REPORT OF THE COMMITTEE INVESTIGATION OF THE CATEGORY "R" RECURRING OCCURRENCE (CH-BH-BNL-2004-005)

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(Revision 1)

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ACRONYMS AND ABBREVIATIONS

AGS	Alternating Gradient Synchrotron
BNL	Brookhaven National Laboratory
Cat "R"	Category "R" recurring occurrence
CAD	Collider-Accelerator Department
CG	Center of Gravity
CH-BHSO	Chicago Operations-Brookhaven Site Office
ECF	Events and Causal Factors Chart
FL	Forklift
GL	Group Leader
HWMF	Hazardous Waste Management Facility
ISM	Integrated Safety Management
JSA	Job Safety Analysis
MDTF	Multidisciplinary Task Force
ORPS	Occurrence Reporting and Processing System
R	Recurring
SBMS	Standards Based Management System
SCR	Significance Category R
T	Ton (2,000 lbs. [pounds])

DEFINITIONS

Center of gravity	Point at which a load is said to be perfectly balanced
Forklift	Powered industrial truck used for lifting and moving loads according to its rated capacity
Forklift mast	Backrest holding lifting, supporting, and carrying mechanism
Incidental rigging	Usually pertains to rigging carried out by personnel with basic training, who undertake rigging operations on a limited basis
Integrated Safety Management	System that requires incorporating 5 Core Functions and 7 Guiding Principles The 5 Core Functions are: 1. Define the work 2. Identify hazards 3. Develop controls 4. Perform work 5. Obtain Feedback & make improvements The 7 Guiding Principles are: 1. Line managers clearly responsible for ES&H 2. Clear ES&H roles and responsibilities 3. Competence commensurate with responsibilities 4. Balanced priorities 5. ES&H standards & requirements identified 6. Hazard controls tailored to work 7. Operations authorization
Load securement	How packages are prevented from moving with forces applied to them
Material handling	Using mechanical means and methods to move materials (for this effort)
Risk assessment	Identifying of risks/hazards and the likelihood that something might go wrong
Routine work	Work that requires limited supervision and planning
Rigger	One whose primary full-time function is to move loads
Rigging	The act of making loads ready to move, to the hoisting and placing of the load
Skill-of-the-craft	Routine work that is within the expected realm of experience and expertise of a properly trained person, and work that can be completed without additional work planning and oversight.
Spotter	A person whose sole responsibility is to visually guide the equipment operator
Strapping	Material used to secure items
Transportation	Use of vehicles to move items on roadways

EXECUTIVE SUMMARY

In response to four mechanical material-handling incidents that took place at Brookhaven National Laboratory (BNL) between August 2003 and March 2004 a Significance Category "R" (Recurring) Occurrence was declared. The Assistant Laboratory Director for Environment, Safety, Health and Quality charged a committee to investigate the incidents and report back the findings, conclusions, and judgments of need. The committee used a variety of techniques to analyze the incidents, including events and causal factors charting, barrier analysis, change analysis, and various forms of root-cause analysis.

The committee also reviewed other occurrences that may have had similar causes. Relevant management systems were examined, and the analyses were applied to the principles of Integrated Safety Management. Once the causal factors for each occurrence were determined, the committee developed them into common causes, from which they drew conclusions and established judgments of need.

The committee chose to recognize the work of a BNL Multidisciplinary Task Force,[1] whose work recently included analysis of two of the four occurrences using events and causal factors charts, the Five Whys, Battelle cause codes, and the Seven Deadly Sins. This report includes the events and causal factors charts and summary charts from the Task Force report. The committee also used the same methods to analyze the remaining two occurrences, but did not apply Battelle codes because these events used the Occurrence Reporting and Processing System (ORPS) codes.

The particular incidents involved using mechanical material handling equipment by BNL Plant Engineering riggers, Central Shops machinists, and a BNL subcontractor. The incidents involved powered industrial trucks (forklifts), a lifting magnet device, and transportation of a load by flatbed trailer. Much of the rigging at BNL is not performed by professional riggers, but by incidental riggers, who have minimal training and varying levels of experience. Plant Engineering riggers are chosen only from the pool of building and grounds utility workers in accordance with the International Brotherhood of Electrical Workers (IBEW) contract.

At BNL, riggers are responsible for handling most of the heavy materials. As a result of staff changes over the last few years, the rigging staff has lost individuals with many years of experience, and the overall level of knowledge has declined. This loss is judged to be a significant factor in the recent failures. Although this point was not specifically examined, BNL's staff who perform incidental rigging probably also have less experienced staff due to turnover.

Each work method failed, and resulted in an occurrence report. The first two events occurred before the new ORPS was established, and so were filed under the "near miss" category. Under the new system, the last two events were filed as Significance Category (SC) 3 occurrences.

Table E1 illustrates the committee's designation of common causes.

[1] Kane, S., et al., "Multidisciplinary Task Force Review of Selected Second and Third 2003 Calendar Quarter Occurrences and Analysis of Management Systems at Brookhaven National Laboratory," Internal Report for the Assistant Laboratory Director of Environment, Safety, Health, and Quality, December 2003.

Table E1. Common Causes

Causes	ORPs Event and Category			
	Forklift Strikes Overhead Lines (Near Miss)	**Magnet Releases Steel Plate (Near Miss)**	**Transformer Dropped (SC3)**	**Load Falls from Flatbed Trailer (SC3)**
Worker competence was not commensurate with responsibilities				X
Poor worker **confidence**, pride, and/or lack of information interfered with feedback mechanism	X	X	X	X
Workers exercised poor judgment in carrying out tasks by assuming they were correct and did not consult supervision	X	X	X	X
Work Planning and Control (including implementation of procedures) was less than adequate	X	X	X	X
Job planning did not address enough other aspects of safety, and critical tasks were not identified	X	X	X	X
Lack of knowledge about the actual weight and/or location of the center of gravity of the piece before moving it		X	X	X
Current Training and Qualifications program on which management depended was inadequate for skill-of-the craft workers to complete all of the required tasks		X	X	X
Management failed to ensure that training included methods of **proper securement of loads** to be moved		X	X	X
Logical flow of information through various forms of **communication failed**	X	X	X	X
Equipment chosen for completing the tasks was less than adequate	X	X	X	X
Workers undertaking the tasks had difficulty in determining who was in charge because **roles and responsibilities were not clear**	X			
Reliance on skill-of-the-craft for routine work without incorporating all of the **tenets of ISM**	X	X	X	X
Although there was no apparent urgency to get the job done, the jobs were attempted with inadequate information.	X	X	X	X
All potential hazards were not identified or controlled	X	X	X	X
Management failed to recognize the need to establish adequate controls on ordering and receiving goods			X	

The committee reached conclusions and identified common causes based on their analysis of the facts as understood from the critique summaries, occurrence reports, and interviews. The Judgments of Need reflect the committee's opinion of what management must do to prevent recurrences.

Table E2. Conclusions and Judgments of Need

Conclusions	Judgments of Need
Workers' competence was not commensurate with their responsibilities. Specific training of workers was less than adequate because it did not fully address placing and securing loads.	1. Management needs to evaluate methods for selecting and training personnel for mechanical material-handling tasks to ensure that they are able to carry out the essential functions.
All four incidents should have been able to be handled within the skill-of-the-craft for mechanical material handling.	2. Management needs to ensure that risk assessments are implemented for all mechanical material-handling tasks.
In all four incidents, focus was misdirected away from safety hazards and risks. Care was not taken in properly choosing the available equipment.	3. Management should ensure that safety aspects of all jobs receive the same focus as medium- and high-risk hazards.
Communication of hazards and necessary information was inadequate.	4. Management needs to ensure that information about object(s) to be moved is passed on to the people moving it.
Hazard identification/Work Planning/ Control and implementation was either less than adequate or nonexistent.	5. Management needs to improve or develop a formalized protocol for ordering, scheduling, and receiving to include disseminating information about materials.

