A proposal on reproducibility of the localized fire test

GTR No.13 TF#4

5th Meeting of the informal working group on GTR No.13 (Phase 2)

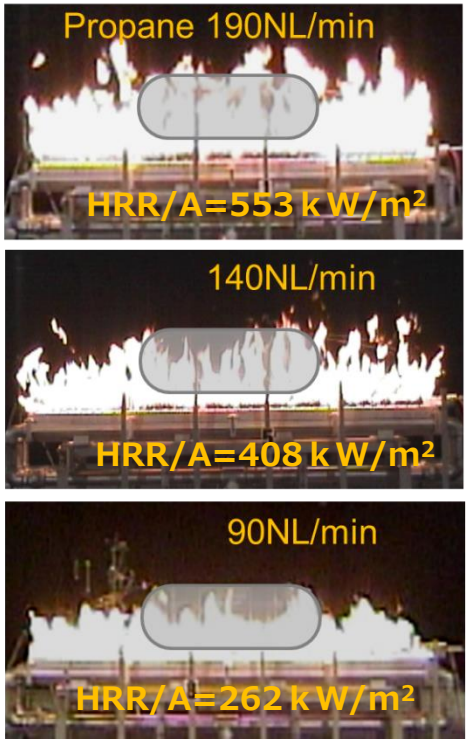
5-7 March 2019 @ Powertech Labs, BC, Canada

Content

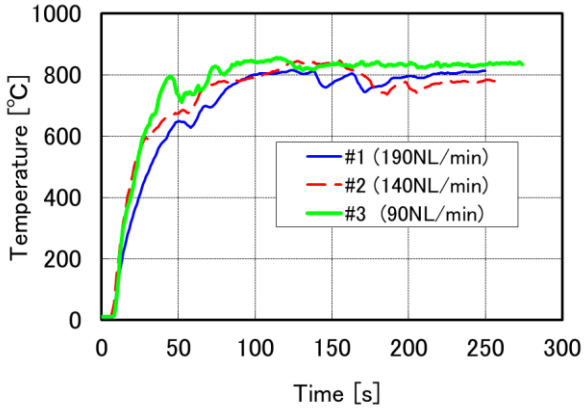
- Background
- Proposal of the localized fire test from JARI
  - ✓ Test method
  - ✓ Problem
- Draft plan & schedule
- Remark

Backgroud

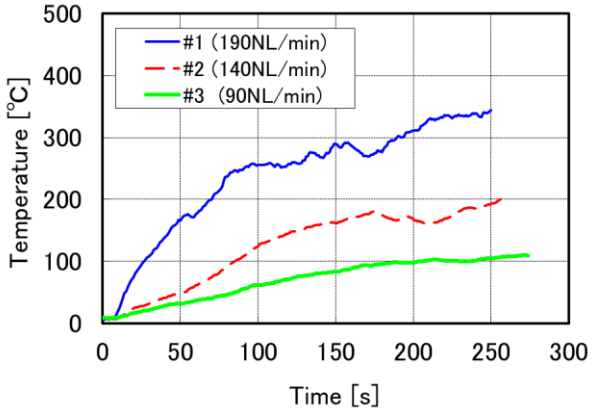
JARI showed that the burner flame height relative to the tank diameter can influence temperatures at the top of the tank and the end boss temperature and the activation time for TPRDs.



