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Activities Of The US-Japan Safety Monitor Joint Working Group

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ACTIVITIES OF THE US-JAPAN SAFETY MONITOR JOINT WORKING GROUP

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This paper documents the activities of the US-Japan exchange in the area of personnel safety at magnetic and laser fusion experiments. A near-miss event with a visiting scientist to the US in 1992 was the impetus for forming the Joint Working Group on Fusion Safety. This exchange has been under way for over ten years and has provided many safety insights for both US and Japanese facility personnel at national institutes and at universities. The background and activities of the Joint Working Group are described, including the facilities that have been visited for safety walkthroughs, the participants from both countries, and the main safety issues examined during visits. Based on these visits, some operational safety ideas to enhance experiment safety are given. The near-term future plans of the Safety Monitor Joint Working Group are also discussed.

I. INTRODUCTION

Part of the US-Japan Bilateral Agreement on Fusion Research[1] is the Joint Working Group (JWG) on Fusion Safety. This JWG was formed in 1992. The US and Japan have hosted visiting researchers at each of the large tokamaks, major experiments and fusion research centers for decades. Most of these exchanges have been performed quite well and without any safety incidents in either country. Unfortunately, in early 1992, there was an event of concern in the US when a visiting Japanese researcher was overcome by leaking nitrogen coolant gas.[2,3] After this event, discussions were held between the Japan Atomic Energy Research Institute (JAERI) and the US Department of Energy (DOE) about conducting safety walkthroughs of fusion research facilities and experiments in each country. Thus, the Safety Monitor JWG was formed. The safety walkthrough is brief tour of a facility followed by suggestions to enhance the safety for visiting researchers. Initially, the walkthroughs were made once per year, with either US personnel traveling to Japan, or Japanese personnel traveling to the US. In the mid-1990's the walkthrough results were assessed and found to be favorable for safety at most of the institutions visited, so the schedule was relaxed to a walkthrough visit every two years. The JWG has noted that at least one other nitrogen gas event has been reported in the chemical industry[4] since the fusion event in 1992. In the more recent event there were several similarities to the fusion event. Two chemical plant workers were performing a visual inspection of a 1.2 m-diameter steel pipe. The workers covered the end of the pipe with opaque plastic to provide darkness so they could better inspect the interior pipe wall using a black light; they were unaware that nitrogen blanket gas was leaking and slowly collecting in the pipe, displacing the air. They were not as fortunate as the fusion researcher; one of the two workers perished and the other suffered permanent impairment after asphyxia. The US Chemical Safety Board has stated that there are typically 6 or 7 fatalities each year due to nitrogen gas asphyxiation in industry, laboratories, and medical facilities,[5] although not all of these event descriptions are published in the literature. The Safety Monitor JWG goal is to support fusion experiments so that the experiments can operate without any annual injuries or fatalities.

Overall, the JWG has found fusion experiments to be well-run, but these experiments are not without hazards. For example, nearly all magnetic fusion experiments have suffered at least one electrical distribution system fire event,[6] there have also been some resistive magnet fires and water coolant leaks that necessitated shutting down to effect repairs,[7] small cryogen leaks,[8] and large vacuum reservoirs are present that pose hazards to personnel.[9] There are radiological hazards[10] and unexpected experiment outages as well.[11] Fusion experiments use large amounts of electrical power, use and generate many types of electromagnetic radiation, use cryogens, high pressure and temperature water and other coolants, and have other hazards as well. Due diligence must be maintained around these experiments to continue to operate safely.

II. SAFETY WALKTHROUGHS

The JWG has made walkthroughs of the major experiments in each country, including the Japan Torus Upgrade (JT-60U), the Large Helical Device, the GAMMA-10 mirror machine, and the GEKKO-XII laser fusion experiment. Some of the Japanese national facilities visited at Naka include the Superconducting Magnet Laboratory, the Radiofrequency Test Stand, the JAERI Electron Beam Irradiation System, and the Neutral Beam research facility. At Tokai-mura, JWG members have visited the Tritium Process Laboratory, the International Thermonuclear Experimental Reactor (ITER) Reactor Structure Lab, and the Fusion Neutron Source. Other, smaller experiments have also been visited at a number of Japanese universities, as given in Table I.

JWG walkthroughs of US facilities have included major experiments, such as the Tokamak Fusion Test Reactor, the Advanced Torsatron Facility, the DIII-D tokamak, and the Alcator tokamak. JWG members have also visited other national facilities, including Oak Ridge National Laboratory, the Lawrence Berkeley Laboratory, Argonne National Laboratory, Sandia National Laboratories, Pacific Northwest National Laboratory, and Lawrence Livermore National Laboratory. Educational facilities visited include the fusion experiments and test apparatus at the University of California (San Diego and Los Angeles campuses), the University of Wisconsin at Madison, the University of Texas, and the smaller experiments at the Massachusetts Institute of Technology (MIT).

