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U. S. Department of Energy
Oak Ridge Operations Office

Type B Accident Investigation Board Report of the UT-Battelle, LLC, Contractor Employee Injuries from a September 7, 2001, Burn Accident at the Oak Ridge National Laboratory, Building 9210

October 2001

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U. S. Department of Energy

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INDEPENDENT REPORT

This report is an independent product of the Type B Investigation Board appointed by G. Leah Dever, Manager, Oak Ridge Operations Office, U.S. Department of Energy. The Board was appointed to perform a Type B investigation of this incident and to prepare an investigation report in accordance with DOE Order 225.1A, *Accident Investigations*.

The discussion of facts, as determined by the Board, and the views expressed in the report are not necessarily those of the U.S. Department of Energy and do not assume and are not intended to establish the existence of any legal causation, liability, or duty at law on the part of the U.S. Government, its employees or agents or contractors, their employees or agents or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

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RELEASE AUTHORIZATION

On September 13, 2001, I appointed a Type B Accident Investigation Board to investigate the September 7, 2001, burn injury of a prime contractor employee who required hospitalization. The UT-Battelle, LLC, employee was working in room 235 of Building 9210 when the accident occurred. The responsibilities of the Board have been satisfied with respect to this investigation. The analysis, identification of contributing and root causes, and Judgments of Need resulting from the investigation were performed in accordance with DOE Order 225.1A, *Accident Investigations*.

I accept the report of the Board and authorize release of the report for general distribution.

G. Leah Dever
Manager
Oak Ridge Operations Office

Date Accepted: 10/22/01

PROLOGUE

This Type B investigation is an important reminder that activities we carry out every day have important health and safety implications.

Many of the activities performed for the Oak Ridge Operations Office involve the routine use of heavy industrial equipment to accomplish the mission. This equipment also has the potential to cause serious personal injury unless appropriate safety measures are implemented. Every piece of equipment needs to be reviewed by competent, knowledgeable people to assure that hazards are identified and barriers and processes are developed to minimize the potential impacts of failure of any part of the equipment and to protect the people that come in contact with the equipment. This investigation points out the need for those safety analyses. If the hazards are appropriately identified and controlled through creation and implementation of physical and administrative barriers, then accidents such as this one can be significantly reduced if not eliminated.

I encourage all federal employees and contractors supporting the Oak Ridge Operations Office to read this report, think about the applicability to their work, and recognize that every piece of equipment presents a unique challenge to identify and negate its hazards. We encourage our federal and contractor employees to embrace and fully implement Integrated Safety Management.

G. Leah Dever
Manager
Oak Ridge Operations

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EXHIBITS AND TABLES

ACRONYMS

AHA	Activity Hazard Analysis
ASME	American Society of Mechanical Engineers
Board	Accident Investigation Board
BWXT	BWXT Y-12, LLC
CFR	Code of Federal Regulations
DOE	U. S. Department of Energy
DSO	Division Safety Officer
e-mail	Electronic Mail Message
ES&H	Environment, Safety, and Health
ESH&Q	Environment, Safety, Health, and Quality
F	Fahrenheit
HASP	Health and Safety Plan
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
JHA	Job Hazard Analysis
JHE	Job Hazard Evaluation
LSD	Life Sciences Division
MJR	Maintenance Job Request
MOU	Memorandum of Understanding
MTP	MTP Custom Machinery Corporation
OAP	Operational Awareness Program
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations Office
OSH	Occupational Safety and Health
P&E	Plant and Equipment
psi	pounds per square inch
QA	Quality Assurance
SBMS	Standards-Based Management System
SME	Subject Matter Expert
SOP	Standard Operating Procedure
S/RID	Standards/Requirements Identification Document
TLVs	Threshold Limit Values
UT-Battelle	UT-Battelle, LLC
WSS	Work Smart Standards
Y-12	Y-12 National Security Complex

EXECUTIVE SUMMARY

On September 7, 2001, an accident occurred at the U.S. Department of Energy (DOE) Oak Ridge National Laboratory (ORNL), Building 9210, which is located at the Y-12 National Security Complex (Y-12) in Oak Ridge, Tennessee. An employee of UT-Battelle, LLC (UT-Battelle), working in Building 9210, room 235, received a serious burn injury when a filter access assembly on a tunnel washer inadvertently opened and discharged hot water (194 degrees Fahrenheit) onto her legs and feet. UT-Battelle, LLC, is the prime contractor for operation of ORNL. The accident occurred during routine operations of the facility commonly known as the "Mouse House." This is a world-renowned research facility housing more than 70,000 mice that are important to medical and genetic research. This inventory of mice is kept in a carefully controlled, sanitized environment. The tunnel washer is a vital piece of equipment for cleaning cages, cage tops, and various other items used in the routine operation of the facility.

The Board concluded that the direct cause of the accident was the inadvertent opening of the filter access assembly when the equipment was in the operational mode where hot water was under pressure inside the assembly. The filter access assembly was the only physical barrier, and the latch on the assembly could be opened with only ten pounds of pressure.

The employee was working alone in room 235 when the accident occurred. At the time of the accident, the worker was placed in the immediate proximity of the filter access assembly due to extreme overcrowding of the room with carts full of cage tops waiting to be cleaned. The carts had been placed in the room in such a manner that only a very narrow path existed between the tunnel washer and the carts. At one point, the path was reduced to only 31 inches wide. The worker had just completed washing a cartload of kill pans, euthanasia lids, and beakers and was exiting the area when the accident occurred. Her normal exit path was blocked by an accumulation of carts full of dirty cage tops that needed cleaning. To exit with the clean product required that the worker navigate a cart with the clean items down a very narrow path bordered by carts full of cage tops on one side and the tunnel washer on the other. It was during this exit maneuver that either the cart or the worker came into contact with the filter assembly, with the subsequent in advertent opening of the filter assembly that allowed scalding hot water to deluge the worker below the waist.

The filter access assembly that opened was a component of the original equipment installed in late 1997. The filter access assembly was located immediately above a pump that forced heated water through the filter and into the tunnel washer. During normal operation, the pressure in the filter assembly was between 30 to 40 pounds per square inch. The access assembly consisted of three part (i.e., an outer plate, a rubber seal, and a hinged clamp with a levered latch that secured the outer plate and seal). When the levered latch was in a relaxed state (open), the outer plate and seal immediately fell to the floor. The tip of the levered latch protruded approximately1/8 inch beyond the end of the filter access assembly. Tests revealed that only ten pounds of pressure was needed to open the latch. The filter access assembly was the only physical barrier between the worker and scalding hot water.

Although there was no history of problems with the component, there was no Job Hazard Analysis (JHA) that would have recognized that the component posed a potential hazard.

Table ES-1. Judgments of Need

No.	Judgment of Need	Related Causal Factor
JON 1	DOE Oak Ridge Operations Office and the DOE ORNL Site Office need to improve the methods used to ensure the contractor is implementing the various components of Integrated Safety Management (ISM).	*DOE Oak Ridge Operations Office, the ORNL Site Office, and the DOE Program Manager have not provided adequate environment, safety, and health (ES&H) emphasis and validation to ensure the contractor is implementing the various components of its Integrated Safety Management System (ISMS). *The ORNL Site Office Program Manager has not recognized the need for regular DOE ES&H reviews within the Life Sciences Division (LSD) facilities at the Y-12 National Security Complex (Y-12). *The ORNL Site Office did not conduct detailed reviews of operating systems or ES&H program reviews of the Life Sciences Division at Y-12.
JON 2	There is a need for the LSD to clarify and improve the Job Hazard Evaluation (JHE)/Activity Hazard Analysis (AHA) process and documentation to ensure adequate and consistent identification of hazards and controls and to train the employees on the results.	*Neither a JHE nor an AHA s was completed for the tunnel washer operation. *The lack of a JHE/AHA and the inadequate standard operating procedures meant that all of the basic job steps or tasks to be performed during the operations were not identified. *The specific tasks to safely check and clean the automatic self-cleaning debris filter assembly were not explained. *The standard operating procedure did not explain the aisle markings on the floor or the proper placement of equipment awaiting cleaning.

No.	Judgment of Need	Related Causal Factor
JON 3	There is a need for UT-Battelle to implement an institutional method to ensure that equipment is evaluated by subject matter experts for safety and health hazards in the design or procurement stage.	*Professional safety and health staff did not evaluate the tunnel washer design and installation for hazards to the workers and adequacy of safety controls. *An inadequate latch was installed on the automatic self-cleaning debris filter. *The exhaust fan for the equipment was located above the equipment, creating a high noise area. *The equipment was not equipped with a fail-safe device to send an alarm and automatically shut down the equipment when catastrophic failure occurred.
JON 4	UT-Battelle needs to ensure selected and approved Work Smart Standards (WSS) sets address the actual hazards and needed controls and there is a clear understanding of the applicability of the various WSS sets.	*The American Society of Mechanical Engineers *Boiler and Pressure Vessel Safety Code* is a standard within the engineering design of facilities WSS set but not within the general industrial WSS set that is applicable to the entire ORNL operation. *UT-Battelle's Engineering and Standard - Based Management System personnel differed as to which ORNL WSS sets applied to purchased equipment to be installed in a building which did not involve modification of the building itself.
JON 5	The LSD's ISMS needs to be improved to specify the need for worker involvement and how that involvement is obtained.	*Workers were not involved in the process to identify the operational hazards and the needed worker protection controls for the tunnel washer operations.

No.	Judgment of Need	Related Causal Factor
JON 6	Improvements are needed in the LSD ISM Program to effectively address feedback and continuous improvement; to ensure timely and sufficiently detailed safety inspections are conducted; ensure corrective actions are completed; and ensure lessons learned are incorporated and executed in the processes within the LSD.	*Safety meeting were not implemented in an effective manner to achieve employee feedback on workplace and operational safety concerns. *The conduct of safety meetings was less than adequate, and attendance was not assured. *Lessons learned recommendations for ensuring that the hazard analysis defined all basic job steps, performing JHAs on excess material in storage, and ensuring that care was taken to keep all walkway/floor areas clear of materials were ineffectively implemented. *Safety inspections were not effective or consistently conducted as required.
JON 7	UT-Battelle needs to develop an expedited method for disposal of excess equipment within Building 9210 at Y-12.	*Excess and unneeded equipment contributed to crowded, congested, and unsafe working conditions.
JON 8	UT-Battelle needs to develop a process to evaluate and ensure that safe working environments are maintained when modifications are made to equipment or equipment support.	*Modifications were made to the steam lines and controls that allowed the equipment to operate beyond the manufacturer's specifications and create an unsafe working condition and premature equipment failure.
JON 9	UT-Battelle needs to ensure that equipment is operated in accordance with design specifications and the vendor's recommendations.	*The standard operating procedures were inadequate for safe operation and did not reflect the requirements outlined in the equipment manual. *The equipment was not calibrated, and the accuracy of operating parameters was not verified. *Preventive maintenance and testing of safety systems were not conducted. *Safety systems, temperature guarantees, and steam regulators were compromised, disengaged, or removed, which allowed the equipment to operate outside of the design limitations and caused premature equipment degradation.

2.0 FACTS

2.1 Accident Description and Event Chronology

2.1.1 Accident Description

On the afternoon of September 7, 2001, a UT-Battelle employee working alone in Building 9210, room 235, was burned on her legs, feet, and left wrist when a filter assembly on the tunnel washer inadvertently opened while the equipment was in use. The worker was operating the equipment to clean pans, cage tops, and beakers used in the animal research facility housed in Building 9210.

The tunnel washer is basically a large square tube where items are passed through it on a conveyor belt while being sprayed with hot detergent or rinse water. The washer is a four-step process: (1) a prewash to remove debris and solids; (2) a wash with detergent; (3) an initial rinse, and (4) a final rinse. There is also a dryer that is not used. The equipment specifications indicate the water in each of these processes can be adjusted up to 195 degrees Fahrenheit (F). The manufacturer does not recommend continuous operations greater than 180°F degrees because of premature deterioration of seals, solenoids, and internal components. However, normal operation at the time of the accident included water temperatures in excess of 180°F. The equipment has a filter assembly on the wash cycle that requires servicing when the water pressure drops below normal operating pressures or in accordance with the operating manual.

The end cap on the filter assembly came off during contact with the worker or the cart the worker was using. The injured worker was

Exhibit 2-1. Tunnel Washer

unclear as to exact action which released the filter assembly latch. Water that was normally

Exhibit 2-2. Latch and Filter Assembly

heated above 180°F degrees and under approximately 30 pounds of pressure was immediately released onto the worker. The filter assembly clamp could be opened with as little as ten pounds of pressure. It was an original piece of equipment. The equipment was an optional component that, as installed, protruded slightly into the work area. The normal setup had the assembly perpendicular to the washer. According to the schematics, it could have been installed parallel to the washer.

The injured worker yelled for help but could not be heard outside the room because of the noise produced by the washer and exhaust

Exhibit 2-3. Filter Assembly Clamp

system. There was no audible alarm because the filter assembly that was inadvertently opened had no pressure-sensitive alarm. The worker's injury was exacerbated because hot water continued to spray the worker for the brief time she was in front of the assembly. The filter assembly that inadvertently opened did not have an automatic cutoff.

The worker exited in the opposite direction from which she had been pushing the cart. The worker stated that she was in a near panic by this time. Shouting for help, she exited through the double doors leading into the hallway, where she continued to shout for help.

2.1.2 Event Chronology

September 7, 2001

Prior to 2:00 pm: Up to the time of the accident, the worker was engaged in the performance of routine duties. She had used euthanasia equipment to kill mice, and she entered room 235 to clean the equipment used in the process. The worker used the tunnel washer to clean one load of laboratory equipment and was exiting the room when the accident occurred.

2:00–2:15 pm: The worker or the cart she was using inadvertently bumped the latch to the filter assembly, which immediately opened and released scalding water onto her legs, feet, and left wrist. The worker moved the cart out of her way, yelled for help, exited the room into the corridor, and continued to call for assistance. She was spotted by her coworkers, who administered initial responder assistance, attempted to calm her down, applied ice to the lower parts of her body, and called 911. Y-12 emergency personnel responded, took charge

of the worker, and transported her to the Oak Ridge Methodist Medical Center.

See Table 2-1 for the event chronology. A comprehensive time line is included in Appendix C.

2:20–5:00 pm: A series of calls were made to inform UT-Battelle management, DOE ORO, DOE Headquarters, and the worker's husband. Those informed of the accident included, but were not limited to, the Life Sciences Division (LSD) Facility Manager, the LSD Division Safety Officer (DSO), the Section Head of the Operations and Support Section, the Atomic Trades Labor Council Safety Officers, the DOE representative, and the Associate Laboratory Director in Washington.

2:24–4:07 pm: The Facility Manager, the LSD DSO, and another member of the Operations and Support Section were dispatched to the accident scene. Caution tape was put up, and the area was restricted. Initial pictures taken of the accident scene confirmed that the machine was "locked out," the doors were closed, and the area was flagged and posted.

September 10, 2001 – UT-Battelle began a Type C investigation.

September 13, 2001

Due to the continuing hospitalization of the worker, the investigation was upgraded to a Type B and the ORO Manager appointed the Board members.

September 7-21, 2001

The worker remained hospitalized for treatment of her burns.

September 21 – Present 2001

The worker was released from the hospital to her home on September 21. She continues to be treated on an outpatient basis for her burns.

2.1.3 Emergency Response

The first person to respond to the injured worker was a coworker that saw her in the hall in obvious distress. She was immediately joined by three more coworkers, who attempted to calm the injured worker and applied ice and water to the injured areas. One of the coworkers called 911. Ice from a nearby machine was applied to the worker's burns until the emergency response team arrived and took control of the injured worker. The emergency response team administered assistance by applying a burn blanket and starting an intravenous drip. The emergency response team commented that the coworkers actions were very good and helped reduce the pain and severity of the injury. The worker was immediately transported to the Methodist Medical Center in Oak Ridge, Tennessee. The Section Head of the Operations and Support Section accompanied the worker in the ambulance to the hospital.