CFRP composite cylinder with a diameter of 280 mm



Temp. of the cylinder bottom center



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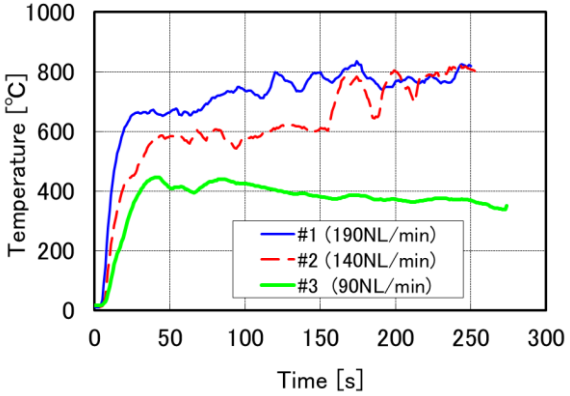
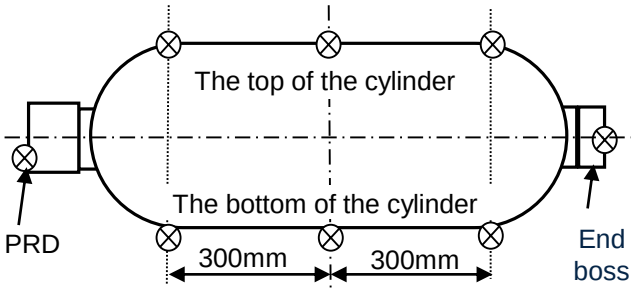
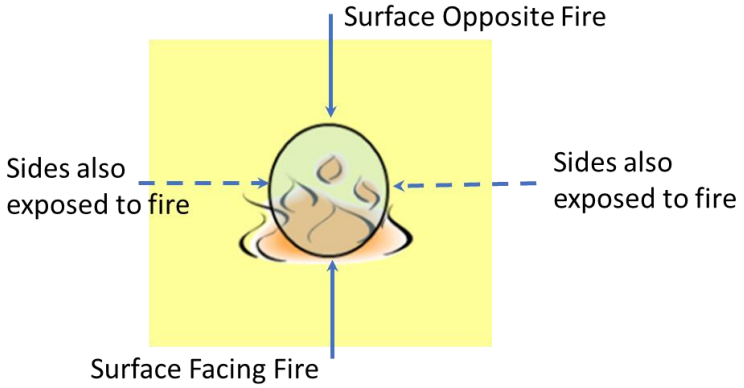


Temp. of the end boss

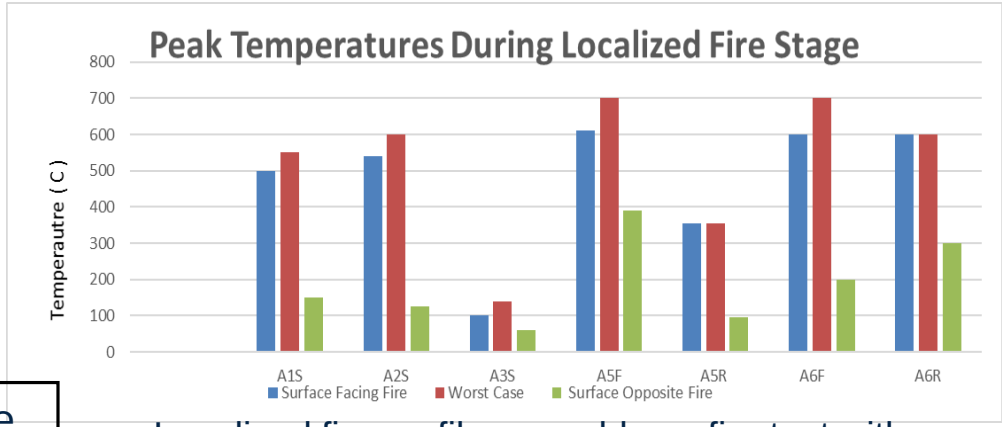


Backgroud

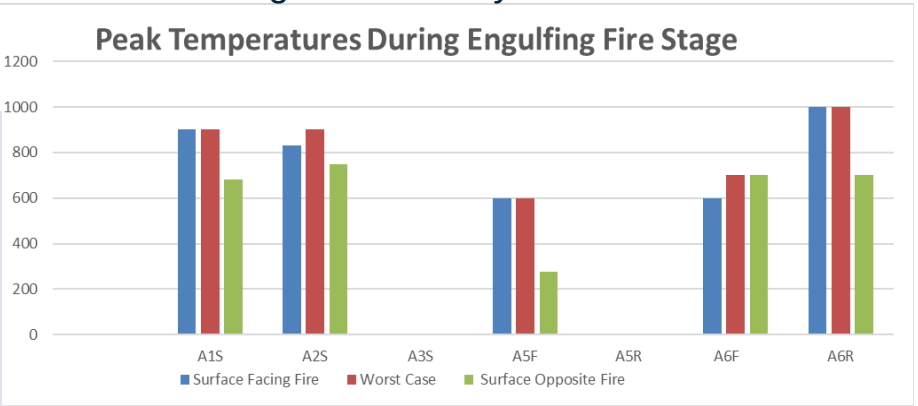
In order to derive an appropriate flame height for the cylinder fire test, JARI's vehicle fire test data was reviewed to investigate the temperature of the flame-contact side and its opposite side.



