

# The Importance of Formality of Operations for Nuclear Criticality Safety – Unspoken Assumptions

Douglas G. Bowen  
Nuclear Data and Criticality Safety Group Leader  
ANS-8 Subcommittee Chair  
Oak Ridge National Laboratory

Tuesday, June 9, 2020

# Agenda

- Background the key elements of a safety program
- Assumptions for the use and implementation of ANS-8 standards for Nuclear Criticality Safety
- Example – “credible” and “unlikely” from ANS-8.1
- Conclusions



# Background

- Work planning is accomplished within a framework of rules, policies, and procedures established by regulatory requirements, consensus standards and good practices
- Subsequently, the safety of those working with fissionable materials outside reactors is dependent upon having a properly trained workforce that completes work in formal, well defined, process based on:
  - Mission of the processes
  - Characteristics of the processes
  - Environmental concerns
  - Work force experience, health of safety management programs, etc.
- Underlying assumptions/concepts
  - Safety culture, i.e., management and worker engagement in safety related concerns at a work site
    - Safety Conscience Work Environment (SCWE) (*NRC Policy/Definition*)
      - “...a work environment where employees are encouraged to raise safety concerns and where concerns are promptly reviewed, given the proper priority based on their potential safety significance, and appropriately resolved with timely feedback to the originator of the concerns and to other employees.”
  - Defense in depth, i.e., strategy for safety measures and features such that single failures cannot lead to accidents
  - Framework of controls, i.e., operational formality to implement & maintain administrative and engineered controls

