TECHNICAL ADVISORY COMMITTEE
on the Transmutation Experimental Facility (TEF)

Meeting held 28-29 October 2015
Tokai, Japan

T-TAC 2015 REPORT

Contents

EXECUTIVE SUMMARY

The Technical Advisory Committee for the Transmutation Experimental Facility project T-TAC met on October 27th and 28th, 2015 at the J-PARC centre, Tokai and toured the laboratory in the High Temperature Research Building as well as the site for the planned construction of TEF. The T-TAC thanks the J-PARC Director Dr. N. Saito for providing a comprehensive view of the TEF project through detailed presentations from his staff.

The key issues on the design and the support R&D for ADS, in particular the LBE technology development with the Accelerator Driven System (ADS) target test facility TEF-T and the study of the reactor physics with MA fuel with the subcritical reactor TEF-P, are perfectly addressed by the involved J-PARC team. Both systems are outstanding and unique in the world for the development of physical, materials and engineering data for the design a large-scale ADS.

The T-TAC members acknowledge the high commitment of the involved J-PARC team to this project, the progress that has been made since the last T-TAC meeting in July 2014 and, given that the appropriate resources are available, the schedules for the launch of the detailed design and construction of TEF-T in FY 2017.

The T-TAC is convinced that the J-PARC complex is the appropriate location for the built-up and operation of both facilities because of the already existing proton beams and the highly-motivated and competent team of scientists and engineers.

In the context of international participation, an attractive program can be mounted with the ADS project MYRRHA in Belgium that can have a complementary role to accelerate the realisation of the ADS transmutation roadmap of J-PARC.

The T-TAC is convinced that J-PARC is responding to the TEF project challenges in a professional manner and that given the proper resources, it can contribute to the development of ADS for the transmutation of high level waste at an engineering level and create important scientific, technological as well as societal benefits.

INTRODUCTION

The Technical Advisory Committee T-TAC for the Transmutation Experimental Facility (TEF) project met on October 27th and 28th, 2015 at the J-PARC centre, Tokai and toured the laboratory in the High Temperature Research Building as well as the site for the planned construction of TEF as well as the site for the construction of the intended TEF. Appendix I gives the agenda for the meeting while Appendix II indicates the charges that the J-PARC director gave to the committee. The full committee (see Appendix III) participated in the two-day meeting, except Yoshiaki Kiyanagi (Nagoya University) who could not attend.

1. OVERVIEW OF J-PARC TEF PROGRAM

The Transmutation Experimental Facility program was presented as part of the roadmap towards the ADS proposed by JAEA for waste transmutation. The structure of the involved R&D sections in J-PARC as of October 1st as well as the updated schedule for the Target (-T) and the Beam Transport (-BT) of the TEF project have been shown.

Observations and Comments:

Even if additional staff joined the Nuclear Transmutation Division since the first T-TAC meeting in 2014, T-TAC estimates that a further reinforcement of the design and licensing team as well as the set-up of a construction team is required in order to launch the construction phase of TEF-T and TEF-BT as presently planned in 2017. Unfortunately, the involvement of the Monju staff as suggested by T-TAC in 2014 for the design for the industrial ADS and in terms of realisation can only be realised on a moderate level.

In response to the recommendations (# 1.1 and 2.1.1) of the previous T-TAC meeting, the parameters of TEF-T (flow rates, wall and sample temperatures, flow velocities, beam current density, dpa and He production levels) needed to address all viable JAEA-ADS candidate concepts have be presented. It has been observed that the DPA level of TEF-T is similar to the completed MEGAPIE project (1 MW spallation window target experiment, with a proton beam intensity of 1,8 mA with an energy of 590 MeV). The experimental program of TEF-T should take profit of the outcomes of the MEGAPIE project.

Recommendations

1.1 In order to launch the construction phase of TEF-T and TEF-BT as planned in 2017 the technological choices should be fixed and documented in a Technical Design report. Ideally, this document would be the base of the next T-TAC meeting.

2. TEF-T DESIGN DETAILS

2.1 Target Station and maintenance

The latest design of the target station taking into account the recommendations of the previous T-TAC report was presented. In particular, the target head design, target loop and the design of the target trolley was shown. Also the MLF based target concept and the new concept has been compared.

