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Framework of the
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Industrial Studies

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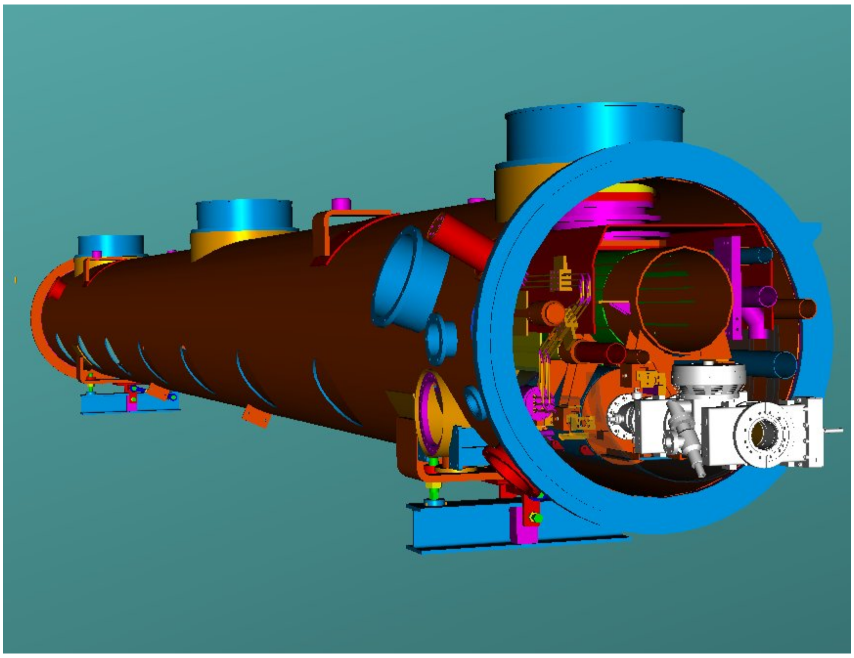


Content :

9. PRESENTATION OF TENDERS (TECHNICAL PART)

9.1 General description of the CONTRACTOR's industrial activities
9.2 Description of the CONTRACTOR's industrial capacities and experiences
9.3 Description of the CONTRACTOR's personnel capacities
9.4 Description of the CONTRACTOR's quality management
9.5 Costs of the IS
9.6 Confirmation of industrial safety rules

10. ATTACHMENTS

A.1 Main design features of the cryomodules
A.2 Assembly schedules of cryomodules at DESY
A.3 Design and assembly goals
A.4 Clean room assembly
A.5 Cryomodule assembly outside clean room
A.6 Assembly of main couplers
A.7 DESY safety rules for visitors and CONTRACTORs

1. SCOPE OF THE INDUSTRIAL STUDIES :

1.1 Motivation

In order to reach the X-ray region (0.1 nm) by means of a Free Electron Laser the European **X**-ray **F**ree **E**lectron **L**aser (X-FEL)-Project is presently under development at DESY .

A new superconducting linear accelerator will supply a pulsed 20-GeV electron beam for the operation of the FEL. The TESLA technology will be used for the linear accelerator.

The X-FEL linear accelerator will consist of about 1000 superconducting niobium 1.3-GHz 9-cell cavities, which will be cooled in a liquid-helium bath at a temperature of 2-K. Always eight cavities, one superconducting magnet package and a beam position monitor will be assembled in cryomodules of about 12.2-m length. The 2-K cryostat will be protected against thermal radiation by two thermal shields cooled to 5-8 Kand 40-80-K respectively. A simplified cross-section of a cryomodule is shown in Fig. 1.

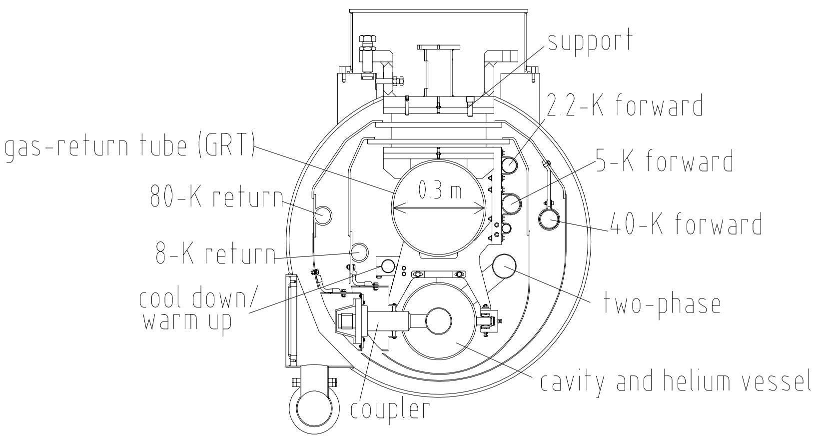


Figure 1: Simplified cross-section of an X-FEL-cryomodule.

To prepare for the construction of the European X-FEL and other superconducting linac-based light sources like the BESSY-FEL[1], the existing cryomodule design and assembly procedures have to be reviewed. The aim is to prepare for series production, as well as to reduce the effort and cost and to increase the performance and reliability.

This review shall be part of the EUROFEL design study work package DS6 ‘Cryomodule Technology Transfer.’ This motivation is further underscored by the fact that superconducting technology has been recommended for the future International Linear Collider (ILC). Currently, the TESLA technology represents the most developed superconducting system applicable to this project. For the ILC more than about 2000 cryomodules will be manufactured.

[1] BESSY- Berliner Elektronenspeichering-Gesellschaft für Synchrotronstrahlung m.b.H.

It is expected that the procurement of about 120 cryomodules, which will be needed for the European X-FEL project, will start at the end of the year 2006. Until this date the design of the cryomodules has to be finalized and the assembly procedures have to be defined. The experience gained during the construction of other large accelerator projects like HERA at DESY or LHC at CERN has shown that industry should be involved in the design and assembly procedures as early as possible in order to adapt the production of components like cryostats to series production in a most efficient way.

1.2 Scope

By means of the present specification and call for tender, qualified (see section 2) companies (called hereafter: CONTRACTOR) are invited to perform these Industrial Studies (called hereafter: IS) for the X-FEL cryomodule design and assembly.

The Deutsches Elektronen Synchrotron (DESY) takes the action for the call for tender and contracting of the IS on behalf of the TESLA-collaboration, the X-FEL project, the EUROFEL design study and the Berliner Elektronenspeichering-Gesellschaft für Synchrotronstrahlung m.b.H. (BESSY) and is called hereafter CUSTOMER.

With respect to the present state of the European X-FEL project, which is now in a preparatory phase, the industrial cryomodule assembly studies are separated from the final procurement procedures for the cryomodules. Both the procurement of the industrial studies as well as the final procurement of the X-FEL cryomodules will be open to qualified industry. The participation in the industrial studies shall not determine the final cryomodule procurement in any way. This means that the participation in the industrial studies is not a necessary condition for the participation in the final procurement procedure of the cryomodules. At the same time, the participation in the industrial studies will not exclude the participation in the final cryomodule procurement.

Industrial studies concerning the preparation of superconducting RF cavities and production of cryomodules have already been prepared for the TESLA design report some time ago. For these industrial studies the related production procedures were defined by DESY and were used as a fixed input for the studies. The studies were confidential.

In contrast to the previous studies, the present cryomodule assembly procedures and some aspects of the present design shall now be analyzed and questioned with respect to the most cost effective serial production.

The key aspects of the study are as follows:

1.2.1 Define the assembly procedure
1.2.1 Analyze cost-reduction and production efficiency measures
1.2.3 Analyze performance improvement measures
1.2.4 Supply a cost estimate for the module production

A substantial part of the IS shall be the presence of CONTRACTOR’s experts during the assembly of two prototype cryomodules at DESY.

The results of the industrial studies will be published and will be available to industry. In particular, the industrial studies will be submitted as a deliverable in the framework of the EUROFEL design study. Any estimation of final cryomodule production costs shall not be published.

The CUSTOMER expects more than one CONTRACTOR for the IS.

2. PREREQUISITES AND QUALIFICATIONS FOR THE PARTICIPATION IN THE CALL FOR TENDER FOR THE IS

To assure the successful completion of the IS, CONTRACTORS who wish to participate in the call for tender must have the following qualifications:

Proof as to the following Must Have criteria:

1) Experience of serial production of large Particle Accelerator Components.
2) Experience of design and construction of Cryogenic Components used at liquid helium temperatures.
3) The Know-How of industrial serial production at hand.

Proof as to the following Should Have criteria:

4) Experience of applied Clean-Room Technology (10-100 ASTM).
5) Experience of applied Ultra-High-Vacuum Techniques (oil- and particle free).
6) General experience in the application of extensive and particular Low Tolerance Quality Assurance Procedures in the required fields.

The requested qualifications have to be proven in the offer by appropriate references. In addition, the CONTRACTOR has to demonstrate that experts with sufficient qualifications are permanently employed and will be available for the entire period of the IS including the cryomodule assemblies at DESY.

A CONTRACTOR, who complies with this section 2, is considered as ‘qualified’ within the framework of this specification and the IS call for tender.

3. INTRODUCTION TO TESLA TECHNOLOGY

For about a decade, the TESLA collaboration has developed superconducting linear accelerator technology for the construction of a 500 GeV center-of-mass electron-positron collider. This technology is now recommended for the **I**nternational **L**inear **C**ollider in the one TeV region (ILC).

Main parts of the TESLA collaboration infrastructure are situated at the **T**ESLA **T**EST **F**ACILITY (TTF) at the DESY laboratory in Hamburg. The infrastructure includes a clean room and a chemical laboratory for the preparation of superconducting niobium 1.3-GHz RF-cavities, a low temperature test area for the RF-tests of single cavities, tools for the assembly of complete cryomodules and a 0.8-GeV test linear accelerator (the **VUV-FEL**-linac).

Early in the TTF project, it was demonstrated that the TESLA technology is well suited for the operation of an electron driver linac for FELs. As a consequence, the TTF-linac will be operated as a user facility of a FEL in the 6 – 30 nm optical wavelength region (VUV-FEL-linac). The development for the European X-FEL-project has been started in order to reach the X-ray region. In addition, the TESLA technology has been adopted by several other FEL-light-source-projects worldwide. In particular, the future BESSY-FEL project in Berlin is based on the TESLA technology. However, this will operate fully CW so that some design changes are required as outlined in Appendix A.1.4.

