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Type C Investigation Report of Crane Two-Blocking Event at 241-SY-101 Double-Shell Waste Tank

**Westinghouse
Hanford Company** Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

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**Westinghouse
Hanford Company**

P.O. Box 1970
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CONTENTS

SUMMARY	1
1.0 SCOPE OF INVESTIGATION	1
2.0 FACTS	
2.1 BACKGROUND INFORMATION	1
2.1.1 General Description of the 241-SY Tank Farm	1
2.1.2 Activities in Progress at the 241-SY Tank Farm	1
2.1.3 Organizational Responsibilities	2
2.1.4 Description of Crane	2
2.1.5 Weather Conditions	2
2.1.6 Personnel Training	2
2.2 SEQUENCE OF EVENTS	3
2.3 EVENT NOTIFICATIONS	4
3.0 ANALYSIS	
3.1 TWO-BLOCK EVENT	4
3.2 TIMELINESS OF EVENT REPORTING	6
4.0 JUDGEMENT OF NEEDS	
4.1 NEEDS ASSOCIATED WITH TWO-BLOCK EVENT	6
4.1.1 Installation of Two-Block Devices or Alarms	6
4.1.2 Worker and Job Supervisor Interface	7
4.1.3 Operator Training	7
4.2 NEEDS ASSOCIATED WITH TIMELINESS OF EVENT REPORTING	7
4.2.1 Management Enforce PIC Training Requirements	7
4.2.2 Develop A Procedure for Cross Contractor Communications	8
SIGNATURE PAGE	9
APPENDICES	
A. MEMORANDA ESTABLISHING THE INVESTIGATION BOARD	
Exhibit A-1	A-1
B. ORGANIZATIONAL CHARTS	
Exhibit B-1. WHC, Tank Waste Remediation System (TWRS)	B-1
Exhibit B-2. WHC, TWRS Projects, Level 2	B-2
Exhibit B-3. WHC, TWRS Projects, Level 3	B-3
Exhibit B-4. WHC, Waste Tank Operations	B-4
Exhibit B-5. WHC, Facility Operations	B-5
Exhibit B-6. WHC, Shift Operations	B-6
Exhibit B-7. WHC, West Facilities	B-7

CONTENTS (continued)

C. FIGURES

Exhibit C-1. Figure 1, 241-SY Tank Farm	C-1
Exhibit C-2. Figure 2, Event Scene, 101-SY Tank	C-2
Exhibit C-3. Figure 3, Events and Causal Factor Chart (Event)	C-3
Exhibit C-4. Figure 4, Barrier Analysis	C-4
Exhibit C-5. Figure 5, Events and Causal Factor Chart (Time)	C-5

LIST OF TERMS

DL	Designated Lead
HHRM	Hanford Hoisting And Rigging Manual
JCS	Job Control System
KEH	Kaiser Engineers Hanford
LTA	Less Than Adequate
ONC	Occurrence Notification Center
PIC	Person In Charge
RL	Department Of Energy Richland Operations Office
TWRSP	Tank Waste Remediation System Projects
WHC	Westinghouse Hanford Company
WTO	Waste Tank Operations

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SUMMARY

This report summarizes the results of a joint Westinghouse Hanford Company (WHC) and Kaiser Engineers Hanford (KEH) investigation into the June 22, 1993 crane event in SY tank farm. The direct cause of the two-block event was operator error; the operator's concentration was distracted from the area of primary responsibility, which was crane operation. Poor work planning and equipment design were contributing factors in the event. Lack of an adequate supply of rope to use as a tag line added increased complexity to the task. This complexity, in the absence of operator aids or designed interlocks to prevent two-blocking the crane, contributed to the event.

The timeliness of event reporting issue appears to center on the completeness of event reporting to the line organization responsible for the facility. The causes of this were inadequate training of the designated person-in-charge (PIC) and no formal requirement for external contractors to notify the facility owner of the event.

1.0 SCOPE OF INVESTIGATION

A joint WHC and KEH team was established to investigate an incident that occurred on June 22, 1993 in the 241-SY Tank Farm involving a mobile crane being operated by KEH personnel. The objectives of the investigation were to determine the causes associated with the crane two-blocking event at the facility. Additionally the team was directed to investigate timeliness of event reporting, including definition of roles, responsibilities, and authorities of the personnel involved.