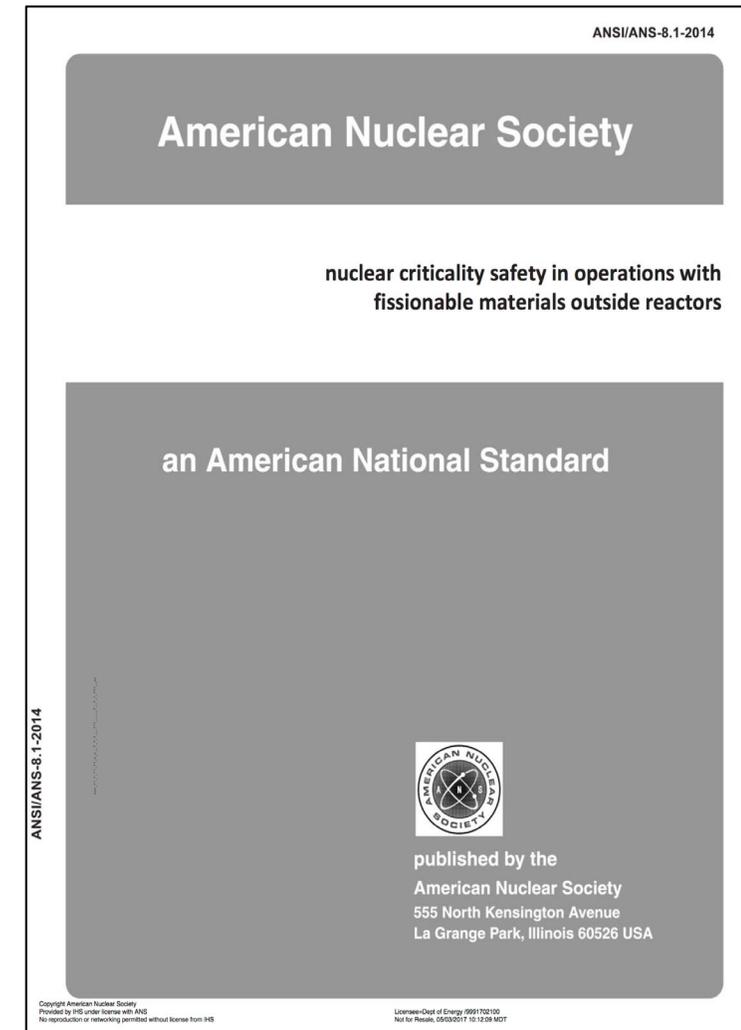


# Formality of Operations

- The following key elements are needed to ensure safety control and limits are implemented, utilized, and maintained for use – all must exist and be healthy for hazardous operations to be conducted safely
  - Conduct of operations
    - Formal documentation, practices, and actions implementing disciplined and structured operations that support mission success and public and worker safety
  - Maintenance and surveillance
    - Ensure equipment is functional and reliable and able to perform as intended, perform preventative maintenance, etc.
  - Training and qualification
    - Program tailored according to the risk associated with the job, ensuring personnel have the necessary knowledge and skills required to perform their duties; qualification is a formal program that defines required education, experience, training, examination, etc. to ensure staff can perform their duties in a safe and reliable manner
  - Configuration management
    - Focuses on establishing and maintaining consistency of a product's performance, and its functional and physical attributes with its requirements, design, and operational information throughout its life

# Requirements & Recommendations

- There are no explicit statements or requirements in the forward, introduction, or scope statements in the ANS-8 series standards about ensuring sites with nuclear facilities have a robust safety culture and ability to implement a formal conduct of operations program – but....
  - ANSI/ANS-8.1-2014 addresses written procedures, management responsibilities, operational control, operational reviews, etc., – covers key formality of operations elements
  - ANSI/ANS-8.19-2014 addresses implementation and maintenance of controls and employee conformance with operational procedures
- Safety culture, defense-in-depth, and operational formality is certainly credited and acknowledged within the standards
- Standard requirements and recommendations are dependent upon healthy safety culture and formality of operations
  - An example will be presented for the use of “credible” and “unlikely” for the Process Analysis Requirement and Double Contingency Principle in ANS-8.1, respectively



# Example – The words “credible” and “unlikely” (ANS-8.1)

- Although not uniquely defined in the standard glossary, “credible” and “unlikely” are used in the process analysis requirement (Section 4.1.2) and the double contingency principle recommendation (Section 4.2.2), respectively

## 4.1.2 Process analysis

Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and **credible** abnormal conditions.<sup>2)</sup> In some cases it may be necessary or desirable to resort to in situ neutron multiplication measurements to confirm the subcriticality of proposed configurations. Guidance for safety in performing such measurements is contained in ANSI/ANS-8.6-1983 (R2010) [8].

## 4.2.2 Double-contingency principle

Process designs should incorporate **sufficient** factors of safety to require at least two **unlikely,** independent, and concurrent changes in process conditions before a criticality accident is possible.<sup>3)</sup>

- A standard dictionary provides adequate definitions for the words unlikely and credible
  - “credible” is defined as “believable, tenable, plausible, or reasonable”
  - “unlikely” is defined as “improbable, doubtful, dubious, or far-fetched”
- The meaning of these words are highly dependent upon the health of a site’s safety culture and formality of operations program
- Site events such as new management, new staff, NCS program formality, infraction history, facility age, or other issues could adversely affect the safety culture and formality of operations
  - Can result in an increase in accidents, NCS infractions, deviations from procedures, etc.
- Thus, the health of a site’s safety culture or facility of operations program is not a constant, i.e., not changing over time, but, instead, varies as a function of time
  - Thus, the meaning of “credible” and “unlikely” can vary over time and should be addressed by a site NCS program
  - Tracking and trending of procedure deviations is one way to look at the health of site safety culture and formality of operations programs

# Example – The words “credible” and “unlikely” (ANS-8.1)

- Although not uniquely defined in the standard glossary, “credible” and “unlikely” are used in the process analysis requirement (Section 4.1.2) and the double contingency principle recommendation (Section 4.2.2), respectively

## 4.1.2 Process analysis

Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and **credible** abnormal conditions.<sup>2)</sup> In some cases it may be necessary or desirable to resort to in situ neutron multiplication measurements to confirm the subcriticality of proposed configurations. Guidance for safety in performing such measurements is contained in ANSI/ANS-8.6-1983 (R2010) [8].

