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AREA SAFETY PROGRAM FOR THE TOKAMAK FUSION TEST REACTOR

By

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PLASMA PHYSICS LABORATORY

PRINCETON UNIVERSITY PRINCETON, NEW JERSEY

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AREA SAFETY PROGRAM FOR THE TOKAMAK FUSION

TEST REACTOR (TFTR)

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INTRODUCTION

The Tokamak Fusion Test Reactor (TFTR) Fig. 1 is the first experimental device built at the Princeton Plasma Physics Laboratory (PPPL) that will be capable of producing a significant amount of fusion energy. The \$314 million project is funded by the U.S. Department of Energy (DOE) as part of a national program to develop nuclear fusion as a source of commercial electric power generation.

TFTR achieved its first plasma on December 24, 1982. In the spring of 1983, the device captured the world's record for the longest energy confinement time ever obtained in a tokamak. During subsequent experiments plasma energy confinement times in the range of 260 ms were recorded where the plasma density was $3.2 \times 10^{13} \text{ cm}^{-3}$, and with ion and electron temperatures in the 1.5 keV range. These long confinement times indicate that plasma confinement time increases as the size of the tokamak is increased.

The mission of TFTR is to reach a program goal of long standing: the production of fusion power output equal to the plasma-heating power input. Since the early 1950's, the achievement of such a "fusion break-even demonstration" has been associated with proof of the scientific feasibility of fusion power--analogous to the fission power demonstration carried out by Enrico Fermi at the University of Chicago in December, 1942.

PPPL, of which TFTR is a part (Fig. 1A), has a relatively large and well organized Safety Department that has the responsibility for the implementation

of the overall safety program. Since safety is everyone's responsibility, management introduced an Area Safety Program in order that everyone, through line management, would play a useful role in the safe running of the Laboratory.

The Department of Energy is fully supportive of the "safety, through line management" approach to an efficient safety organization.

The Safety organization at PPPL is organized in two groups. One group, the Occupational Medicine and Safety (OM&S) Office has primary responsibilities in the areas of fire safety, industrial safety, industrial hygiene, and a medical program.

The second group, called the Project and Operational Safety (PO&S) Office, has responsibilities in the areas of electrical safety, mechanical and cryogenic safety, and health physics (radiation) safety. The OM&S group is responsible for the overall safety training program, as well as auditing other safety programs in the Laboratory. The PO&S group works closely with TFTR and the various other projects and their safety line management program. It also has an approval and sign-off responsibility for the safety aspect of installation and operational procedures.

Both groups are represented on the Executive Safety Board, which in turn reports to the Director of the Laboratory. (Fig. 2)

The Area Safety Program follows a different route via line management, from the Deputy Director of the Laboratory for Technical Operations, through departmental safety managers, on down to the Area Safety Coordinators who have responsibilities for defined areas. It can be seen from the organization chart (Fig. 3) that there are two Departmental Safety Officers (DSO), one for Technology and one for Administration. The DSO in Technology has three deputies, one each for TFTR, Engineering, and Research. In Administration

there is only one deputy. The programs are tailored to suit the needs of particular departments.

The TFTR Area Safety Program suits the needs of a large operational fusion device. Details of its organization (Fig. 4), implementation, and present status are as follows:

Area Plan

The TFTR complex is divided into separate areas, each area being under the jurisdiction of an Area Safety Coordinator who has the following responsibilities:

1. To ensure there is a minimum of safety violations within the area of responsibility, and to rectify quickly any that do occur.
2. To have liaison with the fire chief to ensure that all fire fighting equipment, permanently installed in the area is in good working order.
3. To maintain a good housekeeping policy in the area by ensuring that all trash, packing material, and surplus equipment is removed to the trash disposal unit or to storage at the end of every shift.
4. To prepare the area for the monthly safety inspection by completing the safety check list and recording any safety violations on the transmittal sheet. Any additional safety violations found during the inspection are recorded on this sheet, which is handed to the Area Safety Manager for record purposes and transmittal to the DDSO.
5. To prepare task orders requesting the maintenance division to rectify the designated safety violations. The Area Safety Coordinator also monitors the progress of this work and notifies the Area Safety Manager when the job has been completed.

