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Human Factors Evaluation of the Auxiliary Hot Cell Facility, Sandia National Laboratories, Albuquerque, New Mexico

Hugh O. Whitehurst and Regina L. Hunter

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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**HUMAN FACTORS EVALUATION
OF THE AUXILIARY HOT CELL FACILITY,
SANDIA NATIONAL LABORATORIES,
ALBUQUERQUE, NEW MEXICO**

Hugh O. Whitehurst
Risk & Reliability Analysis Department

Regina L. Hunter
International Environmental Analysis Department

Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-0720

Abstract

The Auxiliary Hot Cell Facility (AHCF) at Sandia National Laboratories, New Mexico (SNL/NM) is a Hazard Category 3 nuclear facility used to characterize, treat, and repackage radioactive and mixed material for reuse, recycling, or ultimate disposal. Mixed waste may also be handled at the AHCF. A significant upgrade to a previous facility, the Temporary Hot Cell, was required to perform this mission. A checklist procedure was used to perform a human-factors evaluation of the AHCF modifications. This evaluation resulted in two recommendations, both of which have been implemented.

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1. INTRODUCTION

The mission of the Auxiliary Hot Cell Facility (AHCF) at Sandia National Laboratories, New Mexico (SNL/NM) is to safely characterize, treat (if required), and repackage radioactive and mixed material for reuse, recycling, or ultimate disposal. Mixed waste may also be handled at the AHCF. A significant upgrade has been made to a previous facility, the Temporary Hot Cell (THC), to support this mission.

Although the AHCF is a new facility, it has been constructed around a pre-existing hot cell, the THC, within a pre-existing building, Building 6597. The following major features have been added:

- A permanent shield wall extends northward from the west wall of the hot cell.
- Eight floor silos have been constructed—two inside the hot cell, and six behind the permanent shield wall—to facilitate package handling and provide shielding during operations and storage.
- The hot-cell roof has been replaced to allow the placement of two roof portals over the two silos in the hot cell.
- A ventilation system has been upgraded to a two-stage high efficiency particulate air (HEPA) filter serving a fume hood and temporary room as well as the hot cell.
- The existing hot-cell jib crane has been upgraded.
- Video cameras may be used to record operations and to facilitate remote-handled operations.
- Fire-extinguishing capability has been added.

These features enhance SNL/NM's ability to safely characterize, handle, treat, and package its radioactive legacy inventory.

The new design—including the eight silos, new roof with portals, jib crane upgrade, and video cameras—should increase both safety and efficiency of operations. Much of SNL/NM's prior experience in training operators and preparing and implementing procedures in Technical Area V (TA-V) in general and the THC in particular will be useful at the AHCF.

Two recommendations resulted from this evaluation. First, an indicator light that was not an alarm was the same color as two nearby alarms. The indicator light has been changed. Second, a visual alarm that was not in the operator's line of sight was moved to be within line of sight and has been made both visual and audible.

2. HUMAN FACTORS EVALUATION

DOE (2002) suggests that because Hazard Category 3 facilities do not have safety-class structures, systems, or components (SSCs), a systematic examination of human factors that meets the requirements of 10 CFR 830 may be accomplished using basic human-factors checklists. The AHCF is a Hazard Category 3 nuclear facility, and thus it is appropriate to use the checklist approach for the human-factors evaluation. Checklists enclosed with DOE memorandum DP-625 (DOE 1992) were used for the evaluation.

When the human-factors analysis was performed, the light on the Exhaust Fan Control Station labeled “ALARM SILENCE ON” was the same color (red) as two alarms on the left. Because this light is not an alarm, it should not be identical to the actual visual alarms. After discussion with AHCF personnel, the color was changed, and a lighted amber switch now indicates that the alarm silence is on. In addition, a flashing amber beacon continues to operate while the condition exists. When the condition is corrected, the beacon goes off; however, the amber switch remains lighted until the alarm is reset.

In-air transfers are of concern because a package could be damaged during these procedures if it is dropped or a crane-operation error occurs and the package impacts something in its path. The package could be dropped if the rigging is not secure or the crane breaks. The procedures to secure the package and maintain the jib crane are the same as were used in the Temporary Hot Cell. The controls for the jib crane will also be the same as previously used. The operators are trained to perform these procedures and have experience. A critical-lift form is filled out and used. An independent check of the rigging and attachment to the crane is performed as part of the pre-use inspection of the rigging, in accordance with the ES&H Manual. A backup generator will be available and operating in case power is lost while the package is being moved.

