CEFDA03-1069
CEFDA03-1082
CEFDA04-1161
TW4-TES-COLABA

Task Title: EUROPEAN ITER SITE STUDIES (EISS)
TW3-TES-EISSg1: EISS 3 generic tasks CEA
TW3-TES-EISS2c: EISS 3 stage 2
TW3-TES-EISS4F: European ITER site study 4 - Cadarache
TW4-TES-COLABA: Cadarache site for ITER - Collaboration with Local Authorities

INTRODUCTION

EISS activities have their own steering process with regular meetings and exchange of information with EFDA and the Commission. The EISS4 contract covers the period from 1st January 2004 to 31st March 2005. A main deliverable will be issued end of March 2005 (ref. GA41-DEL-2004-0006). This document will refer to 36 specific deliverables covering all the topics of the EISS4 contract. The reader who would wish extensive information is requested to ask for these documents.

The following pages are given for reminder and are covering only the main aspects of the contracts.

After the choice of Cadarache as the European site for ITER in November 2003, the subsequent choice of the definitive site between Europe and Japan was expected in 2004. The EISS project (and its corresponding tasks) is, as for previous years, structured to progress on all items on the critical path, with an emphasis on the licensing schedule.

2004 ACTIVITIES

SAFETY & LICENSING

The first version of the main technical document in support of the Safety Authority's instruction, the "Rapport Préliminaire de Sûreté" is almost completed. Nevertheless, a strong enhancement will be necessary once the generic design will be adapted to the specificities of Cadarache. The writing of this document is supported by many studies, performed at European level in parallel. The R&D needs to complete the writing of the RPrS have been identified. The sketch below (figure 1) illustrates the process that was used all along these safety studies.

The first preliminary studies, based on the whole European know-how, enabled the writing and successful instruction process of "Dossier d'Options de Sûreté" by the Safety Authority. More detailed studies were then performed in order to support the first compulsory document, called "Preliminary Safety Report", made of two volumes: a description of the installation and then its safety analysis. A synthesis will be made that could be used in support of the public enquiry.

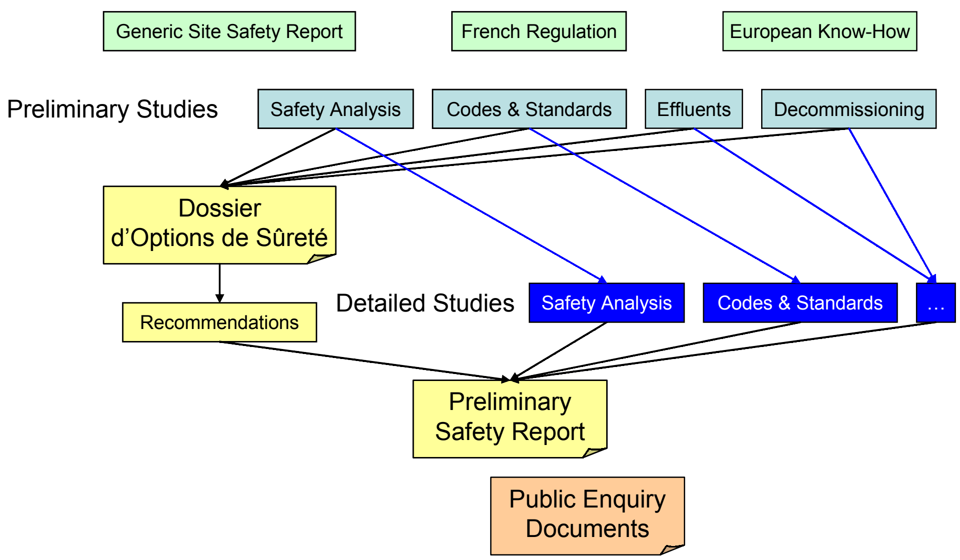

Figure 1 : Process used for safety studies

Here are several examples of studies performed to support this document writing.

The chemical risks including beryllium and chemical zoning aspects have been studied. The fire risk in the nuclear buildings and in particular the tritium building has been evaluated using general descriptions, regulations, fire loads and simulations. Plant states have been defined according to normal operation and incidental and accidental scenarios. Management of waste and casks for mixed waste has been defined. A study to verify the mechanical strength of the ITER tokamak during dismantling has been undertaken. A report on the draft radioprotection zoning was supplied. Work experience in a tritium plant was described.