The emergency response team was on site with the worker within two minutes from the time the 911 call was received. The call was received at 2:16 pm, and they arrived on site at 2:18 pm.

Table 2-1. Event Chronology

Table 2-1 provides the events leading up to and immediately following the accident.

Date/Time	Event
8/31/2001	A weekly walkthrough of Building 9210 was conducted, including room 235. The walkthrough report stated, "weekly, monthly, quarterly log entries missing, dirty mops and mop head on floor, clean mops, wet towel on ½ wall."
9/3/2001	Holiday
9/4/2001	The supervisor stated that he observed only two carts of cage tops and one buggy in room 235.
9/5/2001	The supervisor was on vacation. One cart of cage tops was washed in the tunnel washer.
9/6/2001	The supervisor was on vacation. No cage tops were washed.
9/7/2001	There was no record of cage tops being washed in the tunnel washer during the normal wash hours of 7:00 to 8:00 am; however, the washer operation tape indicated that the washer was on at 07:41 (when the time was corrected).
	The worker was assigned to utility work on the 8:00 am shift
	Prior to the accident, the worker was euthanizing excess mice. The cart she was pushing had two bags of dead mice weighing 6.5 and 8 pounds on the bottom of the cart.
	Just prior to 2:00 pm, the worker entered the room to clean euthanasia trays and beakers.
	At approximately 2:00 pm, the worker turned the tunnel washer on and proceeded to wash euthanasia pans and beakers.
	While initial load was washing, which took approximately four minutes, the worker exited the room to collect additional beakers from the hall outside room 235.
	A second employee moved additional carts containing dirty cage tops into the room, which further blocked the exit path from the washer, and then left the room. Room 235 now contained 20 carts with cage tops, 1 cart with cages, 5 trash cans with cages, and 2 utility carts.

Table 2-1. Event Chronology (continued)

Date/Time	Event
	At approximately 2:10 pm, the worker re-entered room 235 alone and loaded the cart with clean euthanasia pans and beakers on the "clean" side of the washer. The bottom of the cart still contained the bags of dead mice. To exit the room, the worker was forced to move from clean side of washer to the "dirty" side due to the blocked exit path.
	The tunnel washer was still operating when the worker attempted to traverse an aisle between the carts and the tunnel washer where access was limited to 31 inches.
	As the worker passed by the automatic self-cleaning debris filter, she had to negotiate an area where a dirty cart protruded, and either the cart edge or the worker contacted the triclover retaining clamp on the filter, causing it to inadvertently open. The worker was deluged with water reported to be at 194°F at approximately 30 to 40 pounds per square inch (psi).
	The worker called out, but the room noise masked her cries for help. No alarms sounded, and she was forced to exit room under her own power.
	The worker exited the room by returning to the clean side of the tunnel washer and maneuvering between the carts blocking the exit path. She fell on floor in hall outside of room 235.
	The tunnel washer in room 235 remained on and sprayed hot water across the isle. Because the tunnel washer in room 232 was operating, it created a masking noise in hall. No alarm was sounded
	At approximately 2:15 pm, Responder 1 (research assistant) and Responder 2 (postdoctoral fellow) heard moans in the hall and, upon investigation, found the worker lying in hall moaning and saying "burned." The worker was reportedly wet from mid-torso to feet.
	After inquiry, Responder 1 determined that the worker had been burned with hot water from the tunnel washer. Responder 1 also observed water and steam coming from the floor near the tunnel washer.
	Responder 1 immediately left to get ice from the icemaker on an adjacent hall. On her return, she was met by Responder 2 bringing buckets to carry additional ice.
	The Y-12 Janitor called 911 at 2:16 pm according to Y-12 emergency response records.
	A coworker assisted the worker by supporting and comforting her while ice was applied to the burned areas.

Table 2-1. Event Chronology (continued)

Date/Time	Event
	At some point, the worker's shoes and socks were removed. Responder 1 indicated that the burns were severe enough that the act of removing the socks also removed some skin tissue.
	The worker's speech was reportedly mixed and her skin became pale. The supervisor responded and turned off the tunnel washer, noting that water was spraying across the isle onto the dirty cage tops, which were approximately 35 inches away, and the water temperature indicator was registering 194°F.
	The Assistant Facility Manager, a veterinarian, and others responded to the area.
	At 2:18 pm, Y-12 emergency personnel responded, evaluated the injured worker on site, and transported her to the Oak Ridge Methodist Medical Center. She was accompanied by the veterinarian and a coworker.

2.1.4 Medical Summary

The worker sustained first and second degree burns to a substantial portion of her lower body. The emergency response team quantified the burns as covering 20 percent of her body. The upper parts of her legs, torso, and left wrist had mostly first degree burns. The lower parts of her legs, particularly where the worker's socks captured the heat, had second degree burns. The worker has and will continue to undergo treatment for the most severely burned areas. The worker was hospitalized immediately after the accident and remained hospitalized until September 21, 2001.

The worker stated that the burns and subsequent treatment have been very painful. The worker was on a strong pain relief medication for the first 11 days and continues to take prescription pain medicine as required.

2.2 Hazards, Controls, and Related Factors

2.2.1 Physical, Operational, and Administrative Controls

The direct hazard was the 180° to 195°F hot water that was separated from workers by only one physical barrier (a locking latch) that took less than ten pounds of pressure to violate. The available work space was inadequate because of overcrowding with carts of unwashed cage tops, metal cages, and other laboratory equipment.

The tunnel washer was installed in the December 1997 time frame according to the procurement document, and it has been in operation since then. The equipment was installed by the manufacturer. Y-12 assumed maintenance responsibility after the initial

Exhibit 2-4. Hot Water Pipes

warranty period of one year. There was no record of any maintenance actions during the first year of operation. Since Y-12 assumed responsibility, there has been a limited amount of corrective maintenance but no recorded preventive maintenance. Pipes around the filter assembly and other exposed piping were partially insulated because employees had complained of the pipes being hot to the touch. A water leak in the piping near the filter assembly was fixed.

Steam was used to bring the final rinse up to operating temperatures, and changes were made to the steam lines entering the tunnel washer. After the steam line maintenance action, final rinse temperatures were consistently over the design specifications.

An ORNL and Y-12 Memorandum of Understanding (MOU) concerning ORNL organizations located at Y-12 is dated January 24, 1996. The MOU recognizes that the Biology Division (now part of the LSD) is located at Y-12. The MOU delineated the roles and responsibilities of ORNL and Y-12. The MOU states, "ORNL will provide Occupational Safety and Health (OSH) compliance technical support for all ORNL divisions at Y-12 in compliance with ORNL procedures. Required corrections will be addressed by the ORNL divisions utilizing dedicated Y-12 craft support. Tracking of noncompliance will be through the ORNL database." The MOU also states, "ORNL will provide industrial hygiene and industrial safety support, including the tracking and trending of recordable injuries and illnesses,

for ORNL divisions at Y-12 in compliance with ORNL procedures." The Y-12 Area Office, the Y-12 BWXT, LLC (BWXT), Safety Department, the DOE ORNL Site Office, and the UT-Battelle Safety Department recognize that ORNL is responsible for the safety and health of ORNL personnel working in the LSD's Building 9210 at Y-12.

There were Standard Operating Procedures (SOPs) for using the tunnel washer to wash cage tops. The SOP required two people to be present for operation of the equipment. The two-person requirement was important to safety and to the sanitization of the cage tops that were washed in the equipment. Workers who handle dirty cage tops may not handle clean cage tops. The two-person wash process assured that freshly washed cage tops were not contaminated before use. Clean tops were to be immediately placed under a loose cover and identified as clean to avoid contamination.

Based on interviews with employees, it was not uncommon for support staff to do specific routine jobs (such as cleaning "kill" pans and beakers) as a one-person operation. The SOP stated that the clean/dirty rule noted above did not apply to this activity. However, the procedure did not specify that the two-person rule did not apply.

2.2.2 Personnel Performance

All of the support staff are hourly employees covered by a union agreement. A review of overtime and attendance records indicated a high absentee rate and a correspondingly extremely high amount of overtime. The absentees were due in part to earned leave, occupational-related illnesses (e.g., repetitive trauma), and other long-term, nonoccupational illnesses. During the week of the accident, most support staff worked four hours of overtime every day that they reported to work.

The Operations and Support Section Head changed staff duties in July with the intent of addressing the problems created by staff shortages and to improve sanitation of the cage areas. Since the change in staff duties, the actual employee production rate went down according to the Section Head.

The worker attended an initial training session at the time the tunnel washer was installed. Instructions for operating the equipment were generally provided by on-the-job training. The staff was familiar with the SOPs for operating the equipment. Staff members were also familiar with their stop work authority when an unsafe work condition was observed.

2.2.3 Management Systems

The LSD Mouse House is a mature organization that has been in operation for several years. There are SOPs for significant portions of the work, which are contained in A-98-LSD-001, *LSD Animal Resources Section Reference Manual*. The SOPs directly related to the event included SOP A-98-LSD-001, V.E., "Veterinary Rounds and Quality Assessment Inspections," and SOP A-98-LSD-001, VI.J,. "Tunnel Washer Operations."

The *LSD Animal Resources Section Reference Manual*, Section VI, Paragraph J, pertaining to operation of the tunnel washer was written primarily with emphasis on the sequence of operations and the sanitation of the equipment being washed. The operator was not provided with safety information on the controls or checks considered necessary to assure safe operation of the machine. Safe operating temperatures were not provided. The

minimum tank temperature was listed as 180 degrees, but the maximum safe temperature was not listed. The procedure did not specify the maximum operating pressure allowable for the unit. Workers were not informed as to what was an unsafe or dangerous temperature or pressure. Workers were expected to clean the wash tank screen, but they were not informed how to ensure that it was safe to do so. The procedure did not address when and where to place carts containing equipment to be washed, although the floor of room 235 was taped off into clean/dirty sections. The procedure also included an acid wash process, but additional safety precautions were not listed for the process.

The quality assessment SOP stated, "Quality Assurance (QA) inspections are performed for Building 9210 only. These inspections may be attended by the Divisional QA Coordinator, the Veterinary Staff, the Supervisor, the Health and Occupational Safety Officer, and the respective animal care technicians. These inspections are generally performed weekly. Areas inspected include storage areas, cage washing areas, water stations, and any other areas requiring attention. During the inspection, Cage Wash Log Sheets and other documentation of sanitation are evaluated. Vermin traps are examined. The general condition of the facility is noted. The QA Officer generates a 'Walk Thru' report that is circulated to all participants as well as to the attention of any management person noted to have issues that need to be addressed (i.e., Mammalian Genetics and Development Section Head, Divisional Safety Officer, Facility Manager, etc.)."

Walkthroughs were routinely performed until March 7, 2001, when they were discontinued. On that date, the QA Coordinator sent an internal electronic mail message (e-mail) to management that stated, ". . . many items highlighted on the weekly QA walkthroughs are not being addressed in a timely manner. Since the walkthroughs are very time- and personnel-intensive activities, we haven't been getting good value for the effort spent. With . . . [Section Head] . . . concurrence, I am canceling the weekly walkthrough team effort effective today. This will be replaced by one unannounced Friday walkthrough each month . . ." Subsequent to this internal document, walkthroughs were performed on a monthly basis. The last two documented inspections took place on July 6, 2001, and August 31, 2001.

All of the write-ups from the weekly walkthroughs dating from January 7, 2000, through the March 7, 2000, e-mail message noted above, contained at least one negative statement concerning the housekeeping in room 235. The need for an acid wash of the machine was noted several times, as well as the need for other routine cleaning activities. Accumulation of an excessive number of cage tops was noted during one previous inspection. The repetitive nature of some comments indicated that findings from walkthroughs were, in fact, not being addressed in a timely manner.

On July 23, 2001, management implemented a change in personnel assignments. Prior to July 23, there were four groups of staffing assignments (i.e., changer, waterer, washer,

Exhibit 2-5. Room 235 Crowded with Carts of Cages and Cage Tops

and utility). Utility staff members were used to cover absentees and variations in the workload. Although there were four categories of work, staff members actually performed the full array of work. Changers washed cages and cage tops, as well as performing normal changeout of cages and sanitizing cage areas. Waterers changed out cages and washed cages. Washers also performed changeout of cages. As part of the change in assignments, washing duties were assigned to a cadre of four people and changing duties were assigned to a cadre of eight people. There were four utility people who filled in as needed. This change was intended to increase the cleanliness of the animal areas and to mitigate some staffing shortages.

A review of washing records showed that for the month following the change in staff assignments, approximately two carts of cage tops were washed per day. This was approximately 1,000 cage tops. Based on the number of cages in the facility, approximately 1,500 cage tops should have been washed daily. Actual amounts washed versus the requirements created a deficit of 500 (or one cartload) per day of unwashed cage tops. There were only two carts of unwashed cage tops in Room 235 on the evening of September 4, 2001, when the supervisor last

checked the room. On the day of the accident, the number had grown to 23 carts and 5 trash cans in room 235. This number equated to the accumulated deficit (i.e., it was the one-cart accumulation per day that occurred during the time frame when only two carts were being washed per day).

The excessive accumulation resulted in carts being placed in room 235 in a manner that violated the established assignment of floor space and moved the worker closer to the energy source. Surplus equipment was also stored in room 235, which further exacerbated the space restrictions.

Prior to July 23, 2001, there was one documented inspection report of room 235 being in an overcrowded condition similar to that found on September 7, 2001. The interviewees stated that occasionally there was a buildup of carts in the room, but they had seen nothing similar to the conditions that existed on September 7, 2001.

Criteria for cleaning cage tops and other laboratory equipment are documented in the *Guide for the Care and Use of Laboratory Animals*, which is published by Institute of Laboratory Animal Resources of the National Research Council. The criteria states that sanitization of equipment can be achieved by cleaning with the wash and rinse water at temperatures of 143° to180°F or higher. Lower temperatures require more time. The manufacturer's specifications for the tunnel washer state that the wash and recirculated rinse water can be adjusted to 190°F and the final rinse can be adjusted to 195°F. The initial rinse temperature is not adjustable and is fed from the recirculated rinse. The manufacturer states that operation of the equipment at higher temperatures could result in damage to the seals and solenoids. The equipment logs indicate that temperatures for the wash and rinse water on the tunnel washer varied significantly (mostly higher) from design specifications for an extended period of time. The detergent wash and recirculating rinse water routinely ranged from 120° to 195°F, and the final rinse water was recorded at a maximum temperature of 279°F. There was no record of the equipment being calibrated, nor was there a documented reason to operate the equipment outside of the design specifications. On the day of the accident, the water temperature reading for the wash water that burned the worker was reported to be at 194°F by the supervisor at the time he shut down the equipment.

Integrated Safety Management (ISM) was implemented by the DOE in the late 1990s. The DOE has fully embraced ISM and has directed its contractors to fully implement it.

One of ISM principles directs that work is constantly evaluated for hazards to ensure safety. Neither a Job Hazard Evaluation (JHE), an Activity Hazard Analysis (AHA), nor a Job Hazard Analysis (JHA) was prepared for the operation of the tunnel washer that was involved in the accident. The interviewed workers also stated that they were not involved in the hazard identification process to determine what worker protection controls were needed for that equipment.

The ORNL Operational Safety Services Division did not have documentation to indicate that their professional safety and health staff evaluated the tunnel washer's

design for hazards to the workers or the adequacy of the safety controls. The LSD did not have any records to show that a safety design review was conducted for the equipment.