The generic TESLA cryomodule design has been optimized to operate high gradient 1.3 GHz 9-cell niobium cavities in a pulsed RF-mode at a duty cycle of up to 1%. In view of the realization of the TESLA linear collider project, this cryomodule design achieved low costs per unit length for very long accelerator structures, to be competitive with conventional normal-conducting linear collider approaches. A key aspect of the TESLA cryomodule design are very low static cryogenic losses and easy assembly procedures, suitable for the industrial production of large quantities. These design goals were reached by 12.2-m long cryomodules containing eight cavities each, and combining these into long (up to 2.5 km) cryogenic units comprising several cold sections ("cryogenic strings") of 12 cryomodules each. These design features are also favourable and applicable to the X-FEL-linac, which will have an active accelerator length of about 1.6 km.

At the TTF, three different types of prototype cryomodules have been assembled. Currently 5 modules of the second and third generation (Type II and Type III) are installed into the TTF-linac. First generation (Type I) modules are no longer in use.

The main features of the different cryomodule design steps are presented in the attachment A.1).

The generic term “TESLA module” refers to 5 different cryomodule designs which share similarities:

1. TTF type-I modules were the first generation and are no longer in use.
2. TTF type-II modules are similar to the first generation and three such modules are currently installed in the VUV-FEL.
3. TTF type-III modules had the supports of cavities changed (See A.1). Currently two such modules are installed in the VUV-FEL.

4. XFEL modules represent an optimized version of the TTF type-III design that is currently being developed for the XFEL.
5. BESSY-FEL modules represent an optimized version of the TTF type-III design that is currently being developed for the BESSY-FEL and CW applications in general.

The TTF type-III design will be used as the baseline for the X-FEL cryomodules. Therefore, the IS shall concentrate on the type III design and the X-FEL cryomodule design.

The main design and assembly goals for the XFEL-cryomodules are defined in attachment A.3).

At the TTF, single TESLA cavities now reach accelerating fields of more than 35 MV/m at unloaded quality factors in the order of Q= 10^{10}. The latest complete type-III cryomodule prototypes, which are now installed in the VUV-FEL-linac, have shown accelerating field gradients of more than 25 MV/m.

An accelerating gradient of 35 MV/m will be the goal of the next prototype cryomodule (module 6), to be built at DESY in 2005. The goal for the XFEL-cryomodules will be an accelerating gradient of 28 MV/m (see A.3).

4. ASSEMBLY SEQUENCES

The CONTRACTOR shall analyze the assembly procedures starting with the assembly of a cavity string inside the clean room and ending with the complete cryomodule ready for installation on a test stand or a linac. Simplified descriptions of the main assembly sequences are given in the attachments, in order to specify the framework for the offer of the CONTRACTOR. The descriptions in this section as well as the descriptions in the attachments reflect the present state-of-the-art of the cryomodule assembly procedures of the CUSTOMER and are incomplete.

For the IS it shall be assumed that the cavities and the related accessories like fundamental and higher order mode couplers as well as bellows units, gate valves, beam position monitor and the magnet package can be taken as tested, prepared and qualified for the cryomodule assembly. In particular, the cavities are already welded into their individual helium vessels, cleaned, processed and tested.

The cryomodule assembly is separated into two different steps in different environments: clean room assembly (see attachment A.4) and assembly outside the clean room (see attachment A.5). Part of the assembly outside of the clean room is the main-coupler assembly. This is described in attachment A.6.

All steps of the assembly procedures, in particular the assembly inside the clean room, can strongly affect the final performance of the cryomodule. The final accelerating gradients as well as the RF quality factors and the occurrence of dark currents are extremely sensitive to any contamination with particles caused during the assembly. Also the mounting of other equipment, like the tuners and main couplers, requires extreme care.

During the assembly of the next cryomodules, in particular in view of the X-FEL prototype cryomodules, it is to be expected that the procedures will be changed in a number of details by the CUSTOMER. These changes of the assembly procedures as well as design changes of the cryomodule by the CUSTOMER shall not have any effect on the IS contract. The CONTRACTOR shall include the in the offer the flexibility to accommodate these changes of design and assembly procedures during the IS contract by the CUSTOMER. Suggestions for changes of cryomodule design and assembly procedures by the CONTRACTOR are not binding for the CUSTOMER.

5. DELIVERABLES OF THE CONTRACTOR FOR THE IS

5.1 Scope of delivery

Within the IS contract in regard to this complete specification including the attachments the CONTRACTOR shall deliver one cryomodule assembly report for each cryomodule assembly. In addition, a final IS report as well as a separate report on the BESSY-FEL issues have to be delivered which discusses the required production changes and their impact on cost..

As part of these reports, general comments shall be given by the CONTRACTOR with respect to the final performance and costs of the cryomodules or an increase of efficiency or cost reduction in view of the serial production.

5.1.1 The first IS cryomodule assembly report shall be provided no more than 8 weeks after the assembly completion of cryomodule No. 6

5.1.2 The second IS cryomodule assembly report shall be provided no more than 8 weeks after the assembly completion of cryomodule No. 8

5.1.3. The final IS cryomodule assembly report

The report shall be delivered as specified at latest 12 weeks after the assembly of cryomodule 8 will have been finished. (The final report may be combined with the delivery of 5.1.2, if the report will be available in time).

Special issues as defined in section 5.2.2 (Consequences on cryomodule design) and 5.2.3 (Reports on special topics) should be covered as early as possible as attachments to the reports 5.1.1, 5.1.2 or 5.1.3. These attachments may be delivered also independently from the reports 5.1.1 or 5.1.2 but at latest at the delivery of 5.1.3.

5.1.4 A *separate* report on the BESSY-FEL design and assembly issues (5.2.3.4, A.1.4) has to be delivered as early as possible but no later than the delivery of 5.1.3.

5.1.5 Detailed cost issues shall be reported in special attachments separate from the technical reports. Separate documents will discuss the cost of the XFEL and BESSY-FEL modules. These attachments shall be marked as 'confidential' and will not be published by the CUSTOMER.

5.2 Contents of the IS reports

5.2.1 Contents of the assembly reports

The complete cryomodule assembly procedures with reference to section 4 and the related attachments must be reported in form of a protocol from the view point of the CONTRACTORS's experts. The report shall have a resolution of assembly steps, which shall at least correspond to the description in section 4 and the related attachments of this specification. Each single assembly step shall be commented by the CONTRACTOR with respect to the final performance of the cryomodules and the efficiency, costs and involved risks of a series production of about 120 cryomodules. If possible, suggestions for improvements and potential cost savings shall be given.
The CONTRACTOR shall deliver a production overview in the form of a MS Project Gantt Chart. This includes the individual steps and the required manpower.

5.2.2 Consequences for cryomodule design

If improvements of the final performance of the cryomodules or an increase of efficiency or cost reduction in view of the series production can be achieved by changes of the cryomodule design, a report of these design changes shall be given in the IS including the related design sketches.

5.2.3 Reports on special topics

Some special topics should be covered in the IS reports:

5.2.3.1 Transportation of cryomodules /safe-guard design

It is expected that the approximately 120 X-FEL cryomodules have to be transported by cranes and lorries across the manufacture's site, European roads, the DESY site and inside the X-FEL tunnel (by special transportation units). In addition, it can not be excluded that cryomodules have to be transported by air-plane.
The CONTRACTOR shall describe a safe guard design for the transportation of the cryomodules.

5.2.3.2 Assembly of modules with evacuated cavities

In contrast to the present procedure at TTF, it is anticipated that the cavity string will be evacuated after assembly in the clean room and all subsequent assembly steps will be done with the string under vacuum and the pressure monitored by a sputter ion pump.

The CONTRACTOR shall evaluate this change of the procedure and describe the necessary changes of components and the difference in the costs.
The evaluation shall include a risk analysis and shall take into account the effort for a repair, if a leak is detected during the subsequent assembly.

5.2.3.3 Effects of production rates
The procedures shall be optimized for a serial production of about 120 XFEL-identical cryomodules at a production rate of one cryomodule per week. The change of efforts and costs shall be analyzed for changes in the production rate in the range of 0.5 to 2.5 cryomodules per week.

5.2.3.4 BESSY-FEL cryomodule assembly
It shall be reported in a separate document, how the BESSY-FEL cryomodule design (see attachment A.1.4) will affect the assembly procedures and costs and the other issues, such as 5.2.3.1-5.2.3.3, discussed in the documents on the XFEL modules. (References to the documents for the XFEL modules are permitted.)

5.2.4 Contents of the final IS cryomodule assembly report
In the final IS cryomodule assembly report all suggestions for improvements of the assembly procedures and the design shall be summarized. The CONTRACTOR shall include an optimized detailed production overview for the assembly in the form of a MS Project Gantt Chart. The report shall cover a cost analysis, a risk analysis of all production steps und a description of the personnel requirements for the cryomodule assembly.

5.3. Format of the IS cryomodule assembly report
All IS reports and documents, including drawings, shall be written in English. 20 paper copies of the complete report shall be delivered to the CUSTOMER. In addition, the report shall be delivered as a Microsoft Word document file and a *.pdf file on CD. Any drawings shall be delivered as paper copies as well as in *.dxf-format files on CD. On request of the CUSTOMER, representatives of the CONTRACTOR shall present the report during project meetings.

5.4 IS Project Team
The CONTRACTOR shall form a **P**roject **T**eam (PT) at the latest four weeks after start of the contract, consisting of a team leader and of at least two additional experts. The personnel assigned to the tasks must have certified qualifications and relevent competences for the IS. For each of the PT-members a written ‘work-history’, including an experience and education summary, has to be supplied to the CUSTOMER. All members of the PT shall be able to communicate in the English or German language. In general, the PT has to cover all technical expertise described in this specification, in particular in the description of the assembly procedures in the attachments, in order to analyze the assembly procedures as specified for the IS. All members of the PT have to be approved by the CUSTOMER. The replacement of key personnel during the realization of the contract must be justified and approved by the CUSTOMER.
All PT-members shall be permanent employees of the CONTRACTOR.

The obligations of the CONTRACTOR’s PT-leader are project direction and control. The PT-leader must co-ordinate and control all project-specific activities and the corresponding resources and shall ensure realisation of the standards described in this technical specification and successful fulfilment of the contract.

A project management plan must be prepared for the execution of the project. This plan must define the obligations of the PT to the CONTRACTOR. The project management plan shall be submitted to the CUSTOMER at the latest two weeks before the start of the first assembly. It must include, but is not limited to, the following points:

5.4.1 Project management

The responsible project management must be documented by:

- Appointment by name of the PT-leader, specification of his duties and competences in addition to his integration in the organisational structure of the company. The project leader is the sole contact for all issues concerning the contract. If another person is responsible for business issues, then this person must also be named.
- Appointment by name and description of functions and competences of the other PT members.

