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UNITED STATES OF AMERICA

OSART MISSION

GRAND GULF NUCLEAR POWER STATION

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REPORT TO THE GOVERNMENT OF
THE UNITED STATES OF AMERICA

NENS/OSART/92/62
GrandGulf.BMM/n
1992-12-01

PREAMBLE

This report presents the results of the IAEA Operational Safety Review Team (OSART) review of the Grand Gulf Nuclear Station, near Port Gibson, Mississippi in the United States of America. It includes recommendations for improvements affecting operational safety for consideration by the responsible authorities in the United States of America and identifies good practices for consideration by other nuclear power plants.

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FOREWORD

by the

Director General

The IAEA Operational Safety Review Team (OSART) programme assists Member States to enhance safe operation of nuclear power plants. Although good design, manufacture and construction are prerequisites, safety also depends on the ability of operating personnel and their conscientiousness in discharging their responsibilities. Through the OSART programme, the IAEA facilitates the exchange of knowledge and experience between team members who are drawn from different Member States, and plant personnel. It is intended that such advice and assistance should be used to enhance nuclear safety in all countries that operate nuclear power plants.

An OSART mission, carried out only at the request of the relevant Member State, is directed towards a review of items essential to operational safety. A full scope OSART review would cover eight operational areas: management, organization and administration; training and qualification; operations; maintenance; technical support; radiation protection; chemistry; and emergency planning and preparedness. Depending on individual needs, the OSART review can be directed to a few areas of special interest or cover the full range of review topics.

Essential features of the work of the experts and their plant counterparts are the comparison of a plant's operational practices with best international practices and the joint search for ways in which operational safety can be enhanced. The IAEA Safety Series documents, including the Nuclear Safety Standards (NUSS) programme and the Basic Safety Standards for Radiation Protection, and the expertise of the OSART team members form the bases for the evaluation. The OSART methods involve not only the examination of documents and the interviewing of staff but also reviewing the quality of performance. It is recognized that different approaches are available to an operating organization for achieving its safety objectives. Proposals for further enhancement of operational safety may reflect good practices observed at other nuclear power plants.

An important aspect of the OSART review is the identification of areas that should be improved and the formulation of corresponding proposals. In developing its view, the OSART team discusses its findings with the operating organization and considers additional comments made by plant counterparts. Implementation of any recommendations or suggestions, after consideration by the operating organization and adaptation to particular conditions, is entirely discretionary.

An OSART mission is not a regulatory inspection to determine compliance with national safety requirements, nor is it a substitute for an exhaustive assessment of a plant's overall safety status, a requirement normally placed on the respective power plant or utility by the regulatory body. Each review starts with the expectation that the plant meets the safety requirements of the country concerned. An OSART mission attempts neither to evaluate the overall safety of the plant nor to rank its safety performance against that of other plants reviewed. The review represents a 'snapshot in time'; at any time after the completion of the mission care must be exercised when considering the conclusions drawn since programmes at nuclear power plants are constantly evolving and being enhanced. To infer judgements that were not intended would be a misinterpretation of this report.

The report that follows presents the conclusions of the OSART review, including good practices and proposals for enhanced operational safety, for consideration by the Member State and its competent authorities.

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INTRODUCTION

At the request of the Government of the United States of America an IAEA Operational Safety Review Team (OSART) of international experts visited the Grand Gulf Nuclear Station (GGNS) near Port Gibson in Mississippi from 3 to 21 August 1992, to review the operating practices and to exchange technical experience and knowledge between the experts and power station counterparts on how the goal of excellence in operational safety should be further pursued. The Grand Gulf OSART review was the third in the United States of America.

The team (Annex I) was composed of experts from Canada, Finland, Germany, Japan, Spain, South Africa, Sweden and the United Kingdom and IAEA staff members with scientific visitors (observers) from Bulgaria, the Czech and Slovak Federal Republic and Mexico.

Before visiting the power station, the team studied relevant information made available to them to familiarize themselves with the power station's main features, important programmes and procedures and the operating record of recent years. At Grand Gulf, the team of experts, using techniques derived from their collective nuclear experience of 260 years, reviewed documentation on the power station's operational safety indicators, examined applicable procedures and instructions, observed work being carried out and held extensive discussions with power plant personnel. Throughout the period of review, there was an open exchange of experience and opinion between the power station personnel and the OSART experts.

Plant description

The Grand Gulf Nuclear Station (GGNS) is a single unit 1250 MW(e) (net) boiling water reactor (BWR) based on the General Electric Mark 6 design. The plant is owned and operated by the Entergy Corporation, the major electrical energy supplier in Arkansas, Louisiana and Mississippi. The site is 80 km southwest of Jackson, Mississippi, near Port Gibson. Construction began on Grand Gulf in 1974 and the unit was brought into commercial operation in July 1985. Entergy also owns and operates Waterford-3, a 1100 MW(e) pressurized water reactor (PWR) in Louisiana, and Arkansas Nuclear One (ANO), two 900 MW(e) PWRs in Arkansas.

The BWR-6 nuclear steam supply system (NSSS) was supplied by General Electric. The unit features an improved Mark III (pressure suppression) type containment. Main features of BWRs include the direct conversion of feedwater to steam within the pressure vessel, bottom entry control rods and use of a jet pump recirculation system coupled with a turbine pressure control system for ease of load following.

The reactor core consists of 800 fuel assemblies. Total uranium weight is 141 t with a total thermal output of 3833 MW(th). Reactor power is controlled by a combination of 193 control rods and the recirculation of reactor coolant using two speed pumps and flow control valves. Average enrichment of the uranium dioxide fuel for a reloaded core is 2%.

Steam is supplied from the reactor vessel after passing through the cyclone moisture separators and dryers to the 1800 rpm tandem six flow exhaust turbine. The condensers located directly underneath each low pressure turbine are cooled by water which is recirculated through a natural draft cooling tower. The regenerative cycle is completed with the return of feedwater to the reactor vessel after passing through condensate purifiers and low and high pressure preheaters to improve cycle efficiency.

Safety systems to cope with design basis accidents are provided in addition to normal and auxiliary systems. These safety systems include the protection systems, emergency power system, emergency core cooling systems and containment systems. The protective systems initiate a reactor scram (control rod automatic insertion) or actuate other safety functions whenever the limits of the safe operating range are approached. The emergency electrical supply system is supported by two diesel generators and associated controls for providing power to the emergency core cooling systems when required. The emergency core cooling systems have sufficient capacity and redundancy to maintain core cooling until the reactor is in a safe, cold shutdown condition within pressure boundary limits. Subsystems of the emergency core cooling system include the high pressure core spray system (HPCS), low pressure core spray system (LPCS), automatic depressurization system (ADS) and low pressure coolant injection (LPCI).

Main conclusions

In reviewing the Grand Gulf Nuclear Station, the OSART team was greatly impressed by the commitment of management and staff to the achievement of high levels of safety in the operation and maintenance of the plant. Entergy is a well managed utility, which actively supports Grand Gulf in its objectives of achieving excellent regulatory, operating and cost performance. Entergy provides Grand Gulf with clear policy direction, adequate personnel resources, and substantial operating and capital improvement budgets. Grand Gulf has received consistent high ratings during evaluations from both the Institute of Nuclear Power Operations (INPO) and the United States Nuclear Regulatory Commission (USNRC). The OSART confirmed these evaluations.

The OSART identified many positive initiatives which contributed to an environment of continuous improvement. These initiatives were supported by the corporate quality improvement programme. Corporate and plant management are highly visible and actively involved in direct daily contacts with plant staff, where they address

topical issues or reinforce objectives and goals. Many of the indicators of a strong safety culture were noted to be present. Grand Gulf has dedicated management and supervisory staff and well trained and highly motivated operating and maintenance personnel. Technical support at both the corporate and plant level is good. The plant utilizes many innovative techniques to improve plant performance from the standpoint of both nuclear safety and cost effectiveness.

In view of these comments and in fulfilment of one of the principal objectives of the OSART programme, the OSART members made a number of proposals for the consideration of the management of Entergy and Grand Gulf. Although Grand Gulf has had high annual capacity factors throughout its operating lifetime, it has also had a high number of forced outages due to reactor trips. Many of the trips were caused by instrumentation faults. It was recognized that a 'scram reduction task force' was addressing this issue but increased priority and improved management direction was recommended. The high levels of radiation exposure during outages were also of concern. Additional efforts to reduce sources of radiation exposure and contamination were recommended. Grand Gulf is very adequately staffed, but it was noted that technical support personnel were working excessive amounts of overtime during outages. A suggestion was made to re-evaluate and redistribute work loads. Suggestions were also made to improve and/or streamline some of the work approval processes. Owing to the design of the plant and in particular the poor quality of the service water, control of some of the plant chemistry parameters is an ongoing challenge. Additional suggestions were made to improve performance in this area by obtaining technical advice from BWRs in other countries around the world.

The preceding comments must be taken in context. Entergy, Grand Gulf and its staff are clearly demonstrating their commitment to safe operation. However, past accomplishments are not a guarantee of a safe future. This requires all staff to continue to be diligent and open to consider and implement measures to enhance nuclear safety. Having seen the determination of the management of Entergy and Grand Gulf to operate the plant safely, it is to be expected that the proposals will be addressed satisfactorily and implemented with appropriate priority.

1. MANAGEMENT, ORGANIZATION AND ADMINISTRATION

The Grand Gulf Nuclear Station (GGNS) is a well managed nuclear power plant with well qualified staff who are clearly committed to the corporate goal of excellence in the areas of regulatory performance, operating performance and cost performance while maintaining a high regard for people and processes.

The corporate structure strongly supports the integrated team efforts of the site staff with shared goals and objectives being very visible. Staff interviewed were enthusiastic and as individuals determined to maintain an environment of continuous improvement which is well supported by the corporate quality improvement programme. Regular staff surveys are made together with frequent face to face sessions between site staff and senior executives to ensure that issues are dealt with.

The goals and objectives are well documented and communicated and form part of the compensation process at the plant. Performance against these objectives is the subject of detailed reports which a e visibly posted.

The plant is reviewed by the nuclear industry (INPO) and by the regulator (NRC) on a regular basis and formal reports are issued. The plant has consistently scored highly in these assessments and is currently at the highest overall rating by each assessor. The safety record is extremely good and management attention is apparent. This attention is seen as managers move to shift work during planned or forced outages or in the plant tours they conduct. The staff are proactive and numerous examples could be seen of staff being prepared to challenge the status quo or being innovative. The station housekeeping is good and all plant activities show the result of high quality leadership.

1.1 Structure of the Corporate Organization, Responsibilities and Administration

Grand Gulf is a single unit nuclear plant and is one of three nuclear plants operated by Entergy Operations, which is part of Entergy, the major electrical utility in Mississippi, Louisiana and Arkansas.

A reorganization in 1990 combined all of the nuclear plants together into a single operating entity. One of the objectives of this reorganization was to provide a single focus and a better process to ensure nuclear safety. The corporate support functions for design engineering and operations are kept small in order to ensure that site support is located where needed, namely on site. Priorities and direction are set by the site operations group.

Policy making is seen to flow from the overall corporate policy. The corporation conducted extensive surveys of the nuclear industry which resulted in the establishment

of benchmarks to define excellence in performance. The performance indicators are regularly reviewed by corporate executive staff. Entergy Operations has a very vigorous practice of conducting site visits by senior executives. These visits not only focus on the performance indicators but include the personnel issues as well. The corporation has an active quality improvement programme in place.

In general, team work is evident, well supported by the fact that the majority of plant support staff are on site and have a well communicated common goal. All support functions (training, design support, quality assurance, etc.) are on site and are subject to oversight review by several internal and external organizations. These include INPO and the NRC as well as the corporate safety review committee.

Good practice: The senior executive visibility program with its attendant frequent site visits incorporates a feature called the 4Cs. They stand for compliments, convictions, concerns and comments. There is a structured facilitator led session with a selection of plant staff who generate flipcharted issues to be discussed with senior executives. On completion of this the senior staff come in and address all the issues. This provides face to face contact for staff with senior management and presents an opportunity for executives to reinforce values.

1.2 Plant Organization and Management

The Grand Gulf plant organization is defined by a clear organizational chart. Opportunities were taken to flatten the organization while ensuring that supervisory span of control was not excessive. There are 866 approved positions for the single unit station, which is deemed suitable for good operation.

Grand Gulf has a comprehensive set of goals and objectives. These plant objectives are cascaded to plant departments and units that formulate their complementary objectives. The performance against target is widely communicated by prominent displays in the plant and by means of corporate publications. The three major areas in which performance is measured are: high operating performance, high regulatory performance and low cost performance. These are complemented by a fourth area that addresses staff: people and processes.

Detailed administrative procedures exist for all plant activities. These are of a very high quality.

1.3 Quality Assurance Programme

The authority of the Quality Assurance (QA) Department is defined in the plant documentation. The Department has a staff of 44 but is assisted by external resources

to supplement audit capability. The QA staff are actively involved in the review and implementation of plant modifications. Inspection hold points are incorporated in work plans to ensure that standards are met.

The QA section comprises four units: Audits, Reviews, NDE and Inspection. Well written procedures cover all aspects of the Quality Programme activities.

Each year a programme of audits is published that combines mandatory and requested topics. The depth and quality of audits are of a very high standard. Findings are discussed with affected departments before publication in order to ensure that the facts and proposed actions are correct. An exit meeting for each audit is conducted with the Vice President of Operations present. All scheduled audits are completed and the quality deficiency reports (QDRs) that result are effectively dealt with. The average life of a QDR is about 90 days. The Quality Programme at Grand Gulf is subject to corporate audits on a regular basis.

1.4 Regulatory and Other Statutory Requirements

Grand Gulf is subject to the regulations of the Nuclear Regulatory Commission (NRC) in accordance with federal law. Responsibility for compliance with the requirements rests with the Vice President of Nuclear Operations at Grand Gulf.

Responsibilities for the interactions with the NRC are outlined in a set of site directives, which establish the process for achieving excellence in regulatory affairs. The site Nuclear Safety and Regulatory Affairs Department has established an extremely proactive programme to ensure nuclear safety. An example is the outage risk assessment programme.