The AHCF is divided into two ventilation zones. Zone 1 encompasses the AHCF ventilation system, including the hot cell; fume hood; HEPA filter bank; exhaust fan; and ductwork to the hot cell, fume hood, and temporary room if the latter is in place. The overall Building 6597 ventilation system services Zone 2, which encompasses everything outside Zone 1. Zone 2-to-Zone 1 airflow must be maintained during operation at the AHCF. When the human-factors analysis was performed, the air-pressure display was located in a position that will usually not be visible to the operators. The human-factors analysis suggested that given the importance of maintaining air pressure, at least a visual alarm should be used; however, if the alarm is only visual, it should be in the operator’s line of sight. After discussion with AHCF personnel, the design was changed. The original alarm has been replaced with a visual and audible alarm, and all readouts have been relocated to the west wall.

The recommendations made as a result of the human-factors analysis were limited, because considerable thought was given to the safety of the operators and public prior to the performance of the analysis.

3. AHCF HUMAN FACTORS EVALUATION CHECKLISTS

A human factors evaluation for the AHCF was performed in 1999 using the guidance provided in DOE memorandum DP-625, dated December 1, 1992. This chapter provides the checklists and answers. Answers have been updated to reflect as-built conditions and current procedures.

The THC operated under the authorization basis of the Hot Cell Facility (HCF). Neither the HCF nor the THC had safety-class SSCs, and therefore they had no safety limits on operation. There were no releases of radioactive material during operation of the THC.

Many of the checklist questions address emergencies; a working definition of “emergency” for use in responding to the checklist questions is developed below.

The SNL/TA-V Emergency Preparedness Plan (Sandia 2002a) defines an emergency in TA-V as a circumstance or condition that demands immediate response because it has the potential to endanger the health or safety of personnel or property in the area. The plan gives the following examples of such emergencies:

- Nuclear incidents (inadvertent criticality; high radiation; reactor-core disruption, damaged fuel elements, experiments, or targets; etc.);
- Explosion (radiography of explosives, experiments containing explosives);
- Fire; and
- External events (airplane crash, natural phenomena events, etc.)

The AHCF is subject to two types of operational emergencies for which engineering controls are provided: fire and high-radiation conditions. The engineered systems that function to alert workers to fire and high-radiation hazards are the fire-detection and radiation-monitoring systems. Because the AHCF ventilation system plays such an important role in maintaining the integrity of facility radioactive material confinement boundaries, it is also included in this evaluation. The fire-detection, radiation-monitoring, and ventilation systems are the focus of the human factors man-machine interface and function-allocation questions.

The AHCF is subject to the TA-V Emergency Preparedness Plan, which contains information on the following topics associated with TA-V facility emergencies:

- Emergency organization and responsibilities;
- Response actions;
- Facility emergency procedures;
- Hazardous-material locations;
- Fire and other evacuation alarm systems;
- Radiation detectors;
- Emergency-communication systems;
- Emergency-recovery equipment; and
- Emergency logs, checklists, and guidelines.

3.1 HFE CHECKLIST 1

Question 1: Have Operational/Technical Safety Limits (OSRs/TSLs) been maintained in the past 2 years?

Response:

The THC has not operated in the past two years, and when it was in operation, it had no Operational or Technical Safety Limits. When it was in operation, no other types of operational limits were exceeded.

For the AHCF, the unmitigated consequences at the exclusion area boundary are not significant for credible accidents (Oscar et al. 1999). Therefore, the AHCF does not have any Technical Safety Requirements (TSR) -related safety limits.

Question 2: Were correct operator actions taken when the system exceeded a limiting control setting or limiting conditions for operation?

Response:

The operator of the THC always worked within the operational limits at the THC. No limits were exceeded.

Question 3: Were OSR/TSR surveillances performed within required time limits?

