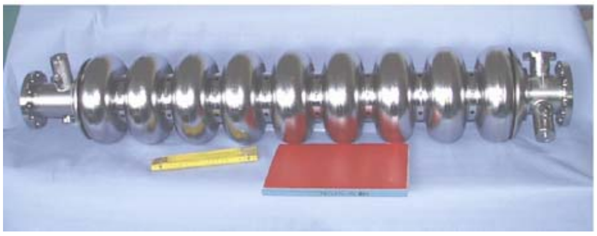
SRF



“Improved Standard Cavity Fabrication”

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CARE JRA1 WP2 "Improved Standard Cavity Fabrication"

Task 2.2: Improved component design

Milestone 2.2.1.3: summary report on the status of art on ancillaries on the experience of various laboratories involved in SC RF.

Summary

This document describes and reports the information retrieving activity performed, in the CARE SRF context, for the Superconductive Cavities ancillaries.

The retrieving and the analysis of the experience of different laboratories working in the field of SC cavities is the first step foreseen for the modification both of the cavity design and the preparation procedure, to improve the performance and the reliability of the SRF accelerating system.

This document is mainly based on the experience of DESY (TTF 1, TTF 2), SNS, RIA and the European ADS activity.

We collected information as technical drawings, data, pictures, assembling procedures, materials, etc. relative to the following items: cold flanges, He tank, and cavity stiffening.

In particular, for what concerns the flanges and the sealing that have to operate at cryogenic temperatures, we have collected the main parameters as the flange and sealing materials, the dimensions, the closing torque, together with some technical drawings. Besides of that, we collected also the data relative to commercial cold connections as Helicoflex.

The information has been referenced and a list of the papers and the sources of the information are reported at the end of the document.

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Summary report on the status of art on ancillaries on the experience of various laboratories involved in SC RF.

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1 Introduction

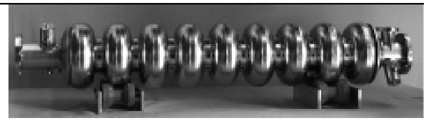
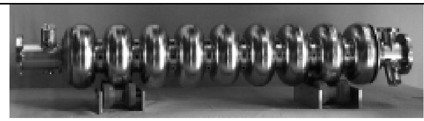
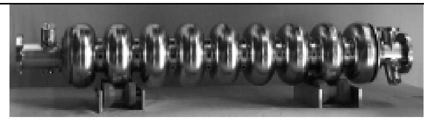
Ancillaries information retrieving: laboratories and projects.

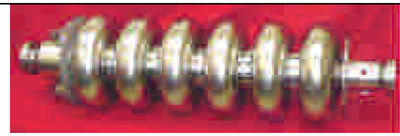
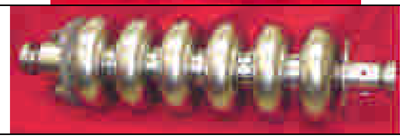
For SC cavities ancillaries information retrieving we analyzed different projects and laboratories: DESY (TTF 1, TTF 2, TESLA, XFEL), CEBAF, SNS, RIA, XADS / TRASCO, JAERI, KEK-B, etc. We concentrated our effort retrieving data relative to cavity stiffening, helium vessels and cold flanges. The final aim is to make available information that will be used in the next future for the improvement of the SC cavities performances and reliability, foreseen in the CARE SRF program.

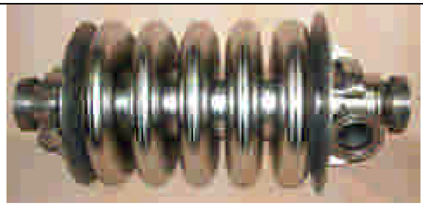
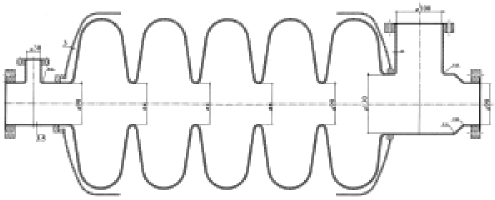
Our work has been organized retrieving information from published papers, drawings, talks, presentations, from the web and private communication.

First is presented a concise summary of the main characteristics of the existing projects in the different laboratories: the rules employed in this first selection are mainly the use of massive Nb cavities, the number of cavities produced/used for the machine, the availability of information, etc.

The large part of the document is based on the information available from DESY (TTF 1, TTF2, TESLA, XFEL), CEBAF, SNS, RIA and the European ADS activity.

	lab.	beam	structure	Cavities and cryomodules	Images	Status
TESLA (TeV Energy Superconducting Linear Accelerator)	DESY, TESLA-collaboration	Pulsed (RF pulse=1.3ms)	Electron positron linear collider	9-cell, 1.3 GHz, Eacc = 35MV/m, β=1; 8-cavities per cryomodule		Only project
TTF I (Tesla Test Facility)	DESY, TESLA-collaboration	Pulsed (RF pulse=1.3ms)	Electron linac, equipped with SASE FEL (saturation @ 80nm)	9-cell, 1.3 GHz, Eacc >15MV/m, β=1; 8-cavities per cryomodule		In operation from 1998 to 2003. Dismissed in 2003
TTF II (Tesla Test Facility)	DESY, TESLA-collaboration	Pulsed (RF pulse=1.3ms)	Electron linac, equipped with VUV SASE FEL	9-cell, 1.3 GHz, Eacc >25MV/m, β=1; 8-cavities per cryomodule		Start operation in 2004
CEBAF (Continuous Electron Beam Accelerator Facility)	TJNAF	CW	Recirculated linac. Designed for 4 GeV (CEBAF I), achieved 6.5 GeV. New goal to 12 GeV in '06 (CEBAF II), 24 GeV in '10, Eacc =12MV/m.	5-cell, 1.5 GHz, Eacc = 5MV/m, Q_0=2.4x10^9; 8 cavities per cryomodule		First layout finished in 1993. Upgraded from 1994 to 2006. In operation
				7-cell, 1.5 GHz, Eacc=12.5MV/m, Q_0=6.5x10^9; 8 cavities per cryomodule		

project	**laboratories**	**beam**	**structure**	**Cavities and cryomodules**	**Images**	**Status**
SNS (Spallation Neutron Source)	ANL, BNL, LANL, LBNL, ORNL	Pulsed	Accelerator-based neutron source composed by a front-end-system, linac (from 185 MeV to 840-1300 MeV), accumulator ring, target	6-cell, 805 MHz, β=0.61, Eacc=10.2MV/m, Q=$5x10^9$; 3 cavities per cryomodule		Under construction (start in 1999, will be finished in 2006)
				6-cell, 805 MHz, β=0.81, Eacc=12.3MV/m, Q=$5x10^9$; 4 cavities per cryomodule		
RIA (Rare Isotope Accelerator)	NSCL, MSU, TJNAF	CW	Heavy ions driver linac accelerator (to 400 MeV, 400 kW)	6-cell, 805 MHz, β=0.47, Eacc=8MV/m		Project started in 2000
				6-cell, 805 MHz, β=0.61, Eacc=10.2MV/m, Q=$5x10^9$;		
				6-cell, 805 MHz, β=0.81, Eacc=12.3MV/m, Q=$5x10^9$;		

project	laboratories	beam	structure	Cavities and cryomodules	Images	Status
ADS (Accelerator Driven System) European activity	INFN TRASCO (TRAsmutazione di SCOrie)	CW	High intensity superconducting proton accelerator in 3 section @ 700 MHz (5-cell: β=0.5, 5-cell β=0.65, β=0.85). Goal is 100-1600 MeV, 25mA	5-cell, 704.4 MHz, β=0.47, E_{acc}=8.5MV/m [1], [2], $Q_0>10^{10}$[3], $Q_0=5x10^9$[1]		Project started in 1999. End: 2002.
	PDS- XADS (Experimental Accelerator Driven System) 5th EU program			5-cell, 704 MHz, β=0.65, Eacc =10 MeV/m [4]	 	R&D on progress Study started in 2001 and finished in 2004.

2 Cavity stiffening

Due to high field and pulsed operation, the Lorentz force produces a detuning of the cavity with respect to the RF supply system. This fact, together with the extremely narrow bandwidth of the SC cavities, forces to develop more stiff accelerating structures.

Recently, stiffening rings have been added also to cavities in not pulsed accelerating structures. This choice is mainly due to the necessity to increase the mechanical stability of the cavities (as in the case of low beta cavities like the TRASCO , SNS and RIA) and to reduce the effect of vibrations (as microphonics).

A summary of data derived from literature and relative to cavity stiffening will be presented, after a brief introduction of main principle of cavity behavior in pulsed RF regime.

2.1 *TESLA/TTF*

LORETZ FORCE DETUNING AND CAVITY STIFFENING

Design and principal parameters of the 1.3 GHz TTF 9-cell cavity (RF pulses of 1.3 ms) (designed for TESLA-500) [5],[6] are in Table 2.1

Coupling cell to cell	1.98 %
Nominal gradient E_{acc} (TESLA-500)	23.4 MV/m
Quality factor	$>10^{10}$
Active length	1038 mm
Cell-to-cell coupling K_{cc}	1.87 %
Iris diameter	70 mm
R/Q	1036 Ω
E_{peak}/E_{acc}	2.0
B_{peak}/E_{acc}	4.26 mT / (MV/m)
Tuning range	+/- 300 kHz
$\Delta f/\Delta L$	315 kHz / mm
Lorentz force detuning constant K_L	1 Hz / $(MV/m)^2$
Q_{ext}	$2.5x10^6$
Cavity bandwidth ($Q_{ext}=3x10^6$) [5]	433 Hz
Cavity bandwidth ($Q_{ext}=2.5x10^6$) [6]	520 Hz

Tab. 2.1: Design and principal parameters of the 1.3 GHz TTF 9 Cell cavity

The mechanical stability is a fundamental problem for RF SC cavities.

The behavior of the cavity depends also on other ancillaries mechanically connected to the cavity, as the helium tank, the tuning system, etc.

The choice of the strategy for the cavity stiffening should be a compromise, for instance, between the cavity mechanical stability (more thick and stable cavities), and the heat exchange capability (more thin cavities, cheaper solution) [7].

At high accelerating gradient the cavity could be driven out of resonance by the submicron mechanical deformations under Lorentz force detuning [7]: the steady state Lorentz force detuning at constant accelerating gradient E_{acc} is:

$$\Delta f = K_L E_{acc}^2$$

This quadratic dependence is also reflected in the dynamic Lorentz force detuning during the RF pulse.

The pulsed operation leads to a time-dependent frequency shift of the 9-cell cavities. The stiffening rings joining neighboring cells are adequate to keep this Lorentz-force detuning within tolerable limits only up to the nominal TESLA-500 gradient of 23.4 MV/m., considering a cavity bandwidth of 434 Hz [7] for the TESLA 9-cell specification the of cavity (@ $Q_{ext} = 3x10^6$).

For detailed information about relationship between cavity deformations, the effect of the Lorentz force detuning etc, see for instance reference [7] and [5].

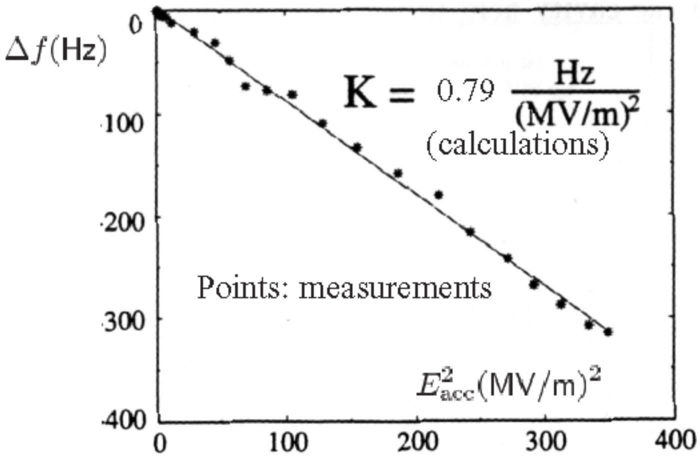


Fig. 2.1: Measurement and calculation of the K_L [7]

Actual stiffening geometry and cavity parameters are reported in the following table 2.2:

9-cell, 1.3 GHz	
Lorentz Force Detuning without stiffening (cavity thickness of 2.5mm)	900 Hz @ 25MV/m [8]
Lorentz Force Detuning with stiffening (cavity thickness of 2.5mm)	About 500 Hz @ 25MV/m for 1.3ms long RF pulse [8]
Tuning range	+/- 300 kHz [8]
Δf/ΔL	315 kHz /mm [8]
Cav. Bandwidth equip. with RF coupler	430Hz (Q_{ext}=3x10^6) [8], 520Hz (Q_{ext}=2.5x10^6) [6]
Stiffening material	Nb [8]
Stiff. Geometry	Nb ring, welded in between adjacent cells [8]. 2mm thickness [See fig. 2.4 and 2.5]
Stiff. Position	56.5mm from the cavity axis

Tab. 2.2: Actual stiffening geometry and cavity parameters for 9 cells 1.3 GHz

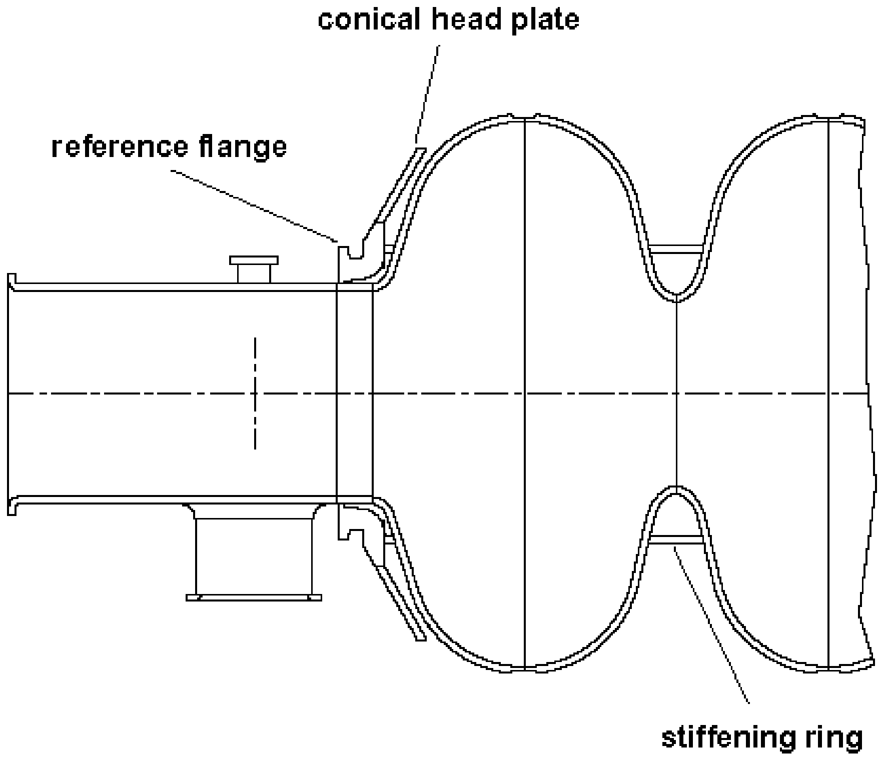


Fig. 2.2: Sketch of the TTF cavity: stiffening ring, reference flange and conical head plate are shown.