> **Good practice:** The development of an outage risk assessment document and computer programme enabled rapid reviews of proposed activities to ensure that optimum selections of sequences of work activities were made to maximize nuclear safety. Examples of such review results were: when to lower the level of the suppression pool and the impact of using a freeze plug.

Grand Gulf has two resident NRC inspectors. In addition the plant is subject to periodic rigorous reviews called Systematic Assessments of Licensee Performance (SALPs). Grand Gulf has consistently scored highly in these SALPs and is currently at the highest rating.

1.5 Industrial Safety Programme

All staff undergo general employee training (GET) which incorporates industrial

safety training. An Occupational Safety and Health committee is in place which investigates accidents and pursues longer term safety issues. This committee is very proactive in its approach. All staff are required to attend monthly safety meetings. At the time of the OSART visit Grand Gulf had exceeded nine million man-hours worked without a lost time accident.

Plant staff generally comply with the plant safety rules. This is supported by line management in the form of plant tours that cover all plant areas. The plant safety co-ordinator was seen to be a visible presence in the plant. From time to time the policy on personal protective equipment was not followed but this was promptly resolved by line management. The plant has an excellent policy on the use of electrical extension cords; however, numerous examples of failure to follow this procedure were observed including use of extension cords in wet conditions.

(1) **Recommendation:** The policy relating to the use of extension cords at Grand Gulf should be reinforced with all staff and there should be a regular review of the work place focusing on extension cord use to ensure a return to compliance.

An adequate level of housekeeping existed in Unit 1 and the outlying buildings; however, a tour of Unit 2 identified a poor level of housekeeping as it applied to worker safety, which was in sharp contrast to that seen in other areas of the plant. While recognizing that Unit 2 is a construction area, the reviewers felt that the habits developed here could be carried over to other areas. In particular the lack of awareness of tripping hazards was noted.

(2) **Recommendation:** The plant policy on the worker safety aspects of housekeeping should be vigorously applied to all staff including contractors in Unit 2.

1.6 Fire-Fighting Programme

The plant has a governing policy on fire protection and several implementing procedures that clearly define the programme. There is also a comprehensive set of fire plans in place.

The fire-fighting role is performed by trained shift personnel. There is a minimum requirement for five staff per shift and this is adequately met, since all operators on shift are trained in fire-fighting. Training includes classroom and live fire-fighting practice. Continuing training is conducted once per quarter for each crew.

There are numerous access controlled doors in the plant which are part of an effective fire barrier that is strictly controlled and their use and significance are covered in general employee training.

The plant undergoes housekeeping tours by plant managers, but plant areas have not been assigned to a specific responsible person.

The installed fire protection facilities are in good material condition and all system and equipment inspections are conducted as scheduled.

The plant has a full-time fire protection co-ordinator with a full-time assistant. Fire crew training was conducted by a full-time person who has now left the company. This person continues to conduct the training on a part-time basis, and the full-time position has been eliminated from the organization.

(1) **Recommendation:** The use of part-time staff for the training of fire crews should be reviewed to ensure that quality is maintained, since a part-time trainer may be unable to maintain his skills or knowledge of the plant.

There is no clear policy on the use of flammable material storage cabinets, routine audits or a process to ensure that only compatible materials are stored in the cabinets. Two such cabinets were observed in a caged area, under cable trays and adjacent to an unsecured gas cylinder.

(2) **Recommendation:** The uncontrolled use of flammable material storage cabinets, with weak ownership, can result in the mixing of incompatible materials and increased risk of fire. A policy and procedure for the control of flammable material storage cabinets in the plant should be developed, with a clear definition of responsibilities.

1.7 Document and Record Management

The plant has an extensive range of policies and procedures that detail all aspects of work. Procedures may be subject to temporary change notices (TCNs), but there are clear requirements for the updating of documents which have such TCNs. There were a number of outstanding TCNs at the time of the OSART review but there was a definite action plan in place to reduce the numbers.

The plant has a record management system that conforms to ANSI specifications. All records are tracked with a computer based system that permits rapid retrieval and includes a comprehensive cross-reference capability.

The plant samples records every two years to ensure that they are not deteriorating. They monitor for film degradation, paper deterioration and the quality of magnetic storage material. Findings are followed up by laboratory analysis.

2. TRAINING AND QUALIFICATION

The Training Section is composed of a manager, an assistant manager, seven supervisors, and thirty-five instructors. All of them have a very high technical competence and good operational experience.

The Training Section has the responsibility for planning, organizing, implementing and recording training activities. Training facilities at Grand Gulf Nuclear Station (GGNS) are excellent and include a full scope specific simulator used for training and retraining of licensed personnel. Training facilities for I&C, mechanical and electrical maintenance and for chemistry are excellent.

Training principles at GGNS are based on INPO guidelines. Management involvement in allocating training resources and setting training policy is exemplary.

A Training Review Group has been established for each section and is an excellent means to pursue and feedback information on the implementation of the training programme, and to obtain the involvement of line managers and supervisors in the training of their staff.

Some of the improvements were suggested in the training area. These were related to the recording of the training activities performed outside the plant giving the training section the responsibility for specific training and retraining of technical support personnel; incorporation of an on-the-job training (OJT) process for health physics personnel; and the incorporation of the Chemistry Supervisor training process into the corresponding procedures. It was also suggested that the laboratory or practical part of retraining for chemistry personnel should be increased. It was finally suggested that a mechanism be developed to have the managers systematically attend the training and retraining courses.

2.1 Organization and Functions

The Training Section at GGNS has a well defined organizational structure with clear lines of communication between the different levels and departments. The Training Section has the overall responsibility for training at GGNS and is headed by the Manager, Nuclear Training. Over 90% of the training activities implemented at GGNS are performed by the Training Section. When training is contracted, both the contractor instructors and the course material are assessed by the Training Section prior to the training. The entire training organization at GGNS is dedicated full-time to training activities.

In order to ensure that training programmes are implemented and that line managers and supervisors are involved in the training process, a Training Review Group (TRG) for each section meets at least quarterly. Line managers and supervisors at GGNS are responsible for informing the Training Section about the training needs of their personnel.

Initial and continuing training programmes are established and implemented for key sections of the plant, and are based on job and task analyses. Continuing training programmes incorporate the feedback from supervisors. Attenders at the initial and continuing training programmes are assessed by examinations and training records are well maintained.

OJT is included in the programmes and the supporting material is well developed and maintained.

Good practice: In order to ensure that training programmes are implemented and that line management and supervisors are involved in the training process, a Training Review Group (TRG) for each section has been established that meets at least quarterly. This group is composed of personnel from the Training Section and from the corresponding work group.

The different requirements for instructor qualification depending on the category of trainees are clearly stated in specific procedures. A well structured training programme for instructors has been developed. Upon the completion of the corresponding training, a technical and/or instructional competence certificate is issued. Contract instructors are monitored and evaluated to ensure an acceptable level of technical and instructional competence.

GGNS has established a comprehensive process to record all training activities and to develop the related documentation. Individual training qualification cards are used to record the individual's current general employee, emergency response and health physics training as defined in his training qualification requirements. Training activities such as attendance at conferences, visits to other nuclear power plants, etc., should be integrated into the training records.

(1) **Suggestion:** Consideration should be given to implementing a process to integrate into the training records those training activities outside the plant (visits to other plants, attendance at conferences, etc.)

Good practice: An Individual Training Qualifications (ITQ) card is given to each person at the plant by the Training Records Group, and indicates those courses required by each qualification category and their expiry dates. Employees use ITQ cards in their possession to schedule their training and to demonstrate its

successful achievement. ITQ cards are updated by computer every time a course is completed.

2.2 Training Facilities, Equipment, and Material

All training facilities for GGNS personnel are located on site. They comprise in excess of 4000 square metres of space devoted to classrooms, laboratories, offices and a full scope, plant specific simulator. All these facilities are of a high quality and very comfortable. Electrical, mechanical, I&C, and chemistry training laboratories are of exceptional quality and have many mock-ups, models, items of equipment, devices, etc., identical or similar to those in the plant. Trainees can perform many different types of tests, simulations, etc. in the training laboratories, thus receiving high quality training.

Good practice: Training laboratories for electrical, mechanical, I&C and Chemistry personnel are of high quality and provide mock-ups, models, equipment and devices for high quality training.

GGNS has a full scope plant specific simulator at the training facility where licensed personnel receive simulator training. From a technical as well as a teaching point of view the simulator at GGNS is operated and maintained to a very high professional standard.

One shift crew was observed at the simulator during a requalification session. The prepared scenario included the use of Emergency Procedure Guidelines and activation of the Emergency Plan. The performance and quality of training were of a high standard.

Classroom material, reference material, video tapes, films, slides and view graphs used for training activities at GGNS were of a high quality. Some examples of lesson plans and handout material for students were examined. They were well structured and easy to use. Also, the OJT training material for several sections was reviewed and found to be of a high standard both technically and for teaching.

2.3 Control Room Operators and Shift Supervisors

GGNS presently has 21 license_ reactor operators (ROs) and 40 licensed senior reactor operators (SROs). The initial training programme for licensed personnel at GGNS has been accredited by INPO. In addition, the Code of Federal Regulations related to operators' licences (10CFR55) and other guidelines and standards have been considered in the definition of the programme. The programme is also based on the Job and Task Analysis (JTA) prepared for RO and SRO positions.

The programme for Reactor Operator Training comprises 1704 hours of classroom training; 600 hours of OJT; and 240 hours of simulator training. The Shift Supervisor Training Program (SRO) covers the training of two categories of candidates: upgrade SRO (coming from a licensed RO position) or direct SRO (coming from outside with education and experience to qualify for SRO candidacy). The duration of these programmes is 1292 hours for upgrade SRO and 2600 hours for direct SRO. (Both containing classroom, simulator and OJT periods).

Training for emergencies and communication and supervisory skills are included in the programme content. Simulator and walk-through examinations are given for each course and require a minimum grade of 80%. The NRC performs the final written examinations, the simulator examinations and the walk-through examinations.

The Licensed Operator Requalification Training programme has also been accredited by INPO. Time devoted to retraining is about 24 days per year, including 60-80 hours on the simulator. Topics are selected using the job and task analysis, feedback from trainees and trainers, and regulatory standards. Requalification examinations are given.

2.4 Field Operators

There are three different categories of field operators at GGNS: Nuclear Operator B (NOB); Auxiliary Operator Nuclear (AON); and Radwaste Operator (RWO). NOBs and AONs are trained and qualified for all buildings and non-radwaste related systems. RWOs are trained and qualified for radwaste related systems.

The initial training programme for Field Operators at GGNS is comprehensive and well structured.

Mechanical, Electrical, and I&C training laboratories are used to supplement the field operator training programme. Upon the completion of the classroom part of the programme (14 weeks for AON) the trainee goes on OJT. Trainees are assessed by examinations. The qualification period ends with a special walk-through examination by the Operations Superintendent or a designate.

Continuing Training is scheduled annually and follows the shift cycle. Involvement of line supervisors and managers in training is provided by the TRG (Training Review Group). The time allocated for continuing training appears very high (about 100 hours every year). Assessment is ensured by examinations with a minimum grade of 80%.

2.5 Maintenance Personnel

The maintenance section of GGNS includes: I&C, electrical, mechanical, and planning and scheduling departments. The initial training programme for maintenance personnel at GGNS is well structured.

The basis for the initial training programme development has been essentially the INPO Guidelines and the JTA. The programme includes classroom courses and practical training. Examinations are used to assess the knowledge acquired and require a minimum grade of 70%. Upon the completion of the classroom and practical part of the programme, the trainee goes on OJT. The initial training programme for supervisors includes one week of classroom training on supervisory skills. The line maintenance organization is heavily involved in training through the TRG.

Continuing training is scheduled annually as determined by the TRG. Supplementary training can be scheduled for selected personnel and/or tasks. Time allocated for continuing training is high, and is divided into 70% classroom training and 30% practical training. Assessment of trainees is performed by examinations with a minimum grade of 70%.

2.6 Technical Support Personnel

The initial training programme for technical support personnel at GGNS meets the accreditation criteria of INPO. The programme covers 340 hours of basic training, 68 hours of management training and 20 hours of simulator training.

OJT is organized by the related work group. This OJT is not controlled or supervised by the Training Section. Specific training for technical staff is necessary in order to achieve a high level of performance in specific tasks. This training should meet adequate teaching criteria and be organized in a systematic way. Emergency preparedness training is included in the programme. Examinations require a minimum grade of 70%.

(1) **Suggestion:** Consideration should be given to making the Training Section responsible for specific training for Technical Support personnel.

A continuing training programme for Technical Support personnel is conducted annually. Its duration is about 40 hours. Topics selected for continuing training include plant and procedural changes and industry experiences. Trainees are assessed through examinations with a minimum grade of 70%. Continuing training on specific topics for each area is not under supervision or under the control of Training Section. This training should meet adequate teaching criteria and be organized in a systematic manner.

(2) **Suggestion:** Consideration should be given to assigning the Training Section to be in charge of specific continuing training for Technical Support personnel.

2.7 Radiation Protection Personnel

INPO guidelines, job and task analyses and training needs of the plant were used to develop the radiation protection training programme. The programme is well organized and comprehensive. An examination grade of 70% or higher is required.

Upon the completion of the theoretical part of the programme, the trainee goes on OJT, but this step of the training programme is not stated in the procedure. Emergency plan and radwaste instructions are also contained in the programme. The health physics supervisor training programme is extended by having one week of supervisory skills training.

(1) **Suggestion:** Consideration should be given to incorporating the OJT process (health physics practical factors) into the procedure "Health Physics Training Program."

An average of 100 hours of continuing training are scheduled each year. The health physics organization is involved in this process through the TRG.

2.8 Chemistry Personnel

The training programme for chemistry personnel was developed using INPO guidelines, the JTA and Chemistry Section training needs. It comprises 648 hours of classroom training. The time dedicated to cover each topic is adequate and assessment of trainees is performed through examinations with a minimum grade of 70%.

