National Institute for Fusion Science (NIFS)

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Peer Review Reports in FY2009

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NIFS Administrative Council External Peer Review Committee

Contents

Chapter 1 Reviews on fusion engineering research

1. 1. Summary

1. Research process and performance

1) Are the subjects we have worked for adequate and appropriate?

The Fusion Engineering Research Center (FERC) has played a key role in your fusion engineering research. Regarding each of the four subordinated themes of *"applied superconductivity"*, *"materials and blanket"*, *"tritium and safety"* and *"helical reactor design"*, it set a proper selection of subjects, which resulted in the production of a large number of fruitful results. Especially, the effort for the helical reactor design is highly commendable. It has led the other work like *materials and blanket* or *tritium and safety*, has advanced basic studies on liquid breeding system, components and blanket materials and has produced novel findings that lead the world's research. Therefore, the subjects are well-chosen and highly appreciated.

LHD's superconducting coil system has been showing excellence in terms of reliability and operation rate. The sub-cooling system you have developed is worthy of international attention. Superfluid cooling research, though, in which Japan is still lagging behind other nations, requires further technical enhancement. The studies on irradiation impacts over superconducting coils or insulation materials are actually significant, and what is a great achievement from them is the successful production of a prototype low-activation GFRP. However, those efforts should look at high-temperature superconductors for a future power plant. Meanwhile, basic science on the indirect-cooled magnet system has been learned with enthusiasm as it should be. It is highly commendable that you have successfully developed SMES that employs a conduction cooled pulse magnet with NbTi conductor to survive a sudden power drop.

Progress is observed on the development of a low-activation blanket material through the evaluation work to see the adaptability of the vanadium-alloy. The development work of a liquid breeder blanket system

has been advanced with the productive findings of corrosion mechanism of the low-activation ferritic steel. The study on how the steel and liquid breeding materials act each other in coexistence is significantly productive as well.

Your sincerity toward the local residents has been proved by the high-sensitive tritium monitor you developed. NIFS has been upgrading tritium-related technologies for the D-D experiment including neutron-shielding analysis and others. It should be highly praised.

Finding an optimal plant size is a big step for the helical reactor designing research. You have demonstrated that the optimum size is a major radius of about 16 meters for a commercial operation because it can keep sufficient Tritium breeding, long-life blankets and a neutron wall loading at the level of 1.5MW/m^2. Encountering the belief that high-density plasma could be only maintained in a reactor under thermally-unstable conditions, you have managed to find a method to make the conditions stable. These excellent achievements have brought reality to a future fusion plant.

2) Have we made effective use of our facilities and achieved satisfactory outcomes regarding each of the subjects in 1)?

You have made good use of your own as well as external facilities through collaborations with tens of laboratories engaged in fusion engineering research. An incomparable number of findings have been produced from the joint activities and this is what represents the effectiveness of the utilization. So, the way of using resources should be highly commended. The efficient flow of cooperation is attributed to the nearly-full participation of domestic reseachers and to the helpful assistance by the Fusion Network. In more concrete terms, over 500 papers have been published by only some 25 researchers during the period from 2004 to 2009, and this is a result of an effective use of the facilities in NIFS as well as universities, Japan Atomic Energy Agency (JAEA) or foreign organizations.

The equipment originally prepared for LHD is now also working for developing ITER superconducting coils, and the fact may help NIFS become a key center for the world’s coil development. However, research over larger-scale coils will require more upgraded devices for evaluation.

Securing an enough budget is an important task as well. Referring to blanket engineering research, further enhancement will be desired in the current liquid-breeding related facilities, which are now under preparation.

3) Have we learned from the past external review results?

Past external reviews targeted *superconductivity, materials and blanket*, and t*ritium and safety*. Taking every single comment humbly and seriously, you have made a great deal of efforts on self-improvement. The efforts include assembling all the related facilities into FERC, increasing the number of research staff, and promoting closer tie-ups with JAEA or ITER. You have also worked hard to advance tritium science and safety technology in the preparation for the D-D experiment. Therefore you have learned well from what were pointed out and has responded to them in an expected way.

