



Glass WAPI Testing

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Water crisis

- Nearly 1 billion people don't have safe water to drink.
- A child dies every 15 seconds from a lack of clean water.
- 1 in 4 children who die before age 5 worldwide, die of a water related disease.



Facts pulled from www.TheWaterProject.org



How do we help the crisis?

- Recent educational campaigns have raised awareness in third world countries that clean water is extremely important
- Pathogens can be killed by simply heating the water to a certain temperature
- Energy is at a premium in these countries and it is not necessary to completely boil the water
- So how do you tell if the water is safe to drink without seeing it boil?

ANSWER: WATER PASTEURIZATION INCIATOR or WAPI



What is a WAPI?

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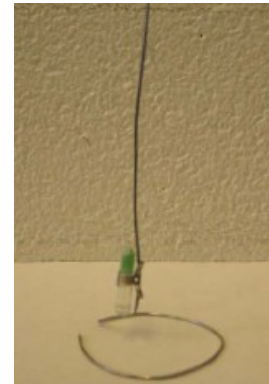
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-WAPI stands for water pasteurization indicator.

-A WAPI is a small glass tube injected with a small amount of colored wax that melts at a specified temperature.

-Using a WAPI is a simple and cheap way to accurately tell if a pot of heated water has reached a specific temperature in order to kill pathogens and bacteria in order for safe drinking to be obtained in third world countries.









How they work/ different types

-WAPIs are color coded to easily distinguish the difference in design temperatures

-WAPIs are designed to function from 65°C to 70°C

-Once water has reached the design temperature, the wax will melt from one side of the capsule to the other indicating water pasteurization has begun

WAPI* Pasteurization Time Chart

*WAPI Water Pasteurization Indicator	Wax Color	Centigrade	Time Required for Pasteurization	Fahrenheit
	YELLOW	70°C	06 min.	158°F
	ORANGE	67°C	15 min.	153°F
	GREEN	65°C	30 min.	149°F
	BLUE	60°C	2 hrs.	140°F

-The higher the temperature, the shorter the amount of time required to pasteurize water



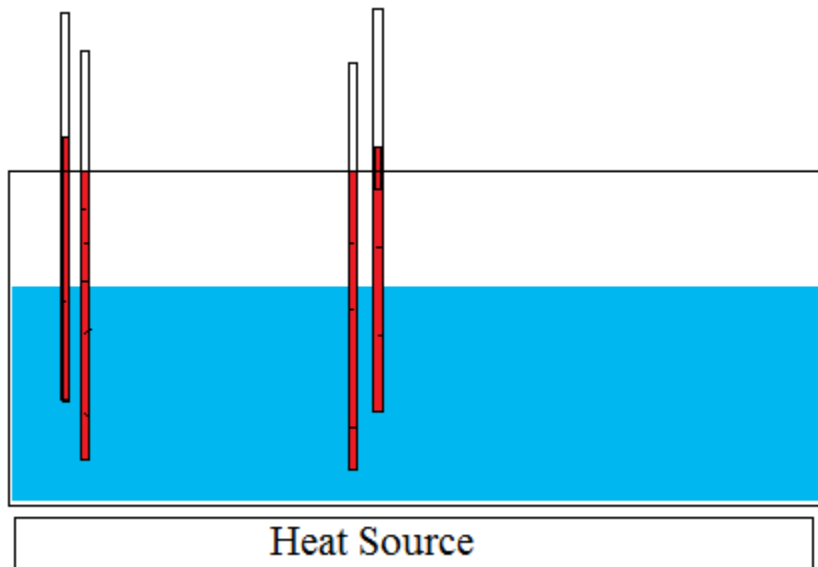
Objective

- The objective for this project is to perform experiments to ensure that the WAPIs have a durability and process of operation that are consistent and effective with the environment that they will be used in.
- The project covers four experiments: One experiment was used to verify the results of our measurement instrumentation, **Uniform Heating Test**, and the other three were used to test the durability of the WAPI, **Age Test**, **Max Temperature Test**, and **Drop Tes**





Uniform Temperature Test



Rough Sketch of
Experimental Setup

Purpose:

- Verify measurement method accuracy is acceptable

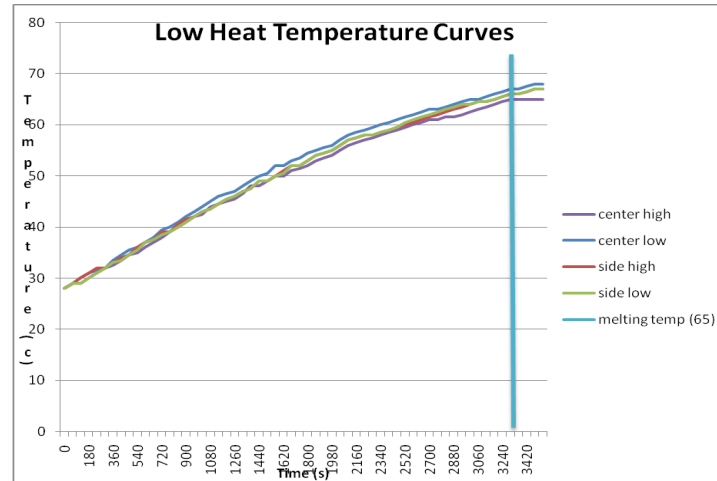
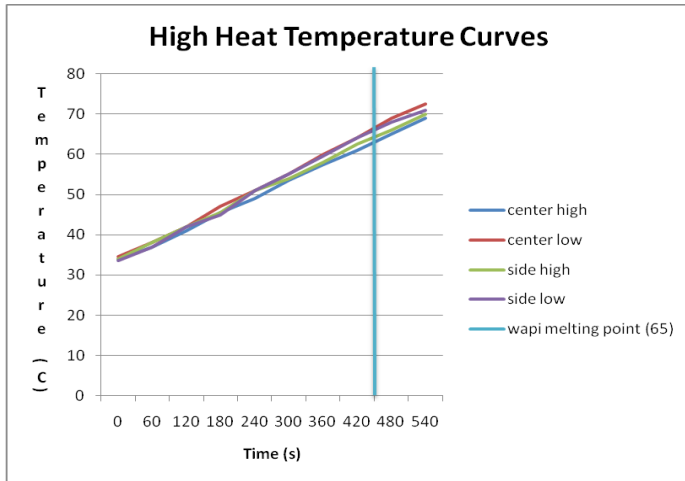
Design:

- Four thermometers placed at desirable locations
- Heat source: gas stove
- River water used



Uniform Temperature Test

GLASS WAPI TEST I



Standard Deviation

$$\sqrt{(4^{\circ}\text{C})^2 + (0.5^{\circ}\text{C})^2 + (0.5^{\circ}\text{C})^2} = \pm 4.06^{\circ}\text{C}$$

Error

$$\frac{4.06^{\circ}\text{C}}{65^{\circ}\text{C}}(100) = 6.25\%$$

Standard Deviation

$$\sqrt{(2^{\circ}\text{C})^2 + (0.5^{\circ}\text{C})^2 + (0.5^{\circ}\text{C})^2} = \pm 2.12^{\circ}\text{C}$$

Error

$$\frac{2.12^{\circ}\text{C}}{65^{\circ}\text{C}}(100) = 3.26\%$$

Conclusion: Some error exist, but with WAPI procedure can be negligible
 Low heat rate produced less error than high heat



Age Test



Purpose:

-Verify design melting temperature of the wax in WAPIs that have been stored for several years to ensure adequate shelf life

Design:

- Obtain WAPIs that were produced several years ago
- Three glass thermometers used to obtain temperature data to account for error found from uniform temperature test
- Collected data at beginning of wax melting and when completely melted