On-the-job training (chemistry practical factors) completes the qualification process. Chemistry Supervisors undergo an additional one week training programme on supervisory skills; however, the supervisory training programme is not mentioned in the associated procedure.

(1) **Suggestion:** Consideration should be given to incorporating the Chemistry Supervisor training process into the procedure "Chemistry Training Program".

About 100 hours per year are dedicated to retraining chemistry personnel; however, use of the laboratory for continuing training is not very extensive. The Chemistry line organization is involved in the development and implementation of retraining programmes through the TRG.

(2) **Suggestion:** Consideration should be given to increasing the laboratory part of retraining for chemistry personnel.

2.9 Management Personnel

It is the policy at GGNS to fill vacancies in supervisory positions with staff from the department concerned. This ensures that they are technically competent; however, this policy is not always implemented for managers. The management positions are usually filled by managers from different sections of GGNS or from the corporate offices of the utility.

The training programme contains classroom training on basic technical topics, including simulator training. Management and supervisory skills courses are also included in the programme. Presently only supervisors follow this programme. Managers only attend the General Employee Training.

(1) **Suggestion:** Consideration should be given to implementing a method that ensures managers' attendance at initial training programmes.

A continuing training programme for management personnel is conducted annually and includes training on emergency procedures. The programme lasts about 40 hours. Managers were noted to be attending the continuing training programme irregularly.

(2) **Suggestion:** Consideration should be given to implementing a mechanism that ensures managers' systematic attendance on continuing training programmes.

2.10 General Employee Training

Several General Employee Training (GET) programmes are defined according to the different work related responsibilities. GET covers plant description, general plant information, quality programmes, security, industrial safety, fire protection, emergency preparedness and radiation protection.

Two examinations cover all the topics included in the courses. The quality of course material available for trainees is excellent. Practical training in radiation protection is performed as required.

GGNS has implemented requalification on all topics of the different GET courses for all the personnel of the plant. This requalification consists of giving the trainees the GET updated information in the form of a handout, a review of the course objectives, a question and answer period and an examination. A minimum examination grade of 70% is required.

3. OPERATIONS

The Grand Gulf Nuclear Station (GGNS) is staffed with well trained and competent operators. Dedicated and experienced off-shift personnel provide excellent support and operations management is committed to excellence. Procedures and administrative control systems are thorough and all encompassing and are strictly implemented.

Staffing numbers on shift are well above the minimum requirements. The practice of performing on and off shift post trip analyses in order to determine correct operation of plant equipment after a reactor trip (scram) and to determine root causes was commendable.

Operating procedures are written and reviewed in a well controlled manner by competent reviewers. Operating errors, while not abnormally excessive, have received management attention. The self verification program and independent verification of sensitive operations clearly demonstrated a desire to enhance nuclear safety. The decision to upgrade the plant process computer, which will provide better plant monitoring from the control room, is commendable.

The operators at GGNS work on different cycles and shifts according to their status. While there may be some advantages in split teams, it was felt by those interviewed that improvements in team spirit and communication are more important, and that working together in a regular team is preferred.

In evaluating the operating history it was found that Unit 1 has experienced 73 reactor trips since it was declared in service. A few of them were manual shutdowns for valid reasons; however, the high number was a concern. Many of these derived from instrumentation problems. Management has recognized the need to correct the situation and formed a "scram" reduction task force. The committee has recommended enhanced preventive maintenance, improved root cause analysis and better management direction. It was encouraging to note that few of the scrams were due to operator error.

A visit to the control room revealed many alarms present and a high number of tags on panels indicating inoperable equipment, some for over one year.

When starting up the unit after an outage trip, there are frequently partially operable nuclear instrumentation systems. A policy of maintaining reactor protection systems fully operable at all times was recommended. The loss of essential auxiliary systems due to planned or unplanned maintenance was not always recognized to entail a loss of the affiliated safety systems. This could result in safety systems being inoperable longer than originally intended.

The authorization and control of work are well managed, but the absence of locks or similar blocking devices when isolating high voltage or pressure systems was a cause for concern.

An inspection of the plant found a clean and tidy environment with some exceptions. A number of incomplete modifications and a number of personnel hazards were identified.

3.1 Organization and Functions

The Operations Superintendent, under direction of the Manager, Plant Operations, is responsible for all plant operations, including radwaste activities, and is in turn assisted by the Shift Superintendent, the Radwaste Supervisor, the Fire Protection Co-ordinator, and the Operations Assistants and Co-ordinators.

The functions and responsibilities for all positions in the Operating Department are clearly defined in various procedures.

Each shift is composed of three Senior Reactor Operators (SROs). The Fire Team leader must be an SRO.

(1) **Suggestion:** Consideration should be given to transferring the role of Fire Team Leader to either the Shift Engineer or one of the unlicensed operators, thus ensuring that all three SROs remain in the control room during a fire that could initiate the emergency plan.

In addition to the three SROs, there are normally three Reactor Operators (ROs), a Shift Engineer, and six unlicensed operators, plus three operators on radwaste systems.

This relatively large team for one unit is a clear indication of management's commitment to safe operation under all conditions, attested to by the fact that few of the many scrams were attributable to operator error.

The supervisory staff work in six shift cycles of twelve hours per shift while the ROs and unlicensed operators work a five shift cycle of eight hours per shift. Despite the advantages of the arrangement, communication between shift members could suffer. A strong cohesive team is essential for nuclear safety. Operators working together frequently form a strong bond which, when managed well, improves strengthens a sense of ownership of the plant.

The maximum period that an operator may work excluding shift handover is 16 hours. This is linked to the 12 hour shifts worked at GGNS. Long working hours, especially during startup after an outage, could result in human error. Shift Engineers

as SROs in training do not work in RO or unlicensed positions. Benefits in terms of team spirit and supervision could be obtained if supervisors have gained some experience in subordinate roles.

(2) **Recommendation:** In the interests of enhanced nuclear safety, all parties should strive for cohesion on shift by working similar cycles.

(3) **Recommendation:** The maximum permissible duration an operator is allowed to work should be reduced to 14 hours if the 12 hour shift remains or 12 hours if working an 8 hour shift cycle.

(4) **Suggestion:** Shift Engineers should be allowed to work in subordinate roles for short periods to gain practical experience.

Good practice: The shift manning numbers are well above the minimum requirements. This ensures adequate staffing during emergencies and provides for additional supervision and overview.

3.2 Operating Facilities and Operating Aids

The control room is not spacious but is well organized with systems arranged in an orderly fashion. Control room annunciators are color coded based on the severity of the alarm; however, these are not clearly distinguishable in the event of an accident. The safety parameter display system (SPDS) is available at the Shift Supervisor's console, enabling him to determine plant status during both normal and accident conditions. The SPDS is also available at the Technical Support Center (TSC) and Off Site Support Center (OSSC). In addition, a process computer, balance of plant (BOP) computer and a General Electric transient analysis system (GETARS) are installed in the control room. These process computers are becoming obsolete and an integrated process computer system is being installed. Grand Gulf Nuclear Station has a good vibration monitoring system. Twenty six pumps and turbines are monitored continuously by this system.

(1) **Suggestion:** Consideration should be given to the installation of an alarm control system computer. This system would provide greater assurance that control operators notice all alarms.

Emergency shutdown is available from a remote shutdown panel. The procedures for this system, which interface with the emergency plan, are provided.

3.3 Operating Rules and Procedures

The Operating Technical Specifications (OTS) are written and approved according

to a thorough authorization process. Adherence to the OTS is management policy and provision is made for interpretation of requirements; however, it is rarely required. The established aim is to take the reactor to criticality with all essential equipment operable. This is not always possible owing to the many failures of the reactor nuclear instrumentation.

(1) **Recommendation:** Every effort should be made to ensure that the plant starts up with all safety and reactor protection systems fully operable. This is especially true after outages when the opportunity exists to take corrective action. This policy would permit the loss of additional equipment during operation without requiring a forced shutdown.

Procedures are written, reviewed and authorized in a well controlled and documented manner. A cross-reference system ensures that the impact of changes is verified by correct correlation to source documents. A number of directives had temporary change notices (TCNs) appended.

(2) **Suggestion:** Consideration should be given to expediting the process to include TCNs into procedures as soon as possible to avoid having to operate with TCNs for long periods of time.

Good practice: The procedure review system ensures that thorough verification is made prior to changes and that only well trained and competent reviewers alter the procedure.

A review of the operating procedures in the plant indicated that they are adequately stored and accessible where needed most. The Shift Supervisor has access to a computer program and is required to verify that the procedure about to be used is the latest revision. In addition, an overall verification of the correctness of the revision in use is conducted every two years.

Provision is made for independent verification of safety related operations. Checklists are used to ensure OTS compliance prior to changing plant states.

Emergency operating procedures include both event based and symptom based procedures. The event or off normal event procedures (ONEPs) deal with a large range of design basis events. Entry into the symptom based or emergency procedures occurs if plant conditions are determined to be beyond the design basis. Regular drills and training ensure that the operators remain familiar with the content of the procedures and the local actions required.

The emergency procedures have been transposed onto a plastic card for easier use. An inspection of a procedure in the control room revealed that it was not marked controlled and was at the incorrect revision.

(3) **Recommendation:** The plasticized emergency procedures in the control room should be kept up to the same standard as all other operating procedures. They should be marked as controlled copies at the latest revision number and replaced when they become tattered or difficult to read.

3.4 Operating History

The operating history of GGNS is characterized by a good capacity factor but coupled with a high forced outage rate. The most common cause of the high trip rate is component failure. Increased management efforts have recently been focused on trip reduction and improvements to the condenser vacuum, feedwater and nuclear instrumentation systems. The number of incident reports was noted to be tending upwards.

The high numbers of alarms and tags on panels two months after the end of the last outage were a cause for concern. Management has recognized the need to reduce work backlog in all groups and has an active programme to do so.

There have been six reactor trips from loss of vacuum since 1985. The off-shift analysis reports for these incidents as well as the off-shift analysis report on a recent trip due to high flux were reviewed. While none of these trips were directly due to operator error, there were apparently no recommendations dealing with what operators should do should similar events recur.

(1) **Recommendation:** Operations should intensify their efforts to reduce the numbers of control room alarms, equipment out of service, red tags, etc., especially when returning the unit from outage. A policy of having no limiting conditions for operation or alarms present at the end of outages is recommended.

(2) **Recommendation:** Present efforts should be increased to find long term solutions to technical causes of reactor trips.

(3) **Suggestion:** Consideration should be given to developing a means of preventing future trips by maximizing the lessons learned from past trips. The Operator Training Section should perhaps be called in to analyse trips with the aim of identifying methods of preventing recurrence even if the cause was not operator error.

Operating management has identified the need to improve the quality of operations and initiated self-verification training and awareness. This is commendable and it is encouraging to discover evidence of this in the plant and on the simulator. A

proceduralized post-trip on- and off-shift analysis ensures that a thorough assessment is made to determine root causes and confirm correct operation of all systems.

Good practices:

(1) The self-verification program will enhance staff's sensitivity to safe operation and will give nuclear safety priority over production.

(2) The on- and off-shift post trip analysis is a thorough process of determining correct operation of plant after a scram and to determine root causes.

3.5 Conduct of Operations

Conduct of operations at GGNS is controlled by a formal procedure that delineates responsibility for different levels of operators on shift and what is expected of them to ensure nuclear safety.

The control room atmosphere was found to be professional. Formal communication was utilized to minimize the potential for operator error. Many systems existed to control work and to ensure that all known plant defects or events were documented and reported. Discipline on the use of these systems appeared good and these systems are used, although a few operators felt that there was duplication of some systems or overlap of the areas they covered. An operator error could end up reported as an incident report (IR) or a quality deficiency report (QDR) or could initiate the human performance evaluation system (HPES). This could make assessment of operator error difficult.

Shift handover by all licensed staff is conducted in the control room and occurs at different times because ROs work a different shift cycle to SROs. Control room activities were well controlled and alarms were responded to promptly. The number of alarms continuously present and defective, the number of LCOs, and condition identifier (CI) stickers on the panels were causes for concern. When faced with production pressure, attitudes towards nuclear safety were found to be sound, although at the end of an outage it was felt that pressure to start up could be the overriding factor and some short cuts could be taken.

Generous shift staffing ensures that after a trip there are adequate resources to handle control room duties safely. During normal operation, one SRO always makes a point of inspecting the plant. The present manning levels were considered to contribute to nuclear safety.

Most staff interviewed felt that the split in shift cycles, resulting in different teams handing over at different times, was detrimental to nuclear safety as it resulted in

inconsistent communication quality and uncertainty. Team spirit could be weakened as one party does not always know the manner of working and communicating of the other, and misunderstandings could occur. No significant errors were given as examples, but a feeling of uneasiness prevailed.

The field operator uses a hand held data logger to record all inspections and the values of various parameters during routines field inspections. He inspects the plant for abnormal noises, vibrations and temperatures. The data logger is down loaded onto a PC for scrutiny by the Shift Supervisor and for use by day shift engineering staff. It was encouraging to hear that senior managers are often seen in the plant.

The installation of remote television cameras around the turbine to reduce radiation exposure was found to be a good idea. However, in some cases, a thorough inspection of the turbine by came a was not possible owing to inadequate lighting or poor picture quality.

(1) **Recommendation:** The present installation of television cameras, cables and lighting for the surveillance of the turbine should be completed.

Other modifications in the plant were found to be incomplete, such as the fitting of an air conditioning unit in the condenser cooling pump station for the cooling of the generator protection systems and the removal of the auxiliary boilers, and some valves fitted to modify a service water system were found to have no labels.

(2) **Recommendation:** All permanent and temporary modifications should be completed on schedule, including the updating of documentation.

Plant cleanness in some areas was in need of attention. This was especially true of the condenser circulating water pump station, the fire water pump station, the post-accident sampling instrumentation rooms and some areas inside the containment. Lighting was also poor in some areas of the containment.

There were many tripping hazards owing to bolts protruding above the floor. The presence of Fyrequel (EHC fluid) around the plant without any warning signs of the dangers of the fluid was a concern. The 125 V DC battery rooms D&E were found to have no warning signs for the danger of unprotected lights. Some pipes were found not to be colour coded.

