TECHNICAL ADVISORY COMMITTEE # 7
on the Transmutation Experimental Facility (TEF)

Meeting held on 22, 26 January & 2 February 2021
Online meetings

T-TAC 2020 REPORT

Contents

EXECUTIVE SUMMARY

The 7th Technical Advisory Committee T-TAC for the Transmutation Experimental Facility (TEF) project held their meeting on 22, 26 January and on 2 February 2021 online.

The T-TAC thanks the J-PARC Director Dr N. Saito for providing a comprehensive view of the TEF project progress through detailed presentations from his staff. T-TAC appreciated the time and diligence all the presenters have invested in order to convey a high density of information and material. T-TAC congratulates the team for the progress accomplished despite of COVID-19 situation and notes that the project has carefully considered the recommendations from the previous T-TAC.

Even T-TAC has been asked this year to advice mainly on the R&D plans, T-TAC is still worried that the activities about Remote Handling and Facility Layout are on a low pace as such activities are deemed difficult to be completely outsourced.

T-TAC recognizes that the R&D topics addressed by the team are in line with the needs for designing and constructing TEF-T. Moreover, the on-going and planned R&D works will provide the hands-on experience required for the safe and efficient operation of the TEF facility. T-TAC considers the R&D works carried out at J-PARC as valuable contributions to the international ADS community and encourages to further deploy the existing collaborative efforts for the Japanese ADS program with domestic or international (SCK CEN, KIT, PSI, …) organizations.

INTRODUCTION

The 7th Technical Advisory Committee T-TAC for the Transmutation Experimental Facility (TEF) project held their meeting on 22, 26 January and on 2 February 2021 online.

T-TAC thanks J-PARC/JAEA for the excellent meeting organization. T-TAC appreciated the time and diligence all the presenters have invested in order to convey a high density of information and material. Also, the efforts of the speakers during the meeting to address the comments & recommendations of previous T-TAC meeting are much appreciated.

Appendix I gives the agenda for the meeting while Appendix II indicates the charges that the J-PARC director gave to the committee. The committee members, as listed in Appendix III participated to all online meetings.

The observations, comments and recommendations included in this report are based on the presentations and information that have been provided to T-TAC during the meeting.

1. R&D activities and future plan of Target Technology Development

1.1 OLLOCHI test campaign plan, Oxygen concentration control & LBE flow rate measurements

Observations

- T-TAC recognizes the successful start of OLLOCHI loop operation. The first operation of OLLOCHI loop with various test materials started under controlled LBE-conditions.
- The developed automatic oxygen control system was successfully validated by dedicated experiments and is working well since the start of OLLOCHI operation.
- Performance of the ultra-sonic flow meter was significantly improved by re-design and probably improved wettability at the contact areas.

Comments

- The corrosion test matrix intended for OLLOCHI represents a large number of different materials and looks like an experimental screening campaign. It contains refractory materials, different steels, and an exotic alloy. This is quite valuable for basic R&D results and will be appreciated by the scientific community. But, for a further TEF-T development a decision on the most promising/relevant materials for the construction of TEF-T should be made in an early stage.
- Both reliable oxygen control systems and reliable flow meters are key components for safe operation of future ADS and current experimental LBE-loops. We congratulate the team for the progress made during the last year regarding the implementation, testing and improved performance of both key instrumentations.

Recommendation

1.1.1 Reconsider the future corrosion test campaign plan with a strong focus on TEF-T relevant materials without ignoring the needs for Verification & Validation of computer code results obtained in the PSi program as well as the needs for the qualification of the candidate materials for the ADS machine.

1.2 Electro-magnetic flow probe development

Observations

- Electro-magnetic flow probe was further developed and its fundamental performance was investigated by means of the test with the apparatus named NALTO.
- The calibration curves of the flow probe were obtained in the experimental study.
- The probe with 4 electrodes which can detect and measure the flow velocity and direction was developed. The prototype probe was manufactured. Some additional works are necessary to launch the test campaign.

Comment

- Due to the possibility to measure very local and vectoral flow distributions such multi-electrode flow probes may be very valuable for validation of the results of the code, as validated codes are of key importance for acceptance of TEF-T safety file by the Regulatory Authorities.

Recommendations

1.2.1 The performance of the probe with 4 electrodes in flowing liquid Pb-Bi needs to be checked as soon as available.

1.2.2 The way of the probe installation in the Pb-Bi target and the circulation loop should be considered.

1.2.3 Focus primarily on further R&D-activities for electro-magnetic flow probes towards validation of code results as well as possible target design improvements and less towards the development of an additional on-line (permanent) flow control instrumentation.