At ORNL, the approved master Work Smart Standards (WSS) set is divided into 12 different WSS sets, plus Standards/ Requirements Identification Documents (S/RIDs) for occurrence reporting and emergency management. Other than the approved S/RIDs, the WSS sets applicable to the tunnel washer were included the standards listed in the ORNL Standards-Based Management System (SBMS) WSS Set Section 1, *Other Industrial, Radiological, and Non-Radiological Hazard Facilities*. This WSS set included, among other standards, the following (as determined by the Authority Having Jurisdiction):

- Title 29 Code of Federal Regulations (CFR) Part 1910, *Occupational Safety and Health Standards*;
- American Conference of Industrial Hygienists Threshold Limit Values (TLVs);
- Applicable National Fire Protection Association Standards;
- The National Electric Code, and
- The National Electric Safety Code.

Not included in that set were the American Society of Mechanical Engineers (ASME), Section VIII, *Boiler and Pressure Vessel Safety Code*, and ASME standard B31, *Process Piping*. These items were listed in the ORNL SBMS WSS Set Section 9, *Engineering Design of Standard industrial, Radiological, Non-Reactor Category 2 & 3 Nuclear, and Accelerator Facilities*. A "Note" for this set stated, "This WSS Set applies to new designs and facility modifications." Discussions with UT-Battelle personnel revealed that there were differing interpretations of the applicability of the Section 9 WSS set to equipment that was procured and installed in a building but which did not involve modification of the building itself.

Safety meetings were not being conducted at the LSD-required frequencies and were often combined with other actions. Participation/ attendance by staff in these meetings was not rigidly enforced, and there was lack of follow up. Quarterly LSD safety meetings were held as follows:

- two quarterly meetings in 1998,
- two meetings in 1999,
- three meetings in 2000, and
- two meetings in 2001.

Safety training was substituted for safety meetings.

The LSD quarterly safety and health inspections were combined with Operational Awareness Program (OAP) visits, effectively eliminating one level of inspection oversight. The last LSD DSO-required quarterly safety inspection of Building 9210 was on March 30, 2000. The last OAP visit of Building 9210 was on September 29, 2000. The OAP bulletin stated, "observations are not tracked in a formal database and no corrective actions are required." However, the LSD maintains an internal tracking system for the observations, and they are followed to completion. There was no follow-up documentation that indicated worker involvement in hazards identification. Some lessons learned applicable to the facility were not implemented.

The DOE ORNL Site Office performed an Integrated Safety Management System (ISMS) Phase II validation of various ORNL divisions. A rating system of "green," "yellow," and "red" was used to specify the level of implementation of the ISMS. The LSD was rated yellow, meaning that the division had some items in place and implemented, yet it also had specific areas needing improvement. When DOE ORO performed an ISMS Phase II Follow-up Verification of UT-Battelle at ORNL in September 2000, the emphasis was placed on the Chemical Technology Division and the Plant and Equipment (P&E) Division, with specific emphasis on the 3019A facility. The LSD was not audited. Neither DOE ORO nor the DOE ORNL Site Office has performed an annual comprehensive Environment, Safety and Health (ES&H) review of ORNL's programs in recent years. That type of review was not performed during calendar year 2001, since the Headquarters Office of Independent Oversight (EH-22) scheduled and performed a review of the site. That type of review was also not performed during calendar year 2000 because the ISMS validation was conducted of Chemical Technology Division and the P&E Division, with emphasis on Building 3019A. In 1999 DOE ORO performed an ES&H review of ORNL but did not specifically look at the activities in Building 9210.

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3.0 Analysis

3.1 Contractual Authority and Responsibilities

3.1.1 DOE Oak Ridge Operations

UT-Battelle is the DOE ORO prime contractor responsible for operation of the ORNL. DOE has specified its ISM expectations in the contract. The DOE ORNL Site Office recognizes that ORNL is responsible for the safety and health of ORNL LSD employees working in Building 9210. The DOE Program Manager recognized his responsibilities in the program management arena, but since this is a non-nuclear facility that is also considered a low hazard facility, ES&H did not receive a high priority. DOE position descriptions for program managers have specific safety and health responsibilities for "assuring that functions carried out under contracts are executed in a manner that protects government and contractor personnel and the general public against environmental, health and safety hazards arising from the performance of contract work."

The DOE Program Manager recognized the broad responsibility for DOE oversight of the contractor's operations to ensure the contract provisions of ISM are fulfilled. The Program Manager's overall responsibility was to help ensure that the assigned mission was achieved. The Program Manager maintained a management awareness of research activities and the requisite safety and quality. More attention was given to critical operations, and the smaller, routine operations were not visited very often. The Program Manager was also available to assist the contractor if problems arose between various DOE prime or support contractors. The Program Manager did not look at equipment during visits to Building 9210.

UT-Battelle Safety and Health personnel and DOE ORNL Site Office Safety and Health personnel have conducted joint OAP visits to Building 9210. The last visit was in September 2000. Those visits were facility walkthroughs and not detailed reviews of operating systems or ES&H program reviews.

3.1.2 UT-Battelle, LLC

ORNL and Y-12 MOU concerning ORNL organizations located at the Y-12 Site is dated January 24, 1996. The MOU recognizes that the Biology Division (now part of the LSD) is located at Y-12. The MOU delineates the roles and responsibilities of ORNL and Y-12. The MOU states, "ORNL will provide OSH compliance technical support for all ORNL divisions at Y-12 in compliance with ORNL procedures. Required corrections will be addressed by the ORNL divisions utilizing dedicated Y-12 craft support. Tracking of noncompliance will be through the ORNL database." The MOU also states, "ORNL will provide industrial hygiene and industrial safety support, including the tracking and trending of recordable injuries and illnesses, for ORNL divisions at Y-12 in compliance with ORNL procedures." The Y-12 Area Office, BWXT Safety Department, DOE ORNL Site Office, and UT-Battelle Safety Department recognize that UT-Battelle is responsible for the safety and health of ORNL personnel working in the LSD, Building 9210, at Y-12.

3.2 Safety Analyses and Reviews

3.2.1 Design Reviews

UT-Battelle Safety and Health recognized their broad responsibility to ORNL employees working in Building 9210, but there were differing levels of understanding as to the level of safety reviews and input needed for safe operations. Engineering and administrative controls were not fully utilized to reduce the hazards to the workers. ORNL technical safety personnel did not review the equipment prior to purchase to identify hazards and needed safety controls. The ORNL Operational Safety Services Division did not have documentation to indicate that their professional safety and health staff evaluated the tunnel washer's design for hazards to the workers or the adequacy of the safety controls. The LSD did not have any records to verify that a safety design review was conducted for the equipment. At the time the equipment was procured and installed, a biologist with the Biology Division was assigned to perform the duties of DSO as a collateral duty. This person has since retired.

During installation of the tunnel washer, the exhaust fan and motor were located above the washer, which created a noise hazard to the equipment operators.

The fan and motor should have been located outside of the room/building, which would only have required an additional 10 feet or less of duct work. Placing the fan over the tunnel washer created a high noise area, and the employees were required to wear hearing protection. The high noise level also made it difficult for people outside the room to hear the injured worker call for help. After the worker sustained severe burns, she had to travel approximately 50 feet to exit the room to obtain help.

The less-than-adequate design of the latch assembly for the automatic self-cleaning debris filter was a primary factor in the accident. The access assembly consisted of three parts (i.e., an outer plate, a rubber seal, and a hinged clamp with a levered latch that secured the outer plate and seal). When the levered latch was in a relaxed state (open), the outer plate and seal immediately fell to the floor.

Exhibit 3-1. Exhaust Fan and Motor above the Tunnel Washer

The tip of the levered latch protruded approximately1/8 inch beyond the end of the filter access assembly.

Exhibit 3-2. Filter Latch Assembly

Lack of a fail-safe or automatic shutdown device on the wash motor and pump, in all likelihood, contributed to the severity of the worker's injuries. Upper temperature and pressure limits were not established and understood. Personnel understood the stated minimum temperatures desired by management for sterilization of the equipment, but they did not understand the dangers of excessive temperatures and pressure. Engineering and administrative controls were not fully utilized to reduce the hazards to the workers.

The *MTP 2200 Series Tunnel, Cage, & Utensil Washer General Specifications* (No.2200-001E) Page 3, Paragraph H, states, "The steam coil is designed to Section VIII, Div 1 of the ASME Unfired Pressure Vessel Code . . . The surface area of the steam coil is sized to maintain a sump temperature of 190 degrees at an average steam pressure of 50 psi." Page 3, Paragraph M, states, "The pre-wash, agent wash, and recirculated rinse treatment are under pressure from horizontal 'Monobloc' type pump with mechanical seals and are equipped with direct reading pressure gauges." The gauge on the prewash is designed to measure up to 60 pounds per square inch (psi), although during the wash cycle that the Board witnessed, the pressure gauge registered only 30 psi. The service manual troubleshooting guide states that for the wash spray jets the "normal pressure is between 30-40 psi." Thirty to 40 psi was the expected normal pressure on the automatic self-cleaning debris filter assembly when the latch assembly failed and released the hot water under pressure.

The Board investigated the DOE/ORNL-approved WSS sets to determine what standards would have been applied to the equipment. The master ORNL WSS set is divided into 12 different WSS sets, plus S/RIDs for occurrence reporting and emergency management. Other than the approved S/RIDs, the WSS sets applicable to the tunnel washer include those listed in the ORNL SBMS WSS Set, Section 1, *Other Industrial, Radiological, and Non-Radiological Hazard Facilities*. This WSS set includes, among other standards, 29 CFR 1910, *Occupational Safety and Health Standards*, TLV references from the American Conference of Industrial Hygienists, the applicable National Fire Protection Association Standards, the National Electric Code, and the National Electric Safety Code, as determined by the Authority Having Jurisdiction.

Not included in that WSS set were Section VIII of the ASME *Boiler and Pressure Vessel Safety Code* and ASME standard B31, *Process Piping*. These items are listed in the ORNL SBMS WSS Set Section 9,

Engineering Design of Standard Industrial, Radiological, Non-Reactor Category 2 & 3 Nuclear, and Accelerator Facilities. A "Note" for this WSS set stated, "This WSS Set applies to new designs and facility modifications." Discussions with ORNL UT-Battelle personnel revealed that there were differing interpretations of the applicability of the Section 9 WSS set to equipment that is procured and installed in a building but which does not involve modification of the building itself. ORNL-QA-P01, *ORNL Quality Assurance Program*, stated, "ORNL staff requesting procurement of items and services are responsible for providing technical, Environment, Safety, Health and Quality (ESH&Q), and other imposed specifications that adequately describe the item . . ."

The WSS set applicable to any operation, equipment and facility needs to be clear and unambiguous to management, supervision, and workers. The ORNL QA Program placed WSS set identification responsibilities on the persons requesting procurement of equipment. As written, the ORNL WSS sets, set titles, and instructions indicated that the ASME Section VIII, *Boiler and Pressure Vessel Safety Code*, was not applicable to procured equipment. This conflicted with DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*, "Contractor Requirements Document," Paragraph 20.b, which states, "Ensure that all pressure vessels, boilers, air receivers, and supporting piping systems conform to (1) the ASME *Boiler and Pressure Vessel Safety Code*; (2) . . . ASME B.31, *Piping Code*; and/or (3) the strictest applicable state and local codes."

According to the introduction to the 1989 ASME *Boiler and Pressure Vessel Safety Code*, the code is applicable to vessels containing water under pressure and hot water supply storage tanks heated by steam if a water temperature of 210 degrees is exceeded. The code also applies to vessels having an internal or external operating pressure exceeding 15 psi with no limitation on size. Pressure vessels are containers for the containment of pressure, either internal or external.

Even though the equipment manufacturer stated in the specifications that the steam coil is designed to ASME *Boiler and Pressure Vessel Safety Code*, it was unclear to the Board whether other portions of the tunnel washer meet the code requirements. ORNL has not clearly stated the applicable standards for this equipment.

Another factor related to the LSD ISMS may be adversely affecting the identification and application of needed safety standards. LSD-ISMS-01, Revision 02, dated January 2001, Section I, Paragraph 5, pertained to the core functions of ISMS and stated, "We view this as an opportunity to streamline and customize requirements based upon Subject Matter Expert (SME) assisted line management analysis of work activities. Such a process will maximize the work output under minimal applicable regulations chosen to protect the public, worker, facilities, and the environment." The LSD ISMS seemed to conflict with the ORNL "culture change" from "expert-based to a standards-based" that was started several years ago. This cultural change was noted in the ISMS Phase II Verification for UT-Battelle performed in September 2000.

3.2.2 Activity Hazard Analysis

LSD-ISMS-01, Revision 02 dated January

2001, Section II., Paragraph 1, "Define the Work and Its Hazards" stated, "Funded projects start and/or continue work activities only after consideration and analysis of all potential hazards." According to DOE G 450.4-1, *Integrated Safety Management System Guide*, Chapter II, Paragraph 3, "The objective of hazards analysis is to develop an understanding of the potential for the hazard to affect the health and safety of the worker, public and the environment."

Neither a JHE, an AHA, nor a JHA had been prepared for the operation of the tunnel washer that was involved in the accident. The Laboratory Animal Resources Section employees interviewed, the affected supervisor, and the DSO indicated that they had not prepared or seen a JHE, AHA, or JHA for the operation. The interviewed workers also stated that they had not been involved in the hazard identification process to determine what worker protection controls were needed for that equipment. The Biology Division (the predecessor of the LSD) had a manufacturer's representative review the equipment and its operation with the workers after installation.

The LSD ISM Program did not clearly explain the involvement of workers in the hazard identification process. Vague statements referred to worker involvement. Section II.1 stated, "Under the leadership of members of the Operations & Support Section, and in consultation with occupants and facility managers, these facilities are classified as to the potential hazards." The same section also stated, "The close working relationship among management, workers, and the SMEs that serve each facility enhances the Division's ability to assure that requirements are know and satisfied." Section II.2. stated that all LSD employees "are expected to identify ESH&Q issues in their workplace . . ." The ISM Program must ensure that specific activities take place to ensure worker involvement in the hazard identification process.

3.3 Operational Controls

3.3.1 Equipment Manual

The LSD, formerly the ORNL Biology Division, was provided with three documents related to the tunnel washer by the vendor (i.e., the original quotation specifications, the *MTP 2200 Series Tunnel, Cage and Utensil Washer Manual*, and the *MTP Series 2200 Service Manual*. The vendor, Custom Machinery Corporation, installed the washer and provided service and maintenance for a period of one year. In addition, the MTP Service Engineer provided equipment checkout and demonstrated the operation and maintenance of the equipment to Biology Division personnel. Because of this service, the importance of the manuals was overlooked and key elements were not incorporated into installation, operating procedures, maintenance activities, and employee training. These oversights provided key components that factored significantly into the accident scenario.

The initial vendor's price quote listed the automatic self-cleaning debris filter as an option that cost $2,230. Subsequent quotes included this option in the overall price. As noted in the barrier analysis, the location of the pumps, piping, and filter may be placed on either side of the washer. In fact the original quote included two separate equipment drawings depicting the external plumbing on opposite sides. In the drawings, the installation of the specific filter assembly is

shown in both the parallel and the perpendicular orientation relative to the length of the washer. A thorough review of the quoted materials might have influenced the actual installation of the washer and precluded the hazard that contributed to the accident.

All three documents state that the "wash temperature is programable to 190°F," "Rinse temperature is programable to 190o F," "Final rinse temperature is programable to 195°F," and "The dryer temperature is manually adjustable to 210°F." The specifications manual (NO. 220-001E) states on page 2, "An agent wash and/or recirculating rinse temperature guarantee may be programmed to insure that minimum treatment temperatures are attained and maintained. Should the temperature guarantee set points not be attained or maintained, the conveyor belt will temporarily stop until the treatment solution reaches the set point temperature. All temperature guarantee variances are annunciated to the operator." Despite this, the optional strip chart printer recorded that the set point temperatures were set at 0° F, the temperature guarantees were off, and the accepted operating temperatures were often above and below those specified by the vendor's manual.

