Trip Report

1996 Meeting of U.S. - Japan Safety Monitor Joint Working Group (JWG)

June 19-27, 1996

A. PURPOSE

The purpose of the 1996 meeting of the U.S. - Japan Safety Monitor Joint Working Group was to informally evaluate the programmatic aspects of safety and health in Japanese fusion research facilities by touring laboratory areas and meeting with researchers and safety professionals. Based upon these interactions, the U.S. - Japan delegation was to provide guidance in an effort to reduce the likelihood of bodily injury and/or property damage. In addition, the U.S. - Japan Safety Monitor Joint Working Group continues to provide criteria for the necessary safety orientation for foreign collaborators (Japanese, U.S., Russian, European, etc.).

B. EXECUTIVE SUMMARY

The U.S. participants in the 1996 U.S. - Japan Safety Monitor Joint Working Group meeting were:

- Richard L. Savercool, Fusion Safety Manager, (General Atomics)
- Joseph A. Smith, Industrial Safety Engineer (Princeton Plasma Physics Laboratory)

The Japanese participants were:

- Masatsugu Shimizu (Japan Atomic Energy Research Institute)
- Teruo Tamano (Plasma Research Center, University of Tsukuba)

Like the U.S. fusion research facilities, there was generally a significant difference, with regard to the safety of working conditions, between laboratories (having larger budgets) and university research facilities (having smaller budgets). However, there were noticeable similarities between many (but not all) of the Japanese laboratories and universities with regard to electrical issues, fire suppression, safety signage, and contractor supervision.

Prior to the next Safety Monitor JWG meeting in Japan (in 1998), it is suggested that electrical installation standards be investigated. In many of the facilities visited, the following electrical issues were found on a fairly consistent basis:

- conductors were exposed at the point where power cables were connected to equipment
- the bottom portion of circuit breaker panels, in many cases, were not enclosed, there-by exposing live conductors (in some cases where the bottom portions of the circuit panels

were enclosed, power cables emitting from the panel were not securely fastened and were supported/hung by the individual wires instead of the conduit or armored exterior)
- "start" and "stop" buttons (and indicator lights) on electrical equipment do not have standardized colors. In the U.S. a red button is used to stop a machine and a green button is used to start a machine. When the Japanese facilities were visited, there were some cases where green buttons were used to stop a machine and red buttons were used to start a machine. In other areas, the opposite was true. In situations where foreign scientists conduct research at a Japanese facility, the control switch configuration could cause inadvertent (and perhaps harmful) activation or deactivation of equipment.

In the U.S., the aforementioned issues are specifically addressed in an industry standard for electrical installations (National Fire Protection Association's National Electrical Code®).

In a few large facilities, it was noticed that automatic fire suppression systems were not always provided. It is recommended that this issue be considered. Due to the relative cost and availability of the experimental equipment found in the Japanese facilities, damage by fire could be very expensive and could curtail experimental activities for several weeks to several months, depending upon a manufacturer's ability to replicate a piece of unique equipment (that is lost due to fire).

In some of the facilities visited, there was extensive use of international safety signs. This feature was very favorable since many of the Japanese laboratories and universities host foreign collaborators. The international signs significantly contribute to the safety of all personnel as the symbols used to denote hazards are readily apparent, even to those who are not fluent in the Japanese language. In particular, the Japan Atomic Energy Research Institute has been very proactive in providing international safety signage. It is recommended that all of the Japanese and U.S. fusion research facilities consider the usage of international safety signs.

In all of the Japanese fusion research facilities, it was noticed that there is no direct supervision or oversight of contractor activities. This situation differs significantly from the U.S. facilities. Contractor personnel are inherently less familiar with a new job site and contractors tend to be involved in construction (using heavy equipment), demolition, excavating, and electrical work. During the course of their work, there may be welding, dust producing activities, utility interruptions (whether scheduled or unscheduled), and/or other unusual activities. Having an in-house construction supervisor, acting as a liaison between the contractor and the university/laboratory can aid in preventing inconveniences and costly property damage that can also lead to interruptions in experimental schedules (such as inadvertent activation of smoke detectors during welding activities, damaging underground utilities while excavating, clean room equipment damage caused by dust-producing activities, etc.). It is suggested that the Japanese fusion research laboratories consider having more strict supervision of contractor activities. In addition, the aforementioned liaison can aid researchers in planning appropriate measures to protect sensitive equipment and building components.

It has been discussed that short term personal exchanges for safety activities (just like scientific personal exchanges) may be very useful. The National Institute for Fusion Science and Japanese universities welcome this idea.

C. SITES VISITED

June 19, 1996 - National Institute for Fusion Science (NIFS) - Toki Site (Toki, Japan)

Contacts Made - Dr. S. Tanahashi, Dr. H. Hirabayashi, Dr. Y. Sakuma, Dr. T. Uda, Dr. A. Moriyama, Ms. K. Sugiyama

In recent years there have been two nonsuperficial incidents at the NIFS Toki Site. One of the incidents involved an explosion of an oven that was heating decaborane for vaporization. In this incident, the heater controller was defective so the heating element was disconnected from the controller and plugged directly into a wall outlet. This situation allowed the oven to reach temperatures in excess of 400 C within 20 minutes. While the temperature increased, the decaborane continued to expand, causing a significant pressure build-up within the oven. The pressure increase eventually caused the oven's viewing window to burst. A burst of burning hydrogen was emitted from the window and burned the face of a researcher who was hospitalized for approximately three weeks. After this accident, a safety inspection team (known as the "Dragon Team") was organized by NIFS management. An investigation of this incident and an inspection of all other experimental equipment was conducted by the team. As a result of this inspection, the heaters are now hard-wired to the temperature controllers. Follow-ups on the remainder of the Dragon Team's findings for all other experimental equipment have not yet been completed.