JWG participants have included JAERI and DOE officials, and safety personnel from fusion institutes. Past and present JWG participants are listed in Table II.

III. SAFETY WALKTHROUGH OVERVIEW

The walkthroughs are generally short visits of perhaps one to two hours per facility, and they focus on overviews of the facility or experiment safety. JWG members tour the facility and discuss safety issues with the hosts. Often the hosts will correct any small lapses of safety, such as securing a gas cylinder, replacing a warning sign, etc. Such actions show a proactive attitude toward safety that is greatly appreciated by the JWG. There are several safety items that are sought or noted in each JWG walkthrough visit. These items are listed in Table III.

TABLE I. Japanese University experiments visited

University	Experiments
University of Tsukuba	Reversed field pinch Super-Ashura laser Tokamak plasma experiment
Tohoku University	High temperature molten salt loop Dynamitron particle accelerator Helical stellarator Alpha particle radioisotope lab Plasma MHD device
Tokyo University	Spherical torus Reversed field pinch Prototype ring trap experiment Spherical tokamak Diagnostics lab Cryogenics lab
Nagoya University	Nagoya divertor simulator Dusty plasma machine Current sustained tokamak Hybrid tokamak Tritium experiment lab
Kyushu University	TRIAM-1M Double plasma device Linear plasma experiment Laser lab
Osaka University	Theta pinch Field reversed configuration injection experiment
Kyoto University	Heliotron J Wave torus Low aspect ratio torus experiment
Toyama University	Hydrogen isotope research center

TABLE II. Safety Monitor JWG Participants

Japanese Participants
Prof. Teruo Tamano, University of Tsukuba
Masatsugu Shimizu, JAERI
Hiromi Hirabayashi, NIFS
Hideo Okada, JAERI
Prof. Yoichi Sakuma, NIFS
Keisuke Hasegawa, JAERI
Prof. Tatsuhiko Uda, NIFS
Naoyuki Miya, JAERI
Prof. Takao Kawano, NIFS
Prof. Takayoshi Norimatsu, Osaka University
Prof. Yuichi Takase, Tokyo University
Mitsuru Otha, JAERI
Haruo Obayashi, JAERI
Ken'ichi Takagi, NIFS
Isao Ohtake, NIFS
US Participants
Steven Rossi, DOE
Gene Nardella, DOE
John Glowienka, ORNL
Richard Savercool, General Atomics
Joseph Smith, PPPL
Lee Cadwallader, INEEL
Matt Fulton, MIT
Michael Viola, PPPL
Catherine Fiore, MIT
Tom Lovell, University of Wisconsin
Joe Stencel, PPPL
Jeff Williams, LLNL
Phil Edmonds, University of Texas

Several safety facts have been uncovered during the JWG visits. The JWG has learned that, while it is rare for a fusion experiment to experience an emergency situation, emergencies have occurred at least once at all large fusion facilities and at most of the smaller experiments. Emergencies have included electrical fires, electrical arcs, large coolant leaks, personnel injuries (such as first aid cases, chemical exposures, and perhaps falls or electrical accidents), crane or hoist load drops, toppled equipment, and other events. Therefore, emergency preparedness is an important aspect of operational safety at fusion experiments. Without facility-specific training, people tend to revert to their original training. Consider that for most US universities, the national emergency telephone number is 911. For most Japanese universities, the national emergency telephone number is 119. The JWG has noted that in both countries the universities rely on municipal emergency services. A visiting researcher at a university, trying to summon emergency aid, could make a mistake under stressful conditions.

TABLE III. Safety Walkthrough Issues and Items

- Experiments are operated professionally, with personnel aware of the hazards
- Safety training is being performed for the staff and visitors
- Safety manual or information is available and multi-lingual
- Visitors would understand and be comfortable with the safety precautions at the facility
- Appropriate safety warnings are in place around the facility
- Emergency exits are marked and not blocked
- Emergency equipment is marked and not blocked
- Facilities are kept clean and combustible material storage is kept small
- Fire extinguishers are marked and accessible
- Telephone list with emergency numbers to call is displayed near the telephone
- Electrical safety is observed
- Electrical panels are accessible in case power shutoff is needed
- Compressed gas cylinders are properly restrained
- Chemicals are properly stored
- Magnetic field safety is observed
- Vacuum safety is observed
- Radiofrequency energy safety is observed

