IMPORTANT INFORMATION ABOUT SIRAD® TECHNOLOGY WHICH USERS SHOULD KNOW

SIRAD is a completely new technology recently pioneered by JP Labs to monitor radiation exposure. Hence, it is not a fully developed, mature technology. It is being improved and optimized. We plan to provide as much information as possible – SIRAD's strengths and weaknesses, pluses and minuses, abilities and limitations, etc. In spite of our sincere efforts, it is not possible to provide every detail about SIRAD technology. In case there are any questions, we urge users to contact us in writing.

- **NOT A SUBSTITUTE:** SIRAD is not a substitute for electronic, X-ray film, TLD (Thermoluminescence Dosimeter) or OSL (Optically Stimulated Luminescence) dosimeters.

- **SENSITIVITY/ACCURACY:** The sensitivity and accuracy of SIRAD is considerably lower than electronic and other dosimeters used by occupational workers. The uncertainty in estimation of dose visually is ~20% (that also depends upon an individual's ability to compare colors and conditions, e.g., light and temperature used during estimation of dose). SIRAD is not a precision dosimeter and must not be used to measure accurate doses, even with equipment, such as spectrophotometers or CCD camera. **In a strict sense, SIRAD is an indicator for estimation of dose range rather than a precise dosimeter.**

- **Metamerism, color reference bars and color matching:** Two colored objects made from two different dyes or pigments may look the same under one light source, but different under another light source. This is known as metamerism. Radiated sensors display a strong metameric phenomenon, i.e., they display different colors under different light conditions, such as sunlight and that from fluorescent or incandescent bulbs. It is further complicated by the fact that the metamerism of radiated sensors change with color intensity. For example, the sensor radiated with 500 rads appears blue under fluorescent light, yet appears purplish under sunlight and incandescent light. It is difficult to reproducibly print color reference bars and it is virtually impossible to create color reference bars which can match the colors of radiated sensors at all dosages under all light conditions. Hence, dose must be estimated under normal fluorescent lights. The dose estimation under any other light conditions may not be accurate.

- **Thermochromism, color reference bars and color matching:** Another property of radiated diacetylenes is thermochromism. A material which displays two different colors at two different temperatures is known as thermochromic. Fortunately, these color changes are reversible. Creating color matching thermochromic bars which can match the colors of radiated sensors at all dosages at all temperatures is extremely difficult. Hence, dose must be estimated at room temperature. Dose estimation under any other temperatures may not be accurate.

- **Effect of UV light:** Diacetylenes are extremely sensitive to ultraviolet light, especially to short wavelength UV light. The unprotected coating of the diacetylenes used in SIRAD is so sensitive that it would develop a blue color equivalent to about tens of rads if exposed to direct summer sunlight in minutes. Diacetylenes used in SIRAD have low sensitivity to UV light. Additionally, we have (1) added UV absorbers in the formulation, (2) protected with films which are UV absorbing and (3) covered with a red protective cover/film which protects the badge from UV and visible light. Fluorescent lights also emit both long and short wavelength UV light. Exposure to UV light can provide a false positive. Hence, other than during reading the dosimeter, exposure to UV lights must be avoided. This is the reason why we added features such as red protective film to protect from UV/sunlight and FIT indicator for monitoring false positive.

- **Thermal annealing and limited service life:** Diacetylenes also develop color during storage (thermal annealing). The higher the temperature and the longer the time in storage, the darker the color. Color development depends upon the integral value of time and temperature, creating limited service life. We have added so called service life extenders to extend the service life of SIRAD. However, the service life of SIRAD is defined as the sensor acquiring color equivalent to half of the lower limit dose bar at room temperature. The service life was determined by extrapolating the data of samples annealed at different temperatures (e.g., 90, 80, 70 and 60^{o}C) to 25^{o}C. For example, the sensor of RADTriage-FIT would develop color equivalent to about one to two rad when stored for one year at room temperature in absence of all radiations. The service life will be reduced to six months at 38^{o}C/100^{o}F and to about one month at 60^{o}C/140^{o}F. The service life could be extended to almost ten years if kept frozen (e.g., -10^{o}C/14^{o}F). This allows SIRAD to be stockpiled at a lower temperature and used in emergencies.

- **Effect of High Temperature:** Diacetylene based sensors could undergo a significant change in sensitivity to radiation and/or service-life when heated above melting point of the diacetylene. The sensors will not monitor radiation when heated near or above their melting points (e.g., above 90^{o}C/194^{o}F for SIRAD sensors). If heated near or above the melting point and cooled to room temperature, depending upon the rate of cooling, the sensors could (1) remain insensitive to radiation or (2) could have different radiation sensitivity and service life depending upon many parameters, such as temperature and the rate of cooling. Under these conditions, the sensor could provide false positive or negative readings and/or lower service-life. Under direct sunlight, the temperature of a truck could exceed 55^{o}C/130^{o}F during shipping and 80^{o}C/176^{o}F near the dashboard of a car. Hence, the diacetylenes selected for SIRAD have a melting point above 90^{o}C. It is less likely that during normal use temperatures would exceed 90^{o}C. In order to monitor integral value of exposure to time and temperature (i.e., service life) and if temperature exceeds 90^{o}C, we have added FIT indicator in one SIRAD (RADTriage-FIT). If the temperature does exceed 90^{o}C the FIT indicator will indicate so, i.e., change from blue to red.

- ***Q. Why diacetylenes as sensors?:*** *Why do we use diacetylenes for the sensor if they have these problems of thermochromism, metamerism, sensitivity to UV light and temperature?*

  A. The main reason for selection of diacetylenes as sensing materials is because they have the highest sensitivity to ionization radiation (such as X-ray and gamma ray) next to developed silver halide grains (film used for X-ray imaging).

- **Diacetylenes used for SIRAD sensors:** Diacetylenes used in SIRAD were selected after evaluating over 200 different diacetylenes. We have diacetylene films significantly more sensitive than that used for the sensor. However, they had one problem or the other, e.g., low melting/inactivation temperature (e.g., 60^{o}C), high sensitivity to UV light, high thermal reactivity (shorter service life), energy dependency, higher post radiation effect or high effect of temperature of radiation. Diacetylenes selected for SIRAD sensors have many desired properties, e.g., high melting point, high X-/gamma ray reactivity, low thermal and UV reactivity and low effect of temperature of radiation and just a few undesired properties, such as metamerism and thermochromism.

- **LLD:** SIRAD dosimeters' lower limit of detection (LLD) is different for different SIRAD. It depends upon how the sensor was made and protected.

- **FIT Indicator:** See information on FIT Indicator.

Stock piling: Do you want radiation dosimeters available for your fellow citizens/coworkers immediately in emergencies? You can stockpile SIRAD radiation dosimeters, e.g., RADTriage, just for this purpose.

The service-life of all SIRADs in a frozen state (e.g., -20^{o}C) is about 10 years. Though the sensors remain active to radiation even at -20^{o}C, the thermal reactivity is minimized, thereby extending the service life to years. The FIT Indicator is a service-life indicator and gets activated when brought to room temperature. When you need the badges, just take them out of the freezer and provide to the users. FIT Indicator will still be essentially colorless (or faint blue color) when removed from the freezer and will start developing color with time and temperature (i.e., will monitor service life).