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ITER MAGNET TECHNICAL MEETING

by Dr. R.J. Thome, Head, Superconducting Coils and Structure Division

A Magnet Technical Meeting was held at the Naka Joint Work Site on February 7–10, 1995. Representatives from all Parties attended. A list of participants is shown overleaf.

The main goal of the meeting was to select an option for the TF coil cross-sectional configuration from among the four options and variants based on layer or pancake windings that were chosen at the November 1994 Magnet Meeting. One of the options was selected by the JCT and the Home Teams to be used as a reference for ITER. The reference retains several features of the previous design (October 1994) that were most attractive, and included several improvements in the design in exchange for an increase of the radial build of 125 mm (relative to the toroidal shear plate design without case as of December 1994). The following summarizes the conclusions of the meeting on this topic:

The reference design will be based on a bucked TF/CS configuration. The reference TF coil cross-section will be the cased coil with radial plates containing thin walled tubular jacketed conductors in grooves. The global support structure to be developed as reference will be the "crown" concept without inboard shear keys between TF coils and with outer intercoil structural components.

Participants in the Meeting

Criteria considered in the selection included consideration of reliability, cost and schedule impact, assembly and maintenance simplification.

One of the main elements in selection criteria was reliability. The selected concept supports this criteria by:

- the use of circular conductors in grooves in steel plates to reduce insulation and conduit stress;
- a redundant insulation strategy in that the turn and ground insulations are separated in space, subjected to separate load paths, and one of them (turn insulation) operates at significantly lower stress. In addition, the turn and ground insulations will each incorporate an electrical barrier such as mica or Kapton;
- the use of support plates to carry the primary loads, leaving only small loads in the conductor to be accommodated at transitions to the joint regions;
- the use of a case to provide the required strength and stiffness against out-of-plane forces and as a secondary guard against conductor and connection helium leakage.

Cost impact and the potential for schedule reduction in manufacture were considered and supported by this concept through:

- the use of radial support plates that are planar, modular, and with few fabrication variations;
- the use of pancake windings so that tooling has few variations and is easily duplicated for parallel processing of modules.

Assembly and maintenance simplification was achieved with the concept through the use of a case and its compatibility with the "crown" concept which:

- allows deletion of shear keys from the inboard straight and curved regions of the TF coils;
- reduces the weight of the bucking cylinder and Central Solenoid;
- allows for a room temperature assembly gap between TF coils and the Central Solenoid outside diameter of about 15 mm.

LIST OF PARTICIPANTS

EU: R. Penco (ANSALDO), E. Salpietro (NET), A. Torossian (CEA)
JA: T. Ando (JAERI), M. Sugimoto (JAERI), Y. Takahashi (JAERI)
RF: A. Alexseev (Efremov)
US: D.B. Montgomery (MIT), P. Titus (MIT), F. Kimball (Martin Marietta)
JCT: R. Aymar, P. Barabaschi, D. Bessette, P.L. Bruzzone, B. Green, M. Huguet, F. Iida, Y. Krivchenkov, N. Mitchell, K. Okuno, F. Puhn, C. Sborchia, M. Shimada, B. Stepanov, J. Stoner, R.J. Thome, R. Vieira, F.M.G. Wong, K. Yoshida, E. Zaptretilina

SECOND TECHNICAL MEETING ON ITER POWER SUPPLY

by Dr. P.-L. Mondino, Head, Plasma and Field Control Division, ITER Naka JWS

The 2nd Technical Meeting on Power Supply was held on 20–24 February 1995 in St. Petersburg (RF), with representatives of the four Home Teams and JCT members. The Meeting was called to review the work done and to plant the future activities with the following aims:

- to analyze and to discuss the draft final reports of the Design Tasks and the cost estimation done by EU and RF Home Teams;
- to inform the Home Teams about the evolution of the design of the Power Supply System;
- to agree on the modified design of the Coil Power Supply and Distribution System that will be formally presented in the Interim Design Report; this scheme is expected to be different from that presented at the 1st Technical Meeting;
- to identify how to cost the above modified design;
- to define and to come to a common agreement on the future Design and R&D tasks.