Proper project organization must be documented by:

- Task structure (Work Breakdown Structure).
- Organisational structure (Organisational Breakdown Structure) of the project created for execution of the contract and the integration of this project in the company. Specification of the tasks defined in the Work Breakdown Structure. Allocation of the responsible personnel to specific tasks, description of special qualifications of the personnel, appointment of deputies for all responsible personnel.
- Definition of the essential elements of project control, such as periodic meetings of the project management, regular meetings with CUSTOMER and as well as periodic meetings with higher committees of the CONTRACTOR, etc.

5.4.2 Project meetings

The CONTRACTOR shall plan and prepare a series of project meetings, whereby the agenda and the participants are to be determined in co-ordination with the CUSTOMER. All meetings shall be take place at DESY, Hamburg or at BESSY,Berlin.

The following major meetings must be held:

- The “kick-off meeting” (KOM) after signing of the contract
- one meeting after the first cryomodule assembly, at latest four weeks after the assembly
- one meeting before the presentation of the first IS assembly report
- one meeting after the second cryomodule assembly, at latest four weeks after the assembly
- one meeting before the presentation of the second IS assembly report
- one meeting before the presentation of the final IS report

CUSTOMER and CONTRACTOR have the right to request special meetings as needed.

The CUSTOMER also has the right to invite other participants of his choice to the meetings. In this case, the CUSTOMER shall inform the CONTRACTOR of external participants.

Unless otherwise arranged, the CONTRACTOR must prepare and provide all minutes of the meetings to the CUSTOMER within five work days. The minutes must be signed by the negotiators of both parties. The signatures confirm only that the content of the minutes correctly represent the agenda of the meeting and the actions agreed upon.

5.5 Presence of CONTRACTOR's representaves during the assembly of cryomodules

At least two representatives of the IS project team of the CONTRACTOR, which have been named before in the project management plan, shall be sent to the assembly of cryomodules to DESY in Hamburg. These representatives shall be able to communicate in the English or German language. These experts have to stay permanently for the complete period of module assembly of 6 weeks or more for each assembly. The dates of the assemblies will be communicated to the CONTRACTOR by the CUSTOMER 2 weeks before the start of the assemblies at the latest.

The CONTRACTOR shall pay all related expenses for the CONTRACTOR's representatives, including travel, accommodation and transportation. Any shift in schedule, breaks or prolongation of the assembly shall not incur extra payments for the CUSTOMER, provided the events are related to technical reasons.

The assembly schedules for the next cryomodules can be found in attachment A.2

6. DELIVERABLES OF THE CUSTOMER

6.1 Cryomodule design drawings

Sets of design drawings (paper copies), which represent the current status of the TTF-type-III design and the X-FEL cryomodule design will be supplied to the CONTRACTOR at the start of the IS contract or as soon as the drawings become available for the CUSTOMER. All cryomodule drawings shall have the status 'ONLY FOR INFORMATION' and shall not be approved for production in any way.

In the interest of the CUSTOMER, the CONTRACTOR should get the current set of design drawings as early and as complete as possible. On the other hand, the CUSTOMER can change any cryomodule design drawings at any time without notifying the CONTRACTOR. Of course, the CONTRACTOR shall only reference the design drawings, which were provided to him.

6.2 Cryomodule assembly procedures

Sets of assembly procedures (paper copies), which represent the current status of the TTF-type-III assembly and the X-FEL cryomodule assembly will be supplied to the CONTRACTOR at the start of the IS contract or as soon as the documents become available for the CUSTOMER. All assembly procedure documents shall have the status 'ONLY FOR INFORMATION' and shall not be approved for production in any way.

In the interest of the CUSTOMER, the CONTRACTOR should get the latest current set of assembly procedure documents as early and as complete as possible. On the other hand, the CUSTOMER can change any assembly procedures at any time without notifying the CONTRACTOR. Of course, the CONTRACTOR shall only reference the assembly procedure documents, which were provided to him.

6.3 Access to the cryomodule assembly

The CUSTOMER will allow representatives of the CONTRACTOR, who have been named before in the project management plan and are accepted by the CUSTOMER, access to the cryomodule assembly areas, provided, the representatives keep strictly to the DESY safety rules and to the additional safety rules for the assembly sites, keep strictly to the IS contract and obey the instructions of the CUSTOMER's representatives, who are in charge of the module assembly. The CUSTOMER shall suspend any CONTRACTOR's representative from accessing the DESY site, who does not comply with the rules cited above. In this case, the CONTRACTOR shall replace his representative, as stipulated in the management plan.

The assembly will take place inside a clean room environment (classes 10 and 100) and inside an industrial hall in building No.28 / Hall 3 at the DESY site in Hamburg. Due to the cleanliness requirements only one representative of the CONTRACTOR will have access to the clean room during the cryomodule assembly. In addition, the access may be limited in time. All related rules for the work inside the clean room, defined by the CUSTOMER's clean room assembly team leader (or his deputy), shall be followed by the CONTRACTOR's representaive.

The CUSTOMER expects more than one CONTRACTOR for the IS. Therefore, also experts from other CONTRACTORS will be around during the module assembly.

An office for three presentatives of the CONTRACTOR will be supplied by the CUSTOMER at the DESY site during the cryomodule assemblies. This office will be available at the DESY site in Hamburg but may be apart from the assembly area.

6.4 Languages used in the documents

German or English may be used in all documents, including drawings and assembly procedures, which will be supplied by the CUSTOMER to the CONTRACTOR.

7. INDUSTRIAL SAFETY

The CONTRACTOR is obliged to follow the legal as well as DESY's safety rules which might exceed the legal ones and to impose them on the CONTRACTOR's personnel (see attachment A.7).

Regardless of these regulations, the CONTRACTOR’s employees visit the DESY site and work at the cryomodule assembly at their own risk or that of the CONTRACTOR.
Before starting to work at the DESY site, the CONTRACTOR has to hand in a complete list of names of all the employees who are going to work at the DESY site to the head of the DESY MKS group and safety officer Bernd Petersen (or his deputy Holger Lierl).
These CONTRACTOR employees need the following safety instructions before starting work at the DESY site and at the cyromodule assembly:

7.1 Instruction on DESY’s safety rules for visitors and CONTRACTORs.

7.2 Instruction on hazardous chemical agents (acids) used in the BCP- and EP- facility close to the cryomodule assembly area.

7.3 General safety instruction for the module assembly and building 28 at DESY.
These instructions will be held by the local safety officers in charge, the receipt of the instructions have to be confirmed in written form.

The general safety instruction for the module assembly and building 28 (7.3) explains several additional risks in the vicinity of the assembly area: use of prototype equipment and tooling, mechanical workshops, cryogen fluids, high-voltages, high power RF and crane transportation. In particular for radiation safety, there are prohibited and controlled areas (VUV-FEL linear accelerator, cavity test facility). The CONTRACTOR’s employees are not allowed to enter those areas.

The CONTRACTOR’s employees are not allowed to operate a crane or to work on electrical installations. In particular, ‘Arbeiten unter Spannung’ with reference to the VDE rules are strictly forbidden.
During the cryomodule assemblies, the CONTRACTOR’s employees are only allowed to work under the direct supervision of DESY-MKS representatives and safety officers that are in charge for the assembly.

If the CONTRACTOR’s personnel are in serious breach of the safety rules DESY can expel them immediately from the site. In this case the CONTRACTOR has to replace them within three working days by appropriate substitutes.

8. CONTRACTURAL TERMS

8.1.Confidentiality Clause

After signing of this Agreement and for a period of five years after completion of the XFEL Design Study Project, the CONTRACTOR commits himself to treat strictly confidential all information, documents, evaluations, drafts, outlines or technical specifications etc., he has received indirectly or directly, written or orally in the context of the project as well those of technical, financial or other business nature (in the following called information“). Accordingly, the CONTRACTOR undertakes that:

- he shall not use any such information and objects, the drawings, the documentation and the assembly procedures etc. for any purpose other than in the framework of the IS call for tender or the IS contract.
- he shall not disclose any such confidential information to any third party and
- such information shall neither be copied, nor otherwise reproduced nor duplicated in whole or in part where such copying, reproduction or duplication has not been specifically authorised in writing by the CUSTOMER.

The confidentiality obligation stipulated above shall not apply to information for which the CONTRACTOR can prove that it:

- had a public nature prior to its communication by the disclosing Party or entered the public domain after such communication but through not fault of the CONTRACTOR;
- was already in its possession at the time of signature of this Agreement;
- is received from a third party without any breach of any secrecy obligation;
- is subsequently developed by or for the receiving Advisory Board Member independently of the confidential information received from the disclosing Party;

The CONTRACTOR shall contractually impose the same obligations on all of his employees, representatives, affiliates, subcontractors or any other person who may have access to confidential information, to the maximum extent and for the maximum duration authorised by law, even beyond the end or the termination of their employment.

The CUSTOMER will keep the informations of the deliverable 5.1.5 (detailed cost issues) confidential.

8.2. User`s Rights, Licenses, Property Rights

The CONTRACTOR will respect the intellectual property rights of the CUSTOMER. In particular, the CONTRACTOR shall not be allowed to deduce any licences or patents from the materials, drawings or documents, which he has received from the CUSTOMER during the IS call for tender or within the framework of the IS contract.

After the delivery of the IS assembly reports and the final report to the CUSTOMER and the related payments of the CUSTOMER to the CONTRACTOR, which are defined in the IS contract, the IS reports including all information, know-how and documents shall be property of the CUSTOMER. In particular, all copyrights for the IS assembly report shall be property of the CUSTOMER.

Knowledge generated in the resultant study , findings and conclusions, described methods and procedures as well as future consequential developments, improvements or enhancements are at the exclusive disposal of the CUSTOMER. In particular, the CUSTOMER has the full and unrestricted use and application thereof, be it directly or indirectly.

The CONTRACTOR shall not charge the CUSTOMER (acting for BESSY, the TESLA collaboration, the EUROFEL design study and the XFEL project) in follow up contracts for any information, any drawings, any documents, any assembly procedures and any know – how, which he has received from the CUSTOMER during the IS call for tender or the IS contract.

Inventions, made by the CONTRACTOR during the contract period and based upon subject matter of the contract will be made aware to the CUSTOMER in writing and offered for acceptance immediately after indication. The CUSTOMER will reply in writing without delay, if he will accept the inventions. The CUSTOMER will keep confidential the inventions and all relevant details he has been informed of as long this is necessary for an unobstructed enforcement.

