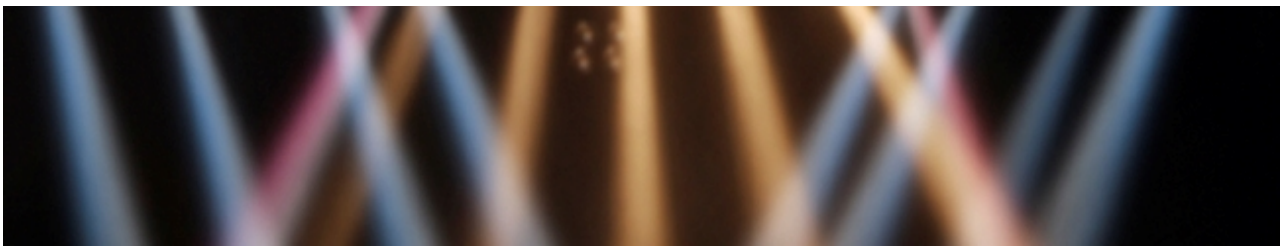

Calibration Factors and Time-and-Distance Guidelines For Use of Theatrical Fog Equipment

NewRuleFX Electronic Actor Cigarette Prop with Cartridge Fluid

Prepared for:
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and

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ENVIRON

Contents

1 Introduction

In 1997-99, at the request of Actors' Equity Association (AEA) and the League of American Theaters and Producers (LATP) and with the support of the Equity-League Pension and Health Trust Funds, investigators from the Mount Sinai School of Medicine (Mt. Sinai) and ENVIRON International Corporation (ENVIRON) conducted a study to evaluate whether the use of smoke, fog, haze, and pyrotechnics special effects in theatrical musical productions is associated with a negative health impact in actors. This effort was initiated in response to ongoing concerns by actors that the use of these theatrical effects may have an impact on their health. The results of this study were presented in the report *Health Effects Evaluation of Theatrical Smoke, Haze, and Pyrotechnics* (Mt. Sinai and ENVIRON 2000).

The results of the Mt. Sinai/ENVIRON study indicate that there are certain health effects associated with actors exposed to elevated or peak levels of glycol smoke/fog and mineral oil. However, as long as peak exposures are avoided, actors' health, vocal abilities, and careers should not be harmed. Pyrotechnics as used on Broadway at the time of the study did not have an observable effect on actors' health.

Mt. Sinai and ENVIRON recommended the following peak guidance levels with respect to glycols and mineral oil:

- The use of glycols should be such that an actor's exposure does not exceed **40 milligrams per cubic meter (mg/m^3)**.
- Mineral oil should be used in a manner such that an actor's exposure does not exceed a peak concentration of **25 mg/m^3**.
- For chronic exposures to mineral oil, the existing standards established for oil mists (**5 mg/m^3** as an eight-hour time-weighted average) should also be protective for actors in theatrical productions.

Comparable guidance levels were developed for glycerol in a subsequent study (ENVIRON 2001b):

- Glycerol should be used in a manner such that an actor's exposure does not exceed a peak concentration of **50 mg/m^3**.
- For chronic exposures to glycerol, the existing standards established for glycerin mists (**10 mg/m^3** as an eight-hour TWA) should also be protective for actors in theatrical productions.

To ensure that peak smoke, fog, and haze levels are below these guidelines, one option available to productions is to conduct show-specific testing at their theatres using an aerosol monitor. In order to conduct this testing, calibration data must be developed for each equipment/fluid combination. These calibration data are necessary to convert the readings of the aerosol monitor to glycol, mineral oil, or glycerol concentrations. A compilation of calibration factors approved for use in evaluating compliance with the peak guidance levels is provided on the Actors Equity web site (http://www.actorsequity.org/library/library.asp?cat=33).

