

# DOMESTIC AND INTERNATIONAL CONSENSUS STANDARDS FOR NUCLEAR CRITICALITY SAFETY – OVERVIEW & STATUS

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## ABSTRACT

The domestic and international consensus standards for nuclear criticality safety (NCS) were developed based on the lessons-learned from process criticality accidents. These consensus standards were developed to reduce the rate of process criticality accidents in facilities that process, store, handle, or transport fissionable materials by hand. After a significant increase in criticality accidents through the mid-1960s, the rate of criticality accidents decreased as a result of these standards, and the criticality accident rate is extremely low from an industrial safety perspective. The last known criticality accident inside the United States was in 1978 (nearly 47 years ago) at the Idaho Chemical Processing Plant, and outside the United States, an accident occurred at Tokai-mura, Japan, in 1999 (almost 26 years ago). The domestic consensus standards for NCS include the American National Standards (ANS) that are prepared and published by the American Nuclear Society and approved by the American National Standards Institute (ANSI). The ANS Standards Board, the NCS Consensus Committee, and the ANS-8 Subcommittee oversee the development and maintenance of these standards. There are currently 18 standards in the ANS-8 series. Nine ANS-8 standards are either in revision mode or planned for revision. A new standard for the use of nondestructive assay measurements (ANSI/ANS-8.28-2024) for NCS was approved in March of 2024. The international consensus standards for NCS calculations, procedures, and practices are maintained and developed within the International Organization for Standardization, Technical Committee 85 “Nuclear Energy,” Subcommittee 5, “Nuclear Fuel Technology,” and Working Group 8, “Nuclear Criticality Safety.” Eleven standards are currently available, four standards are proposed for revision, and four standards are at various stages of development. This paper provides the NCS community with a high-level overview and status report of domestic and international NCS consensus standards to stimulate interest and to support their continued development.

*Key Words:* ISO, ANS, nuclear criticality safety, consensus standards

## 1 INTRODUCTION

For many years, the domestic and international consensus standards for nuclear criticality safety (NCS) have provided guidance for those who conduct hands-on operations with fissionable materials. These consensus standards have been crucial to reducing the number of criticality accidents in process facilities.

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The last known process criticality accident inside the United States was in 1978 (47 years ago at this writing) at the Idaho Chemical Processing Plant, and outside the United States at Tokai-mura, Japan, in 1999 (26 years ago at this writing) [1]. Figure 1 illustrates the chronology of process criticality accidents worldwide since the beginning of the nuclear age. Consensus standards have been an invaluable contributor to reducing the process criticality safety accident rate since their establishment in the mid-1960s. Since that time, the consensus standards for NCS have expanded significantly. This paper provides an overview and status report for both the American National Standards series 8 (ANS-8) and the International Organization for Standardization (ISO) Working Group 8 (WG8) standards and gives a status summary of work in progress for the benefit of the NCS community.

