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Investigation into the A&A Ozone Generation Units

Summary

The following is a summary of the investigation into the A&A ozone generator, model QP2-25. A full report written by Deborah Kon, and a report written by an outside engineering firm is also available. The page numbers noted below refer to the report written by Deborah Kon.

Qualitative Characteristics

- A&A ozone generators do not have any recognized safety approvals such as UL, NSF, and CE (page 1).
- Since the unit is not made of aluminum, there are concerns with the unit rusting and corrosion from ozone and exposure to UV light (page 2). There are also some concerns with corrosion of internal parts from exposure to ozone (page 4), (page 5).
- The unit is inconvenient to install or service since the internal parts cannot be easily accessed (page 2), and in order to switch the voltage on the ballast, the unit must be opened up (six small Philips screws must be undone) and the switch on the ballast must be moved manually (page 4).

Quantitative Analysis

- The ballast is overdriving the lamp. Lamp power is 15-26% higher than the recommended power for the lamp. This will reduce the lamp life and the lamp will fail prematurely (page 7).
- The lamp filaments are not being preheated. This causes sputtering and the blackening of the lamp that decreases the ozone output of the lamp (page 7).
- The airflow control device inside the unit is restrictive and a higher airflow cannot be attained. This reduces the efficacy of the unit in field as the ozone output is compromised. In addition, this makes the unit less responsive and less adaptable in the field (page 9).
- At higher air flows required in the field (5-6 CFH), UltraPure Water Quality's UPP 15 unit is producing more ozone than the A&A unit (page 9).

Laboratory Manager: Deborah Kon
Date: October 26, 2005

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Introduction

The purpose of this report is to evaluate ozone generators manufactured by A&A Manufacturing. This report will be divided into two portions. The first portion will deal with qualitative characteristics of the units, which will describe the outside, and inside appearance of the units. The descriptions will detail the external and internal parts and internal wiring. The second portion of this report will address quantitative aspects of these units. This section will include electrical analysis, airflow analysis, and the analysis of the ozone output. In addition, a report prepared by an independent engineering firm is also available as a supplement to this report.

Part 1. Qualitative Characteristics

Analysis of External Components

Model: QuikPure2 Ozone Oxidation System
Model Number: QP2-25
Manufacturer: A&A Manufacturing

Label on Unit: The unit contains only one label. This label is located on the lid of the unit. The label is blue with a white background. The model and the manufacturer are indicated on the label. Model number is not indicated on the label. The outside of the unit does not contain any approval markings such as UL, NSF, and CE. The lack of approval markings indicates that this unit does not hold any safety approvals. In addition, there is no indication of any electrical ratings such as voltage and frequency. There are no indications of the serial number, date of manufacture, ozone output, and warnings such as risk of electric shock, the harmful nature of UV light, and the danger of ozone inhalation. The label does not provide any installation instructions.

Markings on Packaging: The box, which is used to ship this unit, has the model number of the unit. The box contains a certificate stating that the box meets all construction requirements of applicable freight classification. The size of the box is also provided on the box. The size of the box is 24” x 6 ½” x 4 ½”.

Size of Unit:

Length	=	20 5/8”
Width	=	3 5/8”
Height	=	2”
Weight	=	3 lbs

Colour and Material of Construction: White painted steel

Note: Since the unit is not made of aluminum, there are concerns with rusting in an outdoor environment where the ozone generators for swimming pools are located. There is also a concern of corrosion from ozone and exposure to UV light.

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Access to Internal Components: Opening and removing the entire lid of the unit can access the internal components. Six screws hold down the lid, each screw being 0.4" long and 0.2" in diameter. Two screws are located at the front, two screws are at the back, and there is one screw located at each end. The screws are very small and a very small Philips screwdriver is needed to remove the screws. In order to access the internal components, all the screws must be undone and the entire lid must be removed. These poses some inconvenience, as it is time consuming to remove all the screws first and then have to screw them back on later.

Other Outside Components: The outside of this unit is equipped with a plastic window that is green in colour. The diameter of this window is 0.6". This green window is not electrically connected to the lamp or the power source. Its purpose is to glow when the lamp is on. When this window is glowing, it means that the lamp is on and it gives a visual indication that the unit is working.

The grounding lug is located on the left hand side of the unit, close to the left edge. The lug is made out of copper and it is UL approved. On all units examined, the grounding lug was loose suggesting that it has not been attached properly to the unit. The grounding lug needs to be secured properly when the unit is in the field. In addition, the top screw on the grounding lug used for the grounding wire is not made of aluminum. In addition, the screw used to attach the grounding lug to the unit did not have a star washer.

