

World Robot Summit  
Disaster Robotics Category: Plant Disaster Prevention Challenge  
Pre-Competition Rules 2018 ver. 1.05

These rules are subject to change.

Please see <http://worldrobotsummit.org/en/> for the latest version of the Pre-Competition Rules.

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## 1. Competition Scenario and Background

The competition themes are daily inspections, tests and emergency response taken when a fault occurs at plants, such as in manufacturing, refining, and steel making. Competition tasks and missions are set up in order to correspond to various plants.

### Advantages of Introducing Robots into Plant Inspections

[Autonomous Inspections] Human accidents can be prevented in inspections at offshore plants and other places where it is difficult to dispatch workers and in inspections of equipment such as pumps, tanks and boilers in dangerous environments.

[Early Fault (Abnormality) Detection] Regular inspections by robots can detect faults caused by human error as well as deterioration and signs of aging in equipment. The introduction of robots can prevent accidents caused by these issues before they happen, such as equipment malfunctions, explosions, gas leaks, fires, toxic gas emissions, and the outflow of other harmful substance. In addition, some equipment that operates in high-temperature environments or that has inherently high risks needs to be stopped for inspections and tests. The introduction of robots into these types of environments is expected to heighten efficiency of facilities by allowing inspections and tests while the equipment is running.

[Disaster Response] Any piping damaged during a disaster may leak combustible gas and result in explosions and fire. After disaster strikes, quickly closing valves of fuel piping while opening valves for sprinklers (showers) and foam fire extinguishers near equipment surrounded by combustible gas in the air can act as rapid initial fire-fighting measures.

## 2. Field of Competition

The field of competition shall reproduce actual plants. The plant layout, various target layouts and other details thereof will be released regularly in advance as technical information.

[http://worldrobotsummit.org/wrc2018/disaster/WRC2018\\_DisasterPlantTaskDetails/index\\_en.html](http://worldrobotsummit.org/wrc2018/disaster/WRC2018_DisasterPlantTaskDetails/index_en.html)

### 2.1 Simulated Plant Outline

The main event of 2020 is scheduled to be carried out in a 6-story building of W10 m × D12 m × H 30 m planned for construction in the Fukushima Robot Test Field of Minamisoma City, Fukushima Prefecture. Each floor has the following structure, and the height of each floor is 5 m.

1st floor: Basic equipment (pump, boiler, small tank and pipe lines)

2nd floor: Pipe lines

3rd/4th floors: Medium and large tanks

5th/6th floors: Chimneys



Conceptual Drawing of Simulated Plant

The 2018 pre-competition will be held by constructing a small simulated plant that primarily provides basic equipment and pipe lines at Tokyo Big Sight.

## 2.2. Field of Competition Outline

The equipment for inspections at the preliminary competition are the pipe lines (A)/(B), pumps, small tanks, boiler, and the large tank wall. The field of competition has been broken up into each setup area indicated in Figure 1. Each mission of the competition shall be executed in the mission zone made up of the relevant setup areas.

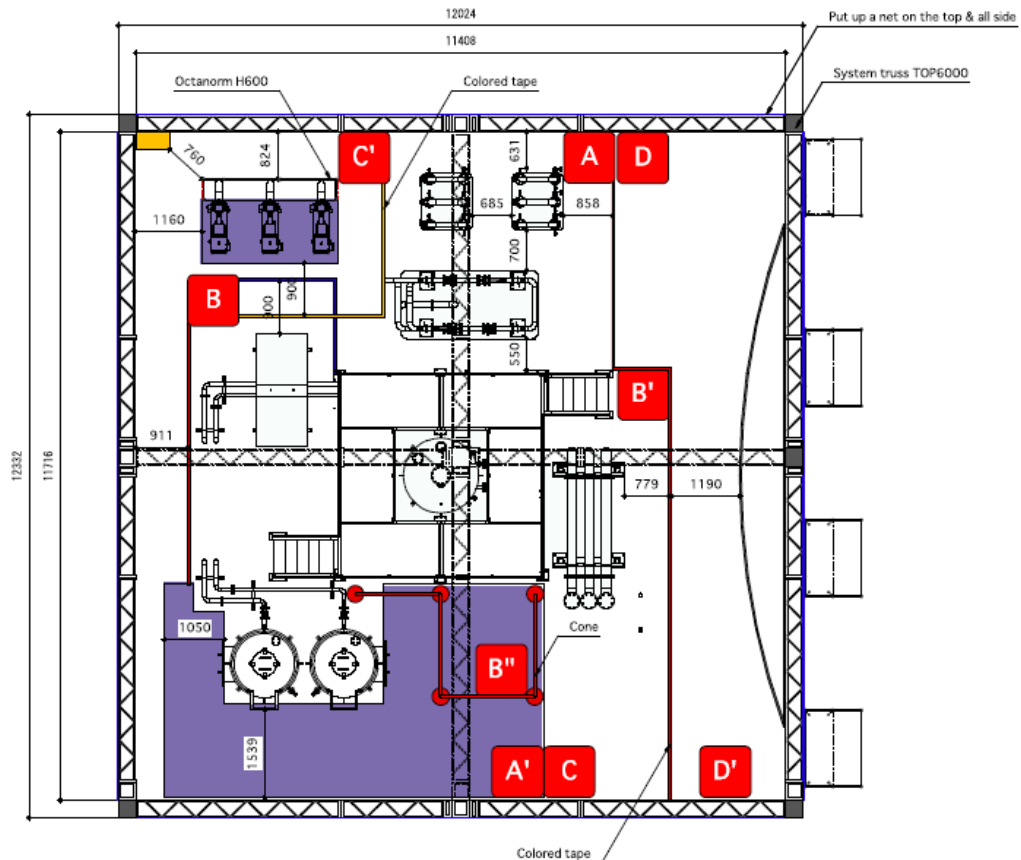
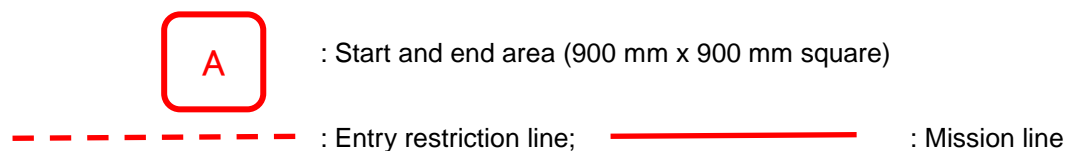


Fig. 1: Field of Competition Layout for the Plant Disaster Prevention Challenge



## 3. Competition Missions

The competition has prepared five competition missions to evaluate the performance of robots in plant inspections. Each competition mission shall be executed based on the directions for each

