WERC Design Contest **ESP# WERC - 2019 –UTA61**

Experiment Safety Plan

Rev _0__

Task # (as given on WERC Website)	6	
School Name	University of Texas at Arlington	
Team Name	UTA61	
Name/Title of Experiment:	Cyanuric acid effect on swimming pool water hardness	
	EMERGENCY → **911**	
Contact Function	Contact Name	Contact Phone (at Event)
Safety Coordinator	Juanita Miller	575-000-0000
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Team Member		
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Required attachments to the ESP:

Attachment 1: Experiment Scope

Attachment 2: Drawing of the Experimental Layout including P&ID

Attachment 3: Normal Operations, Startup and Shutdown Procedures

Attachment 4: Emergency Shutdown Procedure and medical emergency instructions.

Attachment 5: Waste Management Procedure

Attachment 6: Hazard Identification and Mitigation

Attachment 7: Safety Data Sheets

Attachment 1 – Experiment Scope

Provide a concise description of the laboratory experiment to be undertaken.

1. *Explain why the work is being performed, the goal(s) of the experimental program*
    a. *If this is an update/revision of previous ESP describe all changes*
2. *Provide the stoichiometry of any chemical reactions and their heats of reaction*
3. *Demonstrate the inherent thermal safety of your experiment through calculation or through the use of accelerating rate calorimetry data. (*http://chme.nmsu.edu/admin/ehs/experimental-safety-plan-esp/esp-energetics-calculation/ *)*
4. *Include a complete list of all chemicals (reactants and products) involved in the work.*
5. *Include a complete list of all equipment (e.g. autoclave, centrifuge, pump, heat bath etc.) involved in this work*
6. *Include a timeline for this experiment including setup, sample runtime(s)and teardown*

Note that this example is based on gradate research conducted by Juanita Miller, at UTA, in completion of her master's degree in Civil Engineering, December 2006. This is a semi-fictious example since ESPs were not used at UTA during the course of these experiments.

The water conditions for both commercial and home must be maintained within established ranged to ensure the water is sanitary for people to swim in. A compound called cyanuric acid or 1,3,5-triazine-2,4,6-triol is added to traditional disinfectants such as bleach or sodium hypochlorite to enhance the effectiveness of these compounds in killing harmful bacteria, algae and viruses from the swimming pool water.

A current method of synthesis of cyanuric acid is to thermally decompose urea in the following reaction [1]:

$3\ H2N\text{-}CO\text{-}NH2 \rightarrow [C(O)NH]3 + 3\ NH3$

CYA crystallizes from water as the dihydrate

The cyanuric acid follows the following dissociation processes in water :

$[C(O)NH]_3 \rightleftharpoons [C(O)NH]_2[C(O)N]^- + H^+$ ($pK_a = 6.88$)[3]

$[C(O)NH]_2[C(O)N]^- \rightleftharpoons [C(O)NH][C(O)N]_2^{2-} + H^+$ ($pK_a = 11.40$)

$[C(O)NH][C(O)N]_2^{2-} \rightleftharpoons [C(O)N]_3^{3-} + H^+$ ($pK_a = 13.5$)

The theory is that the cyanuric acid is simply an additive to the disinfection process and not consumed during chemical reactions. Thus the concentration will increase in the water which will contribute to the hardness value. If the hardness value in the water exceeds a set level, the water may need to be renewed in the swimming pool. This replacement process is time consuming, expensive and frequently not allowed due to water use restrictions in certain communities.

Attachment 1 – Experiment Scope

This work will investigate the correlation between cyanuric acid concentration and established industry hardness testing methods. In addition, a correlation between cyanuric acid concentration and dissolution rates of actual disinfected swimming pool water will also be established. Swimming pool water will be provided from the researcher's home and it will be tested using conventional techniques for pH, free chlorine, total alkalinity, hardness and acid demand.

Water samples will be prepared with various known concentrations of cyanuric acid, in deionized water, along with test samples from the swimming pool which will contain sodium hypochlorite (bleach) and cyanuric acid. These samples will be analyzed using a gas chromatograph to create a concentration curve.

