REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:8412120157 DOC.DATE: 84/12/05 NOTARIZED: NO DOCKET #
FACIL:50-275 Diablo Canyon Nuclear Power Plant, Unit 1, Pacific Ga 05000275
50-323 Diablo Canyon Nuclear Power Plant, Unit 2, Pacific Ga 05000323
AUTH.NAME AUTHOR AFFILIATION
SHIFFER,J.D. Pacific Gas & Electric Co.
RECIP.NAME RECIPIENT AFFILIATION
KNIGHTON,G.W. Licensing Branch 3

SUBJECT: Forwards updated response to NUREG-0612, "Control of Heavy Lodas" for Unit 2.Submittal anticipates NRC comments similar to comments issued for Unit 1.Changes made equivalent to Unit 1 submittal.

DISTRIBUTION CODE: A033D COPIES RECEIVED:LTR 1 ENCL 40 SIZE: 85
TITLE: OR Submittal: USI A-36 Control of Heavy Load Near Spent Fuel-NUREG-06

NOTES:J Hanchett 1cy PDR Documents. 05000275
OL:09/22/81
J Hanchett 1cy PDR Documents. 05000323
See '84 Reports

	RECIPIENT ID CODE/NAME		COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME		COPIES LTTR	COPIES ENCL
	NRR LB3 BC		7	7	NRR SINGH,A	01	4	4
INTERNAL:	ACRS	13	6	6	ADM/LFMB		1	0
	NRR NEIGHBORS	09	1	1	NRR/DL/ORAB	12	1	1
	NRR/DL/TAPMG		1	1	NRR/DSI/AEB		1	1
	NRR/DSI/ASB		1	1	REG FILE	04	1	1
	RGN5		1	1				
EXTERNAL:	LPDR	03	2	2	NRC PDR	02	1	1
	NSIC	06	1	1	NTIS		1	1
NOTES:			1	1				

TOTAL NUMBER OF COPIES REQUIRED: LTTR 31 ENCL ~~30~~ 29

PACIFIC GAS AND ELECTRIC COMPANY

PGandE 77 BEALE STREET • SAN FRANCISCO, CALIFORNIA 94106 • (415) 781-4211 • TWX 910-372-6587

JAMES D. SHIFFER
VICE PRESIDENT
NUCLEAR POWER GENERATION

December 5, 1984

PGandE Letter No.: DCL-84-373

Mr. George W. Knighton, Chief
Licensing Branch No. 3
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Docket No. 50-275, OL-DPR-80
Docket No. 50-323
Diablo Canyon Units 1 and 2
Updated Response to NUREG-0612, "Control of Heavy Loads"

Dear Mr. Knighton:

PGandE responded to D. G. Eisenhut's letter of December 22, 1980 on heavy load handling (NUREG-0612) on May 9, 1983 for Diablo Canyon Unit 1, and on July 29, 1983 for Diablo Canyon Unit 2. The NRC has commented on PGandE's Diablo Canyon Unit 1 NUREG-0612 submittal, both verbally and in two Technical Evaluation Reports (TERs). PGandE responded to these comments with changes to the Unit 1 submittal on June 15, and September 26, 1984. Anticipating that NRC comments similar to those issued for Unit 1 will be issued for Unit 2, PGandE is enclosing equivalent changes for the original Unit 2 submittal. Changes affecting the CCW pump motor lifting device and the intake structure gantry crane are not repeated, since the auxiliary building and the intake structure are common structures and are covered in the Unit 1 submittal only.

In addition to these Unit 2 changes, other changes have arisen out of the application of the NUREG-0612 guidelines at Diablo Canyon. These other changes are also shown, with sidebars, in the enclosed change pages. They are:

1. The minimum weight of a heavy load, which is the weight of a fuel assembly with its handling tool, was revised from 1,813 pounds to 1,972 pounds to reflect actual use. The new weight is still less than that assumed in the Diablo Canyon FSAR dropped-fuel accident analysis.

A033
1/40

2. The fourteen heavy load paths under the Turbine Building Bridge Cranes are replaced with one large load path covering most of the turbine deck, as shown in the revised Figure 2.1.3.a-7 for Unit 1 and 2.1.3.a-4 for Unit 2. The new load path is safe because there is no spent fuel or safe-shutdown-related components under it.

3. The reactor coolant pump motor lift rig has now been modified, and its analysis, new in Unit 2, has been revised in Unit 1 to reflect the as-built condition.

Sidebars in the right margin of the change pages locate changes from previous submittals. Sidebars in the left margin of the Unit 2 change pages show where Unit 2 differs from Unit 1. Please replace or insert the change pages as indicated on the enclosure cover sheet.

Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it in the enclosed addressed envelope.

Sincerely,

J. Shiffer

Enclosure

cc: Service List

[illegible]

ENCLOSURE

SUBMITTAL CHANGE PAGES

Please substitute these revised pages for the indicated pages, and insert the new pages, in PGandE's May 9, 1983 Diablo Canyon Unit 1 NUREG-0612 submittal, and PGandE's July 9, 1983 Diablo Canyon Unit 2 NUREG-0612 submittal.

CHANGE PAGE(S)	REPLACING	EFFECT
I. Unit 1		
2.1.1-2	2.1.1-2	Revises minimum heavy load weight
2.1.2-5	2.1.2-5	Revises load weight of fuel-handling cranes
Figure 2.1.3.a-7	Figure 2.1.3.a-7	Replaces turbine deck load paths with one large one
2.1.3-12, -13	2.1.3-12, -13	Removes load path designation from turbine deck heavy loads
2.1.3-19	2.1.3-19	Simplifies justification for not analyzing the lower internals lift
2.1.3-20	2.1.3-20	Changes RCP motor lift rig modification from commitment to statement
2.2-6	2.2-6	Revises minimum heavy load weight
A-19	A-19	Changes RCP motor lift rig safety factors to as-built values
II. Unit 2		
i thru iii	i thru iii	Changes tables of contents to reflect change pages
2.1-4	2.1-4	Revises minimum heavy load weight
2.1-11	2.1-11	Revises load weight of fuel-handling cranes
Figure 2.1.3.a-4	Figure 2.1.3.a-4	Replaces turbine deck load paths with one large one

CHANGE PAGE(S)	REPLACING	EFFECT
2.1-20	2.1-20	Removes reference to Footnote 2
2.1-22	2.1-22	Adds lifting device to LP turbine rotor, and removes load path designations from turbine deck heavy loads
2.1-23	2.1-23	Makes Footnote 2 more specific
2.1-26 and -27	2.1-26 and -27	Adds treatment of RCP motor lift rig, and specifies exclusion of other lift rigs more narrowly
Figure 2.1.3.d-5	---	Adds new figure for RCP motor lift rig
2.2-2	2.2-2	Adds reference to Appendix D
2.2-6	2.2-6	Revises minimum heavy load weight
2.2-8	2.2-8	Refers treatment of FHA bridge crane/load block combination to Appendix D
2.3-2	2.3-2	Describes enhanced treatment of containment polar crane/small load combinations
2.3-8 thru -11	2.3-8 thru -13	Gives head and upper internals drop probabilities for drops $\geq$ 24 inches, refers treatment of Polar Crane/small load combinations to Appendix D, and describes new single-failure-proof missile shield hoist
---	Figure 2.3.3-1	Deletes figure of non-single-failure-proof missile shield hoist
2.3-12	2.3-14	Renumbers page
2.3-13 thru -16	2.3-15	Add structural analyses for postulated 24-inch drops of reactor head and upper internals
2.4-4	2.4-4	Increases polar crane reliability number
2.4-8 thru -13	2.4-8 thru -15	Reformats Load/Impact Matrix and adds missing Part IV, "Turbine Building Bridge Crane"

CHANGE PAGE(S)	REPLACING	EFFECT
2.4-14 thru -17	2.4-16 thru -19	Renumbers pages
2.4-18	2.4-20 thru -22 (plus Figure 2.4.2-1)	Refers treatment of large-crane/ small-load combinations to Appendix D
2.4-19 thru -21	2.4-23 thru -25	Renumbers pages
A-1 thru -19	A-1 thru -16	Replaces entire Appendix A, adding RCP motor lift rig analysis results and commitments
D-1 thru -9 (plus Figure D-1)	---	Adds new Appendix D to evaluate large-crane/small-load combinations against NUREG-0612, Appendix C guidelines

PGandE Response

2.1.1

An extensive review and analysis of the Unit 1 equipment location drawings, and subsequent comprehensive plant walkdowns, have identified the overhead load handling systems which carry heavy loads over components required for plant shutdown or decay heat removal, or over irradiated fuel in the reactor vessel or the spent fuel pool. These are called Category 1 handling systems; they are listed in Table 2.1.1-1, and described below.

The review also identified the overhead load handling systems which could not affect plant safety, either due to sufficient physical separation or where the lift weight is less than the defined heavy load (1,972 pounds for DCPP). These are called Category 2 handling systems; they are discussed in Section 2.1.2, along with a detailed discussion of the criteria by which they are placed in that category.

The major Category 1 overhead load handling systems at Diablo Canyon are:

C-140-01 Containment Structure Polar Crane - The containment structure polar crane is an overhead gantry crane located on top of the circular crane wall at elevation 140' (top of rail). This polar crane has a main hook capacity of 200 tons and an auxiliary hook capacity of 35 tons. Its arrangement is shown in Figure 2.1.1-1.

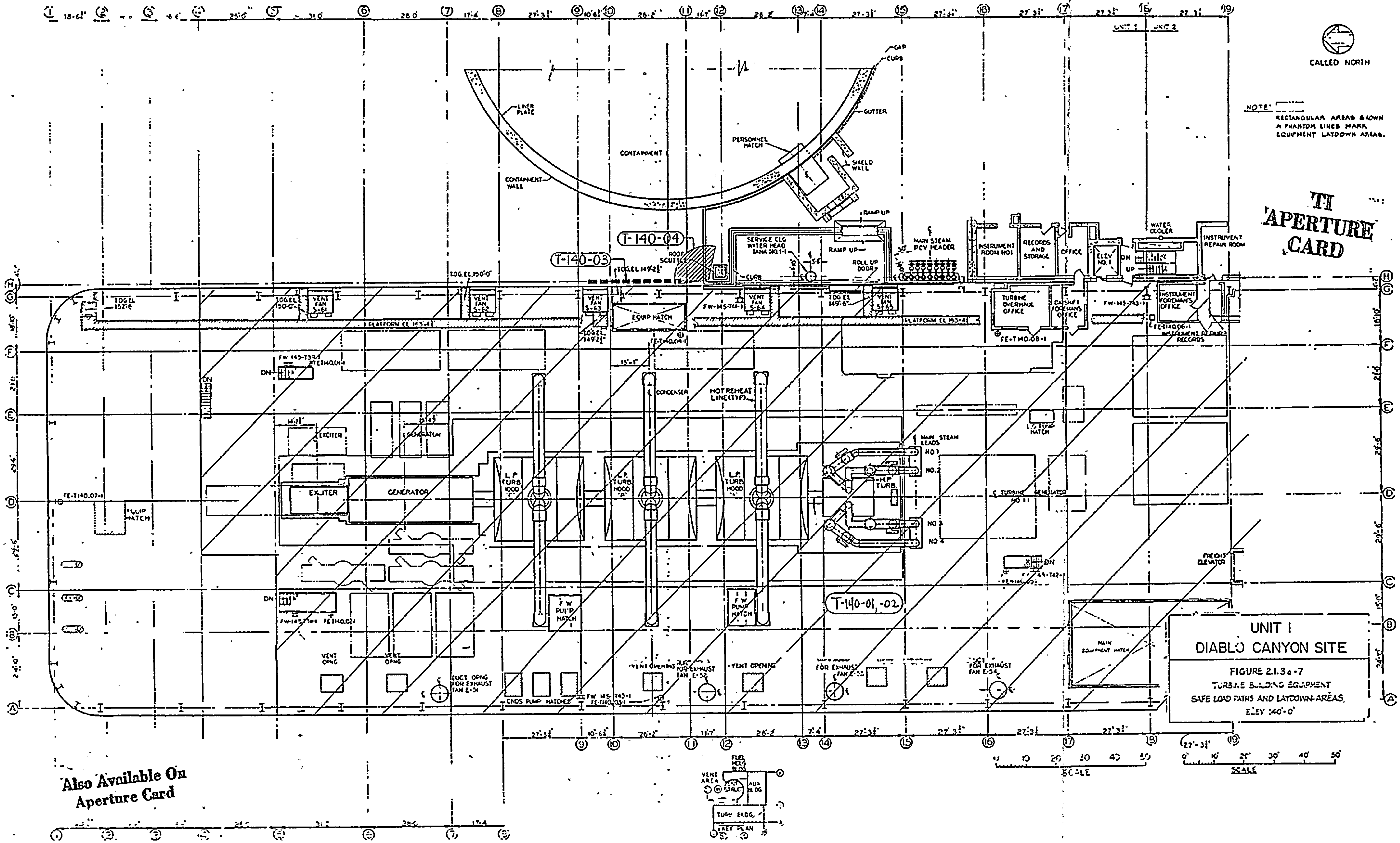
It is not anticipated that the polar crane will be used to lift heavy loads during operational modes 1 (power operation), 2 (start-up), 3 (hot standby), or 4 (hot shutdown). In the unlikely event that it becomes necessary to lift a heavy load with the polar crane during any of these operational modes, the specific lift will be approved by the Plant Staff Review Committee (PSRC) as complying with the guidelines of NUREG-0612, before performing it.

AF-140-08 Fuel Handling Area Crane - The fuel handling area crane, shown in Figure 2.1.1-2, has a 125-ton capacity main hook, and a 15-ton capacity auxiliary hook. The crane is located in the fuel handling area of the auxiliary building. This crane provides service to both Unit 1 and Unit 2 fuel handling areas and also to the hot machine shop area. The bridge crane spans the width of the fuel handling area, about 30 feet above the operating deck (top of rail at elevation 170').

The crane can be used for movement of new or spent fuel in the fuel handling areas and for movement of equipment in the hot shop area. The fuel handling area crane can be used during any operating mode of the plant.