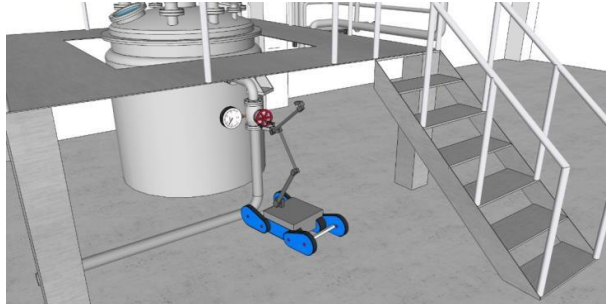
inspection instructions and the competition tasks are set in accordance with the mission (inspection, investigation, maintenance). Each competition mission shall be executed inside of the zone designated for the mission (mission zone). The robot shall move from the start area designated inside of each mission zone to the end area to perform each of the competition tasks by following the directions for the inspection procedure. The robot shall return to the start area after all of the competition tasks are complete. However, each competition task may be performed in any order.

After the competition mission ends, teams shall fill in the inspection and procedural information on the designated report before the start of the next competition mission. If this report is created as digital data, the team shall submit the report saved on a USB flash drive. The ranking for the preliminary competition shall be determined according to the total competition points earned in each mission. The competition points are the total points from the mission points, technical points and time points. More details for each point category are outlined in Chapter 6. An operator shall verify each stage from mobility and inspection (task) to the report if the competition mission is executed through autonomous control.

An outline of each competition mission as well as the competition tasks are explained below.

### MissionP1: Inspection/Maintenance

Competition task: Daily inspections at plants are conducted several times a day by several staff members. The objective is to reduce the labor of inspections via remotely-controlled and autonomous robots. Therefore, in this mission, the robot shall inspect the operational state of facility equipment as well as read and report numerical values from meters and other equipment located in designated places. The robot shall also adjust facility equipment as specified.



#### Required abilities:

[Mobility] The robot shall move in spaces made up of isles (narrow in some sections: approx. 600 mm), stairs and pipe lines. The surface materials include concrete, grating and checker plate.

[Observation and Manipulation] The objects to inspect and operate include meters and valve handles with a shape and location known to teams in advance. The robot shall have the capability to inspect and operate these objects using built-in tools such as sensors and manipulators.

[Environmental Adaptation] The robot shall have the capability to adapt and execute tasks in a standard plant environment where complex pipe lines run around numerous pieces of facility equipment.

[Technical Challenge] The robot shall have the capability to automatically recognize the values of a meter and operate values through feedback based on dynamic changes of the numerical value. This requires a practical level of processing capabilities (speed/accuracy) as well as the capability to conduct inspections through autonomous movement.

#### Description of Competition Tasks and Points:

Conduct daily inspections based on inspection instructions for each inspection object equipment.

##### Pipe Line (A)

##### (1) Check the values of the pressure gauges

Read and report the value of the pressure gauges installed in both horizontal and vertical directions: 10 points/gauge

(Points vary according to the location)

##### (2) Open/close the valves

Turn the handle of the valves installed in both horizontal and vertical directions 90 degrees: 10 points/gauge

(Points vary according to the location)



### (3) Adjust the valves

Turn the handle of the valves installed in both horizontal and vertical directions to a designated angle: 10 points/valve

(Points vary according to the location)

### Three Pumps

#### (1) Check the operational state

Identify the LED display of the control panel and report the operational state: 10 points

#### (2) Check the values of the pressure gauges

Read and report the numerical value of the pressure gauges: 10 points/gauge

#### (3) Open/close the valves

Turn the handle of the valves 90 degrees: 10 points/valve

### Two Tanks

#### (1) Check the values of the water level gauges

Read and report the numerical value of the water level gauges: 10 points/tank

#### (2) Open/close the valves

Turn the handle of the valves 90 degrees: 10 points/tank

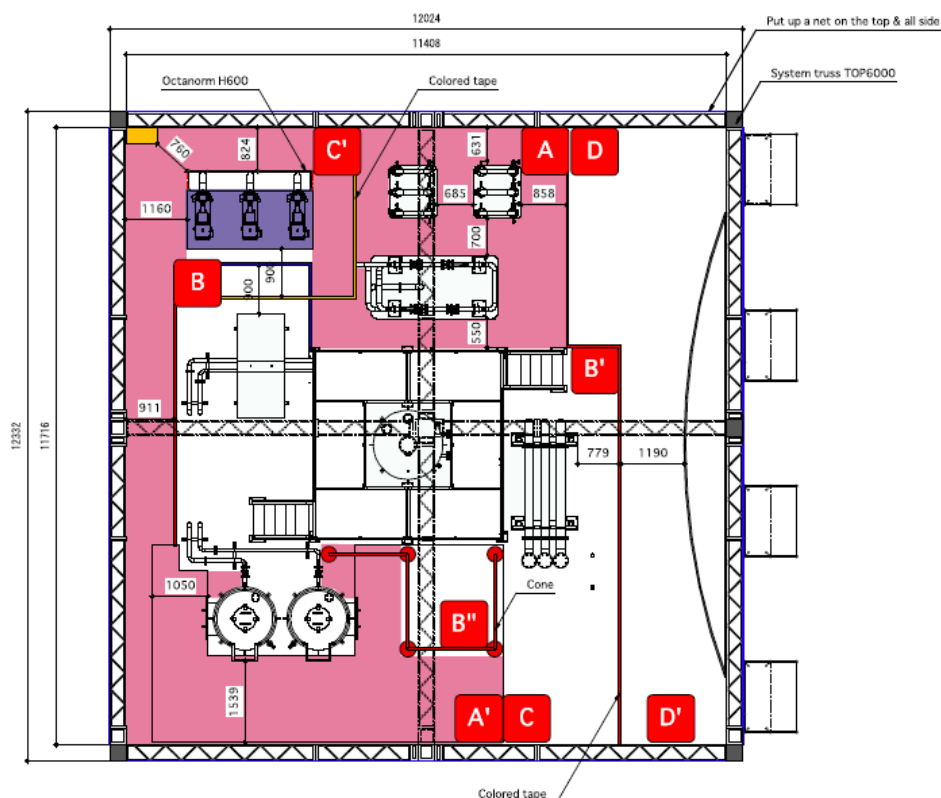


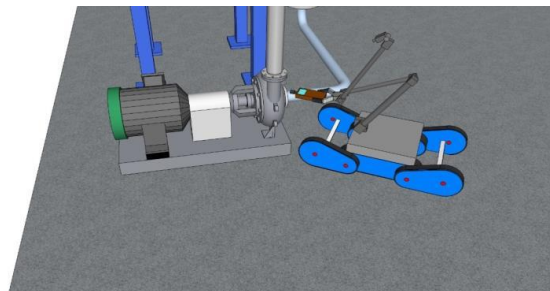
Figure 2: Mission Zone P1

Example of Requirements to Award Technical Points:

- [Mobility] The robot can move autonomously from the start zone to the end zone using self-position estimation methods or other techniques based on the procedural directions.
- [Inspection (Meters)] The autonomous robot can clearly display the dial of meters by automatically identifying the position of the object to inspect (pressure gauge, water level gauge, pump control panel LEDs) via tools such as image processing in addition to controlling the orientation of itself and the manipulator.
- [Adjustment (Handle/Lever Operations)] The autonomous robot can grasp and appropriately rotate the handle/lever by automatically identifying the position of the handle or lever as well as controlling the orientation of the autonomous manipulator and controlling the handling of the end effector.
- [Report] Not applicable.

### Mission P2: Fault Detection

Competition task: Perform a detailed inspection by regularly using a measurement device at a plant. The objective is to discover faults by utilizing sensors and analysis technologies. Therefore, in this mission, the robot shall quickly discover an abnormality cause by aging and degradation over time in facility equipment designated for regular inspection and report the location as well as information about the abnormality.



Required abilities:

- [Mobility] Same as Mission P1
- [Observation and Manipulation] The items to inspect on each piece of equipment include any faults of heat sources, gas leakage (concentration), irregular noise, loose bolt fastenings and water leakage. The robot shall detect faults by using tools mounted to the robot such as sensors and cameras. The competition organizers will not provide the location of an irregularity but will prescribe and inform teams of the instrument used to measure the abnormal phenomenon. Each team may use the measurement instruments provided by the competition organizers or their own devices to measure the abnormal phenomenon.
- \*Tentative measurement instruments provided by the competition organizers: VM-82A (RION) vibration meter/NL-42 (RION) sound level meter

[Environmental Adaptation] Same as Mission P1

Technical Challenge: Detect an abnormality in an environment where the location of the irregularity is unknown. The robot shall utilize and integrate existing measurement technologies (integration technology). This requires a practical level of processing capabilities

(speed/accuracy) as well as the capability to conduct inspections through autonomous movement.

#### Description of Competition Tasks and Points:

Conduct inspections to detect faults ~~abnormalities~~ based on inspection instructions for each inspection object equipment.

#### Pipe Lines (B)

- (1) Find loose bolts in the flange area

Report whether bolts are loose: 10 points/bolt

- (2) Find rusted bolts in the flange area

Report whether bolts have rusted: 10 points/bolt

- (3) Find gas leakage in the piping area

Report the carbon dioxide concentration: 10 points

- (4) Find abnormalities in the surface temperature of piping

Report the location and temperature of abnormal temperatures (difference from appropriate level): 10 points

#### Three Pumps

- (1) Identify an abnormal pump

Identify a pump with fault and report the pump number: 10 points

- (2) Find loose bolts in the stand area

Report the position and number of bolts that are loose: 10 points/bolt

- (3) Find rusted bolts in the stand area

Report the position and number of bolts that have rusted: 10 points/bolt

#### Two Tanks

- (1) Measure the oxygen concentration inside of the tanks

Report the oxygen concentration values: 40 points/tank

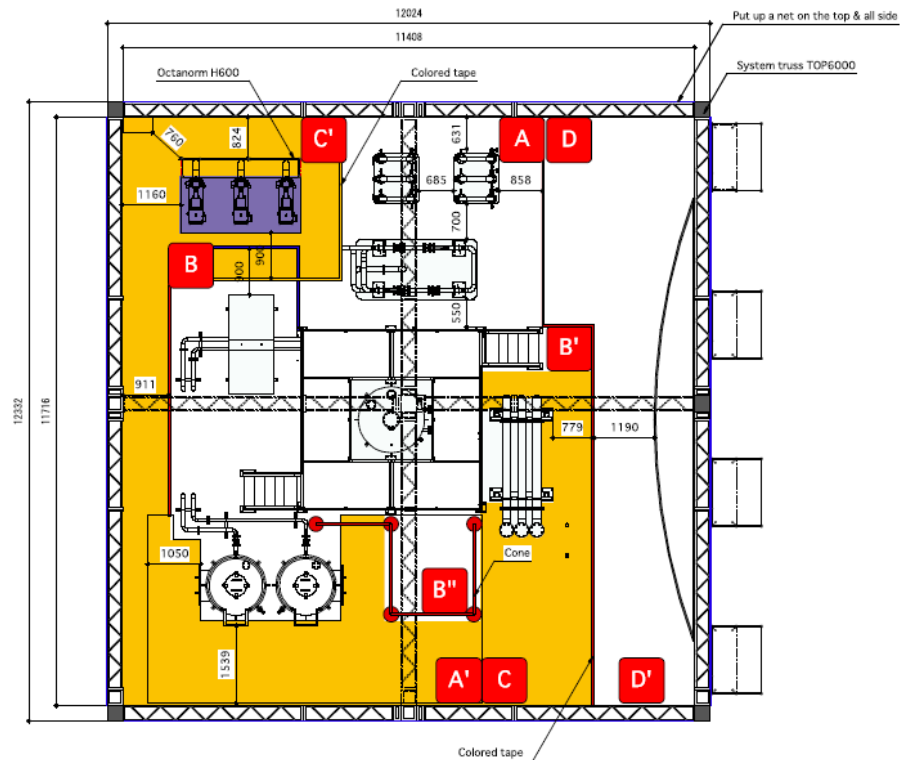


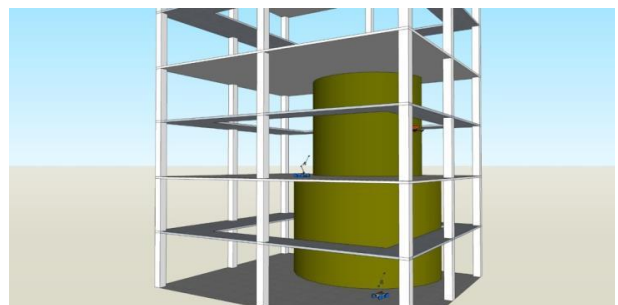
Figure 3: Mission Zone P2

Example of Requirements to Award Technical Points:

- [Mobility] The robot can move autonomously from the start zone to the end zone using self-position estimation methods or other techniques based on the procedural directions.
- [Inspection (Bolts)] The autonomous robot can correctly contact the end effector on the head of the bolts by automatically identifying the position of each bolt in addition to controlling the orientation of itself and the manipulator.
- [Report] The robot can report numerical values that include the axial tension and torque of bolt fastenings, vibration RMS values of the pumps and the sound pressure.