The work for large-scale superconductivity seems a little overly inclusive. It is better to narrow down the focus on a future plant. The LHD sub-cooling system is valued in terms of a stable operation and high operation rates, but what is more desired will be to establish a technology of fault diagnostics . Meanwhile, the effort for the IFMIF or ITER-TBM projects is extremely commendable because it has encouraged universities to join the projects and has established a route of participant. It is significant work to be continued along with the productive collaboration with JAEA and the work of the Safety and Environmental Research Center, one of NIFS's departments.

4) Have we fulfilled a role as COE for universities who study fusion engineering?

Besides the ongoing collaborations of both general and LHD-related, you plan to start another bilateral scheme in FY2010 to lead domestic research with regard to *superconductivity, materials and blanket*, t*ritium and safety, and helical reactor design*. You are currently carrying out tens of joint activities each year, including the international ones mainly between US, South Korea or China. Regarding fusion engineering research, you have been a leading role internationally in the field of *material and blanket,* through JUPITER-II, TITAN or other programs. The Fusion Network, which NIFS has supported and most fusion reseachers belong to, helps its

members study jointly, share information and even get financial aid. These activities show how well you have been fulfilling the COE responsibility.

It is expected you will continue to play the COE role while promoting collaborations with universities. At the same time it is expected as well that you will have a comprehensive approach covering all topics of the fusion engineering study, in order to systematically integrate academic knowledge.

2. Collaboration performance

1) Does our collaboration system function effectively in the field?

Nothing has a more thorough coverage than NIFS's collaboration framework. It contains a general type of joint scheme that covers an extensive area, a more specific one focusing on the LHD, and a bilateral type to make a better use of resources in smaller organizations – more than 400 collaborations are conducted yearly. These activities have developed all related studies and also trained young reseachers. A new bilateral collaboration is expected to begin in 2010 between NIFS and the center that has the best facilities in Japan to study fusion tritium or irradiation effects on reactor materials, and thus, further advancement can be expected. As seen above, your collaboration system functions effectively enough to deserve a high mark.

2) Have we learned from the past external review results?

The system has been reviewed by external eyes several times and a number of comments, including quite detailed ones, were given on it. It is recognized that you have been improving the system properly for more efficient operation of any joint activities. NIFS has responded well in terms of cooperation with ITER or JAEA. You have not only established a new system to pave the way for more universities to participate in the Broad Approach R&Ds include IFMIF but also have served as a contact. In addition, you have provided technical assistant to JAEA for its test blanket module program. All are highly appreciated.

3. Goal and planning

1) Are our subject selection and implementation plans adequate and appropriate?

The next mid-term plan aims at systematization of the academic knowledge accumulated through the previous efforts over the LHD plasma, as a step toward design and construction of a helical-type demo reactor. Priority is given to further improvement of LHD plasma, plasma simulation by a numerical reactor, the progress of the fusion engineering and design discipline. It includes the enhancement of component technologies such as superconducting coil, blanket, tritium handling and low-activated materials, which are all to lead to designing of a better plant. A helical reactor is featured by its excellence of plasma production, no disruption and a steady state operation, and they are what make a reactor of this type very attractive. However, it has also some difficulties. It can provide only limited blanket spaces and requires demanding maintenance work for the continuous coil, which are what you have to overcome. From the standpoint, the goals, subjects and approaches in the plans are all adequate and appropriate.

What is significant is that the plan should put design of a future plant at the center of your fusion engineering research. All the collaborations also should bear in mind that the reactor designing work is a main topic to be tackled in a collective approach including the whole nation.

You may as well consider about a way of another contribution to ITER, that is to say, of entering into partnership with them in TBM. With regard to the IFMIF, a technology expected to come into practice soon, you should keep a leading position in the material research of both domestic and international in order to take an initiative of the new technological business. You are also expected to play a central role in the field of liquid blanket by enhancing facilities. Through making a contribution to advancing a whole fusion engineering research, you will be expected to become a key center of the world in the field.

You are able to share considerable amount of ideas with those involved into the tokamak-plant development. From the perspective of an effective use of limited resources, tasks are to be prioritized. They need to be sort out from a standpoint of what is unique and what is complementary between the two projects of tokamak and helical configuration.

There are a lot of industrial potentials in a fusion engineering technology. Taking advantage of collaboration network, you will help any fruitful findings spread and applied to other fields. While promoting the external effect, you are expected to deepen basic knowledge.

