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FACSIM/MRS-2: Storage and Shipping Model Documentation and User's Guide

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R. A. Sovers

June 1987

Prepared for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830

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PREFACE

The coding presented in this document is based on the processing time estimates available as of September, 1985. Also, the handling of secondary waste (assembly hardware, etc.) has not been included in this description of the model of MRS back-end operations. However, a listing of an expanded version of the back-end model that includes secondary waste handling is given in Appendix B of this document and also in the back-end performance assessment report (Hostick et al. 1987).

EXECUTIVE SUMMARY

The Pacific Northwest Laboratory (PNL) has developed a stochastic computer model, FACSIM/MRS, to assist in assessing the operational performance of the Monitored Retrievable Storage (MRS) waste-handling facility. This report provides the documentation and user's guide for FACSIM/MRS-2, which is also referred to as the back-end model. The FACSIM/MRS-2 model simulates the MRS storage and shipping operations, which include handling canistered spent fuel and secondary waste in the shielded canyon cells, in onsite yard storage, and in repository shipping cask loading areas. The results of the assessment of operational performance of these activities are contained in a second report, FACSIM/MRS-2: Storage and Shipping Performance Assessment (Hostick et al. 1987).

This document provides the necessary information for an individual familiar with simulation analysis to use the model to assess the activities that occur once the consolidated spent fuel is placed in canisters that are then closed by sealed welding. The FACSIM/MRS-2 model provides the user with information about throughput rates, lag storage use, machine utilization, canister queue lengths, shipping cask turnaround times, and train turnaround times for various operating conditions in the back end of the MRS facility. For example, the model can help determine the effect that the following operating conditions have on operating efficiency:

- different canister receipt rates from the front-end to the back-end of the MRS facility
- facility operation at 3 shifts/day for 7 days/week or 3 shifts/day for 5 days/week
- frequency of equipment failures and the length of time for the equipment to be repaired
- placement of canisters from lag storage into onsite storage and retrieval back into lag storage before shipment to the repository
- frequency of train arrivals to ship canisters to the repository.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

This report provides the documentation and user's guide for the model of MRS storage and shipping operations. This effort was undertaken as part of the U.S. Department of Energy sponsored MRS program at PNL.[a]

The focus of the MRS facility assessment is the MRS receiving and handling (R&H) building. When the spent fuel arrives at the MRS facility, it is routed to the R&H building, where the spent fuel is removed from its shipping cask, transferred to the process cell, disassembled, consolidated and canistered. The canisters are either stored in an internal storage vault or placed in casks or drywells and stored in the spent-fuel storage yard area until they are transported to the repository.

The FACSIM/MRS simulation analysis model is presently designed to assess storage in casks because that is the primary storage concept. The model can be modified for assessing alternative storage concepts (drywell) if needed. Figure 1.1 shows a block diagram of the major operations simulated in the FACSIM/MRS model, which consists of two modeling components. The FACSIM/MRS-1 is referred to as the front-end model, and the FACSIM/MRS-2 is referred to as the back-end model.

The FACSIM/MRS model is based on the commercially available simulation language SIMAN from the Systems Modeling Corporation for the IBM-PC and PC-compatible microcomputers. The model was designed to run on either an IBM-PC or PC-compatible computer or a MicroVAX computer. SIMAN provides network symbols that can be used to build graphical models of the MRS R&H operations, which can then be translated into computer code. This code was used to simulate the MRS operations on a minute-by-minute basis. SIMAN also allows random sampling from a variety of statistical distributions to simulate stochastic processes in the MRS facility operations.

The FACSIM/MRS-2 model consists of both a system model and an experimental frame. The system model consists of SIMAN-coded input statements, called block

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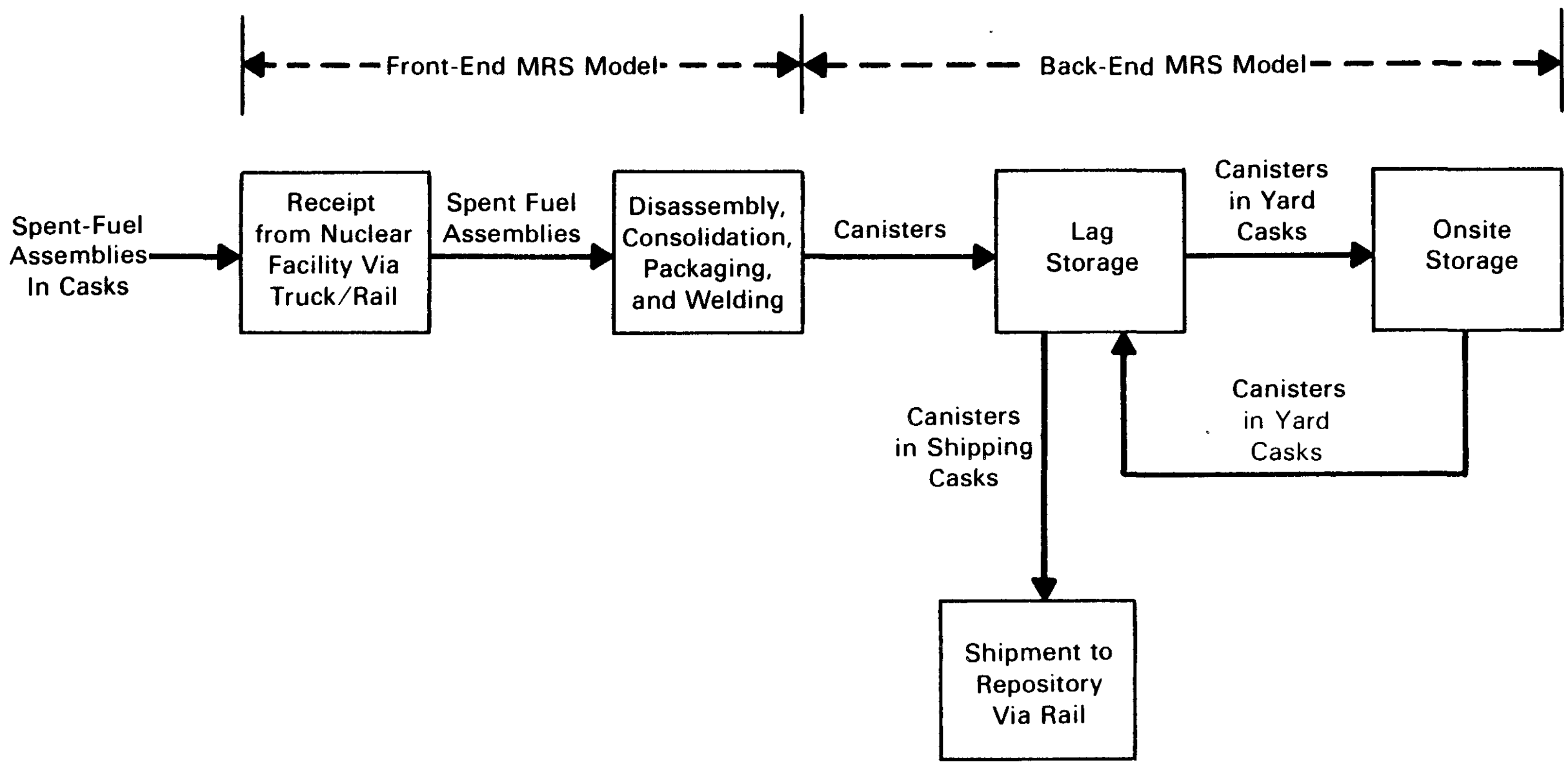


FIGURE 1.1. Organizational Chart of Major Operations Simulated in the Model

operations, which are used to build detailed models of the MRS operations. The experimental frame specifies the input data for executing the model. A text editor is used to change the file of input data, thereby altering model parameters as needed.

A brief description of the MRS facility, the R&H building and the back-end R&H operations is presented in Chapter 2.0. The back-end MRS model and the model assumptions are detailed in Chapter 3.0. The input data for the model are described in Chapter 4.0, and the compiling, linking, and executing of the model are described in Chapter 5.0. The simulation output from the back-end MRS model is discussed in Chapter 6.0. Appendix A contains information on crane failure frequency and repair data, process steps and time estimates for the simulation runs, the default data in the experimental frame, and example output. The listing and the block diagrams of the back-end model are also presented in Appendix A. Appendix B contains a listing of an expanded version of the back-end model that includes secondary waste handling.

2.0 DESCRIPTION OF BACK-END MRS FACILITY OPERATIONS

Back-end MRS facility operations handle spent fuel from the point after canister welding to emplacement of the canister in a lag storage vault cell or within a storage cask or a repository shipping cask. Interactions between the facility yard storage and the receiving and handling (R&H) building are also included as part of back-end operations. The major areas of the facility included in the analysis are shown in Figure 2.1, which shows one half of the R&H building.

The R&H building is composed of two halves, which are essentially mirror images of each other. One half handles spent fuel from pressurized water reactors (PWRs) and the other handles spent fuel from boiling water reactors (BWRs). Areas One through Four, shown in Figure 2.1, were included in the MRS front-end performance assessment report (Lotz and Shay 1987). The following sections describe MRS spent-fuel handling activities following canister welding in Area Four through repository shipment preparation in Area Eight.

2.1 BACK-END CANISTERING AND LAG STORAGE

After disassembly and consolidation in one of the four process cells, spent fuel is canistered and the canister is welded, inerted, decontaminated and inspected. The average PWR and BWR spent-fuel assemblies are assumed to contain 0.462 MTU and 0.186 MTU, respectively. Three consolidated PWR spent-fuel assemblies are placed in a canister, resulting in 1.386 MTU/canister. Seven consolidated BWR spent-fuel assemblies are placed in a canister, resulting in 1.302 MTU/canister.

The canister loading and welding area in the shielded canyon cells consists of a welding, decontamination, and inspection system, as shown in Figure 2.2. One welding machine services two shielded process cells. Following welding and decontamination, a helium leak test is performed to test the weld seal, a swipe for contamination is completed, and the canister is then transferred to an ultrasonic test station to test the integrity of the weld.

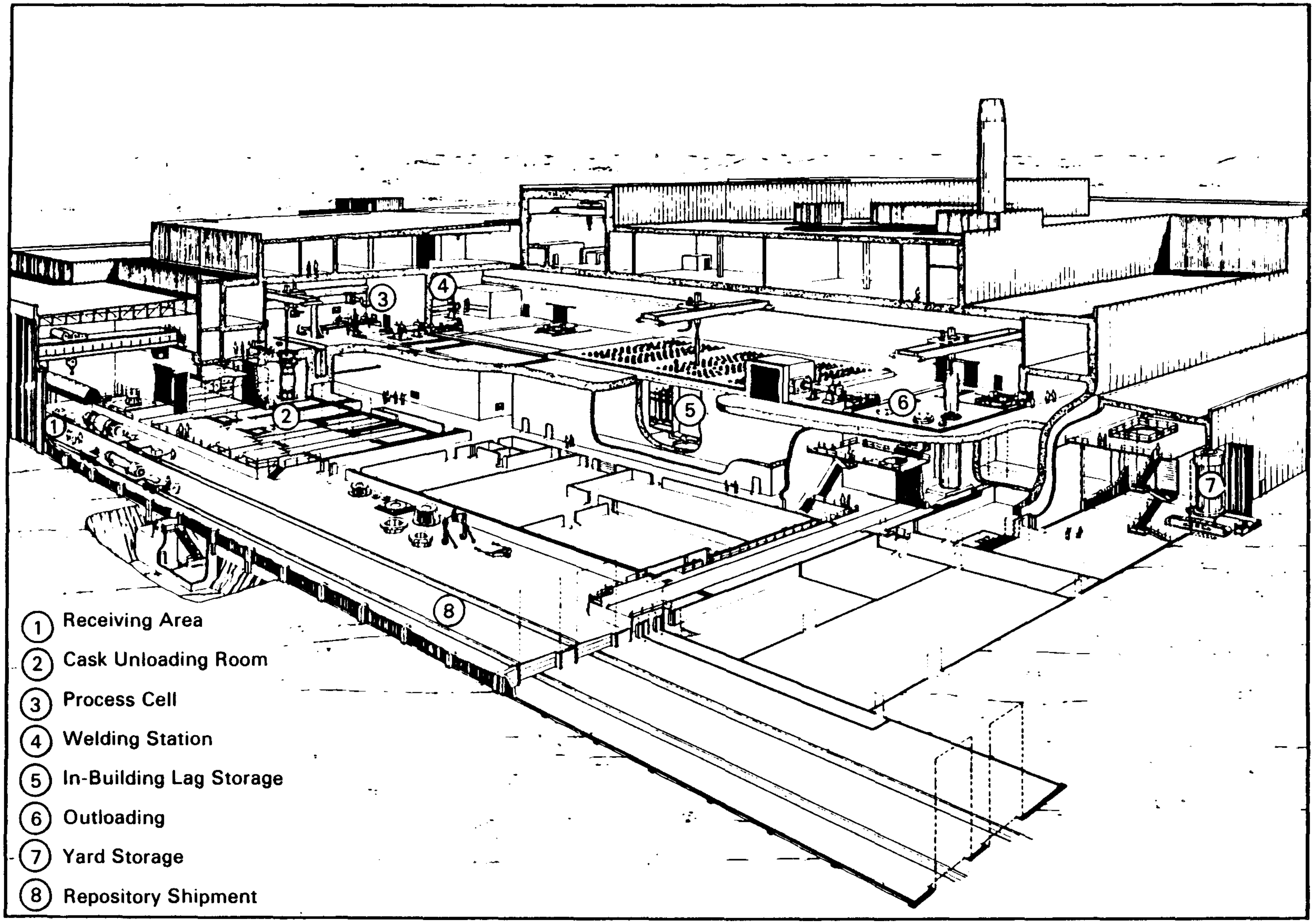
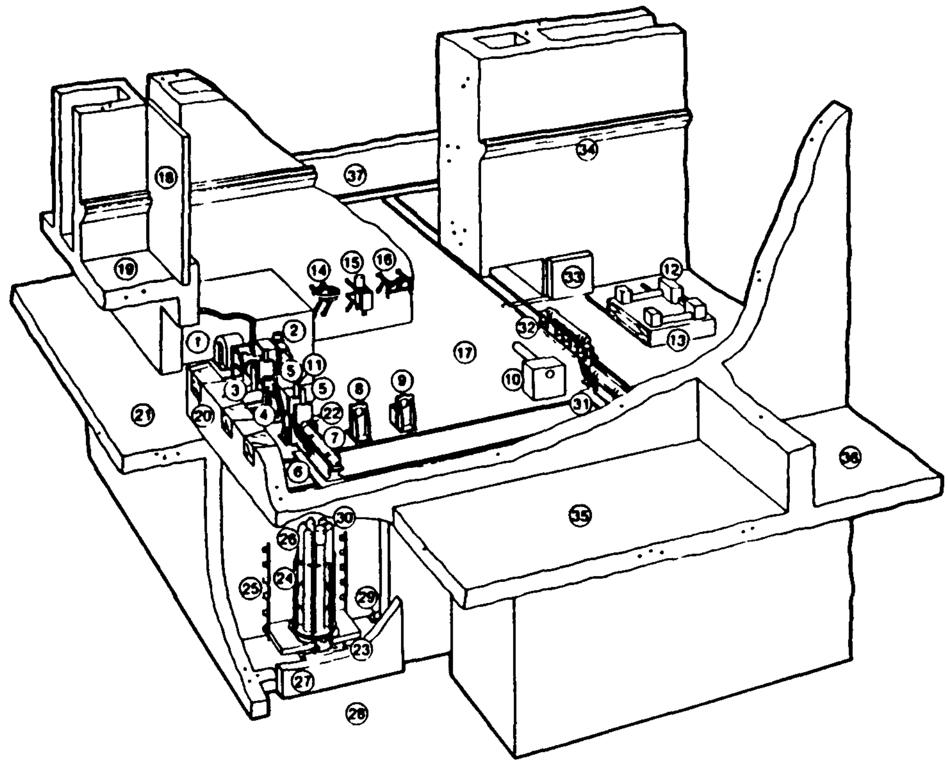


FIGURE 2.1. MRS Receiving and Handling Building (Parsons 1985)



1 Welding Power Generator/Equipment Room
2 Canister Lid Supply System
3 Canister Welding Station
4 Canister Decon/Helium Leak Test Chamber
5 Chamber Isolation Valves
6 Canister Upender No 1
7 Storage Canister
8 Ultrasonic Test Station
9 Canister Cutting Station
10 Fuel Rod Bundle Push Rod System
11 Forge Press Restraint
12 Maintenance Hatch Jacking Mechanism
13 Maintenance Hatch
14 Plug Grapple
15 Pintle Grapple
16 Equipment Lifting Yoke
17 Shielded Canyon Cell #6
18 Maintenance Area Shield Door
19 Crane Maintenance Room
20 Observation Window
21 Operating Gallery
22 Clean Canister and Lid Supply Port
23 Carousel Lift Mechanism
24 Carousel Canister Rack
25 Guide Rail Lift Mechanism
26 Clean Canisters
27 Shield Door
28 Access Corridor
29 Lift Mechanism Hydraulic Pump System
30 Canister Lid Supply Support Tube
31 Canister Upender No 2
32 Canister Pass-Thru Cart
33 Canister Pass-Thru Shield Door
34 35 ton Crane Rails
35 Shielded Process Cell #2
36 Decon Cell
37 Shielded Canyon Cell #5

FIGURE 2.2. Canister Loading and Welding Area

If the weld on the storage canister is unacceptable, the canister is sent to a cutting station for lid removal, and the welding process is repeated. A canister cutting station consists of a fully automatic pipe lathe located near the welding station. If one of the welding stations malfunctions, a canyon cell canister pass-through cart is provided to transfer spent-fuel canisters between the shielded canyon cells.

Following successful completion of the weld, the canister is placed into in-building vault lag storage, field storage, or directly into a repository shipping cask or into a scaled storage cask. Both in-building lag storage vaults have a total capacity of 748 canisters or about 1,000 MTU of spent fuel. The top of the storage vault is covered with a concrete floor with holes on 3-foot centers. Each hole has a removable shielding plug with a lifting pintle identical to the one on the canister. Each in-building lag storage/ loadout area is serviced by two 35-ton overhead cranes. Placing a canister into in-building lag storage requires removing a shielding plug with the 35-ton crane, emplacing the canister into storage, and replacing the shielding plug. Time estimates for back-end canistering and lag storage emplacement are provided in Table 2.1.

Maintenance of the 35-ton cranes is performed in shielded maintenance bays. If one 35-ton crane is out of service, the other 35-ton crane is available to perform all operations. In practice, either crane can perform all shielded canyon cell lifts at a reduced pace. However, this alternative was not modeled because of its minor impact on average crane utilization.

2.2 CONCRETE CASK YARD STORAGE

The yard storage area is designed to temporarily store spent-fuel canisters in sealed storage casks containing 12 canisters in an open field above ground. A diagram of the storage yard in relation to the R&H building is shown in Figure 2.3. Total storage yard capacity is about 15,000 MTU. However, no more than a total of 15,000 MTU can be stored onsite.

Storage casks are fabricated at the MRS cask manufacturing facility and transported to the R&H building when needed. Empty storage casks are prepared for loading in an area adjacent to and below the outloading area.

TABLE 2.1. Back-End Canistering and Lag Storage Emplacement Time Estimates (Parsons 1985)

Operation Description	Operation Time (in minutes)
I. Activities Included in Front-End Performance Model	
Index clean canister carousel, raise rack, lift port plug, set down plug, lift canister, place on Upender No. 1, replace plug	30
Downend Upender No. 1 (with canister), rotate, translate, and position to receive fuel bundle	15
Receive fuel bundle from consolidation process Cell 1	15
Retract from position, rotate canister, and translate to welder centerline	15
Insert canister into chamber, evacuate canister and chamber, backfill with inert gas and weld	20
Transfer canister in decontamination chamber, decontaminate, drain chamber and evacuate chamber for leak check	35
Open air lock, swipe canister while transferring to upender	15
Transfer welded canister to ultrasonic station, inspect and verify weld	45
II. Activities Included in Back-End Performance Model	
Retract canister, translate to open position, upend canister and place canister into vault lag storage or repository shipping cask	15

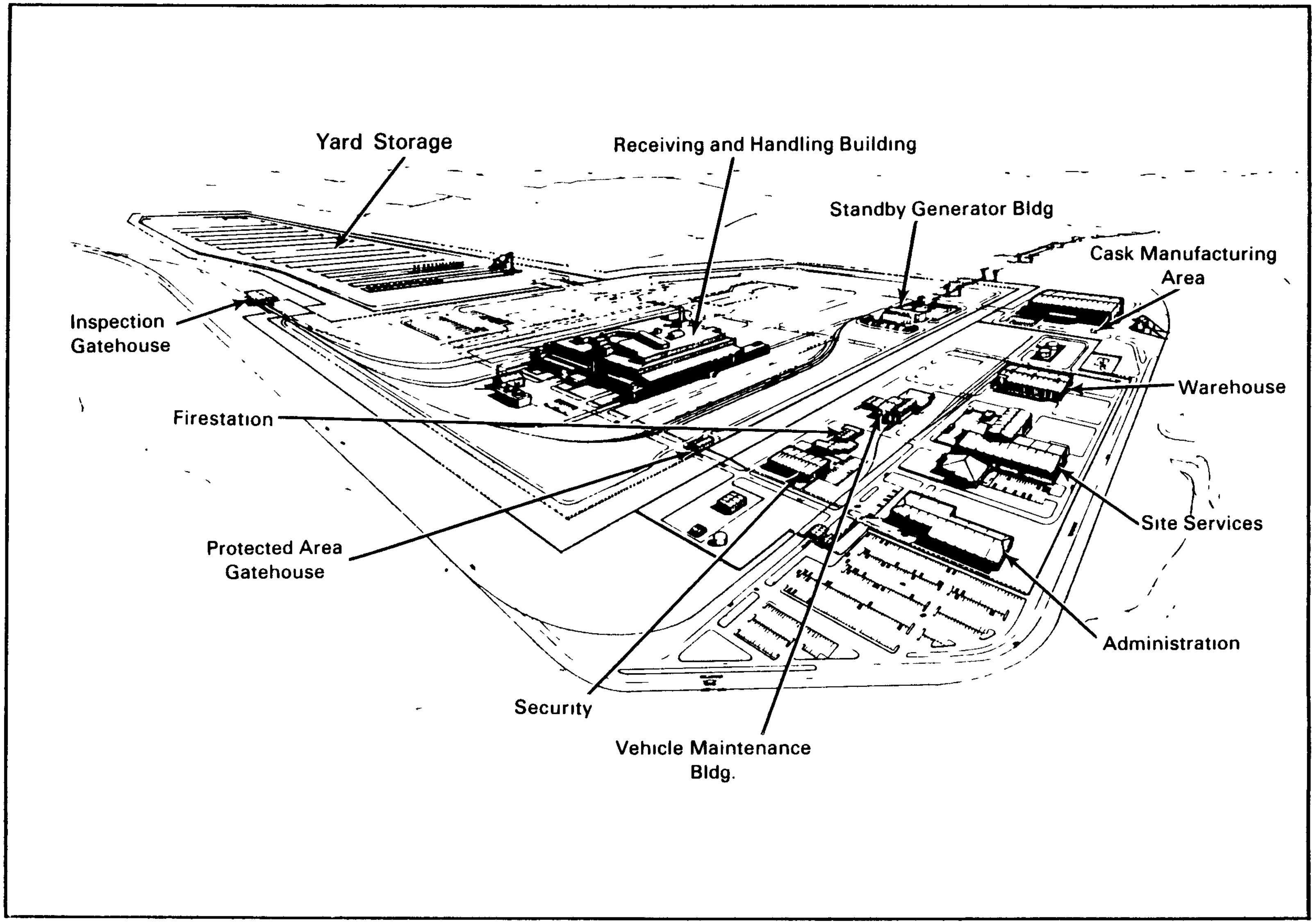


FIGURE 2.3. Storage Yard Location in Relation to the R&H Building (Parsons 1985)

After preparation for loading, the storage cask is moved into a loadout room located beneath the loadout area, and a contamination barrier is installed between the cask and loadout area port. The loadout area port plug and the cask shield plug are removed, and canisters are loaded into the storage cask using one of the 35-ton overhead cranes.

Once loading is completed, the loadout area port plug and the cask shield plug are replaced, and the storage cask is moved into an adjacent area where a contamination survey of the cask top is performed. A metal cask lid is installed, sealed, welded, and inspected. The transporter then moves the cask to the storage yard where the cask-handling crane removes the cask from the transporter. Time estimates for storage cask handling are provided in Table 2.2.

Storage cask retrieval and unloading back into the R&H building are, for the most part, the reverse of loading operations.

2.3 REPOSITORY SHIPPING CASK RECEIVING AND HANDLING

In addition to the storage cask loadout ports, the loadout area also contains repository shipping cask loadout ports. The loadout area also includes space for equipment to overpack canisters for shipment to the repository, which may or may not be used in actual operation. Time estimates for repository shipping cask R&H activities are provided in Table 2.3.

A detailed diagram of the repository shipping cask loading area is shown in Figure 2.4. If overpacks are used, the repository overpack arrives at the R&H building and is placed on the cask cart servicing the repository shipping cask area. The overpack is fitted with a contamination control adapter to reduce airborne contamination during the transfer of the repository overpack into the loadout area.

Once the loadout area port plug is removed, the 35-ton crane is used to place the overpack into the repository overpack welding station pit. The loadout area plug is replaced, and the overpack containment control adapter and cask cart is returned to the repository shipment area where the containment control adapter is removed from the cart. The overpack is loaded with four

TABLE 2.2. Concrete Cask Yard Storage Time Estimates (Parsons 1985)

Operation Description	Operation Time (in minutes)
Emplacement:	
Move cask into unloading room	15
Install contamination barrier and shield ring, move into corridor	15
Remove shield plug, install canisters, install shield plug	300
Remove contamination barrier and shield ring, move into corridor	20
Perform contamination survey of cask top	10
Remove plug lifting eyes, install cover and welder, set up welder	20
Make weld	60
Remove welder	5
Visually inspect weld	10
Perform magnetic particle weld inspection	30
Pressure check cask interior	40
Clean weld area and coat	15
Move cask to storage area	30
Position lifting fixture and lift cask	10
Emplace cask and disengage lifting fixture	15
Complete thermocouple instrumentation connections	30
Return cask transporter to Cask Manufacturing Facility	30
Set new cask on transporter and move to R&H Area	30
Retrieval:	
Load cask onto transporter	35
Move cask to R&H Building	30
Prepare cask for unloading	120
Position cask under exit port	20
Remove shield plugs	20
Unload and decontaminate canisters as necessary	500
Replace shield plugs	20
Remove cask from unloading room	15
Prepare cask for temporary storage prior to decommissioning	60
Transport cask to temporary storage area, remove lifting yoke	30
Place cask on storage pad	35

TABLE 2.3. Time Estimates for Repository Shipping Cask R&H Activities (Parsons 1985)

Operation Description	Operation Time (in minutes)
RO/SCFRO[(a)] inspection at gate	5
Move RO/SCFRO/vehicle to protected area	15
Check to determine contents	10
Survey SCFRO/vehicle for radiation	45
Move RO/SCFRO/vehicle to washdown area	15
Remove road dirt from RO/SCFRO/vehicle	45
Move RO/SCFRO/vehicle to cask-handling area	20
Remove personnel barriers from vehicle	30
Remove impact limiters and shipping restraints	30
Perform contamination survey on SCFRO	30
Place RO cask adapter on cask cart	20
Attach grapple and remove RO from transporter	15
Place RO on cask cart, and install restraints and RO lid	30
Move RO to cask-handling and decontamination room	10
Install contamination barrier adapter on RO cask cart adapter	10
Move RO into unloading room, engage contamination barrier, close shadow shield and close shield door	20
Remove cell entry port plug	20
Unload overpack with lid and place into weld/ decontamination station	20
Exchange grapple, remove RO lid, and place on floor	10
Exchange grapple and replace cell entry port plug to permit preparations for SCFRO	25
Load consolidated fuel canisters in RO, 20 min/SF canister	60
Insert RO lid in place and rotate welding head into position for weld	20

(a) Repository Overpack (RO)/Shipping Cask for Repository Overpack (SCFRO).

TABLE 2.3. (contd)

Operation Description	Operation Time (in minutes)
Weld RO lid via electron beam process and disengage weld head from RO	60
Perform visual inspection on welded RO	10
Open shadow shield and shield door, disengage contamination barrier, and move cask cart with empty RO cask adapter to cask-handling and decontamination room	20
Remove the contamination barrier adapter from the RO cask adapter	10
Survey for contamination and decontaminate if necessary	40
Move cask cart to receiving and inspection area	10
Remove RO cask adapter from cask cart and place in set-down area	15
Exchange 150-ton grapple for shipping cask yoke	5
Engage SCFRO, rotate to vertical, place on cask cart, and secure restraints	35
Move cask cart/SCFRO into cask-handling and decontamination room, close door, and install contamination control barrier adapter	20
Remove outer lid of SCFRO and remove all but four bolts of inner lid	30
Move SCFRO into unloading room, engage contamination barrier, close shadow shield and close shield doors	20
Remove cell entry port plugs, unbolt inner lid fasteners, and lift lid into cell	40
Engage RO pintle grapple and lift completed RO into SCFRO	25
Exchange grapple, replace inner lid of SCFRO, tighten bolts, and replace entry port plug	80
Open shadow shield, shield door, disengage contamination barrier and move cask cart with full SCFRO to cask-handling and decontamination room	20
Complete SCFRO closure installation, remove barrier adapter, survey for contamination, and decontaminate if necessary	150

TABLE 2.3. (contd)

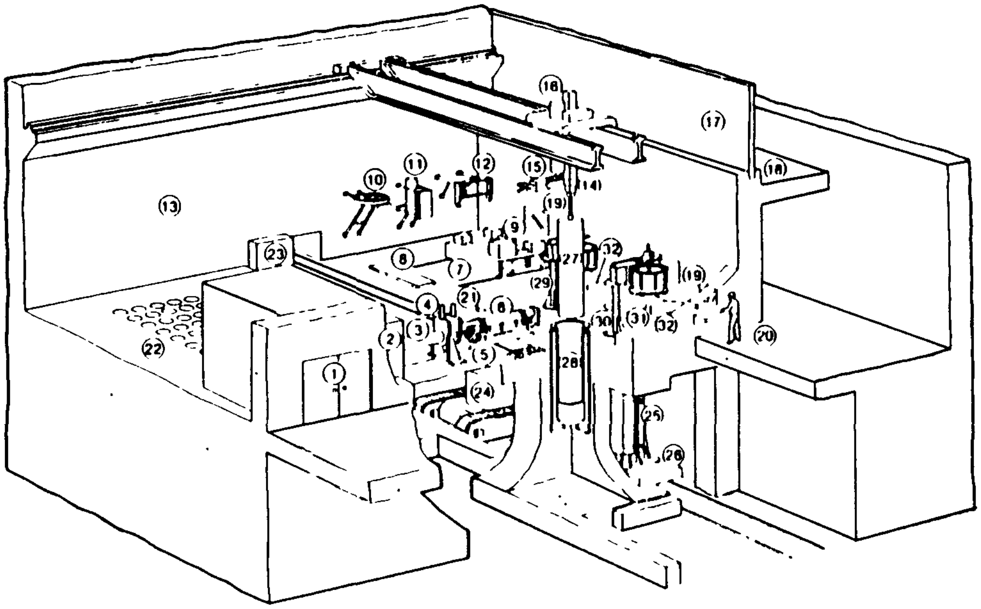
Operation Description	Operation Time (in minutes)
Move cask cart to receiving and inspection area	10
Remove full SCFRO from cask cart, place SCFRO on transport vehicle, and remove lifting yoke	35
Install cask tiedown impact limiters, personnel barriers, etc.	60
Complete preparations for release of full SCFRO and transporter from R&H Building	30

canisters using the 35-ton crane. An electron beam welder is used to secure a lid to the overpack, after which the overpack is inspected and decontaminated. If overpacks are not used, the canisters are loaded directly into a shipping cask.

The repository shipping cask is transported by rail to the repository shipment area of the R&H building, positioned in front of a cask cart, and prepared for unloading. The repository shipping cask is then transferred to the cask cart by the 150-ton crane. The cask cart transfers and mates the cask to the loadout area port. The required shielding is put into place and the loadout area plug is opened. The repository cask is loaded with an overpack or canisters, the port is closed, the outer lid is inspected, and the outer surface is decontaminated. Following decontamination, the repository shipping cask is removed from the cask cart, and placed on the transport vehicle, and final preparations are made to release the shipping cask from the R&H building.

2.4 SECONDARY WASTE

Secondary waste refers to nonfuel material generated by disassembling spent-fuel assemblies and other waste that must be handled, packaged and shipped from the R&H building. Secondary waste is divided into two categories: nonfuel-bearing components and onsite-generated high-activity waste.



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6 Storage Canister
7 Exit Port
8 Lag Storage Cover
9 Exit Port Jacking Mechanism
10 Plug Grapple
11 Pintle Grapple
12 Equipment Lifting Yoke
13 Shielded Canyon Cell #6
14 Power Mast
15 Manipulator
16 35 Ton Cell Crane
17 Maintenance Area Shield Door
18 Crane Maintenance Room
19 Observation Window
20 Operating Gallery
21 Clean Canister and Lid Supply Port
22 Lag Storage Canyon Vault Area
23 Canister Pass-Thru Shield Door
24 Storage Cask and Transporter
25 Repository Overpack Cask Adapter
26 Cask Cart
27 Repository Overpack
28 Repository Overpack Welding/Decon Pit
29 Repository Overpack Welding Head and Jib Support Structure
30 Repository Overpack Decon Head and Jib Support Structure
31 Repository Overpack Port
32 Repository Overpack Port Plug (Outer & Inner)

FIGURE 2.4. MRS Processing Cell Disassembly and Consolidation Area

Nonfuel-bearing components (referred to as hardware) are the nozzles, grids, guidetubes, etc., remaining from spent-fuel disassembly for consolidation. Onsite-generated high activity waste (HAW) consists of spent high-efficiency particulate air (HEPA) filters, spent cartridge filters, spent resins from radwaste systems, and evaporator slurry.

MRS handling of secondary waste consists of loading secondary waste into 55-gallon drums, followed by drum sealing and decontamination. The nonfuel-bearing waste drum processing and decontamination is accomplished in a cell located between adjacent shielded process cells. One nonfuel-bearing processing and decontamination cell is located in each half of the R&H building. Empty drums are brought into a process cell by a cart and placed at the shredder output for filling. Shredder loading is performed by a robot mounted on a powered transverse track that removes hardware from the disassembly consolidation station and places it in a shredder chute. The cart transfers the filled drum to a lid station, where the drum is sealed, and then into the decontamination cell where it is decontaminated and placed on a pallet. Process cell HEPA filters are boxed and removed to an adjacent area where they are compacted and placed into 55-gallon drums. The drums are then moved into the decontamination cell and processed in the same manner as the nonfuel-bearing waste drums.

The loading, drum sealing, and drum decontamination of onsite-generated HAW resulting from radwaste treatment are completed in nearby rooms. These drums are then transferred directly to the loadout area.

Secondary waste is moved from the decontamination cell to the welding station area by a transfer cart carrying a pallet of five 55-gallon drums. The pallet is removed by a 35-ton crane and transferred to the outloading area. The outloading area contains a lag storage area assumed to be capable of containing 15 drums of nonfuel-bearing components and 45 drums of high-activity waste.

Drums are placed into drum baskets that hold five drums stacked in a vertical position. A maximum of nine drum baskets is assumed to be brought into the overpack area at a time through the repository shipping cask loadout port in a similar manner as repository overpacks. The bottom of the drum basket consists of a triangular base plate supporting three side supports for the basket. The top of the basket is formed by a triangular top plate with a lifting pintle that bolts to the side supports. Drum baskets are lifted by the 35-ton crane through the loadout port and into the overpack area, where the top plates are removed by 35-ton crane manipulators and guide pins are installed on the three support members. The operating strategy assumed for bringing in empty drum baskets is to have an empty basket ready for loading in each empty discharge lag-storage basket cavity. The discharge lag storage is assumed to contain a total of 12 basket cavities.

Drum basket loading begins after the drum pallet is placed in the loadout area. A 35-ton crane secures a drum grapple attachment for individual drum lifts. After each drum is loaded into the basket, a triangular plate is placed on top of the drum. After the fifth drum is loaded into the basket, the top plate is installed and the drum grapple attachment is exchanged for a bolt manipulator and torque wrench. The top plate is then bolted to the three basket supports and loading is completed. The 35-ton crane then exchanges the bolt manipulator for a lifting attachment, and the drum pallet is returned to the transfer cart.

Shipping cask capacity for secondary waste is assumed to be three baskets of nonfuel-bearing components, or seven to nine baskets of high activity waste. Secondary waste loading is completed through the repository loadout port, similar to loading shipping casks with spent fuel. Secondary waste can also be stored onsite similar to spent-fuel canisters. However, for the purpose of this performance assessment, it was assumed that all secondary waste would be shipped offsite.

Activity times for secondary waste handling are provided in Table 2.4. Activity times not shown (e.g., preparing secondary waste shipping cask for loading) are assumed to be identical to activity times for similar spent-fuel handling activities.

Arrival rates of secondary waste to the shielded canyon cells are dependent on the MTU received by the MRS facility. Each MTU of spent fuel results in 0.4394 drums of nonfuel-bearing components and 0.3842 drums of high activity waste. At 3600 MTU per year, approximately 2965 drums of secondary waste must be handled.

TABLE 2.4. Activity Times for Secondary Waste Handling

Activity	Time (minutes)
Unload Drum Pallet:	
- 35-ton crane goes to pallet	10
- Secure pallet, move to discharge lag storage	15
- Replace lifting grapple with drum grapple	10
- Place drum 1 into basket	5
- Place spacer plate into basket	8
- Place drum 2	5
- Place plate 2	8
- Place drum 3	5
- Place plate 3	8
- Place drum 4	5
- Place plate 4	8
- Place drum 5	5
- Place plate 5	8
- Replace grapple for plate bolting manipulator	10
- Remove guide pins	5
- Bolt plate	15
- Replace manipulator with lifting device	10
- Return pallet	15
TOTAL	155 minutes
Load in Empty Drum Baskets:	
- Place basket cask adapter on cask cart	20
- Place nine baskets on cart (5 minutes each)	45
- Move to handling room, install contamination barrier adapter	20
- Move to unloading room, mate to port	20
- Remove port plugs with 35-ton crane	20
- Lift nine baskets into discharge lag storage (10 minutes each)	90
- Replace plugs	20
- 35-ton crane secures bolt manipulator	10
- Remove nine pintle plates and store (10 minutes each)	90
- Install nine sets of guide pins (5 minutes each set)	45
- Exchange bolt manipulator for lifting device	10
TOTAL	390 minutes
Return cask cart and remove adapters	80 minutes
Place loaded drum basket into shipping cask	20 minutes

2.5 EQUIPMENT RELIABILITY

MRS back-end equipment reliability was reviewed to determine the impact of equipment failure on facility throughput capability. The following five types of equipment were reviewed:

1. 150-ton bridge cranes
2. mobile 40-ton cranes
3. cask carts
4. yard cask transport vehicles
5. 35-ton bridge cranes.

The results of the reliability analysis formed the basis for modeling randomly occurring equipment failures during the simulation of MRS back-end operation. Failure rates for each equipment type and other reliability considerations are discussed in the following sections.

2.5.1 150-Ton Bridge Crane Reliability

The R&H building is served by one 150-ton crane in each of the two transport vehicle R&H areas. Failure of a 150-ton crane would result in the inability of one-half of the R&H building to handle rail casks and would disrupt repository shipping cask handling. To ensure maximum 150-ton bridge crane reliability, periodic preventive maintenance is assumed to be performed in such a manner as to minimize unplanned downtime. Expected 150-ton crane outage rates are provided in Table 2.5.

2.5.2 Mobile 40-Ton Crane/Cask Carts/Yard Cask Transfer Vehicle Reliability

Mobile 40-ton cranes are used in the cask R&H areas for smaller capacity lifts (i.e., lifts not requiring the use of the 150-ton bridge crane). Spare mobile cranes are expected to be available and no reduction in facility throughput is anticipated to be caused by failures associated with the crane.

The cask cart transports the upended repository shipping cask to the shipping cask loading room. Each half of the R&H building is served by one cask cart dedicated to material leaving the MRS site. A review of cask cart availability revealed that the equipment is expected to have a low maintenance requirement, and no cask cart failures were included in the simulation analysis.

TABLE 2.5. 150-Ton Bridge Crane Outages

Potential Component Failure Rates	Time Between Occurrences	Repair Time Each Occurrence (hours)
1. Planned overhaul (preventive maintenance)	5 yr	168
2. Hook damaged - fails nondestructive testing (NDT)	5 yr	60
3. Cable wear	2 yr	48
4. Brake slips/locks	1 yr	12
5. Control malfunction	6 mo	8
6. Motor problems	5 yr	24
7. Travel malfunction (bridge)	5 yr	48
8. Drum wear	5 yr	48
9. Power supply	5 yr	8
10. Inspections: OSHA,[a] third party, other mandatory checks	1 yr	48
11. Surveillance inspection each shift	8 hr	0.2

(a) OSHA - Occupational Safety and Health Administration.

Yard cask transfer vehicles transport concrete storage casks between the cask storage yard, cask manufacturing facility, and storage cask loading room. Similar to mobile 40-ton cranes, yard cask transfer vehicle failures are not expected to reduce facility throughput.

2.5.3 35-Ton Bridge Crane Reliability

Each shielded canyon cell is served by two 35-ton remotely operated bridge cranes that are used for handling canistered spent fuel and drummed secondary waste. Because failure of a 35-ton crane would reduce MRS back-end handling capability, the simulation model used the expected outages presented in Table 2.6 to account for less than 100% 35-ton crane reliability. If needed, the other 35-ton crane can be used when one is down.

TABLE 2.6. 35-Ton Bridge Crane Outages

Potential Component Failure Rates	Time Between Occurrences	Repair Time Each Occurrence (hours)
1. Planned overhaul (preventive maintenance)	5 yr	168
2. Hook or mast-damaged, fails NDT	5 yr	120
3. Lift power package malfunction	2 yr	72
4. Brake slips/locks	1 yr	24
5. Control malfunction	6 mo	16
6. Motor problems	5 yr	48
7. Travel malfunction (bridge)	5 yr	168
10. Power supply	5 yr	8
11. Remote monitor installation	1 mo	4
12. TV-optics	1 mo	4
13. Audio	1 mo	4
14. Lights	1 mo	4
15. Inspections: OSHA, third party, other mandatory checks	1 yr	72
16. Surveillance inspection each shift	8 hr	0.2

3.0 BACK-END MRS MODEL AND ASSUMPTIONS

The back-end MRS model is a discrete event simulation model developed using the SIMAN simulation language. The model simulates the operation of the back-end of the MRS facility. At the back end of the facility, canisters of spent-fuel rods arrive from the weld inspection station, are placed into lag storage, and then are either shipped to the repository or are placed into onsite storage until they can be shipped to the repository.[a] The model simulates the major activities, including activities that occur simultaneously and those that interact.

