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July 17, 1984

Docket No. 50-320

Mr. B. K. Kanga, Director
Three Mile Island Unit 2
GPU Nuclear Corporation
P.O. Box 480
Middletown, PA 17057

Dear Mr. Kanga:

Subject: Reactor Pressure Vessel Head Lift

By letter dated March 9, 1984, GPU submitted a Safety Evaluation Report (SER) for removal of the reactor pressure vessel head and requested NRC approval of the proposed activity. This letter is in response to the GPU request and includes our detailed safety evaluation of the proposed head removal program. In our safety evaluation, we considered the following: (1) the adequacy of decay heat removal, (2) the potential for core recriticality from core reconfiguration or boron dilution of the reactor coolant, (3) the potential for releases of radioactivity to the environment, (4) the potential for combustible gas or pyrophoric reactions, (5) the consequences of postulated heavy load drop accidents, (6) the adequacy of fire protection, (7) the potential for worker overexposures and the measures for maintaining occupational exposures ALARA, (8) whether any aspects of the head lift program constitute an Unreviewed Safety Question, and (9) the long term safety of removing the head from the reactor pressure vessel.

Based on our detailed review as described in the Enclosure, we conclude the following:

(1) "Loss to ambient" cooling of the reactor coolant system will be sufficient for decay heat removal.

(2) There is little potential for core recriticality either by core reconfiguration or boron dilution.

(3) There is little potential for release of radioactivity to the environment in excess of typical trace quantities currently being discharged.

(4) There is little potential for a combustible gas or pyrophoric reaction.

(5) Appropriate measures have been taken to minimize the potential for, and consequences of, postulated heavy load drop accidents.

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(6) The existing fire protection program is adequate to deal with the relatively small increases in combustible material.

(7) There is little potential for worker overexposure and appropriate measures have been taken to maintain occupational exposures ALARA.

(8) The head removal program does not constitute an Unreviewed Safety Question.

(9) There are insignificant risks related to removal of the head over the long term and, if need be, the head can be replaced on the reactor pressure vessel.

(10) The head lift activities and projected environmental impacts fall within the scope of those previously assessed in the PEIS.

Thus, we conclude that it is safe to proceed with the planned head lift with minimal risk to the health and safety of the onsite workers and offsite public. It is our understanding that, following head lift and subsequent placement of the head on its storage stand, GPU will expeditiously proceed with the placement and filling of the internals indexing fixture and cover on the reactor pressure vessel flange in order to shield the exposed plenum and enhance reactor coolant system processing capability. We anticipate that this activity will be completed in a few work shifts or days. The head removal and related activities can be initiated following formal approval of related procedures and upon issuance of appropriate technical specifications which are being issued separately. Our detailed safety evaluation is enclosed.

Sincerely,

Original signed by
B. J. Snyder

Bernard J. Snyder, Program Director
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Enclosure: As stated

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THREE MILE ISLAND PROGRAM OFFICE

SAFETY REVIEW OF THE

HEAD REMOVAL PROGRAM

1. Introduction

By letter (Reference 1) dated October 11, 1983, GPU submitted the safety evaluation report (SER) for the head removal program, and we initiated our safety review of the proposed activity. An updated version of the head removal SER was submitted by letter (Reference 2) dated March 9, 1984, superseding the original submittal. In the course of our review, we requested additional information on the detailed aspects of head removal activities by letter dated April 9, 1984 (Reference 3). GPU responded to this request by letter dated May 18, 1984 (Reference 4).

Based on information in the aforementioned submittals, information exchanged in discussions with GPU, and information in related documents (TAAG reports, Technical Planning Studies, GPU internal memoranda), we completed our safety review of the planned head removal program. This report documents our detailed safety evaluation.

2. Description of Head Removal Activities

The head removal program encompasses a variety of activities. These activities include, (1) preparations or prerequisites for RPV head removal, (2) lifting the reactor pressure vessel (RPV) head, (3) transferring the RPV head, (4) installation of contamination control systems, and (5) installation of the internals indexing fixture (IIF). Each of these activities is described in detail below.

Preparations for RPV Head Removal

There are a number of actions which are prerequisites to head removal. These preparatory actions include placing the reactor coolant system in the drained down (i.e., at the 321' 6" elevation), depressurized condition, removing the control rod drive mechanism (CRDM) cable bridges, disconnecting and storing CRDM cables, removing stator cooling water spools, removing the catwalk at the south end of the D-rings, parking the remaining 66 CRDM leadscrews, installing the canal seal plate, relocating the auxiliary fuel handling bridge, attaching the gasket to the internals indexing fixture, staging the shielding for placement around the RPV head, placement of shielding on the service structure, detensioning the 60 RPV head studs, removing the RPV head studs to storage stands, filling the RPV flange stud holes with a corrosion inhibitor and sealing the stud holes with mechanical plugs, and attaching two guide studs to the plugs at opposite locations on the vessel flange. Additional preparations include the installation of video and radiation monitoring equipment for viewing, monitoring and directing head lift activities.

Lifting the RPV Head

The RPV head and attached service structure, control rod drive mechanisms, and shielding will be lifted by the requalified reactor building polar crane. The crane is qualified for lifts up to 170 tons and a calibrated load cell will be incorporated to monitor the lift weight. An initial lift (several inches) will be made to determine whether leveling adjustments will be required to the lift rigging to ensure a level lift during head movement to, and placement on, the RPV head storage stand. Once the load leveling is complete, the RPV head will be lifted just high enough to clear the plenum assembly and the guide stud pins for the horizontal movement in the vicinity of the RPV. The lift height will be limited to no more than 53 inches and is expected to be approximately 33 inches as all the RPV studs have been successfully removed and will not interfere with the lift.

Transferring the RPV Head

Following the vertical lift necessary to clear the plenum assembly and guide studs, the exposed portion of the head will be fitted with a bottom cover, if feasible, to collect any gross loose contamination or drippage. This may require an additional 12 inches of lift height to facilitate installation of the cover, raising the total lift height to no more than 45 inches. Then the head will be moved laterally to the south end of the refueling canal (if the bottom cover is not installed after the initial lift, it may be installed here). The head will then be raised vertically to clear the canal walls and any obstructions on the 347' elevation and then transported horizontally to the head storage stand at the 347' elevation. With the aid of tag lines, the head will be lowered to rest on the storage stand. Shielding consisting of water columns will be positioned around the head storage stand to minimize the direct radiation exposure from the contaminated surfaces of the RPV head and withdrawn CRDM leadscrews.