Management of tritiated waste has been investigated. The activation calculations used by ITER have been evaluated. The handling of mixed waste packages to foreseen depositories has been studied. A specification for the DARPE writing has been provided. And the tritium inventory in the ITER vacuum vessel has been further studied.

PUBLIC DEBATE

The relevant authorities, the “Commission Particulière du Débat Public” (CPDP) put in place in 2003 to organise the public debate on “ITER en Provence”, has been frozen until a decision on the site choice is taken.

Before this decision, at the request of the president of the CPDP, a contract had been established with the office “IDES consultant” to assure the secretary general of the Public Debate.

An interim issue of the file of the Public Debate has been sent to the Commission Nationale du Débat Public in July 2004. A call for tender has been launched for the realisation of the layout and the printing of 5000 copies of the final file. The first part of this contract has been realized, composed of the graphic chart, the iconography and the layout, as shown hereafter (figure 2).

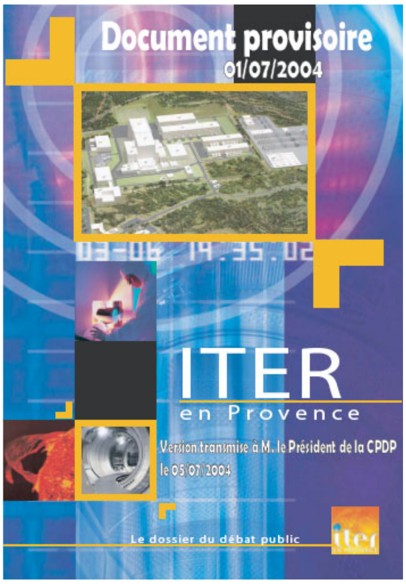

Figure 2 : File of the public debate

Different media have been also prepared for the Public Debate. A multimedia interactive terminal has been purchased to been used on exhibitions and during the Public Debate.

A movie called “ITER, une étoile en Terre de Provence” has been realised, at the intention of the general public (figure 3). A first version of this movie is finished and has been used at several occasions. a few modifications will been asked to the producer. This movie will be showed during the Public Debate and will be distributed on a DVD media.

The movie has been financed by conventions signed with the local authorities and completed by EFDA within the TWA-TES-COLABA task.

Figure 3 : Picture, extracted from the film “ITER, une étoile en Terre de Provence”

IN-FENCE STUDIES

The technical specification for the “First office building” is ready. The call for tender and the implementation could be launched as soon as the site decision is taken. This building will have around 100 offices, several meeting rooms and will host the ITER team before the construction of the main office buildings and other annex buildings (restaurant, public relation centre, medical building, etc.).

The site drawings have been updated, taking into account the ITER team design evolution. A survey of the hydrogeology is performed, with a synthesis report every year (figure 4). This survey will be used to design the draining system.

A 1/500th model of ITER site has been realised for public relation purposes.

TRANSPORT OF THE HEAVY AND LARGE COMPONENTS

The studies concerning the transport of the ITER components have been continued in the goal to transmit the files to the “Direction Départementale de l’Équipement” (DDE) in charge of the realisation of the work on the roads. These studies have also been financed by the local authorities completed by EFDA within the TWA-TES-COLABA task.