The model uses the basic concepts found in queuing models, including probability distributions of interarrival times, queues, storage capacities, machines (resources), probability distributions of service times, decision rules, and probability distributions of failure and repair times. The simulation can be started in either an empty and idle state or, more preferably, with an initial inventory of canisters in lag and onsite storage so that steady-state conditions are achieved more rapidly.

The structure of the model's logic and the basic assumptions made in creating the model are described in the next two sections. The input data to the model are described in Chapter 4.0.

3.1 DESCRIPTION OF BACK-END MRS MODEL

The back-end model of the MRS facility consists of five major submodels that separately handle the responsibility for simulating the following five principal activities:

1. interfacing with the front-end MRS model
2. managing lag storage and onsite storage
3. processing overpack and rail-cask shipments to the repository
4. failing and repairing cranes
5. shutting down operations on the weekend.

(a) The model includes the train arrival from the repository and the train departure to the repository. It does not simulate the round trip to the repository or the unloading operation at the repository.

Figure 3.1 shows the relationship of the five submodels. Each submodel is described briefly in the following sections, accompanied by its own block diagram.

A full listing of the SIMAN commands that comprise the back-end MRS model is given in Appendix A. Appendix A also includes a BLOCKS listing of the back-end MRS model. BLOCKS is a SIMAN feature that generates a graphical flow diagram of the model which is easier to understand than the normal listing of commands.

Although the original model listed in Appendix A does not include the handling of secondary waste, an expanded version of the model listed in Appendix B does include the handling of secondary waste through the shielded canyon cells to the exit ports. Secondary waste refers to nonfuel material generated by disassembling spent-fuel assemblies and other waste that must be handled through the shielded canyon cells. Secondary waste is divided into two

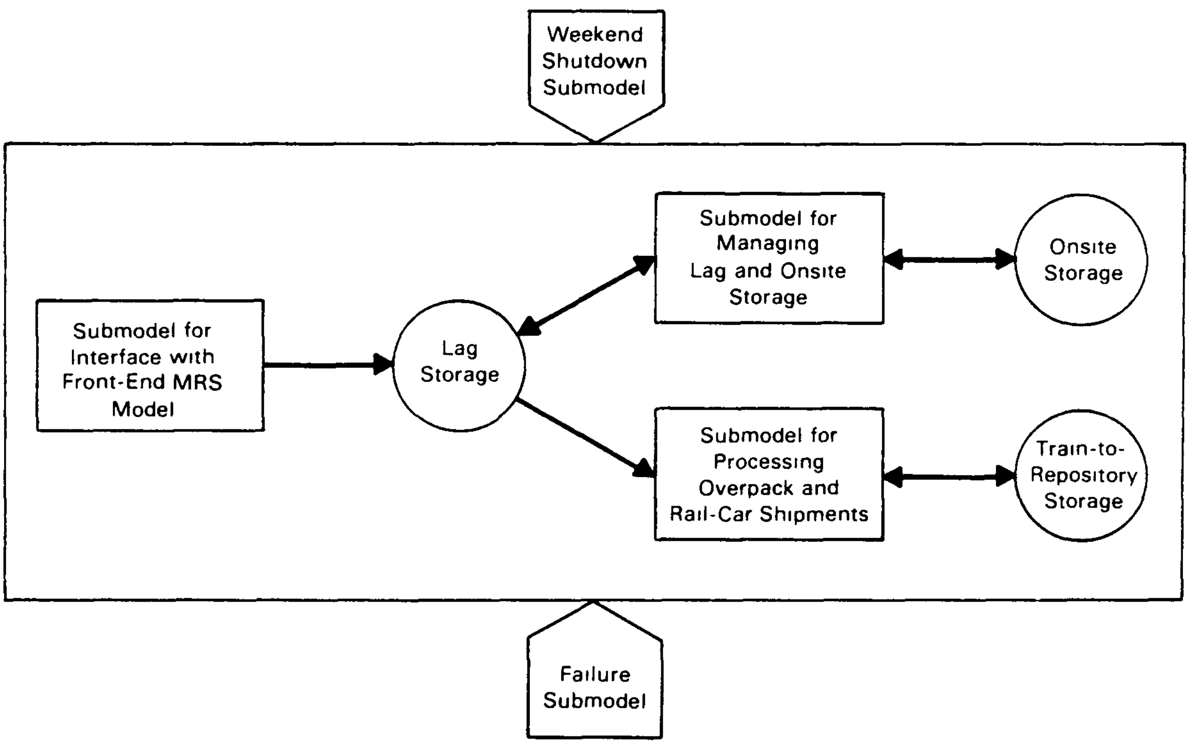

FIGURE 3.1. Major Submodels in Back-End MRS Model

categories: 1) nonfuel-bearing components, and 2) onsite-generated high-activity waste (HAW). Nonfuel-bearing components (referred to as hardware) are the nozzles, grids, guidetubes, etc., remaining from the disassembly, consolidation, and canistering of spent-fuel assemblies. Onsite-generated HAW consists of spent HEPA (high-efficiency particulate air) filters, spent cartridge filters, spent resins from radwaste systems, and evaporator slurry.

3.1.1 Interface with Front-End MRS Model

This submodel starts with the arrival of a welded canister from the weld inspection station, which constitutes the last process in the front-end MRS model. The interarrival times between welded canisters in each half of the R&H building (PWR and BWR sides) are scheduled by randomly sampling from two log-normal distributions [see ED(1) and ED(2) respectively in Table 4.2, which lists the input data]. [In the model, ED(N) refers to the experimental distribution defined for distribution number N on the DISTRIBUTIONS card.] These two distributions track the rate at which the canisters are discharged from the welding station. The arrival of canisters is stopped on weekends if the facility is shut down on weekends.

The logic used to simulate the transfer of the canister to lag storage is the same for each half of the R&H building. Figure 3.2 shows the block diagram for this operation. Before the canister can be placed into lag storage, the 35-ton crane servicing the weld inspection station (referred to as the front 35-ton crane) must be checked to determine if it is operable. The crane's failure, maintenance and repair times are simulated by the failure submodel described in Section 3.1.4. If the crane is not operable, the canister is passed through an access door to the identical crane on the other side of the R&H building.[a] The time to reroute the canister is scheduled by randomly sampling from a triangular distribution [see ED(25) in Table 4.2]. The service time for the crane to place the canister into lag storage is scheduled by randomly sampling from a triangular distribution [see ED(16) in Table 4.2].

(a) The present simulation (pass-through) is as described. Another possibility is for the back 35-ton crane to come forward and move the canister to lag storage. This would require a slight modification to the present model (see Section 3.2).

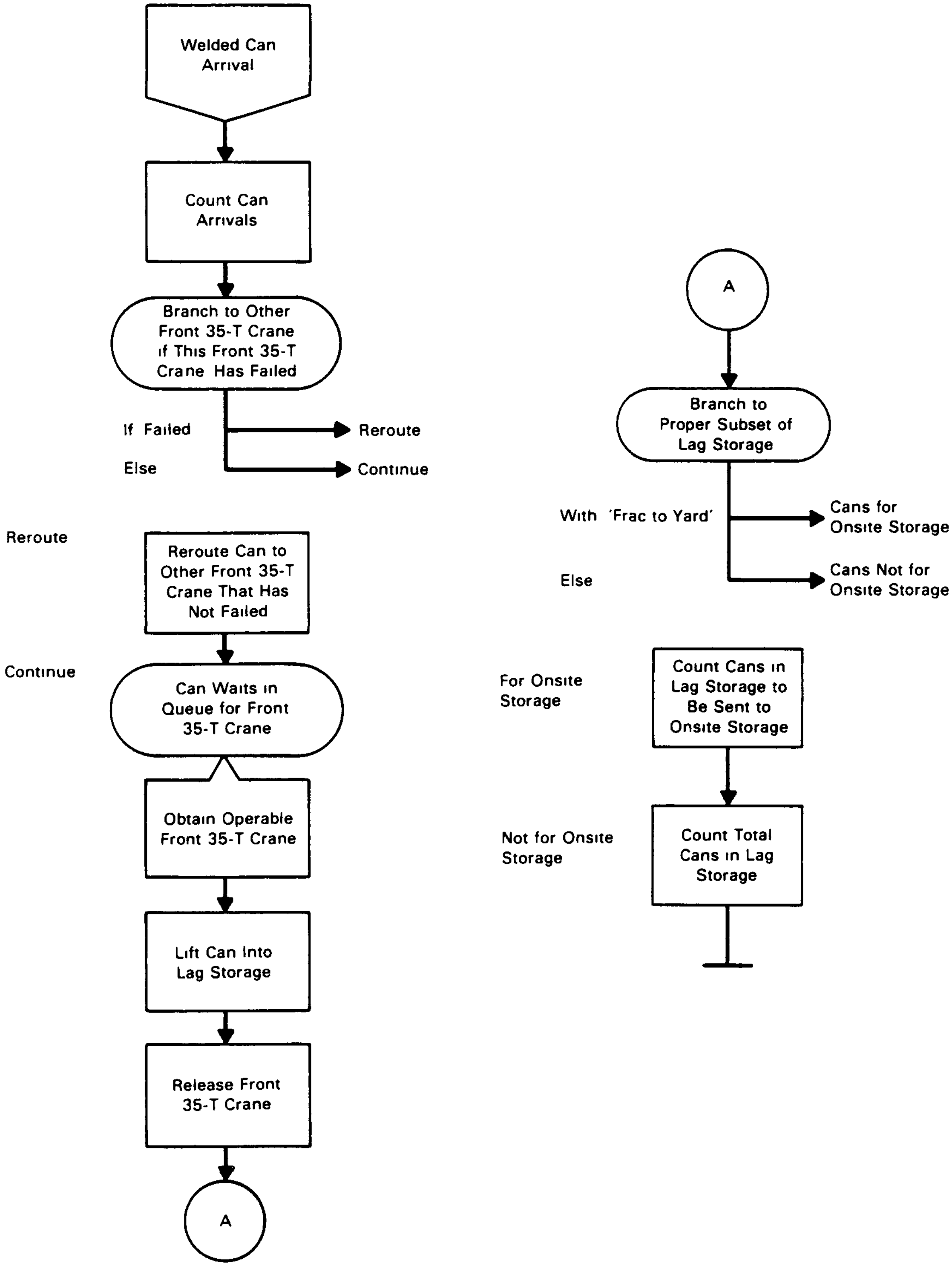

FIGURE 3.2. Interface with Front-End MRS Model

3.1.2 Management of Lag Storage and Onsite Storage

The prudent management of lag storage and onsite storage is accomplished by the model simulation of a lag management logic for each half of the R&H building. The logic periodically checks the following:

1. whether lag storage is above the maximum limit or below the minimum limit specified by the user, requiring canisters to be transferred from lag storage to onsite storage or, conversely, from onsite storage to lag storage
2. whether canisters should be placed from lag storage into onsite storage and subsequently retrieved back into lag storage for reasons other than the maximum and minimum limits, such as, the canister's level of radioactivity.

If neither action is warranted by current conditions, the lag management logic rechecks lag storage after a time delay specified by the user. Figure 3.3 shows the block diagram for the lag management logic.

The user can input values for the maximum and minimum limits for lag storage other than the absolute maximum and minimum as a means to control the canister inventories within lag storage and onsite storage. For example, input of a "maximum" limit significantly below the maximum number of canister positions available in lag storage will provide an upper safety cushion. This will ensure adequate time to transfer canisters from lag storage into onsite storage before the canister inventories in lag storage exceed the absolute maximum limit. Similarly, input of a "minimum" limit significantly above the minimum number of canisters required to load a full train load of rail cars will provide a lower safety cushion. This will ensure adequate time to retrieve canisters from onsite storage (if available) before the canister inventories in lag storage become inadequate to load the rail cars arriving in the near future for shipment to the repository.

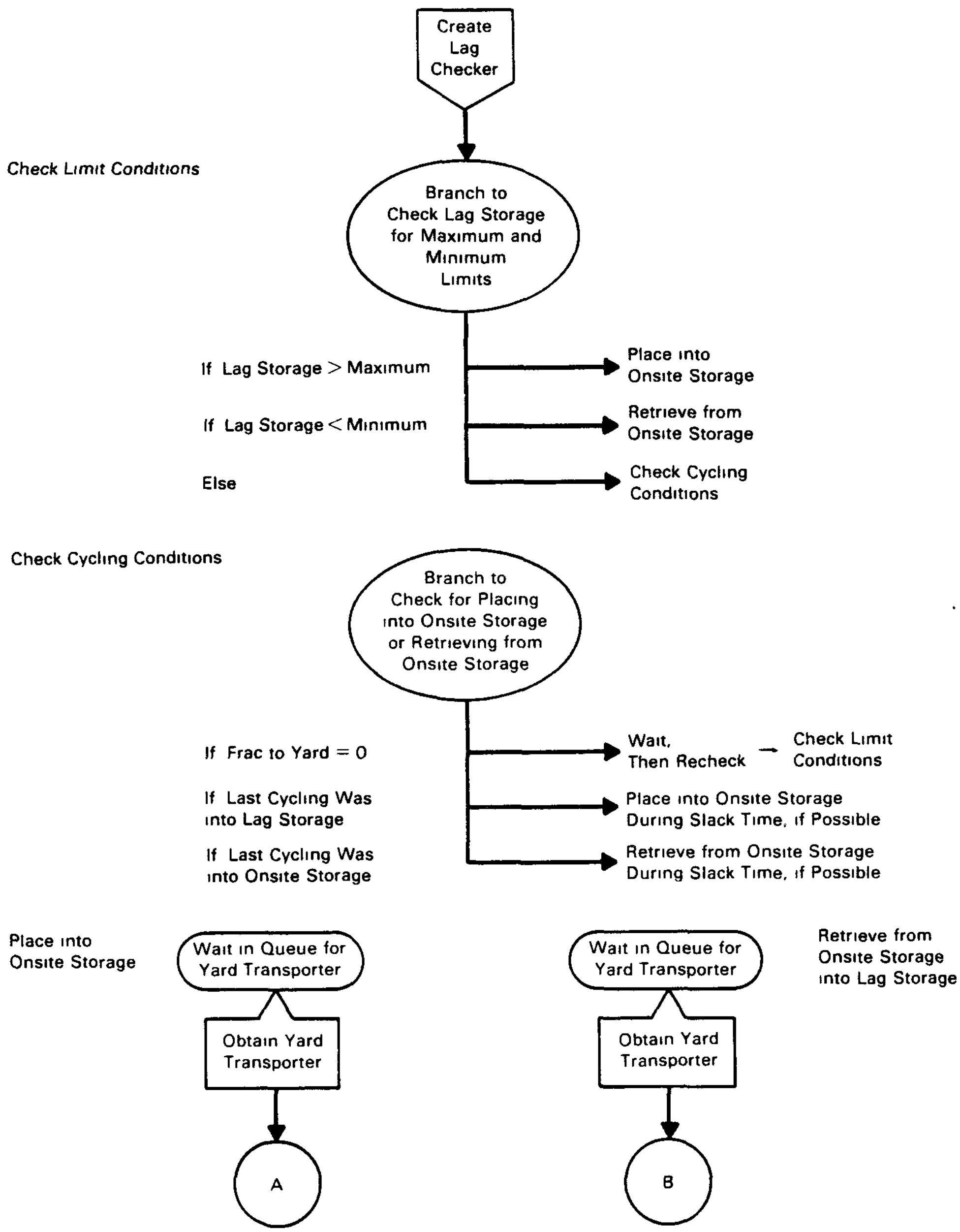

FIGURE 3.3. Lag Management Logic Submodel

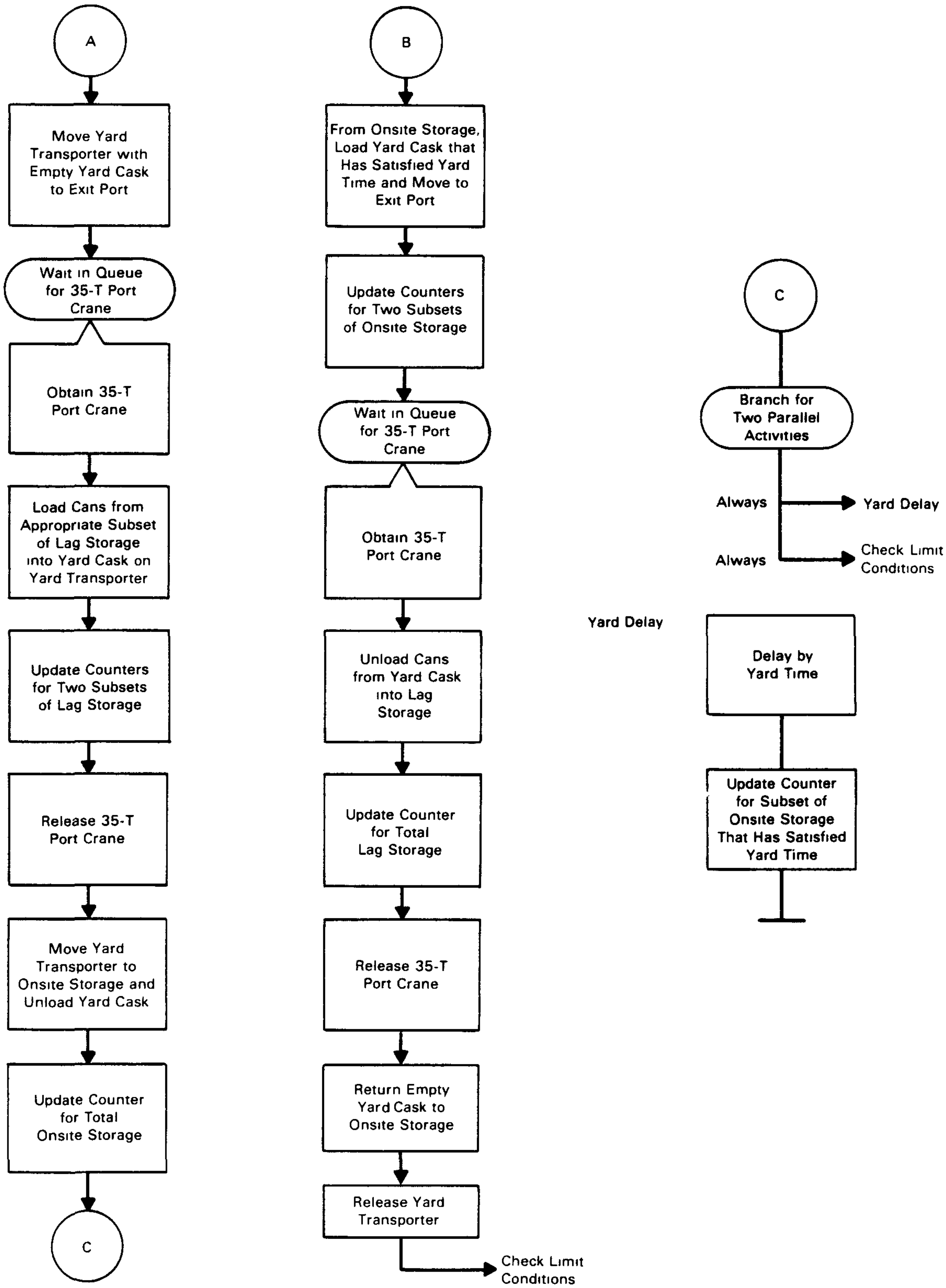

FIGURE 3.3. (contd)

The process of placing canisters from lag storage into onsite storage and subsequently retrieving canisters from onsite storage into lag storage is shown in Figure 3.4.[a] This process is controlled primarily by two input parameters in the model: FRAC TO YARD and YARD TIME.

The first parameter, FRAC TO YARD, specifies the fraction of canisters arriving from the welding station into lag storage that must subsequently be placed into onsite storage. For simulation purposes, lag storage is conceptualized as consisting of two subsets:

1. canisters that must subsequently be placed into lag storage, determined by the input parameter, FRAC TO YARD
2. canisters that do not have to be placed into onsite storage, or have already been retrieved from onsite storage and are eligible to be shipped to the repository.

The procedure for selecting the subset of lag storage into which to place the canisters arriving from the welding station was previously described in Section 3.1.1.

The second parameter, YARD TIME, specifies the minimum residence time each canister must spend in onsite storage before it is eligible to be retrieved back into lag storage for subsequent shipment to the repository. For simulation purposes, onsite storage is also conceptualized as consisting of two subsets:

1. canisters arriving from lag storage
2. canisters in onsite storage that have already satisfied the minimum residence time, YARD TIME, and are eligible to be retrieved back into lag storage for subsequent shipment to the repository.

In the simulation, canisters are placed from lag storage into onsite storage and subsequently retrieved back into lag storage as much as possible during slack times when no rail cars are waiting to be loaded. This strategy reduces

(a) Shown in Figure 3.4, "overpack" is the final container in which geologic disposal occurs.

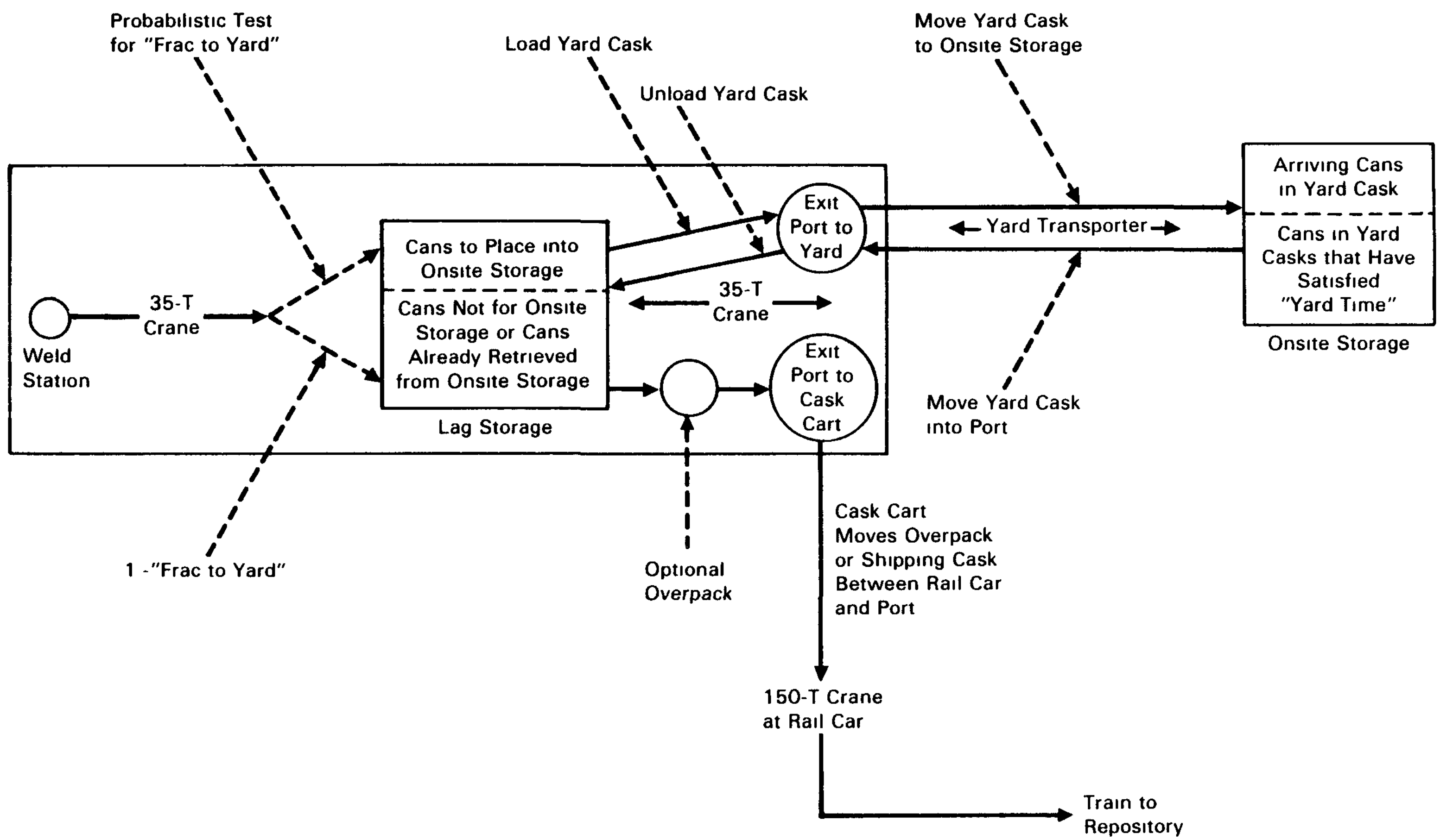

FIGURE 3.4. Simulation of Canister Placement into Onsite Storage and Canister Retrieval from Onsite Storage

the competition for the 35-ton crane that must service both the exit port for shipments to and from onsite storage and the exit port for shipments to the repository. Currently, the lag management logic attempts to consecutively alternate between a placement from lag storage into onsite storage and a retrieval from onsite storage into lag storage in order to balance out the flow of canisters in both directions. If this cycling strategy cannot be achieved, the lag management logic simply transfers in whichever direction is possible. Other cycling strategies can be programmed into the model.

The key input parameters controlling the management of lag storage and onsite storage in the simulation are summarized in Table 3.1 from the input data defined in Chapter 4.0 in Tables 4.1 through 4.3.

Canisters are shipped from lag storage to onsite storage in a yard storage cask using the yard transporter. Each side of the R&H building has one yard transporter. The time to bring the yard transporter and its empty yard cask into the exit port is simulated by the triangular distribution ED(17) in Table 4.2. The 35-ton crane servicing the exit port for onsite storage shipments is used to load canisters from lag storage into the yard cask on the yard transporter. This service time is simulated by another triangular distribution ED(18) in Table 4.2. The time to move the yard transporter to the onsite storage area and to unload the yard cask into onsite storage is simulated by the triangular distribution ED(19) in Table 4.2.

Canisters are also shipped from onsite storage to lag storage in the same yard cask using the yard transporter. The time to load the yard cask from onsite storage onto the yard transporter and bring the loaded yard transporter into the exit port servicing onsite storage shipments is simulated by the triangular distribution ED(6) in Table 4.2. The service time to unload the yard cask and lift the canisters into lag storage using the 35-ton crane is simulated by the triangular distribution ED(7) in Table 4.2. As canisters are transferred between lag storage and onsite storage, the lag management logic collects statistics on the canister inventories in each type of storage.

TABLE 3.1. Key Input Parameters Controlling the Management of Lag Storage and Onsite Storage in the Simulation

	Definition of Input Parameters	Parameter Names in Input Data
1.	Maximum limit desired for lag storage	MAXIMUM = P(1,3)
2.	Minimum limit desired for lag storage	MINIMUM = P(1,4)
3.	Fraction of canisters to place into onsite storage	FRAC TO YARD = P(1,2)
4.	Minimum residence time canister must spend in onsite storage	YARD TIME = P(1,7)
5.	Time delay between rechecks of lag storage conditions	BREAK TIME = ED(5)
6.	Number of canisters shipped in a yard cask from lag storage to onsite storage (same as item 7)	# CANS OUT = P(1,1)
7.	Number of canisters shipped in a yard cask from onsite storage to lag storage (same as item 6)	# CANS IN = P(1,6)
8.	PWR lag storage at beginning of simulation	X(8)
9.	BWR lag storage at beginning of simulation	X(9)
10.	Onsite storage at beginning of simulation	X(10)
11.	Number of canisters in PWR lag storage (Subset 1) waiting to cycle out to onsite storage at beginning of simulation	X(14)
12.	Number of canisters in BWR lag storage (Subset 1) waiting to cycle out to onsite storage at beginning of simulation	X(15)
13.	Number of canisters in onsite storage waiting to be retrieved back into lag storage that have already satisfied the minimum yard residence time at beginning of simulation	X(16)

3.1.3 Processing Overpack and Rail-Cask Shipments to the Repository

This submodel is shown in detail in Figure 3.5. The interarrival times between trains from the repository are determined by randomly sampling from a triangular distribution [see ED(3) in Table 4.2]. All service times involved

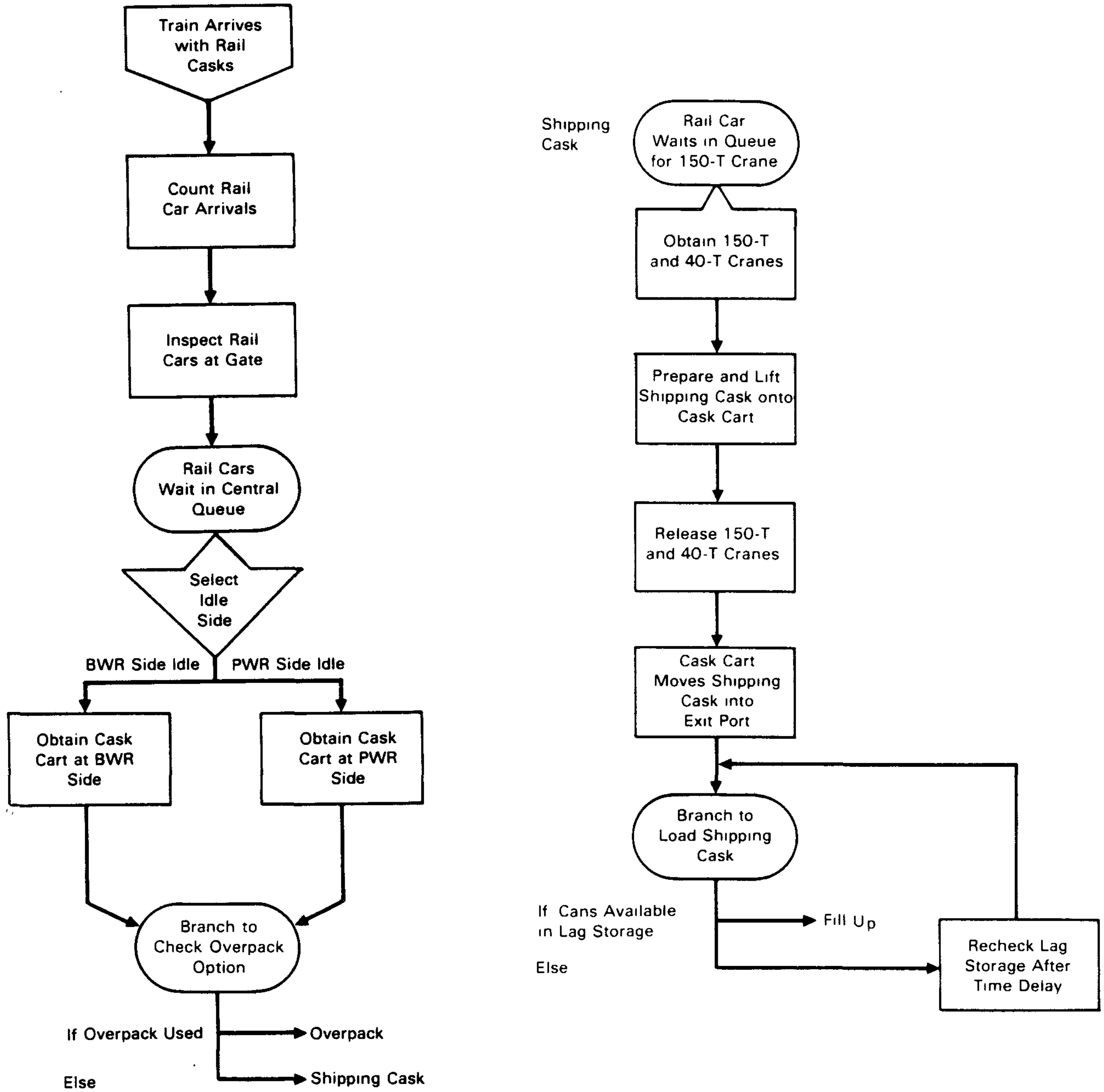

FIGURE 3.5. Rail Cask and Overpack Submodel

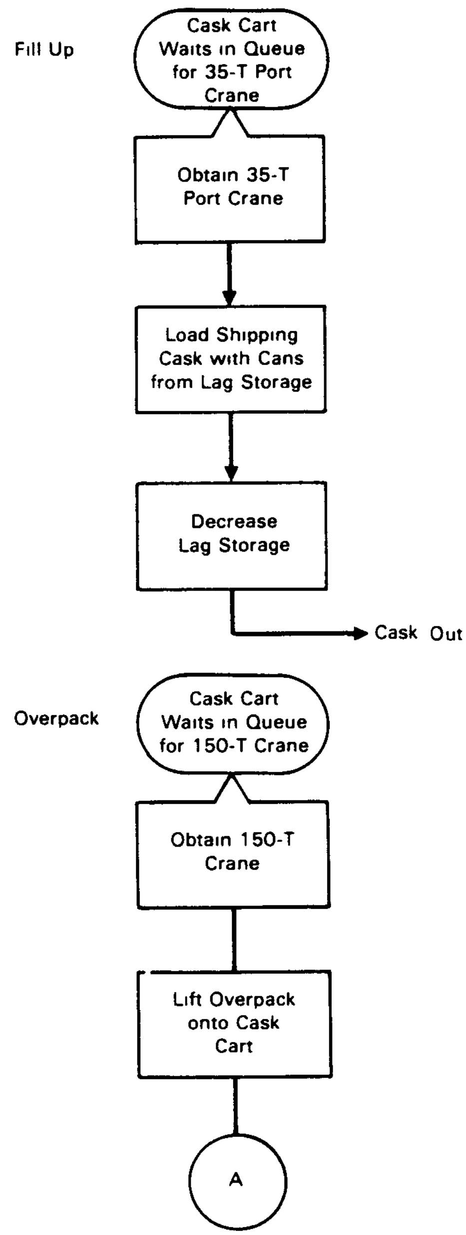

FIGURE 3.5. (contd)

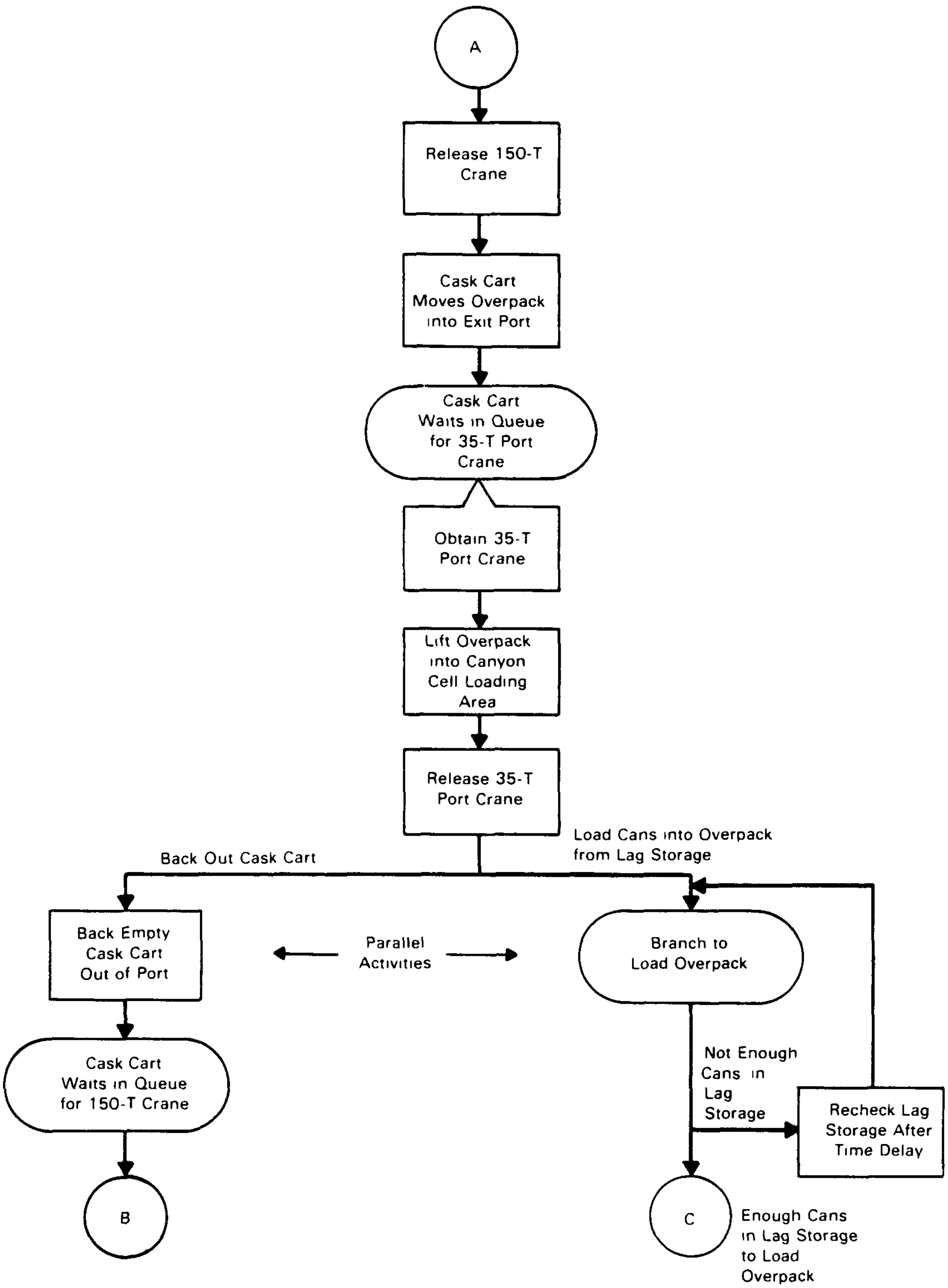

FIGURE 3.5. (contd)

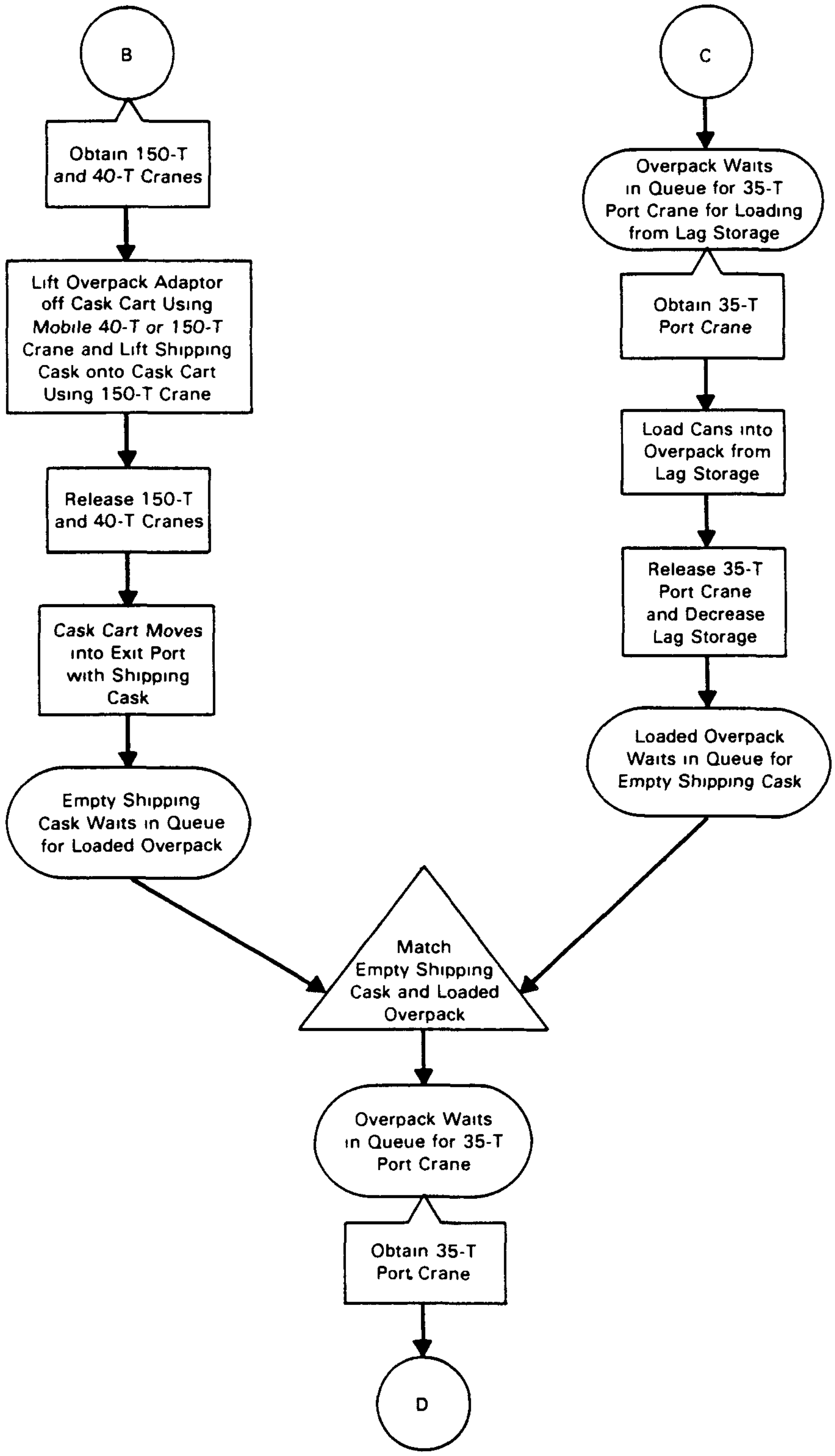

FIGURE 3.5. (contd)

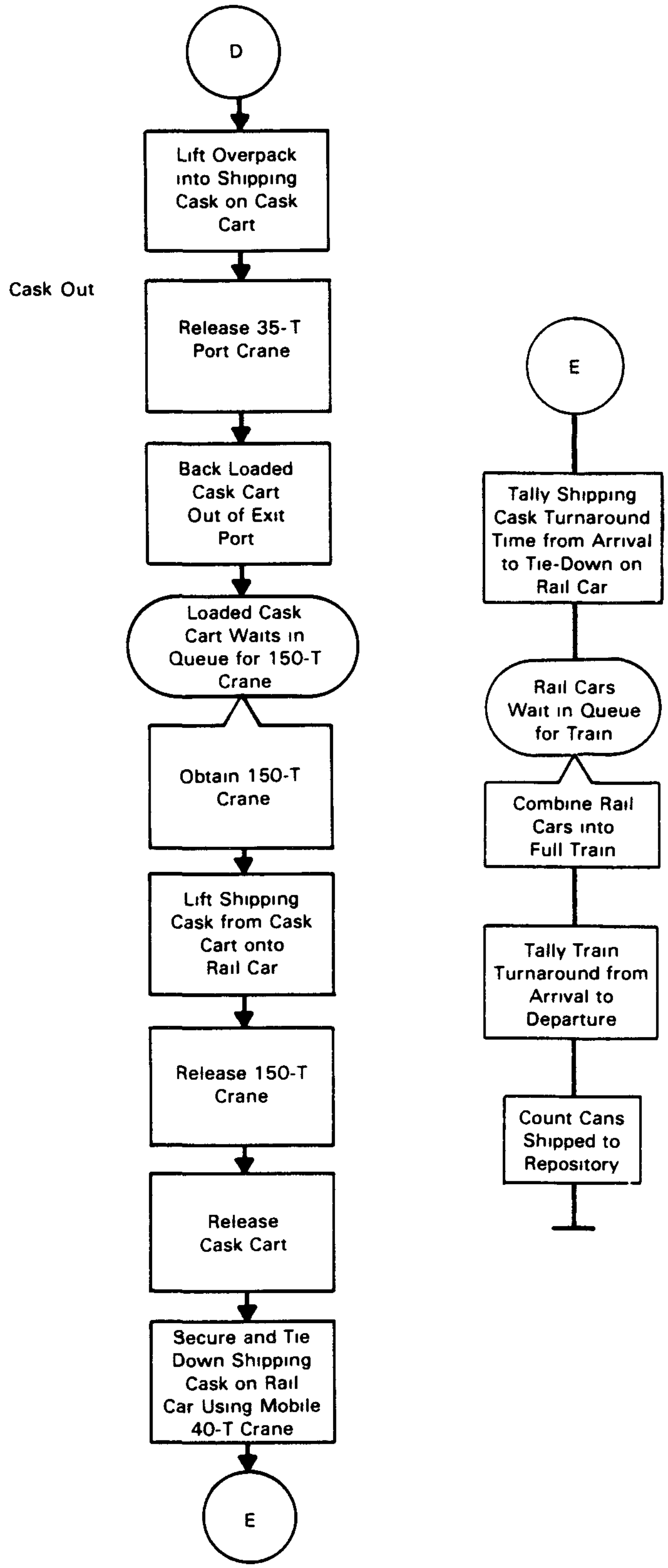

FIGURE 3.5. (contd)

in loading the canisters onto the rail cars for shipment to the repository are determined by sampling from triangular distributions that are defined in the input data and summarized in Table 4.2 of Chapter 4.0.