Installation of Contamination Control Systems

During placement of the head on its storage stand, a second contamination control cover will be placed under the head to prevent the spread of any loose contamination to the containment atmosphere. Additionally, a spray mist system will be installed over the exposed upper portion of the plenum to minimize the potential for generation of airborne particulate radioactivity. This system will prevent the exposed surfaces from drying out in the time period prior to installation of the IIF. Portable instruments will be used to monitor the airborne particulate radioactivity in the building.

Installation of the Internals Indexing Fixture (IIF)

Following the placement of the head on its storage stand and installation of the plenum spray mist system, the IIF and affixed gasket will be seated on the RPV flange to effect a water-tight seal. The IIF will then be filled with 4 to 5 feet of suitably borated water to provide shielding for the exposed upper portion of the plenum. The filled IIF will be fitted with a newly designed cover with integral lead shielding.

3. Health and Safety Issues

A. Decay Heat Removal

The decay heat in the TMI-2 core, currently estimated to be about 17.0 Kw, continues to be adequately dissipated through losses to the reactor building ambient. The partial draindown of the reactor coolant system (RCS) during head removal activities will reduce the effective area for convective heat transfer to the reactor building atmosphere; therefore an increase in average reactor coolant temperature is anticipated. However, the loss-to-ambient cooling mode is expected to be sufficient to keep the average RCS temperature well below the procedural limit of 170°F for the duration of head lift activities and beyond.

GPU has performed conservative analyses which indicate that a substantial margin will exist between the predicted average RCS temperature and the procedural limit. The conservative assumptions used in the analyses include the following:

1) RCS draindown to a level seven and a half feet below the planned level for head lift, with associated reduction in heat transfer surface area;
2) Decay heat levels as of January 1, 1984, seven months prior to the scheduled RCS draindown;
3) Initial temperatures for reactor building ambient and RCS which are well above current measured temperatures.

The bounding case, which incorporates all of the above assumptions, yields an equilibrium RCS temperature of 151°F, thus providing a margin of 19°F below the procedural limit of 170°F.

The actual RCS equilibrium temperatures following draindown for head lift are expected to be closer to 115°F, based on the temperature experience of the drained down RCS during the 10 month Underhead Characterization Study of 1983/84. The reactor coolant temperature never increased higher than approximately 114°F during the Underhead Characterization Study, amounting to a temperature rise of 10 to 12°F from ambient levels (i.e., the RCS temperatures prior to draindown).

Thus, it is highly unlikely that the average RCS temperature will approach the procedural limit during head lift operations with decay heat being removed in the loss-to-ambient mode. However, in the event of unexpected temperature increases, several backup heat removal systems are available. These systems, the Mini-Decay Heat Removal System and the Normal Decay Heat Removal System, are sized to handle decay heat loads well in excess of the present core decay heat. Therefore, adequate backup heat removal capability exists to support head lift activities. The consequences of a postulated head drop on decay heat removal capability during lifting operations are examined in Section 3.G of this report.

B. Criticality

We have reviewed the criticality analyses developed by GPU and find that the conservative assumptions used in these analyses ensure that an adequate degree of subcriticality will be maintained for any credible core configuration. The analyses also indicate that the damaged fuel outside the core will not achieve criticality under postulated credible worst-case conditions.

The damage models postulated for the criticality analyses effectively bound all credible fuel configurations, including those resulting from a reactor vessel head drop accident. For these analyses, the maximum boron concentration in the moderator was assumed to be 3500 ppm. All of the scenarios analyzed yielded K_{eff} values below .99. The realistic K_{eff} values were calculated to be less than .90, indicating the substantial conservatism incorporated in the models. Each analyzed case included several conservative assumptions such as hypothetical 100% fuel failure, no neutron leakage or absorption by structural or poison material, no fuel burnup, maximum fuel enrichment and optimum fuel-moderator ratio. All parameters affecting reactivity were optimized for models where a more credible fraction of failed fuel was assumed. For the out-of-core criticality model, it was assumed that a sphere of 19 assemblies of the highest enrichment (3%) fuel collected in the lower vessel. Another model assumed that 50% of the core formed a hemisphere in the bottom of the vessel. These analyses demonstrate that 3500 ppm boron is adequate to maintain safe shutdown for all credible core damage models.

However, even though 3500 ppm boron is adequate to maintain subcriticality for all credible core configurations, GPU has recently raised the boron concentration in the reactor coolant to 5000 ppm as an added margin of safety which bounds all potential core configurations. GPU analyses indicate that this concentration will maintain subcriticality for any postulated core configuration and we conclude that there is virtually no potential for criticality during head lift for any postulated core reconfiguration.

C. Boron Dilution

We have reviewed the measures taken by GPU to prevent a boron dilution incident and the proposed corrective actions to assure subcriticality of the core in the unlikelv event of such an incident.

Potential boron dilution sources include those systems communicating with the reactor coolant system which contain unborated water or borated water of a lower concentration than the RCS. Some of these systems are the demineralized water system, decay heat removal system, mini-decay heat removal system, core flood system, and secondary cooling water systems. There are a minimum of two isolation barriers for each potential inleakage pathway to prevent dilution of the RCS. These barriers consist of any combination of closed, tagged-out valves, electrically locked out pumps, removed spool pieces, heat exchanger tube boundaries, and water pressure differentials. Periodic surveillance of valve positions and storage tank water levels in systems connected to the RCS will also identify any potential dilution pathways and reduce the potential for boron dilution from these sources.

Systems necessary for makeup and processing of RCS water during head lift activities will be borated to the same concentration as the RCS. All makeup and processing activities will be performed in accordance with approved procedures and samples will be taken to verify the boron concentration in makeup sources prior to addition to the RCS. Samples of RCS water will be taken and analyzed on a weekly basis as a minimum to verify boron concentrations and two independent water level monitors (a third water level monitor will become available after IIF installation) will provide continuous indication of RCS water level and early indication of a dilution event, should one occur, so that corrective action can be employed to isolate the dilution source.