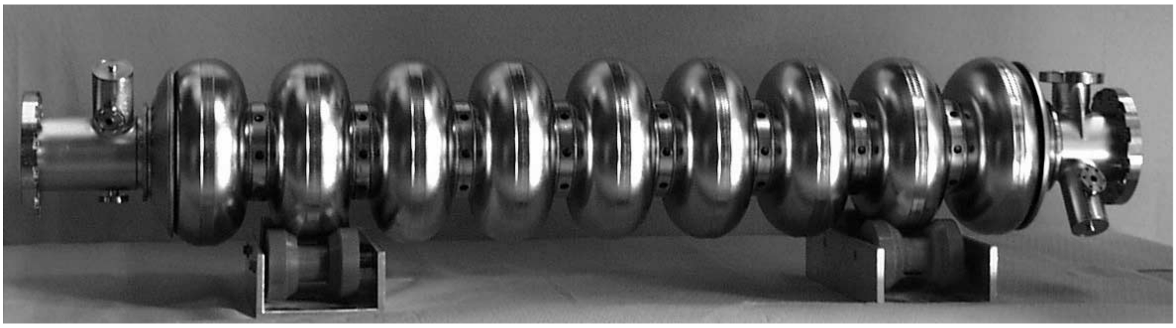


Fig. 2.3: 9 cell TTF cavity with stiffening ring and ancillaries [8]

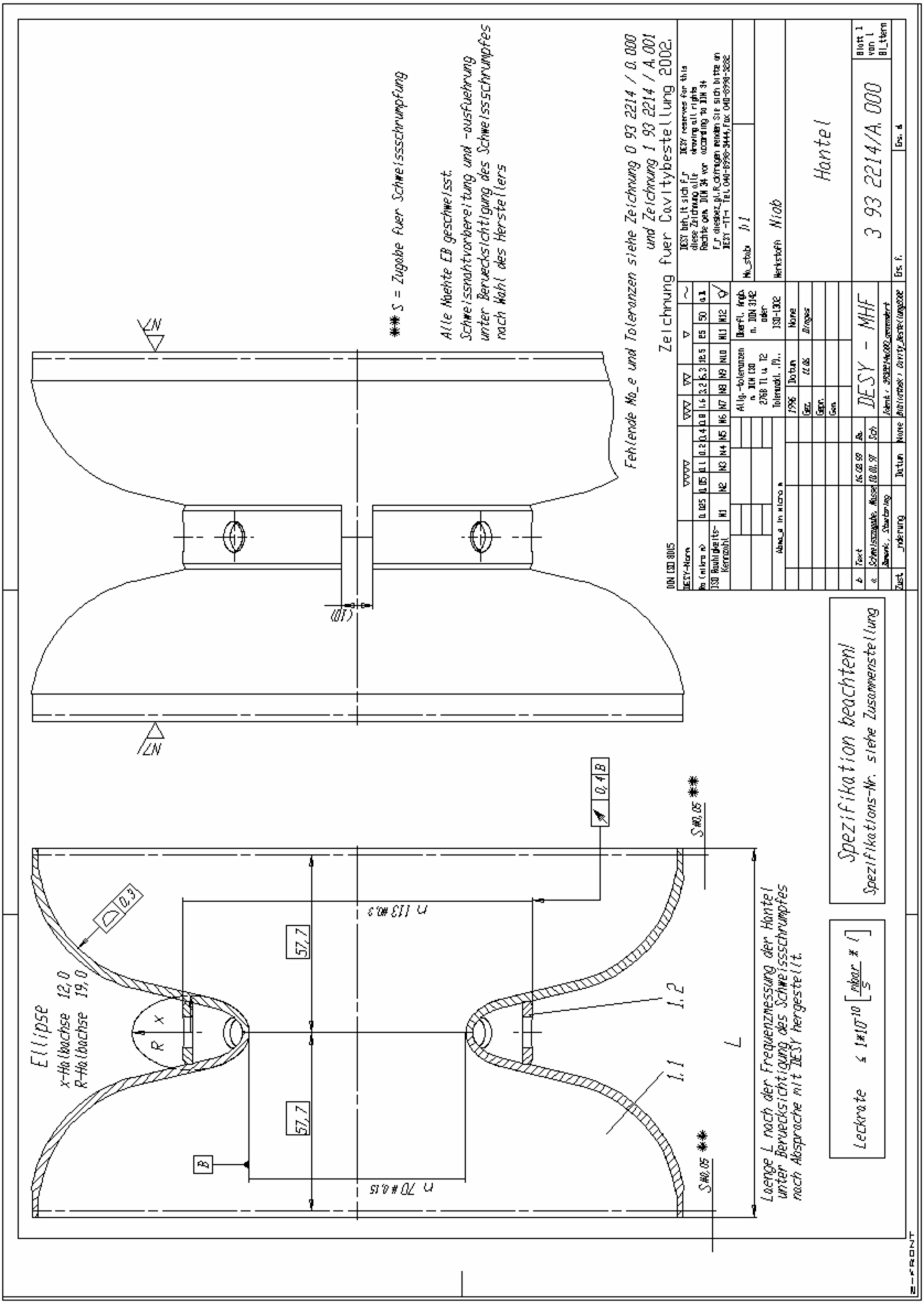


Fig. 2.4: TTF Dumb bell with stiffening ring.

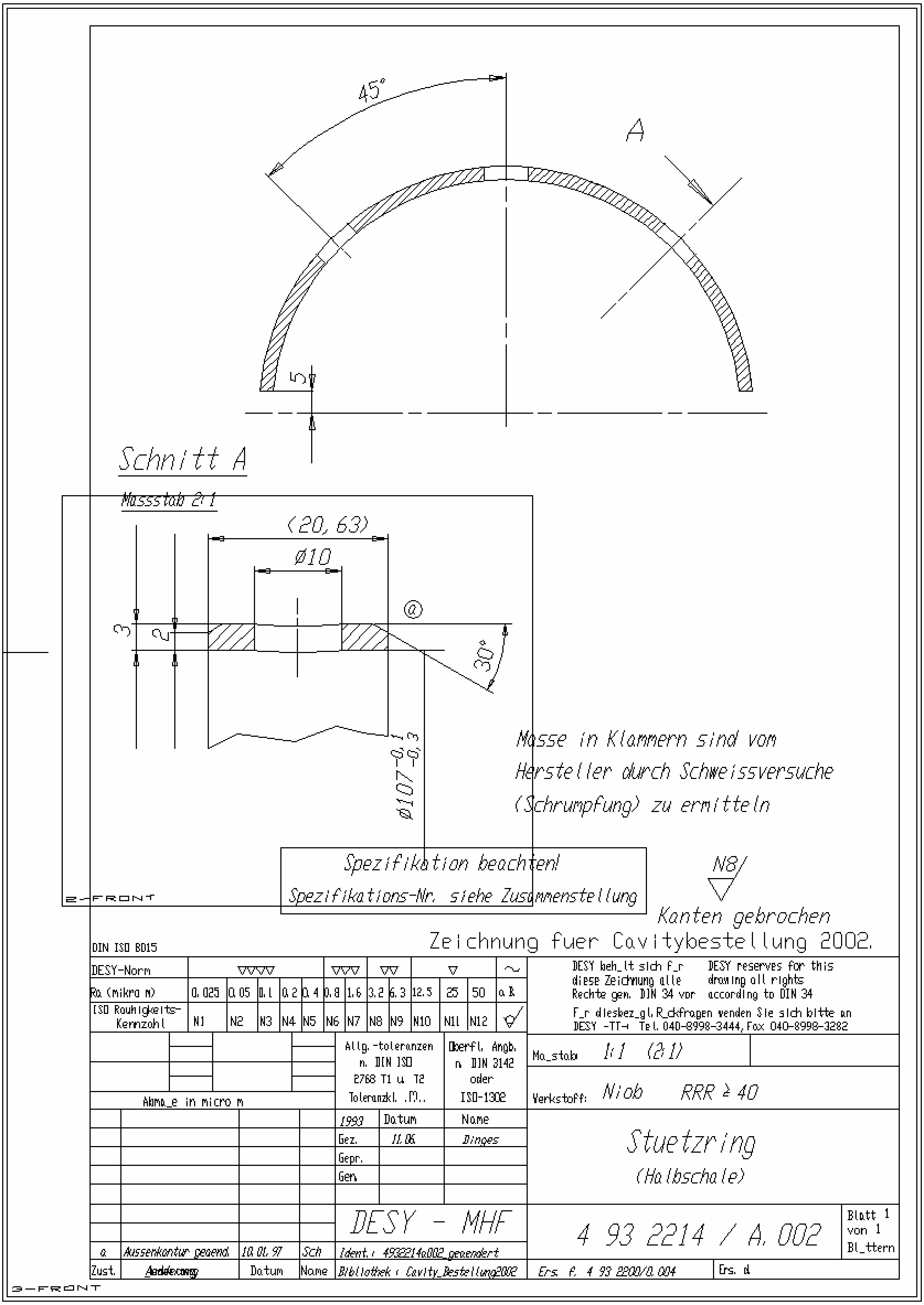


Fig. 2.5: Stiffening ring for TTF cavities

For TESLA-800, the request is to have higher field: Eacc = 35 MV/m [6]: in this case, improvement on the stiffening solution is needed or the cavity deformation must be compensated for instance using a piezoelectric tuner. [6].
Two different strategies have been proposed: the first is based on an improvement of the cavity mechanical properties, the second one foreseen an active deformation compensation using for instance piezo actuators.

(1) Improvement of mechanical properties
    (a) plasma spray
    (b) plasma spray + stiffening rings

(1a) Stiffening by plasma spray

Experimental and computational data shows that the EB welded stiffening rings alone allow a frequency shift of the TESLA 9-cell SRF cavities higher than the cavity bandwidth above Eacc = 28 MV/m [9].
Reference [9] is relative to a proposal of a new stiffening method using a Plasma Sprayed Copper Layer (PSCL) onto bulk Nb cavities. Test of a 1.3 GHz single-cell using the APS (Atmospheric Plasma Spray) technique. Cavity thickness = 2.5 mm of NB (RRR=200), stiffened by 2.5 mm thick copper layer (intermediate 0.2mm thick bonding layer of bronze/aluminum alloy, between Nb and Cu) [9].
In 2001 other tests were performed on a 1.3 GHz TESLA single-cell [10], using a new technique, IPS (Inert gas Plasma Spraying). The following table shows the results.

Coating	3.5 mm Cu layer
Coating porosity and oxidation	8% and very low oxidation
Elastic properties	
Young modulus	72 GPa
UTS	124 MPa
Porosity	8%
Maximum elongation	0.2%
Bond strength	51 MPa
Thermal properties	
Thermal resistance	2 times higher respect to Nb alone
Cavity performances	
Before IPS (Nb alone)	30 MV/m
After IPS (Cu on Nb)	18 MV/m
After IPS (Cu on Nb) and BCP	25 MV/m
K_L (before IPS)	-7.4 Hz / (MV/m)^2
K_L (after IPS)	-2.5 Hz / (MV/m)^2

Tab. 2.3: TTF Cavity performances after the copper deposition: with 2.8 mm thickness of Cu (IPS) K_L goes from -7.4 to -2.52 Hz / (MV/m)^2 [7].

Figure 2.6 and 2.7 show the cavity before and after Cu deposition [10].

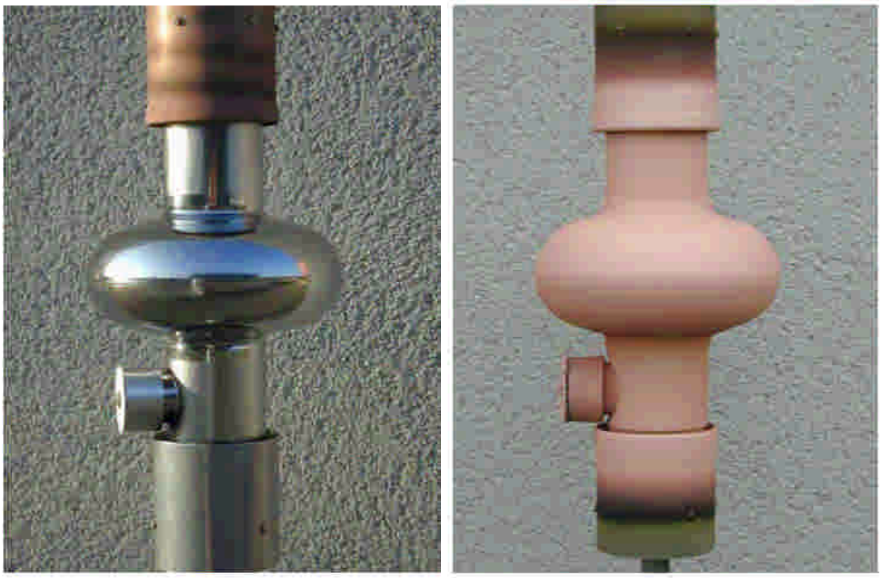


Fig. 2.6 and 2.7: Nb cavity Cu sprayed.

Calculation relative to the extrapolation for a 9 cell structure indicated that the Cu layer at the iris should be of the order of tens of mm [10]

Implications:

- Technical difficulties in the deposition process
- Higher force for cavity tuning

(1b) Mixed solution: using both the stiffening rings and the Cu coating [7]

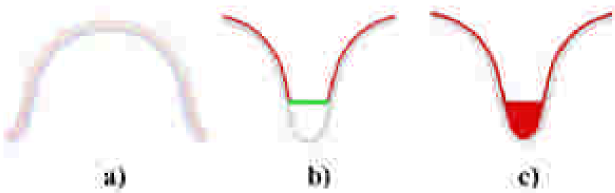


Fig. 2.8: Three different stiffenings: a) homogeneous Cu layer 2mm thick, b) Nb stiffening rings and Cu 2 mm, c) Cu layer 1.6mm and iris reinforcement 23mm.[10]

The proposed solution consists of:

- Spraying a 2mm Cu IPS coating on the cavity (reduction of the radial displacements)
- Cavity equipped with stiffening rings (reduction of the axial displacements)

In this case, disregarding the technical difficulties, the cavity stability should be guaranteed until E_{acc} = 34 MV/m, maintaining the possibility to tune cavity. [7]

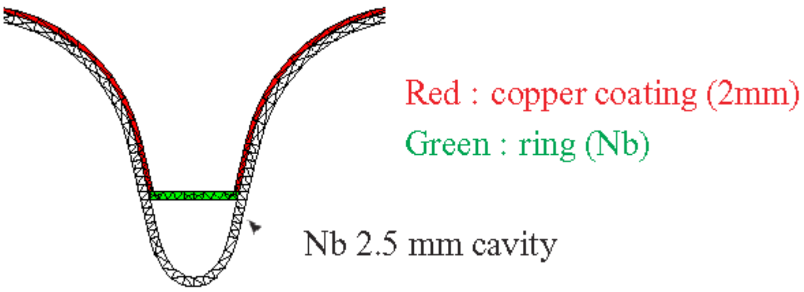


Fig. 2.9 : proposed mixed solution [7].

2 - Active deformation compensation using piezo actuators.

In this case, a piezo actuator acts on the cavity compensating the Lorentz force deformation.

Experimental test done at 25 MV/m, with a single pulse to the piezo actuator, indicates that this approach is feasible [11].

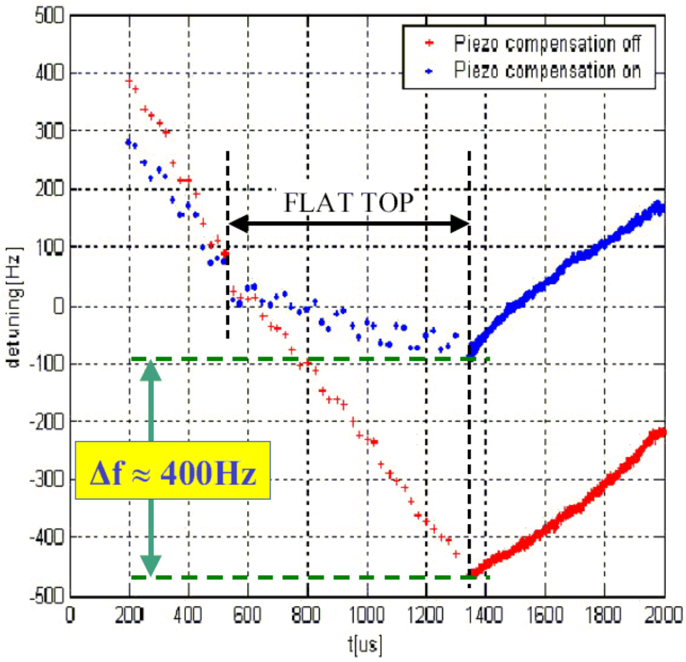


Fig. 2.10: detuning reduction by single pulse to the piezo [11]

For higher field (e.g. 35 MV/m) a resonant compensation test have successfully done [11].

2.2 SNS

LORETZ FORCE DETUNING AND CAVITY STIFFENING

SNS uses two different cavities, both at 805 MHz: β 0.61 and β 0.81.

Both cavities have been designed to ensure the following main parameters [12], [13]:

$E_{surf\ peak} \leq 27.5$ MV/m @ Eacc = 10.2 MV/m

$B_{surf\ peak} < 60$ mT @ Eacc = 10.2 MV/m

K_L <-3 Hz/(MV/m)^2

	β = 0.61, 805 MHz	**β = 0.81, 805 MHz**
Number of cells	6	6
Material	Nb	Nb
Thickness	3.8 mm	3.8 mm

Tab. 2.4: SNS main cavity parameters [12]

SNS 6-cell β = 0.61

The basic electromagnetic parameters for the SNS 6-cell β=0.61 are reported in the following table. The data relative to K_L has been calculated for fixed (ideal) boundary conditions [13]

Frequency [MHz]	805
E_{peak}/E_{acc}	2.71
B_{peak}/E_{acc} [mT/(MV/m)]	5.72
R/Q [Ω]	279
G (R_sQ_0) [Ω]	179
Cell-to cell *k* [%]	1.53
K_L [Hz/(MV/m)^2]	-2.07

Tab. 2.5: Basic Electromagnetic for the SNS β = 0.61.

Three medium beta cavities have been fabricated for the cryomodule prototype: their frequencies were within 150 kHz of the target value [13]. One cavity has been equipped with the He vessel prototype TIG welded: the frequency decreased by about 300 kHz [13].

The He vessel for cavity production will be stiffened by welding titanium cones on the two heads to lower the Lorentz force coefficient. [13]
Calculation for the assembly "cavity-He vessel-tuner" resulted in a static Lorentz force coefficient of about 3.64 Hz/(MV/m)^2 [13]. Therefore, further stiffening of the He vessel is necessary to achieve the specified values for the Lorentz force detuning. [14].