### Mission P3: Diagnosis

Competition Task: Conduct a large-scale inspection assuming major repairs and refurbishment once every several years at the plant. In some cases, the plant may need to be shutdown for cleaning. Therefore, the objective is to utilize the robot for inspections to reduce the period of plant shutdowns and inspect high places and other dangerous areas. Therefore, in this mission, the robot evaluates and diagnoses for the health of large-scale structures, such as piping (including flanges), tanks as well as



chimneys and reports the status of aging and deterioration. The preliminary competition will prepare a wooden wall to simulate the wall of a large tank.

Required abilities:

[Mobility] Same as Mission P1

[Observation and Manipulation] The robot can perform diagnostics of piping, ducts and large-scale structures. The robot shall use tools mounted to the robot such as sensors and cameras. Teams will not be given the location of any deteriorations. However, the competition organizers will prescribe and inform teams of the type of abnormal phenomenon in advance.

[Environmental Adaptation] Same as Mission P1

Technical Challenge: Inspect complicated piping in a wide space such as a large tank and high place such as a chimney. Integrate structural health monitoring technologies to the robot (integration technology). Autonomous control performance is not compulsory, but advanced human-robot integration and data analysis processing capabilities able to support complex, large-scale structures are necessary. This requires a practical level of processing capabilities (speed/accuracy). It is desirable in reports if the robot has the capability to create 3D models in real-time on-site and map the examination results in order to identify the inspection locations.

Description of Competition Tasks and Points:

Evaluate and diagnose the health of structure based on inspection instructions for the large tank wall. Report the results of evaluations and diagnostics for each of the inspection items below in each inspection area (baseboard increments).

(1) Evaluate whether there is cracking

Identify areas with cracking and report the width and length of the cracks: 10 points/crack

(2) Evaluate whether there is rusting

Report the ratio of rusting in designated areas: 10 points/area [Reference: ASTM D610]

(3) Evaluate whether there is float (cavities)

Identify areas with float and report those locations: 40 points/location

Example of Requirements to Award Technical Points:

[Mobility] The robot can set multiple waypoints and move autonomously.

(A target arrival zone needs to be prepared near each piece of equipment)

[Inspection (Diagnosis)] The robot can automatically identify each deteriorations and point a tool such as a camera lens directly at the area.

[Report] The robot can create a 3D map in real-time and display the position of deteriorations on that map.

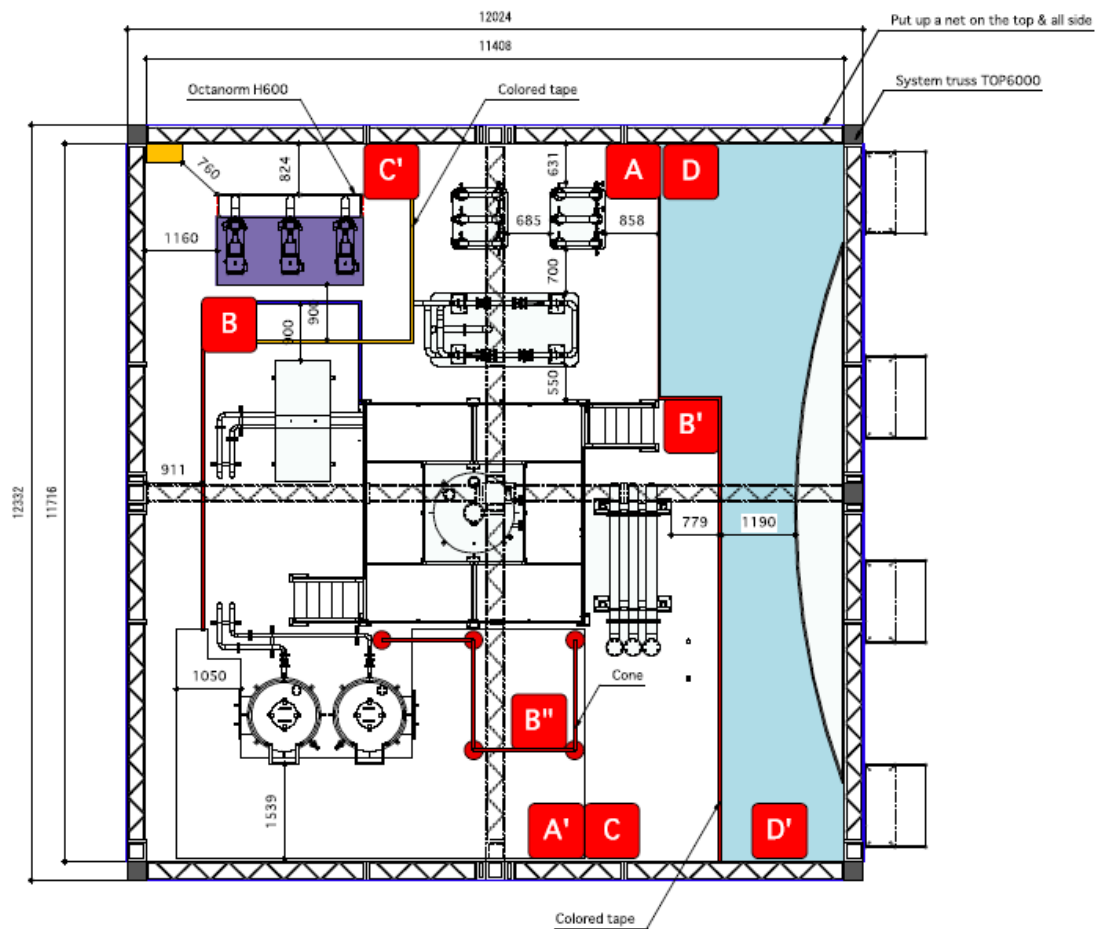
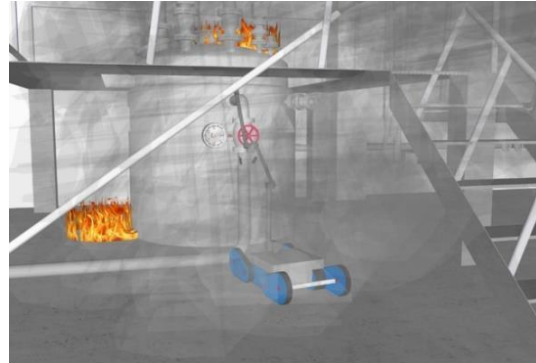


Figure 4: Mission Zone P3

### Mission P4 : Disaster Response: Initial Fire Fighting

Competition Task: An explosion is heard while the robot is conducting a routine inspection. The explosion was caused by a gas leak in piping deteriorated by age. A fire breaks out around the facility equipment and fills the area with smoke (smoke will not be simulated at the preliminary competition). In addition, the situation is volatile with other facility equipment potentially leaking gas, which could also lead to subsequent explosions. It is too dangerous for any human personnel to approach the facility equipment. The objective is to execute initial fire-fighting using the robot to prevent the disaster from spreading. Therefore, in this mission, the robot shall properly open and close valves of various piping of relevant facility equipment and other equipment nearby (opening piping for sprinklers, foam fire extinguishers and fire-fighting equipment while closing combustible gas and oil piping).



