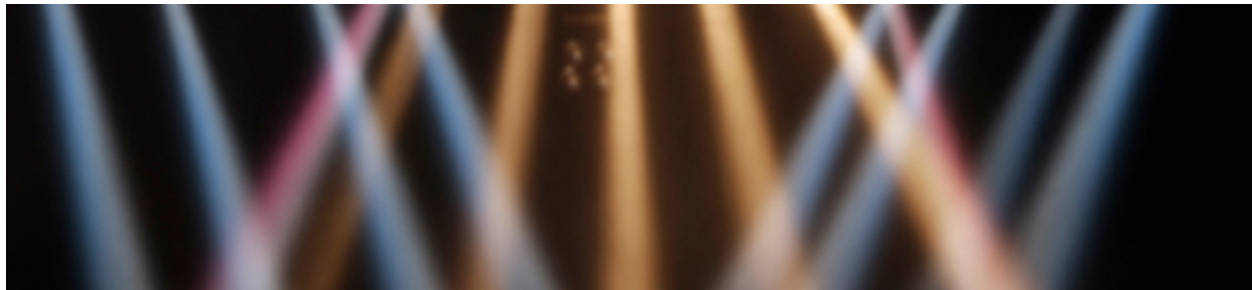




Theatrical Smoke, Fog and Haze Testing: Calibration Factors

Ramboll Environ (formerly ENVIRON) collected the original exposure measurements on which the guidance levels for theatrical smoke and haze testing are based, and developed the air sampling protocol recommended by the Actors' Equity Association. As such, we are uniquely qualified to provide testing services and documentation that would be responsive to any inquiries made by Equity or your cast.



Ramboll Environ has developed a protocol for using a Thermo Scientific PDR-1000AN aerosol monitor to measure concentrations of theatrical smoke, fog and haze. The monitor measures the light scattering produced by particles in the air and reports the results in terms of mass concentration (milligrams per cubic meter, or mg/m^3) with the assumption that the particles in the air are a fine dust. Because different types of particles have different light scattering properties, the readings from the monitor need to be adjusted (or calibrated) when measuring something other than dust (such as fog droplets). The user converts the dust readings to the correct mg/m^3 readings for the fog droplets by multiplying the dust readings by a *calibration factor* for the particular fog fluid/fog machine combination being used for the fog, smoke or haze effect.

The following calibration factors have been developed and approved by Actors' Equity Association and the Broadway League for use in measuring theatrical smoke, fog and haze:

Approved Calibration Factors for Monitoring Theatrical Smoke, Fog, and Haze (updated September 2015)					
Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor	Reference
American DJ (ADJ)	Fog Fury 3000	Froggy's Fog Backwood Bay	glycol	0.39	(35)
		Froggy's Fog Bog Fog	glycol	1.62	(35)
		Froggy's Fog Cryo Freeze	glycol	0.64	(35)
		Froggy's Fog Quick Blast	glycol	0.64	(35)
		Froggy's Fog Velocity	glycol	0.64	(35)
	Fog Storm 1700 HD	Froggy's Fog Cryo Freeze	glycol	2.67	(35)
		Froggy's Fog Quick Blast	glycol	2.67	(35)
Antari	1520 RGB Upshot	Froggy's Fog Quick Blast	glycol	1.28	(35)
	DNG-200	Froggy's Fog Cryo Freeze	glycol	4.99	(35)
	F-5/F-5D Fazer	Froggy's Fog Faze Haze	glycol	0.69	(35)
	ICE	Froggy's Fog Cryo Freeze	glycol	2.54	(35)
	M-5	Froggy's Fog Amusement Park Fluid	glycol	1.41	(35)
		Froggy's Fog Backwood Bay	glycol	1.41	(35)
		Froggy's Fog Bog Fog	glycol	1.03	(35)
		Froggy's Fog Cryo Freeze	glycol	1.74	(35)
	Froggy's Fog Quick Blast	glycol	1.74	(35)	