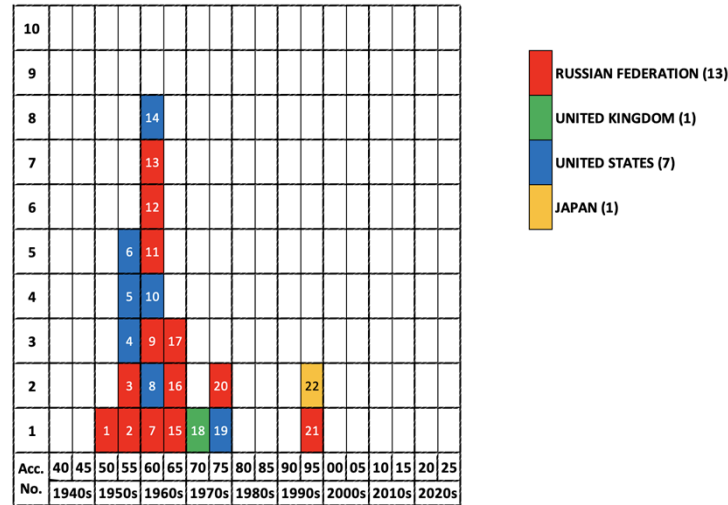


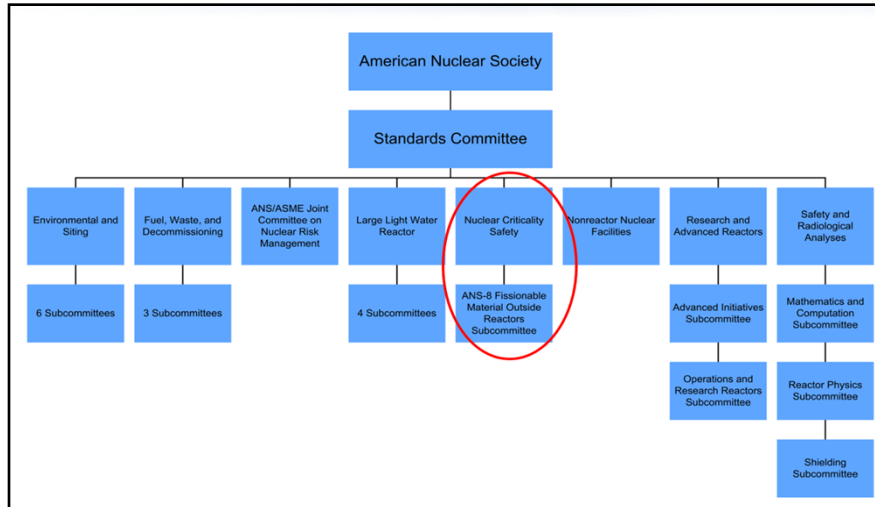
Figure 1. Chronology of the 22 Known Process Criticality Safety Accidents Worldwide, 1943–2025 (Numbers in cells indicate the process accident number)

## 2 DOMESTIC CONSENSUS NCS STANDARDS

The domestic consensus standards for NCS include the ANS-8 standards. The first NCS standard was initiated circa 1960 and was published as the first approved standard in 1964 [2]. This initial standard, ASA N6.1-1964, *Safety Standard for Operations with Fissionable Materials Outside Reactors*, was the precursor to today’s American National Standards Institute/American Nuclear Society (ANSI/ANS) NCS standards for operations with fissionable material outside reactors. Over the years, the number of domestic standards has grown significantly to a total of 18 active standards, with one new standard published since the last ANS Topical Meeting in 2022 (Anaheim, CA).

### 2.1 Organizational Overview

The ANS Standards Board, the NCS Consensus Committee, the ANS-8 Subcommittee, and standard working groups oversee the development and maintenance of the domestic ANS standards for NCS (ANS-8 series standards). An organizational overview of the ANS, Standards Board, and NCS Consensus Committees is provided in Figure 2.



**Figure 2. Structure of the ANS Standards Organization**

The responsibilities of the ANS Standards Board, the NCS Consensus Committee (CC), the ANS-8 Subcommittee (SubC), and standard working group committees are well defined [3]. The ANS Standards Board is responsible for ensuring that applicable policies and procedures have been followed and that the consensus process has been fulfilled. The ANS consensus committees are responsible for ensuring consensus of members for the approval of proposed standards and for managing the development and maintenance of standards within their assigned scopes of responsibilities; for example, the NCS CC is responsible for NCS consensus standards. The ANS-8 subcommittee is responsible for ensuring competent membership, managing working group activities, and performing technical reviews of all proposed and revised standards within their scope of technical responsibility. The standard working groups ensure open, competent, and expert membership (end-user balance of interest is important) to develop and maintain new and existing standards, respectively, within their scopes of interest. All organizations have responsibilities for responding to inquiries relevant to their standards as necessary.

These organizations work in concert to develop and maintain the ANSI/ANS standards. The rules and procedures for developing and maintaining the standards, including roles and responsibilities for working group members, working group chairs, subcommittee chairs, consensus committee chairs, and so forth, are continuously modified and updated to improve the process. The ANS standards website [4] provides reference information about the ANS standards process and describes how volunteers can find opportunities to participate.

## 2.2 Status Report of Domestic Standards

There are currently eighteen standards under the purview of the ANS-8 subcommittee: eight standards are at various stages of the revision process, and ten standards are in maintenance mode (inactive). These standards fall loosely into three main categories: administrative standards, application-specific standards, and emergency planning and response standards. A summary of the current ANS-8 standards and their detailed status is provided in Table I. A standard revision involves some modification (specific or general), whereas standard reaffirmation involves the confirmation that the standard content adequately addresses the domestic need. New standard projects and standard revisions are initiated by the standard working group chair's submittal of the Project Initiation Notification System (PINS) form.