ENVIRON was retained by New Rule Productions, Inc. and Foresight Theatrical to develop calibration factors and time-and-distance guidelines for the NewRuleFX Electronic Actor Cigarette Prop used in the Broadway production of "Side Show". It should be noted that ENVIRON's testing was limited to glycols. According to the manufacturer, these props also contain no nicotine, tar, or tobacco.

2 Testing Methodology

2.1 Sampling Equipment and Materials

Monitoring of short-term concentrations was performed using portable real-time aerosol monitors (*personal* DataRAM Model PDR-1000) manufactured by Thermo Scientific. The PDR-1000 is a high sensitivity (i.e., photometric) monitor that uses a light scattering sensing chamber to measure the concentration of airborne particulate matter (liquid or solid), providing a direct and continuous readout as well as electronic logging of the data.

The PDR-1000 aerosol monitors as obtained are calibrated to Arizona road dust over a measurement range of 0.001 to 400 mg/m^3. In order to be utilized to measure short-term glycol concentrations, the monitors were first calibrated for the smoke and fluids being used. Calibration of the aerosol monitors was conducted by collecting simultaneous measurements with a series of sampling pumps and PDR-1000 aerosol monitors, mounted on tripods.

GilAir BDX-II sampling pumps were used to draw air through collection media. The fluid tested was glycol based;

- For glycols, OSHA Versatile Sampler (OVS) traps were used as the collection media, each containing two sections of XAD-7 resin (200-mg front section, 100-mg back section, separated by a polyurethane foam [PUF] plug). The XAD-7 resin was used to collect both the particulate and vapor phase of the glycol aerosol. A 13-mm glass fiber filter (GFF) plug precedes the front section and a PUF plug follows the back section. This sampling is based on a variation of NIOSH Method 5523 (NIOSH 1996; Pendergrass 1999).
- This calibration sampling was conducted in conjunction with operating the PDR-1000 aerosol monitor.

2.2 Aerosol Monitor Calibration Procedure

A single tripod assembly was used for calibrating the aerosol monitor, consisting of a sampling pump, flexible tubing, sampling media (OVS trap for glycols), and an aerosol monitor. The height of the tripod was set to the breathing zone of the employee conducting the testing, corresponding with the breathing zone of a typical actor.

a. The sampling pumps were calibrated to 2 liters per minute (LPM) using a BIOS Defender 510 pump calibrator. The aerosol monitor was zeroed, the data logging function of the aerosol monitor was turned on, and the data logging time for the aerosol monitor was synchronized.

b. The sampling pumps were turned on, and an ENVIRON staff person blew smoke from the electronic cigarette toward the sampling media at a steady rate. After a period of approximately seven minutes, the pumps were turned off.

c. The OVS traps were capped, labeled, and placed in a cooler with ice packs.

The collection media were submitted for analysis to Analytics Laboratory of Richmond, Virginia, an American Industrial Hygiene Association (AIHA) accredited laboratory.

2.3 Laboratory Analysis

All sample analyses were conducted by using validated analytical methodologies, as described in the ENVIRON Air Sampling Protocol (ENVIRON 2001a).

Samples were analyzed for glycols using a variation of NIOSH Method 5523, which involves the use of a gas chromatograph with a flame ionization detector (GC/FID). The NIOSH Method 5523 was extended to a validated level of quantification (LOQ) of 5.0 to 30.0 micrograms (μg) of each individual glycol per sample.

2.4 Time-and-Distance Monitoring Procedure

To measure the levels of glycol present during various exposure concentrations, the electronic cigarette was operated to mimic potential use during the Broadway production. A series of actions (similar to sucking on a straw) mimicked weak, medium, and strong drags on the electronic cigarette. The drags were immediately followed by steady exhalation to generate various exposure concentrations. A second series of actions mimicked medium and strong drags on the electronic cigarette, immediately followed by slow or fast exhalation to generate various exposure concentrations. We have assumed that Actors are not deeply inhaling the smoke as they use the cigarette prop or taking rapid consecutive drags. The tripod assembly was placed within one foot of the smoke release point during exhalation. The aerosol monitor collected logged data on the smoke levels as the concentrations gradually dissipated.