The second incident involved a construction employee that fell when he stepped on an unsecured (removable) floor covering on an elevated platform (mezzanine). The section of flooring in question was situated unevenly on a crevice. When the employee stepped on the loose section of flooring, it tipped and both the employee and the flooring fell approximately five meters to the permanent floor below.

Although there have been two nonsuperficial incidents at the NIFS Toki Site, it should be noted that this figure represents a very favorable accident record. In recent years, there have been (and continue to be) large-scale construction projects at NIFS. Since construction (in the United States) is considered to be one of the most hazardous industries, it is not uncommon to have a larger number of injuries, especially on a project that is comparable in size to the construction in recent years at NIFS.

In the community of U.S. fusion research facilities, contractors are closely supervised by facility management. This situation is very different at NIFS and other Japanese facilities. Since (U.S.) contractors are not familiar with the operations of experimental facilities, management provides daily supervision of contractors so that damage to personnel, buildings or equipment can be prevented (thus preventing unscheduled interruptions in experimental schedules).

During the visit to the Toki site, it did not appear that Japan has detailed standards that specifically address employee safety and health. This situation is very different from the U.S. Examples of the U.S. standards are as follows:

- All electrical installations must conform to the National Electrical Code®
- Flammable liquids must be stored in accordance with National Fire Protection Association (NFPA) Standards
- Machine tool (lathes, milling machines, grinders, sawing machines, etc.) safe-guarding methods as specified by the American National Standards (ANSI) must be followed

It is suggested that this issue be researched. Having specific requirements, particularly in the electrical installation category, can aid in having a consistent level of safety in experimental areas.

During the visit to the Diagnostics Laboratory, it was discovered that the (air) face velocity at the chemical exhaust hoods is not checked at regular intervals. No regulated chemical agent has been handled in this exhaust hood since this was newly installed. In the U.S., the air velocity at the sash must be 100 ± 20 linear feet per minute (30.5 ± 6.1 linear meters per minute) and should be checked every six months.

The members of the Safety Monitor JWG were impressed with the commitment to provide safety training (handbook and courses in fire drills, radiation safety, electrical safety, compressed and liquid gas handling, crane safety, and waste water handling) to employees and to post signs throughout the facility to warn of potentially hazardous conditions. At this time, the aforementioned items are available only in Japanese. However, only one of the ten foreign visitors at the Toki site is fluent in Japanese. In order to improve these aspects of the NIFS safety program, it is suggested that training materials and signs be made available in English. The U.S. Safety Monitors have offered to assist in the editing of the English-based materials.

In order to protect experimental equipment from fire damage, NIFS has installed automatic fire suppression equipment. This aspect is very favorable. In particular, it was noticed that carbon dioxide systems were used in the basement of the Large Helical Device Building. The use of carbon dioxide was an excellent choice as equipment damage that would otherwise be caused by water sprinklers (that are commonly used in the U.S.) may be averted.

June 20, 1996 - Nagoya University (Nagoya, Japan)

Contacts Made - Professor S. Takamura, Professor N. Ohno, Dr. H. Sugai, Dr. H. Toyoda, Professor K. Morita, Professor K. Soda

In Nagoya University's School of Engineering, there is a proactive effort to promote safety. Examples of these efforts include, but are not limited to:

- Safety education for students (fire extinguisher training, fire drills, handling radioactive isotopes, use of machine tools, chemical safety, etc.)
- The Director of the School of Engineering performs an annual safety inspection of the experimental areas and a report is generated and sent to the Safety Committee
- Dosimetry is used to monitor X-Ray exposure in experimental areas
- Additional accident insurance is provided for students that are involved with plasma science experimental activities
- A safety training film (in English) has been created for visiting foreign scientists

A tour of experimental facilities (Plasma Surface Interactions Laboratory - Dept. of Electrical Engineering, Edge Plasma Physics Laboratory - Dept. of Energy & Science, and Plasma Surface Interactions Laboratory - Dept. of Crystalline Materials Science) was conducted while at Nagoya University. In the Plasma Surface Interactions Laboratory (Dept. of Electrical Engineering) a few items of interest were noted. They are as follows:

- Chlorine gas shower (scrubber) emptied into the sanitary sewer system, thus creating a potential environmental pollution issue
- Belts and pulleys on the vacuum pumps exposed pinch points that could pose a hazard
- Trenches (bus ducts) were not fully covered thereby causing potential trip hazards

The safety poster (emergency information card) found on the door to the laboratory was very favorable in that it provided detailed instructions for procedures and emergency contacts in the event of fire or other emergency. At this time, all persons who use this laboratory are fluent in Japanese. If in the future, non-Japanese collaborators use this area, it would be beneficial to provide this information in a language that is familiar to the particular visiting scientist. In the event of a fire, the safety poster could be destroyed or sustain damage before first responders (fire fighters) could arrive. Therefore, the fire fighters would not have the benefit of the appropriate emergency contacts and information needed to make the area safe (isolate power and other hazardous energy sources) in order to prevent injury to fire fighters or other responders. Therefore, it would be advisable to also post a copy of the safety poster on the outside (hall side) of the laboratory door.

In the event of a chlorine gas release, the Department of Engineering's Plasma Surface Laboratory has provided a Self Contained Breathing Apparatus (SCBA) unit so as to provide respiratory protection. Emergency planning in this area is very commendable. At this time, the SCBA unit is located inside the same room as the chlorine gas source. In the event of a chlorine release, it may not be safe to enter the room to access the SCBA unit. Therefore, it is suggested that the SCBA unit be relocated to a different area outside the room. The location of the SCBA unit should be provided on the safety poster and included in the safety education training program.

In the Department of Energy Engineering & Science's Edge Plasma Physics Laboratory there were a number of electrical safety observations that, in the U.S., would be considered serious safety issues.