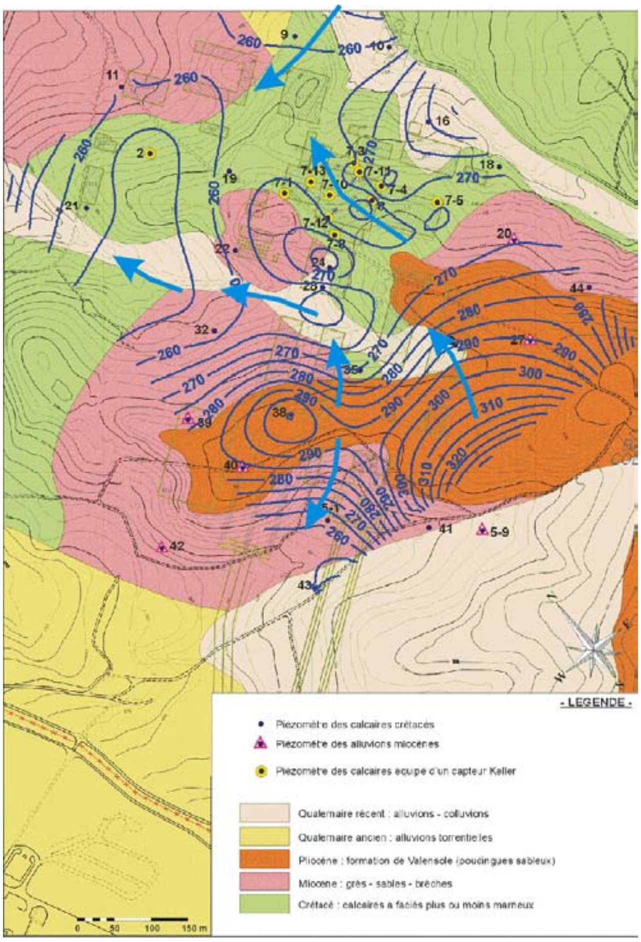

Figure 4 : Hydrologic map recorded in August 2004, by means of the piezometers installed on the site

They concern the ecological survey, characterization of the bridges all along the itinerary, technical studies on unloading quay, feasibility study on a dragging operation, and the detailed profiles of the roads.

Initial state of the environment: following a call for tender with 7 societies, a contract has been established with "Sémaphores" to realise an initial state of the environment on the transport itinerary. The main results of this study take into account the details of the zones requiring some laying-out or creation of trails. An ecological inventory on the natural environment has been made on the four consecutive seasons. This inventory is completed by an inventory on different items like water, housing, patrimony, etc.

Characterization of the bridges: Following a call for tender with 10 companies, a contract with GETEC grouping has been established for this study.

The main items were to analyse the bridges with more of five meters range, to study the effects of the passing by of the ITER loads, and to suggest some solutions for those are not well proportioned.

Technical studies on unloading quay: Five societies have been consulted before to choose INGEROP to realise this study. The main items are to proportion the future quay after geotechnical campaigns, to move 7 pipes of the SHELL facilities, and to lay out the road on the beach.

Feasibility study of a dragging operation: Realised by SAFEGE CETIIS after a call for tender, the objectives of are to list the legal aspects of the operation forecasted, to inventory the initial state, to analyse the sediments to drag and to describe the operation with the destination of the sediments dragged.

Detailed profiles of the roads: The SETEC Company has been chosen after a call for tender to realise this study. The drawing of 77 plans at 1/2000 scale, the study of two examples (a gyratory crossroads and a T crossroads crossing) have been realised with calculation and 3D visualisation of the crossing (figure 5).

Figure 5 : Crane beam transport crossing a roundabout

REPORTS AND PUBLICATIONS

EISS3 stage 1+2 report delivered in June 2004
EISS2 final report delivered in March 2004
EISS4 interim report delivered in January 2005
EISS4 final report to be delivered in March 2005

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CEFDA03-1083

Task Title: TW3-TEP-CRYO2: DESIGN OF ITER CRYOPLANT/CRYO-DISTRIBUTION SYSTEM (AUXILLIARY COLDBOXES, CRYOLINE, …)

INTRODUCTION

The role of the European Participant working group was to provide technical analysis and design study on the ITER cryogenic system.

Both were based on CEA and CERN available experiences, respectively design and operation of the TORE SUPRA tokamak and large scale cryoplants and cryolines for the LEP and LHC particle accelerators. Each of these installations is supplied by European firms (AIR LIQUIDE or LINDE).

Due to this relevant experience and following previous CEA works for the ITER cryogenic system (see references [1], [2], [3], [4], [5]), ITER International Team (IT) has requested support from European Participants to get technical design for the ITER cryo-distribution and cryoplant system.

The main objective of this task (EFDA 03-1083) is to provide input information for establishing the final dimension details of the main tokamak complex and cryoplant buildings, which are time-critical for ITER construction.

The task was broken down as follows (*see 2004 Activities and Reports*).

- Establishing the overall PFD and then detailed PIDs of the ITER cryo-distribution system
- Development of the conceptual design of a typical Auxiliary Cold Box (ACB) for the ITER magnet system (TF coils).
- Updating the conceptual design of the Torus Cryopump Cold Valve Boxes (CVBs) taking into account the 470 K regeneration requirements.