2) Is our system for implementing the plans adequate and appropriate?

According to the new organization plan, you will unify all the related divisions or centers into one research project. Groups of *superconductivity*, *tritium*, *plasma-wall interactions* and *materials and blanket* are all integrated and become an "organic" body. Based on the reconstruction, you will promote collaborations along with the important subjects above, so further progress would be expected. The system is absolutely appropriate to implement the plan. The unification of all the relevant studies, which are currently dispersed in the Department of Large Helical Device Project, FERC and SERC, is a particularly praiseworthy attempt.

What is desired is that you will employ young reseachers as a core member of project in order to nurture leadership within them. On the other hand, key is how well you will integrate a wide array of relevant themes to lead to the realization of a future plant.

1. 2. Recommendation

Various comments, including considerable amount of compliments, are given on every single evaluation items. Based on the comments, we have a discussion over what is necessary for you. Here is a list of summarized recommendations.

It is expected:

(1) you will carry out cross-divisional research activities of fusion engineering centering on the design of helical-type reactor. It will help us understand more about a helical configuration in comparison with a tokamak one, in terms of its merits, features and complementary aspects, and as a consequence will contribute to the realization of a

future energy supply.

(2) you will become a key center for the research of advanced blanket or low-activated materials. You are also expected to take a leadership internationally in the field.

(3) you will develop superconducting coils for a future reactor.

(4) you will educate young reseachers who will lead future projects for a reactor.

(5) advancement of the research you promote will make a major contribution to establishing academic knowledge in a systematic way leading to the goal, the realization of a helical fusion energy supply.

Chapter 2 Reviews on safety management

2. 1. Summery

1. Management system and performance

1) Does our safety-management system respond properly to a shift in relevant law from the National Personnel Authority Regulations to the Industrial Safety and Health Law according to the reorganization of the national universities as corporation? (Please note the role of the Safety and Health Committee and its activities.)

Responding to the shift, NIFS's safety management system changed from a single-based system where the Safety and Environmental Research Center (SERC) solely takes a whole responsibility, to a dual-based system where the responsibility is divided into two – supervising and acting and two separate bodies takes each of them. The Safety and Health Committee take the part of monitoring safety and healthy while the Division for Health and Safety Promotion (DHSP) is the one to act to keep a good condition. The dual system has helped you manage a cycle of Plan-Do-Check-Act work sustainably andsystematically. As a result, you have successfully maintained a safe environment. You have responded satisfactorily to what the new law requires and thus, it is a very good system.

See the system in a concrete way. In accordance with the law, you put your top executive Director-General in the position of General Safety and Health Supervise to head a whole activity. Under theGeneral Safety and Health Superviser, three officers – SafetyOfficer, Health Officer and Industrial Physician – fulfill their own responsibility for safety management, health management or healthcare control respectively. The three specialists compose the Safety and Health Committee with others like those designated by the director-general and those recommended by representative member of NIFS staff. The committeeholds a meeting and inspects regularly. The post of safety officer, which NIFS is not legally required to have, is given to the person who has relevant qualifications. It is actually an excellent decision because the job in NIFS involves several risks such as high electric power, high voltage, ultralow temperature, high-pressure gas and

radioactiveenvironment. The position can function effectively in the organization like you with such potential risk.

The three officers go on an inspection tour separately and results are disclosed on the website. It guarantees high transparency and thus particularly deserves appreciation. The safety officer, for instance, conducts inspection tours following an annual plan, covering 16 buildings including 11 special facilities. The results go through the committee's deliberation and then come as a recommendation to those responsible for safe environment or those for building maintenance. The committee has actually functioned well like this.

2) ***Does the Division for Health and Safety Promotion function properly to ensure safe environment? (Is the structure adequate and appropriate, which consists of 10 offices such as the Environmental Safety Control Office, the Health Control Office and so on?)***

The Division for Health and Safety Promotion (DHSP) serves under the director-general as a team to improve a safety standard as well as to diminish any risks. The task-force division is divided into ten offices, namely (1) *Environmental and Safety Control Office*, (2) *Health Control Office*, (3) *Fire and Disaster Prevention Office*, (4) *Radiation Control Office*, (5) *Electrical Equipment and Work Control Office*, (6) *Machinery and Equipment Control Office*, (7) *High Pressure Gas Control Office*, (8) *Hazard Substances Management Office*, (9) *New Experimental Safety Assessment Office* and (10) *Safety Handbook Publishing Office*, and the meeting of the head of all offices is hold every month. The offices include people legally qualified and site managers. In order to take a systematic approach to cover a range of work including risk management, healthcare for staff, special attention to foreign members and education for students that stay only for several years, it is a well-designed structure.