1.3 TEF-T Safety Assessment

Observation

- The safety policy and the procedure of safety analysis including examples of FMEA (Failure Mode and Effect Analysis) have been presented. FMEA identified an LBE pipe break as the worst-case accident. The impact of an LBE leakage accident has been assessed. Internal and external doses at the site boundary have been calculated on the basis of conservative assumptions. The total

dose obtained is about 300 μSv at the highest LBE temperature. The yearly dose limit for persons who are not nuclear energy workers (referred as members of the public) is 1 mSv, as set out in the Radiation Protection Regulations.

Recommendations

1.3.1 Mention the atmospheric conditions considered in the calculation (wind direction and speed)

1.3.2 Consider validation of the obtained results due to their high importance for the safety assessment

1.3.3 Consider to consult the Safety Protection System for J-PARC MLF

2. R&D activities and future plan of Facility and Application Development

2.1 R&D of superconducting LINAC for ADS

Observations

- T-TAC recognized the steady progress in this topic.
- Detailed design was conducted such as Error study and R&D of the single spoke resonator are ongoing.
- Collaboration with SCK CEN in the frame of MYRRHA (1 visiting scientist during 1 year) and QST (exchanges about Linac Ion source & LEBT) was conducted

Comments

- T-TAC congratulates for working out a solution making it possible to shorten the total length of the accelerator
- R&D of the single spoke resonator showed encouraging results

Recommendation

2.1.1 Consider further optimization of the configuration of the accelerator such as the reduction of cavities at Half Wavelength Resonator (HWR).

2.2 Study of accelerator reliability

Observation

- T-TAC acknowledge the steady progress has been obtained on the study of the reliability study.

Comment

- T-TAC congratulates for implementing the automatic restart procedure in order to reduce the trip duration occurred in the RFQ.

Recommendations

2.2.1 Consider a feasibility study of the semiconductor power source as an alternative for the klystron.

2.2.2 Apply the good result obtained by J-PARC for the automatic restart to the reliability assessment of the ADS linac which is a Continuous Wave system.

2.3 Neutronics experiment at J-PARC and Kyoto-U towards realizing ADS

Observations

- T-TAC recognizes further progress of nuclide production cross section. It was indicated that JENDL/HE2007 will reproduce the results obtained other than Ni(p,x)Na. Backstream neutron spectrum was measured by TOF and compared with a simulation result using different models.

- A plan to use a FFAG accelerator at Kyoto University was introduced to measure the double-differential neutron producing cross section and thick target neutron yields.

Comments

- The nuclide production cross section data and their comparison with various models are useful when performing the simulation calculations.

- T-TAC recognizes collaboration with Kyoto University is a clear advantage to support this work and save resources.

Recommendations

2.3.1 The nuclear data are important in various fields, and it is in general worthwhile to obtain new data. However, explain the reason why the nuclei were chosen including the information related to the ADS and/or scientific importance.

2.3.2 Improvement of JENDL/HE2007 should be launched based on these data in collaboration with a nuclear data group.

2.3.3 Backstream neutron beam causes problem to design the facility shield since massive shield cannot be placed due to the beam duct. Comparison with calculation models and reliability check using foils indicated its accuracy at 3 GeV. To apply the knowledge obtained by these data to the ADS energy of 1.5 GeV, it is better to have similar data at lower energies from similar installations.

2.4 R&D of ADS target experimental facility in J-PARC

Observations

- Development of a luminescence monitor, SiC monitor and IPM monitor was presented and degradation due to DPA were indicated to be very small.
- New displacement cross sections were measured around GeV and checked their consistency with existing data and models.
- Soft error testing capability was expressed as multi-purpose use of the facility, and it still can be solid business for accelerator neutron sources.

Comments

- Different beam monitors have been developed and their feasibility for the use for ADS were discussed based on their performance and DPA hardness. T-TAC encourages the continuation of this study to confirm the feasibility at ADS.
- New data about the displacement cross section were useful to confirm the reliability and it is important finding that the arc model will reproduce the experimental data.
- As written in the last T-TAC report, T-TAC acknowledges the efforts for finding new commercial application like soft errors testing. However, ADS should remain the 'flagship' application.

Recommendations

2.4.1 The heat load will be one of the issues to be considered for the beam monitor. Therefore, heat calculation should be performed.

2.4.2 A future plan about the measurement of displacement cross-section, if exists, should be presented in the light of the global scope.

3. T-TAC CONCLUDING REMARKS

- T-TAC congratulates the team for the progress accomplished despite of COVID-19 and notes that the project has carefully considered the recommendations from the previous T-TAC.

- T-TAC congratulates for the recent start of the OLLOCHI installation and encourages to set up collaborations with organization having similar installations and performing complementary material research program.