2004 ACTIVITIES

This task was the first common ITER cryogenic study of the so called “CEA cryogenic working group for ITER” composed by cryogenic experts from le Service des Basses Températures (SBT) at CEA-Grenoble (France), le Service des Accélérateurs, de Cryogénie et de Magnétisme (SACM), le Service d’Ingéniérie des Systèmes (SIS) at CEA-Saclay (France) and le Service Tokamak Exploitation et Pilotage (STEP) at CEA-Cadarache.

The work of this task was performed with an alternation of working periods and progress - review meetings (six at Grenoble and some others at Garching and Karlsruhe) between CEA cryogenic working group and ITER-IT Cryogenic Group, located in Naka (Japan) and followed by the EFDA/CSU responsible officer from Garching (Germany). The main activities performed in 2004 in the framework of the task EFDA 03-1083 are summarized hereafter.

GENERATION OF PFD/PID FOR ITER CRYO-DISTRIBUTION SYSTEM

The ITER cryogenic distribution is composed of 56 cold boxes (25 under responsibility of cryogenic team / 29 under responsibility of magnet division / 2 under responsibility of 80 K thermal shield team), about 20 cryolines and around 20 warm lines which have to be installed and interconnected at different levels of the tokamak building. To establish PFD/PID, CEA has proposed symbol legend and tag numbering for all components based on ISO standards and its own experiences. The overall PFD and detailed PIDs are now defined (reports [1], [2]) and approved by ITER for all cryo-distribution system with standardization of components (valves, pumps, heaters, ..), instrumentations (temperature, pressure, flow, …) and functions (helium guard, vacuum group, purge/filling, exchange of circulating pumps, …). Each diagram is associated with a list of components detailing their position, function and characteristics. The total number of components is 4500 for all cryo-distribution system including 50 % of active components (cryogenic valves, sensors, heaters, pumps,…) and 50 % of passive components (hand valves, pressure relief valves, heat exchangers, …).

In the present task, CEA has confirmed or introduced the following PID specificities to ensure the highest reliable operation of the ITER cryogenic system:

- The helium guard system for any sub-atmospheric operation for magnets ($T < 4.3$ K), is a simple system confirmed by tens years of operation at CEA (TORE SUPRA) or at CERN (LHC) and requiring minimum additional costs.
- Each cold box has its own vacuum enclosure separated from cryolines by vacuum barriers. A standalone vacuum group is attached to each cold box of the cryo-distribution system to allow pumping of the vacuum enclosure independently of the ITER Service Vacuum System.

- A purge/filling system is also installed on each cold box for individual conditioning with pure helium before cool-down or after local reparation.

- All cryogenic circuits or vacuum enclosures are protected by pressure safety valves with setting pressure equal to 0.15 MPa for vacuum enclosure and around 2.0 MPa for all cryogenic circuits including the LHe bath. This large value (20 bar) for internal circuits is foreseen to reduce the sizing of the relief valves, to lower the number of relief valve opening and to store the maximum of helium inside the cryogenic circuits. All pressure safety valves for one cold box are collected in a recovery header.

DESIGN OF TYPICAL AUXILIARY COLD BOX (ACB) FOR TF COILS

Conceptual designs for TF-ACB answer to ITER requirements and are based on classical and proven technology. The ACB report as well as the attached CATIA drawing files (report [3]) summarise the conceptual design and the assembling procedure proposed for TF-ACB as well as industrial validations of the key components.

The key components of this cold box are the large circulating pump for supercritical helium (3 kg/s at 5 K – 5 bar), the immersed heat exchanger between supercritical helium (5 K – 5 bar) and liquid helium (4.2 K – 0.99 bar) to remove heat loads deposited in magnets, the electrical heater to simulate the TF coil heat loads and a set of safety isolation valves to reduce the amount of cold helium release in the tokamak cryostat in case of helium piping leaks.