Preparation and filing of application of industrial property rights will be made by the CUSTOMER.

In the case that the CUSTOMER informs in writing that he is not interested in filing a patent application, the CONTRACTOR is entitled to file a patent application himself. In this case, the CONTRACTOR grants the CUSTOMER a non – exclusive irrevocable license free of charge for all his domestic and foreign industrial property rights, industrial property rights applications and inventions, provided that they result from the IS contract. The aforementioned provisions shall remain in force for joint inventions made by the CUSTOMER. CONTRACTOR and CUSTOMER will amicably agree upon the relevant proportion and will define in writing this result in addition to the IS contract.

Furthermore, the CUSTOMER shall also be entitled to elect an irrevocable, royality – free, transferable, non – exclusive right and license to use, reproduce, make derivate works, display and perform all copyrightable materials developed within the framework of this IS call for tender and of the IS contract..

8.3 Liability

The Parties agree to hold the other Party harmless for any injury or damages except for those that result from gross negligence or wilful misconduct of that other Party. This same rule or understanding applies with respect to damages or injury suffered by the Parties`visiting personnel during the time of their visit to the facilities of the other Party. Damage suffered by third Parties will be borne by the Party whose personnel is responsible for these.

8.4 Publication of the IS assembly reports and the final report

The complete IS cyromodule assembly reports (as specified in section 5, but with the exception of the confidential part 5.1.5) shall be published by the CUSTOMER and shall be available for both the scientific and industrial communities. In particular, the complete

IS cyromodule assembly reports will be submitted as a deliverable in the framework of the EUROFEL design study DS6.
The report shall be published as paper copies and electronically (e.g. on the X-FEL project web-page).

8.5 Publications by the CONTRACTOR
The CONTRACTOR shall not publish any information, any drawings and any documents, which were handed over by the CUSTOMER in the framework of the IS call for tender or the IS contract respectively, without the written permission of the CUSTOMER.

8.6 Videos and Photographs
The CONTRACTOR needs the written permission of the CUSTOMER to take photographs and to make videos during the cryomodule assemblies. In addition, the works council and all involved employees of the CUSTOMER have to agree. Section 8 of this specification is valid for any photographs or videos taken by the CONTRACTOR. In particular, the CONTRACTOR shall not publish any photographs or videos taken during the cryomodule assemblies, without the written permission of the CUSTOMER.
The CUSTOMER will take photographs and videos during the module assemblies.

9. PRESENTATION OF TENDERS (TECHNICAL PART)

Offers must be either in English or German. If deviations from the present specification are suggested those must be clearly stated. The offers shall contain:

9.1 General description of the CONTRACTOR's industrial activities
(Fields of activity, structure of the company, organisation structure, management structure).

9.2 Description of the CONTRACTOR's industrial capacities and experience with respect to the IS –contract.
In particular, the CONTRACTOR shall prove that he is 'qualified' as defined in section 2 of this specification. In detail, the following topics shall be commented and the comments shall be confirmed by references:

- 9.2.1 Describe the experience and capacities in the series production of cryostats or cold masses for accelerator components using superconducting technologies.
- 9.2.2 Describe the experience and capacities in the application of clean room technologies.
- 9.2.3 Describe the experience and capacities in the application of superconducting RF resonators and the related technologies for particle accelerators.
- 9.2.4 Describe the experience and capacities of the application of high vacuum

techniques and the related test procedures.

9.2.5 Describe the experience and capacities of TIG-welding procedures for austenitic steels, aluminium and titanium.

9.2.6 Describe the experience and capacities for the application of cryogenic technologies (e.g. the use of MLI) in series productions.

9.2.7 Describe the experience and capacities for the series production of ‘high-tech’ equipment (like components for particle accelerators)

9.3 Description of the CONTRACTOR’s personnel capacities

9.3.1 General qualification and educational profile of the CONTRACTOR’s employees

9.3.2 Description of the education, training, certification and experience of the CONTRACTOR’s employees in regard to all topics of section 9.2 (9.2.1 to 9.2.7).

9.3.3 Describe the availability of qualified employees for the IS-contract.

9.4 Description of the CONTRACTOR’s quality management

The CONTRACTOR is obligated to use a suitable quality management (QM) system. The DIN EN ISO 9001 standard shall be the basis for all quality assurance measures. Describe the quality assurance measures in regard to:

9.4.1 Quality assurance in design

9.4.2 Quality assurance in procurement

9.4.3 Quality assurance in production

9.4.4 Quality assurance upon delivery

9.4.5 Documentation

9.5 Costs of the IS

As defined in the contractual and financial part of this call for tender.

The costs of a separate report on the BESSY-FEL cryomodule issues (5.1.4) have to be given.

9.6 Confirmation of industrial safety rules

The CONTRACTOR has to comply with the safety rules as described in section 7. This shall be confirmed in the tender.

The following persons at DESY should be contacted for discussing problems related to this specification:

Technical questions:

Herr Dr.Bernd Petersen, tel. +49 40 8998 3596, e-mail: bernd.petersen@desy.de

Contractual and financial questions:

Herr Roberto Medri, tel. +49 40 8998 4873, e-mail: roberto.medri@desy.de

10. ATTACHMENTS

A.1) Main design features of the cryomodules

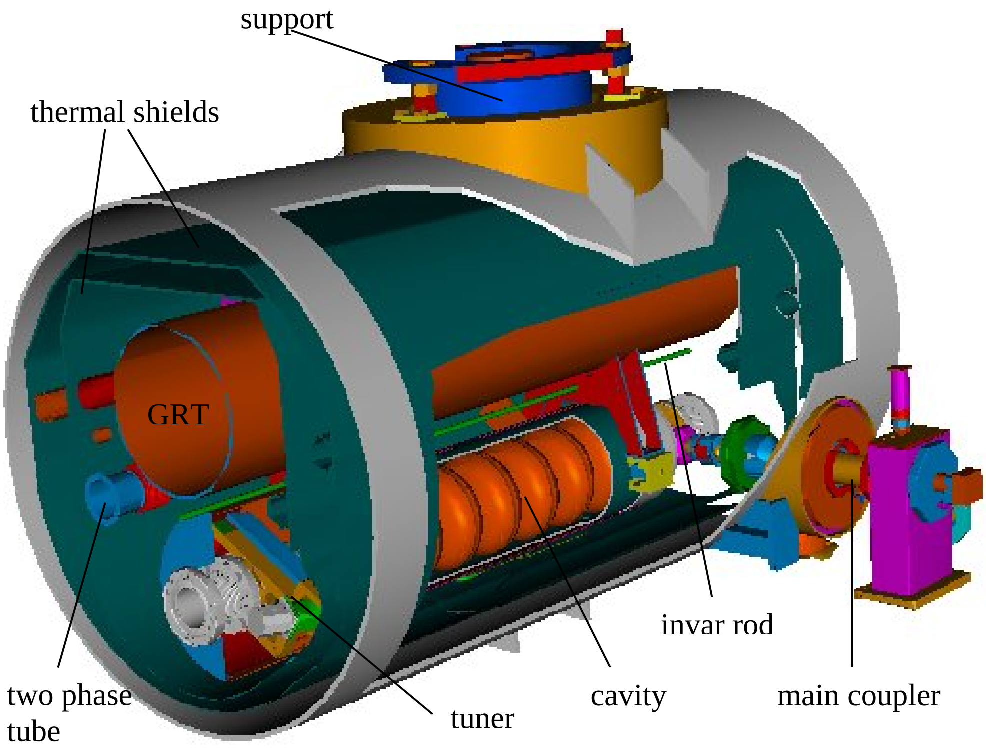


Fig. A.1.1: Cut of a cryomodule, showing one cavity with supports, main coupler, tuner, thermal shields and one of the cryogenic supports of the cryostat.

A.1.1. TTF cryomodule design type III

The cryomodule consists of eight 9-cell 1.3 GHz niobium cavities connected by bellows units. Each cavity is welded into its individual helium vessel, manufactured out of TI2-material. The beam tube flanges consist out of NbTi (45%/55%) alloy and are connected by a special developed sealing system.

Between the helium vessel and the flanges one RF fundamental mode coupler and two higher order mode (HOM) couplers are installed. In addition, each cavity is equipped with one cold tuner, including mechanics and electrical motor.

The helium vessels are covered by sheets of CRYOPERM material for magnetic shielding and multi-layer-insulation (MLI).

The eight cavities are fixed in position by means of an invar rod which minimizes their motion relative to the vacuum vessel due to thermal shrinkage during the cool down of the module. In particular, the distance between the fundamental mode couplers will only change in the order a millimetre during thermal cycling. At one end of the cavity string a superconducting magnet package is added. A beam position monitor (BPM) is attached to the magnet cryostat. All metal manual valves are installed at both ends of the cavity string.

This string of 8 cavities and magnet package is mounted to the gas return tube (GRT, see fig.1). In order to compensate the thermal shrinking of the GRT, the string of cavities can slide in relation to the GRT by means of sliding fixtures.

The GRT is mounted to the outer vacuum vessel by means of three support posts. The 2K area consisting of GRT and cavity string is surrounded by two thermal shields, one at about 4.5 K and the other between 40 – 80 K respectively. Both shields consist of aluminium sheets covered with MLI. The thermal shields are fixed to the support posts. The helium return tubes of both shields are made of extruded aluminium.

The RF fundamental mode couplers (main couplers) consist of a cold and a warm part. Vacuum-wise the cold and warm parts are separated by ceramic windows. The warm part of the couplers are mounted at flanges of the outer vacuum vessel and directed to the cavities through openings in the thermal shields. Thermal intercepts at temperature levels of about 4.5 K and 40 K are connected to the helium supply tubes of the related shield cooling circuits. A common pump line outside of the vacuum vessel connects the warm parts of all eight couplers.

Also the helium gas cooled current leads of the magnet package are directed through the thermal shields.

The cavity helium vessels are supplied by means of a 2-phase forward tube (made of TI2), which is connected to each individual vessel. The helium boil-off released in the two-phase line flows into the GRP through connections located at the junction between modules. Also the cool-down / warm-up bypass tube is connected to each individual helium vessel by means of capillary tubes, which are flanged to the bottom of the vessels. These and other helium process tubes are shown in fig. 1. The magnet package is cooled by means of the 4.5 K helium circuit supply of the 4.5 K thermal shield.