(3) **Recommendation:** Management's attempts to maintain the plant clean and tidy should be strengthened.

(4) **Suggestion:** Consideration should be given to performing a survey of the reactor building to determine the adequacy of lighting.

3.6 Work Authorization

All scheduled work is co-ordinated by the Planning Department and discussed at three daily meetings. The risk of planning work on two safety trains simultaneously is avoided by scheduling work on a given week day to the same train each week so that all staff are aware of which trains may be affected.

Daily programmes are issued and running accounts are kept of safety system unavailability and the number of outages on specific components. The outage of some auxiliaries was not recognized in all cases as the cause of inoperability of the equipment they serve. For example, when the essential service water is isolated, the diesel it cools is declared inoperable, but the other auxiliaries it services are not necessary declared inoperable. A limiting condition of operation is therefore not declared on these components and the number of hours of inoperability is not noted. In the interests of improving nuclear safety, the inoperability of safety systems should be minimized as much as possible. This may mean changing maintenance philosophy from a time based to a performance based programme with the intention of reducing the number of planned interventions.

(1) **Suggestion:** Consideration should be given to declaring equipment inoperable, despite being functional, whenever any essential auxiliary is lost. The accounting of inoperability time under these circumstances would reflect the total time that the component was unable to fulfil its design function.

The existing equipment isolation system at GGNS is clear and comprehensive. The authorization of staff involved is thorough and responsibilities are detailed. The method used to isolate equipment does not require the application of locks or similar controlled devices. The application of a red tag to the point of isolation is considered adequate to ensure worker safety. This is considered sufficient even for the isolation of high voltage and pressure boundary points. A routine check of all red tags is made to ensure their placement on the plant and to replace damaged tags.

(2) **Suggestion:** Consideration should be given to using locks and independent verification to ensure that no staff injury is possible when isolating high voltages and pressures. This is considered to be international practice.

Post-maintenance testing at GGNS is well controlled from the time the scope of maintenance is decided. There is excellent guidance given on which type of testing is necessary depending on the function of the system to be maintained. Planning decides on which tests are to be done, the shift confirms, and the operating assistants verify the results.

An assessment was made of the temporary modification system by reviewing the procedure, talking to staff and walking down a number of these work control permits. The system is thorough and appears to work well.

The controlling procedure allows temporary modifications to be installed prior to Plant Safety Review Committee (PSRC) approval with the requirement that they be removed if the PSRC disapproves.

(3) **Suggestion:** Consideration should be given to requiring PSRC approval for all temporary modifications on safety related equipment prior to installation.

3.7 Accident Management

The station has implemented emergency procedures in the flow-chart format following the Boiling Water Reactor Owners' Group Emergency Plan Guide. The Operations Superintendent has overall responsibility for verification of the emergency procedures and their validation. There are four flow-charts which address different situations. The licensed personnel, such as control room operators, shift supervisors, shift superintendents and shift technical advisors have received training and understand the use of these flow charts.

4. MAINTENANCE

The maintenance organization at the Grand Gulf Nuclear Station (GGNS) is well organized and effective. The Performance and System Engineering (P&SE) Section also provides a very strong supporting force to the maintenance organization. The responsibilities of the maintenance organization and P&SE are clearly defined and they co-operate well.

The Maintenance Department has a written philosophy that is considered a good practice. It constitutes the basis of the safety culture of the maintenance staff and is the source of maintenance goals and objectives.

Several meetings during a normal working day between different plant organizations constitute a basis for good communications between the plant departments and sections.

A computerized work control system covers all work on plant equipment and facilities. The system in use is SIMS (Station Information Management System). It is easy to use, covers work on components, contains equipment history and works as electronic mail, thus ensuring a liaison between the different organizations.

Maintenance performance indicators showed that the backlog of work orders was quite high. The maintenance organization was well aware of the fact and was working to decrease the backlog to meet plant goals.

Equipment was well maintained but tags on equipment in the control room indicated many items of equipment with outstanding work orders or tagged out of service (primarily recorders).

In the area of housekeeping, the extensive painting programme which has been implemented should be mentioned. But housekeeping was not at the same level in all parts of the plant, and it was suggested to implement all efforts to improve the status.

Maintenance workshops are well equipped but they are generally too small. Plans have been made to extend them. However, instrument and tool calibration facilities are very good and well equipped.

Contact between carbon and stainless steel should be prevented. A procedure for materials handling addresses this requirement, and it was suggested that it should be implemented.

A bar code system is used to identify tools. A good feature is that this bar code system binds the work order, the tool and the worker together.

The number of maintenance procedures is large, but they are of good quality and are kept updated.

Preventive maintenance and predictive maintenance programmes are good and effectively support nuclear safety. Reliability centred maintenance on some systems has given good results. This is commendable.

4.1 Organization and Functions

The maintenance organization at GGNS falls under one of the managers reporting to the General Manager, Plant Operations. The Maintenance Department consists of 252 persons in five main sections: mechanical, electrical, I&C, planning & scheduling (P&S) and plant services. The responsibilities and tasks of these different sections are clearly defined.

The Maintenance Department has a written philosophy that constitutes the basis of the maintenance goals and objectives.

The responsibilities of the maintenance staff and interfaces with other departments are clearly defined in procedures. Several meetings held during a normal working day between different plant organizations constitute a basis for good communications between departments and sections.

The quality assurance programme guarantees adequate assessment and generates frequent audits, monitorings and inspections of the maintenance organization and maintenance tasks.

Communication with other organizations is ensured by daily meetings. A morning "plant status" meeting is held to prioritize planned and emergency work. A "Daily Status Report" is prepared and distributed informing all plant personnel about the status of plant operations and the scheduled work activities. A manager's meeting is also held in the morning, which defines the day's work. Problem areas are discussed and additional meetings are scheduled if required. In the afternoon a meeting is held to review the weekly schedule, to discuss the status of the day's priority activities, to add work order items to the weekly plan, to turn in tagouts for the next week's work and to discuss activities for upcoming system/component outages.

> **Good practice:** The written maintenance philosophies can be seen at different places, in procedures as well as on boards, on notice walls in the control room passage, in the meeting rooms and in the managers' offices. The philosophy is based on the safety culture concept and sets goals for the maintenance staff to

strive for high professional standards. The corresponding performance data are published in the Grand Gulf Nuclear Station Maintenance Performance Report.

4.2 Maintenance Programme

A work control system covers all work on plant equipment and work in maintenance facilities. The work control system is based on extensive computer use. The system in use is called SIMS (Station Information Management System), a computerized maintenance management tool which is easy to use, covers work on components, contains equipment history and functions as an electronic mail system, thus ensuring liaison between many organizations. History records of completed work are in SIMS, as well as on microfilm in archives. This allows planners to have direct access to equipment history. Maintenance performance indicators are published monthly in the "Maintenance Performance Report".

4.3 Material Conditions, Facilities and Equipment

A tour of the site indicated that the equipment is generally well maintained, although a lot of equipment in the control room had tags indicating outstanding work or was tagged out of service. Planned modifications to change chart recorders will reduce this problem. No major leakage from equipment was observed during the plant tour. Housekeeping was good in most areas such as the auxiliary building, containment and turbine building, but in some areas it was not at the same level as observed in other parts of the plant. Debris was observed in enclosed areas around switchboards and behind panels. Old tape traces should be removed from the switchboard panels.

(1) **Suggestion:** Consideration should be given to improving housekeeping in some areas on site. One solution could be to assign the areas to well identified responsible persons, the duration of this responsibility being long enough to develop a sense of ownership.

Each working group has its separate facilities and, although they are well equipped, they are generally quite small. The instrument workshop near the control room was found to be in poor condition. It needs to be upgraded to the main shop standards, as already planned, and this should be done as soon as possible. The active work shop is well equipped but overcrowded with equipment. The decontamination room is very small, obliging personnel to perform some decontamination jobs in other areas.

Maintenance tools are well managed and the facilities to store and maintain them are adequate. A good bar code system has been created to control the use of tools. The instrument and tool calibration facilities are in separate, clean and orderly rooms, and

the calibration programme is good. Valve actuator monitoring and testing equipment is widely used at the plant.

Good practice: A bar code system is used to identify tools. The code binds the work order, the tools and the worker together. This increases plant safety, as loose tool control is also improved, and this has also a long term economic benefit. Work preparation is also improved, as the system helps to identify the right tools needed for a specific job.

4.4 Procedures, Records and Histories

All maintenance work is performed against written and approved work documents and/or work instructions in accordance with maintenance policy. The procedures and work instructions used by the maintenance organization are technically accurate and up to date. System engineers are responsible for writing all maintenance procedures. The practical procedures are reviewed during implementation or every second year if not used during the two year period. The existing procedures can be changed using the "Temporary Change Notice Cover Sheet" and changes can be triggered by feedback from maintenance personnel. Corrective maintenance packages are prepared by the Planning and Scheduling Section. The comprehensiveness of these packages is outstanding.

The maintenance history is a part of SIMS. All staff have access to the SIMS history data. This creates a good basis for further work planning activities. The results of tests and measurements are stored in the System Engineers' files and in statistical records, after being reviewed by the corresponding System Engineers, who perform root cause analyses of maintenance problems and trend analyses to identify generic problems.

4.5 Conduct and Control of Maintenance Work

The work control system SIMS is an excellent system to follow and control work preparation and execution. Work details and schedules are discussed during daily meetings. The backlog of work orders was, however, quite high, as was the number of work orders older than 90 days. The maintenance organization was aware of these numbers and was working hard to decrease the numbers in order to reach the plant goals. There was a downward trend in place at the time of the OSART review.

4.6 Preventive, Predictive and Corrective Maintenance

Preventive maintenance (PM) and predictive maintenance schedules and guides are well controlled and the system engineers authorize changes to the programme. All

the repetitive tasks are included in SIMS, such as preventive and predictive maintenance tasks.

Work orders for PM and predictive maintenance jobs are produced by SIMS. The planning and scheduling section makes up job packages indicating the time frame in which the job must be carried out. PM, as well as predictive maintenance, is based on a ten year programme and covers all equipment important to nuclear safety and plant availability. A new reliability centred maintenance (RCM) programme was launched in January 1991. It provides a well documented engineering basis for selecting maintenance strategies for components, thus optimizing the PM programme while ensuring maximum equipment availability at reasonable cost. Good results have been achieved on the five systems on which RCM has been used so far. After completion of PM activities on a specific piece of equipment, its condition is evaluated using a numerical code. This provides the system engineers with a tool to analyse the effectiveness of PM and equipment status. This method of assessing the effectiveness of PM is commendable.

The system engineers collect equipment performance data by predictive maintenance measurements, such as vibration measurements.

The ratio of preventive to total maintenance is about 60%. However, the number of late PMs is presently higher than the plant goal and efforts are being made to reduce the backlog.

A condition identifier (CI) document is used to identify any maintenance problem found in the plant. A CI is converted into a work order (WO) and is called a CI/WO. The SIMS database retains the equipment description, work instructions, data sheets and attachments from maintenance procedures. Items stored in the database can be copied into the WO packages electronically.

The corrective maintenance work observed was carried out using detailed procedures. Equipment was properly isolated and the quality of workmanship was good.

The work history is entered into SIMS maintenance history for all work performed by work orders monitored by SIMS. When the engineering review group reviews the WOs, those which have been marked "indeterminate on component malfunction determination" are transmitted to the responsible system engineer for root cause analysis and equipment failure identification.

4.7 In-service Inspection (ISI)

The in-service inspection programme ensures that the surveillance requirements for inspection and testing of components as described in the appropriate ASME codes are met. The plant is in the process of digitizing all radiographic and X-ray films dating

back to the construction period. This technique will help to retain all information from the old films.

4.8 Stores and Warehouses

The Materials, Purchasing & Contracts Department is composed of a Materials Technical Section, a Materials Management Section, and a Purchasing and Contracts Section.

The Materials Technical Section is responsible for establishing technical and quality requirements, monitoring of spare parts, determining the shelf-life programme, determining the maintenance and receipt inspection requirements for items entering the warehouse, and determining minimum and maximum storage quantities.

About 60,000 items are stored in the warehouse. The storage in the warehouse is crowded but planned reductions in inventories should alleviate this. Environmental conditions are good and humidity is monitored. Safety-related components are properly identified and separated from non-safety-related spares. Preventive maintenance on stored equipment is well organized. Non-conformance items are kept in a separate enclosed area. It was noted that stainless steel plates were being stored on pallets that contained rusty nails. Contact between carbon steel and stainless steel could increase corrosion.

(1) **Suggestion:** Consideration should be given to preventing contact between carbon steel and stainless steel by using inert materials to separate the two materials.

5. TECHNICAL SUPPORT

Technical support was reviewed in the areas of organization and technical support functions, including the scram reduction programme, surveillance test programme, operational experience feedback, plant modifications, reactor engineering, fuel handling and computer capabilities.

The technical support functions at Grand Gulf are provided by a number of plant and utility departments, sections or groups. In practice several departments may collaborate in the provision of a particular technical support function. However, the team found that owing to the well structured management manual and well written procedures and the conscientious approach of the staff, there were no major areas of weakness. The combined efforts of these various groups have in general been successful, although the sharing of duties and responsibilities produces an environment in which communications and the setting of priorities can often be difficult.

The staff responsible for technical support activities are well qualified, knowledgeable, enthusiastic and well aware of their responsibilities. Some of the system engineers are overburdened with work, especially during outages.

The lack of results of the scram reduction programme was noted. This could be attributed to the late introduction of the programme. However, a suggestion was made to assign the programme to a senior manager with the sole responsibility for co-ordination.

The surveillance test programme for the plant contains all the necessary key elements. The programme covers all types of tests and is tracked by a computer system which makes sure that all necessary procedures are included when tests are performed. Good procedures have been implemented for trending of test results. The programme also includes extensive use of vibration analysis techniques. This was identified as a good practice.

In the area of operational experience feedback, suggestions were made to analyse root causes of more events and to expedite requested corrective actions.

Plant modifications programmes were found to be models of thoroughness which exceed those at most nuclear power plants.