2.0 FACTS

2.1 BACKGROUND INFORMATION

2.1.1 General Description of the 241-SY Tank Farm

The 241-SY Tank Farm (Figure 1) consists of three similar one-million gallon, underground, double-shell tanks (Tanks 101-SY, 102-SY, and 103-SY) located just east of the 242-S Evaporator in the 200-West Area. The tank farm was constructed from 1974 to 1976, and it became operational in 1977. There are approximately 55 to 60 risers in the primary tank and annulus that are used to monitor the tank contents and support waste processing activities.

2.1.2 Activities in Progress at the 241-SY Tank Farm

Activities in progress at 241-SY at the time of the event included extensive construction activities above tank 241-SY-101 (101-SY). Hydrogen mitigation activities included installation of a mixing pump in the tank to facilitate gradual release of hydrogen gas, and installation of in-tank camera equipment. The specific work activity associated with this event was related to installing buried cables and tubing to supply power and nitrogen to the 101-SY in-tank camera system. Two pieces of 4 inch schedule 40 piping, one 10 feet and one 20 feet in length, were being moved a distance of approximately 150

feet to a location directly above 101-SY (Figure 2) by a KEH crew. The piping was to be used as a conduit to contain cables and tubing associated with the tank's in-tank camera system.

2.1.3 Organizational Responsibilities

Organizations involved in the event that had a direct relationship either to the event or the reporting of the event were WHC Waste Tank Operations (WTO), WHC Tank Waste Remediation System Projects (TWRSP) and the construction contractor, KEH. The related organizational charts are contained in Appendix A. WTO operates all Waste Tank facilities and TWRSP controls construction activities from an administrative perspective, providing the necessary engineering documents for the construction contractor (KEH) to perform the work.

2.1.4 Description of Crane

The crane used for the lift was a hydraulic, telescopic boom, rotating cab, rough terrain design. The rated lifting capacity is 36,000 pounds with the boom fully retracted, outriggers extended, and 360° rotation. The machine is equipped with a main winch and hook block as well as an auxiliary winch with overhaul ball and hook. The crane was manufactured by the P&H Harnischfeger Company and delivered new in February, 1984. This unit is regulated because it has been in service in surface contamination areas.

The model is Omega 18, serial number E-53137, KEH Equipment Number 17T-19984. A Gerald L. Greer Co., Model BB-550 radio controlled anti-two-block alarm was installed on the auxiliary (whip) line in March, 1985. The alarm is installed on the auxiliary line, since the overhaul ball is reeved with one part of rope while the main block and hook is typically reeved with four parts of rope. Thus, the auxiliary hook moves four times the speed of the main block. This is applicable to lifting/lowering, and boom extension/retraction operations. The fastest moving block or ball is the one most likely to two-block.

2.1.5 Weather Conditions

Hanford meteorology station near the 200 West Area recorded the weather conditions at the time of the event as cloudy, with a temperature of 67 degrees Fahrenheit and steady winds from the west-south-west at 17 miles per hour.

2.1.6 Personnel Training

The KEH crane operator was issued a Equipment Operator's Permit by KEH on April 6, 1992 for operation of a RT-528 Grove Crane. KEH considers the crane being operated at the time of the event equivalent to the RT-528 Grove Crane.

The KEH pipefitter was a journeyman pipefitter and had received signalling and rigging experience through his union.

The designated WHC Job Control System (JCS) PIC, who is responsible for coordinating the field work for this particular work package, had not received any specific PIC training.

2.2 SEQUENCE OF EVENTS

On June 22, 1993, in support of the ongoing installation of tank 101-SY in-tank camera system equipment, two sections (one 10 feet and one 20 feet long) of 4 inch, schedule 40 pipe were required to be staged for installation. The KEH superintendent dispatched a crane operator and pipefitter to stage the piping. The crew of two proceeded to 101-SY and prepared the pipe for movement. A P&H Omega, 18-ton mobile hydraulic crane was located at 101-SY to support construction activities.