The Heyco is located beside the grounding lug. The Heyco is made from a gray plastic and the markings on it are Arlington ½. It is CSA and UL approved. The Heyco contains a 0.5" diameter fitting through which the conduit wires are fed. The inside of this fitting is secured inside the unit with a metal ring. Once the Heyco is unscrewed, it cannot be tightened again. This unit does not have a strain relief.

Three conduit wires are supplied with each unit. Two wires are red in colour and one wire is green. Each wire is approximately 12 feet in length. The colour scheme of the wires is not conventional as normally all three wires are different colors to indicate which wire is the primary and which is the secondary. For 120 V applications, the wires are usually green, white, and black. For 240 V applications, the wires are usually black, red, and green. The wires in the A&A unit are UL approved and they fall under the category of machine-tool wire. These wires are suitable for industrial machinery and may not be the most suited for applications in swimming pools. The wires are 14 AWG, stranded copper, rated at 600 V, 90°C (194 °F). The green grounding conductor is secured inside the unit with a star washer to ensure that the unit is grounded.

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Air Intake Holes: The unit is equipped with four very small openings. These openings are approximately 0.2" in diameter. Two openings are located on both ends of the unit. Since these are the only openings on the unit, it is assumed that the purpose of these openings is to allow air through the unit in order for ozone to be made.

Tubing and Fittings: One end of the unit contains a ¼" fitting which houses a 0.15"in diameter black or brown plastic tubing. The tubing is approximately 5 ft 7/16" long and is made out of a dull and soft plastic material. On the end of tubing leading away from the unit, a popette check valve inside a white fitting is attached. The inside diameter of the valve fitting is 0.1". The unattached end of the fitting is meant to fit the 5 ft 7/16" tubing.

Air Flow Control: 0.5" of the black plastic tubing leads to the inside of the unit through the ¼" black fitting described above. This 0.5" piece of tubing houses the plastic insert that is used to control the air flow. This insert is made out of hard, white plastic material. The length of the insert is 0.5". A very small hole is drilled on the insert facing the inside of the unit. This hole is too small to measure. This whole becomes larger throughout the length of the insert. The hole at the end of the insert facing the outside of the unit is 0.08" in diameter. This unit does not have a drain hole.

Installation and Parts Package: Two mounting tabs are provided on the outside of the unit for installation. If this unit is to be installed horizontally with the tabs facing up, it is easy to rip the unit off the wall since only two tabs are provided on the same side of the unit. Each tab has a 0.2" in diameter hole for screws. Screws and wall plugs were not provided with the unit. Installation instructions and an owner's manual were not provided with the unit.

The parts package contained a brass T-fitting, a ¼" black elbow fitting, two gray ¼ NPTF tubing fittings, and approximately 12 ft of the black, dull, flexible plastic tubing. The inside diameter of the tubing is 0.15".

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Analysis of Internal Components

In order for the internal components to be accessed, the entire lid must be removed. The lid holds down a safety switch. When the lid is on, the safety switch is held down. This switch is in circuit with the lamp and the ballast. When the switch is held down, the circuit is closed and the unit is operational. Once the lid is removed, the switch is released and the circuit is broken. This allows the unit to be off even when the unit is plugged in. The purpose of the safety switch is to ensure that the unit is off when servicing needs to be performed or when the voltage on the ballast needs to be switched.

A vertical steel plate separates the lamp and the ballast. This plate is not painted and there is a concern that ozone will oxidize the unprotected steel plate.

Lamp:

This unit contains one lamp. The lamp is a T5 lamp with an arc length of 300The most comparable lamp that UltraPure Water Quality Inc. offers has the arc length of 290 ± 1.5 mm. The lamp in the A&A unit is model # G18T5VH/4, branded 'A&A Manufacturing', US Patent # 4,700,101. This lamp contains a white cap at each end and it is a single ended, 4-pin lamp. Rating of the lamp was not indicated on the lamp. Further research has indicated that this lamp is an instant start type, similar to STER-L-RAY Germicidal Lamp from Atlantic Ultraviolet Corporation. The lamp manufacturer appears to be Atlantic Ultraviolet Corporation. The lamp seems to be an ozone producing 17 W Instant Start STER-L-RAY Germicidal lamp. The nominal lamp current rating is 425 mA. The lamp is configured with a 4-pin base. The closest lamp from UltraPure Water Quality Inc. is rated at 16W and is used in UltraPure Water Quality's UPP 15 model. Two lamp holders hold the lamp in A&A units in place. The lamp holders are in contact with the glass of the lamp instead of the white end caps of the lamps. This will impact the ozone production of the lamp.