A review of the strip charts revealed that temperatures of the final rinse often exceeded 250° F and, on one occasion, reached 279° F. (See Exhibit 3-3, Strip Chart.)

Interviews indicated that the dryer was not used because the cage tops were often too hot to remove from the conveyer. A telephone conversation with the vendor's maintenance

```
==================================
     LOCKHEED ENERGY SYSTEMS
        MODEL 2236-96-849
          TUNNEL WASHER

04/02/01        10:26:07
CYCLE#  1
TOTAL RUNNING TIME =  *:52:39
==================================

==================================
     LOCKHEED ENERGY SYSTEMS
        MODEL 2236-96-849
          TUNNEL WASHER

04/04/01        06:08:00
CYCLE# 12
TOTAL RUNNING TIME =  *:13:24
==================================

06:13:00
     AGENT WASH 1
        TEMP 183 F
     RECIRCULATED RINSE
        TEMP 169 F
     FINAL RINSE
        TEMP 279 F

06:18:00
     AGENT WASH 1
        TEMP 184 F
     RECIRCULATED RINSE
        TEMP 168 F
     FINAL RINSE
        TEMP 240 F

06:23:00
     AGENT WASH 1
        TEMP 182 F
     RECIRCULATED RINSE
        TEMP 165 F
     FINAL RINSE
        TEMP 255 F

06:24:55   MACHINE SHUT DOWN

RUNNING TIME =  0:16:35
==================================
  DESIGNED AND MANUFACTURED BY
   MTP CUSTOM MACHINERY CORP.
      NIAGARA FALLS, NY
```

Exhibit 3-3. Strip Chart

engineer and quality control personnel revealed that sustained temperatures above 180°F would cause equipment damage and premature failure of internal seals and components. This information was confirmed by the significant number of failed solenoids and leaks reflected in a review of maintenance job requests for the tunnel washer in question.

The *Service Manual for the Model 2200 Tunnel, Cage and Utensil Washer* includes sections on warnings, machine startup, control screens, cycle programming, general machine operation, general maintenance schedules, troubleshooting, and options. These sections are not reflected in the LSD procedures, training, or maintenance records examined by the Board. All interviews conducted reflected a lack of familiarity with the vendor's recommended maintenance and operation information. Maintenance records for Building 9210 for the last two years revealed that preventive maintenance was lacking. There was no indication that the vendor's recommended maintenance schedule was ever followed, including the daily test procedures for safety systems, weekly inspections of the debris filter, weekly greasing of bearings, inspections of temperature probes, pump lubrication, or a semiannual check of the GFI sensor. The following statement is found in the "Warnings Summary" section of the manual: "WARNING–PERSONAL HAZARD AND EQUIPMENT DAMAGE. Safe and efficient operation of this equipment requires scheduled preventative maintenance."

Although there was a pressure gauge located on the filter, employees were not aware of normal operating pressures or what abnormally high or low operating pressures indicated. Since the pressure gauge was not alarmed and did not disengage the pump if the washer was operating out of specification, specific training was needed.

The LSD's procedures did not adequately reflect the information provided in the vendor's manuals, and the manuals were not provided to the employees as part of their initial employee orientation. The informal on-the-job training and the lack awareness of vendor information allowed significant variation in operator competency to evolve and potentially unsafe conditions to be accepted.

3.3.2 Operating Procedures

The *LSD Animal Resources Section Reference Manual*, A-98-LSD-001 Section VI, Paragraph J, pertained to operation of the tunnel washer and was written primarily with emphasis on the sequence of operations and sanitation of the equipment being washed. The manual served as the primary set of SOPs. The operator was not provided with safety information as to the controls or checks necessary to assure safe operation of the machine. Safe operating temperatures were not provided. The minimum tank temperature was listed at 180°F, but the maximum safe temperature was not listed. The procedure did not specify the maximum operating pressure allowable for the unit. Workers were not informed as to what was an unsafe or dangerous temperature or pressure. Workers were expected to clean the wash tank screen, but they were not informed how to ensure that it was safe to do so. The procedure also involved an acid wash process, but additional safety precautions were not listed for that process.

The SOP for tunnel washer operation provided directions for operation of the cage and cage top tunnel washers located in Building 9210. The various procedures in the manual did not identify the discrete tasks of removing the cages and cage tops from the animal rooms, placing them onto carts, any temporary storage of the carts in hallways or rooms, and movement of the carts of cages and tops into the washer rooms. The Board witnessed

various methods and locations used for temporary storage of the carts. According to persons interviewed by the Board, the carts containing cages or cage tops may be placed in hallways or in rooms. The tasks and flexibility are general enough to allow all carts to remain in the hallways or to allow all carts to be moved into the washer rooms. This contributed to the overcrowded condition in room 235 at the time of the accident. The floor of room 235 was marked to indicate the proper pathway to follow when bringing carts to the tunnel washer, but these markings were obscured by the stored carts full of cage tops and water bottles awaiting washing. (See Appendix D for diagram of room 235)

The specific tasks needed to safely check and clean the debris filter assembly were not explained. Employees were expected to understand the process from on-the-job training and experience.

The UT-Battelle supervisor did not have a thorough understanding of the operation of the tunnel washer. The upper temperature and pressure safety limits of the equipment were unknown. The functions of the washer under emergency conditions were unknown. It was unclear that when the emergency stop button was pushed, if the pressure in the debris filter assembly would drop to zero. During a test of the equipment, it was demonstrated that when the pump motor was shut down, the pressure did fall to zero. But, discussions with the equipment manufacturer indicated that the debris filter assembly hot water pump would not automatically shut down when the latch assembly for the screen filter was removed. In other words, when the latch assembly failed and hot water was released, the water pump continued to spray hot water until the supervisor shut down the equipment. The Laboratory Animal Resources Section Chief had the owner's manual for the machine, but the Supervisor did not have a copy. Neither the Section Chief nor the Supervisor were aware that the actual wash and rinse temperatures were higher than that necessary for effective operation. The SOPs for operation of the tunnel washer were inadequate to ensure sufficient worker protection controls were implemented.

Yellow lines were marked on the floor of room 235 to indicate the path of travel and the location to store dirty equipment awaiting washing. Carts containing dirty equipment were located throughout the room, obscuring the yellow lines. There were so many carts in the room (i.e., 22) that inadequate travel space remained for the worker to travel safely from the clean end of the wash machine to the dirty end. This congestion contributed to the occurrence of the accident.

3.3.3 Safety Communications

The LSD's ES&H Program was covered in ES&H-98-LSD-001, Revision 02, dated January 2001, J Paragraph. Section 4.6 stated, "The LSD Safety Meetings are planned by the DSO, held quarterly, and are normally held in conjunction with a Division meeting or Division-wide required training. All division staff (employees, subcontractors, students, and guests) are required to attend" The *LSD ISMS Program Description*, Section II, Paragraph 3, Page 8, stated, "all division staff members (including working guests and students) are responsible for completing mandatory/required training (including quarterly safety meetings) and for maintaining an acceptable level of technical knowledge to perform their assignments safely." Available records indicated that two division safety

meeting were held in 1998, two in 1999, three in 2000, and two so far in 2001. The worker attended the two safety meetings in 1998, one in 1999, none in 2000, and one in 2001. In addition to the safety meetings, the Laboratory Animal Resources Section also conducted regular safety training sessions (approximately every two to three months) on a variety of safety training topics. Within the Laboratory Animal Resources Section, the required safety training sessions tended to take the place of the required safety meetings. The quarterly safety meeting process was not effectively implemented to meet the LSD's requirements. It was not effective as a tool to achieve employee participation in ISMS or feedback on workplace and operational safety concerns.

The tunnel washer operators did not have the knowledge they needed to appreciate the hazards of the equipment and its operation. Hazard identification, analysis, and control were ineffectively performed on the equipment and its operation. The SOP did not explain the hazards and needed controls of the equipment or operation. Since that hazard analysis was not completed, the employees were not adequately trained in the hazards and needed worker protection controls. The employees did not understand or appreciate the serious hazard related to the failed latch assembly.

3.3.4 Work Controls and Inspections

Neither the Laboratory Animal Resources Section Chief, the supervisor, nor the employees thoroughly understood the operation of the tunnel washer and its inherent hazards. Both UT-Battelle and DOE personnel expressed the belief that since it was a commercially available piece of equipment, then it must be safe.

The need to maintain accreditation by the Association for Assessment and Accreditation of Laboratory Animal Care International was a top priority in operation of the tunnel washer. Emphasis was placed on maintaining the minimum temperature necessary for sterilization of the equipment. In doing so, a higher than minimum temperature baseline was set. The *Guide for the Care and Use of Laboratory Animals* states, "Effective disinfection can be achieved with wash and rinse water at 143-180 degrees or more . . . Detergents and chemical disinfectants enhance the effectiveness of hot water . . . " The supervisor noted that the wash temperature after the burn injury was 194 degrees. Records also indicated that final rinse temperatures were routinely above 225°F and sometimes as high as 270°F. This indicated that the safety of the worker was not a priority.

The *LSD Animal Resources Section Reference Manual*, Section VI, Paragraph. F, "Uniforms," was written to reduce employee exposure to allergens. It did state that "personnel should wear appropriate institution-issued protective clothing, shoes or shoe-covers, and gloves." Paragraph K stated the Protective Clothing Policy as, "The company will provide and launder the employee's choice of either coveralls, khaki pants and shirts, or scrub uniforms." The worker injured in the accident was wearing shorts. This did not seem to be in accordance with the procedure, but the Board did not find this nonconformance to be a factor in the accident. Since a hazard analysis of the operation was not performed, it was unclear if other protective clothing should be worn to protect the worker against steam and hot water.

Many problems encountered during the

operation related to inadequate controls and written procedures or instructions. The painted lines on the floor to mark aisleways and the "dirty" and "clean" areas were ignored. Written guidance was not provided to instruct employees what to do or where to place the carts containing dirty cage tops after they left the animal rooms (i.e., place them in temporary storage, in hallways, or in particular rooms). Some time before the accident (on September 5, 6, and 7), Laboratory Animal Resource Section employees moved 20 carts of dirty cage tops from the hallways into room 235, creating an overcrowded and unsafe condition. Adding to the crowded condition was a large discarded roller conveyor, which measured approximately 12 feet by 4 feet. The conveyor had been moved from another room over one year ago, and it was placed in room 235 because there was no where else to put it. The conveyor contributed to the congestion in room 235 and partially blocked the worker's route of egress from the room.

The atmosphere surrounding the operations indicated that certification and production took precedence over safety and health.

3.3.5 Lessons Learned Program

The ORNL Performance-Based Management Subject Area Lessons Learned, Paragraph 1, stated, "The Lessons Learned Program supports two key elements of the Integrated Assessment Program: evaluating overall performance and identifying and implementing actions for improvement." The Performance-Based Management procedure *Reviewing Lessons Learned to Improve Work Planning*, Paragraph 2.0, Step 3, stated, "Using information obtained from reviewing Lessons Learned, managers and staff incorporate implementing controls into their respective tasks to mitigate hazards and to carry out work in a safe and effective manner." Lessons learned was included as a component of the LSD ISMS program description. Section II, Paragraph 5, required lessons learned to be reviewed and distributed to division recipients. It appeared that the lessons learned database was being routinely searched for applicable lessons learned, and the lessons learned were provided to the Laboratory Animal Resources Section. At that point, there were no assurances that any corrective actions were completed or that changes were incorporated in the execution of processes. Examples of some lessons learned where the implementation of controls was questionable are as follows:

- Lessons Learned Identifier B-2001-OR-UTBX10-0503 dated 05-16-2001. Resolution: Care should be taken to keep all walk/floor areas clear of materials.
- Lessons Learned Identifier ESH-QAS-2001-00059 dated 05-07-2001. Resolution: The following action was recommended as a result of the incident: (1) Perform a JHA on Excess Storage.

- Lessons Learned Identifier 2001 HQ-EH-2001-001. Resolution: In defining the work and analyzing the hazards for activities involving chemical solutions, the facilities should: Ensure that the activity hazard analysis defines all basic job steps to be performed. Ensure that the controls and requirements are clearly stated and are implemented in the field.

3.3.6 Emergency Response/Medical

After the initial delay in alerting coworkers of the serious injury (the inability of fellow workers to hear the worker's calls for help was due to the high noise level at the tunnel washer), the emergency treatment provided to the worker was timely and prudent. While one worker used a plant phone to call 911 to summon the on-site Y-12 emergency response team and ambulance, coworkers applied ice and water to the worker's burned areas. The Y-12 emergency response team arrived at the accident scene two minutes after receiving the emergency call. The 911 call was received at 2:16 pm and the arrival time was 2:18pm. Emergency response personnel stated that the care given by the worker's coworkers was good and that the ice and water applied probably helped reduce the temperature of the burned areas and the pain from the burns. Since they arrived promptly, the ice applied by the coworkers did not adversely affect the worker's body temperature. The emergency response team identified second degree burns on both of the worker's feet and legs, with total burns covering 20 percent of her body. They covered the worker with a sterile burn sheet and started an intravenous drip in the worker's left hand. The worker was then transported to the Methodist Medical Center in Oak Ridge, Tennessee. The arrival time at the hospital was 2:35 pm. The worker was hospitalized and remained in the hospital receiving treatments and medications until September 21, 2001.

3.3.7 Implementation Verifications

Technical UT-Battelle safety personnel did not review the equipment prior to purchase to identify the hazards and needed safety controls. UT-Battelle management allowed the installation of the equipment without full consideration of the risk to the operators. UT-Battelle management did not identify the inadequate LSD ISM Program implementation. Line management did not assure that personnel involved in operation of the tunnel washer were cognizant of the hazards associated with the work and the needed worker protection controls.

Procedures ES&H-98-LSD-001, Revision 02, and LSD-ISMS-01, Revision 02, stated, "The Division conducts quarterly general safety inspections as required by the ORNL Safety and Health Program, ORNL-SH-P01. The procedures indicated that they always attempt to combine other required inspections with the scheduled inspections to minimize impact on the division personnel and operations. SA-98-LSD-001, *LSD Integrated Self-Assessment Program*, Revision 03 required the DSO from the Operational Safety Services Division to conduct quarterly ES&H inspections. The quarterly inspections were conducted in a timely manner during calendar year 2000. In calendar year 2001, they were combined with the ORNL OAP visits. The OAP Bulletin Board stated "an OAP visit is not an audit or assessment" and "the observations are not tracked in a formal database and no corrective actions are required." Even though the OAP does not require it, the LSD maintains an internal tracking system for OAP observations, and they are followed to completion. Neither the quarterly safety inspections nor the OAP visits identified congested work and storage areas as a hazardous condition. Even so, the Quarterly Safety Inspection Program appeared to function effectively as one method of providing ISMS feedback, but fulfilling the quarterly safety inspection requirement through the OAP had the effect of eliminating one of the safety controls in the LSD.

From January 7, 2000, through March 2, 2001, the Laboratory Animal Resources Section conducted weekly walkthroughs of Building 9210. Safety and health issues, as well as operational issues, were identified. Housekeeping and sanitation were common problem areas. In March 2001, it was noted that several activities had continuing deficiencies and that many items highlighted on the weekly QA walkthroughs were not being addressed in a timely manner. These problems seem to be a follow-up and enforcement concern. However, as a result, the weekly walkthroughs were canceled and replaced with one unannounced, Friday walkthrough each month. The change to monthly walkthroughs did not seem to result in improved working conditions or operations. The walkthrough policy change reduced the feedback and continuous improvement opportunities.

The DOE ORNL Site Office performed an ISMS Phase II Validation of the various ORNL divisions. A rating system of "green," "yellow," and "red" were used to specify the degree or level of implementation of the ISMS. The LSD was rated "yellow," meaning that the division had some items in place and implemented yet also had specific areas needing improvement. When DOE ORO performed a Phase II Follow-up Verification of UT-Battelle at ORNL in September 2000, the emphasis was placed on the Chemical Technology Division and the P&E Division, with specific emphasis on the 3019 facility. The LSD was not audited.

