STATUS AND VALUE OF INTERNATIONAL STANDARDS FOR NUCLEAR CRITICALITY SAFETY*

C. M. Hopper
Oak Ridge National Laboratory (ret.)
P.O. Box 2008
Oak Ridge, Tennessee 37831-6170
United States of America
hoppercm@ornl.gov

ABSTRACT

This presentation provides an update to the author's standards report provided at the ICNC-2007 meeting. It includes a discussion about the difference between, and the value of participating in, the development of international "consensus" standards as opposed to nonconsensus standards.

Standards are developed for a myriad of reasons. Generally, standards represent an agreed upon, repeatable way of doing something as defined by an individual or group of people. They come in various types. Examples include personal, family, business, industrial, commercial, and regulatory such as military, community, state, federal, and international standards. Typically, national and international "consensus" standards are developed by individuals and organizations of diverse backgrounds representing the subject matter users and developers of a service or product and other interested parties or organizations.

Within the International Organization for Standardization (ISO), Technical Committee 85 (TC85) on nuclear energy, Subcommittee 5 (SC5) on nuclear fuel technology, there is a Working Group 8 (WG8) on standardization of calculations, procedures, and practices related to criticality safety. WG8 has developed, and is developing, ISO standards within the category of nuclear criticality safety of fissionable materials outside of reactors (i.e., nonreactor fissionable material nuclear fuel cycle facilities). Since the presentation of the ICNC-2007 report, WG8 has issued three new finalized international standards and is developing two more new standards. Nearly all elements of the published WG8 ISO standards have been incorporated into IAEA nonconsensus guides and standards.

The progression of consensus standards development among international partners in a collegial environment establishes a synergy of different concepts that broadens the perspectives of the members. This breadth of perspectives benefits the working group members in their considerations of consensus standards developments in their own countries. A testament to the value of the international standards efforts is that nearly all elements of the published WG8 ISO standards have been incorporated into IAEA nonconsensus guides and standards and are mainly consistent with international ISO member domestic standards.

Key Words: nonreactor criticality facility safety standards

1 INTRODUCTION

Within ISO (International Organization for Standardization) there are approximately 220 Technical Committees (TCs), one of which is ISO TC85, nuclear energy, nuclear technologies, and radiological protection. Within TC85 there are three Subcommittees (SCs), one of which is SC5, nuclear fuel cycle. Within SC5 there are five Working Groups (WGs), one of which is WG8, standardization of calculations, procedures and practices related to criticality safety. WG8 has produced six standards on the subject of nuclear criticality safety (NCS) related to nonreactor

* Notice: This manuscript has been authored by UT-Battelle, LLC, under Contract No. DE-AC05-00OR22725 with the U.S. Department of Energy. The United States Government retains and the publisher, by accepting the article for publication, acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this manuscript, or allow others to do so, for United States Government purposes.

nuclear facilities. Since the author's presentation [1] at ICNC-2007, WG8 has issued three finalized ISO standards and is developing two additional standards, one of which is very near completion. This paper provides a status update to the referenced ICNC-2007 meeting presentation, a discussion on the merits of international collaboration in the development of standards, and the need for more international participation in the standards drafting and approval process.

2 ISO NCS STANDARDS STATUS

Over the past four years ISO TC85/SC5/WG8 has issued the following finalized NCS standards:

- ISO 27467:2009 (Ed.1), "Nuclear Criticality Safety—Analysis of a Postulated Criticality"
- ISO 11311:2011 (Ed. 1), "Nuclear Criticality Safety—Critical Values for Homogeneous Plutonium–Uranium Oxide Fuel Mixtures Outside of Reactors"
- ISO 27468:2011 (Ed. 1), "Nuclear Criticality Safety—Evaluation of Systems Containing PWR UOX Fuels—Bounding Burnup Credit Approach"

A final draft international standard (FDIS) is to be voted on for approval in September 2011:

- ISO/FDIS 11320, "Nuclear Criticality Safety—Emergency Preparedness and Response"

A committee draft (CD) in a form and content consistent with a draft international standard (DIS) was submitted in July 2011 to ISO for a member body vote to accept and comment on the CD as a DIS:

- ISO/CD 16117, "Nuclear Criticality Safety—Estimation of the Number of Fissions of a Postulated Criticality Accident"

A brief explanation of the scope and contents of these finalized and draft standards follows.

2.1 Analysis of a Postulated Criticality, ISO 27467:2009 (Ed. 1)

2.1.1 Scope

This standard specifies areas that are important to study when analyzing potential criticality accidents.

It is important that:

1. A criticality accident analysis is performed each time a criticality accident is considered credible, due either to criticality contingencies (double batching, procedural violations, etc.) or to the failure of safety provisions (effectiveness of neutron absorber reduced by fire, etc.).
2. The criticality safety specialist needs to be mindful that the process of evaluation developed in this standard does not cater to the unforeseen, since any actually occurring criticality accident will probably result from a scenario not envisioned or from failure to comply with prevailing regulations.