Tested three designs of 8 year old WAPIs
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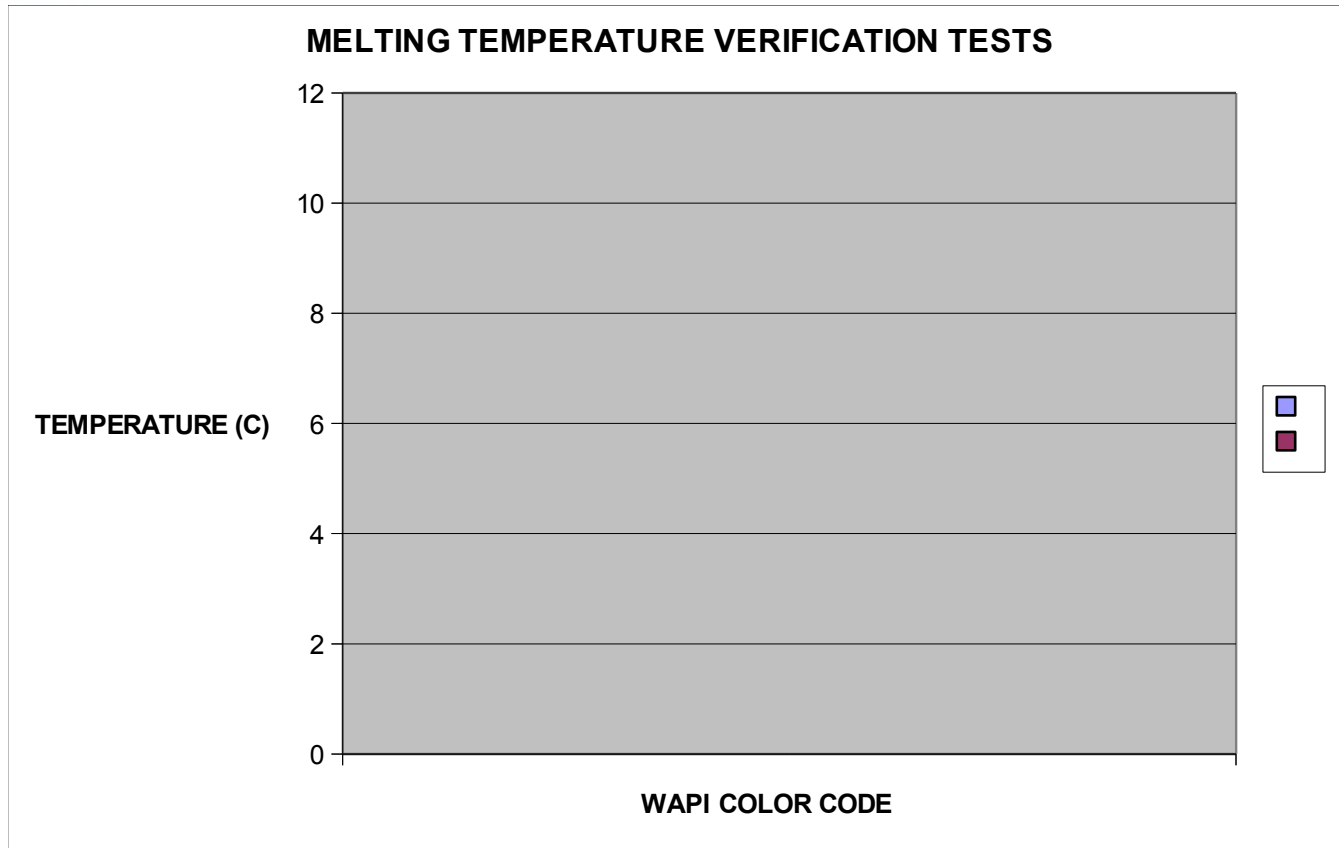


Age Test

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Age Test

$$\text{Error} = (Z_{\alpha/2}) \frac{\sigma}{\sqrt{n}}$$

95% Confidence $(Z_{\alpha/2}) = 1.96$

Summary of Analysis, Error	
WAPI	95% Confidence Error (°C)
Control (65°C, New Green WAPI)	2.26
Green (65°C, 8 Years Old)	3.27
Orange (67°C, 8 Years Old)	1.89
Yellow (70°C, 8 Years Old)	1.60

Conclusion: Data shows that old WAPIs perform just as well as new WAPIs, therefore they have good shelf life of eight years and up



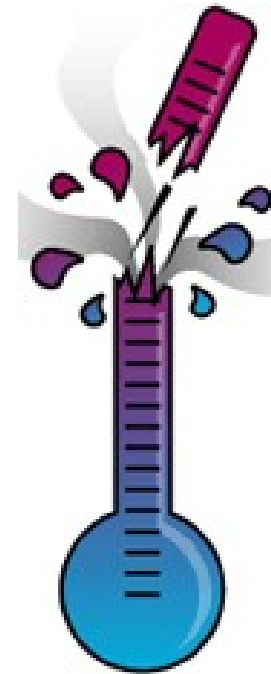
Max temperature test

Purpose:

- Verify that a WAPI has acceptable thermal durability

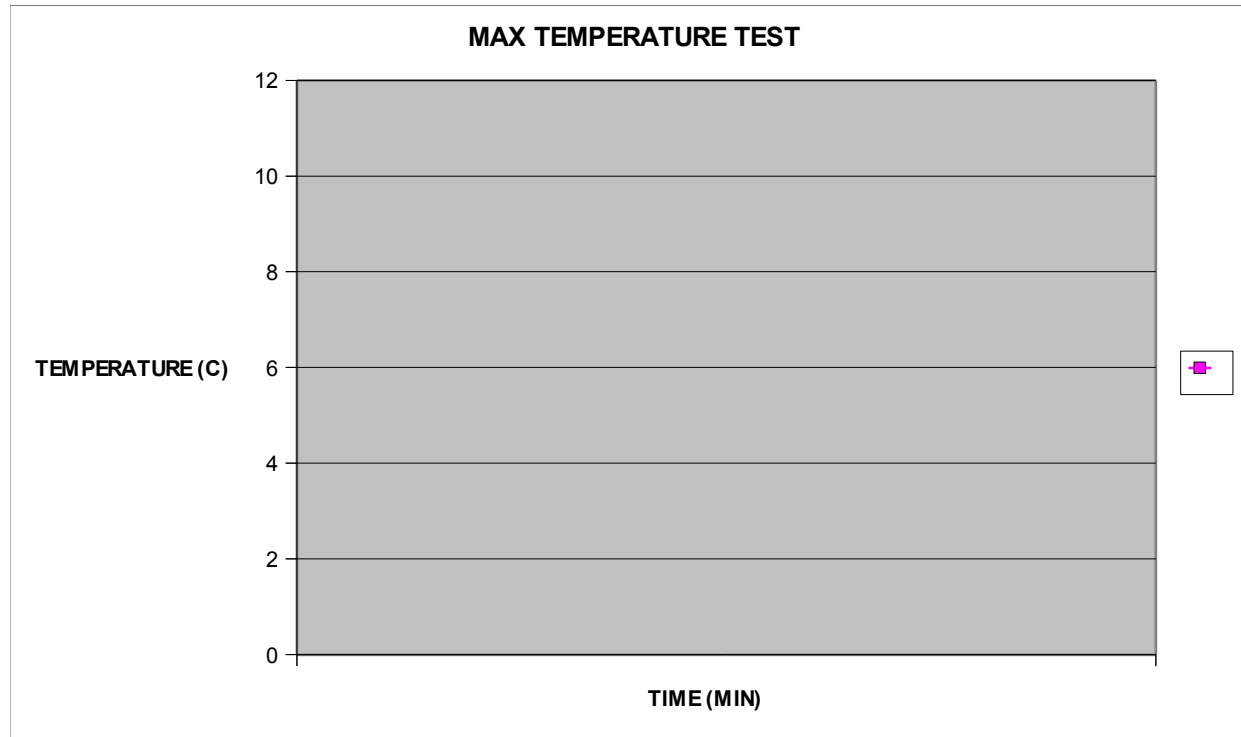
Design:

- Heat water to highest possible temperature on a gas stove for an extended period of time in an open pot
- Ensure WAPI performs well after such abuse





Max temperature test



Conclusion:

- Water never exceeded 107° C and WAPI never sustained any damages throughout test.
- After test WAPI still operated accurately.

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Drop Test

Purpose:

- Assess WAPI structural durability during abuse such as dropping.

Design:

- All WAPIs were dropped from a height of six feet
- Dropped repeatedly until it broke or until 150 drops
- Dropped on four ground surfaces



Stone Floor

Gravel

Dirt
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Grass



Drop Test

ABUSE TESTING (DROP TEST ALL DROPPED FROM 6 FEET)			
DROPPED ON?	NUMBER OF TIMES DROPPED	BREAK? (Y/N)	CRACKS? (Y/N OR N/A)
STONE FLOOR	1	Y	N/A
GRAVEL	28	Y	N/A
GRAVEL	16	Y	N/A
GRAVEL	10	Y	N/A
GRAVEL	16	Y	N/A
GRAVEL	7	Y	N/A
GRASS	150	N	N
DIRT	150	N	N

Conclusion:

- WAPI performed 150 drops on grass and dirt without sustaining any damage
- Care should be taken when handling WAPIs over harder surfaces such as gravel and stone floor
- WAPI structural durability is sufficient for current WAPI production price



Final Conclusions

-Through the experiments performed by the group for age test, max temperature test, and drop test, the product will adequately handle abuse and will be able to continually provide the user with an indication of proper pasteurization temperature.



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(But safe to drink)

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Questions?



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