The next table shows a comparison between measurement and calculation results, for stiffened and unstiffened cavities, for the K_L [14]. Stiffening was at 70 mm (thickness 3 mm). In the final configuration, the stiffening ring diameter is moved to 80 mm.

β = 0.61	**Calculated values**		**Measured data**
	No stiffening	Stiffening @ 70mm	With stiffening ring
Fixed end	-2.89	-1.65	
Ti frame	-7.85	-7.0	-8.25
He vessel	-4	-3.55	
Free end	-31.1	-27.0	

Tab. 2.6: comparison between calculated and measured data for β = 0.61 [14]

In 2002 the K_L coefficient of a cavity equipped with He vessel and tuner was measured. [15]
Data are in the next table.

β = 0.61	Measured
With He vessel	-7 Hz/(MV/m)^2
With He vessel and tuner	-3 Hz/(MV/m)^2
Model (with He vessel and tuner)	-3.6 Hz/(MV/m)^2 (considering tuner stiffness = 2x10^6 kg/m) -2.9 Hz/(MV/m)^2 (considering tuner stiffness = 3.4x10^6 kg/m)

Tab. 2.7: K_L coefficient measurement in 2002. [15]

SNS 6-cell β=0.81

The basic electromagnetic parameters for the SNS 6-cell β=0.81 are in the next table: K_L has been calculated for fixed (ideal) boundary conditions [13]

Frequency [MHz]	805
E_{peak}/E_{acc}	2.19
B_{peak}/E_{acc} [mT/(MV/m)]	4.72
R/Q [Ω]	483
$G(=R_sQ_0)$ [Ω]	260
Cell-to cell *k* [%]	1.52
K_L [Hz/(MV/m)^2]	-0.43

Tab. 2.8: Basic Electromagnetic for the SNS β=0.81.

Comparison between measurement and calculation results for stiffened and unstiffened cavities of K_L [14]. Stiffening was at 80 mm (thickness 3 mm) as in the final configuration. Data are in Tab. 2.9.

β = 0.81	**Calculated values**		**Measured data**
	No stiffening	Stiffening @ 80mm	With stiffening ring
Fixed end	-0.78	-0.43	
Ti frame	-3.62	-3.5	-3.5
He vessel	-1.76	-1.58	
Free end	-12.2	-10.1	

Tab. 2.9: comparison between calculated and measured data for β = 0.81 [14]

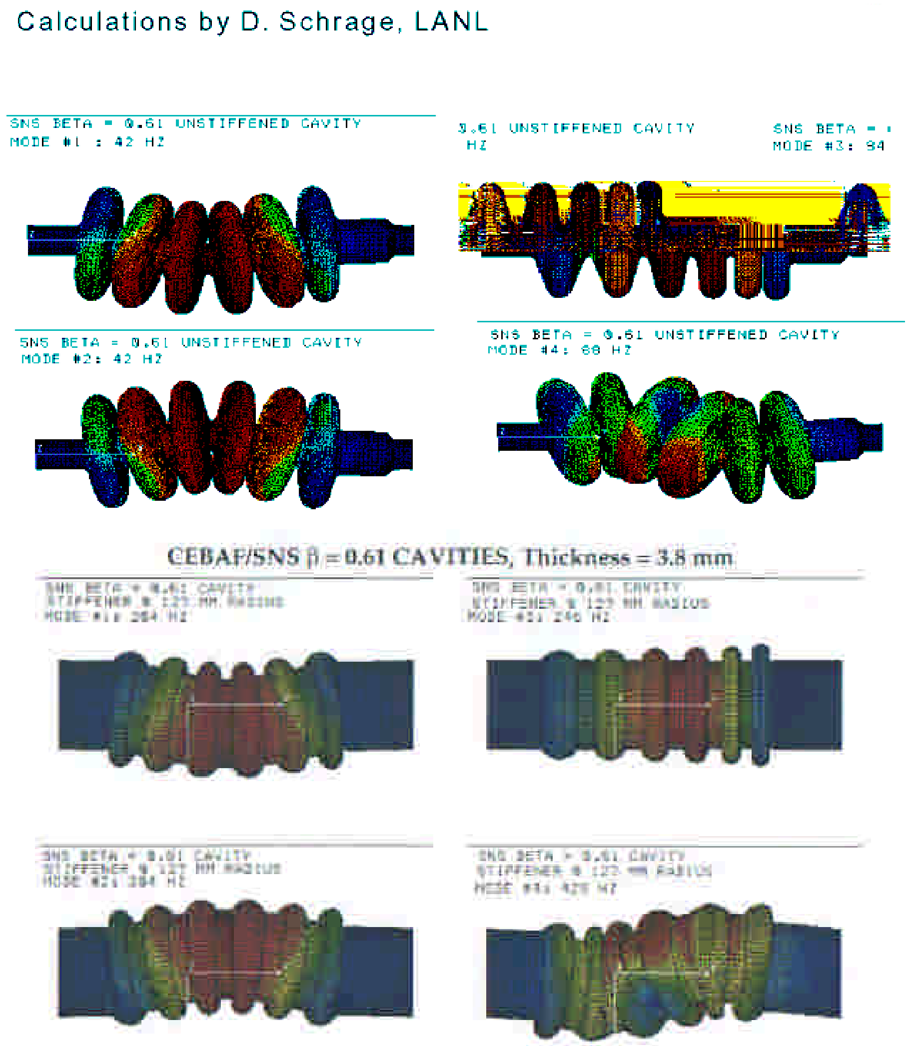


Fig. 2.11: Calculation for the possible vibration mode: stiffening was at 127 mm, for β = 0.61.[12]

The mass production of the cavities for SNS is done by ACCEL. [16].

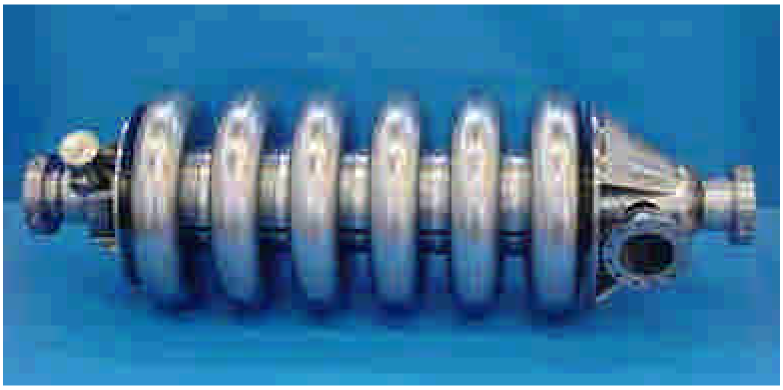


Fig. 2.12: β = 0.61 SNS cavity produced by ACCEL [16].

2.3 RIA

Rare Isotope Accelerator employs three kinds of elliptical cavities with β 0.47, 0.61 and 0.81.

Cavities with β 0.61 and 0.81 are the same as the SNS project.

The cavity β 0.47 is the only one that has been developed. [17]

STIFFENING for 6-cell, β=0.47 [18]	
Lorentz Force Detuning with stiffening	K_L = -13.7 Hz/(MV/m)^2, quite high but ok due to the CW machine [19] [20]
Stiffening material	Nb, Thickness= 3.8 mm
Stiff. Geometry	Stiffening ring

Tab. 2.10: RIA β = 0.47 stiffening parameters.

The high value of the Lorentz coefficient (K_L -13.7 Hz/(MV/m)^2, should not be a problem in itself, since RIA is a CW machine but microphonics may be an issue due to the relatively low beam loading. [19].

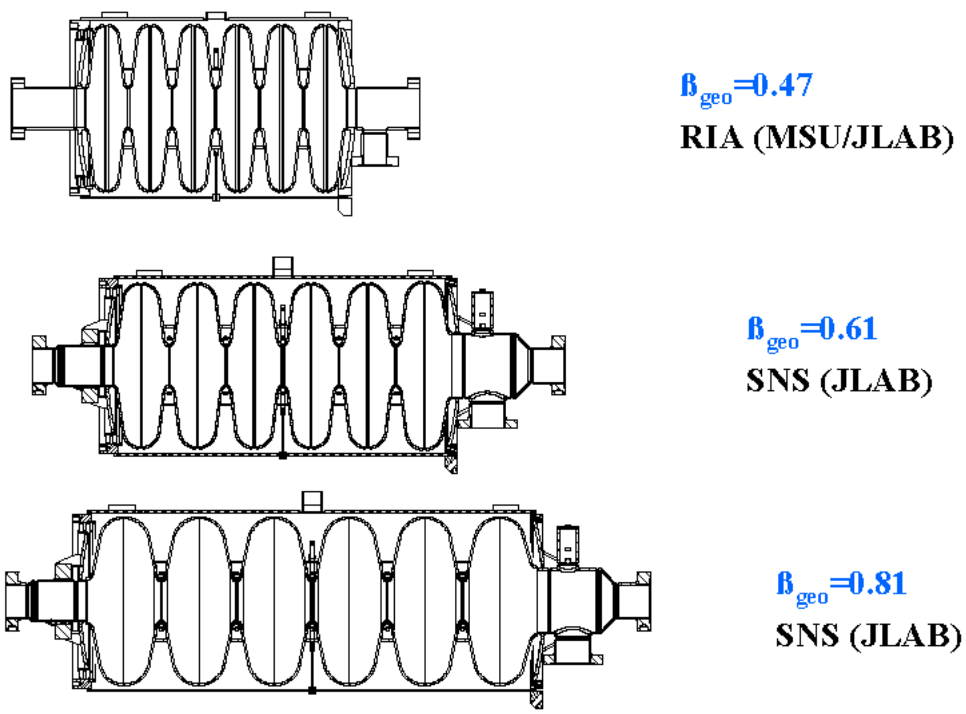


Fig. 2.13: RIA cavities. Stiffening rings are shown. [21]

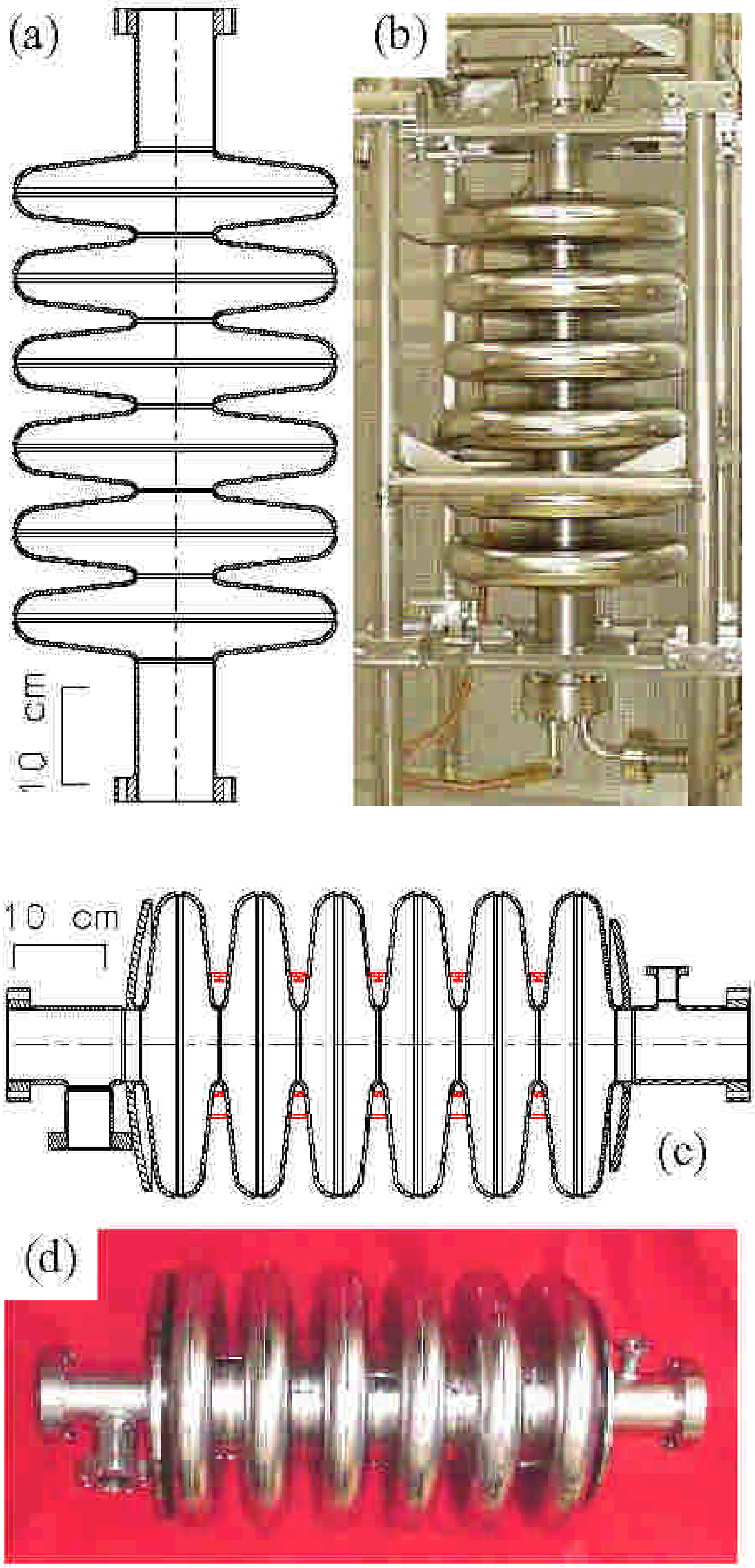


Fig. 2.13. a) Drawing of the β 0.47 without stiffening ring. b) Picture of the same cavity during vertical test. c) and d) Drawing and picture of the stiffened β 0.47 cavity. [18]

2.4 European ADS program: TRASCO and XADS

2.4.1: TRASCO

The main parameter of the low beta (β=0.47) 5 cell TRASCO cavity are reported in the Tab. 2.11. [22], [1]

Geometrical parameters [22]	
Cell geometry length (mm)	100
Cavity length (mm)	900
Iris diameter (mm)	80
Cavity thickness (mm)	4.2
Cavity electromagnetic parameters [22]	
Max E_{peak}/E_{acc}	3.57
Max B_{peak}/E_{acc}	5.88
Cell to cell coupling (%)	1.34
R/Q (Ω)	160

Tab. 2.11: TRASCO β=0.47 main parameters.

Due to its shape, this cavity has been stiffened with TESLA-like welded stiffening rings in order to reduce the Lorentz force detuning, at the operating accelerating field, from about 1 kHz to 620 Hz [22].

Calculations have been done with an accelerating field corresponding to the maximum nominal peak magnetic field of 50 mT on the cavity walls [22]. Moreover, the thickness of 4 mm together with stiffening rings allows maintaining the stresses in all conditions below 50 MPa [22] (e.g. the stress caused by pressure differences).

Stiffening	
Lorentz Force Detuning with stiffening free ends	- 90 Hz/(MV/m)^2 [1]
Lorentz Force Detuning with stiffening fixed ends	- 7 Hz/(MV/m)^2 [1]
Stiffening material	Nb, thickness 4.2 mm
Stiff. Geometry	Ring see Fig. 2.14
Stiff. Position	Ring positioned 70mm from the axis [1], [23].
Welding	Electron beam welding
Notes	Stiffening for mechanical stability (CW)

Tab. 2.12: TRASCO 5-cell cavity, β = 0.47 cavity stiffening characteristics.

Two 5 cell cavities have been produced, namely Z 501 and Z502. Measurements done at JLAB and SACLAY have show, on the stiffened cavity, K_L value ranging between - 20 to - 47 Hz/(MV/m)^2 depending on the boundary conditions of the tests. [1].

Fig. 2.14 shows the stiffening ring, Fig. 2.15 the stiffening ring position and the bell profile.