Figure 3 illustrates the ANS-8 standards recently revised and approved by ANSI. The ANS-8.28 standard was published in March 2024 after 13 years of development. The interest in the ANSI/ANS-8.28 standard

is driven largely by the Defense Nuclear Facilities Safety Board (DNFSB) recommendation for fissile material hold-up NCS concerns in 2007 (DNFSB recommendation 2007-1) [23].

**Table I. Current Status of ANS-8 Series Standards**

Standard	Title
ANSI/ANS-8.1-2014 (R2023)* [5]	Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors
ANSI/ANS-8.3-2022 [6]	Criticality Accident Alarm System Revision
ANSI/ANS-8.6-1983 (R2022) [7]	Safety in Conducting Subcritical Neutron-Multiplication Measurements in Situ
ANSI/ANS-8.7-2022 [8]	Nuclear Criticality Safety in the Storage of Fissile Materials
ANSI/ANS-8.10-2015 (R2020) [9]	Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement
ANSI/ANS-8.12-1987 (R2021) [10]	Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors
ANSI/ANS-8.14-2004 (R2021) [11]	Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors
ANSI/ANS-8.15-2014 (R2024) [12]	Nuclear Criticality Control of Selected Actinide Elements
ANSI/ANS-8.17-2004 (R2024) [13]	Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors
ANSI/ANS-8.19-2014 (R2024) [14]	Administrative Practices for Nuclear Criticality Safety Maintenance
ANSI/ANS-8.20-1991 (R2020) [15]	Nuclear Criticality Safety Training
ANSI/ANS-8.21-2023 [16]	Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors
ANSI/ANS-8.22-1997 (R2021) [17]	Nuclear Criticality Safety Based on Limiting and Controlling Moderators
ANSI/ANS-8.23-2019 (R2024) [18]	Nuclear Criticality Accident Emergency Planning and Response
ANSI/ANS-8.24-2017 (R2023) [19]	Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations
ANSI/ANS-8.26-2024 [20]	Criticality Safety Engineer Training and Qualification Program Maintenance
ANSI/ANS-8.27-2015 (R2020) [21]	Burnup Credit for LWR Fuel
ANSI/ANS-8.28-2024 [22]	Administrative Practices for Non-Destructive Assay Measurements for Nuclear Criticality Safety

\*(R20xx) indicates the year in which the standard was reaffirmed. A reaffirmed standard status indicates (via formal ballot at ANS-8, NCSCC and the Standards Board) that a standard is valid and being used in the community.

## ANS-8 Standards – ANS-8 Standards Recently Approved

Administrative		Application		Application	
ANSI/ANS-8.1	Nuclear Criticality Safety in Operations with Fissionable Material Outside of Reactors	ANSI/ANS-8.6	Safety in Conducting Subcritical Neutron Multiplication Measurements In-Situ	ANSI/ANS-8.22	Nuclear Criticality Safety Based on Limiting and Controlling Moderators
ANSI/ANS-8.10	Criteria For Nuclear Criticality Safety Controls in Operations with Shielding and Confinement	<b>ANSI/ANS-8.7</b>	<b>Nuclear Criticality Safety in the Storage of Fissile Materials (Approved by ANSI 5/6/2022)</b>	ANSI/ANS-8.27	Burnup Credit for LWR Fuel
ANSI/ANS-8.19	Administrative Practices For Nuclear Criticality Safety	ANSI/ANS-8.12	Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside of Reactors	<b>Emergency Response</b>	
<b>ANSI/ANS-8.20</b>	<b>Nuclear Criticality Safety Training (Approved by ANSI 03-27-2025)</b>	ANSI/ANS-8.14	Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors	<b>ANSI/ANS-8.3</b>	<b>Criticality Accident Alarm System (Approved by ANSI 9/9/2022)**</b>
ANSI/ANS-8.24	Validation of Neutron Transport Methods For Nuclear Criticality Safety Calculations	ANSI/ANS-8.15	Nuclear Criticality Safety Control of Selected Actinide Nuclides	ANSI/ANS-8.23	Nuclear Criticality Accident Emergency Planning and Response
<b>ANSI/ANS-8.26</b>	<b>Criticality Safety Engineer Training and Qualification Program (Approved by ANSI 11/21/2024)</b>	ANSI/ANS-8.17	Criticality Safety Criteria For the Handling, Storage, and Transportation of LWR Fuel Outside of Reactors		
<b>ANSI/ANS-8.28</b>	<b>Administrative Practices for the Use of Nondestructive Assay Measurements for Nuclear Criticality Safety (Approved by ANSI 3/12/2024)</b>	<b>ANSI/ANS-8.21</b>	<b>Use of Fixed Neutron Absorbers in Nuclear Facilities Outside of Reactors (Approved by ANSI 6/20/2023)</b>		