The Design Tasks assigned to the EU and RF Home Teams as part of the 1994 Comprehensive Task Agreement have been:

- D48 Switching Network & Coil Protection;
- D49 Capability of the HV Grid: Assessment;
- D50 AC/DC Conversion Schemes;
- D51 Tentative Power Supply Schemes.

Tasks D48 and D50 included in their specifications the need to identify the R&D requirements in their respective areas.

During Monday and Tuesday the RF and EU Home Team representatives presented their design and the JA and US Home Team representatives presented their contributions.

On Wednesday, the JCT staff presented the evolution of the design and the modifications expected for the ITER power supply system. Moreover, the criteria to be used for the cost assessment were discussed. Then, separate meetings were dedicated to:

- power from the HV grid, local energy storage, tentative power supply scheme, AC/DC conversion (Rapporteur I. Benfatto);
- switching network and fast discharge circuit (Rapporteur B. Bareyt);
- design and cost estimation of the power supply system to be described in the Interim Design Report (Rapporteurs I. Benfatto and B. Bareyt);
- the R&D plan (attendance was restricted to the Heads of Delegations, to P.-L. Mondino and A. Roshal for the JCT and to the representatives of industry), (Rapporteur P.-L. Mondino).

Participants in the Meeting

On Thursday afternoon the rapporteurs presented the results of the discussions which took place in the separate meetings. On Friday morning a visit to the Efremov laborabories took place, and all participants had the opportunity to see several prototypes of switches built in the past by the Institute. Some of them are those proposed for future ITER R&D activities. On Friday evening the Technical Meeting was officially closed. However, in order to complete writing of the draft version of the report, nine participants (B. Bareyt, E. Bertolini, S. Bulgakov, A. Coletti, D. Hrabal, V. Kuchinski, A. Maschio, P.-L. Mondino and A. Roshal) also worked on Saturday 25th. Several informal discussions on the overall design took place in parallel.

The conclusions and results of the meeting are shown in the following boxes.

DESIGN ASSESSMENT AND MAIN CHOICES

HV grid

All four Home Team representatives considered the new active power profile with total active power within –250 MW +550 MW as an important improvement. The design of the power supply system will continue: every attempt will be made to reduce further the power requirements from the HV grid, taking into account the constraints from the other systems and from the plasma requirements. Active and reactive power waveforms, including heating and current drive systems, will be reviewed periodically.

More reactive power compensation to reduce the JCT assumptions for the site requirements (400–500 MVAR) could be necessary: however, if reactive power compensation is required its cost is low.

The new power profile with AH power up to 300 MW lasting from start of flat-top to end of burn termination will be discussed by the Home Teams with the EU and RF Power Utilities.

HV substation and AC power distribution

The JCT scheme based on 4 step down transformers has been confirmed. Among the IEC standard voltages, 72 kV with outdoor switchgear has been selected.

Since the AH power has been increased, the following components/subsystems have to be revised:

- *ratings and number of the AH feeders;*
- *reactive power compensation system;*
- *harmonic filtering system.*

AC/DC convertors

The JCT will analyze the final reports prepared by EU and RF Home Teams on the Design Task D49; then the various alternatives will be considered. The reference solution is based on a 2 kV, 43 kA, 12 pulse unit, with back-to-back thyristors. Each arm has several thyristors connected in parallel: the assumptions on the current sharing should be verified on a model.

The participants of the 2nd Power Supply Technical meeting share the impression that both the EU and RF designs will be feasible by the time the ITER Call For Tenders will be issued. Alternatives with different voltages and currents are proposed and will be assessed and compared. The best compromise will be used as basis for the Interim Design Report. R&D may be required to identify the solution that makes the best use of the largest available thyristors in small number, therefore, with small volume and low cost.

Switching networks and discharge circuits

A new scheme will be proposed for the central solenoid with a single 172 kA branch. A full 172 kA pyro-breaker could be used as a back-up device, if R&D on steady-state current capability is successful.

Proposals are made to modify the TF circuit to include the slow discharge circuit in the actual fast discharge scheme. The scheme, considered up to now by the JCT, will be maintained for the Interim Report.