In the area located adjacent to the motor generator, knife switches having exposed conductors were in use. In addition, partially exposed wiring connections (splices, breaker/fuse panel connections) were present. In the U.S., splices would be required to be enclosed in a junction box. In addition, wiring connections would be required to be fully enclosed (in armored cable; electrical metal tubing; or rigid metal conduit, depending on the application). The wiring enclosure (tubing, conduit, etc.) would also be required to be fastened to the base of the circuit panel and the interior of the circuit panel would fully enclose all conductors.

Although some cables were enclosed in trenches (duct banks), ropes were used to support signal and power cables in other areas. In addition, some power cables were draped on the floor, creating a condition where the cable insulation was subject to damage (which could eventually expose live conductors thereby increasing the possibility of electrocution). In the U.S., power cables and signal cables are require to be separated. In addition, all cables are required to be secured/routed in a permanent fashion (such as in a fully enclosed duct bank or cable tray). It should be noted that although floor duct banks were used, there were portions that were not fully enclosed, creating a potential trip hazard. It is suggested that the duct panel covers fully enclose the cables and that cut-outs be made to the covers to accommodate cable runs that emerge from the duct banks. It was also noticed that there was a blocked fire extinguisher. It is recommended that the fire extinguisher be located in an area near a fire exit and that access to the extinguisher be unobstructed at all times.

The Department of Crystalline Materials Science’s Plasma surface Interactions Laboratory was visited. This laboratory is a relatively new facility and employs wiring methods that are similar to (or better than) what is found in the U.S. Consequently, no electrical deficiencies were found. In addition, housekeeping was exceptional. It should be noted that one emergency exit was blocked. In order to facilitate egress in the event of emergency, it is suggested that all exits me kept clear at all times.

June 21, 1996 - Kyoto University (Kyoto, Japan)

Contacts Made - Professor Y. Terumichi, Dr. M. Asakawa, Professor T. Maekawa, Professor H. Tanaka, Associate Professor K. Ishii, Professor K. Tachibana, Associate Professor Y. Yasaka

At Kyoto University, two projects were reviewed—WT-3 (Tokamak) and the HIEI Tandem Mirror.

The WT-3 program has been proactive in instituting a safety training program for students. The training program consists of the following:

- two to three day general safety course (taught in April)
- two day machine tools course
- half day high pressure gas handling course (taught in June)

- one day X-Ray radiation safety course

It should be noted that the safety training is only mandatory for graduate students as they are the only students that are permitted to operate the WT-3 Tokamak machine. It should be noted that there is essentially free access to the machine shop area. Therefore, working alone in this area may be an issue. In the U.S., working with machine tools is generally considered a hazardous operation and requires that more than one person be present while machine tools are being operated.

In order to protect personnel, an interlock stop key system has been installed in the WT-3 Tokamak area. Individuals are required take a key before entering WT-3 machine and/or power supply area. If any of the keys are missing from the interlock panel, then the WT-3 machine will not work. During the tour of the WT-3 facilities, it was mentioned that individuals usually (but not always) take an interlock key before entering the machine area. It is recommended that the use of the interlock keys be strictly enforced.

In addition to the interlock stop key system, there are three other major safety features that aid in protecting personnel in the WT-3 machine area—television cameras, count down alarm, and emergency stop buttons. By having a closed-circuit television system, operators can see if there are any people located in the WT-3 machine area (and abort operation if personnel are present in the experimental area). Second, the count-down alarm provides an audible warning to persons in the experimental facilities just prior to operation of the Tokamak. Lastly, an adequate number of emergency stop buttons are located adjacent to the WT-3 device. With the combination of the interlock stop system and the aforementioned safety features, operation of the WT-3 Tokamak, while persons are located in the machine and/or power supply area, seems highly improbable. The Safety Monitor JWG was very impressed with these features.

At this time, all of the students that operate the WT-3 Tokamak are fluent in Japanese. However, it is recommended that the safety signs that are utilized throughout the facility be standardized with international "warning" or "danger" symbols (to denote high voltage, do not enter, trip hazards, flammables, etc.) so that foreign visitors (who are not fluent in Japanese) are aware of hazards in the experimental areas. It should be noted that international symbol signs are currently in use for "LASER" and "EXIT" signs.

During the tour of the WT-3 area, a few items that were observed need to be addressed. It was noticed that circuit breaker boxes were left open, causing live conductors to be exposed. This situation could lead to electrocution. In addition, there were trenches (bus ducts) that were left partially open, causing a serious trip hazard. It is suggested that the circuit panels be kept closed and the bus ducts be fully covered (with cut-outs where cables emerge from the trenches). Lastly, belts and pulleys on the vacuum pumps were exposed. During operation of the pumps, injury could be caused if the exposed pinch-point areas are contacted by persons.

In order to provide guidance concerning safe work practices and equipment safe-guarding, J. Smith (PPPL) will send a copy of PPPL's Basic Electrical Safety course and information concerning safe-guarding of machine tools.

In the HIEI Tandem Mirror project, students receive safety training in a variety of areas (such as electrical, fire, first aid, high pressure gas, chemical handling, and machining). In addition, the HIEI Tandem Mirror project utilizes an equipment status check board at the entrance of the laboratory. The status board alerts students to the condition of experimental equipment and warns of potential, unique hazards associated with equipment modifications. The JWG members were very impressed with the use of the status board.

In the past, there was one accident where a student received an electrical shock. Fortunately, the student was not seriously injured. In order to prevent similar accidents and equipment damage, some changes in the wiring methods used in the HIEI Tandem Mirror project are recommended. In many areas, there were power cables draped on the floor. This situation could lead to damage to the cable insulation (as persons may scrape the cable on the floor when walking in the lab), thus exposing live conductors. To remediate this situation, it is suggested that cables be fully enclosed in trenches (duct banks) and/or cable trays should be used. It is further suggested that power cables and signal cables be separated.