Head removal will create an additional potential dilution path; water sources in containment could enter the RCS through the open reactor vessel. These sources, including fire service water, decontamination water, and the reactor building spray system water, are normally isolated by at least two isolation boundaries. These systems will be controlled by administrative procedures when not isolated or, in the case of spray systems for control of airborne activity, will be borated to the RCS concentration. After the internals indexing fixture is installed, a cover will be provided to limit entry of water th ough the open vessel and an additional cover will be placed over the work platform when decontamination water is used near the vessel.

If, despite these preventative measures, a boron dilution event does occur, contingency procedures exist to rapidly isolate the pathway or inject boron into the RCS, as necessary, to ensure a concentration sufficient to maintain safe shutdown. We believe that the surveillances in place (e.g., RCS water level) would rapidly identify a dilution event in sufficient time to correct the problem.

Based on the above discussion, we conclude that the preventative measures and corrective actions described by GPU provide adequate assurance to preclude the occurrence of a boron dilution event during head removal activities.

D. Release of Radioactivity

The potential for release of radioactivity to the environment due to activities associated with reactor vessel head removal have been reviewed. The only potential release of radioactivity to the environment is through the airborne pathway. Our review indicates that the activities associated with head removal will not result in significant increases in airborne radioactivity inside the reactor building or in corresponding releases to the environment.

Lifting the reactor head will expose the reactor coolant to the reactor building environment. However, the reactor coolant will remain at near ambient temperatures and, thus, there will be no driving force to significantly evaporate the coolant and cause the dispersion of the entrained radioactivity. The gross radionuclide concentration in the reactor coolant is less than 1 uCi/ml and there are no significant radioiodines and dissolved noble gases (e.g., Kr-85). Typical Kr-85 releases from the plant are less than 1 Ci/day. The tritium concentration in the reactor coolant system is approximately 0.05 uCi/ml. This is significantly less than the tritium concentration in the containment sump or the processed water used in the containment for decontamination purposes. Therefore, evaporation of some of the tritium in the reactor coolant when the head is lifted will not likely cause any significant increases in tritium release into the reactor building or to the environment. Typical tritium releases from the plant are less than 0.1 Ci/day.

As part of the Underhead Characterization Study conducted in 1983/84, a series of air samples were taken under the reactor vessel head after the RCS was drained down to 1 foot below the plenum cover plate to simulate head lift conditions. Several samples were taken after periods of data acquisition manipulations which were expected to generate airborne activity. These samples did not show excessively high levels of airborne radioactive particulates, and the levels were in fact lower than typical levels currently found in the environment of workers conducting cleanup activities in the building.

The head removal activities will involve the movement of materials and components which have contaminated surfaces (e.g., the polar crane, the RPV head and service structure). A number of precautions will be implemented to lessen the potential for generation of radioactive particulates from the contaminated surfaces. These precautions include 1) the installation of a water spray system which may be used to keep the exposed plenum surfaces wet, 2) installation of a contamination control cover for the undersurfaces of the head which will be installed before transfer of the head to the storage stand, if feasible, consistent with minimizing occupational radiation exposures, and 3) use of a contamination control cover to seal the undersurfaces of the head after it is placed on the storage stand. Appropriate personnel respiratory protective equipment will be used by workers during head lift which will be adequate for any reasonably expected increase in airborne particulate radioactivity. We anticipate that the movement of people and contaminated materials and components may increase the local airborne particulate radionuclide concentrations, relative to the ambient building concentrations, similar to the local increases generated by personnel performing other cleanup activities in the reactor building (the so called "pig-pen effect"). These activities should not result in any detectable increase in radioactivity releases to the environment as the local airborne particulate radioactivity either resettles in the building or is swept into the building ventilation system and collected in the system filters. Accordingly, we do not expect the head removal activities to perturb the already low levels (less than 1×10^{-7} Ci/day) of radioactive particulate material releases to the environment.

The only perceived accident that could result in a significant release of radioactivity would be a major disturbance of the reactor core caused by dropping the load on the vessel during head lift. Such an accident could cause the release of some Kr-85 to the reactor building that may still be trapped in the core. However, as a precautionary measure during head removal activities which involve the movement of heavy loads, specifically the reactor pressure vessel head and IIF assembly, the containment will be isolated and the purge secured. The maximum remaining inventory of Kr-85 that could still be in the reactor core is estimated to be 3.7×10^4 Ci. This inventory is less than the 4.4×10^4 Ci of Kr-85 released to the environment during the June - July 1980 reactor building purge. Therefore, even for an accident which causes the entire inventory of Kr-85 to be released into the containment, any subsequent controlled purging of Kr-85 would likely result in an environmental impact less than that of the 1980 Kr-85 purge. Based on the 1980 purge experience, we estimated the maximum exposure to an individual offsite as a result of a subsequent controlled purge of Kr-85 to be 3.7 mrem of beta dose to the skin and 0.04 mrem of gamma dose to the whole-body.

E. Combustible Gas Generation

As a result of the radiolytic decomposition of reactor coolant water into gaseous hydrogen and oxygen, there exists the potential for formation of combustible gas mixtures underneath the head. Those mixtures require a hydrogen concentration of at least 4% in the presence of oxygen at 5% or greater. Accordingly, in the conduct of prior cleanup activities, GPU has measured the hydrogen generation rate from the reactor coolant and the rate is very low (0.01 Ft^3/day or less). Additionally, during head lift, the reactor pressure vessel will be in the depressurized, vented condition and any generated hydrogen will rapidly diffuse into and mix in the containment atmosphere. During the conduct of the Underhead Characterization Study in 1983/84, the RPV was in a condition (i.e., depressurized and vented) which simulated the head lift conditions for a period of 10 months and this experience demonstrated that the measures were adequate to prevent the buildup of combustible gases. We conclude there is little potential for a combustible gas reaction during head lift activities.