Ballast:

This electronic ballast made by Perkin Elmer model number ING36-120/230V is rated for the following lamp type: G36T6/36W. The Input on the ballast is 120V AC, 60 Hz, 0.8A, 230 V AC, 50 Hz, 0.38A. The open circuit voltage is 600V DC. The ballast is class P, type 1, rating A. It is UL/CSA Listed and it contains the CE marking. This ballast has been branded as Atlantic Ultraviolet Corporation. This ballast is rated to drive a 36 W lamp at 450 mA. A switch is located on the outside of the ballast to switch the voltage to 120V AC or to 230V AC. In order to switch voltage, the unit must be opened up and the switch must be moved manually.

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In addition, it should be mentioned that it is time consuming to remove the ballast from the unit in case the ballast needs to be replaced. The difficulty lies in the fact that the
Ballast is mounted vertically in a corner and it is difficult to reach and undo the washers holding the ballast screws.

Wiring Configuration: The lamp attaches to a 4-pin socket that has two blue and two red wires leading from it. In our experience, ozone oxidizes the copper inside the socket; therefore, this is not the best method for wiring. The socket contains UL and CE marking and is rated for 600 V, 660 W.

The two red wires from the lamp socket are attached together, and the two blue wires from the lamp socket are attached together. The red wires are then connected to the red wire leading from the ballast and the blue wires are connected to the blue wire leading from the ballast.

The black power wire leading from the ballast is connected to the safety switch.

One red power wire is connected to the safety switch while the other red power wire is connected to the white power wire on the ballast.

The green wire is grounded to the case.

Part 2. Quantitative Analysis

Electrical Analysis

Electrical measurements of lamp current and lamp voltage were measured at 120V and at 240V. An outside electrical consultant conducted this testing. The following are the results.

Table 1. Electrical Characteristics of A&A Units at 120V, 60 Hz.

Unit	Line Current (A)	Lamp Current (A)	Lamp Voltage (V)
1	0.30	0.52	37
2	0.34	0.50	38
Average Lamp Voltage: 38 V Average Lamp Current: 0.51 A Average Lamp Power: 19 W			

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Table 2. Electrical Characteristics of A&A Units at 240V, 60 Hz.

Unit	Line Current (A)	Lamp Current (A)	Lamp Voltage (V)
1	0.16	0.54	39
2	0.17	0.53	37
Average Lamp Voltage: 38 V Average Lamp Current: 0.54 A Average Lamp Power: 20 W			

Discussion

According to the ballast specifications, the ballast is rated to run a 36 W, T6 lamp. In the A&A unit, the same ballast is running a 17 W, T5 lamp. The high lamp current of 0.51 – 0.54 A is a direct result of the ballast running a lamp that it too low in wattage for the ballast. The high lamp current is the result of the ballast overdriving the lamp. The lamp manufacturer recommended nominal lamp current is up to 450 mA or 0.45 A. The lamp current in the A&A unit is 17% higher than the current recommended by the lamp manufacturer. The lamp power is 15% higher than the rated wattage of the lamp.

An independent engineering firm conducted additional analysis of the A&A units. This report is available as a supplement to this report. They have also measured lamp voltage, lamp current, and lamp power. The following are the results that they have obtained.

Table 3. Electrical Characteristics of A&A Units at 120V, 60 Hz.

Unit	Lamp Current (A)	Lamp Voltage (V)	Lamp Power (W)
1	0.573	37.4	21.4
2	0.605	35.5	21.5
Average Lamp Voltage: 36.5 V Average Lamp Current: 0.589 A Average Lamp Power: 21.5 W			

Table 4. Electrical Characteristics of A&A Units at 230V, 60 Hz.

Unit	Lamp Current (A)	Lamp Voltage (V)	Lamp Power (W)
1	0.573	38.8	22.2
2	0.582	35.3	20.5
Average Lamp Voltage: 37.1 V Average Lamp Current: 0.577 A Average Lamp Power: 21.4 W			

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Discussion

These results also show that the lamp current is very high, much higher than the recommended 450 mA or 0.45 A. The ballast is overdriving the lamp resulting in the lamp power being 26% higher than what the lamp is rated for. This will have a significant impact on the life of the lamp. If the lamp power is at the rated 17 W, the rated lamp life is 10,000 hours. The lamp life is reduced as the lamp wattage exceeds the recommended wattage. It can be predicted that the lamp in the A&A unit will fail prematurely.

In addition, the independent analysis of the A&A units has revealed that the A&A unit is using an instant start ballast/lamp combination. This means that the ballast is not using a preheat cycle to warm the lamp filaments. When the lamp filaments are preheated, the starting is much gentler and the lamp life is preserved. In the case of the A&A unit, the lack of a preheat cycle creates a tremendous stress on the lamp filaments. This causes sputtering and eventual tube end blackening leading to a diminished ozone output. The independent analysis of the A&A units is available as a supplement to this report.