As we move up the organization chart, the next stage is the Area Safety Manager who can be responsible for many Area Safety Coordinators, depending upon the subsystem in which the Manager works. This can vary from one, to as many as seven.

The Area Safety Manager's responsibilities are:

1. To ensure that Area Safety Coordinators perform their duties in an efficient and well organized manner.
2. To arrange the monthly safety inspections and inform the DDSO accordingly by forwarding the proposed schedule and inviting the DDSO to partake in the inspection.
3. To follow up on all work orders issued by the Area Safety Coordinators which have not been closed out at the requested completion date.
4. Through the DDSO, to keep management informed of any new safety hazards in the area.
5. To maintain appropriate safety records.
6. To ensure that all personnel under the Manager's jurisdiction attend the monthly safety training sessions.

7. To be responsible for any safety violations found in the area during safety inspections.

The Area Safety Managers are divided into two main groups that report via an assistant, to the DDSO, who in turn reports to the DSO.

Documentation and Reporting Procedure

Well defined documentation is an essential part of a good safety program. However, since all of the participants in the TFTR program accept their safety responsibilities as an additional task, over and above their normal daily duties, paperwork must be streamlined so as not to create an additional burden, but must contain sufficient information to highlight safety hazards and safety violations. The reporting forms must be so designed that they can be filled in with the minimum of time and effort but will contain all the necessary information required for record purposes.

After much deliberation, TFTR management decided that its program could be managed with three basic forms. The first of these is a check sheet with printed pre-set questions for the use of the Area Safety Coordinator who will complete this form before any inspection takes place. The Area Safety Coordinator will point out any abnormalities to the Area Safety Manager during the inspection, then retain the check sheet on file for future reference.

The second form, known as a "Transmittal Form" (Fig. 5), is intended for use by the Area Safety Manager, who after the monthly inspections, will record all the relevant information taken from the check sheet, plus any

additional items found during the inspection, then after signing the form will transmit it to the DDSO for recording and transmittal to the DSO, who will in turn keep the Deputy Director informed. Thus, one form can be used to convey safety information to all managers in the program.

The third form is used only by the DDSO to present safety information and safety violations to the audience at the Deputy Director's monthly safety meeting.

In parallel with the TFTR documentation are the standard Safety forms issued by the DM&S. These forms are located at various safety stations throughout the Laboratory and can be used by all personnel to report accidents, safety hazards, and safety violations. When completed by the person reporting, they are mailed directly to the safety office for action. Depending upon the incident reported, it can be dealt with directly by the Safety Office, or if it is of a specialized nature, it will be forwarded to the respective project for action.

Naturally, the Safety Officer receiving these reports will assess their importance and allocate a priority according to the nature of the hazard and its injurious effect on personnel or expensive equipment.

Responsibilities

From time to time the question is asked, "Who is responsible for safety?" The answer is that everyone from the Director down to the technician working on TFTR has a line responsibility for safety. The policy behind the Area Safety Program is to protect expensive equipment as well as personnel, and to make it a success by having everyone play a part and not delegate responsibility to someone else.

However, everyone has varying degrees of responsibility. For instance,

design safety -- is it an engineering or a safety responsibility? The answer is both. Engineers should critically review their designs to ensure that all the safety aspects have been incorporated. P&QS should then review and comment on the design. Should a safety issue arise which is considered to be outside of this group's responsibility, it will be passed to OM&S for review. When all safety issues have been satisfied, the design will be signed off as safety approved.

Once the design has been approved by the design review board, all drawings and specifications are under configuration control management. No changes can be made unless approval is first obtained from the Engineering Review Board. Representatives of the safety groups attend the Engineering Review Board meetings and review and comment on all changes. They also participate in acceptance, final testing, and operation of all plants and equipment.

Safety Training

For the safe operation of a highly technological and specialized machine such as TFTR, it is necessary to implement an ongoing safety training program. This has been achieved in general by holding a monthly safety meeting at which all TFTR personnel are required to attend, and in particular by sending selected personnel to specialized training courses organized by the Training Section. At the regular monthly training session a member of the safety division, or e.g., a member from the fire department is invited to talk on a nominated subject. During the current year, talks have been scheduled for such subjects as: fire safety and fire extinguishers, electrical grounding and tag-out procedures, electrical safety, safety in high voltage areas, and radiation.

The duration of such talks is approximately one hour and usually the talk is supported with slides or films.