It was suggested that the temperature difference around the container is reproduced by flame height.



Localized fire profile resembles a fire test with flame height of 1/2 to cylinder diameter.



Engulfing fire profile resembles a fire test with flame height of 2/3 to cylinder diameter.

Task

- ✓ Can a repeatable test method be defined at the flame heights suggested by the JARI vehicle fire test data?
- ✓ How do you control both temperature and fire height?
- ✓ How do manage different tank diameters?

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Evaluation method of flame height

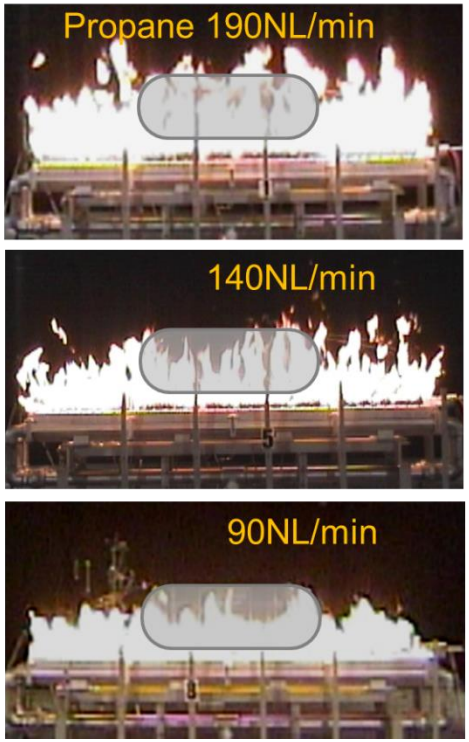
JARI examined the reproducibility improvement plan focusing on the flame height.

There is a method for simply evaluating the flame height during fire test.

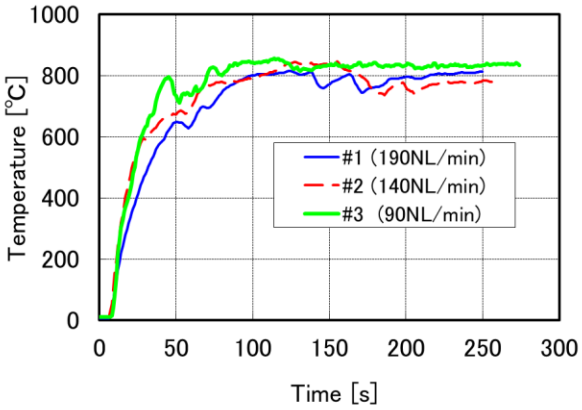
✓the temperature measurement

This method can be carried out at the testing laboratories.

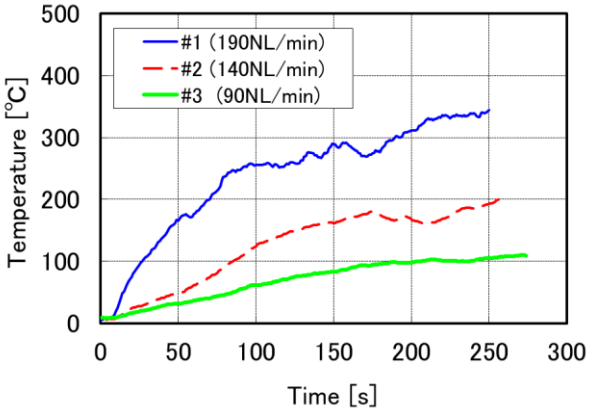
Temperature measurement to define the flame height



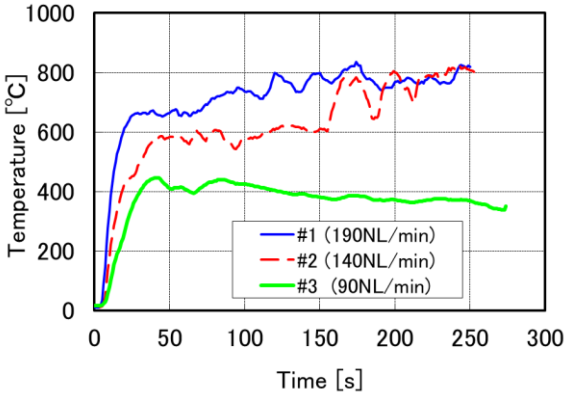
In this experiment, a CFRP composite cylinder with a diameter of 280 mm was used.