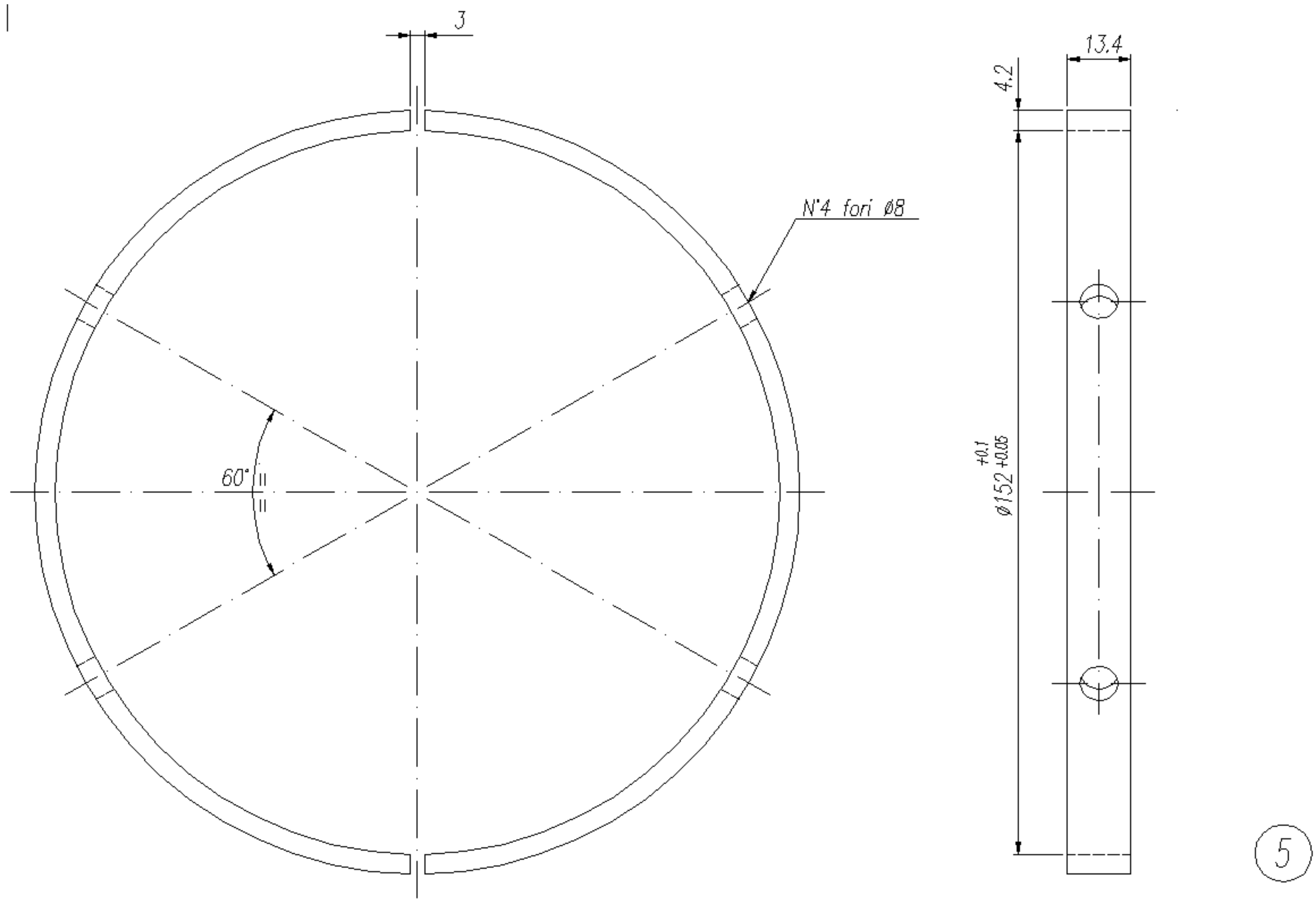


Fig. 2.14: TRASCO stiffening ring .

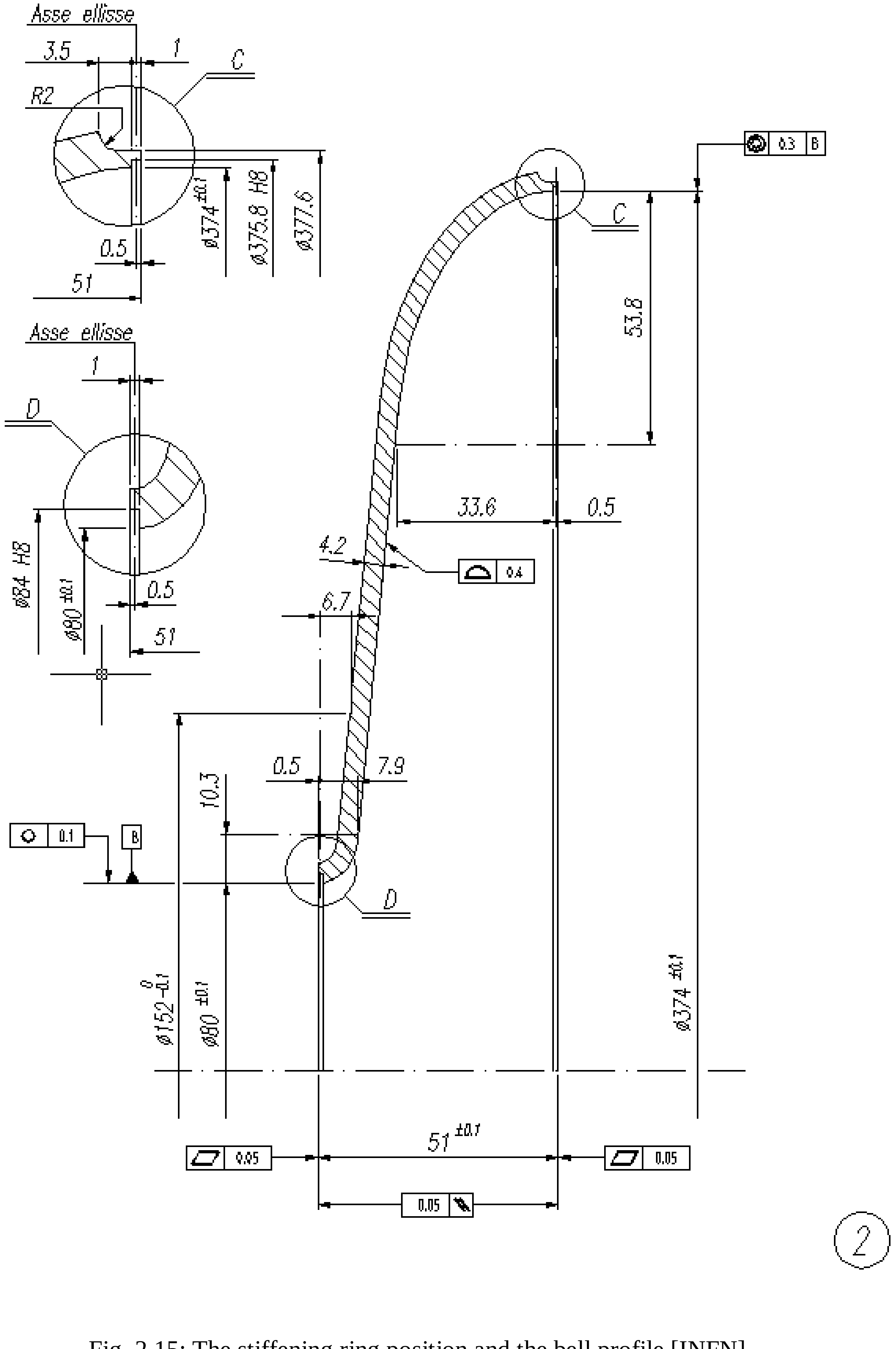


Fig. 2.15: The stiffening ring position and the bell profile [INFN]

2.4.2: XADS

The project is relative to a high power proton CW linac, operating at 700 MHz, with the possibility to operate also as a pulsed machine [7].

Low beta cavities (5-cell $\beta = 0.65$) have been produced and tested.

Cavity parameter [7], [4]	
Cell type	700 MHz 5-cell proton cavities, $\beta = 0.65$
E_{peak} / E_{acc} @ 11 MV/m	2.32
H_{peak} / E_{acc}	4.48 mT/(MV/m)
Wall thickness (calculated by stress distribution analysis, under vacuum (2bar))	4 mm
Stiffening ring	no

3 He Vessel

Th Helium vessel contains the helium needed for cooling and serves at the same time as a mechanical support of the cavity and as a part of the tuning mechanism. Besides that, it is usually used for the transfer of the forces that the tuning system applies to the cavity.

3.1 TESLA/TTF

Three different models of Helium vessel have been realized for TTF.

The first one was used for the first modules produced.

The second one is to superstructures.

Third model is relative to modules 4 and 5.

Figure 3.1 shows the cross section of the three different models of cryomodules, each model has its own helium tank.

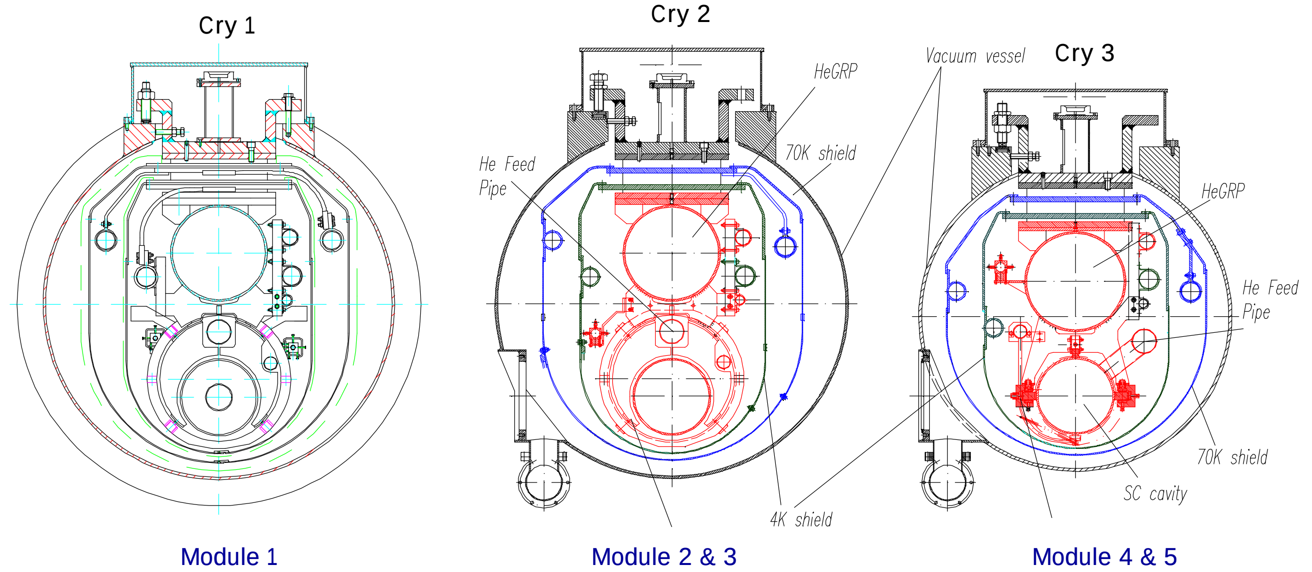


Fig. 3.1: cross section of the three different kind of cryomodules used for TTF.[24]

He VESSEL				
Material	**He vessel components**	**Welding technique**	**Assembly procedure**	**Tuning system**
Ti	2 conical head plates (Nb), 1 Ti bellows, 1 Ti ring, 1 Ti vessel.	EB welded to Nb.	1 Ti bellows is EB welded to the conical Nb head plate at one side of the cavity. 1 Ti ring is EB welded to the conical Nb head plate at the other side. The cavity is then inserted into the tank. Bellows and Ti ring are TIG welded to the Ti vessel.	The Tuning system is linked to the He vessel. It consists of a stepping motor with gearbox and a double lever arm. Moving parts operate @ 2 K in vacuum.

Tab. 3.1: He vessel characteristics [8].

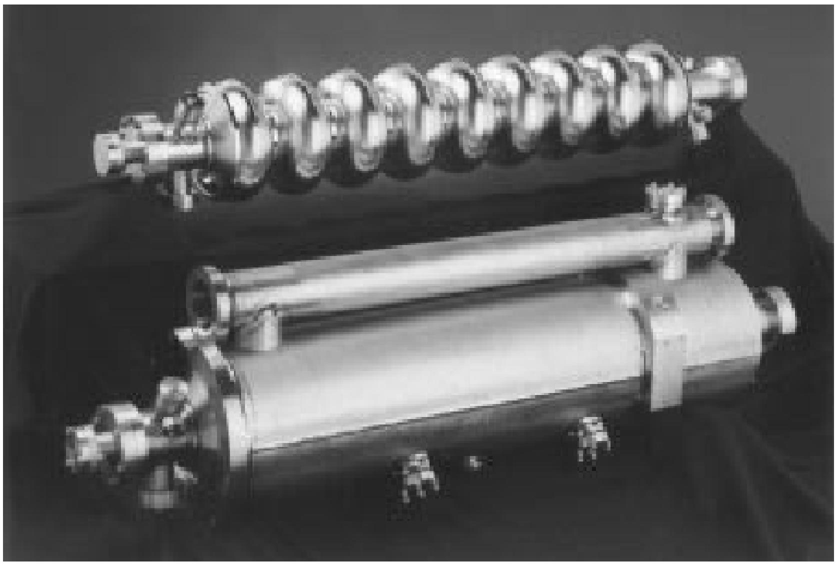


Fig. 3.2: First model of the helium vessel: the two phase feeding tube is on the axis of the structure. [25]

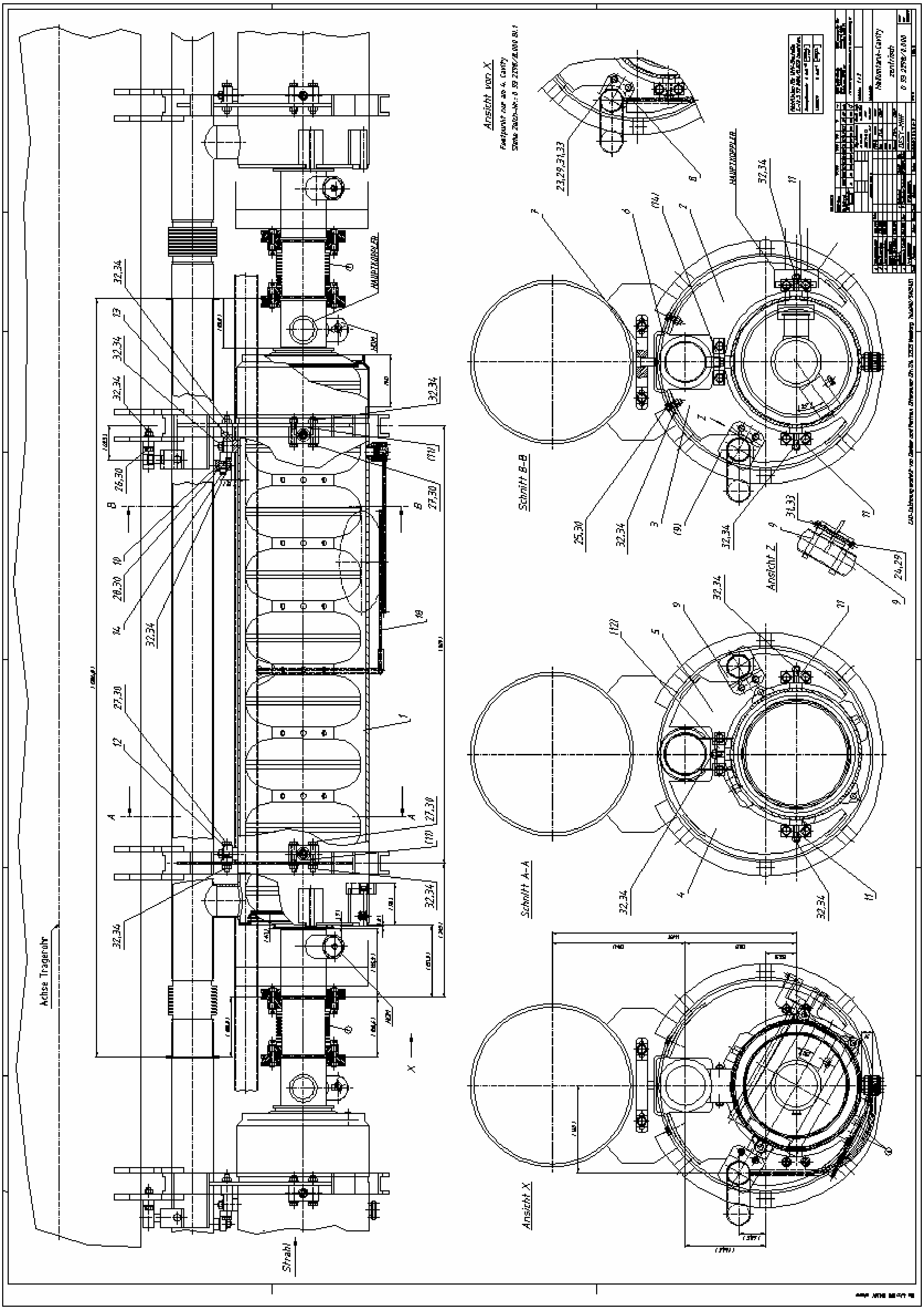


Fig. 3.3: First model of the helium vessel.

A second model of the helium vessel was used for superstructures. The drawing is shown in Fig. 3.4.