## 4.2.2 Double-contingency principle

Process designs should incorporate **sufficient** factors of safety to require at least two **unlikely,** independent, and concurrent changes in process conditions before a criticality accident is possible.<sup>3)</sup>

- A standard dictionary provides adequate definitions for the words unlikely and credible
  - “credible” is defined as “believable, tenable, plausible, or reasonable”
  - “unlikely” is defined as “improbable, doubtful, dubious, or far-fetched”
- The meaning of these words are highly dependent upon the health of a site’s safety culture and formality of operations program
- Site events such as new management, new staff, NCS program formality, infraction history, facility age, or other issues could adversely affect the safety culture and formality of operations
  - Can result in an increase in accidents, NCS infractions, deviations from procedures, etc.
- Thus, the health of a site’s safety culture or facility of operations program is not a constant, i.e., not changing over time, but, instead, varies as a function of time
  - Thus, the meaning of “credible” and “unlikely” can vary over time and should be addressed by a site NCS program
  - Tracking and trending of procedure deviations is one way to look at the health of site safety culture and formality of operations programs

# Example – The words “credible” and “unlikely” (ANS-8.1)

- Although not uniquely defined in the standard glossary, “credible” and “unlikely” are used in the process analysis requirement (Section 4.1.2) and the double contingency principle recommendation (Section 4.2.2), respectively

## 4.1.2 Process analysis

Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and **credible** abnormal conditions.<sup>2)</sup> In some cases it may be necessary or desirable to resort to in situ neutron multiplication measurements to confirm the subcriticality of proposed configurations. Guidance for safety in performing such measurements is contained in ANSI/ANS-8.6-1983 (R2010) [8].

## 4.2.2 Double-contingency principle

Process designs should incorporate **sufficient** factors of safety to require at least two **unlikely**, independent, and concurrent changes in process conditions before a criticality accident is possible.<sup>3)</sup>

- A standard dictionary provides adequate definitions for the words unlikely and credible
  - “credible” is defined as “believable, tenable, plausible, or reasonable”
  - “unlikely” is defined as “improbable, doubtful, dubious, or far-fetched”
- The meaning of these words are highly dependent upon the health of a site’s safety culture and formality of operations program
- Site events such as new management, new staff, NCS program formality, infraction history, facility age, or other issues could adversely affect the safety culture and formality of operations
  - Can result in an increase in accidents, NCS infractions, deviations from procedures, etc.
- Thus, the health of a site’s safety culture or facility of operations program is not a constant, i.e., not changing over time, but, instead, varies as a function of time
  - Thus, the meaning of “credible” and “unlikely” can vary over time and should be addressed by a site NCS program
  - Tracking and trending of procedure deviations is one way to look at the health of site safety culture and formality of operations programs

# Example – The words “credible” and “unlikely” (ANS-8.1)

- Although not uniquely defined in the standard glossary, “credible” and “unlikely” are used in the process analysis requirement (Section 4.1.2) and the double contingency principle recommendation (Section 4.2.2), respectively

## 4.1.2 Process analysis

Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and **credible** abnormal conditions.<sup>2)</sup> In some cases it may be necessary or desirable to resort to in situ neutron multiplication measurements to confirm the subcriticality of proposed configurations. Guidance for safety in performing such measurements is contained in ANSI/ANS-8.6-1983 (R2010) [8].

## 4.2.2 Double-contingency principle

Process designs should incorporate **sufficient** factors of safety to require at least two **unlikely,** independent, and concurrent changes in process conditions before a criticality accident is possible.<sup>3)</sup>

- A standard dictionary provides adequate definitions for the words unlikely and credible
  - “credible” is defined as “believable, tenable, plausible, or reasonable”
  - “unlikely” is defined as “improbable, doubtful, dubious, or far-fetched”
- The meaning of these words are **highly dependent** upon the health of a site’s safety culture and formality of operations program
- Site events such as new management, new staff, NCS program formality, infraction history, facility age, or other issues could adversely affect the safety culture and formality of operations
  - Can result in an increase in accidents, NCS infractions, deviations from procedures, etc.
- Thus, the health of a site’s safety culture or facility of operations program is not a constant, i.e., not changing over time, but, instead, varies as a function of time
  - Thus, the meaning of “credible” and “unlikely” can vary over time and should be addressed by a site NCS program
  - Tracking and trending of procedure deviations is one way to look at the health of site safety culture and formality of operations programs

# Example – The words “credible” and “unlikely” (ANS-8.1)

- Although not uniquely defined in the standard glossary, “credible” and “unlikely” are used in the process analysis requirement (Section 4.1.2) and the double contingency principle recommendation (Section 4.2.2), respectively

## 4.1.2 Process analysis

Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and **credible** abnormal conditions.<sup>2)</sup> In some cases it may be necessary or desirable to resort to in situ neutron multiplication measurements to confirm the subcriticality of proposed configurations. Guidance for safety in performing such measurements is contained in ANSI/ANS-8.6-1983 (R2010) [8].