Observations and Comments:

Concerning the target head, design activities are still in progress to guide the flow inside the target. Double vanes have been proposed during discussions to efficiently reduce flow recirculation at the target window tip. In this case, a possible relocation of the sample holder might be necessary and the flow stability has to be checked. It is essential therefore to carry out a full CFD analysis. Bringing the samples closer together enables to increase their quantity however hampers the possibility to carry out stress tests under radiations. Such kind of tests has a greater interest to the community than static tests.

Recommendations

2.1.1 Elaborate a full CFD and thermomechanical characterization and optimise the beam size in respect to a.o. the DPA of the samples, the target window shape at the center in order to reduce stress level and the detailed design of the sample holder in order to guaranty the flow stability in the sample region.

2.1.2 Users group for the TEF-T facility (ADS, Fusion) should be further consulted to assess specific demands on irradiation conditions in order to define their specifications accordingly

2.2 Irradiation and PIE plan

Irradiation effects on target and cladding material like radiation hardening (embrittlement), swelling, fatigue, creep, erosion-corrosion by LBE have been considered. Swelling behavior including temperature dependence was presented for T91 by using triple ion irradiation (TIARA facility). A high priority area for the intended PIE has been defined in function temperature and DPA.

Observations and Comments:

Some clarification was requested concerning the method for monitoring and maintaining the irradiation conditions a. o. temperature, LBE flow as well as the shape of the DPA field (neutron versus proton).

Recommendations

2.2.1 Set-up the detailed irradiation condition and PIE plan (target and samples) when target design is fixed.

2.3 User applications

A tentative policy for a multipurpose use of TEF-T has been exposed. Applications like the production of isotopes for medical use, irradiation tests for semiconductor device, fundamental nuclear physics, … have been mentioned. The installation of additional devices (pneumatic tube, neutron beam port, ISOL facility) to achieve these goals have been considered.

Observations and Comments:

T-TAC Advisory Committee endorses the concept of pursuing multi-purpose uses of TEF-T, e.g., for fusion materials testing, radioisotope production, and semiconductor testing while the focus remains on the development of nuclear transmutation technology for enhancing the safety of processing and disposal of radioactive waste as written in “Strategic Energy Plan”.

As the semiconductor industry progresses, the technological impact of radiation effects becomes more and more important. In order to produce the extremely fine geometries required at high levels of integration, the transistors become smaller and the integrated circuits are getting more sensitive to parasitic charges induced by radiation and more susceptible to Single Event Upsets (SEUs) triggered by ionizing particles.

Typical application areas where radiation effects on electronics have to be considered are: e.g. satellites that must not fail as repair interventions are impossible to be carried out; the safety of electronic systems in avionics is of utmost importance and must be ensured in spite of the high-altitude radiation levels; planes, cars, trains & communication systems integrate a constantly increasing number of electronic components, increasingly complex, where even relatively low radiation levels can lead to important risks; and finally operation and safety systems at accelerators require a high mean-time-between failures for reaching ultimate design goals and achieving scientific breakthroughs.

Measurements with accelerator-produced proton and heavy ion beams are commonly carried out to generate data which are important for understanding and predicting the behaviour of microelectronic devices and systems in radiation environments. Characterization of single event and/or total dose responses of devices and device technologies to radiation exposure is the goal of most studies. Many of these studies are carried out by means of cyclotrons responding to specific Quality Assurance (QA) standards. An applications catalogue for TEF-T should be identified by taking profit of its outstanding specifications.

Recommendations:

2.3.1 If the proton pulse structure allows, consider the possibility of including a neutron time-of-flight flight path fed by very short (~ns) beam pulses for measurement of neutron-induced reaction cross sections above 1 MeV.

2.4 Facility design

The design policy for the buildings and the utilities based on the requirement material irradiation test for the nuclear transmutation and the multipurpose use has been presented. The TEF-T floor layout (radiation control area, remote handling area, …) including the classification of the negative pressure zones as well as the outline of the ancillary and control system has been shown.

Observations and Comments:

The TEF-T facility design is well advanced and appears to adequately address the requirements.

One small issue is to confirm sufficient shielding between the beam transport line entering the building and the conference room located above this beamline. Alternatively, consider placing an alternate room (such as a hallway or storage room) in this location, which can reduce the chance of worker exposure from both normal and off-normal operation.

The water cooling system as presented is centralised and is feeding in parallel all sub-systems as 'LBE system', 'Shielding in vessel', 'Target trolley' and the 'Proton beam window'. There is no redundancy foreseen. It is also to confirm that no provisions need to be foreseen in case of failure of the central cooling system in order to avoid any potential hazard.