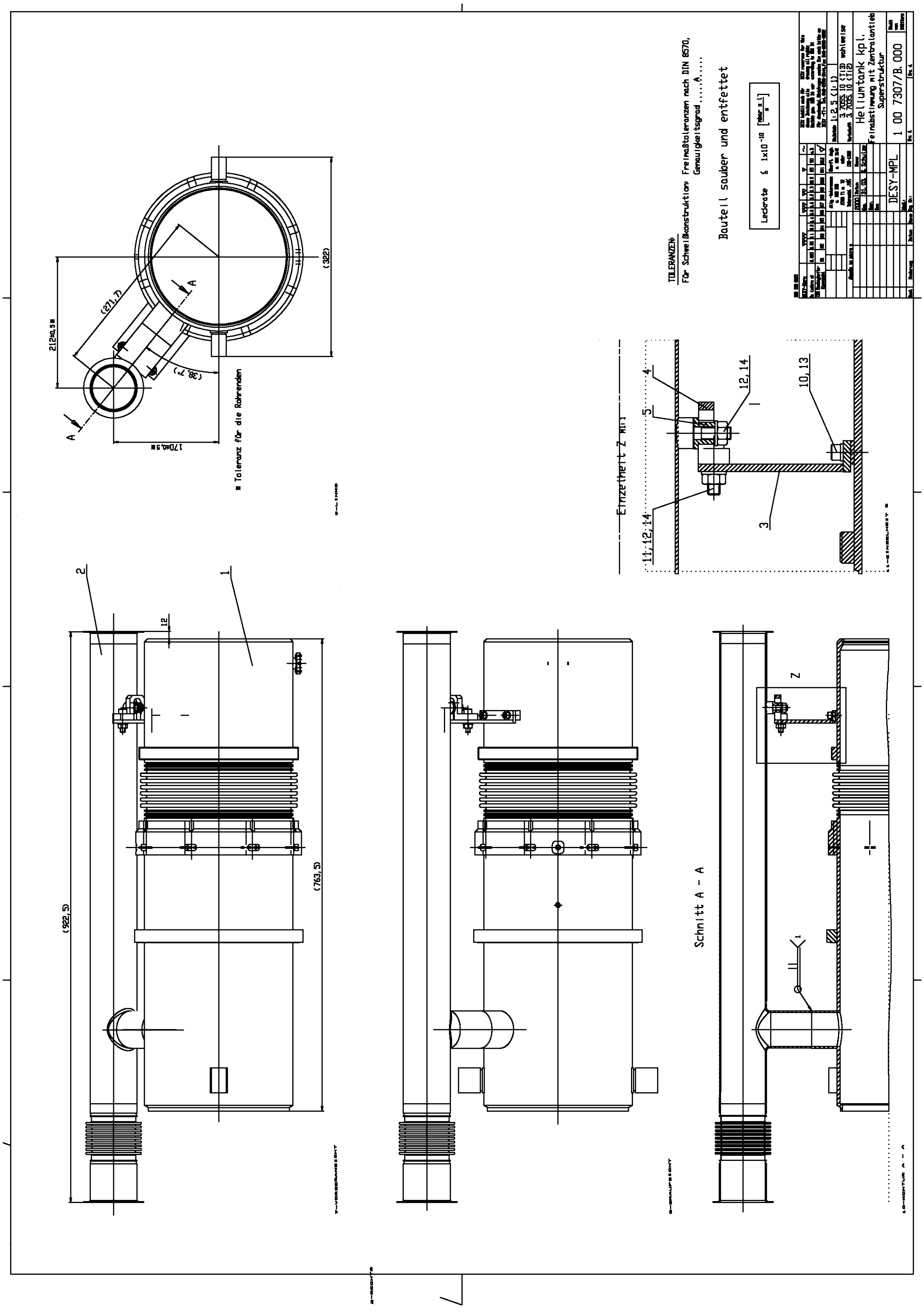


Fig. 3.4: Helium vessel for the superstructures.

Modules 4 and 5 (CRY3) use a different helium vessel. Fig. 3.5 shows the new helium vessel.

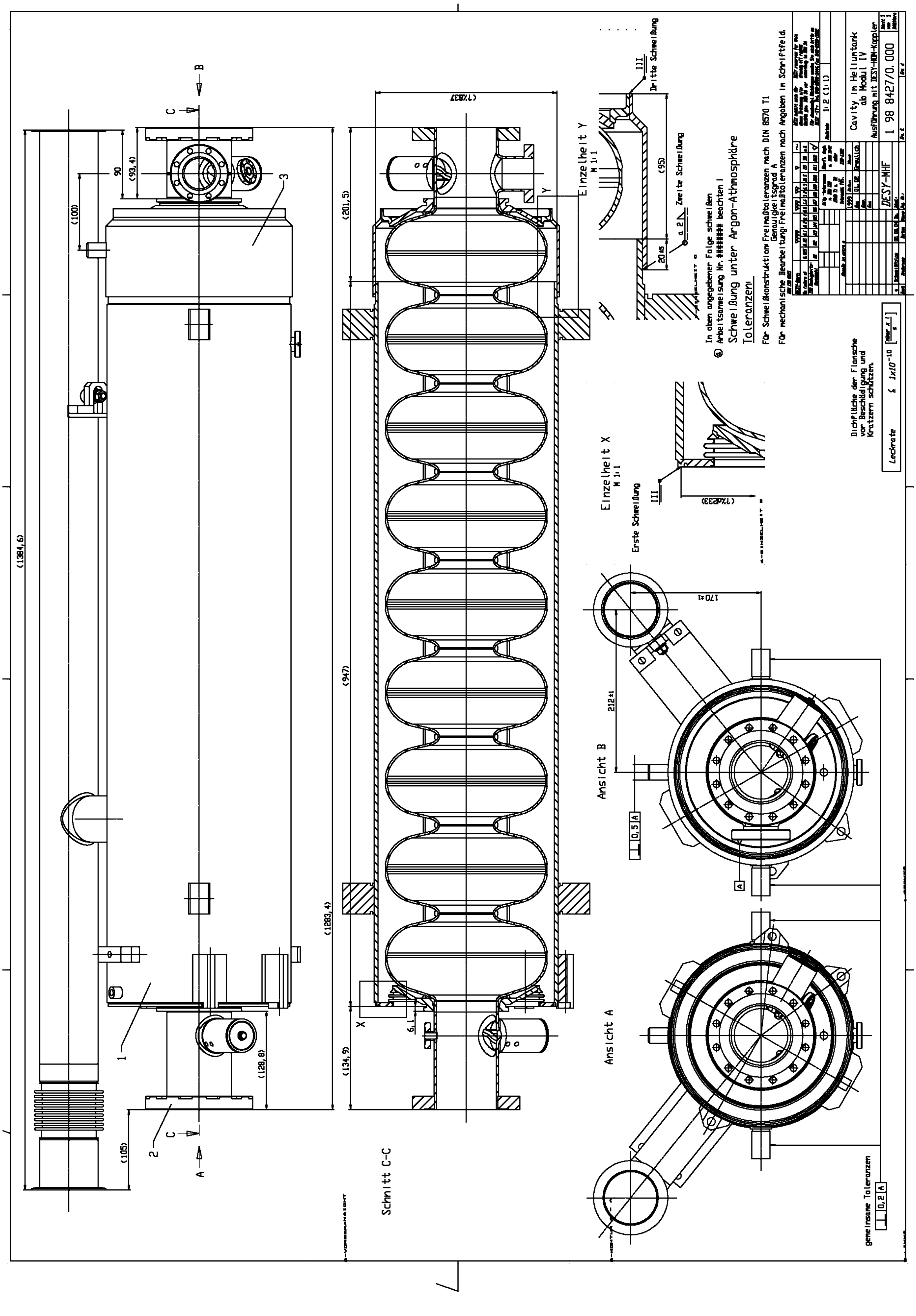


Fig. 3.5: CRY 3 Helium vessel with SC cavity.

3.2 CEBAF

He VESSEL for 7-cell cavity				
Material	**He vessel components**	**Welding technique**	**Assembly procedure**	**Tuning system**
Ti [26]	2 heads (Ti), 2 bellows (Ti), 1 cylindrical shell (Ti), 1 Nb-Ti transition ring [41]. The He vessel has been reduced from 0.61 to 0.25 meter diameter by moving the RF couplers outside of the vessel (2 Ti bellows are incorporated into the vessel) [26], [27]		The heads are welded to a niobium-titanium transition ring, which is part of the cavity end group. The bellows are located near the helium vessel head opposite the FPC and enable cavity tuning. The helium vessel heads are added to the cavity after any high temperature baking in order to avoid embitterment of the titanium. [26]	It consists of a coarse mechanical tuner and a fine piezoelectric tuner. All the components are cold, including the motor, harmonic drive and piezoelectric actuators.[26]

Tab. 3.2: CEBAF Helium vessel main characteristics

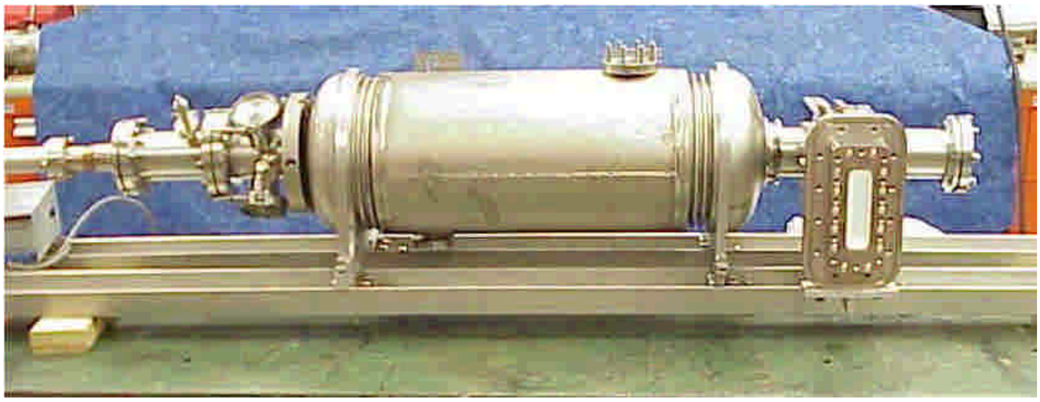


Fig. 3.6: CEBAF He –tank for 7-cell cavity [28]

Fig. 3.7: JLab “OC” shape, 1.5GHz, 7-cell niobium cavity with helium vessel removed [29]

3.3 SNS

The He vessel design (developed with an ASME pressure vessel code) was dictated by [30]:

- a five-atmosphere internal pressure requirement due to the potential upset condition from loss of beamline vacuum
- a two-atmosphere internal pressure requirement due to the potential upset condition from loss of insulating vacuum

He vessel for 6-cell β = 0.61	
Material	Ti, Nb/Ti [12]
He vessel components	Bellow: Ti (hydro-formed [16]), Dished head: NbTi (thickness = 6.35 mm) [30], shell: Ti (thickness = 4.76 mm)
Dimension	Tubes: diameter = 24 in.=610 mm [30], thickness = = 4.76 mm [30]
Welding technique	Ti He vessel TIG welded [13]. The He vessel for cavity production will be stiffened by welding titanium cones on the two heads to lower the Lorentz force coefficient [13].
Assembly and welding procedure	The welding of the helium vessel started with the tack weld of the first head, followed by the cylinder. A three-arm spider is then bolted at the centre of the cavity and then welded to the cylinder. The spider is used to support the cavity against transversal forces. The second helium vessel head is then tack welded to the cavity end dish and to the cylinder. The cavity was then set horizontally on a rotating fixture for full welding, using skip-welding technique. Each helium vessel is equipped with one heater and two diodes for temperature measurement. In one helium vessel per cryomodule, there are also two liquid level probes. [15]
Tuning system	Based on the SACLAY/DESY design for the TESLA cavities, it has been modified to accommodate the larger 805 MHz SNS cavities. The tuner is mounted on the field probe side of the cavity opposite of the fundamental power coupler. The drive system uses a DC stepper motor, with 1.8 degree per step, run through a harmonic drive for reduction of 100:1 and reliability. The tuner and drive system are completely contained within the vacuum space. The tuner bridges a hydro-formed Ti bellows; it is attached to the Nb cavity beam line and the dished head of the Ti He pressure vessel [30].
Tuner requirements	Range = 500 kHz, resolution = 60 Hz, Tuning coefficient = 200 kHz/mm, Bandwidth = 1600 Hz, Cavity spring constant = 10000 pounds/inch=115.212 kg/m [30]

Tab 3.3: SNS 6 cell, β = 0.61 He tank characteristics and assembly procedure

The support and alignment structure utilize the same double-X pattern of austenitic (Nitronic ® 50) 0.5 cm diameter rods as proven reliable in the CEBAF cryomodule, which has the same diameter He vessel. The cavity has an additional center support internal to the He vessel, which anchors the cavity in the transverse directions, yet allows movement along the beamline axis for cooldown and tuning. Each He vessel is secured in the axial direction via 0.5 cm Nitronic® 50. All of the cavity/He vessel supports have been designed to compensate for the additional loading due to transportation of the cryomodules form JLAB to ORNL [30]

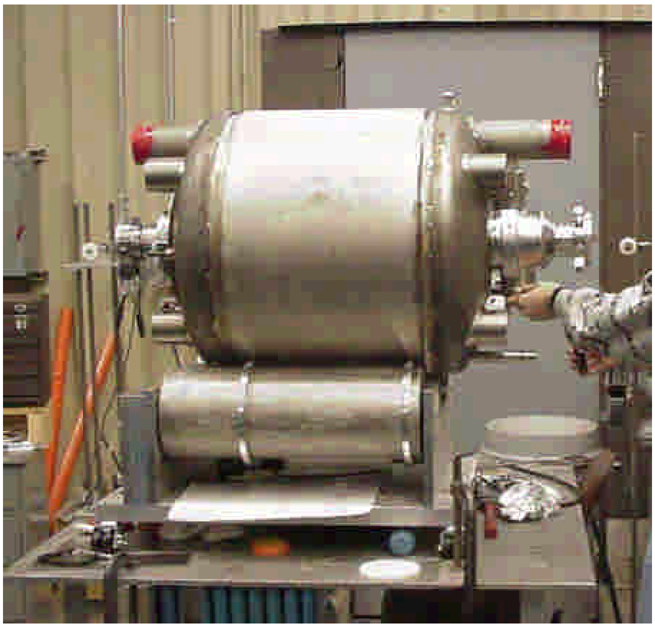


Fig. 3.8: He vessel welding on the SNS β=0.61 cavity [15]

Fig. 3.9: He vessel assembling in cleaning room [31]

3.4 RIA

The helium tank for β = 0.61 and β 0.81 are derived from the SNS ones.

Figure 3.10 shows the β = 0.47 helium vessel. [17]

Fig. 3.10: RIA β = 0.47 helium vessel

3.5 European ADS program: TRASCO and XADS

3.5.1 TRASCO

TRASCO $\beta = 0.47$ 5 cell cavity was tested only in a vertical cryostat, without any helium tank.

The helium tank is under design. The foreseen main parameters are reported in the next table.

He VESSEL				
Material	**He vessel components**	**Welding technique**	**Assembly procedure**	**Tuning system**
Ti	2 Ti disk, NbTi ring, Ti tube	Electron beam	Under design	Coaxial, under design

Tab 3.4: TRASCO $\beta = 0.47$ 5 cell cavity helium vessel.

3.5.2 XADS

R&D on 700 MHz 5-cell proton cavities, β=0.65.

Stainless Steel He vessel, with a brazed interface between the niobium and the stainless steel.

Test to verify the brazing tightness between a Nb tube and SS have been done, in super fluid He. The results have indicated that the maximal stresses at the brazing area are 150 N/mm^2 (for Nb tube), 80 N/mm^2 (for 70µm Cu interface) and 60 N/mm^2 (for the SS flange). An additional load of about 5000 N for each flange have been added to simulate the cold tuning system. Moreover a minimal distance of 9mm between the copper brazed interface and the EB welding of the first cavity iris [32] have to be respected.

He VESSEL β = 0.65 XADS				
Cavity tuning parameters			**Technical and construction**	
$F_{Lorentz}$ (Static longitudinal Lorentz Force)	**Δf/ΔL** (longitudinal frequency sensitivity)	**ΔF/ΔL** (longitudinal cavity stiffness)	**He vessel components**	**Welding technique**
13.86 N	About 250 kHz/mm	About 1592 N/mm	SS tube, SS bellow, Cu interface for brazing	Brazing a SS He-tank on the Nb cavity (copper interface)
Request on New tank stiffening (considering also the CTS) [32]: **About 20000 N/mm**				

Tab.3.5: XADS 700 MHz β = 0.65 He vessel parameters.[32]

The XADS Helium tank is brazed to the Nb cavity and the description here reported is relative to Fig. .

The extremities, normalized 3 mm thick and 400 mm diameter domed cups (1), give a better stiffness than conical ends. For a load applied on the beam tube the longitudinal stiffness can reach about 55 kN/mm, which gives, associated with the cylindrical part of the vessel a total stiffness of about 50 kN /mm.