Approved Calibration Factors for Monitoring Theatrical Smoke, Fog, and Haze (updated September 2015)					
Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor	Reference
	M-8	Froggy's Fog Velocity	glycol	1.74	(35)
		Froggy's Fog Amusement Park Fluid	glycol	1.35	(35)
		Froggy's Fog Backwood Bay	glycol	1.35	(35)
		Froggy's Fog Bog Fog	glycol	1.29	(35)
		Froggy's Fog Cryo Freeze	glycol	2.65	(35)
		Froggy's Fog Quick Blast	glycol	2.65	(35)
		Froggy's Fog Velocity	glycol	2.65	(35)
	M-10	Froggy's Fog Bog Fog	glycol	2.62	(35)
		Froggy's Fog Cryo Freeze	glycol	2.46	(35)
		Froggy's Fog Quick Blast	glycol	2.46	(35)
		Froggy's Fog Velocity	glycol	2.46	(35)
	Antari X-515	Froggy's Fog Amusement Park Fluid	glycol	1.07	(35)
		Froggy's Fog Backwood Bay	glycol	1.07	(35)
		Froggy's Fog Bog Fog	glycol	1.43	(35)
		Froggy's Fog Cryo Freeze	glycol	1.74	(35)
		Froggy's Fog Quick Blast	glycol	1.74	(35)
		Froggy's Fog Velocity	glycol	1.74	(35)
Z-350	Froggy's Fog Beam Splitter	glycol	1.90	(35)	
Barco / High End Systems	F-100	Atmosphere HQ Fluid	glycol	1.21	(10)
		Atmosphere Cold Flow Formula	glycol	2.41	(1)
		Atmosphere Stage Formula	glycol	0.25	(1)
	FQ-100	Atmosphere HQ Fluid	glycol	1.30	(26)
		Atmosphere Stage Formula	glycol	0.96	(26)
Blue Haze Entertainment (BHE)	1550	Froggy's Fog Amusement Park Fluid	glycol	1.07	(35)
		Froggy's Fog Backwood Bay	glycol	1.07	(35)
		Froggy's Fog Bog Fog	glycol	1.43	(35)
		Froggy's Fog Cryo Freeze	glycol	1.74	(35)
		Froggy's Fog Quick Blast	glycol	1.74	(35)
		Froggy's Fog Velocity	glycol	1.74	(35)
Chauvet	1800 FLEX	Froggy's Fog Amusement Park Fluid	glycol	1.00	(35)
		Froggy's Fog Backwood Bay	glycol	1.00	(35)
		Froggy's Fog Beam Splitter	glycol	2.94	(35)
		Froggy's Fog Bog Fog	glycol	1.07	(35)
		Froggy's Fog Cryo Freeze	glycol	0.76	(35)
		Froggy's Fog Quick Blast	glycol	0.76	(35)
		Froggy's Fog Velocity	glycol	0.76	(35)
	AmHaze II	Froggy's Fog Faze Haze	glycol	0.83	(35)
	Geyser	Froggy's Fog Quick Blast	glycol	1.62	(35)
CITC	AquaMax	Organic Haze Fluid	glycerol	1.36	(33)
	Fantasy FX spray can	Fantasy FX Professional Haze	mineral oil	0.87	(20)
	Fog Max	Natural Fogging Fluid	glycol	0.66	(4)
	HazeMax	Water Vapor Haze Fluid	glycerol	1.87	(33)
	Starhazer	High Performance Fluid	mineral oil	0.87	(4)
ePuffer	D-1500 Electronic Cigar**	e-Liquid	glycol	1.04	(30)