The piping was rigged by a pipefitter and crane operator. The pipes had been choked on both ends to prepare for the crane lift. The crane used, a P&H Omega, has dual hoist capabilities. The auxiliary (whip) line was being used because the load was relatively light (~350 lbs). The main hoist line had been withdrawn so the main block was just below the boom tip to keep it out of the way. The crane operator lifted the load approximately 3 feet and with the pipefitter holding one end of the piping to prevent swinging, walked it roughly 100 feet from the 101-SY fence to a location just east of 101-SY. This distance covered was wide and clear of obstacles, thus distractions and difficulties were of little consequence.

The crane operator then positioned the crane so that the load could be lifted over obstacles (tank risers, electrical boxes, ventilation exhaust pipes) and set precisely next to the ditches, which were previously dug. The out riggers of the crane were deployed in preparation to move the load to the final installation location. The crane operator requested the pipefitter tie a tagline to the load to maintain control of the load while lifting it above obstacles. The pipefitter could not find a tagline, so the crane operator decided to swing the load into place. The load was moved through the fixed equipment elevated at approximately 3 feet by booming and swinging the crane. The pipefitter was the flagman for the crane operator and manually guided the pipe through the equipment.

When the load was located in the desired left-to-right location, the pipefitter signaled the crane operator to boom out to place the load above the ditches. While the pipefitter was signaling the crane operator to boom out, he was watching the load. The crane operator extended the crane's boom while watching the load. The crane operator's attention was drawn to the north end of the pipe which was passing near a temporary greenhouse. As the boom was extended, slack was not provided to the main line which hadn't been used for this particular lift.

The main hoist block contacted the boom tip causing what is commonly referred to as "two-blocking." This caused the main hoist wire rope to break and the main block to drop approximately 20 feet, hitting the load first, then another 3 feet to the ground. The pipefitter was at one end of the load when the block fell, approximately 10 feet away. No other

personnel were in the immediate area. The load remained suspended and did not contact any other equipment. The crane operator immediately lowered the load and shut the job down at 1325 hours.

Damage to equipment was limited to the broken main hoist cable and a dent in one of the two 4 inch pipe sections. The total damage estimate is less than \$1,000.

2.3 EVENT NOTIFICATIONS

The crane operator immediately notified his supervisor of the event. The supervisor made multiple notifications and, within several minutes, KEH Management and safety representatives responded to investigate. The KEH notification process continued vertically as well as notification to the Department of Energy Richland Operations Office (RL) at 1532 hours. KEH characterized the event as off-normal and notified the WHC Occurrence Notification Center (ONC) at 1540 hours. This completed the KEH notification process.

WHC personnel from both WHC WTO and WHC TWRSP, who were present in SY farm at the time of the event, became aware of the event almost immediately. This included the cognizant WHC project engineer for the in-tank camera system project, who subsequently contacted the KEH superintendent to inform him of the event. None of the personnel in 101-SY made formal notification of the event to WTO management. Informal word of the event spread within the line organization.

The WTO West Shift supervisor was informally notified of limited details and communicated them to the WTO "A Shift" Manager and Shift Operations Manager at approximately 1500 hours. In a parallel notification process, the WHC JCS PIC who was responsible for coordinating the associated field work was informally notified and relayed limited information to the acting manager of WTO West Facilities at approximately 1515 hours. The acting WTO West Facilities Manager did not report the event to the shift manager or direct the JCS PIC to the WTO "A Shift" Supervisor.

A DOE site monitor for WTO heard about the event and requested information from the facility manager who provided it. The site monitor notified the DOE Senior Site Representative for WTO, who was in conference with DOE-RL senior management for WTO, thus they were notified as well.

3.0 ANALYSIS

3.1 TWO-BLOCK EVENT

An Event and Causal (E/C) Factors analysis of the two-block event (Figure 3) indicated three likely causes of the event: less than adequate (LTA) planning, LTA crane operator attention to proper operation of the crane, and LTA design of the crane equipment. The LTA planning was evidenced by a lack of resources (rope to use as a tagline and a spotter) to aid in movement of the equipment. The lack of tagline resulted in a decision to swing the pipes through fixed equipment rather than over.