Some of the Opportunities for Improvement identified in the DOE ORO follow-up validation report included the following:

- There was a need to clarify and improve the JHE documentation to ensure adequate and consistent identification of hazards and controls within the Chemical Technology Division and the P&E Divison.

- Improvements were needed in the identification of standards and requirements. The WSS set for the Chemical Technology Division and the P&E Division did not include important documentation for DOE industrial safety.

- For feedback and continuous improvement, the need was identified to ensure that corrective actions were completed and that lessons learned were incorporated in the execution of processes in the Chemical Technology Division and the P&E Division.

Based on information gathered during this Type B investigation, those same Opportunities for Improvement would have been applicable to the LSD.

3.4 Analysis Techniques

Several analytical techniques were utilized to determine the causal factors of the accident. Event and causal factors were charted using ISM core functions and guiding principles, and barrier and change analysis techniques were used to analyze facts and identify the accident causes. The causal factors, based on the weaknesses identified with the ISM core functions and guiding principles, collectively contributed to the accident.

3.4.1 Integrated Safety Management System

Management systems were examined as potential contributing and root causes of the accident The Board reviewed the roles of DOE ORO, the DOE ORNL Site Office, and UT-Battelle management in promoting and implementing ISM in this operation. The UT-Battelle ISMS provides a formal, organized process for planning, performing, assessing, and improving the safe conduct of work. Properly implemented, ISM is a "standards-based approach to safety," requiring rigor and formality in the identification, analysis, and control of hazards. The system establishes a hierarchy of components to facilitate the orderly development and implementation of safety management throughout the DOE complex. The guiding principles and core functions of ISM are the primary focus for contractors in conducting work efficiently and in a manner that ensures the protection of workers, the public, and the environment. The Accident Investigation Program requires that accidents be evaluated in terms of ISM to foster continued improvement in safety and to prevent additional accidents.

ISM was implemented by DOE in the late 1990s. DOE has fully embraced ISM and has directed its contractors to fully implement the standard. ORNL's ISM Program has been contractually required since 1998. UT-Battelle assumed those ISM requirements when it took over as the management and operating contractor for ORNL on April 1, 2000. UT-Battelle has an approved ISMS description and had passed its Phase I and II verifications. However, the Board has identified weaknesses in all the ISM guiding principles and core functions.

Table 3-1 summarizes the deficiencies in the application of the five core functions of ISM as they relate to this accident. Table 3-2 summarizes the weaknesses in the application of the eight guiding principles of ISM.

3.4.2 Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all accidents. Barriers are developed into a system or work process to protect personnel and equipment from hazards. For an accident to occur, there must be a hazard that comes into contact with a target because the barriers or controls were not in place, not used, or failed. A hazard is the potential for unwanted energy flow to result in an accident or other adverse consequence. A target is a person or object that a hazard may damage, injure, or fatally harm. A barrier is any means used to control, prevent, or impede the hazard from reaching the target, thereby reducing the severity of the resultant accident or adverse consequence. The results of the barrier analysis are used to support the development of causal factors. Appendix B, Table B-1, contains the barrier analysis.

3.4.3 Change Analysis

Change is anything that disturbs the "balance" of a system which is operating as planned. Change is often the source of deviations in system operations. Change can be planned, anticipated, and desired, or it can be unintentional and unwanted. Change analysis examines planned or unplanned changes that caused undesired results or outcomes related to the accident. This process analyzes the difference between what is normal (or "ideal") and what actually occurred. The results of the change analysis are used to support the

Table 3-1. Weaknesses in Implementation of ISM Core Functions

development of causal factors. Appendix B, Table B-2, contains the change analysis.

3.4.4 Events and Causal Factors Analysis

A causal factors analysis was performed in accordance with the DOE Workbook *Conducting Accident Investigations*, Revision 2. Events and causal factors analysis requires deductive reasoning to determine which events and/or conditions contributed to the accident. Causal factors are the events or conditions that produced or contributed to the occurrence of the accident and consist of direct, contributing, and root causes.

The **direct cause** is the immediate events or conditions that caused the accident. **Contributing causes** are events or conditions that, collectively with other causes, increased the likelihood of the accident but that individually did not cause the accident. **Root causes** are events or conditions that, if corrected, would prevent recurrence of this and similar accidents. The Events and Causal Factors Chart as well as the Causal Factors Analysis is presented in Appendix B (Diagram B-1 and Table B-3).

Significant weaknesses in the implementation of the five core function of ISM contributed to the occurrence of this accident. These weaknesses include the following:
<u>Core Function 1</u> **Define the Scope of Work** • Neither an adequate SOP, a JHE, nor an AHA was available to define all the basic job steps to be performed during the operation.

Table 3-1. Weaknesses in Implementation of ISM Core Functions (continued)

Significant weaknesses in the implementation of the five core function of ISM contributed to the occurrence of this accident. These weaknesses include the following:
Core Function 2 **Analyze the Hazard** • UT-Battelle technical safety and health SMEs did not evaluate the tunnel washer for safety and health hazards in the design and procurement stage. • UT-Battelle did not adequately analyze the hazards of the operation. A JHE/AHA was not performed. • Workers were not involved in a hazard identification process to determine what worker protection controls were needed for the equipment. • UT-Battelle did not identify that the location and orientation of the automatic self-cleaning debris filter assembly and the design of the latch increased the hazard of accidental contact with the energy source. • UT-Battelle did not identify the unique hazards associated with pressure systems containing steam and high-temperature water.
Core Function 3 **Develop and Implement Hazard Controls** • Since the hazards of the equipment and operation were not analyzed, adequate worker protection controls were not developed. • Confusion existed among UT-Battelle personnel as to what WSS sets were applicable to equipment purchases. The ASME *Boiler and Pressure Vessel Safety Code* was not part of the master ORNL WSS set in the base set, Section 1, *Other Industrial, Radiological, and Non-Radiological Hazard Facilities.* • Employees and supervision did not have a clear understanding of the operational parameters of the equipment and the resulting hazards to the workers.
Core Function 4 **Perform Work Within Controls** • The operators were not provided safety information as to the controls or checks which were necessary to assure safe operation of the tunnel washer. • The operators were not informed as to what was a dangerous temperature or pressure so that they knew when an emergency stop was necessary. • The painted lines on the floor used to mark aisleways and the “dirty” and “clean” areas were ignored. • Since a hazard analysis of the operation was not performed, the adequacy of the protective clothing and equipment was in doubt. • Excess/unneeded equipment added to the congestion in the room and impeded easy egress of the injured worker.

Table 3-1. Weaknesses in Implementation of ISM Core Functions (continued)

Significant weaknesses in the implementation of the five core function of ISM contributed to the occurrence of this accident. These weaknesses include the following:
<u>Core Function 5</u> **Provide Feedback and Continuous Improvement** • The LSD has not successfully implemented lessons learned recommendations and incorporated needed changes in the execution of processes. • Quarterly safety inspections, OAP visits, and Laboratory Animal Resources Section walkthroughs were not effective in identifying congested work and storage areas as a hazardous condition. • Quarterly safety inspections were combined or eliminated if OAP visits were planned in the same year. • Safety meetings with employees were inconsistently conducted and did little to obtain employee feedback on hazards and working conditions. • The LSD's written ISMS program document did not clearly explain the methods used to obtain worker involvement and feedback on hazards and needed controls.

Table 3-2. Weaknesses in Implementation of the Eight Guiding Principles of ISM

Significant weaknesses in the implementation the eight guiding principles of ISM contributed to the occurrence of this accident. Weaknesses existed in all the guiding principles and at several levels within the organizations involved. These weaknesses include the following:
Guiding Principle 1 **Line management is directly responsible for the protection of the public, workers, and the environment**. • DOE ORO, the ORNL Site Office, the DOE Program Manager for the LSD, and UT-Battelle did not provided adequate ES&H emphasis and validation to ensure the contractor was implementing the various principles and components of ISM.
Guiding Principle 2 **Clear and unambiguous lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels within the Department and its contractors.** • The ORNL Site Office Program Manager for the LSD did not recognize the need for regular DOE ES&H reviews of the LSD facilities at Y-12. • The ORNL Site Office did not conduct detailed reviews of operating systems or perform ES&H program reviews of the LSD at Y-12. • UT-Battelle did not ensure that ES&H personnel and facility managers had a clear understanding of safety needs and their responsibilities (e.g., performing the AHA, JHE, JHA, etc.).
Guiding Principle 3 **Personnel shall possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.** • The UT-Battelle Supervisor did not have a thorough understanding of the operation of the tunnel washer. • The tunnel washer operators did not have the knowledge needed to appreciate the hazards of the equipment and operation. • Hazard identification, analysis, and control were ineffectively performed on the equipment and operation.
Guiding Principle 4 **Resources shall be effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment shall be a priority whenever activities are planned and performed.** • The atmosphere surrounding the operations indicated that certification and production took precedence over safety and health. • Weekly walkthroughs were reduced to monthly walkthroughs, and open deficiencies were not aggressively addressed.

Table 3-2. Weaknesses in Implementation of the Eight Guiding Principles of ISM (continued)

Significant weaknesses in the implementation the eight guiding principles of ISM contributed to the occurrence of this accident. Weaknesses existed in all the guiding principles and at several levels within the organizations involved. These weaknesses include the following:
Guiding Principle 5 **Before work is performed, the associated hazards shall be evaluated and an agreed-upon set of safety standards shall be established that, if properly implemented, will provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences.** • Without a safety review and hazard analysis of the equipment, the evaluation of the adequacy of the applicable WSS sets was ineffectual or nonexistent. • Employees and supervision were unaware of the excessively high temperatures being sustained during the operation of the tunnel washer. • The tunnel washer was routinely operated at temperatures in excess of those specified in the tunnel washer manual. • Deficiencies were evident in the implementation of the manufacturer's maintenance recommendations. • The procedures and operator aids were either lacking, not communicated, or ignored, which allowed the ingress and egress avenues to the tunnel washer to be obstructed.
Guiding Principle 6 **Administrative and engineering controls to prevent and mitigate hazards shall be tailored to the work being performed and associated hazards.** • Engineering and administrative controls were not fully utilized to reduce the hazards to the workers. • The design of the latch assembly for the automatic self-cleaning debris filter was less than adequate for its application. • The administrative controls in room 235 that designated the path of travel and the area for storage of dirty equipment failed due to congestion and an overabundance of carts. • Lack of a fail-safe or automatic shutdown device on the washer motor and pump contributed to the severity of the injuries.
Guiding Principle 7 **The conditions and requirements to be satisfied for operations to be initiated and conducted shall be clearly established and agreed-upon.** • Line management did not assure that personnel involved in washer operation were cognizant of the hazards associated with the work and the needed worker protection controls. • There was inadequate safety and health involvement and evaluation of the procurement, installation, and operation of the tunnel washer. • The ORNL Site Office and UT-Battelle did not adequately evaluate the LSD ISM Program to determine the division's failure to implement the DOE-required ISM principles and core functions. • The DSO and the supervisor did not recognize the need to perform a hazard analysis on the operation of the tunnel washer.
Guiding Principle 8 **Workers will be involved in all phases of work planning and execution.** • Workers were not adequately involved in analyzing and controlling the hazards associated with this operation.

4.0 JUDGMENTS OF NEED

Judgments of Need are the managerial controls and safety measures determined by the Board to be necessary to prevent and/or minimize the probability or severity of a recurrence. They flow from the causal factors, which are derived from the facts and analyses. Judgments of Need are directed as providing guidance for managers during the development of corrective actions.

Table 4-1. Judgments of Need

No.	Judgment of Need	Related Causal Factor
JON 1	DOE ORO and the DOE ORNL Site Office need to improve the methods used to ensure the contractor is implementing the various components of ISM.	*DOE Oak Ridge Operations Office, the ORNL Site Office, and the DOE Program Manager have not provided adequate ES&H emphasis and validation to ensure the contractor is implementing the various components of its ISMS. *The ORNL Site Office Program Manager has not recognized the need for regular DOE ES&H reviews within the LSD facilities at Y-12. *The ORNL Site Office did not conduct detailed reviews of operating systems or ES&H program reviews of the LSD at Y-12.
JON 2	There is a need for the LSD to clarify and improve the JHE/AHA process and documentation to ensure adequate and consistent identification of hazards and controls and to train the employees on the results.	*Neither a JHE nor an AHA s was completed for the tunnel washer operation. *The lack of a JHE/AHA and the inadequate standard operating procedures meant that all of the basic job steps or tasks to be performed during the operations were not identified. *The specific tasks to safely check and clean the automatic self-cleaning debris filter assembly were not explained. *The standard operating procedure did not explain the aisle markings on the floor or the proper placement of equipment awaiting cleaning.

Table 4-1. Judgments of Need (continued)

No.	Judgment of Need	Related Causal Factor
JON 3	There is a need for UT-Battelle to implement an institutional method to ensure equipment is evaluated by SMEs for safety and health hazards in the design or procurement stage.	*Professional safety and health staff did not evaluate the tunnel washer design and installation for hazards to the workers and adequacy of safety controls. *An inadequate latch was installed on the automatic self-cleaning debris filter. *The exhaust fan for the equipment was located above the equipment, creating a high noise area. *The equipment was not equipped with a fail-safe device to send an alarm and automatically shut down the equipment when catastrophic failure occurred.
JON 4	UT-Battelle needs to ensure selected and approved WSS sets address the actual hazards and needed controls and there is a clear understanding of the applicability of the various WSS sets.	*The American Society of Mechanical Engineers *Boiler and Pressure Vessel Safety Code* is a standard within the engineering design of facilities WSS set but not within the general industrial WSS set that is applicable to the entire ORNL operation. *UT-Battelle's Engineering and Standard - Based Management System personnel differed as to which ORNL WSS sets applied to purchased equipment to be installed in a building which did not involve modification of the building itself.
JON 5	The LSD's ISMS needs to be improved to specify the need for worker involvement and how that involvement is obtained.	*Workers were not involved in the process to identify the operational hazards and the needed worker protection controls for the tunnel wash operations.

Table 4-1. Judgments of Need (continued)

No.	Judgment of Need	Related Causal Factor
JON 6	Improvements are needed in the LSD ISM Program to effectively address feedback and continuous improvement; to ensure timely and sufficiently detailed safety inspections are conducted; ensure corrective actions are completed; and ensure lessons learned are incorporated and executed in the processes within the LSD.	*Safety meeting were not implemented in an effective manner to achieve employee feedback on workplace and operational safety concerns. *The conduct of safety meetings is less than adequate and attendance was not assured. *Lessons learned recommendations for ensuring that the hazard analysis defined all basic job steps, performing JHAs on excess storage, and ensure care was taken to keep all walk/floor areas clear of materials were ineffectively implemented. *Safety inspections were not effective or consistently conducted as required.
JON 7	UT-Battelle needs to develop an expedited method for disposal of excess equipment within Building 9210 at Y-12.	*Excess and unneeded equipment contributed to crowded, congested, and unsafe working conditions.
JON 8	UT-Battelle needs to develop a process to evaluate and ensure that safe working environments are maintained when modifications are made to equipment or equipment support.	*Modifications were made to the steam lines and controls that allowed the equipment to operate beyond the manufacturer's specifications and create an unsafe working condition and premature equipment failure.
JON 9	UT-Battelle needs to ensure that equipment is operated in accordance with design specifications and the vendor's recommendations.	*The SOPs were inadequate for safe operation and did not reflect the requirements outlined in the equipment manual. *The equipment was not calibrated, and the accuracy of operating parameters was not verified. *Preventive maintenance and testing of safety systems were not conducted. *Safety systems, temperature guarantees, and steam regulators were compromised, disengaged, or removed, which allowed the equipment to operate outside of the design limitations and caused premature equipment degradation.