Chemicals used:

DI Water

Cyanuric acid

Sodium hypochlorite

Equipment used:

Stirring hot plate

Analytical balance

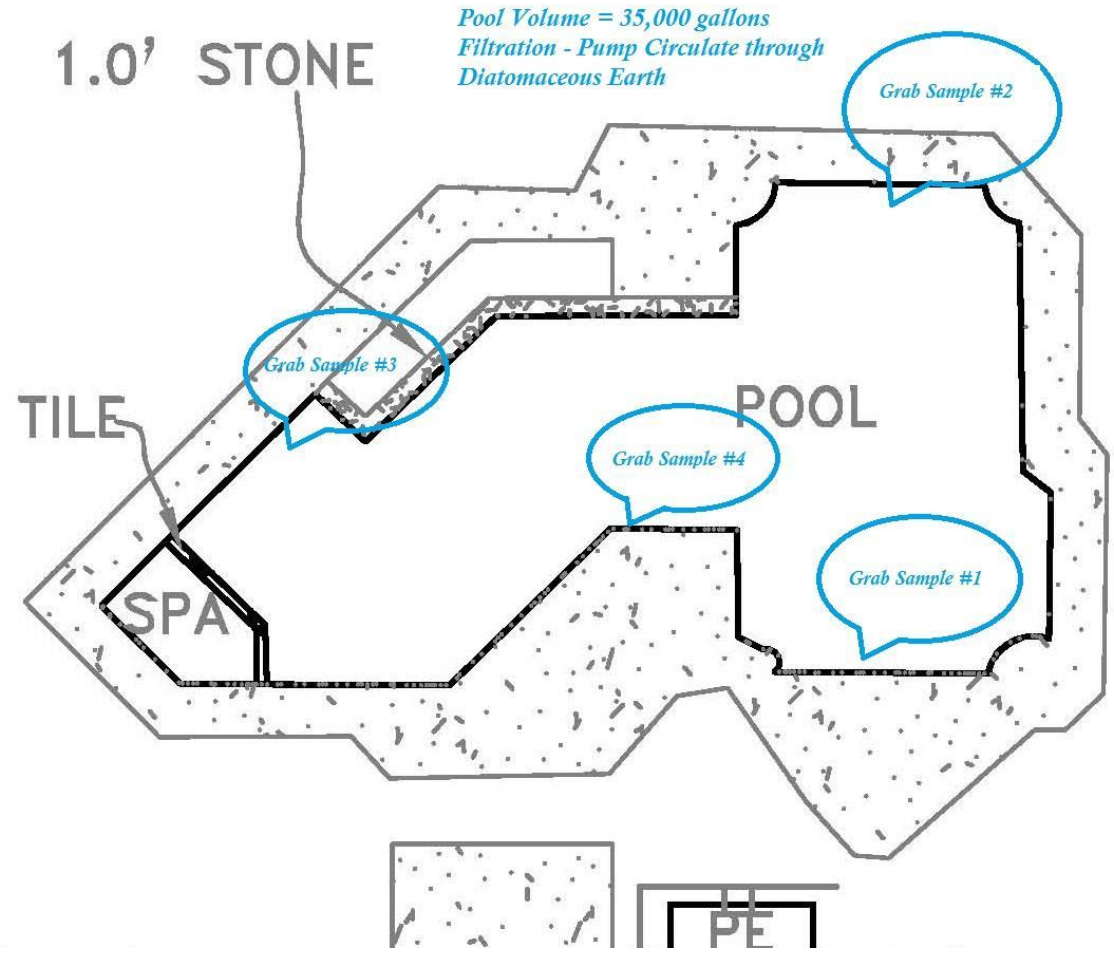
1 liter plastic bottles with caps

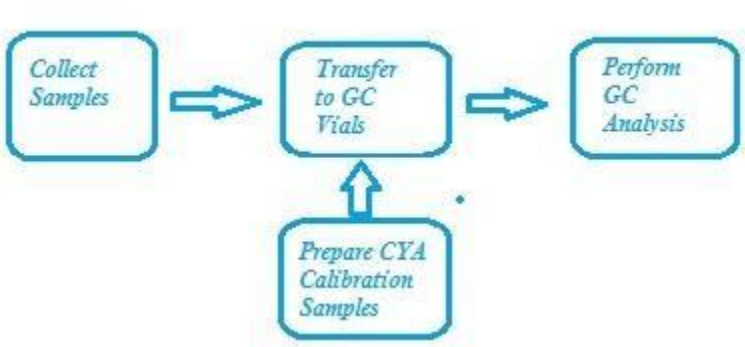
GC vials appropriate for the instrument used

Thermofisher Gas Chromatograph with auto-sampler

Attachment 2 - Drawing of the Experimental Layout including P&ID

Provide a detailed drawing of the experiment including P&ID's showing all inputs and outputs for equipment..





Attachment 3 – Normal Operations, Startup and Shutdown Procedures

*Provide a **step-wise** procedure that describes **in detail** how the work will be performed. The procedure should begin and end with the equipment in the normal idle (inoperative) state.*

*Include a statement of the required PPE **at the beginning** of the procedure, and at every location in the procedure where the PPE requirements change.*

Include details of how you will meet the required elements of your chosen task (e.g. run time, run rate, sample rate etc.)

Indicate where hazardous feedstock chemicals will be stored, how they will be transported to the location of the experimental work, how they will be transferred from storage vial into the experimental apparatus, and how they will be returned to storage.

Fill out the Take into account those items for which you indicate "yes" on the NMSU Lab Hazard Assessment Checklist, which is found at the end of this document..

Safety glasses, long pants and closed toe shoes will be required in the Chemistry lab while preparing samples and running the gas chromatograph

Good non-slip shoes are required while collecting grab samples from the swimming pool. Always sit or kneel down on decking while collecting samples to avoid becoming off-balance and falling into the pool.

The CYA chemical will be stored in the Civil Engineering Lab when not being used to make up the calibration samples.

CYA Calibration Curve – Sample Preparation