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The ANS-8.3 standard was approved by ANSI in 2022 but is still being implemented by many sites across the US Nuclear Regulatory Commission (NRC) and the US Department of Energy (DOE) complex.

**Figure 3. Recently Revised ANS-8 Standards (Red Shaded Cells Indicate Revised Standards)**

## ANS-8 Standards – ANS-8 Revisions

Administrative		Application		Application	
ANSI/ANS-8.1	Nuclear Criticality Safety in Operations with Fissionable Material Outside of Reactors (In revision since 2017)	ANSI/ANS-8.6	Safety in Conducting Subcritical Neutron Multiplication Measurements In-Situ	ANSI/ANS-8.22	Nuclear Criticality Safety Based on Limiting and Controlling Moderators (In revision since 2019 – currently in ANS-8 ballot process)
ANSI/ANS-8.10	Criteria For Nuclear Criticality Safety Controls in Operations with Shielding and Confinement (Revision in development)	ANSI/ANS-8.7	Nuclear Criticality Safety in the Storage of Fissile Materials	ANSI/ANS-8.27	Burnup Credit for LWR Fuel
ANSI/ANS-8.19	Administrative Practices For Nuclear Criticality Safety (Revision scope recently approved)	ANSI/ANS-8.12	Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside of Reactors (In revision since 2007)	<b>Emergency Response</b>	
ANSI/ANS-8.20	Nuclear Criticality Safety Training	ANSI/ANS-8.14	Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors	ANSI/ANS-8.3	Criticality Accident Alarm System
ANSI/ANS-8.24	Validation of Neutron Transport Methods For Nuclear Criticality Safety Calculations	ANSI/ANS-8.15	Nuclear Criticality Safety Control of Selected Actinide Nuclides	ANSI/ANS-8.23	Nuclear Criticality Accident Emergency Planning and Response
ANSI/ANS-8.26	Criticality Safety Engineer Training and Qualification Program	ANSI/ANS-8.17	Criticality Safety Criteria For the Handling, Storage, and Transportation of LWR Fuel Outside of Reactors		
ANSI/ANS-8.28	Administrative Practices for the Use of Nondestructive Assay Measurements for Nuclear Criticality Safety	ANSI/ANS-8.21	Use of Fixed Neutron Absorbers in Nuclear Facilities Outside of Reactors		

**Figure 4. Standard Revisions in Progress or Being Considered**

Figure 4 illustrates the ANS-8 standards in the process of being revised or with near-future plans to be revised. The following standards are currently in the process of being revised: ANS-8.1, 8.12, 8.19, and 8.22. The ANS-8.1, 8.12, and 8.22 standards have been in the revision process for several years now. The ANS-8.19 working group defined their revision scope based on discussions of the intent of each of the recommendations and requirements as mandated by the ANS-8 subcommittee chair in 2017. The revision scope has recently been approved by the Standards Board. The ANS-8.1 standard is undergoing a general revision incorporating lesson learned since the last general revision in 2014 while also considering a Criticality Safety Support Group (CSSG) recommendation (2016-04) [24] regarding NCS community issues related to the cost-effective use of process analysis to preclude criticality accidents during process operations. The driver for the CSSG recommendation is the requirement by US Department of Energy (DOE) regulations [25] which stipulate that a criticality accident must be precluded for natural phenomena such as seismic events, as considered credible by the safety analysis community.

Recommended wordings by the CSSG for natural phenomena (ex-process events) were considered by the ANS-8.1 working group, but progress is still pending further working group discussion. The ANS-8.1 working group is also considering calculations performed by Oak Ridge National Laboratory to verify the validity of the current single- and multi-parameter subcritical limits [26]. The ANS-8.22 standard is currently in the ANS-8 ballot stage in which the working group is resolving technical comments related to broad implementation of the standard's requirements at all NRC and DOE nuclear facilities. The ANS-8.12 revision has been under way since circa 2007. The need for the standard in the United States waned after the Mixed Oxide Fuel Fabrication Facility (MFFF) at the Savannah River Site was canceled. Despite the MFFF cancelation, the ANS-8.12 working group calculated new subcritical limits for the standard [27] in addition to other improvements currently being considered.

