

**Localized fire test for improve
reproducibility
-Selection of standardized burner-**

GTR No.13 TF#4

5 November 2019 @ SpOrt Stuttgart, Stuttgart, Germany

Contents

- ◆ **Selection of burner specifications @CSA**
- ◆ **Evaluation of Bunsen type burner @JARI**

Contents

- ◆ **Selection of burner specifications @CSA**
- ◆ Evaluation of Bunsen type burner @JARI



Issue

- ◆ As a reproducibility improvement plan, JARI will continue to consider the following two options for improving the test method.

Test method 1-a: Prescribed burner configuration

- ✓ The LPG flow range that satisfies the container surface temperature of the JARI vehicle fire test using the standardized burner is specified.
- ✓ It is confirmed that the container bottom temperature specified in GTR13 phase 1 is satisfied within the specified LPG flow rate range during the fire test.

Test method 1-b: No specified the burner configuration

- ✓ Before the fire test, the LPG flow rate that satisfies the surface temperature of the standard container of the JARI vehicle fire test is derived, and the uniformity of the fire source is proved.
- ✓ The fire test of the container is performed at the LPG flow rate obtained above. (The measurement of the temperature at the bottom of the container is aimed at the absence of wind effects)

Issue of Method 1-a

- ✓ There is a method of specifying the configuration of the burner and the LPG flow rate range.
- ✓ However, it is considered that variations may occur depending on the difference in the environment of the test site (ex. barriers and windbreaks).
- ✓ Also, in order to determine the structure of the burner, we want to understanding the influence of the difference in the structure of the burner of each Laboratory.
- ✓ JARI and CSA conducted the fire test using two burners.

UNGTR 13 - Bonfire Testing

- ✓ Objective to achieve Reproducibility / Repeatability of testing result between testing labs
 - Different burner designs
 - Wind effects (test area)

Bonfire testing Data

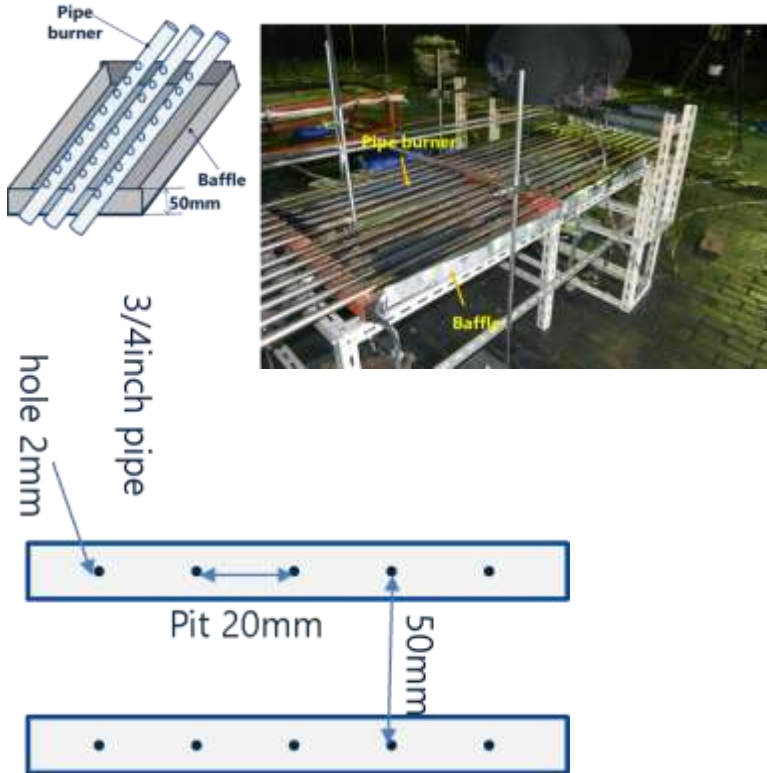
- ✓ Two days of testing at CSA Group Langley
- ✓ DAY 1 – CSA Parking lot testing (with wind effects)
- ✓ DAY 2 – Field Site testing (with no wind effects)
 - Bonfire test burner inside protective steel tube to mitigate wind effects
- Two types of comparison tests performed
 1. UN-GTR bonfire profile
 2. Stepping flow test
- Two types of burners used
 1. Pipe Burner -Diffusion flame -JARI design
 - 1-2mm drilled holes, located 20mm apart
 2. Bunsen type Burner- CSA design
 - Fuel mixing burner tips, located 50mm apart

Comparison of Burners

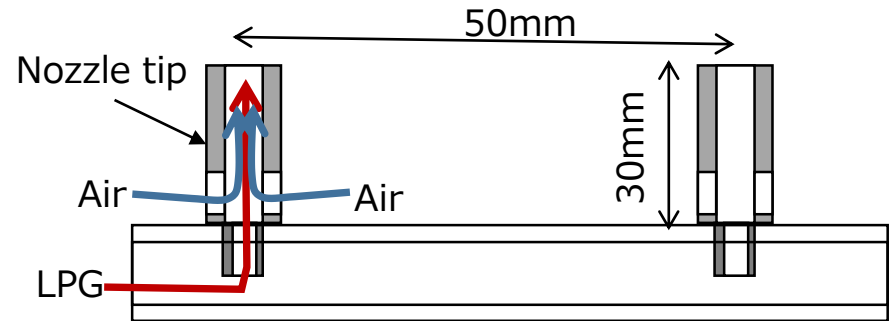
	Bunsen type burner	Pipe burner
L x W	177 cm x 31.5 cm	163 cm x 25 cm
Space between tips or hole	50mm	20 mm
Space between tubes	105mm	50 mm
Premix	Yes (Air is mixed by the venturi effect resulting from the LPG flow.)	no
Nozzle tip	yes	no (hole only)
Tank	Steel D=320 mm L= 950 mm	Steel D=320 mm L= 950 mm
Tube diameter	3/4" pipe	3/4 " pipe

Comparison of Burners

Pipe burner



Bunsen type burner

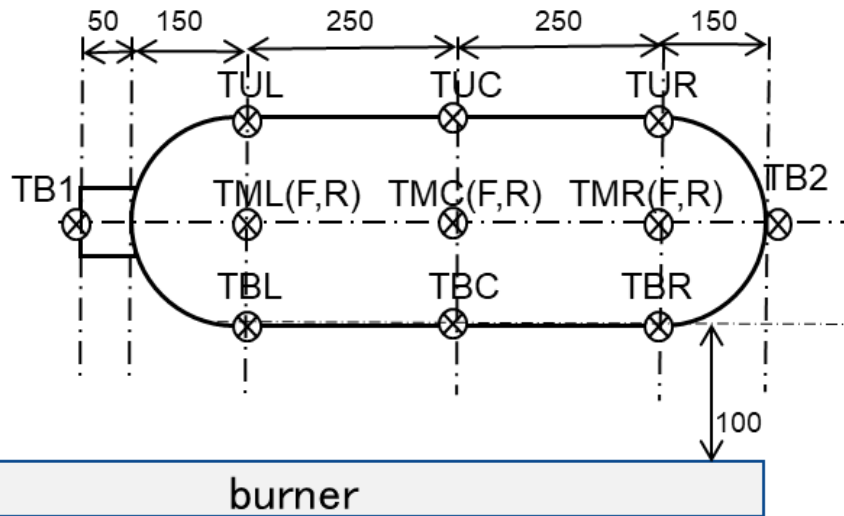


Nozzle tip

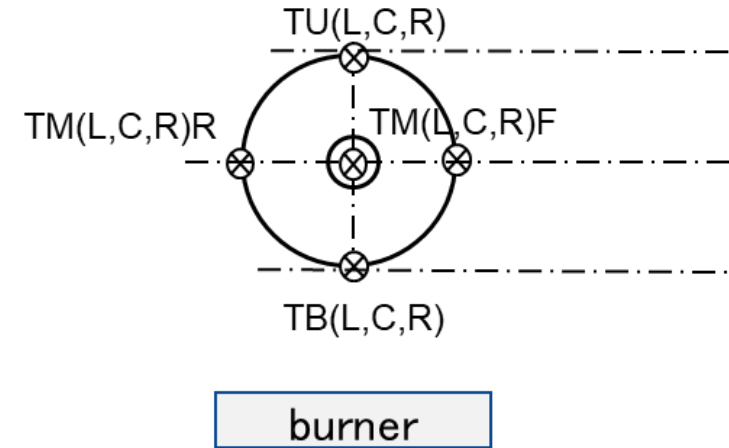


location & orientation of nozzle tip

Test Tank Setup



⊗ Thermocouple



Note: Temperature within 5mm from the container surface.

It is not the temperature at 25mm from the surface specified by GTR13.

Engulfing Fire in Parking Lot

Pipe burner



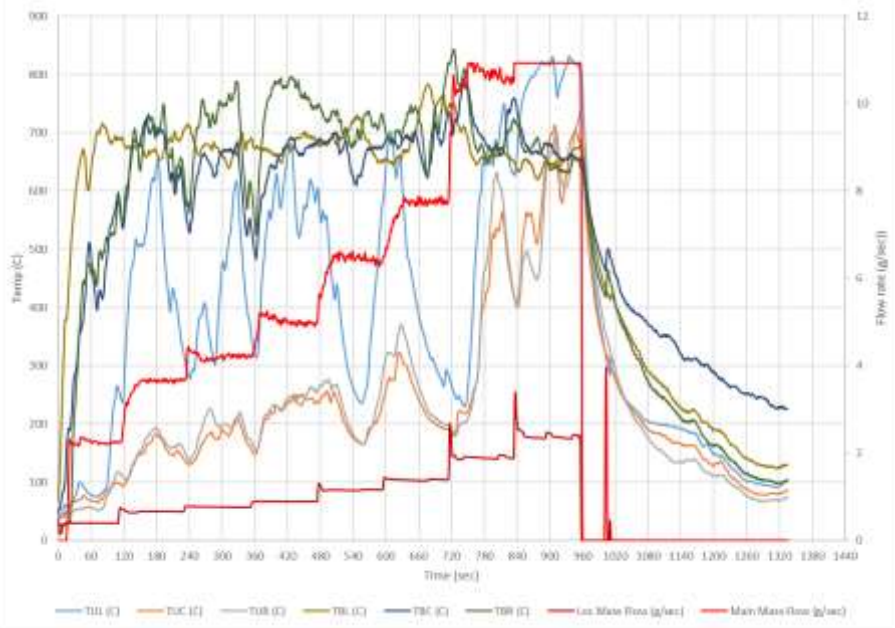
Bunsen type burner



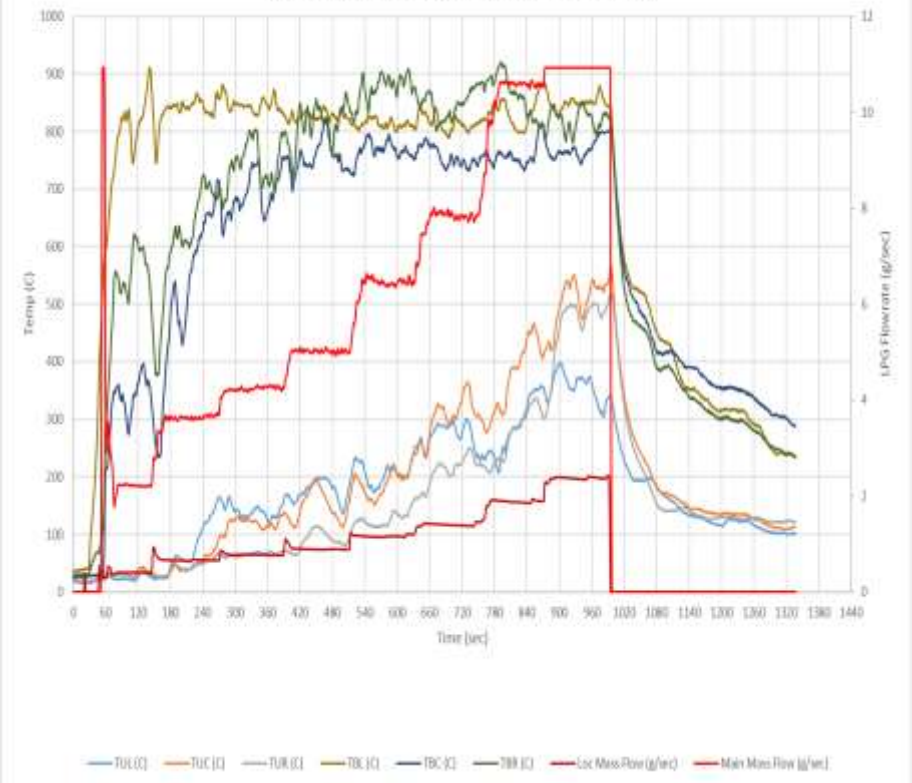
Burner Comparison In Parking Lot – Step Flow