Arriving rail cars from the repository wait in a central queue by the R&H building. An individual rail car is routed for loading to the idle side of the building (PWR or BWR). Canisters shipped on the rail cars to the repository can either be directly placed into a shipping cask (Option 1) or placed into an overpack, which is then placed into the shipping cask (Option 2).

In the first option, the shipping cask is prepared for unloading from the rail car onto the cask cart using the 150-ton and 40-ton cranes. The shipping cask is removed from the rail car and placed onto the cask cart using the 150-ton crane. The cask cart then moves the shipping cask into the exit port of the building that services shipments to the repository. The 35-ton crane servicing the exit ports loads the canisters from the lag-storage vault into the shipping cask. The cask cart moves the loaded shipping cask from the exit port back out to the 150-ton crane, which lifts the shipping cask off the cask cart onto the rail car. The cask cart is then made available for loading the next shipping cask.

The shipping cask turnaround time is tallied. The rail cars that are loaded with full shipping casks are combined into a full train load for shipment to the repository. The train turnaround time at the MRS facility is tallied to complete the loading process.

In the second option, an overpack is loaded first onto the cask cart using the 150-ton crane. The cask cart moves the overpack into the exit port of the building that services shipments to the repository. The 35-ton crane then lifts the overpack into the canyon cell loading area.

Next, two parallel activities take place: 1) the 35-ton crane loads canisters from the lag-storage vault into the overpack and the overpack is sealed, and 2) the empty cask cart moves back to the rail car, where the overpack adaptor is removed, and the 150-ton crane lifts the shipping cask off the rail car onto the cask cart. The cask cart then moves the shipping cask into the exit port.

When the overpack is loaded and the empty shipping cask is in the exit port, the 35-ton crane lowers the overpack into the shipping cask on the cask cart. Following cask lid placement, the cask cart moves the loaded shipping cask from the exit port back out to the 150-ton crane, which lifts the shipping cask off the cask cart onto the rail car. As in the first option, the shipping cask and train turnaround times at the MRS facility are tallied to complete the loading process.

3.1.4 Failure and Repair of Cranes

The block diagram for the failure and repair of the bridge-mounted cranes is shown in Figure 3.6. The repair of the mobile 40-ton crane is not anticipated to be a significant problem and was therefore not included in the analysis. This submodel simulates four different frequencies (i.e., severities) of random failures and maintenance outages for each of the three cranes in each half of the R&H building. Each type of failure is assumed to be independent of the others and is modeled using a separate breakdown entity. Once the scheduled failure time has arrived, the entity fails the crane as soon as it is idle and holds it until its repair time has elapsed. Following repair, the crane is made available again. The entity is then recycled and delayed until the next scheduled breakdown of this type.

Scheduled failures are not allowed on weekends if the facility is shut down on weekends. In this case, the scheduled failure is delayed until the first weekday. Repair work is allowed on weekends because maintenance personnel are assumed to be on duty at all times.

The different types of failures, frequency of occurrence, and times for repair are defined using the ARRIVALS and PARAMETERS cards in the input data (see Table 4.4 and Appendix A.3). Each arrival specification in the ARRIVALS card creates a breakdown entity which occurs at the beginning of the simulation.

Each breakdown entity has a mean frequency of occurrence (i.e., mean delay time to failure) and a mean repair time (i.e., mean delay time to repair), which are defined using parameter sets in the PARAMETERS card. The parameter sets providing the mean time to failure and mean repair time in the PARAMETERS

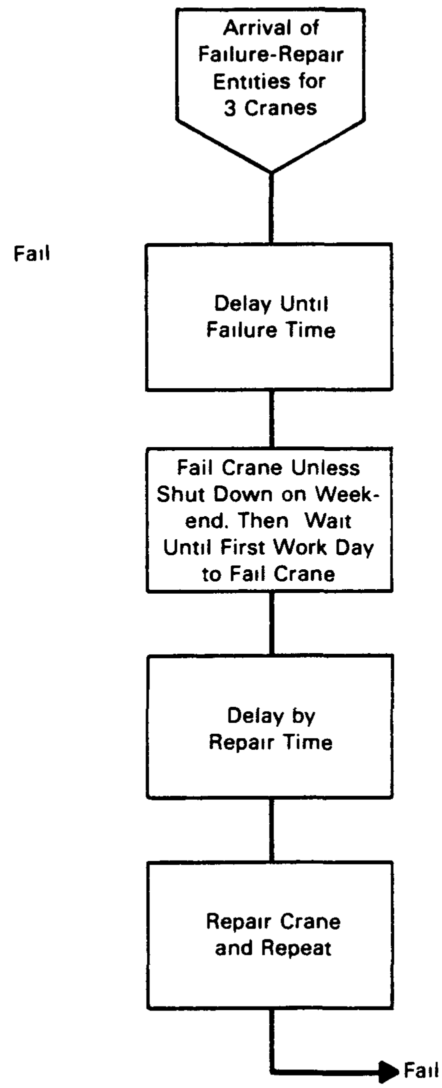

FIGURE 3.6. Failure and Repair Submodel

card are referenced by the values specified for the second and third attributes, respectively, by the ARRIVAL sets in the ARRIVALS card. The first attribute in each ARRIVAL set specifies whether the crane targeted for failure is located in the PWR or BWR side of the R&H building.

In the default input data (see Appendix A.3), the first type of failure occurs with a mean frequency of four months, the second with a mean frequency of six months, the third with a mean frequency of two years, and the fourth with a mean frequency of five years. Failures that occur with a mean frequency of four months have much smaller mean repair times (0.67 days) than more serious failures, which occur with a mean frequency of five years (7 days).

The random delay time to failure for each breakdown entity is scheduled by sampling from an erlang distribution with the mean delay time to failure defined in its associated parameter set. The random delay time to repair is scheduled by sampling from an exponential distribution with mean delay time to repair defined in the associated parameter set for the breakdown entity.

3.1.5 Weekend Shutdowns

The block diagram for the weekend shutdown submodel is shown in Figure 3.7. This weekend submodel turns on the back end of the MRS facility for 4.9 days and off for 2.1 days to simulate a facility shutdown for the weekend. An extra 0.1 days are included in the weekend to allow for shutdown of the machines at the end of the work week. Canister arrivals from the weld station into the back end of the MRS facility are stopped during the weekend shutdown. However, train arrivals from the repository can be optionally continued during the weekend.

Two of each of the following machines (one for each half of the R&H building) are shut down during the weekend:

- front 35-ton crane servicing the weld station
- yard transporter servicing the onsite storage area
- cask cart servicing the rail car
- back 35-ton crane servicing the two exit ports
- 150-ton and 40-ton cranes servicing the rail car.

None of the machines are shut down until they have completed their current activity at the end of the work week. Any crane that is broken down by the failure submodel is not shut down by the weekend submodel unless its repair work is completed during the weekend.

The ALTER operation, instead of the SEIZE operation, from the SIMAN language was used to produce the machine failures and weekend shutdowns. The use of the SEIZE operation would have biased upward the utilization statistics for the machines.

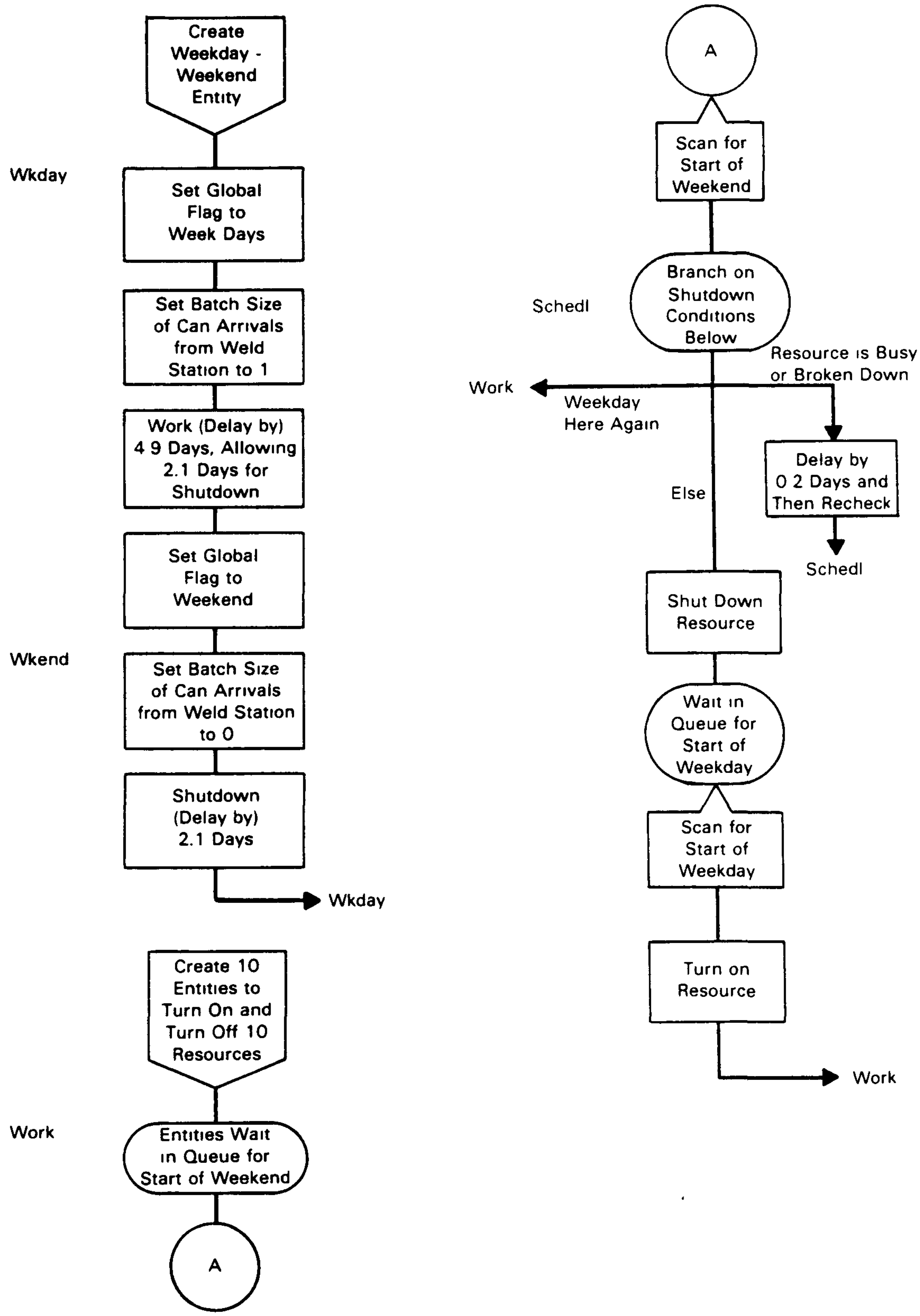

FIGURE 3.7. Weekend Shutdown Submodel

3.2 MODEL ASSUMPTIONS

Developing a computer model to represent the basic structure of a real system inevitably involves assumptions. The assumptions are necessary to build a model that produces a good approximation to the real system yet is not bogged down by its complexity. The principal assumptions made regarding the structure, decision rules, random processes, and system data entering into the model of the back end of the MRS facility are listed below for each major activity simulated in the model.

Interfacing with the Front-End MRS Model

- Canister interarrival times from the weld inspection station (the last station in the front-end MRS model) to the back end of the MRS facility are determined by sampling from two lognormal distributions defined in the input data (one for each side of the building).
- Canister arrivals are stopped on weekends if the facility is shut down on weekends.
- The average PWR and BWR spent-fuel assemblies contain 0.462 MTU and 0.186 MTU, respectively. Three PWR spent-fuel assemblies are in a canister, resulting in 1.386 MTU/canister. Seven BWR spent fuel assemblies are in a canister, resulting in 1.302 MTU/canister. These data are used in estimating annual PWR and BWR arrival rates in MTU/year and canisters/year.
- The 35-ton crane servicing the welding station is used to move canisters from the welding station into lag storage.
- If the 35-ton crane at the welding station is down for repair or maintenance, the canister on the mobile table is rerouted through an access door to the identical crane in the other half of the building. Breakdowns of the mobile table were not included in the analysis. The time for rerouting, as well as the time for nearly all other activities in the model, is determined by sampling from triangular distributions defined in the input data.

- If the 35-ton crane at the exit port is down, the canisters continue to be placed into lag storage by the 35-ton crane at the welding station. If lag storage exceeds 374 canisters in either half of the building's back-end storage, the model stops the simulation and prints a summary report.
- The possibility that both 35-ton cranes servicing one canyon vault storage area would fail simultaneously is included in the model.
- The model could be modified so that the front and back 35-ton cranes in each half of the building assume each other's duties if either one is down and so that both lag storages are used evenly.
- Secondary waste, generated during the disassembly process, was not included in the analysis. However, the expanded version of the model that is listed in Appendix B includes the handling of the secondary waste.

Management of Lag Storage and Onsite Storage

- The lag-storage vault in each half of the building has 374 positions for storing canisters of spent-fuel rods.
- The fraction of canisters arriving from the welding station into lag storage that must subsequently be placed into onsite storage is specified by the input parameter, FRAC TO YARD. The desired fraction is simulated by sampling from a uniform distribution between 0 and 1 and checking whether the random number lies in the range between 0 and FRAC TO YARD. This probabilistic test is applied to each canister arriving from the welding station into lag storage in order to determine how many canisters must be placed into onsite storage.
- Canisters are transferred (due to the input parameter, FRAC TO YARD) between lag storage and onsite storage (in either direction) as much as possible during slack times when no rail cars are waiting to be loaded or are in the process of loading at the R&H building.

- Sufficient canisters that arrive from the welding station into lag storage and that are designated for placement into onsite storage must be available to fill a yard cask before any placement into onsite storage can occur.

- Canisters that are designated for placement into onsite storage must be retrieved back into lag storage before they are eligible to be loaded into an overpack or shipping cask.

- Canisters that are placed into onsite storage must remain in onsite storage for a minimum residence time specified by the input parameter, YARD TIME, before they are eligible to be retrieved back into lag storage. YARD TIME can be any number greater than or equal to 0. As a simplifying assumption, the model does not allow a different yard time independently for each yard cask as a function of the canister's radioactive characteristics of the canisters stored within that yard cask. The input of the age, burnup, and thermal characteristics of the spent fuel consolidated within the canisters can be incorporated into the model in the future and stored as attributes of each canister by modifying the logic in the model. Currently, yard time can be changed from a constant to a distribution, which would result in a different yard time for each yard cask, by a simple modification of the model and the input data.

- All yard storage casks are assumed to be filled to capacity. Upon return to R&H building, yard storage casks are assumed to be emptied completely.

- Canisters retrieved from onsite storage are placed directly into lag storage from an arriving yard cask by the 35-ton crane servicing the exit port. This activity is scheduled as much as possible during slack times when no rail cars are being loaded. For this reason, canisters are first placed into lag storage, rather than directly loaded into an overpack or shipping cask from the yard cask.

- The lag management logic attempts to alternate between a placement of a canister from lag storage into onsite storage and a retrieval of a canister from onsite storage into lag storage to balance out the flow of canisters in both directions. If this transfer strategy cannot be achieved, the lag management logic transfers in whichever direction is possible. Other transfer strategies can be programmed into the model and would require changing the BRANCH statements in the front part of the submodel for management of lag and onsite storage.

- If lag storage exceeds the maximum limit specified by the input parameter, MAXIMUM, which may be $\leq$374, canisters are transferred from lag storage to onsite storage even if 0% placement into onsite storage is specified in the input data (FRAC TO YARD = 0).
- If lag storage drops below the minimum limit specified by the input parameter, MINIMUM, canisters are transferred from onsite storage (if available) into lag storage even if 0% placement into onsite storage is specified in the input data. Canister transfers needed because lag storage drops below the minimum limit can take place even if rail cars are waiting to be loaded. However, the canisters stored within the yard casks in onsite storage must still satisfy the minimum residence time (YARD TIME) before they are eligible to be transferred back into lag storage.
- Only fully loaded yard casks are moved between lag storage and onsite storage (in either direction).
- The maximum lag storage was set to 374 canisters in each half of the building, and the maximum onsite storage was set to 10,000 canisters (see COUNTERS card in the input data in the appendix). If either of these limits is exceeded, the model stops the simulation and prints a summary report.
- The priorities assumed in allocating machines (resources) in the model are ordered by type of activity as follows:

a. All activities related to placing canisters from the welding station into lag storage or retrieving canisters from lag storage for shipment to the repository are assigned priority one (highest).

b. All activities performed by the lag management logic, including placing canisters from lag storage into onsite storage or retrieving canisters from onsite storage into lag storage, are assigned priority two.

Processing Overpack and Rail-Cask Shipments to the Repository

- This submodel can operate either with or without overpacking the canisters in the shipping cask (see OVERPACK parameter in Table 4.1). The default input data operate without overpacking.
- The 35-ton crane at the exit port unloads the overpack from the cask cart at the exit port, moves canisters from lag storage into the overpack, and loads the overpack into the shipping cask at the exit port if overpacking is used.
- Only canisters that do not need to be placed into onsite storage or that have already been placed into onsite storage and retrieved back into lag storage can be loaded into the overpack or shipping cask. If insufficient canisters are available for loading an overpack or shipping cask, lag storage is rechecked for a sufficient number of canisters after a time delay (see CHECK TIME parameter in Table 4.2).
- Train interarrival times from the repository are determined by sampling from a triangular distribution defined in the input data. The average multicar train interarrival time input for the triangular distribution in the default input data (see Chapter 4.0) was calculated by equating the expected annual canister shipments to the repository to the expected annual canister arrivals into the back end of the MRS facility. This is equivalent to simulating a steady-state operation of the MRS facility in which the expected annual canister shipments to the repository are equal to the expected annual canister

arrivals into the back end of the MRS facility. However, other average train interarrival times and other train interarrival distributions can be defined in the input data.

- Train arrivals from the repository can be allowed during weekend shutdowns.
- Arriving rail cars are assumed to wait in a central queue by the R&H building until they can be loaded at one of the two sides of the building. An individual rail car is routed for loading to the side of the building that is idle. If both sides are idle, the rail car is routed to the BWR side because it has the higher annual arrival rate in the default input data.
- Shipping cask turnaround time is computed from the time the shipping cask arrives at the inspection gate until it is loaded back onto the rail car. This includes all waiting times and the idle time over the weekend if the facility is shut down on weekends.
- Train turnaround time is computed from the time of train arrival at the inspection gate until a full train of rail cars is loaded. All waiting time and the idle time over the weekend are included if the facility is shut down on weekends.

Failure and Repair of Cranes

- Only the two 35-ton cranes and the 150-ton crane in the back end of the MRS facility are modeled for breakdown and repair. Failures of the cask cart, yard transporter and 40-ton crane occur too infrequently or are repaired quickly enough so that they have a small impact on the system.
- The time to failure for a crane is determined by sampling from an erlang distribution.
- The time to repair of a crane is determined by sampling from an exponential distribution.
- Crane failures are not allowed to occur on weekends if the facility is shut down on weekends.

- Repair work is allowed on weekends.

Weekend Shutdowns

- The facility operates 3 shifts/day for 365 days/year if it is not shut down on weekends.
- The facility operates 3 shifts/day for 4.9 days/week if it is shut down on weekends. During weekend shutdowns, an extra 0.1 days are included in the weekend to allow for shutdown of the machines at the end of the work week and startup at the beginning of the work week.
- During weekend shutdowns, none of the machines are shut down until they have completed their current activity at the end of the work week.

4.0 INPUT DATA TO BACK-END MRS MODEL

A SIMAN simulation model consists of both a system model and an experimental frame. The latter specifies the experimental conditions for executing the model. All input data to the back-end MRS model are specified in the SIMAN experimental frame using the following elements (i.e., cards): BEGIN, PROJECT, DISCRETE, REPLICATE, INITIALIZE, DISTRIBUTIONS, PARAMETERS, ARRIVALS, TALLIES, DSTAT, COUNTERS, RESOURCES, and END. The first three cards must be the BEGIN, PROJECT, and DISCRETE cards, and last card must be the END card. The rest of the cards may appear in any order.

A listing of the default data in the experimental frame for the back-end MRS model is given in Appendix A. The parameters of greatest interest for the back-end MRS model are defined on the PARAMETERS and INITIALIZE cards in the experimental frame. Most operational scenarios can be simulated by changing only a few of the data values on these two cards.

The default values on the DISTRIBUTIONS, PARAMETERS and INITIALIZE cards are summarized in Tables 4.1 through 4.3, shown at the end of this chapter because of their length. To use data other than the given defaults, the user simply uses a text editor, such as Edlin, Word Star, or Word Perfect, to replace the default data in the experimental frame with the desired data.

All time parameters are entered using units of days. SIMAN allows fractional time inputs in the simulation to provide more accurate information about system interaction and synchronization.

The user may also want to specify which time-dependent data generated by the simulation are to be stored in SIMAN output files that are created with the TALLIES and DSTAT cards. These files can be used with the SIMAN Output Processor or with other software packages, such as LOTUS 1-2-3, to manipulate and plot the time-dependent data.

The format of the cards listed above is described in Pegden (1985). A summary of each type of card's format is shown below. The default values assigned to the parameters by SIMAN, if no input values are specified, are enclosed in parentheses.

PROJECT, TITLE, ANALYST, MON/DAY/YEAR;

TITLE - Project title, alphanumeric, up to 20 characters (blank).

ANALYST - Analyst name, alphanumeric, up to 20 characters (blank).

MON/DAY/YEAR - Three integers separated by slashes (1/1/2000).

DISCRETE, MENT, MATB, NFIL, NSTA;

MENT - Maximum number of concurrent entities in the system, integer (0).

MATB - Maximum number of attributes associated with an entity, integer (0).

NFIL - Number of queue files in the model, integer (0).

NSTA - Number of stations in the model, integer (0).

REPLICATE, NRUNS, TBEG, DTRUN, ISYS, ISTAT, DTCLR;

NRUNS - Number of simulation runs to execute, integer (1).

TBEG - Starting time of first run, real number (0.0).

DTRUN - Maximum length of each run, real number (infinite).

ISYS - Option for initializing the system status between runs, specified as YES or NO (YES).

ISTAT - Option for discarding the statistics between runs, specified as YES or NO (YES).

DTCLR - Offset time from beginning of run when summary statistics are cleared (0.0).

TALLIES: N, ID, NUNIT: repeats ...;

N - The number of the tally register, integer (none). These numbers must be listed sequentially starting at 1 and must match the tally number in the model.

ID - Title of the tally variable in the output, maximum of 16 alphanumeric characters, including embedded blanks (blank).

NUNIT - The output file number containing the individual observations for the tally variable for use in the SIMAN Output Processor, integer (no saving).

DSTAT: N, DVAR, ID, NUNIT: repeats ...;

N - The number of the DSTAT register, integer (none). These numbers must be listed sequentially beginning at 1.

DVAR - Discrete change variable for which time-persistent statistics are to be recorded, specified as X(K), NE(K), NQ(K), NR(K), NT(K), LC(K), MR(K), or MT(K), where K denotes an integer (blank).

ID - Title of DSTAT variable in the output, maximum of 16 alphanumeric characters, including embedded blanks (blank).

NUNIT - The output file number containing the individual observations for the DSTAT variable, integer (no saving).

COUNTERS: N, ID, LIMIT, REINIT, NUNIT: repeats ...;

N - The counter number, integer (none).

ID - Title of counter variable in the output, maximum of 16 alphabetic characters (blank).

LIMIT - The counter limit, integer (infinite). The simulation stops and gives a summary report if the counter exceeds this limit.

REINIT - Option to re-initialize the counter between runs, specified as YES or NO (YES).

NUNIT - The output file number containing the individual observations for the counter, integer (no saving).

The COUNTERS card is used to set a limit on the maximum number of canisters that can be stored in lag storage in each half of the R&H building and in onsite storage. These limits are currently set to 374 canisters in each lag storage vault and 10,000 canisters in onsite storage. If these limits are exceeded, the simulation stops and prints a summary report.

RESOURCES: N, RNAME, NCAP: repeats ...;

N - The resource number, specified as an integer for a simple resource, or a range of numbers for an indexed resource, specified as either N1 or N1-N2 (none).

RNAME - The resource name, maximum of eight alphanumeric characters (none).

NCAP - Resource capacity or capacities, specified as an integer for a simple resource or list of integers separated by commas for an indexed resource (1).

In the back-end MRS model, the machines are indexed resources with the indices and capacities shown below:

1-2 front 35-ton cranes (labeled WCRANE or West Crane in the model) servicing the PWR and BWR welding stations, respectively, each station with one crane.

3-4 yard transporters servicing the PWR and BWR ports, respectively, each port with one cart.

5-6 cask carts servicing the PWR and BWR exit ports, respectively, each side with one cask cart.

7-8 back 35-ton cranes (labeled ECRANE or East Crane in the model) servicing the PWR and BWR exit ports, respectively, each side with one crane.

9-10 150-ton cranes (labeled OH or overhead crane in the model) servicing the rail cars on the PWR and BWR sides, respectively, each side with one crane.

The resource indices are referenced in the model. Consequently, the data on the RESOURCES card should not be changed unless the user is intimately familiar with the model.

INITIALIZE, VAR=VALUE, VAR=VALUE, repeats ...;

VAR - The variable to be initialized, specified as J, global variable X(K), S(K), or D(K), where K is an integer (none).

VALUE - The value to be assigned to the variable at the beginning of the run, constant (none).

DISTRIBUTIONS: N, TYPE: repeats ...;

N - The distribution number (none).

TYPE - The distribution type specified as RA(IS), EX(IP, IS), ER(IP,IS), UN(IP, IS), TR(IP,IS), RN(IP,IS), RL(IP,IS), GA(IP,IS), BE(IP,IS), NP(IP,IS), WE(IP,IS), DP(IP,IS), CP(IP,IS), CO(IP), where IP and IS are integers denoting the parameter set number on the PARAMETERS card and the random number stream, respectively (none).

The distributions in SIMAN are defined as follows:

RA(IS) - Uniform in the interval: 0-1
EX(IP,IS) - Exponential
ER(IP,IS) - Erlang
UN(IP,IS) - Uniform
TR(IP,IS) - Triangular
RN(IP,IS) - Normal
RL(IP,IS) - Lognormal
GA(IP,IS) - Gamma
NP(IP,IS) - Poisson
WE(IP,IS) - Weibull
DP(IP,IS) - User-defined discrete probability distribution
CP(IP,IS) - User-defined continuous probability distribution
CO(IP) - Constant.

PARAMETERS: N, P1, P2, ...: repeats ...;

N - Parameter set number, integer (none).

P - Parameter value, constant (none).

The number and meaning of these parameters depend on the distribution of the random variable on the DISTRIBUTIONS card that is referencing the parameter set. The definitions for each of the distributions included in SIMAN are summarized below.

DISTRIBUTION	Parameters P1	P2	P3
Exponential (EX)	mean		
Erlang (ER)	exponential mean	k (number of exponentials summed)	
Uniform(UN)	minimum	maximum	
Triangular(TR)	minimum	mode	maximum
Normal(RN)	mean	standard deviation	
Lognormal(RL)	mean	standard deviation	
Gamma(GA)	beta	alpha	
Beta(BE)	theta	phi	
Poisson(WP)	mean		
Weibull(WE)	beta	alpha	
Empirical Discrete Probability (DP)	Pk, k = 1,3,...	denote associated cumulative probabilities	
	Pk, k = 2,4,...	denote values of the random variable	
Constant (CO)	constant value		

The DISTRIBUTIONS and the PARAMETERS cards in the default input data for the back-end MRS model are summarized in Table 4.2 at the end of the chapter. The DISTRIBUTIONS card specifies the type of distribution that is sampled for the system operation defined in Table 4.2 to determine the operation time delay. All of the triangular distributions sampled to estimate the service times in the back-end MRS model are defined on the DISTRIBUTIONS and PARAMETERS cards. The modes, or most likely values, of the triangular distributions (except for the train interarrival times) are the average service times obtained from Conceptual Design Report (Vol. VI, Book I, The Ralph M. Parsons Company 1985). The minimum values of the triangular distributions were estimated as 0.90 times the most likely values; the maximum values were estimated as 1.25 times the most likely values. The service activity numbers defined in Table 4.2 are described in Appendix A. Note that all time parameters on the PARAMETERS card for the model are entered using units of days.

In the model, ED(N) refers to the experimental distribution defined for distribution number N on the DISTRIBUTIONS card. For example, the experimental distributions, ED(1) and ED(2), for the interarrival times between canisters are summarized below from Table 4.2.[a]

Canister Interarrival Times From Lognormal Distributions ED(1) and ED(2)

	PWR Side	BWR Side
Mean	0.28757 days/canister	0.2572 days/canister
Standard Deviation	0.09831	0.10973

Assuming 1.386 metric tons of uranium (MTU) in a PWR canister and 1.302 MTU in a BWR canister (see Section 3.1), the expected annual number of canisters and MTU arriving into the back end of the MRS facility are calculated as follows.

PWR Side: $\frac{365 \text{ days/yr}}{0.28757 \text{ canister/day}} = 1269$ canisters/yr, or

1269 canisters/yr * 1.386 MTU/canisters = 1759 MTU/yr

BWR Side: $\frac{365 \text{ days/yr}}{0.2572 \text{ canister/day}} = 1419$ canisters/yr, or

1419 canisters/yr * 1.302 MTU/canister = 1847 MTU/yr.

Total: 2688 canisters/yr, or 3606 MTU/yr.

(a) The means and standard deviations were obtained by running the front-end model for the MRS facility.

Another receipt rate scenario generated by running the front-end model for the MRS facility to assess throughput rates resulted in the following data for the two experimental distributions, ED(1) and ED(2):

Canister Interarrival Times From Lognormal Distributions ED(1) and ED(2)

	PWR Side	BWR Side
Mean	0.24358 days/canister	0.22102 days/canister
Standard Deviation	0.10248	0.10391

These data generate the following expected annual number of canisters and MTU arriving into the back end of the MRS facility:

PWR Side: 1498 canisters/yr = 2077 MTU/yr.
BWR Side: 1651/canisters/yr = 2150 MTU/yr.
Total: 3149 canisters/yr = 4227 MTU/yr.

One of the scenarios of interest is the simulation of steady-state conditions in which the expected annual shipment of canisters to the repository is equal to the expected annual arrival of canisters into the back end of the MRS facility. The experimental distribution for the interarrival times between trains from the repository is defined in Table 4.2 as ED(3), a triangular distribution. The mean time needed between train arrivals to achieve steady-state operation of the back end of the MRS facility is calculated below.

Assume that canisters arrive with interarrival times determined by sampling from two lognormal distributions and that trains arrive from the repository with interarrival times determined by sampling from a symmetric triangular distribution as follows:

Canister interarrivals on PWR side: Lognormal (u_1, 6_1)
Canister interarrivals on BWR side: Lognormal (u_2, 6_2)
Train interarrivals from repository: Triangular (min, u_3, max)

where

u_1, 6_1 and u_2, 6_2 = the mean and standard deviation of the two lognormal distributions, respectively

min, u_3, max = minimum, mean and maximum of the symmetric triangular distribution.

Then, the number of canisters shipped to the repository is calculated as follows:

$$\text{CANS IN TRAIN} = \begin{matrix} \text{CANS IN CASK * X(1) if OVERPACK = 0} \\ \text{CANS IN PACK * X(1) if OVERPACK = 1} \end{matrix}$$

where

CANS IN TRAIN = number of canisters shipped to the repository in a train load of rail cars.

CANS IN CASK = number of canisters in a shipping cask, which is used for shipment if overpacking is not used.

CANS IN PACK = number of canisters in an overpack, which is used for shipment inside a shipping cask if overpacking is used.

OVERPACK = option to overpack canisters before shipment to the repository, with 0 = no overpacking, and 1 = overpacking.

X(1) = number of rail cars in a train to and from the repository.

Thus, if the MRS facility operates at 24 hrs/day for 7 days/week, the expected annual arrival and shipment of canisters is calculated as follows:

$$\text{Expected annual arrival of canisters} = \frac{365}{u_1} + \frac{365}{u_2}$$

$$\text{Expected annual shipment to repository} = \frac{365}{u_3} * \text{CANS IN TRAIN}$$

Solving,

$$u_3 = \frac{365 * \text{CANS IN TRAIN}}{(\frac{365}{u_1} + \frac{365}{u_2})}$$

$$u_3 = \frac{\text{CANS IN TRAIN}}{(\frac{1}{u_1} + \frac{1}{u_2})}$$

where

u_3 = the mean time between train arrivals from the repository needed to achieve steady-state operation of the back end of the MRS facility.

For the default data in Table 4.2, u_3 = 2.0365 days/train for a 3600 MTU/yr throughput rate, where each train consists of 5 rail cars that can transport 3 canisters in a shipping cask on each rail car. The minimum and maximum train interarrival times were set to 0.5 days below and above the average in a symmetric triangular distribution.

The ARRIVALS card is used to specify the external arrival of entities at the crane stations, simulating four different frequencies of failures for each of the three cranes in the back end of the MRS facility. The format of the ARRIVALS card is given below. The default values assigned to the parameters by SIMAN, if no input values are specified, are enclosed in parentheses.

ARRIVALS: N, TYPE, DT, NB, A1, A2, A3, ... repeats;

N - Arrival number, integer (none).

TYPE - Entity type, specified as STATION(K), QUEUE(K), or EVENT(K), where K is an integer (none).

DT - Offset time, real number (0.0).

NB - Batch size, integer (1).

A1,... - Attribute values, specified as an ordered list of real values (0.0).

Failure and repair data for the cranes are shown in Appendix A. Independent exponential distributions were assumed to represent the times to failure and repair times for the individual crane components. For simulation purposes, failure data with the same frequency were combined into erlang distributions by summing the exponential distributions. It may be shown that if X_1, X_2, ..., X_n are independent, identically distributed exponential random variables with a mean of $1/\lambda$, then the sum, $X_1 + X_2 + \ldots + X_n$, has an erlang distribution with mean $n * 1/\lambda$ (Ross 1980; Mendenhall 1981). This approach was used for the three failure frequencies of 1 month, 6 months, and 1 year. The corresponding repair times for the same failure frequencies were also summed for simulation purposes. This approach resulted in erlang failure frequencies of 4 months, 6 months, and 2 years, with corresponding exponential mean repair times of 16 hours, 16 hours, and 96 hours, respectively.

The fourth failure frequency (5 years) was treated as a major breakdown or planned overhaul and modeled using an exponential failure distribution (i.e., erlang distribution with only one exponential in the summation). For the 5-year failure frequency (only), the maximum mean repair time (168 hours) was used for the corresponding exponential mean repair time. In the downtime corresponding to the 5-year failure frequency, all major crane components were assumed to be checked and serviced at the same time using parallel service activities.

The erlang failure distributions and exponential repair distributions are coded directly into the failure and repair submodel and do not appear on the DISTRIBUTIONS card. Table 4.4 (shown at the end of this chapter) summarizes the default input data from the ARRIVALS and PARAMETERS cards that simulate the crane failures in the back-end MRS model. The three attribute values listed in the arrival specifications on the ARRIVALS card are assigned to each SIMAN failure entity to specify the following data:

1. The crane designated for failure (1 = PWR side, 2 = BWR side).
2. The parameter set number on the PARAMETERS card that defines the following failure parameters for the erlang distribution that is coded into the failure and repair submodel:

a. the mean of each exponential distribution summed into the erlang distribution.

b. the number (N) of exponentials summed into the erlang distribution. Note that the mean failure frequency (average time between failures) of the erlang distribution is N * exponential mean failure frequency input in days.

3. The parameter set number on the PARAMETERS card that defines the mean time to repair for the exponential distribution coded into the failure and repair submodel that corresponds to the erlang failure distribution defined in (2). Note that the exponential mean time to repair increases for the different erlang failure frequencies to model more severe types of failures.

Each failure entity simulating a failure frequency and its corresponding repair time are repeated throughout the simulation. For example, the first failure frequency (the least severe type of failure) recurs randomly from an erlang distribution throughout the length of the simulation with an average time of 120 days between failures. Its corresponding random repair time is determined at each failure occurrence by sampling from an exponential distribution with an average repair time of 0.167 days.

TABLE 4.1. Input Data to Back-End MRS Model (nonstochastic variables)

Parameter	Synonym in Model	Description of Parameter	PARAMETERS Card Default Value in Parameter Set No. 1
P(1,1)	# CANS OUT	Number of canisters shipped in a yard cask from lag storage to onsite storage	12
P(1,2)	FRAC TO YARD	Fraction of canisters arriving from the welding station that are to be placed into onsite storage	0
P(1,3)	MAXIMUM	Maximum canister inventory desired in lag storage (same for each half of R&H building). This parameter is normally set as a safety cushion below the absolute maximum of 374 canister positions (see COUNTERS card) in lag storage.	200
P(1,4)	MINIMUM	Minimum canister inventory desired in lag storage (same for each half of R&H building). This parameter is normally set greater than or equal to at least one train load of canisters to the repository.	50
P(1,5)	CANS IN PACK	Number of canisters in full overpack	3
P(1,6)	# CANS IN	Number of canisters in yard cask shipped from onsite storage into lag storage [must be the same as P(1,1)]	12
P(1,7)	YARD TIME	Minimum time canisters within yard cask must spend in onsite storage before they can be retrieved back into lag storage	0

TABLE 4.1. (contd)

Parameter	Synonym in Model	Description of Parameter	PARAMETERS Card Default Value in Parameter Set No. 1
P(1,8)	WKEND TRAINS	Option to specify whether trains can arrive from the repository during weekend shutdowns: 0 = no trains can arrive from the repository during weekend shutdowns 1 = trains can arrive from the repository during weekend shutdowns. If the facility is not shut down on weekends, then trains can arrive from the repository during weekends regardless of the value input for P(1,8).	0
P(1,9)	OVERPACK	Option to overpack canisters before shipment to the repository: 0 = no overpacking 1 = overpacking	0
P(1,10)	CANS IN CASK	Number of canisters loaded into shipping cask for shipment to the repository if no overpack is used. Note: if this value is changed from its default value of 3, then the value for parameter set 51 must also be changed in Table 4.2.	3

TABLE 4.2. Input Data to Back-End MRS Model (stochastic variables)

DISTRIBUTIONS Card: Exp. Dist. No.	DISTRIBUTIONS Card: Exp. Dist.	Synonym in Model	Description of Operation	Activity No.	Par. Set. No.	PARAMETERS Card, Default Value in Parameter Set (time in days): Mean	Standard Deviation	
ED(1)	RL(2,1)	N/A	Interarrival times between PWR canisters from welding station (days/canister)	108	2	0.28757	0.09831	
ED(2)	RL(3,2)	N/A	Interarrival times between BWR canisters from welding station (days/canister)	108	3	0.2572	0.10973	
ED(4)		N/A	Not Used					
ED(5)	CO(6)	BREAK TIME	Time delay between rechecks by lag management logic on minimum and maximum inventory limits input for lag storage		6	0.042	N/A	
						MIN	MODE	MAX[a]
ED(3)	TR(4,3)	N/A	Interarrival times between trains from repository to R&H building (days/train)		4	1.5365	2.0365	2.5365
ED(6)	TR(7,6)	CAN TO PORT TIME	Time delay to retrieve yard cask with its 12 canisters from yard storage and move to port using yard transporter	Table A.4	7	.117	.13	.1625
ED(7)	TR(8,7)	LIFT CANS TO LAG	Time delay to unload 12 canisters from yard cask at port into lag storage using 35-ton crane	Table A.3	8	.315	.35	.438
ED(8)	TR(9,8)	CASK MOVE IN	Time delay to move shipping cask into port using cask cart	357-360	9	.068	.076	.095
ED(9)	TR(10,9)	CASK LOAD	Time delay to load shipping cask at port with overpack	325-328	10	.171	.19	.238
ED(10)	TR(11,4)	CASK MOVE OUT	Time delay to move shipping cask out of port using cask cart	329-330	11	.027	.03	.0375
ED(11)	TR(12,6)	SECURE & TIE	Time delay to secure and tie down shipping cask onto rail car	331-332	12	.054	.06	.075

TABLE 4.2. (contd)

DISTRIBUTIONS Card						PARAMETERS Card: Default Value in Parameter Set (time in days)		
Exp. Dist. No.	Exp. Dist.	Synonym in Model	Description of Operation	Activity No.	Par. Set. No.	MIN	MODE	MAX[a]
ED(12)	TR(13,7)	PACK TO PORT	Time delay to move empty overpack into port using cask cart	314-316	13	.025	.028	.035
ED(13)	TR(14,8)	LIFT PACK	Time delay to lift empty overpack from cask cart at port into canyon cell loading area	317-320	14	.045	.05	.0625
ED(14)	TR(15,9)	LOAD PACK[b]	Time delay for 35-ton crane to load one canister from lag storage into overpack	321-324	15	.028	.03	.038
ED(15)	TR(16,4)	GATE INSPEC	Time delay to inspect and prepare each shipping cask upon arrival at R&H building	301-310	16	.153	.17	.213
ED(16)	TR(33,6)	CAN TO LAG	Time delay to lift one canister from welding station into lag storage using 35-ton crane	108	33	.009	.01	.0125
ED(17)	TR(34,7)	CART TO PORT	Time delay to move yard transporter into port with empty yard cask	215, 216, 201, 202	34	.054	.06	.075
ED(18)	TR(35,8)	CANS INTO CASK	Time delay to lift 12 canisters from lag storage into yard cask at port using 35-ton crane		35	.187	.208	.26
ED(19)	TR(36,9)	CASK TO YARD	Time delay to move yard cask from port to onsite storage and unload yard cask	204-214	36	.162	.18	.225
ED(20)	TR(37,4)	CASK ONOFF	Time delay to lift the shipping cask onto or off the cask cart using the 150-ton crane	308, 309, 356	37	.059	.066	.083
ED(21)	TR(38,6)	OP ON	Time delay to lift the overpack onto the cask cart using the 150-ton crane	309, 311, 312, 313	38	.059	.066	.083
ED(22)	TR(39,7)	CARTOUT	Time delay to back empty cask cart out of port to 150-ton crane	350-353	39	.050	.056	.07

TABLE 4.2. (contd)

DISTRIBUTIONS Card						PARAMETERS Card: Default Value in Parameter Set (time in days)		
Exp. Dist. No.	Exp. Dist.	Synonym in Model	Description of Operation	Activity No.	Par. Set. No.	MIN	MODE	MAX[a]
ED(23)	TR(40,8)	ADAPTOFF	Time delay to lift the adaptor off the cask cart using the 150-ton crane	354	40	.009	.01	.0125
ED(24)	CO(41)	CHECK TIME	Time interval before rechecking lag storage to see if there are sufficient canisters to load overpack or shipping cask		41	N/A	.042	N/A
ED(25)	TR(50,9)	CAN REROUTE TIME	Time delay to reroute canister to front 35-ton crane at welding station on other side of R&H building if the front 35-ton crane at welding station on this side is broken		50	.019	.021	.026
ED(26)	TR(51,4)	LOAD SHIP CASK	Time delay to load 3 canisters from lag storage into shipping cask using back 35-ton crane at exit port		51	.037	.042	.052

(a) For all the triangular distributions, except the train interarrival times, the minimum time = 0.90 * mode time and the maximum time = 1.25 * mode time. Descriptions of the activity numbers are given in the appendix.
(b) The model multiplies the time delay for one canister by the input parameter P(1,5), the number of canisters in a full overpack, to obtain the total time delay to load the overpack with canisters from lag storage.