## 4.2.2 Double-contingency principle

Process designs should incorporate **sufficient** factors of safety to require at least two **unlikely**, independent, and concurrent changes in process conditions before a criticality accident is possible.<sup>3)</sup>

- A standard dictionary provides adequate definitions for the words unlikely and credible
  - “credible” is defined as “believable, tenable, plausible, or reasonable”
  - “unlikely” is defined as “improbable, doubtful, dubious, or far-fetched”
- The meaning of these words are highly dependent upon the health of a site’s safety culture and formality of operations program
- Site events such as new management, new staff, NCS program formality, infraction history, facility age, or other issues could adversely affect the safety culture and formality of operations
  - Can result in an increase in human errors, NCS infractions, deviations from procedures, degrade defense-in-depth, etc.
- Thus, the health of a site’s safety culture or facility of operations program is not a constant, i.e., not changing over time, but, instead, varies as a function of time
  - Thus, the meaning of “credible” and “unlikely” can vary over time and should be addressed by a site NCS program
  - Tracking and trending of procedure deviations is one way to look at the health of site safety culture and formality of operations programs

# Example – The words “credible” and “unlikely” (ANS-8.1)

- Although not uniquely defined in the standard glossary, “credible” and “unlikely” are used in the process analysis requirement (Section 4.1.2) and the double contingency principle recommendation (Section 4.2.2), respectively

## 4.1.2 Process analysis

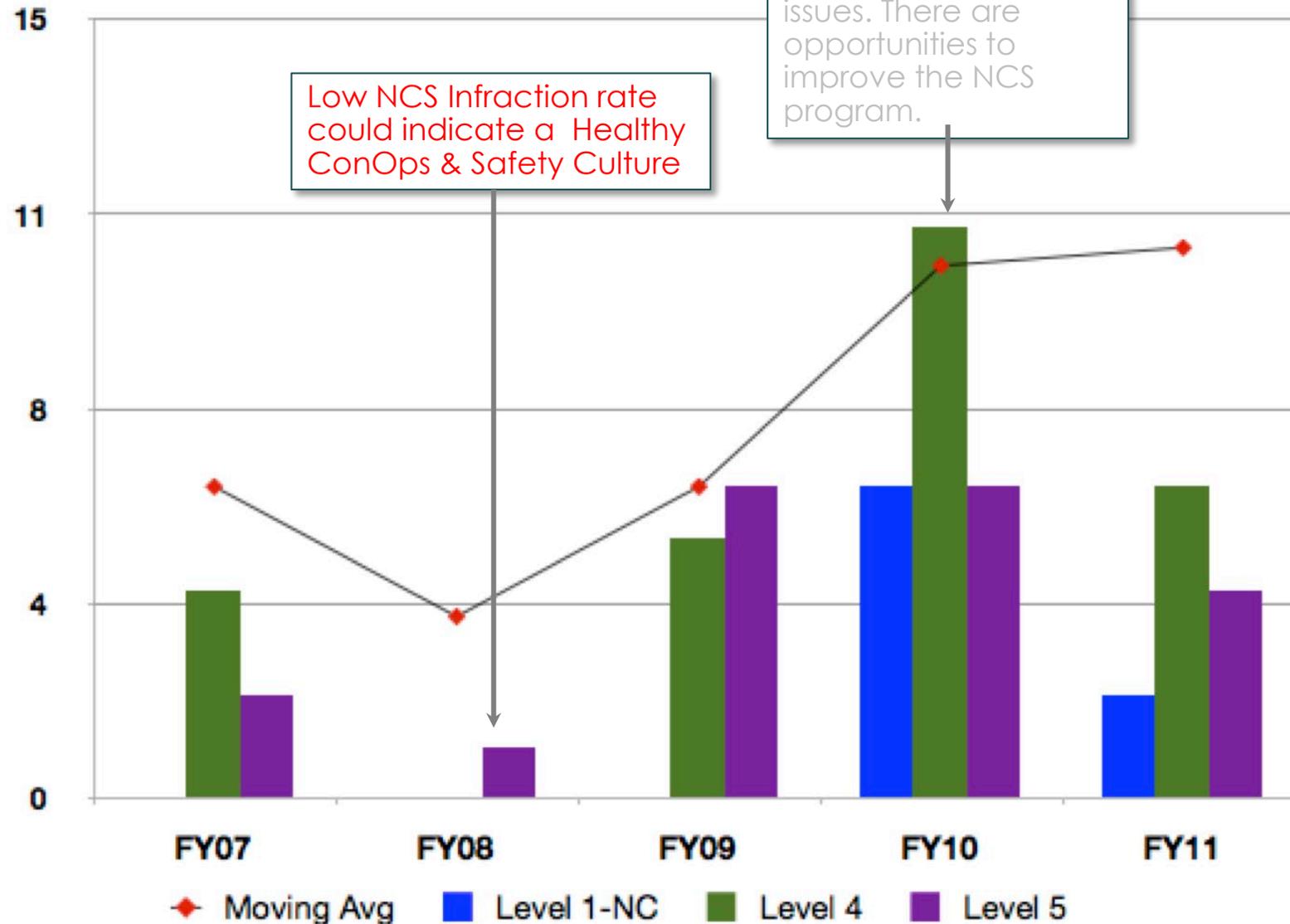
Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and **credible** abnormal conditions.<sup>2)</sup> In some cases it may be necessary or desirable to resort to in situ neutron multiplication measurements to confirm the subcriticality of proposed configurations. Guidance for safety in performing such measurements is contained in ANSI/ANS-8.6-1983 (R2010) [8].