Determination of Air Flow Restriction

The following experiments were performed in order to determine the effectiveness of the A&A's airflow control device and to determine how restrictive it is. The airflow for this set of experiments was set using the UltraPure Water Quality's Air Flow Control Insert. After the airflow was set, this particular insert was removed and the tubing was connected to the A&A units that contained their original air flow control device. This has allowed us to determine how restrictive A&A's air control device is.

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Table 5. Airflow Determination of A&A Units.

Air Flow Set Using UltraPure Water Quality's Least Restrictive Air Flow Control Insert		
Inches of Insert Used	**Set Air Flow (CFH)**	**Air Flow of A&A Unit (CFH)**
1	4.0	2.8
2	4.0	3.0
3	4.0	3.0
1	6.0	3.8
2	6.0	3.0
3	6.0	4.2
1	8.0	4.2
2	8.0	4.6
3	8.0	4.8
Air Flow Set Using UltraPure Water Quality's Middle Restriction Air Flow Control Insert		
Inches of Insert Used	**Set Air Flow (CFH)**	**Air Flow of A&A Unit (CFH)**
1	4.0	2.8
2	4.0	3.4
3	4.0	4.0
1	6.0	3.8
2	6.0	4.0
3	6.0	4.8
1	8.0	4.2
2	8.0	5.2
3	8.0	6.2
Air Flow Set Using UltraPure Water Quality's Most Restrictive Air Flow Control Insert		
Inches of Insert Used	**Set Air Flow (CFH)**	**Air Flow of A&A Unit (CFH)**
1	4.0	3.0
2	4.0	3.2
3	4.0	3.4
1	6.0	4.0
2	6.0	4.4
3	6.0	5.6
1	8.0	4.8
2	8.0	5.8
3	8.0	5.8

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Discussion

These results have indicated that the air flow control device in the A&A unit is more restrictive than UltraPure Water Quality's Air Flow Control Insert, irrespective of the type of insert and amount of the insert used. The highest air flow obtained by the A&A unit was 6.2 CFH compared to 8 CFH that was set using UltraPure Water Quality's Air Flow Control Insert. The inability to attain a higher air flow for the A&A unit will reduce the ozone output and thus the efficacy of the A&A unit in the field. The inability to attain a higher air flow also makes the A&A unit less responsive and adaptable in the field.

Determination of Ozone Output

The ozone output was obtained at 240V at various airflows. The ozone output of the A&A units was compared to the ozone output of the UltraPure Water Quality's UPP 15 model. For this set of experiments, the airflow control insert was removed from the A&A units in order to be able to set the desired airflow.

Table 6. Ozone Output of the A&A Units and UPP 15 Units at 240 V.

Air Flow (CFH)	Ozone Output of A&A Units	Ozone Output of UPP 15 Units
2	263.5419 ppm 0.5644 mg/min	147.5835 ppm 0.3161 mg/min
4	242.4586 ppm 1.0385 mg/min	117.4644 ppm 0.5031 mg/min
6	212.3395 ppm 1.3642 mg/min	108.4287 ppm 0.6966 mg/min

Discussion

At each airflow, it is apparent that the ozone output of the A&A units is approximately two times higher than the ozone output of the UPP 15 units. This is not surprising since the A&A units use an electronic ballast. The ozone output is expected to be higher with an electronic power source compared to an electromagnetic power source. In addition, the ozone output is also expected to be higher with the A&A units since the lamp is being over driven. A high lamp current will produce a higher ozone output at the expense of the lamp life and unit reliability. In addition, the ozone output of the A&A unit is higher than the ozone output of the UPP 15 unit at a low airflow of 2 CFH. At an air flow of 6 CFH which is a more realistic air flow in the field, the ozone output of the UPP 15 unit is higher compared to the ozone output of the A&A unit at 2 CFH. This indicates that at higher air flows encountered in the field, the UPP 15 unit is producing more ozone than the A&A unit whose air flow is restricted by the internal air flow control device.

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Conclusion

The evaluation of the ozone generators manufactured by A&A Manufacturing has revealed that this ozone generator does not have any recognized safety approvals such as UL, NSF, and CE. In addition, the unit lacks appropriate warnings, installation instructions, and a manual for the installer and the pool owner. The unit is not convenient to service since the internal parts cannot be easily accessed and the voltage on the ballast needs to be manually changed before the installation. In addition, there is concern with the unit rusting in an outdoor environment and with ozone oxidizing internal components of the unit.

The main issues with this unit are that the ballast and the lamp are not suited to work together. The lamp is being overdriven which will cause it to fail prematurely thus affecting the unit's reliability in the field. In addition, the starting of the lamp is very hard on the lamp, which over time will reduce the ozone output of the lamp. The airflow control device provided inside the A&A unit is very restrictive. This will reduce the efficacy of this unit in the field, as the ozone output will be affected.

Overall, the efficacy and reliability of these units in the field is a concern and should be addressed by the manufacturer.