From: Steven Orth RIII
To: RI John White; Mike Shannon; Robert Haag
Date: 12/23/05 7:29AM
Subject: Evaluation of Radiological Incidents

Release

Greetings,

Region III developed the attached procedure to aid us in the review of complex radiological incidents/issues. We used the lessons learned from our experiences with the Davis Besse Hot Particle problems and the general experience of our inspectors. We thought it may be useful to share it with others.

Happy Holidays,

Steve

CC: Roger Pedersen; Stephen Klementowicz

C-81

DIVISIONAL INSTRUCTION DI-IP-93812
EVALUATION OF RADIOLOGICAL INCIDENTS

Effective Date: 05/12/2005

Point of Contact: Plant Support Team Leader

Supercedes: N/A

Approval: **/RA by Roy Caniano Acting For/**
Cynthia D. Pederson, Director
Division of Reactor Safety

A. Purpose

This divisional instruction provides guidance intended to be used by reactor health physics staff as a companion to Regional Procedure 1219, "Special Inspections at Reactor Sites," to ensure that follow-up inspections of radiological events are sufficiently comprehensive so that all potential underlying issues and contributors to the event are explored. The guidance contained herein can also be used by management to ensure that the staff adequately evaluated a radiological event and that all precursors which led to the event have been identified and evaluated.

While this guidance is not all inclusive, it provides a template or checklist that can be utilized during follow-up of radiological exposure events, focusing on uncontrolled radiation exposures, to ensure key aspects of a licensee's radiation protection (RP) program have been reviewed and to aid the inspection team in the transition from event response to an evaluation of the underlying issues. Although the principle purpose of the guidance is to be used for special inspections, the guidance may also be used to evaluate complex reactor radiological incidents that do not meet the significance thresholds of special inspections.

B. References

1. NRC Inspection Procedure 93812, "Special Inspection."

2. Regional Procedure RP-1219, "Special Inspections at Reactor Sites."

3. NRC Inspection Procedure 83728, "Maintaining Occupational Exposure ALARA."

4. NRC Inspection Procedure 71841, "Human Performance."

5. NRC Inspection Procedure 83501, "Significant Uncontrolled Radiation Exposure."

6. Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Are ALARA."

7. Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations and Assumptions For A Bioassay Program."

8. Regulatory Guide 8.27, "Radiation Protection Training for Personnel at Light-Water Cooled Nuclear Power Plants."

C. Discussion

The charter of a special inspection identifies the scope of the inspection effort. In the evaluation of radiological incidents, the inspection should review both the occupational and public radiation safety components of the incident, as applicable.

Uncontrolled radiation exposures at reactor sites usually result from one or more of the following problems:

1. Poor work planning and hazards evaluation, including failure to conduct appropriate surveys;
2. Inadequate job coverage or work oversight;
3. Inadequate instruction to workers including incomplete requirements or briefings;
4. Poor response to changing conditions by the radiation protection staff and radiation worker;
5. Procedure related issues;
6. Lack of supervisory involvement or management support;
7. Lack of effective communication; and
8. Human performance issues.

All of the circumstances that led to the radiological event should be reviewed to ensure that all significant radiological deficiencies are identified and assessed. For special inspections, fact finding should be emphasized to ensure a full understanding of the circumstances including conditions that preceded the event and the chronology of the event.

Events generally have multiple contributing factors that are often inter-connected; therefore, an organized and thorough approach to the inspection is essential. To reconstruct an event and understand its precursors, the inspection should start as far back in time from the incident as may be relevant to the ensuing event.

Inspectors should always consider the impact of the event on both occupational and public radiation safety. For example, the inspectors should determine if the event led to or potentially caused contamination to be transported offsite. If an offsite issue was created, determine if it resulted from a failure to properly control work or other onsite performance deficiency or as otherwise directed by the Inspection Charter.

D. Definitions

None.