A cryomodule of TTF-type-III-design has a length of 12.2 m, an outer diameter of 1.2 m and a mass of about 7900 kg.

A.1.2. The X-FEL cryomodule design

Although the Type-III cryomodules serve as the baseline design for the X-FEL modules, their design has not yet been finalized. Important input from the IS is expected for the improvement of the present design.

The following cryomodule parts will be changed with respect to section A.1.1 (Type III):

A.1.2.1 Superconducting magnet package

The magnet package and the magnet cryostat will be completely new designed.

In contrast to the TTF-type magnet, a superferric quadrupole will be used for the X-FEL. The magnet package will be cooled by means of the 2K helium bath in series with the cavities. The support of the magnet package will be made in line with the cavity support structure. High temperature superconducting current leads (HTSC) or conventional conduction cooled current leads (LHC-type) will be installed instead of gas cooled current leads.

A.1.2.2 Beam position monitor (BPM)
The BPM and the beam tube inside the magnet package will be new designed.

A.1.2.3 Fast piezo-tuners
Fast piezo-tuner devices will be added to the mechanical tuners.

A.1.2.4 Helium process tubes and flanges
Special flanges will be used at the ends of the helium process tubes. These will be suitable for connections during tests as well as welding in the final X-FEL linac configuration. The welding connections will be prepared for welding machines.
The diameter of the 40/80 K process tubes will be increased to DN 80.

A.1.2.5 Coupler valves
The couplers will be installed without manual valves.

A.1.2.6 Flanges on module vacuum vessel
The use of metallic gaskets including changes of the flange design will be considered.

A 1.2.7 Overall length of the cryomodule
The overall length of the cryomodule will be changed in the order of some centimetres.

<u>A.1.3 TTF cryomodule design type II</u> (only for information, no subject of IS)
In contrast to TTF design type III, no invar rod is used for the suspension of the cavities. As a result, the main couplers at both ends of the cryomodule move in a range of about +/- 15 mm during warm up and cool down and the alignment procedures are different. The vacuum vessel is larger. As a consequence the position of the helium process tubes is different from type III. In particular, the cavity helium vessels are different. The 2-phase tube is centered at the top of the helium vessels

<u>A.1.4 BESSY-FEL cyromodule layout</u>
The BESSY-FEL modules, in almost all respects, follow the design of the eight-cavity XFEL modules. Changes will only be made to those components that otherwise would limit the ability to operate the modules CW.

Most modifications are due to the fact that the dynamic load *per cavity* is as high as 20 W, or nearly a factor 20 more than that for the X-FEL modules. As a result, the dimensions of the cryogenic lines had to be changed as follows (see Fig. A.1.2):

1. The connection between the helium tank and the two-phase line was increased from 56 mm diameter to 90 mm to lower the heat flux density.
2. The diameter of the two phase line was increased from 72 mm to 100 mm to improve the mass flow.
3. The diameter of the connection between the two-phase line and GRT was increased to 90 mm.

An ongoing test program may result in a further increase of these diameters. *However, the diameter of the 300-mm GRT was left unchanged.* Hence the support structures for cavities, cryostat and cryogenic distribution lines etc. remain unaffected.

Each module will be equipped with its own Joule Thomson (JT) valve. This is in contrast to the XFEL modules, where only one JT valve per 10-module cryostring is required, and hence no JT valve is included *in* the XFEL modules themselves. The assembly sequence and techniques for the BESSY-FEL modules may be impacted significantly by this design change.

Unlike in the XFEL layout, there is no connection of the two-phase lines between neighbouring modules. This avoids "cross talk" from one module to the next that otherwise would complicate the liquid-level control in the two-phase lines.

An additional connection between the two-phase line and the GRT was incorporated in each module. One connection is now situated near the JT valve to effectively remove flash gas. The other is located near the reservoir to exhaust the gas that is produced by the compensation heater.

In all likelihood, the compensation-heater system must also be modified. Tests will show, whether a distributed layout (e.g., in the two-phase line or in each helium tank) is necessary for CW operation.

The tuner and input coupler systems, too, may require some modification, pending the outcome of CW tests. These changes will, however, be made to fit within the constraints of the existing Type-III module/cavity design.

The elimination of the 4-K shield is also being considered. The impact of this omission on the assembly sequence, production cost and performance of the module should be analyzed by the CONTRACTOR.

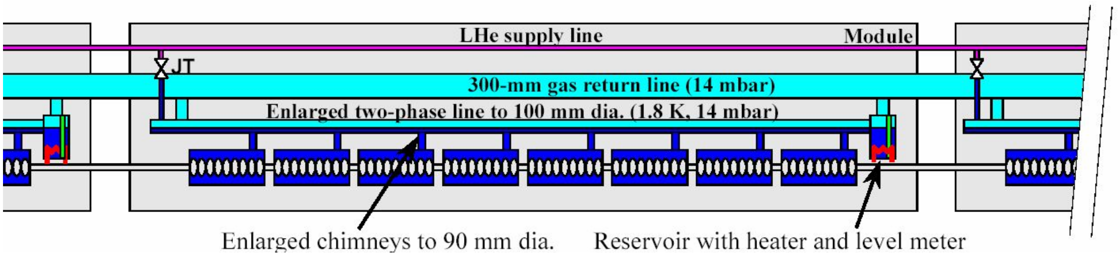


Figure A.1.2: Schematic of the proposed layout for the CW BESSY-FEL modules. A distributed compensation heater is also being considered.

A.2 Assembly schedules of cryomodules at DESY

Table A.2.1 shows the next scheduled cryomodule assemblies at DESY. **The CONTRACTOR shall take part in the cryomodule assemblies with the production numbers 6 and 8.**

As an option, the CONTRACTOR may also be present at the assembly of module 7 (Type II). But the CUSTOMER shall not be charged for any efforts of the CONTRACTOR related to the assembly of module 7 with reference to the IS contract.

Table A.2.1: The next scheduled module assemblies (preliminary)

internal modul production number	design type	status of planning	assembly not before	comment
6	**TTF-III**	**scheduled**	**August 2005**	**35 MV/m high gradient module**
7	TTF-II	scheduled	September 2005	VUV-FEL linac spare module
8	**X-FEL**	**not yet scheduled**	**end of 2006**	**X-FEL prototype**
9	X-FEL	not yet scheduled	?	X-FEL prototype

A.3 Design and assembly goals

The IS cryomodule assembly study in the framework of the IS contract shall focus on the main XFEL-cryomodule design and assembly goals.

In general, the already existing design and assembly procedures of prototype cryomodules have to be reviewed by the IS with respect to serial production, reduction of efforts and costs, and increase of performance.
The procedures shall be optimized for a serial production of about 120 XFEL-identical cryomodules at a production rate of one cryomodule per week.

A.3.1 RF performance of the superconducting cavities
As a baseline for the XFEL-project, each individual cavity of an XFEL-cryomodule shall reach an accelerating gradient of at least 28 MV/m (operational in the linac) at an unloaded quality factor of $Q_0 = 1*10^{10}$. For the operation of the XFEL-linac the cavities will be operated at about 23.5 MV/m or lower. The assembly procedures shall be optimized to reach those goals.
Beside those goals, the assembly of module 6 shall provide an additional test: each individual cavity of module 6 shall reach an accelerating gradient of 35 MV/m at unloaded quality factor in the order of $Q= 5*10^9$ (or better).

Field emission shall be avoided. Dark currents shall be reduced to < 50 nA per cavity.

A.3.2 Cryogenic heat loads
The cryogenic heat loads as defined in table A.3.1 shall not be exceeded.

Table A.3.1: The cryogenic loads of one XFEL-cryomodule containing 8 cavities and one quadrupole package at 2-K. The dynamic loads are calculated for an accelerating field of E_{acc} = 23.5 MV/m, a macro pulse of 1.35 ms and a pulse repetition rate of 10 Hz at an unloaded RF-quality factor of $Q_0 = 1*10^{10}$ corresponding to a beam energy of 20 GeV for the XFEL-linac.

cooling circuit	static load [W]	dynamic load [W]	sum of loads [W]
2 K	1.44	8.75	10.19
5-8 K	8.64	5.70	14.34
40-80 K	70	117	187

Any optimizations of heat loads with respect to the different temperature levels have to take into account the coefficients of performance (COP) of the refrigerator, as shown in table A.3.2.

Table A.3.2: The estimated coefficients of performance (COP) for the XFEL-refrigerator

COP = primary power / power at temperature level

Temperature level	COP W/W
2 K	600
5 – 8 K	200
40 – 80 K	20

Optimizations shall reach the lowest possible reasonable overall primary power input.

A.3.3 Alignment tolerances

The position of each cavity shall not deviate more than +/- 0.3 mm from the middle axis of the module. The quadrupole position shall not deviate more than +/- 0.3 mm and the BPM shall not deviate more than +/- 0.2 mm from the quadrupole magnetic axis. The roll tolerances of the quadrupole shall not exceed +/- 0.3 mrad.

(The module axis shall not deviate more than +/- 0.2mm from an ideal straight axis in the XFEL-tunnel.) All tolerances are RMS values.

A.3.4 Radiation dose

Any material used in the cryomodules shall tolerate a gamma radiation dose of $5*10^6$ Gy without loss of function.

A.3.5 Vacuum

For the beam vacuum the integral helium leak rate of the complete string must be < 10^{-10} mbar l/s. The anticipated pressure before cool down is about 10^{-6} mbar using a sputter ion pump (60 l/s) at one end of the string.

For the warm coupler vacuum the helium leak rate must be < 10^{-10} mbar l/s for all components and connections. The anticipated pressure measured in the pump line is about 10^{-10} mbar using a sputter ion pump (60 l/s) and a titanium sublimation pump.

The tolerable leak rate for the insulating vacuum is < 10^{-6} mbar l/s. The anticipated pressure before cool down is <10^{-3} mbar. For the TTF-type III module this pressure is reached using one turbo molecular pump station with about 200 l/s pumping speed per module. Replacing the O-ring gaskets by metal seals or welded solutions one pump station should be used for the initial pump down of 4 modules.

A.3.6 Legal requirements

The cryomodule design and assembly shall meet all legal requirements. In particular, the ‘Betriebssicherheitsverordnung’, the ‘Gerätesicherheitsgesetz’, AD2000 code, the ‘Druckgeräterichtlinie 97/23EG’ and the CE-certification rules.