1.0 INTRODUCTION

1.1 Background

On March 15, 2004, cognizant management personnel and ORPS categorizers at BNL held an initial meeting to discuss recent material-handling events with regard to the possibility of declaring a significance category "R" occurrence. A vote was taken and closely affirmed the need for the "R" occurrence. However, since a DOE-wide ORPS meeting was scheduled, it was decided to wait and get feedback from that meeting about the appropriateness of an "R" occurrence.

Meanwhile, interim measures were taken on March 19, 2004. The Interim Assistant Laboratory Director for Facilities and Operations issued a memorandum to the Plant Engineering Division rigging supervisors with an action plan to emphasize reducing the risk of rigging accidents. Shortly thereafter, that agreement was modified to ensure that there was increased supervision by the rigging supervisors, and that they documented all important information.

On March 24, 2004, BNL's department chairs and division managers were notified that a Significance Category "R" Occurrence had been declared, based on recurring problems with material handling. In particular, as was noted in the ORPS Notification Report, the following events formed the basis of that judgment:

1. 8/12/03, Forklift Load Strikes Overhead Lines, Off-Normal, (CH-BH-BNL-BNL-2003-0013).
2. 9/4/2003, Lifting Magnet Device Releases Steel Plate, Off-Normal, (CH-BH-BNL-BNL-2003-0018); and
3. 12/30/03, Transformer Dropped During Rigging, Significance Category 3, (CH-BH-BNL-AGS-2003-0001);
4. 3/5/04, Load Falls Off Flatbed Truck During Transport, Significance Category 3, (CH-BH-BNL-AGS-2004-0002);

1.2 Project Descriptions

The project involved in the first occurrence (CH-BH-BNL-BNL-2003-0013) was the demolition of the former Hazardous Waste Management Facility, Building 445. BNL personnel developed the documentation, while BNL's subcontractors undertook the actual work. They were using a forklift to move a trailer-mounted generator.

The second occurrence (CH-BH-BNL-BNL-2003-0018) involved a BNL Tool and Instrument Maker operating an overhead crane and a Close Proximity Lifting Magnet to reposition a heavy steel plate on a Nomura horizontal milling machine.

The third occurrence (CH-BH-BNL-AGS-2003-0001) involved an experienced professional BNL rigging crew. A supplier sent a shipment of electrical components on a flatbed truck. Since there was no room for the oversized crates in the Receiving building (Building 100), it was decided to unload the components at a Collider-Accelerator Department (CAD) storage area in Building 912. The shipment manifest contained no information that would have been helpful to the rigging crew.

The fourth occurrence (CH-BH-BNL-AGS-2004-0002) involved the same BNL rigging crew. Old activated beam components were loaded onto the rigger's tractor-trailer flatbed to be transported from one side of Building 912 to the high-radiation storage area on the other side of the building.

1.3 Scope, Purpose, and Methodology

The Assistant Laboratory Director for Environment**,** Safety, Health and Quality issued a memorandum charging this committee (See Appendix A). The committee began its investigation on April 9, and completed it on April 29, 2004.

The **scope** of the committee's investigation was to review the existing critiques, investigate any gaps, complete root-cause analyses, and determine if there is common causality between the four events that make up the Significance Category "R" Recurring Occurrence issued on March 24, 2004.

The committee's **purpose** was to determine if there were common causes, and to recommend corrective measures to aid preventing similar events Lab-wide, improving safety during mechanical material handling.

The committee conducted its investigation, with very helpful observations from Peter Kelley and Jerald Bond of the Brookhaven Site Office, using the following **methodology**:

- Reviewed the facts discussed in the Occurrence Reports and critiques. Conducted selected interviews of riggers, supervisors, and others.
- Used information and analysis from first two incidents completed by the Mul**t**idisciplinary Task Force Review.[1]
- Used Events and Causal Factors Charting, Barrier Analysis and Change Analysis, along with The Five Whys and The Seven Deadly Sins and ORPS codes to determine causes.
- Discussed other material-handling incidents that might give a historical perspective to their findings and recommendations.
- Validated the common causes using Barrier and Control Analysis and Change Analysis
- Drew conclusions and developed Judgments of Need based analyzing the information gathered and with the principles of Integrated Safety Management.

2.0 FACTS AND ANALYSIS

2.1 Summaries of Specifically Designated Occurrences

In the Significance Category "R" Occurrence Report (CH-BH-BNL-BNL-2004-0005), four occurrences were identified as indicators that there were recurring material-handling problems at BNL. The following summaries are taken from the respective ORPS reports:

2.1.1 Forklift Strikes Overhead Lines (8/12/03)

Under a contract with the Environmental Management Directorate, a subcontractor was operating a powered industrial truck (forklift) within the fenced yard of the former Hazardous Waste Management Facility (HWMF). The forklift was transporting a trailer-mounted generator along a roadway passing close to Building 445 below the power and communication lines. This task was covered in the work plans included in the Job Safety Analysis (JSA).

The JSA specifically stated the requirements for using spotters to keep personnel away from the heavy equipment and for ensuring that the forklift's mast/backrest would not come in contact with overhead lines. To be safe, a requirement was added to the JSA to measure that clearance before beginning work.

The spotter was called away to open an overhead door, leaving the operator to watch for clearance. No measurements were taken. The forklift moved, raising the load by only a few inches, but the height of the mast's extension temporarily blocked the operator's view of the location of the overhead lines. The mast touched the lowest cable while the operator was concentrating on avoiding contact with the building.

The tension caused by contact with the cable put stress the backstay cable at the pole. It parted, causing the cables to sag close to the roadway. There were no injuries, and at no time was there contact with the electric-power cables.

2.1.2 Lifting Magnet Device Releases Steel Plate During Lift (9/4/03)

A tool and instrument maker on the night shift was using a crane with a magnetic lifting device to reposition a stock steel plate (81" x 17 ¼" x 4") on a Nomura Milling Machine. Collimator shielding plates were to be fabricated from the stock. According to the drawing provided, its finished weight would be 1,151 lbs.

Since very little material would be taken off the stock, the tool and instrument maker thought that he could use the magnetic lifting device that had a load rating of 1,210 lbs. He felt this was adequate because he knew there was always a built-in safety factor.

However, as the load was raised about seven inches from the table, the magnet released and dropped the steel plate. The actual calculated weight of the finished part was 1,485 lbs. and that of the stock was 1,600 lbs.

This person already had completed the process on the first of two plates on the previous night, but now was unable to complete the second. Therefore, he left that plate ready to be turned and completed on his next shift, but failed to leave a note informing the day shift operator of his intentions. He erroneously assumed that the day-shift operator would not continue the job.

The incident occurred when, after working on the job, the day-shift tool and instrument maker started to reposition the plate for the night shift operator.

2.1.3 Transformer Dropped During Rigging (12/30/03)

At approximately 0900 hours, a flatbed truck arrived at the BNL warehouse containing seven crates for the CAD. Since there were no provisions to unload such a crate at Building 100, it was decided to unload it at Building 912. The riggers assigned to the CAD reported to do so.

The load arrived with incomplete manifests. The contents were unknown, nor was there any indication of the center of gravity and weight. After maneuvering a couple of large crates, which were closely packed together, a 3.5-ton forklift was chosen for the job. The first five crates were unloaded and transported from the truck to storage without incident.

The sixth crate was significantly heavier than the rest. It was picked up, and the forklift turned, as on the previous five transports to storage. However, as the forklift carrying the crate passed through a pothole, the load destabilized and fell.

As had been done for the previous five trips, the Group Leader walked alongside the load as a spotter. As the load began to fall, he attempted to push back against the falling load, to no avail. He suffered minor abrasions on his legs as the crate fell.

2.1.4 Load Falls Off Flatbed Truck During Transport (3/5/04)

Riggers assigned to the CAD were transporting five old activated beam-line components from one area to another by truck. The truck drove at the prescribed speed of 5 mph over a relatively smooth roadway.

After covering approximately one-half mile, the incident occurred. A radiological technician in a vehicle following the transport saw that one of the packages, known to contain an approximately 2,500 lb. absorber device, had begun to wobble. It is important to note here that the object was not weighed until after the incident when it was determined to weigh 5,100 lbs.