Response:

The pre-existing hot cell, the THC, previously operated to accomplish a specific task (i.e., packaging of irradiated fuel elements for return shipment to the Savannah River Site) while the SNL TA-V HCF was being decontaminated. This task was performed under the HCF authorization basis, and there were no specific OSR/TSR-required surveillances associated with this task.

Question 4: Has the facility been in compliance with OSR/TSR administrative control requirements?

Response:

There were no previous OSR/TSR administrative control requirements for the THC. The AHCF Operational Readiness Review will ensure that the AHCF is in compliance with all TSR administrative control requirements when it begins operation under the new authorization basis.

3.2 HFE CHECKLIST 2

Question 1: Are there written procedures for operation (startup/shutdown), emergency operations, and OSR/TSR surveillances?

Response:

Operating procedures have been prepared for the following systems and equipment:

- Ventilation system;
- Hot cell;
- Fume hood;
- Hot-cell manual fire-extinguishing system; and
- Building and hot-cell cameras.

Emergency procedures for TA-V facilities, including the AHCF, are provided in the TA-V Emergency Preparedness Plan (Sandia 2002a). When the TA-V Fire/ Evacuation Alarm System is activated, AHCF personnel immediately evacuate to the Building 6582 Emergency Assembly Point. No emergency conditions require AHCF personnel to remain in any of the AHCF workspaces to perform emergency operations, although operators may at their discretion extinguish small or incipient fires within the hot cell with the manual fire-extinguishing system. Other than the manual fire-extinguishing system, the AHCF does not contain emergency instruments or controls, and thus has no emergency operating procedures; however, event-response procedures include a requirement to make the load safe if an event occurs during an in-air transfer.

The AHCF Preventive Maintenance Surveillance Guide covers the following TSR-required surveillances:

- Verification of Zone 1-to-Zone 2 ventilation system differential pressures when the hot-cell roof plugs are in place;
- Performance of a channel functional test for differential pressure measurement devices;
- Calibration of differential pressure indicating devices;
- Verification of Zone 2-to-Zone 1 airflow direction;
- Performance of a HEPA filter bank in-place leak test.

Other operational surveillance activities are also performed in accordance with the Preventive Maintenance Surveillance Guide.

Question 2: Are all written emergency operating procedures included in previous safety analyses?

Response:

No emergency conditions require personnel to remain in any of the AHCF workspaces to perform emergency operations. Thus, there are no AHCF-specific emergency operating procedures. There are event-response procedures, however.

Question 3: Are changes to emergency operating procedures outlined, summarized and described in previous safety analyses?

Response:

No emergency operating procedures are invoked by the AHCF safety analyses.

Question 4: Have changes made to the control over the conduct of work (involving changes to emergency procedures) been documented in previous safety analyses?

Response:

No emergency operating procedures are invoked by the AHCF safety analyses.

Question 5: Have operational changes, such as setpoint changes been incorporated into the procedures and described in previous safety analyses?

Response:

Because the AHCF is a Category 3 nuclear facility, it does not have any operational safety limits or limiting control settings to be incorporated into procedures and described in facility safety analyses. LCOs have been developed as required by the new authorization basis and incorporated into procedures.

Question 6: Is there a formal process for correcting technical deficiencies in written procedures?

Response:

The Conduct of Operations Manual for TA-V Nuclear Facilities specifies the process for developing, reviewing, issuing, and revising AHCF procedures (SNL 2002b). This process requires that operating procedures be periodically reviewed for technical accuracy and revised when they are found to be inadequate because of procedural deficiencies or errors, changes in identified hazards, or changes in operating conditions.

3.3 HFE CHECKLIST 3

Question 1: Are the qualification statements for operators, technicians, maintenance workers, and training staff consistent with the applicable ANSI standard or equivalent position qualification?

Response:

The AHCF is a non-reactor Category 3 nuclear facility. Therefore, the personnel qualification requirements will be specified in a Project/Experiment Quality Plan (PEQP), which will be reviewed for consistency with DOE Order 5480.20A.

Question 2: Do the training or replacement training programs for unit staff meet the requirements and recommendations of the applicable ANSI standards?

Response:

No ANSI standard specifically addresses qualification and training for non-reactor Category-3 nuclear-facility personnel. Instead, the training program requirements contained in DOE Order 5480.20A are applicable to AHCF personnel. The training

program has been periodically reviewed in internal and external audits to ensure consistency with DOE Order 5480.20A.