This standard does not address detailed administrative measures, for which the responsibility lies with the public authorities, nor does it deal with criteria used to justify the accident criticality analysis of a nuclear facility.

Consistent with the scope of ISO TC85/SC5 Working Group 8, this standard does not apply to nuclear power plants.

2.1.2 Contents

This standard includes the following:

- objectives of a nuclear criticality accident analysis

- components of the analysis, expectations for postulating an accident scenario and its associated neutronics calculations
- evaluation of the accident physics, including neutron and gamma radiation fields, via calculational codes, simplified models, or experimental results
- demonstration of timely alarm actuation
- estimation of airborne releases and their impact
- general actions required in accordance with the emergency response plan following a criticality accident

2.2 Critical Values for Homogeneous Plutonium–Uranium Oxide Fuel Mixtures Outside of Reactors, ISO 11311:2011 (Ed. 1)

2.2.1 Scope

This standard specifies common reference critical values (of which the effective neutron multiplication factor, k_{eff} is equal to 1) for homogeneous water-moderated plutonium–uranium oxide mixtures based on an inter-code comparison of calculated critical values. It is applicable to operations with unirradiated mixed uranium–plutonium oxide (MOX) outside nuclear reactors.

A classical validation approach for these systems is difficult because of the paucity of critical experiments for MOX fuel.

Various reference systems, in terms of isotopic compositions, thicknesses of water reflection, and densities of oxide, are evaluated by different combinations of calculation codes and nuclear data libraries (i.e., different calculation schemes).

The critical values defined in this standard are the lowest of those calculated by each of these calculation schemes and accepted as credible. These values are not absolute critical values.

2.2.2 Contents

This standard provides critical values (smallest of 12 to 17 computed) for combinations of the following materials, moderator and reflector conditions, and geometries.

- specific reference fissile media evaluated regarding
  - two plutonium weight percent contents (35.0 weight % and 12.5 weight %)
  - two oxide (UO_2 + PuO_2) densities (3.5 g/cm^3 and 11.03 g/cm^3)
  - one uranium isotopic composition (0.718 weight % ^{235}U and 99.282 weight % ^{238}U)
  - three plutonium isotopic contents
    - 100 weight % ^{239}Pu
    - 95.0 weight % ^{239}Pu and 5.0 weight % ^{240}Pu
    - 65.88 weight % ^{239}Pu, 20 weight % ^{240}Pu, 12.94 weight % ^{241}Pu, 1.18 weight % ^{242}Pu
  - two degrees of water moderation (3 weight % H_2O and optimum for minimum critical values)
- two water reflector conditions (2.5 cm and 30.0 cm of water)

- three geometric configurations
  - sphere
  - infinite length cylinder
  - infinite section slab

2.3 Evaluation of Systems Containing PWR UOX Fuels—Bounding Burnup Credit Approach, ISO 27468:2011 (Ed. 1)

2.3.1 Scope

This standard establishes an evaluation methodology for nuclear criticality safety with burnup credit. It identifies important parameters and specifies requirements, recommendations, and precautions to be taken into account in the evaluations. It also highlights the main important technical fields to ensure that the fuel composition or history considered in calculations provides a bounding value of the effective neutron multiplication factor, k_{eff}.

The standard is applicable to transport, storage, disposal, or reprocessing units implying irradiated fissile material from pressurized water reactor (PWR) fuels that initially contain uranium oxide (UOX). Fuels irradiated in other reactors (e.g., boiling water reactors) and fuels that initially contain mixed uranium–plutonium oxide are not covered in the standard.

The standard does not specify requirements related to overall criticality safety evaluation or eventual implementation of burnup credit.

2.3.2 Contents

This standard prescribes the bounding approach for a given application and range of irradiated fuels by considering

- distribution of burnup,
- nuclide concentration calculations, and
- criticality safety calculations.

2.4 Emergency Preparedness and Response—A Committee Draft (CD), ISO/FDIS 11320

2.4.1 Scope

This standard provides criteria for emergency preparedness and response to minimize consequences due to a nuclear criticality accident. The criticality safety of operations is evaluated in accordance with ISO 1709. It applies to a site with one or more facilities that might contain significant quantities and concentrations of fissile material.

The extent to which this standard needs to be applied depends on the overall criticality risk presented by the facilities at the site. The standard does not apply to

- off-site transport and transit storage of packages with fissile material,
- sites with operating nuclear power plants, or
- facilities with research reactors that are licensed to become critical or near-critical

provided that there are no operations with fissile material external to the reactor for which a credible criticality accident risk exists.