- Bottom (TB) & Top (TU) Temperatures

Pipe burner



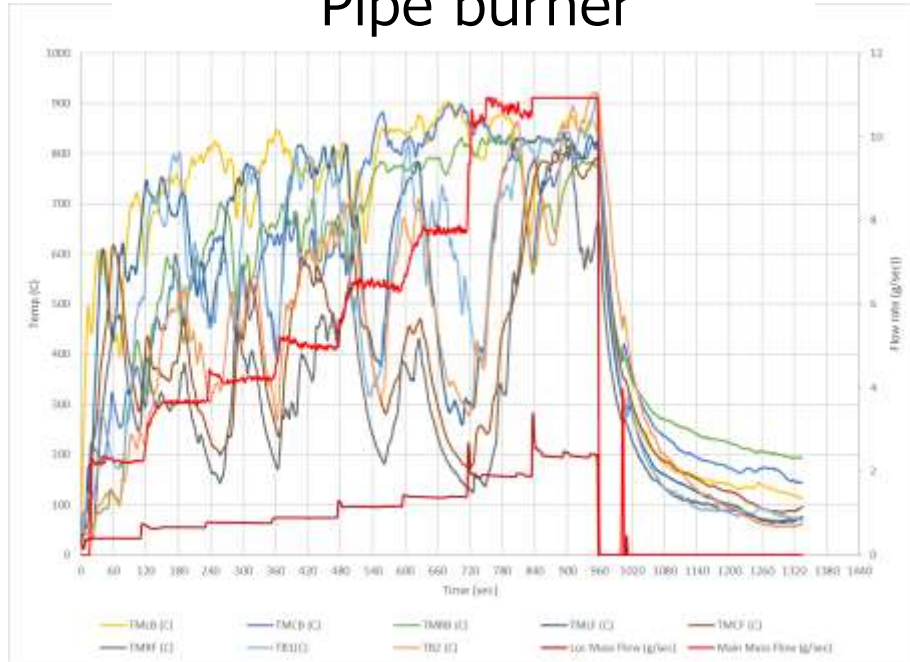
Bunsen type burner



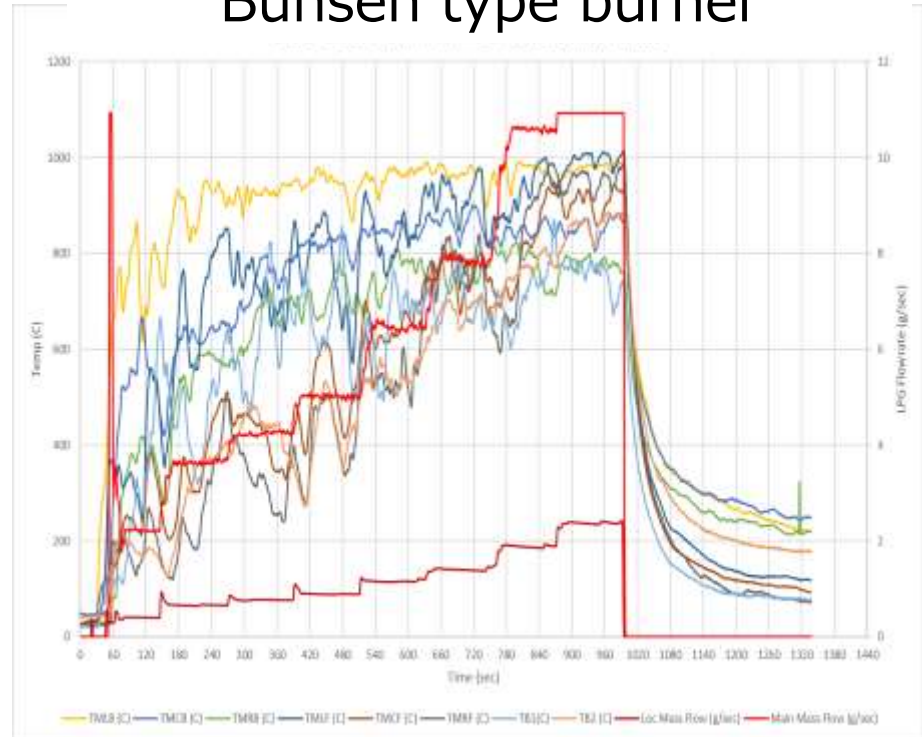
Burner Comparison In Parking Lot – Step Flow