TABLE 4.3. Input Data and Calculated Variables in Back-End MRS Model (global variables)

Global Variable	Description	Default Value on INITIALIZE Card
X(1)	Number of rail cars in each train arriving from the repository at the R&H building	5
X(2)	Offset time from the beginning of the simulation before the first train arrives from the repository	0
X(3)	Total number of canisters in X(1) rail cars combined as a train for shipment to the repository	No input value[a]
X(4)	Flag set to 1 if the 35-ton crane at the welding station on the PWR side of the building is broken	No input value
X(5)	Flag set to 1 if the 35-ton crane at the welding station on the BWR side of the building is broken	No input value
X(6)	Count of PWR canister arrivals from the welding station	No input value
X(7)	Count of BWR canister arrivals from the welding station	No input value
X(8)	Count of PWR canisters in lag storage at beginning of simulation	150
X(9)	Count of BWR canisters in lag storage at beginning of simulation	150
X(10)	Count of canisters in onsite storage at beginning of simulation	0
X(11)	Count of rail-car arrivals to R&H building	No input value
X(12)	Count of canisters shipped to the repository	No input value
X(13)	Number of rail casks waiting to be loaded at the R&H building	No input value

TABLE 4.3. (contd)

Global Variable	Description	Default Value on INITIALIZE Card
X(14)	Count of canisters in PWR lag storage waiting to be placed into onsite storage at beginning of simulation	0
X(15)	Count of canisters in BWR lag storage waiting to be placed into onsite storage at beginning of simulation	0
X(16)	Count of canisters in onsite storage waiting to be retrieved back into lag storage and having already satisfied the minimum yard residence time at beginning of simulation	0
X(17)	Not used	
X(18)	Offset time on create blocks in submodel that shut down facility on weekends 0 = shut down facility on weekends 1.E6 = do not shut down facility on weekends	1.E6
X(19)	Flag calculated in submodel that shuts down facility on weekends to distinguish between weekdays and weekends 1 = current simulated time is a weekday (workday) 2 = current simulated time is a weekend	No input value
X(20)	Counter calculated in submodel that shuts down facility on weekends to store the indexed resource numbers into the first attribute of the SIMAN weekday-weekend entity	No input value
X(21)	Batch size for creating canister arrivals from the welding station in the interface submodel. If the facility is shut down on weekends, the weekend submodel resets the batch size to 0 on weekends (no canister arrivals) and back to 1 on weekdays (workdays).	1

TABLE 4.3. (contd)

Global Variable	Description	Default Value on INITIALIZE Card
X(22)	Number of rail cars in each train arriving from the repository at the R&H building. This variable is initially set to X(1) internally by the model, but is then reset to 0 during weekend shutdowns by the weekend submodel if no trains are to arrive from the repository during weekend shutdowns. During the work week, X(22) is then reset to X(1) by the weekend submodel.	No input value
X(23)	Number of canisters shipped per rail car to the repository. This variable is set internally by the model to CANS IN PACK if OVERPACK is set to 1 and to CANS IN CASK if OVERPACK is set to 0 (Table 4.1).	No input value
X(24)	Switch calculated by PWR lag manager to try to alternate retrieval into lag storage on PWR side of R&H building with placement into onsite storage 0 = last cycle into lag storage on PWR side 1 = last cycle out to onsite storage from PWR side	No input value
X(25)	Switch calculated by BWR lag manager to try to alternate retrieval into lag storage on BWR side of R&H building with placement into onsite storage 0 = last cycle into lag storage on BWR side 1 = last cycle out to onsite storage from BWR side	No input value
X(26)	Flag calculated by PWR lag management logic to determine from which of the two subsets of lag storage canisters should be taken when transferring canisters from lag storage into onsite storage: 0 = subset of canisters in lag storage that do not need to cycle out to onsite storage or have already returned from onsite storage (only used to transfer out to onsite storage under certain conditions when canisters exceed the maximum number desired in lag storage due to parameter MAXIMUM in the input data)	No input value

TABLE 4.3. (contd)

Global Variable	Description	Default Value on INITIALIZE Card
	1 = subset of canisters in lag storage waiting to cycle out to onsite storage (used when cycling canisters out to onsite storage due to parameter FRAC TO YARD in the input data).	
X(27)	Flag calculated to perform a similar function by BWR lag management logic as described above for X(26) and the PWR lag management logic.	No input value

(a) Global variables with no input values are computed internally by the model.

TABLE 4.4 Input Data to Back-End MRS Model (crane failure and repair data)

ARRIVALS Card		PARAMETERS Card Failure Parameters for Erlang				PARAMETERS Card Corresponding Repair Parameters for Exponential	
Crane Station	Crane Label in Model[a]	Parameter Set Number	Exponential Mean	Number of Exponentials	Erlang Failure Frequency (days)	Parameter Set Number	Exponential Mean (mean time for repair)
5-Weld, Lag	35-ton West	17	30	4	120	25	0.67
5-Weld, Lag	35-ton West	18	180	1	180	26	0.67
5-Weld, Lag	35-ton West	19	365	2	730	27	4
5-Weld, Lag	35-ton West	20	1825	1	1825	28	7
6-Lag, Exit Ports	35-ton East	21	30	4	120	29	0.67
6-Lag, Exit Ports	35-ton East	22	180	1	180	30	0.67
6-Lag, Exit Ports	35-ton East	23	365	2	730	31	4
6-Lag, Exit Ports	35-ton East	24	1825	1	1825	32	7
9-Rail Cars	150-ton OH	42	30	4	120	46	0.67
9-Rail Cars	150-ton OH	43	180	1	180	47	0.67
9-Rail Cars	150-ton OH	44	365	2	730	48	4
9-Rail Cars	150-ton OH	45	1825	1	1825	49	7

(a) The 35-ton West crane refers to the crane servicing the welding station. The 35-ton East crane refers to the crane servicing the exit ports. The 150-ton OH crane refers to the crane servicing the rail cars.

5.0 COMPILING, LINKING, AND EXECUTING THE BACK-END MRS MODEL

After the data are input into the experimental frame, the user is ready to compile, link, and execute the back-end MRS model. These three procedures are accomplished in the following four steps:

1. Compile the system model stored in the file BKMRS.MOD to form the model file BKMRS.M using the SIMAN model processor.
2. Compile the experimental frame stored in the file BKMRS.EXP to form the experiment file BKMRS.E using the SIMAN experiment processor.
3. Link the model file BKMRS.M and the experiment file BKMRS.E together into the program file BKMRS.P using the SIMAN link processor.
4. Execute the program file BKMRS.P using the SIMAN run processor.

The commands to accomplish these four steps are given below in the proper sequence for the SIMAN simulation packages on the IBM-PC and VAX minicomputer.

PC Version of SIMAN	VAX Version of SIMAN
1. MODEL BKMRS.MOD BKMRS.M	MOD BKMRS
2. EXPMT BKMRS.EXP BKMRS.E	EXP BKMRS
3. LINKER BKMRS.M BKMRS.E BKMRS.P	LNK BKMRS BKMRS
4. SIMAN BKMRS.P or	SIM BKMRS
SIMAN BKMRS.P > OUTPUT.LST	

The PC version requires the user to specify the file names of the compiled model and experiment files, while the VAX version automatically creates a .M file for the compiled model file and an .E file for the compiled experiment file. Once the user has compiled the system model to form the model file (Step 1), the model will not have to be recompiled again unless the logic is changed inside the system model. However, the user must recompile the experiment file and link it with the compiled model file (Steps 2 and 3) each time new data are entered into the experimental frame for a new simulation. The fourth step in the PC version of SIMAN shows how the user has the option to route the simulation summary report to the terminal screen or to a file on the floppy diskette.

The system model (BKMRS.MOD) and experimental frame (BKMRS.EXP) use about 32,000 and 7,500 bytes, respectively, of storage space on a floppy diskette. The compiled and linked program (BKMRS.P) uses about 55,000 bytes of storage space on a floppy diskette. The back-end MRS model (BKMRS.P) requires about ten minutes on an IBM-PC to simulate six months of operation of the back end of the MRS facility.

6.0 SIMULATION OUTPUT FROM THE BACK-END MRS MODEL

The simulation output from the back-end MRS model can provide statistical estimates on almost any status variables of interest for assessing the operational performance of the back end of the MRS facility. The output currently includes statistics on 54 different status variables collected during the simulation. SIMAN reports the statistics in two types of output:

1. A SIMAN Summary Report
2. An optional set of SIMAN output files containing data for use by the SIMAN Output Processor and other post processors.

The SIMAN Summary Report prints information concerning TALLY, DSTAT, and COUNTER variables. The TALLY variables provide summary statistics on time-dependent status variables. Examples are the shipping cask turnaround times (queue waiting time + service time) for the PWR and BWR sides of the R&H building and the train turnaround times (queue waiting time + service time) for the whole MRS facility. The summary statistics consist of the mean, standard deviation, minimum, maximum, and the number of observations over the length of the simulation.

The DSTAT variables provide summary statistics on 41 discrete time-dependent status variables (see Table 6.1). Statistics consist of the mean, standard deviation, minimum, maximum, and time period. A complete listing of all the DSTAT variables in the model is given in Appendix A. The principal DSTAT variables of interest are summarized below, together with their DSTAT number on the SIMAN Summary Report.

The COUNTER variables provide summary statistics on 20 status variables. These show the system status at the end of the simulation run. Most of the COUNTER variables were previously included in the DSTAT variables. However, 6 new status variables tabulate the number of failures and repairs for the 35-ton cranes servicing the welding station, the 35-ton cranes servicing the exit ports, and the 150-ton cranes servicing the rail cars. The failure and repair totals include both sides of the building.

TABLE 6.1. Principal DSTAT Variables

DSTAT Number	Description of Discrete Status Variables
1-2	Canister queue lengths waiting for the 35-ton crane servicing the welding station in each half of the R&H building. The queue capacity is two canisters, each on a separate upender table.
11	Rail (shipping) cask queue lengths
22-31	Utilization of cranes, cask cart, and yard transporter in each half of the building
32-33	Canister arrivals into the back end of the MRS facility in each half of the building
34-35	Lag storage requirements in each half of the building
36	Onsite storage requirements
37	Rail (shipping) cask arrivals from the repository
38	Throughput rate, i.e., number of canisters shipped to the repository
39-40	Number of canisters in each lag storage waiting to be placed into onsite storage, resulting from the input parameter, FRAC TO YARD
41	Number of canisters waiting to be retrieved from onsite storage that have satisfied the minimum residence time specified by the input parameter, YARD TIME.

The second type of simulation output consists of SIMAN output files that contain all of the individual time-dependent data used to generate the SIMAN Summary Report. Each of the TALLY and DSTAT (discrete change) variables printed in the SIMAN Summary Report can be assigned a separate SIMAN output file for saving all of the individual observations and chronological history generated by the simulation. Each variable change and the time of the change are then recorded in the assigned output file. SIMAN creates file names of the form, OUTPUT.#, where # is the file number that the user assigns to a given TALLIES or DSTAT variable on the TALLIES or DSTAT cards.

Since stochastic simulations are a sampling experiment, the output from the back-end MRS model should be interpreted using statistical methods to estimate the true system response over time. The SIMAN Output Processor can be applied to the SIMAN output files to analyze and interpret the individual time-dependent data using the following statistical and graphical methods:

1. Statistical tests, such as correlations, moving averages, grouping the data into batches, confidence intervals about the mean, comparison of means, and one-way analyses of variances.

2. Graphical presentations, such as histograms, correlograms, bargraphs, and plots on X-Y axes.

In addition, the SIMAN-formatted files can be exported as DIF-formatted files for use by LOTUS 1-2-3 or ASCII-formatted files.

An example simulation is included in Appendix A. The model and default input data in the experimental frame are listed. The sample output was generated by simulating the operation of the back end of the MRS facility for 11 years, using 3 shifts/day and 7/days/week, with a receipt rate of 3600 MTU/year. The handling of secondary waste was not included in this particular example, but is included in Appendix B. The values of the input parameters (Section 3.2.2) used to simulate the management of lag storage and onsite storage in the sample output are listed in Table 6.2.

A listing of the SIMAN Summary Report also is provided in Appendix A, along with examples of the graphics that can be obtained from the SIMAN output files containing the raw data from the simulation. The graphs were generated using the SIMAN data files created with the TALLIES and DSTAT cards. The raw data generated were compressed to yield time averages based on quarters of a year for the DSTAT variables using a user-programmed routine. The histograms were generated using the SIMAN Output Processor. This is only a partial subset of the raw data that can be obtained from the SIMAN output files. Additional information can be obtained from the output files with the use of the SIMAN Output Processor.

TABLE 6.2. Values of the Input Parameters for Simulating Management of Lag Storage and Onsite Storage in the Sample Output

Global Input Parameters		Nonstochastic Input Parameters
PWR lag storage at startup	= X(8) = 200	# CANS OUT = P(1,1) = 12
BWR lag storage at startup	= X(9) = 200	FRAC TO YARD = P(1,2) = 0.25
Onsite storage at startup	= X(10) = 50	MAXIMUM = P(1,3) = 280
Canisters in PWR lag storage waiting to cycle out to onsite storage at startup	= X(14) = 50	MINIMUM = P(1,4) = 70 # CANS IN = P(1,6) = 12
Canisters in BWR lag storage waiting to cycle out to onsite storage at startup	= X(15) = 50	YARD TIME = P(1,7) = 30
Canisters in onsite storage waiting to be retrieved back into lag storage at startup	= X(16) = 50	

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APPENDIX A

BACK-END MODEL INFORMATION--MODEL LISTING AND INPUT DATA

APPENDIX A

BACK-END MODEL INFORMATION--MODEL LISTING AND INPUT DATA

This appendix contains information on crane failure frequency and repair data (Section A.1), process steps and time estimates for the simulation runs (Section A.2), the default data in the experimental frame (Section A.3) and example output (Section A.4). Also included are the listing (Sections A.5) and block diagrams (Section A.6) of the back-end MRS model.

A.1 CRANE FAILURE FREQUENCY AND REPAIR DATA

The data used to form the failure and repair submodel for the cranes are listed below. These data were obtained from personal contacts with managers of nuclear facilities and are based upon the managers' maintenance experience with cranes. The data are representative of failure of crane components. However, because the 35-ton crane most likely will be of power mast design, these failure rates are not exact (i.e., power mast cranes can be designed without

Crane Equipment Failure and Repair Data

Component Failure	Frequency	Repair (hr)
1. Major breakdown or planned overhaul	5 yr	168
2. Hook fails	5 yr	120
3. Break slips/locks	1 yr	24
4. Control malfunction	6 mo	16
5. Motor problems	5 yr	48
6. Travel malfunction	5 yr	168
7. Drum wear	5 yr	72
8. Power supply	5 yr	8
9. Remote monitor installed	1 mo	4
10. Television optics	1 mo	4
11. Audio	1 mo	4
12. Lights	1 mo	4
13. Inspections and mandatory checks	1 yr	72

cables, and therefore no drum failures will occur). As better information on MRS crane failure rates and designs are developed, the model parameters will need to be updated and revised.

A.2 PROCESS STEPS AND TIME ESTIMATES FOR MRS SIMULATION

The process steps and their average time estimates used in the simulation of the back end of the MRS facility are listed in Tables A.1 through A.5.

TABLE A.1. Estimated Process Time for Packaging of Spent Fuel (Parsons 1985)

Shielded Canyon Cell Packaging Operations for Spent Fuel (all time in minutes)

Activity Number	Operation Description	Operation Time	West Cell Crane	Upender Number 1	Upender Number 3	Canister Weld/DC Chamber	Master/ Slave Manipulation	UT Inspect Station	Lid Cutting Station	Clean Canister Carousel
100	Index clean canister carousel, raise rack, lift port plug, set down plug, lift canister, place on Upender Number 1, replace plug	30	30	30	--	--	--	--	--	30
101	Downend Upender Number 1 (with canister), rotate, translate, and position to receive fuel bundle	15	--	15	---	--	--	--	--	--
102	Receive fuel bundle from consolidation process Cell 1 (simultaneously with activity 46 from Cell 1 or Cell 3)	15	--	15	--	--	--	--	--	--
103	Retract from position, rotate canister, and translate to welder centerline	15	--	15	--	5	--	--	--	--
104	Insert canister into chamber, evacuate canister and chamber, backfill with inert gas and weld	20	--	20	--	20	--	--	--	--
105	Transfer canister into decontamination chamber, decontaminate, drain chamber, and evacuate chamber for leak check	35	--	35	--	35	--	--	--	--
106	Open air lock, swipe canister while transferring to upender	15	--	15	--	15	15	--	--	--
107	Transfer welded canister to ultrasonic station, inspect and verify weld	45	--	45	--	--	--	45	45	--
108	Retract canister, translate to open position, upend canister and place canister into lag-storage vault	15	15	15	--	--	--	--	--	--
SUBTOTAL (Critical Path Items 102-108)		160	15	160	0	75	15	45	45	0
TOTAL		205	45	205	0	75	15	45	45	30

TABLE A.2. Estimated Process Times for Sealed Storage Casks (Parsons 1985)

Shielded Canyon Cell Field Operations for Sealed Storage Cask (all time in minutes)

Activity Number	Operation Description	Operation Time	Monorail Crane	Cask Xporter	West Cell Crane
201	Move cask into unloading room	15	--	15	--
202	Install contamination barrier and shield ring, move into corridor	15	15	15	--
203	Remove shield plug, install canisters, install shield plug	300	--	--	300
204	Remove contamination barrier and shield ring, move into corridor	20	20	20	--
205	Perform contamination survey of cask top	10	--	10	--
206	Remove plug lifting eyes, install cover and welder, set up welder	20	20	20	--
207	Make weld	60	--	60	--
208	Remove welder	5	5	5	--
209	Visually inspect weld	10	--	10	--
210	Magnetic particle inspect weld	30	--	30	--
210A	Pressure check cask interior	40	--	40	--
211	Clean weld area and coat	15	--	15	--
212	Move cask to storage area	30	--	30	--
213	Position lifting fixture and lift cask	10	--	10	--
214	Emplace cask and disengage lift fixture	15	--	15	--
215	Return cask transporter to Casks Manufacturing Facility	30	--	30	--
216	Set new cask on transporter and move to Receiving and Handling area	30	--	30	--
SUBTOTAL (Critical Path Items 201-216 less 203)		315	60	255	0
TOTAL (201-216 where 210 and 210A are parallel operations)		615	60	255	300

The estimates numbered 100 through 107 are modeled in the front end of the MRS facility. The activities modeled in the back end of the MRS facility begin with activity number 108.

TABLE A.3. Estimated Times for Processing Retrieved Canisters (spent fuel and high level waste) (Parsons 1985)

Procedure	Time: Hour	Time: Minute
Remove canister from concrete cask or drywell transfer shield; place on Shielded Canyon Cell 6 upender	--	20
Perform contamination survey of canister[a]	--	20
Decontaminate canister if required[a]	--	30
Resurvey canister for contamination	--	20
Transfer clean canister to in-building lag storage in preparation for repository overpack processing or alternative shipping processing	--	20
TOTAL	1	50
TOTAL (if decontamination not required)	--	40
TOTAL (if contamination survey indicates canister is clean)	1	0

(a) First canister removed from cask is surveyed for contamination; if contamination is indicated by survey, the canister and all subsequent canisters from the cask are decontaminated. All canisters from drywells are surveyed when removed from the transfer shield.

Total cask (12 canisters) processing time required for all to be decontaminated = 18 hours 20 minutes.

Total cask (12 canisters) processing time required for all clean canisters = 8 hours 20 minutes.

TABLE A.4. Estimated Times for Sealed Storage Cask Handling (Parsons 1985)

Procedure	Time Hour	Time Minute
Retrieval		
Load cask onto transporter	--	35
Move cask to R&H building	--	30
Prepare cask for unloading	2	0
Subtotal	3	5
Unloading		
Position cask under exit port - engage contamination barrier - close shadow shield	--	20
Remove shield plugs from exit port; remove shield plug from cask	--	20
Unload and decontaminate canisters	Varies	
Subtotal (minimum time)	--	40
Discharge		
Replace cask shield plug and exit port shield plugs	--	20
Open shadow shield and disengage contamination barrier; remove cask from unloading room	--	15
Prepare cask for temporary storage	1	0
Transport cask to temporary storage area; remove lifting yoke	--	30
Place cask onto storage pad	--	35
Subtotal	2	40
Total	6	25

TABLE A.5. Estimated Process Times for Repository Overpack and Shipping Cask for Repository Overpack (Parsons 1985)

Repository Overpack (RO)/Shipping Cask for Repository Overpack (SCFRO) Operations in Shielded Canyon Cell

Activity Number	Operation Description	Operation Time (minutes) RO	SCFRO
301	RO/SCFRO inspection at gate	5	5
302	Move RO/SCFRO/vehicle to protect area	15	15
303	Check bill of laden (BOL) to determine contents	10	10
304	Survey SCFRO/vehicle for radiation	0	45
305	Move RO/SCFRO/vehicle to washdown area	15	15
306	Remove road dirt for RO/SCFRO/vehicle	45	45
307	Move RO/SCFRO/vehicle to cask handling area	20	20
308	Remove personnel barriers from vehicle	0	30
309	Remove impact limiters and shipping restraints	30	30
310	Perform contamination survey on SCFRO	0	30
Subtotal		140	245
311	Place RO cask adapter on cask cart	20	--
312	Attach grapple and remove RO from transporter	15	--
313	Place RO on cask cart, install restraints, and RO lid	30	--
314	Move RO to Cask Handling and Decontamination Room	10	--
315	Install contamination barrier adapter	10	--
316	Move RO into Unloading Room, engage contamination barrier, close shadow shield and close shield door	20	--
317	Remove cell entry port plug	20	--
318	Unload overpack with lid and place into weld/decontamination station	20	--
319	Exchange grapple, remove RO lid, and place on floor	10	--
320	Exchange grapple and replace cell entry port plug to permit preparations for SCFRO	25	--
Subtotal		180	0
321	Load consolidated fuel canisters in RO, 20 min/SF canister	80	--
322	Insert RO lid in place and rotate welding head into position for weld	20	--
323	Weld RO lid via electron beam process and disengage weld head from RO	60	--
324	Perform visual inspection on welded RO	10	--
Subtotal		170	0
Subtotal (maximum of 321-324 or 350-360)		245	145

TABLE A.5. (contd)

Repository Overpack Parallel Operations

Activity Number	Operation Description	Operation Time (minutes) RO	SCFRO
350	Open shadow shield and shield door, disengage contamination barrier, move cask cart with empty RO cask adapter to Cask Handling and Decontamination Room (after Activity 320)	20	--
351	Remove the contamination barrier adapter from the RO cask adapter	10	--
352	Survey for contamination and decontaminate if necessary	40	--
353	Move cask cart to Receiving and Inspection area	10	--
354	Remove RO cask adapter from cask cart and place in setdown area	15	--
355	Exchange 150-ton grapple for shipping cask yoke	5	--
356	Engage SCFRO, rotate to vertical, place on cask cart, and secure restraints (SCFRO prepared from Activity 310)	35	35
357	Move cask cart/SCFRO into Cask Handling and Decontamination Room, close door, and install contamination control barrier adapter	20	20
358	Remove outer lid of SCFRO and remove all but four bolts of inner lid	30	30
359	Move SCFRO in Unloading Room, engage contamination barrier, close shadow shield and close shield doors	20	20
360	Remove cell entry port plugs, unbolt inner lid fasteners, and lift lid into cell	40	40
TOTAL		245	145

Repository Overpack (RO)/Shipping Cask for Repository Overpack (SCFRO) Operations in Shielded Canyon Cell

Activity Number	Operation Description	Operation Time (minutes) RO	SCFRO
325	Engage RO pintle grapple and lift completed RO into SCFRO (SCFRO prepared and ready from Activity 360)	25	25
326	Exchange grapple, replace inner lid of SCFRO, tighten bolts, and replace entry port plug	80	80
327	Open shadow shield, shield door, disengage contamination barrier and move cask cart with full SCFRO to Cask Handling and Decon Room	20	20
328	Complete SCFRO closure installation, remove barrier adapter, survey for contamination, decontaminate if necessary	150	150
329	Move cask cart to Receiving and Inspection area	10	10
330	Remove full SCFRO from cask cart, place SCFRO on transport vehicle, and remove lifting yoke	35	35
331	Install cask tiedown impact limiters, personnel barriers, etc.	60	60
332	Complete preparations for release of full SCFRO and transporter from Receiving and Handling building	30	30
Subtotal		410	410
TOTAL (critical path Items 311-330)		745	465
TOTAL (noncritical path items)		230	230
TOTAL		975	695

TABLE A.5. (contd)

SUMMARY OPERATIONS DESCRIPTION	REPOSITORY OVERPACK (RO) OPERATION Total Min	Hr	Min
A. Tasks not on Critical Path	230	3	50
B. Tasks on Critical Path	745	12	25
C. TOTAL	975	16	15

	SHIPPING CASK FOR REPOSITORY OVERPACK (SCFRO) OPERATION		
		Operation	
	Total Min	Hr	Min
A. Tasks not on Critical Path	230	3	50
B. Tasks on Critical Path	465	7	45
C. Total	695	11	35

A.3 DEFAULT DATA IN EXPERIMENTAL FRAME FOR THE BACK-END MRS MODEL

```
BEGIN;
PROJECT, BACK END MRS MODEL, HARLAN HUBER, 12/30/85;
DISCRETE,1000,4,42,10;
REPLICATE,1,0,4015;
INITIALIZE,X(1) = 5,X(2) = 0,X(8)=150,X(9)=150,X(10)=0,X(14)=0,
           X(15)=0,X(16)=0,X(18)=1.E6,X(21)=1;
RESOURCES:1-2,WCRANE,1,1:3-4,YCART,1,1:5-6,CART,1,1:7-8,ECRANE,1,1:
          9-10,OH,1,1;
DISTRIBUTIONS:1,RL(2,1):2,RL(3,2):     ! CAN ARRIVAL DISTRIB.
      3,TR(4,3):                       ! CASK ARRIVAL DIST.
      4,TR(5,4):                       ! DECOM PROC FOR CANS(NOT USED)
      5,CO(6):                         ! BREAK TIME LAG MANAGER DIST.
      6,TR(7,6):                       ! CAN TO PORT TIME DIST.
      7,TR(8,7):                       ! LIFT CANS TO LAG DIST.
      8,TR(9,8):                       ! CASK MOVE IN DIST.
      9,TR(10,9):                      ! CASK LOAD DIST.
     10,TR(11,4):                      ! CASK MOVE OUT DIST.
     11,TR(12,6):                      ! SECURE & TIE DIST.
     12,TR(13,7):                      ! PACK TO PORT DIST.
     13,TR(14,8):                      ! LIFT PACK DIST.
     14,TR(15,9):                      ! LOAD PACK DIST.
     15,TR(16,4):                      ! GATE INSPECTION DIST.
     16,TR(33,6):                      ! CAN TO LAG DIST.
     17,TR(34,7):                      ! CART TO PORT DIST.
     18,TR(35,8):                      ! CANS INTO CASK DIST.
     19,TR(36,9):                      ! CASK TO YARD DIST.
     20,TR(37,4):                      ! CASK ONOFF DIST.
     21,TR(38,6):                      ! OP ON DIST.
     22,TR(39,7):                      ! CARTOUT DIST.
     23,TR(40,8):                      ! ADAPTOFF DIST.
     24,CO(41):                        ! CHECK TIME CONSTANT
     25,TR(50,9):                      ! CAN REROUTE DIST.
     26,TR(51,4);                      ! LOAD SHIPPING CASK DIST.
PARAMETERS:1,12,0.0,200,50,3,12,0,0,   ! LAG AND YARD PAR.
      0,3:                             !
   2,.28757,.09831:3,.2572,.10973:     ! CAN ARRIV. DIST. PAR.(3600 MTU/YR)
   4,1.5365,2.0365,2.5365:             ! CASK ARRIV DIST. PAR.
   5,0.25,0.35,0.45:                   ! DECOM DIST. PAR.
   6,0.042:                            ! BREAK TIME FOR LAG MANAGER
   7,.117,.13,.1625:                   ! CAN TO PORT TIME
   8,.315,.35,.438:                    ! LIFT CANS TO LAG
   9,.068,.076,.095:                   ! CASK MOVE IN
  10,.171,.19,.238:                    ! CASK LOAD
  11,.027,.03,.0375:                   ! CASK MOVE OUT
  12,.054,.06,.075:                    ! SECURE & TIE
  13,.025,.028,.035:                   ! PACK TO PORT
  14,.045,.05,.0625:                   ! LIFT PACK
  15,.028,.030,.038:                   ! LOAD PACK WITH ONE CAN FROM LAG
  16,.153,.170,.213:                   ! GATE INSPEC FOR ONE RAIL CASK
  17,30.0,4:18,180.,1:                 ! WCRANE FAIL PAR.
  19,365,2:20,1825,1:                  ! WCRANE FAIL PAR.
  21,30.0,4:22,180.,1:                 ! ECRANE FAIL PAR.
  23,365,2:24,1825,1:                  ! ECRANE FAIL PAR.
  25,0.67:26,0.67:                     ! WCRANE REPAIR PAR.
```

```
  27,4.0:28,7.0:                          ! WCRANE REPAIR PAR.
  29,0.67:30,0.67:                        ! ECRANE REPAIR PAR.
  31,4.0:32,7.0:                          ! ECRANE REPAIR PAR.
  33,.009,.01,.0125:                      ! CAN TO LAG PAR.
  34,.054,.06,.075:                       ! CART TO PORT PAR.
  35,.187,.208,.26:                       ! CANS INTO CASK PAR.
  36,.162,.18,.225:                       ! CASK TO YARD PAR.
  37,.059,.066,.083:                      ! CASK ONOFF PAR.
  38,.059,.066,.083:                      ! OP ON PAR.
  39,.050,.056,.07:                       ! CARTOUT PAR.
  40,.009,.01,.0125:                      ! ADAPTOFF PAR.
  41,.042:                                ! CHECK TIME
  42,30.0,4:43,180.,1:                    ! OH CRANE FAIL PAR.
  44,365,2:45,1825,1:                     ! OH CRANE FAIL PAR.
  46,0.67:47,0.67:                        ! OH CRANE REPAIR PAR.
  48,4.0:49,7.0:                          ! OH CRANE REPAIR PAR.
  50,.019,.021,.026:                      ! CAN REROUTE PAR.
  51,.037,.042,.052;                      ! LOAD SHIP. CASK WITH 3 CANS PAR.
ARRIVALS:1,STATION(5), 0.0,1,1,17,25:
         2,STATION(5), 0.0,1,2,17,25:  ! 4 MO. FREQ. WCRANE FAIL.
         3,STATION(5), 0.0,1,1,18,26:
         4,STATION(5), 0.0,1,2,18,26:  ! 6 MO. FREQ. WCRANE FAIL.
         5,STATION(5), 0.0,1,1,19,27:
         6,STATION(5), 0.0,1,2,19,27:  ! 2 YR. FREQ. WCRANE FAIL.
         7,STATION(5), 0.0,1,1,20,28:
         8,STATION(5), 0.0,1,2,20,28:  ! 5 YR. FREQ. WCRANE FAIL.
         9,STATION(6), 0.0,1,1,21,29:
        10,STATION(6), 0.0,1,2,21,29:  ! 4 MO. FREQ. ECRANE FAIL.
        11,STATION(6), 0.0,1,1,22,30:
        12,STATION(6), 0.0,1,2,22,30:  ! 6 MO. FREQ. ECRANE FAIL.
        13,STATION(6), 0.0,1,1,23,31:
        14,STATION(6), 0.0,1,2,23,31:  ! 2 YR. FREQ. ECRANE FAIL.
        15,STATION(6), 0.0,1,1,24,32:
        16,STATION(6), 0.0,1,2,24,32:  ! 5 YR. FREQ. ECRANE FAIL.
        17,STATION(9), 0.0,1,1,42,46:
        18,STATION(9), 0.0,1,2,42,46:  ! 4 MO. FREQ. OH CRANE FAIL.
        19,STATION(9), 0.0,1,1,43,47:
        20,STATION(9), 0.0,1,2,43,47:  ! 6 MO. FREQ. OH CRANE FAIL.
        21,STATION(9), 0.0,1,1,44,48:
        22,STATION(9), 0.0,1,2,44,48:  ! 2 YR. FREQ. OH CRANE FAIL.
        23,STATION(9), 0.0,1,1,45,49:
        24,STATION(9), 0.0,1,2,45,49;  ! 5 YR. FREQ. OH CRANE FAIL.
COUNTERS: 1,PWR CAN LAG STRG,374:2,BWR CAN LAG STRG,374:
          3,YARD STORAGE,10000:
          4,PWR CANS TO YRD:5,BWR CANS TO YRD:6,PWR CANS FRM YRD:
          7,BWR CANS FRM YRD:8,NOT USED:9,NOT USED:
         10,NOT USED:11,NOT USED:12,CANS TO REPOS:
         13,NOT USED:14,WCR FAILS:15,WCR FIXES:
         16,ECR FAILS:17,ECR FIXES:18,OHC FAILS:
         19,OHC FIXES:20,PWR CAN ARRIVALS:21,BWR CAN ARRIVALS:
         22,PWR LAG TO YARD:23,BWR LAG TO YARD:24,YARD TO LAG:
         25,RAIL CASK WAITNG;
TALLIES: 1,PWR CASK TURNARD:2,BWR CASK TURNARD:
         3,TRAIN TURNAROUND;
```

```
DSTAT: 1,NQ(15),PWR 35T WCR Q:2,NQ(16),BWR 35T WCR Q:
       3,NQ(9),PWR ECR LD CSK Q:4,NQ(10),BWR ECR LD CSK Q:
       5,NQ(13),PWR ECR ULD PK Q:6,NQ(14),BWR ECR ULD PK Q:
       7,NQ(5),PWR ECR YDOT Q:8,NQ(6),BWR ECR YDOT Q:
       9,NQ(23),PWR ECR YDIN Q:10,NQ(24),BWR ECR YDIN Q:
       11,NQ(17),RAIL CASK Q:12,NQ(18),PWR PK READY Q:
       13,NQ(19),BWR PK READY Q:
       14,NQ(31),PWR ECR LD PK Q:15,NQ(32),BWR ECR LD PK Q:
       16,NQ(21),PWR OHC LD PK Q:17,NQ(22),BWR OHC LD PK Q:
       18,NQ(25),PWR OHC LD TRN Q:19,NQ(26),BWR OHC LD TRN Q:
       20,NQ(29),PWR OHC LD CSK Q:21,NQ(30),BWR OHC LD CSK Q:
       22,NR(1),PWR 35T WCR UTIL:23,NR(2),BWR 35T WCR UTIL:
       24,NR(3),PWR YRDCART UTIL:25,NR(4),BWR YRDCART UTIL:
       26,NR(5),PWR CSKCART UTIL:27,NR(6),BWR CSKCART UTIL:
       28,NR(7),PWR 35T ECR UTIL:29,NR(8),BWR 35T ECR UTIL:
       30,NR(9),PWR 150T OH UTIL:31,NR(10),BWR 150T OH UTIL:
       32,X(6),PWR CAN ARRIVALS:33,X(7),BWR CAN ARRIVALS:
       34,X(8),PWR LAG STORAGE:35,X(9),BWR LAG STORAGE:
       36,X(10),YARD STORAGE:37,X(11),RAIL CASK ARVS:
       38,X(12),CANS TO REPOS:39,X(14),PWR LAG TO YARD:
       40,X(15),BWR LAG TO YARD:41,X(16),YARD TO LAG;
END;
```

A.4 EXAMPLE OUTPUT FROM BACK-END MODEL

Output Figures A.1 through A.3 provide a measure of how both MRS internal (i.e., lag-storage vault) and external yard storage levels fluctuate over time. These examples of simulation output provide a valuable measure of the adequacy of MRS internal/external spent-fuel storage. Although not shown, additional information is collected on the minimum and maximum amounts of material in storage, and the duration of spent fuel in storage. Table A.6 lists example output from the back-end MRS model.

