. After completing the mission, submit processed images of the meters used to confirm the readings: 10 points/tank

(2) Open and Close Valves

Adjust the valves as indicated in the inspection instructions: 10 points/tank

Required Abilities:

[Mobility] The area that must be traversed is a walkway (600mm wide at narrowest point), slopes, group of pipes, and the surfaces consist of concrete, grating, and checker plate. The robot must be able to move around this area.

[Observation & Control] The targets of inspection and adjustments will be meters and valves of a
pre-disclosed shape and position. The robot must be able to inspect and adjust the targets through the use of its sensors and manipulators.

[Adapting to the Environment] Robots must have the ability to adapt to an everyday plant environment comprising of various machines and equipment, as well as a maze of pipes. They must also have the ability to deal with fogged or dirty glass on the faces of the meters.

[Technical Challenges] Along with automatic recognition of the meter readings, the robot should have the ability to deal with changes in the readings and control the valves accordingly. Additionally, they need to have a practical level of processing power (speed and accuracy), and the ability to perform autonomous checks.

Examples of how to gain technical points:
[Mobility] Can move from the start area to the end area autonomously, through use of SLAM.
[Inspection (meters)] Automatically recognize the position of the targets to inspect (pressure gauge, water level gauge, the pump’s LED control panel) through image processing. Then, by autonomous control of itself and its manipulator, the robot automatically recognizes the meter’s dial and displays the numerical readings on a PC monitor.
[Adjustments (handle/lever operation)] Can automatically recognise the handle or lever’s position, and can grasp the handle or valve with the autonomous manipulator’s attitude control and end effectors handling system, and make the appropriate turn.
[Report] n/a
Mission P2: Fault Detection and Emergency Response

Competition mission:
Detailed inspections using measuring devices are regularly carried out in plants. This mission’s objective is to discover abnormalities in equipment and machinery caused by human error or by deterioration while still in their early stages. The robot should not only employ hand-held measuring devices and robotic technology but also by combining its sensing and analytical technologies. Moreover, it is possible that fires or explosions could occur due to gas leaking from old, deteriorating pipes. As the room fills with gas, it becomes too dangerous for human workers to approach. In order to ensure the employee’s safety, and to contain the accident, initial firefighting procedures should be carried out by a robot. Therefore, in mission P2, the robot must detect abnormalities in the equipment and machinery, and respond to an emergency after an accident occurs.

Target facilities: pipes (B), pump x 3, boiler, tank (small), foam fire extinguishers.

Task details and points:
Perform daily inspections and detect abnormalities in each of the target facilities in accordance
with the inspection instructions. And, after an accident occurs, carry out initial firefighting procedures. The task consists of discovering gas leaks or abnormal temperatures in the pipes, specifying which pumps are emitting abnormal vibrations, and measuring the concentration of oxygen in the tank. After the alarm sounds, the robot must operate a handle to manually turn on the foam fire extinguisher. Using a photograph of the measuring device to report the readings is not allowed.

Pipes (B)
(1) Detect gas leaks in the pipes.
   Report the CO2 concentration: **10 points**
(2) Detect abnormal temperatures on the pipes’ surfaces.
   Report the location and difference in temperature: **10 points**

Pump x 3
(1) Specify which pump has abnormalities.
   Specify which pump has abnormalities by reporting the pump number: **10 points**

Tank (small) x 2
(1) Measure the concentration level of oxygen inside the tank.
   Report the oxygen concentration reading: **40 points/tank**

Boiler
Lower Inspection walkway (confined space)
(1) Confirm the pressure gauge reading.
   Take a reading of the pressure gauges in designated locations, confirm the pressure is set to the amount specified in the inspection instructions, and report. After completing the mission, submit processed images of meters used to confirm the readings: **20 points/place**
(2) Opening and closing the valves
   Adjust the valves whose pressure gauge does not correspond to that indicated in the instruction manual so that they show that the indicated amount: **20 points/place**

Upper Inspection Walkway (accessed by stairs)
(3) Confirm thermometer readings:
   Take the temperature readings, confirm the temperature is set to the amount specified in the inspection instructions, and report. After completing the mission, submit processed images of meters used to confirm the readings.