- Middle Temperatures

Pipe burner



Bunsen type burner



Pipe burner



Engulfing Fire in Tube

Pipe burner



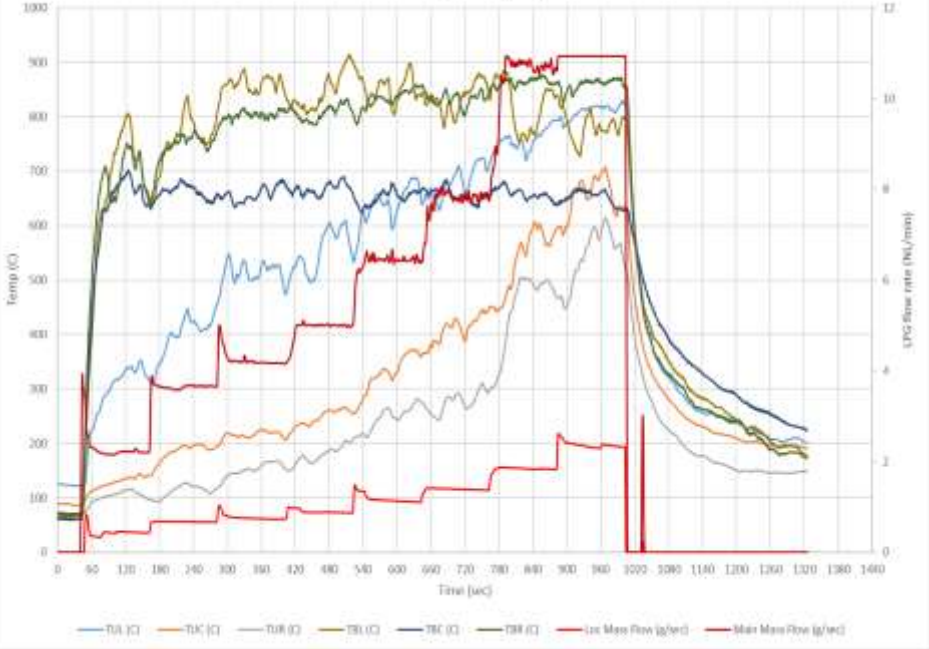
Bunsen type burner



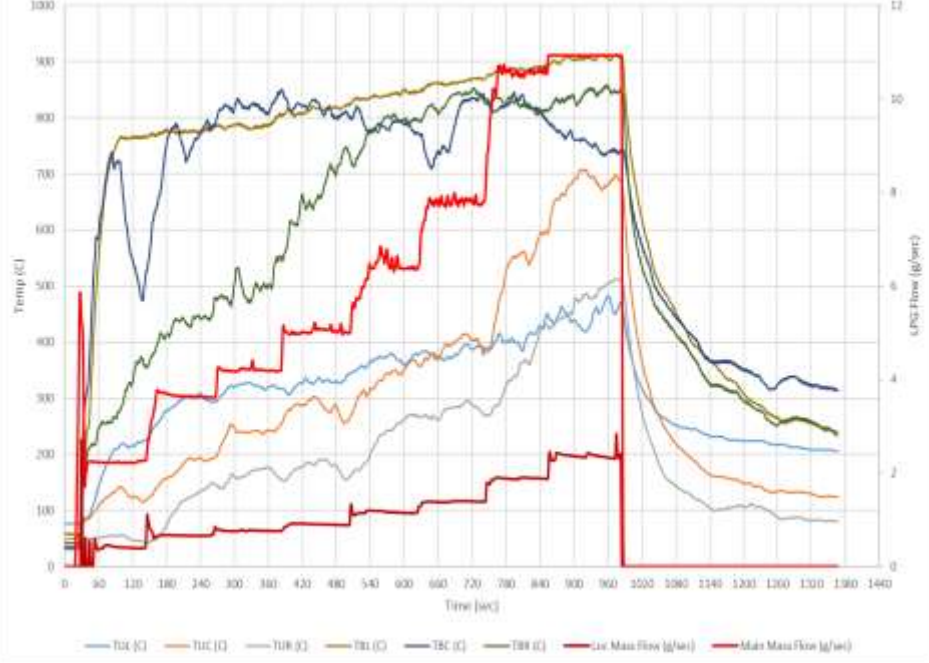
Burner Comparison in Tube – Step Flow

- Bottom (TB) & Top (TU) Temperatures

Pipe burner



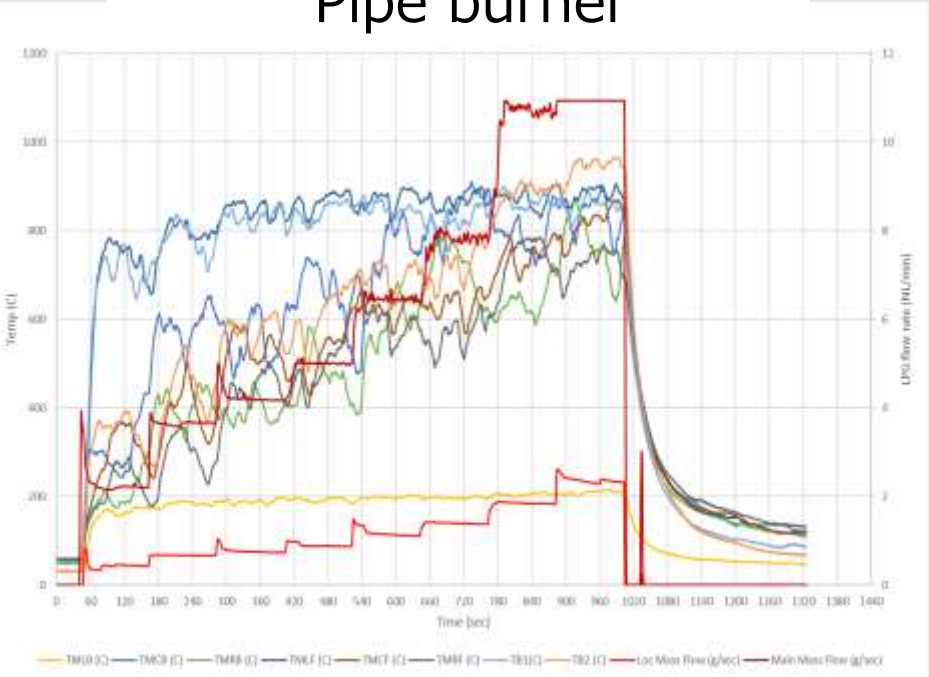
Bunsen type burner



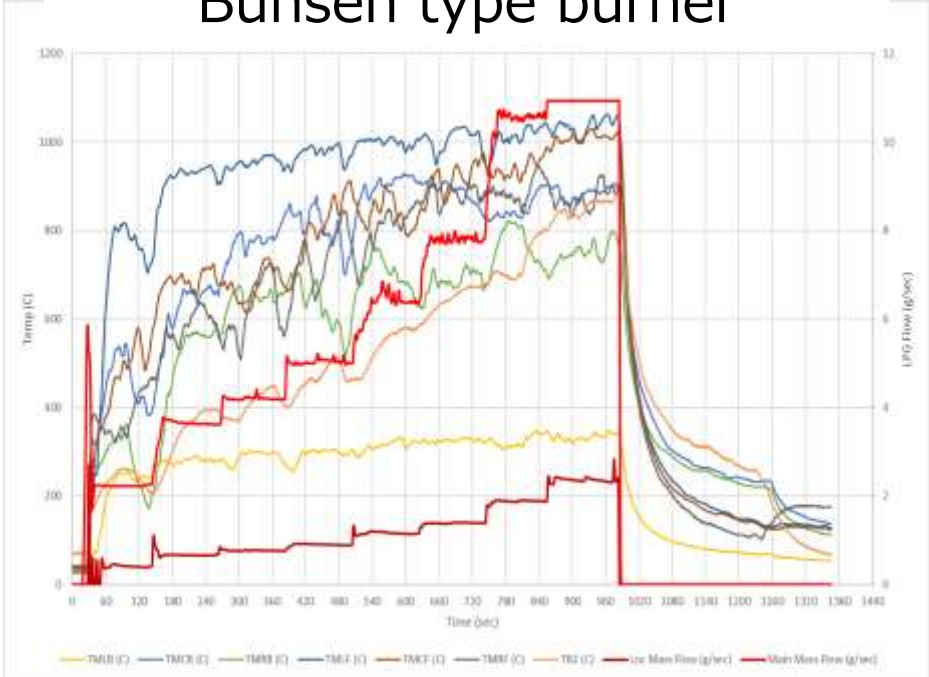
Burner Comparison in Tube – Step Flow

- Middle Temperatures

Pipe burner



Bunsen type burner



Bunsen type burner



150NL/min



180NL/min



230NL/min



250NL/min



280NL/min



380NL/min

Bunsen type burner



Pipe burner



150NL/min



180NL/min



230NL/min



250NL/min

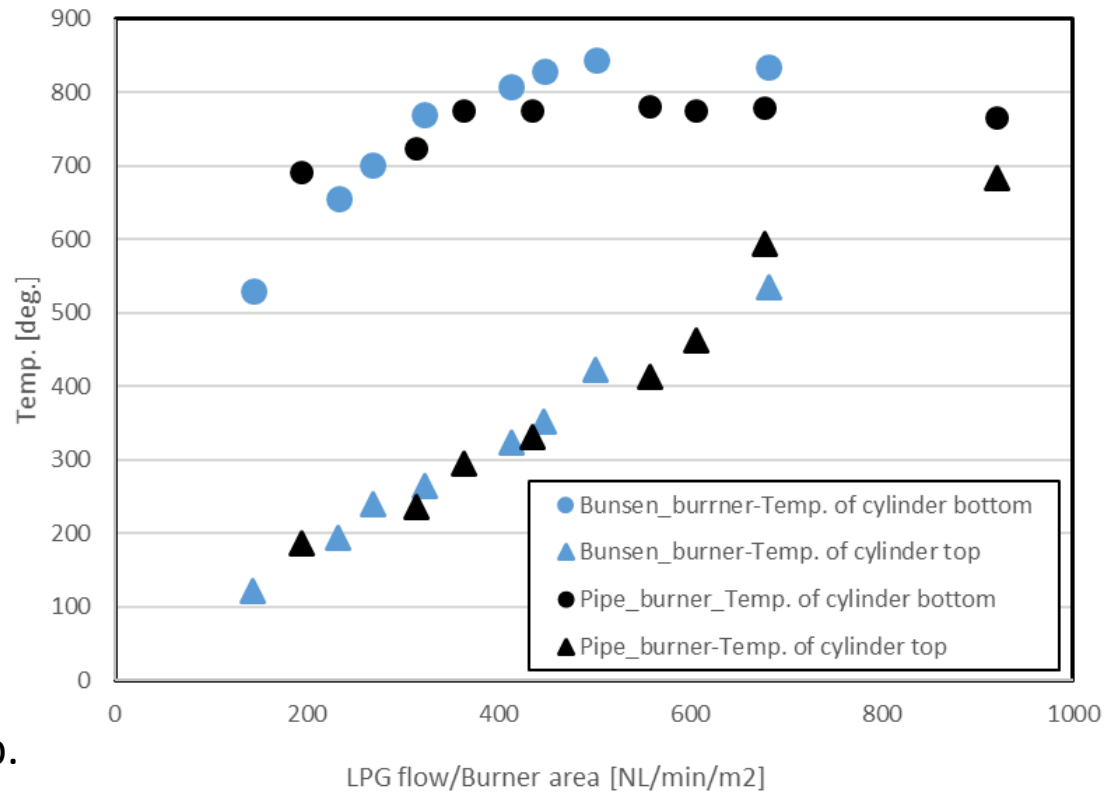
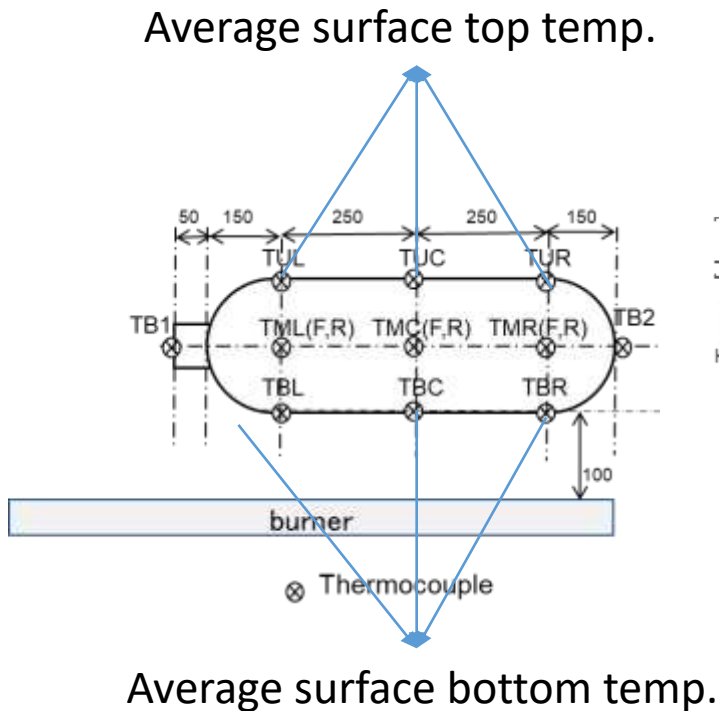


280NL/min



380NL/min

Ave. Cylinder surface Top and bottom temperature

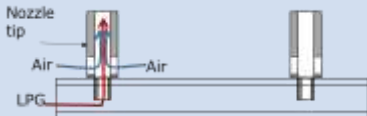
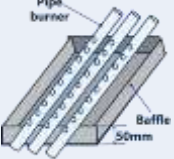
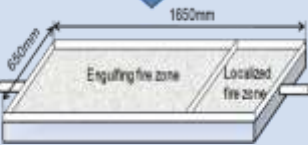


In the absence of wind, there is little difference between a pipe burner and a Bunsen type burner.

Discussion

- ✓ The Bunsen type burner used in this test is less disturbed by the wind than the pipe type diffusion flame burner, and the temperature profile around the container is stable.
- ✓ In addition, the specification of this Bunsen type burner is easy and has features that make it easy to set temperature conditions based on JARI's vehicle fire test data.
- ✓ As a result of the above, JARI concluded that the Bunsen type burner is appropriate for the standard burner specified by Method1-a.
- ✓ JARI evaluated the Bunsen burner at indoor fire testing site where there is almost no wind influence.

Suitable standardized burner

Burner	Applicability	Burner specification	Cost	Flame type	Judgment
<p>Bunsen type</p> 	<p>◎ (Insensitve to wind. Wide temperature range can be set with low flow rate.)</p>	<p>◎ (Burner tips used in the market)</p>	<p>○</p>	<p>Partial pre-mix flame</p>	<p>◎</p>
<p>Pipe</p> 	<p>△ (Only No wind case)</p>	<p>◎ (Simple)</p>	<p>◎</p>	<p>Diffusion flame</p>	<p>△</p>
<p>Blanket</p> 	<p>△ (Only No wind case, See at appendix)</p>	<p>X (Difficult to obtain parts in each country)</p>	<p>○</p>	<p>Diffusion flame</p>	<p>△</p>

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JARI fire test -part1 (Method1-a)

The LPG flow range that satisfies the container surface temperature obtained in the JARI vehicle fire test is derived.

During the fire test, examine the temperature around the container at a constant wind speed to guide how to monitor the wind.