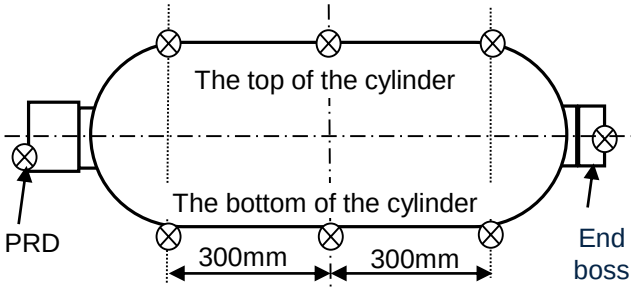
Temp. of the cylinder bottom center



Temp. of the cylinder top center

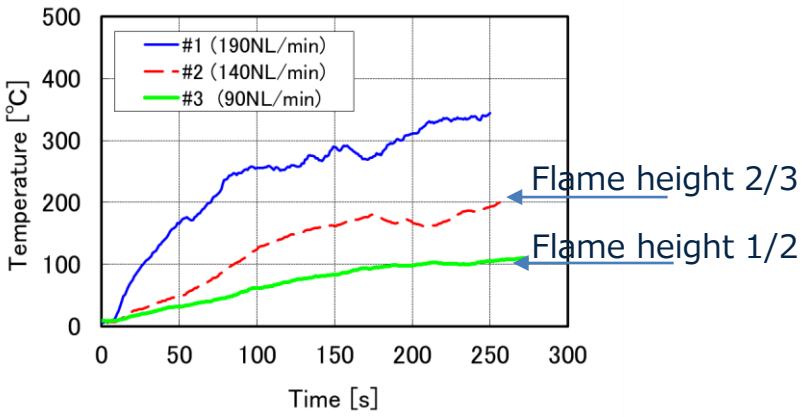


Temp. of the end boss



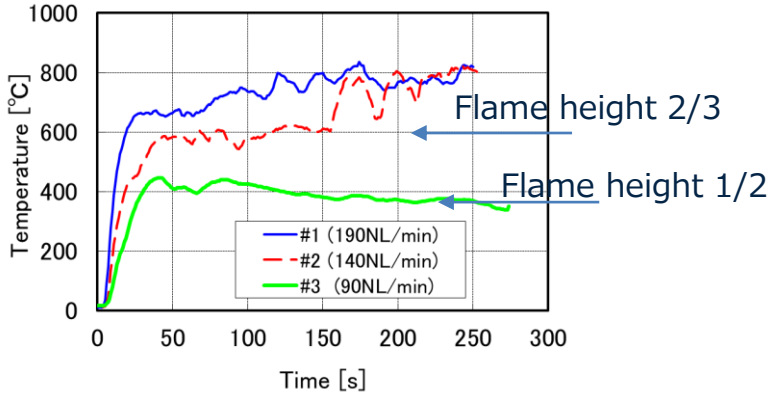
The burner flame height relative to the cylinder diameter can influence temperatures at the top of the cylinder and the end-boss. Flame height can be defined by adding several temperature measuring points.

Temperature measurement to define the flame height



Temp. of the cylinder bottom center

Ex. 1)
When the flame height requires 1/2 of the diameter
⇒ the end-boss part is 400 °C,
the bottom of the cylidner is 100 °C



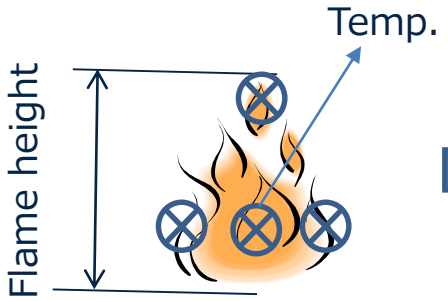
Temp. of the end-boss

Ex. 2)
When the flame height requires 2/3 of the diameter
⇒ the end-boss part is 600 °C,
the bottom of the cylidner is 200 °C

Proposal of localized fire test method – Way of thinking

① Based on the JARI vehicle fire test data, the standard fire sources (flame height, flame temperature etc.) in the localized fire and the engulfing flame area are determined.
② LPG flow rate to become a standard fire source is measured by a burner of testing laboratory.
③ The localized fire test is performed by the standard fire source according to the obtained LPG flow rate.