After an alarm sounds:
Activate the foam fire extinguishers near the walkway. (Manually open the cover and turn the
handle 90 degrees): 40 points.

Required Abilities:

[Mobility] The same abilities as in mission P1, plus the ability to traverse a catwalk. (Space restrictions: confined, climbing stairs)

[Observation and Controls] The robot should inspect whether or not there are abnormal temperatures, gas leaks (concentration), abnormal vibrations, etc. The robot should detect abnormalities using its sensors and cameras. The location of the abnormalities will be unknown. Details of the types of abnormalities will be released by the organisers beforehand.

You may use devices provided by the competition organisers to detect abnormalities, or you may use devices of your own.

*Measuring devices provided: Vibrometer VM-82A (RION), Sound level meter NL-42 (RION)

[Report] The ability to specify and report the location of abnormalities is required.

[Adapting to the Environment] The same abilities are required as in mission P1.

Technical Challenge:

(1) The ability to automatically recognize meter readings, while dealing with changes in the readings and controlling the valves accordingly. Additionally, need to have a practical level of processing power (speed and accuracy), and the ability to perform autonomous checks.

(2) Detect abnormalities in conditions where the locations they occur are unknown. Implementing existing measuring devices, and the technology to integrate these with the robot’s own measuring equipment is necessary.

(3) Implementing comprehensive, practical abilities. In particular, to be able to implement tasks in a noisy, unknown environment. In addition, to be able to appropriate the abilities necessary in routine inspection missions for emergency response after an accident occurs.

Examples of how to gain technical points:

[Mobility] Can move from the start area to the end area autonomously, through use of SLAM.

[Inspection (meters)] Automatically recognize the position of the targets to inspect (pressure gauge, water level gauge, the pump’s LED control panel) through image processing. Then, by autonomous control of itself and its manipulator, the robot automatically recognizes the meter’s dial and displays the numerical readings on a PC monitor.

[Adjustments (operating handle/lever)] Can automatically recognize the handle and lever’s position, can grasp it with the autonomous manipulator’s attitude control and end effectors handling system, and make the appropriate turn.

[Report] Can digitalise and report the numerical value of gas concentrations and pump vibrations RMS/sound pressure.
Mission P3: Diagnosis: Pipes and Duct

Competition Mission:

It is assumed that every few years, large-scale inspections and improvements are carried out in a plant. This may mean that plant operations have to stop, and cleaning may also be carried out. In particular, work such as detecting rust within groups of pipes, loose bolts on flanges, cleaning inside ducts and finding foreign substances/objects, is very difficult as it takes place in narrow confined spaces. For this reason, by using robots, plant operations can be stopped for a shorter amount of time and they can be used to reach high and dangerous areas of the plant. In mission P3 the robot must assess and diagnose the soundness of facilities such as pipes (including flanges) and ducts.

Target facilities: Pipes (C), Ducts

Task details and points:
Assess and diagnose the soundness of pipes and the inside of the duct in accordance with the inspection instructions. For the mission tasks, the robot must report the results of its assessment of the following points in each of the inspection areas. After the task has been completed, the processed images that were used to assess abnormalities must be submitted.

Pipes (C)

1. Discover loose bolts on the flanges.
   Report whether the bolt is loose or not: 10 points/place

2. Detect bolts with rust on the flanges.
   Report whether the bolt has rust or not: 10 points/place

3. Detect rust (as a QR code) on the surface of the pipes.
   Report if there is rust or not: 10 points/place
Inside the Duct

(4) Detect the presence of rust: QR marker
(5) Detect foreign object(s) (location and photograph): Submit images after completing the task.

*The team member in charge of safety is allowed to bring the robot to the duct entrance, and to pick up the robot from the other side.