E. Organizational Responsibilities

1. Division Director/Deputy, Division of Reactor Safety

   a. Maintains overall responsibility for the implementation of the Region III reactor radiation safety inspection program.

   b. Approves the scope of radiation safety inspection activities under Regional Procedure 1219, "Special Inspections at Reactor Sites," involving radiological incidents at reactor facilities.

   c. Reviews and approves findings related to radiation safety inspections of radiological incidents at reactor facilities.

2. Team Leader, Plant Support Team

   a. Oversees the day-to-day implementation of the Region III reactor radiation safety inspection program.

   b. Recommends the scope of the review of radiological incidents at Region III reactor facilities.

   c. Reviews inspectors' findings related to radiation safety inspections of radiological incidents at reactor facilities and recommends disposition to the division director, as appropriate.

3. Radiation Safety Inspectors

   a. Conducts inspections of reactor radiological incidents.

   b. Ensures that the circumstances surrounding the radiological incident are understood and that both occupational and public radiological aspects are reviewed.

   c. Ensures that limitations (procedural, resources, etc.) are brought to the attention of the Plant Support Team Leader.

F. Implementation

The following guidance provides questions which inspectors should attempt to answer, as applicable, during review of radiological exposure events and other radiological incidents.

1. Work Planning

a. Was the radiation protection (RP) staff adequately involved in the planning and scheduling of the work activity that led to the event?

b. Was the RP staff notified/consulted if the work schedule was significantly altered?

c. Was sufficient lead time provided to allow for a thorough ALARA review of the work package?

- Were historical job files effectively used?
- Was work not previously conducted at the site or revised work techniques not previously used benchmarked at other sites?
- Were industry and licensee lessons learned applied to the work package?
- Were radiological engineering controls adequately evaluated and incorporated into the work package?
- Were specific radiological hold points and stop work conditions specified as part of the radiation work permit (RWP) and/or ALARA Plan?
- Were the radiological hold points developed for the job consistent with previous surveys and job history data, commensurate with the hazards?
- Was mockup training provided for unique or complex tasks that required the use of specialized tools/equipment or techniques?
- Were well thought-out contingency plans developed should work scope or conditions change?
- Were "as found" conditions within the scope of the planning basis? If not, what actions were taken?

d. Were work areas walked-down by the work group and RP staff as part of the work package preparation to identify any impediments or special radiological considerations?

e. Did the Station ALARA Committee complete a thorough review of the ALARA plan?

- Did they challenge the ALARA controls, work scope, dose estimates, etc?

f. Did the RP program include provisions for the identification and control of difficult-to-detect nuclides (transuranic isotopes and pure beta emitters)?

- Was the program consistent with industry guidance including NRC Information Notices?

- Did the licensee implement this program as required?

g. Were TEDE ALARA evaluations technically sound and based on either actual radiological conditions or historical conditions that applied to the work activity?

   - Were the expected radiological conditions confirmed prior to the initiation of work?

h. Were adequate pre-job briefings provided?

   - Were the expected radiological conditions and controls discussed during the briefing, including hold points and contingencies?

   - Did all involved RP staff and workers attend the briefing?

   - Was there an adequate exchange of information amongst the participants?

   - Was the briefing held within about 24-hours of the start of the work?

i. Was sufficient time allocated in the work schedule to allow for engineering controls to be put in place (ventilation systems, auxiliary lighting, system flush/fills, decontamination activities and CRUD burst cleanup, etc.) and for scaffolding and shielding to be installed to support the work?

j. Did the work schedule include provisions to ensure work was sequenced to obtain the greatest dose benefit (timing of work relative to CRUD burst, system flushing/hydrolazing, water balancing and installation of conventional shielding)?