This decision added complexity to the movement, resulting in a need to reconsider the use of additional resources. As a result of failing to use at least one more spotter, the crane operator allowed himself to become distracted from the proper operation of the crane. His attention was diverted to observing the load path rather than control of the crane.

The equipment used was LTA in that the crane did not have an anti-two-block device on the main hoist. The crane had been retrofitted with an anti-two-block alarm on the auxiliary hook only. This two-block alarm provides no indication for a main hoist two-block condition.

The E/C chart, as well as a barrier analysis (Figure 4), also identifies a lack of formal control that may result in a spotter or other ground support personnel being under an unused block if the load is low to the ground. The Hanford Hoisting and Rigging Manual (HHRM) prevents ground support personnel from ever positioning themselves under a lifted load. However, if the load is low to the ground, as was the case in this event, nothing prevents ground support personnel from standing directly below the unused block, which may be well above the ground personnel. This places the employee in a direct path of harmful energy with only one barrier in place: the crane operator.

A barrier analysis of the event was performed to evaluate potential energy source impact on personnel safety. Two energy sources were identified which potentially could have resulted in significant personnel injury or equipment damage. The two sources of energy identified were the auxiliary hook and associated load, and the unloaded main hook. The analysis of both energy paths are shown in parallel to demonstrate the similarities and differences of existing and potential barriers. Barriers in place at the time of the event are shown as solid barriers on the analysis and barriers which are recognized as potentially available but not present are shown as dashed barriers.

In this particular accident, the only barrier which prevented serious injury to the flagman, who was the most likely person to be harmed by the falling main hoist block, was his distance from the point of impact. The existence of this barrier is not explicitly controlled by training or procedure. The failed human barrier was caused by the crane operator being preoccupied with the proximity of the load to fixed equipment. A two-block alarm device on the main hoist was identified as an operator aid that may redirect the operator's attention to a dangerous situation, however this cannot be regarded as a barrier to prevent it.

Two barriers prevented the second energy source (auxiliary hook and load) from threatening the flagman's safety. The two barriers are operator awareness and the pipefitter's distance from the load. These barriers were significantly enhanced in this instance as a result of administrative controls in place and the installation of an operator aid. Working beneath a suspended load is prohibited, and addressed in the HHRM. Operator awareness was focused on the load and auxiliary hook. Additionally, a two-block alarm feature on the auxiliary hoist was available as an operator aid to enhance operator awareness. Two-block

prevention devices (control neutralizing) for both hoists are shown as an available barrier in both energy paths. Although available, these devices were not installed on the crane.

3.2 TIMELINESS OF EVENT REPORTING

An Event and Causal Factors analysis of the timeliness of the event reporting (Figure 5) was performed. Less than adequate communications between KEH personnel in the facility and the manager responsible for the facility, WTO Shift Manager, is indicated as the cause of the LTA event notification process. KEH limited direct communication about the event to the project engineer and did not communicate directly with facility management or the WHC JCS PIC. The WHC JCS PIC failed, once informed of the event, to directly notify the WTO "A Shift" Manager, and was not directed to report to the WTO "A Shift" Manager by the acting WTO West Facilities Manager.

The notification process of a potential event usually begins with the shift manager initiating notifications to WHC management and oversight organizations, including the RL site representative for WTO. The RL site representative then informs senior RL management.

Because the communication breakdown occurred prior to the event information reaching the WTO shift manager, RL was never officially notified of the event by the shift manager. However, because RL became aware of the event, they completed their internal notifications which led to WHC senior management being notified.

4.0 JUDGEMENT OF NEEDS

This section draws conclusions regarding the types of managerial controls necessary and sufficient to prevent or minimize the probability of recurrence.

4.1 NEEDS ASSOCIATED WITH TWO-BLOCK EVENT

4.1.1 Installation of Two-Block Devices or Alarms

A standard for two-block protection needs to be established and applied to the use of mobile cranes on site based on risk, both to personnel and equipment.