① Determination of the standard fire source

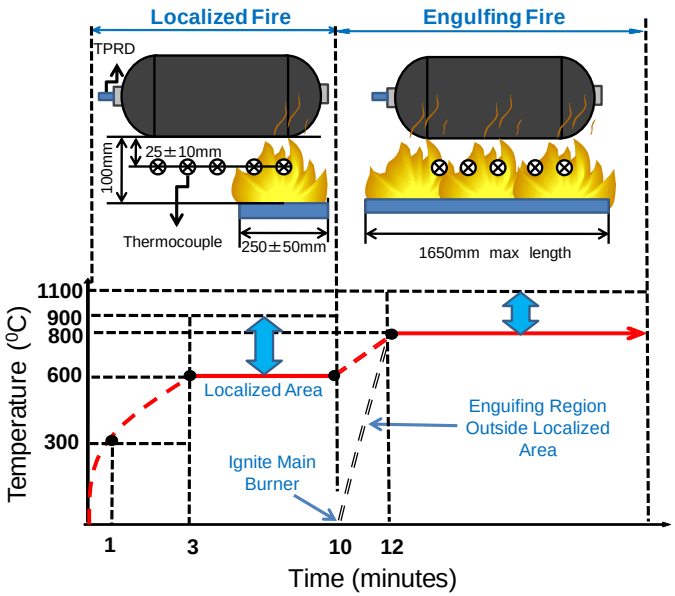


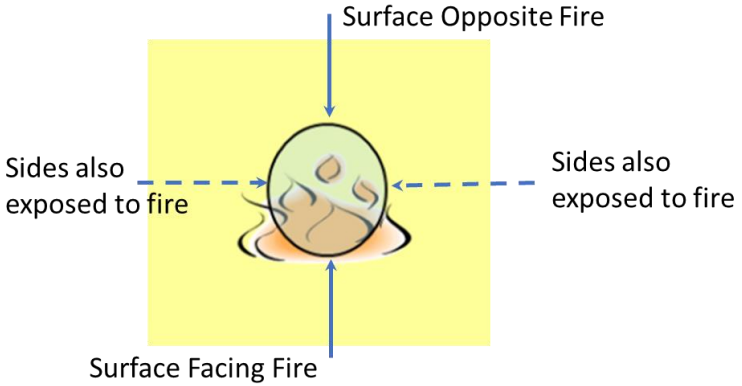
② Determination of the flow rate of burners for forming a standard fire source

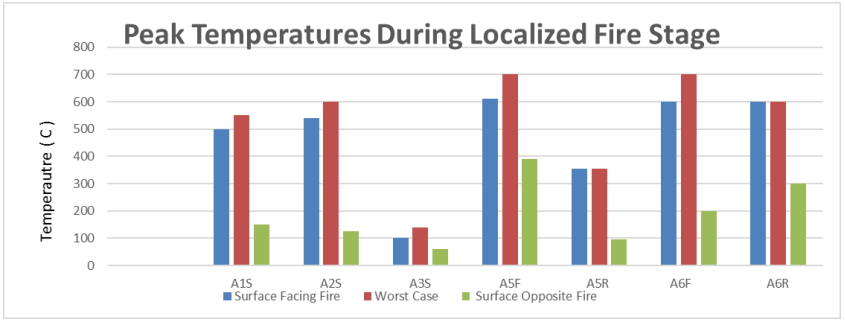
③ Localized fire test

Determination of the standard fire source

bottom temp. profile + oppsite & side temp. profile





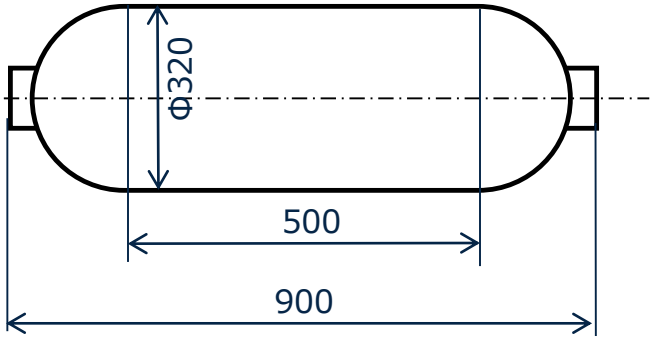


In the proposed revision of the localized fire test , in addition to the temperature profile of the cylinder bottom (the flame contact side) derived from the JARI vehicle fire data, flame height is defined from the temperature of the cylinder top side (opposite of the flame contact side)and the middle height like the end-boss .