In order to provide guidance concerning safe electrical work practices and laser safety, J. Smith (PPPL) will forward a copy of PPPL's Basic Electrical Safety and laser safety courses to the HIEI Tandem Mirror Project manager.

At this time, students are permitted to work alone on machine tools. In the U.S., working with machine tools is generally considered a hazardous operation and requires that more than one person be present while machine tools are being operated. It is suggested that machine tool use, as it relates to working alone, be reevaluated.

The JWG members were very impressed with the care that is taken when Silane (explosive) gas is used. First, students are not permitted to work alone when handling Silane. Second, gas detectors are located throughout the laboratory and will provide warning if Silane is detected. In addition, the gas detectors are serviced yearly so as to assure their reliability.

At the entrance of the laboratory, a safety poster is provided. The safety poster provides the names and telephone numbers of individuals that are familiar with the operations and content of the laboratory. In addition, the poster also identifies the compressed gases (and identifies Silane as a flammable gas) that are used in the lab. In the event of an emergency, this information would be very valuable to fire fighters and other first responders and would significantly aid in reducing the likelihood of injury to emergency personnel. The HIEI Tandem Mirror Project Management should be commended for their efforts in this area.

To protect students and researchers from hazards associated with chemical vapors, a vent hood is in place. At this time, the vent hood is not serviced. In the U.S., the air velocity at the sash must be 100 ± 20 linear feet per minute (30.5 ± 6.1 linear meters per minute) and should be checked every six months. It is suggested that servicing the vent hood be considered.

June 24 - Kyushu University (Fukuoka, Japan)

Contacts Made - Dr. K. Murakoa, Professor S. Itoh, Dr. M. Uchiumi, Dr. M. Sakamoto, Dr. K. Nakamura, Dr. M. Bowden, Professor N. Yoshida

At Kyushu University, three facilities were seen—TRIAM Facility, Diagnostics Laboratory, and the Material Science Laboratory.

At the TRIAM Tokamak reactor facility, the JWG members were very impressed with the safety-related design and the operational safety aspects. In particular, the high voltage interlock systems (and the associated annual maintenance/testing program) were considered to be noteworthy. In addition, the storage and gas detection measures associated with hydrogen were also very impressive. The TRIAM project has also been very proactive in providing safety training. The following courses are currently offered:

- Compressed Gas Training
- Fire Extinguisher Training
- X-Ray Radiation Exposure and Dosimetry Training
- Electrical (High Voltage) Safety Training
- Machine Tool Usage Training

The fire detection and suppression components consist of a monitored smoke detection system and manually operated halon suppression equipment. The monitored smoke detection system is excellent, however it is recommended that an automatic suppression system be considered. Like many plasma research laboratories, the TRIAM facility contains unique equipment that could be both difficult and costly to replace. If manual activation of the current halon suppression system is delayed (from the time that the smoke detection system registers), additional damage (from smoke, heat, and flames) could result. Please note that smoke tends to be "sooty" and can damage or ruin electronic equipment (by coating connections, conductors, sensors, etc.). As noted earlier, damage or destruction of unique components may be difficult to replace. Therefore, a single fire could have the potential to interrupt experimental operations for several weeks (or months).

Since the TRIAM vacuum vessel is occasionally entered, a confined space entry program has been established. At this time, the oxygen level inside the vacuum vessel is checked, prior to entry. It is suggested that the concentration of explosive and toxic gas also be checked prior to entry. In the U.S. this practice is considered standard in all confined space entry activities.

In the Material Science Laboratory (Research Institute for Applied Mechanics), a comprehensive safety training program (and safety culture) has been developed along with a safety booklet, that covers chemical handling and high voltage safety. The booklet also has one or two pages of unique safety-related information concerning each experimental area. Various pages of the booklet, that correspond to each experiment, have been posted on the doors of their respective experimental areas.

In order to promote a safety culture, students are required to receive safety training based upon the previously mentioned safety booklet. As part of the training, new students are also required to draw a schematic diagram of the laborator(y)(ies) where they will be working. In these diagrams, the students must denote hazards (such as high voltage, compressed gases, flammables, etc.) that are contained in the lab. The diagrams are then posted on the door at the entrance of the laboratory. This training process is one of the best that the JWG members observed during the 1996 Japan visit.

The Material Science Laboratory's safety program has been developed as a result of a few minor accidents in previous years. In an effort to prevent serious injury, individuals are not permitted to work alone in high voltage areas.

During the visit to the Material Science Laboratory, many noteworthy practices were observed, however one recommendation was generated. In the Pulse and Steady Heat Loading Simulator Room, there was a circuit breaker panel that was blocked. It is suggested that clear access be maintained approximately one meter in front of the panel (and that a clear passage be maintained to access the panel).

June 25 - Tokyo University (Tokyo, Japan)

Contacts Made - Dr. N. Inoue, Dr. M. Katsurai, Dr. H. Toyama, Dr. Y Ogawa, Dr. Y Ono, Dr. K. Hanada

A tour of the following experimental areas was conducted at Tokyo University:

- REPUTE-1 Laboratory
- Tokyo Spherical Tokamak (TST) Project
- Tokyo Spheromak 3 (TS-3)

Tokyo University's overall safety and health program, for fusion research, is very informal. Although a safety manual has been developed, it is not currently available in English. It should be noted that all students in the fusion science curriculum are fluent in Japanese. However, there are occasions when foreign scientists, who are not fluent in Japanese, visit Tokyo University's fusion research facilities. In those cases, safety information, found in the safety manual and/or on "warning" or "danger" signs may not be readily apparent. At this time, no safety training is required for graduate students. It is recommended that an electrical safety course be offered. J. Smith (PPPL) will forward a copy of PPPL's Basic Electrical Safety course to Dr. N. Inoue. It is suggested that training in the following subjects be offered as appropriate:

- Capacitor Bank Accessing
- Radiation Safety
- Laser Safety Training

J. Smith (PPPL) will forward a copy PPPL's version of the aforementioned courses.

In the REPUTE-1 Laboratory, a few life safety issues were identified. In the event of a power failure, egress from the experimental area could be difficult as it does not appear that emergency lighting is provided. Since there are physical obstacles (stairs, doors, and potential trip hazards created by the presence of experimental equipment) and electrical equipment hazards (motor generator, capacitor banks, etc.), it is suggested that emergency lighting be provided. In the capacitor bank area, the doors on the metal enclosure (around the capacitor banks) do not open fully as they are partially obstructed by the motor generator. It is suggested that a sliding door be used in place of the current hinged door.

It is recommended that an automatic carbon dioxide fire suppression system be considered for the motor generator. In the event of a fire the motor generator could be both difficult and costly to replace. Without an automatic fire suppression system, damage (caused by smoke, heat, and flames) could also be sustained by other pieces of (unique) experimental equipment (such as capacitor banks or the REPUTE-1 reactor). Please note that smoke tends to be "sooty" and can damage or ruin electronic equipment (by coating connections, conductors, sensors, etc.). As noted earlier, damage or destruction of unique (difficult to replace) components may occur. Therefore, a single fire could have the potential to interrupt experimental operations for several weeks (or months). In addition, it is suggested that pipe chases and conduit runs in all areas be sealed to aid in preventing the circulation of smoke, heat, and flames in a fire situation.

The TST Project has a staff of approximately ten (including students) and uses senior students to orient junior students regarding the operation of the experimental equipment. The orientation period is approximately six months. Although the machine can be operated at almost anytime of the day, no one is ever permitted to work alone. The JWG members were very pleased to see that this requirement was in place.

In the TST machine area, a number of recommendations (mostly electrical-related) were noted. They are as follows:

- A nonmetallic sheathed cable, affixed to the wall of the pit area adjacent to the TST machine, was used to power an outlet. In the U.S., rigid metal conduit would be required for this application (as the TST machine area would be considered an "industrial" area).
- On the TST machine, there were exposed conductors on the toroidal field coils. It is recommended that these conductors be insulated so that possible electrocutions can be prevented.

- In order to further prevent electrocution and exposure to ionizing radiation, all doors that lead to the TST machine area should be interlocked (so that the machine will automatically shut down in the event that any of the doors are opened during operation).
- At the base of the circuit breaker panels, there are exposed conductors (where the wires connect to the panel). To prevent electrocution, it is suggested that the conductors be covered (perhaps with plexi-glass).
- It was noticed that there were bottles of compressed Hydrogen gas that were not secured. A chain or strap, located at approximately 2/3 the height of each cylinder, should be used to secure the cylinder from falling.

Since foreign (non Japanese speaking) collaborators sometimes experiment on the TST machine, it is recommended that "warning" or "danger" signs having international symbols be used. In particular, it is suggested that the "Danger High Voltage" sign that is used on the Capacitor Bank Room be replaced with a sign that utilizes international symbols.

In the Tokyo Spheromak Three (TS-3) Project, students receive three to five days of training related to operation of machine tools (lathes, drill presses, etc.) and experimental equipment (such as motor generators). The TS-3 project should be commended on these efforts.

In the machine and machine component areas, a number of recommendations were generated. They are as follows:

- A number of compressed gas bottles, located in the hall adjacent to the Capacitor Bank/Power Supply Room were gang-chained. A chain or strap, located at approximately 2/3 the height of each cylinder, should be used to secure each individual cylinder from falling (one chain per cylinder).
- On the exterior of the Capacitor Bank/Power Supply Room, it is recommended that a safety poster be provided. The safety poster should list the names and telephone numbers of individuals that are familiar with the operations and contents of the room. In addition the poster should also identify specific hazards associated with the area (such as high voltage) and measures to "safe" the area (such as denoting the location of breakers that isolate energy sources that feed equipment in the room). In the event of an emergency, this information would be very valuable to fire fighters and other first responders and would significantly aid in reducing the likelihood of injury to emergency personnel.
- In the TS-3 machine area and in the laser laboratory, located above the TS-3 machine, it is suggested that clear access to the exits be maintained. In a building emergency, such as a fire, an unobstructed exit would facilitate rapid egress.
- In order to be able to easily isolate energy sources in an emergency situation, a clearance of one meter should be maintained in front of all circuit breaker panels.

June 26 - Electrotechnical Laboratory (ETL) (Tsukuba, Japan)

Contacts Made - Dr. K. Hayase, Dr. Y. Owadano, Dr. S. Takaaki

The ETL facility has developed a safety manual and/or training programs in areas such as radiation, high voltage, lasers, compressed gases, crane use, chemical handling/disposal, and machine tools. The JWG members were very impressed with the attention that ETL has given to developing the aforementioned manuals and/or training courses. During the visit to ETL it was indicated that there is no formal policy concerning working alone. It is suggested that a policy concerning this issue be developed. In the U.S., working alone is generally not permitted while engaged in activities such as:

- working on scaffolds
- confined space entry
- working on exposed, energized, electrical circuits
- operating cranes, hoists, and heavy equipment
- operating machine tools
- using explosives and/or powder actuated tools
- handling potentially hazardous substances (cryogenics, caustics, etc.)
- using class 2 or class 3 radioactive sources

In addition, individuals with medical impairments (such as heart disease, convulsive disorders, etc.) are not permitted to work alone.