TABLE 2.1.2-2
"UNDERWEIGHT" CATEGORY 2 SYSTEMS

CRANE	DESCRIPTION	LOAD WEIGHT, LBS
C-140-02	Manipulator Crane	1,972
C-140-03	½T Containment Dome Service Crane	1,000
C-140-04	1T Reactor Cavity Service Crane	1,500
C-140-05	1T Containment Equipment Crane	1,000
AF-140-01	1/8T Monorail for Roughing Filters	40
AF-140-02	1/8T Monorail for HEPA Filters	40
AF-140-03	1/8T Monorail for HEPA Filters	40
AF-140-04	1/8T Monorail for Carbon Filters	40
AF-140-05	1/8T Monorail for HEPA Filters	40
AF-140-06	1/8T Monorail for Carbon Filters	40
AF-140-07	1T Rotating Jib for Misc. Equipment	1,000
AF-140-09	1T Spent Fuel Bridge Crane	1,972
AF-140-17	1T New Fuel Davit Crane	1,972
AF-115-01	1/8T Monorail for HEPA and Roughing Filters	40
AF-115-02	1/8T Monorail for HEPA Filters	40
AF-115-03	1/8T Monorail for Carbon Filters	40
AF-115-06	2T Monorail for Fire Pump 0-1	1,440
AF-115-07	2T Monorail for Fire Pump 0-2	1,440
AF-100-01	1T Monorail for Spent Fuel Pool Pump 1-1	905
AF-100-02	1T Monorail for Refueling Water Purifier Pump 1-1	268
AF-100-03	1T Monorail for Spent Fuel Pool Skim Pump 1-1	186
AF-85-02	2T Monorail for Seal Water Heat Exchanger 1-1	1,120



8412120157-01 12-3-84

TABLE 2.1.3.c-1
HEAVY LOADS, THEIR WEIGHTS AND THEIR LIFTING DEVICES

CRANE	LOAD	WEIGHT [tons]	LIFTING DEVICE	PROCEDURE
AF-73-05 & -06 Containment Spray Pumps 1-1, 1-2, 2-1, & 2-2 & Charging Pumps 1-3 & 2-3 (2T Monorail)	Containment spray pump motor	1.7	4 slings	12.2
	Containment spray pump	1.35	2 slings	12.2
	Reciprocating charging pump motor	1	2 slings	8.9
	Reciprocating charging pump fluid drive	.95	4 slings	8.9
AF-64-04 & -05 Residual Heat Removal Pumps (4T Monorail)	Motor with impeller	2.1	4 slings	10.2
T-140-01 & -02 2-115T Turbine Bldg. Bridge Cranes	Generator Rotor	192 (96 Per Crane)	Slings; hooks spaced 17' apart by cable loops	22.1
	Exciter	40	Special lifting device[2], with 4 slings	22.3
	Exciter housing	8.5	Slings	22.2
	LP turbine crossover tee	22	2 turnbuckles to main hook	4.6
	LP turbine rotor, with lifting device	105	Special lifting device[2], with adjustable slings, basket configuration	4.1
	HP turbine rotor	55	Same as LP rotor	4.1

TABLE 2.1.3.c-1
HEAVY LOADS, THEIR WEIGHTS AND THEIR LIFTING DEVICES

CRANE	LOAD	WEIGHT [tons]	LIFTING DEVICES	PROCEDURE
T-140-01 & -02 (Continued)	Condensate pump casing	13	Slings	2.1
	FW pump turbine cover	9	Slings, to auxiliary hook	3.3
	LP turbine outer cover	70	2 slings in basket configuration	4.5
	LP turbine inner cover #1	28	Special lifting device[2] and slings	4.5
	LP turbine inner cover #2	57.5	Same as LP turbine outer cover	4.5
	HP turbine cover	85	Same as LP turbine outer cover	4.4
	HP throttle valves	6	2 slings	4.15
	Mobile crane	20	4 slings	50.2
	Turbine blade ring half	4.25 max	Fixed sling and 2 chainfalls	4.2
	Turbine bearing cover	2. max	2 slings, or special lifting device[2]	4.3
	FW pump hatch cover	3.4	4 slings	3.3
	FW pump turbine rotor	1.9	Slings	3.3
	Condensate pump motor	5.5	Slings	2.1
	Condensate pump hatch cover	1	2 slings	2.1
	HP turbine enclosure roof section	2.95	4 slings	4.14

is conservatively accounted for by derating the slings by ½% per fpm of hoisting speed; further conservatism is introduced by setting the hoist speed for derating to the administrative maximum of 20 fpm, regardless of the lower maximum speeds of most of the hoists. Thus, the load rating marked on the sling ID tags will be 10% less than the rating allowed by ANSI B30.9-1971. Since the derating is based on an administrative maximum hoist speed, and no credit is taken for a slower hoist speeds on certain cranes, none of the slings is restricted.

2. Special Lifting Devices

The term "special lifting device" is defined broadly, for this submittal, as anything used for rigging a heavy load that is not generically available commercially, but rather is designed and fabricated for one or more particular loads.

There are five special lifting devices that must conform with ANSI N14.6-1978:

- Reactor Vessel Head Lifting Device
- Reactor Internals Lifting Device
- Reactor Coolant Pump (RCP) Motor Lifting Device
- Reactor Vessel Inspection Tool (RVIT) Lifting Device
- Component Cooling Water (CCW) Pump Motor Lifting Device

The first four devices have been shown to satisfy the intent of all applicable ANSI N14.6-1978 requirements. PGandE is presently procuring a new CCW pump motor lifting device which will meet the ANSI N14.6 structural requirements.

The reactor vessel head lifting device, shown in Figure 2.1.3.d-2, consists of a welded and bolted structural steel frame, with suitable rigging for lifting and storing the head during refueling operations. It is evaluated in detail against ANSI N14.6 in Appendix A.

The reactor internals lifting device, shown in Figure 2.1.3.d-3, is another structural steel frame suspended from the Containment Polar Crane. When used to remove the upper internals, it is lowered onto the guide tube support plate and manually bolted to the plate with three bolts. The lower internals are removed and installed in a similar fashion, with three bolts into the support flange. Bushings on the lifting device frame engage guide studs in the vessel flange to provide lateral guidance during removal and replacement of the internals packages. The device's adequacy while lifting the upper internals is evaluated in detail against ANSI N14.6 in Appendix A. The lifting device is not evaluated for the lower internals lift, since there is no fuel in the reactor during this lift.

The reactor coolant pump motor lifting device, shown in Figure 2.1.3.d-5, consists primarily of 3 sling assemblies and a spreader assembly. The sling assemblies are connected at the top to a master link engaging the polar crane hook. Each sling assembly consists of a sling, a pair of shackles, and a turnbuckle, all general-purpose catalogue items. The slings have been replaced with new slings, each rated at 20 tons under ANSI B30.9-1971. Design safety margins for these items were derived by comparing the rated loads, proof loads, and the ultimate loads against the actual lifted loads. The spreader assembly consists of three tubular members attached end to end to form a triangle. Three side plates are bent around and welded at the corners. The sling assemblies, spread by the triangular structure, bear against these side plates. The lift rig was supplied by Westinghouse, who performed a design evaluation recently to verify its compliance to NUREG-0612 and ANSI N14.6-1978 requirements. The evaluation results, modified for the new 20-ton slings, are presented in detail in Appendix A.

PGandE plans to contract out the reactor vessel inspection to specialized contractors, and to require the contractor's RVIT lifting device to comply with all applicable portions of ANSI N14.6. PGandE's present reactor vessel inspection contractor is Westinghouse Nuclear Services Division (WNSD). The Westinghouse RVIT and its lifting device are shown in Figure 2.1.3.d-4. The lifting device consists of a double tripod of structural steel with a central hook. Once the hook engages the eye at the top center of the RVIT, the feet of the lower tripod are forced down onto three steadying pads by the hydraulically-actuated upper tripod, forming a rigid unit. WNSD has qualified this lifting device under ANSI N14.6. The calculations are filed at the WNSD offices in Pittsburgh, PA, in file 95041-9, with reference number PDC-TSST-C-80-157. They are available on request.

The CCW pump motor lifting device is used to transmit the motor weight from the two lift points to the hook of the monorail hoist above. It is required because of the limited headroom beneath the hoist. A new device will be built before the next CCW pump motor lift. The new device will satisfy the requirements of ANSI N14.6 (Sections 3, 4, and 5). The CCW pump motor is not a critical load as defined in Section 2 of ANSI N14.6, so Section 6 requirements do not apply.

It is seen in Table 2.1.3.c-1 that the remaining special lifting devices are not important to safety. They do not carry loads over spent fuel, or over safe-shutdown components except those that are needed to serve the lifted equipment. These lifting devices are thus excluded from the ANSI N14.6 evaluation.

PGandE Response

2.2.2

The spent fuel bridge crane (AF-140-16) is excluded from the above category because it can be used only for moving fuel assemblies. Since its largest load is a spent fuel assembly (weighing 1,972 pounds, including its handling tool), and since a "heavy load" is defined in NUREG-0612 as weighing more than a spent fuel assembly and its handling tool, this crane is incapable of carrying a heavy load over the spent fuel pool.

TABLE A-3.4

STRESS EVALUATION RESULTS
RCP MOTOR LIFT RIG CATALOGUE ITEMS

PART NAME	LIFTED LOAD (kip) (INCLUDES DLF)	RATED LOAD (kip)	STRESS DESIGN FACTOR WHEN COMPARED TO PROOF LOAD (1)	ULTIMATE LOAD
Master Link	101.9	160.0	3.2	5.4
Sling (2)	101.9	108.4	4.0	5.3
Shackle	34.0	70.0	4.5	12.4
Turnbuckle	34.0	37.0	2.2	5.5

NOTES:

(1) The proof load for a part is defined as the load which the part can carry without undergoing any visible permanent deformation.

(2) PGandE has replaced the Westinghouse-provided slings with a new three-sling bridle rated at 108.4 kips, with a proof load of 411.2 kips and an ultimate load of 542.0 kips.

DIABLO CANYON UNIT 2
NUREG-0612 SUBMITTAL

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PGandE Response

2.1.1

An extensive review and analysis of the Unit 2 equipment location drawings, and subsequent comprehensive plant walkdowns, have identified the overhead load handling systems which carry heavy loads over components required for plant shutdown or decay heat removal, or over irradiated fuel in the reactor vessel or the spent fuel pool. These are called Category 1 handling systems; they are listed in Table 2.1.1-1, and described below.

The review also identified the overhead load handling systems which could not affect plant safety, either due to sufficient physical separation or where the lift weight is less than the defined heavy load (1,972 pounds for DCPP). These are called Category 2 handling systems; they are discussed in Section 2.1.2, along with a detailed discussion of the criteria by which they are placed in that category.

The major Category 1 overhead load handling systems at Diablo Canyon are:

C-140-07 Containment Structure Polar Crane - The containment structure polar crane is an overhead gantry crane located on top of the circular crane wall at elevation 140' (top of rail). This polar crane has a main hook capacity of 200 tons and an auxiliary hook capacity of 35 tons. Its arrangement is shown in Figure 2.1.1-1.

It is not anticipated that the polar crane will be used to lift heavy loads during operational modes 1 (power operation), 2 (start-up), 3 (hot standby), or 4 (hot shutdown). In the unlikely event that it becomes necessary to lift a heavy load with the polar crane during any of these operational modes, the specific lift will be approved by the Plant Staff Review Committee (PSRC) as complying with the guidelines of NUREG-0612, before performing it.

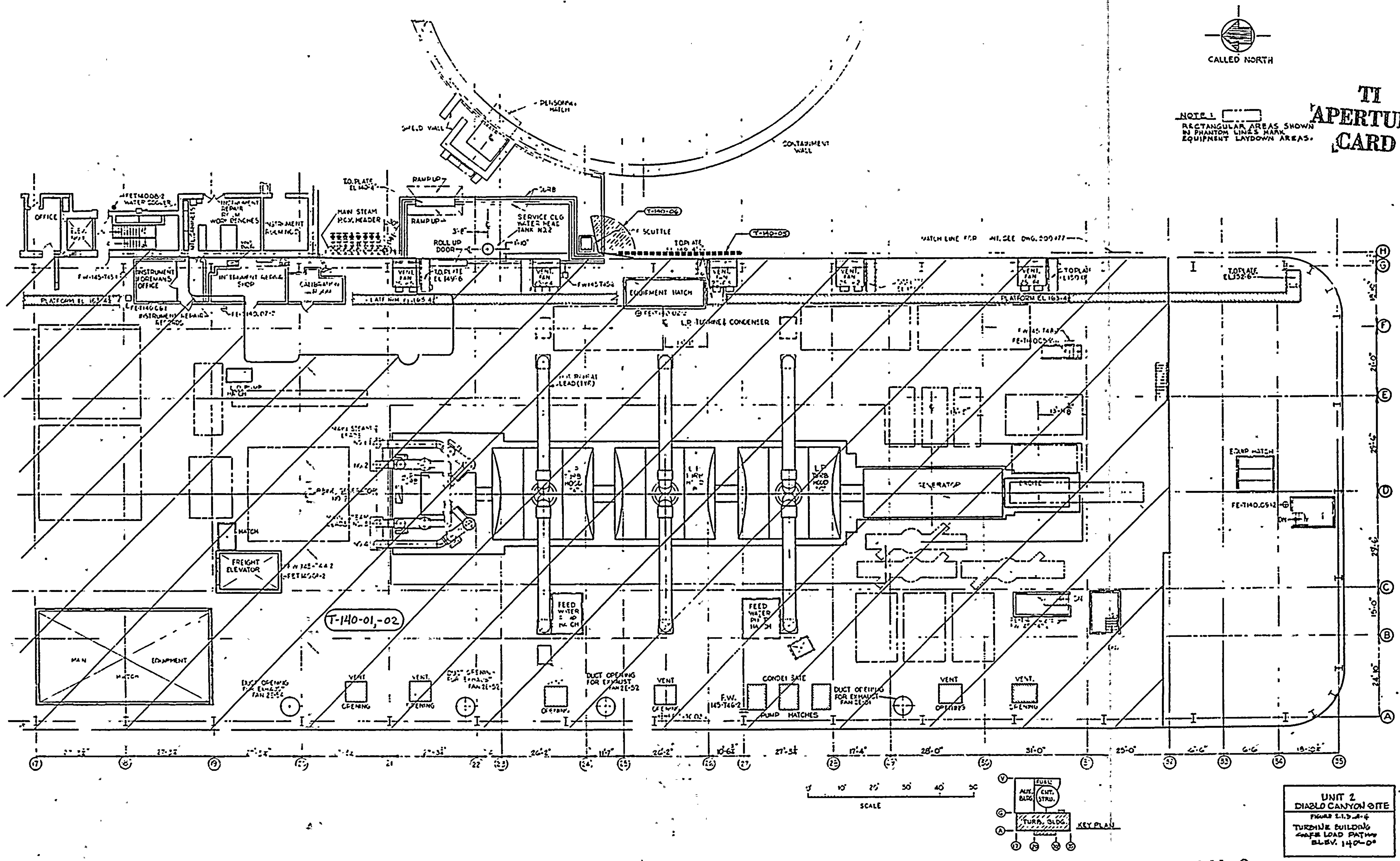
AF-140-08 Fuel Handling Area Crane - The fuel handling area crane, shown in Figure 2.1.1-2, has a 125-ton capacity main hook, and a 15-ton capacity auxiliary hook. The crane is located in the fuel handling area of the auxiliary building. This crane provides service to both Unit 1 and Unit 2 fuel handling areas and also to the hot machine shop area. The bridge crane spans the width of the fuel handling area, about 30 feet above the operating deck (top of rail at elevation 170').

The crane can be used for movement of new or spent fuel in the fuel handling areas and for movement of equipment in the hot shop area. The fuel handling area crane can be used during any operating mode of the plant.