Required Abilities:

[Mobility] Must be able to move through narrow spaces such as around groups of pipes (restricted space) and inside a duct (narrow, confined space).

[Observation and Control] The target areas to diagnose are pipes and a duct. Robots should use their sensors and cameras. The location of abnormalities and foreign objects will not be made known, but teams will be told of the type of abnormalities and objects beforehand by the organisers.

[Report] Must be able to specify and report the location of the abnormalities and foreign objects.

[Adapting to the Environment] Must be able to adapt to the environment in the same way as in mission P1.

Technical Challenge:

Survey a complex group of pipes and the confined space inside a duct. It is not essential for the robot to have integration technology and autonomous control, but it does need a high level of human to robot interactivity to deal with the complex, narrow spaces, as well as data analysis processing power. A practical level of processing power (speed and accuracy) is required. It is desirable that when reporting the location of findings, the robot can create a 3D model of the area in real time, and map the results of the survey.

Examples of how to gain technical points:

[Mobility] Set several Waypoints and autonomously traverse the area.

[Inspection (bolt)] Automatically recognize the position of the bolt through image processing, and through the autonomous robot body and manipulator’s attitude control, touch the end effector to the bolt head.

[Inspection (diagnosis)] The robot can autonomously point a camera directly at the area using a manipulator and automatically recognize and analyse each abnormality (rust, foreign object, etc.)

[Report] Can report the numerical value of the bolt’s tension/torque.

[Report] Can create a 3D map in real time, and indicate the positions of the abnormalities on the map.
Mission P4: Diagnose: Tank

Competition Mission:

It is assumed that every few years, large-scale inspections and improvements are carried out in plants. This may mean that plant operations have to stop, and cleaning may also be carried out. By using robots, plant operations can be stopped for a shorter amount of time and they can be used to reach high and dangerous areas of the plant. In particular, robots can improve safety and productivity when detecting rust or floats on large surfaces areas of facilities such as tanks. Therefore, in mission P4 the robot must analyse the soundness of a large structure (tank), and report any deterioration.

Target facilities: tank (medium), tank (large)

![Mission zone P4](image)

Figure 5: Mission zone P4

Task details and points:

Analyze and diagnose the soundness of the surface of a medium and large tank and their spiral staircases in accordance with the inspection instructions. Submit processed images used to analyse abnormalities after completing the task.

Report the diagnosis results of the following items for each inspection area (each baseboard).

1. Presence of cracks.
   - Specify the location of the crack and report its length and width: **10 points/place**

2. Presence of rust.
   - Report the ratio of rust in the designated area: **10 points/area** [reference: ASTM D610]

Required Abilities:

- **Mobility** Requires the ability to traverse high places and (spiral) stairs.
- **Observation and Control** The target areas for diagnosis are medium and large tanks. Robots must use their sensors and cameras. The location of the abnormalities is unknown, but the but teams will be told of the type of abnormalities by the organisors in advance.
- **Report** Requires the ability to specify and report the type, state, and location of abnormalities.
[Adapting to the Environment] Ability to adapt to the environment in the same way as mission P1.

Technical Challenges:
Survey a wide surface area such as that of a large tank. It is not essential for the robot to have integration technology or autonomous control, but it does need a high level of human to robot interactivity to deal with the complex, wide areas, as well as data analysis processing power. A practical level of processing power (speed and accuracy) is required. It is desirable when reporting the location of your findings to create a 3D model of the area in real time, and have the ability to map the results of the survey.

Examples of how to gain technical points:
[Mobility] Set several Waypoints and autonomously traverse the area.
(It is necessary to set up an arrival point zone near each of the facilities.)
[Inspection (diagnosis)] Can autonomously point a camera directly at the area using a manipulator, and automatically recognize each abnormality’s state and location.
[Report] Can create a 3D map in real time, and indicate the positions of the abnormalities on the map.
Mission P5: Overall Performance

Competition Mission:
An accident (explosion) occurs during a round of inspections, and a roll call reveals that one employee is missing. Therefore, in mission P5, encompasses the overall theme of the competition, as the robot must perform a daily inspection as well as respond to a disaster and find a missing person.