Determination of flow rate to be a standard fire source

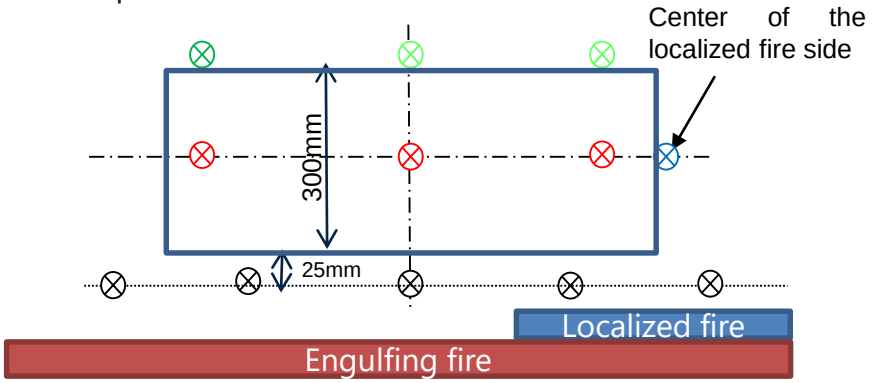
In order to match the burner fire source used in the localized fire test with the standard fire source, the flow rate is controlled using a dummy cylinder. A dummy cylinder is used an steel pipe or a pail can of a diameter of about 300 mm. Temperature in addition to the conventional cylinder bottom is measured cylinder central and top of the cylinder.

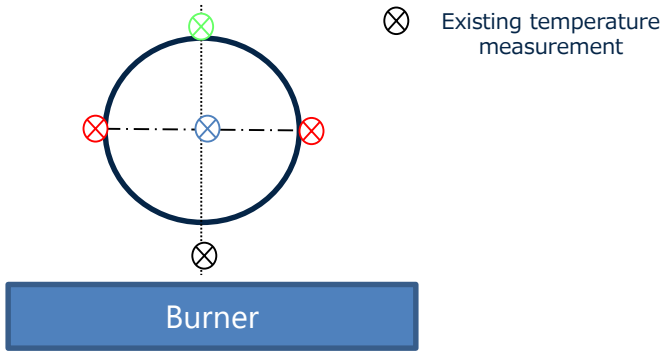
Dummy cylinder (Steel) used for JARI vehicle fire test



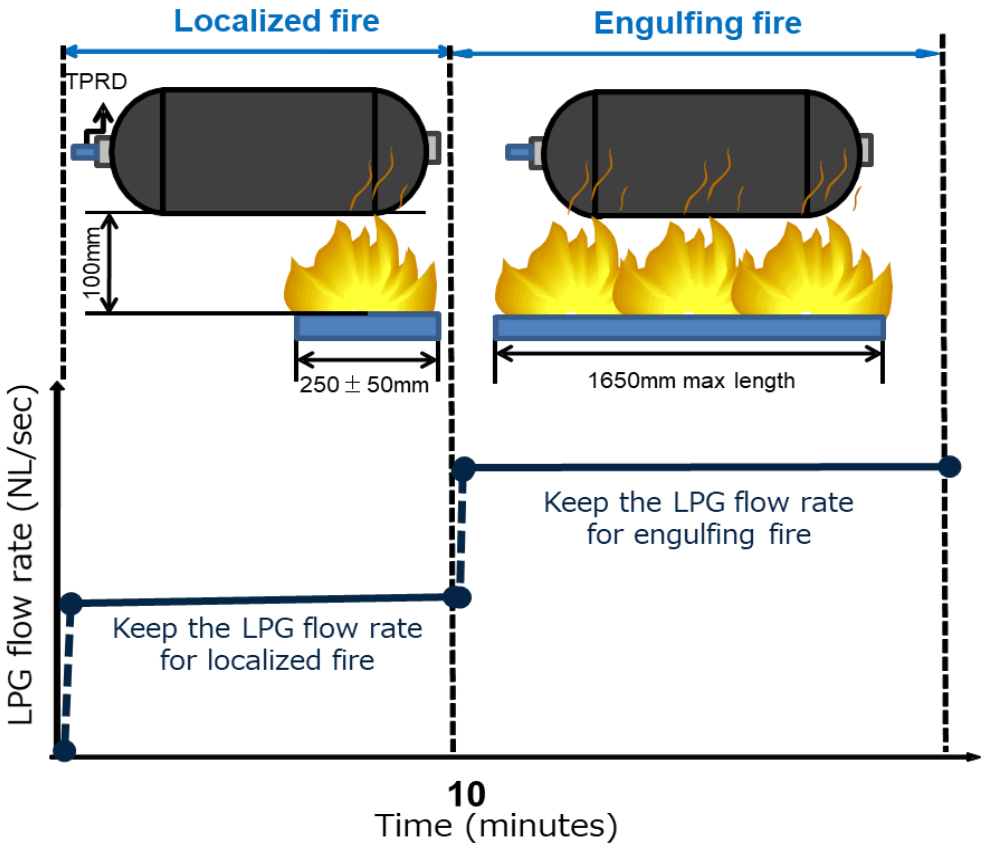
As a substitute for the JARI dummy cylinder, a pail can of about 300 mm in diameter and steel pipe are used.