In the Toroidal Plasma Experiment (TPE) laboratory, it was noticed that smoke detection was provided but automatic fire suppression equipment was not installed. It is recommended that an automatic fire suppression system be considered for the TPE area. In the event of a fire, the TPE devices could be both difficult and costly to replace. Without an automatic fire suppression system, damage (caused by smoke, heat, and flames) could also be sustained by other pieces of (unique) experimental equipment (such as the capacitor banks that are located beneath the existing TPE machine). Please note that smoke tends to be "sooty" and can damage or ruin electronic equipment (by coating connections, conductors, sensors, etc.). As noted earlier, damage or destruction of unique components may be difficult (and costly) to replace. Therefore, a single fire could have the potential to interrupt experimental operations for several weeks (or months). In addition, it is suggested that pipe chases and conduit runs in all areas be sealed to aid in preventing the spread of smoke, heat, and flames to other experimental areas such as the KrF Eximer Laser located in an adjacent laboratory.

It is recommended that access to the capacitor bank area be more restricted. At this time, the individual capacitor banks are not enclosed (and hence not designed to automatically discharge in the event that one enters the cap bank area). Therefore, it is suggested that the capacitors be fully enclosed and that the aforementioned interlocks be installed so that possible electrocution hazards can be eliminated.

The KrF Eximer Laser experiment staff has developed a four page laser safety manual. In addition to providing valuable safety information, the manual has also been translated into English. The KrF Laser experiment staff should be commended for their efforts in this area.

In the KrF Eximer Laser laboratory, a few recommendations were generated. They are as follows:

- In order to prevent trips and falls, the trenches (bus ducts) should be fully covered. In areas where cables emerge from the trenches, a cover with cutouts, just large enough to accommodate the emerging cable(s), should be used.
- Since lasers are in use and a potential eye hazard exists, it is suggested that the doors that lead into the laboratory be interlocked so that the laser will automatically shut-off when a door is opened.

June 26 - National Research Institute for Metals (NRIM) (Tsukuba, Japan)

Contacts Made - Dr. M. Okada, Mr. T. Nakagawa, Dr. J Nagakawa, Dr. Kitahara, Dr. Hikawa, Dr. H. Wada, Dr. T.Shimada

The NRIM research facilities has a very proactive safety program. This program requires that safety inspections be conducted every other month. In addition, the Director General conducts an annual site-wide safety inspection. The NRIM has been particularly diligent in its approach to electrical safety. In order to maintain consistency in the safety (and quality) of their in-house electrical work, they have developed their own standard for electrical installations— "*NRIM Manual for Equipment Installation at the Standard Laboratory Building, First Edition.*" The NRIM should be commended for their efforts in this area.

The NRIM Cyclotron Laboratory was a very well maintained facility. In particular, the JWG members were particularly impressed with the electrical wiring methods used in this area (as no electrical deficiencies were found). It appears that the *NRIM Manual for Equipment Installation at the Standard Laboratory Building* has been a success.

The NRIM Tsukuba Magnet Laboratory was visited. Although the tour of the magnet facility was brief, the JWG members were impressed with the overall attention to safety that is given to operations at this facility. Since the Magnet Laboratory is heavily involved in super-conducting magnet research, cryogenic liquids are widely used. In order to reduce the likelihood of cryo burns, it is suggested that use of a face shield, cryo gloves, and an apron be required when handling cryogenic liquids. In addition, it is recommended that oxygen detectors be supplied in areas where cryogens are used (as many cryogens tend to be asphyxiants).

June 27 - Japan Atomic Energy Research Institute (JAERI) - Naka and Tokai Sites (Naka, Japan and Tokai, Japan)

Contacts Made - Dr. S. Shimamoto, Dr. A. Funahashi, Mr. M. Shimizu, Mr. H. Okada, Mr. T. Hiyama, Mr. K. Hasegawa, Dr. T. Ando, Dr. H Nakajima, Dr. T. Imai, Dr. Y. Ohara, Dr. H. Takeuchi, and Dr. M. Ohta

The JT-60 and JF2-TM projects have placed much emphasis on safety training. In particular, courses have been developed for the following:

- Confined Space Safety
- Radiological Safety (also available in English)
- High Voltage Safety (also available in English)
- High Pressure Gas Safety
- Fall Hazard Safety
- Organic Solvent Safety
- Laser Safety
- Crane Safety
- Material Movement Safety
- Traffic Accident Procedure

Special training for foreign visitors (offered in English) has been developed. In addition to the radiological and high voltage safety courses, the following materials have been created:

- Hand Book on Safe Work Practices in Fusion Energy Research and Development

- Instruction Manual of the Control of Safety and Sanitation for Foreign Visitors JFT-2M

- Cardiopulmonary Resuscitation (video)

- How to work Safely in Controlled Areas (video)

- Safety Rules for Research and Development (video)

In recent years, the JAERI organization has evaluated hazards in individual work sites and posted "warning" or "danger" signs that utilize international symbols. The sign wording is also provided in both English and Japanese. Since there are approximately 50 foreign researchers at the JAERI facilities, the bilingual verbiage and international symbols that are used on the signs significantly contribute to their effectiveness in identifying (and communicating) hazards to all laboratory personnel. The JWG members were very impressed with these features.

A safety inspection program has been created (at both the JT-60 and JFT-2M sites) in order to identify (and remediate) unsafe conditions. The facility inspection program involves monthly walk-thrus by general managers, biannual reviews by department directors, and an annual inspection by the Director General. The JAERI organization should be commended for their management commitment to safety.

