Chameleon Technical Data Sheet

1. Sensitivity Data

The sensitivity of the Chameleon sensors was determined by exposing individual cassettes to a challenge agent for varying amounts of time. Observers were asked to view the cassettes and provide feedback as to when a color change was visible. The sensitivity was derived from the minimum exposure time needed for all observers to acknowledge a color change.

Table 1. Chameleon Cassette Sensitivity to Challenge Agents

Sensor	Challenge Gas	PEL[1]		½ IDLH[2]		Multiple IDLH	
		Concentration	Response Time	Concentration	Response Time	Concentration	Response Time
Acid / low pH	Hydrogen chloride	5 ppm	30 min.	25 ppm	5 min.	89 ppm	10 sec.
Base / high pH	Ammonia	50 ppm	3 min.	150 ppm	1 min.	247 ppm	10 sec.
Chlorine/Fluorine	Chlorine	1 ppm	25 min.	5 ppm	4 min.	28 ppm	12 sec.
Hydrogen Sulfide	Hydrogen sulfide	20 ppm	7 min.	50 ppm	3 min.	610 ppm	5 sec.
Iodine	Iodine	0.1 ppm	Under evaluation	1 ppm	5 min.	Under evaluation	
Phosgene	Phosgene	0.1 ppm	30 min.	1 ppm	5 min.	55 ppm	4 sec.
Phosphine	Phosphine	0.3 ppm	16 min.	25 ppm	2 min.	55 ppm	40 sec.
Sulfur Dioxide	Sulfur Dioxide	5 ppm	10 min	50 ppm	3 min.	109 ppm	55 sec.

[1] PEL means Permissible Exposure Limit, as defined by OSHA: "8-hour Time Weighted Average." An employee's exposure to any substance, which shall not exceed the 8-hour Time Weighted Average given for that substance, during any 8-hour work shift of a 40-hour workweek.

[2] IDLH means Immediately Dangerous to Life or Health: An atmospheric concentration of any toxic, corrosive or asphyxiate substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere. IDLH values are based on effects that might occur as a consequence of a 30-minute exposure.

2. Stability Data

An accelerated aging study was conducted to determine the shelf life of Chameleon sensors. The purpose of the study was to accelerate the effects of long-term storage in order to predict the shelf life at various temperatures. Individually packaged sensors were stored in a 60ºC oven and the performance was tested at regular intervals for response to a challenge agent. The results were correlated to results at 25ºC using the Q10 rule[3]. The accelerated aging results were verified by performing a real-time stability study at 23ºC. The results from these studies showed that the performance of each of the sensors was satisfactory for up to two years at room temperature, with the exception of the iodine, sulfur dioxide and phosphine sensors. The recently released iodine and sulfur dioxide sensors are currently being validated for a two-year shelf life. The approved shelf life of the phosphine sensor is 6 months.

Table 2. Accelerated Shelf-Life Study Results

Sensor	Stability Test Duration Temperature=60°C	Shelf Life @ 25°C
Acid / low pH	70 days	2 years
Base / high pH	70 days	2 years
Chlorine/Fluorine	70 days	2 years
Hydrogen sulfide	70 days	2 years
Iodine*	34 days	1 year
Phosgene	70 days	2 years
Phosphine*	17 days	6 months
Sulfur Dioxide*	33 days	1 year

*Stability results based on accelerated aging technique, real-time stability evaluation in progress

3. Service-Life Data

The following table summarizes the test conditions used to determine the service-life of each type of sensor. The sensors were stored under these conditions unpackaged. At the end of 24 hours, the samples were exposed to challenge agent and compared to unconditioned samples. The results indicate that the Chameleon sensors are fully functional for a minimum of 24 hours even under harsh environmental conditions.

[3] Q10 Rule: An accelerated aging technique based on assumptions that the chemical reactions involved in the deterioration of materials follow the Arrhenius function; for every 10 ºC increase in temperature, the reaction rate (or rate of degradation) doubles.

Table 3. Service-Life Test Parameters

Service-Life Condition	Temperature	Relative Humidity
Desert	50°C	20%
Tropical	50°C	95%
Arctic	-30°C	60%
Ambient	23°C	50%

4. Interference Test Results

Cassettes were exposed for one hour to static concentrations of toluene, N,N-diethyl-*m*-toluamide (DEET), bleach, diesel, jet fuel (JP-8) and gasoline. Following exposure to the field interferent, the sensors were exposed to the challenge agent and compared to controls.