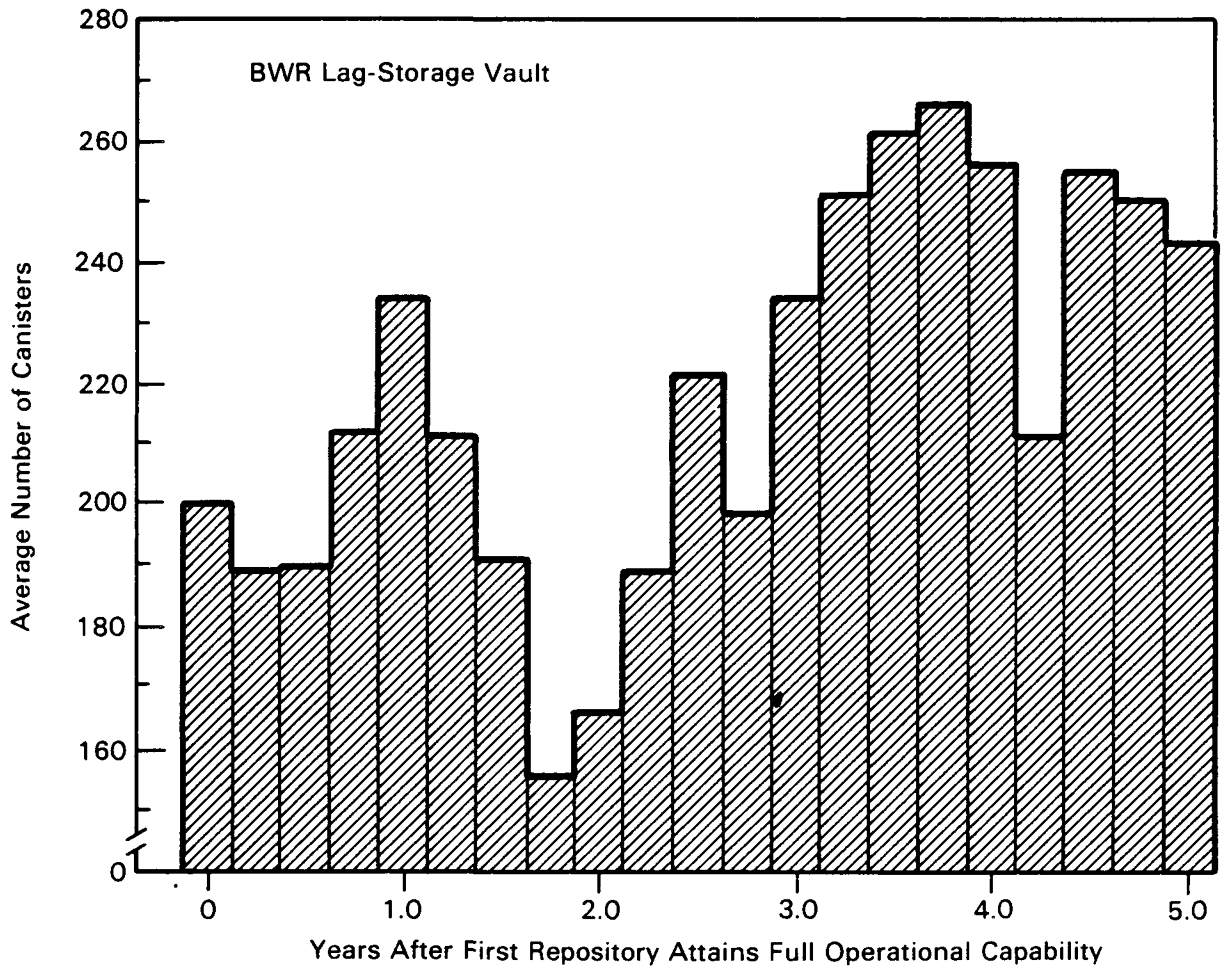


FIGURE A.1. Average Quarterly BWR Lag-Storage Vault Levels

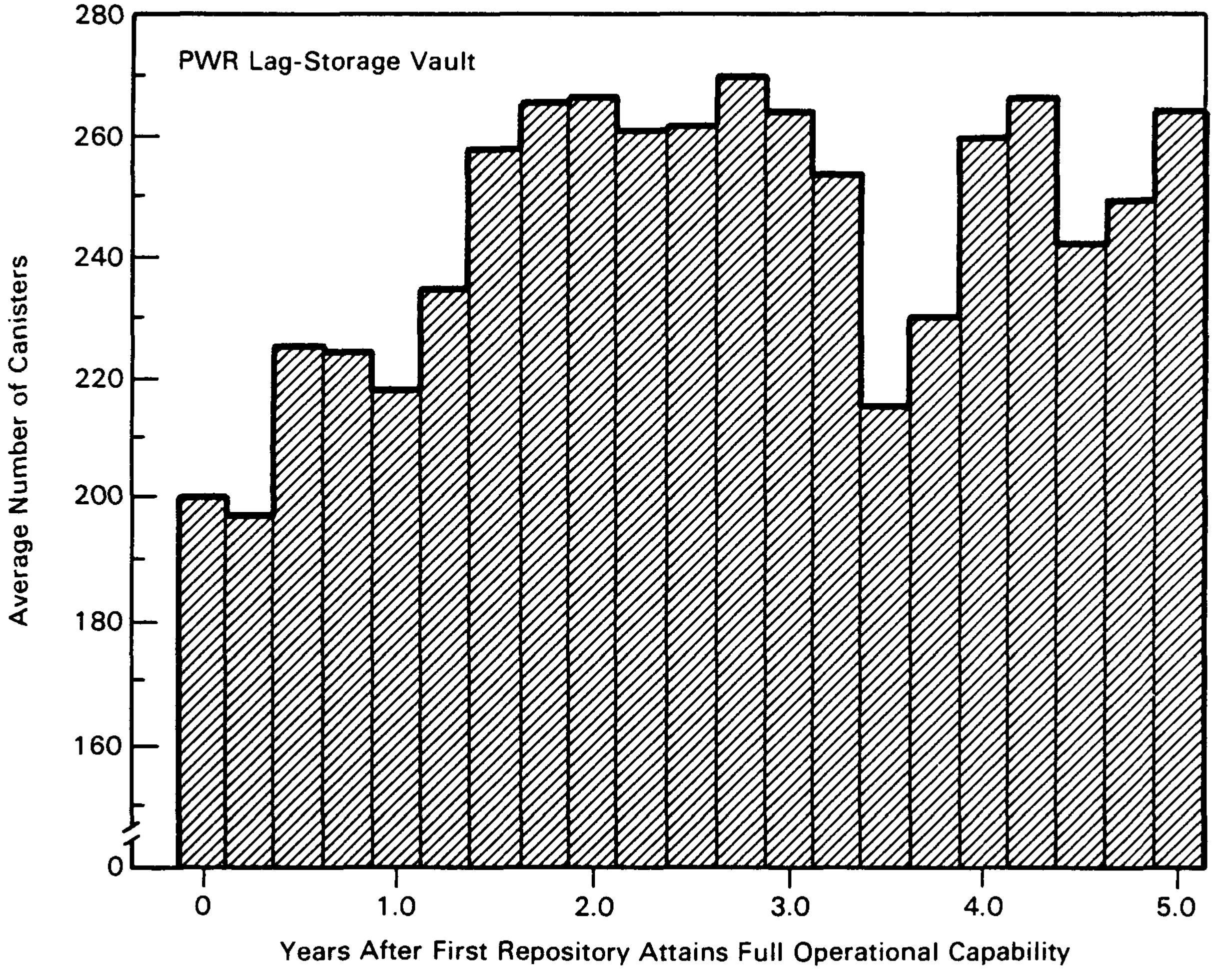


FIGURE A.2. Average Quarterly PWR Lag-Storage Vault Levels

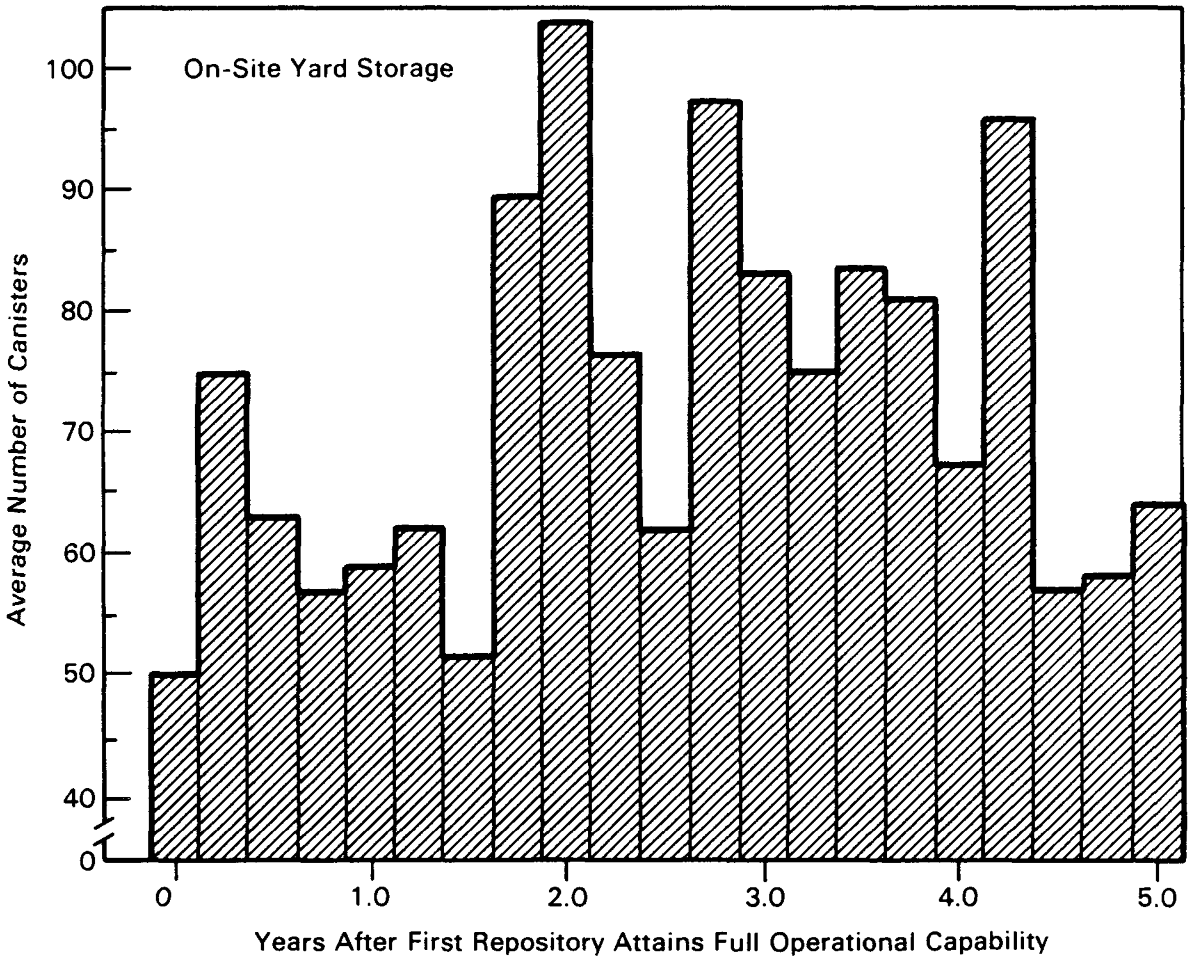


FIGURE A.3. Average Quarterly Onsite Yard Storage Levels

TABLE A.6. Example Output from Back-End MRS Model

SIMAN Summary Report

Run Number 1 of 1

Project: BACK END MRS MODEL
Analyst: HARLAN HUBER
Date : 12/30/1985

Run ended at time : .4015E+04

Tally Variables

Number	Identifier	Average	Standard Deviation	Minimum Value	Maximum Value	Number of Obs.
1	PWR CASK TURNARD	.78220	.32817	.48886	10.48291	4714
2	BWR CASK TURNARD	.80931	.43010	.48657	18.89185	5116
3	TRAIN TURNAROUND	4.03786	1.17400	1.64600	23.26990	1965

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Minimum Value	Maximum Value	Time Period
1	PWR 35T WCR Q	.00	.01	.00	2.00	4015.00
2	BWR 35T WCR Q	.00	.00	.00	1.00	4015.00
3	PWR ECR LD CSK Q	.01	.11	.00	1.00	4015.00
4	BWR ECR LD CSK Q	.01	.11	.00	1.00	4015.00
5	PWR ECR ULD PK Q	.00	.00	.00	.00	4015.00
6	BWR ECR ULD PK Q	.00	.00	.00	.00	4015.00
7	PWR ECR YDOT Q	.00	.07	.00	1.00	4015.00
8	BWR ECR YDOT Q	.00	.03	.00	1.00	4015.00
9	PWR ECR YDIN Q	.00	.05	.00	1.00	4015.00
10	BWR ECR YDIN Q	.00	.01	.00	1.00	4015.00
11	RAIL CASK Q	.58	1.05	.00	4.00	4015.00
12	PWR PK READY Q	.00	.00	.00	.00	4015.00
13	BWR PK READY Q	.00	.00	.00	.00	4015.00
14	PWR ECR LD PK Q	.00	.00	.00	.00	4015.00
15	BWR ECR LD PK Q	.00	.00	.00	.00	4015.00
16	PWR OHC LD PK Q	.00	.00	.00	.00	4015.00
17	BWR OHC LD PK Q	.00	.00	.00	.00	4015.00
18	PWR OHC LD TRN Q	.00	.05	.00	1.00	4015.00
19	BWR OHC LD TRN Q	.01	.08	.00	1.00	4015.00
20	PWR OHC LD CSK Q	.01	.08	.00	1.00	4015.00
21	BWR OHC LD CSK Q	.01	.11	.00	1.00	4015.00
22	PWR 35T WCR UTIL	.04	.19	.00	1.00	4015.00
23	BWR 35T WCR UTIL	.04	.20	.00	1.00	4015.00
24	PWR YRDCART UTIL	.14	.34	.00	1.00	4015.00
25	BWR YRDCART UTIL	.11	.31	.00	1.00	4015.00
26	PWR CSKCART UTIL	.37	.48	.00	1.00	4015.00

TABLE A.6. (contd)

27	BWR CSKCART UTIL	.41	.49	.00	1.00	4015.00
28	PWR 35T ECR UTIL	.13	.34	.00	1.00	4015.00
29	BWR 35T ECR UTIL	.12	.33	.00	1.00	4015.00
30	PWR 150T OH UTIL	.16	.37	.00	1.00	4015.00
31	BWR 150T OH UTIL	.18	.38	.00	1.00	4015.00
32	PWR CAN ARRIVALS	7001.55	4051.08	.00	14036.00	4015.00
33	BWR CAN ARRIVALS	7844.96	4515.26	.00	15662.00	4015.00
34	PWR LAG STORAGE	256.77	20.20	152.00	311.00	4015.00
35	BWR LAG STORAGE	242.01	32.24	129.00	295.00	4015.00
36	YARD STORAGE	91.98	25.22	26.00	158.00	4015.00
37	RAIL CASK ARVS	4903.24	2838.70	.00	9830.00	4015.00
38	CANS TO REPOS	14691.88	8516.09	.00	29475.00	4015.00
39	PWR LAG TO YARD	6.12	3.67	.00	51.00	4015.00
40	BWR LAG TO YARD	6.29	3.74	.00	50.00	4015.00
41	YARD TO LAG	2.67	2.98	2.00	50.00	4015.00

Counters

Number	Identifier	Count	Limit
1	PWR CAN LAG STRG	262	374
2	BWR CAN LAG STRG	262	374
3	YARD STORAGE	134	10000
4	PWR CANS TO YRD	6444	Infinite
5	BWR CANS TO YRD	5376	Infinite
6	PWR CANS FRM YRD	6516	Infinite
7	BWR CANS FRM YRD	5220	Infinite
8	NOT USED	0	Infinite
9	NOT USED	0	Infinite
10	NOT USED	0	Infinite
11	NOT USED	0	Infinite
12	CANS TO REPOS	29475	Infinite
13	NOT USED	0	Infinite
14	WCR FAILS	125	Infinite
15	WCR FIXES	125	Infinite
16	ECR FAILS	127	Infinite
17	ECR FIXES	127	Infinite
18	OHC FAILS	143	Infinite
19	OHC FIXES	143	Infinite
20	PWR CAN ARRIVALS	14036	Infinite
21	BWR CAN ARRIVALS	15662	Infinite
22	PWR LAG TO YARD	3	Infinite
23	BWR LAG TO YARD	1	Infinite
24	YARD TO LAG	2	Infinite
25	RAIL CASK WAITNG	0	Infinite

Run Time : 4 Hour(s) and 17 Minute(s)

A.5 BACK-END MRS MODEL LISTING

```
BEGIN;
SYNONYMS:ECR YDOT QUE=M+2:
         ECRANE QUEUE=M+8:
         YDIN CART QUE=M+8:
         PACK ECRANE QUE=M+12:
         LAG SIZE=M-2:
         YARD STORAGE=3:
         CANS IN YARD=NC(3):
         LAG STORAGE=M:
         LAG STORAGE CANS=NC(M):
         LAG=M-2:
         CANS IN LAG=NC(M-2):
         # CANS OUT=P(1,1):
         FRAC TO YARD=P(1,2):
         MAXIMUM=P(1,3):
         MINIMUM=P(1,4):
         CANS IN PACK=P(1,5):
         # CANS IN=P(1,6):
         YARD TIME=P(1,7):
         WKEND TRAINS=P(1,8):
         OVERPACK=P(1,9):
         CANS IN CASK=P(1,10):
         SIZE LAG=NC(M-6):
         RAIL CASK QUE=17:
         WCRANE QUE=M+14:
         OVER PACK QUE=M+17:
         BREAK TIME=ED(5):
         CAN TO PORT TIME=ED(6):
         LIFT CANS TO LAG=ED(7):
         CASK MOVE IN=ED(8):
         CASK LOAD=ED(9):
         CASK MOVE OUT=ED(10):
         SECURE & TIE=ED(11):
         PACK TO PORT=ED(12):
         LIFT PACK=ED(13):
         LOAD PACK=ED(14)*P(1,5):
         GATE INSPEC=ED(15):
         CAN TO LAG=ED(16):
         CART TO PORT=ED(17):
         CANS INTO CASK=ED(18):
         CASK TO YARD=ED(19):
         YDOT CART QUE=M:
         CANS TO YARD=M+1:
         CANS FROM YARD=M+3:
         RECYCLE TO YARD=M+21:
         RECYCLE TO YRD=M+19:
         RECYCLE TO LAG=24:
         RECYL TO YRD=NC(M+19):
         RECY TO YRD=NC(M+21):
         RECYL TO LAG=NC(24):
         RAIL CARS WAIT=25:
         OVP ARV PORT=M+7:
         OVP LV PORT=M+9:
         CANS TO REP=12:
```

```
        WCRANE FAILS=M+9:
        WCRANE FIXES=M+10:
        ECRANE FAILS=M+10:
        ECRANE FIXES=M+11:
        OH FAILS=M+9:
        OH FIXES=M+10:
        OH QUEUE = M+20:
        CAN ARRIVALS=M+19:
        CASK ONOFF = ED(20):
        ECR YDIN QUE=M+20:
        OH OUT = M+24:
        OP OH Q = M+26:
        OP ON = ED(21):
        CARTOUT = ED(22):
        FOR OH = M+28:
        ADAPTOFF = ED(23):
        CHECK TIME=ED(24):
        CAN REROUTE TIME=ED(25):
        LOAD SHIP CASK=ED(26):
        LOADING Q = M+30:
        LOAD Q =M+6:
        LOAD TRAIN Q=M+38;
;
;   IN THE MODEL NOMENCLATURE BELOW, THE WEST CRANE IS THE 35-TON CRANE
;   PRIMARILY SERVICING THE WELDING STATION, THE EAST CRANE IS THE 35-
;   TON CRANE PRIMARILY SERVICING THE EXIT PORTS, AND THE OVERHEAD CRANE
;   IS THE 150-TON CRANE SERVICING THE RAIL CARS.
;
;************************************************************************
;   SUBMODEL WHICH INITIALIZES COUNTERS IN THE EVENT INITIAL LAG STORAGE
;   OR YARD STORAGE IS NON-ZERO AT STARTUP.
;************************************************************************
        CREATE,1;
        ASSIGN:X(22)=X(1);                 INITIALIZE # RAIL CARS IN REP TRAIN
        COUNT:1,X(8);                      INITIALIZE PWR LAG STORAGE COUNTER
        COUNT:2,X(9);                      INITIALIZE BWR LAG STORAGE COUNTER
        COUNT:3,X(10);                     INITIALIZE YARD STORAGE COUNTER
        COUNT:22,X(14);                    INITIALIZE PWR LAG CANS WAITING
;                                          TO RECYCLE TO YARD
        COUNT:23,X(15);                    INITIALIZE BWR LAG CANS WAITING
;                                          TO RECYCLE TO YARD
        COUNT:24,X(16):DISPOSE;            INITIALIZE YARD CANS WAITING TO
;                                          RECYCLE TO LAG STORAGE
;
;************************************************************************
;   SUBMODEL WHICH SHUTS DOWN THE BACK-END MRS FACILITY ON WEEKENDS.
;   ASSUME THAT NO CANNISTERS ARRIVE FROM THE FRONT-END FACILITY TO
;   THE BACK-END FACILITY ON WEEKENDS (NOTE X(21) SET BELOW).
;************************************************************************
;
        CREATE,1,X(18);                    CREATE WORKDAY-WEEKEND ENTITY
WKDAY   ASSIGN:X(19)=1;                    SET GLOBAL FLAG FOR WORKDAYS
        ASSIGN:X(21)=1;                    SET BATCH SIZE FOR CAN ARRIVALS
;                                          IN INTERFACE SUBMODEL
```

```
        ASSIGN:X(22)=X(1);                    SET # RAIL CARS IN TRAIN FROM REP
        DELAY:4.9;                            WORK 4.9 DAYS,ALLOWING 0.1 DAYS
;                                             TO SHUT DOWN ON WEEKENDS
WKEND   ASSIGN:X(19)=2;                       SET GLOBAL FLAG FOR WEEKENDS
        ASSIGN:X(21)=0;                       NO CAN ARRIVALS IN INTERFACE
        BRANCH,1:                            !OPTION TO SHUT DOWN TRAINS FROM
          IF,'WKEND TRAINS'.EQ.0,NTRAIN:     !REP DURING WEEKEND SHUT DOWNS
          ELSE,YTRAIN;
NTRAIN  ASSIGN:X(22)=0:NEXT(DELAYS);          NO WEEKEND TRAINS ARRIVE FROM REP
YTRAIN  ASSIGN:X(22)=X(1);                    YES WEEKEND TRAINS ARRIVE FROM REP
DELAYS  DELAY:2.1:NEXT(WKDAY);                SHUT DOWN FOR 2.1 DAYS
;
        CREATE,10,X(18);                      CREATE 10 ENTITIES,ONE FOR EACH
;                                             OF 10 RESOURCES
        ASSIGN:X(20)=X(20)+1;                 X(20) INITIALIZED TO 0
        ASSIGN:A(1)=X(20);                    STORE RESOURCE # IN ATTRIBUTE #1
WORK    QUEUE,41;                             QUEUE FOR SCAN CONDITION TO CHECK
        SCAN:X(19).EQ.2;                      FOR START OF WEEKEND
SCHEDL  BRANCH,1:                            !BRANCH CONTROL FOR WEEKEND
          IF,X(19).EQ.1,WORK:                !RESUME WORK
          IF,MR(A(1)).EQ.0,RETRY:            !RESOURCE IS BROKEN DOWN
          ELSE,SHUTDN;                        SHUT DOWN RESOURCE
RETRY   DELAY:0.2:NEXT(SCHEDL);               DELAY TO SEE IF RESOURCE IS STILL
;                                             BUSY OR BROKEN DOWN
SHUTDN  BRANCH,1:                            !SHUT DOWN ALL RESOURCES ON WEEKEND
          IF,A(1).LE.2,SHDWCR:               !WEST CRANES
          IF,A(1).LE.4,SHDYCT:               !YARD CARTS
          IF,A(1).LE.6,SHDCRT:               !CASK CARTS
          IF,A(1).LE.8,SHDECR:               !EAST CRANES
          ELSE,SHDOH;                         OVERHEAD CRANES
SHDWCR  ASSIGN:M=A(1);                        SHUT DOWN WEST CRANES
        ALTER:WCRANE(M),-1:NEXT(CWKDAY);
SHDYCT  ASSIGN:M=A(1);                        SHUT DOWN YARD CARTS
        ALTER:YCART(M-2),-1:NEXT(CWKDAY);
SHDCRT  ASSIGN:M=A(1);                        SHUT DOWN CASK CARTS
        ALTER:CART(M-4),-1:NEXT(CWKDAY);
SHDECR  ASSIGN:M=A(1);                        SHUT DOWN EAST CRANES
        ALTER:ECRANE(M-6),-1:NEXT(CWKDAY);
SHDOH   ASSIGN:M=A(1);                        SHUT DOWN OVERHEAD CRANES
        ALTER:OH(M-8),-1;
CWKDAY  QUEUE,42;                             QUEUE FOR SCAN CONDITION TO CHECK
        SCAN:X(19).EQ.1;                      FOR START OF WEEK DAY (WORK DAYS)
        BRANCH,1:                            !BRANCH CONTROL FOR WORK
          IF,MR(A(1)).EQ.1,WORK:             !RESOURCE IS NOT SHUT DOWN
          ELSE,TURNON;
TURNON  BRANCH,1:                            !TURN ON RESOURCES FOR WEEKDAYS
;         IF,A(1).LE.2,TONWCR:               !WEST CRANES
          IF,A(1).LE.4,TONYCT:               !YARD CARTS
          IF,A(1).LE.6,TONCRT:               !CASK CARTS
          IF,A(1).LE.8,TONECR:               !EAST CRANES
          ELSE,TONOH;                         OVERHEAD CRANES
TONWCR    ASSIGN:M=A(1);                      TURN ON WEST CRANES
          ALTER:WCRANE(M),+1:NEXT(WORK);
TONYCT    ASSIGN:M=A(1);                      TURN ON YARD CARTS
```

```
          ALTER:YCART(M-2),+1:NEXT(WORK);
TONCRT    ASSIGN:M=A(1);                       TURN ON CASK CARTS

          ALTER:CART(M-4),+1:NEXT(WORK);
TONECR    ASSIGN:M=A(1);                       TURN ON EAST CRANES
          ALTER:ECRANE(M-6),+1:NEXT(WORK);
TONOH     ASSIGN:M=A(1);                       TURN ON OVERHEAD CRANES
          ALTER:OH(M-8),+1:NEXT(WORK);
;
;**********************************************************************
;   SUBMODEL WHICH CREATES MACHINE FAILURES AND REMOVES THE FAILED
;   MACHINE FROM THE SYSTEM FOR A SPECIFIED REPAIR PERIOD.  CURRENTLY
;   ONLY WEST CRANE, EAST CRAME, AMD OVERHEAD CRANE FAILURES ARE
;   INCLUDED IN THE MODEL.  NO FAILURES ARE ALLOWED ON WEEKENDS IF THE
;   FACILITY IS SHUT DOWN ON WEEKENDS.  HOWEVER, IT IS ASSUMED THAT
;   MAINTENANCE PERSONNEL ARE ON DUTY AT ALL TIMES AND SO REPAIR WORK
;   IS ALLOWED ON WEEKENDS.
;**********************************************************************
        STATION,5;
WFAIL   DELAY:ER(A(2),8);                      DELAY UNTIL NEXT BREAK DOWN
;
BRK1    BRANCH,1:                              !CHECK IF WEST CRANE A(1) IS
          IF,MR(A(1)).EQ.0,DELAY1:             !ALREADY DOWN DUE TO WEEKEND
          ELSE,BR1;                            !SHUTDOWN OR PREVIOUS FAILURE
;
DELAY1  DELAY:1:NEXT(BRK1);                    DELAY 1 DAY AND RECHECK
BR1     BRANCH,1:                              !CHECK WHICH WEST CRANE TO BK
          IF,A(1).EQ.1,ALT1:
          ELSE,ALT2;
;
ALT1    ALTER:WCRANE(1),-1;                    BREAK DOWN IDLE WEST CRANE #1
        COUNT:'WCRANE FAILS',+1;
        ASSIGN:X(4)=1;                         FLAG WCRANE(1) AS BROKEN
        DELAY:EXP(A(3),9);                     DELAY UNTIL REPAIR OF CRANE
        COUNT:'WCRANE FIXES',+1;
        ASSIGN:X(4)=0;                         FLAG WCRANE(1) AS NOT BROKEN
        BRANCH,1:
          IF,MR(A(1)).EQ.1,WFAIL:
          ELSE,TNON1;
TNON1   ALTER:WCRANE(1),+1:NEXT(WFAIL);        REPAIR OF CRANE COMPLETED
;
ALT2    ALTER:WCRANE(2),-1;                    BREAK DOWN IDLE WEST CRANE #2
        COUNT:'WCRANE FAILS',+1;
        ASSIGN:X(5)=1;                         FLAG WCRANE(2) AS BROKEN
        DELAY:EXP(A(3),9);                     DELAY UNTIL REPAIR OF CRANE
        COUNT:'WCRANE FIXES',+1;
        ASSIGN:X(5)=0;                         FLAG WCRANE(2) AS NOT BROKEN
        BRANCH,1:
          IF,MR(A(1)).EQ.1,WFAIL:
          ELSE,TNON2;
TNON2   ALTER:WCRANE(2),+1:NEXT(WFAIL);        REPAIR OF CRANE COMPLETED
;
        STATION,6;
        ASSIGN:J=A(1)+6;
```

```
        ASSIGN:A(4)=J;
EFAIL   DELAY:ER(A(2),8);                   DELAY UNTIL NEXT BREAK DOWN
;
BRK2    BRANCH,1:                           !CHECK IF EAST CRANE A(1) IS
          IF,MR(A(4)).EQ.0,DELAY2:          !ALREADY DOWN DUE TO WEEKEND
          ELSE,BR2;                         !SHUTDOWN OR PREVIOUS FAILURE
DELAY2  DELAY:1:NEXT(BRK2);
;
BR2     BRANCH,1:                           !CHECK WHICH EAST CRANE TO BK
          IF,A(1).EQ.1,ALT3:
          ELSE,ALT4;
;
ALT3    ALTER:ECRANE(1),-1;                 BREAK DOWN IDLE EAST CRANE #1
        COUNT:'ECRANE FAILS',+1;
        DELAY:EXP(A(3),9);                  DELAY UNTIL REPAIR OF CRANE
        COUNT:'ECRANE FIXES',+1;
        BRANCH,1:
          IF,MR(A(4)).EQ.1,EFAIL:
          ELSE,TNON3;
TNON3   ALTER:ECRANE(1),+1:NEXT(EFAIL);     REPAIR OF CRANE COMPLETED
;
ALT4    ALTER:ECRANE(2),-1;                 BREAK DOWN IDLE EAST CRANE #2
        COUNT:'ECRANE FAILS',+1;
        DELAY:EXP(A(3),9);                  DELAY UNTIL REPAIR OF CRANE
        COUNT:'ECRANE FIXES',+1;
        BRANCH,1:
          IF,MR(A(4)).EQ.1,EFAIL:
          ELSE,TNON4;
TNON4   ALTER:ECRANE(2),+1:NEXT(EFAIL);     REPAIR OF CRANE COMPLETED
;
        STATION,9;                          150 TON OH CRANE FAILURES
        ASSIGN:J=A(1)+8;
        ASSIGN:A(4)=J;
OFAIL   DELAY:ER(A(2),8);                   DELAY UNTIL NEXT BREAKDOWN
;
BRK3    BRANCH,1:                           !CHECK IF OH CRANE A(1) IS
          IF,MR(A(4)).EQ.0,DELAY3:          !ALREADY DOWN DUE TO WEEKEND
          ELSE,BR3;                         !SHUTDOWN OR PREVIOUS FAILURE
DELAY3  DELAY:1:NEXT(BRK3);
;
BR3     BRANCH,1:                           !CHECK WHICH OH FAILS
           IF,A(1).EQ.1,ALT5:
           ELSE,ALT6;
;
ALT5    ALTER:OH(1),-1;                     BREAKDOWN IDLE 150 TON CRANE #1
        COUNT:'OH FAILS',+1;
        DELAY:EXP(A(3),9);                  DELAY UNTIL REPAIR OF CRANE
        COUNT:'OH FIXES',+1;
        BRANCH,1:
          IF,MR(A(4)).EQ.1,OFAIL:
          ELSE,TNON5;
TNON5   ALTER:OH(1),+1:NEXT(OFAIL);         REPAIR OF CRANE COMPLETED
;
ALT6    ALTER:OH(2),-1;                     BREAKDOWN IDLE 150 TON CRANE #2
```

```
        COUNT:'OH FAILS',+1;
        DELAY:EXP(A(3),9);                DELAY UNTIL REPAIR OF CRANE
        COUNT:'OH FIXES',+1;
        BRANCH,1:
          IF,MR(A(4)).EQ.1,OFAIL:
          ELSE,TNON6;
TNON6   ALTER:OH(2),+1:NEXT(OFAIL);       REPAIR OF CRANE COMPLETED
;
;*********************************************************************
;   SUBMODEL WHICH CREATES CANISTER ARRIVALS TO THE SYSTEM AT THE
;   OUTLET OF THE  WELD INSPECTION STATION (I.E., BEGINNING WITH
;   ACTIVITY NO. 108) AND PUTS THE CANISTERS INTO LAG STORAGE.
;*********************************************************************
;
;
        CREATE,X(21):ED(1);               CREATE PWR CAN AT EXIT OF WELDER
;                                         X(21) INITIALIZED TO 1 BUT CAN BE
;                                         MODIFIED IN WEEKEND SUBMODEL
        ROUTE:0,1;                        ROUTE TO STATION 1
        CREATE,X(21):ED(2);               CREATE BWR CAN AT EXIT OF WELDER
        ROUTE:0,2;                        ROUTE TO STATION 2
;
        STATION,1-2;                      MOVE CAN FROM UT INTO LAG ST
        COUNT:'CAN ARRIVALS',+1;          COUNT CAN ARRIVALS OF EACH TYPE
        ASSIGN:X(M+5)=X(M+5)+1;           COUNT CAN ARRIVALS FOR DSTAT ELE.
        BRANCH,1:                        !BRANCH ON STATION NUMBER
          IF,M.EQ.1,CHK1:
          ELSE,CHK2;
CHK1    BRANCH,1:
          IF,X(4).EQ.1.AND.X(5).EQ.0,    !IF WCRN 1 IS BROKEN AND WCRN 2 IS

          SWH1:                          !NOT BROKEN, SWITCH TO WCRN 2.

          ELSE,CRNQUE;                   !ELSE, CONTINUE WITH WCRN 1.
CHK2    BRANCH,1:
          IF,X(5).EQ.1.AND.X(4).EQ.0,    !IF WCRN 2 IS BROKEN AND WCRN 1 IS
          SWH2:                          !NOT BROKEN, SWITCH TO WCRN 1.
          ELSE,CRNQUE;                   !ELSE, CONTINUE WITH WCRN 2.
;
SWH1    ASSIGN:M=2;                       REROUTE CAN TO WEST CRN 2
        DELAY:'CAN REROUTE TIME':        !DELAY TO REROUTE CAN TO WEST CRN
2
        NEXT(CRNQUE);
;
SWH2    ASSIGN:M=1;                       REROUTE CAN TO WEST CRN 1
        DELAY:'CAN REROUTE TIME';         DELAY TO REROUTE CAN TO WEST CRN
1
;
CRNQUE  QUEUE,'WCRANE QUE';               QUEUE UP FOR WEST CRN NOT BROKEN
        SEIZE,1:WCRANE(M);                SEIZE WEST CRANE
        DELAY:'CAN TO LAG';               DELAY TO LIFT CAN INTO LAG ST
;                                         (ACT. 108)
        RELEASE:WCRANE(M);                RELEASE WEST CRANE
        BRANCH,1:                        !CHECK WHETHER ARRIVING CANS SHOULD
          WITH,'FRAC TO YARD',RECYCL:    !RECYCLE FROM LAG STORAGE TO YARD
```

```
          ELSE,LAG;                          !STORAGE
RECYCL    ASSIGN:X(M+13)=X(M+13)+1;           COUNT CANS IN LAG STORAGE WAITING
          COUNT:'RECYCLE TO YARD';            TO RECYCLE TO YARD STORAGE
LAG       ASSIGN:X(M+7)=X(M+7)+1;             COUNT LAG STORAGE FOR DSTAT ELE.
          COUNT:'LAG STORAGE':DISPOSE;        INCREASE LAG STORAGE BY ONE
;
;***********************************************************************
;   SUBMODEL FOR LAG AND YARD STORAGE MANAGEMENT. EACH HALF OF THE R & H
;   BUILDING HAS AN ENTITY WHICH PERIODICALLY CHECKS TO SEE IF ITS
;   LAG STORAGE IS BELOW THE MAXIMUM LIMIT SPECIFIED BY THE USER
;   AND ABOVE THE MINIMUM LIMIT SPECIFIED BY THE USER. IF LAG STORAGE
;   EXCEEDS THE MAXIMUM LIMIT, THEN CANISTERS ARE MOVED OUT TO THE
;   YARD STORAGE SECTION OF THE MRS.  IF LAG STORAGE IS BELOW THE
;   MINIMUM LIMIT, THEN CANISTERS ARE BROUGHT IN FROM THE YARD STORAGE
;   SECTION OF THE MRS TO ENSURE THAT ENOUGH CANISTERS ARE IN LAG
;   STORAGE TO SERVICE CASK ARRIVALS FROM THE MRS REPOSITORY. THE LAG
;   MANAGER ALSO PERIODICALLY CHECKS FOR CYCLING CANISTERS FROM LAG
;   STORAGE OUT TO YARD STORAGE AND FROM YARD STORAGE INTO LAG STORAGE
;   IF CYCLING IS SPECIFIED IN THE INPUT DATA,I.E.,FRAC TO YARD > 0.
;***********************************************************************
;
;   CHECK LAG STORAGE FOR MAXIMUM AND MINIMUM LIMITS
;
          CREATE,1;                           PWR LAG MANAGER ENTITY
          ROUTE:0,3;                          ROUTE TO STATION 3
          CREATE,1;                           BWR LAG MANAGER ENTITY
          ROUTE:0,4;                          ROUTE TO STATION 4
;
          STATION,3-4;                        PROCESS LAG CHECKER ENTITIES
;
;   LAG MANAGER CONTROL TO CHECK FOR MAXIMUM AND MINIMUM LIMITS IN LAG STORAGE
;
CHKMAX    BRANCH,1:
          IF,'CANS IN LAG'.LE.'MAXIMUM',     !CHECK FOR MAXIMUM LAG STORAGE
          CHKMIN:
          IF,'FRAC TO YARD'.EQ.1.0,YRDOUT:
          ELSE,YARDOT;
;
CHKMIN    BRANCH,1:
          IF,'CANS IN LAG'.GE.'MINIMUM',     !CHECK FOR MINIMUM LAG STORAGE
          CHKBRN:
          IF,'RECYL TO LAG'.GE.'# CANS IN', !
          YRDINN:
          ELSE,CHKBRN;
;
;   LAG MANAGER CONTROL TO CHECK FOR CYCLING CONDITIONS
;
CHKBRN    BRANCH,1:
          IF,'FRAC TO YARD'.EQ.0,WAIT:       !WAIT IF NO CANS ARE TO CYCLE
          IF,X(M+21).EQ.0,CHKCY1:            !LAST CYCLE WAS INTO LAG STORAGE
          ELSE,CHKCY3;                        LAST CYCLE WAS OUT TO YARD STOR.
;
;   PURPOSE OF FOUR BRANCHES CHKCY1-CHKCY2 AND CHKCY3-CHKCY4 IS TO TRY TO
;   ALTERNATE BETWEEN CYCLING OUT TO YARD STORAGE AND CYCLING INTO LAG
```

```
;   STORAGE IF POSSIBLE. OTHER CYCLING STRATEGIES COULD BE PROGRAMMED INTO
;   THE SUBMODEL HERE.
;
;   CHKCY1-CHKCY2 TRY TO CYCLE FROM LAG STORAGE OUT TO YARD STORAGE.
;   IF NOT POSSIBLE, THEY TRY TO CYCLE FROM YARD STORAGE INTO LAG STORAGE.
;
CHKCY1   BRANCH,1:                          !CHECK FOR CYCLING FROM LAG
         IF,NR(M).GT.0,WAIT:                !STORAGE OUT TO YARD STORAGE
         IF,'RECYL TO YRD'.LT.'# CANS OUT',
         CHKCY2:
         IF,X(13).EQ.0 .AND. NR(M+2).EQ.0,
         YRDOUT:
         IF,'RECYL TO YRD'.GT.(0.50*'CANS IN LAG'),
         YRDOUT:
         ELSE,CHKCY2;
CHKCY2   BRANCH,1:                          !CHECK FOR CYCLING FROM YARD
         IF,NR(M).GT.0,WAIT:                !INTO LAG STORAGE
         IF,'RECYL TO LAG'.LT.'# CANS IN',
         WAIT:
         IF,X(13).EQ.0 .AND. NR(M+2).EQ.0,
         YRDINN:
         IF,('CANS IN LAG'-'RECYL TO YRD')
         .LT.'MINIMUM',YRDINN:
         ELSE,WAIT;
;
;  CHKCY3-CHKCY4 TRY TO CYCLE FROM YARD STORAGE INTO LAG STORAGE.
;  IF NOT POSSIBLE, THEY TRY TO CYCLE FROM LAG STORAGE OUT TO YARD STORAGE.
;
CHKCY3   BRANCH,1:                          !CHECK FOR CYCLING FROM YARD
         IF,NR(M).GT.0,WAIT:                !INTO LAG STORAGE
         IF,'RECYL TO LAG'.LT.'# CANS IN',
         CHKCY4:
         IF,X(13).EQ.0 .AND. NR(M+2).EQ.0,
         YRDINN:
         IF,('CANS IN LAG'-'RECYL TO YRD')
         .LT.'MINIMUM',YRDINN:
         ELSE,CHKCY4;
CHKCY4   BRANCH,1:
         IF,NR(M).GT.0,WAIT:                !CHECK FOR CYCLING FROM LAG
         IF,'RECYL TO YRD'.LT.'# CANS OUT',!STORAGE OUT TO YARD STORAGE
         WAIT:
         IF,X(13).EQ.0 .AND. NR(M+2).EQ.0,
         YRDOUT:
         IF,'RECYL TO YRD'.GT.(0.50*'CANS IN LAG'),
         YRDOUT:
         ELSE,WAIT;
;
WAIT     DELAY:'BREAK TIME':NEXT(CHKMAX);    DELAY TO CHECK LAG STORAGE FOR
;                                            MANAGING LAG STORAGE INVENTORY
;   SHIP CANS OUT TO YARD
;
YRDOUT   ASSIGN:X(M+21)=1;                   SET FLAG THAT LAST TRANSFER WAS
;                                            OUT TO YARD STORAGE
         ASSIGN:X(M+23)=1;                   CANS TAKEN OUT OF LAG SUBSET
```

```
;                                                WAITING TO CYCLE TO YARD STORAGE
YARDOT   QUEUE,'YDOT CART QUE';                  QUEUE UP FOR YARD CART
         SEIZE,2:YCART(M-2);                     SEIZE YARD CART
         DELAY:'CART TO PORT';                   DELAY UNTIL YARD CART ARRIVES
;                                                (INCLUDES ALSO ACT. 214,215,
;                                                 201,& 202)
         QUEUE,'ECR YDOT QUE';                   QUEUE UP FOR EAST CRANE
         SEIZE,2:ECRANE(M-2);                    SEIZE EAST CRANE
         DELAY:'CANS INTO CASK';                 DELAY TO MOVE CANS INTO CASK
;                                                (CRANE GOES BACK AND FORTH TO
;                                                 MOVE '# CANS OUT' INTO CASK,
;                                                 ALSO INCLUDES ACT. 203)
         BRANCH,1:                              !CHECK WHICH SUBSET OF LAG CANS
         IF,X(M+23).EQ.1,CNTCYL:                !WERE TAKEN FROM
         ELSE,CNTLAG;
CNTCYL   ASSIGN:X(M+11)=X(M+11)-'# CANS OUT';UPDATE CYCLE COUNTERS
         COUNT:'RECYCLE TO YRD',-'# CANS OUT';
         ASSIGN:X(M+23)=0;
CNTLAG   COUNT:'LAG SIZE',-'# CANS OUT';         DECREASE LAG STORAGE SIZE
         ASSIGN:X(M+5)=X(M+5)-'# CANS OUT'; COUNT LAG STORAGE FOR DSTAT ELE.
         RELEASE:ECRANE(M-2);                    RELEASE EAST CRANE
         DELAY:'CASK TO YARD';                   DELAY TO MOVE CASK TO YARD
;                                                (INCLUDES ACT. 204 THRU 213)
         COUNT:'YARD STORAGE',+'# CANS OUT';INCREASE YARD STORAGE SIZE
         ASSIGN:X(10)=X(10)+'# CANS OUT';        COUNT YARD STORAGE FOR DSTAT ELE.
         COUNT:'CANS TO YARD',+'# CANS OUT';INCREASE COUNT OF CANS TO YARD
         RELEASE:YCART(M-2);                     RELEASE YARD CART
         BRANCH,2:                              !PARALLEL ACTIVITIES
           ALWAYS,YDELAY:                       !KEEP CAN IN YARD STORAGE FOR AT
                                                !LEAST 'YARD TIME'
           ALWAYS,CHKMAX;                        RECYCLE LAG MANAGER ENTITY
YDELAY   DELAY:'YARD TIME';                      DELAY FOR YARD RESIDENCE TIME
         ASSIGN:X(16)=X(16)+'# CANS OUT';        UPDATE RECYCLE COUNTERS
         COUNT:'RECYCLE TO LAG',+'# CANS OUT':DISPOSE;
;
;   SHIP CANS FROM YARD INTO LAG STORAGE
;
YRDINN   ASSIGN:X(M+21)=0;                       SET FLAG THAT LAST TRANSFER WAS
                                                !INTO LAG STORAGE
         ASSIGN:X(16)=X(16)-'# CANS IN';         UPDATE RECYCLE COUNTERS
         COUNT:'RECYCLE TO LAG',-'# CANS IN';
YARDIN    QUEUE,'YDIN CART QUE';                 QUEUE FOR YARD CART
          SEIZE,2:YCART(M-2);                    SEIZE YARD CART
          DELAY:'CAN TO PORT TIME';              DELAY FOR SHIP FROM YARD TO PORT
          QUEUE,'ECR YDIN QUE';                  QUEUE FOR EAST CRANE
          SEIZE,2:ECRANE(M-2);                   SEIZE EAST CRANE
          DELAY:'LIFT CANS TO LAG';              DELAY FOR UNLD CANS INTO LAG STR.
          COUNT:'YARD STORAGE',-'# CANS IN';DECREASE YARD STORAGE
          ASSIGN:X(10)=X(10)-'# CANS IN';        COUNT YARD STORAGE FOR DSTAT ELE.
          COUNT:'LAG',+'# CANS IN';              INCREASE LAG STORAGE
          ASSIGN:X(M+5)=X(M+5)+'# CANS IN'; COUNT LAG STORAGE FOR DSTAT ELE.

          COUNT:'CANS FROM YARD',+'# CANS IN';INCREASE COUNT OF CANS FROM YARD
          RELEASE:ECRANE(M-2);                   RELEASE EAST CRANE
```

```
          RELEASE:YCART(M-2):NEXT(CHKMAX);  RELEASE YARD CART
;
;*********************************************************************
;     SUBMODEL FOR RAIL CASK ARRIVALS.  SHIPPING CASKS ARRIVE
;     AND ARE ASSIGNED TO THE PWR OR BWR SIDE TO AWAIT LOADING.
;     UPON CASK ARRIVAL, EITHER (1) A SHIPPING CASK IS BROUGHT INTO
;     THE PORT AND CANISTERS ARE PLACED INTO THE SHIPPING CASK, WHICH
;     IS THEN PLACED BACK ONTO THE RAIL CAR, OR (2) A REPOSITORY
;     OVERPACK IS BROUGHT INTO THE PORT AND CANISTERS ARE PLACED
;     INTO THE OVERPACK, WHICH IS THEN LOADED INTO THE SHIPPING
;     CASK AND PLACED BACK ONTO THE RAIL CAR.
;*********************************************************************
;
          CREATE,X(22),X(2):ED(3):MARK(1);  CREATE TRAIN ARRIVAL TO R&H BLDG
;                                           WITH X(22) RAIL CASKS. NOTE
;                                           X(22)=X(1) IN ASSIGN SUBMODEL BUT
;                                           CAN BE MODIFIED IN WKEND SUBMODEL
          ASSIGN:X(11)=X(11)+1;             COUNT RAIL CASK ARRVS FOR DSTAT
          ASSIGN:X(13)=X(13)+1;             # OF RAIL CASKS WAITING TO LOAD

          COUNT:'RAIL CARS WAIT',+1;        COUNT RAIL CARS WAITING TO LOAD
          DELAY:'GATE INSPEC';              DELAY FOR GATE INSPECTION
          QUEUE,'RAIL CASK QUE';            RAIL CASKS WAIT IN CENTRAL QUEUE
          SELECT,POR:BWR:PWR;               SEND RAIL CASK TO BWR OR PWR SIDE
;
PWR       SEIZE,1:CART(1);                  SEIZE CASK CART AT PWR SIDE OF BLDG
          ASSIGN: M = 1:NEXT(CONTRL);       LOAD RAIL CASK AT PWR SIDE OF BLDG
;
BWR       SEIZE,1:CART(2);                  SEIZE CASK CART AT BWR SIDE OF BLDG
          ASSIGN: M = 2;                    LOAD RAIL CASK AT BWR SIDE OF BLDG
;
;   DETERMINE WHETHER OR NOT REPOSITORY OVERPACK IS TO BE USED
;
CONTRL    ASSIGN:X(13)=X(13)-1;             # OF RAIL CASKS WAITING TO LOAD
          COUNT:'RAIL CARS WAIT',-1;        COUNT RAIL CARS WAITING TO LOAD
          BRANCH,1:                        !CHECK IF REP. OVPACK IS TO BE USED
            IF,'OVERPACK'.EQ.1,OVPACK:     !OVERPACK IS TO BE USED
            ELSE,SPCASK;                   !ONLY SHIPPING CASK IS TO BE USED
;
;   SHIP CANISTERS TO YARD WITHOUT USING OVERPACK
;
SPCASK    ASSIGN:X(23)='CANS IN CASK';      SET CANS SHIPPED PER RAIL CAR
          QUEUE,'FOR OH';                   QUEUE UP FOR OVERHEAD CRANE
          SEIZE,1:OH(M);                    SEIZE OVERHEAD CRANE
          DELAY:'CASK ONOFF';               SET SHIPPING CASK ON CASK CART
          RELEASE:OH(M);                    FREE OVERHEAD CRANE
          DELAY:'CASK MOVE IN';             DELAY TO MOVE CASK CART INTO PORT
LOADUP    BRANCH,1:                        !CHECK FOR SUFFICIENT ELIGIBLE CANS
            IF,('LAG STORAGE CANS'-'RECY TO YRD')
            .GE.'CANS IN CASK',FILLUP:
            ELSE,IDLING;
FILLUP    QUEUE,'ECRANE QUEUE';             QUEUE FOR EAST CRANE
          SEIZE,1:ECRANE(M);                SEIZE EAST CRANE
          DELAY:'LOAD SHIP CASK';           LOAD SHIPPING CASK WITH CANS
```

```
        COUNT:'LAG STORAGE',-'CANS IN CASK';DECREASE LAG STORAGE
        ASSIGN:X(M+7)=X(M+7)-'CANS IN CASK':!COUNT LAG STORAGE FOR DSTAT
        NEXT(CASKOT);
IDLING  DELAY:'CHECK TIME':NEXT(LOADUP);  DELAY FOR SUFFICIENT CANS FOR
CASK
;
;   SHIP CANISTERS TO YARD USING OVERPACK
;   BRING REPOSITORY OVERPACK INTO PORT USING CASK CART
;
OVPACK  ASSIGN:X(23)='CANS IN PACK';      SET CANS SHIPPED PER RAIL CAR
        ASSIGN:A(2)=1;                    ASSIGN A(2) TO MATCH QUES BELOW
        QUEUE,'OH QUEUE';                 WAIT FOR OH CRANE
        SEIZE,1:OH(M);                    SEIZE OH CRANE
        DELAY:'OP ON';                    SET OVERPACK ON CASK CART
        RELEASE:OH(M);                    FREE OH CRANE
        DELAY:'PACK TO PORT';             MOVE CASK CART TO PORT
        QUEUE,'PACK ECRANE QUE';          WAIT FOR EAST CRANE
        SEIZE,1:ECRANE(M);                SEIZE EAST CRANE
        DELAY:'LIFT PACK';                LIFT OVERPACK INTO BLDG
        RELEASE:ECRANE(M);                RELEASE EAST CRANE
        BRANCH,2:                        !PARALLEL ACTS: BACK OUT CART AND
           ALWAYS,OUT:                   !LOAD CANS INTO OVERPACK INSIDE
           ALWAYS,LOAD;                   R&H BLDG
;
LOAD    BRANCH,1:
           IF,('LAG STORAGE CANS'-'RECY TO YRD')
           .GE.'CANS IN PACK',FILL:      !NOTE CANS THAT MUST FIRST RECYCLE
                                         !TO YARD FROM LAG STORAGE ARE NOT
                                         !ELIGIBLE UNTIL THEY HAVE RECYCLED
                                         !BACK INTO LAG STORAGE
           ELSE,IDLE;
FILL    QUEUE,'LOADING Q';                QUEUE FOR EAST CRANE TO LOAD OVPK

        SEIZE,1:ECRANE(M);                SEIZE EAST CRANE
        DELAY:'LOAD PACK';                DELAY TO LOAD CANS INTO OVERPACK
        RELEASE:ECRANE(M);                RELEASE EAST CRANE
        COUNT:'LAG STORAGE',-'CANS IN PACK';DECREASE LAG STORAGE
        ASSIGN:X(M+7)=X(M+7)-'CANS IN PACK';COUNT LAG STORAGE FOR DSTAT
        BRANCH,1:
          IF,M.EQ.1,PCKPWR:
          ELSE,PCKBWR;
PCKPWR  QUEUE,18:DETACH;                  LOADED PWR OVPK READY IN R&H BLDG
PCKBWR  QUEUE,19:DETACH;                  LOADED BWR OVPK READY IN R&H BLDG
;
IDLE    DELAY:'CHECK TIME':NEXT(LOAD);    DELAY FOR SUFFICIENT CANS FOR OVPK
;
;   BACK EMPTY CASK CART OUT OF PORT
;
OUT     DELAY:'CARTOUT';                  DELAY TO MOVE CASK CART OUT OF PORT
        QUEUE,'FOR OH';                   QUEUE UP FOR OVERHEAD CRANE
        SEIZE,1:OH(M);                    SEIZE OVERHEAD CRANE
        DELAY:'ADAPTOFF'+'CASK ONOFF';    LIFT OVPK ADAPTOR OFF CART AND
;                                         SET SHIPPING CASK ON CASK CART
        RELEASE:OH(M);                    FREE OVERHEAD CRANE
```

```
;
;   BRING CASK CART WITH SHIPPING CASK INTO PORT
;
          DELAY:'CASK MOVE IN';               DELAY TO MOVE CASK CART INTO PORT
          BRANCH,1:
            IF,M.EQ.1,CSKPWR:
            ELSE,CSKBWR;
CSKPWR    QUEUE,7:DETACH;                     CASK CART QUEUES AT PWR PORT
          MATCH,2:                           !MATCH CASK CART IN PWR LOAD Q
          CSKPWR,CONT:                       !WITH LOADED OVERPACK IN PWR
          PCKPWR;                            !OVER PACK QUE ON A(2)
CSKBWR    QUEUE,8:DETACH;
          MATCH,2:                           !MATCH CASK CART IN BWR LOAD Q
          CSKBWR,CONT:                       !WITH LOADED OVERPACK IN BWR
          PCKBWR;                            !OVER PACK QUE ON A(2)
CONT      QUEUE,'ECRANE QUEUE';               MATCH,SO QUEUE FOR EAST CRANE
          SEIZE,1:ECRANE(M);                  SEIZE EAST CRANE
          DELAY:'CASK LOAD';                  DELAY TO LOAD OVPK ON CASK CART
CASKOT    RELEASE:ECRANE(M);                  RELEASE EAST CRANE
          DELAY:'CASK MOVE OUT';              DELAY TO MOVE CASK CART OUT
          QUEUE,'OH OUT';                     QUEUE UP FOR OVERHEAD CRANE
          SEIZE,1:OH(M);                      SEIZE OVERHEAD CRANE
          DELAY:'CASK ONOFF';                 DELAY TO LIFT CASK ONTO TRAIN
          RELEASE:OH(M);                      RELEASE OVERHEAD CRANE
          RELEASE:CART(M);                    RELEASE CASK CART
          DELAY:'SECURE & TIE';               DELAY TO SECURE SHIP. CASK ON TRN
          TALLY:M,INT(1);                     TALLY SHIP. CASK TURNAROUND TIME
;
;   COMBINE LOADED RAIL CASKS INTO TRAIN FOR REPOSITORY
;
          QUEUE,'LOAD TRAIN Q';               QUEUE RAIL CASKS TO TRAIN
          COMBINE:X(1),FIRST;                 COMBINE X(1) RAIL CASKS INTO TRAIN
          ASSIGN:X(3)=X(1)*X(23);
          COUNT:'CANS TO REP',+X(3);          COUNT CANS TO REPOSITORY
          ASSIGN:X(12)=X(12)+X(3);            COUNT CANS TO REPOSITORY FOR DSTAT
          TALLY:3,INT(1):DISPOSE;             TALLY TRAIN TURNAROUND TIME
END;
```