F. Pyrophoricity

During head lift activities, the reactor coolant will be lowered approximately 1 foot below the plenum cover and there exists the potential for a pyrophoric reaction of any material on the cover when it is exposed to air. The issue of pyrophoricity as it relates to the head lift program was extensively evaluated by the staff (Reference 5) in response to a request for action pursuant to 10 CFR 2.206 of the Commission's regulations. The staff's response cited the results and experience of the Underhead Characterization Study of 1983/84 and other cleanup related studies in drawing the following conclusions: (1) there is little material (approximately 1 millimeter in depth) present on the plenum surface; (2) flame and spark tests indicate the material on the plenum surface is not pyrophoric; (3) material filtered from the reactor coolant system during the accident lacks any pyrophoric content; (4) material scraped from control rod drive mechanism leadscrews lacks any pyrophoric content, and (5) samples of material removed from the damaged core have not shown any tendency to undergo a pyrophoric reaction. Additionally, recent flame and spark tests on several core samples did not indicate any pyrophoric characteristics in the samples. Accordingly, we conclude there is little potential for a pyrophoric reaction during the head lift program.

G. Heavy Load Drop Accident Analyses

On December 22, 1980, the staff issued a letter to all licensees of operating plants on the control of heavy loads. In this letter the NRC requested that each licensee review the controls for the handling of heavy loads to determine the extent that the requirements of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," have been met. Also contained in the December 22, 1980 letter was a request for additional information on the control of heavy loads. Section 2.1 of the letter requested information on the requirements for overhead handling systems, Section 2.2 requested a response to specific requirements for overhead handling systems operating in the vicinity of fuel storage racks, Section 2.3 stated specific requirements of overhead handling systems operating in the containment and Section 2.4 stated specific requirements for overhead handling systems operating in plant areas containing equipment required for reactor shutdown, core decay heat removal or spent fuel pool cooling. Responses to Sections 2.1 and 2.2 were forwarded by the licensee and addressed by the staff in previous correspondence. Sections 2.3 and 2.4 are discussed by GPU in the licensee's head lift safety evaluation report.

<u>Load Handling in the Containment Building</u>

NUREG-0612, Section 5.1.3 provides guidance concerning the design and operation of load handling systems in the vicinity of the reactor core. The licensee was required to demonstrate that adequate measures have been taken to ensure that, in the vicinity of the core, either the likelihood of a drop which might damage spent fuel is extremely small, or that the estimated consequences of such a drop will not exceed the limits set by the evaluation criteria of NUREG-0612, Section 5.1, Criteria I through III.

Criterion I of Section 5.1 requires that, "Releases of radioactive material that may result from damage to spent fuel based on calculations involving accidental dropping of a postulated heavy load produce doses that are well within 10 CFR Part 100 limits of 300 rem thyroid, 25 rem whole body (analyses should show that doses are equal to or less than 1/4 of Part 100 limits)."

In response, the licensee has stated that the impact of the RPV head and service structure dropping onto the vessel may cause a release of gaseous radioactivity into the reactor building environment. An uncontrolled release of this activity to the environment is precluded by containment integrity during head removal. As discussed in Section 3.D of this report, the worst case gaseous release (Krypton-85) would result in doses which are a small fraction of the 10 CFR 100 limits. Although little airborne particulate material would be expected from a load drop, any material generated would be within the containment boundary. Any of the airborne material which does not settle out would be processed through high efficiency particulate air (HEPA) filters prior to release to the environment and we conclude that airborne particulates will have no significant impact on the doses resulting from postulated Kr-85 releases. Therefore the requirments of Criterion I have been satisfied.

Criterion II requires that, "Damage to fuel and fuel storage racks based on calculations involving accidental dropping of a postulated heavy load does not result in a configuration of the fuel such the K_{eff} is larger than 0.95." Accordingly, we have considered the significance of a postulated head drop on the reactor pressure vessel which results in fuel reconfiguration. As discussed in Section 3.3 of this report, criticality analyses for postulated core configurations with 3500 ppm boron in the RCS yielded realistic K_{eff} values which were less than .90. Further, GPU has recently raised the boron concentration in the RCS to 5000 ppm to ensure safe shutdown for any hypothetical core configuration. We conclude that the requirements of Criterion II have been met.

Criterion III requires that, "Damage to the reactor vessel or the spent fuel pool based on calculations of damage following accidental dropping of a postulated heavy load is limited so as not to result in water leakage that could uncover the fuel, (makeup water provided to overcome leakage should be from a borated source of adequate concentration if the water being lost is borated)."

All heavy load movements in the head removal program will be made in the reactor building and there are no movements which could impact the spent fuel pool. Heavy loads that will be handled during the head removal evolution include the reactor pressure vessel head assembly, which is comprised of the lift rigging, the vessel closure head, the CRDM motor tube assemblies, the service structure, and attached shielding with its support frames. Other heavy loads include the internals indexing fixture (IIF), the fixture cover and the cover shielding plates. The lifting of any combination of loads is limited to a maximum weight equal to the rating of the reactor building polar crane which is 170 tons.

While in the vicinity of the RPV, the head lift height will be monitored and controlled. As all the RPV studs have been successfully removed, the head lift height for required clearances will be approximately 33 inches. Cover placement on the underside of the head following the initial lift may require an additional 12 inches of clearance over the RPV. Thus, the head lift height in the vicinity of the RPV would be no higher than 45 inches maximum.

GPU has provided an evaluation of the effects of a load drop on the RPV in Attachment 3 of their head lift SER. In this analysis, GPU stated that depending on the components that are attached to the head during the lift, the assembly could weigh from 158 to 170 tons. Each weight has a corresponding maximum lift height, equal to the maximum vertical distance that the load could be dropped without a breach of RCS integrity (i.e., failure of the reactor pressure vessel or the attached in-core instrument tubes). For reference, GPU has analyzed the case where the service structure shielding is in place and all studs are removed. GPU has already removed all studs in preparation for head lift. The weight under these conditions was conservatively assumed to be 174 tons. This assumed weight is approximately 10 tons more than the actual weight of the head and attached shielding (about 163 tons). The maximum lift height, assuming a worst case point load drop (structure tilts when dropped and hits the vessel or plenum at an angle), is calculated to be 56.1 inches. The GPU load drop calculations have been reviewed by the NRC Structural and Geotechnical Engineering Branch, and this review provides confirmation of GPU's results. We conclude that the measures employed by GPU to limit head lift height in the vicinity of the RPV are adequate to mitigate the consequences of an accident. Therefore, there is adequate protection against uncovering the fuel and Criterion III is satisfied.