✓ Temperature of 6 points in the center of the cylinder height(Red mark), 3 points in the top of the cylinder(Green mark), 1 point the cylinder on the center of localized fire (Blue mark) is measured by thermocouples.





To execute a localized fire test

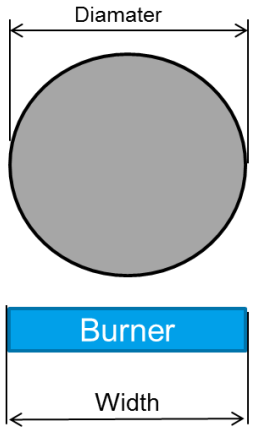


Execute form a localized fire test according to the flow rate at which the standard fire source is obtained. Therefore, since the flow rate is fixed, the fire source is not controlled by the temperature profile.

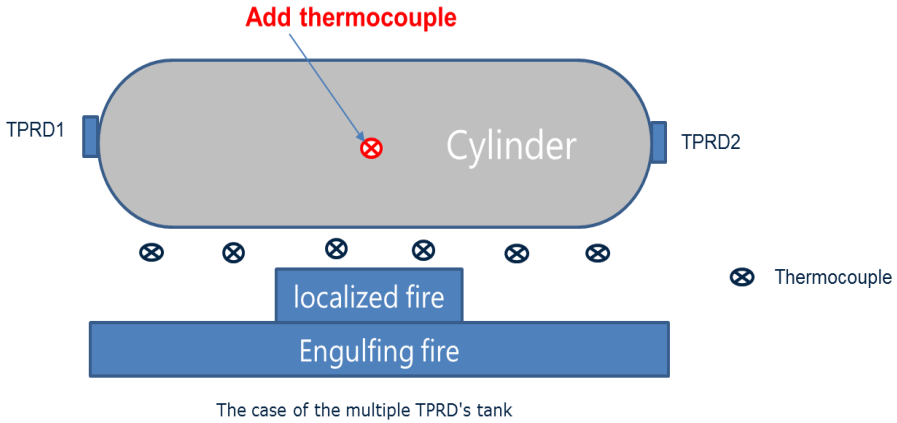
The merit of this method, we can expose the cylinder by fire source according to the JARI vehicle fire situation. Then, the standard fire source becomes constant by using a unified dummy cylinder (steel pipe), and the variation in the testing laboratories is reduced. In addition, the influence of combustion of combustible materials such as CFRP and shoulder pads is as CFRP and shoulder pads is eliminated.

About problems

- ✓ Equity fairness due to different cylinder sizes
- ✓ About the width of fire source
- ✓ When the localized fire area is not at the end of the cylinder
- ✓ On the difference of burner structure between localized fire and engulfing fire
- ✓ Influence of differences in components and heat value of LPG in each country



The cylinder size and fire source width



The case of the multiple TPRD's tank

The case of the localized fire area is not at the end of the cylinder

Burner structure (Incliding diffusion flame or premixed flame)