Reactor engineering and fuel handling were found to be well documented and managed. Advanced computer codes are available on site and at the corporate office for evaluation of reactor core performance. Some suggestions were made to optimize fuel handling performance.

There are no major suggestions in the computer capability area other than to implement as soon as possible the integrated plant data system and to expedite the installation of the computer network on site.

5.1 Organization and Functions

Technical support functions for Grand Gulf are assigned to different departments at the power plant and to the Design Engineering Department which is part of the corporate Entergy Operations organization. Most of the Design Engineering Department is located on site. The Design Engineering organization is large (125 employees) and for most design needs of Grand Gulf it is self-sufficient. The co-operation from all employees of the different departments and sections appeared to be good. Co-operation is based on good relationships between the employees at all levels and in particular at the management level.

There are adequate resources for the technical support function and the qualification levels and experience of technical support personnel were found to be appropriate.

Availability of computer hardware and software support is very good. Internal quality assurance review functions are well established.

Twenty five system engineers are responsible for the technical support function for almost 250 systems and support Operations and Maintenance when there are problems with plant systems. All changes to a system must be reviewed by the system engineer. With this organization Operations and Maintenance have access to high quality personnel with good knowledge of station systems. This function also provides a means of communication between the Operations and Construction Departments. It was noted that system engineers were overburdened with work during normal operations and in particular during outages.

(1) **Suggestion:** Consideration should be given to reducing the workload (overtime work) of system engineers without jeopardizing the important support they provide to the plant's safe and reliable operation.

The operating history of GGNS shows a large number of scrams. A detailed list of modifications based on root cause analyses of the scrams has been prepared. A detailed list of procedural changes has also been prepared. Altogether this is a very comprehensive programme. The programme has high priority within the management team but sole responsibility for the scram reduction programme and its implementation has not been assigned to a senior manager. A well documented report with root cause analyses was prepared in 1991. The lack of appropriate results could be attributed to the late introduction of the programme.

(2) **Suggestion:** Consideration should be given to assigning the scram reduction programme to a senior manager with the sole responsibility for co-ordination of the programme.

5.2 Surveillance Test Programme

The responsibility for maintenance of the Plant Surveillance Programme is assigned to the Performance and System Engineering Section (P&SE). Each system is assigned to a system engineer who has responsibility for technical support for the system, which includes setting up an appropriate test programme for the system. The basis for designing the test programme is regulatory requirements and vendor specifications.

All test schedules are kept in a database, the Surveillance and Repetitive Task programme (SIMS). The programme includes an extensive use of vibration analysis methods to monitor changes in rotating equipment.

Engineering reviews take place in the Engineering Support group (ES) in P&SE, which issues a daily list of tests to be performed during the upcoming 14 day period.

All results are reported back to the ES groups for documentation and trending. The results are also transmitted to the system engineer who is responsibile for the system. If the results are not in accordance with what is expected, the system engineer must ensure that corrective actions are taken. All test results are microfilmed and can be retrieved for analysis and trending.

Good practice: All major rotating equipment is monitored by a computerized vibration analysis programme. The programme takes "fingerprints" of the equipment. This provides a tool for early detection of degradation and allows time to take preventive action before a component breaks down.

Surveillance programme co-ordination with other activities is provided at a daily meeting with the personnel in charge of Maintenance and Operations. At this meeting the time schedule is agreed upon for performing the tests. Test sheets indicate all activities including regulatory penalties if tests are not performed.

5.3 Operational Experience Feedback

Operational experience feedback (OEF) is provided by the Nuclear Safety and Regulatory Affairs Department. The programme looks at items such as: technical inadequacies, radiological events, system or component inoperability, equipment failures, transient upsets (scrams, turbine trips) and common mode failures. It does not evaluate

human performance errors, near misses or industrial safety items. These are tracked by other work groups.

(1) **Suggestion:** Consideration should be given to increasing the number of events which are analysed in depth using root cause analysis.

Well developed procedures exist for screening, evaluation, distribution and feedback of OEF reports. Root causes of reactor scrams and LERs are analysed in the reports. Other events are not analyzed in depth. Criteria for initiation of significant event reports are provided and all events are entered into a computer based event file. A number of items were noted for which corrective actions were slow.

(2) **Suggestion:** Consideration should be given to improving the closeout of actions requested by the OEF programme.

Evaluations are performed by engineers in the OEF section who have been appropriately trained. External events are treated in the same way as events initiated at GGNS.

The Human Performance Evaluation System (HPES) started in 1988 following the INPO initiated programme format. Management attention to the programme is adequate but it appears that greater priority has been given to actions that bring results quickly (one year or shorter).

(3) **Suggestion:** Consideration should be given in the HPES programme to raising the priority of actions that require longer times to close out.

5.4 Plant Modifications

Plant modifications are managed in three phases. Initiation of the request for modification, which includes assessment, evaluation and approval of the request; design of the modification; and implementation of the modification. The Plant Manager approves all requests for modification and later in the process approves implementation of all modifications that are carried out in the plant. All activities associated with the modification process are well described in formal documentation and procedures.

Corrective actions are implemented if anything in the process goes wrong. Quality deficiency reports are initiated, a working group is formed and root cause analysis is performed. Justification for modifications is provided by the Design Engineering Department. Modifications are reviewed at meetings where safety, reliability and budgetary considerations are discussed. Some utilities and power plants use probablistic risk assessment techniques.

(1) **Suggestion:** Consideration should be given to implementing probablistic risk assessment techniques for optimizing the modification programme.

The procedure for making safety related design changes, which is used also for non-safety-related modifications, required eleven signatures (eight reviews and three approvals). A large number of signatures (review and approval) have also been found on other documents. Some documents are unnecessarily signed several times by the same person.

(2) **Suggestion:** Consideration should be given to reviewing the necessity for such a large number of reviews, approvals and signatures before starting work as is presently required by the procedures for plant design changes.

The complete modification programme at GGNS is a model of thoroughness which exceeds those at many nuclear plants. There are a number of good features, such as strong design organization on the site and single design modification packages which contain all documents required from initiation of the modification to implementation, including all document changes, training and testing. The use of a project leader supported by the system engineer adds further to the effectiveness of the programme. This programme is commendable.

5.5 Reactor Engineering

The responsibility for reactor engineering work (RE) is divided between the Nuclear Engineering Analysis Department (NEAD) at Entergy Operations headquarters and the Performance and System Engineering Section (P&SE) at site. All responsibilities are well documented. The reactor engineering (RE) group in the P&SE report the results of reactor engineering work and core performance monthly to management and the fuel vendor. There is good information exchange within the corporate organization.

The reload calculations are performed by the fuel vendor and reviewed by the NEAD and the RE groups at site. The core loading layout for new fuel is approved by NEAD. The startup of the reactor includes global shutdown measurements and follows a precalculated sequence. No local shutdown measurements are performed. Adjustment of control rod pattern and optimization of control rod sequence are performed by the RE group and approved by the corporate organization. It was noted that no measurements of local shutdown margin were performed. The common practice in other BWRs outside the USA is to perform local measurements to determine the shutdown margin with a method which is as close as possible to the real situation.

(1) **Suggestion:** Consideration should be given to using local measurement techniques in order to determine shutdown margins.

5.6 Fuel Handling

Fuel handling activities are the responsibility of the reactor engineering (RE) group in the Performance and System Engineering (P&SE) Section on-site. When activities are performed by other parts of the organization or vendors the RE group acts as the supervisor for this work. There are no inspection activities foreseen in this area other than when problems occur.

Upon arrival on-site, new fuel assemblies are visually inspected by both the vendor and by plant personnel. The normal procedure is to store all fresh fuel assemblies in the spent fuel pond. However, fresh fuel can also be stored in a dry storage facility in this area. The access to the area is normally open to Operations and Maintenance personnel.

The fuel handling equipment for loading and unloading the core is adequate. There is no equipment other then underwater TV for inspection or measurement of fuel elements. Such activities are normally performed by vendor(s) who also supply the necessary equipment. It was noted that there was no programme to follow-up on the performance of lead assemblies. Only if a fuel failure occurred would an inspection take place. The purpose of lead assemblies is to make sure that operations will not cause a problem. The root cause of fuel failures is not normally investigated.

(1) **Suggestion:** Consideration should be given to the introduction of a follow-up programme for lead assemblies.

(2) **Suggestion:** Consideration should be given to carrying out root cause analyses in the event of fuel failures.

Repairs are performed during outages on fuel assemblies unloaded from the core. Common practice in other BWRs is to let the activity decrease before failed fuel rods are moved and also to restrict access to the spent fuel pond area during the repairs.

(3) **Suggestion:** Consideration should be given to avoid repairing failed fuel assemblies which have been unloaded from the core during an outage.

5.7 Computer Capabilities

Utilization of the process control computer is assigned to the Computer Services (CS) Group within the Performance & System Engineering Section. Other computers such as business computers are handled by the Information Systems and Telecommunications Section which reports to the Information Systems and

Telecommunications Department of Entergy Operations in Jackson, but is located at the site and services site needs. All computer units on-site are adequately staffed.

The documentation and quality control procedures for computers are well organized and developed. A systematic approach was noted for reviewing procedures developed for the new integrated plant data system which is under development. The process for initiating and reviewing modifications is well documented. A well developed comprehensive procedure is in place for process computer applications.

Process computer software and hardware are not considered to be safety related systems. However, the process computers are managed as if they were safety related systems. A quality assurance programme has been developed to cover the whole life cycle of the software.

The business computer system is a network of personal computers (PCs) (approximately 600) at site which is yet not complete. The PC network has access to the corporate mainframe computer system at New Orleans.

There is a long term policy for maintaining the computer system and relevant software at the appropriate level.

For process computer systems there is a long term programme in place for an integrated plant data system. Up to date technology, design principles and specifications for replaceability, reliability, quality control for hardware and software, and testing will be introduced. Some of the important users are not yet included in the integrated PC network on-site. Two years ago it was decided to install an integrated plant data system. The programme was originally scheduled to be completed in 1994. The project has been rescheduled for completion in 1997.

(1) **Suggestion:** Consideration should be given to providing the necessary resources for the integrated plant data system and completing the project by 1994 as originally scheduled.

6. RADIATION PROTECTION

The health physics group at the Grand Gulf Nuclear Station (GGNS) is responsible for both radiological and industrial safety on site. The radiological management systems are extensive and well documented. The group is adequately staffed. The electronic dosimetry programme and the method of pre-job reviews using the "surrogate" tour to reduce the time spent in high radiation areas were commendable features.

Most of the radiation exposure of GGNS staff and contractors occurred during refuelling outages. It was a concern that the collective exposure for recent outages showed an increasing trend. It was noted however that the station management and the health physics organization were committed to the reduction of individual and collective radiation exposure and had active programmes in place to achieve these goals. Concern was expressed on the number of cases of personal contamination and contamination of clothing associated with the refuelling programme.

In many areas it was noted that the conversion of radioactivity levels to dose was based on data from ICRP-2, which dates from 1959. It was suggested that dose records for personnel at the plant should be calculated using the most recent authoritative advice available. Additional suggestions were made relating to eating and drinking in the controlled area, the recording of gaseous and liquid effluents, and some of the radiological considerations in the emergency plan.

The radiological protection personnel were found to be well trained and provided good support for routine maintenance and refuelling operations. They provide the management with a regular overview of the radiological conditions on the station.

6.1 Organization and Administration

The Nuclear Regulatory Commission provides detailed guidance and instructions in radiation protection through the Code of Federal Regulations. These regulations are extremely detailed and do not allow much initiative to be developed at the power stations. The radiation protection organizational structure is well documented in the Administrative and Radiation Protection procedures.

The Senior Health Physicist, who is also the Radiation Control Superintendent, reports to the Manager, Plant Operations. For radiological protection matters the Radiation Control Superintendent has direct access to the Vice-President, Plant Operations. The radiation control organization provides dosimetry, solid waste disposal, portable instrument calibration, respiratory protection, ALARA advice and operational radiological services to the station. It is an integrated organization with technicians and

supervisors being encouraged to study in order to progress to higher posts in the organization. The permanent group of 61 staff is supplemented by up to 80 contract health physics technicians during refuelling outage periods.

There is a well developed training system for all health physics personnel. The training requirements for each post have been well documented. Retraining for radiation workers takes place, including respirator fitting and contamination control takes place.

All radiological measurements are documented, catalogued in a computer data base and microfiched. Daily, weekly and monthly reports are prepared for management and quarterly reports are provided to the NRC. Regular audits are conducted by the quality assurance section. Activities at the power station are examined by the NRC and by INPO. The radiological safety programme had been reviewed by both groups and was considered to be satisfactory.

It was noted that the 1992 goal was less than one case of personnel contamination per 1000 radiation work permit (RWP) man-hours. This condition is very easy to achieve and does not require any significant effort by controlled area workers to remain well below it.

(1) **Suggestion:** Consideration should be given to revising the goal for cases of personnel contamination to a lower and more challenging target level.

6.2 Radiation Exposure/Radiation Work Procedures

All controlled area workers are required to undertake training in the radiation procedures appropriate for plant work and be assessed in their ability to apply the procedures. Workers in areas of potentially high activity who are required to wear respirators must be medically approved to wear respirators, and be fitted and tested with the appropriate size of respirator.

All staff, contractors and visitors who enter the controlled area are issued with electronic dosimeters in addition to whole body thermoluniscent dosimeters. Electronic dosimeters are issued against RWP numbers thus enabling the dose for each job to be easily recorded.

All work in the controlled area is assessed in advance by the health physics ALARA section, which estimates the anticipated collective dose for the work. On the basis of this estimate they issue an RWP which shows the expected dose rate, the collective dose for each part of the work and the appropriate protective clothing. Before work commences the operational Health Physics Supervisor discusses the radiological, special equipment, decontamination and radwaste requirements in a meeting with all the

members of the working party to ensure that everyone is aware of all the details of the work procedure.