TABLE 2.1.2-2
"UNDERWEIGHT" CATEGORY 2 SYSTEMS

CRANE	DESCRIPTION	LOAD WEIGHT, LBS
C-140-08	Manipulator Crane	1,972
C-140-09	½T Containment Dome Service Crane	1,000
C-140-10	1T Reactor Cavity Service Crane	1,500
C-140-11	1T Containment Equipment Crane	1,000
C-140-12	1T Rotating Jib for Misc. Equipment	1,600
C-140-13	1T Rotating Jib for Misc. Equipment	1,600
AF-140-10	1/8T Monorail for Roughing Filters	40
AF-140-11	1/8T Monorail for HEPA Filters	40
AF-140-12	1/8T Monorail for HEPA Filters	40
AF-140-13	1/8T Monorail for Carbon Filters	40
AF-140-14	1/8T Monorail for HEPA Filters	40
AF-140-15	1/8T Monorail for Carbon Filters	40
AF-140-18	1T Rotating Jib for Misc. Equipment	1,000
AF-140-16	1T Spent Fuel Bridge Crane	1,972
AF-140-18	1T New Fuel Davit Crane	1,972
AF-115-14	1/8T Monorail for HEPA and Roughing Filters	40
AF-115-15	1/8T Monorail for HEPA Filters	40
AF-115-16	1/8T Monorail for Carbon Filters	40
AF-100-09	1T Monorail for Spent Fuel Pool Pump 2-1	905
AF-100-10	1T Monorail for Refueling Water Purifier Pump 2-1	268
AF-100-11	1T Monorail for Spent Fuel Pool Skim Pump 2-1	186
AF-100-17	1T Monorail for Spent Fuel Pool HX 2-1	1,600

TI APERTURE CARD



Also Available On Aperture Card

8412120157 -02 12-3-84

TABLE 2.1.3.c-1
HEAVY LOADS, THEIR WEIGHTS, AND THEIR LIFTING DEVICES

CRANE	LOAD	WEIGHT [tons]	LIFTING DEVICE	PROCEDURE
C-140-07 Containment Polar Crane (200T Gantry)	A. Reactor Head w/CRDM and lifting device	172.5	Special lifting device, pinned directly to main hook[1]	7.2, 7.3
	B. Upper internals w/lifting device	77.5	Special lifting device, pinned directly to main hook[1]	7.6
	C. Lower internals w/lifting device	142.5	Special lifting device, pinned directly to main hook[1]	7.7
	D. Missile shield	17	Slings	50.9
	E. Internals lifting device	7.5	Pinned directly to main hook[1]	50.8
	F. Reactor head lifting device	12.5	Pinned directly to main hook[1]	50.7
	G. Reactor coolant pump internals	3.8	Slings	7.30
	H. Reactor coolant pump motor	43.8	Special lifting device, pinned to hook	7.31
	I. Reactor coolant pump flywheel	6.4	Special lifting device, pinned to hook	7.33
	J. Reactor coolant pump hatch	1.5	4 slings	7.29
	K. Containment fan cooler motor	2	Slings	23.2
	L. Head studs in basket	5.4	4 slings	7.28
	M. Reactor vessel inspection tool	5.25	Special lifting device, pinned directly to main hook	by contractor
	Main hoist load block	7.3	-	-

TABLE 2.1.3.c-1
HEAVY LOADS, THEIR WEIGHTS, AND THEIR LIFTING DEVICES

CRANE	LOAD	WEIGHT [tons]	LIFTING DEVICE	PROCEDURE
T-140-01 & -02 2-115T Turbine Bldg. Bridge Cranes	Generator rotor	192 (96 Per Crane)	Slings; hooks spaced 17 feet apart by cable loops	22.1
	Exciter	40	Special lifting device[2], with 4 slings	22.3
	Exciter housing	8.5	Slings	22.2
	LP turbine crossover tee	22	2 turnbuckles to main hook	4.6
	LP turbine rotor, with lifting device	105	Special lifting device[2], with adjustable slings, basket configuration	4.1
	HP turbine rotor	55	Same as LP rotor	4.1
	Condensate pump casing	13	Slings	2.1
	FW pump turbine cover	9	Slings to auxiliary hook	3.3
	LP turbine outer cover	70	2 slings in basket configuration	4.5
	LP turbine inner cover #1	28	Special lifting device[2] and slings	4.5
	LP turbine inner cover #2	57.5	Same as LP turbine outer cover	4.5
	HP turbine cover	85	Same as LP turbine outer cover	4.4
	HP throttle valves	6	2 slings	4.15
	Mobile crane	20	4 slings	50.2
	Turbine blade ring half	4.25 max.	Fixed sling and 2 chainfalls	4.2

TABLE 2.1.3.c-1
HEAVY LOADS, THEIR WEIGHTS, AND THEIR LIFTING DEVICES

CRANE	LOAD	WEIGHT [tons]	LIFTING DEVICE	PROCEDURE
T-140-01 & -02 (Continued)	Turbine bearing cover	2 max.	2 slings, or special lifting device[2]	4.3
	FW pump hatch cover	3.4	4 slings	3.3
	FW pump turbine rotor	1.9	Slings	3.3
	Condensate pump motor	5.5	Slings	2.1
	Condensate pump hatch cover	1	2 slings	2.1
	HP turbine enclosure roof section	2.95	4 slings	4.14
	Turbine rotor lifting beam	5	2 slings	4.1
	Main hoist load block	3	-	-
T-119-13 Moisture Separator Reheater No. 2-2A (20T Monorail)	High pressure tube bundle	14.5	Slings	4.7
	Low pressure tube bundle	9.85	Slings	

NOTES:

(1) Load cells attached for monitoring loads.

(2) Not analyzed in Section 2.1.3.d, because it is not lifted over safe shutdown components or spent fuel.

is conservatively accounted for by derating the slings by ½% per fpm of hoisting speed; further conservatism is introduced by setting the hoist speed for derating to the administrative maximum of 20 fpm, regardless of the lower maximum speeds of most of the hoists. Thus, the load rating marked on the sling ID tags will be 10% less than the rating allowed by ANSI B30.9-1971.

2. Special Lifting Devices

The term "special lifting device" is defined broadly, for this submittal, as anything used for rigging a heavy load that is not generically available commercially, but rather is designed and fabricated for one or more particular loads.

There are four special lifting devices that must conform with ANSI N14.6-1978:

- Reactor vessel head lifting device
- Reactor internals lifting device
- Reactor coolant pump (RCP) motor lifting device
- Reactor vessel inspection tool (RVIT) lifting device

All four have been shown to satisfy the intent of all applicable ANSI N14.6-1978 requirements.

The reactor vessel head lifting device, shown in Figure 2.1.3.d-2, consists of a welded and bolted structural steel frame, with suitable rigging for lifting and storing the head during refueling operations. It is evaluated in detail against ANSI N14.6 in Appendix A.

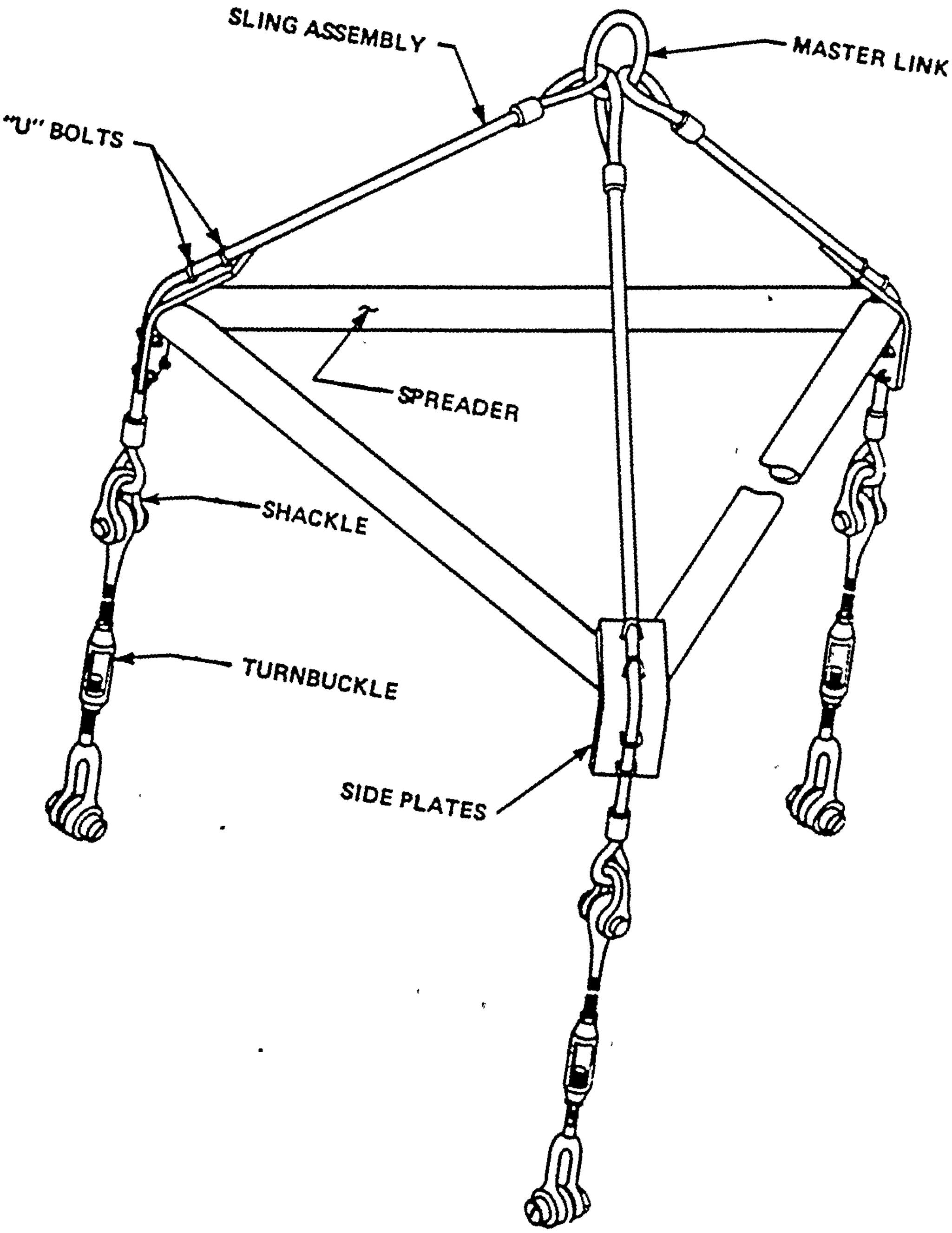
The reactor internals lifting device, shown in Figure 2.1.3.d-3, is another structural steel frame suspended from the containment polar crane. When used to remove the upper internals, it is lowered onto the guide tube support plate and manually bolted to the plate with three bolts. The lower internals are removed and installed in a similar fashion, with three bolts into the support flange. Bushings on the lifting device frame engage guide studs in the vessel flange to provide lateral guidance during removal and replacement of the internals packages. The device's adequacy while lifting the upper internals is evaluated in detail against ANSI N14.6 in Appendix A. The lifting device is not evaluated for the lower internals lift, since there is no fuel in the reactor during this lift.

The reactor coolant pump motor lifting device, shown in Figure 2.1.3.d-5, consists primarily of three sling assemblies and a spreader assembly. The sling assemblies are connected at the top to a master link engaging the polar crane hook. Each sling assembly consists of a sling, a pair of shackles, and a turnbuckle, all general-purpose catalogue items. The slings have been replaced with new slings, each rated at 20 tons under ANSI B30.9-1971. Design safety margins for these items were derived by

comparing the rated loads, proof loads, and ultimate loads against the actual lifted loads. The spreader assembly consists of three tubular members attached end to end to form a triangle. Three side plates are bent around and welded at the corners. The sling assemblies, spread by the triangular structure, bear against these side plates. The lift rig was supplied by Westinghouse, who performed a design evaluation recently to verify its compliance with NUREG-0612 and ANSI N14.6-1978 requirements. The evaluation results, modified for the new 20-ton slings, are presented in detail in Appendix A.

PGandE plans to contract the reactor vessel inspection to specialized contractors, and to require the contractor's RVIT lifting device to comply with all applicable portions of ANSI N14.6. PGandE's present reactor vessel inspection contractor is Westinghouse Nuclear Services Division (WNSD). The Westinghouse RVIT and its lifting device are shown in Figure 2.1.3.d-4. The lifting device consists of a double tripod of structural steel with a central hook. Once the hook engages the eye at the top center of the RVIT, the feet of the lower tripod are forced down onto three steadying pads by the hydraulically-actuated upper tripod, forming a rigid unit. WNSD has qualified this lifting device under ANSI N14.6. The calculations are filed at the WNSD offices in Pittsburgh, PA, in file 95041-9, with reference number PDC-TSST-C-80-157. They are available on request.

It is seen in Table 2.1.3.c-1 that the remaining special lifting devices are not important to safety, since they do not carry loads over safe-shutdown components or spent fuel. These lifting devices are thus excluded from the ANSI N14.6 evaluation.



UNIT 2
DIABLO CANYON SITE

FIGURE 2.1.3.d–5
REACTOR COOLANT PUMP
MOTOR LIFTING DEVICE

PGandE Response

2.2

Only two heavy loads are carried in the vicinity of the spent fuel pool - the fuel handling area bridge crane load block (2.5 tons) and a spent fuel shipping cask (assumed 67.5 tons). Through reference to Appendix D, Section 2.2.3 shows that the load block is adequately protected against dropping, because the crane meets the intent of all ten NUREG-0612, Appendix C guidelines while carrying the empty load block. Administrative procedures further protect the spent fuel by restricting movement of the load block over the spent fuel pool. Section 2.2.4 shows that the spent fuel cask is protected against falling onto "hot" spent fuel by redundant bridge and trolley travel limit switches that keep the cask well away from this fuel, and thus, the consequences of a cask drop will not violate NUREG-0612 criteria.

PGandE Response

2.2.2

The spent fuel bridge crane (AF-140-16) is excluded from the above category because it can be used only for moving fuel assemblies. Since its largest load is a spent fuel assembly (weighing 1,972 pounds, including its handling tool), and since a "heavy load" is defined in NUREG-0612 as weighing more than a spent fuel assembly and its handling tool, this crane is incapable of carrying a heavy load over the spent fuel pool.

PGandE Response

2.2.3

The only crane listed in Section 2.2.1 which is not excluded in Section 2.2.2 is the fuel handling area bridge crane (AF-140-08). This crane carries two heavy loads in the spent fuel pool area: the spent fuel cask (assumed 67.5 tons), and the unloaded load block (2.5 tons).

This crane has been upgraded to meet the reliability criteria of Section 5.1.6 and Appendix C of NUREG-0612, for the load block load (see Appendix D).

PGandE Response

2.3

There are seven load-handling systems in the Diablo Canyon containment. Section 2.3.1 describes the five that operate in the vicinity of the reactor. Section 2.3.2 shows that only three carry heavy loads over or in the reactor vessel -- the containment polar crane (C-140-07), the head stud tensioner monorail (C-140-12), and the missile shield hoist (C-140-14). Section 2.3.3 shows that all but four of the heavy load lifts satisfy the intent of the NUREG-0612, Section 5.1.6 guidelines. Section 2.3.4 analyzes the consequences of the remaining postulated drops, and demonstrates that the drops would have no effect on fuel integrity in the reactor, or on core uncovering.

PGandE Response

2.3.3

The following heavy loads are carried with sufficient design features to make the likelihood of a load drop extremely small:

Crane	Load	Weight
C-140-07	Reactor head with lifting device (above 24")	172.5T
C-140-07	Upper internals with lifting device (above 24")	77.5T
C-140-07	Unloaded internals lifting device	7.5T
C-140-07	Unloaded head lifting device	12.5T
C-140-07	Reactor vessel inspection tool (RVIT)	5.25T
C-140-07	Unloaded load nlock	7.3T
C-140-14	Missile shield	17T

The next two subsections analyze the likelihood of dropping the reactor head and the reactor upper internals, on a probabilistic basis. The third subsection shows that the containment polar crane, as modified, can carry the four lightest heavy loads at a level of reliability that satisfies the NUREG-0612 requirements. The last subsection describes modifications to the missile shield load handling system that provide complete redundancy of all functional parts.

C-140-07/Reactor Head (above 24 inches)

The lifting of the reactor vessel head by the containment polar crane is done in two stages. First, the head is lifted to a height from which a load drop would not unduly damage the reactor, and the crane and rigging are extensively tested and inspected. Second, after the tests and inspections, the head is lifted the rest of the way to its storage stand. The second part of the head lift has been studied on a probabilistic basis. Using fault tree methods, the study calculated the annual probability of dropping the reactor vessel head onto the open vessel after the initial lift. A summary of the method used and the results are presented here.

The crane and its associated controls, the head removal and installation procedures, the testing and inspection procedures, and the training procedures were reviewed. Basic events were identified, and a fault tree was constructed. The combinations of basic events (i.e., minimal cut sets) that would result in the drop of the vessel head were determined. Using estimated and published basic event probability data, the annual probability of head drop during refueling was computed.

The top event for the analysis was defined as a head drop from a height exceeding 24 inches. The procedures in use at Diablo Canyon require that, during removal from the vessel the head be checked for level at one inch above the vessel flange. This is followed by a test of the crane brakes at six inches above the flange. These inspections increase the reliability of the lifting system during the subsequent lift, by allowing correction of rigging errors and incipient equipment failures.

From a careful review of the crane control systems and operating procedures, a large number of basic events were identified. The main events contributing to the head drop above 24 inches are overspeed (from both human error and equipment malfunction, but primarily equipment) and structural failure (from inadequate structural strength). The risk contribution from the overspeed event has been reduced by the planned installation of an overspeed device on the containment polar crane, as described in Appendix D, Section D4. Other descriptor events such as two-blocking and load-binding (from catching the head on the alignment pins) were also considered, but their contribution is insignificant.