Table 4. Field Interferent Study Observations

Field Interferent / Sensor	Toluene	DEET	Household Chlorine Bleach	Diesel Fuel	Gasoline	JP-8 Jet Fuel
Acid / Low pH	C	- Interference	False +	C	C	C
Base / High pH	C	C	C	C	C	C
Chlorine/Fluorine	C	C	C	C	C	C
Hydrogen Sulfide	C	C	C	C	C	C
Iodine	C	C	C	C	C	C
Phosgene	C	C	C	C	C	C
Phosphine	C	C	C	C	C	C
Sulfur Dioxide	C	C	C	C	C	C

*C – test complete, no interference *- interference – caused a 1 minute delay in exposure
*False + - visible color change in viewing window to light blue (bleaching)

5. Chameleon Water Immersion Testing

One hundred samples of each Chameleon sensor were immersed in salt water for a minimum of one hour. Following immersion, the cassettes were evaluated for any detrimental effects. The samples were then exposed to challenge agent and compared to control samples. The performance of the sensors was satisfactory and no effects from water immersion were noted.

6. Chameleon Oil/Fuel on Water Immersion Testing

Oil/Fuel mixture: Equal parts of commercial 10W-30 motor oil, gasoline, and diesel fuel were mixed and dispersed in salt water to form an oil/fuel on water system.

Procedure: Chameleon sensor cassettes in Chameleon armbands were immersed in the oil/fuel on water system at 10-minute intervals over a period of one hour (7 immersions total). Each immersion event consisted of three 10-second immersions through the film on water system followed by a resting period in air. The oil/fuel film on water was replenished following each immersion. The performance of the Chameleon when exposed to agent vapor challenge was evaluated relative to a control Chameleon system.

Cosmetic effects: No deleterious effects were noted on the performance of the cassette snap mechanism, the cassette and badge body labels, or the badge body materials.

Test conditions: Chameleon systems were challenged with 0.5 IDLH agent vapor concentrations at 70-80 %RH (22-23 ^{o}C).

Table5. Sensor Test Results – Oil/Fuel on Water Immersion

Cassette	Challenge agent (concentration)	Response time
Acid / Low pH	Hydrogen Chloride (25ppm)	30 seconds
Base / High pH	Ammonia (150ppm)	3 minutes
Chlorine/Fluorine	Fluorine (12.5ppm)	> 9 minutes
Hydrogen Sulfide	------ (50ppm)	3 minutes
Iodine	Currently under evaluation	
Phosgene	------ (1ppm)	3 minutes
Phosphine	Currently under evaluation	
Sulfur Dioxide	Currently under evaluation	

7. Chameleon Liquid Challenge Results

The following Chameleon sensors were challenged with solutions using two methods:

1. The cassettes were immersed in 100ml of each solution.
2. A drop of solution was applied to the back of the cassette.

The visible response time was the same for each method and can be found in the following table.

Table 6. Sensor Liquid Challenge Results

Chameleon Sensor	Solution Concentration (w/v)	Response Time (min.)
Acid / Low pH	7.4%	3min.
Base / High pH	0.004%	1min.
Chlorine/Fluorine	0.005%	3-4min.
Hydrogen Sulfide	0.4%	4-5min.
Iodine	0.002%	4min.

Solution Preparation

1. Acid/low pH sensor

A 100ml solution was prepared by diluting 20ml of a 37% stock solution of hydrochloric acid (HCl) with de-ionized water.

2. Iodine

An iodine solution was prepared by dissolving 0.0020g of iodine crystals in 100ml of de-ionized water.

3. Chlorine/Fluorine

The sensor was tested using 0.0049g of trichloro-s-triazinetrione (pool tablets, 90% available chlorine) dissolved in 100ml of de-ionized water.

4. Base/high pH sensor

A 39ppm solution of ammonium hydroxide in de-ionized water was prepared by adding 15µl of 29% stock solution to 100ml de-ionized water.

5. Hydrogen Sulfide

Hydrogen sulfide gas (6086ppm) was bubbled into 100ml of de-ionized for ~3 hours, resulting in a final solution concentration of 4100ppm (assuming saturation, solubility = 0.41g in 100ml water).