2. Job Coverage, Work Oversight and Management Support

   a. Were there adequate pre-job surveys and ongoing surveys throughout the work evolution to define the radiological conditions?

   b. Did these surveys (including air samples) adequately assess the hazards including an assessment of alpha, beta, gamma, and neutron radiation, as applicable?

   c. Was the RP staff (both technicians and supervisors) given specific job coverage assignments?

   d. Were RP staff resources sufficient to provide adequate coverage?

e. Did the assigned RP staff participate in the pre-job briefings and the mock-up training?

f. Was the RP staff assigned job coverage responsibilities sufficiently experienced and knowledgeable of those tasks?

g. Did ALARA and supervisory staff monitor radiological performance as work progressed?

h. Was the RP staff that provided job coverage burdened with other tasks which adversely impacted their oversight or focus?

i. Did the RP staff assigned to cover work have stop work authority and did they exercise that responsibility, if warranted?

j. Did radiation workers understand their responsibility to communicate with and follow the instructions of the RP staff?

k. Did excessive overtime, fatigue or distractions adversely impact job coverage?

l. Were radiological issues given proper management support and priority so that work schedule pressure did not override radiological safety?

   - Was this philosophy promulgated from the top down to all staff levels?

m. Was RP management directly involved in follow-up of the event or did management otherwise oversee event response?

3. Qualifications and Training

   a. Did individuals understand their responsibility and authority under the RP program for the work activity?

      - Did station management and work group supervisors endorse worker adherence to RP requirements? If yes, how was this accomplished?

   b. Did problems with training or instruction cause or contribute to the event?

      - What were the specific problems with the training or instruction?

   c. Did worker inexperience or unfamiliarity contribute to the event?

   d. Were workers equipped with the necessary tools and other equipment to perform the task properly?

- Did the workers understand how to properly use the tools and equipment?
- Did the tools/equipment function as intended?

e. Was mockup training provided as necessary?

- Was the mockup training adequate?
- Did mockup training include the use of all protective equipment, communications equipment and specialized tooling to best simulate the actual work activity conditions?
- Were problems identified during the mockup training fed back into the planning process?

f. Were procedures, the RWP or the ALARA Plan that governed the work activity consistent with what workers were taught or instructed to do?

4. Human Performance

a. Did communication problems cause or contribute to the event?

- Was radiological and other information important to the successful execution of the work communicated in sufficient detail so all workers understood their roles, responsibilities and the work priorities?
- Were communications within the RP organization and between RP and other departments evaluated as a possible event contributor?
- Was information communicated accurately?
- Was information timely relative to the work activity so it would not be forgotten over time?
- Was information misunderstood or misinterpreted?
- Was there inconsistency in the information which contributed to misunderstandings?
- Was verbally communicated information consistent with the documented work package?
- Was information sought-out and questions asked if workers were unsure?

b. Was the work properly executed consistent with expectations and requirements?

- Were STAR (stop-think-act-review) principles used?
- Was there inattention to detail?
- Was there a lack of questioning attitude?
- Was there a lack of awareness of plant or radiological conditions that impacted job performance?
- Were there too many concurrent tasks?
- Was there excessive time pressure to complete tasks, if so, from whom and why?
- Were there task interruptions or distractions that impacted worker focus?
- Did workers experience cognitive overload or underload (boredom)?

c. Did procedure use/adherence adversely impact the work?

- Was the work performed without appropriate procedures or were incorrect procedures used?
- Were procedure prerequisites met?
- Were procedure steps circumvented?
- Were procedures adequate?
- Was procedure compliance not stressed?
- Were procedure steps compatible with the work package and pre-job brief?

d. Did fitness-for-duty issues impact the work?

- Was there substance abuse or worker illness?
- Was worker fatigue a factor (excessive overtime, called into work outside regular schedule, lack of breaks during shift)?

e. Did environmental or other external factors impact the work (excessive cold, heat, humidity, poor lighting, unstable footing, cramped working area, noise, protective gear constrained movement or impacted communications)?

5. Risk Assessment

a. Was the licensee's dose or other hazards assessment consistent with the known sequence of the event?

b. Was the dose assessment technically sound and did it consider all potential exposure pathways and nuclides?

- Were time and motion studies performed or the event reenacted (necessary for exposures from high source terms or in complicated physical configurations)?

- Was the source term fully evaluated and understood (pure beta or alpha emitters), especially for plants with poor fuel performance?

- Was the potential for deep (gamma) dose from large activity discrete particle skin contaminations considered?