A very good feature of this pre-job briefing is that a complete set of plant video films or a 'surrogate tour' is available to display the exact work area to the working group. Points of high radiation and areas to which temporary shielding must be fitted can be shown using this system. The ALARA group also conducts post-job reviews. Where there are difficulties encountered during the work, such as spread of contamination, personnel contamination or unnecessary dose incurred, a Radiological Deficiency Report (RDR) is prepared. Each RDR is examined by staff from the working groups involved and recommendations are made to improve the work procedures. Where it is considered that personnel have been negligent, they may be disciplined, banned from entry into the controlled area or referred for retraining. This procedure reflects the management commitment to ensure that controlled area work is undertaken correctly and with the lowest possible radiation exposure.

Good practice: The thorough preparation for each job with a pre-work meeting for all the staff involved is very good. The ability to display the relevant parts of the working area to staff using the 'surrogate tour' during the meeting is an excellent feature.

6.3 Internal Radiation Exposure

A notable part of the respiratory protection programme was the very stringent training and test programme. Prospective respirator wearers are required to pass a medical examination, be clean shaven and undergo a respirator fit test. When personnel require respirators in the plant their personal details are input to a computer which checks that they are approved to wear respirators and permits the issue of the correctly sized (bar coded) respirator.

All respirators are monitored and physically examined before issue. They are not tested for leakage. It was noted that bubble hoods and air line respirators are used during outages. Where there are difficulties with heat stress associated with wearing respiratory protective equipment the use of an air cooling vortex unit should also be considered.

(1) **Recommendation:** All respirators for use in the plant should be tested for inward leakage before being reissued.

(2) **Suggestion:** Consideration should be given to the use of air cooled radiation protection hoods and clothing.

Eating and drinking are allowed within the controlled area at locations specifically approved by the Radiation Control Superintendent. Two places have been designated as eating areas, the office associated with the radiochemical laboratory and the control room of the radwaste building. Although personnel monitor between the work area and the eating area they do not have hand washing facilities. It is not considered to be a good practice to allow eating and drinking so close to radioactive material.

(3) **Suggestion:** Consideration should be given to the practice of allowing eating and drinking within the controlled area with a view to banning all eating and drinking within the area.

All personnel are required to be monitored on leaving contaminated areas and again on leaving the controlled area. A similar procedure exists for tools and equipment. There were 145 cases of contamination of skin and personal clothing in the period January-July 1992 of which 125 occurred during the most recent refuelling outage. Investigation revealed that up to 68 of the personnel contamination cases were due to the high levels of contamination on washed clothing returned from the contract laundry at Vicksburg.

(4) **Recommendation:** The permissible contamination levels on reissued protective clothing and on cleaned personnel and equipment should be examined so that the clearance levels are reduced to the extent that personnel will not be contaminated by wearing supposedly clean protective clothing.

With the allowable contamination level on persons leaving the plant being 100 counts/min/scan on the personnel portal contamination monitor, a significant proportion of persons are found to be contaminated at the exit from the controlled area. This contamination is due to short lived fission and activation products with a contribution from radioactivity from natural sources, i.e. radon. For most people the activity decays sufficiently within a 10-20 minute period to enable them to leave the plant. The present arrangements cost working time and reduce workers' confidence in the monitoring systems.

(5) **Suggestion:** Consideration should be given to conducting a review of the airborne contamination levels of GGNS, the use of protective clothing in the controlled area, and the sensitivity of the airborne particulate monitors and portal contamination monitors.

6.4 Radiation Protection Instrumentation, Equipment and Facilities

There are adequate stocks of portable radiation and contamination monitoring equipment on the station. The instruments are maintained and calibrated by the health physics group against nationally traceable standards. Digital alarm dosimeters are used

for all staff entering the controlled area. Two months after the end of the outage, 487 of the 2000 dosimeters were not available for use. In the calibration of contamination monitors, the actual efficiency of the probe is not recorded. If there is a progressive deterioration of a contamination probe the trend will not be observed until the efficiency falls below 10%.

(1) **Suggestion:** The measured efficiency of contamination probes should be recorded on the calibration certificate.

The potentially high radiation areas of the plant, the off-gas system and the effluent systems are all monitored with a fixed radiation monitoring system, alarms being generated locally and in the main control room. A matter of concern was that one area gamma monitor was continuously in alarm at the 10 mrem/hr (100 μSv/h) level. A request to raise the alarm setting had been prepared but was taking several weeks to receive approval. In the meantime the flashing red light in the plant was being ignored and the single visual alarm on the operator's desk which dealt with 120 radiation alarms was being obscured. The fixed radiation monitoring system is designed to provide control room staff and controlled area workers with information and warning of an unusual circumstance. When alarms occur they should be cleared quickly and if an alarm setting requires revision, it should be changed as soon as possible.

(2) **Suggestion:** Consideration should be given to streamlining the procedure for changing alarm settings to maintain greater credibility in the alarm monitoring network.

6.5 Personnel Dosimetry

All persons entering the Grand Gulf controlled area wear a four element thermoluminescent dosimeter. The system has been approved by the US National Institute of Standards and Technology and has performed excellently in intercomparison exercises.

Where personnel are working with reactor components and other active components, up to 14 dosimeters may be worn to allow for the inhomogeneous nature of the radiation field. The plant policy is to restrict exposures to less than 1 rem (10 mSv) per quarter year and management approval is required to exceed this level. In the recent refuelling outage approximately 200 persons received extensions of up to 1.5 rem (15 mSv), 50 of up to 2 rem (20 mSv) and 10 of up to 2.5 rem (25 mSv) for the quarter.

The plant goal of 450 man-rem for 1992 was exceeded by the end of July with 415 man-rem being incurred during the recent refuelling outage. An upward trend of the collective dose for recent outages was noted. This was not encouraging.

(1) **Recommendation:** GGNS should conduct a review of its radiation exposures. A more vigorous programme to reduce radiation exposures especially during refuelling outages is necessary.

Electronic dosimeters are required for all entrants to the controlled area and entrants are required to enter under an approved job number. This system does enable the doses incurred on each job to be evaluated and work practices to be examined to reduce the exposure for the next repeat operation.

Good practice: The policy of allocating each electronic dosimeter issued in the controlled area to a work procedure enables the radiation exposure for each job to be computed every day. This rapid feedback of collective dose information allows corrective action to be taken immediately when an unusual exposure is recorded.

All entrants to the controlled area are monitored in a whole body monitor before access is authorized. On completion of work at the power station the whole body count is repeated. Internal radiation exposure is normally very low but the computer analysis of the gamma spectrum from the large sodium iodide detector does allow organ activities to be calculated very quickly. If unusual features are seen on the sodium iodide detector unit a germanium detector body monitor is available to provide better resolution of the gamma spectrum. The conversion from activity to organ dose is undertaken using the data and methodology of ICRP-2 (1959). A procedure exists for the assessment of internal radiation using urine or faecal sampling but the procedure has not been used. The biological data for the conversion of activity in a body organ to organ dose and whole body dose has been revised more than once by the ICRP in the past 30 years. It is considered that the personnel dose calculations for internal exposure should be performed using the most recent authoritative advice available.

(1) **Suggestion:** Consideration should be given to using the latest ICRP recommendations for computing internal radiation exposures. If the new dose calculation techniques do not produce identical results to those recommended by regulatory authorities, both sets of dose information should be recorded in the individual's personnel file.

6.6 Radioactive Wastes, Control and Monitoring of Effluents and Environmental Surveillance

Solid active waste storage at the plant is streamed into dry waste, bead resin and powder resin. Whenever practicable the waste is sent off-site for incineration and compaction. Sludge and oil waste which are combustible are included in the waste taken off-site for incineration. Non-combustible, non-compactible and high active solid wastes

are dispatched directly to Barnwell, South Carolina for burial. Waste volumes have remained in the 9000-10000 cubic feet (255-283m^3) range for 1989-1991 but with 7616 cubic feet (216m^3) dispatched by the beginning of August it is likely that the "goal" of 9000 cubic feet (255m^3) for 1992 will be exceeded.

The facilities for handling solid waste and the drying of resins in preparation for disposal are good and despite having shipped waste with a radioactivity of 260 Ci (9.62 TB_q) this year radiological exposures of the operators are low.

All liquid waste from the plant is collected and its radiation content is reduced by treatment in filters and resin beds. The processing is very thorough with the discharge levels to the Mississippi River being less than 1% of the authorized limit. The activities of each isotope in the waste are measured and then converted into a radiation exposure of a member of the public. While this final step is useful, the primary indications for liquid waste should be the activity of waste discharged. It is probable that the conversion factors from activity to radiation exposure will change with time and the activity figures are a more useful long-term indicator.

Gaseous effluents from the individual ventilation units are measured regularly and the radioactivity discharged into the atmosphere is computed. The gaseous discharges are also less than 1% of the appropriate limits with the data well measured and recorded. As for liquid effluents, it is considered that the primary indicator should be the radioactivity of the effluents released and not the estimated radiation exposure to persons near the plant.

(1) **Suggestion:** Consideration should be given to using the radioactivity measured at the point of discharge as the main indicator for examining trends in effluents.

Environmental samples are collected from the area around the plant and dispatched to an external laboratory for analysis. Results are available after 4-6 weeks. At least three continuous air samplers are operated in the area around the plant to indicate the potential exposure to persons living near the plant.

With the discharges being at such a low level, the only plant radioactivity detected in the environment is in the sludge in the Mississippi River where the liquid effluent is discharged. If the liquid effluent increases to a greater proportion of the allowable discharge, it may be necessary to extend the discharge line into an area where the active waste will be swept away by the river.

6.7 Radiation Protection Support During Emergencies

Four Health Physics staff are available on each shift to respond to an emergency. They provide initial advice in the Technical Support Center (TSC) (adjacent to the

central plant control room) and at the Operational Support Center (OSC) (Maintenance Building) together with coverage for rescue teams and site surveys.

Emergency teams entering the plant would wear electronic dosimeters as used in standard plant entries. Under emergency conditions the health physics supervisor is expected to provide advice on the electronic dosimeter settings for the emergency teams, on the taking of potassium iodide tablets and on the conditions for evacuating control centres.

(1) **Suggestion:** Consideration should be given to the prior establishment of electronic dosimeter parameters for emergency teams. Suitable alarm points would be a body dose in the range of 2-5 rem (20-50 mSv) and a dose rate of 20-50 rem/h (200-500 mSv/h).

Potassium iodide tablets are available for emergencies. Present plant policy is to make extensive use of breathing apparatus and not to issue potassium iodide tablets unless a projected thyroid dose of 25 rem (250 mSv) is calculated.

(2) **Suggestion:** Consideration should be given to using potassium iodide tablets at a projected thyroid dose of less than 25 rem (250 mSv) as presently stated in the emergency procedures.

The extensive plant network of radiation monitors and automatic gaseous and liquid monitoring systems does provide the operators in the main control room with considerable data on radiological conditions in and around the plant. Many of the plant operation parameters are duplicated at the TSC and OSC. However, the radiological data can only be obtained from the records in the main control room.

The radiation and air activity levels in the TSC and OSC are programmed to be measured at an early stage of the emergency. There are no advisory levels established at which consideration would be given to evacuating the control rooms.

The site emergency plan includes the measurement of air activity and radiation around the site. However, the main gamma spectrometry facilities are situated in the chemistry laboratory in an area which is not likely to be accessible during the emergency. No arrangements have been made to assess the isotopic composition of the release at an alternative site location.

(3) **Recommendation:** As the dose due to inhaled radioactive materials depends on the isotopes absorbed it is recommended that arrangements be made to use site gamma spectrometry facilities outside the controlled area during emergencies. If it is undesirable to establish a separate laboratory, the gamma spectrometers that are used with the whole body monitors could be set up to determine the isotopes present in the samples.

The teams undertaking the radiation measurements on and around the site are equipped with high range dose rate meters (0-50 rem/h) (0-500 mSv/h) and medium range dose rate meters (0-5 rem/h) (0-50 mSv/h). With these instruments it is difficult to measure dose rates below 1 mrem/h. As normal background is 0.01 - 0.02 mrem/h (0.1-0.2 μSv/h), a radiation leak that increased the dose rate by a factor of 10-20 could go undetected.

(4) **Suggestion:** Consideration should be given to replacing some of the present radiation dose rate instruments supplied to the emergency teams with instruments which will measure background radiation. This will enable the areas of suspected contamination to be identified more readily.

7. CHEMISTRY

The Chemistry Section of the Grand Gulf Nuclear Station (GGNS) is part of the Operations Department but it is not engaged in operational tasks such as operation of water treatment systems; it only performs surveillance tasks. This organization results in short communication lines and allows a fast response to any deviations from normal values.

The number of staff who are partly on shift is adequate for the tasks which need to be performed by the section. The employees are very professional, highly educated and well trained. The training programme, consisting of initial classroom training followed by on-going training and on-the-job training, is adequate.

Because of its design features, GGNS requires high quality chemistry procedures and a high level of expertise. Such special design features are forward pumped heater drainwater, non-stabilized stainless steel in the reactor coolant systems and use of stellite in the reactor vessel and components.

To optimize the chemical performance, it was suggested to improve the condensate polishing system. The quality of the service water, which is used for many purposes, is a great challenge to the chemists. Although the chemists have developed, through an excellent research and development programme, an optimized treatment of this water to ensure safe plant operation, it was suggested that a service water purification system be installed which would avoid excessive use of chemicals and their release to the environment. The fact that this service water with added chemicals can be treated to produce extremely pure make-up water with less than 5 ppb total organic carbon (TOC) was commendable.

The measures taken against intergranular stress corrosion cracking (IGSCC) enable the plant to be operated in accordance with "conventional water chemistry guidelines" and not to the "hydrogen water chemistry guidelines." The plant has no experience in enrichment of oxyhydrogen gas in pipes and valves with stagnating steam. It was suggested to approach plants in Europe to get more information about this phenomenon.

The use of the so called "soft shutdown" method, to minimize activity buildup, was considered to be commendable. The use of the CHECMATE code edited by EPRI to control the erosion/corrosion programme was also considered to be a good practice.

In order to collect early information on the introduction of organics into the reactor, it was suggested that a conductivity measurement unit be installed on one of the main steam pipes.

The chemical procedures are excellent, the laboratories and their equipment go beyond the normal standard, the sampling systems and on-line instrumentation are comprehensive, and housekeeping, industrial safety, quality control programmes and working spaces are adequate. A terminal connected to the plant computer system in the laboratory, which enables the chemistry staff to relate their work to the operational conditions, was considered to be a good feature.