3 Results and Discussion

3.1 Aerosol Monitor Calibration

Total glycol concentrations were calculated from the analytical data. Only the glycol species detected in the air samples were included. To develop a calibration curve for each glycol fluid, the average aerosol monitor readings during the period of time in which air was drawn through the OVS trap for each air sample were calculated and plotted against the total glycol concentration data.

The glycol calibration curve for the electronic cigarette tested is shown in Figure 1. First order regression curve is also shown on this figure. The calibration factor, calculated from the slope of the regression, is summarized in Table 1.

Table 1: Summary of Calibration Factors

Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor
NewRuleFX	Electronic Actor Cigarette Prop	Cartridge Fluid	Glycol	0.44

3.2 Use of Calibration Factors

The real-time aerosol monitor readings can be converted to glycol concentrations using the appropriate calibration factor for the fluid, as follows:

$$CONC = C \times PDR$$

where:

CONC = air concentration of total glycols, mg/m^3

C = aerosol monitor calibration factor (mg/m^3)/ (mg/m^3 aerosol)

PDR = aerosol monitor reading, mg/m^3 aerosol

For example, an uncalibrated reading of 100 mg/m^3 on the aerosol monitor would correspond to a glycol concentration of 44 mg/m^3 for the Electronic Actor Cigarette Prop with Cartridge Fluid. These calculated concentrations can then be compared with the peak guidance levels. The peak guidance level for glycols of 40 mg/m^3 would correspond to an uncalibrated aerosol monitor reading of 90.9 mg/m^3 for the Electronic Actor Cigarette Prop with Cartridge Fluid.