What is notable is that DHSP is not an independent body with full-time staff dedicated to the work. It is rather a cross-sectional entity getting in the whole institute, in other words, an assemblage of researchers, engineers and administrative members. This comes from a policy that any safety issues should be handled with legal, technological and administrative expertise, which is very respectable.

The division goes to the check-up round each month. It is meaningful for the cross-departmental and cross-hierarchical groups to observe real conditions. It is one of contributors to environmental improvement.

Safety education you yearly provide reflects real operations including handling of high electric power, high voltage, ultralow temperature, high pressure gases and radiation. Lectures are given, either individually or all together, four times a year, and about 200 of NIFS members have to take at least one of them. It is an appropriate safety service.

3) Do we provide safety education for in-house students adequately and appropriately?

About fifty students are studying at NIFS, including those who belong to the Graduate University of Advanced Studies or Sokendai, Nagoya University or other schools, and about half of them are taking an experimental course. “Tutorial for Safe Experiment” is a special program for the students to learn about handling radiation, electricity and hazardous materials. Each class is taught by a researcher who handles them in a real activity. In 2008, for example, eighteen classes including tours were provided during three months from November to January. The course is well designed as safety education because students can get practical knowledge through observing real scenes as well as basic knowledge.

Adding a comprehension test will be an idea in order to enhance the education efficacy as well as to increase safety awareness in students. A lecture should be given to all as early as possible after a new year starts.

2. Safety performance as an inter-university research institute

1) Are the visiting co-researchers including the graduate students educated and managed their safety adequately and appropriately?

The three offices of DHSP – Environmental Safety Control Office, New Experimental Safety Assessment Office and Safety Handbook Publishing Office – are particularly involved in the work for the visiting researchers. They deal with a Japan-US safety inspection scheme, carry out safety checks on any new machines that external co-researchers may use, or create

safety handbooks and provide educational programs. All the work is approached institutionally, and safety management and education are properly provided.

As promoting some 400 collaborations each year, NIFS has to ensure safe environment for those visiting co-researchers. After all explanations, you ask them to review what they have learned with a check sheet and then to sign for acknowledgement. The process is equally asked to NIFS staff, students and company employees. This is a necessary procedure.

Safety lectures are also open to employees of private companies. NIFS takes in considerable number of company workers as a specialist of high power, high voltage, ultralow temperature, high-pressure gases or radioactiveenvironment. Around 100 of those workers undertake a course to learn policy and philosophy of NIFS safety management. Labor Standard Supervision Office's inspection, Use and safety of a crane, Re-education of electronic safety were among the topics prepared for the lecture in May 2009, for example. Results of health or safety inspections are also accessible to these workers. It is fairly open to outside and really a respectable way of providing safety services.

2) Are the foreign co-researches provided safe environment?

The three DHSP offices also take care of foreign co-researchers, likewise any other visiting researchers. They handle the Japan-US inspection, check safety of any new machines, and provide safety handbooks and education programs. You have done a great job particularly for the international inspection scheme. Although it is quite demanding work due to a cultural gap in a concept of safety between the two nations, you have responded properly to what the US side has pointed out. The English version of the handbook is regularly revised with assistance of the American counterpart. The sustainable and cross-organizational approach is very commendable. Foreign staff is also adequately cared in terms of emergency provisions. Warning signs are expressed in English and international indicators are adopted. The annual event of a disaster-prevention drill includes bilingual announcements. The safety training, which is usually provided in a form of lecture, are available in English as well on an individual base.

It is undoubted that you are attempting to ensure as much safety as possible for those who do not speak Japanese under the cross-departmental system.

Forty one of the non-Japanese have taken the annual lectures so far, but all the classes were given in Japanese. From now on, you should consider providing the regular class in English as well. It is also desired that you get ready to make bilingual emergency announcements any time necessary.

