

# TechTopics No. 14

## X-radiation emissions by vacuum interrupters

Vacuum circuit breakers have, for many years, included a label to advise users of the potential for emission of X-radiation under certain conditions. These labels led users to wonder what the real exposure to X-radiation might be.

Many newspaper articles written in the 1960s warned of the hazards associated with radiation emissions from color TV picture tubes and from microwave ovens. This led to the passage of the Radiation Control for Health and Safety Act of 1968. This act was written in very generic language, with the result that any device that can emit radiation under any circumstances was subject to the Act. In addition to imposing requirements on TVs, microwaves, medical X-ray equipment, nuclear facilities, and other sources of radiation, the language of the Act includes vacuum interrupters.

Under what circumstances can a vacuum interrupter emit X-rays? X-rays may be produced when a substantial voltage is imposed across open contacts in a vacuum. For vacuum interrupters, this means that X-rays may be produced when a voltage well above the operating voltage is imposed across the open contacts. For practical purposes, this means that X-rays are not produced during normal operation, and only become of any significance when dielectric (high-potential) tests are being conducted. X-rays are not produced when the contacts are closed, or when the interrupter is de-energized.

In response to the passage of the Radiation Control Act, a joint task force of representatives of the industry and government was formed. Tests of X-radiation emission by vacuum interrupters from all manufacturers were conducted. In addition, exposure limits established by government regulations were evaluated in comparison to normal test practices to determine reasonable limits on X-radiation emission by vacuum interrupters. The results of these studies formed the basis for ANSI C37.85, "Alternating-Current High-Voltage Power Vacuum Interrupters — Safety Requirements for X-Radiation Limits," first issued in 1972.

The task force determined that a reasonable cumulative exposure limit was 500 milliroentgens (mR) per year. It was also estimated that a person performing high-potential tests would perform no more than 2,000 one-minute tests in a year, or 33.3 hours of tests. The 500 mR upper limit, in 33.3 hours of tests, defined a limitation of 15 mR/hour (at a distance of one meter) for a vacuum interrupter. This became the limit used for qualification of a vacuum interrupter to ANSI C37.85. This standard also established the requirement that manufacturers provide an appropriate X-radiation label on the vacuum interrupter or on the circuit breaker.

Experience has suggested that these limits were conservatively derived, and further, that the actual emission levels from vacuum interrupters are well below the limits established in ANSI C37.85. A few pertinent reasons for this level of conservatism include:

- The cumulative exposure limit of 500 milliroentgens (mR) per year is about 10 percent of the limit established by current government regulations.
- The assumed level of 2,000 high-potential tests per year is more than nearly any user might actually perform in a year.
- X-radiation exposure is inversely related to the square of the distance from the vacuum interrupter. Thus, doubling the distance from the vacuum interrupter reduces the X-radiation exposure by a factor of four.
- For electrical safety reasons, test personnel generally maintain distances from the object under test well in excess of the one-meter distance used to establish the emission limits in the standard.

- Modern vacuum interrupters exhibit levels of X-radiation emission well below the allowable limits in the standard. Siemens' vacuum interrupter emission is of the order of a few percent of the limits established in the standard. These low levels of X-radiation emission are verified by annual certification testing conducted by a branch of the German government.

The emission limits established in ANSI C37.85 assume that high-potential tests are conducted at the "field test" voltage allowed in the relevant apparatus standards. The field test voltage is 75 percent of the factory test on new equipment. Field test voltages for vacuum interrupters on Siemens' circuit breakers are shown in the table.

### Field test voltages

Circuit breaker type	Rated maximum design voltage (kV)	Factory test voltage (kV rms)	Field test voltage (kV rms)	Field test voltage (kV dc)
GMSG circuit breakers used in GM-SG or GM-SG-AR metal-clad switchgear	4.76 kV 8.25 kV 15.0 kV	19 kV 36 kV 36 kV	14 kV 27 kV 27 kV	20 kV 38 kV 38 kV
38-3AH circuit breakers used in GM38 metal-clad switchgear	38.0 kV	80 kV	60 kV	85 kV
SDV outdoor circuit breakers	15.5 kV 25.8 to 27.6 kV 38.0 kV	50 kV 60 kV 80 kV	37.5 kV 45 kV 60 kV	53 kV 64 kV 85 kV

The dc test voltage is listed even though it is not officially supported by ANSI. Practically, it is recognized that dc high-potential test equipment is more easily transported than ac high-potential test equipment, so most field dielectric tests are conducted using dc. However, it is important that dc high-potential test equipment employing unfiltered half-wave rectifiers not be used. These test sets often produce peak voltages much higher than indicated by the test set. Therefore, the actual voltage applied to the vacuum interrupter by such test sets will be significantly higher than the voltage for which the vacuum interrupter is qualified. This, in turn, has two unfortunate consequences. First, and most important, the level of X-radiation emission may be much higher than that which occurs at the correct test voltage. Second, the leakage current during the test may be so high that test personnel may conclude that the vacuum interrupter has lost vacuum, when it has not. For these reasons, dc high-potential test devices using half-wave rectification must not be used to test vacuum interrupters.

Decades of experience have shown that there is little practical exposure to X-radiation from vacuum interrupters. X-rays are produced only with open contacts, and are insignificant at normal operating voltages. During high-potential testing, the exposure is also at low levels if test personnel remain at distances appropriate for the test voltage involved. Even though the exposure is low, X-radiation labels are required in order to comply with the original 1968 legislation.

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Siemens Industry, Inc.  
7000 Siemens Road  
Wendell, NC 27591

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