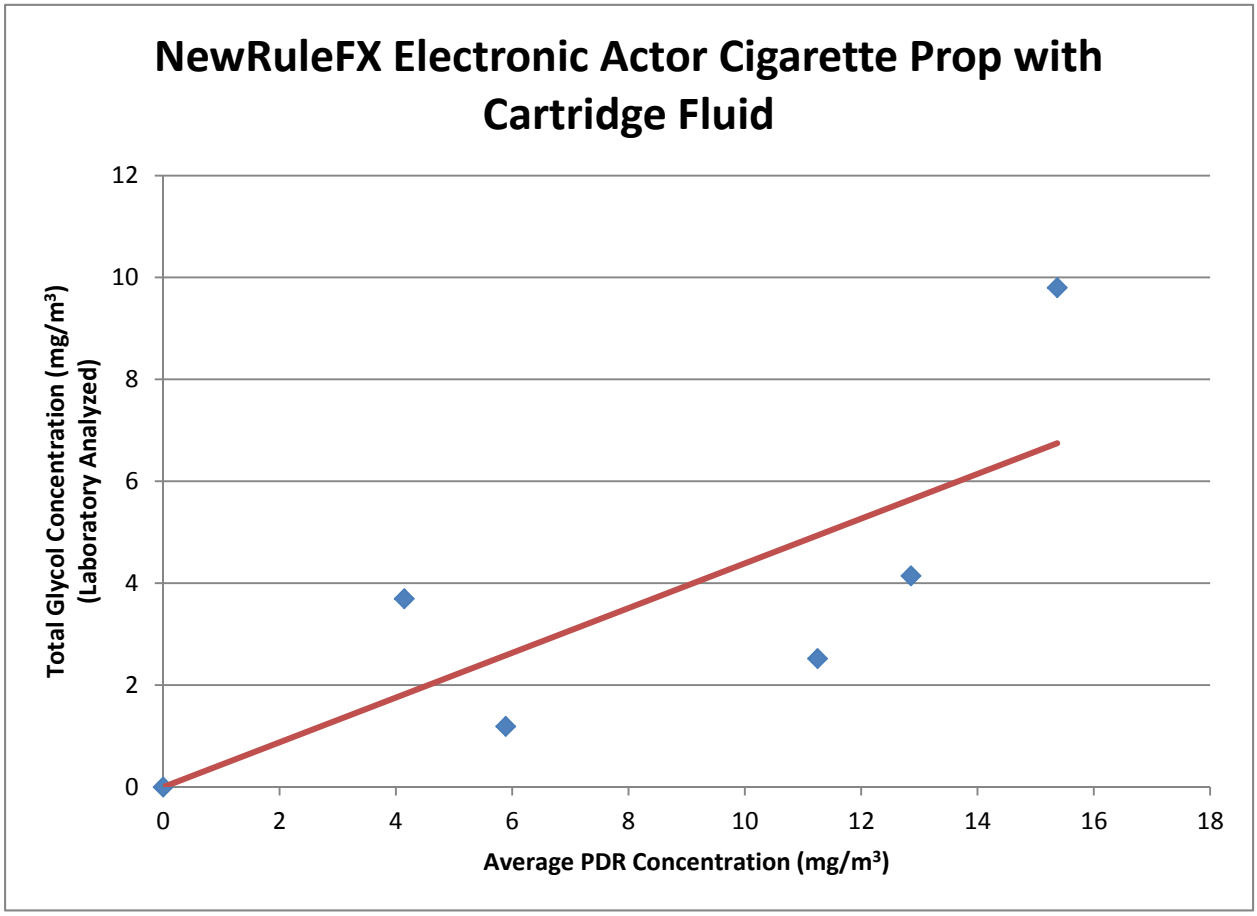


Figure 1. Calibration curve for the NewRuleFX Electronic Actor Cigarette Prop with Cartridge Fluid. Calibration factor, based on slope of curve, is 0.44 (mg/m^3 glycol)/ (mg/m^3 aerosol).

3.3 Time-and-Distance Guidelines

ENVIRON measured the glycol concentration at a distance of one foot, monitoring how the concentration dissipated with time following weak, medium, and strong drags on the electronic cigarette prior to medium steady exhalation. ENVIRON took a second set of concentration dissipation measurements using medium and strong drags on the electronic cigarette followed by slow or fast exhalation. Based on the simulated actions to mimic cigarette smoking, weak or medium drags on the electronic cigarette prior to medium steady exhalation, as well as medium drags prior slow or fast exhalation and strong drags prior to slow exhalation, did not produce an exceedance of the guidance levels within the breathing zone. Table 2 provides the average time (in seconds) after the end of the cue release after which the glycol concentrations will have fallen below the guidance levels. Thus, in order to prevent peak exposures to actors, strong drags taken on the electronic cigarette should not be exhaled at medium or rapid speeds.

It should be reiterated that the Time-and-Distance Guidelines provided in Table 2 is intended to allow a production to use the NewRuleFX Electronic Actor Cigarette Prop without conducting monitoring. However, these Guidelines may not be appropriate for all productions. Table 2 is

based on the use of the electronic cigarette with weak, medium, or strong drags prior to exhalation or medium or strong drags prior to slow or fast exhalation.

Productions may want to use different configurations for positioning the actors (e.g., multiple actors smoking), or provide on-stage ventilation. In addition, many productions may have other stage-specific conditions (e.g., on-stage activities and props that enhance dispersion) that would allow actors to be present in areas that are restricted under these Guidelines but which, in fact, do not exceed the guidance levels. In those cases, production-specific monitoring would be recommended to evaluate whether peak exposure may occur.

TABLE 2
Summary of Time-and-Distance Guidelines for Fog Generation
NewRuleFX Electronic Actor Cigarette Prop Cartridge Fluid

Strength of drag	Speed of exhale	Average time (in sec) after which air concentrations are below Guidance Level (40 mg/m^3) at a distance of 1 ft.
Weak	Medium	0
Medium	Medium	0
Strong	Medium	10
Medium	Slow	0
Medium	Fast	0
Strong	Slow	0
Strong	Fast	30

4 References

ENVIRON International Corporation (ENVIRON). 2001a. Evaluation of short-term exposures to theatrical smoke and haze: Air sampling protocol. Prepared for Equity-League Pension and Health Trust Funds. May 14.