Prepare the following samples of Cyanuric Acid in deionized water by weighing the dry CYA powder on an analytical balance on the countertop in the Civil Engineering Lab. Mix the CYA powder in one liter of water and allow to dissolve for 24 hours at room temperature. Label each container with the material name and concentration

Sample #	Cyanuric Acid (CYA) – ppm or mg/liter
1	0.1
2	0.5
3	1.0
4	1.5
5	2.5
6	5.0
7	10.0
8	20.0

Obtain clean vials for the gas chromatograph and transfer solution from each sample bottle to a vial. Label each vial with the material and concentration. Place the vials in a plastic box with a lid to transport them to the chemistry lab for analysis.

Grab Sample Collection and Preparation

Collect the following grab samples from the swimming pool using a 1 liter plastic bottle with a cap. Proceed to the sample collection location as shown on the map in Attachment #1, kneel or sit on the pool

deck. Remove the cap from the bottle. Submerse the bottle to a depth of 12 inches and hold the bottle under water until no more bubbles appear. Carefully remove the bottle from the water, so it remains full, and cap it. Label the bottle with description of material contents, location and date. Repeat this procedure at each collection location for the date and time shown in the matrix.

Date	Sample #1	Sample #2	Sample #3	Sample #4
08/06/06	Deep End	Deep End	Middle	Shallow End
08/16/06	Deep End	Deep End	Middle	Shallow End
08/26/06	Deep End	Deep End	Middle	Shallow End

Transport these samples in a plastic box with a lid to the Civil Engineering lab.

Obtain clean vials for the gas chromatograph and transfer solution from each sample bottle to a vial. Label each vial with the material and concentration. Place the vials in a plastic box with a lid to transport them to the chemistry lab for analysis.

Gas Chromatograph Analysis

Load vials from either CYA calibration or grab samples in the auto-sampler. Turn on the carrier gas and allow the system to come to equilibrium. Select the program for CYA data collection. Run each sample and record the amount of CYA detected in solution.