Another fact the JWG realized is that emergency services personnel are not typically multi-lingual. To address that problem, one Japanese university posted the phonetic Japanese pronunciation of fire ("ka sai") with the emergency phone number. If the non-Japanese speaking caller dialed the emergency number and said this phonetic word, the emergency services operator would then send all types of emergency services personnel – firefighters, police, and paramedics – to the telephone's location. In that way, the responding personnel would be fully equipped for any emergency. Some readers might consider this to be an inappropriately large response effort for an emergency, but it is a reality of the language barrier if the Japanese-speaking researchers are incapacitated and are unable to place the emergency call themselves. The US universities tend to rely on visitors having an adequate command of English. The national institutes in both countries typically have their own emergency brigades, or response teams and sometimes even their own fire departments, so they have an institutional emergency phone number. These numbers vary a great deal. For example, there are four-digit numbers at the Naka site

(7222), at Princeton (3333), and at GA (2002), while the INEEL has a three-digit number (777). It is important to post the emergency phone number prominently near telephones so that visitors in stressful emergency situations will use the correct emergency number. Dialing an incorrect number will lead to unnecessary delay in getting help and great frustration on the part of the caller that may lead to bad decisions.

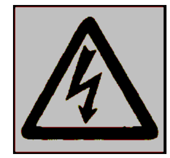
Several past reports of the JWG walkthroughs are available to download over the internet, at http://fusion.gat.com/safety/JWG/jwghome.html and http://www.nifs.ac.jp/collaboration/Japan-US/safety.pdf. The US JWG members visiting Japanese facilities in 2004 were impressed with the safety progress in nearly all of the labs and the attention that had been given to the items identified during the previous safety walkthrough in 1999. Some labs even discussed the 1999 safety items during their facility overview presentation and had the items listed along with their current response to date. Some researchers have approached the JWG safety walkthrough as an unofficial, non-regulatory safety review of their facility and have taken guidance from the JWG on methods to improve operations safety.

IV. RECOMMENDATIONS

Over the course of several JWG walkthroughs, the JWG members have noted potential enhancements to the safety of any fusion experiment facility. There are some low cost actions that can be performed to aid visiting researchers and improve facility safety. The first and foremost is to supplement the written safety signs with internationally recognized pictogram signs. These are sometimes referred to as "universal symbols". There are several reasons for using pictogram symbols. First, these pictograms transcend the language barrier and are much less expensive than translating all warning signs into another language. Second, the visual picture reinforces any multi-lingual warning signs. Third, the pictograms are memorable, usually more memorable than a worded sign. Pictograms are available commercially through several safety equipment companies. Some pictograms are also available in a text;[12] many of the safety symbols presented in that text meet the direction given by the International Organisation for Standardization (ISO),[13] the American National Standards Institute (ANSI),[14] and the US National Fire Protection Association (NFPA).[15] At most facilities, merely supplementing the existing signs with pictograms would be an inexpensive step to enhance safety while avoiding the cost of translation. A few of the suggested pictograms, usually in color, are shown here in black and white drawings to serve as examples:

Fire Exit

High voltage



Emergency Shower

The JWG has noted other low cost actions that can enhance operational safety. These are:

- Using daily safety checklists before experiment operation
- Performing a visual search and sweep before commencing operation
- Appointing a key person of the day to track safety and operations issues
- Holding brief pre-operation meetings
- Instituting once-a-month cleanup days

The safety checklists help the operators and researchers to survey the facility before operation to verify that everything is in its proper place and that the machine is ready for operation. Having operators walk through the facility can reveal conditions or situations that the control room instruments can not. The visual observation guarantees that no one is left in the experiment room and can also spot any equipment that is not correctly set up before operation, such as loose tools near an electromagnet. The "key person" concept is already in use at many facilities; this person tracks the details of the operating day. Brief pre-operation meetings allow the staff and visitors tp discuss the day's plan and any limitations that the experiment might be experiencing, equipment that should not be operated or operated with special provisions, etc. Cleanup sessions keep facility combustibles reduced to low levels, reduce slipping and tripping hazards, keep exits clear of storage, keep electrical panels clear of storage, promote pride and good morale, and in general the JWG has found that well-run operations with good house-keeping are also safe operations. Experiments that are kept clean also generally give better scientific results. These are very modest effort tasks that will increase the operational safety of fusion experiments.

V. FUTURE ACTIVITIES

With continued support from DOE and JAERI, the JWG plans to continue with safety walkthroughs at the present frequency to keep safety a prominent part of the operation of fusion experiments and to maintain the experiment staff awareness of visitor safety. The US JWG members completed a walkthrough in Japan in February 2004. The next scheduled visit is for Japanese JWG safety personnel to visit US facilities in late 2005 or early 2006. The facilities to be visited include the DIII-D tokamak at San Diego, the National Spherical Torus Experiment at Princeton, the Alcator C-Mod tokamak at MIT, the Safety and Tritium Applied Research facility at the Idaho National Engineering and Environmental Lab, and other facilities, possibly including the National Ignition Facility.

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