Required abilities:

[Mobility] Same as Mission P1

[Observation and Manipulation] The equipment is the same as Mission P1 combined with initial fire-fighting and debris removal.

[Environmental Adaption] The robot can adapt to an environment during a disaster (smoke, water, oil, debris and other unknown circumstances with almost no prior information).

Technical Challenge: The robot must realize comprehensive and practical capabilities. In particular, the robot shall aim to successfully work in an unknown environment with external interference. In addition, the robot shall aim to leverage the capabilities used in each competition task on pages 1 to 3 in this emergency situation.

Description of Competition Tasks and Points:

Conduct daily inspections based on inspection instructions for the boiler. Each team shall handle initial fire-fighting after a disaster strikes.

#### Boiler

Walkway inspection (narrow space):

(1) Check the values of the pressure gauges

Read and report the numerical values of the gauges: 20 points/gauge

(2) Open/close the valves:

Turn the handle of the valves 90 degrees: 20 points/valve

Walkway inspection (traverse a stairway):

(3) Check the values of the temperature gauges

Read and report the numerical values of the gauges: 20 points/gauge

After the siren and other warning alarms sound:

- (4) Close the valves of fuel piping in the corridor inspection (turn the lever 90 degrees: 40 points).  
Open the start valve of the foam fire extinguisher near the walkway inspection (open the cover of the start valve manually, and then turn the handle 90 degrees: 40 points).

Example of Requirements to Award Technical Points: Conforms to P1

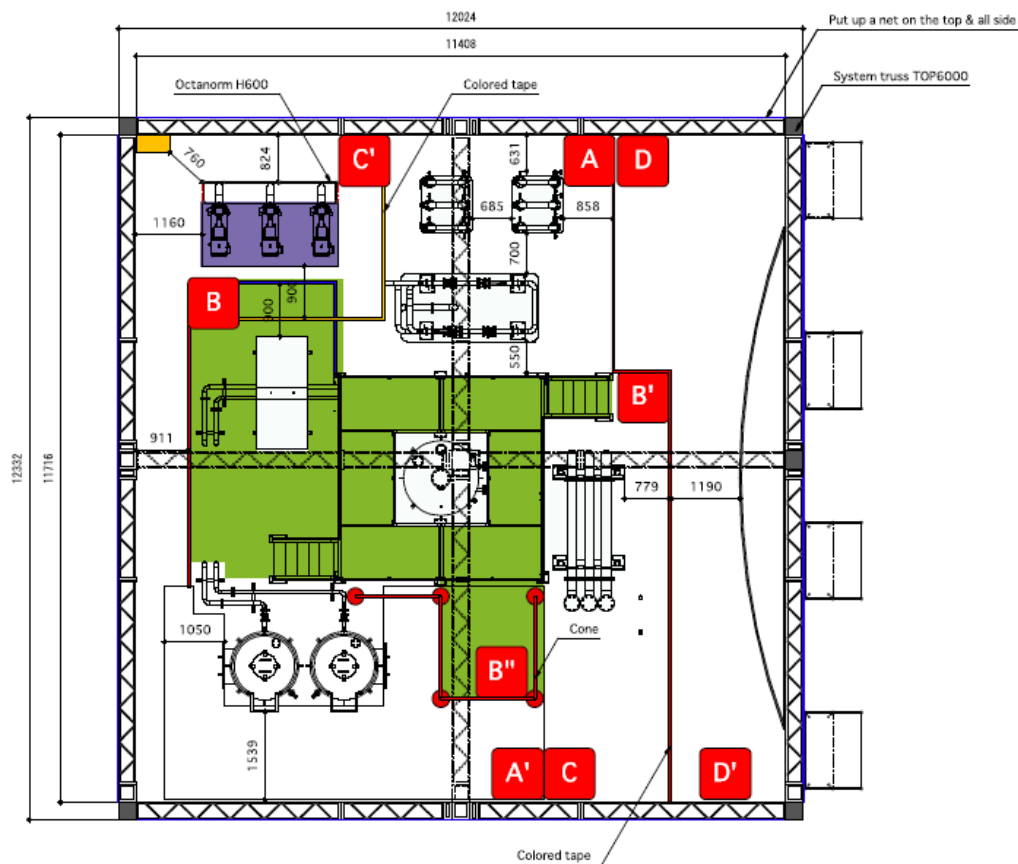
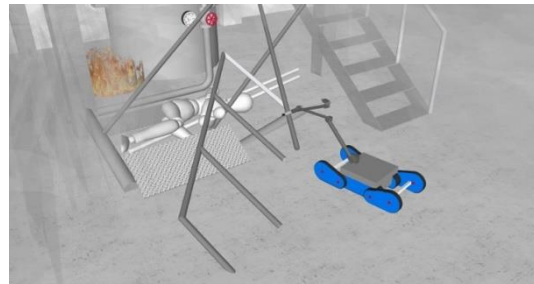


Figure 5: Mission Zone P4



### Mission P5 : Disaster Response: Search

Competition Task: One employee is still missing in the count after the disaster (explosion). The plant learns the missing person was in an office on the second floor before the explosion. Therefore, in this mission, the robot shall search of the missing person to prevent a secondary accident.



Required abilities:

[Mobility] The robot shall move in the same manner as Mission P1/P2 in an environment with debris.

[Observation and Manipulation] The robot shall remove debris and search for missing person.

[Environmental Adaption] The robot shall adapt to an environment during a disaster (an unstructured environment with smoke, water, oil, debris and other unknown circumstances with almost no prior information).

Technical Challenge: The robot must realize comprehensive and practical capabilities. In particular, the robot shall aim to successfully work in an unstructured environment with external interference. In addition, the robot shall aim to leverage the capabilities used in each competition task on pages 1 to 3 in this emergency situation.