A.4 Clean room assembly

A.4.1 String assembly

Inside a class 100 / class 10 (ASTM) clean room eight cavities, two gate valves, eight bellows, one quadrupole and one beam position monitor are located on a railing system. They are pre-cleaned and ready for assembly. Each of the eight cavities is sealed with flange- and antenna connections and the interior is under ultra high vacuum conditions. The sequence of assembly starts with connection of the first cavity (beam pipe long side) and one gate valve. The opposite side (beam pipe short) is connected to one bellows, which serves as the vacuum tight and flexible interconnection to the next cavity in line. Cavity no 8 is connected to the beam position monitor. This monitor is connected to the quadrupole and the second gate valve. This subunit is a separate assembly unit which has to be completed inside the clean room before this unit is connected to the cavity string. During all assemblies the particle contamination of the individual components as well as that of the sub units after the assembly procedure is monitored.

Fig. A.4.1: A complete cavity-string in the clean room

A.4.2 Alignment of units

Inside the clean room the most important alignment is the horizontal positioning of the cold part of the input coupler with respect to the vertical plane parallel to the beam asix and in respect to each other. After fixation of the bellows the cavities are rigidly connected to each other with respect to rotational positioning and no readjustment afterwards is possible.

The longitudinal and lateral displacement as well as the alignment of the string with respect to the beam axis can be corrected afterwards so that these parameters need to be installed with a precision on ±1 mm only.

The axial and the lateral alignment are done individually on every cavity and on the quadrupole unit right before the bellows connection between the individual items is done.

The longitudinal positioning of the cavities/ input couplers is done after the string is completed.

For alignment a tool giving the position of the beam axis is installed on the cavity rail. A bridge tool rest upon the four brackets of the cavity helium tank and is equipped with two fine balances that allow to measure and readjust the lateral and rotational position of the cavity.

After aligning the beam pipe flange (cavity long beam pipe side) to the beam axis the lateral alignment is done. Finally the rotational adjustment of the coupler port within an accuracy of < 0, 3 mrad with respect to the horizontal plane and the neighbouring cavities completes the cavity alignment procedure.

The bellows flanges are aligned with respect to the cavity beam pipe flanges to which they will be connected. The rotational and the beam axis alignment is done with respect to the beam line flange bore holes while the lateral adjustment is done by the parallelism of the flange planes

A.4.3 Installation

A.4.3.1 Cavity connections

Each cavity is vented to normal atmosphere via an ultra pure venting system right before the assembly. In a first step of the cavity assembly the bellows flange is aligned with respect to the cavity flange of the long beam pipe side of a cavity. Each beam pipe flange is opened in a well defined procedure right before the connection to the bellows starts. After this connection is made the bellows is aligned in respect to the beam pipe flange of the cavity short side pipe of the previous resonator. During the alignment operation the bellows is closed by a cover which is removed just before both flanges are compressed on each other.

A.4.3.2 Cavity and gate valve connection

For this operation the cavity no one is well aligned and the gate valve flange is aligned with respect to the cavity beam pipe long side flange to ensure a smooth and particle free procedure. Before the assembly itself the gate valve is controlled for functionality and particle contamination. After this operation the cavity is vented to normal atmosphere and the cavity flange is removed in a well defined procedure.

A.4.3.3 BPM and cavity connection

The unit, build up from a beam position monitor, a quadrupole and a gate valve is preassembled inside the class 10 clean room and aligned with respect to reference marks on the quadrupole. Before and during these preassemble steps the particle contamination of the individual components as well as that of the sub units right after the assembly procedure is controlled.

The quadrupole unit is aligned with respect to reference marks and the beam axis while the connecting bellows flange is aligned with respect to the beam pipe flange short side of the cavity no 8. During this operation the bellows is closed by a cover which is removed just before both flanges are compressed on each other. The cavity beam pipe flange is opened and removed in the same well defined procedure like applied for the cavity to cavity connection.

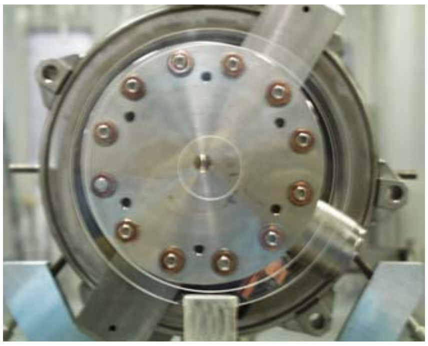


Fig.A.4.2: Alignment of beam pipe flange to the beam axis

Fig. A.4.3: Dismounting procedure of a flange (beam pipe short side) with aligned bellows

Fig.A.4.4: Installation of a beam pipe short side fixture for dismounting of a flange

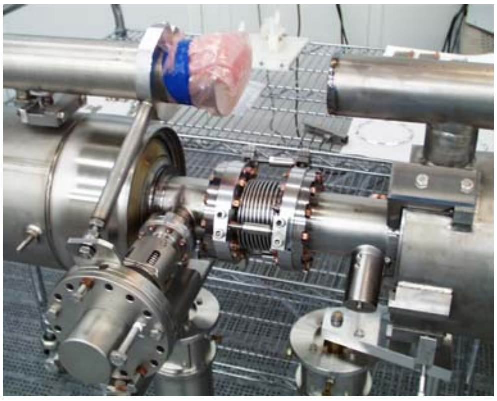


Fig. A.4.5: View on a finalized cavity interconnection via a bellows

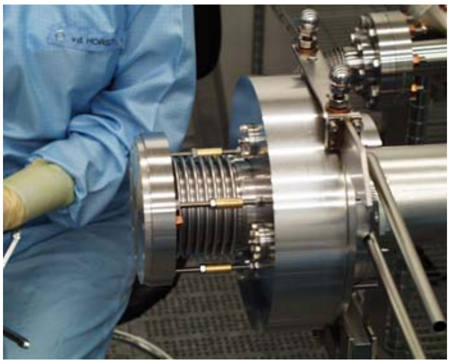


Fig. A.4.6: Quadrupole bellows before installation to cavity no 8

<u>A.4.4 Vacuum Leak check</u>

At DESY the size of the clean room class 10 area is limited. Therefore a subunit of the first four cavities is vacuum leak tested during the string assembly using an oil free pump station. Once the string is complete, an integral leak test of the whole unit is performed using Helium over at least 12 hours. If leak tight, the string is vented with ultra pure gas (Argon) as some steps of the further assembly of the type III module can not be performed with the cavity string under vacuum.

A.5 Cryomodule assembly outside clean room

A.5.1. This assembly description is based on the TTF-cryomodule- type III design.
A type III cryomodule has a length of 12.2 m, a diameter of 1.2 m and a mass of 7900 kg.

A.5.2. Main components of a type III TTF-cryomodule

1 vacuum vessel
1 cold mass
1 cavity-string (8 cavities with quadrupole package, BPM and gate valves)
8 RF main couplers

A.5.2.1 Parts of the vacuum vessel

1 vessel
2 sliding sleeves including flanges
3 vacuum caps for support posts
2 supports with stringers

A.5.2.2 Parts of the cold mass

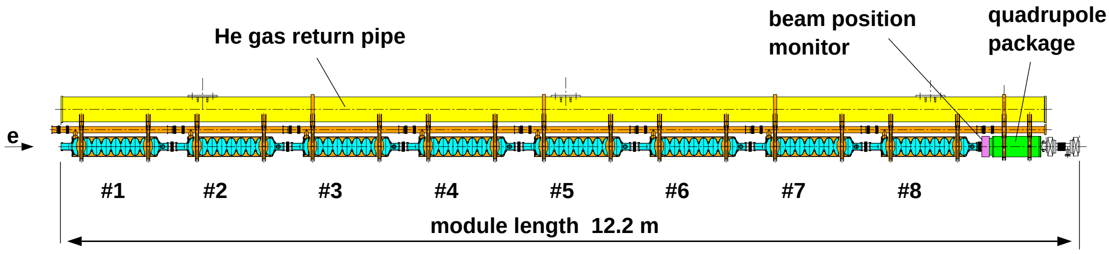


Fig. A.5.1: Side view of the cold mass

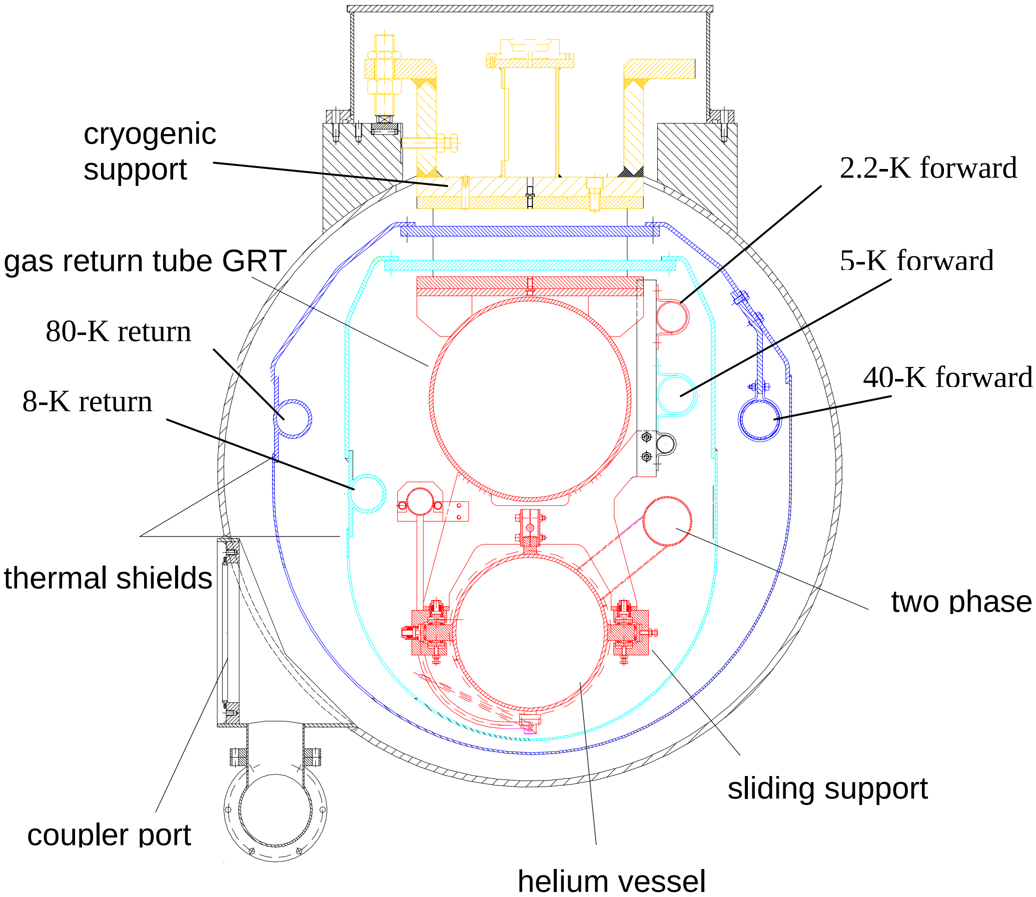


Fig. A.5.2 Cross section of the cryomodule

1	ø300mm tube, helium Gas Return Tube (GRT)
1	2.2K-forward tube
1	5K-forward tube
1	8K-return tube
1	40K-forward tube
1	80K-return tube
1	cool-down/warm-up tube
3	supports
1	5 K- thermal shield (incl. MLI and spacer)
1	80K- thermal shield (incl. MLI and spacer)
	temperature sensors