3. Safety performance as an inter-university research institute

1) Is our safety-management system well-prepared for the reorganization of research division in 2010?

During the next six years, you are going to get all fundamental knowledge systematically integrated to lead to the realization of a fusion energy supply. For the goal, you have reorganized the research section, from the ongoing multiple structure with two departments and three centers, into a single structure with one department. Reseachers belong to one of divisions that compose the big department, namely, Department of Helical Plasma Research. They are supposed to work in a cross-divisional framework for common targets, or what you call *projects*, of LHD study, numerical experiment and fusion engineering pursuit. Besides the projects, you also plan to conduct D-D experiment during the period and thus, aspire to establish an especially robust radiation-control system. Your safety policy for the experiment is to be esteemed as a product of communications between you and the local resident.

Your safety management, while generally maintaining the current system, will make two changes. One is a change in accordance with the reconstruction, dividing the SERC responsibility and moving some to an expert team. Safety-control part will be assumed by DSHP while research part will be by the Department of Helical Plasma Research. Second is an enhancement of the radiation-controlling facility. The Radiation Control Office will be reinforced and two independent organizations will be newly established for the D-D experiment. One is “Safety Committee”, made up with internal staff and authorized to stop the campaign in any case a problem occurs. The other is “Safety Monitoring Commission” consisting entirely of non-NIFS members and offering an external supervision on the

experiment. What you have to do now is to work out details over the two committees in terms of their commission, independency and relation of the two. It is also desired to give a concrete shape to how the two should react in emergency. Overall, it is a very good system to carry out the radioactive experiment because it is likely to guarantee functionality, reality, efficacy and transparency at a sufficient level.

2) Are our plans for safety control while conducting deuterium experiments adequate and appropriate?

In the preparation for the deuterium experiment, you are strengthening (1) overall radiation monitoring system, (2) education and training of radiation and (3) environmental measurement facilities. The overall system monitors dose, radioactivity and device conditions, which is sufficient. The environmental measurement will use time-resolution technique from minute- to real-time levels, using current instruments. New measurement devices are under development as well. You have great potential to make an innovative contribution in this field of study.

Tritium control is one of the critical tasks for the D-D experiment. You have set an extremely strict figure of tritium level over the evacuation or the purge process, much lower than what is legally regulated. Based on the strict target, you have calculated a specification of the tritium removal machine at the maximum purge rate. It shows a much lower tritium concentration level than the targeted. So the provisions are fairly sufficient.

Another critical task is how to handle the water containing tritium. While limiting a maximum amount of drained water below the statutory level, you are going to have the Japan Radioisotope Association take over the water after storing temporarily to check tritium level by yourself. Such belt-and-brace provisions are really desired to contain the spill of the contaminated water either in an ordinal operation or in any emergency.

Scrupulous attention is also paid to any work inside the vacuum chamber or in the controlled area. For those workers, changing space is prepared as well as contamination-detector and decontaminating facilities. Tritium level is monitored and negative pressure is controlled. A temporal working room will be set whenever necessary and all access to the LHD building is under

control. These provisions show how hard you work to prevent tritium leaking and how much you care about the safety of workers, which is highly commendable.

2. 2. Recommendations

Overall, your efforts are highly praised. However, there is no 100% in safety management and you have to continue to pursue the perfect score all the time. From the point of view, we have picked up some recommendations. Here is a summary.

It is expected;

(1) you will enhance risk-predicting ability in staff as well as increase safety awareness in them. You will continue the annual practice of how to respond to disasters because it is very effective to boost awareness. You will also have more opportunities to share any less-serious cases, inject them into risk-prevention training and let precautious skills permeate routine work.

(2) you will provide a special care toward those who are expected to lead the D-D experiment and take huge responsibility for the campaign. Meanwhile, it is also important to prevent only a certain group of people from suffering from excessive burdens.

(3) you will make clear who is to bear a whole responsibility for safety education for graduate students. It is also expected you will make safety education available equally to foreign students as well as to Japanese and will provide one as early as possible in April. It is desired that the course is accredited and accompanied by a comprehensive test.

(4) you will be well-prepared for *Laws Concerning the Prevention from Radiation Hazards due to Radioisotopes and Others*. A more concrete shape should be given to the planned framework of the Safety Committee, the Safety Monitoring Commission and the Radiation Protection Office, and also to how to share emergency responsibility.