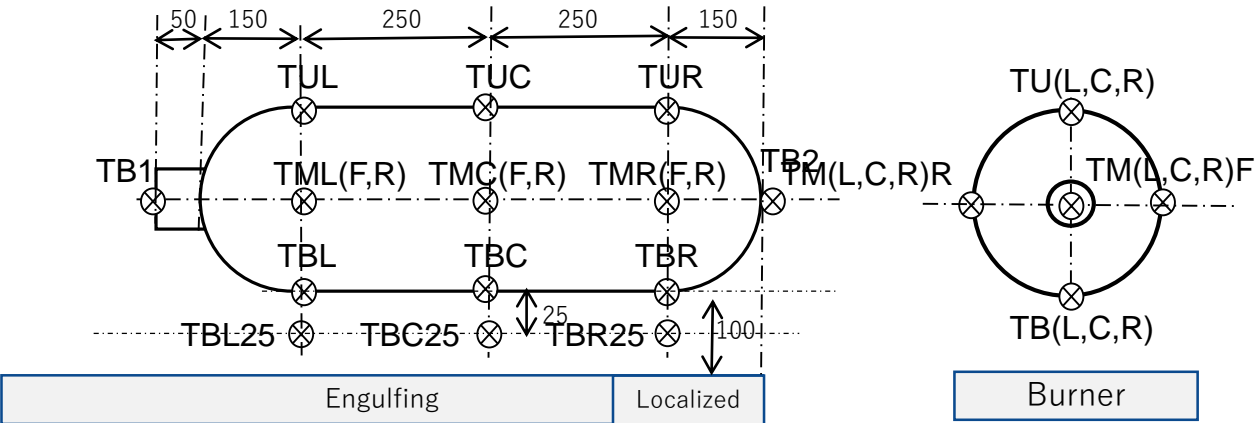
Burner : Bunsen type burner

Tank: Simulated container used in vehicle fire test (dia. 320×length 850mm)

Test #	Burner width[mm]	Fire stage (Length[mm])	Wind velocity[m/s]	Wind direction	Fire location
1	250	Localized fire 250	0	None	100
2	250	Engulfing fire 1000	↓	↓	↓
3	600	Localized fire 250			
4	600	Engulfing fire 1000			
5	250	Engulfing fire 1000	3	Diagonal direction	↓

JARI fire test (Method1)

Thermocouple



Burner
(Width 600mm)

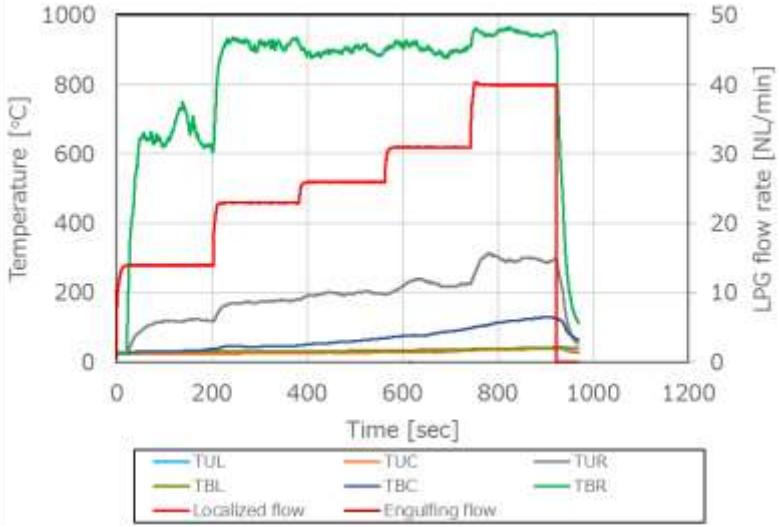


location & orientation

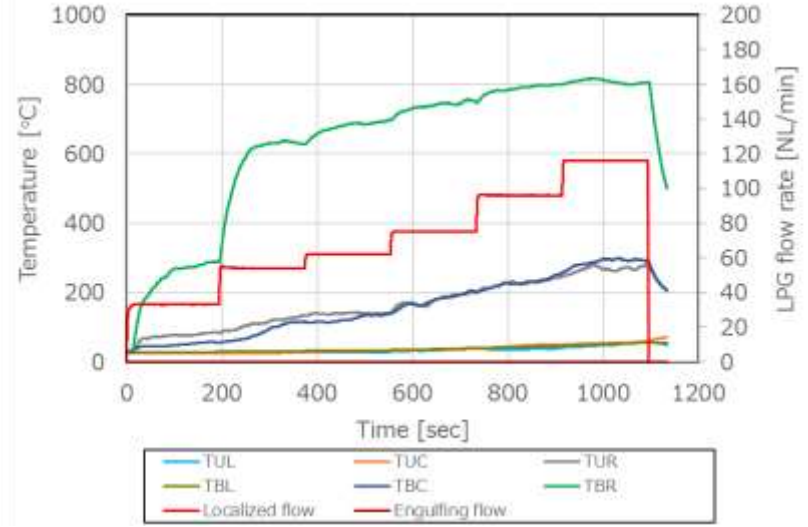


Case of Localized fire -Step Flow Test

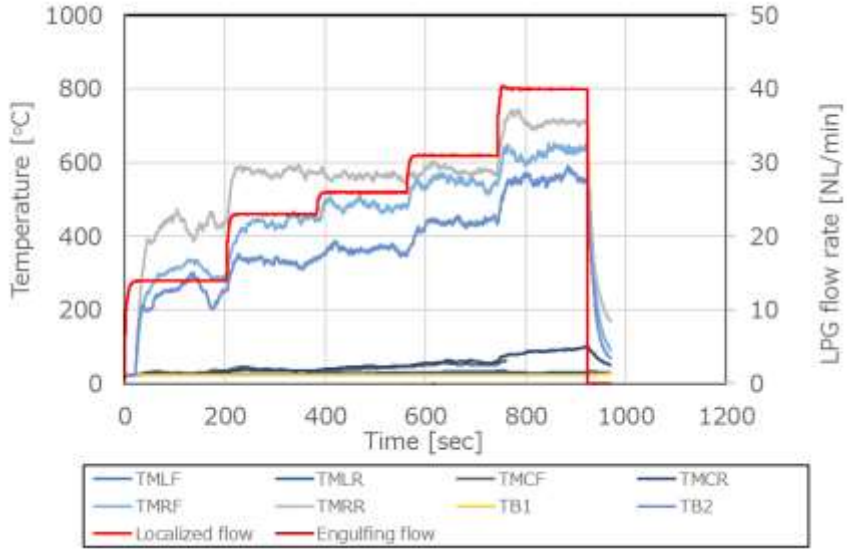
#1 Width 250mm Top&Botom temp.



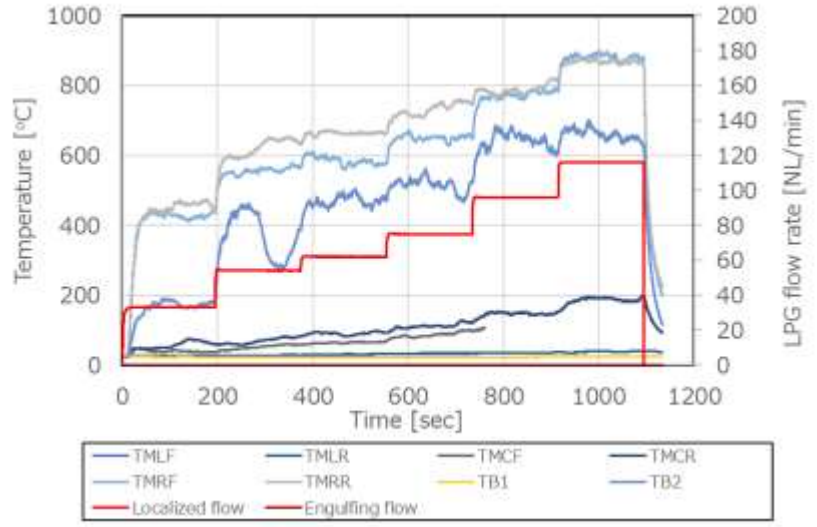
#3 Width 600mm Top & Bottom temp.



#1 Width 250mm Middle temp.

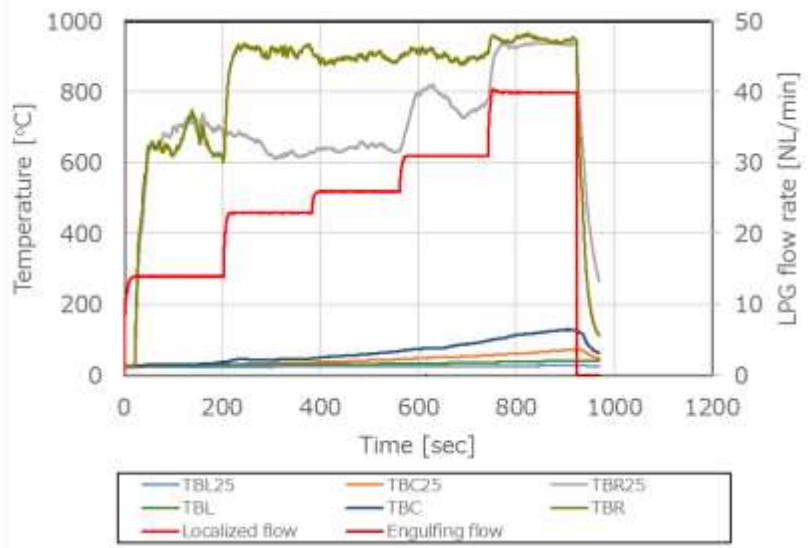


#3 Width 600mm Middle temp.

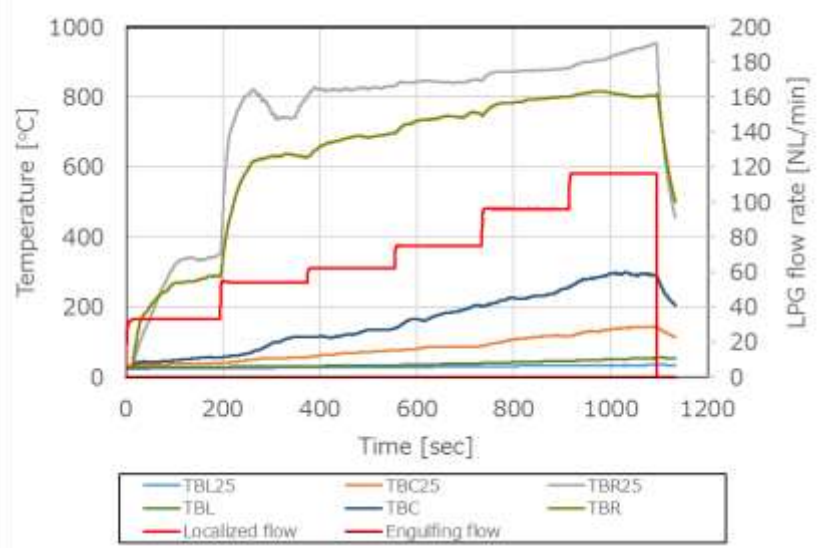


Case of Localized fire – Step Flow Test

#1 Width 250mm Bottom temp



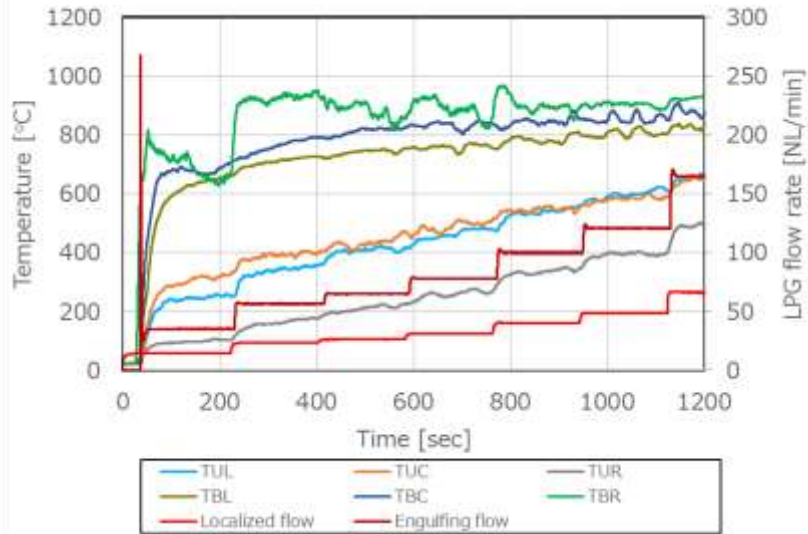
#3 Width 600mm Bottom temp



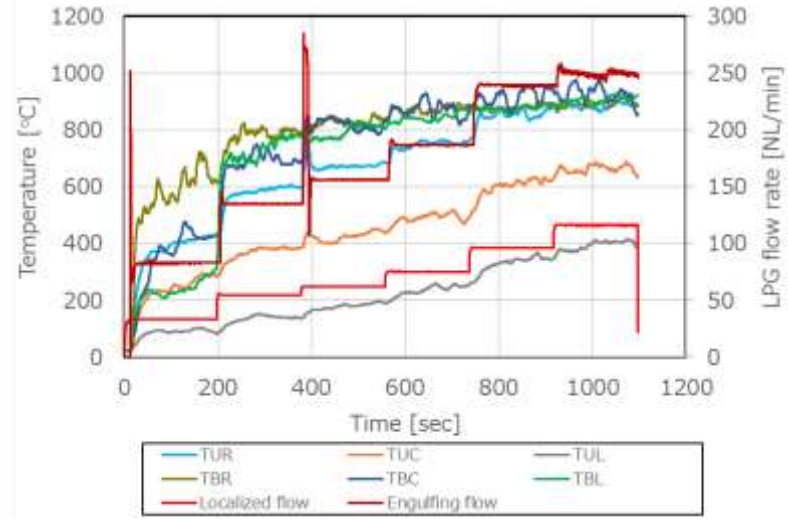
A burner with a width of 600 mm can be controlled over a wider temperature range.