During the tours of the Naka and Tokai sites, a few items were noted. They are as follows:

- In the lower floor of the Neutral Beam Injection Laboratory Building, it is suggested that a permanent emergency lighting system be provided so as to provide an adequate and reliable illumination source in the event of a failure of the normal lighting system (in order to facilitate safe and rapid egress from the area).
- In the RF Heating Laboratory, it was noticed that one of the fire doors in the high bay area was left open (as it appeared that the door's self-closing mechanism was not functioning properly). In addition, it was noted that there were unsealed penetrations (cable runs) in a fire wall (wall that separates the high bay area and the RF Control Room). It is recommended that the fire doors be kept closed at all times and that penetrations in all fire walls be sealed. Doing so will prevent the spread of heat and smoke in a fire situation and help minimize damage to experimental equipment. Please note that smoke tends to be "sooty" and can damage or ruin electronic equipment (by coating connections, conductors, sensors, etc.). Damage or destruction of unique components may be difficult to replace. Therefore, a single fire could have the potential to interrupt experimental operations for several weeks (or months).
- In the Superconducting Magnet Laboratory, there was a fire door that was propped open. In order prevent additional property damage in a fire situation (see previous item), it is suggested that all fire doors be kept closed at all times.
- It was noticed that automatic fire suppression is not provided in many of the experimental areas. Without an automatic fire suppression system damage (caused by smoke, heat, and flames) could also be sustained by (unique) experimental equipment (such as capacitor banks, neutral beam equipment, RF equipment, etc.). Please note that smoke tends to be "sooty" and can damage or ruin electronic equipment (by coating connections, conductors, sensors, etc.). As noted earlier, damage or destruction of unique components may be difficult to replace. Therefore, a single fire could have the potential to interrupt experimental operations for several weeks (or months).

D. ACKNOWLEDGMENTS

The U.S. - Japan Safety Monitor JWG members would like to thank all of the individuals who participated in the facility tours. The U.S. JWG members especially thank the hosting institutions for their very gracious hospitality. In addition, the U.S. members were very appreciative of Teruo Tamano and Masatsugu Shimizu for their efforts in organizing the trip agenda and travel arrangements. Their attention to detail prior to and during the trip made the entire event both profitable and enjoyable to all.

□

APPENDIX A (Itinerary)

June 17, 1996 (Monday) - Leave U.S.

June 18 (Tuesday) - Arrive in Japan

June 19 (Wednesday) - NIFS Toki site

Visitors:

Richard L. Savercool (GA)
Joseph A. Smith (PPPL)

Masatsugu Shimizu (JAERI)
Hideo Okada (JAERI)

Host:

Shugo Tanahashi, Tatsuhiko Uda (NIFS)

Tel: 052-789-4571 (Nagoya Higashiyama Site);

Tel: 0572-57-5676 (Toki Site)

Fax: 052-789-4248

Agenda:

9:00 Picked up at Nagoya Tokyu Hotel (by Prof. Tanahashi and a member of the NIFS administration office)
10:30 Arrive at Toki Site
Overview (Prof. Tanahashi)
11:00 - 11:45 Tour of Heating Building (Prof. Kuroda)
12:00 - 13:00 Lunch
13:30 - 14:15 Tour of Diagnostics Building (Prof. Hamada)
14:20 - 15:05 Tour of Cryogenic System Building (Prof. S. Nishimura)
15:10 - 16:10 Tour of Machine Building (Prof. K. Nishimura)
16:15 - 16:30 Discussion
16:30 Leave Toki Site
18:00 Arrive at Nagoya Tokyu Hotel
18:30 - 20:00 Dinner at Restaurant "Nangoku-Shuka" in the hotel

June 20 (Thursday) - NIFS and Nagoya University

Visitors:

Richard L. Savercool (General Atomics)
Joseph A. Smith (Princeton Plasma Physics Laboratory)

Masatugu Shimizu (JAERI)

Participants (Nagoya University)

Shuichi Takamura
Hidero Sugai
Yoshihiko Uesugi
Hirotaka Toyoda
Noriyasu Ohno
Minyou Ye

Agenda:
9:00 Picked up at Nagoya Tokyu Hotel (by a member of the NIFS administration office)
10:00 Arrive at NIFS Higashiyama Site
Welcome (Deputy Director: Prof. Sato)
10:30 Pickup at NIFS to Nagoya University (arranged by NIFS member)
10:30 - 11:00 Visit to Takamura Laboratory
(Location at Nagoya Univ.: Room 420, 5th Bldg. of School of Eng.)
Overview of Fusion Research at School of Eng. in Nagoya Univ. (Takamura)
11:00 - 12:00 Visit to Sugai Laboratory
(Location at Nagoya Univ. :Room 605, 5th Bldg. of School of Eng.)
Tour of 5th Bldg. Sugai Laboratories (Sugai)
12:00 - 13:30 Lunch arranged by Sugai Lab.
13:30 - 15:00 Visit to Takamura Laboratory
(Location at Nagoya Univ.:Room 420, 5th Bldg. of School of Eng.)
Tour of 6th Bldg. Takamura Laboratories (Uesugi)
Tour of 5th Bldg. Takamura Laboratories (Ohno)
15:00 - 16:00 Joint Meeting at Small Conference Room
Overview of Safety Program in School of Eng.
Comments from Visitors
Discussion (Takamura , Sugai, Uesugi, Toyoda, Ye, Ohno)
16:00 Return to Tokyu Hotel
18:00 - 20:00 Dinner arranged by Takamura Lab.