A few seconds later, the same technician observed a restraining strap break. The package with the absorber struck a 55-gallon drum and both fell to the ground. The driver of the vehicle carrying the load responded to the honking of a horn behind him, and slowed to a stop just forward of where the load fell off his truck.

The Rigging Group Leader had examined all of the components before they were wrapped during the previous day. The riggers loaded the five wrapped activated beam components onto the rear end of the flatbed, securing them with two tie-down straps fastened from one side of the flatbed to the other. The riggers recognized that the absorber was top heavy, and, as a precaution, another "belly" strap was secured around it and the next heaviest component, a large pig/target cave.

However, the riggers did not account for all of the forces on the load. The tall heavy absorber was strapped together with the large pig (target cave) on wheels, which was perceived to add additional stability to the load. In fact, the opposite effect may have been true.

This event served as a catalyst for calling for a broader review of BNL's mechanical material-handling processes.

2.2 Discussion of Applicability of Other Occurrences

The committee explored several past occurrences for similarities with the four occurrences under investigation. The following occurrence was reviewed because it was cited under the former ORPS system as an Emergency Occurrence and, like this occurrence, its causes were related to inadequately planning the work and securing the load.

2.2.1 Radioactive Waste Container Tips Over Spilling Its Contents (CH-BH-BNL-BNL-2001-0014, 6/18/01, Emergency Occurrence)

A B-25 container containing approximately three cubic yards of radioactive material was shipped to the warehouse for weighing before shipment off site. It was transported both ways via a BNL rack truck. At the storage facility, a six-ton capacity Yale forklift was used to take the container off the truck at Building 650.

The load was picked up with the tines spread to the widest width possible under the load. As the truck backed away, the rear tires went into a depression in the driveway. The load, still several feet above the ground, toppled over and fell onto the ground spilling its contents.

Had this load been strapped before it was lifted and moved, the incident might never have happened. The root cause was identified as a deficiency in organizing and planning the work, related to conditions and assumptions, retrieval work documents, and procedures.

While this incident has similarities with three of the "R" category cases, the difference is that this incident involved personnel who only do incidental forklift operations compared with the personnel involved with the Significance Category R occurrences. This highlights the fact that Significance Category R corrective actions must consider mechanical material handling by non-riggers.

3.0 CAUSAL ANALYSIS

3.1 Events and Causal Factors Charts

Events and causal factors charts are useful in establishing the flow of the incident and tracing those items that relate to the events. The charts are based on the critiques, occurrence reports, and interviews available well after the incidents occurred. Figures 1 and 2 were taken from the report of the Multidisciplinary Task Force (MDTF), and the committee generated Figures 3 and 4.