Discussion:

Although this event involved a dual hoist crane, the potential for two-blocking exists for both single and dual hoist cranes. The mobile crane industry has compensated for this by incorporating two-block protection into new crane designs. For older cranes without such devices, the use of a single human barrier, the operator, to prevent occurrence of a two-block event will periodically fail. While the use of single hoist cranes and/or two-block alarms can enhance the human barrier, a risk based consequence of a two-block event needs to be evaluated.

4.1.2 Worker and Job Supervisor Interface

Job planning and performance expectations should be clearly established between supervision and the designated leads before dispatching designated leads to the field. Any modifications to the planned activities that could affect the safety envelope of the activity should be reviewed with the supervisor.

Discussion:

When a craft member of a crew is assigned the responsibility of designated lead for a hoisting and rigging activity in accordance with the HHRM, the responsibility should not include job planning. A lack of resources in the field resulted in the crane operator/designated lead to use a second choice method to accomplish the task. Motivation to pursue additional resources to complete task in the safest manner needs to be emphasized to designated leads before they are dispatched to the field. Accepting an increase in job difficulty by moving the pipe through fixed equipment because there was no rope to use as a tagline was a likely initiator of this event. WHC equipment and personnel were available in the SY Tank Farm at the time of the event and were not requested. Reluctance to request cross contractor assistance is anticipated and requires training and management support to overcome.

4.1.3 Operator Training

Mobile crane operators' and supervisors' training should include distraction awareness training.

Discussion:

Proper, safe operation of mobile cranes depends heavily on the crane operator to maintain the crane in a safe configuration. On the job distractions can seriously hamper an individual's ability to safely perform this task. Although elimination of distractions is the preferred solution, is not usually realistic. Through training to identify and compensate for these conditions, the individual crane operator and supervisor can improve their ability to perform safely.

4.2 NEEDS ASSOCIATED WITH TIMELINESS OF EVENT REPORTING

4.2.1 Management Enforce PIC Training Requirements

Tank Farms management needs to assure that personnel are properly trained before being placed on the approved WHC JCS PIC list for Tank Farms.

Discussion:

Many of the problems associated with timeliness of communicating event information can be attributed to the failure of WHC JCS PIC to inform WTO Shift management. Instead of informing the WTO Shift management, the JCS PIC notified the acting manager of West Facilities which is an

operations support function. The acting West Facilities manager failed to make the proper notifications. The expectations of the responsibility of the PIC had not been communicated to the designated JCS PIC and the JCS PIC had not received any specific PIC training before being placed on the JCS PIC list.

4.2.2 Develop A Procedure for Cross Contractor Communications

A clear policy of notification for events which involve multiple organizations, WHC divisions, contractor personnel and/or facilities needs to be established to ensure that facility management is aware of off normal events in their facilities.

Discussion:

KEH personnel handling of the event was effective. Field investigation and initial notifications were initiated within 20 minutes of the event. WHC ONC notifications were within two hours and fifteen minutes of the occurrence. However, there is no policy for contractors to formally notify the facility operations manager (WTO) or WHC safety counterparts of an event. Similarly, events that involve WHC organizations working in facilities other than their own could result in similar communications problems.

Type C Investigation of a Crane Two-Block Event at 241-SY Tank Farm

SIGNATURES

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 Thomas W. Halverson, Chairman
 Waste Tank Operations
 Westinghouse Hanford Company

8/20/93
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 Mark S. Garrett
 Certified Accident Investigator
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8/20/93
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Roger L. Hildremyr
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8/19/93
 Date

Ray Pope
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 Certified Accident Investigator
 Westinghouse Hanford Company

8-20-93
 Date

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WHC-MR-0433

APPENDIX A

WHC-MR-0433

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**Westinghouse
Hanford Company**
**Internal
Memo**

From: President's Office
Phone: 6-5107 B3-01
Date: June 23, 1993
Subject: ACCIDENT INVESTIGATION

