NUCLEAR CRITICALITY ACCIDENTS IN THE WORKPLACE

FACT SHEET

INTRODUCTION

This fact sheet provides information on nuclear criticality accidents that have occurred since the beginnings of the nuclear industry with primary focus on those that have occurred in the workplace.

NUCLEAR CRITICALITY ACCIDENTS

A nuclear criticality accident is the occurrence of a self-sustaining neutron chain reaction that is either unplanned or behaves unexpectedly. Only a few special nuclear materials such as enriched uranium or plutonium are capable of supporting a self-sustaining neutron chain reaction, hereinafter called nuclear criticality. Nuclear criticality results in the same reactions that occur in a nuclear reactor. The products of nuclear criticality are heat, radiation, and radioactive materials called fission products. Nuclear reactors are designed so that:

- nuclear criticality is controlled and can be terminated,
- fission products are contained and managed to protect people from their radiation,
- the heat produced may be beneficially used, for example to boil water to make steam to drive a generator to produce electricity, and
- some of the radiation produced may be used to produce beneficial products such as medical isotopes or for research, but in all cases arrangements such as shielding are present to protect people from radiation.

Special nuclear materials must be handled and processed, often on an industrial scale, outside nuclear reactors. Industrial work with these special nuclear materials includes the manufacture of nuclear reactor fuel, chemical processing to concentrate, purify, or change their form for various industrial applications, and various defense-related activities. A prime consideration in the design, construction, and operation of industrial facilities to process special nuclear materials is the prevention of nuclear criticality. Unfortunately, if special nuclear materials are improperly handled outside a nuclear reactor, it is possible for a nuclear criticality accident to occur in the workplace. The immediate result of a nuclear criticality accident is the production of an uncontrolled and unpredictable radiation source that can be harmful, even lethal, to people who are nearby. In the workplace, nuclear criticality accidents last from a fraction of a second up to several minutes, but may persist for much longer times, depending upon the specific conditions.

A nuclear criticality accident itself provides various mechanisms that tend to terminate the accident and workplace personnel can also take actions to terminate persistent accidents. One accident that occurred in an experimental facility persisted for over six days before it was terminated by facility personnel.

NUCLEAR CRITICALITY ACCIDENT EXPERIENCE

Since the beginnings of the nuclear industry in the early to mid 1940C-s, there have been 60 known nuclear criticality accidents. These known accidents have occurred in Argentina, Belgium, Canada, France, Japan, the Russian Federation, the United Kingdom, the United States, and Yugoslavia and publicly available data report on them.

Thirty-eight of the nuclear criticality accidents involved special nuclear material in a nuclear reactor or laboratory environment in arrangements that were intended to achieve nuclear criticality but behaved unexpectedly. In these 38 nuclear criticality accidents, some provisions for personnel protection such as shielding or large distances between people and the nuclear criticality accident site were available. The majority of these accidents have occurred in nuclear facilities in the United States.

The remaining 22 nuclear criticality accidents involved special nuclear materials in manufacturing or processing plant environments; *i.e.*, in the workplace. The activities being conducted were never intended to achieve nuclear criticality and there were no arrangements intentionally present to protect people near the accident site from the radiation produced. The majority of these accidents have occurred in special nuclear material processing facilities in the former Soviet Union.

All of the 22 manufacturing environment nuclear criticality accidents involved accumulation of an excessive amount of special nuclear material. Of the 22 accidents, 21 involved solutions or mixtures of enriched uranium or plutonium compounds with water or organic chemicals and one involved plutonium metal. That over 95% of the accidents involved solutions or mixtures of special nuclear materials with water or organic chemicals is not surprising. When water or organic chemicals are added to special nuclear materials, the amount of special nuclear material necessary for nuclear criticality is reduced. Handling and controlling liquids is also relatively more difficult than controlling solid materials because liquids tend to leak and flow to unexpected locations.

HISTORICAL WORKPLACE NUCLEAR CRITICALITY ACCIDENT CONSEQUENCES

Since the first manufacturing environment nuclear criticality accident in 1953, the consequences have included 9 fatalities and significant radiation exposure to at least 36 people. The fatalities have all been personnel who were within about 1 meter (a little over 1 yard) of the accident. The significant radiation exposures have all been to personnel located within about 5 meters (about 5.5 yards) of the accident.

Physical damage to property and equipment from manufacturing environment nuclear criticality accidents has been essentially nonexistent. The most severe physical effect was observed when a nuclear criticality accident occurred within a 1000 liter (about 250

gallons) capacity steel tank and caused the tank to move about 10 millimeters (about 3/8 inch). In most cases, the equipment in which an accident has occurred has been reusable after modest or no radioactive material cleanup.

Business interruption from manufacturing environment nuclear criticality accidents has varied depending upon the site and the time. In some instances, facilities were restarted after minimal interruption for investigation and cleanup and in other instances facilities were completely replaced with new ones that incorporated design features to decrease the likelihood of having a nuclear criticality accident. Since the mid-1970C-s, the occurrence of a nuclear criticality accident has tended to cause very long shutdowns of manufacturing facilities for investigation and remediation. In some instances, the affected facilities have been completely shut down and never returned to production.

NUCLEAR CRITICALITY ACCIDENTS - ADDITIONAL INFORMATION

Descriptions of the known nuclear criticality accidents appear in publicly available literature. The most authoritative publication describing the accidents that have occurred is a compilation entitled “A Review of Criticality Accidents - 2000 Revision” by a team of United States and Russian Federation authors. The publication is available from the Los Alamos National Laboratory in Los Alamos, New Mexico, as document number LA-13638 dated May 2000. At the time this fact sheet was prepared, the document could also be read on-line at the website http://www.csirc.net/10_Library/00_Reports/13638/la-13638.pdf.

This factsheet was prepared by the Nuclear Criticality Safety Division of the American Nuclear Society. Contact the American Nuclear Society at (708)352-6611 or through their web site at http://www.ans.org for additional information.