June 21 (Friday) - Kyoto University

Visitors:

Richard L. Savercool (GA)
Joseph A. Smith (PPPL)

Masatsugu Shimizu (JAERI)

Morning: Leave for Kyoto

11:00-13:00 WT-3 and OTHERS

Dept. of Phys. Faculty of Science

Prof. Yasushi Terumichi
Phone: 075-753-3807
Dr. Makoto Asakawa
Phone: 075-753-3808

Dept. of Fundamental Energy Science, Faculty of Energy Science

Prof. Takashi Maekawa
Phone: 075-753-4730
Associate Prof. Hitoshi Tanaka
Phone: 075-753-4731

Dept. of Phys. and Mechanics, Faculty of Engineering

Associate Prof. Keishi Ishii
Phone: 075-753-5221

13:00-14:00 Lunch
14:00-16:00 HIEI and OTHERS

Dept. of Electronics, Faculty of Engineering

Prof. Kunihide Tachibana

Associate Prof. Yasuyoshi Yasaka

June 24 (Monday) - Kyushu University

Visitors:

Richard L. Savercool (GA)
Joseph A. Smith (PPPL)

Teruo Tamano (Univ. of Tsukuba)

9:00 Leave Hotel Blossom Fukuoka (guide by Tamano)
10:00 - 12:00 Tour of TRIAM Facility, Research Institute of Applied Mechanics
(Prof. Satoshi Itoh and his laboratory members)
12:00 - 13:00 Overview of Diagnostics Lab, Interdisciplinary Graduate School of Engineering Science
(Prof. Muraoka; Luncheon Meeting)
13:00 - 14:00 Tour of Diagnostics Lab (Prof. Muraoka and his lab's members)
14:30 - 16:00 Overview and Tour of Material Science Lab, Research Institute of Applied Mechanics (Prof. Yoshida)
16:00 Leave for Fukuoka
19:30 Dinner in Fukuoka (arranged by Prof. Muraoka)

June 25 (Tuesday) Tokyo University

Visitors:

Richard L. Savercool (GA)
Joseph A. Smith (PPPL)

Teruo Tamano (Univ. Tsukuba)

7:10 Leave for Tokyo Haneda from Fukuoka Airport
8:40 Arrive at Haneda
Drop in Hotel Okura
11:00 - 11:30 Overview of Institute of Engineering (Prof. Inoue)
11:30 - 12:30 Tour of REPUTE Lab, Institute of Engineering (Prof. Inoue)
12:30 - 13:30 Lunch
13:30 - 14:30 Tour of TST Lab, Institute of Science (Prof. Toyama)
14:30 - 15:30 Tour of TS-3, Institute of Engineering (Prof. Katsurai)
15:30 Leave for the Hotel

June 26 (Wednesday) - Electrotechnical Laboratory and National Research Institute for Metals, Tsukuba Laboratories

Visitors:

Richard L. Savercool (GA)
Joseph A. Smith (PPPL)

Teruo Tamano (Univ. of Tsukuba)
Makoto Ichimura (Univ. of Tsukuba)

Host (Electrotechnical Laboratory):

Dr. Hayase

phone: 0298-58-5763

fax: 0298-58-5754

8:30 - 10:30 Bus to Tsukuba
10:30 Welcome and Introduction
11:00 TPE Program and Objectives, and Safety Program
Tour of Experimental Facilities (TPE-2M, TPE-1RM20)
12:00 Lunch
13:00 Super-Ashura Program and Objectives, and Safety Program
Tour of Super-Ashura,
14:30 Leave Electrotechnical Laboratory

Visit to National Research Institute for Metals, Tsukuba Laboratories

Host:

Dr. Shiraishi
phone: 0298-53-1025
fax: 0298-53-1087
e-mail: siraisi@nrim.go.jp

14:45 Arrive at National Research Institute for Metals, Tsukuba Laboratories
14:50 Overview (Manager, General Administration Office)
15:05 Tour of Cyclotron Facility (Dr. Hikawa)
15:50 Leave for the 2nd Site
16:00 Tour of Superconductor Magnet Facility (Dr. Wada)
17:00 Leave NRIM
Evening Dinner (arranged by Tamano)

June 27 (Thursday) - JAERI

Participants:

Richard L. Savercool (GA)
Joseph A. Smith (PPPL)

Teruo Tamano (Univ. of Tsukuba)

Agenda:
0900 departure from Ueno station (JR: Super Hitachi no.7)
1021 arrival at Katsuta station (JAERI people will pick up at Katsuta station)
1100 welcome
1110 outline of safety control of Naka Establishment
1130 tour of JT-60 control room (under operation)
1200 lunch
1300 overview of super conducting coil research system and safety approach & tour of SCC system
1350 overview of neutral beam injection research system and safety approach & tour of NBI system
1440 overview of radio frequency heating research system and safety approach & tour of RF system
1530 departure for Tokai Research Establishment
1600 tour of JFT-2M
1630 discussion
1700 departure for Mito
1745 dinner
2015 departure from Mito station for Ueno (JR:Super Hitachi no.30)
2124 arrival at Ueno station

June 28 (Friday) - Return to U.S.

APPENDIX B (Bibliographic Listing of Safety-Related Literature Acquired)

- Overview of Safety Issues at the National Institute for Fusion Science
- Safety Booklet (Kyushu University - Research Institute for Applied Mechanics)
- Toroidal Plasma Experiment Program, Objectives, and Safety Program at the Electrotechnical Laboratory
- Laser Safety Manual (Electrotechnical Laboratory - KrF Eximer Laser experiment)
- Supervising Structure for Radiation Protection at the National Research Institute for Metals
- Manual for Equipment Installation at the Standard Laboratory Building (National Research Institute for Metals)
- Overview of Naka Fusion Research Establishment (Japan Atomic Research Institute)

Divisions in charge of Safety Management

- Inspection and Check Concerning Safety and Sanitation
- Safety Education Program for Foreign Researcher
- Emergency Measures
- Inner Rules at Naka Site
- Safety Signs in English
- Guide for Emergency Measures (Japan Atomic Research Institute)
- Guide for Safe Use of Experimental Devices and Dangerous Materials (Japan Atomic Research Institute)
- Guide for Radiation Protection (Japan Atomic Research Institute)
- Administration of Safety and Sanitation on JFT-2M (Japan Atomic Research Institute)
- Safety Working in RF Heating Laboratory (Japan Atomic Research Institute)