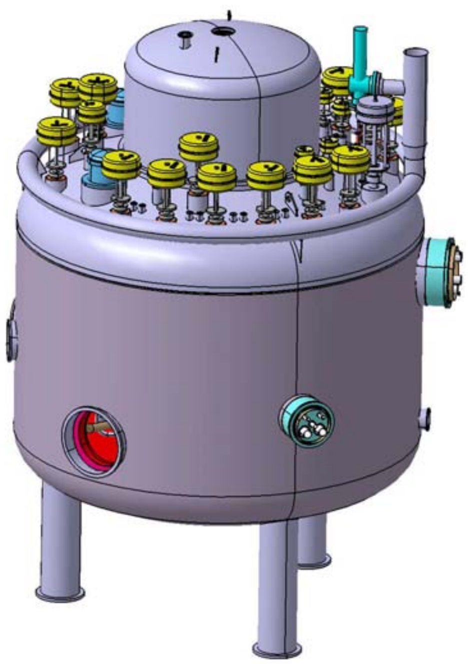

Figure 1 : TF-ACB (4.2 m in diameter)

Specific helium guard system is recommended for all components operating below atmospheric system as detailed in PID study. In addition to these specific components, TF-ACB within a stainless steel vacuum enclosure of about 4.2 mm in diameter and 6.5 m in height for a total weight of 24 tons, contains several internal stainless steel piping with tube bend design (avoiding the use of bellows), one 80 K thermal shield, MLI (multi layer insulation) and a dedicated number of cryogenic valves, pressure safety valves and instrumentation to control the supercritical helium cooling flow for the TF coils.

The thermo-mechanical calculations have given the corresponding heat loads and have validated the mechanical design mainly based on the CODAP French code.

The pressure drop (direct impact on circulating pump power) and heat load calculations have indicated larger values than expected and should be integrated in the future global review of the cryogenic system.

The pressure drops could possibly be reduced through an increase of the piping diameter, however the heat loads (mainly coming from cryogenic valves) will be more difficult to reduce.

DESIGN OF TYPICAL COLD VALVE BOX (CVB) FOR TORUS CRYOPUMPS

As for TF-ACB studies, conceptual designs for CVBs fulfil present ITER requirements and are based on classical and proven technology. The CVB report as well as the attached CATIA drawing files (report [4]) summarise the conceptual design and the assembling procedure of the Torus Cryopump CVB as well as industrial validations of the key components.

In addition to the constraints associated with the magnetic field and radiation environment existing in the ITER Port Cell where is located the equipment, the CVB has to accept the cyclic regeneration required for the 4.5 K cryopanels at different temperature levels: 100 K, 300 K and seldom at 470 K.

This high temperature imposes the selection of special materials (joints) or components (sensors and insulation) to ensure reliable operation.

Each CVB within a stainless steel vacuum enclosure of about 1.5 m in diameter and 1.8 m in height for a total weight of 3 tons, contains several internal stainless steel piping with tube bend design (avoiding the use of bellows), one 80 K thermal shield, MLI (multi layer insulation) and a dedicated number of valves, pressure safety valves and instrumentation to control the helium cooling flow for the Torus Cryopumps as well as for the Pellet Injection System (PIS).

The thermo-mechanical calculations have given the corresponding heat loads and have validated the mechanical design mainly based on the CODAP French code.

Finally, even if the proposed CVB design fulfils the present requirements, special attention will be required in future for definition and position of standalone vacuum group and recovery header for pressure safety valves, heat flux assessment in cryopumps and PIS interfaces.

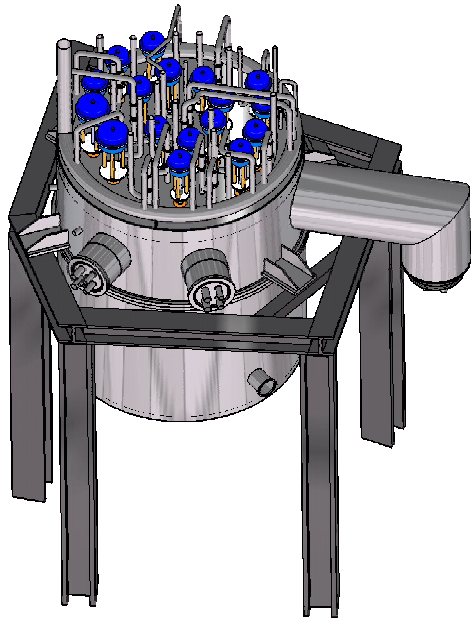

Figure 2 : Torus cryopump CVB (1.5 m in diameter)

CONCLUSIONS

The proposed overall PFD and detailed PIDs (associated with component lists) for all ITER cryo-distribution system have defined all components and instrumentation required to insure reliable control of the cooling loops for the magnets, cryopumps and 80 K thermal shields. ITER has now adopted a helium guard system to protect all sub-atmospheric circuits based on solutions adopted and validated for years at CEA for TORE SUPRA and at CERN for LHC.