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5.0 BOARD SIGNATURES

Date: 10/12/01

Bobby Price, Chairperson
DOE Accident Investigation Board
Director, Information Resources Management Division
Oak Ridge Operations Office

Date: 10/15/01

David Buhaly, Accident Investigator*
DOE Accident Investigation Board
Operations Division
Oak Ridge Operations Office

Date: 10/15/01

Tim Wilson, Member
DOE Accident Investigation Board
Operations Division
Oak Ridge Operations Office

* Trained Accident Investigator

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6.0 BOARD MEMBERS, ADVISORS, AND STAFF

Chairperson	Bob Price, DOE ORO
Member	David Buhaly, DOE ORO
Member	Tim Wilson, DOE ORO
Technical Editor	Karen Brown Informatics Corporation
Administrative Support	Melisa Hart Critique, Inc. Patty Humphrey, DOE ORO
DOE Advisors	Scott McGill, Maintenance Terri Slack, Office of Chief Counsel
Observer	Doug Miller, UT-Battelle

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Appendix A: Type B Investigation Board Appointment Memorandum

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DOE F 1325.8
(4/93)

United States Government **Department of Energy**

Oak Ridge Operations Office

memorandum

DATE: September 14, 2001

REPLY TO
ATTN OF: SE-32:Mullins

SUBJECT: **TYPE B INVESTIGATION - OAK RIDGE NATIONAL LABORATORY EMPLOYEE BURN INJURIES AT THE Y-12 NATIONAL SECURITY COMPLEX, OAK RIDGE, TENNESSEE**

TO: B. W. Price, Director, Information Resources Management Division, AD-41, ORO

You are hereby appointed Chairman of the Investigation Board to investigate the September 7, 2001, burn injuries to an employee of UT-Battelle, LLC working at Building 9210, Y-12 National Security Complex. This incident meets a Type B investigation per the requirements contained in DOE Order 225.1A, "Accident Investigations."

You are to perform a Type B investigation of this incident and to prepare an investigation report. The report shall conform to requirements detailed in DOE Order 225.1A and DOE G 225.1A-1, "Implementation Guide for Use with DOE 225.1A, Accident Investigations." The Board will be comprised of the following members:

David Buhaly, Laboratory Programs Support Team, SE-311, Trained Investigator
Tim Wilson, Environmental Management Programs Support Team, SE-312, Board Member

The scope of the Board's investigation is to include, but is not limited to, identifying all relevant facts; analyzing the facts to determine the direct, contributing, and root causes of the incident; developing conclusions; and determining judgments of need that, when implemented, should prevent the recurrence of the incident. The Board will focus on and specifically address the role of DOE and contractor organizations and Integrated Safety Management Systems. The scope will also include an analysis of the application of lessons learned from similar accidents within the Department.

If additional resources are required to assist you in completing this task, please let me know and it will be provided. A representative from General Counsel will be appointed to serve as the Board's legal liaison. You and members of the Board are relieved of your other duties until this assignment is completed.

The Board will provide my office with weekly reports on the status of the investigation but will not include any findings or arrive at any premature conclusions until an analysis of all the causal factors have been completed. Draft copies of the factual portion of the investigation report will be submitted to my office and the contractor for factual accuracy review prior to the report finalization.

The final investigation report should be provided to me by October 15, 2001. Any delay to this date shall be justified and forwarded to this office. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report. A copy of the Oak Ridge Accident Investigation Guidelines is attached for your use. If you have any questions, please contact me, or Robert Poe at 576-0891.

G. Leah Dever
Manager

Attachment:
ORO AI Guidelines

cc w/o attachment:
S. Cary, EH-1, 7A-097, HQ/FORS
J. F. Decker, SC-1, HQ/FORS
T. Rollo, EH-21, HQ/270CC
D. Vernon, EH-24, HQ/GTN
M. Johnson, SC-3, 7B-084, HQ/FORS
P. M. Dehmer, SC-10, HQ/GTN
A. A. Patrinos, SC-70, HQ/GTN
M. Branton, LM-10, ORO
W. J. Brumley, NADP-6
J. W. Robertson, NADP-6
J. T. Mitchell, BWXT Y-12, LLC

Appendix B: Analysis

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Table B-1. Barrier Analysis

Hazard	Target: Worker	
Barriers	**Purpose**	**Analysis/Effect on Accident**
Equipment configuration	Equipment installation often offers several options to optimize the configuration for maintenance, performance, and safety.	The barrier failed because the debris filter assembly, as well as other hot water components, could have been installed on the opposite side of the tunnel washer. The part that failed would have never come in contact with the injured worker because the tunnel washer itself would have been an effective barrier. The current configuration appeared to have been selected for ease of installation and maintenance.
Minimize hazardous energy	Generally, the less the energy source, the less the hazard. Lower the temperature and reduce the burn hazard.	The barrier failed because the water temperatures in all areas of the tunnel washer were higher than necessary. The temperature in the washer that burned the employee was 194°F. The *Guide for the Care and Use of Laboratory Animals* states that wash water at 143° to 180°F is adequate.
Latch and cover design	Closures for pressure systems separate the hazardous energy from the workers.	The barrier failed because the latch was inadvertently released on accidental contact so that the hot water under pressure deluged the worker. The filter assembly that opened was an optional device, and the latch design made it extremely easy to open. The other tunnel washers did not have a similar item. The selection of this item as an option brought it into this picture. Without it, there would not have been an accident.

Table B-1. Barrier Analysis (continued)

Hazard	Target: Worker	
Barriers	**Purpose**	**Analysis/Effect on Accident**
A fail-safe automatic cutoff switch for the debris filter assembly	An automatic " kill switch" is sometimes used to monitor pressurized containers to reduce or eliminate discharges.	This barrier failed because the pressure system was not equipped with an automatic kill switch. The filter assembly had a pressure gauge mounted to it. The gauge was used to determine the condition of the filter (i.e., its pressure would drop if the filter became clogged). A kill switch between the pressure gauge and the washer pump would instantly reduce the pressure and thus reduce the spraying of hot water.
Adequate work space around equipment	Provide working room and distance to keep employees from the hazardous energy source.	This barrier failed because the crowded working conditions caused the employee to walk and push the cart next to and against the debris filter assembly. At the time of the accident, the room was overcrowded with numerous carts and tables containing equipment that needed to be washed.
Emergency alarms	Call immediate attention to a hazardous condition or accident	The barrier failed because the debris filter assembly was not equipped with an alarm to warn of catastrophic failures. The pressure system was breeched, and the victim/target was exposed to scalding hot water. No one was aware of her injuries until she exited into the hallway. Alarms would possibly have shortened the response time.
Hazard analysis	A forward-looking process for the identification and control of hazards	The barrier failed because the process was not utilized. The hazards of the equipment were not identified and controlled prior to procurement, at installation, or during operation.

Hazard	Target: Worker	
Barriers	**Purpose**	**Analysis/Effect on Accident**
Procedures/work control	To describe and control the operational process so that it can be accomplished safely and effectively	The barrier failed because of numerous operational, safety control, and warnings were omitted in the existing procedures. A significant omission was the responsibility for storage of carts of dirty cage tops from the time of collection to the time of washing. The manufacturer's operating procedures, warnings, and maintenance recommendations outlined in the equipment manual were not followed.
ISM Program implementation and verification	To ensure worker protection by compliance with DOE directives and national consensus standards	This barrier failed because the ISMS was inadequate and surveillance failed to identify the problems at ORNL, the LSD, and the work site.

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Table B-2. Change Analysis

Normal "Ideal"	Actual	Analysis
Adequate health and safety review of design during procurement stages for potential hazards	No documented health and safety review was performed during the procurement process.	The self-cleaning debris filter was an optional item. A review might have identified the hazards associated with the location of the high-temperature piping, filter orientation, choices of clamps available from the vendor, or the need for a pressure sensitive safety cutoff. All of these choices might have prevented or mitigated the effects of the accident.
Proper preventive maintenance and evaluation prior to affecting repairs	Maintenance did not reflect the vendor's recommendations, and affected repairs were not directed at the problem but at the symptomatic observations.	Vendor-specified maintenance was not conducted on the tunnel washer. The temperature guarantees were turned off to allow the equipment to operate outside of its design limits. Modifications to the steam and hot water systems allowed temperatures to exceed the design limits of the equipment and temperature-sensitive components, leading to increased maintenance costs and operation of the tunnel washer beyond safe parameters. The injured worker was burned by water at temperatures above programmable limits and above the temperatures necessary to achieve proper disinfection.
QA and proper calibration of equipment	The temperature probes were not maintained in accordance with the vendor's recommendation. The actual temperatures were not compared to the data recorders, and there was no record of the equipment being calibrated. The data recorders were not reviewed to assure that operation of equipment was within the design parameters. Temperature indicator tapes were used to verify that temperatures of 180°F were reached for disinfection, but the LSD did not identify the maximum temperature reached or if equipment was rinsed prior to the rinse water being vaporizing due to excessive heat.	Review of the data recorder tapes revealed temperature inconsistencies. Final rinse temperatures were recorded to a maximum of 279°F in the final rinse. Usual and accepted temperatures well in excess of manual and programmable limits were noted. Excessive temperatures not only increased the potential hazard but resulted in premature failure of solenoids and the internal seals of the tunnel washer. The dryer in the washer was not used due to excessive heating of the cages and cage tops, despite the vendor's manual specifying that the manual limit for the dryer was 210°F.

Table B-2. Change Analysis (continued)

Normal "Ideal"	Actual	Analysis
JHA conducted to identify potential hazards associated with the washer	There was no record of a JHA being conducted in conjunction with the design phase, procurement, instillation, or operation of the tunnel washer.	A review of the design schematics revealed that the motors, pumps, and associated piping could have been located on the back side of the tunnel washer. In that case, the washer would have provided a physical barrier to the hazard. The review also revealed that the refuse filter could have been mounted parallel to the motor, in which case the motor mount would have provided an effective barrier to the cart striking the clamp that opened. Insulation to some of the piping was not installed until after employees had previously received burns, and the insulation was not adequate to shield all exposed thermal hazards. The clamp that opened was one of two styles offered by the vendor. The clamp that opened was either chosen for ease of access or by not specifying the clamp with the more aggressive closure.
Procedures are written with adequate QA and prescriptive description so as to be concise and easily understood	Procedure A-98-LSD-001. J. (which was updated July 2001) *Tunnel Washer Operation*, lacked QA/ quality control and clarity. The procedure did not reflect the actual tunnel washer operation or the vendor's manual.	Depending on the page, this procedure was labeled both as an Operations procedure or a Veterinary procedure. Page 2 of the procedure specified operation of tunnel washers for cage washing on the first, second, and third floors. The tunnel washer located in room 235 was used for washing wire cages, yet it had a separate and different procedure embedded on pages 4–6. Although reduced staffing was allowed on the tunnel washer in room 235, it was not specified in the procedure. However, it could be interpreted from the procedure that one person was permitted to operate the washer alone. Interviews confirmed an inconsistent understanding of the procedure, and observations revealed that actual operations were not consistent with the equipment manual or the procedure.
Training is consistent, uniform, and adequate to perform the required tasks	Initial training on operation of the tunnel washer in room 235 was provided by the vendor. Discussions with animal care personnel, supervisors, and facility management revealed varying levels of operation and maintenance understanding.	Since new employee training consisted of reading procedures and on-the-job training, it was evident that the levels of operator knowledge were widely divergent and inadequate.

Table B-2. Change Analysis (continued)

Normal "Ideal"	Actual	Analysis
Operator aids are placed to provide obvious reminders of operating requirements	Marks on the floor of room 235 were presumed to delineate "clean" and "dirty" sides and to delineate cart storage boundaries so as to allow unimpeded access to the washer. However, the markings were not labeled, and the placement of the carts and water bottle transports obscured the marks.	Operator aids were not clearly identified, and the procedures did not mention the designations or the need to provide unobscured access around the tunnel washer. Carts were placed on the lines, and access to the washer was reduced to less than three feet at several points.
Adequate, well-trained staff are available to perform required duties	An analysis of the actual hours worked both before and after managerial changes and the absenteeism due to long-term disability indicated staffing levels under ideal conditions were marginal. However, injuries and absenteeism rates resulted in staffing rates that were below the levels necessary to meet workload requirements.	A review of the actual man-hours worked over a representative period of time indicated relatively constant levels. However, due to the disability of four employees and sporadic absenteeism, the remaining workforce was required to work excessive overtime in an attempt to compensate. For three days prior to the accident, almost all available employees worked four hours of overtime per day. In July 2001, procedures and staffing changes were implemented in an attempt to specialize and to compensate for the staffing problems. This change may have had a direct bearing on the conditions leading to the accident. Because the changers no longer had responsibility for washer operations, there was an intentional or unintentional disconnect that allowed an unusual accumulation of carts full of dirty cage tops in the halls. On the day of the accident, these carts of cage tops were present in room 235 and effectively blocked ingress/egress, thereby forcing the employee into the close proximity of the debris filter clamp that released.

Table B-2. Change Analysis (continued)

Normal "Ideal"	Actual	Analysis
Cage tops are washed on a regular and adequate schedule	Cage top washing for the month preceding the accident was inadequate to meet daily usage. Excess carts of dirty cage tops were allowed to accumulate in the halls, and in a relatively short time (between September 4 and 7), these carts were relocated into room 235, which effectively blocked the ingress/egress and contributed to the accident.	Based on the current inventory of mice and scheduled changes, Building 9210 generates approximately 30,000 dirty cage tops per month. This requires washing of approximately 1,500 cage tops per working day. Records indicated that 900 to 1,000 tops (2 carts) were washed per day for the month preceding the accident. The estimated deficit equated to the inventory of the carts of dirty tops that were located in room 235 on September 7, 2001. A brief analysis (or even observation) of the accumulating carts of cage tops in the halls should have alerted the staff that ensuing deficiencies of clean tops was inevitable. However, the procedures to identify clean cage tops from dirty ones were not being followed.
Walkthroughs are conducted on a frequent basis, and noted deficiencies corrected in a timely manner	Weekly walkthroughs were discontinued, and monthly unannounced walkthroughs were initiated in March 2001, although the procedures were not amended to reflect this change. The change was initiated because the weekly walkthroughs were not considered to be cost effective, since corrective actions for noted deficiencies were not being taken despite the fact that three to four management levels were either present at the walkthroughs or received the reports.	The weekly walkthroughs were specified in the *Veterinary Rounds and Quality Assurance Inspections* procedure and were "to ensure that adequate veterinary care is provided and that standards for animal care are maintained." Reports, however, tended to emphasize general housekeeping. The individuals that changed the frequency of the walkthroughs should have had the authority to ensure that corrections to noted deficiencies were implemented but chose to reduce the opportunities to note deficiencies. The rationale for the change was to generate corrective action tracking, but there was no indication that a greater corrective response would have been expected. In addition, the scheduling of the unannounced walkthroughs allowed as much as a 54-day interval between inspections. The inspection conducted one week prior to the accident failed to identify any issues related to the accident.