Impact of a Load Drop on Safe Shutdown Functions

Section 2.4 of Enclosure 3 of the December 22, 1980 letter to all licensees requires that the licensee satisfy Criterion IV of Section 5.1 of NUREG-0612 and present in matrix form all heavy loads and potential impact areas where damage might occur to safety related equipment. The licensee has provided that matrix as Table 4.9.2-1 of their head lift SER. Enclosure 3 also requires that the licensee indicate which of the load and impact area combinations can be eliminated because of separation and redundancy of safety related equipment. For load/target combinations that impact safety related equipment, GPU is required to state their basis for determining that load drops will not affect the ability to perform a safety related function (reactor shutdown, core decay heat removal and containment integrity).

The required safe shutdown functions that apply to TMI-2 in its current condition are (1) the capability to maintain subcriticality, (2) the capability to maintain decay heat removal, and (3) the capability to maintain the integrity of components whose failure could result in excessive off-site releases. The ability to maintain subcriticality was discussed previously in this section as well as in Section 3.B, and the ability to minimize off-site releases was previously discussed in Section 3.D. Decay heat removal capability will be maintained because of the head lift height restrictions described earlier in this section, the passive loss to ambient cooling mode (which only depends on water being retained in the RCS), and the various options available for introducing borated water into the RCS. We conclude that the requirements of NUREG-0612 have been satisfied.

H. FIRE PROTECTON

In Revision 1 of the GPU Fire Protection Program Evaluation, dated June 15, 1982, GPU stated that the average combustible loading in the containment building was 1.10 lbs./ft.^{2} (equivalent pounds of wood). That combustible loading value is still an accurate assessment of current combustibles inside of containment. GPU has stated in their head lift safety evaluation that the head removal activities will increase the average combustible loading by 0.098 lbs. (wood equivalent)/ft.^{2}. This amounts to a relatively small increase ($<$10%) of combustible material to the existing inventory.

For the head lift program we have evaluated the fire protection measures available to cope with any fires.

Fire hose stations described in Section 3.7.10.4 of the Proposed Technical Specifications (PTS) are located near the west stairway and the southwest stairway on the 305' elevation, and on the east and west D-ring on the 367' elevation. With the failure of a fire hose station, GPU is required to route an equivalent capacity fire hose to the unprotected area within an hour. Fire Detection instruments are provided in the building, as discussed in Section 3.3.3.8 of the PTS. One hour fire watches are required with the failure of one of these instruments.

We conclude that the existing fire protection measures, including those such as fire watches, combustible inventory control, and television camera surveillance, are adequate to cope with the relatively small increase in combustible loading (8.9%) in the reactor building.

I. Occupational Exposure

Individual Worker Exposure

Head removal activities will involve manual manipulations around significant sources of radiation (e.g., the underside of the head and the exposed plenum), and there exists the potential for individual worker overexposure. However, for head removal and related tasks, GPU has established measures (e.g., use of shadow shielding and distance from known sources) to reduce worker exposure and minimize the potential for overexposure. Based on existing administrative procedures and controls, the radiation exposures to any individual cleanup worker will be kept below the regulatory limits for occupational radiation doses, i.e., 3 Rem per quarter and an accumulated dose of 5 Rem per year for every year for workers over 18 years of age.

The majority of head removal activities will be performed in gamma radiation fields of 75 - 150 mrem/hr. The highest gamma radiation fields where workers will be stationed are not expected to exceed 300 mrem/hour. We have evaluated the maximum radiation fields under expected and abnormal conditions for assurance that no worker will exceed the dose limits specified in 10 CFR 20.101.

Throughout the entire head removal evolution, there will be adequate real-time monitoring instrumentation to allow for continuous monitoring and evaluation of the occupied areas. Pre-entry planning and continuous personnel monitoring dosimetry will minimize the potential for overexposure. Should unexpected difficulties occur, such as leakage from the IIF after placement on the reactor pressure vessel flange and subsequent filling, contingency plans exist (e.g., remote clamping of the IIF) to eliminate the need for personnel access to high dose-rate areas.

Based on data collected during the Underhead Characterization Study, estimates were made of dose rates to be expected after head removal. The calculated dose rate in the refueling canal at a distance of about five feet from the inside diameter of the vessel flange is about 10 R/hr. However, following head lift, the installation of the IIF and subsequent filling with water will be performed remotely such that the worker exposure to those relatively high radiation fields will not be necessary.

We have reviewed the design features for IIF sealing which are intended to produce a tight seal without the need for personnel access into the refueling canal area. To provide a watertight seal, a soft gasket will be placed on the IIF and seated on the RPV flange during IIF installation. The gasket seating surface on the RPV flange is outboard of the second flange O-ring and inboard of the mating point between the RPV flange and head mating surfaces. This surface, which is expected to be clean, will be inspected prior to positioning the IIF. The IIF flange surface has been inspected to assure that there are no dents or surface marks that would cause leakage. A mockup test has been performed which simulated the installation and water filling of the IIF on the RPV flange. These inspections and tests provide assurance that no significant leakage should occur under the weight of the IIF alone. Hold down "dogs" (at least 10) will be bolted around the IIF to ensure both alignment and a tight gasket seal on the RPV flange. As a contingency the refueling canal may be partially flooded if modifications are needed on the IIF and gasket to ensure leak tightness. We conclude that there is reasonable assurance that the IIF can be installed and filled with water remotely, allowing the water to shield the strong radiation source from the upper plenum surfaces, with little risk of worker overexposure.

Based on the above radiological considerations, we expect that during head removal activities, radiation exposures to cleanup workers can be kept at levels below those limits of 10 CFR 20.101.