Question 3: Have all appropriate facility workers been trained to conduct emergency operations (i.e., site evacuation)?

Response:

No emergency conditions require personnel to remain in any of the AHCF workspaces to perform emergency operations, although AHCF operators will be trained on procedures for the use of the manual fire-extinguishing system on small and incipient fires. Event-response procedures include a requirement to make the load safe if an event occurs during an in-air transfer.

The TA-V Emergency Preparedness Plan requires that all AHCF personnel immediately evacuate to the Building 6582 Emergency Assembly Point when the TA-V Fire/Evacuation Alarm System is activated. Annual emergency training includes evacuation drills and a TA-V Safety Orientation/Evacuation film that addresses TA-V emergency conditions and responses.

3.4 HFE CHECKLIST 4

Question 1: Is staffing adequate for control room crews (i.e., operators and supervisors) and local workstations (technicians and supervisors)?

Response:

Instrumentation and controls for the AHCF consist primarily of ventilation-system fan and damper control panels located on the west wall of the hot cell. The ventilation system is the primary AHCF system that warrants close operator attention; an alarm will notify staff of any impairment of function.

The operations to be performed in the AHCF are variable, and operating needs and staffing levels must be carefully balanced to prevent unnecessary radiological exposures of personnel. Staffing requirements will vary between one and a few workers. These workers may include facility operators, a facility supervisor, and a radiological control technician, as needed. The Technical Safety Requirements specify minimum staffing requirements.

AHCF operations will generally be limited to a single day shift. If the need arises, additional operations and radiological control personnel can be added to support multiple shift operations.

Question 2: Have staffing assignments been made for upset or emergency conditions?

Response:

No emergency conditions require AHCF personnel to perform emergency operations. Operators may at their discretion extinguish small or incipient fires using the manual fire-

extinguishing system. Specific staffing assignments for TA-V emergencies are addressed in the TA-V Emergency Preparedness Plan.

3.5 HFE CHECKLIST 5

Question 1: Are required controls and displays available in a single control area (i.e., all emergency instruments and controls in one room)?

Response:

The AHCF is housed in the High Bay of Building 6597, which consists of a single room. Controls and alarms at the AHCF fall into three categories:

- Ventilation-system controls and alarms on a single control panel;
- Audible alarms that can be heard throughout the AHCF and associated visual alarms that identify the problem type and location;
- Portable controls that are designed to be readily accessible to the operators, wherever work is being performed; and
- Alarms that are audible or visible to the operators, wherever work is being performed.

Question 2: Do displays, controls, and alarms support timely performance of abnormal or emergency operations (i.e., radiation alarms set at appropriate thresholds)?

Response:

No emergency conditions require personnel to remain in any of the AHCF workspaces to perform emergency response operations.

The TA-V fire/evacuation alarm system is a system of local warning bells that are activated either manually by pull-box switches located at most exit doors throughout TA-V, or automatically by facility fire-detection systems. A fire-annunciation panel for the facilities in TA-V is located in the emergency control center of Building 6577, which is the security center for TA-V. The automatic fire alarm setpoints are established in compliance with the Fire Protection Code to provide timely response to incipient fires in continuously occupied areas of the AHCF.

Radiation monitoring devices are installed locally in TA-V facilities to aid operating personnel in detecting and evaluating radiological events and conditions. A radiation level that trips a radiation detection device results in an audible alarm and a visual readout at a local station. The audible radiation alarms produce high-pitched sounds that are easily distinguishable from the fire/evacuation alarm bells. In the AHCF, radiation monitors are strategically located to provide adequate warning of potential radiation hazards to workers. Radiation area monitor (RAMs) are generally set to alarm at an exposure threshold of 5 mrem/hr. A RAM on the north wall is set to alarm at 100 mrem/hr. Continuous air monitors (CAMs) are generally set to alarm in accordance with the RPPM (SNL latest issue a). These alarm thresholds are well below the threshold for which worker health and safety is a concern.

The ventilation-system controls addressed in response to Question 1 above alert AHCF personnel to malfunctions of the ventilation system. A local differential pressure gauge provides an indication of exhaust HEPA filter performance.