Figure 4 also illustrates how the ANS-8.10, 8.14, and 8.17 standards are undergoing the process to define their scope for a new revision, and community stakeholders are being sought to form working groups for these revisions. Although they are not discussed herein, CSSG recommendations are being considered for the ANS-8.10 and ANS-8.23 standards based on the 2016-04 recommendation [24]. The ANS-8.23 working group recently submitted a revision scope for approval based on discussions regarding requirements and recommendations. The ANS-8.5 standard [28] for the use of borosilicate glass Raschig rings as a neutron absorber was withdrawn a few years ago after content from ANS-8.5 was incorporated into ANS-8.21, which addresses the use of fixed neutron absorbers. The remaining standards (not

highlighted in Figure 4) are in maintenance mode and are largely inactive, although some working groups have been discussing basis statements for their standard requirements and recommendations.

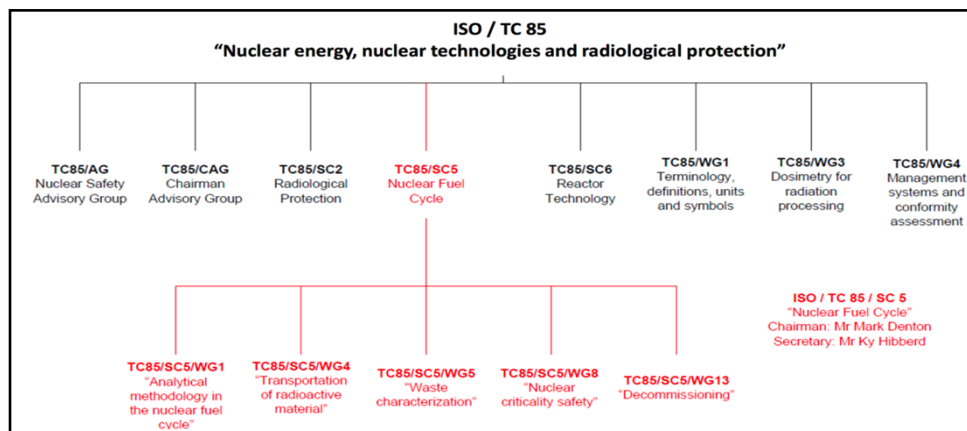
### 3 INTERNATIONAL CONSENSUS NCS STANDARDS

#### 3.1 Organizational Overview

Approximately 220 technical committees (TCs) are included within the ISO. ISO TC85 covers nuclear energy, nuclear technologies, and radiological protection [29]. One of the three subcommittees (SCs) within TC85 is SC5, *nuclear fuel cycle*. One of the five WGs under SC5 is WG8, *nuclear criticality safety* [29]. Figure 2 illustrates the structure of ISO TC85 and the organizational location of WG8, *nuclear criticality safety*. Twenty participating countries review, comment, and vote on the ISO TC85SC5 standards developed by WG8. Each of those countries is represented by one of its national standards bodies. In the development of ISO NCS standards, countries highlighted in red in Table II are very active, participating in annual meetings and discussions, and those highlighted in blue are moderately active, participating in occasional annual meetings and discussions. The countries not highlighted have limited activity supporting NCS ISO standards. The participating countries and their representing standards body [30] are listed in Table II [31].

**Table II. Participating Countries in ISO and Representing Standards Body**

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



**Figure 5. Structure of the ISO [31]**

#### 3.2 Active Projects and Status of Currently Approved ISO NCS Standards

ISO TC85/SC5/WG8, *Nuclear Criticality Safety*, is analogous to ANS Subcommittee 8, except there are fewer standards. The process used to generate new ISO standards is somewhat different than the process for generating standards for ANS. ISO working groups spend a significant amount of time debating standard proposals before a New Work Item Proposal (NP) ballot is submitted for consideration. Recently, SC5 recommended that Preliminary Work Items be created for some of the WG8 discussions regarding proposed standards that were not ready for the NP phase, which would allow for tracking