Table B-3. Causal Factors

DIRECT CAUSE			
The direct cause of the accident was the inadvertent release of the retaining latch on the automatic self-cleaning debris filter assembly, which resulted in the expulsion of 194° F water onto the equipment operator.			
No.	**Contributing Causes**	**Discussion**	**Related Judgment of Need**
CC-1	The design and installation of the tunnel washer was inadequate for safe operation.	• The latch assembly installed on the automatic self-cleaning debris filter assembly was inadequate for its location and use with the high-hazard hot water. • The exhaust fan for the equipment was located above the equipment, creating a high noise area. • The equipment was not equipped with a fail-safe device to automatically shut down the equipment when catastrophic failure occurred.	JON 3 JON 8
CC-2	The hazards associated with operation of the tunnel washer were not analyzed.	• UT-Battelle did not adequately analyze the hazards of the operation. A JHE/AHA was not performed. • Workers were not involved in a hazard identification process to determine what worker protection controls were needed for the equipment. • UT-Battelle did not identify the unique hazards associated with pressure systems containing steam and high-temperature water.	JON 2 JON 5 JON 8
CC-3	The basic job steps or tasks to be performed during the operation were not identified.	• The SOP and the lack of a JHE and an AHA did not define all of the basic job steps to be performed during the operation. • The vendor's recommendations and procedures were not incorporated into the basic SOPs.	JON 2 JON 9

Table B-3. Causal Factors (continued)

CC-4	The operators were not provided safety information as to the controls or checks which were necessary to assure safe operation.	• The tunnel washer was routinely operated at temperatures in excess of those specified in the tunnel washer manual. • The operators were not informed as to what was a dangerous temperature or pressure so that they knew when an emergency stop was necessary. • Employees and supervision did not have a clear understanding of the operational parameters of the equipment, and the resulting hazards to the workers. • Attendance of Laboratory Animal Resource Section personnel at safety meetings was inconsistent and not enforced. Required safety training (General Employee Training, Hazard Communication, etc.) and operational training frequently took the place of safety meetings and had little to do with the safety of operations.	JON 2 JON 5 JON 6 JON 9
CC-5	The work control processes were inadequate.	• The Laboratory Animal Resource Section SOPs did not identify the discrete tasks of removing the cages and cage tops from the animal rooms or where to place them while awaiting washing. • At the time of the accident, the floor markings for the“clean” and “dirty” areas and the markings designating the proper path for travel and storage of carts were obscured. • Excess and unneeded equipment contributed to unsafe working conditions.	JON 2 JON 7
CC-6	Lessons learned recommendations were not effectively implemented.	• The LSD did not have a system in place to assure that corrective actions from lessons learned were completed or that changes were incorporated in the execution of processes. • Three lessons learned were identified that the LAR had access to and which were ineffectively implemented. Two of them related to the need to have complete AHAs/JHAs.	JON 6

CC-7	Safety inspections were infrequent and ineffective.	• Weekly walkthroughs by facility management and supervision did not result in timely correction of deficiencies, so the schedule for walkthroughs was changed to monthly. • Combining the quarterly DSO safety inspections with the OAP visits in 2001 had the effect of eliminating one of the safety controls in the LSD. An OAP visit was not conducted in 2001 from January through the time of the accident. • ORNL Site Office personnel participated in the annual OAP visits, but they did not perform technical reviews of equipment, operations, or ES&H programs.	JON 1 JON 6 JON 9
No.	**ROOT CAUSES**	**Discussion**	**Related Judgment of Need**
RC-1	DOE ORO and the ORNL Site Office did not ensure the contractor implemented the various components of ISM.	• DOE ORO failed to review the LSD ISM Program and thereby did not identify weakness in that program. • The ISMS review method used by the ORNL Site Office did not identify significant deficiencies in the LSD ISM Program implementation at the facilities at Y-12. • The ORNL Site Office Program Manager did not perform or request regular ES&H reviews within the LSD facilities at Y-12.	JON 1
RC-2	Safety and health SMEs did not evaluate the hazards of the tunnel washer.	• Line management did not recognize the need to have professional safety and health staff review the design and installation of equipment that contained high water temperatures and pressure systems. • The safety and health SMEs did not evaluate the equipment to identify the hazards to workers. They did not assist in the preparation of a JHE/AHA for operation of the tunnel washer.	JON 3
RC-3	The specific WSS set applicable to the tunnel washer was unclear or inadequate.	• The washer contained a steam and pressure system, but the ASME *Boiler and Pressure Vessel Safety Code* was not included in the ORNL general industrial WSS set applicable to the equipment. • Confusion existed within UT-Battelle as to the application of the ORNL WSS set 9 to free-standing equipment.	JON 4

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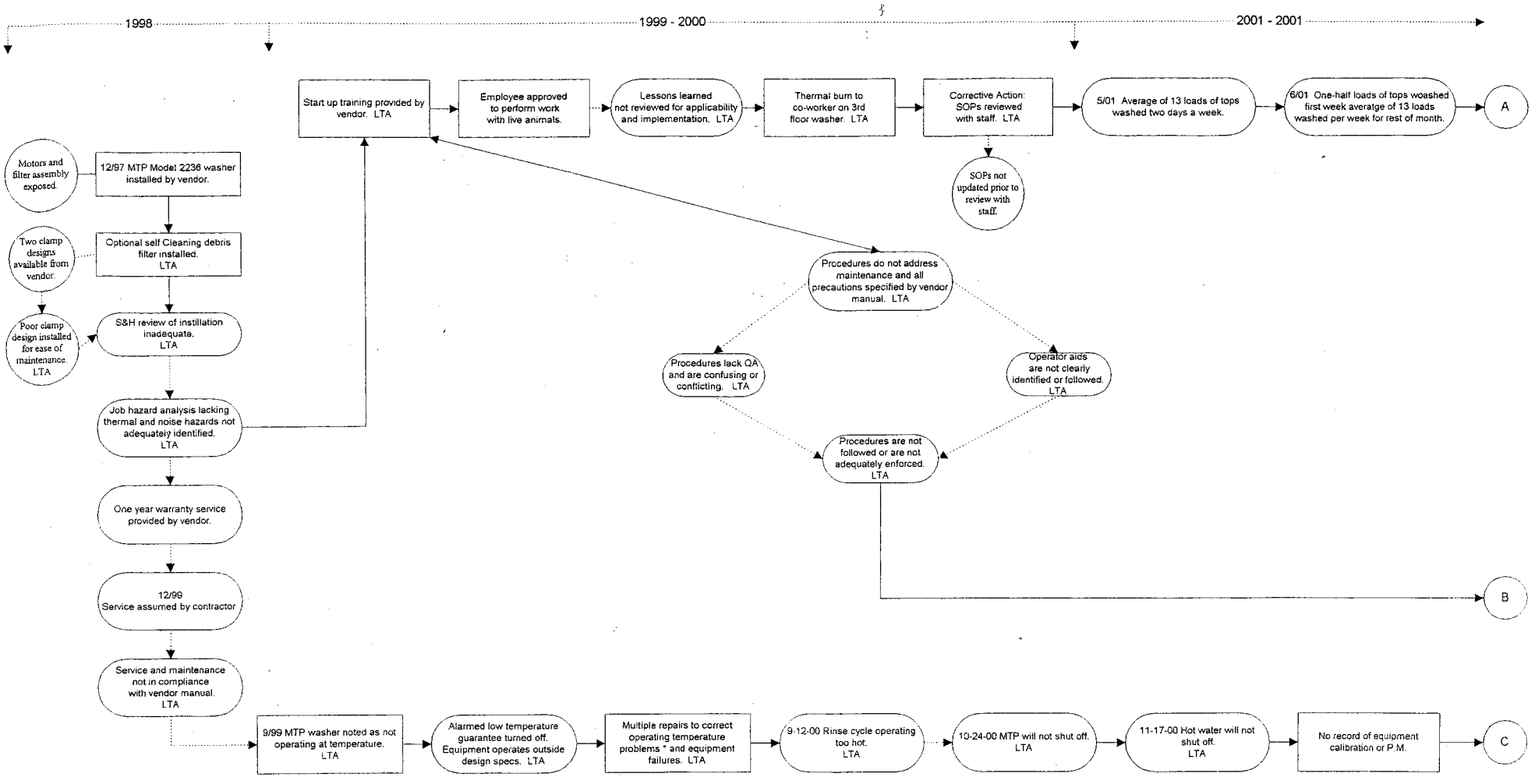
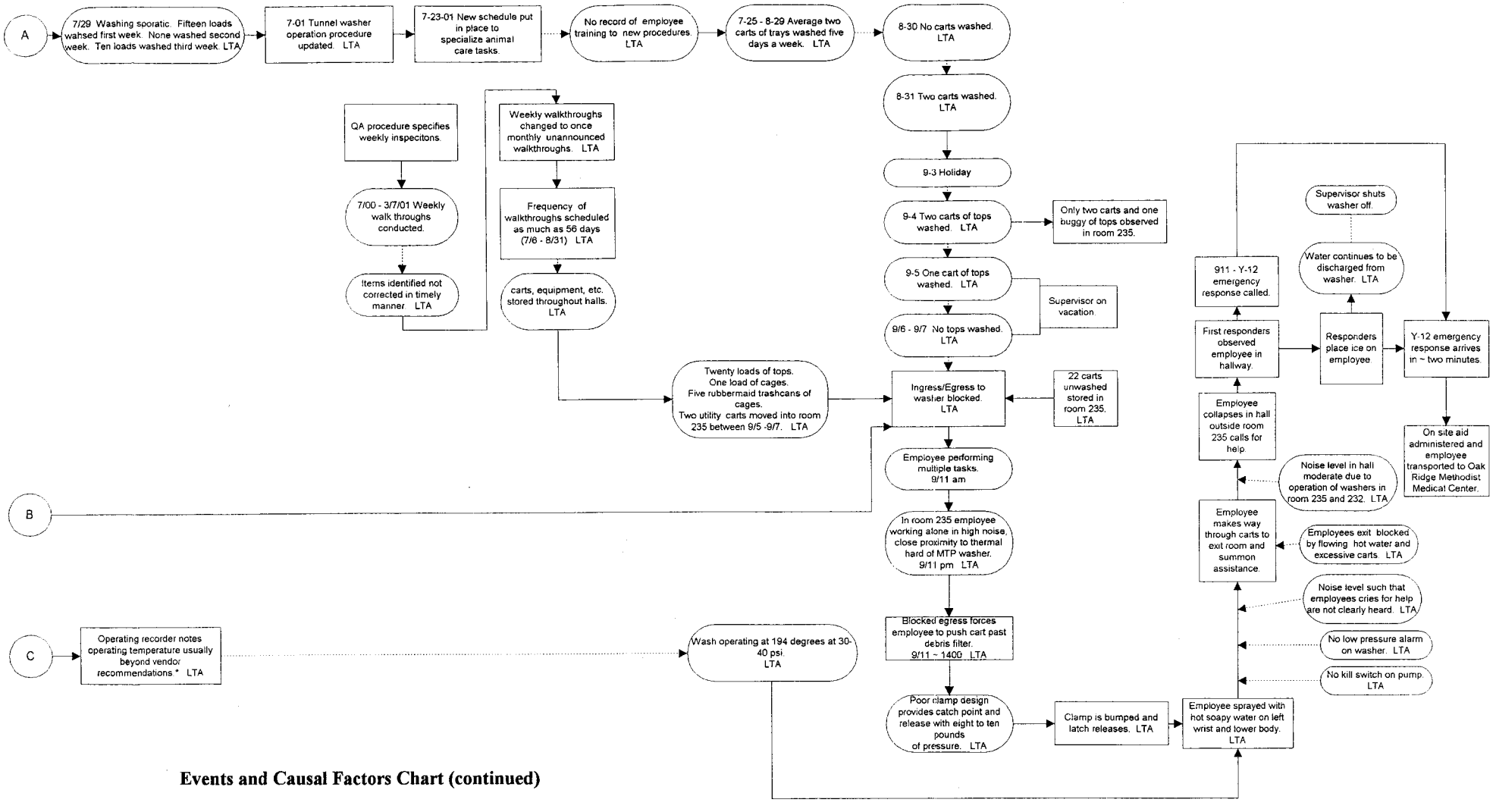


Diagram B-1
Events and Causal Factors Chart



Events and Causal Factors Chart (continued)

Appendix C: Comprehensive Time Line

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Comprehensive Time Line

Key events are shown in bold.

Date	Event
9/5/95	**The worker 36050 was hired.**
9/5/95	**The worker received *New Employee Orientation* training.**
10/30/97	Custom Machine Corporation provided a final quote for the MTP Model 2236 Tunnel, Cage and Utensil Washer to LSD.
12/97 or 1/98	**Delivery was taken on the MTP Model 2236 tunnel washer. Startup training was provided to employees, including Ms. Porter.**
12/97 - 12/98	Service and maintenance for the MTP Model 2236 were provided by the vendor.
3/5/98	**The LSD checklist to determine baseline training requirements was completed. The worker was approved to perform work with live animals.**
MJR 9/20/99	**(Maintenance Job Request) "Tunnel\Port Washer not up to temperature - Trap replaced on washer"**
MJR 9/30/99	**"Reinsulate the unsealed ends of tunnel washer where fitters replaced trap and modified steam lines"**
MJR 10/28/99	**"Remove steam regulator in room 235 above the east dryer, replace the control with straight pipe"**
MJR 1/5/00	**"Remove insulation to repair leaking water line at the SW end of tunnel port washer"**
MJR 1/24/00	**"Repair or replace steam trap on final rinse of MTP washer"**
MJR 1/24/00	**"Repair hot water line leak at 235 unit located at SW end of unit at floor level"**
MJR 3/2/00	**"Replace leaking union in room 235"**
3/20/00	**The Animal Care Taker Accident/Incident Report stated, "Thermal (Steam) burn to Left Arm from cage washer tank on third floor. Corrective action was to review SOP's with staff."**

Comprehensive Time Line (continued)

MJR 5/16/00 **"Replace final rinse solenoid valve on the MTP tunnel port washer in room 235"**

MJR 5/31/00 "Reinsulate piping on tunnel port washer"

7/00 **A-98-LSD-001V, "Quality Assurance," Section E.,** ***Veterinary Rounds and Quality Assessment Inspections*** **procedure was updated. The procedure specified that QA inspections were to be conducted weekly by the Division QA Coordinator, the Veterinary Staff, the Supervisor, the Health and Occupational Safety Officer, and respective animal care technicians. "Walk-thru" reports were to be generated.**

MJR 7/19/00 **"Repair steam leak in room 235 at the MTP washer, a 3 piece union is leaking near the hot water pump"**

MJR 9/12/00 **"MTP rinse cycle getting too hot, adjust hot water valve"**

MJR 10/26/00 **"MTP won't shut off, provide fitter support to troubleshoot and repair hot water solenoid on MTP washer in room 235"**

MJR 11/17/00 **"MTP hot water will not shut off, troubleshoot and repair hot water solenoid on the tunnel washer"**

MJR 1/25/01 **"Repair lift on MTP washer"**

3/7/01 **Internal UT-Battelle memorandum from Barbara Beatty to Foltz, Edds, Barker, Hodge, Hunsucker, Johnson, and Blair, Subject: "Weekly QA WalkThrus - 9210," ". . . identified several activities with continued deficiencies." ". . . many items highlighted on the weekly QA walkthroughs are not being addressed in a timely manner." "With Charmaine Foltz's concurrence, I am canceling the weekly walkthrough team effort effective today. This will be replaced by <u>one unannounced Friday walkthrough each month</u>. However when an uncorrected deficiency appears on two sequential monthly walkthrough report, an initial LSD corrective action form will be issued and tracked to completion. As QAC I will perform the random monthly Friday QA walkthrough, but will from time to time invite one of the former walkthrough team members to accompany me if needed."**

3/23/01 A weekly walkthrough of Building 9210 was conducted.

Comprehensive Time Line (continued)

4/20/01	A weekly walkthrough of Building 9210 was conducted
5/25/01	**A weekly walkthrough of Building 9210 was conducted, and a note on the report stated, "Congratulations: great walkthru!"**
5/01	Cage tops were washed an average of 2 days a week, with 9 to 17 carts of cage tops washed per week
6/01	One and a half loads of cage tops were washed the first week. An average of 13 loads of cage tops were washed for the next 3 weeks.
7/01	A-98-LSD-001, Chapter VI, "Operations," Section J, *Tunnel Wash Operation*, was updated.
7/03/01	Five carts of cage tops were washed in the tunnel washer.
7/6/01	Ten carts of cage tops were washed in the tunnel washer.
7/6/01	A weekly walkthrough of Building 9210 was conducted. A note on the report stated, "GREAT WALKTHRU!" Other items noted in the writeup were, "Rm 235 dirty towels left on half wall; clean items on old roller table - not labeled."
7/20/01	Ten carts of cage tops were washed in the tunnel washer.
7/23/01	Three carts of cage tops were washed in the tunnel washer.
7/23/01	**A new staffing schedule was implemented by C. Foltz.**
7/25/01	Three carts of cage tops were washed in the tunnel washer.
7/26/01	Two and a half carts of cage tops were washed in the tunnel washer.
7/27/01	Three carts of cage tops were washed in the tunnel washer.
7/30/01	Two and a half carts of cage tops were washed in the tunnel washer.
8/6/01	Two and a half carts of cage tops were washed in the tunnel washer.
8/7/01	Three carts of cage tops were washed in the tunnel washer.
8/8/01	One cart of cage tops were washed in the tunnel washer.