Figure 1. Forklift Strikes Overhead Lines

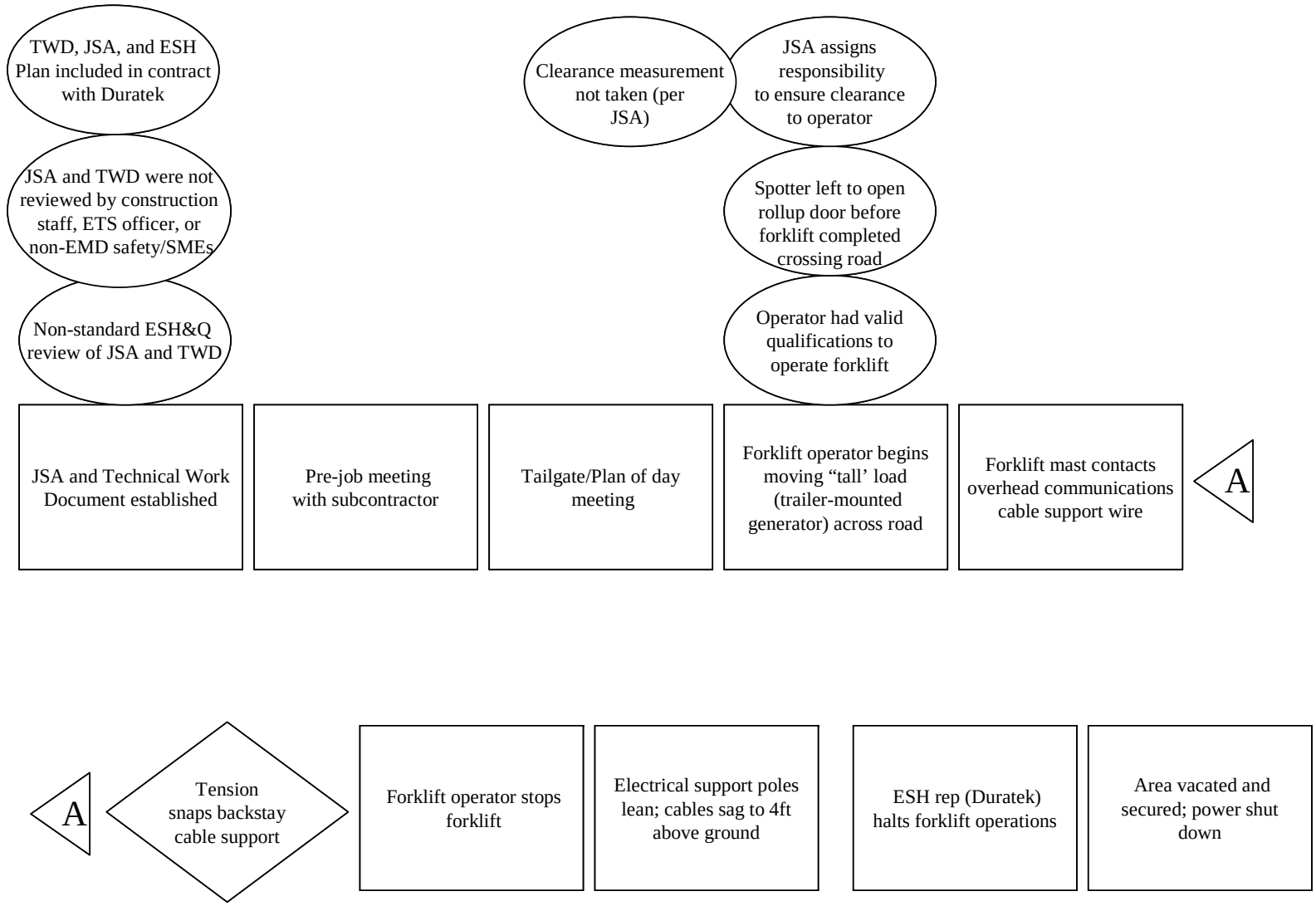


Figure 2. Lifting Magnet Device Releases Steel Plate During Lift

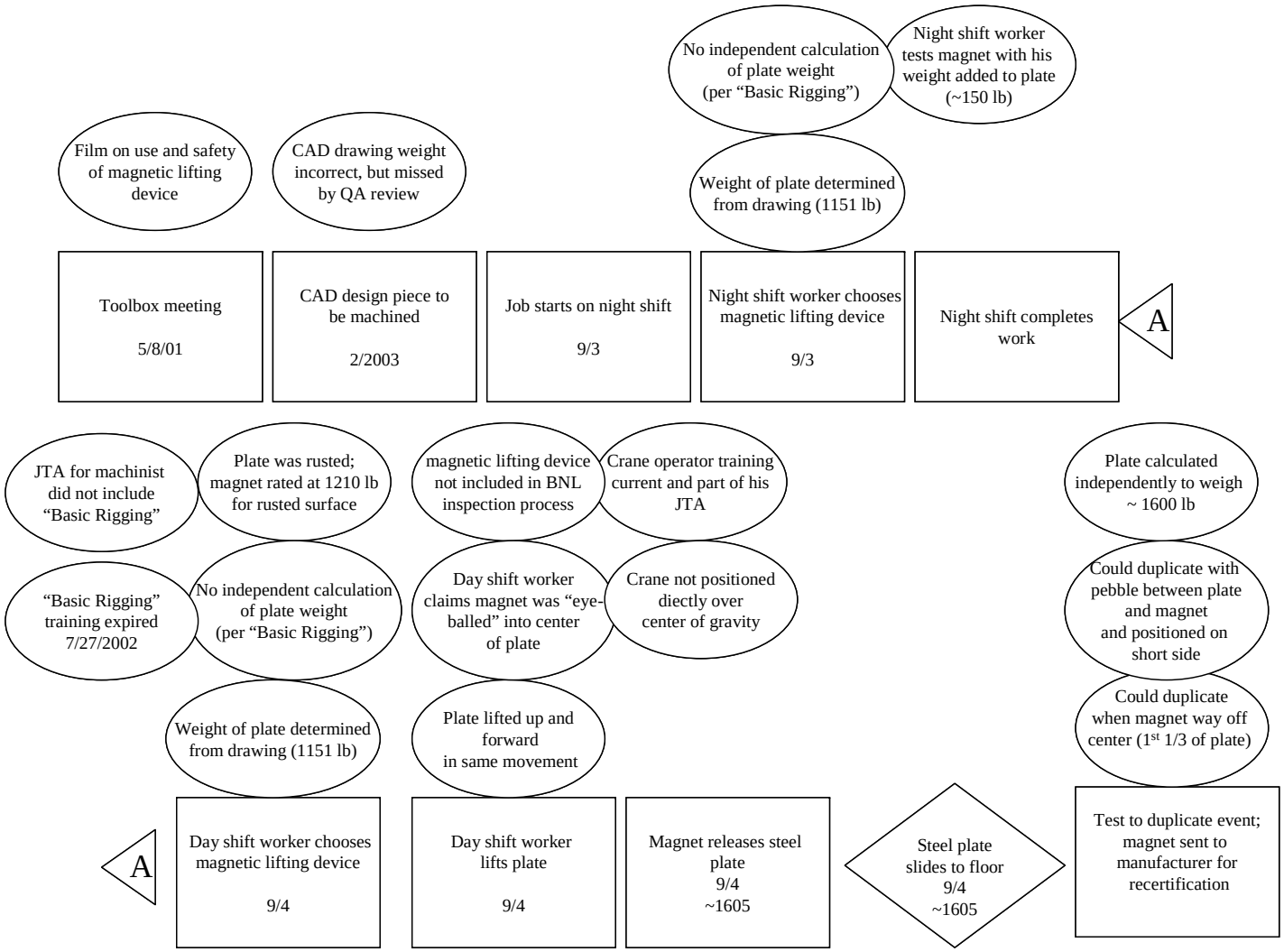


Figure 3. Transformer Dropped During Rigging

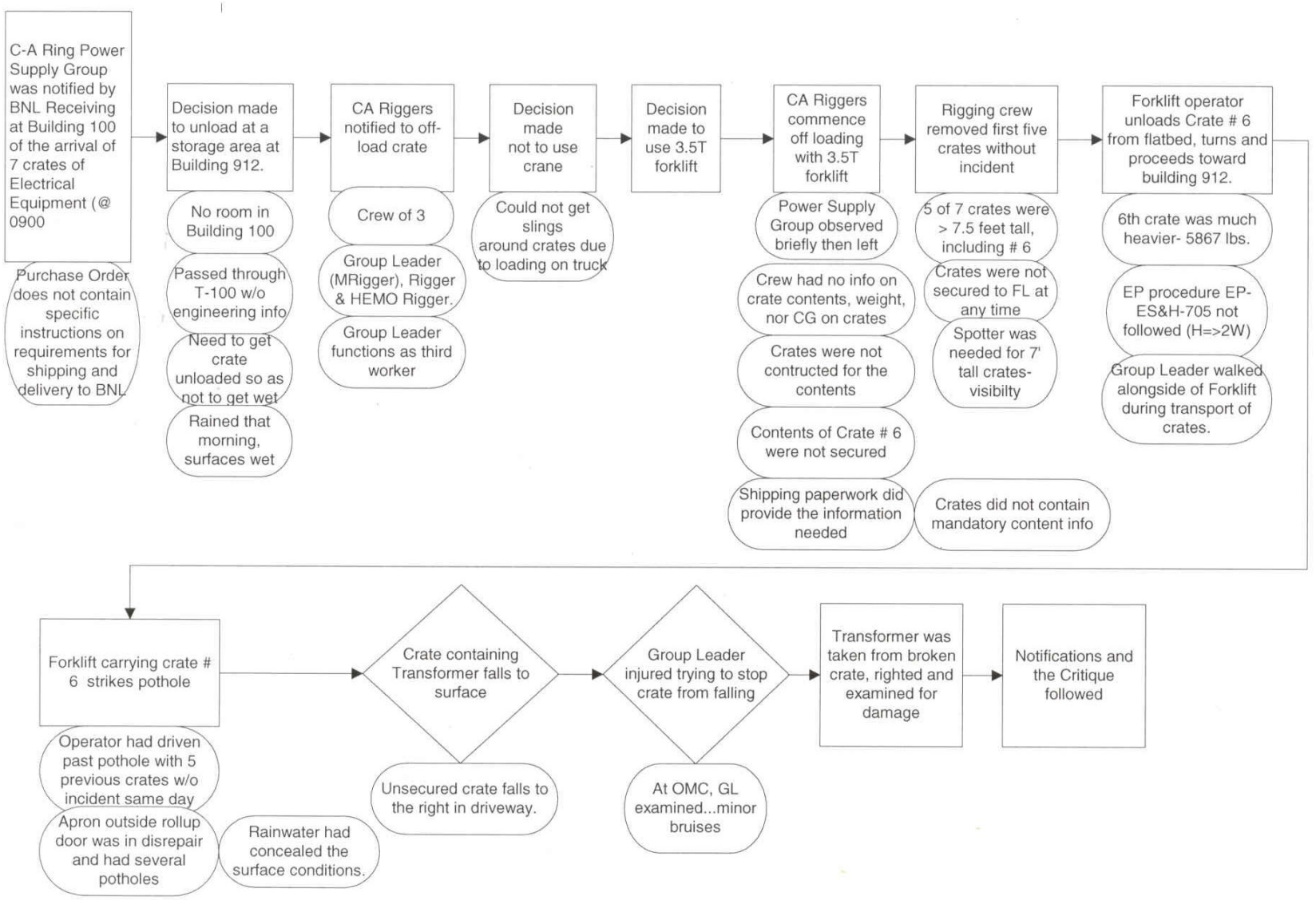
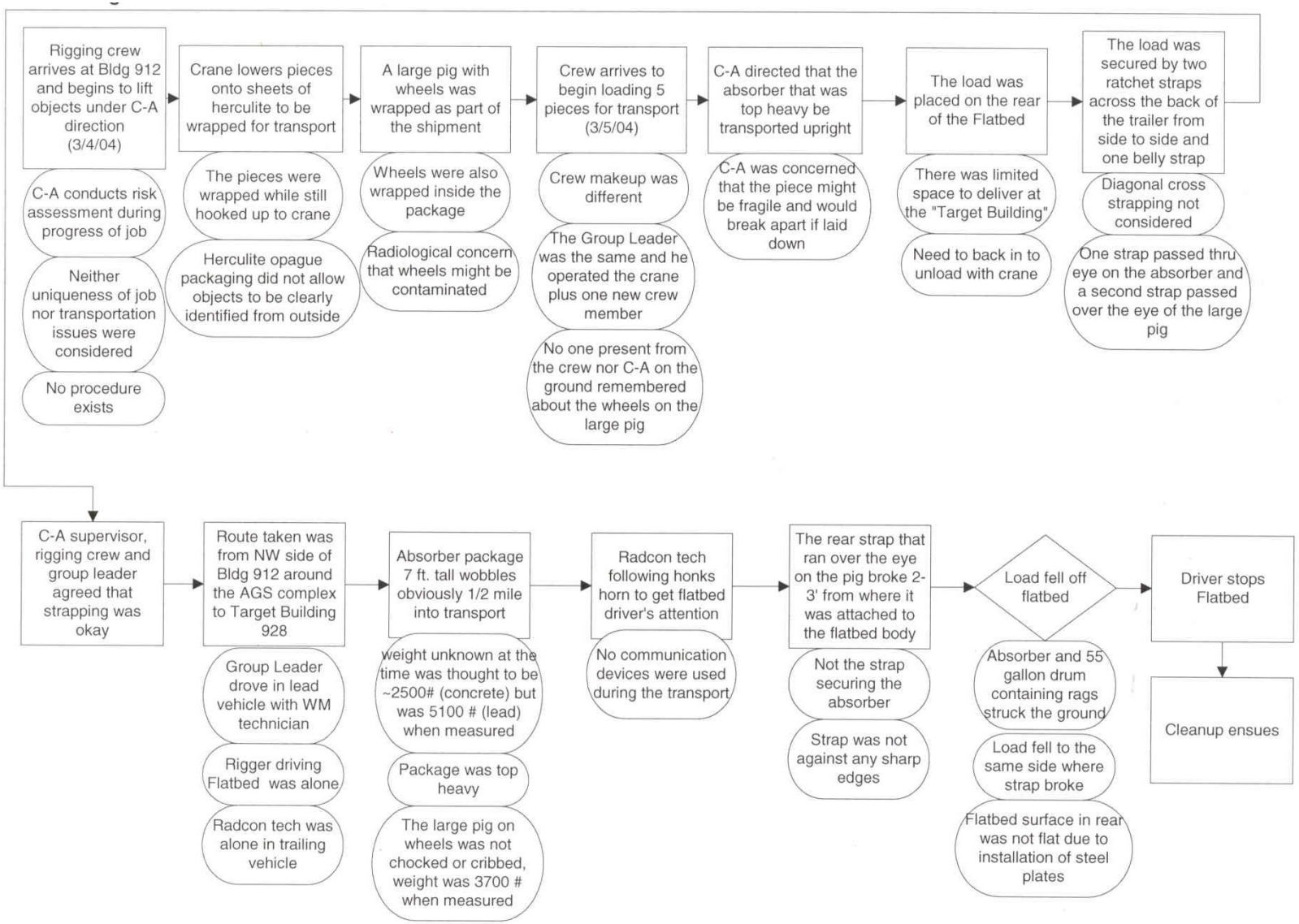