Approved Calibration Factors for Monitoring Theatrical Smoke, Fog, and Haze (updated September 2015)					
Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor	Reference
FireBase	SG-1300	Froggy's Fog Training Smoke FR-Fire Rescue Formula	glycol	0.58	(35)
		Froggy's Fog Training Smoke Q-Quick Dissipating	glycol	1.69	(35)
		Froggy's Fog Training Smoke XD-Extreme Density	glycol	0.86	(35)
	SG-2600	Froggy's Fog Training Smoke FR-Fire Rescue Formula	glycol	0.99	(35)
		Froggy's Fog Training Smoke XD-Extreme Density	glycol	3.11	(35)
	SG-M1500	Froggy's Fog Training Smoke FR-Fire Rescue Formula	glycol	1.41	(35)
		Froggy's Fog Training Smoke Q-Quick Dissipating	glycol	1.74	(35)
		Froggy's Fog Training Smoke XD-Extreme Density	glycol	1.03	(35)
	SG-M1800	Froggy's Fog Training Smoke FR-Fire Rescue Formula	glycol	1.35	(35)
		Froggy's Fog Training Smoke Q-Quick Dissipating	glycol	2.65	(35)
		Froggy's Fog Training Smoke XD-Extreme Density	glycol	1.29	(35)
	SG-M3000	Froggy's Fog Training Smoke Q-Quick Dissipating	glycol	2.46	(35)
		Froggy's Fog Training Smoke XD-Extreme Density	glycol	2.62	(35)
	hazebase	Base Classic	Froggy's Fog Amusement Park Fluid	glycol	0.58
Froggy's Fog Backwood Bay			glycol	0.58	(35)
Froggy's Fog Bog Fog			glycol	0.86	(35)
Froggy's Fog Cryo Freeze			glycol	1.69	(35)
Froggy's Fog Quick Blast			glycol	1.69	(35)
Base Hazer Pro		Froggy's Fog Velocity	glycol	1.69	(35)
		Base Hazer Liquid	glycol	0.43	(35)
Base High Power 220V		Froggy's Fog Faze Haze	glycol	0.76	(35)
		Froggy's Fog Backwood Bay	glycol	0.99	(35)
		Froggy's Fog Bog Fog	glycol	3.11	(35)
Le Maitre Ltd.	G300	Molecular Fog Fluid	glycol	0.53	(4,24,25)
		Quick Dissipating	glycol	2.65	(4,24,25)
		Regular Haze (C-Beam) Fluid	glycerol	0.09	(10,24,25)
		Standard Smoke Fluid	glycol	0.30	(4,9,24,25)
	G300/LSG/Freezefog Pro or equivalent chiller	Molecular Fog Fluid	glycol	4.95*	(7,25,28)
	G-Force	Molecular Fog Fluid	glycol	0.53	(4,24,28)
		Quick Dissipating	glycol	2.65	(4,24,28)
		Standard Smoke Fluid	glycol	0.30	(4,9,24,25)
	G-Force/LSG/Freezefog Pro or equivalent chiller	Molecular Fog Fluid	glycol	4.95*	(7,25,28)
	Mini Mist	Standard Smoke Fluid	glycol	2.24	(10,25)
	MVS	Froggy's Fog Neutronic Haze Fluid	glycerol	0.35	(35)
	Neutron XS	Froggy's Fog Neutronic Haze Fluid	glycerol	0.09	(35)
		Neutron Haze Fluid	glycerol	0.12	(2,25)
	Opti Mist Ranger	Mini Mist Canister	glycol	3.01	(1,25)