The SS parts (2) are brazed on the Niobium cut off at a minimal distance of 9 mm from the nearest EB welds. The thickness of these rings is 15 mm to reduce the hoop thermal stresses at the copper interface without over stressing the niobium tube . The de coupling bellow (3) allows 6 mm displacement. Four supports (4) are welded close to the external diameter of the cups (where the tank stiffness is higher) to fix the CTS. The vessel (5), 400 mm diameter, is as close as possible to the cavity equators to limit the volume available for helium inventory. A 40 mm CF cryogenic port onto the tank (6) is used for the feeding of super fluid helium from an auxiliary pot. Two 16 mm CF ports (7,8) at the bottom of the tank are respectively dedicated to the cool down of the cavity and the relation to the auxiliary pot for the LHe level measurements. [4]

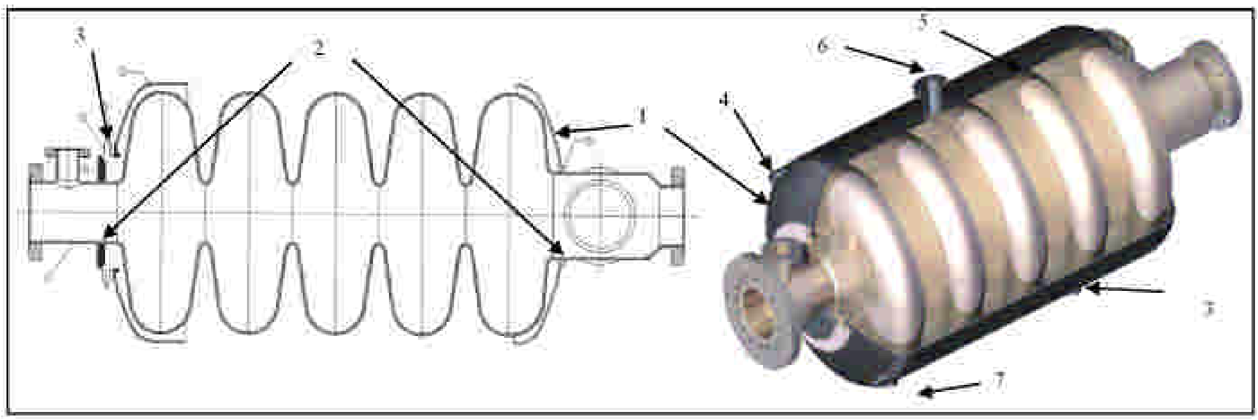


Fig. 3.11:.XADS Helium vessel sketch and picture [32].

Fig. 3.12 Single cell β = 0.65 with the SS He-tank end caps [32]

4 Cold flanges and sealing

The choice of the cold connection in superconducting accelerator is a critical point.

A cold connection must have the following characteristics: extremely low leak rate (also at low temperature), reliable behaviour (also during thermal cycles), easy to assembly procedure, compatible with clean room environment, cleanable, and finally cheap.

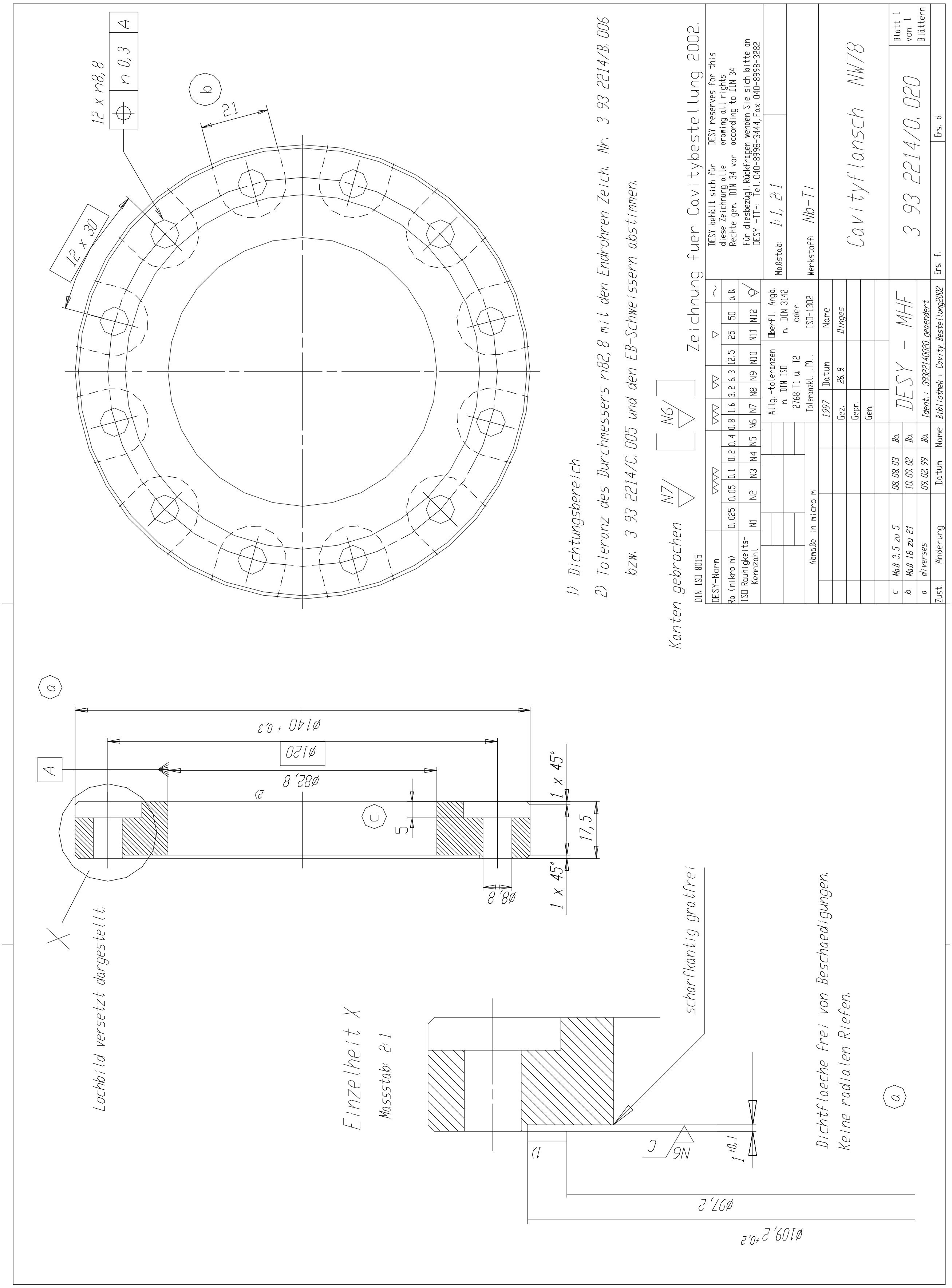
In this document are reported a retrieving of cold connection system used in superconducting accelerators: for every machine a schedule is shown to summarize, for each kind of flanges, the main constructive parameters as the closing torque, the material and the shape of the seal; together with the technical drawings.

Also commercial flanges and seals are used in SC cavity: we collected some information about Conflat CF flanges and Helicoflex.

4.1 TESLA - TTF

TTF Beam flange

TTF Beam flange male	
Material	NbTi
O.D.	140.0 mm
Thickness	17.5 mm
Number of holes	12
Bolt circle diameter	120.0 mm
Groove depth	1.0 mm
External groove diameter	109.2 mm
Screw	Stud bolt M8 1.4429 (Germany W.N.17007) or X 2 CrNiMoN 17 13 3 (DIN 17006)
Nut	CuNiSil - Cu5 (DIN 17 672)
Washer	A4 both sides (UNI 5962)
Closing torque	28-30 Nm
Seal	AlMgSi 0,5 Diamond shape (DIN 1746)
Pipe connection	Electron beam welding


12 x ⌀8,8
⌀0,3 A
12 x 30
21
1) Dichtungsbereich
2) Toleranz des Durchmessers ⌀82,8 mit den Endrohren Zeich. Nr. 3 93 2214/B.006
bzw. 3 93 2214/C.005 und den EB-Schweissern abstimmen.
Kanten gebrochen N7 (N6)
Zeichnung fuer Cavitybestellung 2002.
DIN ISO 8015
DESY-Norm
Ra (mikro m)
ISO Rauhigkeits-Kennzahl
0.025 0.05 0.1 0.2 0.4 0.8 1.6 3.2 6.3 12.5 25 50 o.B.
N1 N2 N3 N4 N5 N6 N7 N8 N9 N10 N11 N12
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Abmaße in micro m
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Gez. 26.9 Dinges
Gepr.
Gen.
Cavityflansch NW78
DESY - MHF
3 93 2214/0.020
Blatt 1 von 1 Blättern
c Maß 3,5 zu 5 08.08.03 Ba.
b Maß 18 zu 21 10.09.02 Ba.
a diverses 09.02.99 Ba.
Zust. Änderung Datum Name
Ident.: 39322140020 geaendert
Bibliothek: Cavity Bestellung2002
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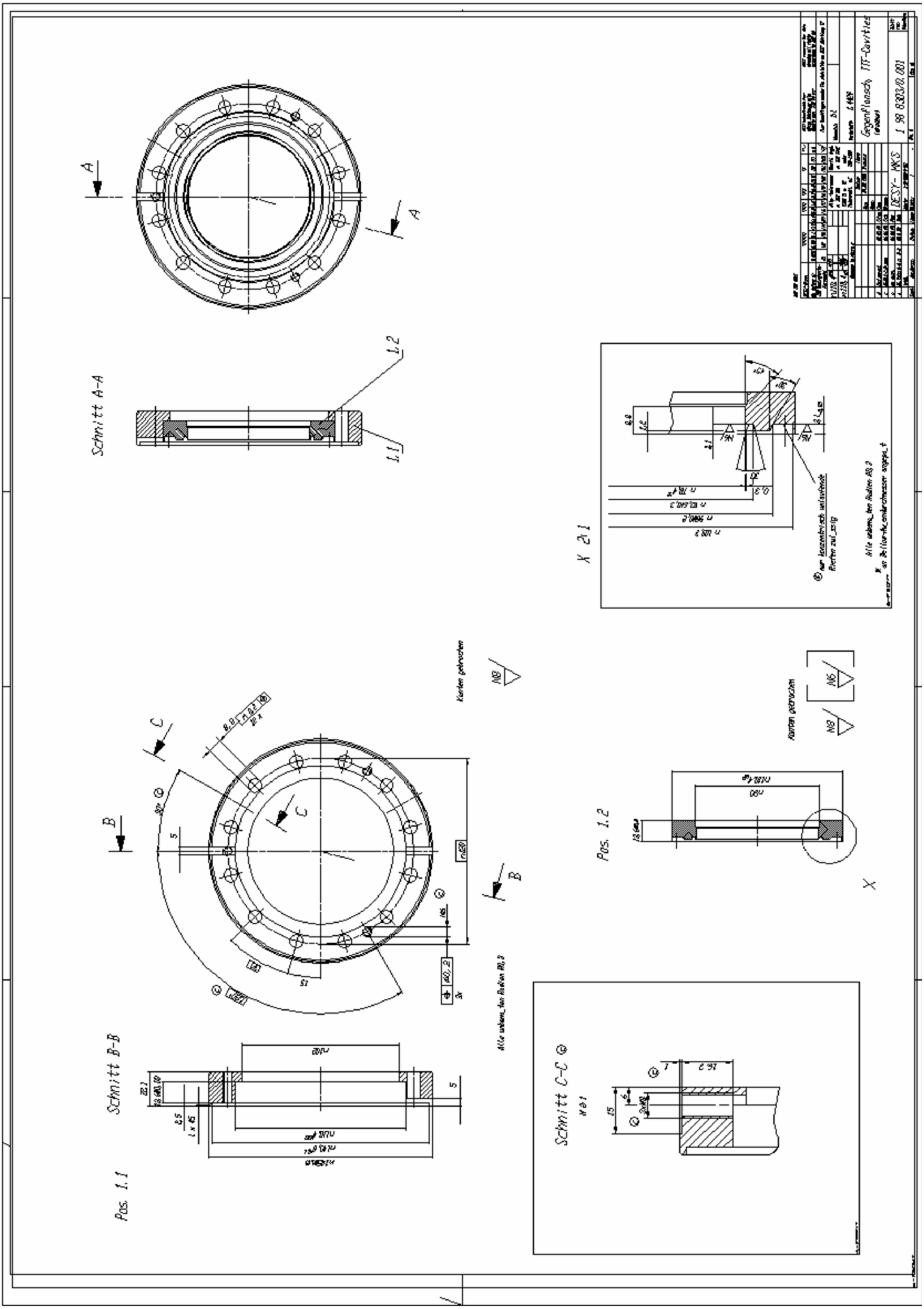
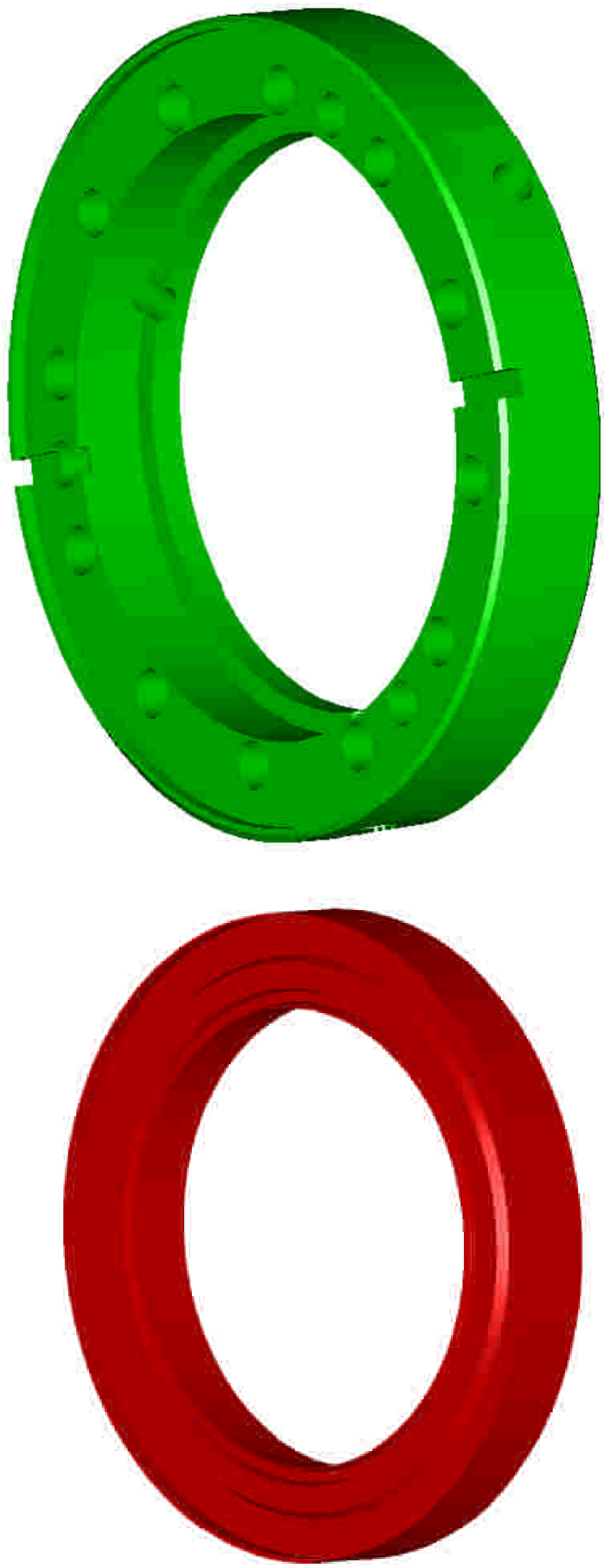
Ers. d.
A
⌀140 +0,3
⌀120
⌀82,8
1 x 45°
17,5
5
⌀8,8
X
Lochbild versetzt dargestellt.
Einzelheit X
Masstab: 2:1
scharfkantig gratfrei
Dichtflaeche frei von Beschaedigungen.
Keine radialen Riefen.
1 +0,1
N6
⌀97,2
⌀109,2 +0,2

TTF Beam flange female	
Material	
O.D.	140.6 mm
Thickness	19.6 mm
Groove depth	1.9 mm
Internal groove diameter	96.0 mm
External groove diameter	109.2mm
Number of holes	12
Bolt circle diameter	120 mm
Screw	Stud bolt M8 1.4429 (Germany W.N.17007) or X 2 CrNiMoN 17 13 3 (DIN 17006)
Nut	CuNiSil - Cu5 (DIN 17 672)
Washer	A4 both sides (UNI 5962)
Closing torque	28-30 Nm
Seal	AlMgSi 0,5 Diamond shape (DIN 1746)



Schnitt A-A
Schnitt B-B
Schnitt C-C
Pos. 1.1
Pos. 1.2
Kanten gebrochen
Gegenflansch TTF-Cavities
DESY - MKS



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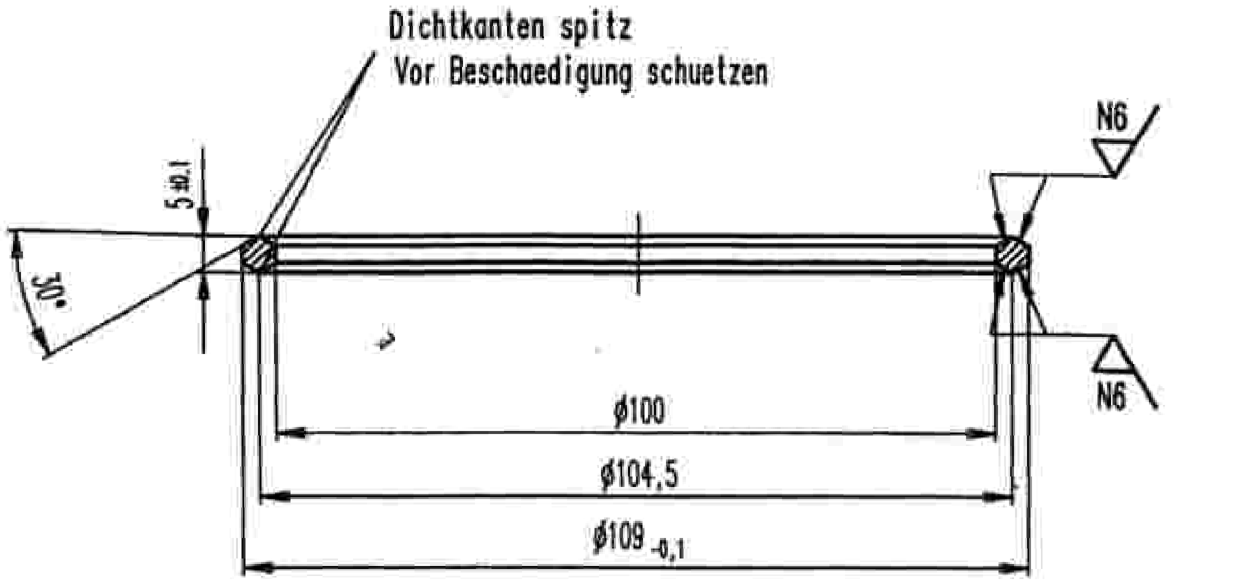
M 1:1



Bauteil sauber und entfettet.