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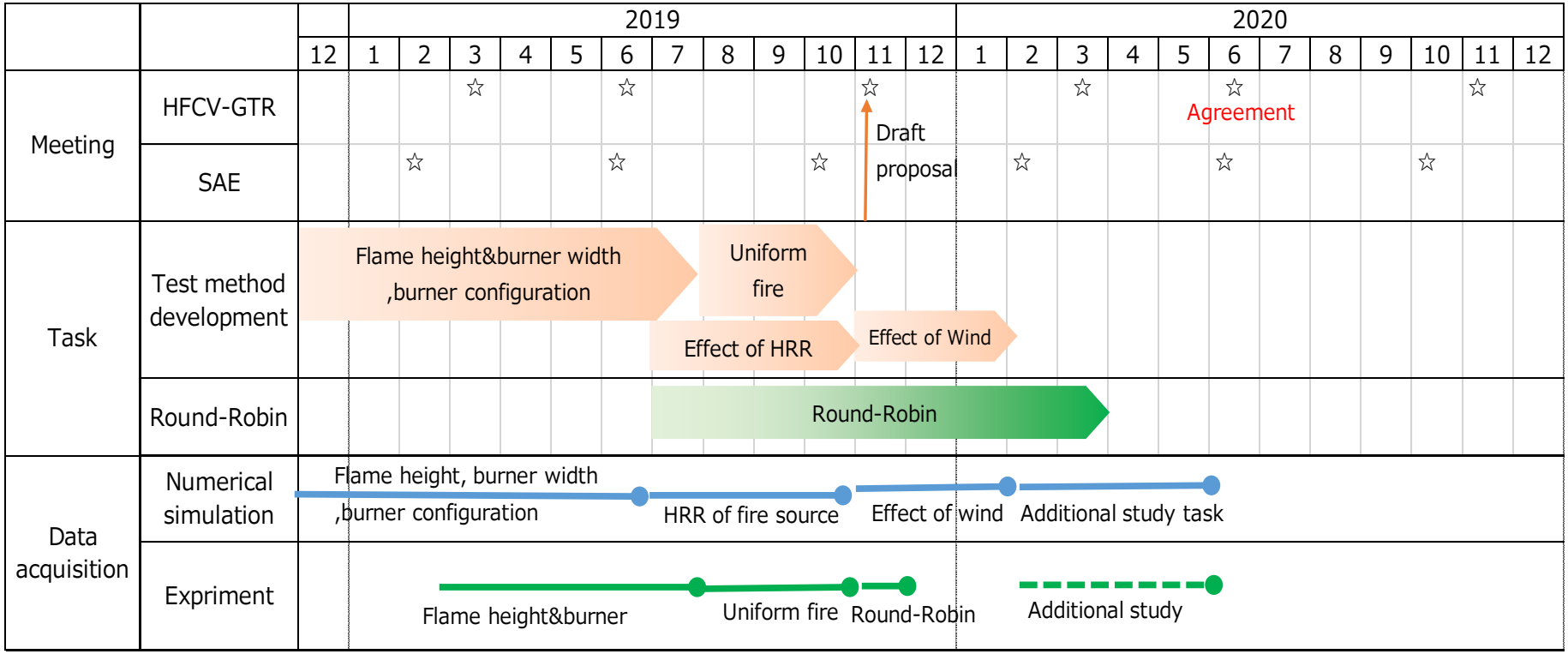
  - ✓ Problem
- Future policies of JARI
- schedule
- Remark

Future policies of JARI

- Test method by dummy cylinder
  - ✓ Influence of fire source width
  - ✓ Influence of differences in burner structure
  - ✓ Relationship between flame height and surrounding temperature of cylinder
  - ✓ Influence of cylinder size and fire source width
- Regulation of uniform fire source
- Regulation of wind speed and wind shield
- Influence of difference in LPG calorific value of fire source
- Burner structure
- Round Robin Test

Draft schedule



JARI aims for international agreement in June 2020 on measures to improve the reproducibility of the localized fire test.

Content

- Cylinder temperatures and flame height by fire test
- Evaluation method of the flame height
- Influence of flame height by HRR/A
- Temperature measurement to define the flame height
- Proposal of the localized fire test from JARI
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Remark

- ✓ It was suggested that the flame temperature measurement method can regulate flame height.
- ✓ Therefore, we examined the new localized fire test method using the standard fire source.
- ✓ Using the dummy cylinder, derive the condition (LPG flow rate) to be the standard fire source, and perform the localized fire test under that condition.
- ✓ In this method, we will expose the cylinder with standard fire sources based on fire test data, and we will evaluate using the same dummy container, so we believe that the influence of variation in the test laboratories will be reduced.
- ✓ Task :cylinder sizes, the width of fire source, burner structure, LPG quality of each country, the case of a cylidner with multiple PRDs.

Thank you for your attention