Approved Calibration Factors for Monitoring Theatrical Smoke, Fog, and Haze (updated September 2015)					
Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor	Reference
Look Solutions	Cryo-Fog	Cryo-Fog Fluid	glycol	0.91	(16,21)
	Orka	Regular-Fog Fluid	glycol	0.23	(8)
	Power Tiny	Tiny Fluid	glycol	0.49	(15)
	Tiny Compact/Tiny C07	Tiny Fluid	glycol	0.76	(4,21)
	Tiny Fogger/Tiny F07	Tiny Fluid	glycol	0.76	(4,21)
	Tiny FX/Tiny CX	Tiny Fluid	glycol	0.71	(31,37)
	Tiny S	Tiny Fluid	glycol	0.69	(31)
	Unique/Unique2 Hazer	Unique Fluid	glycol	0.30	(4,12)
	Viper II (NT)	Quick-Fog Fluid	glycol	2.02	(17)
		Regular-Fog Fluid	glycol	1.46	(4,12)
Slow-Fog Fluid		glycol	0.90	(31)	
Viper II/ LSG MKII or equivalent chiller	Quick-Fog Fluid	glycol	0.89	(32)	
Martin Professional	Jem Compact Hazer Pro	Jem C+ Fluid	glycol	0.70	(38)
	Jem Glaciator	Jem B2 Heavy Fog Fluid	glycol	3.41	(4)
	Jem Glaciator X-Stream	Jem C3 Heavy Fog Fluid	glycol	3.23	(23)
	Jem Hazer Pro	Jem C+ Fluid	glycol	0.88	(38)
	Jem Ready 365	Jem R365 Haze Fluid	glycol & glycerol	0.24	(38)
	Jem Roadie	Jem Pro-Smoke Super ZR Fluid	glycol	0.62	(27)
	Jem ZR12-DMX	Jem Pro-Smoke Super Fluid	glycol	1.12	(4)
	Jem ZR24/7 Hazer	Jem Pro-Haze Fluid	glycol	0.76	(5)
	Jem ZR33 Hi-Mass	Froggy's Fog Cryo Freeze	glycol	2.20	(35)
		Froggy's Fog Quick Blast	glycol	2.20	(35)
		Froggy's Fog Velocity	glycol	2.20	(35)
		Jem Pro-Smoke Super Fluid	glycol	0.79	(23)
		Jem ProSteam Simulation Fluid	glycol	2.31	(23)
	Jem ZR44	Froggy's Fog Backwood Bay	glycol	0.77	(35)
		Froggy's Fog Bog Fog	glycol	1.40	(35)
		Froggy's Fog Cryo Freeze	glycol	0.95	(35)
		Froggy's Fog Quick Blast	glycol	0.95	(35)
		Froggy's Fog Velocity	glycol	0.95	(35)
	K-1	Froggy's Fog K-razy Haze	glycol	0.49	(35)
	Magnum 2000	Froggy's Fog Backwood Bay	glycol	0.93	(35)
		Froggy's Fog Bog Fog	glycol	1.21	(35)
		Froggy's Fog Cryo Freeze	glycol	1.01	(35)
		Froggy's Fog Quick Blast	glycol	1.01	(35)
		Froggy's Fog Velocity	glycol	1.01	(35)
	Magnum 2500Hz	Jem Pro-Haze Fluid	glycol	0.28	(23)
	MDG Fog Generators	Mini-Max	MDG Dense Fluid	glycol	3.21
Atmosphere APS		MDG Neutral Fluid	mineral oil	0.78	(1)
MAX 3000 APS		MDG Neutral Fluid	mineral oil	0.78	(1)
MDG MAX 3000 APS through accumulator box		MDG Neutral Fluid	mineral oil	0.27	(6)
New Rule FX	Electronic Actor Cigarette Prop**	Cartridge Fluid	glycol	0.44	(36)
Pure Smoke	Electronic Cigarette**	Electronic Cigarette Flavors	glycol	0.33	(29)
Reel EFX, Inc.	DF-50	Diffusion Fluid	mineral oil	0.78	(1)
		Froggy's Fog DaFiddy Oil-Based Haze	mineral oil	0.40	(35)
		Master Fog DEE-EFF-50	mineral oil	0.37	(40)
Robe	Fog 1550 FT	Froggy's Fog Amusement Park Fluid	glycol	1.07	(35)
		Froggy's Fog Backwood Bay	glycol	1.07	(35)
		Froggy's Fog Bog Fog	glycol	1.43	(35)
		Froggy's Fog Cryo Freeze	glycol	1.74	(35)
		Froggy's Fog Quick Blast	glycol	1.74	(35)