Target facilities: pipes (A), pump x 3, tank (small) x 2, boiler

Task details and points:
The daily inspection tasks will be based on P1/P2. After an alarm sounds, the robot should move while removing scattered rubble from its path (40 points), as well as search for an employee (mannequin) left inside the plant and report their position (40 points). What and how information should be reported is detailed in the inspection instructions.

*There is a surprise task: This will be revealed on the morning of the competition.

Required Abilities:
[Mobility] Requires the ability to traverse areas covered in rubble.
[Observation and Control] Requires ability to remove rubble and search for a missing employee.
[Adapting to the Environment] Requires the same abilities as in P1 to adapt to the surroundings. It is also necessary to be able to adapt to disaster environments (unstructured environment such as smoke, water, oil, rubble, etc. with little information in advance.)

Technical Challenges:
Comprehensive and practical abilities are required. In particular, the ability to carry out work in an unknown environment with external interference. Furthermore, the robot should be able to appropriate its abilities used in the mission tasks for an emergency situation.

Examples of how to gain technical points: Based on P1/P2
4. The Targets of Inspections

4.1 Outline of Facilities/Structures

1st Floor (both a/b)

4.1.1 Pipes

4.1.1.1 Pipes (A)
Horizontal pipes
Specifications:
JIS-SGP Pipe (80A), JIS-SS (10K) flange, JIS-SS welded elbow (bend)
Pressure gauge, ball valve (80A), gate valve (80A), rubber seated valve (80A)
Points to inspect:
(1) Pressure gauge measurements (P1, P5): 3 range types 0.25, 1.0, 1.6 MPa. Reading accuracy should be within ±5%. The gauges will be installed between heights of approximately 600mm to 1800mm.
(2) Opening and closing valves (P1, P5): Levers (Approx. 400mm in length) and round handles.
Contents of the report (criteria): n/a

Vertical Pipes
Specifications:
JIS-SGP pipe (80A), JIS-SS (10K) flange, JIS-SS welded elbow (bend)
Pressure gauge, ball valve (80A), butterfly valve (80A), rubber seated valve (80A)
Points to inspect:
(1) Pressure gauge measurements (P1, P5): 3 range types 0.25, 1.0, 1.6 MPa. Reading accuracy should be within ±5%. The gauges will be installed between heights of approx. 600mm to 1800mm.
(2) Opening and closing valves (P1, P5): Levers (Approx. 400mm in length) and round handles.
Contents of the report (criteria): n/a
4.1.1.2 Pipes (B)
Specifications:
JIS-SGP Pipe (150A), JIS-SS (10K) flange, JIS-SS welded elbow (bend)
Points to inspect:
(1) Assess soundness (Rust, presence of gas leaks (carbon dioxide concentration), abnormal temperatures etc.) (P2)

Report Contents (criteria)
Presence and location of abnormalities
Details will be released separately online.

4.1.2 Pump

Specifications:
Single suction centrifugal pump (100x80 caliber, 7.5kW)
JIS-SGP Pipe (80A, 100A), JIS-100A flange (10K, suction side), JIS-80A flange (10K, discharge side), pressure gauge, 80A ball valve. Installed on stand 125mm in height.

Points to inspect/adjust:
(1) Pressure gauge measurement (P1, P5): 1.0MPa range. Reading accuracy with ±5%. Installed at a height of approx. 1500mm.
(2) Opening and closing of valves (P1, P5): Lever handle (approx. 400mm in length, installed at height of approx. 1200mm.)
(3) Soundness (abnormal noise/vibrations, loose/rusty bolts on foundations.)