## 4.2.2 Double-contingency principle

Process designs should incorporate **sufficient** factors of safety to require at least two **unlikely,** independent, and concurrent changes in process conditions before a criticality accident is possible.<sup>3)</sup>

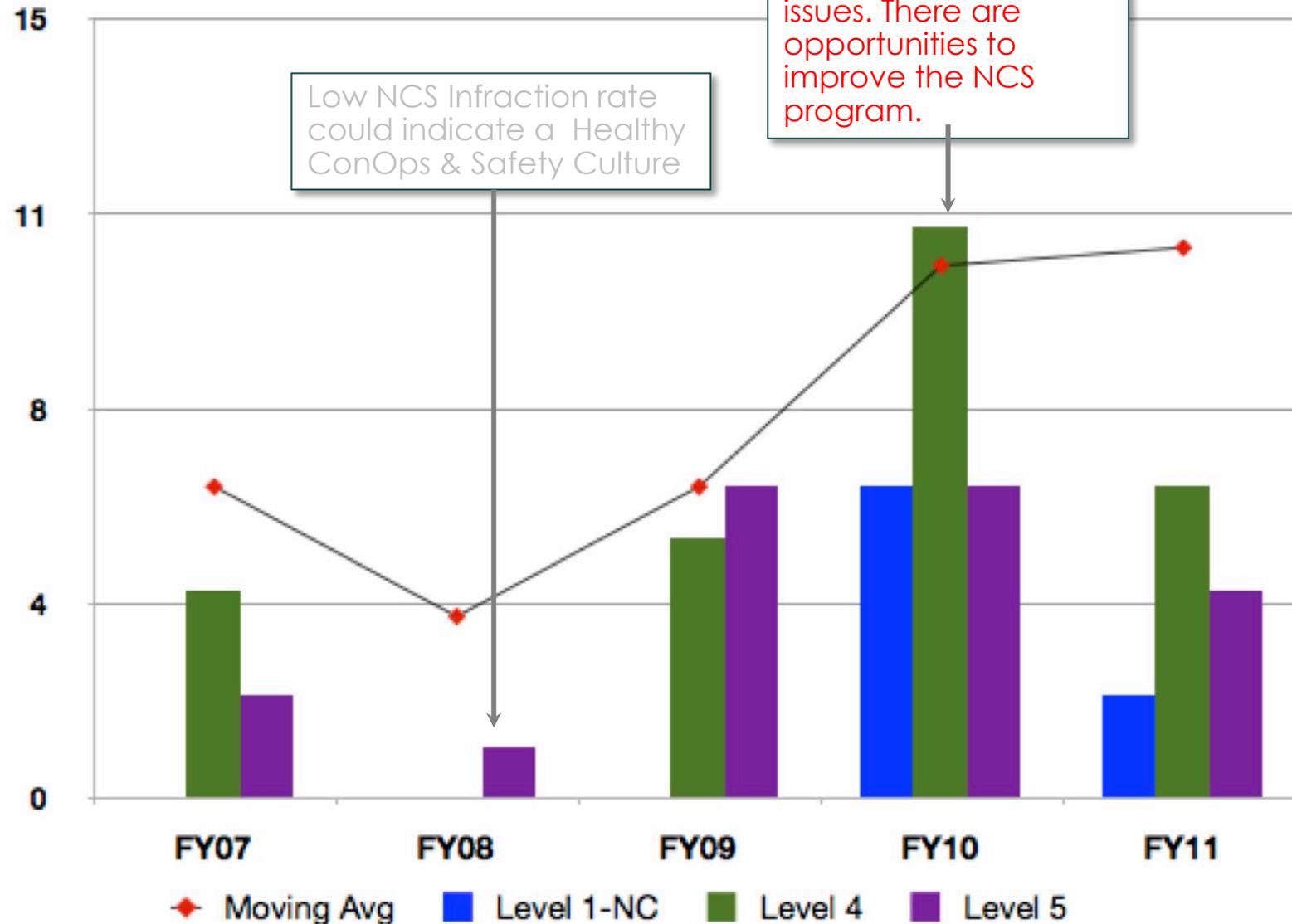
- A standard dictionary provides adequate definitions for the words unlikely and credible
  - “credible” is defined as “believable, tenable, plausible, or reasonable”
  - “unlikely” is defined as “improbable, doubtful, dubious, or far-fetched”
- The meaning of these words are highly dependent upon the health of a site’s safety culture and formality of operations program
- Site events such as new management, new staff, NCS program formality, infraction history, facility age, or other issues could adversely affect the safety culture and formality of operations
  - Can result in an increase in accidents, NCS infractions, deviations from procedures, etc.
- Thus, the health of a site’s safety culture or facility of operations program is not a constant, i.e., not changing over time, but, instead, **varies** as a function of time
  - Thus, the meaning of “credible” and “unlikely” can also vary over time and should be addressed by a site NCS program
  - Tracking and trending of procedure deviations is one way to look at the health of site safety culture and formality of operations programs

# Infraction Tracking



- The first case in FY08 may indicate healthy site programs
- The second case in FY10 clearly indicates there is an increase in operational deviations
  - Could indicate degradation in safety culture or formality of operations
  - “Credible” abnormal conditions could have drifted – initiating events once considered to be not credible may now be credible