Description of Competition Tasks and Points:

Daily inspections comply with P1/P4

The robot shall move while removing scattered debris (40 points) after the siren and other warning alarms sound, search for one employee (mannequin) who still remains inside the plant, and report the location of the missing employee (40 points).

There will be a surprise task.

Example of Requirements to Award Technical Points: Conforms to P1

Mission Zone P5 combines the mission zones for P1 and P4.

## 4. Inspections

### 4.1 Outline of Equipment/Structures

#### 4.1.1 Pipe Lines

##### 4.1.1.1 Pipe Line (A)

###### Specifications:

JIS-SGP piping (80A), JIS-SS (10K) flanges, and

JIS-SS welded elbows (bending)

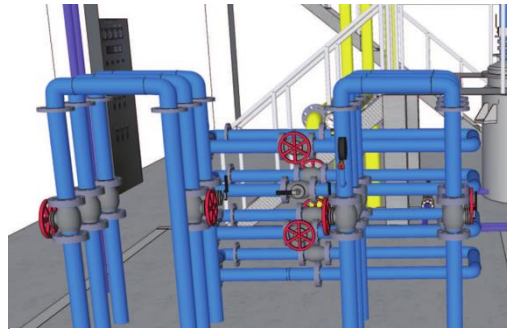
Pressure gauges, ball valves (80A), stop valves (80A), and rubber seated valves (80A)

###### Items for Inspection:

- (1) Pressure gauge measurements (P1/P5): The three types of measurement ranges will be 0.25, 1.0 and 1.6 MPa. The values shall be read with an accuracy within  $\pm 5\%$ . The gauges will be installed at a height between approximately 600 mm to 1,800 mm.
- (2) Opening/closing valves (P1/P5): Levers (length of approximately 400 mm) and round handles

###### Report content (judging criteria):

Not applicable.



\*The image is for illustrative purposes

##### 4.1.1.2 Pipe Line (B)

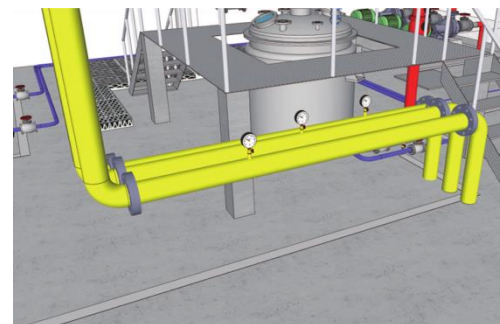
###### Specifications:

JIS-SGP piping (150A), JIS-SS (10K) flanges, and

JIS-SS welded elbows (bending)

###### Items for inspection:

- (1) Integrity evaluation (deteriorations such as corrosion, gas leakages, presence of abnormal concentration of carbon dioxide, loose/rusty bolts, irregular heat; P2)



\*The image is for illustrative purposes only.

###### Report content (judging criteria):

Presence and location of deteriorations. More detailed information is planned for release separately online.

#### 4.1.2 Pump

###### Equipment specifications:

Single suction volute pumps—

(Aperture 100 × 80; 7.5kW)

JIS-SGP piping (80A/100A), JIS-100A flanges (10K/suction side), JIS-80A flanges (10K/discharge side), pressure gauges and 80A ball valves.

The installation on the stand has a height of approximately 125 mm

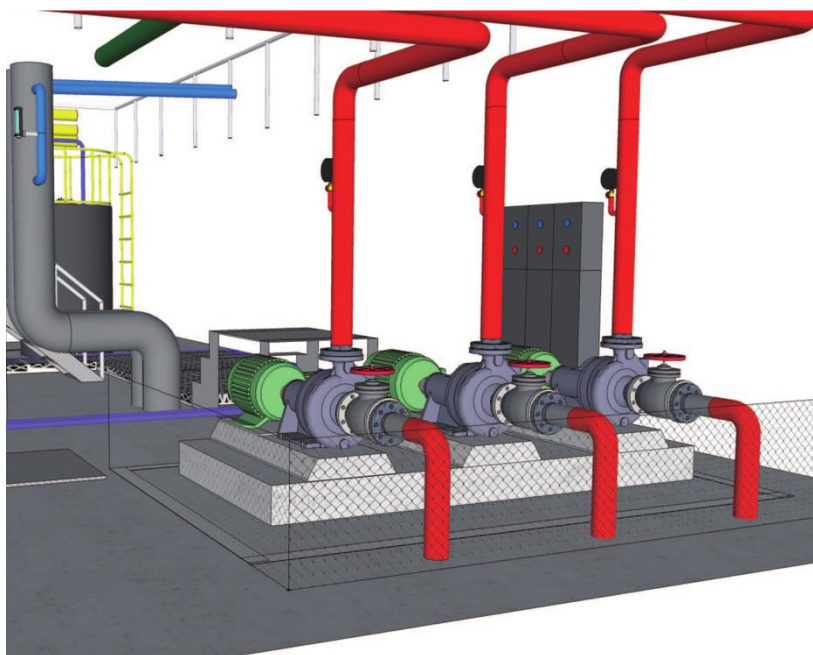
#### Items for Inspection/Maintenance

- (1) Pressure gauge measurements (P1/P5): The range of measurements is 1.0 MPa. The values shall be read with an accuracy within  $\pm 5\%$ . The gauges will be installed at a height of approximately 1,500 mm.
- (2) Opening/closing valves (P1/P5): Lever handle (length of approximately 400 mm installed at a height of approximately 1,200 mm)
- (3) Integrity (abnormal noise/vibrations and loose/rusting foundation bolt fastenings; P2)

#### Report content (judging criteria):

Presence and location of deteriorations The judging criteria is scheduled to comply with the ISO machine vibration evaluation standards (ISO10816-3).

More detailed information is planned for release separately online.



\*The image is for illustrative purposes only.