Report contents (criteria)
Presence and location of abnormalities. Criteria based on ISO machine vibration evaluation standards (ISO10816-3). Details will be released separately online.
4.1.3 Small Tank

Specifications:
JIS-SS welded steel plate assembly (φ 1,200 × H1,900mm)
Ladder (no railing, effective width 400mm, step interval 300mm, 7 steps)
Inspection hatch (ceiling, a diameter of 300mm, swing bolt fixed detachable hatch)
Inspection hatch (bottom, a diameter of 600mm, bolt fixed detachable hatch)
Water level gauge on side of the tank (tubular liquid level gauge), discharge 50A ball valve

Points to inspect/adjust
(1) Side of tank: Check the water level (P1, P5)
(2) Operate handle valve (P1, P5)
(3) Ceiling hatch: Measure the concentration of oxygen in the tank (P2)
(4) Opening and closing ceiling hatch (Was open in the preliminary competition)

Report contents (criteria)
(1) Measure the water level: Accuracy within ±5%
(2) Oxygen concentration: Accuracy within ±30%
Criteria comply with the ordinance on prevention of anoxia.

4.1.4 Boiler

Specifications:
Small boiler (φ 1,300 × H1,550mm)
JIS-SGP pipe (50A, 80A, 250A) JIS-250A flange joint (10K) x 1, JIS-80A flange joint (10K) x 2, pressure gauge x 4 or more, thermometer x 1, 50A bolt valve (lever) x 2, 80A ball valve (lever)
Inspection Deck:
Walkway width 1000mm
Skeleton Stairs (Full width 700mm (effective width 600mm), step depth 240mm, stair riser height 227mm, 40° incline.)
Foam fire extinguisher, manual starting device.
Ref: Itachibori Mfg. Co., Ltd
http://www.itachibori.co.jp/

Points to inspect/adjust:
(1) Pressure gauge measurement (P4): 2 types of range, 1.0 and 1.6 MPa. Installed at approx. 500mm from the floor and approx. 1500mm from the walkway.
(2) Thermometer measurements (P4): A range of 0-200°C, and installed at a height of approx. 1700mm from the walkway.
(3) Handle operation (P4): Opening and closing water and fuel pipes/adjusting pressure, opening and closing fire extinguisher. Installed approx. 1500mm from the walkway.
(4) Report contents (criteria)
(1) Pressure/temperature measurements: Accuracy within ±5%
2nd Floor

4.1.5 Pipes (C)

Specifications:
JIS-SGP Pipe (500A), JIS-SS (10K) flange (100A, 200A, 300A)
JIS-SGP Pipe (300A), JIS-SS (10K) flange (100A, 200A, 300A)
JIS-SGP Pipe (200A), JIS-SS (10K) flange (200A)
JIS-SGP Pipe (100A), JIS-SS (10K) flange (100A, 200A, 300A)
JIS-SGP Pipe (50A), JIS-SS (10K) flange (100A, 200A, 300A)
JIS-VP Pipe (200), JIS (10K) flange (200A)
JIS-VP Pipe (50), JIS (10K) flange (50A)
Pressure Gauge, gate valve (50A, 100A, 200A)

Points to inspect: Soundness evaluation (Rust on the pipe’s surface, rusty/loose bolts on the flanges)
Report contents (criteria): Presence and location of abnormalities. Details will be released separately online.
4.1.6 Duct
Galvalume Steel Plate (500mm x 300mm, 1.6mm thick)

3rd/4th Floors
4.1.7 Medium Tank
Material: Steel, 1.9m radius, approx. 5m height, with spiral staircase (1m width)

4.1.8 Large Tank
Material: Steel, 2.8m radius, approx. 5m height, with spiral staircase (1m width)
4.2 Outline of targets to inspect/adjust

4.2.1 Pressure Gauge

JIS B 7505-1 Bourdon Tube Pressure Gauge will be installed. Nagano Keiki Co., Ltd. General Industrial Pressure Gauge (universal pressure gauge), AC20-181-2000 (A: Type A/Lower connection φ 75), measurement ranges of 0.25, 1.0, 1.6 MPa.