Comparison of width – Case of engulfing fire , Step Flow

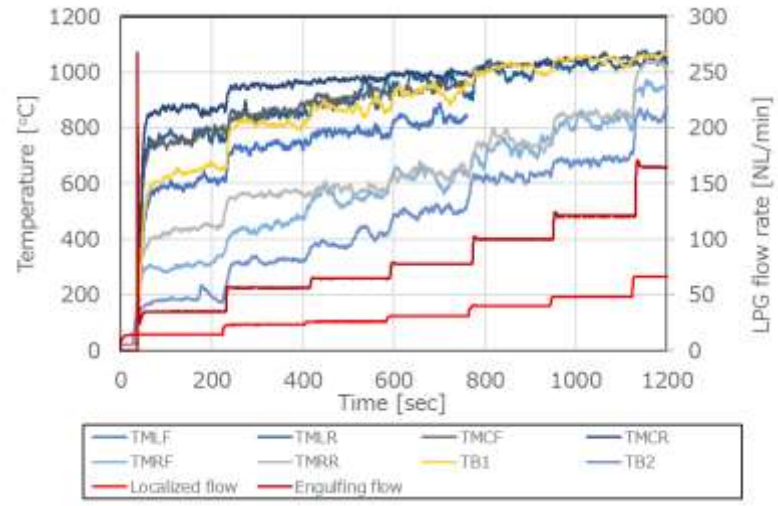
#2 Width 250mm Top&Botom temp.



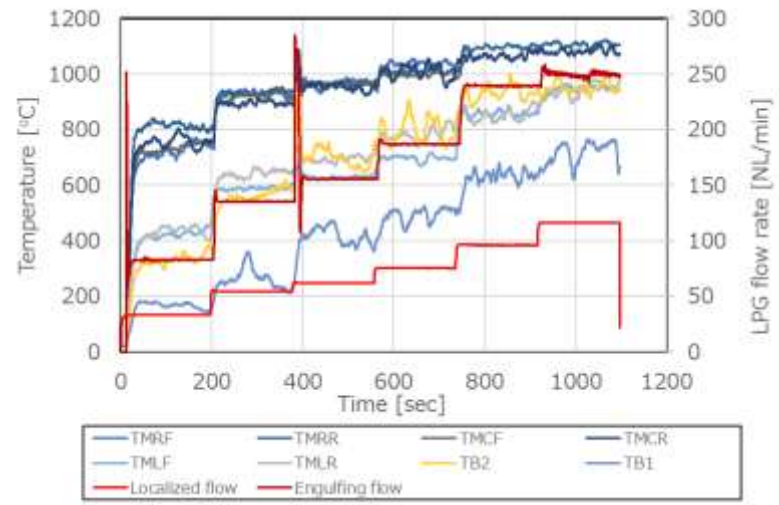
#4 Width 600mm Top & Bottom temp.



#2 Width 250mm Middle temp.

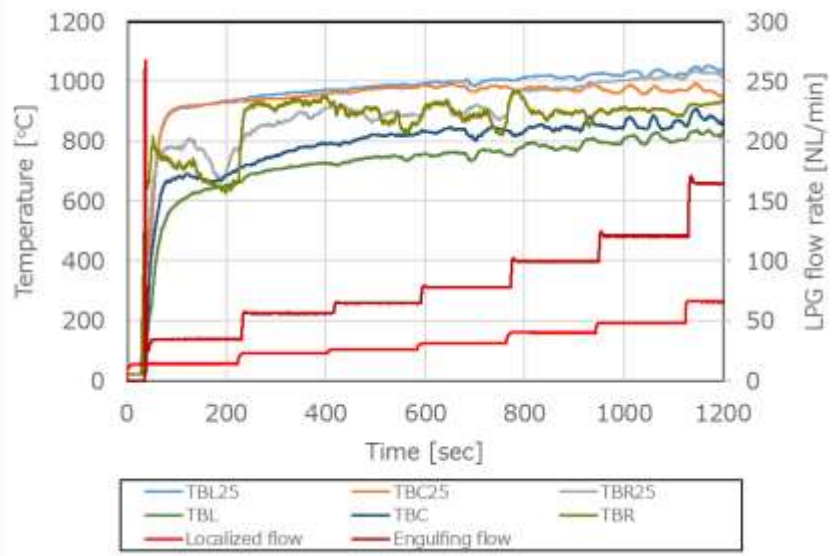


#4 Width 600mm Middle temp.

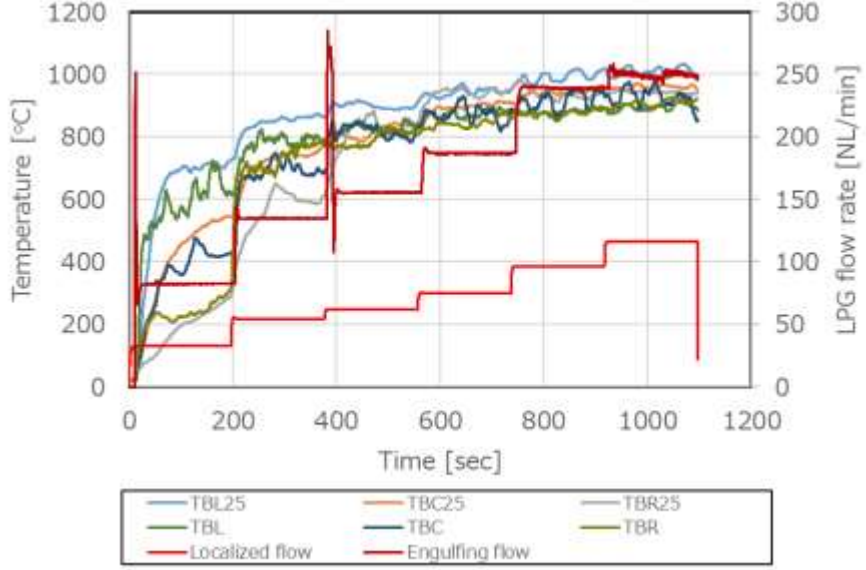


Comparison of width – Case of engulfing fire , Step Flow

#2 Width 250mm Bottom temp



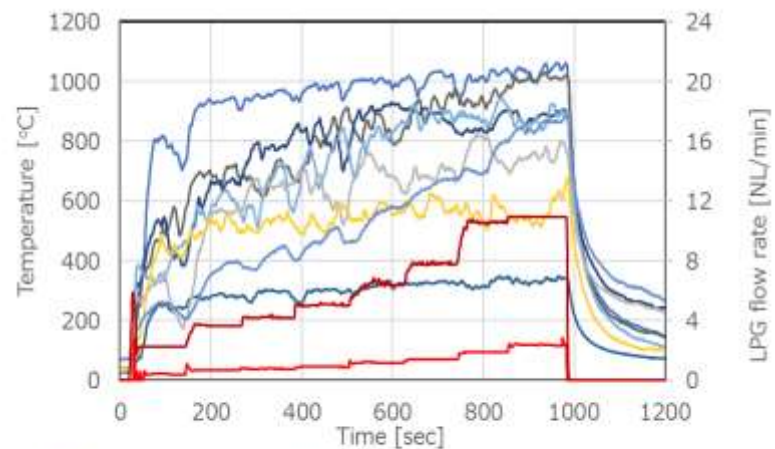
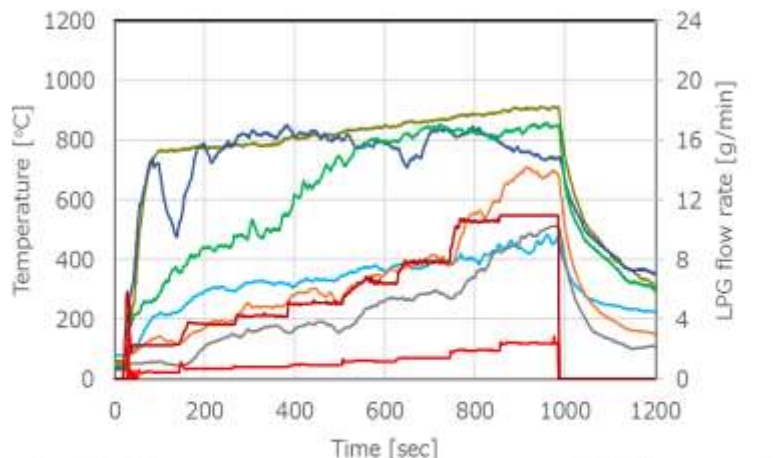
#4 Width 600mm Bottom temp



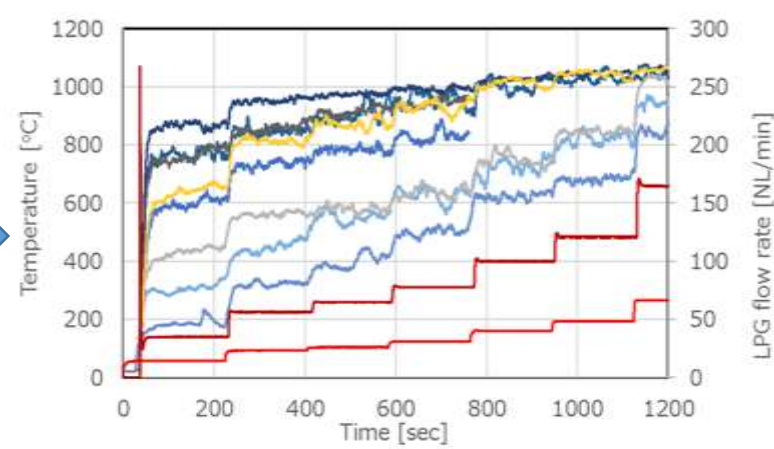
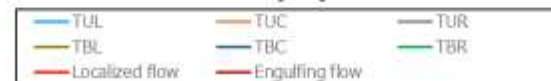
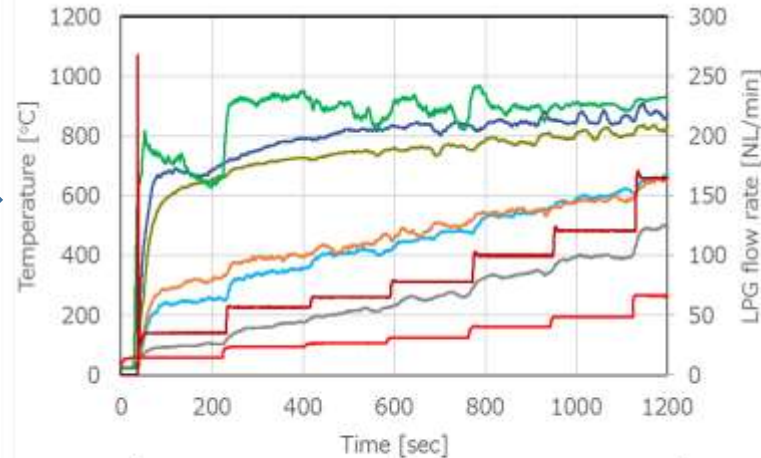
A burner with a width of 600 mm can be controlled over a wider temperature range.