Figure 4. Load Falls Off Flatbed Truck During Transport



3.2 The Five Whys

The "Five Whys" is a simple technique used to get deeper into causes, but depends on the event and the first "why" chosen. The following are summaries of this exercise.

3.2.1 MDTF Review of Forklift Load Strikes Overhead Lines

Two issues were identified: (1) There was no spotter, and (2) the forklift's mast extended more than one foot higher than the lowermost cable. The facts were that work practices were taken for granted, the job was properly planned, and the JSA that clearly specified measuring the clearance to the height of the lowest overhead obstruction was not followed.

3.2.2 MDTF Review of Lifting Magnet Device Releases Steel Plate During Lift

Two issues were identified: (1) The plate weight exceeded the rated capacity of the magnet, and (2) the crane was not positioned directly over the hook attached to the magnet. The facts were that there was no independent calculation of the weight, and none of the five signatories on the CAD drawing verified the noted weight, which was incorrect. The crane operator failed to follow training and procedures.

3.2.3 Transformer Dropped During Rigging

Two issues were identified: (1) The load was not secured as required, and (2) the forklift struck a pothole. The facts were that the riggers did not have enough information to safely move the load because there was little to no communication. The pothole had existed for some time and was not repaired because it was not deemed a significant hazard.

3.2.4 Load Falls Off Flatbed Truck During Transport

The issue identified was that the load was not properly secured. The rigging crew made an error in judgment when they decided on placing, distributing, and strapping the load. The weight of one of the pieces was underestimated, and the crew's knowledge and experience about the forces that act on the load was inadequate. Overall, the Laboratory did not appreciate the significance of the cargo and load, and the methods used to secure and transport it.

3.3 Dew's Seven Deadly Sins

The MDTF adapted John Dew's article on quality[2] for safety in evaluating the earlier occurrences (Forklift Strikes Overhead Lines and Lifting Magnet Device Releases Steel Plate During Lift). For consistency, this committee used it to categorize the other two incidents. The following are the applicable "sins" for each incident:

3.3.1 MDTF Review of Forklift Load Strikes Overhead Lines

The overconfidence/hubris of the forklift driver.

3.3.2 MDTF Review of Lifting Magnet Device Releases Steel Plate During Lift

The overconfidence/hubris as well as the ignorance, lack of fundamental knowledge, tunnel vision, and thinking "inside the box" of the two tool and instrument makers.

[2] Dew, John, "The Seven Deadly Sins of Quality Management," *Quality Progress*, Vol. 36, No. 9, pp. 59-65 (September 2003).

3.3.3 Transformer Dropped During Rigging

The overconfidence/hubris of the power supply group, the packaging firm, and the riggers.

3.3.4 Load Falls Off Flatbed Truck During Transport

The lack of fundamental knowledge, tunnel vision, and thinking "inside the box" of the work planners and riggers.

Table 1. Barrier Analysis

Hazard/Risk	Direct Barrier Failure	Possible Contributing Factor	Possible Root Cause	Loss Event	Evaluation
Forklift Strikes Overhead Lines					
Overhead lines	Failure to measure clearance	Forklift moved forward and operator could not see lines	Failure to measure clearance as required by JSA	Mast struck low hanging cable	Near miss occurred due to failure to follow JSA and measure clearance
Forklift moved without spotter	Spotter	Spotter not present when lift began to move	Not following prescribed procedure from JSA		Operator knew spotter had left, yet he did not wait as prescribed in JSA requirement
	Communication	Spotter not present to communicate with operator			Non-issue
JSA	Work planning	Roles were not specifically clarified in JSA nor could feedback be verified	JSA not followed		Cannot be certain if operator or spotter ever saw JSA and if responsibilities were understood
Choice of equipment	Appropriate size forklift	Forklift mast extended >1 foot higher than lowest cable	Stop work not enacted		If clearance were measured, either a different forklift would have been chosen, the lines would have been set higher, or the job would have been stopped until a solution was found.
Closeness to building	Operator skill and training	Operator focused on getting job done and the proximity to the building	Proceeded without spotter		He could not see where he was going relative to the generator on the tines. Yet he continued without a spotter.
Lifting Magnet Device Releases Steel Plate During Lift					
Determining weight of piece	Operator #1's judgment	Knowledge of how job is done but relied on assumptions to justify actions	Failure to determine accurate weights	Magnet releases steel plate	Near miss –no injury. Operator made too many assumptions and errors in judgment and technique. He also knew that a stronger magnet was on the other side of the shop.
Communication	Operator # 2's judgment	Did not observe problems, nor question anything and assumed it was okay	Failure to determine accurate weights and procedures		Both operators failed to take adequate precautions for safety. There was inadequate communication between operators during shift turnover.
"Rapid" setting	Setting proper speed for overhead crane	Speed was set too fast			Since it was not centered over the load, the rapid setting may have contributed to the device releasing the piece.
Weight of piece on drawing	Verification of engineering drawing measurements	Calculated weights on drawing was wrong	Failure of work planning to verify accuracy on drawing		Several people signed off on drawing, but had not verified the weight of the stock, leaving it up to the operator.