Attachment 4 -. Emergency Shutdown Procedure

*Provide a **step-wise** procedure that describes how the equipment will be brought to a safe state in the event of an emergency. The description should include a detailed explanation of how to attend to potential medical emergencies that may result.*

Do not work alone in the laboratory. The act of collecting grab samples should be performed with someone else around or having a means of communication in case of emergency such as a cell phone.

If an emergency happens in the Civil Engineering Lab: Close any open chemicals. Turn off hot plate stirrer. Evacuate the area per established protocol.

If an emergency happens in the Chemistry Lab: Close the carrier gas cylinder valve. Turn the power off to the gas chromatograph. Ensure any chemical containers are closed. Evacuate the are per established protocol.

In case of spill: Don't use your hands to clean up broken glass, use a broom and dust pan. Put the broken glass into a glass box not the trash. Use paper towels to clean up any water spill and put the wet towels into the normal trash since this is not a hazardous waste. In case of spill of CYA powder, clean up with wet paper towels and put into the trash.

Attachment 5 - Waste Management Procedure

Prepare a Waste Management Procedure that provides the exact nature and estimated volumes of all wastes to be generated in performing these experiments. NMSU will provide containers and forms to be filled out by the researcher for proper disposal of materials. An example Waste tracking form is attached for reference.

Cyanuric acid is not a hazardous material when mixed with water. However, for this experiment all samples will be combined into plastic carboys which will be collected by EHS. An NMSU waste tracking form will be attached to the waste container with necessary information completed (see Attachment 8).

Attachment 6 – Hazard Identification and Mitigation

Identify ALL HIGH hazards associated with the experiment. The analysis must consider

- *all sources of energy (electric, chemical, hydraulics, mechanical, compressed gases),*
- *extreme conditions of pressure or temperature (from flame or steam to cryogenics),*
- *chemical storage,*
- *housekeeping,*
- *fire, and/or*
- *biological hazards.*

Examples of HIGH hazards to include (list not exhaustive):

- *substances that are highly reactive, radioactive, highly flammable, pyrophoric, highly toxic, mutagenic, teratogenic, carcinogenic, or have very low exposure limits,*
- *high voltage, high RF, x-ray, laser (class 3b or 4),*
- *high temperatures, and*
- *high pressure or pressurizing vessels.*

When in doubt about whether a substance represents a HIGH HAZARD, ask for assistance.

For each HIGH hazard (use the checklist as a guide to identifying these hazards, chme.nmsu.edu/files/2013/11/Lab-PPE-selection1.pdf), provide the following information:

1. *description of the HIGH hazard;*
2. *operational and engineering controls that will be used (based on identified industry best-practices used in addressing this safety hazard);*
3. *required PPE (beyond minimum) when this HIGH hazard is present; and*
4. *special training (beyond minimum) that is necessary.*

Basic hazards include slip/trip/fall around the swimming pool during collection of grab samples. Be sure to wear good non-slip shoes and skit or kneel while collecting the samples.

Otherwise were safety glasses, long pants and close toe shoes when working in either the Civil Engineering Lab or the Chemistry Lab.

Items identified in NMSU JSA Checklist include:

Gas under pressure – Be sure to turn the cylinder valve slowly on the carrier gas cylinder when starting the gas chromatograph. Listen for any leaks from the piping. Turn the gas off if hissing is heard and contact the lab manager for assistance. Turn the carrier gas cylinder off after sample runs are completed and ready to shut down the instrument.

Spill cleanup - Don't use your hands to clean up broken glass, use a broom and dust pan. Put the broken glass into a glass box not the trash. Use paper towels to clean up any water spill and put the wet towels into the normal trash since this is not a hazardous waste. In case of spill of CYA powder, clean up with wet paper towels and put into the trash.

Glassware washing – Be sure to use non-slip rubber gloves while washing glassware. Place wet glassware on a drying rack. Don't use your hands to clean up broken glass, use a broom and dust pan. Put the broken glass into a glass box not the trash.