### 4.1.3 Small Tanks

#### Equipment specifications:

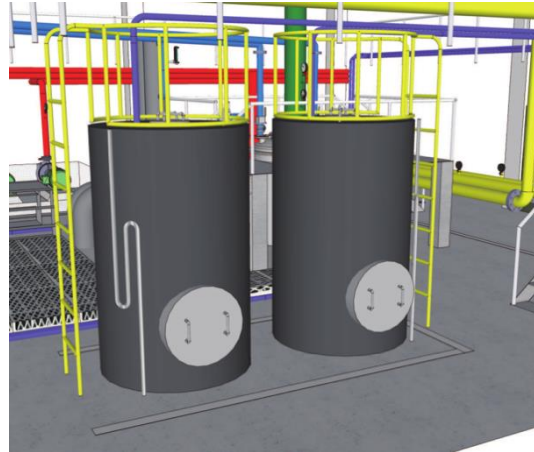
JIS-SS steel plate welded assembly structure ( $\phi$  1,200 × H 1,900 mm)

Ladder (no safety fence, effective width of 400 mm, a step interval of 300 mm and 7 steps)

Inspection hatch (swing-bolt fixed detachable hatch in the ceiling with a diameter of approximately 300 mm)

Inspection hatch (bottom, diameter  $\phi$  600 mm, bolt fixed detachable hatch)

Tank side surface water level gauge (tubular type liquid level gauge) Discharge part 50A ball valve



#### Items for Inspection/Maintenance

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

\*The image is for illustrative purposes only.

#### Report content (judging criteria):

- (1) Water level measurements: Accuracy within  $\pm 5\%$
- (2) Oxygen concentration measurements: Accuracy within  $\pm 30\%$

The judging criteria is scheduled to comply with the Ordinance on Prevention of Anoxia, etc.

### 4.1.4 Boiler

#### Equipment specifications:

Small boiler ( $\phi$  1,300 × H 1,550 mm)

JIS-SGP piping (50A, 80A, 250A), JIS-250A flange joint (10K) x 1, JIS-80A flange joints (10K) x 2, pressure gauges x 4 or more, temperature gauge x 1, 50A ball valve (lever) x 2, 80A ball valve (lever)

Inspection Deck:

Walkway width; 1,000 mm

Skeleton staircase (full width: 700 mm {effective width: 600 mm}, step depth: 240 mm, riser height: 227 mm, inclination about 40 deg.)

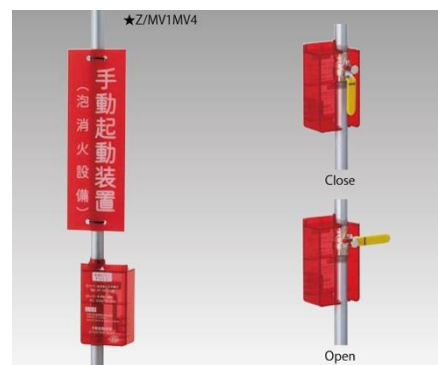
Manual starting device of foam fire extinguishing equipment

Foam Fire Extinguishing Equipment

Manual Starting Device

Reference: Itachibori Mfg. Co., Ltd.

<http://www.itachibori.co.jp/>

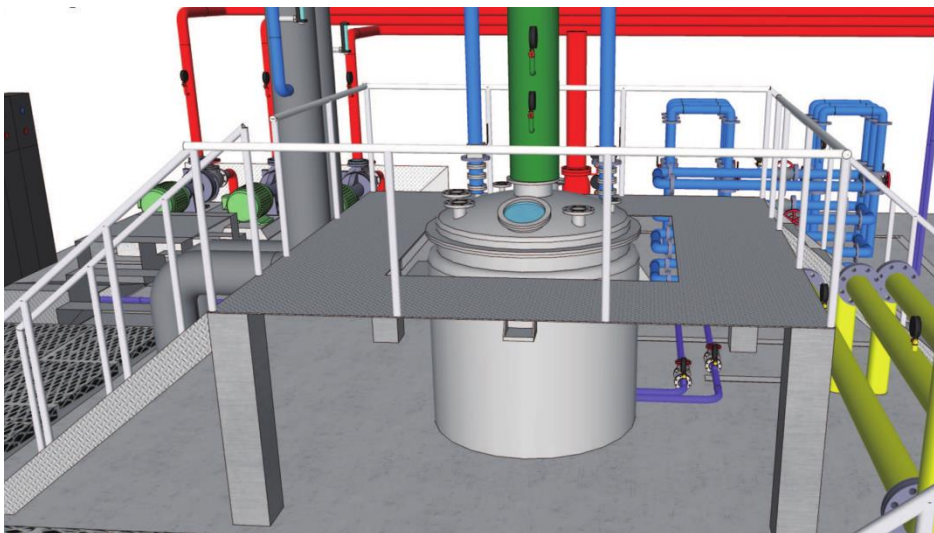


#### Items for Inspection/Maintenance

- (1) Pressure gauge measurements (P4): The two types of measurement ranges will be 1.0 and 1.6 MPa. The gauges will be installed at a height approximately 500 mm from the floor and approximately 1,500 mm from the inspection walkway.
- (2) Temperature gauge measurements (P4): The range of measurements is 0 to 200 degrees. The gauges will be installed at a height approximately 1,700 mm from the inspection walkway.
- (3) Handle operation (P4): Open and close the water and fuel piping, adjust pressure as well as open and close piping for fire-fighting equipment  
The gauges will be installed at a height approximately 1,500 mm from the inspection walkway.

#### Report content (judging criteria):

- (1) Pressure/temperature measurements: Accuracy within  $\pm 5\%$



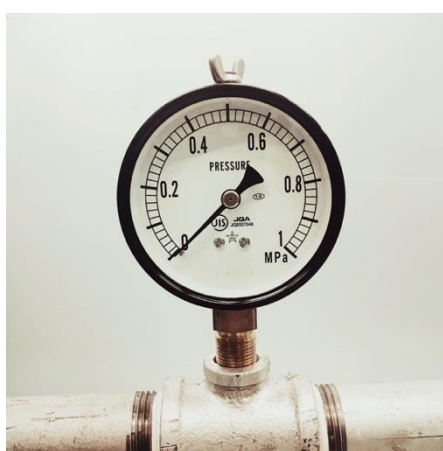
\*The image is for illustrative purposes only.

## 4.2. Outline of Inspections/Maintenances

Plan to prepare standard products according to piping system

### 4.2.1 Pressure Gauges

JIS B 7505-1 Bourdon Tube Pressure Gauges are planned to be the pressure gauges in this competition. Nagano Keiki General Industrial Pressure Gauges (universal pressure gauges) and AC20-181-2000 (A: Type A/Lower connection;  $\phi$  75); The measurement range is planned to be 0.25, 1.0, 1.6 MPa.



Ex. Made by Migishita Seiki MFG Co., Ltd. General purpose pressure gauge S-31-1MP  
Nagano Keiki Co., Ltd.: <http://www.naganokeiki.co.jp/>

### 4.2.2 Temperature Gauges

Nagano Keiki Bimetal Thermometer TB14-000-110A; Measurement range: 0 to 200 degrees Celsius



### 4.2.3 Water Level Gauges

Showa Instrument Information Tubular Type Level Gauge LG-0610 with a measurement range up to a water level of approximately 1,400 mm.