Approved Calibration Factors for Monitoring Theatrical Smoke, Fog, and Haze (updated September 2015)					
Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor	Reference
		Froggy's Fog Velocity	glycol	1.74	(35)
Rosco Laboratories	1500 / 1600	Rosco Clear Fog Fluid	glycol	1.82	(1)
		Rosco Fog Fluid	glycol	1.27	(1)
		Rosco Light Fog Fluid	glycol	1.38	(1)
		Rosco Stage & Studio Fluid	glycol	1.56	(1)
	1750	Rosco Fog Fluid	glycol	0.58	(19)
		Rosco Stage & Studio Fluid	glycol	0.67	(19)
	Alpha 900	Rosco Clear Fog Fluid	glycol	1.82	(1)
		Rosco Fog Fluid	glycol	1.27	(1)
		Rosco Light Fog Fluid	glycol	1.38	(1)
		Rosco Stage & Studio Fluid	glycol	1.56	(1)
	Delta 3000	Rosco Clear Fog Fluid	glycol	1.43	(4)
		Rosco Fog Fluid	glycol	1.00	(4)
		Rosco Light Fog Fluid	glycol	1.35	(4)
		Rosco Stage & Studio Fluid	glycol	1.97	(4)
	Delta Hazer	Rosco Delta Hazer Fluid	glycol	0.71	(18)
	Mini-V	Rosco Fog Fluid	glycol	0.55	(34)
		Rosco Stage & Studio Fluid	glycol	0.85	(34)
	PF-1000	Rosco Clear Fog Fluid	glycol	1.82	(1)
		Rosco Fog Fluid	glycol	1.27	(1)
		Rosco Light Fog Fluid	glycol	1.38	(1)
Rosco Stage & Studio Fluid		glycol	1.56	(1)	
V-Hazer	Rosco V-Hazer Fluid	glycol	0.68	(34)	
Vapour	Rosco Fog Fluid	glycol	0.44	(34)	
	Rosco Stage & Studio Fluid	glycol	0.85	(34)	
Vapour Plus	Rosco Fog Fluid	glycol	0.82	(34)	
	Rosco Stage & Studio Fluid	glycol	0.78	(34)	
SFX Design	Fog Master FM-1	AquaFog Fluid	glycol	0.19	(3)
Smoke Factory	Tour Hazer	Tour Hazer Fog Fluid	glycol	0.30	(4)
Smoke In Style	Electronic Pipe Prop**	FeelLife E-Liquid	glycol & glycerol	0.42	(39)
Ultratec Special Effects (fka Le Maitre Special Effects)	G100	Directors Choice	glycol	4.17	(1,9,25)
		Extra Quick Dissipating	glycol	3.17	(1,25)
		Quick Dissipating	glycol	3.45	(1,25)
	G150	Directors Choice	glycol	4.17	(1,9,25)
		Extra Quick Dissipating	glycol	3.17	(1,25)
		Molecular Fog Fluid	glycol	2.58	(1,25)
		Pro Beam (Long Lasting)	glycol	1.42	(4,25)
		Quick Dissipating	glycol	3.45	(1,25)
	G3000	Directors Choice	glycol	0.30	(4,9,24,25)
		Molecular Fog Fluid	glycol	0.53	(4,24,25)
		Pro Beam (Long Lasting)	glycol	0.67	(4,24,25)
		Quick Dissipating	glycol	2.65	(4,24,25)
		Regular Haze Fluid	glycerol	0.09	(10,24,25)
		Froggy's Fog Amusement Park Fluid	glycol	1.07	(25,35)
		Froggy's Fog Backwood Bay	glycol	1.07	(25,35)
		Froggy's Fog Bog Fog	glycol	0.88	(25,35)
		Froggy's Fog Cryo Freeze	glycol	2.96	(25,35)
		Froggy's Fog Quick Blast	glycol	2.96	(25,35)
	Froggy's Fog Velocity	glycol	2.96	(25,35)	
	G3000/LSG or equivalent chiller	Molecular Fog Fluid	glycol	4.95*	(7,25)
	Power Fog Industrial (PFI) or PFI 9D	Directors Choice	glycol	0.99	(4,9,11,25)
		Molecular Fog Fluid	glycol	2.77	(4,11,25)
		Pro Beam (Long Lasting)	glycol	1.36	(4,11,25)
Quick Dissipating		glycol	1.37	(4,11,25)	
Power Fog Industrial 9D	Extra Quick Dissipating	glycol	1.23	(22,25)	

Approved Calibration Factors for Monitoring Theatrical Smoke, Fog, and Haze (updated September 2015)					
Manufacturer	Machine	Fluid	Fluid Type	Calibration Factor	Reference
	(PFI 9D) with LSG-MKII or equivalent chiller	Molecular Fog Fluid	glycol	0.75	(13,25)
		Quick Dissipating	glycol	0.21	(22,25)
	Radiance Hazer	Froggy's Fog Neutronic Haze Fluid	glycerol	1.06	(25,35)
		Neutron/Luminous 7 Haze Fluid	glycerol	0.26	(14,25)
	Show Fogger Pro	Directors Choice	glycol	0.44	(4,9,25)
		Pro Beam (Long Lasting)	glycol	0.44	(4,25)
		Quick Dissipating	glycol	2.56	(4,25)
	Stage Fogger DMX	Directors Choice	glycol	0.99	(4,9,25)
		Molecular Fog Fluid	glycol	2.77	(4,25)
		Pro Beam (Long Lasting)	glycol	1.36	(4,25)
		Quick Dissipating	glycol	1.37	(4,25)

Notes:

- * Due to monitor overloading during the calibration testing for this combination, the resulting calibration factor of 4.95 is known to be overestimated. This value can be used as a conservative (i.e., health protective) screening value. If monitoring results using this calibration factor result in exposures exceeding the guidance levels, it is recommended that additional testing to refine this calibration factor be conducted.
- ** Testing of e-cigarette and related products is limited to second hand exposure after being exhaled by the user; the initial amount inhaled directly from the product was not measured.