Question 3: Have communication areas been established throughout the facility (i.e., emergency telephones)?

Response:

Because the AHCF is located in a single room, the High Bay Building 6597, no internal communications system is needed. Alarms are audible and visible throughout the AHCF. Three telephones are available.

There is a TA-V-wide fire and evacuation alarm system. In the event the TA-V fire/evacuation alarm system fails to operate, the Public Address (PA) System will be used to spread the evacuation message to on-site personnel in TA-V. PA System stations are located throughout TA-V. The PA System is also used to instruct and inform site personnel of important developments during the course of an emergency.

Question 4: Are safety related controls and displays grouped by process function (i.e., emergency shutdown controls and displays on one panel vs. two)?

Response:

Controls are organized by emergency types and are located to be most accessible to the operator:

- Ventilation-system controls and alarms are located on a single control panel;
- Audible alarms that can be heard throughout the AHCF and associated visual alarms that identify the problem type and location;
- Portable controls are designed to be readily accessible to the operators, wherever work is being performed; and
- Alarms that are audible or visible to the operators, wherever work is being performed.

Question 5: Do all controls, displays, and instruments at your workstation have labels?

Response:

Yes, all controls, displays, and instruments are labeled.

Question 6: Does your workstation include:

- easy physical access;
- controlled radiological hazards;
- controlled chemical hazards;
- acceptable noise levels;
- appropriate temperatures;
- appropriate humidity?

Response:

As part of the Title II design review, all aspects of AHCF work conditions were reviewed. The AHCF operations areas are readily accessible from the outside ground level through a number of doors that directly connect the Building 6597 High Bay with the outside or with Building 6591.

Areas in which radiological activities will be conducted are appropriately posted and controlled in accordance with the SNL Radiological Protection Procedures Manual (RPPM; SNL latest issue a). Hazardous chemicals will be controlled in accordance with the SNL Environment, Safety and Health (ES&H) Manual (SNL latest issue b). Noise levels are expected to be acceptable for all continuously occupied areas of the AHCF. Appropriate temperatures are maintained in all continuously occupied areas of the AHCF. No controls are necessary to maintain humidity within an acceptable range.

Question 7: Are the workspace environments acceptable for accomplishment of responsibilities in emergency operations?

Response:

The appropriate response to either a fire or radiological emergency in the AHCF is evacuation of facility personnel. No emergency conditions require AHCF personnel to remain in any of the facility workspaces to perform emergency operations; however, operators may at their discretion extinguish small or incipient fires within the hot cell with the manual fire-extinguishing system. The AHCF contains emergency lighting in the event of a loss of normal power, and multiple exit doors facilitate rapid evacuation of personnel from the building.

3.6 HFE CHECKLIST 6

Question 1: Do automatic monitoring devices (i.e., temperatures, pressures, levels, radiation) support operator understanding of status of parameters important to safety?

Response:

The zoned fire detection system includes heat and smoke detectors and sprinkler system flow switches that actuate alarm strobes and bells. Automatic monitoring devices in the radiation monitoring system include RAMs and CAMs. Activation of these devices and their associated alarms requires evacuation of personnel from the area being monitored by the alarming device.

The important parameters in the ventilation system are the Zone 2-to-Zone 1 differential pressure and system exhaust-flow velocity. Automatic monitoring devices directly measure these parameters and provide the operations staff with a clear understanding of radioactive material confinement-barrier integrity. A decrease in the Zone 2-to-Zone 1 differential pressure below the alarm setpoint will result in an audible alarm. Similarly, cessation of air flow results in an audible alarm. The appropriate response to these alarms is specified in TSRs.

Question 2: Do automatic safety control devices (i.e., automatic shutdown systems) reliably support the operators in emergencies?

Response:

No automatic safety control devices in the AHCF are required to support operations personnel in an emergency. No emergency conditions require AHCF personnel to remain in any of the facility workspaces or to perform emergency operations.

Question 3: Are automatic alarm devices at a threshold that supports timely operator control functions in emergencies?

Response:

No automatic alarm devices in the AHCF are required to support operations personnel in an emergency. No emergency conditions require AHCF personnel to remain in any of the facility workspaces or to perform emergency operations.

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