A.6 BLOCKS LISTING FOR BACK-END MRS MODEL

```
SYNONYMS
        ECR YDOT QUE=M+2
        ECRANE QUEUE=M+8
        YDIN CART QUE=M+8
        PACK ECRANE QUE=M+12
        LAG SIZE=M-2
        YARD STORAGE=3
        CANS IN YARD=NC(3)
        LAG STORAGE=M
        LAG STORAGE CANS=NC(M)
        LAG=M-2
        CANS IN LAG=NC(M-2)
        # CANS OUT=P(1,1)
        FRAC TO YARD=P(1,2)
        MAXIMUM=P(1,3)
        MINIMUM=P(1,4)
        CANS IN PACK=P(1,5)
        # CANS IN=P(1,6)
        YARD TIME=P(1,7)
        WKEND TRAINS=P(1,8)
        OVERPACK=P(1,9)
        CANS IN CASK=P(1,10)
        SIZE LAG=NC(M-6)
        RAIL CASK QUE=17
        WCRANE QUE=M+14
        OVER PACK QUE=M+17
        BREAK TIME=ED(5)
        CAN TO PORT TIME=ED(6)
        LIFT CANS TO LAG=ED(7)
        CASK MOVE IN=ED(8)
        CASK LOAD=ED(9)
        CASK MOVE OUT=ED(10)
        SECURE & TIE=ED(11)
        PACK TO PORT=ED(12)
        LIFT PACK=ED(13)
        LOAD PACK=ED(14)*P(1,5)
        GATE INSPEC=ED(15)
        CAN TO LAG=ED(16)
        CART TO PORT=ED(17)
        CANS INTO CASK=ED(18)
        CASK TO YARD=ED(19)
        YDOT CART QUE=M
        CANS TO YARD=M+1
        CANS FROM YARD=M+3
        RECYCLE TO YARD=M+21
        RECYCLE TO YRD=M+19
        RECYCLE TO LAG=24
        RECYL TO YRD=NC(M+19)
        RECY TO YRD=NC(M+21)
        RECYL TO LAG=NC(24)
        RAIL CARS WAIT=25
        CVF ARV PORT=M+7
```

```
OVP LV PORT=M+9
CANS TO REP=12
WCRANE FAILS=M+9
WCRANE FIXES=M+10
ECRANE FAILS=M+10
ECRANE FIXES=M+11
OH FAILS=M+9
OH FIXES=M+10
OH QUEUE=M+20
CAN ARRIVALS=M+19
CASK ONOFF=ED(20)
ECR YDIN QUE=M+20
OH OUT=M+24
OP OH Q=M+26
OP ON=ED(21)
CARTOUT=ED(22)
FOR OH=M+28
ADAPTOFF=ED(23)
CHECK TIME=ED(24)
CAN REROUTE TIME=ED(25)
LOAD SHIP CASK=ED(26)
LOADING Q=M+30
LOAD Q=M+6
LOAD TRAIN Q=M+38
```

IN THE MODEL NOMENCLATURE BELOW, THE WEST CRANE IS THE 35-TON CRANE PRIMARILY SERVICING THE WELDING STATION, THE EAST CRANE IS THE 35-TON CRANE PRIMARILY SERVICING THE EXIT PORTS, AND THE OVERHEAD CRANE IS THE 150-TON CRANE SERVICING THE RAIL CARS.

```
**********************************************************************
   SUBMODEL WHICH INITIALIZES COUNTERS IN THE EVENT INITIAL LAG STORAGE
   OR YARD STORAGE IS NON-ZERO AT STARTUP.
**********************************************************************

10:   | CREATE,1    |
      |             |
            ↓
20:   | ASSIGN      |
      | X(22)=X(1)  |      INITIALIZE # RAIL CARS IN REP
            ↓
30:   | COUNT       |
      | 1,X(8)      |      INITIALIZE PWR LAG STORAGE CO
            ↓
```

40: COUNT | 2,X(9) — INITIALIZE BWR LAG STORAGE CO

50: COUNT | 3,X(10) — INITIALIZE YARD STORAGE COUNT

60: COUNT | 22,X(14) — INITIALIZE PWR LAG CANS WAITI

TO RECYCLE TO YARD

70: COUNT | 23,X(15) — INITIALIZE BWR LAG CANS WAITI

TO RECYCLE TO YARD

80: COUNT | 24,X(16) — INITIALIZE YARD CANS WAITING

RECYCLE TO LAG STORAGE

```
*****************************************************************
   SUBMODEL WHICH SHUTS DOWN THE BACK-END MRS FACILITY ON WEEKENDS.
   ASSUME THAT NO CANNISTERS ARRIVE FROM THE FRONT-END FACILITY TO
   THE BACK-END FACILITY ON WEEKENDS (NOTE X(21) SET BELOW).
*****************************************************************
```

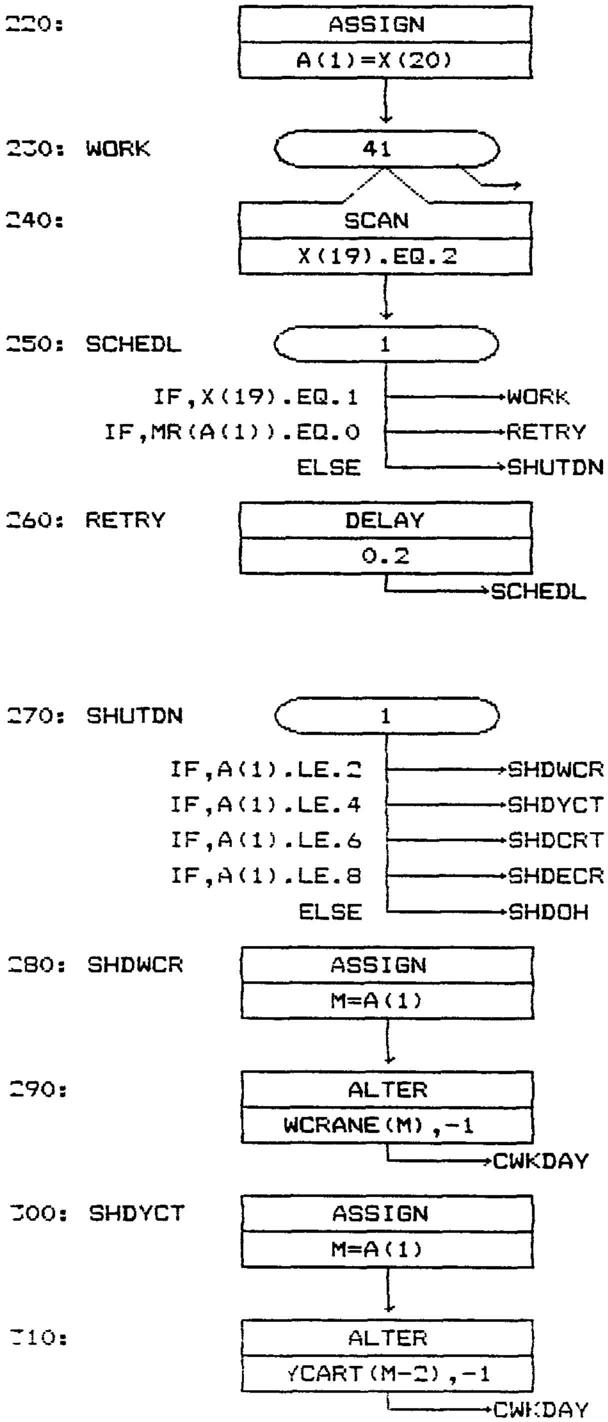
90: CREATE,1,X(18) — CREATE WORKDAY-WEEKEND ENTITY

100: WKDAY ASSIGN | X(19)=1 — SET GLOBAL FLAG FOR WORKDAYS

110: ASSIGN | X(21)=1 — SET BATCH SIZE FOR CAN ARRIVA

IN INTERFACE SUBMODEL

120:		ASSIGN X(22)=X(1)	SET # RAIL CARS IN TRAIN FROM
130:		DELAY 4.9	WORK 4.9 DAYS,ALLOWING 0.1 DA TO SHUT DOWN ON WEEKENDS
140:	WKEND	ASSIGN X(19)=2	SET GLOBAL FLAG FOR WEEKENDS
150:		ASSIGN X(21)=0	NO CAN ARRIVALS IN INTERFACE
160:		1 IF,'WKEND TRAINS'.EQ.0 → NTRAIN ELSE → YTRAIN	OPTION TO SHUT DOWN TRAINS FR REP DURING WEEKEND SHUT DOWNS
170:	NTRAIN	ASSIGN X(22)=0 → DELAYS	NO WEEKEND TRAINS ARRIVE FROM
180:	YTRAIN	ASSIGN X(22)=X(1)	YES WEEKEND TRAINS ARRIVE FRO
190:	DELAYS	DELAY 2.1 → WKDAY	SHUT DOWN FOR 2.1 DAYS
200:		CREATE,10,X(18)	CREATE 10 ENTITIES,ONE FOR EA OF 10 RESOURCES
210:		ASSIGN X(20)=X(20)+1	X(20) INITIALIZED TO 0



STORE RESOURCE # IN ATTRIBUTE

QUEUE FOR SCAN CONDITION TO C

FOR START OF WEEKEND

BRANCH CONTROL FOR WEEKEND

RESUME WORK

RESOURCE IS BROKEN DOWN

SHUT DOWN RESOURCE

DELAY TO SEE IF RESOURCE IS S

BUSY OR BROKEN DOWN

SHUT DOWN ALL RESOURCES ON WE

WEST CRANES

YARD CARTS

CASH CARTS

EAST CRANES

OVERHEAD CRANES

SHUT DOWN WEST CRANES

SHUT DOWN YARD CARTS

320: SHDCRT — ASSIGN: M=A(1) — SHUT DOWN CASK CARTS

330: ALTER: CART(M-4),-1 → CWKDAY

340: SHDECR — ASSIGN: M=A(1) — SHUT DOWN EAST CRANES

350: ALTER: ECRANE(M-6),-1 → CWKDAY

360: SHDOH — ASSIGN: M=A(1) — SHUT DOWN OVERHEAD CRANES

370: ALTER: OH(M-8),-1

380: CWKDAY — 42 — QUEUE FOR SCAN CONDITION TO C

390: SCAN: X(19).EQ.1 — FOR START OF WEEK DAY (WORK D

400: 1 — BRANCH CONTROL FOR WORK

IF,MR(A(1)).EQ.1 → WORK — RESOURCE IS NOT SHUT DOWN

ELSE → TURNON

410: TURNON — 1 — TURN ON RESOURCES FOR WEEKDAY

IF,A(1).LE.4 → TONYCT — YARD CARTS

IF,A(1).LE.6 → TONCRT — CASK CARTS

IF,A(1).LE.8 → TONECR — EAST CRANES

ELSE → TONOH — OVERHEAD CRANES

IF,A(1).LE.2,TONWCR: — WEST CRANES

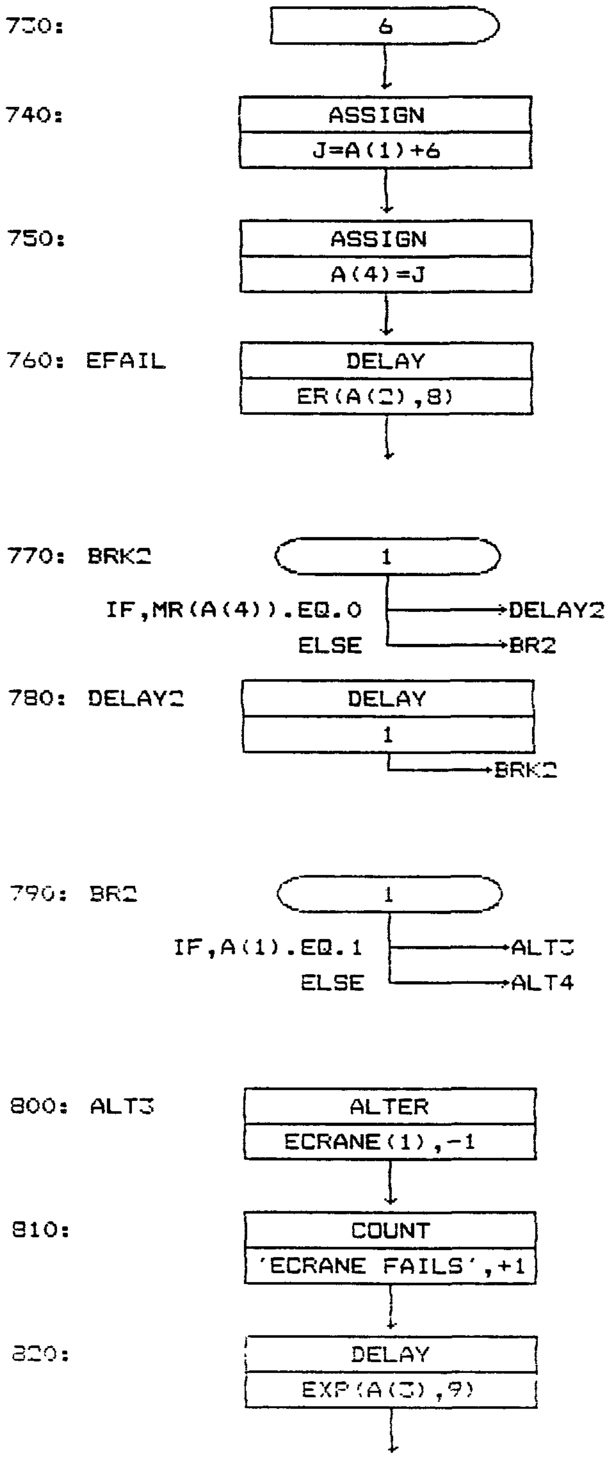
420: TONWCR — ASSIGN: M=A(1) — TURN ON WEST CRANES

```
430:                ALTER
                    WCRANE(M),+1
                        └──────→WORK

440: TONYCT         ASSIGN
                    M=A(1)                  TURN ON YARD CARTS
                        ↓
450:                ALTER
                    YCART(M-2),+1
                        └──────→WORK

460: TONCRT         ASSIGN
                    M=A(1)                  TURN ON CASK CARTS
                        ↓
470:                ALTER
                    CART(M-4),+1
                        └──────→WORK

480: TONECR         ASSIGN
                    M=A(1)                  TURN ON EAST CRANES
                        ↓
490:                ALTER
                    ECRANE(M-6),+1
                        └──────→WORK

500: TONOH          ASSIGN
                    M=A(1)                  TURN ON OVERHEAD CRANES
                        ↓
510:                ALTER
                    OH(M-8),+1
                        └──────→WORK
```

```
**********************************************************************
   SUBMODEL WHICH CREATES MACHINE FAILURES AND REMOVES THE FAILED
   MACHINE FROM THE SYSTEM FOR A SPECIFIED REPAIR PERIOD.  CURRENTLY
   ONLY WEST CRANE, EAST CRAME, AMD OVERHEAD CRANE FAILURES ARE
   INCLUDED IN THE MODEL.  NO FAILURES ARE ALLOWED ON WEEKENDS IF THE
   FACILITY IS SHUT DOWN ON WEEKENDS.  HOWEVER, IT IS ASSUMED THAT
   MAINTENANCE PERSONNEL ARE ON DUTY AT ALL TIMES AND SO REPAIR WORK
   IS ALLOWED ON WEEKENDS.
**********************************************************************
```

```
520:                 [ 5 ]

530: WFAIL           DELAY
                     ER(A(2),8)                  DELAY UNTIL NEXT BREAK DOWN

540: BRK1            ( 1 )                       CHECK IF WEST CRANE A(1) IS
     IF,MR(A(1)).EQ.0 ---->DELAY1                ALREADY DOWN DUE TO WEEKEND
                ELSE ---->BR1                    'SHUTDOWN OR PREVIOUS FAILURE

550: DELAY1          DELAY
                     1                           DELAY 1 DAY AND RECHECK
                      ---->BRK1

560: BR1             ( 1 )                       CHECK WHICH WEST CRANE TO BK
     IF,A(1).EQ.1 ---->ALT1
             ELSE ---->ALT2

570: ALT1            ALTER
                     WCRANE(1),-1                BREAK DOWN IDLE WEST CRANE #1

580:                 COUNT
                     'WCRANE FAILS',+1

590:                 ASSIGN
                     X(4)=1                      FLAG WCRANE(1) AS BROKEN

600:                 DELAY
                     EXP(A(3),9)                 DELAY UNTIL REPAIR OF CRANE

610:                 COUNT
                     'WCRANE FIXES',+1
```

```
620:                 ASSIGN
                     X(4)=0                    FLAG WCRANE(1) AS NOT BROKEN

630:                 ( 1 )
      IF,MR(A(1)).EQ.1  ---->WFAIL
              ELSE      ---->TNON1

640: TNON1           ALTER
                     WCRANE(1),+1              REPAIR OF CRANE COMPLETED
                                ---->WFAIL

650: ALT2            ALTER
                     WCRANE(2),-1              BREAK DOWN IDLE WEST CRANE #2

660:                 COUNT
                     'WCRANE FAILS',+1

670:                 ASSIGN
                     X(5)=1                    FLAG WCRANE(2) AS BROKEN

680:                 DELAY
                     EXP(A(3),9)               DELAY UNTIL REPAIR OF CRANE

690:                 COUNT
                     'WCRANE FIXES',+1

700:                 ASSIGN
                     X(5)=0                    FLAG WCRANE(2) AS NOT BROKEN

710:                 ( 1 )
      IF,MR(A(1)).EQ.1  ---->WFAIL
              ELSE      ---->TNON2

720: TNON2           ALTER
                     WCRANE(2),+1              REPAIR OF CRANE COMPLETED
                                ---->WFAIL
```



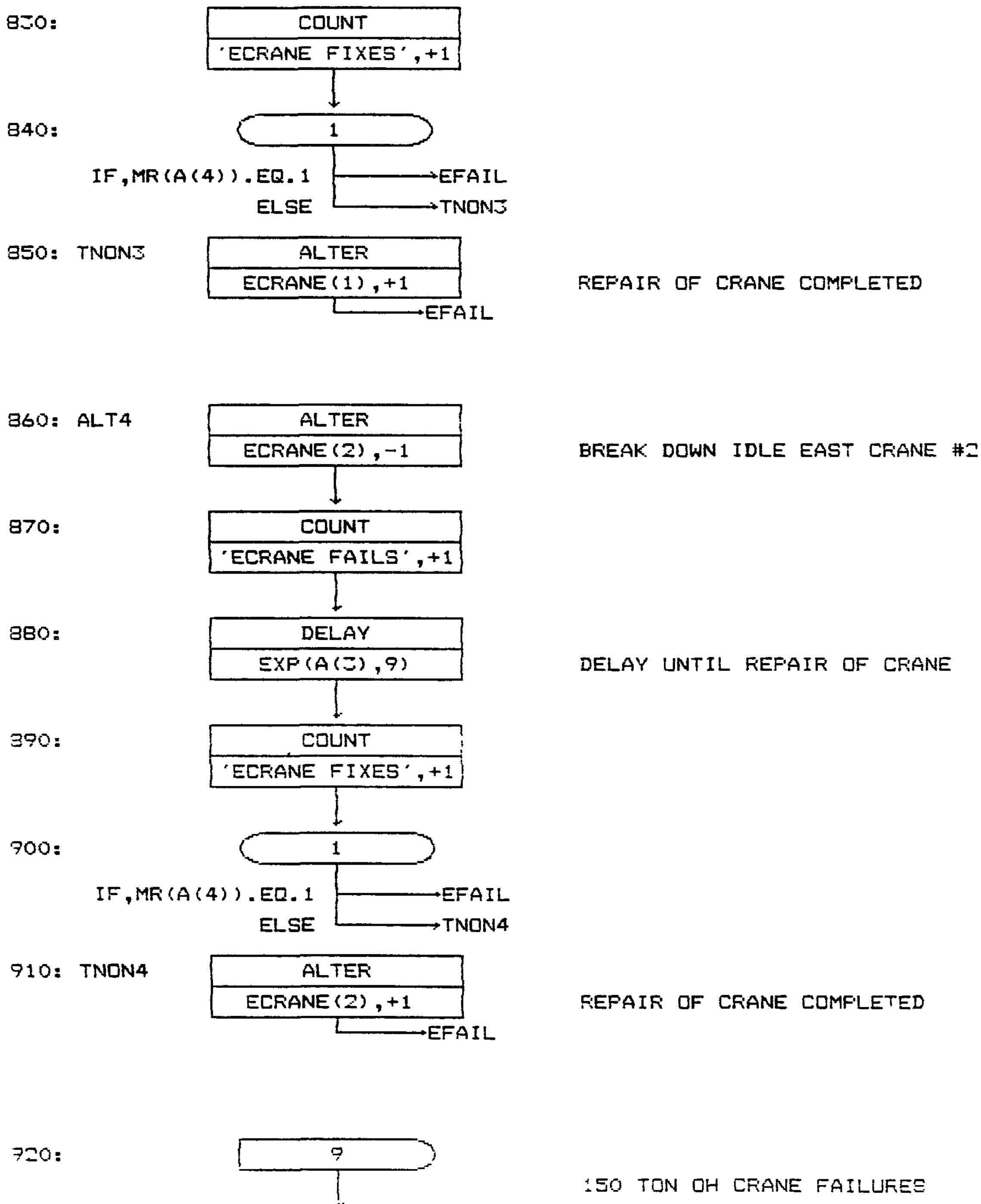
DELAY UNTIL NEXT BREAK DOWN

CHECK IF EAST CRANE A(1) IS
ALREADY DOWN DUE TO WEEKEND
!SHUTDOWN OR PREVIOUS FAILURE

CHECK WHICH EAST CRANE TO B

BREAK DOWN IDLE EAST CRANE #1

DELAY UNTIL REPAIR OF CRANE


830:
COUNT
'ECRANE FIXES',+1
840:
1
IF,MR(A(4)).EQ.1
EFAIL
ELSE
TNON3
850: TNON3
ALTER
ECRANE(1),+1
EFAIL
REPAIR OF CRANE COMPLETED
860: ALT4
ALTER
ECRANE(2),-1
BREAK DOWN IDLE EAST CRANE #2
870:
COUNT
'ECRANE FAILS',+1
880:
DELAY
EXP(A(3),9)
DELAY UNTIL REPAIR OF CRANE
890:
COUNT
'ECRANE FIXES',+1
900:
1
IF,MR(A(4)).EQ.1
EFAIL
ELSE
TNON4
910: TNON4
ALTER
ECRANE(2),+1
EFAIL
REPAIR OF CRANE COMPLETED
920:
9
150 TON OH CRANE FAILURES

```
930:                 ASSIGN
                     J=A(1)+8

940:                 ASSIGN
                     A(4)=J

950: OFAIL           DELAY
                     ER(A(3),8)            DELAY UNTIL NEXT BREAKDOWN

960: BRK3            1                     CHECK IF OH CRANE A(1) IS
     IF,MR(A(4)).EQ.0  ---->DELAY3         ALREADY DOWN DUE TO WEEKEND
                 ELSE  ---->BR3            'SHUTDOWN OR PREVIOUS FAILURE

970: DELAY3          DELAY
                     1
                       ---->BRK3

980: BR3             1                     CHECK WHICH OH FAILS
        IF,A(1).EQ.1   ---->ALT5
                ELSE   ---->ALT6

990: ALT5            ALTER
                     OH(1),-1              BREAKDOWN IDLE 150 TON CRANE

1000:                COUNT
                     'OH FAILS',+1

1010:                DELAY
                     EXP(A(3),9)           DELAY UNTIL REPAIR OF CRANE

1020:                COUNT
                     'OH FIXES',+1
```

```
1030:                  ( 1 )
          IF,MR(A(4)).EQ.1 ──→OFAIL
                      ELSE ──→TNON5

1040: TNON5            ALTER
                     OH(1),+1              REPAIR OF CRANE COMPLETED
                           ──→OFAIL

1050: ALT6             ALTER
                     OH(2),-1              BREAKDOWN IDLE 150 TON CRANE

1060:                  COUNT
                   'OH FAILS',+1

1070:                  DELAY
                   EXP(A(3),9)             DELAY UNTIL REPAIR OF CRANE

1080:                  COUNT
                   'OH FIXES',+1

1090:                  ( 1 )
          IF,MR(A(4)).EQ.1 ──→OFAIL
                      ELSE ──→TNON6

1100: TNON6            ALTER
                     OH(2),+1              REPAIR OF CRANE COMPLETED
                           ──→OFAIL
```

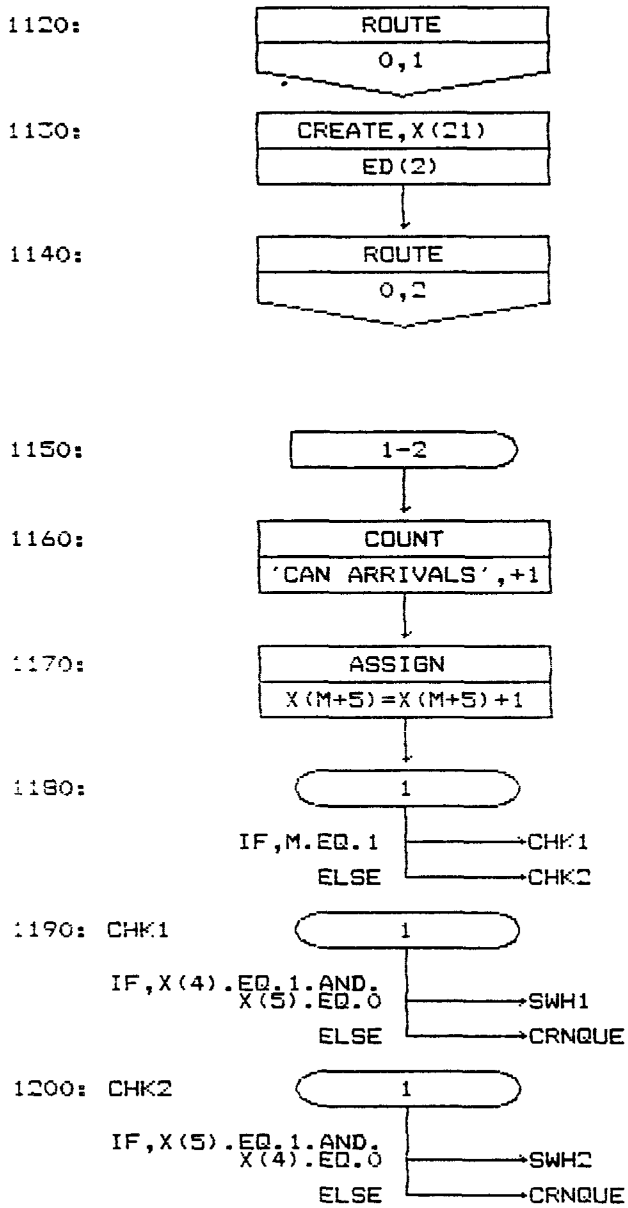
****

SUBMODEL WHICH CREATES CANISTER ARRIVALS TO THE SYSTEM AT THE OUTLET OF THE WELD INSPECTION STATION (I.E., BEGINNING WITH ACTIVITY NO. 108) AND PUTS THE CANISTERS INTO LAG STORAGE.

****

```
1110:              CREATE,X(21)
                      ED(1)                CREATE PWR CAN AT EXIT OF WEL

                                    X(21) INITIALIZED TO 1 BUT CAN
```

MODIFIED IN WEEKEND SUBMODEL



ROUTE TO STATION 1

CREATE BWR CAN AT EXIT OF WEL

ROUTE TO STATION 2

MOVE CAN FROM UT INTO LAG ST

COUNT CAN ARRIVALS OF EACH TY

COUNT CAN ARRIVALS FOR DSTAT

BRANCH ON STATION NUMBER

IF WCRN 1 IS BROKEN AND WCRN
!ELSE, CONTINUE WITH WCRN 1.

IF WCRN 2 IS BROKEN AND WCRN
!ELSE, CONTINUE WITH WCRN 2.

```
1210: SWH1     ASSIGN
               M=2                      REROUTE CAN TO WEST CRN 2

1220:          DELAY                    DELAY TO REROUTE CAN TO WEST
               'CAN REROUTE TIME'
                 └──────→CRNQUE

1230: SWH2     ASSIGN
               M=1                      REROUTE CAN TO WEST CRN 1

1240:          DELAY                    DELAY TO REROUTE CAN TO WEST
               'CAN REROUTE TIME'

1250: CRNQUE   WCRANE QU                QUEUE UP FOR WEST CRN NOT BFO

1260:          SEIZE,1
               WCRANE(M)                SEIZE WEST CRANE

1270:          DELAY
               'CAN TO LAG'             DELAY TO LIFT CAN INTO LAG ST

                                                  (ACT. 108)

1280:          RELEASE
               WCRANE(M)                RELEASE WEST CRANE

1290:          1                        CHECK WHETHER ARRIVING CANS S
    WITH 'FRAC TO YARD' ──→RECYCL       RECYCLE FROM LAG STORAGE TO Y
    ELSE                ──→LAG          'STORAGE

1300: RECYCL   ASSIGN
               X(M+13)=X(M+13)+1        COUNT CANS IN LAG STORAGE WAI
```

1310: COUNT — 'RECYCLE TO YARD' — TO RECYCLE TO YARD STORAGE

1320: LAG — ASSIGN — X(M+7)=X(M+7)+1 — COUNT LAG STORAGE FOR DSTAT E

1330: COUNT — 'LAG STORAGE' — INCREASE LAG STORAGE BY ONE

****

SUBMODEL FOR LAG AND YARD STORAGE MANAGEMENT. EACH HALF OF THE R & H BUILDING HAS AN ENTITY WHICH PERIODICALLY CHECKS TO SEE IF ITS LAG STORAGE IS BELOW THE MAXIMUM LIMIT SPECIFIED BY THE USER AND ABOVE THE MINIMUM LIMIT SPECIFIED BY THE USER. IF LAG STORAGE EXCEEDS THE MAXIMUM LIMIT, THEN CANISTERS ARE MOVED OUT TO THE YARD STORAGE SECTION OF THE MRS. IF LAG STORAGE IS BELOW THE MINIMUM LIMIT, THEN CANISTERS ARE BROUGHT IN FROM THE YARD STORAGE SECTION OF THE MRS TO ENSURE THAT ENOUGH CANISTERS ARE IN LAG STORAGE TO SERVICE CASK ARRIVALS FROM THE MRS REPOSITORY. THE LAG MANAGER ALSO PERIODICALLY CHECKS FOR CYCLING CANISTERS FROM LAG STORAGE OUT TO YARD STORAGE AND FROM YARD STORAGE INTO LAG STORAGE IF CYCLING IS SPECIFIED IN THE INPUT DATA,I.E.,FRAC TO YARD   0.

****

CHECK LAG STORAGE FOR MAXIMUM AND MINIMUM LIMITS

1340: CREATE,1 — PWR LAG MANAGER ENTITY

1350: ROUTE — 0,3 — ROUTE TO STATION 3

1360: CREATE,1 — BWR LAG MANAGER ENTITY

1370: ROUTE — 0,4 — ROUTE TO STATION 4

```
1380:                  ( 3-4 )
                          |
                                        PROCESS LAG CHECKER ENTITIES
```

LAG MANAGER CONTROL TO CHECK FOR MAXIMUM AND MINIMUM LIMITS IN LAG STO

```
1390: CHKMAX           ( 1 )
   IF,'CANS IN LAG'.
     LE.'MAXIMUM'      |------>CHKMIN     CHECK FOR MAXIMUM LAG STORAGE
      IF,'FRAC TO
     YARD'.EQ.1.0      |------>YRDOUT
             ELSE      |------>YARDOT

1400: CHKMIN           ( 1 )
   IF,'CANS IN LAG'.
     GE.'MINIMUM'      |------>CHKBRN     CHECK FOR MINIMUM LAG STORAGE
    IF,'RECYL TO LAG
     '.GE.'# CANS IN'  |------>YRDINN
             ELSE      |------>CHKBRN
```

LAG MANAGER CONTROL TO CHECK FOR CYCLING CONDITIONS

```
1410: CHKBRN           ( 1 )
      IF,'FRAC TO
       YARD'.EQ.0      |------>WAIT       WAIT IF NO CANS ARE TO CYCLE
    IF,X(M+21).EQ.0    |------>CHKCY1     LAST CYCLE WAS INTO LAG STORA
             ELSE      |------>CHKCY2     LAST CYCLE WAS OUT TO YARD ST
```

PURPOSE OF FOUR BRANCHES CHKCY1-CHKCY2 AND CHKCY3-CHKCY4 IS TO TRY TO ALTERNATE BETWEEN CYCLING OUT TO YARD STORAGE AND CYCLING INTO LAG STORAGE IF POSSIBLE. OTHER CYCLING STRATEGIES COULD BE PROGRAMMED INTO THE SUBMODEL HERE.