Collective Worker Exposure

We have estimated the total occupational radiation exposure for all the tasks which make up the head removal program. We estimate the activities related to head removal will result in a collective occupational dose ranging from 300 person-Rems to 1,100 person-Rems. While we expect the actual head lift to result in about 20% of the collective dose, no other single task is expected to account for more than 10% of the maximum expected occupational dose. The head removal activities consist of numerous tasks including pre-head lift preparations, final detensioning of the reactor pressure vessel head studs, the actual head lift and transfer to the head storage stand, the installation of the IIF, the installation of shielding, and various radiation health physics surveillance and monitoring activities. A number of these activities, such as the installation of shielding on the IIF cover and around the head storage stand and reactor vessel service structure, will have a long-term dose rate reduction effect for maintaining occupational doses as low as reasonably achievable (ALARA).

In comparison with the licensee's estimate of occupational dose (410 - 760 Person-Rems) our estimate encompasses a larger range. Our low estimate is somewhat below the licensee's low estimate because ongoing reactor building dose reduction activities may significantly reduce ambient radiation levels prior to head lift. While we concur that GPU's overall estimates are fairly realistic, we felt that it is prudent to include in our estimate the pessimistic "worst case" upper range. Our high estimate covers the possibility of operational difficulties in the critical time between head lift and IIF installation and filling, and the possible need for more cleanup or additional shield placement following head lift. In addition, our high estimate accounts for some isolated "hot spot" locations where we have calculated higher dose-rates in comparison with GPU's calculations. Although worker occupancy at those locations is not expected, our high estimate includes the possible placement of additional shielding and the need for workers to be in the vicinity.

The staff's final Programmatic Environmental Impact Statement (PEIS) related to the TMI-2 cleanup, issued in March 1981, estimates the occupational exposure to be incurred by cleanup workers to be 2,000 to 8,000 person-Rem. Actual occupational exposure for cleanup activities to date (1993 Person-Rem as of May 11, 1984) plus that projected to occur during head removal fall well within the estimated range of the PEIS.

Maintaining Occupational Exposures ALARA

GPU is required to maintain occupational exposures ALARA throughout all cleanup operations, including during RPV head removal activities. Accordingly, we have reviewed the head removal program to ensure GPU compliance with the ALARA principle.

Prior to, during and following head lift, workers will be exposed to radiation from sources within the head, the reactor vessel and from other sources within the building. The measures that will be taken to reduce doses for the following activities have been evaluated: head lift preparation, head lift and internals indexing fixture (IIF) installation, and the impact of the filled IIF and stored RPV head on work in the reactor building following head lift.

Head lift preparation activities are currently underway, supported by GPU's ongoing dose reduction program. The radiation background present in the reactor building accounts for a substantial portion of the collective occupational dose. An effective ALARA program, therefore, requires an ongoing dose rate reduction effort to reduce the background radiation levels in the reactor building. Since the fall of 1982, GPU has had in place an aggressive dose reduction program. Currently the average radiation levels in the reactor building are about 140 mrem/hr at the 305 foot level, 70 mrem/hr at the 347 foot level and 60 mrem/hr at the RPV head service structure area. These levels represent a substantial decrease from the average fields of about 350 mrem/hr, 120 mrem/hr and 160 mrem/hr at the corresponding locations when the dose reduction program was initiated. The transit dose incurred by workers in the building has also been reduced from about 40 mrem per worker entry to about 14 mrem per worker entry. The dose reduction program consists mainly of identifying, removing, shielding, and/or decontaminating discrete radiation sources.

Head lift will expose workers not only to present radiation sources but to "new sources" such as the highly contaminated underside of the reactor vessel head, the highly contaminated leadscrews that will be parked in the RPV head service structure, and the plenum which is also highly contaminated. Accordingly, GPU has made preparations to ensure that doses are ALARA during head removal. Distance and shadow shielding will be used to minimize the doses to workers who must guide the head lift and the installation of the IIF. They will be stationed on the tops of the D-rings and will not be immediately adjacent to the head. Shielding will be placed on the service structure to reduce the dose rate from the lead screws. Water columns will be used to shield workers from the underhead sources after placement of the head on its storage stand.

After the RPV head has been placed on the head storage stand, and the IIF installed, there is the potential for the reactor vessel and head sources to impact work in the reactor building. The major "new" sources of radiation on the 347 foot elevation of the reactor building will be the leadscrews in the parked position inside the head service structure, the "shine" from the underhead surfaces with the head supported four feet off the floor on the storage stand, and the exposed plenum. The leadscrew source will be shielded by the CRDM motor tubes, stators, service structure barrel, service structure shield assemblies (lead blankets of 44 $lbs./ft^2$ which extend from the head flange up to the monorail support beams) and the twelve foot high and approximately two foot thick water shield columns. The "shine" from the underhead surfaces will also be shielded by the water columns.

The exposed plenum souce will be shielded by the IIF and its cover. The IIF will be installed semi-remotely from the polar crane and D-rings, and filled with water (4 to 5 feet) to shield the exposed plenum, which is a strong radiation source. As the reactor coolant level is raised in the IIF, the coolant will be processed to lessen the concentration of radioactive material in the coolant to ensure that it does not significantly contribute to doses. Dose rates on the IIF from sources in the vessel are expected to be about 5-15 mrem/hour with the IIF fully filled. This dose rate will be further reduced by the incorporation of approximately 1 inch of lead shielding in the IIF cover.

GPU ALARA efforts are directed not only at minimizing radiation fields, but also at minimizing the accumulated stay time of personnel in radiation areas, consistent with the tasks that must be accomplished. For example, new stud handling tools with air pressure drives were procured for use in unthreading the studs, reducing the time required for operation by a factor of about three.

The licensee also has an extensive program to ensure that workers are adequately prepared to conduct the in-reactor building tasks expeditiously. Methods to reduce stay time involve the preplanning, training, and mockup exercises prior to execution of the tasks and supervision by closed circuit television whenever possible.

Based on our view of the licensee's plans and programs, we have determined that there is adequate assurance that the head removal activities will be performed consistent with the principle to maintain doses to the workers at ALARA levels.