The resistors are not a real technical problem. Industrial solutions can be found. The resistors for the discharge circuit can use natural air cooling. Indoor or outdoor alternatives will be compared. The cooling system of the DC circuit breakers and make switches must be redundant. Otherwise, in case of loss of the cooling system, the fast discharge must be initiated causing a plasma disruption. Due to the fact that the multiaction switches are based on multistage switches and commutation capacitor banks, the reliability of such systems has to be carefully investigated for both 60 kA and 172 kA switches.

R&D REQUIREMENTS

The R&D is required to define reliable technical solutions for:

- *Current Commutation Unit for multiple operation;*
- *Explosively Actuated Circuit Breakers for coil protection;*
- *Make Switches.*

The Current Commutation Unit for multiple operation will be used both in the switching networks for breakdown and plasma initiation and in the discharge circuits for protection of the superconducting coils in case of quench.

The current commutation unit is made up of a mechanical by-pass switch that normally carries the steady-state current (60 kA) and is able to open it and to transfer to a parallel circuit breaker; it is also able to close and to shortcircuit resistors. The circuit breaker is able to carry the current for a short time only. With the help of a counter pulse circuit the current can be interrupted and transferred to a resistor.

The counter pulse circuit is made up of a capacitor bank, of a saturable inductor and of a make switch to discharge the capacitor. In this way an artificial zero of current is produced in the circuit breaker. The main component for which R&D is required is the mechanical bypass switch, even if limited R&D is necessary also for the circuit breaker.

The Explosively Actuated Circuit Breaker for coil protection is present for back-up protection and should be triggered only if the related circuit breaker that appears in series fails to interrupt.

The Make Switches will progressively shortcircuit the resistors used to extract energy at current initiation and will be used as crowbars for protection.

The Russian colleagues organized the meeting very well; staff was available for long hours and also on Saturday. Vladimir Kuchinski, Head of the RF Delegation, deserves to be commended.

Last, but not least, the opportunity offered to us to attend the performance of the Swan Lake Ballet has to be mentioned. It was the 100-year anniversary of the first performance in the same theater. It was excellent and all of us present will not forget it.

LIST OF PARTICIPANTS

EU: E. Bertolini, P. Bordignon, J. Bottereau, A. Coletti, D. Hrabal, M. Huart, A. Maschio, S.M. Tenconi
JA: Y. Matsuzaki, H. Sasao, M. Tsuneoka
RF: S. Bulgakov, N. Daniel, V. Kuchinski, N. Mikhailov, S. Smolovik
US: A. Nerem, C. Neumeyer
JCT: C. Ahlfeld, B. Bareyt, I. Benfatto, P.-L. Mondino, A. Roshal

AVAILABILITY AND CURRENT STATUS OF FENDL-1 NUCLEAR DATA LIBRARIES FOR FUSION APPLICATIONS

by S. Ganesan*), A.B. Pashchenko, H. Wienke, IAEA Nuclear Data Section, Vienna, Austria

Introduction

The IAEA Nuclear Data Section, in co-operation with several national nuclear data centres and research groups. has created the first version of an internationally available Fusion Evaluated Nuclear Data Library (FENDL-1).
The FENDL library has been selected to serve as a comprehensive source of processed and tested nuclear data tailored to the requirements of the Engineering Design Activity (EDA) of the ITER Project and other fusion-related development projects. At the ITER neutronics co-ordination meeting in San Diego, USA, in February 1995, the ITER participants agreed to use FENDL in all design calculations.

Content

The present version of FENDL consists of the following sublibraries for which the documentation and the FTP subdirectory for on-line service are given below.

1. FENDL/A-1.1 (April 1993): neutron activation cross-sections, selected from different available sources, for 636 nuclides, given in four representations:

   - FENDL/A: "point data", i.e. cross-sections as function of energy in ENF-6 format (see IAEA-NDS-148, Rev. 2, Feb. 1995).
     FTP subdirectory: ACTIVATION.FENDLA

   - "MCNP": data processed into continuous energy format for input to the Monte-Carlo neutron/photon transport code MCNP (see IAEA-NDS-168, Rev. 2, Feb. 1995).
     FTP subdirectory: ACTIVATION.PROCESSED.MCNP