Ex. Migishita Seiki MFG Co., Ltd. General purpose pressure gauge S-31-1MP
4.2.2 Thermometer

Nagano Keiki Co., Ltd. Bimetal Thermometer, TB14-000-11-A,
Measurement range 0-200°C

4.2.3 Water Level Gauge

Showa Instrument Information Co., Ltd. Tubular type level gauge LG-0610,
reading up to 1400mm.

Showa Instrument Information Co., Ltd.
http://www.showa-kk.com/

4.2.4 Valves

Lever handle:
KITZ Corporation 10K Cast Iron Ball Valve, 10FCTB (50A, 80A)

Round handle valve:
Tomoe Valve Co., Ltd. Rubber Seated Valve, 700Z-2F (80A)
KITZ Corporation Class 150 Cast Bronze Gate Valve, EBH (80A)

From left: Ball Valve, Rubber Seated Gate Valve, Gate Valve

KITZ Corporation http://www.kitz.co.jp/english/
Tomoe Valve Co., Ltd. www.tomoevalve.com/english/index-e.html

Ref: Torque needed to rotate
(1) Handle: Approx. 0.8Nm
KITZ Corporation Class 125 Cast Brass Gate Valve, FR 1B (25A)
(2) Lever: Approx. 2.0Nm
KITZ Corporation Type 600 Brass Ball Valve TK 1B (25A)

4.3 Abnormalities

Cracks, rust

Photos are from the preliminary competition. For details please refer to attached materials.

4.4 Road Surface Types

The rubble consists of items an inspection robot is able to deal with (thin pipes, including those that have been bent, etc.)

Ref: Mock pipe debris from the preliminary competition
5. Competition Schedule

Set up (robot inspections): 2 days, Preliminary rounds: 2 days, Final: 1 day.
No postponement for rain (waterproofing measures essential)
- The competition field building does not have outside walls, and so rainwater may blow in.
- Rainwater may flow down from the upper levels.

Time for test runs has been planned for the morning of the first day of preliminary rounds.

Competition time:
Preliminary round: Mission/30 mins (set up 5 mins, compete 20 mins, removal from field 5 mins.)
Final: Mission/40 mins (set up 5 mins, compete 30 mins, removal from field 5 mins.)
Team changeover: 10~15 mins.

6. Scoring

Competition points are the total “mission points”, “technical points”, and “time points” for each mission.

6.1 Mission Points: Assessing Mission’s Level of Achievement

The points gained for completing the competition tasks within each mission are called “mission points”. The level of achievement for each mission can be assessed through the mission points. Moreover, once a robot completes a task and passes through the checkpoint area, “arrival points” are added to the score. (Arrival point = (no. robots arrived/no. robots) x 20 points.)

6.2 Technical Points: Assessing Robot’s Technical Level

Teams that implement advanced robotic technology will be awarded technical points. Technical points will be added depending on the type of technology and how many types of technology. They will be calculated as 10% to a maximum of 20% of the points for each mission. Technical points will be authorized based on a hearing by the judges during the robot inspections before the competition. Teams may be required to demonstrate their robot’s technical capabilities.

Here are some examples:
(i) Is able to move autonomously to specified areas for inspection/operation, as well as patrol the surrounding area.
(ii) Can automatically recognize a handle’s position, and autonomously operate it.
(iii) Can report the results of an inspection for abnormalities as a numerical reading. (e.g. issues with a pump, loose bolts.)
(iv) Is able to create a map in real time, and show on the map the results of its inspections and
diagnosis.
(v) Energy-saving measures have been taken into account (self-assessment.)
(vi) Is able to deal with adverse environments (water and dust proof (IP), explosion proof.) (self-
assessment.)
*Whether evidence (a certificate etc.) will be required for (vi) is currently being reviewed.
*Automatic recognition will be essential in the 2020 competition.

6.3 Time Points: Assessing the time taken to complete missions.

We plan to award points for completing each mission within a certain time.