Round robin test – Case of engulfing fire , Step Flow,width=250mm

CSA fire testing site (Large tube)



JARI fire testing site (Indoor)



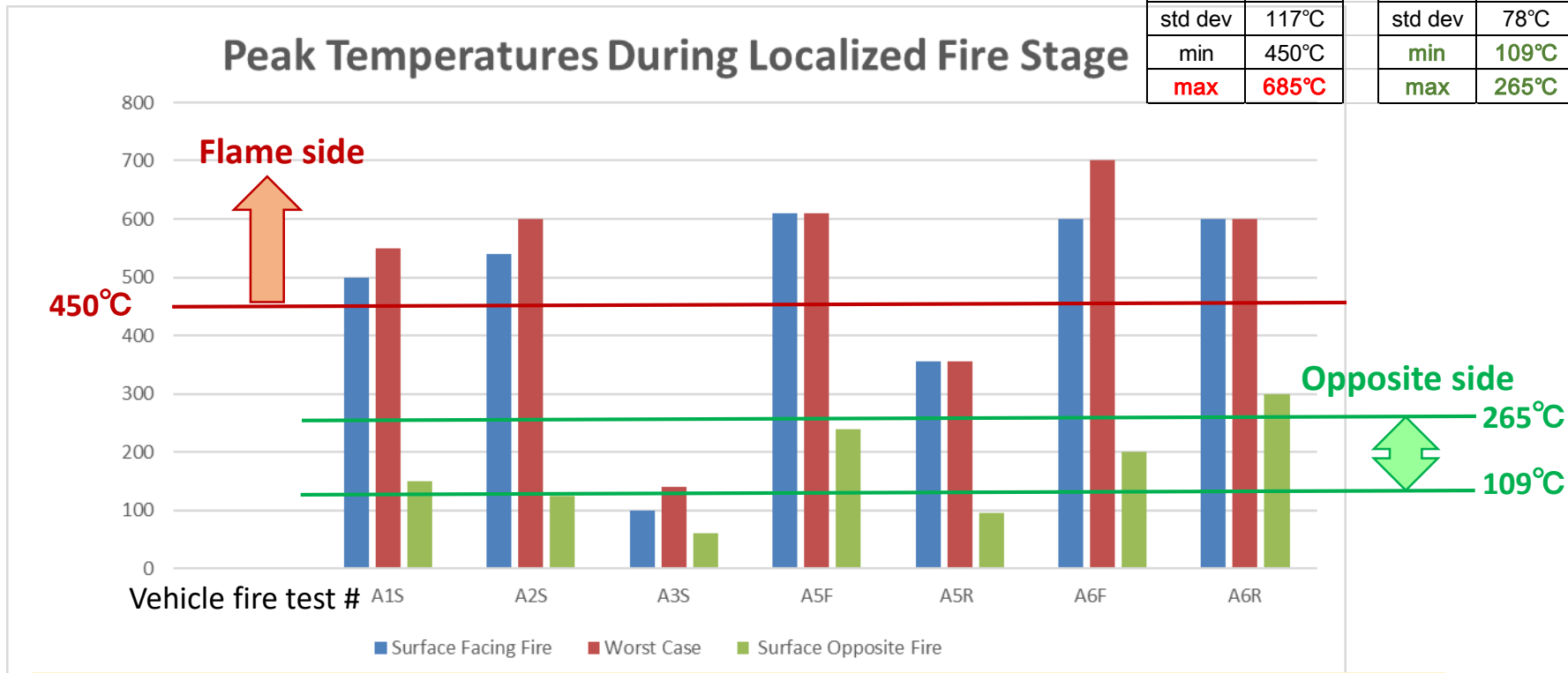
There is almost no difference between the two laboratories.

Operating window of the configuration

-Localized fire stage

Flame side		Opposite side	
A1S	550°C	A1S	150°C
A2S	600°C	A2S	120°C
A5F	605°C	A5F	250°C
A5R	350°C	A5R	100°C
A6F	700°C	A6F	200°C
A6R	600°C	A6R	300°C
avg	568°C	avg	187°C
std dev	117°C	std dev	78°C
min	450°C	min	109°C
max	685°C	max	265°C

Using thermocouples within 5mm of the surface



Require temp. of localized fire stage

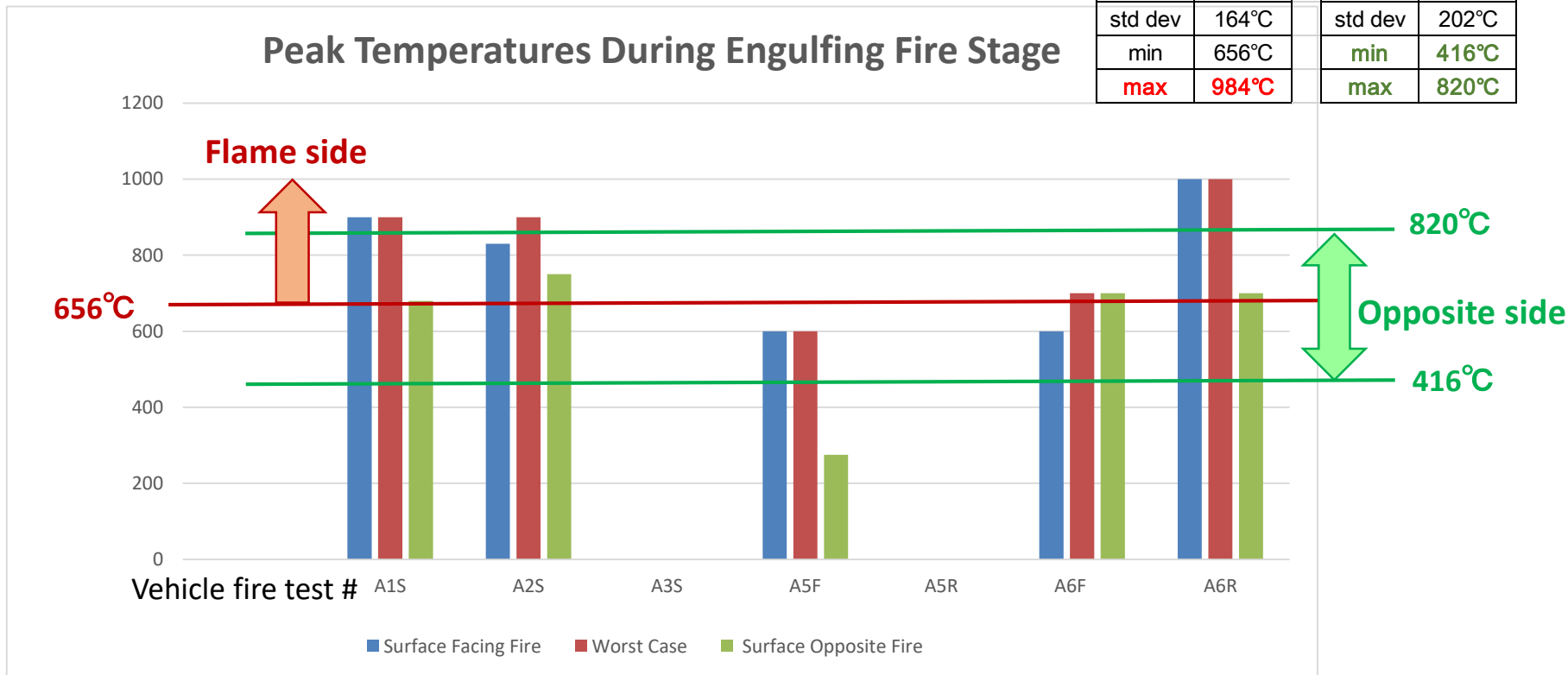
Flame side (TBR) = 450 °C or more, Opposite side (TUR) = 109 – 265°C

Operating window of the configuration

-Engulfing fire stage

Flame side		Opposite side	
A1S	900°C	A1S	680°C
A2S	900°C	A2S	750°C
A5F	600°C	A5F	260°C
A6F	700°C	A6F	700°C
A6R	1000°C	A6R	700°C
avg	568°C	avg	618°C
std dev	164°C	std dev	202°C
min	656°C	min	416°C
max	984°C	max	820°C

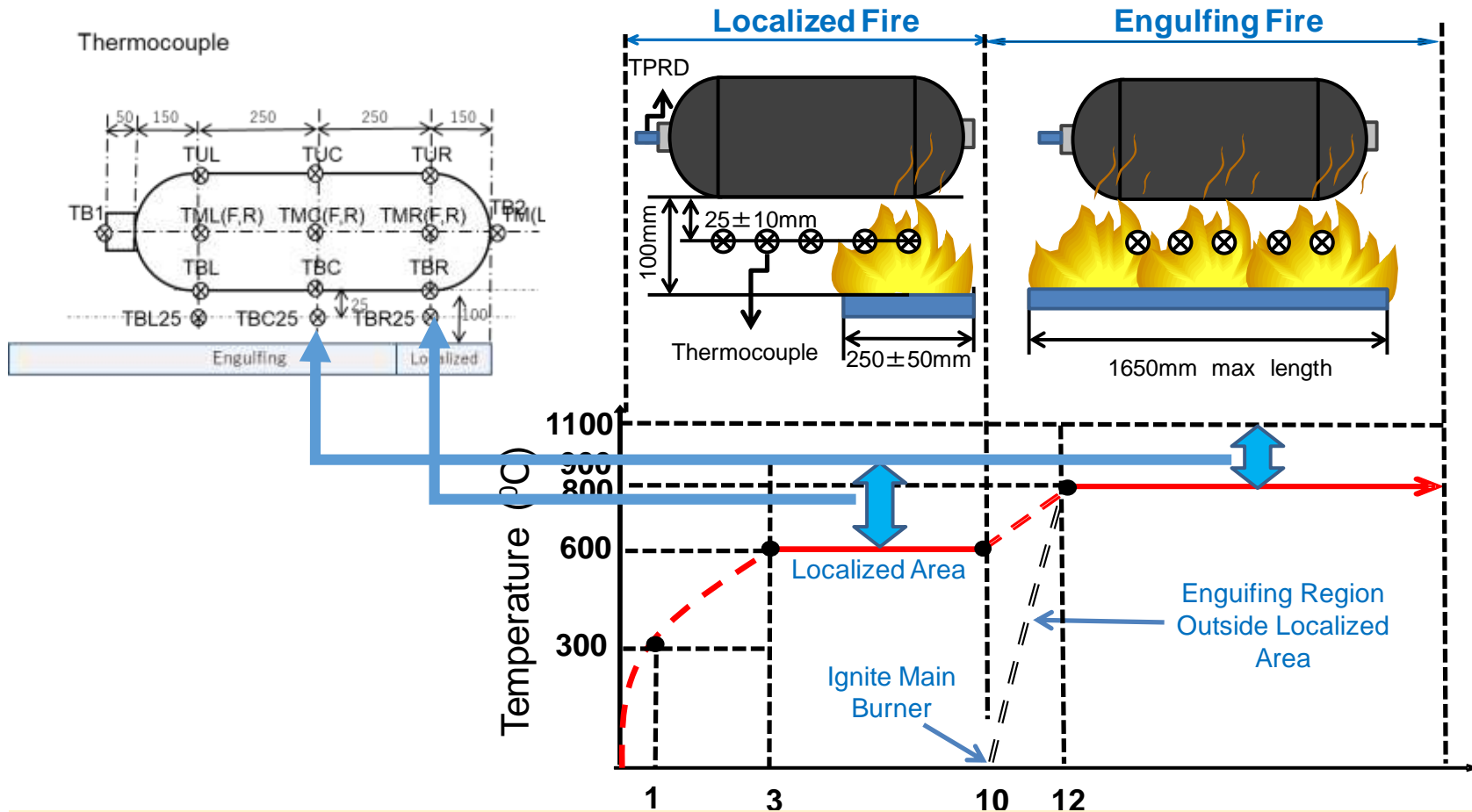
Using thermocouples within 5mm of the surface