Plans are being prepared to hold future safety training sessions on the following subjects:

- o Electrical hazards in high voltage areas
- o Safety in operating and maintaining cryogenic plant
- o Entry and safe working in oxygen deficient enclosures
- o Contamination control
- o Repair and replacement of components under radioactive conditions
- o Working in tritium areas
- o Disposal of radioactive components and material.

Examinations are held at the end of each specialized training course and a certificate of competence is awarded to all successful candidates.

Allocated Safety Areas

The TFTR complex has been divided into well defined safety areas under the jurisdiction of an Area Safety Coordinator. The person chosen to fill this post is one who either continually works in that area, or is very familiar with it, having been connected with the design of the components, or their installation. This person is therefore in a position to identify quickly any safety hazard or violation and take the appropriate steps for its correction. In many cases, because of familiarity with the area and its equipment, the individual is able to make suggestions which could prevent the occurrence of safety hazards.

Since some of the areas under the tokamak are very congested (Fig. 6) and border close to one another, it is essential that there is a spirit of cooperation between the Area Safety Coordinators, and an interchange of

information regarding the operation of plant and safety rules in their respective areas. This is of great importance since emergency evacuation routes pass from one area into another.

The area boundaries are usually dictated by building construction or the similarity of the equipment located therein. In the case of transformer and capacitor yards, it is defined by the safety fences. There are also areas where boundaries cover more than one floor and still remain under the jurisdiction of one Area Safety Coordinator. Examples of this are the upper and lower data acquisition rooms, and the various research laboratories on the periphery of the main complex.

Notices are posted in appropriate places in each area giving the names of the Area Safety Coordinator and alternate, and telephone numbers where they can be reached both in and out of working hours.

Hoisting and Rigging

For reasons of safety to personnel, and possible down time which could affect the operational schedule of a very expensive machine, all lifting and lifting equipment on TFTR is strictly controlled. This control is maintained through the Lift Committee, which is chaired by the manager of P&OS, and whose members are professional engineers with backgrounds embracing fabrication of steel structures and the lifting and relocation of large components.

When a lift is planned, an application, supported by a detailed lift procedure, is submitted to the Lift Committee for approval. If approved, that procedure must be followed in detail, and the specified rigging must be used in the same configuration as shown on the approved drawing. Should a change be required due to some unforeseen circumstance in the field, a "Field Change Order" showing the required change must be resubmitted to the Lift Committee for approval. During high consequence, or special high consequence lifts, a

representative from the safety group is in attendance.

A high consequence lift is defined as, "a load or operation in which the failure of the operation would result in an injury to personnel resulting in lost time, or a programmatic schedule delay between two and four weeks, or a monetary loss between \$50,000 and \$250,000, or a release of radioactivity resulting in an individual dose between 1 rem & 5 rem."

A special high consequence lift is defined as "a load or operation in which the failure of the operation would result in an unacceptably serious injury (fatality) to personnel, or a programmatic schedule delay exceeding four weeks, or a monetary loss exceeding \$250,000, or a release of radioactivity resulting in an individual dose rate exceeding 5 rem."

The safe use of lifting equipment and rigging is controlled by line management, while the mandatory examination and periodic load testing is controlled by the industrial safety engineer from the Safety Group.

Approved lift procedures are kept on file for future use should a similar lift be required. They can, of course, be slightly modified and resubmitted to the lift committee for re-approval.

Safety Hazards and Violations

Examples of safety hazards and violations found during monthly area inspections are as follows:

1. Temporary electrical wiring installed in an unsafe manner. Electrical installations claimed to be temporary but have been, or could be, in service for a year or more.
2. Grounding sticks for high voltage areas that are not always of an approved type.

3. Locally made pieces of lifting equipment which have not been approved by the Lift Committee, or load tested.
4. Incorrect use of cranes and rigging.
5. Mezzanine floors which do not have approved ladders or toe boards fitted.
6. Water based fire fighting equipment installed in high voltage areas.

These are a few of the more serious safety hazards which when found are dispositioned and corrected quickly, or if this is not possible, the piece of equipment is shut down until a safe solution to the problem is found. Line management, through its supervisors, is able to take care of the more common OSHA violations as and when they occur.

Effectiveness of Program

Since the Area Safety Program has now been operating for six months, it is possible to evaluate its effectiveness.

