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The Issue

- In a TLUD stove the flame is detached from the gasification process. Under certain circumstances, the flame can go out and the gasification process can continue.
- This "flameout" condition poses a hazard to the operator due to the high carbon monoxide emissions. <u>About 22%</u> of wood gas produced by gasification is CO.
- The smoke from gasification, when unburned is reported to "stink". However, CO is an odorless gas.



Acceptable CO Levels

- OSHA PEL (permissible exposure limit):
 - 50 ppm (55 mg/m³) as an 8-hour average
- National Research Council Emergency Exposure Guidance Levels Existing short-term exposure guidelines:(EEGLs):
 - 60-minute EEGL: 400 ppm
- National Institute for Occupational Safety and Health (NIOSH)
 - <u>The Immediately Dangerous to Life or Health (IDLH) concentration for carbon</u> <u>monoxide (CO) is 1,200 ppm¹</u>. This value is based on acute inhalation toxicity data in humans and is set to prevent life-threatening health effects or escape-impairing symptoms.

CARBON MONOXIDE LEVELS CHART

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) ppm	Recommended Safe Level				
6 ppm	WHO 24 Hour Average				
9 ppm	ASHRA 8 Hour Average EPA 8 hour 8 Hour Average NAAQS 8 Hour Average WHO 8 Hour Average	Physical Symptoms physical symptoms may include headache, fatique, dizziness and/or nausia.			
25 ppm	ACGIH 8 Hour Average				
30 ppm	WHO 1 Hour Average				
35 ppm	NIOSH 8 Hour Average NAAQS 1 Hour Average	Physical symptoms after 6-8 hours.			
50 ppm	OSHA 8 hour Average (PEL)				
80-69 ppm	UL 30 Day Alarm				
7 ppm	WHO 15 Minute Average				
70-149 ppm	UL 1-4 Hour Alarm				
200 ppm	NIOSH 15 minute STEL	Physical symptoms after 2-3 hours.			
150-399 ppm	UL 10-50 Minute Alarm UL 4 Minute Alarm	Physical symptoms in 1-2 hours. Life threatening 3 hours			
		Physical symptoms in 45 minutes. Unconscious in 2 hours. Fatal in 2-3 hours.			
300 ppm		Physical symptoms in 20 minutes. Fatal within 1 hour.			
1,600 ppm		Physical symptoms in 5-10 minutes. Fatal within 25-30 minutes.			
3,200 ppm		Physical symptoms in 1-2 minutes. Fatal within 10-15			
6.400 ppm		minutes.			
2,800 ppm		Fatal within 1-3 minutes.			

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Exposure Level

Exposure Level Depends upon...

- Duration of upset
- Amount of fuel
- Rate of gasification (influenced by stove design)
- Size of the room
- Air exchange rate of the room
- Exposure time

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What can cause a flameout?

- Wind
- Wet fuel
- Insufficient primary air
- Loss of secondary air
- Poor lighting procedure
- ?



Flameouts Caused by Wind

Stove Tested: Peko Pe Fuel tested: Bamboo

Only flameout datapoints are shown.



WHO's PT Model

 The WHO has published a performance target (PT) model to ensure that a region's locally specific emissions targets would enable the same air quality and health outcomes as the ISO Voluntary Performance Targets.

Variable	Units	Mean	SD	Min	Max	Distribution
Daily Cooking Time	min/day (24 hours)	180.0	51.0	60.0	390.0	Normal
Air Exchange Rate	exchanges/hour	30.0	15.0	4.0	100.0	Log normal
Kitchen Volume	m ³	38.0	22.0	8.0	110.0	Log normal





Design Considerations

Flame stability can be influenced by

- Pot support height
- Fuel-to-pot distance
- Primary/secondary air configurations
- Other yet to be known





Conclusions

Although this data is not comprehensive, CO exposure from flameout can pose a significant health risk to TLUD stove operators depending on the conditions.



Recommendations

- Flame stability should be a design consideration in TLUD stove development
- More testing and analysis is needed to further understand all the factors that contribute to TLUD flameouts
- Consider warning and/or instructing adopters of TLUDs on how to manage the hazards of TLUD flameouts