The basic event probability data and the associated uncertainties (defined by error factors) were obtained from the following sources:

- "Control of Heavy Loads at Nuclear Power Plants" (NUREG-0612), USNRC, 1980
- Rasmussen et al., "Reactor Safety Study" (WASH-1400), USNRC, 1975
- Swain and Guttman, "Handbook of Human Reliability Analysis With Emphasis on Nuclear Power Plant Applications" (NUREG/CR-1278), Sandia National Laboratories, 1980
- "System Reliability Service Data Bank" (SYREL), UKAEA

The structural failure data taken from the above sources include the effects of design/fabrication and other human errors in addition to the effects of inadequate structural strength. The probability of structural failure after the initial lift was computed by performing structural reliability analyses for crane loads associated with the events. These structural reliability analyses were based on the very conservative assumption that ten independent elements, each with the minimum specified design strength, are present in series. Other conservatisms in the PRA analysis are:

- In most cases, the occurrence of first operator error in a minimal cut set was set at 10^{-2}/event with an error factor of 10.
- In many cases, a crane operator error subsequent to the first operator error was assumed to be completely coupled (i.e., dependent in a statistical sense). For example, in a load hangup event or a two-blocking event, it was assumed that the operator would fail, with probability one, to press the stop pushbutton, given that he failed to place the master switch in the off position.
- No credit was taken for corrective action by the operator during overspeed events.

A total of 77 minimal cut sets for the vessel head drop were considered. The resulting drop probability is 2.3×10^{-7}/yr, which compares favorably with the failure probability estimates for single-failure-proof handling systems given in NUREG-0612, Figure B-3 (4×10^{-7} to 1×10^{-4} and 7×10^{-5} to 7×10^{-3}/yr). Therefore, no specific analysis of the consequences is necessary.

C-140-07/Upper Internals (above 24 inches)

Lifts of the upper internals were analyzed using the same general method as for the reactor vessel head drop analysis. Specific modifications were made to account for differences in the structural failure probability, since failure is less likely given the successful lift of the heavier reactor vessel head. The data sources and assumptions used for the quantitative analysis were the same as for the head drop analysis.

A total of 78 minimal cut sets were considered in the upper internals drop analysis. The resulting probability of a drop exceeding 24 inches is 1.7×10^{-7}/yr, which compares favorably with the failure probabilities of single-failure-proof handling systems given in NUREG-0612, Figure B-3. Therefore, no specific analysis of the consequences is necessary.

C-140-07/Small Loads

The containment polar crane carries several loads that qualify as heavy loads, but are much smaller than the polar crane's 200-ton capacity. These are the unloaded internals lifting device (weighing 7.5 tons), the unloaded head lifting device (12.5 tons), the reactor vessel inspection tool with its lifting device (5.25 tons), and the unloaded main hoist load block (7.3 tons). The containment polar crane, as modified, has sufficient design features to carry these smaller loads with single-failure-proof levels of reliability. Appendix D evaluates these four crane/load combinations against each of the ten single-failure-proof guidelines of NUREG-0612, Appendix C, and finds that the intent of each guideline is met.

C-140-14/Missile Shield

The reliability of the missile shield load handling system will be raised to a very high level with the installation of a new single-failure-proof hoist (C-140-14). The new hoist will be mounted on the steam generator shield wall above the missile shield. It will be designed, fabricated, and installed in accordance with the applicable portions of NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants." (For instance, Section 5 of NUREG-0554, "Bridge and Trolley," does not apply because the hoist will be stationary.) Procurement of the hoist has been initiated, and installation will be completed before the end of the first refueling outage.

Conclusion

Based on the evaluations presented here and in Appendix D, the following crane/load combinations have an extremely small probability of load drop:

Crane(s)	Loads	Justification
C-140-07	Reactor head with lifting device (above 24")	PRA
C-140-07	Reactor upper internals with difting device (above 24")	PRA
C-140-07	Unloaded head lifting device	(see Appendix D)
C-140-07	Unloaded internals lifting device	(see Appendix D)
C-140-07	RVIT with lifting device	(see Appendix D)
C-140-07	Unloaded load block	(see Appendix D)
C-140-14	Missile shield	Single-failure-proof

NRC Request (Enclosure 3)

2.3.4

"For cranes identified in 2.3.1, above, not categorized according to 2.3.3, demonstrate that the evaluation criteria of NUREG 0612, Section 5.1, are satisfied. Compliance with Criterion IV will be demonstrated in your response to Section 2.4 of this request. With respect to Criteria I through III, provide a discussion of your evaluation of crane operation in the containment and your determination of compliance. This response should include the following information for each crane:

a. Where reliance is placed on the installation and use of electrical interlocks or mechanical stops, indicate the circumstances under which these protective devices can be removed or bypassed and the administrative procedures invoked to ensure proper authorization of such action. Discuss any related or proposed technical specification concerning the bypassing of such interlocks.

b. Where reliance is placed on other, site-specific considerations (e.g., refueling sequencing), provide present or proposed technical specifications and discuss administrative or physical controls provided to ensure the continued validity of such considerations.

c. "Analyses performed to demonstrate compliance with Criteria I through III should conform with the guidelines of NUREG 0612, Appendix A. Justify any exception taken to these guidelines, and provide the specific information requested in Attachment 2, 3, or 4, as appropriate, for each analysis performed."

PGandE Response

2.3.4

Four heavy loads are analyzed in this section for post-drop compliance with Criteria I through III of Section 5.1. These loads are:

Crane	Loads	Weight
C-140-07	Reactor head with lifting device (up to 24")	172.5T
C-140-07	Upper internals with lifting device (up to 24")	77.5T
C-140-07	Lower internals with lifting device	142.5T
C-140-12	Reactor head stud tensioner	1.3T

Criteria I through III are satisfied, no matter which load is dropped, if the drop occurs anywhere but over the reactor vessel. Criteria I and II limit the allowable radioactive releases and neutron multiplication factor resulting from a drop onto fuel; outside the reactor, fuel assemblies must be handled one at a time, due to the design of the manipulator crane. Sections 2.1 and 2.2 of NUREG-0612 show that damage to a single 100-hour-cooled PWR fuel assembly have acceptable consequences, even in an unfiltered containment. Criterion III requires assurance that the core will not be uncovered as a result of a drop; the Diablo Canyon reactor vessel penetrations are several feet above the top of the core, so nothing short of a reactor vessel failure or failure of the residual heat removal system (covered in Section 2.4, below) could cause core uncovering. Therefore, only drops onto or into the reactor vessel will be considered.

The containment polar crane may carry other heavy loads besides those listed above, but the load paths for other loads are outwards to the annulus region. These loads are kept from moving over the reactor by administrative means.

Reactor Head (up to 24 inches)

The reactor head lift is done in two stages. After an initial lift of no more than 24 inches, the brakes are tested and the entire load handling system is inspected. After the tests and inspections, the lift proceeds very reliably. Section 2.3.3 above has shown that the reliability of the load handling system after the initial lift and inspections is equivalent to that of a single-failure-proof system. Therefore, the maximum height for a credible head drop onto the open reactor vessel is 24 inches.

The reactor vessel was, therefore, structurally analyzed to determine the consequences of this maximum drop. A dynamic analysis model was developed in which the vessel internals, vessel shell, supporting nozzles, attached piping, and nozzle supports were represented by finite elements. The dynamic structural response of the vessel model to the dropped head's impact was calculated using the time-history method. The resulting peak stresses or loads for the critical vessel components are listed in Table 2.3.4-1 and are compared with the components' ultimate stresses or loads as applicable.

Note that these safety margins are based on a comparison of predicted stresses or loads to the component's stress or load capacity. However, for an impact loading event with limited drop energy, it is more appropriate to compare the predicted ductility demand to the allowable ductility ratio. This is because excursion into the plastic range is usually permitted if the ductility ratio is not excessive. But, since the stresses and loads were within the elastic limit or very close to it, conventional strength safety margins were computed. If the safety margins had been computed on the basis of ductility, they would have been much higher than those shown in Table 2.3.4-1, because all the reserve plastic energy would still have been available.

The comparisons of Table 2.3.4-1 show that the critical components have ample safety margin, so no vessel failure or other unacceptable consequences would result from the postulated head drop.

Upper Internals (up to 24 inches)

The reactor upper internals are lifted the same way as the reactor head, with tests and inspections after an initial lift of no more than 24 inches. The second stage of the lift, after the tests and inspections, was shown in Section 2.3.3 above to be much more reliable than the generic single-failure-proof load handling systems analyzed in NUREG-0612, Appendix B. Therefore, the maximum height for a credible upper internals drop into the open reactor vessel is 24 inches.

The critical vessel components impacted by the dropped upper internals were modeled with nonlinear finite elements as in the head drop analysis, and a time-history calculation yielded the peak deformations from the drop. Table 2.3.4-2 compares these peak deformations with the yield deformations of the critical vessel components. The table shows that all the critical components would remain in the elastic deformation region except for the guide thimbles, which would deform to a ductility ratio of 2.73. Such a low ductility ratio is considered safe, especially since before this deformation is reached the upper internals would contact the hold-down spring, which would transfer the impact load primarily to the vessel support. The vessel support was already shown, in Table 2.3.4-1, to be able to withstand the much larger impact load of the reactor head.

The comparisons of Table 2.3.4-2 show that the postulated 24-inch drop of the upper internals into the open reactor vessel would have no unacceptable safety consequences.

Lower Internals Drop

The lower internals are lifted only after all the fuel is out of the reactor, so no radioactive release, criticality, or core uncovering is possible.

Reactor Head Stud Tensioner

The reactor head stud tensioner is handled by a single-purpose monorail (C-140-12), which is permanently attached to the reactor head lifting device. Furthermore, the tensioner is mounted and used only while the head is installed

on the reactor vessel, and it travels only over the vessel flange. Therefore, the stud tensioner presents no threat to the fuel, since it will not penetrate the six-inch thick reactor head at a location where only a glancing impact is possible.

TABLE 2.3.4-1

REACTOR VESSEL RESPONSE
TO 24-INCH REACTOR HEAD DROP

Component	Predicted Stress (ksi) or Force (kips)	Ultimate Capacity	Safety Margin (1)
Vessel shell	22.9 ksi	50 ksi	2.2
Core barrel	30.1 ksi	75 ksi	2.5
Vessel nozzle	8,010 kips	10,750 kips	1.3
Nozzle support box beam	8,149 kips	15,080 kips	1.9
Nozzle support wall	8,149 kips	18,830 kips	2.3

Notes:

(1) Based on stress or loads, since components are within or near elastic limits. If based on more appropriate ratio of ultimate deformation to drop deformation, values would be much higher.

TABLE 2.3.4-2

REACTOR VESSEL RESPONSE
TO 24-INCH UPPER INTERNALS DROP

Component	Predicted Deformation (inches)	Deformation at Yield (inches)	Post-Drop Status
Hold down spring	.054	.076	Elastic
Preload spring	1.069	1.789	Elastic
Guide thimble	1.864	.684	Plastic(1)
Fuel rod	.142	.160	Elastic
Lower core support	.053	.067	Elastic

Note:

(1) Ductility ratio = 2.73

PGandE Response

2.4.1

While the cranes at Diablo Canyon were not designed to satisfy the criteria of NUREG-0612, Section 5.1.6, for all loads to be carried, they are nevertheless designed for high operating reliability. For example, the containment polar crane has been shown in Section 2.3.3 above, to have a reliability of 99.99998% per lift. Moreover, in some cases the heavy loads are very light in relation to the crane's design capacity, and all of the major cranes have been modified with fully redundant hoist travel limit switches, so the probability of dropping these "light" heavy loads is negligible. These crane/load combinations are discussed in Section 2.4.2.c.

Table 2.4.2-1 Load/Impact Matrix (Sheet 1 of 6)

Part I. Containment Polar Gantry Crane (C-140-07)

Load	Elevation (feet)	Floor Coordinates	Component Impacted	Hazard Elim. Category	Notes
A. Reactor Head (172.5T)	117	230°-240°, 25'	Conduit KX511 (TE-443B, Reactor Coolant Temperature)	b	Redundant TE-413B, -423A, -423B, -433A, -433B, -443A, -443B
	100	120°-240°, 34'-50'	Line 24 (E1, E2)	d	See Reliability Analysis, Section 2.3.3
	100	211°-230°, 22'-47'	Line 109 (E2)	b	Redundant RHR Path (E1)
	100	225°, 8'-50'	Line 12 (E2, E3)	b	Redundant RHR Path (E1)
	100	230°-251°, 27'-50'	Line 1991 (E2)	b	Redundant RHR Path (E1)
	100	233°-257°, 23'-57'	Line 1994 (E2)	b	Redundant RHR Path (E1)
	100	234°, 26'	Line 246 (E2, E3)	b	Redundant RHR Path (E1)
	100	239°-245°, 28'-30'	Line 1159 (E2)	b	Redundant RHR Path (E1)
	100	270°-290°, 21'-26'	Line 1991 (E2)	b	Redundant RHR Path (E1)
	100	270°-325°, 53'-38'	Line 24 (E1, E2)	d	See Reliability Analysis, Section 2.3.3
	100	315°, 37'	Line 9 (E1, E2)	d	See Reliability Analysis, Section 2.3.3
F. Head Lifting Device (4.5T)	100	45°, 33'	Line 10 (E1, E2)	d	See Reliability Analysis, Section 2.3.3
	100	135°, 8'-30'	Line 11 (E2, E3)	d	See Reliability Analysis, Section 2.3.3
H. RCP Motor (43.8T)	140	238°, 25'-37'	PT-403, PT-405 Tubing (Reactor Coolant Pressure)	b	Tubing for One PT Will Be Rerouted Away From the Load Path
	117	6°-48°, 64'-67'	Line 3845 (E1)	b	Redundant RHR Path (E3)
	117	6°-298°, 56'-67'	Line 508 (E1)	b	Redundant RHR Paths (E2, E3)
	117	317°-5°, 48'-87'	Line 3844 (E1)	b	Redundant RHR Paths (E2, E3)
	107	40°-50°, 36'-42'	Line 24 (E1, E2)	b	Redundant RHR Path (E3)
	100	40°-45°, 26'-57'	Line 254 (E1, E2)	b	Redundant RHR Path (E3)
	100	45°-52°, 40'-50'	Line 2000 (E1)	b	Redundant RHR Paths (E2, E3)
	100	45°-55°, 21'-28'	Line 1146 (E1, E2)	b	Redundant RHR Path (E3)
	100	103°-107°, 37'-51'	Line 2000 (E1)	b	Redundant RHR Path (E3)
	100	120°, 48'	Line 50 (E2, E3)	b	Redundant RHR Path (E1)
	100	211°-240°, 59'	Line 508 (E1)	b	Redundant RHR Paths (E2, E3)
	100	224°, 35'-39'	Line 1158 (E2, E3)	b	Redundant RHR Path (E1)
	100	224°, 42'-55'	Line 238 (E2)	b	Redundant RHR Path (E1)
	100	311°-314°, 37'-49'	Line 1999 (E1)	b	Redundant RHR Path (E3)
	100	315°, 37'-55'	Line 253 (E1, E2)	b	Redundant RHR Path (E3)
	100	325°, 45'	Line 13 (E1, E2)	b	Redundant RHR Path (E3)
	91	40°, 57'	Line 254 (E1, E2)	b	Redundant RHR Path (E3)
	91	45°, 32'	Line 6 (E1, E2)	b	Redundant RHR Path (E3)
	91	135°, 32'	Line 7 (E2, E3)	b	Redundant RHR Path (E1)
	91	145°, 33'	Line 1153 (E2, E3)	b	Redundant RHR Path (E1)
	91	224°, 38'	Line 1158 (E2, E3)	b	Redundant RHR Path (E3)
	91	225°, 36'	Line 961 (E2, E3)	b	Redundant RHR Path (E1)
	91	230°, 36'	Line 8 (E2, E3)	b	Redundant RHR Path (E1)
	91	236°, 55'	Line 256 (E2, E3)	b	Redundant RHR Path (E1)
	91	293°-315°, 55'	Line 253 (E1, E2)	b	Redundant RHR Path (E3)
	91	310°, 36'	Line 5 (E1, E2)	b	Redundant RHR Path (E3)
	91	311°, 49'	Line 1999 (E1)	b	Redundant RHR Path (E3)
	91	314°-320°, 40'	Line 958 (E1, E2)	b	Redundant RHR Path (E3)