   - "VITJ-E": VITAMIN-J 175 group data (ASCII) processed for input to the REAC* 2/3 transmutation code using the VITAMIN-E weighting spectrum (see IAEA-NDS-168, Rev. 2, Feb. 1995).
     FTP subdirectory: ACTIVATION.PROCESSED.VITJ_E

   - "VITJ-FLAT": VITAMIN-J 175 group data (ASCII), processed with a flat weighting spectrum using the GROUPIE pre-processing code (see IAEA-NDS-148, Rev. 2, Feb. 1995).
     FTP subdirectory: ACTIVATION.PROCESSED.VITJ_FLAT

2. FENDL/D-1.0 (Jan. 1992): nuclear decay data for 2900 nuclides in ENDF-6 format, extracted from ENDF/B-6 and ENSDF (see IAEA-NDS-167, Jan. 1995). FTP subdirectory: DECAY.FENDLD

3. FENDL/DS-1.0 (Oct. 1993): neutron activation data for dosimetry by foil activation. This is identical with file 1 (neutron activation cross-sections) of the International Dosimetry File IRDF-90 version 2 of Oct. 1993 (see IAEA-NDS-141, Rev. 2, Oct. 1993), given as multigroup data in 640 group extended SAND-2 format, without covariance data. FTP subdirectory: DOSIMETRY.FENDLDS

4. FENDL/C-1.0 (Nov. 1991): data for the fusion reactions D(d,n), D(d,p), T(d,n), T(t,2n), He-3(d,p) extracted from ENDF/B-6 and processed (see IAEA-NDS-166, Jan. 1995). FTP subdirectories: FUSION.FENDLC an FUSION.PROCESSED.

5. FENDL/E-1.0 (Nov. 1994): data for coupled neutron-photon transport calculations, including
   - a data library for neutron interaction and photon production for 63 elements or isotopes, selected from ENDF/B-6, JENDL-3, or BROND-2 (see IAEA-NDS-128, Rev. 1, Feb. 1995)
   - a photon-atom interaction data library for 34 elements taken from ENDF/B-6 (see IAEA-NDS-58, Rev. 2, Sept. 1990)

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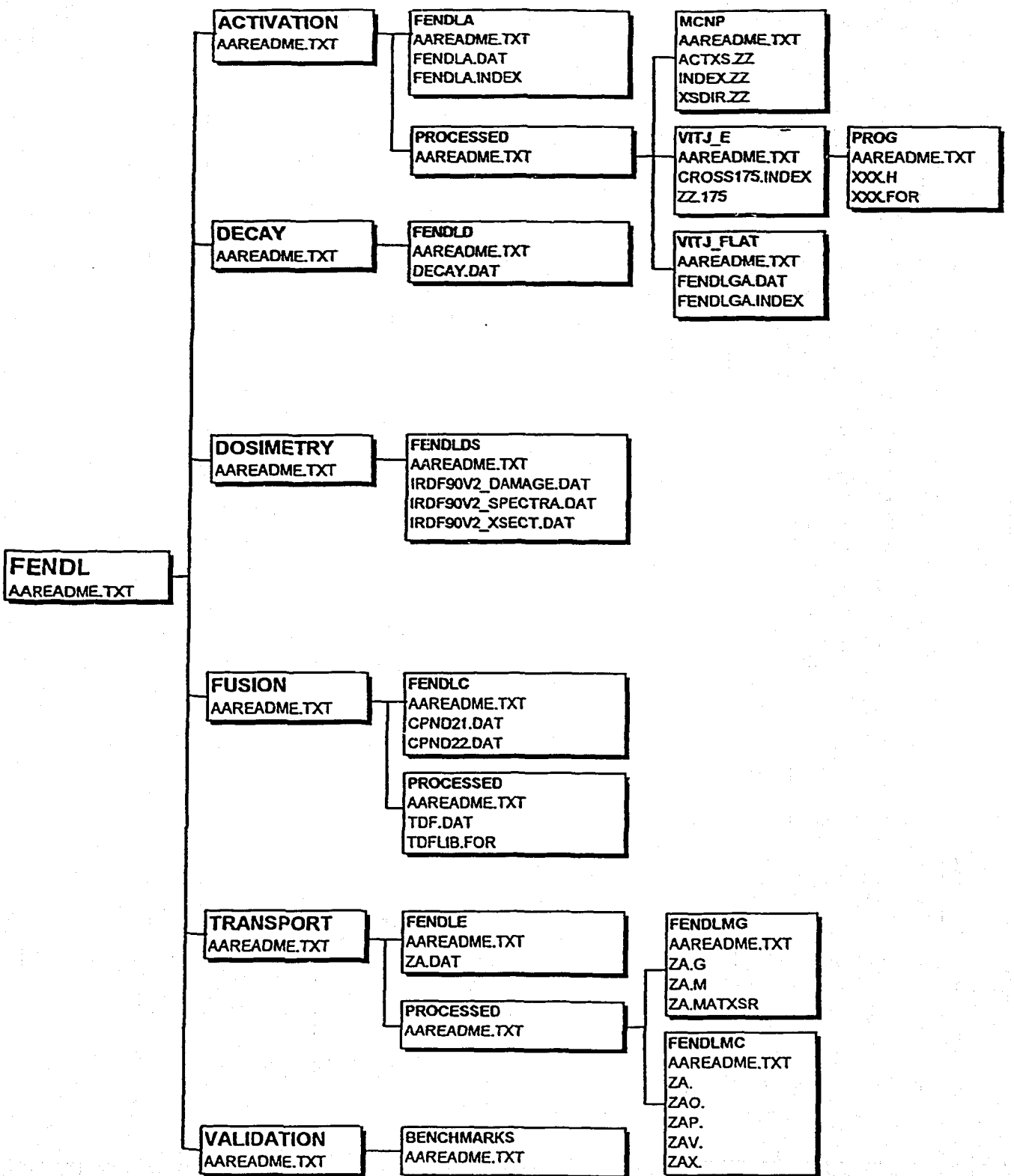
*) Present address: Bhabha Atomic Research Centre, Trombay, Bombay, India