3. EXPERIMENTS AND RESULTS FOR TEF-T DESIGN

3.1 TEF-T Target Mockup Loop

The "Mock-up loop of TEF-T Target Station" is a demonstration test loop with the same configuration of the primary cooling system of TEF-T target. The purpose and objectives of the test loop are well defined. The recommendation of the 1st T-TAC Meeting (#2.3.9) concerning the safety study has not yet been addressed due to changes in the design for TEF-T target.

During discussion, it has been stated that 60l/min (nominal speed) are sufficient to cool. In this case the temperature of 470°C is reached and the local speeds in window are 1,4 m/s. The max flow of the pump is 120 l/min. When setting the flow to 120 l/min a temperature of 450°C is reached and the local speeds in window are 2,8 m/s. Double walled heat exchanger with LBE in-between is considered. Leakage detection in the heat exchangers remains an issue.

Observations and comments:

Concerning the heat exchanger, the secondary medium is water. Outlet temperature is 200°C and water pressure is 2 MPa. Saturated pressure of pressurized water at 200°C is about 1,45 MPa. However 2 MPa boiling point is 213 °C. There is only a small margin in temperature. Subcooled boiling can quickly occur, and the boiling bubble collapse in the water bulk flow. However, if a certain amount of generated steam is surrounded by subcooled water periodically, water hammer may occur because of quick condensation of the steam, and as a result the heat exchanger can be damaged by the water hammer.

Recommendations:

3.1.1 Assess the risk of waterhammer and if necessary work out countermeasures to avoid damage of the heat exchanger.

3.1.2 Analyze the effect of beam trip scenario's on the operation of the mock-up loop of TEF-T Target station

3.2 High Temperature Corrosion Test Loop

For the realization of TEF-T and future ADS systems, the generation of appropriate corrosion data of relevant materials like T91 and SS316L steels in the temperature range of interest between 400°C and 550°C is of absolute necessity. JAEA has designed and built the "High-Temperature Material Corrosion Test Loop (HTC)", to obtain the desired information.

The status for the HTC loop as of October 2015 is that the conditioning operation without LBE and the modification of heaters and sample exchange box has already started, whereas the oxygen sensors and the oxygen control system (OCS) will be installed until March 2016.

Observations and comments:

The purpose and objectives of the HTC loop, based on the presentation of Shigero Saito, and the recommendations of the 1st T-TAC Meeting in July 2014 are well addressed and implemented. Nevertheless, the presented flow scheme requires some modifications:

- The ultra-sonic flow meter should be located better after the EM-pump in flow direction.
- The splitting of the main flow path into two sections is rather risky. Depending on the flow resistances in each test section, different flow rates could be the result. If there are no additional flow meters in each test section, the actual flow rate is more or less unknown!
- The sample holder of 430 mm of length with rectangular thin-walled plates (10x14 mm), exposed in each of the two test sections, will be removed from the loop corresponding to the test schedule. Due to the sample design, turbulent resp. mixed-flow conditions will occur in both test sections with different characteristics!

Recommendations:

3.2.1 Install the flow meter after the EM-pump and foresee additional flow meters in each test section.

3.2.2 Perform a careful thermal hydraulic analysis of the two test sections, with and without inserted sample holders, to identify the corresponding flow pattern.

3.2.3 This helps to identify the kind of flow (laminar, turbulent, mixed flow) for both test sections, their differences and to estimate the active length of each test section to be used for sample exposure.

3.3 Oxygen sensor and potential control

The compatibility of structural and cladding materials, mainly steel-based, is one of the key challenges for the use of heavy liquid metals, like lead or LBE, as coolant of prospective nuclear and transmutation reactors. One measure to minimize the materials corrosion is the controlled addition of oxygen to the LBE to promote the oxidation of steel elements, e.g. iron and chromium, for the formation of stable and protective oxide layers on the surface of highly loaded parts. The concentration must be high enough to oxidize iron, the main component of the steels, but should not exceed the value at which oxidation of lead can occur. Hence, the concentration range of oxygen must be kept between ca. 10^{-5} and 10^{-7} wt.-% to fulfill these conditions.