Chapter 3 Summary

Based on the results obtained so far, NIFS will move on a next phase in 2010. During the period of the 2nd Mid-Term Plan, the institute aspires to establish academic knowledge systematically leading to a helical prototype reactor. One of the keys to attain the goal is the reinforcement of its fusion engineering research. The research needs to concentrate on the issues more clearly and at the same time, has to take a comprehensive approach. Another key is safety management. NIFS accepts a large number of co-researchers visiting for the collaborations it promotes, and it is a duty as a COE to ensure safety environment for those people. Safety management is as essential as infrastructure maintenance. From this point of view, the 2009 review was determined to target the two activities. The external peer review committee was set up by the Administrative Council, and subcommittees specializing in each were formed under the committee. Here is a brief of how we came through and what we have concluded as an external reviewer.

At the first meeting, details of perspective were worked out and fixed up as follows.

I Evaluation items on fusion engineering research

1. Research process and performance
   1) Are the subjects NIFS has worked for adequate and appropriate?
   2) Has NIFS made effective use of its facilities and achieved satisfactory outcomes regarding each of the subjects in 1)?
   3) Has NIFS learned from the past external review results?
   4) Has NIFS fulfilled a role as COE for universities who study fusion engineering?
2. Collaboration performance
   1) Does NIFS's collaboration system function effectively in the field?
   2) Has NIFS learned from the past external review results?
3. Goal and planning
   1) Are NIFS's subject selection and implementation plans adequate and appropriate?
   2) Is NIFS's system for implementing the plans adequate and appropriate?

II Evaluation items on safety management

1. Management system and performance
   1) Does NIFS's safety-management system respond properly to a shift in relevant law from the National Personnel Authority Regulations to the Industrial Safety and Health Law according to the reorganization of the national universities as corporation? (Please note the role of the Safety and Health Committee and its activities.)
   2) Does the Division for Health and Safety Promotion function properly to ensure safe environment? (Is the structure adequate and appropriate, which consists of 10 offices such as the Environmental Safety Control Office, the Health Control Office and so on?)
   3) Does NIFS provide safety education for in-house students adequately and appropriately?
2. Safety performance as an inter-university research institute
   1) Are the visiting co-researchers including the graduate students educated and managed their safety adequately and appropriately?
   2) Are the foreign co-researchers provided safe environment?
3. Future plan
   1) Is NIFS's safety-management system well-prepared for the reorganization of research division in 2010?
   2) Are NIFS's plans for safety control while conducting deuterium experiments adequate and appropriate?

At the second meeting, NIFS made a full explanation over each point above. Subcommittee members discussed NIFS performance and each group summed up its opinions. At the third meeting, the committee discussed the results from the subcommittees and recommendations to give NIFS on the future activities, and then wrapping up the report.

Regarding fusion engineering research, most committee members appreciated all the three aspects; *Research process and performance*, *Collaboration performance* and *Goal and planning*. The committee also encourage NIFS: (1) to advance the research around reactor design in a cross-divisional approach, (2) to become a domestic stronghold for studies of advanced blanket or low-activated materials while to ensure a leading position internationally as well, (3) to boost the development work of superconducting coils for a future reactor and (4) to make a great contribution to enhancing the academic approach toward a helical-type

reactor through developing its own fusion engineering research. In addition to them, emphasis was made on the importance of educating young personnel who will be actively involved in future-plant projects.

Regarding safety management, the committee also gave high marks on the three; *management system* and *performance, safety performance as an inter-university research institute* and *future plan*. The effort for the deuterium experiment received especially high commendation for its scrupulous attention and measures. In order to reinforce safety management the committee suggests: (1) to promote risk-prediction practice, (2) to enrich safety education for students, (3) to train the Safety Officer to help strengthening its expertise and (4) to give a more concrete shape to the system related to the deuterium-discharge experiment.

NIFS has accomplished the targets planned in the past and its future plan meets requirements satisfactorily both its fusion engineering research and safety management, which brought in the good review result. In closing, we would like to reconfirm what we believe NIFS will make; a major breakthrough toward a helical reactor in the research as well as a further reinforcement of the safety previsions.

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