Hazard/Risk	Direct Barrier Failure	Possible Contributing Factor	Possible Root Cause	Loss Event	Evaluation
Training refresher	Training was expired	Operators did not take refresher course, nor request waiver of practical test			It is doubtful that refresher training would have helped, as experience was the driver that allowed them to make so many assumptions.
The pick	Lifting procedure	Operator did not put the crane directly over the hook			Too much lateral movement was placed on lifting device by improperly locating the crane over the hook
Transformer Dropped During Rigging					
Missing Specs	No shipping papers (bill of lading); weight was not marked, nor center of gravity information	Rigging crew failed to stop the job due to lack of information		Crate falls and transformer is damaged	There were several breakdowns in communication: Purchasing and the broker and shipper, Receiving and the CAD power supply group, and this group and the riggers. The bill of lading was not sent until after the incident
Path of travel, apron/surface problems	Surfaces free from encumbrances and in good repair	Presence of potholes and broken concrete			Supervision and management knew this, but the condition was accepted and not remedied.
Choice of equipment	Large pieces with no information difficult to choose forklift.	Bulky load should have been secured to the mast during transport as per Plant Engineering procedures			After the incident, engineering determined that the 3.5-ton forklift chosen was the right one. There was also a false sense of security because the first five crates were so light.
Unstable/unknown load	Implementation of Plant Engineering procedural directions	Crew assumed that the sixth crate did not need to be secured because the previous five had not been secured	Failure to secure load		Failure to secure the load according to procedure stating that t it is required if the height is twice the narrowest width.
Group Leader tries to stop falling load	Plant Engineering procedure not followed	Failure to stay out of the danger zone		Employee injured by falling transformer	The person impulsively tried to stop the momentum of a load of approximately 6,000 lbs. His training and experience should have prevented this.
Unsecured load in crate	Shippers should have ensured that the load was secured in the crate before shipping	Each bump in the road may have moved the piece inside its crate, thereby adding to the instability of the whole crate.			The combination of this movement inside the crate, the road surface's disrepair and the unknowns contributed to this incident.
Load Falls Off Flatbed Truck During Transport					
Movement of load	Rear strap broke	Allowed movement of load	Failure to secure load	Load fell during transport	The method of strapping this load was acceptable to those present at the loading site. However, there were unforeseen circumstances due to their lack of knowledge and experience.

Hazard/Risk	Direct Barrier Failure	Possible Contributing Factor	Possible Root Cause	Loss Event	Evaluation
Wheels on large pig	No chocks nor cribbing used	Overriding Health Physics concerns about the possibility of radioactive components on wheels			This barrier was not used due to possible forgetfulness of those who were there while wrapping occurred. Therefore no one questioned it.
Use of Herculite (opaque plastic sheeting) to wrap activated, slightly contaminated pieces for transport	Visual inspection of pieces to be loaded	No one thought that it was a problem	Poor job planning; poor judgment		There was some conjecture that wrapped wheels would be restricted from rolling.
Communication related to job planning for all functions	Taking responsibility	The groups involved handled the job in a compartmentalized fashion. Non-riggers assumed that the whole material movement and transportation job was skill-of-the-craft	Poor job planning		Several organizations were involved in the activity. They either did not communicate on the issues, or deferred authority and responsibility to others.
Unknown load details	Communication on load specifics	Evaluation of load weight and methods of securing It were inadequate			This information, which was not validated until after the incident, would have made a difference in the method of placing and securing the load.
Method of securing the load	Left to the workers' skill-of-the-craft	Crew used poor judgment in method of securing load	BNL has guidance on methods of loading or securing the load		It was routine rigging work.
Large top-heavy piece (absorber)	Communication and strapping	Unable to get approval to lay piece down rather than upright. Inadequate strapping was used.			There was a fear that the absorber would break apart from bumping on the roadway. Criss-cross strapping was not used.

Table 2. Change Analysis

Ideal Conditions	Current Conditions	Consequence
Forklift Strikes Overhead Lines		
Clearance for overhead lines was measured	Clearance not measured	Forklift mast struck telephone cable, pulling it to within 4 feet of the ground
Procedures are followed as required	JSA was not followed	Increased the risk of an incident
Spotter was on the scene	Spotter was absent from the scene	Lack of guidance on visibility
The right equipment (forklift) was chosen for the job	Forklift mast was too high, cables were too low	Mast struck cable
Operator has view of lines and route of travel	Operator could not see lines, concentrated on closeness to building, and had poor sense of his surroundings	Increased the risk of an incident
Lifting Magnet Device Releases Steel Plate		
An adequate lifting magnet was chosen for the job	Magnet chosen was less than adequate because the material was too heavy. An adequate magnet was located across the shop floor, but operators chose not to get it	Forces on the plate were too great for the magnet and the steel plate dropped to the ground.
Shift change conditions and job turnover are verbally communicated, information passed on, and questions discussed	Personnel typically leave notes, but communication between workers and with engineering was less than adequate	Led to faulty assumptions by staff
Procedures were followed and machine operators confirm the load	Rather than procedures, assumptions were used to assess the load	Increased the risk of an incident
Drawings are correct and information is verified	Weight of final piece on drawing was incorrect and not verified	Contributed to incident
Crane picked steel plate as assigned and above the hook.	Crane was not positioned as prescribed above the hook	Initial misalignment
Machine operators maintained training requirements	Operator's refresher training had lapsed over a year.	Not qualified
Transformer Dropped During Rigging		
Roads and working surfaces are paved and smooth	Surfaces over which the forklift traveled were covered with potholes and broken concrete	Unsecured load in crate, combined with the forces on it, caused the fall during movement.
Procedures are followed, and loads that are twice as high as their narrowest width are strapped to the mast.	Procedure was not followed, and the load was not strapped to the mast.	Made the load susceptible to instability
Personnel remain in the safe zone during transportation	Group leader spotting the load was in the danger zone and raced to the other side in the danger zone to brace the falling crate	Worker sustained minor leg injury.
All heavy electrical equipment is secured in its own crate for safe shipping	Transformer was not properly secured in crate by shipper.	Instability of load inside crate may have contributed to instability of crate on forklift.

Ideal Conditions	Current Conditions	Consequence
A manifest, shipping papers, or bill of lading listing deliverables and particulars, such as weight, accompanies shipments.	No shipping documents accompanied the shipment to BNL.	Lack of necessary information increased the risk
Purchase orders include special handling, shipping and delivery requirements.	Material was shipped with minimum handling requirements specified to the shipper.	Dangers were not adequately communicated.
Load Falls Off Flatbed Truck During Transport		
All loads are properly secured, and transportation procedures are in place	Load was not secured and no transportation procedure existed	The load was improperly secured to contain both horizontal and lateral forces. This procedure was affected by inaccurate knowledge about the weight of the top-heavy absorber and the large target cave.
Wheels are chocked or cribbed to prevent movement	Wheels were hidden under wrapping and no cribbing nor chocking was used	Wheels could still move under the Herculite
Crew of well-seasoned, skilled, and experienced riggers load and secure loads	No specific training exists for securing loads. Experience of rigging staff has significantly decreased over the last few years because of retirements and layoffs.	Although riggers know how to secure loads, a mistake was made that might have been avoided.
Top-heavy loads are secured by lying them down, and they are transported in a manner to ensure they will not fall.	Top-heavy load is secured by one cross strap through its eye, and a bellyband around the target cave.	Did not stabilize the load
Job planning was completed thoroughly and in concurrence with ISM	Job planning was less than adequate	The focus in job planning was on radiological issues instead of rigging, loading, and securing the components safely.
Straps and methods for securing the load are properly selected	Inadequate selection, strap broke, and questionable methods were used	Load was not properly secured

Table 3. Common Causes[3]

Causes	ORPs Event and Category			
	Forklift Strikes Overhead Lines (Near Miss)	**Magnet Releases Steel Plate (Near Miss)**	**Transformer Dropped (SC3)**	**Load Falls from Flatbed Trailer (SC3)**
Worker competence was not commensurate with responsibilities				X
Poor worker **confidence**, pride, and/or lack of information interfered with feedback mechanism	X	X	X	X
Workers exercised poor judgment in carrying out tasks by assuming they were correct and did not consult supervision	X	X	X	X
Work Planning and Control (including implementation of procedures) was less than adequate	X	X	X	X
Job planning did not address enough other aspects of safety, and critical tasks were not identified	X	X	X	X
Lack of knowledge about the actual weight and/or location of the center of gravity of the piece before moving it		X	X	X
Current Training and Qualifications program on which management depended was inadequate for skill-of-the craft workers to complete all of the required tasks		X	X	X
Management failed to ensure that training included methods of **proper securement of loads** to be moved		X	X	X
Logical flow of information through various forms of **communication failed**	X	X	X	X
Equipment chosen for completing the tasks was less than adequate	X	X	X	X
Workers undertaking the tasks had difficulty in determining who was in charge because **roles and responsibilities were not clear**	X			
Reliance on skill-of-the-craft for routine work without incorporating all of the **tenets of ISM**	X	X	X	X
Although there was no apparent urgency to get the job done, the jobs were attempted with inadequate information.	X	X	X	X
All potential hazards were not identified or controlled	X	X	X	X
Management failed to recognize the need to establish adequate controls on ordering and receiving goods			X	

[3] Table 5 also appears as Table E1 in the Executive Summary of this report.