Observations and comments:

The purpose and the objectives of the oxygen concentration measurement with electrochemical oxygen sensor, including oxygen control process, are well addressed. Most of the recommendations of the 1st T-TAC Meeting last year, as presented by Takanori Sugawara are fulfilled, except:

- The calibration of Bi/Bi2O3 sensor type was not successful, compared to Pt/air sensor. The reason for this effect is complex and any solution for this problem is time consuming.
- The calibration process of oxygen sensors itself is on the right path. But only calibration at a single oxygen potential (e.g. saturated condition) is not enough, especially at the beginning of the learning phase, to understand better the quality and the scatter in the manufacturing process of sensors.
- The long-term testing of oxygen sensors in flowing condition has been stopped after quite short time due to sensor (ceramic?) failure.

Recommendations:

3.3.1 Rely only on Pt/air sensor for all future applications to save time and budget.

3.3.2 Calibration of oxygen sensor should be done additionally at a second oxygen potential e.g., the Co/CoO potential which is around 900 mV at 500°C for Pt/air sensor. This gives better confidence about sensor performance. Later in future, when the quality of the manufacturing of oxygen sensor at J-PARC is understood and given, one can go back to a single point calibration.

3.3.3 The long-term testing of Pt/air sensor in flowing LBE must be pushed on. To minimize the risk of thermal shocking of sensor during re-filling with LBE, a careful draining and filling procedure has to be worked out.

3.4 Elemental Technologies

The "Mock-up loop of TEF-T Target Station" is a demonstration test loop with the same configuration/components of the primary cooling system of TEF-T target. Most of the components are at actual scales, except the heat generation unit which simulates the heating power of the proton beam. The construction of the loop was finished after the 1st T-TAC meeting within the end of JFY 2014. The major objectives of the mock-up loop are focused on remote handling techniques, freeze valves and liquid metals related instrumentation. In the report of the last T-TAC meeting in July 2014, the T-TAC expressed its concerns about the use of freeze valves in a large-scale facility like TEF-T, whereas the development and qualification of instrumentation and remote handling techniques has to be of high priority. Therefore, J-PARC has started new activities within "Elemental Technologies" to clarify open questions resp. to perform the required functional tests.

- Freeze-seal valve
- Automatic pipe welding
- Remote operation tests for package heater and flange joints

Observations and comments:

The objectives of this task are well addressed, as shown by Toshinobu Sasa. Nevertheless, two activities have to be considered very carefully because of their immense impact on the operation of the target loop:

- To minimize the number of mechanical valves to a minimum level is in agreement with the experience of the T-TAC. Nevertheless, to incorporate a so-called freeze-seal valve into the target loop might have a tremendous impact on the safety of the whole loop system. Because LBE is time-dependent expanding during solidification, high mechanical stresses, even above the ultimate tensile strength of most typical steels, can result in structural failures of the piping system. The level of mechanical stress depends on the cooling rate, onset temperature of cooling and dwell time in the solid state. All presented parameters, fast cooling from high(er) temperature and remaining for about 5000 hours in the frozen condition, can represent a worst-case scenario for the lifetime of the freeze-seal valve.
- The automatic cutting and re-welding of connecting target tubes to avoid joints/flanges is always supported. But, any re-welding of T91 tubes needs a subsequent annealing heat treatment of the welding zone at 760°C for about 2 hours to avoid weld embrittlement. For SS 316L, the precipitation of carbides during air cooling of the weld might cause an embrittlement, too, although not at the same level as for T91 steel.
- The use of LBE instead of mercury as liquid metal for a spallation target requires different operational adaptations, like continuous pre-heating or easy exchangeability of pipes. By applying Fast Reactor Technology from JAEA, so-called "Package Heater" which can be remote machine operated look very reasonable and feasible for this application.

Recommendations:

3.4.1 Perform mockup tests with instrumented strain gauges at realistic and prototypical conditions to measure the stress/strain levels in the piping walls during solidification. This will help for risk assessment and optimization of freeze-seal valve operation.

3.4.2 For T91 steel consider external movable heater systems to perform the required heat treatment, including air cooling afterwards to room temperature. Check the quality of the welds by metallographic investigations and charpy tests of welding zones.

3.4.3 For 316L steel, check whether a heat treatment is generally necessary or not (charpy tests of welding zones), or if you can use a Ti-stabilized variant of 316 steel (316-Ti) which prevents carbide precipitations at the grain boundaries by means of 0.5 wt.-% of alloyed titanium.