CHKCY1-CHKCY2 TRY TO CYCLE FROM LAG STORAGE OUT TO YARD STORAGE.
IF NOT POSSIBLE, THEY TRY TO CYCLE FROM YARD STORAGE INTO LAG STORAGE.

```
1420:  CHKCY1          ( 1 )                    CHECK FOR CYCLING FROM LAG
          IF,NR(M).GT.0          ──→WAIT        STORAGE OUT TO YARD STORAGE
          IF,'RECYL TO YRD'
          .LT.'# CANS OUT'       ──→CHKCY2
          IF,X(13).EQ.0.A
          ND.NR(M+2).EQ.0        ──→YRDOUT
          IF,'RECYL TO
          YRD'.GT.(0.50*
          'CANS IN LAG')         ──→YRDOUT
          ELSE                   ──→CHKCY2

1430:  CHKCY2          ( 1 )                    CHECK FOR CYCLING FROM YARD
          IF,NR(M).GT.0          ──→WAIT        INTO LAG STORAGE
          IF,'RECYL TO LAG
          '.LT.'# CANS IN'       ──→WAIT
          IF,X(13).EQ.0.A
          ND.NR(M+2).EQ.0        ──→YRDINN
          IF,('CANS IN LA
          G'-'RECYL TO YR
          D').LT.'MINIMUM'       ──→YRDINN
          ELSE                   ──→WAIT
```

CHKCY3-CHKCY4 TRY TO CYCLE FROM YARD STORAGE INTO LAG STORAGE.
IF NOT POSSIBLE, THEY TRY TO CYCLE FROM LAG STORAGE OUT TO YARD STORAGE

```
1440:  CHKCY3          ( 1 )                    CHECK FOR CYCLING FROM YARD
          IF,NR(M).GT.0          ──→WAIT        INTO LAG STORAGE
          IF,'RECYL TO LAG
          '.LT.'# CANS IN'       ──→CHKCY4
          IF,X(13).EQ.0.A
          ND.NR(M+2).EQ.0        ──→YRDINN
          IF,('CANS IN LA
          G'-'RECYL TO YR
          D').LT.'MINIMUM'       ──→YRDINN
          ELSE                   ──→CHKCY4

1450:  CHKCY4          ( 1 )
          IF,NR(M).GT.0          ──→WAIT        CHECK FOR CYCLING FROM LAG
          IF,'RECYL TO YRD'
          .LT.'# CANS OUT'       ──→WAIT        STORAGE OUT TO YARD STORAGE
          IF,X(13).EQ.0.A
          ND.NR(M+2).EQ.0        ──→YRDOUT
          IF,'RECYL TO
          YRD'.GT.(0.50*
          'CANS IN LAG')         ──→YRDOUT
          ELSE                   ──→WAIT
```

1460: WAIT — DELAY 'BREAK TIME' → CHKMAX — DELAY TO CHECK LAG STORAGE FO

MANAGING LAG STORAGE INVENTORY

SHIP CANS OUT TO YARD

1470: YRDOUT — ASSIGN X(M+21)=1 — SET FLAG THAT LAST TRANSFER W

OUT TO YARD STORAGE

1480: ASSIGN X(M+23)=1 — CANS TAKEN OUT OF LAG SUBSET

WAITING TO CYCLE TO YARD STORA

1490: YARDOT — OT CART Q — QUEUE UP FOR YARD CART

1500: SEIZE,2 YCART(M-2) — SEIZE YARD CART

1510: DELAY 'CART TO PORT' — DELAY UNTIL YARD CART ARRIVES

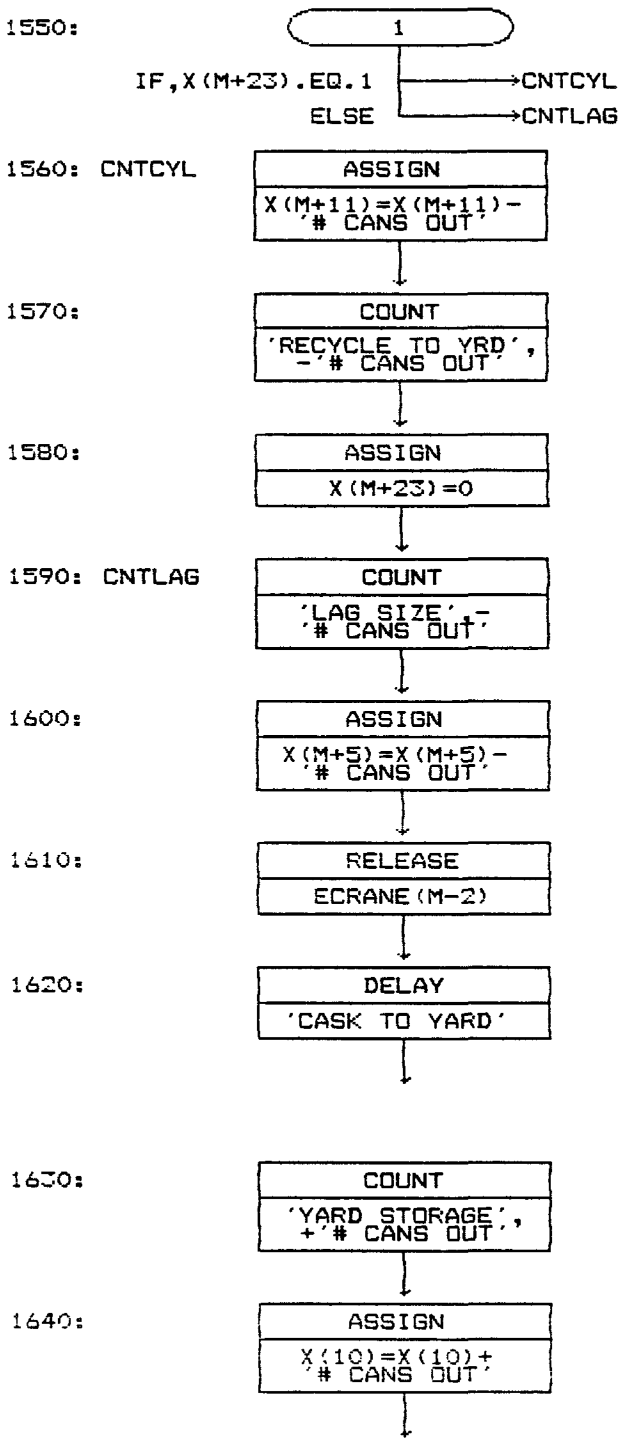
(INCLUDES ALSO ACT. 214,215,
201,& 202)

1520: CR YDOT Q — QUEUE UP FOR EAST CRANE

1530: SEIZE,2 ECRANE(M-2) — SEIZE EAST CRANE

1540: DELAY 'CANS INTO CASK' — DELAY TO MOVE CANS INTO CASK

(CRANE GOES BACK AND FORTH TO
MOVE '# CANS OUT' INTO CASK,
ALSO INCLUDES ACT. 203)



CHECK WHICH SUBSET OF LAG CAN
WERE TAKEN FROM

UPDATE CYCLE COUNTERS

DECREASE LAG STORAGE SIZE

COUNT LAG STORAGE FOR DSTAT E

RELEASE EAST CRANE

DELAY TO MOVE CASK TO YARD

(INCLUDES ACT. 204 THRU 213)

INCREASE YARD STORAGE SIZE

COUNT YARD STORAGE FOR DSTAT

1650: COUNT 'CANS TO YARD', +'# CANS OUT' — INCREASE COUNT OF CANS TO YAR

1660: RELEASE YCART(M-2) — RELEASE YARD CART

1670: 2 — PARALLEL ACTIVITIES

ALWAYS → YDELAY — KEEP CAN IN YARD STORAGE FOR

ALWAYS → CHKMAX — RECYCLE LAG MANAGER ENTITY

1680: YDELAY DELAY 'YARD TIME' — DELAY FOR YARD RESIDENCE TIME

1690: ASSIGN X(16)=X(16)+'# CANS OUT' — UPDATE RECYCLE COUNTERS

1700: COUNT 'RECYCLE TO LAG', +'# CANS OUT'

SHIP CANS FROM YARD INTO LAG STORAGE

1710: YRDINN ASSIGN X(M+21)=0 — SET FLAG THAT LAST TRANSFER W

1720: ASSIGN X(M+21)=0

1730: COUNT 'RECYCLE TO LAG', -'# CANS IN'

1740: YARDIN	IN CART Q	QUEUE FOR YARD CART
1750:	SEIZE,2 / YCART(M-2)	SEIZE YARD CART
1760:	DELAY / 'CAN TO PORT TIME'	DELAY FOR SHIP FROM YARD TO P
1770:	CR YDIN Q	QUEUE FOR EAST CRANE
1780:	SEIZE,2 / ECRANE(M-2)	SEIZE EAST CRANE
1790:	DELAY / 'LIFT CANS TO LAG'	DELAY FOR UNLD CANS INTO LAG
1800:	COUNT / 'YARD STORAGE', -'# CANS IN'	DECREASE YARD STORAGE
1810:	ASSIGN / X(10)=X(10)- '# CANS IN'	COUNT YARD STORAGE FOR DSTAT
1820:	COUNT / 'LAG',+'# CANS'IN'	INCREASE LAG STORAGE
1830:	ASSIGN / X(M+5)=X(M+5)+ '# CANS IN'	COUNT LAG STORAGE FOR DSTAT E
1840:	COUNT / 'CANS FROM YARD', +'# CANS IN'	INCREASE COUNT OF CANS FROM

1850: RELEASE / ECRANE(M-2) — RELEASE EAST CRANE

1860: RELEASE / YCART(M-2) → CHKMAX — RELEASE YARD CART

****

SUBMODEL FOR RAIL CASK ARRIVALS. SHIPPING CASKS ARRIVE AND ARE ASSIGNED TO THE PWR OR BWR SIDE TO AWAIT LOADING. UPON CASK ARRIVAL, EITHER (1) A SHIPPING CASK IS BROUGHT INTO THE PORT AND CANISTERS ARE PLACED INTO THE SHIPPING CASK, WHICH IS THEN PLACED BACK ONTO THE RAIL CAR, OR (2) A REPOSITORY OVERPACK IS BROUGHT INTO THE PORT AND CANISTERS ARE PLACED INTO THE OVERPACK, WHICH IS THEN LOADED INTO THE SHIPPING CASK AND PLACED BACK ONTO THE RAIL CAR.

****

1870: CREATE,X(22),X(2) / ED(3) — 1 — CREATE TRAIN ARRIVAL TO R&H B

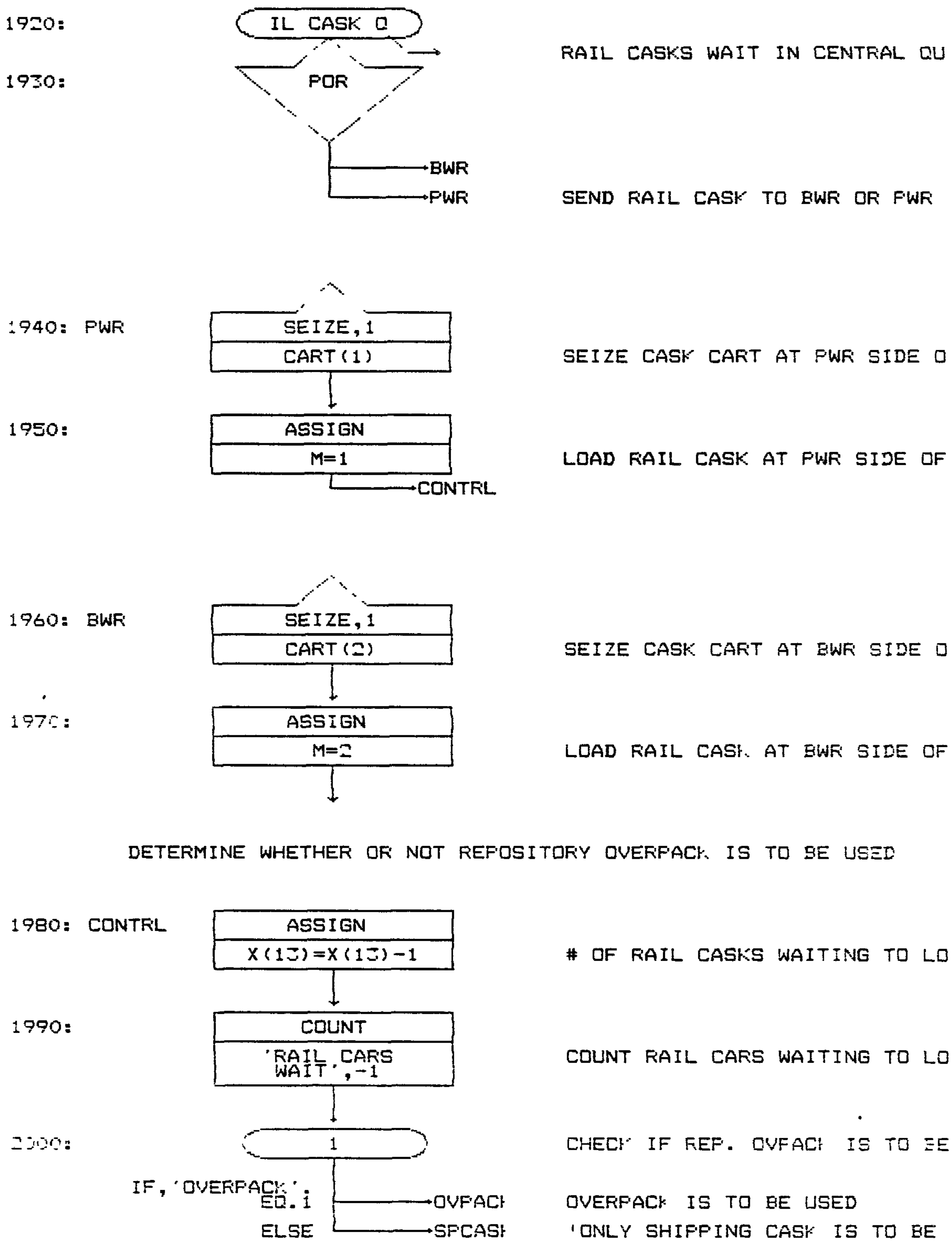
WITH X(22) RAIL CASKS. NOTE X(22)=X(1) IN ASSIGN SUBMODEL CAN BE MODIFIED IN WHEND SUBMO

1880: ASSIGN / X(11)=X(11)+1 — COUNT RAIL CASK ARRVS FOR DST

1890: ASSIGN / X(13)=X(13)+1 — # OF RAIL CASKS WAITING TO LO

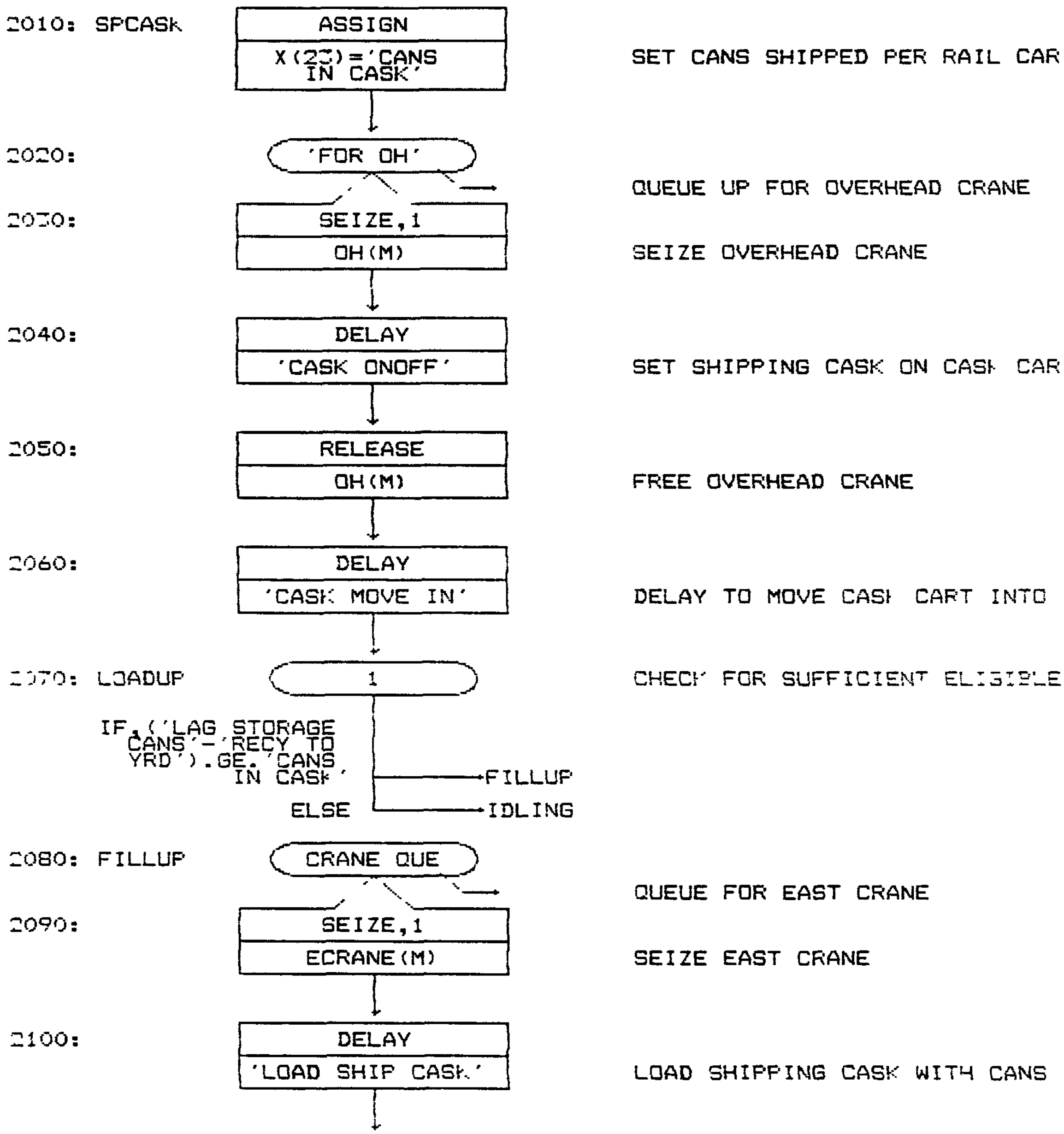
1900: COUNT / 'RAIL CARS WAIT',+1 — COUNT RAIL CARS WAITING TO LO

1910: DELAY / GATE INSPEC' — DELAY FOR GATE INSPECTION



1920:
IL CASK Q
RAIL CASKS WAIT IN CENTRAL QU
1930:
POR
BWR
PWR
SEND RAIL CASK TO BWR OR PWR
1940: PWR
SEIZE,1
CART(1)
SEIZE CASK CART AT PWR SIDE O
1950:
ASSIGN
M=1
CONTRL
LOAD RAIL CASK AT PWR SIDE OF
1960: BWR
SEIZE,1
CART(2)
SEIZE CASK CART AT BWR SIDE O
1970:
ASSIGN
M=2
LOAD RAIL CASK AT BWR SIDE OF
DETERMINE WHETHER OR NOT REPOSITORY OVERPACK IS TO BE USED
1980: CONTRL
ASSIGN
X(13)=X(13)-1
OF RAIL CASKS WAITING TO LO
1990:
COUNT
'RAIL CARS WAIT',-1
COUNT RAIL CARS WAITING TO LO
2000:
1
CHECK IF REP. OVPACK IS TO BE
IF,'OVERPACK'.EQ.1
OVPACK
OVERPACK IS TO BE USED
ELSE
SPCASH
'ONLY SHIPPING CASK IS TO BE

SHIP CANISTERS TO YARD WITHOUT USING OVERPACK



2110: COUNT — 'LAG STORAGE',-'CANS IN CASK' — DECREASE LAG STORAGE

2120: ASSIGN — X(M+7)=X(M+7)-'CANS IN CASK' — COUNT LAG STORAGE FOR DSTAT
→ CASKOT

2130: IDLING DELAY — 'CHECK TIME' — DELAY FOR SUFFICIENT CANS FOR
→ LOADUP

SHIP CANISTERS TO YARD USING OVERPACK
BRING REPOSITORY OVERPACK INTO PORT USING CASK CART

2140: OVPACK ASSIGN — X(23)='CANS IN PACK' — SET CANS SHIPPED PER RAIL CAR

2150: ASSIGN — A(2)=1 — ASSIGN A(2) TO MATCH QUES SEL

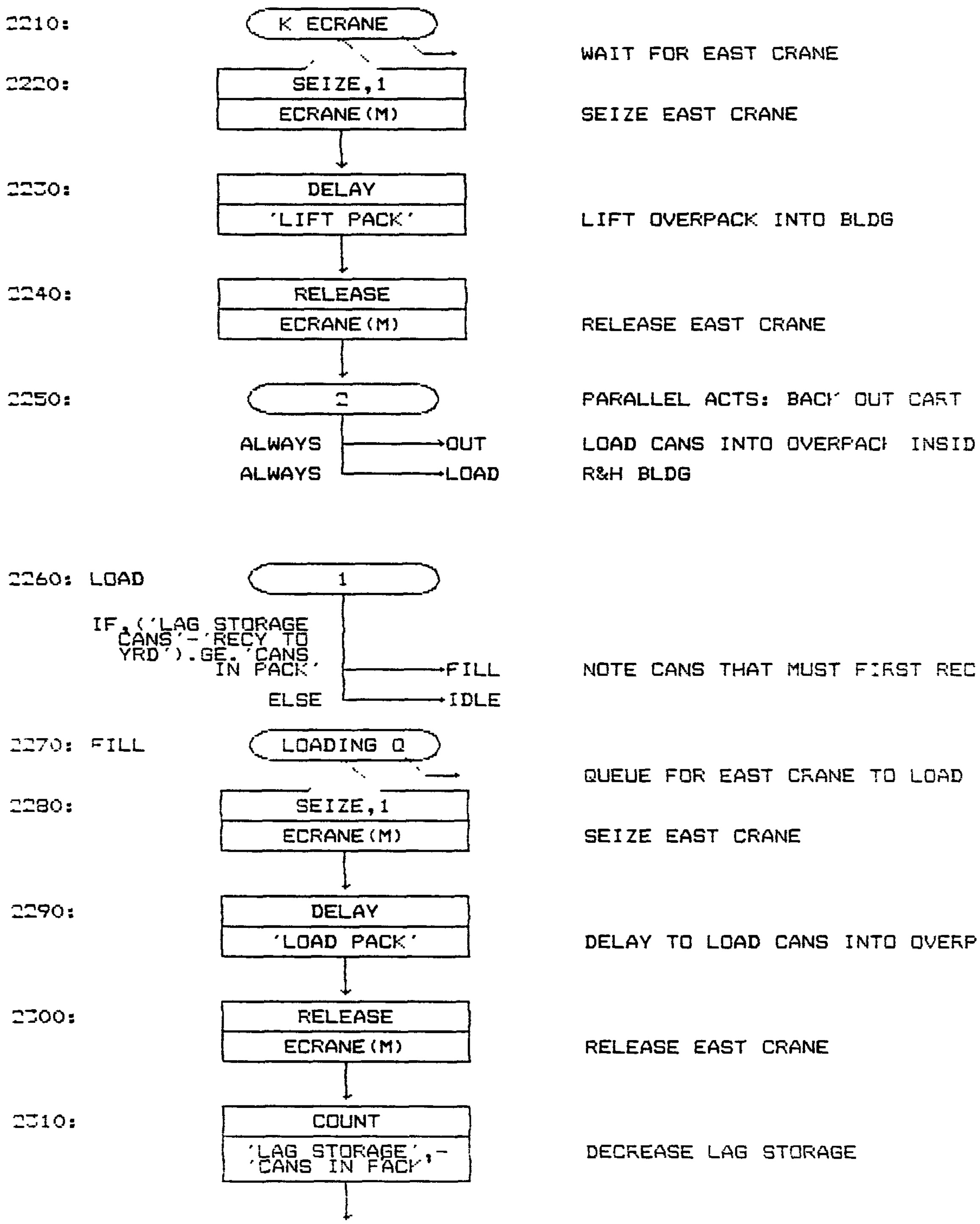
2160: 'OH QUEUE — WAIT FOR OH CRANE

2170: SEIZE,1 — OH(M) — SEIZE OH CRANE

2180: DELAY — 'OP ON' — SET OVERPACK ON CASK CART

2190: RELEASE — OH(M) — FREE OH CRANE

2200: DELAY — 'PACK TO PORT' — MOVE CASK CART TO PORT



2210: K ECRANE
WAIT FOR EAST CRANE
2220: SEIZE,1
ECRANE(M)
SEIZE EAST CRANE
2230: DELAY
'LIFT PACK'
LIFT OVERPACK INTO BLDG
2240: RELEASE
ECRANE(M)
RELEASE EAST CRANE
2250: 2
PARALLEL ACTS: BACK OUT CART
ALWAYS
OUT
LOAD CANS INTO OVERPACK INSID
ALWAYS
LOAD
R&H BLDG
2260: LOAD
1
IF.('LAG STORAGE CANS'-'RECY TO YRD').GE.'CANS IN PACK'
FILL
NOTE CANS THAT MUST FIRST REC
ELSE
IDLE
2270: FILL
LOADING Q
QUEUE FOR EAST CRANE TO LOAD
2280: SEIZE,1
ECRANE(M)
SEIZE EAST CRANE
2290: DELAY
'LOAD PACK'
DELAY TO LOAD CANS INTO OVERP
2300: RELEASE
ECRANE(M)
RELEASE EAST CRANE
2310: COUNT
'LAG STORAGE',-'CANS IN PACK'
DECREASE LAG STORAGE

2320: ASSIGN | X(M+7)=X(M+7)-'CANS IN PACK' — COUNT LAG STORAGE FOR DSTAT

2330: 1
IF,M.EQ.1 → PCKPWR
ELSE → PCKBWR

2340: PCKPWR 18 → LOADED PWR OVPK READY IN R&H

2350: PCKBWR 19 → LOADED BWR OVPK READY IN R&H

2360: IDLE DELAY | 'CHECK TIME' → LOAD — DELAY FOR SUFFICIENT CANS FOR

BACK EMPTY CASK CART OUT OF PORT

2370: OUT DELAY | 'CARTOUT' — DELAY TO MOVE CASK CART OUT O

2380: 'FOR OH' — QUEUE UP FOR OVERHEAD CRANE

2390: SEIZE,1 | OH(M) — SEIZE OVERHEAD CRANE

2400: DELAY | 'ADAPTOFF'+'CASKONOFF' — LIFT OVPK ADAPTOR OFF CART AN

SET SHIPPING CASK ON CASK CART

2410: RELEASE | OH(M) — FREE OVERHEAD CRANE

BRING CASK CART WITH SHIPPING CASK INTO PORT

2420:		DELAY 'CASK MOVE IN'	DELAY TO MOVE CASK CART INTO
2430:		1	
		IF,M.EQ.1 → CSKPWR	
		ELSE → CSKBWR	
2440:	CSKPWR	7	CASK CART QUEUES AT PWR PORT
2450:		2	MATCH CASK CART IN PWR LOAD Q
		CSKPWR → CONT	WITH LOADED OVERPACK IN PWR
		PCKPWR	'OVER PACK QUE ON A(2)
2460:	CSKBWR	8	
2470:		2	MATCH CASK CART IN BWR LOAD Q
		CSKBWR → CONT	WITH LOADED OVERPACK IN BWR
		PCKBWR	'OVER PACK QUE ON A(2)
2480:	CONT	CRANE QUE	MATCH,SO QUEUE FOR EAST CRANE
2490:		SEIZE,1 ECRANE(M)	SEIZE EAST CRANE
2500:		DELAY 'CASK LOAD'	DELAY TO LOAD OVPK ON CASK CA
2510:	CASKOT	RELEASE ECRANE(M)	RELEASE EAST CRANE

2520:	DELAY / 'CASK MOVE OUT'	DELAY TO MOVE CASK CART OUT
2530:	'OH OUT'	QUEUE UP FOR OVERHEAD CRANE
2540:	SEIZE,1 / OH(M)	SEIZE OVERHEAD CRANE
2550:	DELAY / 'CASK ONOFF'	DELAY TO LIFT CASK ONTO TRAIN
2560:	RELEASE / OH(M)	RELEASE OVERHEAD CRANE
2570:	RELEASE / CART(M)	RELEASE CASK CART
2580:	DELAY / 'SECURE & TIE'	DELAY TO SECURE SHIP. CASI CN
2590:	TALLY / M,INT(1)	TALLY SHIP. CASK TURNAROUND T

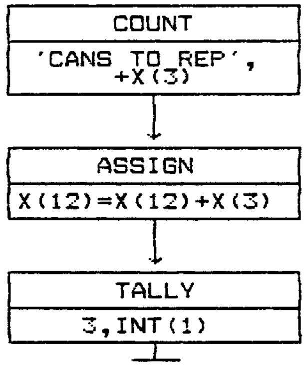
COMBINE LOADED RAIL CASKS INTO TRAIN FOR REPOSITORY

2600:	OAD TRAIN	QUEUE RAIL CASKS TO TRAIN
2610:	COMBINE / X(1),FIRST	COMBINE X(1) RAIL CASKS INTO
2620:	ASSIGN / X(3)=X(1)*X(23)	