progress on proposed work. After a successful NP ballot—which consists of a majority vote by participating member (P-member) countries and at least five P-member countries committing to work on project development—the working groups can elect to go through a Committee Draft (CD) stage that incorporates NP ballot comments. A CD ballot can then be processed to ensure that the proposed standard is on solid ground before proceeding to the Draft International Standard (DIS) stage. If there is consensus agreement among the working group members that the proposed standard is ready for the DIS stage, then the CD stage may be skipped. The DIS ballot stage is a three-month balloting process. The proposed standard is translated to French, and both English and French versions are submitted to all 20 ISO P-member countries for ballot. The default track duration comprises 36 months of development work (working group and CD stages). An accelerated 24-month track may be implemented for less complicated or more well-developed standards. For complicated standards, an extended 48-month track is available [31].

Currently, eleven ISO active standards are under the purview of WG8. Table III provides the status of the existing ISO Nuclear Criticality Safety standards, and Table IV provides a listing and information on proposed WG8 standards that are in the Preliminary Work Item (PWI) phase of development.

**Table III. Current ISO TC85/SC5/WG8 standards**

Standard	Title	Status	Comments
ISO 1709-2018 [32] (ISO 1709:2018/ Amd1:2022)	Nuclear Energy – Fissile Materials – Principles of Criticality Safety in Storing, Handling, and Processing	Revision	Revision completed in 2018. An immediate amendment was completed to address comments presented during the DIS ballot at the time. In 2024, WG8 initiated discussions for a general revision of ISO 1709. See PWI 1709.
ISO 7753-2023 [33]	Nuclear Energy – Performance and Testing Requirements for Criticality Detection and Alarm Systems	Inactive	Revision completed in 2023.
ISO 11311-2011 /Amd1:2022 [34]	Nuclear Criticality Safety – Critical Values for Homogeneous Plutonium–Uranium Oxide Fuel Mixtures Outside of Reactors	Inactive	Amendment recently completed in 2022.
ISO 11320-2011 [35]	Nuclear Criticality Safety – Emergency Preparedness and Response	Inactive	No activity; maintenance mode.
ISO 14943-2004 [36]	Nuclear Fuel Technology – Administrative Criteria Related to Nuclear Criticality Safety	Inactive	No activity; maintenance mode.
ISO 16117-2013 [37]	Nuclear Criticality Safety – Estimation of the Number of Fissions of a Postulated Criticality Accident	Revision	Minor revision to be proposed by Japan for WG8 consideration. See the ISO 16117-2013/PWI Amd1 listed below.
ISO 27467-2009 [38]	Nuclear Criticality Safety – Analysis of a Postulated Criticality Accident	Inactive	No activity; maintenance mode.
ISO 27468-2011 [39]	Nuclear Criticality Safety – Evaluation of Systems Containing PWR UOX Fuels – Bounding Burnup Credit Approach	Revision	Discussions lead by the United States related to using a less conservative approach similar to the ANS-8.27 burnup credit standard. France has changes to merge into the US proposals.
ISO 22946:2020 [40]	Nuclear Criticality Safety – Solid Waste Excluding Irradiated and Non-Irradiated Nuclear Fuel	Inactive	No activity; maintenance mode.
ISO 21391:2019 [41]	Nuclear Criticality Safety – Geometrical Dimensions for Subcriticality Control – Equipment and Layout	Inactive	No activity; maintenance mode.
ISO 23133:2021 [42]	Nuclear Criticality Safety – Nuclear Criticality Safety Training for Operations	Inactive	No activity; maintenance mode.

Six standards that were revised/amended since 2018 are now inactive and in maintenance mode. Many of these standards will be due for systematic review in the near future to determine whether they are still useful to the ISO community. A revision was completed in 2022 for ISO 7753, which is driving the requirement for the Criticality Accident Alarm System (CAAS) needs assessment proposed standard (PWI 25404).