4. <u>10 CFR 50.59 Evaluation</u>

We have reviewed GPU's planned head lift to determine if any aspects of the program involve a change in the technical specifications incorporated in the license or an "unreviewed safety question" when evaluated against the criteria of 10 CFR 50.59 (changes, tests and experiments). There are many aspects of the head removal program which are conducted in the same manner as for an undamaged or normally operating nuclear power plant and these activities do not differ from the way they have been described in GPU's Final Safety Analysis Report (FSAR) for TMI-2. These activities, including the draindown of the reactor coolant system, the parking of the CRDM leadscrews, and the final detensioning and removal of the RPV studs and nuts, do not involve changes to the technical specifications or an "unreviewed safety question." On the other hand, the actual lifting of the head involves a number of changes to the technical specifications and there are other changes to the facility which involve a potential "unreviewed safety question." Our discussion of the aspects of the program which involve changes to the plant technical specifications is provided in the related Amendment of Order, issued concurrently with this safety evaluation report. The aspects of the program which involve a potential "unreviewed safety question" are discussed below.

We have determined that the only aspects of the program which differ from a routine head lift and therefore require evaluation are the "changes" to the facility which are made to minimize occupational exposure from known significant sources of radiation (e.g., the RPV head, service structure and contained CRDM leadscrews and the exposed plenum). Specifically, the changes to the facility include the handling of lead shield blankets on the RPV head and service structure, the placement of water shield columns around the RPV head and service structure on the storage stand, and the placement of a lead shield cover over the IIF after placement and filling of the IIF on the RPV flange. In view of the potential for shield failure or a load drop, we have reviewed these changes to determine if they involve an "unreviewed safety question." A proposed change involves an unreviewed safety question (i) if the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the safety analysis report may be increased; or (ii) if a possibility for an accident or malfunction of a different type than any evaluated previously in the safety analysis report may be created; or (iii) if the margin of safety as defined in the basis for any technical specification is reduced.

With regard to criteria (i) above, we conclude that the proposed changes to the facility do not increase the probability or consequences of an accident or malfunction for the following reasons: (1) The load handling capabilities of the structure and components supporting the water columns, lead blankets, and lead shield cover are well in excess of the imposed loads and there is little potential for structural failure. (2) There is little potential for a load drop as the reactor building polar crane has been successfully tested at 214 tons and requalified for lifts up to 170 tons. Any required lifts associated with shield handling would be only a fraction of the load capability of the crane. (3) Because of the condition of the facility, including the fact that the core decay heat is only 17 Kw and the core is devoid of short lived radioiodines and high energy noble gases, the consequences of any accident associated with head lift activities would be less than those evaluated in the FSAR. (4) Safety equipment associated with the control and release of radioactive material will be fully operational in the event of an accident.

With regard to criterion (ii) above, we conclude that none of the accidents considered are of a different type than those evaluated previously in the FSAR for the following reasons: (1) The head lift program activities are basically the same as those previously considered in the FSAR. (2) The accidents considered to result from those activities are shield failure or a shield drop, either of which could fail systems underneath the load, including possible failure of the RCS. (3) Failure of the RCS results in a loss of coolant accident (LOCA) which is the bounding high consequence event previously analyzed in the FSAR. However, in the present TMI-2 condition, a LOCA would be a much lower consequence event because of the low decay heat and absence of radioiodines and high energy noble gases. (4) Thus, while additional lower consequence events have now been considered for the head lift program, the program activities themselves do not create the possibility of an accident or malfunction of a different type from those previously evaluated.

With regard to criterion (iii) above, we have reviewed the TMI-2 Technical Specifications and associated bases, including those for the Water Injection Cooling and Reactivity Control Systems, Instrumentation, Reactor Coolant System, and Plant Systems. Based on our review, we conclude that: (1) Such margins of safety as are discussed in the basis for any technical specification are not reduced or affected by the facility "changes" for head removal. (2) The safety systems discussed in the technical specifications have sufficient redundancy of function so that the loss of any system as a result of shield failure or a shield drop will have minimal effects. (3) There is no credible accident related to the head removal "changes" to the facility which could significantly impact any of the safe shutdown functions of maintaining subcriticality, decay heat removal and containment integrity.

Based on the above, we conclude that the changes to the facility as a result of the head removal program do not represent an "unreviewed safety question."

5. Long Term Safety of Head Removal

In our review, we have considered the long term safety of removing the head from the RPV as the potential exists for future delays in cleanup activities from funding constraints or technical problems (e.g., stuck plenum).

Removal of the RPV head is a prerequisite to further reactor disassembly and subsequent defueling. Once the head is removed and placed on its storage stand, the head will remain in shielded storage for, at least, several years as the cleanup progresses through plenum removal and defueling. Lack of funding for future cleanup activities or technical problems may lengthen the time necessary to complete plenum removal and defueling. The completion of defueling is currently the highest priority as achievement of this milestone will significantly reduce the risks associated with the plant in its present condition. In view of the potential for cleanup delays, we have evaluated the safety significance of removing the head in the very near term.

In our review, we have considered the risks as well as the benefits or advantages of removing the head now vice the alternative of leaving the head in place until the major funding uncertainties are eliminated. We believe that the risks associated with near term head removal are extremely small for a number of reasons. First, the core decay heat is very small at 17 Kw and requires only purely passive means (i.e., loss to ambient) for decay heat removal. Second, with the RCS borated to at least 3500 ppm, the system will remain subcritical for any credible core configuration. The present boron concentration is approximately 5000 ppm and GPU plans to maintain this concentration throughout reactor disassembly and defueling. Additionally, the increased RCS boron provides an even greater margin of safety for a postulated boron dilution event, notwithstanding the other measures (e.g., double isolation of systems connected to the RCS) employed to minimize the potential for such an event. Third, the ability to isolate and maintain the integrity of the containment to mitigate the consequences of postulated events would make the risks to the offsite public from any credible scenario extremely small. Further, the plant is in a relatively benign condition with insignificant quantities of radioiodines and a noble gas inventory (Kr-85) trapped in the fuel which is less than the pre-purge inventory of 1980. Given the plant conditions and the measures in place to maintain the safe shutdown of the facility, it is difficult for us to postulate any credible scenario which could pose serious risks to the offsite public, regardless of the status of the head.