7.1 Organization and Functions

The Chemistry Section of the Grand Gulf Nuclear Station is part of the Operations Department. The section is divided into four groups. The first group, the operational group, monitors the main systems of the plant. The staff work shifts, especially because of their work relating to liquid waste discharges, operational upsets and emergency calculations. The second group works in the chemical treatment of service water and performs excellent research work in the area of fouling in coolers. The third group performs technical support work, meaning that they perform non-routine analyses and are in charge of the chemical and radiochemical instrumentation. The fourth group operates an environmental laboratory where non-radioactive waste water is controlled and where environmental sampling and environmental analyses are carried out.

Internal communications are supported by periodic meetings at different levels, such as the internal section meetings as well as meetings between the section and the Operations Manager. As the Chemistry Section belongs to the Operations Department, the communication line with the operators is short.

External communication is supported by monthly meetings with the Plant Manager; by periodic management review meetings; by annual presentations to the Vice-President and by monthly, quarterly and annual reports. Communication with external organizations is via corporate communication with company wide "peer groups" and through EPRI/INPO meetings or seminars.

Usually new members of the chemistry staff come either from college or from the Navy. The initial classroom training lasts 17 weeks and is followed by ongoing training in areas such as special events in the industry or new instrumentation. This ongoing training takes approximately one week per year for each person. Additionally, chemistry personnel attend the mandatory annual refresher training required for all station personnel. The whole training programme matches the requirements for "Accreditation for the National Academy of Nuclear Training" which was initiated by INPO.

7.2 Chemical Treatment, Material Concept, Activity Build-up and Corrosion

The Grand Gulf Nuclear Station is a plant with forward pumped feedwater drains. Plants with this type of design of feedwater drains usually have more corrosion products in the reactor and thus a higher risk of contamination through activated corrosion products. The condenser tube material is stainless steel so there is no "natural" zinc dosage input into the reactor. If zinc were present in the reactor water, it would be incorporated into the corrosion layers, thereby preventing the absorption of the unwanted cobalt-60 into these layers.

The condensate purification system consists of deep bed filters with limited efficiency to separate particulate corrosion products. To overcome this deficiency, three pre-coat filters are used for startup, with a total capacity of 40% of the total feedwater flow. In GGNS both the deep bed filters and the pre-coat filters introduce resin into the reactor.

Resin debris is destroyed in the reactor by producing organic acids and sulphuric acid, thus increasing the conductivity and decreasing the pH of the reactor water and consequently increasing the risk of intergranular stress corrosion cracking.

(1) **Suggestion:** The pre-coat filters of the condensate purification system should be equipped with filter elements with a porosity small enough to retain the fine particles of the powder resins.

(2) **Suggestion:** Measures should be taken to reduce the release of resin fines by improving the ultrasonic backwash process.

It is also important to note that GGNS is of a generation of BWRs that contain large amounts of stellite in the reactor components, especially on the control rod pins and rollers. For this reason GGNS has high radiation exposures to personnel. Activity reduction measures should have high priority.

The service water at GGNS is a mixture of groundwater and river water pumped from deep horizontal wells. Owing to the temperature and oxygen concentration ranges of this mixture and because of the content of iron and manganese, some bacteria, especially "iron bacteria", find optimal living conditions and cause difficulties in the connected cooling systems. These bacteria together with inorganic materials build up a slimy sludge on the surfaces of pipes and coolers and leave deposits in the emergency cooling basins.

An advanced procedure to enable the plant to operate in a satisfactory manner by adding several chemicals in different locations in the service water systems and with different concentrations has been developed. A task force group consisting of staff from several sections of the plant was brought together to find a permanent solution to this

problem. It had been decided to use chemical treatment of service water for the next several years. Cooling water systems should be designed such that they can be operated safely without the need to add large amounts of chemicals to prevent fouling in pipes and coolers. This is especially important for the protection of the environment.

(3) **Suggestion:** Consideration should be given to installing a service water purification system to aerate and clarify the water before it enters the service water system. By this method, iron, manganese and the inorganic particles are removed and the higher oxygen concentration keeps the bacteria from developing. This water treatment method is used worldwide in nuclear power plants operating in a closed cooling mode.

Good practice: To optimize the chemical treatment of service and cooling water, the plant uses a scale model test unit which can simulate plant conditions such as heat transfer in the condenser tubes. The test unit is equipped with a ball cleaning system which is rather unique in the power generating industry.

Great efforts were made during the construction period to minimize corrosion and particularly intergranular stress corrosion cracking (IGSCC). Low carbon stainless steel, less sensitive to IGSCC, has been used on safety-related systems, and the welds concerned have been heat treated for stress relief. In addition to the corrective measures taken for all sensitive parts of the system, it was also considered reasonable that the plant be operated in accordance with the "conventional water chemistry guidelines" and not the "hydrogen water chemistry guidelines" recommended for BWRs with non-stabilized stainless steel or low carbon steel.

In pipes containing stagnant steam, the steam condenses partially, and the radiolysis gases remain in the gaseous phase, are enriched and build up oxygen-hydrogen mixtures. This problem could be solved by installing catalysers and temperature monitoring equipment in the pipes affected or by continuously flushing the pipes with steam.

(4) **Suggestion:** Consideration should be given to collecting information from plants in European countries relating to a programme against oxygen-hydrogen gas enrichment in pipes with stagnant steam.

A computer program developed by EPRI, "CHECMATE", is used to predict erosion/corrosion in steel piping components. This program can optimize plant inspection programmes, determine the impact of changes on operating conditions and erosion/corrosion rates, and evaluate new or modified designs to minimize erosion/corrosion damage. CHECMATE predicts erosion/corrosion rates in piping components for single phase and two phase systems, and calculates the remaining time before reaching the minimum acceptable wall thickness.

Good practice: Using the computer code CHECMATE developed by EPRI for predicting locations susceptible to erosion/corrosion is an excellent way to avoid pipe breaks by erosion/corrosion. For single phase and two phase systems it can predict erosion/corrosion rates and calculate the time remaining before reaching the minimum user defined acceptable wall thickness.

A special feature of BWRs with forward pumped heater drains is a higher concentration of iron hydroxides in the feedwater, leading to slightly loose crud on the fuel surfaces. During shutdown these activated solid particles can become loose and distributed within the reactor and the connected systems and can cause widespread contamination. To avoid this, regular plant shutdown is performed using a controlled temperature decrease or soft shutdown. Operations attempts not to exceed a cooldown rate of 30°F (16°C) per hour. The reason is that a fast temperature drop generates large steam bubbles which can remove crud particles.

7.3 Chemical Surveillance Programme and Procedures

The chemical surveillance programme is comprehensive and contains all requirements of EPRI guidelines and requirements of the manufacturers of the plant components and takes into account the operating experience of the plant. The surveillance programme is properly scheduled. A new computerized scheduling system is under development. Key chemistry parameters are trended on a daily basis, covering a two week period, to detect deviations from normal conditions. Long term trends are included in monthly, quarterly and yearly reports.

Fuel integrity is monitored by measuring radioactive noble gases in the off-gas stream. The results of these measurements are used to calculate the "fuel reliability index" for INPO. If fuel leakage is detected, the defective fuel assemblies are localized by flux tilting during operation at reduced power, shortly before an outage. Final determination of the leakers is made by fuel sipping tests. Fuel assemblies identified as leakers are not used in another fuel cycle.

Demineralized water is produced from well water after chemical treatment. The purification equipment is installed in a trailer. The purification process is the best available for water with organic contamination. The actual values are much lower than the specifications, especially regarding total organic carbon.

Good practice: The production of make-up water with an extremely low total organic carbon (TOC) concentration of about 5 ppb is considered to be an excellent practice.

Contaminated waste water is collected in two different tanks. One tank collects the equipment drains, which are usually reprocessed and pumped back to the system.

The other tank collects floor drains which are more polluted, especially with organic material, and are usually released after treatment. Two independent operating trains, normally not cross-connected, are used for waste water purification. The purified water from the equipment drain systems is returned to the condensate storage tank. Waste from the floor drain system is released to the river after chemical and radiochemical analysis.

7.4 Operational History and Recording of Results

Information on chemistry performance is sent out to management, other plant groups and corporate staff. Daily chemistry results are distributed only within the plant. Monthly, quarterly and annual reports are widely distributed. Reports on abnormal situations are written within the "Plant Incident Reporting Programme". Operational upsets are explained in the routine chemistry reports. Plant and industry operating experience is examined by a plant group and transmitted to the sections concerned. If necessary, a formal response is prepared. When applicable, it is included in the chemistry training programme.

7.5 Laboratories, Equipment and Instruments

Two laboratories are available in the controlled area. One is a hot laboratory where contaminated samples are treated; the other is the clean laboratory for analyses of samples with little or no contamination.

Very advanced and effective instruments to perform trace analyses in water chemistry are available. There are several ion chromatographs for the determination of cations and anions; atomic absorption spectrometers; an inductive coupled plasma spectrometer; an infrared spectrometer; a gas chromatograph; and TOC analysers for organic carbon. This equipment enables the chemistry staff to perform highly specialized analyses, which go beyond the usual standards in the nuclear industry.

The clean laboratory is equipped with a terminal connected to the plant computer system. Through this terminal any operational data in preselected configurations are available in the laboratory. This allows the chemists to take their readings and samples related to operational conditions. This is very important during load transients or during operational changes to plant equipment.

Good practice: It is very important for the chemists to be well informed about operational conditions of the plant in order to promote excellent performance in the chemical monitoring of the NPP. A terminal connected to the plant computer system provides the data.

All sampling points necessary for the surveillance of condensate water, feedwater, reactor water and auxiliary water systems are installed and are operating satisfactorily. On-line instrumentation monitors the conductivity, oxygen concentration and pH value of the main plant systems. Three on-line ion chromatographs directly measure the chemical parameters in condensate water, feedwater and condensate polisher effluents. In order to monitor the migration of organical material into the reactor, measurement of conductivity in steam should be used, since this method gives the fastest response.

(1) **Suggestion:** The plant should consider installing a conductivity monitoring system in the main steam system, capable of monitoring resin introduction into the reactor in real time.

A post-accident sampling system has been installed to monitor the concentrations of airborne radionuclides after accidents in the containment and in the dry well. It also monitors the concentration of radionuclides in the reactor coolant water, in the residual heat removal system water and in the suppression pool water. This manual sampling system is supplemented by continuously operating surveillance systems for gaseous effluents on all major ventilation release pathways. The accident sampling system is well designed and easy to operate.

7.6 Quality Control of Operational Chemicals

All chemicals used in the plant are evaluated for their harmfulness to the plant. Accepted chemicals are documented in a chemical evaluation log-book and harmful chemicals are listed in another log-book and are considered as restricted chemicals. Restricted chemicals can be used only with a chemical use permit. Storage, use and disposal of these chemicals must be controlled by the holder of the permit.

Acceptance testing is performed on new ion exchange resin and diesel fuel. The quality of other chemicals such as lubricating oils is performed by checking vendors' specifications.

8. EMERGENCY PLANNING AND PREPAREDNESS

The emergency planning and preparedness programme for Grand Gulf Nuclear Station (GGNS) was reviewed, particularly the activities of the station. In addition, the interaction between the GGNS and the off-site emergency planning agencies at local and state level were reviewed. The contacts between the station emergency preparedness personnel with the local and state officials were found to be frequent with adequate working relations.

The near site emergency operations facility provides a good setting for the co-ordination of the on-site and off-site emergency response since it accommodates representatives of all main parties. Further, it was found that public information activities in an emergency are co-ordinated to the extent that joint press conferences are planned. In general the emergency facilities and their equipment were considered to be good and well maintained.

The responsibilities among the GGNS organization are well defined for both emergency planning and response. The number of people (8) with different backgrounds and expertise who are devoted to emergency preparedness tasks is a commendable feature.

In general, the measures planned for emergency response at GGNS were considered to be well defined and effective. However, it was found that the environmental monitoring programme in case of a radioactive release is not preplanned in adequate detail. It was recommended to review and revise it accordingly.

The systematic emergency preparedness training programme combined with frequent drills and exercises was considered to be good.

8.1 Emergency Planning and Preparedness Organization (Site/Utility)

The legal basis for planning and maintaining preparedness to cope with emergencies at nuclear power plants in the USA is the Code of Federal Regulations, specifically 10CFR50.47 and 10CFR50, Appendix E. More detailed regulations are provided by the "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants". This guide was jointly prepared by the US Nuclear Regulatory Commission and the Federal Emergency Management Agency. In addition, the NRC has developed detailed guidance relating to solely on-site emergency planning and preparedness. These regulations set a good framework for co-ordinated on- and off-site emergency plans.

The GGNS organization includes an Emergency Preparedness Department of eight people headed by an Emergency Preparedness Manager. He is assisted by four emergency planners, an operations co-ordinator, and two administrators. The emergency preparedness staff are responsible for the preparation and maintenance of the GGNS emergency plan and its implementing procedures as well as for the maintenance of the emergency facilities and their equipment. The operations co-ordinator has an operations background and co-ordinates scenario preparation and the conduct of emergency exercises. The Emergency Preparedness Manager reports to the Director, Plant Projects and Support. The considerable number of personnel devoted full-time to emergency planning and preparedness tasks is commendable. The Emergency Preparedness Department is responsible for the co-ordination and liaison with federal, state and local agencies involved in GGNS emergency planning and preparedness activities. The plan and its revisions are reviewed and formally approved by plant management and the Plant Safety Review Committee. The plan also requires the approval of the NRC.

The plant emergency organization is activated partly or fully depending on the severity of the emergency. The on-site emergency organization is headed by an Emergency Director. He has several groups under his command in the areas of plant operations, technical/engineering support, radiation protection, security and repair. The off-site plant emergency organization deals with the overall response, particularly off-site, and contacts with other emergency organizations, the public and the media.