A.5.2.3 Parts of the cavity-string

8	cavities with helium vessels
8	cavity tuning systems
1	superconducting magnet package with beam position monitor (BPM) and

higher order mode (HOM) absorber
2 vacuum valves
8 Cryoperm magnetic shielding sheets
multi layer insulation (MLI)
temperature sensors

A.5.2.4 Main parts of the RF main coupler

8 cold parts (already installed before the roll-out from the clean room)
8 warm parts
8 wave guide box
8 bellows
1 coupler vacuum pump line system including pump unit

A.5.3. Assembly procedure
The assembly outside the clean room will proceed in five steps

A.5.3.1 String Roll-Out
Before the roll-out, the guide rail and the cold mass have to be aligned.
The assembled string consisting of eight cavities and the magnet package is rolled-out of the clean room by means of a guide rail. Among other things, alignment procedures and the control of the cavity resonator frequencies will follow the roll-out step.

5.3.1.1 alignment of guide rail and cold mass
5.3.1.2 roll-out of cavity string
5.3.1.3 control of resonator frequencies

A.5.3.2 Connection of cold-mass to cavity string
Among other things, this assembly step consists of the mounting of multi-layer-insulation (MLI) and Cryoperm magnetic shielding sheets on the cavity helium vessels, the installation of the cold tuners, the welding of the Ti2 2-phase tube, the installation of coupler supports, the installation of different sensors, the related RF- and helium leak tests, and the final connection of the string to the cold-mass.

3.2.1 alignment of the cavity-string
3.2.2 connections to cold mass
3.2.3 mounting of cool-down/warm-up tubing and flanges
3.2.4 mounting of MLI around the helium vessels
3.2.5 installation of Cryoperm magnetic shielding sheets
3.2.6 welding of 2-phase tube connections
3.2.7 installation of tuners, including RF-measurements
3.2.8 helium leak-check of 2K helium circuit
3.2.9 mounting of magnet-package to cold mass
3.2.10 installation of main coupler supports
3.2.11 installation of thermal sensors etc.

Fig.A.5.3: Tuner parts and main coupler parts at the inter-connection of two cavities at the cavity string

Fig. A.5.4: The cavity-string attached to the cold-mass

A.5.3.3 Lift-up of cold-mass and cavity string

Among other things this assembly step consists of the lift-up of cold mass and cavity string, the alignment of cavities and magnet package and the preparation of 4.5 K and 40/80K helium shield process tube connections. The transport to the module cantilever is prepared.

3.3.1 lift-up of cold mass with cavity string connected
3.3.2 alignment of magnet package
3.3.3 welding of magnet package process tube connections
3.3.4 helium-leak check of magnet package process tube connections
3.3.5 final installations of Cryoperm sheets (magnetic shieldings)
3.3.6 4 K and 80 K thermal connections to main couplers
3.3.7 preparations for transport to cantilever

Fig. A.5.5 : Transport of the cold-mass and cavity-string to the cantilever

A.5.3.4 Cold-mass and cavity string in cantilever

Among other things this assembly step consists of the mounting of the thermal shields including MLI and the connections of the thermal intercepts of RF-cables to the shields. The MLI is prepared for main coupler and current lead feedthroughs. Thermometers are installed. There are tests of the resonator frequencies.

3.4.1 installation of 4K thermal shield, including welds and MLI
3.4.2 installation of heat-sinks for RF-cables
3.4.3 installation of 80K thermal shield, including welds and MLI
3.4.4 measurements of RF frequencies
3.4.5 cut-aways in MLI for RF main couplers and current leads
3.4.6 final installation of thermal sensors

Fig. A.5.6 : Cold-mass and cavity-string in cantilever

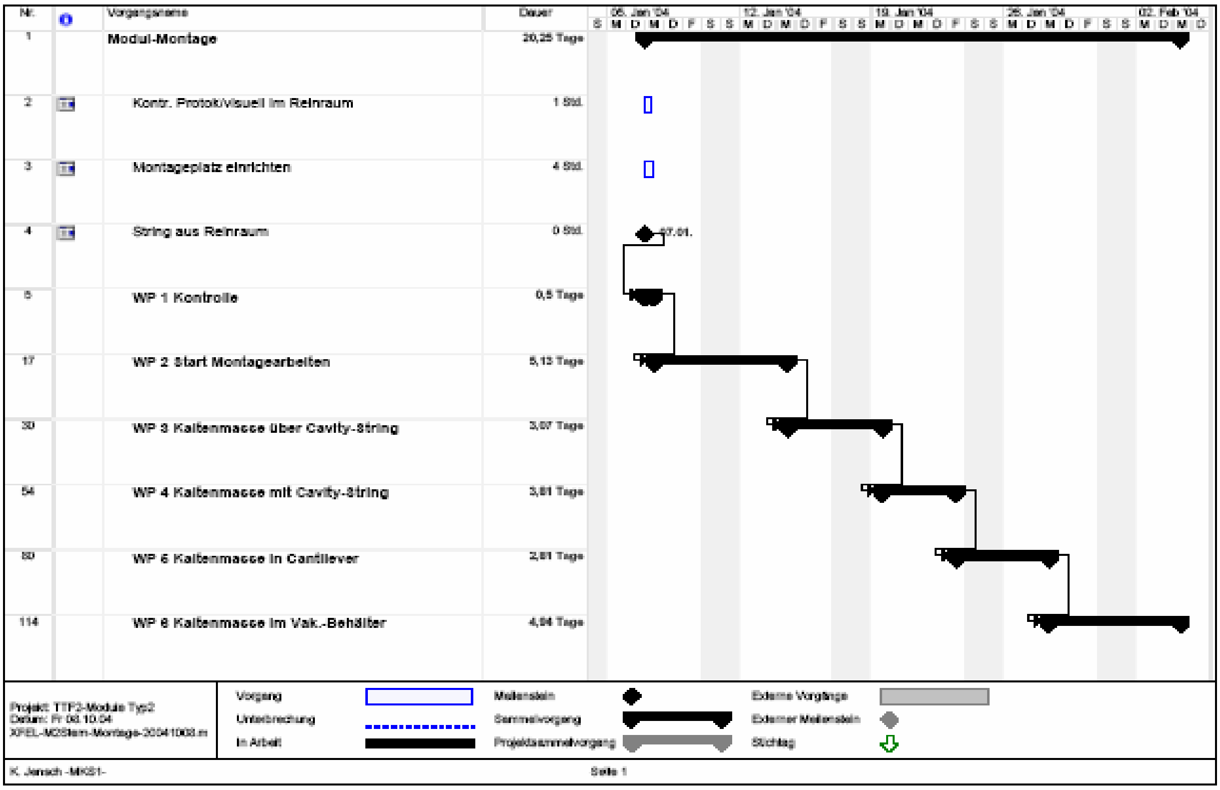
A.5.3.5 Installation into Vacuum Vessel

The vacuum vessel is shifted over the cold-mass. The support posts for the cold mass at the vacuum vessel are mounted. The cavity string and the magnet package are aligned in reference to alignment posts on the vacuum vessel. The warm parts of the main couplers are installed, followed by a leak test of the coupler-vacuum. The current leads are installed, followed by a high voltage test. There is a helium leak test of the cavity vacuum (beam-vacuum). There are tests of the resonator frequencies under vacuum conditions.

3.5.1 vacuum vessel is shifted over the cold mass
3.5.2 the support posts for the cold mass at the vacuum vessel are mounted
3.5.3 load of cold mass is taken over by the vacuum vessel
3.5.4 alignment of cavities and magnet package
3.5.5 installation of RF main couplers and coupler vacuum pump line system including pump unit (see A.6)
3.5.6 helium leak check of coupler vacuum
3.5.7 installation of current leads including high-voltage tests
3.5.8 helium leak check of cavity vacuum (beam-vacuum)
3.5.9 cavity RF frequency measurements under vacuum conditions
3.5.10 installation of vacuum caps
3.5.11 cryomodule ready for installation into the linac/ test stand
3.5.12 cabeling of different sensors and devices (stepper-motors)

Fig. A.5.7: Mounting of MLI at the 5-K shield

A.5.4. Present schedule and personnel requirements for assembly outside clean room
On the basis of 4 experienced experts 20-22 working days (20-22 x 4 x 8 h) are needed for the assembly outside clean room (including measurements of resonator frequencies, helium leak tests, high voltage measurements, tuner tests and tests of different sensors).



A.5.5. Technical prerequisites for the assembly outside clean room
A.5.5.1 Orbital WIG-welding of Ti2 and CrNi-steels (1.4541, 1.4429)
A.5.5.2 Wig-welding of aluminium
A.5.5.3 Welding procedures corresponding to AD2000/HP0
A.5.5.4 Alignment deviations < 0.2 mm
A.5.5.5 Detection of helium leak rates < 10^{-10} mbar*l/sec
A.5.5.6 RF measurements of cavities
A.5.5.7 High voltage test (VDE rules and DESY-MKS working instructions for ‘Arbeiten unter Spannung’ must be followed)
A.5.5.8 General experience with cryogenic components for operation at a temperature of 2K, in particular, in the application of MLI insulation and thermal intercepts and the use of low temperature instrumentation

A.6 Assembly of main couplers (TTF type III)

(This procedure is only valid when the cavity vacuum is not evacuated.)

Equipment/Tool/Parts checklist:

- Coupler drawings set.
- Clean Room / clothing.
- Tools → toolbox.
- Special mounting setup:
    - Long Rail-slider for warm-coax assembly;
    - Hook-rod for warm-coax assembly;
    - Long M5-inner screwdriver;
    - Tuning mechanism flange screws tightening lever;
    - Warm window ceramic plastic cover.
- Vacuum leak-searching setup.
- Coupler parts:
    - Cold part → already mounted
    - Warm coax part assembly
    - WG box assembly
    - Tuning mechanism
    - Cu seals
    - Rubber seals
    - Capasitors
    - HV coils
    - Pick-ups
    - Photomultiplier windows
    - Cables e-
    - Coupler Support parts
    - Screws
- Superisolation foil;
- T-tubes + feedthroughs.