3.4.4 Guarantee a proper cleaning of the cut target tubes from sticking LBE before re-welding to a new target.

4. TEF-BT DESIGN DETAILS INCLUDING EXTRACTION FROM LINAC

The status of the TEF – BT design has been presented including the revised optics design, construction plan and the development of the beam monitor. The completed conceptual studies for the beam extraction were exposed. A two-step beam extraction method is selected requiring pulse bending magnets, DC septum magnet and improved quadrupole magnet. The production of the pulse bending magnets with the correction magnets were finished. Finally, the status of the laser charge exchange (LCE) was shown, in particular the stability tests in progress for the laser source and the preparation of the LCE test using low energy H^+ beam.

Recommendations:

4.1 Concerning the TEF-BT design, continue investigations into various options (wire grid, IR imaging and visible imaging of luminescent coating) for measuring the beam profile on target.

4.2 To achieve improved resolution and avoid radiation damage to fiber optics, consider straight light paths with turning mirrors in lieu of fiber optic bundles for transmitting images to the camera.

5. TEF-P OVERVIEW

For TEF-P there were two presentations: TEF-P Design by K. Tsujimoto and R&D for TEF-P Design by T. Sugawara. First the conceptual design target of ADS in JAEA was shown. Sub-criticality was set to k-eff = 0.97. Fuel in the core is nitride fuel of MA, Pu and Zr, (MA+Pu)N+ZrN. One of the merit of the proposed ADS is to able to transmute a large amount of MA, 250 Kg MA per 300 Equivalent Full Power Days. The transmutation rate is about 5 times higher than the Minor Actinide transmutation in fast reactors presently investigated in Japan. In the core the MA content is about 50 to 70 %, and due to the high contents of MA the neutronics parameters such as criticality, void reactivity, Doppler reactivity estimated by the present calculation systems have large uncertainties.

To reduce the large uncertainties for ADS Tsujimoto proposed a new critical assembly because the fuel for the present FCA (Fast Critical Assembly) is not available. The new critical assembly has a proton beam injection and a large amount of MA of kg-order, and will be operated in both critical and sub-critical conditions. The preliminary results for regulatory requirement, physical protection and fabrication process of MA bearing fuel were also shown.

T. Sugawara presented R&D programs now undergoing at JAEA. Four kinds of testing equipment (TE) were prepared; TE for fuel loading, fuel identification, fuel cooling and fuel coolability in air circulation. The TE preparations are important , and from the experiments it is concluded that basic outlooks for the remote handling and cooling were obtained. Mock-up testing of MA fuel pin remote handling has shown good success. Tests should be extended to demonstrate the ability of the remote handling equipment to operate reliably in the anticipated high radiation environment of the MA fuel.

Observations and comments:

For the two presentations there were some questions and comments. The most important comment concerns the time schedule of the TEF-P experimental program and the requirement of individual measurement techniques such as sub-criticality, Doppler reactivity, power distribution etc. Some preliminary results were presented for regulatory requirements, but it is necessary to investigate what items are required from the regulatory authority for this type of critical assembly. Also MA will be used and so it is necessary to consider what nuclides must be included in the dose assessment in loss of containment accidents. Also the integrity of the geometry must be verified under loss of coolant accidents. The assumption that only halogen and noble fission products gasses are released during off-normal events may not be sufficiently conservative. Engage the regulator early in the design process regarding assumed release fractions for americium during off-normal events. For the fuel fabrication, fuel manipulation and storage of MA (Am) should be considered.

CONCLUSIONS

The Technical Advisory Committee for the Transmutation Experimental Facility project T-TAC met on October 27th and 28th, 2015 at the J-PARC centre, Tokai and toured the laboratory in the High Temperature Research Building as well as the site for the planned construction of TEF.

The T-TAC members acknowledge the high commitment of the involved J-PARC team to this project and the progress that has been made since the last T-TAC meeting in July 2014.

The key issues on the design and the support R&D for ADS, in particular the LBE technology development with the ADS target test facility TEF-T and the study of the reactor physics with MA fuel for the subcritical reactor TEF-P, are perfectly addressed by the involved J-PARC team. Both systems are outstanding and unique in the world for the development of physical, materials and engineering data for the design a large-scale ADS.