On the other hand, there are significant benefits, in relation to long-term safety, to be derived from removing the head now and proceeding with subsequent cleanup activities (e.g., plenum inspection) as expeditiously as possible. First, it is recognized that head removal is an absolute prerequisite to the sequential tasks of reactor disassembly and defueling, including plenum jacking and removal and core defueling. Head removal will permit the necessary inspections of the plenum condition and removal tolerances to effect the planning for plenum removal. Head removal will also permit further inspections of the damaged core and the capability for locating fuel in the lower head so that defueling planning can proceed. There are other benefits from head removal. The installation of the IIF and integral pump on the RPV following head removal will enhance the RCS processing capability through the Submerged Demineralizer System (SDS) and corresponding capability to recover from increases in coolant radioactivity levels ("crud bursts"). With the head in place, the RCS requires pressurization to achieve reasonable processing rates through the SDS because of partially plugged flow in the letdown line. An additional independent RCS water level monitor will also be available with the installation of the IIF to further increase the protection for a boron dilution event. The primary benefit from head removal now, though, is that it allows continued progress toward the ultimate goal of fuel removal and is a step closer to reducing the risks associated with the present plant condition. There are sufficient funds ($94 million) available this calendar year to make substantial progress in the cleanup and prospects are good for additional cleanup money in future years with the present initiative by the Edison Electric Institute to secure industry contributions. It would seem prudent to pursue the cleanup as vigorously as possible with the prospects for future funding.

We have considered the feasibility of replacing the head on the RPV for, as yet, an unspecified reason. Once the head is removed, current plans indicate that it will remain on the storage stand through reactor disassembly and defueling. Following defueling, the head may be put back on the RPV for future flushing of the primary system to remove contamination from system piping. However, until the cleanup progresses to that stage, we cannot identify at this time any technical reason for having to put the head back on.

There will be no need to pressurize the RCS with the head in place to process reactor coolant through the Submerged Demineralizer System as the installed IIF and integral pump will provide adequate processing capability. Nor does the head have to be in place to shield the plenum as the IIF, filled with water, and shield cover provide adequate shielding for the plenum source. Moreover, if need be, the refueling canal can always be flooded for such contingencies. Head replacement would not be needed for decay heat removal, ALARA purposes or to assure subcriticality. Notwithstanding the lack of any overriding reasons to put the head back on the RPV, there is no reason why the head could not be replaced on the RPV and tensioned for pressure retaining capability for whatever purpose. This conclusion is based, in part, on a Technical Advisory and Assistance Group (TAAG) study (Reference 7) of replacing the reactor vessel head. The TAAG, an advisory group to TMI-2, concluded that present cleanup plans do not preclude replacement of the RPV head and tensioning for pressure retaining capability. Pressure retaining capability can be achieved by replacing a desired number of the RPV studs which have been removed and placed in storage. For example, as few as a dozen symmetrically replaced studs, tensioned to first pass elongation levels, would provide in excess of 300 psig of pressure retaining capability. We conclude that, for whatever contingency that might arise, RCS integrity can be reestablished at any time in the reactor disassembly and defueling program, should the need arise.

We have also considered the ramifications of leaving the head in place until further funding for years 1985 and beyond is absolutely assured. It is essential to recognize that meaningful progress towards the priority goal of reactor disassembly and defueling cannot be made with the head in place on the RPV. Leaving the head in place effectively stops the clock for reactor disassembly and defueling and, thus, lengthens the overall time necessary to complete cleanup once cleanup activities resume.

Inasmuch as plant deterioration will continue as a function of time, purposely delaying cleanup or establishing "hold points" when progress could be made has risks associated with it. We believe that it is clearly in the public interest to progress with cleanup, as funds permit, regardless of the lack of firmly committed funding in future years as the risks of proceeding are extremely small and the benefits are significant. We make this judgement based on our review to confirm that GPU's financial resources are adequate to maintain the reactor in a safe condition with the head removed or to replace the head on the RPV if the circumstances dictate.

5. Conclusion

In our review of the head lift program, we have considered the health and safety issues of decay heat removal, criticality, boron dilution, release of radioactivity, combustible gas generation, pyrophoricity, accident analyses, fire protection, and occupational exposure. Additionally, we have considered whether any aspects of head lift constitute an Unreviewed Safety Question and the long term safety of head removal. Based on our review we find that (1) "loss to ambient" cooling of the RCS will be sufficient for decay heat removal, (2) there is little potential for core recriticality either by core reconfiguration or boron dilution, (3) there is little potential for release of radioactivity in excess of typical trace quantities currently being discharged, (4) there is little potential for a combustible gas or pyrophoric reaction, (5) appropriate measures have been taken by GPU to minimize the potential for, and consequences of, postulated accidents, (6) the existing fire protection program is adequate to deal with the relatively small increases in combustible material, (7) there is little potential for worker overexposure and appropriate measures have been taken by GPU to maintain occupational exposures ALARA, (8) the head removal program does not constitute an Unreviewed Safety Question, and (9) there are insignificant risks related to removal of the head over the long term and, if need be, the head can be replaced on the RPV. We also find that the head lift activities and projected environmental impacts fall within the scope of those previously assessed in the PEIS (Reference 6).

We conclude that its safe to proceed with the planned head lift with minimal risk to the health and safety of the onsite workers and offsite public.

REFERENCES

1) Letter, 4410-83-L-0203, Kanga to Snyder, "Head Removal Safety Evaluation Report," October 11, 1983.

2) Letter, 4410-84-L-0014, Kanga to Snyder, "Head Removal Safety Evaluation Report," March 9, 1984.

3) Letter, Snyder to Kanga, "Head Removal Safety Evaluation Report," April 9, 1984.

4) Letter, 4410-84-L-0079, Kanga to Snyder, "Head Removal Safety Evaluation Report Additional Information," May 18, 1984.

5) Letter, Denton to Lewis, "Director's Decision Under 10 C.F.R. 2.206," February 17, 1984.

6) NRC Final Programmatic Environmental Impact Statement Related to Decontamination and Disposal of Radioactive Wastes Resulting from March 28, 1979 Accident at TMI-2 Nuclear Station, Unit 2, March 1981.

7) Seventh Report, Technical Advisory and Assistance Group, TMI-2, April 23, 1984.