  - There could be more “unlikely” changes in process conditions now compared to in FY08 (unlikely changes in process conditions could be more likely and consequences could be more severe)

# Infraction Tracking



- The first case in FY08 may indicate healthy site programs
- The second case in FY10 clearly indicates there is an increase in operational deviations
  - Could indicate degradation in safety culture or formality of operations
  - “Credible” abnormal conditions could have drifted – initiating events once considered to be not credible may now be credible
  - There could be more “unlikely” changes in process conditions now compared to in FY08 (unlikely changes in process conditions could be more likely and consequences could be more severe)

# Conclusions

- The working group ultimately decided not to add definitions for these words to the standard glossary
  - they should be defined and agreed to by the site management, NCS staff/advisors, and site regulator
- One reason for this decision was the health of a site's safety culture and formality of operations at a site is a complex arrangement of
  - upper management and process supervisor engagement,
  - operator training and certification,
  - and formal, written procedures, among other characteristics,
- The health of a site safety culture and formality of operations is not a constant – it varies as a function of time
  - The meaning of standard requirements/recommendations can be affected, e.g., "credible," , "unlikely"
  - Defense-in-depth can vary and even degrade
  - Tracking and trending procedure deviations, annual process walkdowns, management/regulator engagement and independent assessments can help maintain a healthy environment for implementation of the ANS-8 standards at a site
  - Ensure criticality safety evaluation controls are applicable (maintenance) long term