To:	M. S. Garrett	R1-62	G. E. McPherson	T4-10
	T. W. Halverson	R2-50	B. P. Moyers	G7-08
	R. S. Hildremyr	G7-32	R. Pope	H5-70
	D. W. McMyler	S2-53		
cc:	W. T. Alumkal	R2-52	M. K. Korenko	B3-08
	C. E. Anderson	G7-11	D. J. Swaim	B3-51
	R. T. French	P8-47	TMA:DJS File/LB	

An incident occurred June 23, 1993 in SY Tank Farm involving a mobile crane operated by Kaiser Engineers Hanford Company (KEH). Fortunately, no one was injured and equipment damage (i.e., broken wire rope) appears to be minor. However, this incident must be viewed in the context of its potentially serious consequences. Westinghouse Hanford Company (WHC) and KEH are jointly establishing a team to conduct an investigation of this incident. The team should use direction provided in DOE Order 5484.1, "Environmental Protection, Safety and Health Protection Information Reporting Requirements," to conduct their investigation, analyze the incident, develop corrective actions, and structure the final report. Investigation team members are identified below:

Tom Halverson, WHC, Chairman
Mark Garrett, WHC, Certified Accident Investigator
Roger Hildremyr, KEH, Certified Accident Investigator
David McMyler, WHC
Gerry McPherson, WHC
Ben Moyers, KEH
Ray Pope, WHC

The investigation should also address the timeliness of event reporting and the definition of roles, responsibilities, and authorities of the personnel involved.

~~Please establish the team immediately and begin your investigation process full time until completed.~~ Notify us if there are any obstacles in conducting or completing this assignment.

Thomas M. Anderson
President

R. T. French, General Manager
Kaiser Engineers Hanford Company

cls

**Westinghouse
Hanford Company****Internal
Memo**

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	R. S. Hildremyr	G7-32	R. Pope	H5-70
	D. W. McMyler	S2-53		
cc:	W. T. Alumkal	R2-52	M. K. Korenko	B3-08
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The investigation should also address the timeliness of event reporting and the definition of roles, responsibilities, and authorities of the personnel involved.

Please establish the team immediately and begin your investigation process full time until completed. Notify us if there are any obstacles in conducting or completing this assignment.

Thomas M. Anderson
 President

 R. T. French, General Manager
 Kaiser Engineers Hanford Company

cls

APP A-2

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APPENDIX B

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Tank Waste Remediation System

WHC-MR-0433

APP B-1

TWRS Projects

Tank Waste Projects

Tank Waste Projects
MA Cahill, Manager
7F500

TJ Huisman, Secy

Waste Tank Operations

AL Hein, Secy.
CP Allen, AA.
TD Kaiser, AA.
SG Spencer, AA.

Facility Operations

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Shift Operations

Shift Operations
JJ Badden, Manager
7C120

LC Rager, Secy.
JL Klos, Supvr.
RE Manis, Engr.
GL Mergel, PO
KR Hager, Ck.
AM Borell, Student

A Shift
WL Morris, Mgr.
7C120

See Chart 1.1.1.1

B Shift
GN Hanson, Mgr.
7C120

See Chart 1.1.1.2

C Shift
BD Biddle, Mgr.
7C120

See Chart 1.1.1.3

D Shift
RJ Shupe, Mgr.
7C120

See Chart 1.1.1.4

E Shift
TW Bohan, Duty Mgr.
7C120

See Chart 1.1.1.5

Surveillance
WJ Kennedy, Supvr.
7C121

D Scott, Engr.
SA Caylor, NPO
RB Hammer, NPO
TN Miller, NPO
WA Morris, NPO
JS Rodriguez, NPO
CL Sanchez, NPO
AG Steffens, PO
RJ Wildenberg, NPO
DW Wilson, NPO

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West Facilities

1.1.2 6/93

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APPENDIX C

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WHC-MR-0433

APP C-1

- ① Load Path
(approximate)
- ② Crane Location
(approximate)
- ③ Location of
Fallen Block

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241-SY-101 Double Shell Tank
Crane Two-Block Event Scene

Sequence of Events

June 22, 1993

Barrier Analysis for Crane Two-Block Event at 241-SY-101 Tank Farm

June 22, 1993

Events and Causal Factor Chart

Event Notification Process

Solid lines separate 3 parallel notification processes.

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APP C-5

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