- T-TAC recognizes the collaborative efforts already deployed by J-PARC for the Japanese ADS program with other organizations on national and international (SCK CEN, KIT, PSI, …) level and further encourages growth in it.

- Even T-TAC has been asked this year to advice mainly on the R&D plans, T-TAC is still worried that the activities about Remote Handling and Facility Layout are on a low pace. As these activities are difficult to completely outsource and therefore still request a significant amount of in-house work, preparatory works (like specifications definition) to achieve the proof-of-principle are deemed important for respecting the planning.

- T-TAC recognizes that the R&D topics addressed by the team are in line with the needs for designing and constructing TEF-T. Moreover, the on-going and planned R&D works will provide the hands-on experience required for the safe and efficient operation of the TEF facility.

- T-TAC considers the R&D works carried out by J-PARC as valuable contributions to the international ADS community.

4. SUMMARY OF THE RECOMMENDATIONS BY SECTIONS IN THE REPORT

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1.2.3 Focus primarily on further R&D-activities for electro-magnetic flow probes towards validation of code results as well as possible target design improvements and less towards the development of an additional on-line (permanent) flow control instrumentation.

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2.1.1 Consider further optimization of the configuration of the accelerator such as the reduction of cavities at Half Wavelength Resonator (HWR).

2.2 Study of accelerator reliability

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2.3.1 The nuclear data are important in various fields, and it is in general worthwhile to obtain new data. However, explain the reason why the nuclei were chosen including the information related to the ADS and/or scientific importance.

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2.4 R&D of ADS target experimental facility in J-PARC

2.4.1 The heat load will be one of the issues to be considered for the beam monitor. Therefore, heat calculation should be performed.

2.4.2 A future plan about the measurement of displacement cross-section, if exists, should be presented in the light of the global scope.

Appendix I – Agenda for 7th T-TAC Meeting

22nd January, 2021			
Japan	EU		
16:00	8:00	Welcome, Mission of T-TAC	N. Saito
16:30	8:30	Closed session	
17:00	9:00	Report from the Target Technology Development Section	
17:00	9:00	Latest topics and answers for previous recommendation	T. Sasa
17:40	9:40	Oxygen concentration control and LBE flow rate measurements	H. Obayashi
18:20	10:20	Electro-magnetic flow probe development	G. Ariyoshi
19:00	11:00	TEF-T Safety Assessment	T. Sasa
19:30	11:30	Closed session	
20:00	12:00	Adjourn	

26th January, 2021			
Japan	EU		
17:00	9:00	Report from the Facility and Application Development Section	
17:00	9:00	R&D of superconducting LINAC for ADS	Y. Kondo
17:30	9:30	Study of accelerator reliability	H. Takei
18:00	10:00	Neutronics experiment at J-PARC and Kyoto-U towards realizing ADS	K. Nakano
18:30	10:30	R&D of ADS target experimental facility in J-PARC	S. Meigo
19:00	11:00	Closed session	
20:00	12:00	Adjourn	

2nd February, 2021			
Japan	EU		
16:00	8:00	Closed session	
18:00	10:00	Summary report by the chair person	M. Schyns
19:00	11:00	Adjourn	

Other presentations from J-PARC without oral talking:

Overview of Nuclear Transmutation Division	F. Maekawa
R&D on ADS based partitioning and transmutation technology in JAEA	F. Maekawa

Appendix II – Mission and charge to T-TAC 2020 from J-PARC

by Dr N. Saito

1. Mission of T-TAC

To advise primarily to the following items:

- Validity of base-line parameters to meet the primary purpose of TEF (revised concept), that is, contributing to nuclear transmutation technology development
- Feasibility of the proton beam transport, LBE target system and related systems for TEF including safety policy, operation and maintenance scheme
- Adequacy of time-line (resource and schedule)

Charge of T-TAC 2020

In addition to the recurrent request described in its mission, T-TAC 2021 is especially asked to advice on progress in the ongoing R&D activities from the viewpoint of ADS activities in the world.

Appendix III - Committee members for T-TAC 2020

	NAME	AFFILIATION	POSITION
1	Marc SCHYNS	SCK CEN	Director of the Advanced Nuclear Systems Institute
2	Michael BUTZEK	Forschungszentrum Jülich	Team leader automation, magnet bearing and gears
3	Yoshiaki KIYANAGI	Graduate School of Engineering, Nagoya University	Professor, Graduate School of Engineering
4	Keishi SAKAMOTO	National Institutes for Quantum and Radiological Science and Technology	Director of Nuclear fusion reactor materials research and development
5	Georg MÜLLER	Karlsruhe Institute of Technology	Deputy Director, Head of Department Professor
6	Masatoshi KONDO	Tokyo Institute of Technology, Institute of Innovative Research, Laboratory for Advanced Nuclear Energy	Associate professor