N7 [N6]

DIN ISO 8015

DESY-Norm	▽▽▽▽					▽▽▽		▽▽		▽			~
Ra (mikro m)	0.025	0.05	0.1	0.2	0.4	0.8	1.6	3.2	6.3	12.5	25	50	o.B.
ISO Rauhigkeits-Kennzahl	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	✓

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Abmasse in micro m

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Oberfl. Angb. n. DIN 3142 oder ISO-1302

Massstab: 1 : 1

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	Datum	Name
Gez.	24.04.03	Bandelmann
Gepr.	29.4.03	Band
Gen.		
Erzeug.		

Cavity Dichtung NW 78

DESY-MKS3

Ident.: BA07_5_3

Bibliothek : Modul_3

4 02 1565 / A.002

Blatt von Blaetter

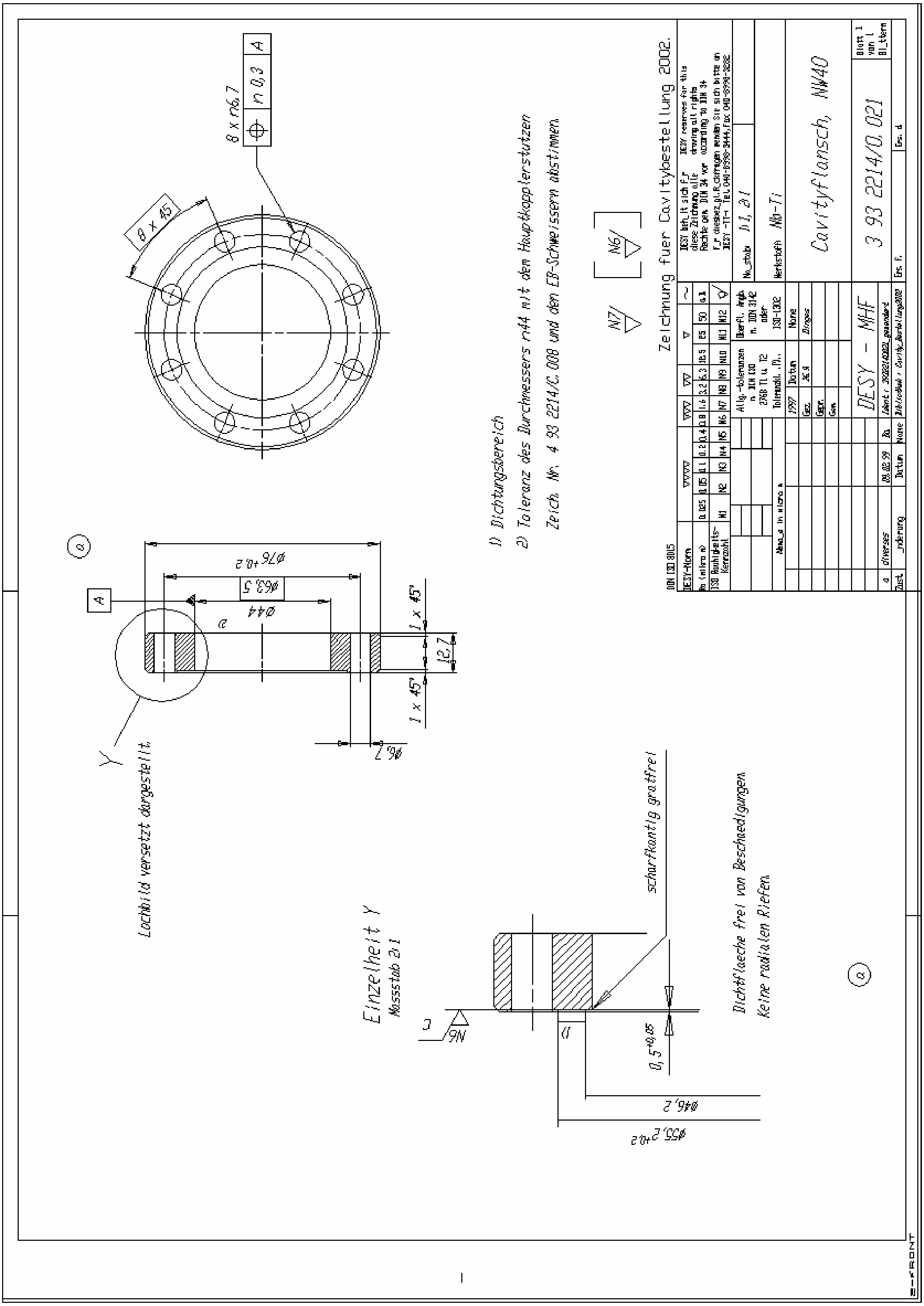
Zust.	Aenderung	Datum	Name

Ers. f. 4 98 3710 / A.002

Ers. d.

TTF Coupler flange

TTF Coupler flange male	
Material	NbTi
O.D.	76.0 mm
Thickness	12.7 mm
Number of holes	8
Bolt circle diameter	63.5 mm
Groove depth	0.5 mm
External groove diameter	55.2 mm
Screw	Stud bolt M6 1.4429 (Germany W.N.17007) or X 2 CrNiMoN 17 13 3 (DIN 17006)
Nut	CuNiSil - Cu5 (DIN 17 672)
Washer	A4 both sides (UNI 5962)
Closing torque	
Seal	AlMgSi 0,5 Diamond shape (DIN 1746)
Pipe connection	Electron beam welding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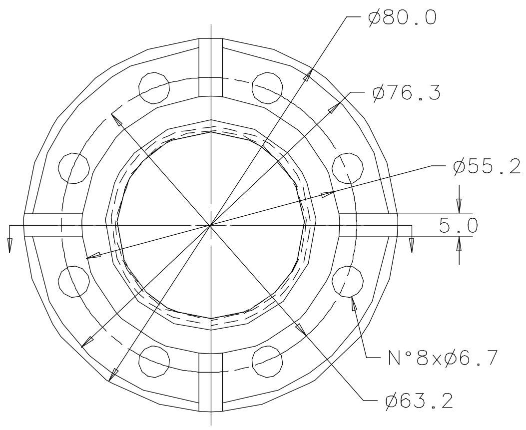
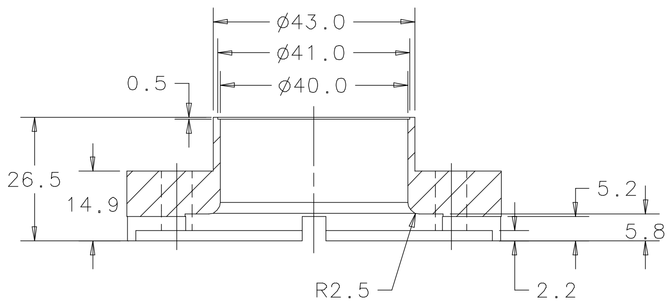
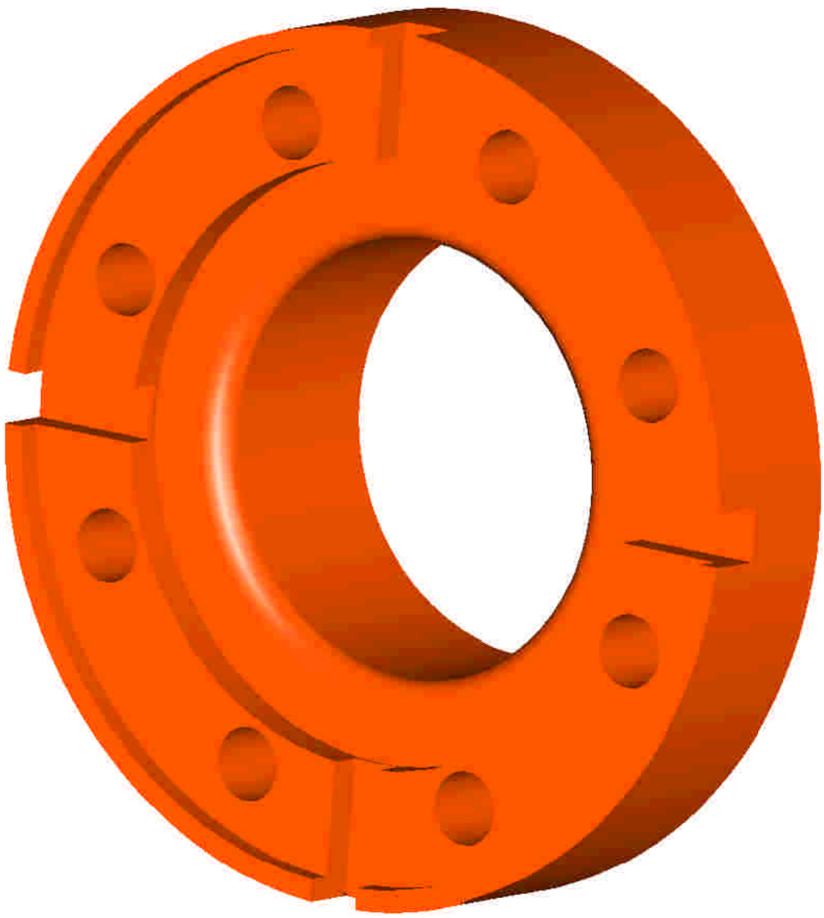
8 x n6,7
n 0,3
A
⌀76 +0,2
⌀63,5
⌀44
12,7
1 x 45°
⌀6,7
Y
Lochbild versetzt dargestellt.
Einzelheit Y
Massstab 2:1
scharfkantig gratfrei
0,5 +0,05
⌀46,2
⌀55,2 +0,2
Dichtflaeche frei von Beschaedigungen
Keine radialen Riefen
N7
N6
Werkstoff Nb-Ti
Cavityflansch, NW40
DESY - MHF
3 93 2214/0.021

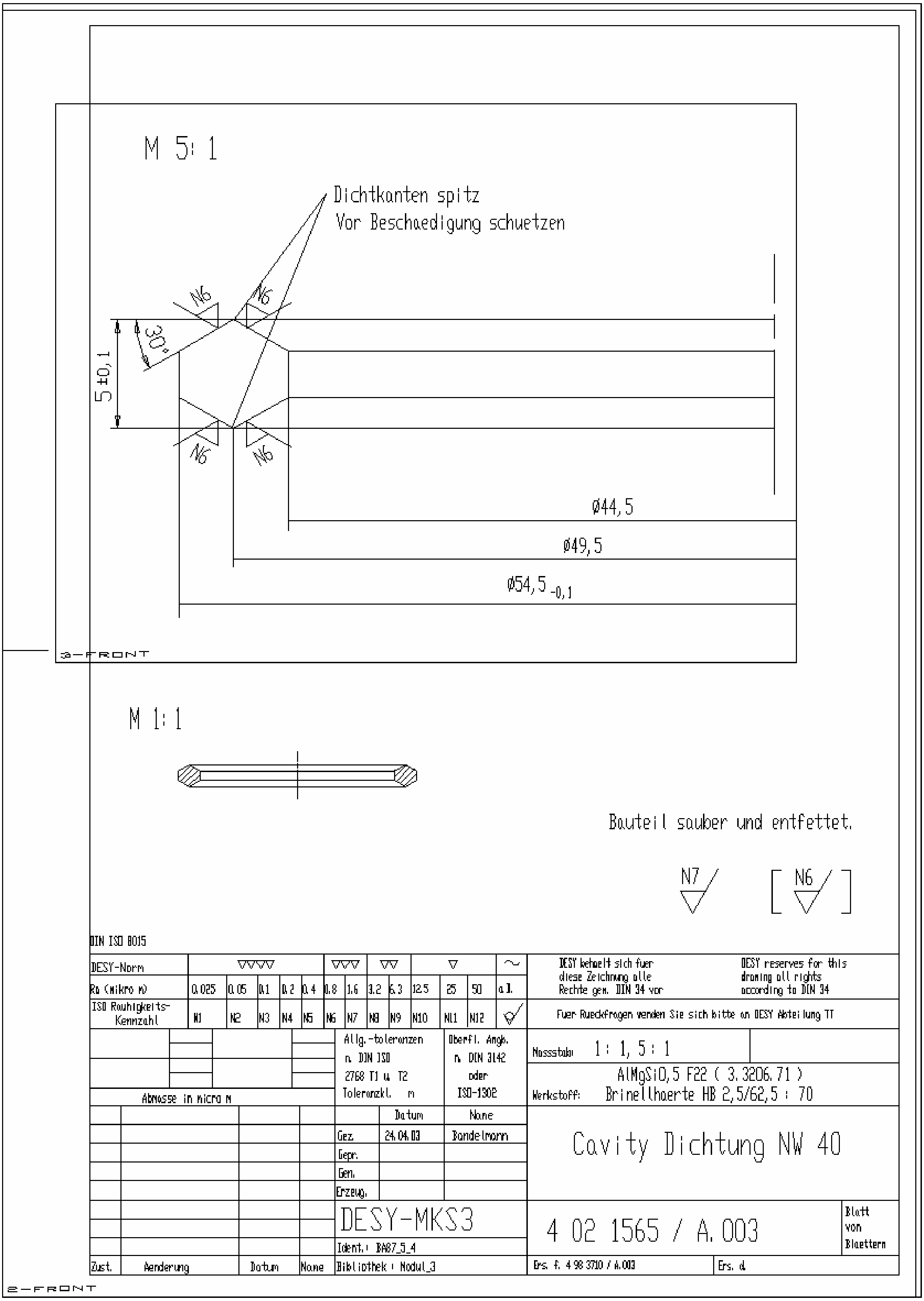
TTF Coupler flange female	
Material	
O.D.	76.3 mm
Thickness	24.3 mm
Groove depth	3.6 mm
Internal groove diameter	-
External groove diameter	55.2 mm
Number of holes	8
Bolt circle diameter	63.5 mm
Screw	Stud bolt M6 1.4429 (Germany W.N.17007) or X 2 CrNiMoN 17 13 3 (DIN 17006)
Nut	CuNiSil - Cu5 (DIN 17 672)
Washer	A4 both sides (UNI 5962)
Closing torque	
Seal	AlMgSi 0,5 Diamond shape (DIN 1746)