ENVIRON International Corporation (ENVIRON). 2001b. Theatrical Haze and Fog Testing for Mamma Mia!, Winter Garden Theatre. Prepared for Mamma Mia! Broadway and Nina Lannan Associates. November 12.

Mount Sinai School of Medicine and ENVIRON International Corporation (Mt. Sinai and ENVIRON). 2000. Health effects evaluation of theatrical smoke, haze, and pyrotechnics. Prepared for Equity-League Pension and Health Trust Funds. June 6.

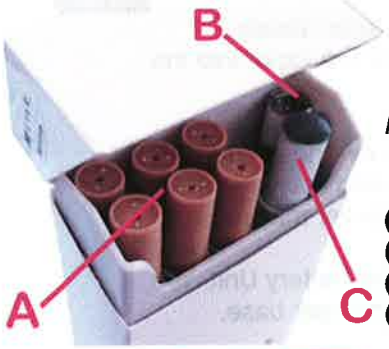
National Institute for Occupational Safety and Health (NIOSH). 1996. Method 5523: Glycols, Issue 1. NIOSH Manual of Analytical Methods (NMAM). Fourth Edition. May 15.

Pendergrass, S.M. 1999. Determination of glycols in air: Development of sampling and analytical methodology and application to theatrical smokes. AIHA Journal, 60:452-457.

Appendix A:
Technical Specifications

Actor CIGARETTE

Prop Kit Assembly & Usage Instructions



—AVOID DAMAGE—READ PRIOR TO USE—

Familiarize yourself with the main components of the prop kit:

(A) 6 Vapor Cartridge Refills
(B) Atomizer Unit —note direction it is stored in the box.
(C) Battery Unit - (screwed into charger base)
(D) Charger Base/Storage case

(E) Perforated slide switch access

(F) AC Plug Prongs
(G) LED indicator Light

To Use Your Actor Cigarette Kit

Fully charge before first use.

Invert charger/storage box and find perforated rectangle (E). Carefully remove perforated section to access the AC 110v. charging plugs (F). Depress and slide the charger plug out so the plugs extend from the side of the charger base. Plug the kit into a standard AC 110volt outlet and allow to charge.

The LED indicator (G) on the front of the box will glow to indicate the charging status.

- **SOLID RED** indicates the battery is still being charged.
- **SOLID GREEN** indicates the battery is fully charged and ready for use.

Once fully charged, remove the Atomizer Unit (B) from it's storage position. Gently unscrew Battery Unit (C) to remove from charger base (D).

Gently screw the Atomizer Unit (B) onto the Battery Unit (C). Do not over-tighten. The Vapor Cartridge (A) that is pre-installed is a usable cartridge that was installed for quality testing prior to being shipped, it may be used until depleted or you may replace it. It may not perform to the full capacity of the six fresh Vapor Cartridges (A)

To replace the Vapor Cartridge(A) grasp the shaft of the Battery Unit (C) and the end of the Vapor Cartridge and pull straight apart. This is a friction fit. When installing a new cartridge, gently slide the Vapor Cartridge onto the Atomizer Unit. The metal heater tip will pierce the foil seal in the new Vapor Cartridge.

To avoid damage to the delicate vaporizer assembly:
DO NOT twist the cartridge.
DO NOT touch or impact the vaporizer assembly.

Once the prop is assembled you may now use it. Draw in slow, steady breaths, then exhale the vapor. It is not necessary to inhale the vapor into the lungs to produce a convincing smoking effect.

TIP: Repeated constant use will cause the unit to overheat. Give the device a chance to cool down between breaths. Rapid cycling may cause the system to shut off. If the unit is overheated, permanent damage to the vaporizer may occur.