- Was the contaminants solubility class determined and applied properly to any dose assessments?

- Were Intake Retention Factors applied correctly and based on the proper intake pathway and solubility class, as supported by the bioassay data?

- Did dose assessment calculations that were based on field data and the event re-enactment and time-line correspond with actual dosimetric or bioassay data? Were discrepancies evaluated and reconciled?

- Were all potential intakes or dose pathways considered?

- Were potential changes of energy of the radiation considered for underwater exposure events?

c. Were the instrumentation and analyses methods appropriate for the dose reconstruction?

- Were in-vivo counter characteristics (total body or organ specific detector and isotope library) considered?

- Were in-vitro samples analyzed for the appropriate excretion pathway?

- Were all applicable radionuclides included in the licensee's analytical methods (e.g., spectroscopy software libraries)?

- Were bioassay analysis lower limits of detection (LLDs) appropriate and meaningful?

- Was the instrumentation and dosimetry used to evaluate dose adequate?

d. Was the licensee's response to the event commensurate with the risk estimate and were the actions taken appropriate and in the best interest of pubic safety?

- Were additional controls placed on the source of exposure/intake to prevent continued problems?

- Was medical screening or treatment including cytogenetic studies considered?

- Was work stopped to eliminate ongoing risk to others?

- Were in-vivo or in-vitro bioassays considered and performed in a timely manner, so that appropriate (including short-lived) nuclides could be measured?

- Did the licensee properly oversee the collection of in-vitro bioassay samples?

- Was there proper chain-of-custody over the in-vitro samples collected and were they prepared/packaged properly?

- Did the licensee communicate with the vendor performing bioassay analyses as to the analyses sought, including the required LLDs for specified nuclides?

- Were in-vivo bioassays completed by trained and experienced individuals using appropriate equipment?

- Did the licensee verify that vendor analytical services satisfied industry quality control requirements?

- Did the licensee complete an extent of condition evaluation to determine if others may have been exposed to similar hazards previously?

- Were surveys performed to identify all articles of contaminated clothing, personal belongings, and in residences, vehicles, and other establishments where contamination may have been transported?

- Were other potentially impacted areas in the public domain surveyed for the possible presence of radioactive material?

6. Event Scenario

   a. Did the licensee interview all personnel directly and indirectly involved in the incident, as well as all levels of management whose area of responsibility connected with the persons involved in the event (those indirectly involved may contribute invaluable information about generic issues that could have bearing on the incident)?

   b. Was a time-line established that was consistent with the interviews and other data gathered?

   c. Did inspectors interview involved staff to corroborate the licensee's information?

   d. Were all incident related records/documents compiled and reviewed by the licensee, and did they support the event scenario and time-line?

   e. Was physical evidence connected with the incident preserved (survey instrumentation which yielded erroneous readings, smears and air samples which can be re-analyzed, etc.)?

   f. Is the licensee's understanding of the event supported by the facts?

   g. Were the assumptions made concerning the sequence of the events (time intervals, exposure time, etc.) reasonably conservative and supported by the extension of verifiable facts?

   h. If the incident involved a release of radioactive material to the environment, what was the source of that release? Was that source attributable to a work performance or planning issue?

7. Problem Identification & Resolution (PI&R)

   a. Prior to the event, did licensee (or contractor) assessments, audits, field observations, or its corrective action program, etc., identify problems similar to those that caused or contributed to the event?

      - What corrective actions were taken to address identified deficiencies?

      - Were the corrective actions adequate, timely and verified to be effective?

      - If not identified by the licensee's PI&R program, why not?

b. Did industry audits, notices, operating experiences or (NRC) inspections previously identify problems that caused or contributed to the event or otherwise were similar?

- What actions were taken to address the problems identified or to review the industry notices for applicability?

- Is the licensee's operating experiences program sufficiently mature to ensure industry information is properly and timely evaluated and corrective actions are implemented?

- Are corrective action effectiveness reviews performed as warranted by the significance and complexity of the problem?

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