2.4.2 Contents

The standard addresses many facets of emergency preparedness:

- responsibilities
- evaluations
- location and design of operations
- immediate evacuation zones
- emergency response plans
- equipment and materials
- classroom training, exercises, and evacuation drills
- response
- evacuation

2.5 Estimation of the Number of Fissions of a Postulated Criticality Accident, ISO/CD 16117

2.5.1 Scope

This standard provides a methodology and guidance to estimate a reasonably maximal value of the number of fissions of a postulated criticality accident. The fission number estimate, associated with its postulated criticality accident, impacts the accident emergency planning and response because it is used for the estimation of possible radiation doses and of possible radioactive materials release.

The standard applies to nuclear facilities, plants, laboratories, storage, and transportation of fissile material (but not to nuclear power reactor cores) where a credible criticality accident hazard could develop. However, the standard does not provide a methodology and guidance to determine bounding accident scenarios nor does it cover criticality accident detection, which is dealt with by ISO 7753.

2.5.2 Contents

The standard provides general principles for the estimation of the number of fissions resulting from a criticality accident scenario as provided by a criticality accident analysis. It addresses the determination of fission number estimate via simplified and calculational tools with numerous references and sources of data.

3 MERITS OF COLLABORATIVE INTERNATIONAL STANDARDS DEVELOPMENT

ISO TC85/SC5 has 19 participating countries that review, comment, and vote on the standards that WG8 develops. Those countries are represented by one of their national standards bodies. The participating countries and their representing standards body [2] are listed here.

Argentina (IRAM)
Belgium (NBN)
Bulgaria (BDS)
Canada (SCC)
China (SAC)
France (AFNOR)
India (BIS)
Islamic Republic of Iran (ISIRI)
Japan (JISC)
Kenya (KEBS)
Republic of Korea (KATS)
Netherlands (NEN)
Russian Federation (GOST R)
Spain (AENOR)
Sweden (SIS)
Switzerland (SNV)
United Kingdom (BSI)
United States of America (ANSI)
Ukraine (DSSU)

It requires no less than five participating countries to progress a standard to the FDIS stage for voting by the participating countries as a final ISO standard. Approval as a final ISO standard requires a two-thirds majority of the ISO TC85/SC5 participating country votes, and not more than one-quarter of the total number of votes cast can be negative. Abstentions and negative votes without technical reasons are not counted in the approval process.

Once a new work item project is approved by five or more participating countries and a project leader is identified, the active working group members develop a committee draft (CD) for review and commenting by participating countries. The working group then develops another draft considering the resolution of comments. Upon resolution of the first round of comments, the active working group members then prepare the draft international standard (DIS) for a second round of review, comment, and comment resolution whereupon the active working group members prepare the final draft international standard (FDIS). The FDIS is distributed to the ISO participating countries for a final vote. This entire process is held to a fairly rigorous time schedule of 36 months from inception to published standard.

Typically, the active WG8 members attend the annual WG8 meeting and work throughout the year to provide drafts of standards, reviews, comments, and comment resolutions by way of the World Wide Web international network email. Generally, the active members of the working group are experts that are delegated by their national standards development organization and are employed by industry and government or represent another organization in liaison with ISO such as the International Electrotechnical Commission (IEC), EURATOM, IAEA, and the European Commission. A broad diversity of knowledge and experience is brought together in the process of developing these standards.

The sharing of diverse international experiences and perceptions through the standards development process provides a synergistic environment that broadens the working group members' perspectives and matures their development of a standard. In addition, the standards development process expands the members' experience and knowledge, which they may apply in their own country.

4 NEED FOR INCREASED INTERNATIONAL PARTICIPATION

Though ISO TC85/SC5 has 19 participating countries that review, comment, and vote on WG8 standards, it is rare for there to be more than 5 participating countries represented on the active membership of WG8. Those countries are represented by one of their national standards bodies. In the past eight years no more than five participating countries had representatives at the annual WG8 meeting. They include:

- Argentina (IRAM)
- Canada (SCC)
- France (AFNOR)
- Republic of Korea (KATS)
- Sweden (SIS)
- United Kingdom (BSI)
- United States of America (ANSI)

Greater ISO TC85/SC5 Working Group 8 participation will ensure that its work products can continue to form a bridge between the public and private sectors with broad perspectives concluding in consensus positions. On the one hand, many of its member institutes are part of the governmental structure of their countries or are mandated by their governments. On the other hand, some members have their roots uniquely in the private sector, having been set up by national partnerships of industry associations, thereby requiring private sector support.

Individuals are encouraged to apply to participate in the activities of WG8 by contacting their national standard development organization in a registered ISO participating country. If granted participation, the individuals will be appointed as delegates to the meetings and/or as points of contact for the development of ISO standards.

REFERENCE

1. C. M. Hopper, "Status and Relevance of ISO Standards with OECD NEA WPNCS and IAEA FCF Initiatives," *International Conference on Nuclear Criticality Safety (ICNC 2007)*, St. Petersburg, Russia, May 28–June 1, 2007.
2. International Organization for Standardization, http://www.iso.org/iso/home.html.