6.4 Terms for Tallying Points and Determining a Winner

Regarding the competition points, the overall score is the total of “Mission points”, “technical
points” and “time points”, and the points awarded to each team are standardized by the maximum
amount of points available for each mission. The teams that can progress to the final will be the 4
teams with the most points awarded in the preliminary rounds.

7. Team Members

A maximum of 10 team members can apply via the Team Description Papers (TDP). Only team
members may enter the paddock area.
The roles of the team members are determined as follows:
- Team leader (1 person): Organises the team. Only the team leader may dispute the competition
results.
- Robot Operator (2 people): The person who controls the robot. The robot operators may enter the
operator area.
- Network Administrator: Manages the team’s network.
- Safety Manager: Monitors the robots during mission attempts, and ensures the safety of the
surrounding area.
- Assistants: Help to transport the robot to and from the start area.

Only the team leader and the robot operators may enter the operation box. Robot operators and
safety managers must not share the same role. Other roles may be held concurrently, and apart
from the team leader members may switch roles for each mission.
Additional members and other changes must be applied for in advance.
8. Competition robots

- There are no restrictions on the shape of the robot. They may take any shape, be it crawler, drone, humanoid, legged, serpentine, etc.
- There is no limit on the number of robots that may be used for the competition. However, there are the following constraints.
  1. At the start of the mission, the total projected area (surface area) of the surface of the base of the whole robot when in its starting position, must not exceed the start area of 1.44m² (1.2m x 1.2m). However, the surface area of robots that have been brought in halfway through the task will be measured in the state they were moved in.
  2. There are no restrictions on height.
  3. Once the mission has started, the robot base surface area may exceed 1.44 m².
- The maximum weight of the robot(s) in total is 130kg.
- The competition robots and operating systems are limited to those described in the team description papers. However, any changes and additions to the competition robot(s) must be applied for and be accepted at least 1 week before the onsite participant registration.
- The competition robots and operating systems are limited to those that pass the robot inspection carried out in advance of the competition. However, separate safety tests for drones will be carried out onsite. Details of robot inspections and safety tests will be released at a later date.
- It is possible to make changes to the competition robot between missions, but no changes may be made during the mission.
- Only batteries that have safety guarantees may be used.
- Teams are responsible for preparing for an emergency (such as a fire) should their robot malfunction.
- Teams must comply with the laws, such as the Radio Act, of the competition country (Japan).
- As a safety measure for traversing stairs, robots must be fitted with eye plates or eye bolts so that a safety belt (lanyard, auto belay, etc.) can be attached with a carabiner. Robots that cannot have a safety belt attached will not be able to participate in this mission.
- We plan to restrict the flight area for drones (UVA). (Depending on the use of protective net)
9. The Missions

Restart: Once the mission has started, the team leader can request to deal with any of the robot’s technical malfunctions. However, a 2-minute penalty will be incurred when the chief referee accepts this request.
- Once a request has been made, the team assistant must move the robot back to the start area. The points gained for that task so far will be retained. However, after restarting the mission, tasks already completed may not be attempted again.

Withdrawal: Team may request to withdraw if they are unable to complete the mission.

Dangerous Actions: Teams who perform the following actions will be subject to a large point reduction or disqualification from the competition.
- Obstruct another team
- Significantly damage the field
- Other actions deemed dangerous by the referees.

- The team safety manager must accompany the robot during the mission so as to provide against unforeseen circumstances.
- The team leader may challenge the mission results by declaring their objection to the referees. Objections must be made in the time between missions.
- Robot maintenance may be performed at any time during the mission as long as it takes place in the start area.

10. Communication Network

Teams should set up their own network between the operator’s computer and the robot. Use of a wireless or wired connection is allowed. This communication network must comply with the World Robot Summit (WRS) communication regulations.

11. Awards

The ranking will be decided based on the scores (see chapter 6).

12. Miscellaneous

All teams must follow the instructions of the competition organisers.
Revision History
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Ver.0.36 (2019/5/15): Revised