Table 2.4.2-1 Load/Impact Matrix (Sheet 2 of 6)

Part I. Containment Polar Gantry Crane (C-140-07)

Load	Elevation (feet)	Floor Coordinates	Component Impacted	Hazard Elim. Category	Notes
M. Reactor Vessel Inspection Tool (5.2T)	117	181°, 15'	Conduit KX513 (TE-433A and TE-433B, Reactor Coolant Temperature)	b	Redundant TE-413A, -413B, -423A, -423B, -443A, and -443B
	117	155°, 15'	Conduit KX515 (TE-433B, Reactor Coolant Temperature)	b	Redundant TE-413A, -413B, -423A, -423B, -433A, -443A, and -443B
	100	105°, 55'	Valve 8148 Tubing (Charging & Boration)	c	Load Lifted Only After Cold Shutdown
	100	116°, 55'	Valve 8145, 8146, 8147 Tubing (Charging & Boration)	c	Load Lifted Only After Cold Shutdown
	100	114°-161°, 54'-68'	Line 50 (E2, E3)	b	Redundant RHR Path (E1)
	100	123°-146°, 68'	Line 24 (E1, E2)	b	Redundant RHR Path (E3)
	100	129°, 24'	Line 1152 (E2, E3)	b	Redundant RHR Path (E1)
	100	130°-182°, 26'-55'	Line 255 (E2, E3)	b	Redundant RHR Path (E1)
	100	131°-187°, 16'-28'	Line 1993 (E2)	b	Redundant RHR Path (E1)
	100	135°, 8'-30'	Line 11 (E2, E3)	b	Redundant RHR Path (E1)
	100	158°, 8'-20'	Line 3 (E2)	b	Redundant RHR Path (E1)

Table 2.4.2-1 Load/Impact Matrix (Sheet 3 of 6)

Part II. Spent Fuel Area Bridge Crane (AF-140-08)

Load	Elevation (feet)	Floor Coordinates	Component Impacted	Hazard Elim. Category	Notes
A. New Fuel Cask (3T)	100	T+19, 21+1-16	Line 222 (B2, C2)	b	Redundant Depressurization and Charging Paths (B1, C1)
B. Spent Fuel Cask (67.5T)	100	T+4-12, 21+16	Line 222 (B2, C2)	b	Redundant Depressurization and Charging Paths (B1, C1)

Table 2.4.2-1 Load/Impact Matrix (Sheet 4 of 6)

Part III. Fuel Handling Building Monorails

Load	Elevation (feet)	Floor Coordinates	Component Impacted	Hazard Elim. Category	Notes
AF-100-14. AFW Pump 2-2 Motor (2.15T)	85	20[3], T-U	Conduit K6993 (AFW Pump 2-3)	b	Redundant AFW Pump 2-1

Table 2.4.2-1 Load/Impact Matrix (Sheet 5 of 6)

Part IV. Turbine Building Bridge Cranes (T-140-01 and T-140-02)

Load	Elevation (feet)	Floor Coordinates	Component Impacted	Hazard Elim. Category	Notes
None					

Table 2.4.2-1 Load/Impact Matrix (Sheet 6 of 6)

Part V. Turbine Building Monorails

Load	Elevation (feet)	Floor Coordinates	Component Impacted	Hazard Elim. Category	Notes
T-119-12. MSR 2-2A HP Tube Bundle (14.5T)	85	F+3, 22-20[3]	CCW HX 2-2	e	Will Not Penetrate Floor at Elevation 119'
	85	F+5, 20+12	Line 104 (B2, C2, E2, E3)	e	Will Not Penetrate Floor at Elevation 119'
	85	F+3, 20+19	Line 103 (B1, C1, E1)	e	Will Not Penetrate Floor at Elevation 119'
	85	F+3, 20+25	Line 95 (B1, C1, E1)	e	Will Not Penetrate Floor at Elevation 119'
	85	F+3, 21	FCV-602 Tubing (CCW HX 2-1 ASW Inlet)	e	Will Not Penetrate Floor at Elevation 119'
	85	F+5, 21+8	Line 96 (B2, C2, E2, E3)	e	Will Not Penetrate Floor at Elevation 119'
	85	F+5, 21+16	Line 714 (B2, C2, E2, E3)	e	Will Not Penetrate Floor at Elevation 119'

NRC Request (Enclosure 3)

2.4.2.b

"For each interaction identified, indicate which of the load and impact area combinations can be eliminated because of separation and redundancy of safety-related equipment, mechanical stops and/or electrical interlocks, or other site-specific considerations. Elimination on the basis of the aforementioned considerations should be supplemented by the following specific information:

(1) For load/target combinations eliminated because of separation and redundancy of safety-related equipment, discuss the basis for determining that load drops will not affect continued system operation (i.e., the ability of the system to perform its safety-related function).

(2) Where mechanical stops or electrical interlocks are to be provided, present details showing the areas where crane travel will be prohibited. Additionally, provide a discussion concerning the procedures that are to be used for authorizing the bypassing of interlocks or removable stops, for verifying that interlocks are functional prior to crane use, and for verifying that interlocks are restored to operability after operations which require bypassing have been completed.

(3) Where load/target combinations are eliminated on the basis of other, site-specific considerations (e.g., maintenance sequencing), provide present and/or proposed technical specifications and discuss administrative procedures or physical constraints invoked to ensure the continued validity of such considerations."

PGandE Response

2.4.2.b

This section discusses three of the five hazard elimination categories that are used in the load/impact matrix (Table 2.4.2-1) to show that no postulated load drop would impair the ability to safely shut down Diablo Canyon. The three categories are: (1) separation and redundancy, (2) mechanical stops or electrical interlocks, and (3) load scheduling. Because there are more than five hundred load/impacts listed, a separate analysis of each impact would make this report unnecessarily large and unwieldy. Therefore, the general points of each type of analysis used to develop the matrix are given here and in the following two sections. The information needed to fill out the analysis for each particular load/impact is given in the "Notes" column of Table 2.4.2-1.

(1) Redundancy. Diablo Canyon's safe shutdown systems were designed on the principle of redundancy of all active components, in order to meet the single failure criterion. The extensive equipment redundancy resulted in considerable redundancy of pipes, tubing, and ventilation ducts.

Electric circuits and instrument tubing runs are all designed to serve only one piece of active equipment each, so equipment redundancy implies redundancy of these auxiliaries. Thus, electrical cabling and instrument tubing redundancy is treated by the effect of their failure on the redundant active components.

The redundancy of a piping system cannot be analyzed by individual piping segments (lines), but by the ability of the whole system to maintain flow and retain pressure after a failure. The piping system at Diablo Canyon provides flow paths for five safe shutdown functions:

A = reactor coolant circulation
B = core depressurization (pressurizer spray)
C = charging and boration
D = high-pressure cooling (steam dump)
E = low-pressure cooling (RHR)

The flow path for Function A is not redundant; the hazard from load drops onto the reactor coolant pressure boundary is eliminated by load scheduling, as discussed in Section 2.4.2.b(3). Two flow paths were chosen for each of the other functions (three for Function E). The individual lines were then listed for each flow path. Of the total of 277 lines, only fifteen are common to all redundant flow paths for any function.

In the load/impact matrix, redundancy based on physical separation eliminates the hazard unless: (1) a single drop of the largest load carried along a load path impacts all redundant active components or their attendant electric circuits or tubing runs, or (2) a single drop hits enough pipes to eliminate all redundant flow paths for any function.

One final consideration is the loss of an active component, such as a valve or its control wiring or tubing, that could eliminate a flow path. Then the flow path could be lost even if no lines for that flow path were lost. Because of extensive use of cross-ties, most safe shutdown equipment can be valved into either of the redundant flow paths. But when the equipment loss also causes the loss of a flow path, the equipment is also listed in the "Component Impacted" column as part of a flow path, and its postulated loss is analyzed for its effect on both equipment redundancy and flow path redundancy.

(2) Mechanical stops. None of the Unit 2 cranes or monorails has mechanical stops, so this hazard elimination category was not used in the Unit 2 analysis.

(3) Load Scheduling. Once cold shutdown is achieved, the components needed only to achieve it (not maintain it) can be impacted without creating a hazard.

For clarity, an entire class of load/impacts in the containment was left out of the load/impact matrix because of load scheduling. Examples of systems in the containment that are needed only to achieve cold shutdown are:

- o reactor pressure boundary
- o pressurizer spray
- o charging and boration
- o high-pressure core cooling (steam dump)

The only safe shutdown function that is needed in the containment during operating modes 5 (cold shutdown) and 6 (refueling) is the continuity and pressure boundary of at least one RHR flow path.

On the other hand, the containment polar crane is the only crane in the containment that carries heavy loads over safe shutdown components, and it is used as such only during operating modes 5 and 6. Thus, the only heavy load in the containment during non-cold-shutdown periods is the containment polar crane load block. This crane/load combination was shown in Section 2.3.3 to be held with extremely high levels of reliability.

NRC Request (Enclosure 3)

2.4.2.c

"For interactions not eliminated by the analysis of 2.4.2.b, above, identify any handling systems for specific loads which you have evaluated as having sufficient design features to make the likelihood of a load drop extremely small and the basis for this evaluation (i.e., complete compliance with NUREG 0612, Section 5.1.6, or partial compliance supplemented by suitable alternative or additional design features). For each crane so evaluated, provide the load-handling-system (i.e., crane-load-combination) information specified in Attachment 1."

PGandE Response

2.4.2.c

Section 2.3.3 above showed that the conservative design of the containment polar crane, combined with lifting procedures designed to catch any problems before they cause a drop, results in a highly reliable lifting system for the reactor head and upper internals. Nevertheless, because of their importance to safety, analyses were performed of load drops both into the reactor (Section 2.3.4) and along their load paths to their laydown areas (Table 2.4.2-1). The following heavy loads are very light in relation to their cranes' capacity, and safety modifications have been made to the cranes, so the probability of dropping these particular loads is extremely small.

Crane	Load	Weight [tons]
C-140-07	Main hoist load block	7.3
C-140-07	Load block + internals lifting device	14.8
C-140-07	Load block + head lifting device	19.8
C-140-07	Load block + RVIT	12.55
AF-140-08	Main hoist load block	2.5
T-140-01(-02)	Main hoist load block	3

Appendix D details why dropping these loads is considered incredible, by showing that the cranes satisfy the intent of all ten single-failure-proof guidelines in NUREG-0612, Appendix C.

NRC Request (Enclosure 3)

2.4.2.d

"For interactions not eliminated in 2.4.2.b or 2.4.2.c, above, demonstrate using appropriate analysis that damage would not preclude operation of sufficient equipment to allow the system to perform its safety function following a load drop (NUREG-0612, Section 5.1, Criterion IV). For each analysis so conducted, the following information should be provided:

(1) An indication of whether or not, for the specific load being investigated, the overhead crane-handling system is designed and constructed such that the hoisting system will retain its load in the event of seismic accelerations equivalent to those of a safe shutdown earthquake (SSE).

(2) The basis for any exceptions taken to the analytical guidelines of NUREG 0612, Appendix A.

(3) The information requested in Attachment 4."

PGandE Response

2.4.2.d

There is one location where a load drop could cause a loss of safe shutdown capability if the load continued through all intervening floors. The tube bundles of moisture separator reheater (MSR) 2-2A are pulled from their shell two floors directly over the CCW heat exchanger. The hazard from this postulated drop is not eliminated by considerations of separation and redundancy, physical restraints on crane movement, load scheduling, or extremely small load drop probability.

In addition, a number of heavy loads weighing 5.5 tons or less are carried over the turbine building operating deck. Their lift height is generally limited by operating procedure to twelve inches over the deck. This section shows that these loads need no load paths, because dropping them could not have unacceptable consequences.

In response to Section 2.4.2.d of Enclosure 3, the following information on the postulated impacts is provided:

(1) The ability of a handling system to retain its load during a safe shutdown earthquake does not apply to this analysis. Hoist failure is assumed, and the direction of PGandE's response throughout is that the resulting postulated load drop would not endanger safe-shutdown capability. The initiating event for a crane failure could be an earthquake or any other cause. It has been PGandE's approach not to prove that a postulated accident is impossible if its consequences can be shown to be acceptable.

(2) No exception is taken to the guidelines of NUREG-0612, Appendix A.

(3) The format provided in Attachment 4 of Enclosure 3 has been used to report the structural evaluation of plant structures subjected to the postulated heavy load drops. The details of the assumptions, methodology used, and conclusions for each drop case are presented in Appendix C. A summary is provided in the following paragraphs.

Attachment 4 of Enclosure 3 requires that the consequences of any postulated load drop be evaluated to demonstrate compliance with Criteria III and IV of NUREG-0612, Section 5.1. This was done using the following basic approach:

> If there is an intervening floor or floors between the heavy load and its postulated target, and if it can be shown that the drop of the heavy load does not 1) result in structural collapse of the floor structure, or 2) result in the perforation of the floor slab, or 3) generate destructive secondary missiles that could hit the target, then the functioning of the safe-shutdown component is assured in spite of the load drop.

Using this basic approach, the consequences of the postulated load drop were evaluated in terms of local damage and overall structural collapse. Local damage was assessed in terms of perforation and spalling using semi-empirical equations based on published test results. Actual floor thicknesses were compared to the minimum thicknesses required to preclude perforation and spalling. Overall structural ability to prevent collapse was evaluated using

an energy balance technique. Accordingly, the strain energy capacity of the structure at the lower-bound collapse load and at its deformation limit (based on permissible ductility ratio) was equated to the kinetic energy of the postulated drop. In computing the strain energy capacity, all appropriate failure modes (such as shear, bending, membrane action, etc.) were considered.

Using the results of local damage and overall structural response evaluation, the lift heights were modified so that the postulated load drop would not result in any of the following unacceptable consequences:

a. perforation (i.e., complete penetration) of the floor slab
b. collapse of the floor structure
c. generation of secondary missile that can cause unacceptable damage to essential components

The lift height limitations have been incorporated into the applicable operating procedures. Thus, Criteria III and IV are satisfied.

APPENDIX A

EVALUATION OF RPV HEAD, INTERNALS, AND RCP MOTOR LIFTING DEVICES AGAINST ANSI N14.6-1978 AND NUREG-0612 REQUIREMENTS

A1.0 INTRODUCTION

The RPV head lift rig, the reactor internals lift rig, and the RCP motor lift rig were designed and built by Westinghouse for Diablo Canyon Nuclear Power Plant before 1971, i.e., prior to the issuance of ANSI N14.6-1978. Hence, these three devices were not designed to comply with the requirements of ANSI N14.6-1978. However, a detailed item-by-item comparison of these requirements and those used for the design, manufacture, inspection, maintenance, and testing of these three devices was performed by Westinghouse. A summary of this comparison is presented in Section A2.0 of this appendix. This section also identifies the areas where the ANSI requirements are either not directly satisfied or not directly applicable. For these areas, either justifications have been provided in support of taking exceptions to ANSI N14.6 requirements or equivalent alternatives have been proposed.

In addition to the item-by-item comparison of requirements, a detailed stress evaluation of the major load-carrying components of the three lifting rigs and the load cell linkage was performed to determine the actual margins of safety. The computed stresses and the margins of safety were examined in the light of applicable ANSI N14.6-1978 and NUREG-0612 requirements. These results are presented in Section A3.0 of this appendix. The computed stresses were always found to be well below the material yield strengths, or applicable AISC allowables, thereby demonstrating a reasonable degree of safety against structural failure. A few of the components, however, do not satisfy the ANSI N14.6-1978 margin of safety criteria when supplemented by NUREG-0612. The available stress design factors for these components were examined critically, and justifications have been provided to demonstrate that these components are structurally adequate.