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





#### 4.2.4 Valves

Level handle valves:

KITZ Corporation 10K Cast Iron Ball Valve 10FCTB (50A/80A)

Round handle valves:

Tomoe Valve Rubber Seated Valve 700Z-2F (80A)

KITZ Corporation Class 150 Cast Bronze Gate Valve EBH (80A)



From Left: Ball Valve, Rubber Seated Valve and Gate Valve

KITZ Corp.: <http://www.kitz.co.jp/english/>

Tomoe Valve Co., Ltd.:

[www.tomoevalve.com/english/index-e.html](http://www.tomoevalve.com/english/index-e.html)

Reference: Torque required for rotation

(1) Handle: Approximately 0.8 Nm

KITZ Corporation Class 125 Brass Gate Valve FR 1B (25A)

(2) Lever: Approximately 2.0 Nm

KITZ Corporation Type 600 Brass Ball Valve TK 1B (25A)

#### 4.3 Deteriorations

See attached reference materials

#### 4.4 Types of road surface

Concrete, grating, checker plates and stairs

Slope: 15 deg

#### 4.5 Debris

The competition plans debris which assumes objects that inspection robots can handle (fine piping, distorted objects, etc.).



## 5. Competition Schedule

Setup (robot inspections): 2 days; Preliminary competition: 4 days; Final contest: 1 day

Each team is scheduled to have time for a test run in the morning of the first day for the preliminary competition.

Competition time: 30 minutes/mission (Setting: 5 minutes; Competition: 20 minutes; Take down: 5 minutes)

## 6. Scoring Method

### 6.1 Mission Points: Evaluation of Mission Achievement Level

The mission points are made of the points earned in the competition tasks achieved in each mission (inspection examination/temporary measures). The mission points are determined through an evaluation of the achievement level for each mission.

### 6.2 Technical Points: Evaluation of Robot Technology Level

Each team who has achieved advanced robot technologies will earn technology points. The technology and 10% up to 20% of the points for each mission according to that technology can be earned as technical points

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The judges determine the technical points based on an interview during the robot inspection before the competition. However, teams may be asked to demonstrate their technology during this interview.

Some examples are provided below.

- (i) The robot can move autonomously to areas for the designated inspections and operations as well as conduct patrols
- (ii) The robot can identify the position and operate handles autonomously
- (iii) The robot can report the results of inspections for deteriorations (ex. pump irregularities/loose bolts)
- (iv) The robot can create maps in real-time and display diagnostic results of inspections and evaluations on the map that is created
- (v) The robot takes into account energy savings (self-assessment)
- (vi) The robot employs environmental resistance measures  
(water, dust {IP} and explosion proofing) (self-assessment)

\*The competition organizers are reviewing whether to ask for evidence (certificates, etc.) to be submitted for (vi)

\*Teams may identify the values of the various meters visually in the preliminary competition, but the main event in 2020 plans to require automated recognition of these values.

### 6.3 Time Points: Evaluation of Speed

Points are added according to the speed of each mission.

### 6.4 Requirements for Aggregating Points and Determining Winners

The competition points earned by teams in each mission include the official number of points earned in missions by each team according to the maximum number of points available in each mission. The top four teams to move onto the final contest will be determined according to the results of the preliminary competition (ranking based on points earned in missions).

## 7. Team Members

A maximum of ten team members shall apply via Team Description Papers (TDP) in advance. Only team members are allowed to enter the paddock area (team waiting room).

The role of team members is determined as follows.

- Team leader (one person): The team leader organizes the team. Only the team leader may challenge the competition results.
- Robot operators (two persons): The robot operators are the personnel who operate the robots. Only the robot operators are qualified to enter the operator area.
- Network administrators: Network administrators manage the team network.
- Safety manager (one person/robot): The safety managers monitor the robots during operation to ensure safety in the surrounding area.
- Helpers: Helpers transport the robot to the start point or restart point.

Operators and safety managers must be different. Concurrent roles are possible for the remaining roles. In addition, other than the team leader, team members may switch their role for each mission.

Additions and changes to team members need to be applied for in advance.

## 8. Competition Robot

- The competition robot may take any form such as a crawler, drone, humanoid, leg, or snake.

The number of robots used for competition shall be unlimited.

- The total area for the bottom of the robot may not exceed four square meters at the start of the competition. The robot may protrude from the start area, but teams must follow the directions of the judges about the position of setup.
- The height is unlimited.
- After the start of the competition, the bottom area may exceed 4 square meters.
- The maximum weight of each robot shall be 130 kg/unit.
- The competition robots and operation systems are limited to those described in the Team Description Papers (TDP) submitted in advance.
- The competition robots and operation systems are subject to tests in advance. Only robots which pass these tests may be used in the competition.
- The competition robots may be changed for each mission. However, the robots may not be changed during the mission.
- Teams must use batteries that are guaranteed to be safe to use.
- Teams must prepare for emergencies by considering their response to robot malfunctions such as fire.

Comply with the laws of the competition country (Japan) such as Radio Act etc.

## 9. About the Missions

**Restart:** Teams may restart to handle technical problems, but they will receive a 2 minute penalty.

- The robot returns to the start point when restarting. Teams will maintain the points that they have earned up until the restart. However, tasks that have already been completed may not be retried.

**Withdrawal:** Teams may withdraw if they cannot complete the mission

**Dangerous actions:** Any team who engages in any of the following actions shall have a large number of points deducted or be disqualified from the competition.

- Interfering with other teams
- Causing drastic damage to the field
- Any other action deemed dangerous by the judges
- Safety managers must accompany the robot during the mission and be ready to take action for any unforeseen circumstances.
- The team leader may challenge the mission results determined by the judges. Teams have until the start of the next competition task to challenge the results.

## 10. Communication Network

Each team shall configure a wireless or wired communication environment between the computers of the operator and robot. The communication network must comply with the regulations related to communication designated separately by the World Robot Summit (WRS) as a whole.

## 11. Awards

The ranking shall be determined according to the score calculated based on Chapter 6. The expert judging committee will determine the winners of special awards, including the technology and idea awards.

## 12. Other

All teams must follow the instructions of the organizers during the competition.

#### Revision History

Ver.0.95 (November 11, 2017): First draft

Ver.0.96 (March 1, 2018): Changed the maximum weight from 100 kg to 130 kg (Chapter 7)

Ver.1.04 (July 14, 2018): Revisions for Version 1

Ver.1.05 (July 17, 2018): Revisions for Version 2; Revisions to the piping information of equipment