**Table IV. New WG8 Standard Proposals**

Standard	Title	Status	Comments
PWI 1709	Nuclear Energy – Fissile Materials – Principles of Criticality Safety in Storing, Handling, and Processing	2024 proposal in the early stages of committee discussion	The United Kingdom is leading discussions on a general revision of ISO 1709 to include general restructuring to provide more guidance on hazards analysis, periodic testing and review, continuous improvement, and knowledge sharing.
ISO 16117:2013/PWI Amd1	Nuclear Criticality Safety – Estimation of the Number of Fissions of a Postulated Criticality Accident	2024 proposal – NP ballot is the next step	Japan and France co-lead this proposed amendment/revision.
PWI 22409	Risk Assessment	Proposed long ago. To be discussed in 2025 WG8 meetings to determine path forward	Preliminary drafts still being debated in WG8 (Canada is the lead country for this project). The scope of the risk assessment standard is focused on overall risk reduction and not the subcriticality assessment.
PWI 25452	Validation of $k_{eff}$ Computational Methods	Scope being discussed by WG8	Preliminary draft being debated in WG8 (United States and France co-lead this project). The standard will likely provide guidance on validation that is more broad than ANS-8.24.
PWI 16510	Mass Control	Scope outline discussed in 2024	Recently proposed by France. Goal is to provide guidance on the control the mass parameter
PWI 25404	Criticality Accident Alarm System Needs Assessment	Information sought from WG8 members. Scope to be discussed in 2025	Recently proposed by the United Kingdom.

One standard has been developed and published by WG8 since the last topical meeting report [43] in 2022: ISO 7753:2023, *Nuclear Energy – Performance and Testing Requirements for Criticality Detection and Alarm Systems* [33]. Furthermore, six projects are proposed to support development of the WG8 standards listed in Table III as PWI projects. This indicates ample WG8 work for next next 3–5 years. The PWI for a revision to ISO 1709 (PWI 1709) is in the early stages of development and may expand the standard in the areas of hazards analysis, NCS implementation, and follow-up activities after control implementation. Some minor revisions are being made to the standard for the estimation of the number of fissions of a postulated criticality accident (ISO 16117) under a PWI amendment for this standard (ISO 16117-2013/PWI Amd1). The PWI amendment also provides clarifications in the standard text regarding the assumptions that must be made during estimation of the number of fissions, as well as and minor edits to Annex D.

A US WG8 member proposed a less conservative burnup credit approach similar to that given in ANS-8.27 for ISO 27468. WG8 members from France have proposed some additional modifications. A PWI was not generated for this proposed revision; depending upon WG8 feedback in the near future, this revision may proceed directly to an NP ballot.

The PWI for the proposed risk assessment standard (PWI 22409) has made slow, positive progress. The goal of the standard is to augment guidance for hazards analysis in ISO 1709 using risk assessment methodologies. The validation PWI (PWI 25452) was proposed by a US WG8 member from the US Nuclear Regulatory Commission (NRC) to create an ISO validation standard similar to the ANS-8.24 standard. This standard is slated to include some discussion in an annex related to similarity assessment for benchmark selection. The mass control PWI (PWI 16510) is focused on a standard to define a mass unit and fissile medium, to determine a limit and means of control, to transfer mass from location to location, and to examine abnormal conditions. The PWI for performing a CAAS needs assessment (PWI 25404) may provide a needs analysis methodology to determine the criteria to examine assessing the residual risk of a criticality accident after implementation of NCS control sets for operations. Early discussions have involved learning how member countries perform their assessments. This standard would be used in conjunction with ISO 7753.

## 4 CONCLUSIONS

This paper provides a recent status report of domestic and international NCS consensus standards. Substantial interest in the domestic and international NCS standards drives significant progress in development of the standards. Standards work is an important process to provide NCS standard end users with the guidance needed to ensure NCS in process facilities that handle fissionable materials outside of nuclear reactors. The ongoing development and maintenance of NCS standards helps to ensure that the NCS process accident rate is as low as possible (see Figure 1). Interested stakeholders should consider participating in the NCS consensus standards process to ensure that their experiences and needs are considered in the domestic and international NCS standards.

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  - NCS Consensus Committee (<https://www.ans.org/standards/committees/ncscc/>)
  - ANS-8 subcommittee members
  - ANS-8 working group chairs and working group members
- International Standards Organization (<https://www.iso.org/home.html>)
  - TC85, *Nuclear energy, nuclear technologies, and radiological protection* members (<https://www.iso.org/committee/50266.html>)
  - TC85/SC5, *Nuclear installations, processes and technologies* members (<https://www.iso.org/committee/50328.html>)
  - TC85/SC5/WG8, *Nuclear Criticality Safety*, members and co-convenor

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