The responsibilities and lines of authority of the emergency response staff are adequately described in the GGNS Emergency Plan. The overall functions include: activation of the emergency organization; classification of the emergency; assessment of the emergency and radiological conditions on- and off-site; planning and implementing measures to control the emergency and mitigate its effects; notifying and recommending protective actions to authorities responsible for off-site emergency measures; notifying and informing the off-site officials of the development of the accident; and public information.

Altogether some 270 people are designated to the GGNS emergency response organization. The planning basis is that there are four emergency response teams available. To be able to activate the emergency response organization within prescribed time limits, there are some 50 people on call to augment the on-site shift.

Several persons of the off-site organizations arrive in the near-site GGNS Emergency Operations Facility (EOF) to provide co-ordination of the GGNS personnel and local, state and federal authorities. In addition, GGNS is prepared to send technical advisors to the Emergency Operations Centers (EOCs) of the county, in a local parish if requested to do so when the centres are activated. Contacts with the NRC are through two telephone lines and the NRC site team is expected to arrive at the GGNS Emergency Operations Center (EOC) and Technical Support Center (TSC).

8.2 Emergency Plans (Site/Utility)

The GGNS Emergency Plan describes the plant emergency response organization in the form of a diagram showing the positions and their reporting relationships. The minimum staff on shift and the required capability of augmenting the on-shift personnel with additional key people within 30 or 60 minutes are defined. The main duties and actions required to be taken by the emergency organization are adequately specified in the plan. The plan also has another good feature in that it provides a policy statement. The policy requires that protection of plant personnel and general public be given the highest priority, plant system and equipment protection being secondary.

The emergency plan describes in a general way the emergency organizations and functions of governmental agencies. The local services that can be asked to provide support for plant emergency response are recorded in the plan. These services include the Claiborne County Hospital and ambulance service for medical support, the local medical centre and regional medical centres serving as a back-up. In the event of serious contamination, injury or overexposure, personnel can be taken to New Orleans. The county fire department, the sheriff's department and the police department provide fire and law enforcement support respectively.

The GGNS Emergency Plan defines four categories of emergencies in increasing levels of severity, called unusual event, alert, site area emergency and general emergency.

The Shift Superintendent is responsible for the declaration of an emergency and the activation of emergency measures. He acts in the role of emergency director until relieved by the on-call manager. If an alert has been declared, the GGNS emergency organization is partly activated (Technical Support Center and Operational Support Cente). During a site area and a general emergency the whole GGNS emergency organization is activated.

The state and local emergency organizations are notified in any declared emergency within 15 minutes. They activate their emergency organizations in case of a site area and a general emergency. The state and federal emergency organizations send personnel to the GGNS emergency command centres. Thus they have access to all relevant information and good communications with all involved parties.

There are technical, engineering, operations and radiation protection personnel headed by the Emergency Director at the TSC who assess the plant status and accident development. They support the control room staff and may give advice to control the accident. They have data links and a safety parameter display system (SPDS) at their disposal. Plant status is recorded at status boards with preselected parameters. There are also agreements with vendors and INPO to obtain aid to analyse the accident and to find methods to solve problems.

The GGNS personnel at the EOF assess the radiological conditions and make recommendations for protective actions to the state and local organizations. They use a dose calculation program MESOREM. Off-site monitoring teams are dispatched and directed by the EOF radiation protection personnel.

In the event of a serious accident, plant conditions are used as a basis for recommendations for protective actions. On the basis of NRC guidance, evacuation is recommended for near site population up to two miles or more if a core melt accident is in progress and if evacuation does not pose a risk to evacuees. Protective action recommendations based on radiological conditions are made in accordance with the Environmental Protection Agency (EPA) guidelines.

8.3 Emergency Procedures (Site/Utility)

Emergency plan procedures provide detailed guidance on conducting planned GGNS emergency measures. These procedures include personnel protection measures such as issue of dosimeters; search and rescue; transport of injured individuals; policy for administration of potassium iodide tablets; radiological monitoring and control of designated emergency vehicles; operation of the GGNS emergency centres including the Emergency News Media Center; maintenance of emergency equipment and supplies; and training and drills.

After declaring an emergency, the Shift Superintendent assigns a control room operator to serve as a communicator who notifies the local and state agencies and the NRC. Activation of the plant response personnel is through personal pagers and an automated paging system.

The shift must be augmented within 30 minutes to meet the requirements of procedure. The TSC must be operable within 60 minutes upon declaration of alert and the EOF within 60 minutes upon declaration of site area emergency. When the EOF is operable it takes over the overall conduct of GGNS response and has the responsibility to evaluate the radiological situation off-site, to make protective action recommendations to the state and local emergency organizations, to arrange additional resources if needed and to inform the public and the media.

After the Operational Support Center (OSC) is operational, the teams leaving for the plant for search and rescue, first aid, corrective and assessment actions are formed, equipped, briefed and dispatched. All teams include a health physicist for radiological assessment and advice. They maintain contact with portable transmitter/receivers (walkie-talkies). A systematic means of briefing the teams using preplanned briefing forms has been established.

The environmental monitoring teams are dispatched at the EOF. For their personal protection they have protective clothing, respiratory equipment, dosimeters and KI tablets available. The GGNS radiological monitoring programme for emergency situations provides field monitoring at the site fence and near the site, starting within a few kilometres from the site. Measuring routes and points are not preplanned. Detailed methods to process incoming field data and to compare measured and calculated data have not been developed. Thus the value of measured data either to confirm the calculated exposure values or to obtain a basis for assessment in the event of an unmonitored release is limited. Further, the monitoring instruments are not sensitive enough to measure gamma radiation dose rate levels which are only slightly above background levels.

(1) **Recommendation:** The GGNS radiological field monitoring programme for emergency situations should be reviewed and revised accordingly. The environmental monitoring plan for the early phase following an atmospheric release should aim at determining the areas affected and obtaining plume characteristics: direction and speed, dose rates as functions of time and space, radioactivity levels and radionuclide compositions. If possible from a radiological safety standpoint, the initial survey should follow preselected routes in the general direction of the plume and measurements should be made at prenumbered and easily identifiable measuring points shown on a map, to facilitate their identification and the transmission of data. For developing an understanding of severity, a detailed method should be preplanned to process incoming field data and to compare them with calculated values. The instruments used should be capable of observing normal background radiation levels.

The people in the protected area of the plant can be notified through a public address system and advised to evacuate when necessary. They are accounted through the security system when leaving the protected area. The security personnel are responsible for implementing the evacuation of people on-site but outside the security area. This is done through a vehicle patrol and a guard/guards walking through the buildings. Also supervisors are responsible for their workers. However, no accounting of those people outside the protected area is preplanned. This evacuation method is not very effective and may cause an unnecessary delay in evacuating people who are not aware that they are required to evacuate.

(2) **Suggestion:** Consideration should be given to developing an effective way of notifying and counting people within the GGNS controlled area but outside the protected area, in the event of an evacuation of people not required to remain on the site.

There is no policy and there are no preplanned arrangements to inform personnel, in areas and buildings that cannot be reached by public address systems operated from

the control room about a declared emergency situation if no protective measures are required in those areas. This can cause confusion among personnel.

(3) **Suggestion:** Consideration should be given to developing a policy and making arrangements to inform all personnel on-site if an emergency is declared.

8.4 Emergency Response Facilities, Equipment and Resources (Site/Utility)

The GGNS has two main emergency response centres on-site, specifically designed and dedicated to be used in an emergency. One of these centres is the TSC planned for emergency staff who mainly assess the safety and radiological status of the plant and help the control room staff to control the accident situation.

The TSC is suitably located at an upper level next to the control room and has a view of the control room. The TSC has the same habitability characteristics as the control room, such as a filtered air intake and maintaining overpressure. It has an emergency lighting system and communications equipment. The TSC has a safety parameter display system (SPDS), plant and radiation status data links, a computer programme for dose calculations, and necessary documents such as emergency plans, emergency operating procedures and plant descriptions and drawings. The TSC can accommodate about 25 persons, but is somewhat limited in size to provide working space for so many persons. Status boards have predefined parameters to follow the accident development.

The other on-site centre is the OSC, which is planned to serve as an assembly and dispatching area for personnel who may be needed to go to the plant. Radiation protection personnel who would support the teams also assemble there. There are protective clothing, respiratory protective equipment and containers for contaminated clothing available. A surrogate tour facility is also situated in the OSC. The OSC is located in the maintenance shop, which is not planned to be habitable if there is a substantial radioactive release. In such a case the OSC would evacuate to the EOF.

The EOF is situated about one kilometre from the site. It is planned to be habitable under emergency conditions. It has a high protection factor, filtered air, closed air circuit and overpressure provisions, and a diesel generator for emergency power. The EOF has ample space for staff of GGNS, state and federal emergency response organizations. It is well organized, has equipment and material comparable with that of the TSC, including SPDS, and can provide plant status and environmental monitoring data to interested parties. Thus it provides a good setting for co-ordinated emergency response. There is also a backup EOF in Vicksburg, Mississippi.

For media information there is an Emergency News Media Center about eight kilometres from the plant. There are facilities for staff from GGNS and local, state and

federal information staff and press conferences for about 200 people. The corporate headquarters serves as a backup media centre and provides information to the public via ten telephone lines.

Between the GGNS and local and state emergency response centres there are dedicated hot lines and there are UHF radio connections to the local emergency centres. There is a telephone for the NRC Health Physics Network (HPN) and another for the NRC Emergency Notification System (ENS). In addition, there are a number of commercial telephone lines. There is a system of sound powered telephones to keep contact between the control room, TSC and OSC. Mobile teams and emergency vehicles are equipped with portable radios.

The plant has three vehicles available for monitoring teams. There are three monitoring and sampling kits for the teams. There are area process and effluent monitors with readings available in the control room and a few with readings in the TSC and EOF. Meteorological information comes from a 50 m and a 10 m tower. To notify the population around the plant of an emergency there are 43 sirens within 16 km of the station.

8.5 Off-site Emergency Planning and Preparedness

The off-site measures to protect people in a nuclear emergency at GGNS are the responsibility of the two state and two local governments affected by the emergency planning zones around GGNS. The Mississippi Emergency Management Agency (MEMA) is the state authority which plans and co-ordinates emergency response. Among other things MEMA arranges training for emergencies. The lead technical agency at the state level is the Mississippi State Department of Health/Division of Radiological Health.

The Louisiana Radiation Protection Division (LRPD) develops and co-ordinates specific emergency plans for nuclear power stations in the state of Louisiana. The Louisiana Office of Emergency Preparedness (LOEP) is responsible for co-ordinating evacuation activities. The radiological emergency plans in the two states provide a means to require assistance from governmental agencies if protective actions are needed.

A major part of the GGNS plume exposure emergency planning zone is in Claiborne County, Mississippi. The County Civil Defense Director directs the protective actions within the county in accordance with the radiological emergency plan.

In Tensas Parish, Louisiana, the president of the parish policy jury is responsible for the protective actions, which are described in the radiological emergency plan. Federal assistance provided by several agencies is subsequent to a request from a state and under the command of the governor.

The Department of Energy (DOE) has arrangements to provide substantial assistance in the area of radiological monitoring. The GGNS may also ask for this assistance.

8.6 Training, Drills and Exercises

There is an extensive training programme that systematically covers all GGNS people who are assigned to the emergency response organization. They are required to retrain annually and pass a test. A training programme is planned to meet the specialized qualifications required for each emergency organization position. Each person who is on emergency on-call list must have valid training records. One person among the training staff is assigned full-time on emergency preparedness training.

There is an opportunity for each of the four emergency teams to participate in an exercise as a player or controller annually. This is a good feature of the exercise programme.

Exercise scenarios include accidents that are serious enough to require activation of off-site organizations. In a recent exercise the simulator was used and control room staff could actually respond. This is a commendable feature. Annual exercises last typically seven or eight hours and quarterly drills some four hours. Shift turnover of emergency response personnel has not been practiced during an exercise as yet. Thus members of the emergency organization do not get practice in this matter and co-ordination of incoming and outgoing teams may turn out to be poor.

(1) **Suggestion:** Consideration should be given to including shift turnover in drills or exercise arrangements.

In addition, smaller scale drills are conducted such as testing of communications, health physics drills first aid drills and post-accident sampling drills. Co-ordination of GGNS personnel and local hospital staff in dealing with a contaminated injured person is practiced annually. Also the local voluntary fire brigade comes once a year to participate in a fire drill together with GGNS staff.

8.7 Liaison with the Public and the Media

The emergency response organization includes a staff of six people assigned to tasks at the Emergency News Media Center (ENMC) and a few people at the Emergency Information Center in Jackson. This staff is headed by a company spokesperson who reports to the off-site emergency co-ordinator at the EOF. The people assigned as company spokespersons are generally from the top management of

the GGNS. The background of technical spokespersons is technical. They have little experience in dealing with the media, particularly not in a possibly hectic atmosphere with an enormous demand for information. This can diminish the effectiveness of information efforts.

(1) **Suggestion:** Consideration should be given to arranging media training of those persons assigned as company spokespersons and as technical spokespersons in emergencies.

ACKNOWLEDGEMENTS

The Government of the United States of America, the United States Nuclear Regulatory Commission, the Entergy Corporation and Grand Gulf nuclear power station (GGNS) personnel provided valuable support to the Grand Gulf OSART team. Throughout the review, Entergy Operations and Grand Gulf management and counterparts were open minded, co-operative and supportive in creating a productive working atmosphere. Assistance from the typist and liaison personnel was essential to the smooth running of the review. The IAEA, the Division of Nuclear Safety and the Nuclear Power Plant Operational Safety Services Section wish to thank all those concerned for the excellent working conditions during the OSART mission.

ANNEX I: THE GRAND GULF OSART TEAM

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ANNEX II: SCHEDULE OF ACTIVITIES

1.	Preparatory meeting for OSART review of Grand Gulf NPS	4-5 November 1991
2.	Official request from the Resident Representative of the USA to the IAEA to conduct an OSART mission to Grand Gulf NPS	23 December 1991
3.	IAEA confirmation of OSART review	15 January 1992
4.	Recruitment of team members	February-May 1992
5.	Advance Information Package sent to team members	June 1992
6.	Submission of OSART mission report to Resident Representative of the United States of America.	December 1992