2630: COUNT CANS TO REPOSITORY

2640: COUNT CANS TO REPOSITORY FOR

2650: TALLY TRAIN TURNAROUND TIME



APPENDIX B

LISTING OF EXPANDED BACK-END MODEL HANDLING SECONDARY WASTE

```
BEGIN,100,1,,PRIME,YES;
;
;     *****************************************************************
;     DEFINITION BLOCK:
;
;        PURPOSE:  To initialize the system.
;                  ( This must be the first submodel in LINKER )
;
;        ASSUMPTIONS:
;             1. The number of canisters into the system equals the
;                number of canisters out.
;
;        TIME UNITS:    Days
;
;        GLOBAL VARIABLES:
;             1. # rail casks / train
;             4. # rail casks / train w/sec waste cars
;             5. # of sec waste casks on hand ( max 10 )
;             8. Initial PWR Lag Size
;             9. Initial BWR Lag Size
;            10. Initial Onsite Size
;            22. Cask Batch Size.
;            41. Time of arrival of sec waste cask #1
;            42. Time of arrival of sec waste cask #2
;            43. Time of arrival of sec waste cask #3
;            44. Time of arrival of sec waste cask #4
;            45. Time of arrival of sec waste cask #5
;            46. Time of arrival of sec waste cask #6
;            47. Time of arrival of sec waste cask #7
;            48. Time of arrival of sec waste cask #8
;            49. Time of arrival of sec waste cask #9
;            50. Time of arrival of sec waste cask #10
;
;        COUNTERS:
;             1. PWR Lag Storage Size
;             2. BWR Lag Storage Size
;             3. Onsite Storage Size
;
;        PARAMETER SETS:
;             2. In: MTU/Year             Out: Mean PWR days/canister
;             3. In: BWR Portion          Out: Mean BWR days/canister
;             4.                          Out: Mean days/train
;            52. In: Hardware Drums/MTU   Out: Hardware days/drum
;            53. In: Filter Drums/MTU     Out: Filter days/drum
;            54. In: nothing              Out: BWR/PWR DP
;
;        EXPERIMENTS:   MRS
;
;     *****************************************************************
;     IMPLEMENTATION BLOCK:
;        DEVELOPMENT INFORMATION:
;           MODELED BY:                    ON:
;                   AT: Pacific Northwest Laboratory
;                       Richland, Washington  99352
```

```
;           MACHINE/OPERATING SYSTEM:
;           SIMAN VERSION            :
;
;        MODIFICATION HISTORY:
;           MODIFIED BY:                     ON:
;           REASON FOR MODIFICATION:
;           DESCRIPTION OF MODIFICATION:
;
SYNONYMS:
          CANS IN PACK            =P(1,5):       ! Parameters
          OVERPACK                =P(1,9).EQ.1:
          CANS IN CASK            =P(1,10);
;     *****************************************************************
;     CODE BLOCK:
;
         CREATE,1;
;
;  Calculate Train Arrival Rate
;
         BRANCH,1:
            IF,'OVERPACK',OVERPACK:
            ELSE,REG_PACK;
;
OVERPACK ASSIGN:P(4,2)='CANS IN PACK':NEXT(CLCTRAIN); Cans/Cask
;
REG_PACK ASSIGN:P(4,2)='CANS IN CASK';                Cans/Cask
;
CLCTRAIN ASSIGN:P(4,2)=P(4,2)*(1.386-.084*P(3,1)); Avg MTU/Cask
         ASSIGN:P(4,2)=365*P(4,2)*X(1)/P(2,1);     Days / Train
         ASSIGN:P(4,1)=0.8*P(4,2);
         ASSIGN:P(4,3)=1.2*P(4,2);
;
;  Calculate Secondary Waste Arrival Rates
;
         ASSIGN:P(52,1)=365/P(2,1)/P(52,1)*5; Days/5Drums from Drums/MTU
;
         ASSIGN:P(53,1)=365/P(2,1)/P(53,1)*5; Days/5Drums from Drums/MTU
;
         ASSIGN:P(54,1)=P(3,1);             BWR Portion
;
;  Calculate Canister Arrival Rates
;
         ASSIGN:P(3,1)=365/P(3,1)/P(2,1)*1.302;       Days/Canister
;
         ASSIGN:P(2,1)=365/(1-P(54,1))/P(2,1)*1.386;  Days/Canister
;
;  Initial Miscellaneous Variables
;
         ASSIGN:X(22)=X(1);                 # Rail Casks / Train In
         ASSIGN:X(4)=X(1);                  # Rail Casks / Train Out
;
;  Initialize Counters
;
         COUNT:1,X(8);                      PWR Lag Storage Counter
```

```
        COUNT:2,X(9);                          BWR Lag Storage Counter
        COUNT:3,X(10);                         Onsite Storage Counter
;
;  Set up the sec waste casks-on-hand arrival times.
;
        ASSIGN:J=41+X(5);
LOOP    ASSIGN:X(J)=1E30;
        ASSIGN:J=J+1;
        BRANCH,1:IF,J.LE.50,LOOP;
END;
```

```
BEGIN,200,1,,CANISTER,YES;
;
;     ******************************************************************
;     DEFINITION BLOCK:
;
;        PURPOSE:  To create canister arrivals to the system, and
;                  move them into lag storage.  ( Beginning with
;                  activity no. 108 )
;
;        ASSUMPTIONS:
;
;        TIME UNITS:    Days
;
;        GLOBAL VARIABLES:
;             6. PWR Canister Arrivals
;             7. BWR Canister Arrivals
;             8. PWR Lag Storage
;             9. BWR Lag Storage
;            14. PWR Lag waiting to move to onsite storage
;            15. BWR Lag waiting to move to onsite storage
;            21. Canister Batch Size from welding
;
;        STATIONS:
;             1. PWR Canyon
;             2. BWR Canyon
;
;        QUEUES:
;             1. PWR Canisters waiting for west crane
;             2. BWR Canisters waiting for west crane
;
;        RESOURCES:
;                WCRANE: 35-Ton Cranes @ west end of canyons
;
;        COUNTERS:
;             1. PWR Lag Storage
;             2. BWR Lag Storage
;
;        PARAMETER SETS:
;
;        EXPERIMENTAL DISTRIBUTIONS:
;             1. PWR Canister Interarrival Time
;             2. BWR Canister Interarrival Time
;            16. Canister to Lag movement time
;            25. Time to pass canister through to other canyon
;
;        EXPERIMENTS:   MRS
;
;     ******************************************************************
;     IMPLEMENTATION BLOCK:
;        DEVELOPMENT INFORMATION:
;           MODELED  BY: HD Huber           ON:
;                    AT: Pacific Northwest Laboratory
;                        Richland, Washington  99352
;           MACHINE/OPERATING SYSTEM: IBM PC / DOS 3.1
```

```
;            SIMAN VERSION          : 3.0
;
;         MODIFICATION HISTORY:
;            MODIFIED BY: RA Sovers          ON: 6 June 1986
;            REASON FOR MODIFICATION: Adding Secondary Waste Stream
;            DESCRIPTION OF MODIFICATION:
;
SYNONYMS:
          FRAC TO YARD            =P(1,2):     ! Param
          CAN ARRIVALS            =M+10:       ! Counter ID
          LAG STORAGE             =M:
          CAN TO LAG              =ED(16):     ! Delay
          CAN REROUTE TIME        =ED(25);
;
;      *****************************************************************
;      CODE BLOCK:
;
         CREATE,X(21):ED(1);                PWR Canister @ welder exit
         ROUTE:0,1;
;
         CREATE,X(21):ED(2);                BWR Canister @ welder exit
         ROUTE:0,2;
;
         STATION,1-2;                       MOVE CAN FROM WELDER INTO LAG
         COUNT:'CAN ARRIVALS';              COUNT CAN ARRIVALS OF EACH TYPE
         ASSIGN:X(M+5)=X(M+5)+1;            COUNT CAN ARRIVALS FOR DSTAT
         BRANCH,1:                          !BRANCH ON STATION NUMBER
           IF,M.EQ.1,CHK1:
           ELSE,CHK2;
;
CHK1     BRANCH,1:
           IF, MR(1).EQ.0 .AND.        ! If WCR 1 is broken and WCR 2
               MR(2).NE.0,       SWH1: ! is not, switch to WCR 2
           ELSE,CRNQUE;
;.
CHK2     BRANCH,1:
           IF, MR(2).EQ.0 .AND.        ! If WCR 2 is broken and WCR 1
               MR(1).NE.0,       SWH2: ! is not, switch to WCR 1
           ELSE,CRNQUE;
;
SWH1     ROUTE:'CAN REROUTE TIME',2;   Reroute canister to west canyon
;
SWH2     ROUTE:'CAN REROUTE TIME',1;   Reroute canister to east canyon
;
CRNQUE   QUEUE,M;                                 <<Q 1 - 2 >>
         SEIZE,1:WCRANE(M);                 SEIZE WEST CRANE
         DELAY:'CAN TO LAG';                Activity # 108
         RELEASE:WCRANE(M);                 RELEASE WEST CRANE
         BRANCH,1:                          !CHECK IF ARRIVING CANS SHOULD
           WITH,'FRAC TO YARD',RECYCL:      !CYCLE FROM LAG STORAGE TO ON-
           ELSE,LAG;                        !SITE STORAGE
;
RECYCL   ASSIGN:X(M+13)=X(M+13)+1;          COUNT CANS IN LAG STORAGE
;                                           WAITING TO CYCLE TO ONSITE STR
;
LAG      ASSIGN:X(M+7)=X(M+7)+1;            COUNT LAG STORAGE FOR DSTAT
         COUNT:'LAG STORAGE':DISPOSE;       INCREASE LAG STORAGE BY ONE
;
END;
```

```
BEGIN,300,1,,CASKS,YES;
;
;     *****************************************************************
;     DEFINITION BLOCK:
;
;        PURPOSE:  To model the arrivals of train loads of casks, and
;                  there subsequent loading and shipping.
;
;        ASSUMPTIONS:
;
;        TIME UNITS:    Days
;
;        ATTRIBUTES:
;             1. Arrival Time
;
;        GLOBAL VARIABLES:
;             1. Number of casks per train
;             2. Offset time to first train arrival
;             3.
;             8.
;             9.
;            11.
;            12. Canisters to Repository
;            22. Incoming Casks / Train
;            23.
;
;        QUEUES:
;             3. Rail Cask Queue ( waiting for cask cart )
;             4. \_ wait for Overhead Crane to load cask onto cart
;             5. /
;             6. \_ wait for East Crane to load canisters into cask
;             7. /
;             8. \_ wait for Overhead Crane to load Ovrpck onto cask crt
;             9. /
;            10. \_ wait for East Crane to lift Ovrpck into building
;            11. /
;            12. \_ wait for East Crane to Load canisters into Ovrpck
;            13. /
;            14. PWR Overpack wait for Cask ( Match to 68 )
;            15. BWR Overpack wait for Cask ( Match to 69 )
;            16. \_ wait for Overhead Crane to remove overpack adapter
;            17. /
;            68. PWR Cask wait for Overpack ( Match to 14 )
;            69. BWR Cask wait for Overpack ( Match to 15 )
;            70. \_ wait for East Crane to load overpack into cask
;            71. /
;            72. \_ wait for Overhead Crane to lift cask onto rail car
;            73. /
;            74. combine a train of cask cars together. << LVF(1) >>
;
;        RESOURCES:
;                CART:   Cask Carts
;                OH:     150-Ton Overhead Cranes
;                ECRANE: 35-Ton Cranes @ east end of canyon
```

```
;
;        COUNTERS:
;             1. PWR Lag Storage Size
;             2. BWR Lag Storage Size
;            13. Canisters to Repositories
;            14. Incoming Rail Cars Waiting
;
;        TALLIES:
;             1. PWR Cask Turnaround Time ( Arrival -> Full )
;             2. BWR Cask Turnaround Time ( Arrival -> Full )
;             3. Train Turnaround Time    ( Arrival -> Departure )
;
;        PARAMETER SETS:
;
;        EXPERIMENTAL DISTRIBUTIONS:
;             3. Cask Train Interarrival Time
;             8. Cask Move in time
;             9. Cask Load Time
;            10. Cask Move out time
;            11. Time to Secure & Tie down
;            12. Pack to Port time
;            13. Lift Pack
;            14. Load Pack
;            15. Gate inspection
;            20. Cask On Off
;            21. Op On
;            22. Cart Out
;            23. Adapter Off
;            24. Check Time
;            25. Load Ship Cask
;
;        EXPERIMENTS:   MRS
;
;     *******************************************************************
;     IMPLEMENTATION BLOCK:
;        DEVELOPMENT INFORMATION:
;           MODELED  BY:                    ON:
;                    AT: Pacific Northwest Laboratory
;                        Richland, Washington  99352
;           MACHINE/OPERATING SYSTEM:
;           SIMAN VERSION           :
;
;        MODIFICATION HISTORY:
;           MODIFIED BY:                    ON:
;           REASON FOR MODIFICATION:
;           DESCRIPTION OF MODIFICATION:
;
SYNONYMS:
         CANS IN PACK          =P(1,5):        ! Parameters
         OVERPACK              =P(1,9).EQ.1:
         CANS IN CASK          =P(1,10):
         LAG STORAGE CANS      =NC(M):
         RECY TO YRD           =NC(M+16):
         CANS TO REP           =13:            ! Counter IDs
```

```
          RAIL CARS WAIT          =14:
          LAG STORAGE             =M:
          CASK MOVE IN            =ED(8):        ! Delays
          CASK LOAD               =ED(9):
          CASK MOVE OUT           =ED(10):
          SECURE & TIE            =ED(11):
          PACK TO PORT            =ED(12):
          LIFT PACK               =ED(13):
          LOAD PACK               =ED(14)*P(1,5):
          GATE INSPEC             =ED(15):
          CASK ONOFF              =ED(20):
          OP ON                   =ED(21):
          CARTOUT                 =ED(22):
          ADAPTOFF                =ED(23):
          CHECK TIME              =ED(24):
          LOAD SHIP CASK          =ED(26);
;
;     *****************************************************************
;     CODE BLOCK:
;
        CREATE,X(22),X(2):ED(3):MARK(1);  Train arrival to R&H
        ASSIGN:X(11)=X(11)+1;             COUNT RAIL CASK ARRVS FOR DST
        COUNT:'RAIL CARS WAIT';           COUNT RAIL CARS WAITING TO LD
        DELAY:'GATE INSPEC';              DELAY FOR GATE INSPECTION
        QUEUE,3;                               <<Q 3 >>
        SELECT,POR:
          BWR:
          PWR;                            SEND RAIL CASK TO BWR OR PWR
;
PWR     SEIZE,1:CART(1);                  SEIZE CASK CART AT PWR SIDE
        ASSIGN:M=1:NEXT(CONTRL);          LOAD RAIL CASK AT PWR SIDE
;
BWR     SEIZE,1:CART(2);                  SEIZE CASK CART AT BWR SIDE
        ASSIGN:M=2;                       LOAD RAIL CASK AT BWR SIDE
;
;   DETERMINE WHETHER OR NOT REPOSITORY OVERPACK IS TO BE USED
;
CONTRL  COUNT:'RAIL CARS WAIT',-1;        COUNT RAIL CARS WAITING TO LD
        BRANCH,1:                         !CHECK IF REP. OVPACK IS USED
          IF,'OVERPACK',OVPACK:           !OVERPACK IS TO BE USED
          ELSE,SPCASK;                    !ONLY SHIPPING CASK USED
;
;   SHIP CANISTERS TO ONSITE STORAGE WITHOUT USING OVERPACK
;
SPCASK  ASSIGN:X(23)='CANS IN CASK';      SET CANS SHIPPED PER RAIL CAR
        QUEUE,M+3;                                  <<Q 4 - 5 >>
        SEIZE,1:OH(M);                    SEIZE OVERHEAD CRANE
        DELAY:'CASK ONOFF';               SET SHIPPING CASK ON CASK CAR
        RELEASE:OH(M);                    FREE OVERHEAD CRANE
        DELAY:'CASK MOVE IN';             DELAY TO MOVE CSK CRT TO PORT
LOADUP  BRANCH,1:                         !CHECK FOR SUFF. ELIGIBLE CANS
          IF,('LAG STORAGE CANS'
          -'RECY TO YRD').GE.
          'CANS IN CASK',FILLUP:
```

```
          ELSE,IDLING;
FILLUP    QUEUE,M+5;                        <<Q 6 - 7 >>
          SEIZE,1:ECRANE(M);                SEIZE EAST CRANE
          DELAY:'LOAD SHIP CASK';           LOAD SHIPPING CASK WITH CANS
          COUNT:'LAG STORAGE',-
            'CANS IN CASK';                  DECREASE LAG STORAGE
          ASSIGN:                           !COUNT LAG STORAGE FOR DSTAT
            X(M+7)=X(M+7)-'CANS IN CASK':
            NEXT(CASKOT);
IDLING    DELAY:'CHECK TIME':NEXT(LOADUP);  DELAY FOR SUFF. CANS FOR CASK
;
;   SHIP CANISTERS TO ONSITE STORAGE USING OVERPACK
;   BRING REPOSITORY OVERPACK INTO PORT USING CASK CART
;
OVPACK    ASSIGN:X(23)='CANS IN PACK';      SET CANS SHIPPED PER RAIL CAR
          QUEUE,M+7;                        <<Q 8 - 9 >>
          SEIZE,1:OH(M);                    SEIZE OH CRANE
          DELAY:'OP ON';                    SET OVERPACK ON CASK CART
          RELEASE:OH(M);                    FREE OH CRANE
          DELAY:'PACK TO PORT';             MOVE CASK CART TO PORT
          QUEUE,M+9;                        <<Q 10 - 11 >>
          SEIZE,1:ECRANE(M);                SEIZE EAST CRANE
          DELAY:'LIFT PACK';                LIFT OVERPACK INTO BLDG
          RELEASE:ECRANE(M);                RELEASE EAST CRANE
          BRANCH,2:                         !PARALLEL ACTS: BACK OUT CART,
            ALWAYS,OUT:                     !LOAD CANS INTO OVERPACK INSDE
            ALWAYS,LOAD;                    R&H BLDG
;
;   NOTE CANS THAT MUST FIRST CYCLE OUT TO ONSITE STORAGE FROM LAG
;   STORAGE ARE NOT ELIGIBLE FOR SHIPMENT TO THE REPOSITORY UNTIL
;   THEY HAVE BEEN RETRIEVED BACK INTO LAG STORAGE.
;
LOAD      BRANCH,1:                         !CHECK FOR SUFF. ELIGIBLE CANS
            IF,('LAG STORAGE CANS'
            -'RECY TO YRD').GE.
            'CANS IN PACK',FILL:
            ELSE,IDLE;
FILL      QUEUE,M+11;                       <<Q 12 - 13 >>
          SEIZE,1:ECRANE(M);                SEIZE EAST CRANE
          DELAY:'LOAD PACK';                DELAY TO LOAD CANS INTO OVPK
          RELEASE:ECRANE(M);                RELEASE EAST CRANE
          COUNT:'LAG STORAGE',-
            'CANS IN PACK';                  DECREASE LAG STORAGE
          ASSIGN:X(M+7)=X(M+7)-
            'CANS IN PACK';                  COUNT LAG STORAGE FOR DSTAT
          BRANCH,1:
            IF,M.EQ.1,PCKPWR:
            ELSE,PCKBWR;
PCKPWR    QUEUE,14:DETACH;    LOADED PWR OVPK       <<Q 14 >>
PCKBWR    QUEUE,15:DETACH;    LOADED BWR OVPK       <<Q 15 >>
;
IDLE      DELAY:'CHECK TIME':NEXT(LOAD);    DELAY FOR SUFF. CANS FOR OVPK
;
;   BACK EMPTY CASK CART OUT OF PORT
```

```
;
OUT      DELAY:'CARTOUT';                  DELAY TO MOVE CKCRT OUT OF PRT
         QUEUE,M+15;                                 <<Q 16 - 17 >>
         SEIZE,1:OH(M);                    SEIZE OVERHEAD CRANE
         DELAY:'ADAPTOFF'+'CASK ONOFF';    LIFT OVPK ADAPTOR OFF CART,
;                                          SET SHIPPING CASK ON CASK CART
         RELEASE:OH(M);                    FREE OVERHEAD CRANE
;
;    BRING CASK CART WITH SHIPPING CASK INTO PORT
;
         DELAY:'CASK MOVE IN';             DELAY TO MOVE CKCRT INTO PRT
         BRANCH,1:
           IF,M.EQ.1,CSKPWR:
           ELSE,CSKBWR;
CSKPWR   QUEUE,68:DETACH;                            <<Q 68 >>
CSKBWR   QUEUE,69:DETACH;                            <<Q 69 >>
;
         MATCH,1:                          !MATCH CASK CART IN PWR LOAD Q
           CSKPWR,CONT:                    !WITH LOADED OVERPACK IN PWR
           PCKPWR;                         !OVER PACK QUE ON ATTR. A(1)
;
         MATCH,1:                          !MATCH CASK CART IN BWR LOAD Q
           CSKBWR,CONT:                    !WITH LOADED OVERPACK IN BWR
           PCKBWR;                         !OVER PACK QUE ON ATTR. A(1)
;
CONT     QUEUE,M+69;                                 <<Q 70 - 71 >>
         SEIZE,1:ECRANE(M);                SEIZE EAST CRANE
         DELAY:'CASK LOAD';                DELAY TO LOAD OVPK ON CASK CT
CASKOT   RELEASE:ECRANE(M);                RELEASE EAST CRANE
         DELAY:'CASK MOVE OUT';            DELAY TO MOVE CASK CART OUT
         QUEUE,M+71;                                 <<Q 72 - 73 >>
         SEIZE,1:OH(M);                    SEIZE OVERHEAD CRANE
         DELAY:'CASK ONOFF';               DELAY TO LIFT CASK ONTO TRAIN
         RELEASE:OH(M);                    RELEASE OVERHEAD CRANE
         RELEASE:CART(M);                  RELEASE CASK CART
         DELAY:'SECURE & TIE';             DELAY TO SECURE SHP CSK ON TRN
         TALLY:M,INT(1);                   TALLY SHIP. CASK TURNAROUND TM
;
;    COMBINE LOADED RAIL CASKS INTO TRAIN FOR REPOSITORY
;
         QUEUE,74;                                   <<Q 74 >>
         COMBINE:X(4),FIRST;               COMBINE X(1) RAIL CSKS INTO TRAIN
         ASSIGN:X(4)=X(1);                 Reset Train Counter to normal
         ASSIGN:X(3)=X(1)*X(23);
         COUNT:'CANS TO REP',+X(3);        COUNT CANS TO REPOSITORY
         ASSIGN:X(12)=X(12)+X(3);          COUNT CANS TO REPOS. FOR DSTAT
         TALLY:3,INT(1):DISPOSE;           TALLY TRAIN TURNAROUND TIME
END;
```

```
BEGIN,400,1,,LAGMGR,YES;
;
;     ****************************************************************
;     DEFINITION BLOCK:
;
;        PURPOSE:  Lag storage manager.  Checks to see if canisters in
;                  lag should be sent to onsite and vice versa.
;
;        ASSUMPTIONS:
;
;        TIME UNITS:    Days
;
;        GLOBAL VARIABLES:
;             8.
;             9.
;            10.
;            13.
;            16.
;            24.
;            25.
;            26.
;            27.
;
;        STATIONS:
;             3. PWR Lag Manager
;             4. BWR Lag Manager
;
;        QUEUES:
;            18. PWR Outgoing Yard Cart
;            19. BWR Outgoing Yard Cart
;            20. PWR Outgoing East Crane
;            21. BWR Outgoing East Crane
;            22. PWR Incoming Yard Cart
;            23. BWR Incoming Yard Cart
;            24. PWR Incoming East Crane
;            25. BWR Incoming East Crane
;
;        RESOURCES:
;                YCART:  Yard Carts
;                ECRANE: 35-Ton Cranes @ east end of canyon
;
;        COUNTERS:
;             1. PWR Lag Storage Size
;             2. BWR Lag Storage Size
;             3. Yard Storage Size
;             4. PWR Canisters to the yard
;             5. BWR Canisters to the yard
;             6. PWR Canisters from the yard
;             7. BWR Canisters from the yard
;            17. PWR Canisters in the yard to recycle to lag
;            18. BWR Canisters in the yard to recycle to lag
;            19. Canisters in Lag to recycle to the yard
;
;        PARAMETER SETS:
```

```
;
;       EXPERIMENTAL DISTRIBUTIONS:
;            5. Break Time
;            6. Can to Port Time
;            7. Time to lift cans to lag
;           17. Cart to port time
;           18. Time to put cans into yard cask
;           19. Yard Cask to yard time
;
;       EXPERIMENTS:   MRS
;
;    *****************************************************************
;    IMPLEMENTATION BLOCK:
;       DEVELOPMENT INFORMATION:
;          MODELED  BY:                  ON:
;                   AT: Pacific Northwest Laboratory
;                       Richland, Washington  99352
;          MACHINE/OPERATING SYSTEM:
;          SIMAN VERSION          :
;
;       MODIFICATION HISTORY:
;          MODIFIED BY:                  ON:
;          REASON FOR MODIFICATION:
;          DESCRIPTION OF MODIFICATION:
;
SYNONYMS:
          # CANS OUT             =P(1,1):        ! Parameters
          FRAC TO YARD           =P(1,2):
          MAXIMUM                =P(1,3):
          MINIMUM                =P(1,4):
          # CANS IN              =P(1,6):
          CANS IN LAG            =NC(M-2):
          RECYL TO YRD           =NC(M+14):
          RECYL TO LAG           =NC(19):
          YARD STORAGE           =3:             ! Counter IDs
          RECYCLE TO LAG         =19:
          LAG                    =M-2:
          LAG SIZE               =M-2:
          CANS TO YARD           =M+1:
          CANS FROM YARD         =M+3:
          RECYCLE TO YRD         =M+14:
          YDOT CART QUE          =M+15:          ! Queues
          ECR YDOT QUE           =M+17:
          YDIN CART QUE          =M+19:
          ECR YDIN QUE           =M+21:
          YARD TIME              =P(1,7):        ! Delays
          BREAK TIME             =ED(5):
          CAN TO PORT TIME       =ED(6):
          LIFT CANS TO LAG       =ED(7):
          CART TO PORT           =ED(17):
          CANS INTO CASK         =ED(18):
          CASK TO YARD           =ED(19);
;
;    *****************************************************************
```

```
;      CODE BLOCK:
;
;
;    CHECK LAG STORAGE FOR MAXIMUM AND MINIMUM LIMITS
;
          CREATE;                   PWR Lag Maneger
          ROUTE:0,3;
;
          CREATE;                   BWR Lag Manager
          ROUTE:0,4;
;
          STATION,3-4;              Lag Manager submodel
;
;    LAG MANAGER CONTROL TO CHECK FOR MAXIMUM AND MINIMUM LIMITS IN LAG STR
;
CHKMAX    BRANCH,1:
            IF,'CANS IN LAG'.LE.'MAXIMUM',
            CHKMIN:                       !CHECK FOR MAXIMUM LAG STORAGE
            IF,'FRAC TO YARD'.EQ.1.0,YRDOUT:
            ELSE,YARDOT;
;
CHKMIN    BRANCH,1:
            IF,'CANS IN LAG'.GE.'MINIMUM',
            CHKBRN:                       !CHECK FOR MINIMUM LAG STORAGE
            IF,'RECYL TO LAG'.GE.'# CANS IN',
            YRDINN:
            ELSE,CHKBRN;
;
;    LAG MANAGER CONTROL TO CHECK FOR CYCLING CONDITIONS
;
CHKBRN    BRANCH,1:
            IF,'FRAC TO YARD'.EQ.0,WAIT:      !WAIT IF NO CANS ARE TO CYCLE
            IF,X(M+21).EQ.0,CHKCY1:          !LAST CYCLE INTO LAG STR
            ELSE,CHKCY3;                     LAST CYCLE OUT TO ONSITE STR
;
;    PURPOSE OF FOUR BRANCHES CHKCY1-CHKCY2 AND CHKCY3-CHKCY4 IS TO TRY TO
;    ALTERNATE BETWEEN CYCLING OUT TO ONSITE STORAGE AND RETRIEVING INTO LAG
;    STORAGE IF POSSIBLE. OTHER CYCLING STRATEGIES COULD BE PROGRAMMED INTO
;    THE SUBMODEL HERE.
;
;    CHKCY1-CHKCY2 TRY TO CYCLE FROM LAG STORAGE OUT TO ONSITE STORAGE.
;    IF NOT POSSIBLE, THEY TRY TO RETRIEVE FROM ONSITE STORAGE INTO LAG
;    STORAGE.
CHKCY1    BRANCH,1:                          !CHECK FOR CYCLING FROM LAG
            IF,NR(M).GT.0,WAIT:              !STORAGE OUT TO ONSITE STORAGE
            IF,'RECYL TO YRD'.LT.
            '# CANS OUT',CHKCY2:
            IF,X(13).EQ.0.AND.NR(M+2).EQ.0,
            YRDOUT:
            IF,'RECYL TO YRD'
            .GT.(0.50*'CANS IN LAG'),YRDOUT:
            ELSE,CHKCY2;
CHKCY2    BRANCH,1:                          !CHECK FOR RETRIEVING FROM
            IF,NR(M).GT.0,WAIT:              !ONSITE STORAGE INTO LAG STR
```

```
          IF,'RECYL TO LAG'.LT.'# CANS IN',
          WAIT:
          IF,X(13).EQ.0.AND.NR(M+2).EQ.0,
          YRDINN:
          IF,('CANS IN LAG'-'RECYL TO YRD')
          .LT.'MINIMUM',YRDINN:
          ELSE,WAIT;
;
;  CHKCY3-CHKCY4 TRY TO RETRIEVE FROM ONSITE STORAGE INTO LAG STORAGE.
;  IF NOT POSSIBLE, THEY TRY TO CYCLE FROM LAG STORAGE OUT TO ONSITE STR.
;
CHKCY3  BRANCH,1:                          !CHECK FOR RETRIEVING FROM
          IF,NR(M).GT.0,WAIT:              !ONSITE STORAGE INTO LAG STR.
          IF,'RECYL TO LAG'.LT.'# CANS IN',
          CHKCY4:
          IF,X(13).EQ.0.AND.NR(M+2).EQ.0,
          YRDINN:
          IF,('CANS IN LAG'-'RECYL TO YRD')
          .LT.'MINIMUM',YRDINN:
          ELSE,CHKCY4;
CHKCY4  BRANCH,1:
          IF,NR(M).GT.0,WAIT:              !CHECK FOR CYCLING FROM LAG
          IF,'RECYL TO YRD'.LT.
          '# CANS OUT',WAIT:                !STORAGE OUT TO ONSITE STR.
          IF,X(13).EQ.0.AND.NR(M+2).EQ.0,
          YRDOUT:
          IF,'RECYL TO YRD'
          .GT.(0.50*'CANS IN LAG'),YRDOUT:
          ELSE,WAIT;
;
WAIT    DELAY:'BREAK TIME':NEXT(CHKMAX);   DELAY TO CHECK LAG STR FOR
;                                          MANAGING LAG STORAGE INVENTORY
;   SHIP CANS OUT TO ONSITE STORAGE
;
YRDOUT  ASSIGN:X(M+21)=1;                  SET FLAG THAT LAST TRANSFER
;                                          WAS OUT TO ONSITE STORAGE
        ASSIGN:X(M+23)=1;                  CANS TAKEN OUT OF LAG SUBSET
;                                          WAITING TO CYCLE TO ONSITE STR
YARDOT  QUEUE,'YDOT CART QUE';             QUEUE UP FOR YARD CART
        SEIZE,2:YCART(M-2);                SEIZE YARD CART
        DELAY:'CART TO PORT';              DELAY UNTIL YARD CART ARRIVES
;                                          (INCLUDES ALSO ACT. 214,215,
;                                           201,& 202)
        QUEUE,'ECR YDOT QUE';              QUEUE UP FOR EAST CRANE
        SEIZE,2:ECRANE(M-2);               SEIZE EAST CRANE
        DELAY:'CANS INTO CASK';            DELAY TO MOVE CANS INTO CASK
;                                          (CRANE GOES BACK AND FORTH TO
;                                           MOVE '# CANS OUT' INTO CASK,
;                                           ALSO INCLUDES ACT. 203)
        BRANCH,1:                          !CHECK WHICH SUBSET OF LAG
          IF,X(M+23).EQ.1,CNTCYL:          !CANS WERE TAKEN FROM
          ELSE,CNTLAG;
CNTCYL  ASSIGN:X(M+11)=X(M+11)-
          '# CANS OUT';                     UPDATE CYCLE COUNTERS
```

```
         COUNT:'RECYCLE TO YRD',-
           '# CANS OUT';
         ASSIGN:X(M+23)=0;
CNTLAG   COUNT:'LAG SIZE',-'# CANS OUT';     DECREASE LAG STORAGE SIZE
         ASSIGN:X(M+5)=X(M+5)-'# CANS OUT'; COUNT LAG STORAGE FOR DSTAT
         RELEASE:ECRANE(M-2);                RELEASE EAST CRANE
         DELAY:'CASK TO YARD';               DELAY TO MOVE CASK TO YARD
;                                            (INCLUDES ACT. 204 THRU 213)
         COUNT:'YARD STORAGE',+'# CANS OUT';INCREASE ONSITE STORAGE SIZE
         ASSIGN:X(10)=X(10)+'# CANS OUT';    COUNT ONSITE STORAGE FOR DSTAT
         COUNT:'CANS TO YARD',+'# CANS OUT';INCREASE CAN COUNT TO ONSITE
         RELEASE:YCART(M-2);                 RELEASE YARD CART
         BRANCH,2:                           !PARALLEL ACTIVITIES
           ALWAYS,YDELAY:                    !CAN IN ONSITE STR FOR YRD TM
           ALWAYS,CHKMAX;                    RECYCLE LAG MANAGER ENTITY
YDELAY   DELAY:'YARD TIME';                  DELAY FOR ONSITE STORAGE TIME
         ASSIGN:X(16)=X(16)+'# CANS OUT';    UPDATE CYCLING COUNTERS
         COUNT:'RECYCLE TO LAG',+
           '# CANS OUT':DISPOSE;
;
;   SHIP CANS FROM ONSITE STORAGE INTO LAG STORAGE
;
YRDINN   ASSIGN:X(M+21)=0;                   LAST TRANSFER INTO LAG STR.
         ASSIGN:X(16)=X(16)-'# CANS IN';     UPDATE CYCLING COUNTERS
         COUNT:'RECYCLE TO LAG',-
           '# CANS IN';
YARDIN   QUEUE,'YDIN CART QUE';              QUEUE FOR YARD CART
         SEIZE,2:YCART(M-2);                 SEIZE YARD CART
         DELAY:'CAN TO PORT TIME';           DELAY FOR SHIPMENT TO PORT
         QUEUE,'ECR YDIN QUE';               QUEUE FOR EAST CRANE
         SEIZE,2:ECRANE(M-2);                SEIZE EAST CRANE
         DELAY:'LIFT CANS TO LAG';           DELAY FOR UNLD CANS INTO LAG
         COUNT:'YARD STORAGE',-'# CANS IN'; DECREASE ONSITE STORAGE
         ASSIGN:X(10)=X(10)-'# CANS IN';     COUNT ONSITE STORAGE FOR DSTAT
         COUNT:'LAG',+'# CANS IN';           INCREASE LAG STORAGE
         ASSIGN:X(M+5)=X(M+5)+'# CANS IN';   COUNT LAG STORAGE FOR DSTAT
         COUNT:'CANS FROM YARD',+
           '# CANS IN';                      INCREASE CAN COUNT FROM ONSITE
         RELEASE:ECRANE(M-2);                RELEASE EAST CRANE
         RELEASE:YCART(M-2):NEXT(CHKMAX);    RELEASE YARD CART
END;
```

```
BEGIN,500,1,,WEEKEND,YES;
;
;     *****************************************************************
;     DEFINITION BLOCK:
;
;        PURPOSE:  Shut down the MRS Back-End facility on weekends.
;
;        ASSUMPTIONS:
;             1. No canisters arrive from the front-end facility on
;                weekends.
;             2. Any machine broken down at the start of a weekend will
;                be repaired by Monday morning.
;
;        TIME UNITS:    Days
;
;        ATTRIBUTES:
;             1. Resource Number
;
;        GLOBAL VARIABLES:
;             1. Number of casks in a train.
;            21. Canister Batch Size
;            22. Cask Batch Size
;
;        QUEUES:
;            26.  Waiting till weekend
;            27.  Waiting till work day
;
;        RESOURCES:
;             1-2. WCRANE  35-Ton Cranes @ west end of canyon
;             2-3. YCART   Yart Carts
;             4-5. CART    Cask Carts
;             6-7. ECRANE  35-Ton Cranes @ east end of canyon
;             8-9. OH      150-Ton Overhead Crane
;
;        PARAMETER SETS:
;
;        EXPERIMENTS:   MRS
;
;     *****************************************************************
;     IMPLEMENTATION BLOCK:
;        DEVELOPMENT INFORMATION:
;           MODELED  BY: HD Huber           ON:
;                    AT: Pacific Northwest Laboratory
;                        Richland, Washington  99352
;           MACHINE/OPERATING SYSTEM: IBM-PC/DOS 3.1
;           SIMAN VERSION            : 3.0
;
;        MODIFICATION HISTORY:
;           MODIFIED BY: RA Sovers          ON: 6/10/86
;           REASON FOR MODIFICATION:  Model Efficiency
;           DESCRIPTION OF MODIFICATION: Replaced scans with signal &
;                                        wait.
;
SYNONYMS:
           WKEND TRAINS             =P(1,8):
           WORK DAY                 =1:
           WEEKEND                  =2;
 ;
```

```
;      *****************************************************************
;      CODE BLOCK:
;
          CREATE;                                CREATE WORKDAY-WEEKEND ENTITY
          ASSIGN:J=0;                            For use in the segment below
;
WKDAY     SIGNAL:'WORK DAY';                     Workday Signal
          ASSIGN:X(21)=1;                        Canister Batch Size
          ASSIGN:X(22)=X(1);                     # of Rail cars in train
          DELAY:4.9;                             Work 4.9 days, allowing 0.1
;                                                days to shutdown on weekends
          SIGNAL:'WEEKEND';                      Weekend Signal
          ASSIGN:X(21)=0;                        no can arrivals
          ASSIGN:X(22)=X(1)*'WKEND TRAINS';      Shut down trains if desired
          DELAY:2.1:NEXT(WKDAY);                 weekend is 2.1 days long.
;----------------------------------------
          CREATE,10;                             create 1 for each resource
          ASSIGN:M=MOD(J,2)+1;                   resource index
          ASSIGN:J=J+1;
          ASSIGN:A(1)=J;                         resource # to effect
;
WORK      QUEUE,26;                                      <<Q 41 >>
          WAIT:'WEEKEND';                        WAIT FOR THE WEEKEND
SCHEDL    BRANCH,1:
            IF,MR(A(1)).EQ.0,CWKDAY:             !RESOURCE IS BROKEN DOWN
            ELSE,SHUTDN;                         SHUT DOWN RESOURCE
;
SHUTDN    BRANCH,1:                              !SHUT DWN ALL RESOUR. ON WKEND
            IF,A(1).LE.2,SHDWCR:                 !WEST CRANES
            IF,A(1).LE.4,SHDYCT:                 !YARD CARTS
            IF,A(1).LE.6,SHDCRT:                 !CASK CARTS
            IF,A(1).LE.8,SHDECR:                 !EAST CRANES
            ELSE,SHDOH;                          OVERHEAD CRANES
;
SHDWCR    ALTER:WCRANE(M),-1:NEXT(CWKDAY);       Shut Down West Cranes
;
SHDYCT    ALTER:YCART(M),-1:NEXT(CWKDAY);        Shut Down Yard Carts
;
SHDCRT    ALTER:CART(M),-1:NEXT(CWKDAY);         Shut Down Cask Carts
;
SHDECR    ALTER:ECRANE(M),-1:NEXT(CWKDAY);       Shut Down East Cranes
;
SHDOH     ALTER:OH(M),-1;                        Shut Down Overhead Cranes
;
CWKDAY    QUEUE,27;                                      <<Q 42 >>
          WAIT:'WORK DAY';                       WAIT FOR WORK DAY
          BRANCH,1:                              !TURN ON RESOURCES FOR WKDAYS
            IF,A(1).LE.2,TONWCR:                 !WEST CRANES
            IF,A(1).LE.4,TONYCT:                 !YARD CARTS
            IF,A(1).LE.6,TONCRT:                 !CASK CARTS
            IF,A(1).LE.8,TONECR:                 !EAST CRANES
            ELSE,TONOH;                          OVERHEAD CRANES
;
```

```
TONWCR    ALTER:WCRANE(M),+1:NEXT(WORK);      Turn On West Cranes
;
TONYCT    ALTER:YCART(M),+1:NEXT(WORK);       Turn On Yard Carts
;
TONCRT    ALTER:CART(M),+1:NEXT(WORK);        Turn On Cask Carts
;
TONECR    ALTER:ECRANE(M),+1:NEXT(WORK);      Turn On East Cranes
;
TONOH     ALTER:OH(M),+1:NEXT(WORK);          Turn On Overhead Cranes
;
END;
^Z
```

```
BEGIN,600,1,,FAIL,YES;
;
;     *****************************************************************
;     DEFINITION BLOCK:
;
;        PURPOSE:  Cause machines to fail.
;
;        ASSUMPTIONS:
;             1. Failures do not occur on weekends.
;             2. Repair can continue on weekends.
;             3. An unlimmited number of maintenance workers exist.
;             4. If a repair last into the weekend, it must be fininshed
;                by th efollowing Monday morning.
;
;        TIME UNITS:    Days
;
;        ATTRIBUTES:
;             1. Resource Index / Number
;             2. ER Param Set for MTBF
;             3. EX Param Set for Repair Time
;
;        GLOBAL VARIABLES:
;            22. Weekend indicator ( 0:Weekend, Other:Workday )
;
;        STATIONS:
;             5. West Crane Failures
;             6. East Crnae Failures
;             7. Overhead Crane Failures
;
;        RESOURCES:
;             1-2. WCRANE: 35-Ton Cranes @ west end of canyon
;             6-7. ECRANE: 35-Ton Cranes @ east end of canyon
;             8-9. OH:     150-Ton Overhead Cranes
;
;        COUNTERS:
;              8. West Crane Failures
;              9. East Crane Failures
;             10. Overhead Crane Failures
;
;        PARAMETER SETS:
;
;        EXPERIMENTS:   MRS
;
;     *****************************************************************
;     IMPLEMENTATION BLOCK:
;        DEVELOPMENT INFORMATION:
;           MODELED  BY:                   ON:
;                    AT: Pacific Northwest Laboratory
;                        Richland, Washington  99352
;           MACHINE/OPERATING SYSTEM:
;           SIMAN VERSION          :
;
;        MODIFICATION HISTORY:
;           MODIFIED BY:                   ON:
```

```
;            REASON FOR MODIFICATION:
;            DESCRIPTION OF MODIFICATION:
;
SYNONYMS:
          WEEKEND                 =X(21).EQ.0:
          WCRANE FAILS            =8:
          ECRANE FAILS            =9:
          OH FAILS                =10;
;
;     *****************************************************************
;     CODE BLOCK:
;
         STATION,5;
WFAIL    DELAY:ER(A(2),8);                    DELAY UNTIL NEXT BREAK DOWN
;
BRK1     BRANCH,1:                            !CHECK IF WEST CRANE A(1) IS
           IF,MR(A(1)).EQ.0,DELAY1:           !ALREADY DOWN DUE TO WEEKEND
           ELSE,BR1;                          SHUTDOWN OR PREVIOUS FAILURE
;
DELAY1   DELAY:1:NEXT(BRK1);                  DELAY 1 DAY AND RECHECK
;
BR1      ALTER:WCRANE(A(1)),-1;               Break Down West Crane
         COUNT:'WCRANE FAILS';
         DELAY:EXP(A(3),9);                   DELAY UNTIL REPAIR OF CRANE
         BRANCH,1:
            IF,'WEEKEND',WFAIL:
            ELSE,TNON1;
TNON1    ALTER:WCRANE(A(1)),+1:NEXT(WFAIL);     REPAIR OF CRANE COMPLETED
;----------------
         STATION,6;
         ASSIGN:M=A(1);
         ASSIGN:A(1)=A(1)+6;
EFAIL    DELAY:ER(A(2),8);                    DELAY UNTIL NEXT BREAK DOWN
;
BRK2     BRANCH,1:                            !CHECK IF EAST CRANE A(1) IS
           IF,MR(A(1)).EQ.0,DELAY2:           !ALREADY DOWN DUE TO WEEKEND
           ELSE,BR2;                          !SHUTDOWN OR PREVIOUS FAILURE
DELAY2   DELAY:1:NEXT(BRK2);
;
BR2      ALTER:ECRANE(M),-1;                  Break Down East Crane
         COUNT:'ECRANE FAILS';
         DELAY:EXP(A(3),9);                   DELAY UNTIL REPAIR OF CRANE
         BRANCH,1:
           IF,'WEEKEND',EFAIL:
           ELSE,TNON3;
TNON3    ALTER:ECRANE(M),+1:NEXT(EFAIL);      REPAIR OF CRANE COMPLETED
;----------------
         STATION,7;                           150 TON OH CRANE FAILURES
         ASSIGN:M=A(1);
         ASSIGN:A(1)=A(1)+8;
OFAIL    DELAY:ER(A(2),8);                    DELAY UNTIL NEXT BREAKDOWN
;
BRK3     BRANCH,1:                            !CHECK IF OH CRANE A(1) IS
           IF,MR(A(1)).EQ.0,DELAY3:           !ALREADY DOWN DUE TO WEEKEND
```

```
          ELSE,BR3;                        !SHUTDOWN OR PREVIOUS FAILURE
DELAY3  DELAY:1:NEXT(BRK3);
;
BR3     ALTER:OH(M),-1;                  BREAKDOWN IDLE 150 TON CRANE
        COUNT:'OH FAILS';
        DELAY:EXP(A(3),9);               DELAY UNTIL REPAIR OF CRANE
        BRANCH,1:
          IF,'WEEKEND',OFAIL:
          ELSE,TNON5;
TNON5   ALTER:OH(M),+1:NEXT(OFAIL);      REPAIR OF CRANE COMPLETED
;
END;
```

```
BEGIN,700,1,,SECWASTE,YES;
;
;     ****************************************************************
;     DEFINITION BLOCK:
;
;        PURPOSE:        Model secondary waste streams
;
;        ASSUMPTIONS:
;
;        TIME UNITS:     Days
;
;        ATTRIBUTES:
;             M. Fuel Type: ( 1: PWR, 2: BWR )
;            NS. Secondary Waste Type ( 1: Hardware, 2: Filters )
;            IS. # of batches
;             1. Drum Arrival Time
;             2. Secondary Waste Type ( 1: Hardware, 2: Filters )
;             3. PWR/BWR, Hdwre/Filters Indicator
;
;        GLOBAL VARIABLES:
;             4. Outbound Casks / Train
;
;        QUEUES:
;            28. \_ sec waste drum waiting for pallet
;            29. /
;            30. \_ waiting for empty basket
;            31. /
;            32. \_ waiting for cask cart to load empty baskets on
;            33. /
;            34. \_ waiting for Overhead crane to load empty baskets
;            35. /
;            36. \_ waiting for East Crane to unload empty baskets
;            37. /
;            38. \_ waiting for West Crane to move pallet
;            39. /
;            40. \_ waiting for Overhead Crane to remove adapter
;            41. /
;            42. \_ combining West & East operations
;            43. /
;            44. \_ waiting for west crane to return pallet
;            45. /
;            46. PWR Hardware - combining a cask of baskets
;            47. BWR   "              "          "
;            48. PWR Filters  -       "          "
;            49. BWR   "              "          "
;            50. Basket Load \_ matched
;            51. Cask        /
;            52. combining load & cask
;            53. \_ waiting for cask cart to move cask
;            54. /
;            55. \_ waiting for Overhead Crane to move cask onto cart
;            56. /
;            57. \_ waiting for East Crane to load baskets into cask
;            58. /
```

```
;           59. \_ waiting for room in LAG for empty baskets
;           60. /
;           61. waiting for another cask. ( signal 3 )
;
;       RESOURCES:
;                   PALLET - Drum Pallets
;                   LAG    - Secondary Waste Lag Storage
;                   ECRANE - 35-Ton Cranes @ east end of canyon
;                   WCRANE - 35-Ton Cranes @ west end of canyon
;                   CART   - Cask Carts
;                   OH     - 150-Ton Overhead Cranes
;
;       COUNTERS:
;           15. Hardware Drums in
;           16. Filter Drums in
;           20. PWR Empty Baskets
;           21. BWR Empty Baskets
;
;       TALLIES:
;            4. PWR Hardware \
;            5. BWR Hardware  \_ Time from entry till exit in cask.
;            6. PWR Filters   /
;            7. BWR Filters  /
;
;       PARAMETER SETS:
;            54. DP: Fuel Type Determination: < 1: PWR, 2: BWR >
;            55. DP: # of Hardware Baskets / Cask
;            56. DP: # of Filter Baskets / Cask
;
;       EXPERIMENTAL DISTRIBUTIONS:
;            15. Gate Inspection Time for incoming Casks
;            27. Hardware Drums - Interarrival Time
;            28. Filter Drums - Interarrival Time
;            29. Lead time on cask order
;            30. Constant Time to load a basket on a cask cart
;            31. Time per basket to load onto a cask cart
;            32. Time to move cask cart w/baskets to Load/Unload room
;            33. Constant Time to Remove & Replace plugs
;            34. Time per empty basket to load into LAG
;            35. Time to load & move pallet to east end.
;            36. Time to replace the grapple
;            37. Time to move west crane the length of the canyon
;            38. Time to return the cask cart
;            39. Time to unload the basket adapter from the cask cart
;            40. Time to move a pallet of drums into a basket
;            41. Time to fetch & Return the empty pallet
;            42. Time to move a cask onto the cask cart from the rail car
;            43. Time to move the cask cart to the Load/Unload room
;            44. Constant time to load basket
;            45. Time per basket to load into the cask
;
;       EXPERIMENTS:   MRS
;
;     ******************************************************************
```

```
;     IMPLEMENTATION BLOCK:
;        DEVELOPMENT INFORMATION:
;           MODELED  BY:                    ON:
;                    AT: Pacific Northwest Laboratory
;                        Richland, Washington  99352
;           MACHINE/OPERATING SYSTEM:
;           SIMAN VERSION           :
;
;        MODIFICATION HISTORY:
;           MODIFIED BY:                    ON:
;           REASON FOR MODIFICATION:
;           DESCRIPTION OF MODIFICATION:
;
SYNONYMS:
      HARDWARE IN            =  15:         ! Counter ID
      FILTERS IN             =  16:         !   "    "
      # BASKETS              =  IS:
      FUEL TYPE              =  DP( 54, 5 ):
      GATE INSPEC            =  ED( 15 ):
      SW Activity 1          =  ED( 29 ):
      SW Activity 2          =  ED( 30 ) + IS * ED( 31 ):
      SW Activity 3          =  ED( 32 ):
      SW Activity 4          =  ED( 33 ) + IS * ED( 34 ):
      SW Activity 5          =  ED( 35 ):
      SW Activity 6          =  ED( 36 ):
      SW Activity 7          =  ED( 37 ):
      SW Activity 8          =  ED( 38 ):
      SW Activity 9          =  ED( 39 ):
      SW Activity 10         =  ED( 40 ):
      SW Activity 11         =  ED( 41 ):
      SW Activity 12         =  ED( 42 ):
      SW Activity 13         =  ED( 43 ):
      SW Activity 14         =  ED( 44 ) + IS * ED( 45 );
;
;     ****************************************************************
;     CODE BLOCK:
;
         CREATE,X(21):ED(27):MARK(1);      Hardware Drums ( Batch: 5 )
         COUNT:'HARDWARE IN',5;
         ASSIGN:A(2)=1:NEXT(ASGNFUEL);
;
         CREATE,X(21):ED(28):MARK(1);      Filter Drums   ( Batch: 5 )
         COUNT:'FILTERS IN',5;
         ASSIGN:A(2)=2;
ASGNFUEL ASSIGN:M='FUEL TYPE';
         ASSIGN:NS=A(2);
;
         QUEUE,M+27;                            <<Q 28 - 29 >>
         SEIZE:PALLET(M);
;
         QUEUE,M+29;                            <<Q 30 - 31 >>
         SEIZE:LAG(M);
;
         ASSIGN:'# BASKETS'=0;
```

```
         QUEUE,M+58;                          <<Q 59 - 60 >>
         SEIZE:BASKET(M);
         BRANCH,1:
            IF,NR(M+14).EQ.MR(M+14),BASKET:
            ELSE,WAIT_ECR;
;
BASKET   QUEUE,M+31;                          <<Q 32 - 33 >>
         SEIZE,0:CART(M);             Wait for Cask Cart
         ASSIGN:J=MR(M+12)-NR(M+12)+1; # of openings
         ASSIGN:'# BASKETS'=MN(9,J);          # of baskets to order
;
         QUEUE,M+33;                          <<Q 34 - 35 >>
         SEIZE,0:OH(M);               Wait for Overhead Crane
         DELAY:'SW Activity 2';       Load Cask Cart
         RELEASE:OH(M);
         DELAY:'SW Activity 3';       Move Baskets to Unloading Room
         ALTER:BASKET(M),'# BASKETS';
         COUNT:M+19,'# BASKETS';      Count the number of empty baskets
;
WAIT_ECR ALTER:BASKET(M),-1;
         RELEASE:BASKET(M);
         QUEUE,M+35;                          <<Q 36 - 37 >>
         SEIZE,0:ECRANE(M);
         BRANCH,2:
            ALWAYS,WAIT_WCR:
            IF,'# BASKETS'.NE.0,MOVEBSKT:
            ELSE,REPGRAP;
;
MOVEBSKT DELAY:'SW Activity 4';
         BRANCH,2:
            ALWAYS,REPGRAP:
            ALWAYS,RETURNCT;
;
WAIT_WCR QUEUE,M+37;                          <<Q 38 - 39 >>
         SEIZE,0:WCRANE(M);
         DELAY:'SW Activity 5';       Move to East End
         BRANCH,2:
            ALWAYS,COMBINE:
            ALWAYS,RET_WCR;
;
RET_WCR  DELAY:'SW Activity 7';
         RELEASE:WCRANE(M):DISPOSE;
;
RETURNCT DELAY:'SW Activity 8';
         QUEUE,M+39;                          <<Q 40 - 41 >>
         SEIZE,0:OH(M);               Wait for Overhead Crane
         DELAY:'SW Activity 9';
         RELEASE:OH(M);
         RELEASE:CART(M):DISPOSE;
;
REPGRAP  DELAY:'SW Activity 6';
COMBINE  QUEUE,M+41;                          <<Q 42 - 43 >>
         COMBINE:2;
ACT_10   DELAY:'SW Activity 10';
```

```
        BRANCH,2:
           ALWAYS,RETPALET:
           ALWAYS,RSTGRAP;
;
RETPALET QUEUE,M+43;                            <<Q 44 - 45 >>
        SEIZE,0:WCRANE(M);
        DELAY:'SW Activity 11';
        RELEASE:WCRANE(M);
        RELEASE:PALLET(M):DISPOSE;
;
RSTGRAP  DELAY:'SW Activity 6';
        RELEASE:ECRANE(M);
        ASSIGN:A(3)=1;                  For use in time AVG.
        ASSIGN:A(2)=NS+54;              Param Set for #
        ASSIGN:IS=M;
        ASSIGN:M=M+NS*2-2;                          <<M 1 - 4 >>
;
;  Combine Baskets into a cask, & wait for the cask
;
        ASSIGN:J=DP(A(2),5);
        QUEUE,M+45;                             <<Q 46 - 49 >>
        COMBINE:J,SUM;
        ASSIGN:A(2)=M;
        ASSIGN:M=IS;
        ASSIGN:'# BASKETS'=A(3);
        ASSIGN:A(3)=A(1)/A(3);          Compute Avg Time in Sys.
        ASSIGN:A(1)=0;
        BRANCH,2:
           ALWAYS,LOAD_QUE:
           ALWAYS,ORDER;
;
LOAD_QUE QUEUE,50:DETACHED;                     <<Q 50 >>
;
CASK_QUE QUEUE,51:DETACHED;                     <<Q 51 >>
;
        MATCH,2:
           LOAD_QUE,LOAD&CSK:
           CASK_QUE,LOAD&CSK;
;
LOAD&CSK QUEUE,52;                              <<Q 52 >>
        COMBINE:2,SUM;
        ASSIGN:A(2)=M+NS*2+1;       Tally Number for Drum Time in System
;
        QUEUE,M+52;                             <<Q 53 - 54 >>
        SEIZE:CART(M);
        QUEUE,M+54;                             <<Q 55 - 56 >>
        SEIZE:OH(M);
        DELAY:'SW Activity 12';  Move Cask to Cart
        RELEASE:OH(M);
        DELAY:'SW Activity 13';  Move Cart to Loading Area
        QUEUE,M+56;                             <<Q 57 - 58 >>
        SEIZE,0:ECRANE(M);
        DELAY:'SW Activity 14';  Move Baskets into Cask
        RELEASE:LAG(M),'# BASKETS';      Free up room in LAG
```

```
        ASSIGN:X(4)=X(4)+1;        Add this cask to the outgoing train
        TALLY:A(2),INT(3):NEXT(CASKOT);  Average Time/Basket
;
ORDER   BRANCH,2:
           ALWAYS,GET_CASK:
           IF,X(5).GT.0,GOT_CASK:
           ELSE,WAIT_CSK;
;
GET_CASK DELAY:'SW Activity 1';
        DELAY:'GATE INSPEC';
        FINDJ,41,50:MAX(X(J));
        ASSIGN:X(J)=TNOW-'GATE INSPEC';
        ASSIGN:X(5)=X(5)+1;
        SIGNAL:3:DISPOSE;
;
WAIT_CSK QUEUE,61;                                     <<Q 61 >>
        WAIT:3,1;
GOT_CASK ASSIGN:X(5)=X(5)-1;         Allocate a cask rail car
        FINDJ,41,50:MIN(X(J));
        ASSIGN:A(1)=X(J);            Cask Entry Time
        ASSIGN:A(3)=0;
        ASSIGN:X(J)=1E30:NEXT(CASK_QUE);
END;
```

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