4.0 HAZARD CONTROLS AND ANALYSIS/INTEGRATED SAFETY MANAGEMENT

This analysis attempts to show the connection to the Integrated Safety Management System's (ISM) Five Core Functions and Seven Guiding Principles (see lists given in Definitions, page v)

4.1 Forklift Strikes Overhead Lines

The work was well defined in the work planning documentation, most notably in the JSA done by personnel from BNL's Environmental Management Directorate. Hazards were identified and controls were put in place. The problem arose with the subcontractor's implementation of the plan.

The forklift operator attempted to move the load in direct violation of the plan. The seven guiding principles of ISM appeared to be in place, and posed no problem. The sole exception was the lack of a clear perception of their roles and responsibilities on the part of the subcontractor's personnel.

4.2 Lifting Magnet Device Releases Steel Plate

The core functions of ISM rest upon the assumption that the routine work would be done by BNL's Tool & Instrument Makers under skill-of-the-craft, and the work was defined up to that point. This assumption also was representative of errors at the drawing level. The signatories did not verify all of the information on the drawings. Identifying the hazards involved with, and the controls needed in the process was left up to the skill-of-the-craft. The workers involved one day-shift person and one night-shift person.

The incident resulted from the faulty manner in which they performed the work. Not only did they fail to ask questions about the job at hand, but they failed to provide feedback. The seven guiding principles of ISM had no role in the incident

4.3 Transformer Dropped During Rigging

The unloading of a shipment of crates of unknown weight and center of gravity, along with lack of shipping papers posed a large problem for the unloading process and ISM's core functions. The load arrived unannounced and unplanned, but the riggers assigned to CAD were expected to handle it under skill-of-the-craft. Hazards were identified, but since the riggers handled the first five crates without incident, they did not see a need to develop special controls for the sixth crate.

This overconfidence resulted in poor work performance and unsafe acts. There was no feedback to CAD or to Plant Engineering management on this process. The Master Rigger actually acted as a spotter and walked in the danger zone alongside the forklift as it moved each load. There was no feedback until the incident and injury.

4.4 Load Falls Off Flatbed Truck During Transport

The only part of the work that was planned in detail was done according to the Radiological Work Permit (RWP) that did not include rigging. The scope of the work, over two days, was well defined, but lacked focus on other issues such as securing and transporting the load.

Since there was no focus or questions beyond shipping the radioactive material to storage, all of the hazards and risks were not examined and identified. Experience only dictated the controls that were used. None of the participants had any knowledge of over-the-road needs. In carrying out this work, everything from choosing the equipment, configuring the load, and securing the

load was less than adequate. The only feedback given was by those who did not understand these parameters.

Of the seven guiding principles, the ones that were not successfully met were clear environment, safety, and health roles and responsibility, and competence commensurate with responsibilities. It was never clear who was in charge, beyond the radiological issue.

5.0 CONCLUSIONS AND JUDGMENTS OF NEED

Table 4 reflects the committee's conclusions based on its analysis of the facts as understood from the critique summaries, occurrence reports, and interviews that resulted in identifying common causes. The Judgments of Need reflect the committee's opinion on what management needs to do to prevent recurrences.

Table 4. Conclusions and Judgments of Need[4]

Conclusions	Judgments of Need
Workers' competence was not commensurate with their responsibilities. Specific training of workers was less than adequate because it did not fully address placing and securing loads.	1. Management needs to evaluate methods for selecting and training personnel for mechanical material-handling tasks to ensure that they are able to carry out the essential functions.
All four incidents should have been able to be hand within the skill-of-the-craft for mechanical material handling.	2. Management needs to ensure that risk assessments are implemented for all mechanical material-handling tasks.
In all four incidents, focus was misdirected away from safety hazards and risks. Care was not taken in properly choosing the available equipment.	3. Management should ensure that safety aspects of all jobs receive the same focus as medium- and high-risk hazards.
Communication of hazards and necessary information was inadequate.	4. Management needs to ensure that information about object(s) to be moved is passed on to the people moving it.
Hazard identification/Work Planning/ Control and implementation was either less than adequate or nonexistent.	5. Management needs to improve or develop a formalized protocol for ordering, scheduling, and receiving to include disseminating information about materials.

[4] Table 4 also appears as Table E2 in the Executive Summary of this report.

6.0 RECOMMENDATIONS

The committee arrived at the following recommendations as corrective measures to mitigate the issues that prompted this occurrence report. There is no significance in the order of the list.

1. Laboratory Management needs to instill a cultural/behavioral change in safety at all levels, similar to the successes of Environmental Management System (14001), ISM, and Radiological Protection.

2. The Laboratory should develop an enhanced Mechanical Material Handling Program for qualifying and re-qualifying all involved personnel. This course should help workers understand the limits of their expertise and encourage feedback questions for guidance.

3. The Laboratory should eliminate waivers for all incidental mechanical material handlers. Re-qualification should be mandatory, and be conducted by sufficiently trained, experienced, and objective evaluators. The Laboratory should have full-time evaluators to support this effort. In addition, the Laboratory should develop, for example, an official forklift obstacle course.

4. Future selection of riggers should follow the same criteria as currently used to hire operational trades personnel.

5. Organizational managers should determine the criteria for using incidental or professional mechanical material handlers. Before deciding, managers should rely on risk assessment along with work planning and controls to develop and carry out jobs.

6. Organizational managers should ensure that the training qualifications of all incidental mechanical material handlers are current.

7. Management should ensure that the following changes are made to the ordering, scheduling, and receiving process:

    a. Requirements should include proper shipping papers (with the necessary rigging information);

    b. Purchase Orders should include:

        1. The requirement for special markings on all packages to indicate their weight and center of gravity;
        2. A copy of the bill of lading enumerating the contents of the package and weight; and,
        3. Details and scheduling requirements for delivery with appropriate personnel.

    c. Receiving should check bills of lading, indicating the freight contents, before the items are sent out.

    d. Delivery vehicles should not enter BNL without proper shipping papers, such as bills of lading. Deliveries should be scheduled first and verified at the Main Gate.

    e. BNL's management should specify that deliveries requiring unloading by riggers should be scheduled in advance so that the work can be planned rather than reactively carried out.

APPENDIX A

Charge Letter

Assistant Laboratory Director / ESH&Q Directorate

BROOKHAVEN NATIONAL LABORATORY

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for the U.S. Department of Energy

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April 6, 2004

Mr. Jack Ellerkamp
Safety and Health Services Division
Building 120
Brookhaven National Laboratory
Upton, NY 11973-5000

Dear Mr. Ellerkamp:

I request your assistance by chairing a cross-functional team to review the existing critiques, investigate any apparent gaps, complete root cause analysis, and determine if there is common causality between the four events that make up the "R" category occurrence reported on March 25, 2004. Two of the incidents were evaluated as part of the Multidisciplinary Task Force Review, whose report was issued in December 2003.

The team will make recommendations for corrective measures to aid in the prevention of similar events, and will provide me with a report by April 23, 2004.