The T-TAC considers that the preparation of the works for the 'beam transport' to TEF-T and for the 'extraction' of the 400 MeV LINAC is very well advanced and that given the appropriate resources the presented planning to start the TEF-T construction works in FY 2017 is credible. An extensive know-how concerning beam transport exist at J-PARC. Also, the first meters of the gallery to transport the beam to TEF-T already exists in the 400 MeV accelerator tunnel and no time-consuming dismantling works of existing installations for site preparation are needed for the construction of the TEF facilities as it could already be observed by T-TAC during the tour in 2014. The approach of the safety steps to isolate TEF-P from the accelerator beam is credible. A co-existence of TEF-T and the intended TEF-P to be realized in a next step is found to be possible by T-TAC. Licensing of TEF-T facility can therefore be in-line with the proposed time-schedule.

In the meantime, activities for the realisation of target station, the development of the Lead Bismuth Eutectic technology (corrosion, key components, …) and the detailed definition of the irradiation condition and PIE plan (target and samples) can progress further following the presented schedules. T-TAC formulated a list of recommendations for these topics.

The completion of the conceptual design phase foreseen should be documented in a Technical Design Report (TDR). The T-TAC would be pleased to get the document preferably in advance of the possible next T-TAC meeting.

SUMMARY OF THE RECOMMENDATIONS BY SECTIONS IN THE REPORT

1. OVERVIEW OF J-PARC TEF PROGRAM

1.1 In order to launch the construction phase of TEF-T and TEF-BT as planned in 2017 the technological choices should be fixed and documented in a Technical Design report. Ideally, this document would be the base of the next T-TAC meeting.

2. TEF-T DESIGN DETAILS

2.1. Target Station and maintenance

2.1.1. Elaborate a full CFD and thermomechanical characterization and optimize the beam size in respect to a.o. the DPA of the samples, the target window shape at the center in order to reduce stress level and the detailed design of the sample holder in order to guaranty the flow stability in the sample region.

2.1.2. Users group for the TEF-T facility (ADS, Fusion) should be further consulted to assess specific demands on irradiation conditions in order to define their specifications accordingly

2.2 Irradiation and PIE plan

2.2.1 Set-up the detailed irradiation condition and PIE plan (target and samples) when target design is fixed.

2.3 User applications

2.3.1 If the proton pulse structure allows, consider the possibility of including a neutron time-of-flight flight path fed by very short (~ns) beam pulses for measurement of neutron-induced reaction cross sections above 1 MeV.

3. EXPERIMENTS AND RESULTS FOR TEF-T DESIGN

3.1 TEF-T Target Mockup Loop

3.1.1 Assess the risk of waterhammer and if necessary work out countermeasures to avoid damage of the heat exchanger.

3.1.2 Analyze the effect of beam trip scenario's on the operation of the mock-up loop of TEF-T Target station

3.2 High Temperature Corrosion Test Loop

3.2.1 Install the flow meter after the EM-pump and foresee additional flow meters in each test section.

3.2.2 Perform a careful thermal hydraulic analysis of the two test sections, with and without inserted sample holders, to identify the corresponding flow pattern.

3.2.3 This helps to identify the kind of flow (laminar, turbulent, mixed flow) for both test sections, their differences and to estimate the active length of each test section to be used for sample exposure.

3.3 Oxygen sensor and potential control

3.3.1 Rely only on Pt/air sensor for all future applications to save time and budget.

3.3.2 Calibration of oxygen sensor should be done additionally at a second oxygen potential e.g., the Co/CoO potential which is around 900 mV at 500°C for Pt/air sensor. This gives better confidence about sensor performance. Later in future, when the quality of the manufacturing of oxygen sensor at J-PARC is understood and given, one can go back to a single point calibration.

3.3.3 The long-term testing of Pt/air sensor in flowing LBE must be pushed on. To minimize the risk of thermal shocking of sensor during re-filling with LBE, a careful draining and filling procedure has to be worked out.

3.4 Elemental Technologies

3.4.1 Perform mockup tests with instrumented strain gauges at realistic and prototypical conditions to measure the stress/strain levels in the piping walls during solidification. This will help for risk assessment and optimization of freeze-seal valve operation.

3.4.2 For T91 steel consider external movable heater systems to perform the required heat treatment, including air cooling afterwards to room temperature. Check the quality of the welds by metallographic investigations and charpy tests of welding zones.