A2.0 COMPARISON OF THE REQUIREMENTS

ANSI N14.6-1978 contains detailed requirements for the design, fabrication, testing, maintenance, and quality assurance of special lifting devices. This document was not in existence when Westinghouse designed, fabricated, and tested the RPV head, RPV internals, and RCP motor lift rigs. Westinghouse had defined the design, fabrication, and quality assurance requirements on detailed manufacturing drawings and purchase order documents. Westinghouse also issued field assembly instructions for these rigs which included an initial load test followed by nondestructive surface examinations of critical welds. These requirements have been compared to ANSI N14.6-1978 requirements. A summary of the comparison of those requirements which are considered important in demonstrating the continued load handling reliability of the lifting devices is presented in this section. This comparison

identified a few areas in which the devices are not in strict compliance with the applicable ANSI N14.6 requirements. These incompatibilities are also discussed in this section, along with their resolutions.

A2.1 ANSI N14.6-1978, Section 3.1: Designer's Responsibilities

a. Preparation of Design Specification and a Stress Report

Assembly drawings, detailed manufacturing drawings, and purchasing documents contain the following requirements, which are considered to be equivalent to a design specification:

(i) ASTM or ASME specifications or specially listed requirements for the critical load path items

(ii) Welding, weld procedures, and welds to be in accordance with ASME Boiler and Pressure Vessel Code, Section IX

(iii) Special nondestructive testing for specific critical load path items to be performed to written and approved procedures in accordance with ASTM or specified requirements

(iv) Letters of compliance for materials and specifications

A stress report was not originally required. However, a detailed stress report has since been prepared. A summary of this report is presented in Section A3.0.

b. Specification for Repair Procedures and Acceptance Criteria

Repair procedures and acceptance criteria for repair procedures were not specified originally.

Weld repairs and inspections will be performed in accordance with the applicable requirements of ANSI N14.6-1978 and ASME Section XI. Should pins, bolts, or other fasteners need repair, they will be replaced in lieu of repair. The replacement parts will be procured in accordance with the original or equivalent requirements for materials and nondestructive testing.

c. Preparation of a Critical Items List

The preparation of a critical items list was not originally required. However, five such lists have since been prepared for the three lift rigs. These lists include the material identification, and the applicable volumetric and surface inspections that were performed in the fabrication of these special lifting devices. In some instances, nondestructive testing was not specified since the actual stresses are low compared to the strength of the material.

The material selection for most critical items (except for the general purpose catalogue items in the RCP motor lift rig) was made to ASTM, ASME, or special material requirements. The material requirements were supplemented by Westinghouse-imposed nondestructive testing and/or special heat treatment requirements for almost all of the critical items. Westinghouse required all welding, welders, and weld procedures to be in accordance with ASME Boiler and Pressure Vessel Code, Section IX, for carbon steel welds. Westinghouse required a certificate or letter of compliance that the materials and processes used by the manufacturer were in accordance with the purchase order and drawing requirements. Westinghouse also performed final inspections on these devices and, in some instances, issued quality releases for the internals and head lifting rigs.

A2.2 ANSI N14.6-1978, Section 3.2: Design Criteria

a. Stress Design Factor

This section requires a stress design margin or factor of three when compared to yield strength, and five when compared to ultimate strength.

The devices were originally designed to the requirement that the stress design factors (SDF), when compared to the ultimate strength, would be at least five. Thus, the ANSI requirements were not strictly satisfied, especially when these requirements are modified by NUREG-0612, Section 5.1.1(4).

A new stress evaluation of the three devices has been performed. The results of this evaluation and a discussion on the structural adequacy of the critical components have been presented in Section A3.0.

b. Fracture Toughness Design basis for High Yield-to-Ultimate-Ratio Materials

Fracture toughness requirements for materials with high yield to ultimate strength ratio were not originally specified in the design. However, very few components (a few pins and adaptors) fall into the special category specified in the ANSI standard. Although the fracture toughness was not determined for these components, the material selection was based on excellent fracture toughness characteristics. Also, it can be observed from Table A-3.1 (Item 1 only) and A-3.2 (Items 4, 5, 6, and 27) that the calculated stresses in these items are only a small fraction of their strength. Hence, these components are considered structurally satisfactory and reliable.

c. Drop Weight or Charpy Impact Tests for Load-Bearing Members

Although drop weight or Charpy impact tests were not performed for the load-bearing members (except for the upper and lower clevises

on the internals lift rig), the material selection was based on excellent fracture toughness. Also, the calculated stresses in the load-bearing members are only a small fraction of the ultimate strength of the material, and the rigs are used very infrequently. Thus, the components are considered to be safe against failure resulting from the lack of fracture toughness.

A2.3 ANSI N14.6-1978, Section 3.3: Design Considerations

a. Lamellar Tearing

Lamellar tearing was considered in the design of both the RPV head lift rig and internals lift rig. To reduce the possibility of lamellar tearing, a stiffener bolt was added to the sling block body, and nondestructive tests (ultrasonic, magnetic particle, and radiograph) of the base material and assembly welds were required. The consideration of lamellar tearing is not applicable to any of the RCP motor lift rig components.

b. Corrosion by Decontamination

Corrosion due to decontamination was not specifically addressed since no significant contamination is likely to occur during the life of the plant.

c. Even Distribution of Loads to All Load-Bearing Attachments

Even distribution of loads is evident from the design of these rigs. Locking plates, pins, etc., are used throughout these lifting devices to assure even distribution of loads.

d. Position Indicator for Remote Actuating Mechanisms

Remote actuation is used only when engaging the internals rig with the internals, which uses a long-handled tool. The tool depresses a spring-loaded tube and turns the engaging screw into the internals. No specific position indicator was considered necessary; visual differences in the top of the spring-loaded tube would indicate that the internals are engaged.

A2.4 ANSI N14.6-1978, Section 3.4: Design Considerations to Minimize Decontamination Efforts

The configuration of the lifting devices was based on functional requirements and no specific consideration was given to minimize decontamination efforts. However, minimization of decontamination efforts is not considered essential for reliable load handling by the lifting rigs.

A2.5 ANSI N14.6-1978, Sections 3.5 and 3.6: Coatings and Lubricants

Compliance with the requirements listed in Sections 3.5 and 3.6 of ANSI N14.6-1978 is not considered essential for reliable load handling by the lifting rigs.

A2.6 ANSI N14.6-1978, Section 4.1: Fabricator's Responsibilities

This section of the ANSI standard contains specific fabrication for proper quality assurance, document control, deviation control, procedure control, material identification, and certification of compliance. It requires that welding procedures, welders, and welding operators be qualified under ASME Boiler and Pressure Vessel Code, Section XI, or AWS Structural Welding Code D1.1.

At the time the lifting rigs were fabricated, a formal fabricator quality assurance program was not required for all items. However, the fabricator's welding procedures and nondestructive testing procedures were reviewed by Westinghouse prior to use. Most of the critical load-carrying members required letters of compliance for material requirements. Westinghouse performed certain checks and inspections during various steps of fabrication. Final Westinghouse review included visual, dimensional, procedural, cleanliness, personnel qualification, etc., and in most cases, issuance of a quality release to ensure conformance with drawing requirements. Thus, even though a formal quality assurance program was not required per ANSI requirements, checks and inspections by Westinghouse during fabrication and subsequent load testing assure reliable load handling capability of the devices.

Some of the above requirements were not applied for the RCP motor lift rig. However, this is not considered critical because this rig has very few welds. Also, the welds are either not essential for the stability of the rig or are lightly stressed (see Table A-3.3)

A2.7 ANSI N14.6-1978, Section 4.2: Fabrication Inspector's Responsibilities

Westinghouse quality assurance personnel performed in-process and final inspections similar to those required in Section 4.2 of ANSI N14.6-1978.

A2.8 ANSI N14.6-1978, Section 4.3: Fabrication Considerations to Minimize Decontamination and Corrosion

In fabricating the devices, no specific consideration was given to minimize future decontamination and corrosion. However, good fabrication procedures and processes comparable to general industry practice were used, which assures reliable load handling by the devices.

A2.9 ANSI N14.6-1978, Section 5.1: Owner's Responsibilities Towards Acceptance Testing, Maintenance, and Assurance of Continued Compliance

a. Verification of the Performance Criteria, and Functional Testing

The ANSI standard requires the owner to verify that the performance criteria have been met by the design specification and functional testing.

Since there was no design specification for these rigs, load testing was performed on the reactor vessel head lift and internals rigs at field assembly. The rigs were 100 percent load-tested, and nondestructive testing was conducted on critical welds following the test. The Westinghouse Quality Release is considered an acceptable alternate to verifying that the criteria for letters of compliance for materials and specifications (required by the Westinghouse drawings and purchasing document) were satisfied.

PGandE has performed a 150% load test of the RCP motor lift rig to verify its functional adequacy. (See also Section A2.10 below.)

b. Scheduled Periodic Testing Against Performance Criteria

Maintenance and inspection procedures for the RPV head and upper internals lift rigs will require a visual check of critical welds and parts after lifting the load to a limited height, from which an accidental drop would not cause any unacceptable damage. (See also the response to Item 2.3.4.) The RCP motor lift rig will be visually inspected before each use. Since this rig essentially consists of three slings with spreader bars, and has no critical structural welds, visual inspection is the only requirement.

c. Procedures

Procedures are being developed for the control of the special lifting devices, outlining their proper use and maintenance and noting any limitations to their use. They will be available for inspection at the site.

d. Load Limit Marking

The load limits and other limitations on the use of the RPV head, reactor internals, and RCP motor lift rigs will be specified in their procedures. Since these devices are obviously unique, there is no need to mark them with the weight of the few loads they carry.

e. Record of Required Testing, Maintenance, and Repair

Maintenance procedures will require keeping a detailed history of each rig, including instances of damage, distortion, replacement, and repair.

A2.10 ANSI N14.6-1978, Section 5.2: Acceptance Testing

This section contains requirements for:

a. An initial load test equal to 150 percent of the maximum load followed by nondestructive testing of critical load-bearing parts and welds.

b. The qualification of replacement parts.

After the field assembly, the head and internals lift rigs were subjected to a load test equal to 100 percent of the load, followed by nondestructive testing (NDT) of the critical welds. This load test, plus the large design margins found in the detailed stress analysis (see Section A3), assure that the head and internals lift rigs are capable of handling the design loads safely.

The RCP motor lift rig has been load-tested to 150 percent of the maximum load, followed by visual inspection of critical load-bearing parts and all welds. Additional NDT of welds is not necessary, since the welds are not critical.

Replacement parts meeting the original or equivalent requirements will be used.

A2.11 <u>ANSI N14.6-1978, Section 5.3: Testing to Verify Continuing Compliance</u>

This section primarily requires that the lifting rigs be subjected annually either to a load test equal to 150 percent of the maximum load or to dimensional testing, visual inspection, and nondestructive testing of load-carrying welds.

For the reasons indicated below, neither an annual load testing nor a nondestructive testing is considered practical or necessary for the RPV head and internals lift rigs:

- These special lifting devices are used during plant refueling (or during cold-shutdown condition) which is approximately once per year. During plant operation, these special lifting devices are inaccessible since they are permanently installed in the containment. They cannot be removed from the containment unless they are disassembled, and no known purposes exist for disassembly. Load testing to 150 percent of the total weight before each use would require special fixtures, and is impractical to perform.

- Annual load testing to 150 percent load inside containment would increase the probability of the hazard which NUREG-0612 intends to reduce, because the load test would subject the rig to a load higher than it would be subjected during actual load handling. Also, the ANSI-specified load test will almost double the number of lifts and the risks associated with them.

- The ANSI requirement of annual load testing is primarily intended to reduce the probability of fatigue failure resulting from yielding and damage during heavy usage, which is common to most devices. The RPV head and internals lift rigs are expected to be used only once a year. Because of this infrequent use, and because the actual stress levels in the critical load-bearing members (see Section A3) are low compared to their yield strength, fatigue failure is not considered realistic.

- o PGandE is implementing an alternate program for continued testing and maintenance, which meets the intent of NUREG-0612 and ANSI N14.6-1978. At the start of each outage requiring the lifting devices, the program will require a comprehensive visual examination by qualified personnel. This inspection will check all critical load-bearing welds and components for evidence of degradation or cracking. Qualified personnel will also inspect the devices for obvious deformation or cracking before each use of the lifting devices. Finally, the major load-bearing welds and critical areas will be nondestructively examined when the lifting devices are repainted every ten years. This testing interval is justified by the lifting devices' low usage (only 20 to 30 times) over the ten-year period.

The RCP motor lift rig will also be used very infrequently (around twice per year), so annual 150% load testing is considered excessive. The rig has no critical welds, so nondestructive testing is not required. Accordingly, PGandE is implementing an alternate program for continued testing and maintenance of this rig, which meets the intent of NUREG-0612 and ANSI N14.6-1978. The program will require visual inspection at the beginning of each outage requiring the RCP motor lift rig, and a 150% load test every five years.

A2.12 <u>ANSI N14.6-1978, Section 5.4: Maintenance and Repair</u>

This section requires that the repairs and alterations, if needed, be done in accordance with the original requirements and that the defective bolts, studs, and nuts be replaced rather than repaired.

The maintenance procedures will be updated to incorporate the above requirements.

A2.13 <u>ANSI N14.6-1978, Section 5.5: Nondestructive Testing Procedures, Personnel Qualifications, and Acceptance Criteria</u>

This section requires that nondestructive testing and inspection be performed in accordance with the applicable sections of ASME Boiler and Pressure Vessel Code, Section V (Articles 1, 6, 7, 24, and 25) and Section III, Division 1 (paragraphs NF-5340 and NF-5350).

Liquid penetrant, magnetic particle, ultrasonic, and radiograph inspections were performed on critical welds in accordance with Westinghouse specifications, or as noted on detailed drawings. The requirements in these specifications and drawing notes meet the intent of the applicable ASME code requirements.

Additional nondestructive testing is not considered necessary for reasons listed in Section A2.11 above. Should repair of any load-bearing weld become necessary, the repaired weld will be tested in accordance with the original or equivalent requirements.

A2.14 ANSI N14.6-1978, Section 6: Special Lifting Devices for Critical Loads

This section requires that lifting devices handling critical loads be designed either as a single-failure-proof system, or have twice the normally required stress design factor.

The RPV head and internals lift rigs were not designed as single-failure-proof systems. However, the computed stress design factors for almost all the critical items are high (see Section B3.0 of this appendix), demonstrating the ability of these two rigs to handle the designated loads safely and reliably.

The loads lifted by the RCP motor lift rig are not critical loads as defined in Section 2 of ANSI N14.6, so Section 6 does not apply to this lift rig.

A3.0 STRESS EVALUATION

A detailed stress analysis of the RPV head, internals, and RCP motor lift rigs was performed to evaluate the compliance of these rigs to ANSI N14.6-1978 and NUREG-0612, Section 5.1.1(4). This section presents the method of evaluation, results, and a discussion of the structural adequacy of the rigs.

A3.1 Evaluation Method

Section 5.1.1(4) of NUREG-0612 requires that the lifting devices be designed to meet the stress design factors (SDF) specified in ANSI N14.6-1978. NUREG-0612 also requires that the SDF computation be based on the combined maximum static and dynamic loads, rather than on the static load alone as required by ANSI.

The dynamic load on the lifting rigs resulting from sudden stopping of the crane hook while lowering the load depends on the hoisting speed, combined stiffness of the crane, wire ropes, lifting devices, and the static weight of the load. Because of the flexibility of the wire ropes, the applicable dynamic load factor (DLF) is not likely to be much larger than 1.0, especially since the hoisting speed is very low (3.8 fpm for the head and the upper internals, and less than 20 fpm for the RCP pump motor). Based on CMAA 70 criteria, the dynamic load would be 1/2 percent of the load per foot per minute of hoisting speed, but not less than 15 percent of the load. This criterion was used to compute the DLF for all the designed lift rig components, resulting in a DLF of 1.15.