The team members are:

Jack Ellerkamp (Chair), Safety and Health Services Division
Ray Karol, Collider-Accelerator Department
James O'Malley, Plant Engineering Division
Frank McNeill, Plant Engineering Division
Phil Harrington, Training and Qualifications Program Office
Antonio McGill, Plant Engineering Division

Please let me know immediately if you are not available. The opening meeting will be conducted on Wednesday, April 7, 2004, at 2:00 p.m., in Building 120 Upstairs Conference Room.

Sincerely yours,

J. E. Tarpinian, CHP

c: M. Bebon
C. Dimino
S. Hoey
R. Lebel
E. Lessard
D. Lowenstein
R. McNair
A. McNerney
E. Murphy
B. Schwaner

APPENDIX B

Summary Tables on Causality

Table B1. Forklift Strikes Overhead Lines[5]

ORPS Occurrence	Forklift load strikes overhead lines	
Date	August 12, 2003	
Consequence	Backstay cable parted, pole leans over, cables sag to within 4 feet of road surface	
Direct Cause	Forklift mast contacts lower most cable	
	Issue A	**Issue B**
Contributing Cause(s)	No spotter	Forklift mast extends ~ 1 foot higher than lower most cable
Why?	Spotter stopped spotting to open rollup door	Inappropriate forklift used
Why?	Work was not properly planned	Clearance measurement not taken
Why?		JSA which requires "measure height of backrest extension to height of lowest overhead obstruction" was not followed.
Causal Code(s)	1. Planning and organizing f. Inadequate work organization ▪ Roles and responsibilities not defined or clear	3. Work process controls d. Work performance not within controls ▪ Original work plan (JSA) not followed
7 Deadly Sins	4. Overconfidence/Hubris	4. Overconfidence/Hubris
Root Cause	Roles and responsibilities of the spotter were not defined in the work plan, and the clearance measurement was not taken as required by the JSA	

[5] Table 5 from Multidisciplinary Task Force Review

Table B2. Lifting Magnetic Device Releases Steel Plate[6]

ORPS Occurrence	Lifting magnet device releases steel plate during lift	
Date	September 4, 2003	
Consequence	Near Miss	
Direct Cause	Magnet releases plate	
Contributing Cause(s)	1) Failure to determine weight 2) Weight on drawing incorrect	
Why?	Magnetic force was insufficient to overcome the other forces acting on the plate (weight, off-center crane hook)	
	Issue A	**Issue B**
Why?	Plate weight exceeded rated capacity of magnet	Crane was not positioned directly over the hook attached to the magnet.
Why?	1) No independent calculation of weight 2) Weight marked incorrectly on drawing	Crane operator failed to follow training and procedures
Why?	1) Failure to follow basic crane operator procedure 2) Weight marked incorrectly on drawing	
Why?	2) Neither one of the five signatories on the CAD drawing independently verified the weight	
Causal Code(s)	3. Work process controls g. Procedures not used or followed correctly ▪ Unexpected result 3. Work process controls b. Design Implementation Process Inadequate ▪ Design Verification inadequate	3. Work process controls g. Procedures not used or followed correctly ▪ Unexpected result
7 Deadly Sins	4. Overconfidence/Hubris 5. Ignorance, lack of fundamental knowledge/ tunnel vision/thinking inside the box	4. Overconfidence/Hubris
Root Cause	An under-rated lifting magnet was used because the weight of the plate was not independently calculated by the operator (per crane operator training) nor verified by the drawing signatories, and an additional lateral force was applied to the magnet because the operator failed to follow the procedure for positioning the crane directly over the magnet.	

[6] Table 8 from the Multidisciplinary Task Force Review

Table B3. Transformer Dropped During Rigging

ORPS Occurrence	Transformer dropped during rigging	
Date	December 30, 2003	
Consequence	Property damage and occupational injury, Significance Category 3 occurrence	
Direct Cause	Employee received minor abrasions when unstrapped load fell while traveling over an uneven surface.	
Contributing Causes	1. No one from the CAD Power Supply Group, nor Receiving communicated with the riggers about the load. 2. There was no preliminary inspection of documentation (bill of lading, shipping manifest) before unloading at BNL's receiving control point. 3. The transformer was not properly secured in crate by shipper, nor was the crate properly labeled. 4. The method of transport chosen was less than adequate. 5. Job planning was less than adequate as it failed to identify that it was important to properly secure the load. 6. Assumption that it was a routine job despite the unknown risk posed by the load. 7. The level of the staff's experience had declined significantly. 8. Forklift struck a pothole. 9. Riggers' perception that they needed to please the customer and complete the job without all the information normally required.	
	Issue A	**Issue B**
Why?	Load was not secured	Forklift struck pothole
Why?	Riggers did not know what was in the crates and did not think they needed to secure them	Potholes were in the path of travel from the flatbed to the storage area
Why?	Previous five crates were successfully moved without securing them	Potholes were not repaired
Why?	Riggers recognized that the conditions changed and that the configuration of the sixth crate was very different, but did not stop to evaluate	Potholes had not been reported for repair.
Why?	Riggers did not have enough information on the load (weight, center of gravity, how it was mounted in the crate, and what it was)	They were not deemed a significant hazard
ORPS Causal Codes	A1B5C02: Physical environment LTA A2B4C03: Material packaging LTA A2B4C07: Marking/Labeling LTA A2B5C04: Procurement LTA A3B1C06: Wrong action based A3B3C06: Individual underestimated A4B3C11: Inadequate work package prep A5B4C01: Communication between WG	
7 Deadly Sins	Overconfidence/Hubris based on limited experience	
Root Cause	Riggers developed a false sense of security while handling the first five crates. Since they were so light, they decided not to strap the loads, thus violating procedures. The Group Leader violated procedure by escorting loads in the danger zone	

Table B4. Load Falls Off Flatbed Truck During Transport

ORPS Occurrence	Load falls off flatbed truck during transport
Date	March 5, 2004
Consequence	Near Miss, Significance Category 3 Occurrence
Direct Cause	During transport, an inadequately secured load fell from a flatbed trailer onto the roadway
Contributing Cause (s)	1. Load inadequately secured because of means and methods chosen. 2. Load's configuration with the heavy pieces off to one side on the rear of the trailer. 3. BNL has no guidance or procedure on properly securing loads. 4. Underestimated weight of the absorber at ~ 2500 lbs. 5. Assumption of acceptable risk was based on incorrectly estimating the weights of objects transported, leading to the poor conclusion that the top-heavy load was not an issue. 6. Work plan and permit consisted of Health Physics (RWP) concerns only, and reliance on skill-of-the-craft. 7. The absence of clear roles and responsibilities made it difficult for workers to understand who was in charge of the transportation. 8. The use of Herculite opaque plastic sheeting concealed the wheels, which may have caused the workers to forget their presence and possibly prevented them from chocking or cribbing the target cave.
Why?	Load was not properly secured
Why?	Riggers thought that securing the load with two lateral straps across the flatbed and one around the absorber and large target cave was sufficient.
Why?	Riggers made an error in judgment.
Why?	All riggers forgot that one wrapped package contained a large heavy pig with wheels, and their lack of knowledge about lateral movement underestimated the forces on objects.
Why?	Laboratory management has not properly addressed the issues of cargo, load, securing, and transporting loads.
Causal Codes (ORPS)	A2B4C01: Material Handling LTA A2B4C04: Material Shipping LTA A3B1C06: Wrong action selected A3B3C05: Incorrect assumption A4B1C09: Previous corrective action A4B3C08: Job Planning did not identify A4B5C11: Change not communicated A5B4C01: Communication between WG
7 Deadly Sins	There was a lack of fundamental knowledge, and continued "thinking inside the box" because workers had always done it this way.
Root Cause	Work planning was less than adequate and planning staff did not recognize its importance. No other aspects were considered. Several elements of the ISM Program failed as a result. BNL management's emphasis on maintaining skilled and knowledgeable rigging personnel was not adequate. The number of BNL's experienced rigging personnel has dwindled greatly in the last few years due to retirements and lay-offs. This is exemplified by the dearth of fundamental knowledge needed in dealing with this type of load and more difficult ones.

APPENDIX C

Minority Reports

None