3.4.3 For 316L steel, check whether a heat treatment is generally necessary or not (charpy tests of welding zones), or if you can use a Ti-stabilized variant of 316 steel (316-Ti) which prevents carbide precipitations at the grain boundaries by means of 0.5 wt.-% of alloyed titanium.

3.4.4 Guarantee a proper cleaning of the cut target tubes from sticking LBE before re-welding to a new target.

4 TEF-BT DESIGN DETAILS INCLUDING EXTRACTION FROM LINAC

4.1 Concerning the TEF-BT design, continue investigations into various options (wire grid, IR imaging and visible imaging of luminescent coating) for measuring the beam profile on target.

4.2 To achieve improved resolution and avoid radiation damage to fiber optics, consider straight light paths with turning mirrors in lieu of fiber optic bundles for transmitting images to the camera.

Appendix I

Agenda for 2nd T-TAC Meeting

Date: 28 – 29, Oct., 2015
Venue: Main Conference Room, J-PARC Center Research Building 2F,
Tokai, JAEA

<u>**28, Oct. (Wed.)**</u>

7:45	Shuttle bus from Terrace Inn Katsuta
8:45	Welcome (Closed, N. Saito)
8:50	Mission of T-TAC (Closed, N. Saito)
9:00	Closed Session for T-TAC Member
9:40	Overview of J-PARC TEF Program (F. Maekawa)
10:00	Break
10:30	TEF-T Overview (T. Sasa)
10:40	TEF-T Design Details
	Target Station and Maintenance (10:40-11:10, T. Sasa)
	Irradiation and PIE plan (11:10-11:25, N. Okubo)
	User Applications (11:25-11:40, H. Iwamoto, K. Nishio)
	Facility Design (11:40-12:00, H. Kinoshita)
12:00	Lunch
13:00	Experiments and results for TEF-T design
	TEF-T Target Mockup Loop (13:00-13:30, H. Obayashi)
	High Temperature Corrosion Test Loop (13:30-14:00, S. Saito)
	Oxygen sensor and potential control (14:00-14:30, T. Sugawara)
	Elemental Technologies (14:30-15:00, T. Sasa)
15:00	Break
15:30	TEF-BT Design Details including extraction from LINAC
	TEF-BT Design (15:30-16:00, S. Meigo)
	Beam Extraction from LINAC (16:00-16:20, M. Yoshimoto)
	Beam separation for TEF-P (16:20-16:40, H. Takei)
16:40	Closed Session for T-TAC Member
17:30	Adjourn
17:30	Shuttle bus to Terrace Inn Katsuta
19:00	Dinner at Katsuta Area

29, Oct. (Thu.)

8:00	Shuttle Bus from Terrace Inn Katsuta
9:00	TEF-P Overview
	TEF-P design (9:00-9:30, K. Tsujimoto)
	Experiments for TEF-P Design (9:30-10:00, T. Sugawara)
10:00	Break
10:30	Closed Session for T-TAC Member
12:00	Lunch
13:00	Closed Session for T-TAC Member
15:00	Summary Talk by T-TAC member
15:50	losing
16:00	Site tour (including photo near the TEF site)
	High Temperature Research Building (Guide: S. Saito)
17:00	Adjourn
17:00	Shuttle Bus to Terrace Inn Katsuta

Appendix II

Charges to T-TAC 2015 from J-PARC

by **N. Saito**

T-TAC was required to advice primarily on the following charges:

- Validity of base-line parameters to meet the primary purpose of TEF including both TEF-T and TEF-P that is contributing to nuclear transmutation technology development
- Feasibility of proton beam transport, LBE target system and related systems for TEF -T including safety policy, operation and maintenance scheme
- Adequacy of time line (resource and schedule)
- In addition to usual recommendations on facility design R&D activities, it is asked to Evaluate Technical readiness for starting detailed design and construction of TEF-T in FY 2017

Appendix III

T-TAC Committee members for 2015

Name		Affiliation	Field
1	Marc Schyns (chair)	SCK•CEN	ADS Technology
2	Yacine Kadi	CERN	ADS and Spallation Target Technology
3	Yoshiaki Kiyanagi	Nagoya University	Spallation Target Technology
4	Jürgen Konys	KIT	Lead Bismuth Application Technology
5	Eric Pitcher	ESS	ADS and Spallation Target Technology
6	Minoru Takahashi	Tokyo Tech.	Lead Bismuth Application Technology
7	Toshikazu Takeda	Fukui University	Nuclear Reactor Technology