The proposed conceptual design for ACB and CVB is a typical design and dimensions should be adapted to the latest ITER requirements for the 4.5 K SHe cooling loops. For all proposed design of cold boxes, CEA recommends avoiding the use of bellows (risk of leaks) and consequently only U-bend or L-bend shapes are defined for the internal piping.

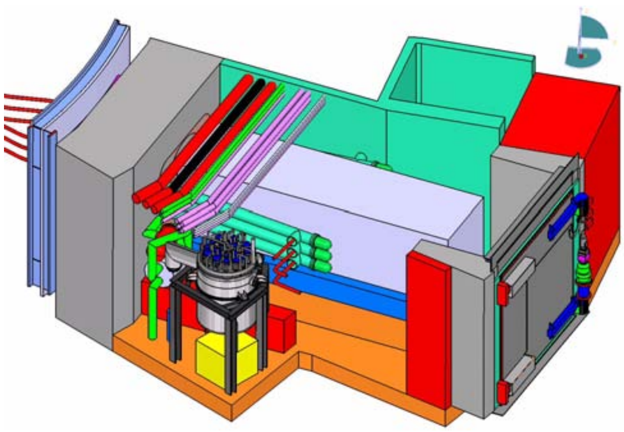

Figure 3 : CVB for Torus Cryopump and PIS installed in one ITER Port Cell

The severe requirements (building constraints / magnetic field / radiation / 470K regeneration for cryopumps) require compact design for ACB and CVB and impose specific selection of components and sensors. One can note that such compact design is risky for any maintenance or reparation during the lifetime of ITER. Furthermore, validations (requiring sometimes specific developments) of cryogenic key components are recommended before the procurement phase to ensure the reliable installation-control-maintenance of the cryogenic system in the tokamak building.

Both ACB and CVB studies were developed with CATIA V5 at CEA and successful exchanges of CATIA files with ITER/Garching were performed in December 2004 opening better integration of CEA works in ITER drawing database and also better understanding of ITER constraints by CEA designers.

Additional works on the ITER cryoplant and cryo-distribution system have to be performed in the coming years to assess the ITER cryogenic system according recent updated requirements such as HTS current leads for magnets and to detail some critical parts of the cryogenic system and associated building layouts. In complement to these design studies, some component and instrumentation qualification campaigns have also to be planned to define potential components and instrumentation for the ITER cryogenic system and also magnet and thermal shield cryogenic loops.

REFERENCES

[1] Design Description Document DDD 3.4 : Cryoplant and Cryodistribution System - N 34 DDD 8 R0.2, Vladimir KALININ, 2004.

[2] Design of ITER-FEAT cryoplant to achieve stable operation over a wide range of experimental parameters and operation scenarios - Proceedings of 21th Symposium on Fusion Technology (SOFT-21) - Madrid (Spain), Vladimir KALININ et al, 2000.

[3] Design and Performance analysis of the ITER cryoplant and cryodistribution - Proceedings of 19th International Cryogenic Engineering Conference (ICEC-19) - Grenoble (France), François MILLET et al, 2002.

[4] Design and operating features of ITER cryoplant, Proceedings of 2003 Cryogenic Engineering Conference (CEC-03) - Anchorage (USA), François MILLET et al, 2003.

[5] Cryogenic subsystem to provide for nominal operation and fast regeneration of the ITER primary cryo-sorption vacuum pumps - Proceedings of 2003 Cryogenic Engineering Conference (CEC-03), Anchorage (USA), Vladimir KALININ et al., 2003.

REPORTS AND PUBLICATIONS

[1] CEA Study for Process Flow Diagram (PFD) and Piping Instrumentation Diagram (PID) for the ITER cryo-distribution system (including AUTOCAD drawings and component lists) - Note SBT/04-244/FM, François Millet, November 2004.

[2] Description of the PFD for the ITER cryo-distribution system - Note SBT/04-58 rev 2/FM, François Millet, November 2004.

[3] Conceptual Design for Auxiliary Cold Box for Toroidal Magnets (including CATIA drawings) - Technical Report DAPNIA-SACM - Philippe Chesny, March 2005.

[4] Conceptual Design for Cold Valve Box for Torus Cryopumps and Pellet Injection System (including CATIA drawings) - Note SBT/CT/05-01 - François Millet and Yoann Machizaud - March 2005.

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