The stresses in the designed lift rig components subjected to combined static and dynamic loads were computed using a conventional structural analysis and strength of materials approach. For the purpose of evaluation against ANSI and NUREG-0612 requirements, design margins of safety or stress design factors were computed for each rig component. For

shear and tensile stresses, in accordance with Section 3.2.1 of ANSI N14.6-1978, two stress design factors were computed:

$$SDF_y = \frac{S_y}{S} \quad \text{(Eq. A-3.1)}$$

$$\text{and } SDF_u = \frac{S_u}{S} \quad \text{(Eq. A-3.2)}$$

where

SDF_y = stress design factor corresponding to yield strength

SDF_u = stress design factor corresponding to ultimate strength

S_y = yield strength of the material

S_u = ultimate strength of the material

S = computed shear or tensile stress based on combined static and dynamic loads

For the general purpose catalogue items used in the RCP motor lift rig, the SDF values were computed similarly, except that they were based on manufacturer's proof load values and ultimate load values. The proof load for a component is the load which the component can carry without undergoing any permanent visible deformation. The ultimate load is the load at which the component fails. The DLF for the general purpose catalogue items was chosen the same as the DLF used in Section 2.1.3.d(1) (1/2 percent of the load per foot per minute of hoisting speed, or 10%). Accordingly, the lifted loads in Table A-3.4 include a 10% DLF.

For some of the rig components, the critical stress types were bending, bearing, combined tension and bending, or compression, and not shear or tension. For these components, stress design factors were computed on the basis of AISC-allowable stress as shown below:

$$SDF_y = C \times \frac{S_a}{S} \text{ or } C \times SI \quad \text{(Eq. A-3.3)}$$

$$SDF_u = SDF_y \times \frac{S_u}{S_y} \quad \text{(Eq. A-3.4)}$$

where

C = margin of safety inherent in AISC code allowables (a value of C = 1.6 was used)

S_a = AISC allowable stress

S = computed stress

SI = stress index computed for combined tension and bending based on AISC allowable stresses.

SDF_y, SDF_u, S_y, and S_u are as defined earlier.

For rig components subjected to bearing, combined tension and bending, and axial compression, Equations A-3.3 and A-3.4 present an appropriate method of computing the margin of safety or stress design factor.

A3.2 Results and Discussion

The computed stresses (for combined static and dynamic loads) and the stress index factors in the designed components (i.e., excluding the catalogue items) of the RPV head lift rig, internals lift rig, and RCP motor lift rig are presented in Tables A-3.1, A-3.2, and A-3.3, respectively. The allowable stresses based on AISC specification are also listed in these tables. It is observed from this table that:

a. For every such component of these three rigs, the stresses resulting from the combined static and dynamic loads are less than the AISC-allowable stresses.

b. Except in very few components, the computed stresses are only a small fraction of the yield or ultimate strength of the material.

c. For most of the components, the stress design factor requirements of ANSI N14.6-1978, Section 3.2.1 are satisfied. For a few of the components, the stiffer requirements of Section 6.0 are also satisfied.

The evaluation results for the general purpose catalogue items used in the RCP motor lift rig are presented in Table A-3.4. It is observed from this table that for every item there is a large safety margin against failure, the minimum being 5.4.

Even though not all of the rig components are in complete compliance with the stress design factor requirements of ANSI N14.6-1978, the rigs are considered structurally safe and reliable, for the following reasons:

(i) The computed stresses are, in general, well within AISC allowable stresses.

(ii) After the field assembly, the head and internals lift rigs were fully load-tested. Subsequent visual and nondestructive examination did not reveal any signs of cracking, damage, or yielding in any component or weld. The RCP motor lift rig was similarly tested to 150% of the load with the same results.

(iii) No significant deterioration of the load-carrying capacity of the rigs is anticipated with continued use, since the stresses are, in general, only a small fraction of the ultimate strength, and the rigs are very infrequently used. This eliminates the concern about the fatigue failure observed in heavily used rigs.

(iv) The requirement of thorough visual inspection following the initial lift before moving to the full lift height reduces significantly the probability of large, unacceptable drops.

(v) The very high design margins (as high as 10) required by the ANSI standard are not considered essential for safe load handling. In fact, providing a uniform design margin in excess of, say, 2.0 (the AISC code is based on a design margin of approximately 1.6) does not reduce the structural failure risk significantly, unless abnormal uncertainty exists in the material properties, DLF computation method, or stress analysis method. In the case of these three rigs, none of these parameters are considered to have abnormal uncertainties.

A4.0 CONCLUSION

Item-by-item evaluation of the RPV head, internals, and RCP motor lifting devices shows that, in general, the rigs meet the intent of the ANSI N14.6-1978 standard. Some of the operation and maintenance procedures will be modified to comply with ANSI requirements.

The results of the detailed stress evaluation of the designed items showed that the computed stresses are, in general, well within the AISC allowable stresses, and in many cases, these are only a fraction of the ultimate strength of the material. The stress design factor requirements of ANSI N14.6-1978 are not completely satisfied; nevertheless, for the reasons listed in Section A3.2, the rigs are considered to have safe load-handling capability.

TABLE A-3.1

STRESS EVALUATION RESULTS
HEAD LIFT RIG

PART NAME	CRITICAL STRESS TYPE	CALCULATED STRESS S (ksi)	AISC ALLOWABLE STRESS Sa (ksi)	STRESS DESIGN FACTOR WHEN COMPARED TO YIELD	ULTIMATE
6" dia. pin	SHEAR	6.6	48.0	18.2	20.5
	BEARING	10.4	108.0	16.6	18.7
	BENDING	27.5	79.2	4.6	5.2
Top lug	SHEAR	10.4	15.2	3.7	6.7
	BEARING	10.4	34.2	5.3	9.7
	TENSION	10.4	17.1	3.7	6.7
Sling block body	TENSION	4.1	18.0	7.3	11.7
Side lug	SHEAR	6.8	15.2	5.6	10.3
	BEARING	6.8	34.2	8.1	14.8
	TENSION	6.8	17.1	5.6	10.3
5" dia. pin	SHEAR	3.5	42.0	30.0	38.6
	BEARING	7.3	94.5	20.7	26.6
	BENDING	12.1	69.3	9.2	11.3
Clevis	SHEAR	6.9	14.4	5.2	10.1
	BEARING	7.3	32.4	7.1	13.8
	TENSION	6.9	16.2	5.2	10.1
Sling lifting leg	SHEAR	2.5	14.0	14.0	28.0
	TENSION	7.6	21.0	4.6	9.2
Clevis	SHEAR	6.9	14.4	5.2	10.1
	BEARING	7.3	32.4	7.1	13.8
	TENSION	6.9	16.2	5.2	10.1
5" dia. pin	SHEAR	3.5	42.0	30.0	38.6
	BEARING	7.3	94.5	20.7	26.6
	BENDING	12.1	69.3	9.2	11.8
Lug	SHEAR	6.9	15.2	5.5	10.1
	BEARING	6.8	34.2	8.0	14.8
	TENSION	6.9	17.1	5.5	10.1
Arm	COMPRESSION	2.4	19.5	13.0	22.3
	WELD SHEAR	2.2	18.0	13.1	27.3

TABLE A-3.1 (Cont'd)

PART NAME	CRITICAL STRESS TYPE	CALCULATED STRESS S (ksi)	AISC ALLOWABLE STRESS Sa (ksi)	STRESS DESIGN FACTOR WHEN COMPARED TO YIELD	STRESS DESIGN FACTOR WHEN COMPARED TO ULTIMATE
5" dia. pin	SHEAR	3.1	42.0	33.9	43.5
	BEARING	6.7	94.5	22.6	29.0
	BENDING	11.0	69.3	10.1	13.0
Clevis	SHEAR	6.3	14.4	5.7	11.1
	BEARING	6.7	32.4	7.7	15.0
	TENSION	6.3	16.2	5.7	11.1
Lifting leg	SHEAR	2.7	14.0	13.0	25.9
	TENSION	6.9	21.0	5.1	10.1
Clevis	SHEAR	5.2	14.4	6.9	13.5
	BEARING	8.4	32.4	6.2	12.0
	TENSION	5.2	16.2	6.9	13.5
4" dia. pin	SHEAR	5.1	42.0	20.6	26.5
	BEARING	8.4	94.5	18.0	23.1
	BENDING	22.5	69.3	4.9	6.3

TABLE A-3.2

STRESS EVALUATION RESULTS
UPPER INTERNALS LIFT RIG

PART NAME	CRITICAL STRESS TYPE	CALCULATED STRESS S (ksi)	AISC ALLOWABLE STRESS Sa (ksi)	STRESS DESIGN FACTOR WHEN COMPARED TO YIELD	ULTIMATE
7-1/2" dia. hook pin	SHEAR	2.1	40.0	46.7	60.8
	BEARING	6.4	90.0	22.5	29.4
	BENDING	7.1	66.0	14.9	19.4
Side plate	SHEAR	8.2	17.2	5.3	8.8
	BEARING	8.0	38.7	7.6	13.3
	TENSION	6.5	19.4	6.7	11.2
6" dia. adaptor pin	SHEAR	3.4	42.0	30.8	39.4
	BEARING	8.0	94.5	18.8	24.3
	BENDING	13.9	69.3	8.0	10.2
Upper adaptor	SHEAR	8.1	48.0	14.9	16.7
	BEARING	3.8	108.0	45.0	50.8
	TENSION	8.7	54.0	13.9	15.5
Load cell	SHEAR	8.1	46.0	14.3	17.5
	TENSION	14.0	69.0	8.2	10.0
Bottom adaptor	SHEAR	8.1	48.0	14.9	16.7
	BEARING	5.0	108.0	34.5	38.8
	TENSION	9.3	54.0	12.9	14.5
6" dia. removable pin	SHEAR	3.0	42.0	35.5	45.7
	BEARING	4.6	94.5	32.5	42.0
	BENDING	12.4	69.3	8.8	11.4
Top lug	SHEAR	4.7	15.2	8.0	14.9
	BEARING	4.6	34.2	11.8	21.8
	TENSION	4.7	17.1	8.0	14.9
Support pipe	TENSION	1.9	21.0	18.6	31.8
Support plate	TENSION	0.4	22.8	93.1	171.6
Side lug	SHEAR	1.2	15.2	32.3	59.6
	BEARING	4.4	34.2	12.5	22.9
	TENSION	3.0	17.1	12.5	23.3
4" dia. clevis pin	SHEAR	2.8	44.0	40.0	50.8
	BEARING	4.5	99.0	34.9	44.6
	BENDING	11.4	72.6	10.2	12.9

TABLE A-3.2 (Cont'd)

PART NAME	CRITICAL STRESS TYPE	CALCULATED STRESS S (ksi)	AISC ALLOWABLE STRESS Sa (ksi)	STRESS DESIGN FACTOR WHEN COMPARED TO YIELD	ULTIMATE
Upper clevis	SHEAR	4.5	20.0	11.0	17.6
	BEARING	4.4	45.0	16.5	26.3
	TENSION	4.5	22.5	11.0	17.6
Sling leg	SHEAR	1.9	12.8	16.5	31.0
	TENSION	6.3	19.2	5.1	9.6
Lower clevis	SHEAR	1.9	20.0	25.9	41.4
	INTERACTION RATIO FOR COMBINED BENDING AND TENSION	0.52	1.0	3.1	4.9
4" dia. clevis bolt	SHEAR	3.3	42.0	32.2	41.4
	BEARING	8.7	94.5	17.3	22.4
	BENDING	4.6	69.3	23.9	30.8
Spreader leg assembly	BEARING	6.9	32.4	7.5	12.2
	COMPRESSION	3.8	18.9	7.8	12.7
Backing block	BEARING	6.9	27.0	6.3	15.7
	COMPRESSION	4.7	18.0	6.1	15.3
End plate	BEARING	3.8	32.4	13.5	21.8
Spacer	BEARING	8.7	45.0	8.2	11.6
	INTERACTION RATIO FOR COMBINED BENDING AND TENSION	0.58	1.0	2.7	3.9
	WELD SHEAR	1.1	18.0	46.7	65.3
Leg channels	TENSION	5.0	21.6	7.1	11.6
Brace plate	WELD SHEAR	2.8	18.0	10.2	21.4
Leg support block	SHEAR	3.4	16.0	12.0	19.2
Adaptor	SHEAR	1.3	12.0	22.5	56.5
	TENSION	4.9	18.0	6.1	15.3

TABLE A-3.2 (Cont'd)

PART NAME	CRITICAL STRESS TYPE	CALCULATED STRESS S (ksi)	AISC ALLOWABLE STRESS Sa (ksi)	STRESS DESIGN FACTOR WHEN COMPARED TO YIELD	ULTIMATE
Outer tube	SHEAR	3.4	12.0	8.8	22.4
	TENSION	5.6	18.0	5.3	13.3
Guide sleeve	SHEAR	3.4	12.0	8.8	22.4
	BEARING	10.0	27.0	4.3	10.8
Engaging screw	SHEAR	3.9	46.0	29.6	36.1
	BEARING	10.0	103.5	16.5	20.2
	TENSION	7.4	69.0	15.3	19.0

TABLE A-3.3

STRESS EVALUATION RESULTS
RCP MOTOR LIFT RIG DESIGNED COMPONENTS

PART NAME	CRITICAL STRESS TYPE	CALCULATED STRESS S (ksi)	AISC ALLOWABLE STRESS Sa (ksi)	STRESS DESIGN FACTOR WHEN COMPARED TO YIELD	ULTIMATE
Spreader tube	Compression	6.72(1)	19.35(1)	4.6(1)	4.6
Tube-to-tube weld	Compression	3.80	21.00	9.2	15.8
Tube-to-plate weld (2)	Principal	11.79	21.00	3.0	5.1
Side plate	Tension	2.41	13.50	14.9	24.1

NOTES:

(1) Based on buckling considerations. Stress design factor corresponding to yield was computed using the basic factor of safety inherent in the AISC design allowables (=1.6)

(2) This weld is not a critical weld since, if it fails, the spreader tube ends will bear against the side plate without causing any instability. The stresses are computed under the extremely conservative assumptions that the tube-to-tube weld does not exist and that the tube ends are not butting against each other.

TABLE A-3.4

STRESS EVALUATION RESULTS
RCP MOTOR LIFT RIG CATALOGUE ITEMS

PART NAME	LIFTED LOAD (kip) (INCLUDES DLF)	RATED LOAD (kip)	STRESS DESIGN FACTOR WHEN COMPARED TO PROOF LOAD (1)	ULTIMATE LOAD
Master link	101.9	160.0	3.2	5.4
Sling(2)	101.9	108.4	4.0	5.3
Shackle	34.0	70.0	4.5	12.4
Turnbuckle	34.0	37.0	2.2	5.5

NOTES:

(1) The proof load for a part is defined as the load which the part can carry without undergoing any visible permanent deformation.

(2) PGandE has replaced the Westinghouse-provided slings with a new three-sling bridle rated at 108.4 kips, with a proof load of 411.2 kips and an ultimate load of 542.0 kips.

APPENDIX D

LIGHTER CRANE/LOAD COMBINATIONS

PGandE has performed a point-by-point comparison against the NUREG-0612, Appendix C guidelines, for seven lighter crane/load combinations for which NUREG-0612 compliance was based on low load-drop probability. The following crane/load combinations were evaluated:

Crane	Load	Weight (tons)
C-140-07	Main hoist load block	7.3
C-140-07	Load block + internals lifting device	14.8
C-140-07	Load block + head lifting device	19.8
C-140-07	Load block + RVIT	12.55
AF-140-08	Main hoist load block	2.5
T-140-01(-02)	Main hoist load block	3

The ten sections of this appendix evaluate these crane/load combinations against the ten Appendix C guidelines. In each section, the guideline is quoted directly from NUREG-0612, Appendix C, and the evaluation follows.