Require temp. of engulfing fire stage

Flame side (TBR) = 656 °C or more, Opposite side (TUR) = 416 – 820°C

GTR13 phase1 bottom temp under 25mm



Require temp.

Localized fire stage TBR25 = 600-900 °C , Engulfing fire stage TBC25 = 800 – 1100°C

Test#1-2 (Wide=250mm, Localized fire)

Localized fire requirement temperature:

TBR (450°C more), TBR25(600-900°C), TUR(109-265°C)

Temp. of cylinder bottom (TBR)	Temp. of cylinder bottom (TBR25)	Temp. of cylinder top (TUR)	LPG Flow rate [NL/min]	HRR [kW]
650°C	470°C	105°C	10	16
720°C	680°C	112°C	14	22
865°C	650°C	155°C	17	27
905°C	625°C	165°C	20	32
900°C	665°C	200°C	23	37
885°C	710°C	220°C	26	41
855°C	685°C	250°C	30	48
960°C	880°C	300°C	40	64
960°C	930°C	370°C	50	80

Diffusion flame



Premix flame

For a localized fire with a width of 250 mm, the required temperature is satisfied when the LPG flow rate is in the range of 17 to 30 NL / min.

Test#2 (Wide=250mm, Engulfing fire)

Engulfing fire requirement temperature:

TBC (656°C more), TBC25(800-1100°C), TUC(416-820°C)

Temp. of cylinder bottom (TBC)	Temp. of cylinder bottom (TBC25)	Temp. of cylinder top (TUC)	LPG Flow rate [NL/min]	HRR [kW]
680°C	925°C	315°C	48	77
780°C	950°C	395°C	79	126
820°C	980°C	440°C	91	145
830°C	975°C	500°C	109	174
850°C	975°C	550°C	139	222
855°C	970°C	585°C	170	271
870°C	960°C	655°C	230	367

The required temperature is satisfied when the LPG flow rate is 91 NL /min or more.

Test# 3 (Wide=600mm, Localized fire)

Localized fire requirement temperature:

TBR (685 °C more), TBR25(600-900°C), TUR(109-265°C)

Temp. of cylinder bottom (TBR)	Temp. of cylinder bottom (TBR25)	Temp. of cylinder top (TUR)	LPG Flow rate [NL/min]	HRR [kW]
280°C	340°C	80°C	33	53
630°C	745°C	120°C	54	86
690°C	825°C	140°C	61	97
745°C	845°C	190°C	75	120
795°C	880°C	230°C	96	153
805°C	935°C	270°C	116	185

For a localized fire with a width of 600 mm, the required temperature is satisfied when the LPG flow rate is in the range of 54 to 96 NL / min.

Test# 4 (Wide=600mm, Engulfing fire)

Engulfing fire requirement temperature:

TBC (656°C more), TBC25(800-1100°C), TUC(416-820°C)

Temp. of cylinder bottom (TBC)	Temp. of cylinder bottom (TBC25)	Temp. of cylinder top (TUC)	LPG Flow rate [NL/min]	HRR [kW]
435°C	520°C	275°C	116	86
700°C	740°C	380°C	189	301
800°C	835°C	435°C	218	348
865°C	900°C	500°C	262	418
930°C	945°C	620°C	335	534
930°C	960°C	670°C	365	582

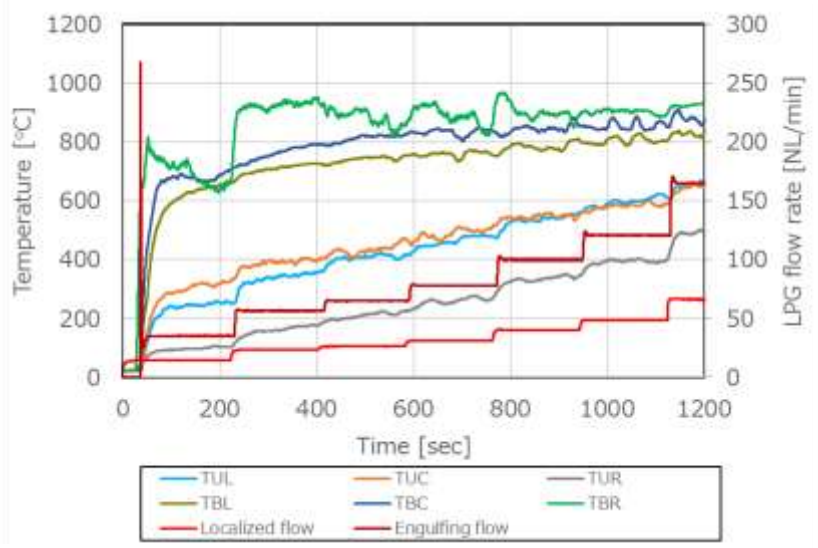
For the engulfing fire with a width of 600 mm, the required temperature is satisfied when the LPG flow rate is 218 NL/min or more.

Wind effect Test #5(Wide=250mm, Engulfing fire)

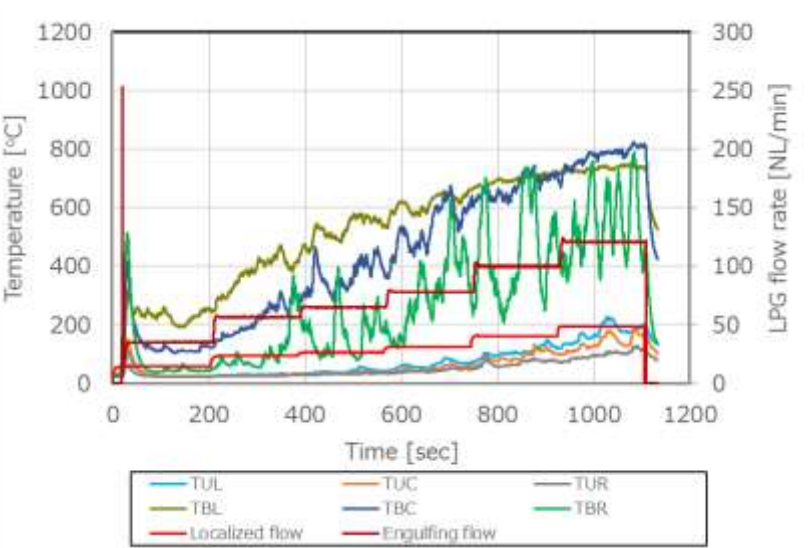


Wind effect – Case of engulfing fire , Step Flow

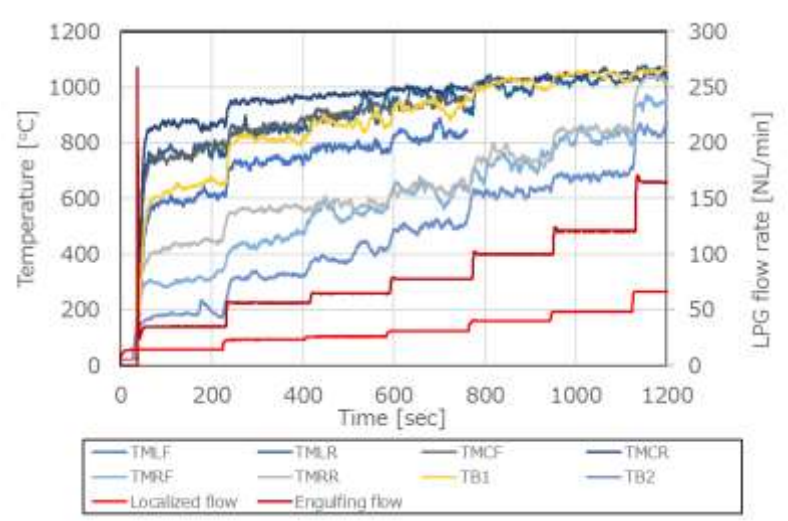
#2 No wind Top&Bottom temp.



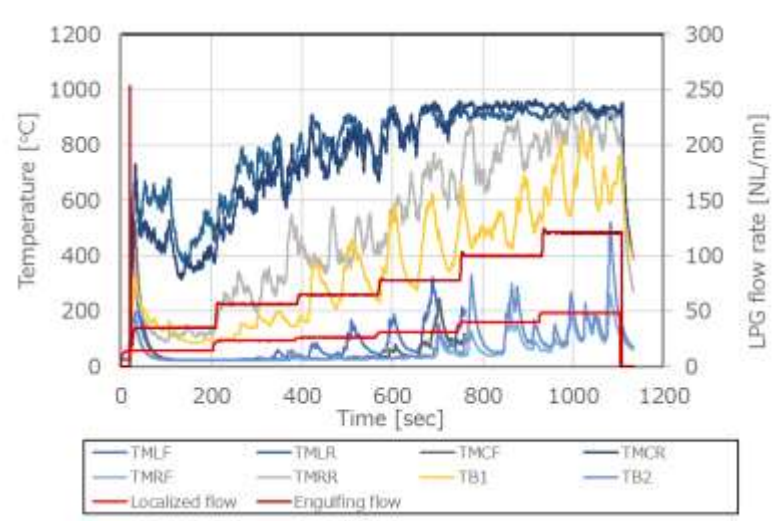
#5 wind 3m/s Top & Bottom temp.



#2 No wind Middle temp.