When finished using the prop. Carefully unscrew the Vaporizer Unit from the Battery Unit. You may leave the cartridge installed. GENTLY screw the Battery Unit into the charger base. Replace the atomizer into the storage case with the threaded insert UP.

Do not attempt to place the Atomizer Unit into the storage case threaded side down. Doing so will jam the Atomizer Unit into the case and you will damage the atomizer trying to remove it.

Following these instructions should allow your prop to function for a great deal of time. Replacement cartridges are available online at NewRuleFX.com

TROUBLESHOOTING

Charger Light BLINKING RED indicates an error with the battery unit, no battery installed in the charger unit, or incorrectly installed in the charger. If battery is correctly installed and unit still blinks red, the battery has reached the end of pits serviceable life and must be replaced.

Cigarette Battery Unit Tip LED Blinking. The battery is low or depleted. Charge Battery Unit.

LED on tip glows, but no smoke is produced. Cartridge is depleted or foil from cartridge is jamming heater tip. Replace Vapor Cartridge with fresh one, be sure there is nothing obstructing the heater tip on the Vaporizer. If this does not fix the issue the Vaporizer heater system may have been damaged.

Appendix B:
List of Ingredients

ActorCigarette.com Smoking Prop Vapor Cartridge Ingredient List

	INGREDIENTS	CONTENT
1	VANILLA EXTRACT	<2%
2	MENTHOL	<2%
3	MINT OIL	<2%
4	2, 3, 5-TRIMETHYLPYRAZINE	<0.5%
5	2, 3, 5, 6-TETRAMETHYLPYRAZINE	<0.5%
6	2, 5-DIMETHYLPYRAZINE	<0.5%
7	2-ACETYLPYRAZINE	<0.5%
8	2-METHYL BUTYRIC ACID	<1%
9	A-TERPINEOL	<0.5%
10	ETHYL MALTOL	<0.5%
11	GUAIACOL	<0.5%
12	2-ACETYL PYRIDINE	<0.5%
13	PURE WATER	<3%
14	PROPYLENE GLYCOL	>60%

Appendix C:
Summary Sheet

Calibration Factor and Time-and-Distance Guidelines

NewRuleFX Electronic Actor Cigarette Prop with Cartridge Fluid

Prepared for New Rule Productions, Inc. by ENVIRON International Corporation

ENVIRON developed calibration factors and Time-and-Distance guidelines for the NewRuleFX Electronic Actor Cigarette Prop.

The cartridge fluid for the Actor Cigarette is a glycol-based fog fluid. Calibration factors were developed to allow a Thermo Scientific PDR-1000 aerosol monitor to be used to measure concentrations glycols in the air after being released from the Actor Cigarette.

The measured concentrations should be compared against the peak exposure guidance level for glycols, which is 40 mg/m^3.

The calibration curve for glycols is shown below:

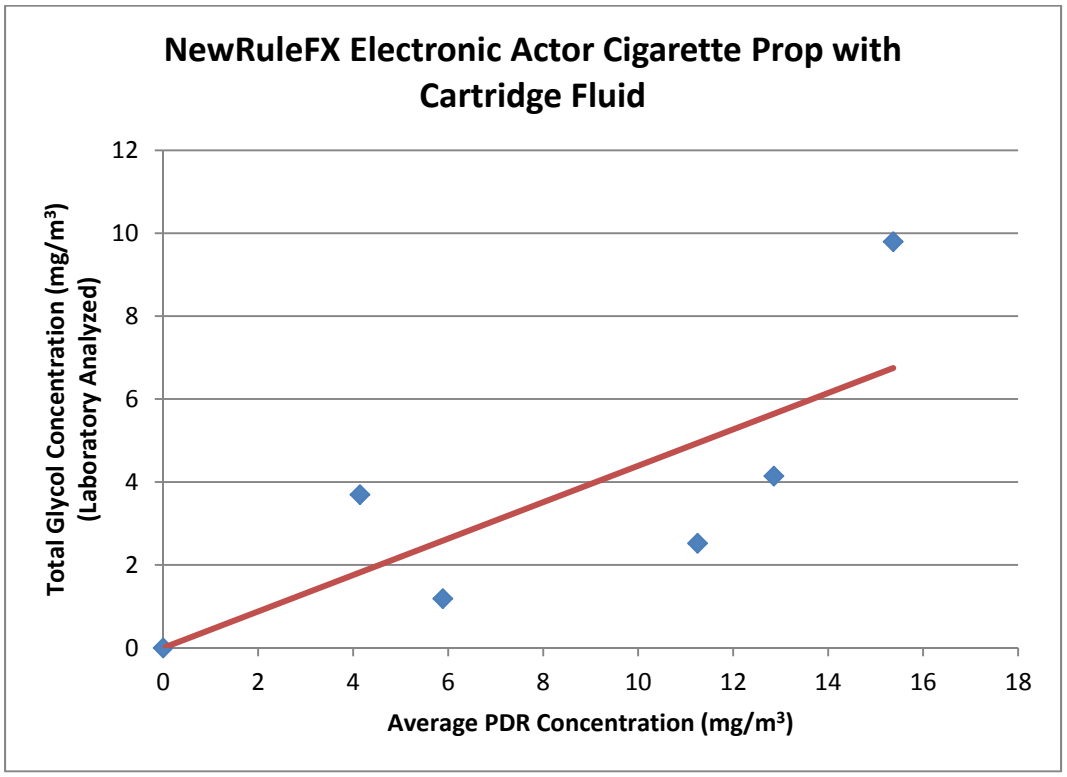


Figure 1. Calibration curve for the NewRuleFX Electronic Actor Cigarette Prop with Cartridge Fluid. Calibration factor, based on slope of curve, is 0.44 (mg/m^3 glycol)/ (mg/m^3 aerosol).

Summary of Calibration Factor				
Manufacturer	**Machine**	**Fluid**	**Fluid Type**	**Calibration Factor**
NewRuleFX	Electronic Actor Cigarette Prop	Cartridge Fluid	Glycol	0.44

Time and Distance Guidelines. ENVIRON measured the glycol concentration at a distance of one foot, monitoring how the concentration dissipated with time following weak, medium, and strong drags on the electronic cigarette prior to medium steady exhalation. ENVIRON took a second set of concentration dissipation measurements using medium and strong drags on the electronic cigarette followed by slow or fast exhalation. Based on the simulated actions to mimic cigarette smoking, weak or medium drags on the electronic cigarette prior to medium steady exhalation, as well as medium drags prior slow or fast exhalation and strong drags prior to slow exhalation, did not produce an exceedance of the guidance levels within the breathing zone.

The following table provides the average time (in seconds) after the end of the cue release after which the glycol concentrations will have fallen below the guidance levels. Thus, in order to prevent peak exposures to actors, strong drags taken on the electronic cigarette should not be exhaled at medium or rapid speeds.

Summary of Time-and-Distance Guidelines for Fog Generation NewRuleFX Electronic Actor Cigarette Prop Cartridge Fluid		
Strength of drag	**Speed of exhale**	**Average time (in sec) after which air concentrations are below Guidance Level (40 mg/m^3) at a distance of 1 ft.**
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Medium	Medium	0
Strong	Medium	10
Medium	Slow	0
Medium	Fast	0
Strong	Slow	0
Strong	Fast	30

It should be reiterated that the Time-and-Distance Guidelines provided above are intended to allow a production to use the tested equipment and fluid combinations without conducting monitoring. However, these Guidelines may not be appropriate for all productions. Productions may want to use different configurations for positioning the actors (e.g., multiple actors smoking), or provide on-stage ventilation. In addition, many productions may have other stage-specific conditions (e.g., on-stage activities and props that enhance dispersion) that would allow actors to be present in areas that are restricted under these Guidelines but which, in fact, do not exceed the guidance levels. In those cases, production-specific monitoring would be recommended to evaluate whether peak exposure may occur.