D1. STRESS LIMITS

Guideline

"The allowable stress limits should be identified and be conservative enough to prevent permanent deformation of the individual structural members when exposed to maximum load lifts."

Evaluation

All of the lighter loads are very small compared to the design capacities of the cranes. Table D-1 summarizes the maximum stresses due to the loads, and compares them to the material allowable stresses (yield or ultimate as applicable) of the critical components. In this table, the margins of safety were computed by comparing the weights of the above-listed lifted items with the design loads, assuming that the stress level in the crane components due to the design load is equal to the allowable design stress. This is a conservative assumption, since the design stress is generally kept lower than the allowable value.

Table D-1 shows that the stress levels in the crane components due to the above-listed loads are extremely small and could not cause any permanent deformation.

D2. MINIMUM OPERATING TEMPERATURE

Guideline

"The minimum operating temperature of the crane should be determined from the toughness properties of the structural materials that are stressed by the lifting of the load."

Evaluation

Material toughness properties for the crane structural members are not critical while lifting and moving the lighter loads, because:

a. The stress levels are only a small fraction of the yield stress (see Table D-1).

b. The minimum design temperature inside the containment is 70°F, and the operating temperature is much higher.

D3. SEISMIC CAPACITY

Guideline

"The crane should be capable of stopping and holding the load during a seismic event equal to a Safe Shutdown Earthquake (SSE) applicable to that facility."

Evaluation

The structural components of each crane were evaluated for the scenario of a Hosgri seismic event simultaneous with the lifting of the design load, even though the probability of an extreme earthquake such as the Hosgri to occur during such infrequent lifts may be insignificant. These evaluations were performed as part of the overall seismic safety evaluation of the plant structures. Results showed that the crane structures can withstand the Hosgri event without collapse, even while lifting the design loads.

The stresses in the crane structures due to Hosgri seismic event while lifting and moving the lighter loads were not computed because these loads are very small compared to the design loads. However, to estimate the seismic safety margin associated with these smaller loads, Table D-2 has been prepared by proportioning the results of the crane seismic analysis for the design loads. Even though the design-load analyses were nonlinear, such proportioning is considered conservative because these loads are much lighter than the design load. The computed margins are high, so it is concluded that the cranes are capable of safely withstanding a Hosgri-level seismic event while lifting and moving these smaller loads.

D4. FAIL-SAFE BRAKES

Guideline

"Automatic controls and limiting devices should be designed so that component or system malfunction will not prevent the crane from stopping and holding the load safely."

Evaluation

Each of the four subject hoists is provided with two electrically-released, spring-set holding brakes. Each brake is rated at 150% of the rated torque of the main hoist motor, and is automatically applied upon loss of voltage to the hoist motor. One of the brakes is located on a hoist motor shaft extension at the opposite end from the output shaft, and the other is on an extension shaft from the hoist motor pinion at the first stage of the speed reducer. Braking torque is transmitted through the speed reducer gearing to the drum gear.

The lighter loads evaluated here are very small compared to the design capacities of the cranes. As a result, the safety margins for mechanical crane components are very high for these crane/load combinations. Therefore, transmission of braking torque through these substantially designed mechanical components will provide adequate braking to hold the subject crane loads, even upon loss of power to the main hoist motors.

The reliability of the mechanical holding brakes and other mechanical components is further enhanced by periodic inspections and maintenance performed under Mechanical Maintenance Procedure 50.3, "Overhead, Gantry, and Mobile Crane Inspection, Testing, and Maintenance." In addition, an overspeed switch will be added to each of the four subject hoists. The switch will de-energize both the existing undervoltage relay and the brake solenoid coils directly. Addition of this device will provide redundancy of automatic braking controls.

D5. DUAL REEVING

Guideline

"Design of the wire rope reeving system should include dual wire ropes."

Evaluation

Instead of dual wire rope reeving, each of the subject hoists has one continuous wire rope with one attaching point at each end of the drum.

However, the safety margins for the wire ropes and other mechanical crane components are extremely high for the lighter crane/load combinations. Indeed, Table D-1 shows that the minimum crane reeving safety margin is 54.6 for the heaviest of these light lifts. This is much greater than the 10:1 safety factor discussed as an acceptable alternative to duality in NUREG-0612, Appendix C, paragraph 5 of the section on "Implementation of NUREG-0554 for Operating Plants."

In addition, wire rope reeving system reliability is enhanced by periodic inspections of crane components performed under Mechanical Maintenance Procedure 50.3, "Overhead, Gantry, and Mobile Crane Inspection, Testing, and Maintenance."

D.6 HOISTING LIMIT SENSORS AND CONTROLS

Guideline

"Sensing devices should be included in the hoisting system to detect such items as overspeed, overload, and overtravel and cause the hoisting action to stop when limits are exceeded."

Evaluation

All five cranes have redundant overtravel sensing devices, in the form of hoist limit switches to prevent two-blocking. They are described in Section D.7 below.

The cranes do not have sensing devices to detect overspeed at present. Operating procedures require that hoisting and lowering speeds be monitored visually at all times during a heavy load lift, both by the crane operator and the rigger-in-charge. In addition, an overspeed device will be added to each of the subject hoists, as described in Section D4 above.

Overload sensing devices are not necessary for these lighter loads. They weigh only a small fraction of the design capacity of the cranes, so the only overload possible would come from load hangup, on a stationary object, the potential for which is minimal. Hangups occur when some protrusion of a load is caught under a stationary object, or when a protruding stationary object catches on a hook of the load or sticks into the space over it. The following paragraphs present the results of PGandE's review of potential crane load hangups.

C-140-07/Main Hoist Load Block

Figure D-1 shows that the load block has no protrusions to catch on a stationary object (such as the crane's gantry leg cross brace), since the hook is protected from above by the sheaves. Since the main hoist load block has no specific load path, its entire travel range was surveyed for protruding stationary objects that could stick through the reeving or catch on the hook. Inspection of the containment between elevations 140 feet and 202 feet revealed no such object. As for the reactor cavity area, the only overhanging or protruding stationary objects are the reactor missile shield, the reactor cavity service crane, and the manipulator crane. The missile shield is well away from any of the load paths that go over the reactor: it is north, and the load paths are all in the east-west direction. In any case, it has no protrusions in either its operating or stored position (see Figure 2.3.3-1). The two cranes must be stowed away--the reactor cavity service crane latched to the reactor cavity wall, and the manipulator crane moved to the east end of its rails--as a prerequisite to moving any load over the reactor cavity. This prerequisite is in the

maintenance procedure for every load whose load path is over the reactor cavity, including the load block. The lack of suitable objects for load hangup within the range of the load block, plus the very high safety factors and redundant limit switches, make a load block drop extremely unlikely.

C-140-07/Load Block + Head Lifting Device

Figure 2.1.1-2 shows that there are no protrusions on the head lifting device to catch any looped or overhanging stationary objects. Inspection of the load path (C-140-07F) has revealed no protruding stationary objects that could fit into the loop between the diagonal brace and cross-brace of the device or into the crane reeving.

C-140-07/Load Block + Internals Lifting Device

Figure 2.1.1-3 shows that the internals lifting device has no protrusions that could hang up on a looped or overhanging stationary object. Inspection of the load path, from the equipment hatch counterclockwise along the annulus at 140 feet to 130°, then in over the gantry leg cross-brace to the reactor, has revealed no protruding stationary objects that could fit into the loop between the device's diagonals and spreader or into the crane reeving.

C-140-07/Load Block + Reactor Vessel Inspection Tool (RVIT)

The RVIT is assembled inside the crane rail near the RCP 1-3 motor maintenance mount area, then carried into the reactor along the same load path as the internals lifting device, but not in such a way as to engage in a looped or overhanging stationary object, unless the overhang is hooked downward or 8 feet deep. There are no such overhangs on the RVIT load path. The transducer arm is fully retracted and positioned under one of the support legs during the installation and removal of the RVIT, so the support leg protects the transducer arm from hangups. Finally, the load path has no protruding stationary objects that could catch in the RVIT or the crane reeving.

One other conceivable source of load hangups is the binding of the RVIT guide bushings on the vessel guide studs during tool removal. This is prevented by the design of the tool; the guide bushings have a nominal radial clearance of 3/8 of an inch, and a hydraulic leveling arrangement on the RVIT lifting rig keeps the RVIT firmly levelled. Figure 2.1.3d-4 shows the RVIT and its lifting rig.

AF-140-08/Main Hoist Load Block

There are no protruding objects in the spent fuel pool area within the limits of motion for the load block.

T-140-01(-02)/Main Hoist Load Block

The load block has no protrusions outside the reeving, and there are no protruding objects anywhere in the traveling range of the load block that would fit over the hook of the load block or into the loops of the reeving.

D7. TWO-BLOCKING

Guideline

"The reeving systems should be designed against the destructive effects of 'two-blocking'."

Evaluation

All of the subject hoists have redundant (geared and weighted) limit switches to prevent two-blocking. These limit switches will be wired according to the requirements of NUREG-0554, Section 4.5. The modifications will be installed by the end of the second refueling outage, and tested by the alternate method described in paragraph 8 of NUREG-0612, Appendix C.

D8. HOIST DRUM CATCHER

Guideline

"The hoisting drum(s) should be protected against dropping should its shafts or bearings fail."

Evaluation

Each subject crane is provided with one main hoist drum supported by a stub shaft extending from each end. Each shaft is supported by bearings and associated structures mounted directly to the trolley structure.

The lighter loads are very small compared to the design capacities of the cranes. Therefore, the safety margins for the drum support components are very high for these crane/load combinations, and the drums are held against falling with very high reliability while holding these loads.

Drum support component reliability is further enhanced by periodic inspection and maintenance performed under Mechanical Maintenance Procedure 50.3, "Overhead, Gantry, and Mobile Crane Inspection, Testing, and Maintenance."

D9. ADDITIONAL SAFETY DEVICES

Guideline

"Safety devices such as limit switches provided to reduce the likelihood of a malfunction should be in addition to those normally provided for control of maloperation or operator error."

Evaluation

Both the geared limit switches to prevent two-blocking and the overspeed devices on the four subject hoists are in addition to those provided for control of maloperation or operator error.

D10. COLD PROOF TEST

Guideline

"The crane system should be given a cold proof test if material toughness properties are not known."

Evaluation

Refer to Section D2.

Table D-1

CRANE COMPONENT STRUCTURAL SAFETY MARGINS

Crane	Heaviest Evaluated Load	Critical Component	Design Load (tons)	Stress Due to Load[1]	Safety Margin to Yield (y) or Ultimate (u) Strength
C-140-01	Load block and head lifting device[2] (19.8 tons)	Reeving	269.5[3]	$.018f_u$	54.6(u)
		Hook and load block structure	269.5[3]	$.047f_y$	21.3(y)
		Crane structure	269.5[3]	$.057f_y$	17.7(y)
AF-140-08	Main hoist load block (2.5 tons)	Reeving	159.4[4]	$.0038f_u$	266.0(u)
		Crane structure	159.4[4]	$.012f_y$	83.1(y)
T-140-01 (-02)	Main hoist load block (3 tons)	Reeving	153.4[3]	$.0049f_u$	205.0(u)
		Crane structure	153.4[3]	$.015f_y$	67.0(y)

Notes:

(1) Includes dynamic load factor of 1.15 (per CMAA 70 for hoisting speed up to 30 fpm) on the lifted item. f_u = ultimate stress, f_y = yield stress.

(2) This is the heaviest of the four lighter heavy loads carried by this crane.

(3) Includes impact factor of 1.3 per AISE 6-1969.

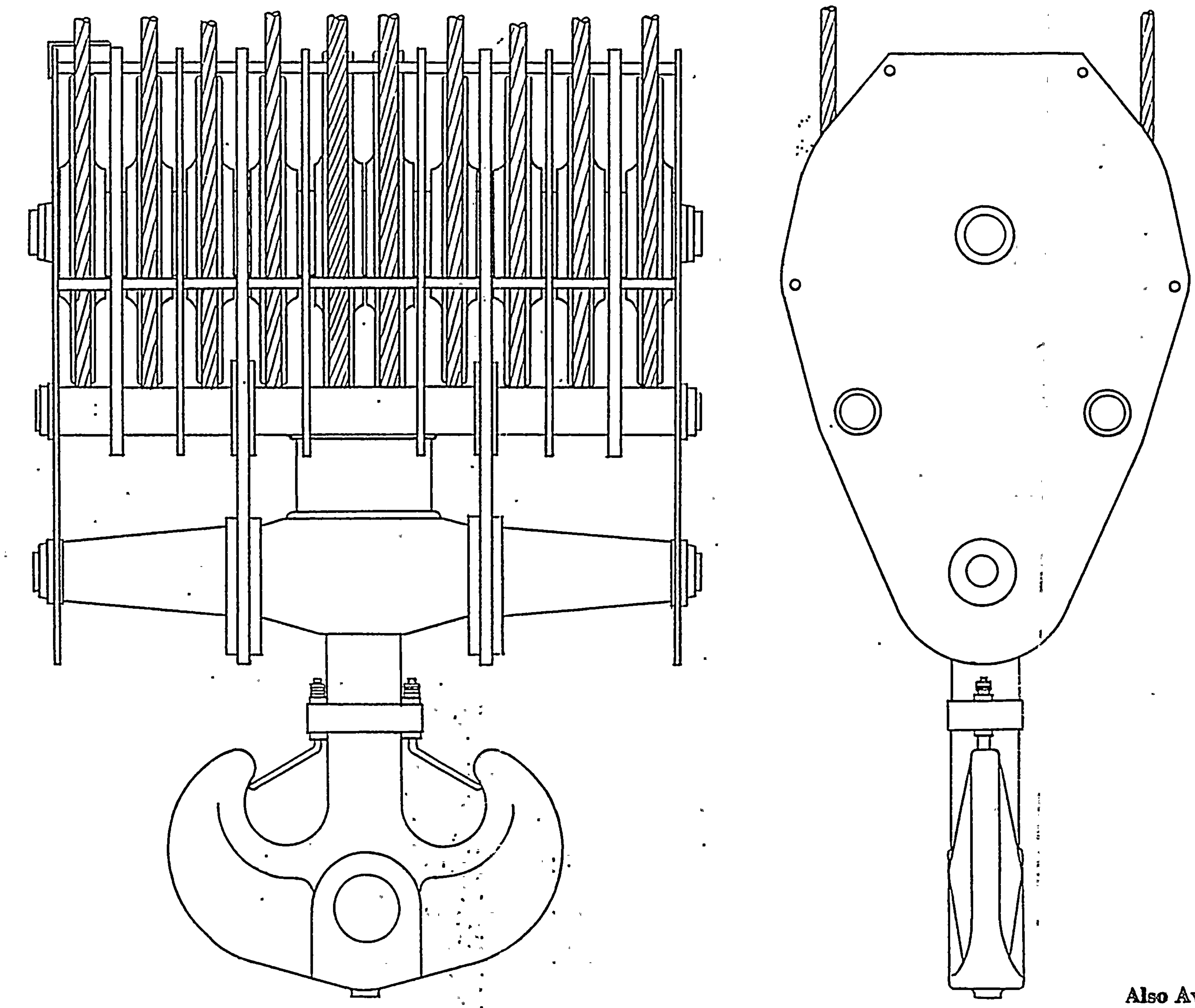
(4) Includes impact factor of 1.25 per 1969 AISC Manual.

Table D-2

CRANE SEISMIC SAFETY MARGINS

Crane	Heaviest Evaluated Load	Minimum Seismic Safety Margin While Lifting or Moving Load
C-140-01	Load block + head lifting device (19.8 tons)	10
AF-140-08	Main hoist load block (2.5 tons)	64
T-140-01 (-02)	Main hoist load block (3 tons)	42

Note: Safety margin = $\frac{\text{allowable load or stress}}{\text{computed load or stress}}$



TI APERTURE CARD

Also Available On Aperture Card

UNIT 2
DIABLO CANYON SITE

FIGURE D-1

CONTAINMENT POLAR CRANE LOAD BLOCK

8412120157-03 12-3-84