Comprehensive Time Line (continued)

8/9/01	Two carts of cage tops were washed in the tunnel washer.
8/10/01	Two carts of cage tops were washed in the tunnel washer.
8/13/01	Two and a half carts of cage tops were washed in the tunnel washer.
8/14/01	Two carts of cage tops were washed in the tunnel washer.
8/15/01	Two carts of cage tops were washed in the tunnel washer.
8/16/01	Three carts of cage tops were washed in the tunnel washer.
8/17/01	Two carts of cage tops were washed in the tunnel washer.
8/20/01	Two carts of cage tops were washed in the tunnel washer.
8/21/01	Two and a half carts of cage tops were washed in the tunnel washer.
8/22/01	Two carts of cage tops were washed in the tunnel washer.
8/23/01	Two carts of cage tops were washed in the tunnel washer.
8/24/01	Two carts of cage tops were washed in the tunnel washer.
8/27/01	Two carts of cage tops were washed in the tunnel washer.
8/28/01	One cart of cage tops were washed in the tunnel washer.
8/29/01	Two carts of cage tops were washed in the tunnel washer.
8/30/01	**No cage tops were washed in the tunnel washer.**
8/31/01	**A weekly walkthrough of Building 9210 was conducted that included room 235. Notations on the report were, " weekly, monthly, quarterly log entries missing, dirty mops and mop head on floor, clean mops, wet towel on ½ wall."**
8/31/01	Two carts of cage tops were washed in the tunnel washer.
9/3/01	Holiday

Comprehensive Time Line (continued)

9/4/01 Two carts of cage tops were washed in the tunnel washer.

9/4/01 The supervisor stated that he observed only two carts of cage tops and one buggy in room 235

9/5/01 The supervisor was on vacation.

9/5/01 One cart of cage tops were washed in the tunnel washer.

9/6/01 The supervisor was on vacation.

9/6/01 No cage tops were washed in the tunnel washer.

September 7, 2001 (The Day of the Accident)

9/7/01 There was no record of cage tops being washed in the tunnel washer during the normal wash hours of 7:00 to 8:00 am; however, the washer operation tape indicated that the washer was on at 07:41, when the time is corrected.

The worker was assigned to utility work on the 8:00 am shift.

Numerous carts of cage tops and cans of cages were present in room 235.

It was reported that another worker moved additional carts into the area just after lunch.

Prior to the accident, the worker was euthanizing excess mice. The cart she was pushing had two bags of dead mice weighing 6.5 and 8 pounds on bottom of cart

Just prior to 2:00 pm, the worker entered the room to clean euthanasia trays and beakers.

At approximately 2:00 pm, the worker turned the tunnel washer on and proceeded to wash euthanasia pans and beakers.

While this initial load was washing (which took approximately four minutes), the worker exited the room to collect additional beakers from the hall outside of room 235.

A second employee moved additional carts containing dirty cage tops into

Comprehensive Time Line (continued)

room 235 (which further blocked the exit path from the washer) and left the room. The room now contained 20 carts with cage tops, 1 cart with cages, 5 trash cans with cages, and 2 utility carts.

At approximately 2:10 pm, the worker re-entered room 235 alone and loaded the cart with clean euthanasia pans and beakers on the "clean" side of the washer, using the cart that contained the bags of dead mice at the bottom. The worker was forced to move from the clean side of the tunnel washer to the "dirty" side due to the blocked exit.

The tunnel washer was still operating as the worker traversed the narrow isle between the carts and the washer. Access in this area was limited to 31 inches.

As the worker passed by the automatic cleaning debris filter, she had to negotiate an area where a dirty cart was protruding. Either the cart edge or the worker contacted the triclover retaining clamp on the filter, causing it to open.

The worker was sprayed with water reported to be a at 194^{o}F and at a pressure of 30 to40 psi.

The worker called out, but the room noise masked her cries for help. No alarms sounded, and the injured worker was forced to exit the room under her own power.

The worker exited the room by returning to the "clean" side of the washer and maneuvering between carts blocking the exit path. She then fell on the floor in the hall outside of room 235.

The tunnel washer in room 235 remained on and was spraying hot water across the isle. The running washer created a masking noise in the hall.

No alarm was sounded.

At approximately 2:15 pm, Responder1 (Research Assistant) and Responder 2 (Postdoctoral Fellow) heard moans in the hall. Upon investigation, they found the worker lying in hall moaning and saying "burned." The worker was reportedly wet from mid-torso to feet.

After inquiry, Responder 1 determined that the worker had been burned with hot water from the tunnel washer. She observed water and steam coming from the

Comprehensive Time Line (continued)

floor near the washer.

Responder 1 immediately left to get ice from icemaker on an adjacent hall. On return, she was met by Responder 2 bringing buckets to carry additional ice.

According to the Y-12 emergency response records, the Y-12 Janitor called 911 at 2:16 pm.

A coworker assisted the worker by supporting and comforting the worker while ice was applied to the burned areas.

At some point, a researcher assisted the worker in removing her shoes and socks. Responder 1 indicated that the burns were severe enough that the act of removing the socks also removed some skin tissue.

The worker's speech was reportedly mixed and she became pale.

The supervisor responded and turned off the tunnel washer. The supervisor noted that the water was spraying across the isle to the dirty cage tops (approximately 35 inches away) and the water temperature indicator was registering 194^{o}F.

Two other UT-Battelle employees (the Section Head and Assistant Facility Manager) and others responded to the area.

At 2:18 pm, Y-12 emergency personnel responded, evaluated the worker, provided initial aid on site, and transported the worker to the Oak Ridge Methodist Medical Center. The worker was accompanied by the Section Head and a coworker.

At 2:20 pm, the LSD's Facility Manager, who is located at ORNL, was informed by telephone of the accident at Building 9210.

At 2:24 pm, the LSD's DSO (who had been paged with 911) returned call and was informed of the accident.

A team consisting of the Facility Manager, the DSO, and another member of the Operations and Support Section were dispatched to scene of accident to begin gathering information.

At 2:29 pm, LSD management (i.e., the Associate Division Director) was called

Comprehensive Time Line (continued)

from a meeting and informed of the accident.

At 2:33 pm, there was a page/call from the Facility Assistant to the Section Head of Operations and Support Section. The caller stated that an animal facility worker had been "burned badly" while using the tunnel washer on the second floor of Building 9210. The caller said that a team from ORNL was on the way. The caller said that he would call and inform the union safety officers.

At 2:35 pm, the Laboratory Shift Superintendent called the Associate Division Director and informed him that a burned worker was being transported to Y-12 Medical for evaluation. The Associate Director said that he would call the Associate Laboratory Director in Washington, D.C. He asked the Laboratory Shift Superintendent to inform the Laboratory Safety Director.

At 2:40 pmp, a call/page was made to the DOE Representative and a message was left.

At 2:45 pm, A return call in response to a page was made by the LSD Veterinarian. She was with the injured worker at Methodist Medical Center, and she thought that worker might be flown to an outside burn center.

At 2:49 pm, the DOE Representative returned the call/page. She was provided with all of the available information, and she asked to be kept informed of developments.

At 2:50 pm, the Assistant Laboratory Director (who was in Washington, D.C.) was informed.

The Oak Ridge Methodist Medical Center called and asked for patient information, since the injured worker was not communicative. The Oak Ridge Methodist Medical Center noted that the initial evaluation indicated first degree burns around waist area and second degree burns around the worker's feet.

At 2:55 pm, the Veterinarian asked the LSD to the injured worker's husband.

At 3:00 pm, the worker's husband was on the way to the hospital.

At 3:03 pm, a call was received from the Operational Safety Services team. They were told that an injured worker had been found screaming in the hall by two members of the research staff. The responders provided immediate assistance, including removal of socks, etc., and icing the worker's injured feet

Comprehensive Time Line (continued)

while awaiting the arrival of emergency personnel.

The first impression was that a "quick release" on an in-line filter housing had "popped" or was "bumped," allowing the hot water to escape and burn the worker. Pictures were taken at the scene. Caution tape was put up, and the area was restricted.

At 3:17 pm, the Assistant Facility Manager paged for an update and to be sure that union safety personnel had been informed. One of the union's safety personnel had been there and agreed with the initial conclusion that the quick release had been "bumped or "snagged."

The Acting Section Head of the research section had been informed. The Field Engineer assigned to area had been reached (off site) and was informed.

The Assistant Facility Manager informed the LSD that this was "our newest piece of equipment" and that it had been "working fine." There had been "no significant problems in the last months."

At 3:26 pm, the veterinarian was paged at the hospital and asked to provide an update. She said the ambulance driver had complimented the staff members who helped the injured worker and said they did "a terrific job" in their response immediately after the accident.

At 3:35 pm, the DOE Representative was updated. There was a discussion on the categorization of the probable Occurrence Report. It was agreed it was "off-normal." The DOE Representative told them that there would probably be an investigation and that the type would depend upon extent of the worker's injuries and hospitalization time.

At 3:55 pm, there was a call from the Laboratory Shift Superintendent who had Publication Relations on the line. He was provided with a summary of the draft being prepared for the notification occurrence report. The LSD discussed the categorization with the Laboratory Shift Superintendent and was told that they would continue consideration.

It was determined that no notification would be necessary until Monday, September 10.

At 4:00 pm, the LSD was informed that the Operational Safety Services team was on their way back to ORNL from Building 9210.

Comprehensive Time Line (continued)

At 4:05 pm, the Laboratory Director of Facilities and Operations called the division office and said to be sure to preserve the scene for possible reconstruction.

At 4:07 pm, a page/call was placed to the Assistant Facility Manager. He said the machine was "locked out," the doors were closed, and the area was flagged and posted.

At 4:08 pm, a call was made from the Laboratory Shift Superintendent to the Operational Safety Services Division Director, who wanted to know "What's happening?" and stated, "My office was not informed."

At 4:14 pm, the Operational Safety Services team arrived back at ORNL. They delivered and discussed the report. They invited the Operational Safety Services Director and Associate to attend.

At 4:20 pm, with Laboratory Shift Superintendent involvement, the event was categorized as "Off Normal, 3A ON1."

At 5:00 pm, the discussion between the team and Operational Safety Services Division personnel ended. The division was given a copy of two of the pictures.

At 5:10 pm, a call was made to the veterinarian at the Oak Ridge Methodist Medical Center. She stated that the worker was in a room, wrapped, and treated. The worker was in pain, and medication was being administered.

A call was made from the Laboratory Safety Director to the Associate Division Director stating that an investigation was to start on Monday morning.

At 5:20 pm, a call was made to the veterinarian at the Oak Ridge Methodist Medical Center. She stated that the worker was in a room, wrapped, and treated. The worker was in pain, and medication was being administered.

At 5:25 pm, the DOE Representative said that it was acceptable to wait until Monday to provide the remainder of the pictures.

Comprehensive Time Line (continued)

At 5:45 pm, an e-mail was sent to the LSD Director, Associate Division Director, and the Assistant Laboratory Director. A corrected version was then sent (date erroneously entered on first draft) with the notification text.

9/10/01 **UT-Battelle convened a Type C investigation.**

9/12/01 **The Type C Investigation Team turned over all information to DOE for the Type B investigation.**

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Appendix D: Diagram of Room 235 in Building 9210

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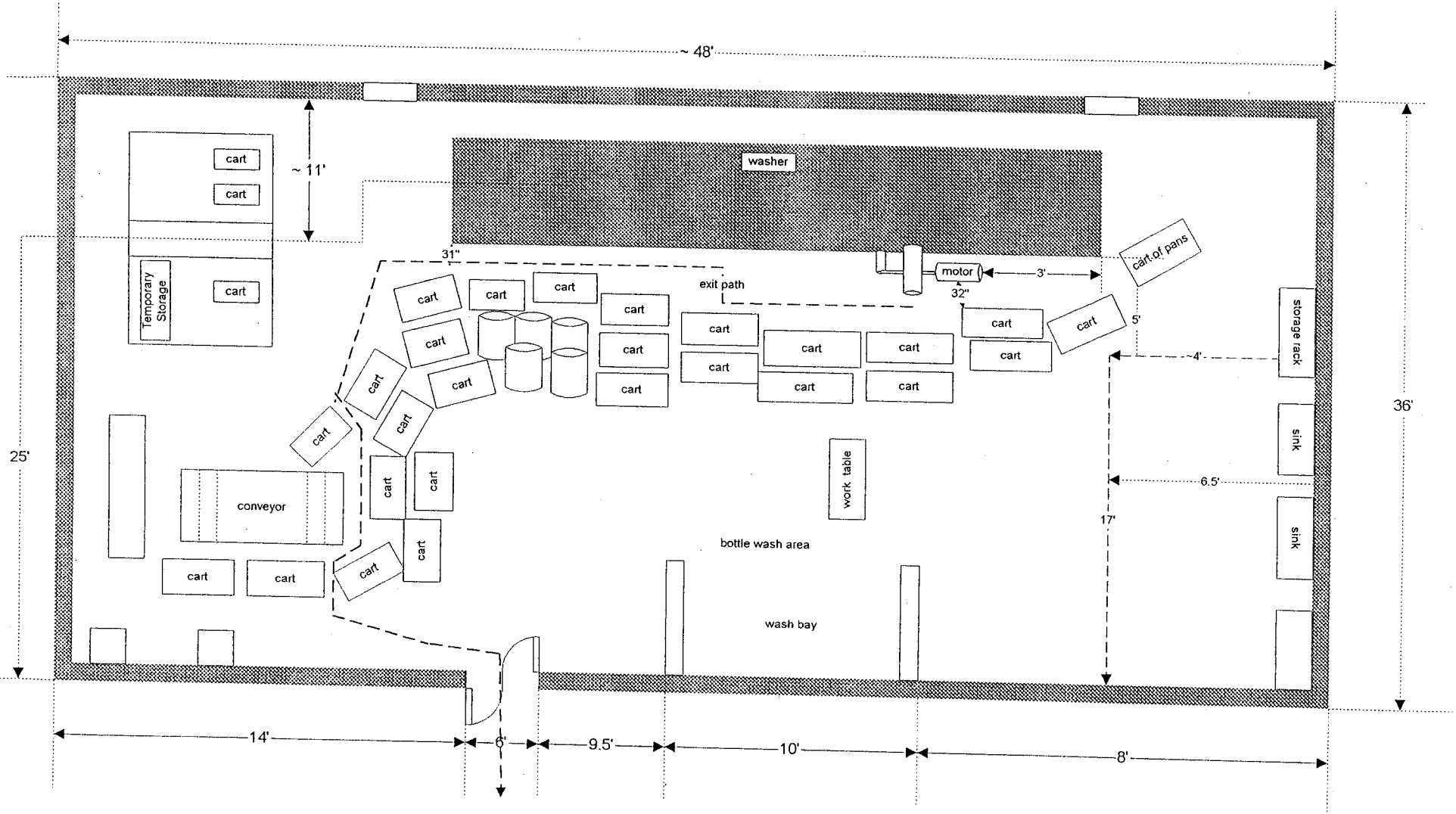
Accident Investigation Sketch of Physical Evidence Locations and Orientations



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