This evaluation has been made in the following manner:

1. Compare the number of safety violations reported at the first inspection with those reported six months later. It was very noticeable that there was a steady decline in the items reported. Also, those reported were actioned and closed out in a shorter time frame.

2. There has been a reduction in the number of re-occurring safety violations.
3. Defects and inefficiencies in fire fighting equipment have been reduced, mainly because the Area Safety Coordinators notify the Fire Chief immediately, and continue to progress the work order until the defect has been rectified.
4. The general maintenance of the TFTR complex has improved, because defects such as broken treads on stairs, broken concrete floors, loose floor tiles etc., all of which constitute a safety hazard are now reported during inspections and the repair work continually progressed with the maintenance division until completed.
5. The general housekeeping throughout the area has improved. In general, personnel tend to be less untidy in clean, well organized areas. Packing cases and packing materials are now cleared from working areas quickly, and pieces of wood are not left on the floor with nails protruding upwards, creating a safety hazard.

6. There has been a reduction in lost time accidents now that personnel are becoming more safety conscious. Safety through line management is an effective tool in this respect.

Conclusion

Overall the Area Safety Program has proved to be a very successful operation. There is no doubt that a safety program organized through line management is the best way to involve all personnel. Naturally, when the program was first started, there was some criticism and a certain resistance on the part of a few individuals to fully participate. However, once the program was underway and it could be seen that it was working to everyone's advantage, this reluctance disappeared and a spirit of full cooperation is now enjoyed. It is very important that for this success to continue there must be a two way flow of information, both from the Area Safety Coordinators up through line management, and from senior management, with decisions and answers, back down through the management chain with the utmost dispatch. As with all programs, there is still room for improvement. This program has started a review cycle with a view to streamlining certain areas and possibly increasing its scope in others.

References

Princeton Plasma Physics Laboratory Health and Safety Manual.
Department of Energy Hoisting and Rigging Manual.
Princeton Plasma Physics Laboratory Area Safety Coordinator Program

Acknowledgments

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Fig. 1 Tokamak Fusion Test Reactor (TFTR)

Fig. 1A Aerial View of the IFTR Complex

LABORATORY SAFETY ORGANIZATION

Fig. 2

ORGANIZATION OF AREA SAFETY PROGRAM

Fig. 3

T.	F.	T.	R.
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DEPUTY DESIGNATE
SAFETY OFFICER
E. H. RAPPE

ASSISTANT HONORARY
JUDGE LARRY R. BROWN
B. 1948

**SAFETY
MANAGER**

PLASMA PHYSICS LABORATORY
PRINCETON UNIVERSITY
TOKAMAK FUSION TEST REACTOR
AREA SAFETY COORDINATOR
PROGRAM STRUCTURE
T.F.R.

DATE	10/10/70	TIME	10:00
NAME	JOHN J. HARRIS	ADDRESS	1000 10TH AVE N
PHONE	214-211-1111	CITY	DALLAS
STATE	TX	COUNTY	DALLAS
ZIP	75201	AGE	35
SEX	M	HAIR	B
EYES	B	SKIN	F
HEIGHT	5'10"	WEIGHT	170
EDUCATION	B.S.	EMPLOYMENT	TECHNICAL
RELIGION	C	POLITICAL	D
HOBBIES		SPORTS	
REFERENCES		REMARKS	

Fig. 4 Chart of Area Safety Coordinator Program Structure

Date of Report: _____

SAFETY MANAGER'S CONSOLIDATED SELF INSPECTION REPORT

1. THE SELF INSPECTIONS FOR MY AREAS (USING CHECK LIST) WERE COMPLETED ON _____.
2. THE DEFICIENCIES NOTED AND PLANNED CORRECTIVE ACTIONS ARE LISTED BELOW:

ITEM #	DEFICIENCY	PLANNED CORRECTIVE ACTIONS	COMPLETION DATE
		(Attach additional sheets if required)	

Safety Manager _____ Date _____

REVIEWED

J. McCann	Date	} Assistant DSO
K. M. Young	Date	
G. H. Rappe	Date	DSO
E. Simon	Date	DSO

cc: D. Grove
J. R. Thompson

Fig. 5 "Transmittal Form"

Fig. 6 Congested Area Under TFTR