1. Install the Clean Room at coupler position.
2. Mount the coupler support.
3. Put the multilayer-superisolation cut flaps aside
4. Check the 70K-flange position → it must be centered.
5. Check the distance between 70K and Iso.vac flanges (approx. 211 mm).
6. Measure coupler antenna and e- pickups impedance with DMM → must be ∞.
7. Install the rail-slides to fix 70K flange.
8. Remove threaded rods holding the cold part.
9. Remove 70K flange ceramic window protecting cap.
10. Prepare the CF100 rounded Cu seal → slightly tap it and set into place.

11. Check the warm-coax assembly, install e-2 pickup (if not installed), insert the long M5-inner screwdriver into the inner-coax in vertical position (warm window ceramic protecting cap must be put on).
12. Slide warm-coax assembly in (holding long M5-inner screwdriver), put 16 CuNiSi M8×35 screws, tighten them (use long-arm outer 13 screwdriver, do at least 4 rounds).
13. Install supporting hook-rod to hold out-coax part.
14. Remove rail-slider and install the support for warm-coax assembly on the coupler support brackets (to hold the coupler straight).
15. Attach e-2 cable (use special SMA connector key).
16. Put superisolation foil around the outer-coax part.
17. Set small O-ring on the iso.vac flange, set big O-ring with Al frame into place on the module, use sealing lubricant (fat) on rubber seals.
18. Install iso.vac flange into place, put 12 M8 screws (not all 24 holes: through one).
19. Attach 2 center steel half rings by 6 M6 screws.
20. Tighten all screws.
21. Remove the supporting hook-rod.
22. Install the vacuum valve (CF35), ensure the proper angle of the valve (45°).
23. Install the e-3 pickup antenna and PM window.
24. Remove warm window ceramic protecting cap.
25. Install 2 Cu RF contact springs on the tuning rod.
26. Put CF25 Cu seal and insert the tuning rod inside the inner conductor rotated by 90° with respect to the final position, push the tuning mechanism and rotate the tuning mechanism assembly by 90°, check whether it is firmly attached, then put 4 M5 screws, attach the tuning mechanism flange screws tightening lever and tighten M5 screws.
27. Install adjustment mechanism.
28. Leak check the warm coupler vacuum
29. Put on the warm window ceramic plastic cover.
30. Slide the WG-box into place
31. Install the capacitor, fix it by only 2 inner screws, not tight.
32. Attach the WG-part to the coupler support. Use small amount of a lubricant on the 4 connecting axles, correct supporting brackets position if needed.
33. Install the brass half-flanges (use 6 M4 steel screws).
34. Check the WG-part alignment with a level tool, correct if needed.
35. Fasten all screws now.
36. Install the HV coil and WG-box cover plate.
37. Attach the tuning knob and fix it (side screw).
38. Set protecting plate on the WG-window.
39. Remove the Clean Room.
40. Check the HV input impedance with the DMM.

A.7 DESY Safety information for Visitors and Contractors

Safety -D5- Safety Information DESY, February 2005

1. Safety Organisation
The Industrial Safety Regulations, Accident Prevention Measures, and Health Provisions at DESY conform to the German Statutory requirements and to those of the European Community. The DESY board of directors fulfils its obligations in this respect by appointing **Safety Officers** within the groups who are responsible for ensuring that the safety regulations and accident prevention measures are obeyed. Similarly, with respect to radiation safety, the groups have their own nominated **Radiation Safety Officers.** Advice on **questions of safety** (excluding radiation safety matters) can be obtained through the safety engineers, Annette Nienhaus (ext. 3585, building 35, room 14), Stefan Schrader (ext. 2085, room 13) or Yvonne Dundama (ext. 2865, room 12) -D5-. Mrs. Dundama -D5-is responsible for **hazardous materials** and their **disposal** (ext. 2865, building 35, room 14). In addition to the group -D5-questions concerning **safety in the halls** may be directed to the group -ZMEA- where Mr. Sinram (ext. 3714, building 1d, room 11), is the contact person.

Radiation protection questions should be directed to the group -D3- in the persons of Mr. Tesch (ext.4915 building 1c, room 278) or Mrs. Racky (ext. 3690, building 1c, room 275).

Industrial medical advice and assistance may be obtained from Dr. Bandelow (ext. 2171, building 1a, room 107).

DESY-Emergency Call: Tel. 2500

All accidents, fires, or other emergency situations should be reported via this telephone number. In the event of language difficulties the number of the telephone extension from which you are calling indicates where you are. The emergency call number alerts the DESY **Technical Emergency Service** which then arranges for all necessary assistance, e.g. Fire Service, Ambulance, etc. The Technical Emergency Service is available 24 hours a day, seven days a week. For more general information, and to report technical problems please use the telephone extension number 5555 or from outside DESY call ext. 8998-5555.

2. Safety Instructions
Except in the accompaniment of an experienced person, nobody is allowed to undertake any work or enter any experimental area at DESY without having first received instructions from the **local Safety Officer** on special dangers which might be expected, warning or alarm signals which could occur, rescue facilities which are available, and how one should react under emergency circumstances. The issue of a magnetic card allowing independent access to the HERA halls is also conditional on a course of instructions on local safety requirements. If it is intended to work over an extended period it is necessary to take part in a general DESY safety course provided by the group -D5-.

3. Companies and Firms

When engaging a firm or company to execute work on the DESY site the originator of the order is obliged to ensure that the local Safety Officer is informed of the work and that any employees of the company involved in the work receive adequate safety instructions.

4. Rules of the road

The general German road traffic regulations also apply on the DESY site. The maximum speed is 30 km/h (20 mph). Particular care must be taken due to the relatively large number of pedestrians on the roads. The transport of special loads over the site is also a hazard which can be regularly expected. One must drive particularly **slowly** in the vicinity of sharp curves, road works and building activities

5. Cranes and lifting tackle

According to German law, cranes and motorised lifting equipment may only be operated by authorised personnel. Appropriately trained and tested guests may receive limited authorisation to operate such equipment in agreement with ZMEA- (ext. 3714) and the safety group -D5- (ext. 3585 / 2865).

6. Electrical equipment

Electrical equipment at DESY must conform to the VDE standards. The experimental and accelerator areas contain a wide range of electrical equipment and it is not always possible to erect an enclosure around each individual item. Such rooms are therefore declared as electrical service rooms where only authorised personnel are allowed. Before commencing work in such areas you must contact the responsible Safety Officer and ascertain what possible hazards exist.
7. Strong electromagnetic fields Owners of **pacemakers or other implants** have to inform their local Safety Officer to get a safety instruction. As a rule notices warn of areas where strong **magnetic fields** may be encountered. Hazards of various kinds can be expected. People with heart pacemakers must avoid these places. Nobody should stay longer than is necessary in areas of strong magnetic fields. Large ferromagnetic objects can be subjected to strong, even irresistible, attractive forces which could lead to material damage or personal injury. Small magnetic items like the frames of glasses, small tools or a bunch of keys can be wrenched out of the hand and cause damage such as short circuits in electrical equipment or the puncturing of foils in gas systems. Many high frequency units working at **high power** are to be found around the DESY site. They are adequately screened externally and any work which might jeopardise this screening, e.g. loosening screws orflanges, is strictly forbidden.

8. Radiation Safety

During their operation particle accelerators emit radiation at a level which can be lethal. Doors leading into these areas have illuminated signs Zutritt verboten, Strahlung, Sperrgebiet" - No entry, Radiation, Prohibited area. A red lamp on the door indicates that the area is interlocked and opening the door causes an immediate switching off of the accelerator. Areas in which the radiation level is high, but within tolerance levels, are marked with the legend " Vorsicht Strahlung, Zutritt für Unbefugte verboten, Kontrollbereich" - Danger radiation, no entry for unauthorised persons, controlled area.

9. Gases

Gases come under the heading of hazardous materials. Gases must be handled in such a way that the DESY safety regulations are observed and no risks are taken. Instructions for the safe operation of the equipment must be kept available. Systems and pipes with flammable gases must be approved by the safety group -D5- (ext. 3585/2865) before they are put into operation.

Existing "no smoking" regulations are to be observed. Gases can only be procured through the gas stores -ZMEA6-. Exceptions are only allowed by agreement with Mr. von Schröder -ZMEA6- (ext. 3884). The standard German colour code is used to indicate the contents of gas cylinders. The handling of cryogenic, liquefied gases is restricted to particular groups. A detailed course of instruction is required before any work with these materials may be undertaken.

10. Working with Naked flames or sparks
Welding, cutting, soldering and grinding operations may only be carried out when they can be shown not to be dangerous. Because of the obvious risks associated with flying sparks proposals for such work must be agreed with the local Safety Officer before commencement. If they are to be carried out in the experimental halls -ZTS- must be informed in good time so that the necessary safety precautions can be taken. In order to avoid false alarms the technical emergency service must disable any smoke detectors in the immediate vicinity. On safety grounds, in fire risk areas a man with a fire extinguisher must be standing by during the work.

11. Equipment brought to DESY
Any equipment or apparatus brought to DESY by visiting groups, the operation of which could involve danger or risk, must be reported to the local Safety Officer and, when required, be inspected and approved by the safety group -D5-(ext. 3585/2085). Examples of such equipment are: pressure vessels, gas supply rigs, or electrical equipment. Please get in touch with the safety group -D5- in good time before putting your equipment into operation.

12. Hazardous materials and their disposal
Work involving hazardous materials must be reported to the local Safety Officer, any hazardous materials brought onto the DESY site must also be registered with him. There are rules for the disposal of such materials or contaminated items, and they must be observed. Mrs. Dundama (-D5-, ext. 2865), who is the DESY specialist in this field, will be pleased to help you.

13. Alcohol on the DESY site
Working under the influence of alcohol or the consumption of any type of alcoholic beverage at work is, for safety reasons, strictly forbidden over the whole of the DESY site

14. Further safety information
Detailed safety information with respect to working at DESY is to be found in:
-DESY Safety Regulations (-D5-),
-Safety Information for Guests (-V1- and the Guest Office)
-DESY Radiation Protection Regulations (D3)
-HASLAB Safety Regulations (HASYLAB)