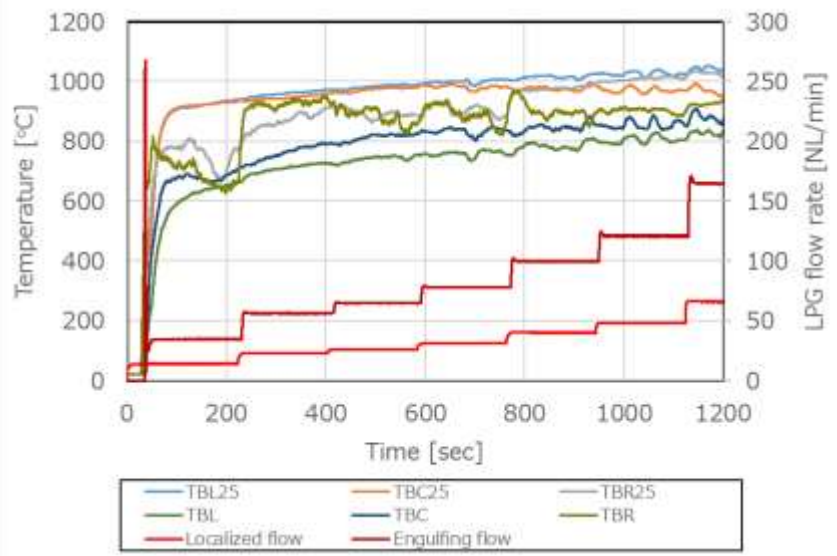


#5 Wind 3m/s Middle temp.

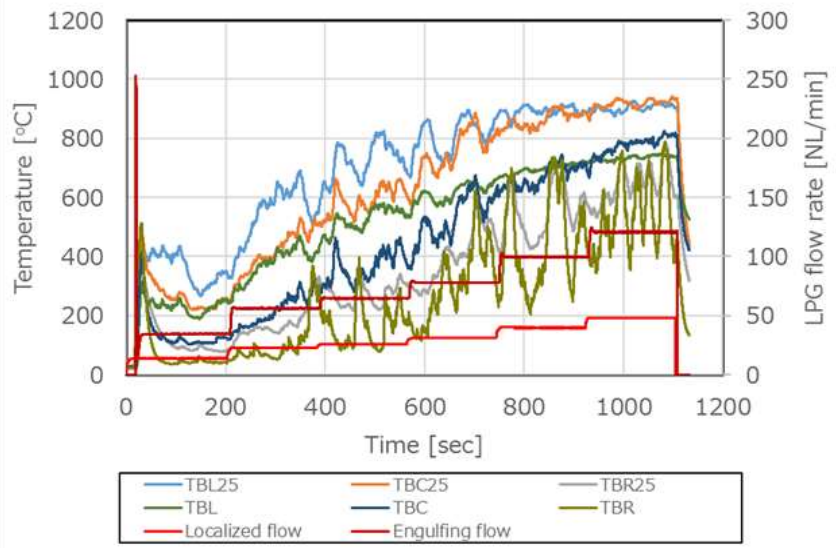


Wind effect – Case of engulfing fire , Step Flow, Width 250mm

#2 No wind Bottom temp



#5 Wind 3m/s Bottom temp



In the presence of wind, the temperature around the container decreases. Also, a temperature difference occurs depending on the wind direction. It is considered possible to monitor the wind by regulating the temperature variation 25mm below the container bottom 25mm defined in GTR13 phase 1 and the LPG flow rate.

Discussion

JARI was evaluate the Bunsen burner at an experimental site where there is almost no wind influence.

- ✓ **Dimensions (width)**

- A burner with a width of 600 mm can be controlled over a wider temperature range.

- ✓ **LPG flow rate**

- The LPG flow rate that satisfies the required temperature is in the range of 54 - 96NL/min during localized fire stage, or more 218NL/min during engulfing fire stage.(width 600mm)

- ✓ **Round robin**

- There was little difference between CSA and JARI.

- **Wind**

- It is considered possible to monitor the wind by regulating the temperature variation 25mm below the container bottom 25mm defined in GTR13 phase 1 and the LPG flow rate.

JARI Fire testing Schedule

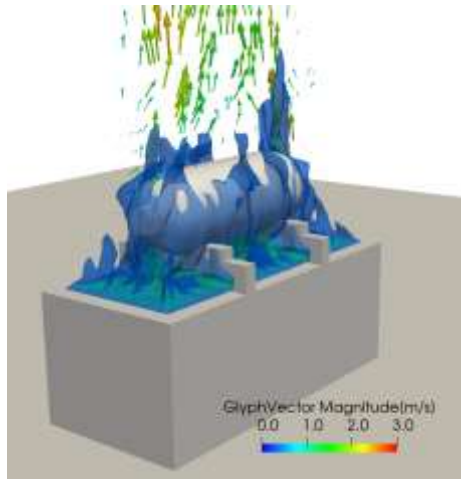
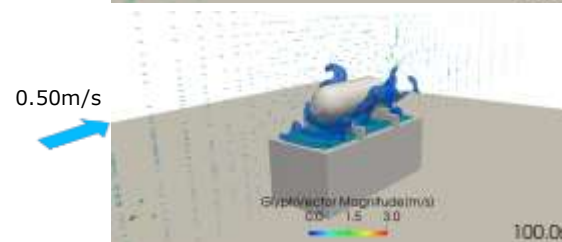
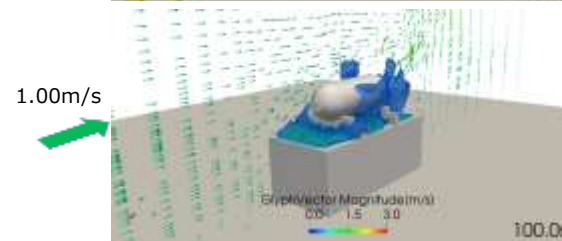
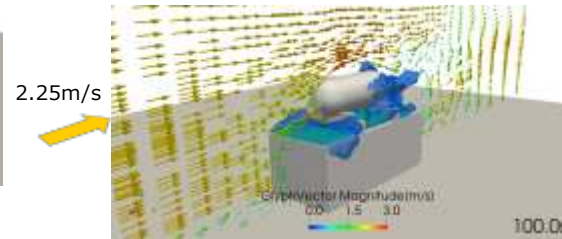
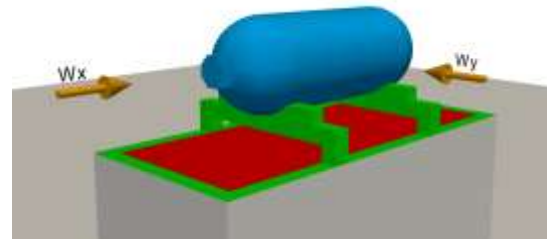
	<i>Sep-19</i>				<i>Oct-19</i>					<i>Nov-19</i>				<i>Dec-19</i>			
	1-7	8-14	15-21	22-28	9/29-5	6-12	13-19	20-26	27-11/2	3-9	10-16	17-23	24-30	1-7	8-14	15-21	22-28
JARI TEST			Create Pre-mix burner														
							Burner width effect LPG step up test Wind effect								Add. test		
SAE TF4						★											
GTR 13										☆							

	<i>Jan-20</i>					<i>Feb-20</i>				<i>Mar-20</i>			
	12/29-1/4	5-11	12-18	19-25	26-2/1	2-8	9-15	16-22	23-29	1-7	8-14	15-21	22-28
	Add. test										Demonstration @Hy-SEF		
						★							
													☆ (Tokyo)



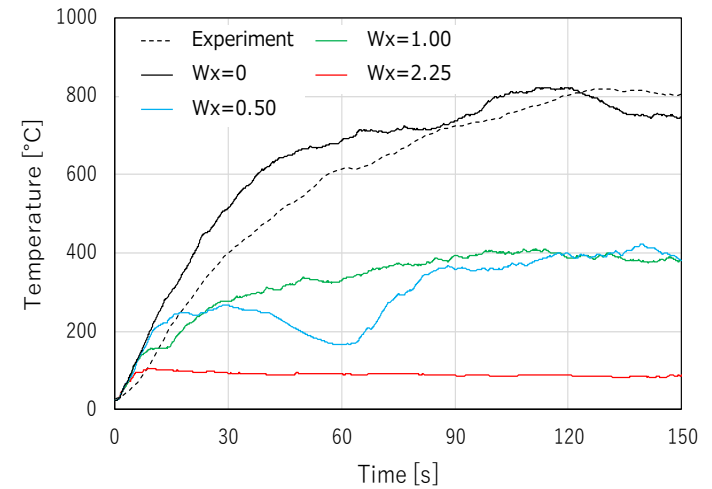
Appendix

The effect of wind on the blanket burner



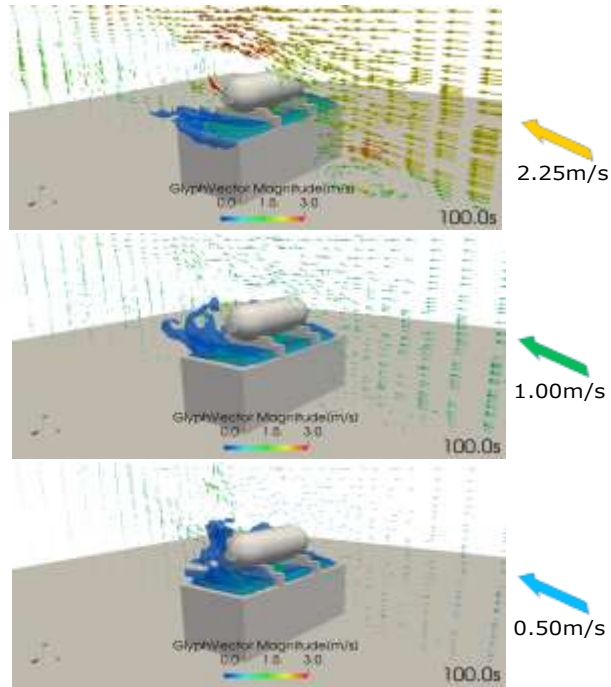
No wind case

Temperature contours and velocity vector distributions with wind, W_x

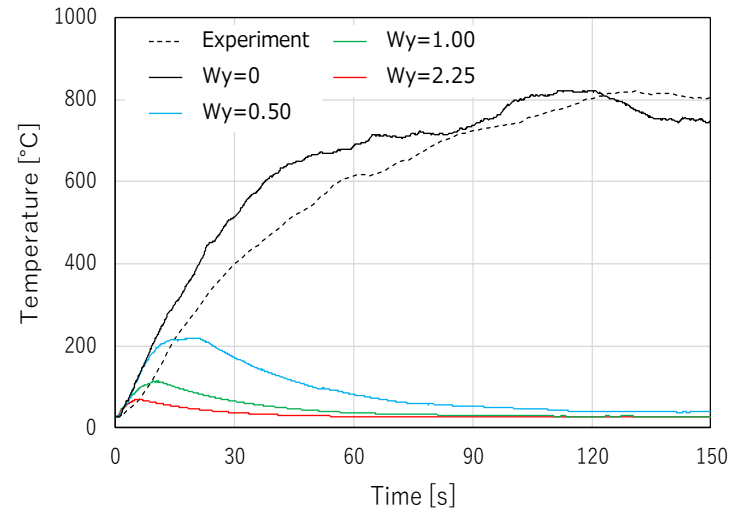


Temperature profiles at bottom center under 25mm with wind, W_x .

The effect of wind on the blanket burner



Temperature contours and velocity vector distributions with wind, W_y



Temperature profiles at bottom center under 25mm with wind, W_y .