Disclaimer: This table does not represent an endorsement of any equipment-fluid combination by Ramboll Environ. Please note that the use of fluids in machines other than those recommended by the manufacturer is subject to the equipment manufacturer's terms and conditions.

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 32. *Theatrical Smoke and Haze Testing for The Lion King Gazelle Tour, Paramount Theater*, prepared by ENVIRON International Corporation for Disney Worldwide Services, Inc., March 2014.
 33. *Calibration Factors and Time-And-Distance Guidelines for Use of Theatrical Fog Equipment: Aquamax with Organic Haze Fluid and HazeMax with Water Vapour Haze Fluid*, prepared by ENVIRON International Corporation for CITC, August 2014.
 34. *Calibration Factors and Time-And-Distance Guidelines for Use of Theatrical Fog Equipment: Vapour with Rosco Stage & Studio Fluid, Vapour with Rosco Fog Fluid, Vapour Plus with Rosco Stage & Studio Fluid, Vapour Plus with Rosco Fog Fluid, Mini-V with Rosco Stage & Studio Fluid, Mini-V with Rosco Fog Fluid, and V-Hazer with V-Hazer Fluid*, prepared by ENVIRON International Corporation for Rosco Laboratories, May 2014.
 35. *Calibration Factors and Time-And-Distance Guidelines for Use of Theatrical Fog Equipment: Bog Fog/K-razy Haze/Training Smoke XD, Backwood Bay/Faze Haze/Training Smoke FR, Velocity/Cryo Freeze/Quick Blast/Training Smoke Q, Techno Fog/Beam Splitter, Neutronic Haze, DaFiddy, Swamp Juice 2009 Formula, Light Fog*, prepared by ENVIRON International Corporation for Froggy's Fog, December 2014.
 36. *Calibration Factors and Time-And-Distance Guidelines for Use of Theatrical Fog Equipment: New Rule FX Electronic Actor Cigarette Prop with Cartridge Fluid*, prepared by ENVIRON International Corporation for New Rule Productions Inc. and Foresight Theatrical, October 2014.
 37. Letter from Look Solutions to ENVIRON International Corporation regarding Tiny CX, December 12, 2014.
 38. *Calibration Factors for Use of Theatrical Fog Equipment: Jem Compact Hazer Pro with Jem C+ Fluid, Jem Hazer Pro with Jem C+ Fluid, Jem Ready 365 with R365 Haze Fluid*, prepared by ENVIRON International Corporation for Martin Professional, January 2015.
 39. *Environmental Testing of Theatrical Fog Equipment: Smoke In Style Electronic Pipe Prop with FeelLife E-Liquid*, prepared by Ramboll Environ, June 2015.
 40. *Environmental Testing of Theatrical Fog Equipment: Reel EFX DF-50 with Master Fog DEE-EFF-50 Fluid*, prepared by Ramboll Environ, September 2015.

Manufacturers:

Barco / High End Systems - <http://www.highend.com/products/effects/>
Crawford International Theatrical Corporation (CITC) - <http://www.citcfx.com/>
Froggy's Fog - <http://www.froggysfog.com/>
Le Maitre Ltd. - <http://www.lemaitreusa.com>
Look Solutions - <http://www.looksolutionsusa.com/products/machines/>
Martin Professional - <http://www.martin.com/productgroup/productgroup.asp?pg=jemsmoke>
Master Fog - <http://www.master-fog.com/>
MDG Fog Generators - <http://www.mdgfog.com/en/index.html>
New Rule FX - <http://www.newrulefx.com/>
Reel EFX - <http://www.reelefx.com/index.php?c=product.list>
Rosco Laboratories - <http://www.rosco.com/us/products/fog.cfm>
SFX Design, Inc. - <http://www.sfxdesigninc.com/>
Smoke Factory - http://www.smoke-factory.de/eng/sf_produkte.htm
Ultratec Special Effects, Inc. - <http://www.ultratecfx.com/>

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