FENDL-1.0 Directory Tree for FTP Transfer



These are available in three representations:

- original ENDF-6 format, as above, with resonance-parameters where applicable.
  FTP subdirectory: TRANSPORT.FENDLE
- "FENDL/MG" (Nov. 1994): data processed by NJOY into multigroup data in GENDF and MATXSR format (see IAEA-NDS-129, Rev. 3, Feb. 19[illegible]).
  FTP subdirectory: TRANSPORT.PROCESSED.FENDLMG
- "FENDL/MC" (Nov. 1994): data processed into the ACE format needed for input to the Monte-Carlo code MCNP4A (see IAEA-NDS-169, Rev. 2, March 1995).
  FTP subdirectory: TRANSPORT.PROCESSED.FENDLMC

FENDL Benchmarks

The task of validation of the FENDL-1 as required by the customer, i.e. the ITER team, is considered to be a task of high priority in the coming months. The FENDL/VALIDATION/BENCHMARKS subdirectory contains compiled fusion benchmark descriptions and data, provided by the international community of benchmark specialists, for validation of the above-mentioned FENDL working nuclear data libraries.

The well tested and validated nuclear data libraries in processed form of the FENDL-2 are expected to be ready by mid-1996 for use by the ITER team in the final phase of ITER EDA after extensive benchmarking and integral validation studies in the 1995-1996 period.

INTERNET/FTP Online Access to FENDL Files

The FENDL data files can be electronically transferred to users from the IAEA Nuclear Data Section online system through INTERNET. In the Nuclear Data Section open are 'FENDL', a subdirectory was created for each sublibrary. The FENDL directory tree and subdirectory names are given above. The file transfer via INTERNET (UNIX system) can be performed by 'ftp' command to the address 'iaeand.iaea.or.at' or '161.5.2.2'. The user should log on to the foreign user name 'FENDL'. No password is required. After having logged on, the user can set the definition to any required subdirectory and transfer files as desired. A grand total of 47 (sub)directories with 810 files with total size of nearly 2 million blocks or about 1 Gigabyte (1 block = 512 bytes) of numerical data is currently available on-line.

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kouvchinnikov, ITER Office, IAEA, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: 43 1 237762 (phone 2360 6392).

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