I-DEAS model file: desy_cry3.mf1 – INFN Milan



M 5: 1
Dichtkanten spitz
Vor Beschaedigung schuetzen
N6
N6
30°
5 ±0,1
N6
N6
Ø44,5
Ø49,5
Ø54,5 -0,1
M 1: 1
Bauteil sauber und entfettet.
N7
[N6]
DIN ISO 8015
DESY-Norm
Ra (mikro m)
0.025
0.05
0.1
0.2
0.4
0.8
1.6
3.2
6.3
12.5
25
50
a.l.
ISO Rauhigkeits-Kennzahl
N1
N2
N3
N4
N5
N6
N7
N8
N9
N10
N11
N12
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Oberfl. Angb. n. DIN 3142 oder ISO-1302
Abmasse in micro m
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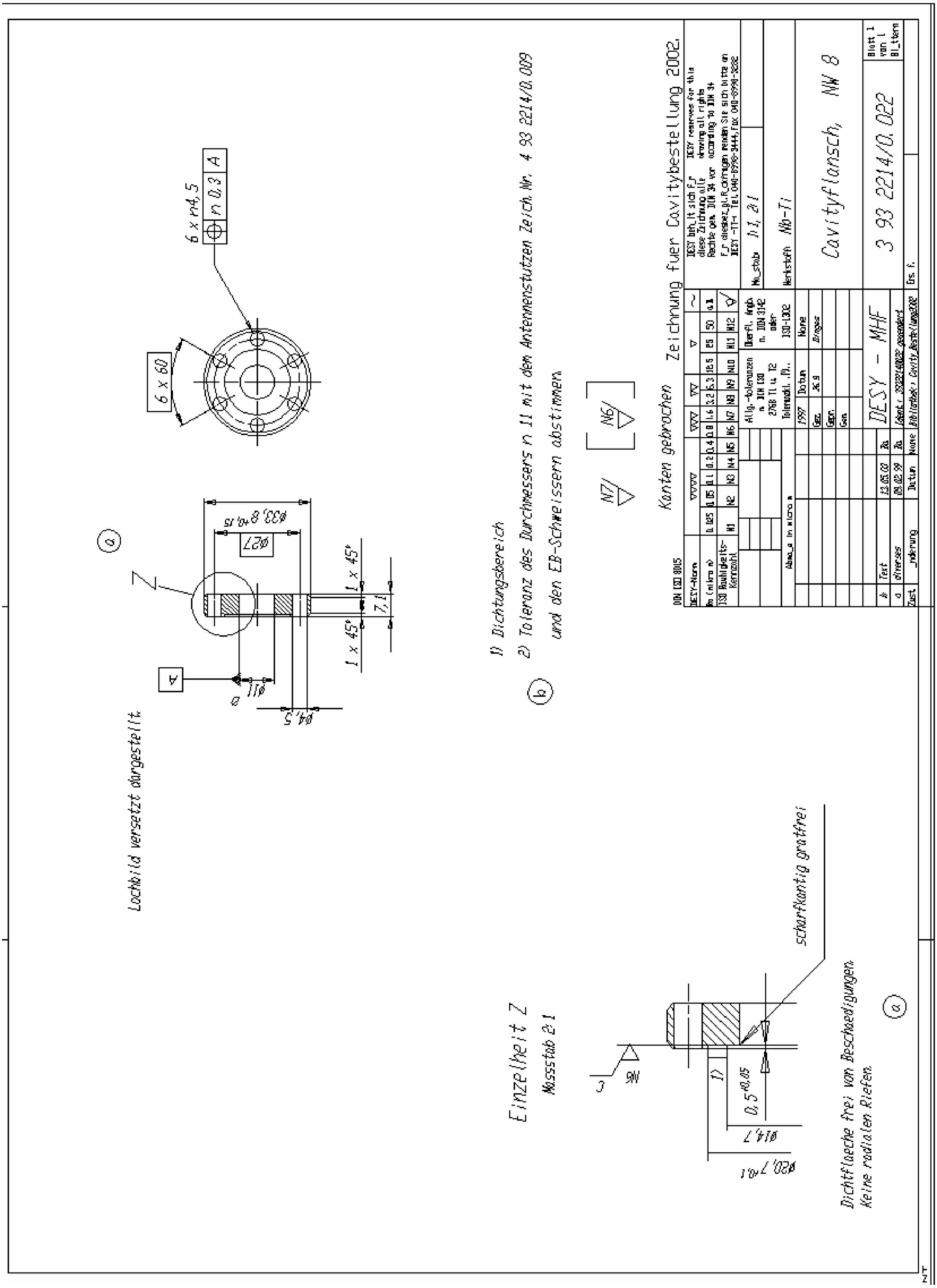
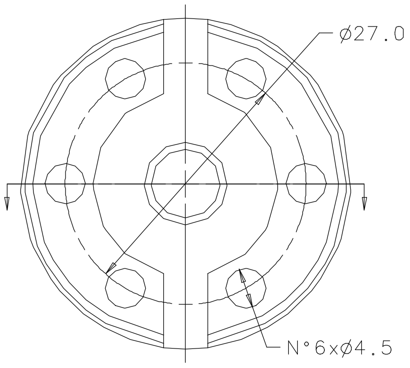
Brinellhaerte HB 2,5/62,5 : 70
Datum
Name
Gez.
24.04.03
Bandelmann
Gepr.
Gen.
Erzeug.
Cavity Dichtung NW 40
DESY-MKS3
Ident.: BA87_5_4
4 02 1565 / A.003
Blatt
von
Blaettern
Zust.
Aenderung
Datum
Name
Bibliothek : Modul_3
Ers. f. 4 98 3710 / A.003
Ers. d.

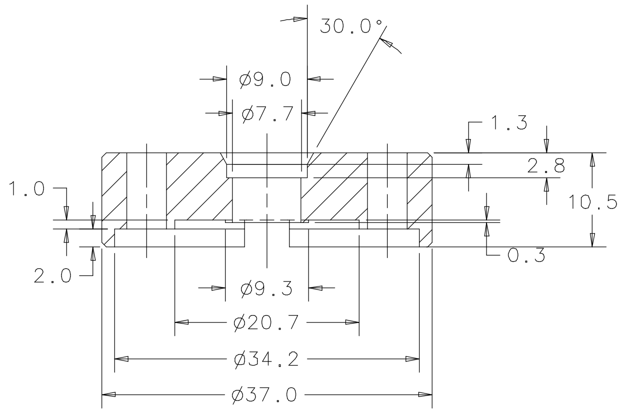
TTF Pick up flange

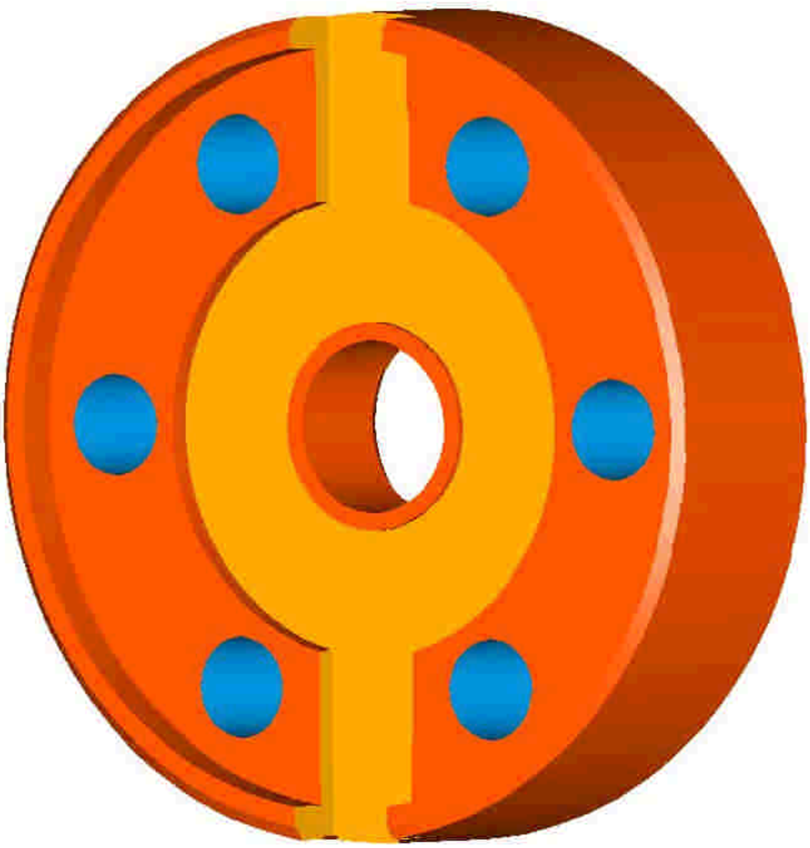
TTF Pick up flange male	
Material	NbTi
O.D.	33.8 mm
Thickness	7.1 mm
Number of holes	6
Bolt circle diameter	27.0 mm
Groove depth	0.5 mm
External groove diameter	20.7 mm
Screw	Stud bolt M4 1.4429 (Germany W.N.17007) or X 2 CrNiMoN 17 13 3 (DIN 17006)
Nut	CuNiSil - Cu5 (DIN 17 672)
Washer	A4 both sides (UNI 5962)
Closing torque	
Seal	AlMgSi 0,5 Diamond shape (DIN 1746)
Pipe connection	Electron beam welding


Zeichnung fuer Cavitybestellung 2002
Kanten gebrochen
1) Dichtungsbereich
2) Toleranz des Durchmessers n 11 mit dem Antennenstutzen Zeich.Nr. 4 93 2214/0.009
und den EB-Schweissern abstimmen.
Lochbild versetzt dargestellt
6 x 60
6 x n4,5
Einzelheit Z
Massstab 2:1
scharfkantig gratfrei
Dichtflaeche frei von Beschaedigungen.
Keine radialen Riefen.
Werkstoff Nb-Ti
Cavityflansch, NW 8
DESY - MHF
3 93 2214/0.022

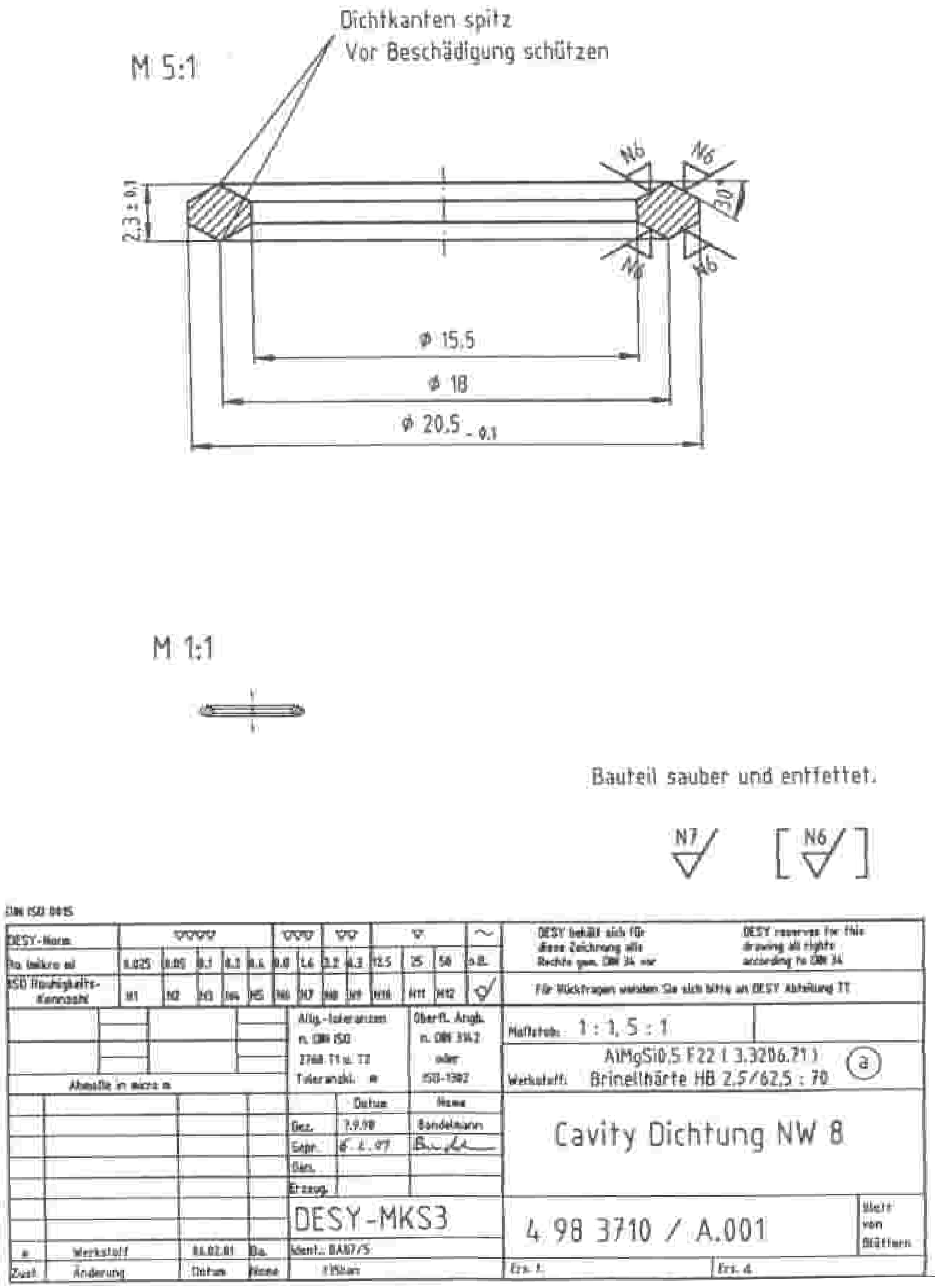
TTF Pick Up flange female	
Material	
O.D.	34.2 mm
Thickness	8.5 mm
Groove depth	1.0 mm
Internal groove diameter	9.3 mm
External groove diameter	20.7 mm
Number of holes	6
Bolt circle diameter	27.0 mm
Screw	Stud bolt M8 1.4429 (Germany W.N.17007) or X 2 CrNiMoN 17 13 3 (DIN 17006)
Nut	CuNiSil - Cu5 (DIN 17 672)
Washer	A4 both sides (UNI 5962)
Closing torque	
Seal	AlMgSi 0,5 Diamond shape (DIN 1746)







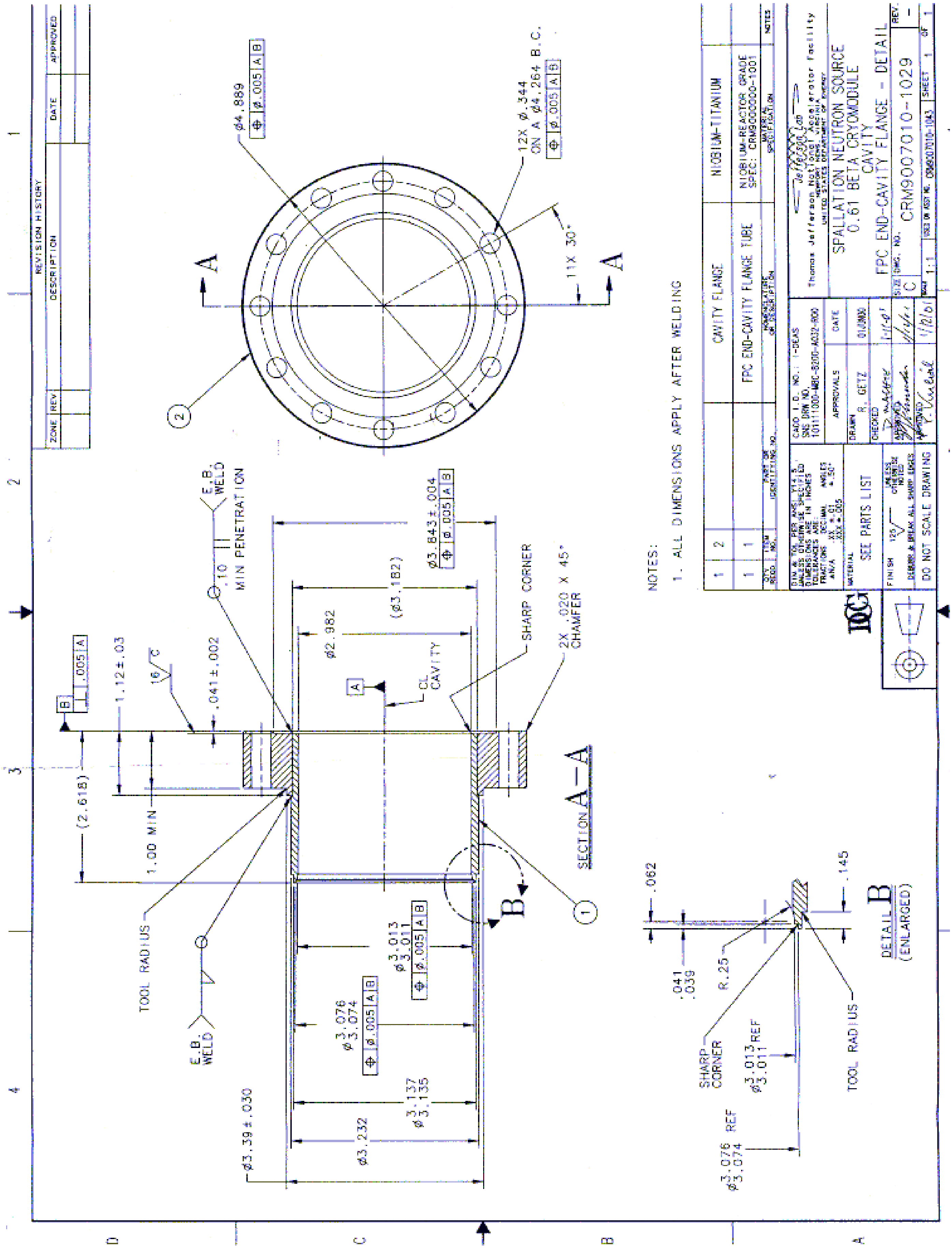
I-DEAS model file: desy_cry3.mf1 – INFN Milan


Dichtkanten spitz
Vor Beschädigung schützen
M 5:1
2,3 ± 0,1
N6
30°
ϕ 15,5
ϕ 18
ϕ 20,5 - 0,1
M 1:1
Bauteil sauber und entfettet.
N7
N6
DESY-Norm
Allg.-Toleranzen
Oberfl. Angb.
Maßstab: 1 : 1, 5 : 1
AlMgSi0,5 F22 (3.3206.71)
Werkstoff: Brinellhärte HB 2,5/62,5 : 70
Datum
Name
Gez.
7.9.98
Bandelmann
Cavity Dichtung NW 8
DESY-MKS3
4 98 3710 / A.001
Werkstoff
Zust.
Änderung
Datum
Name

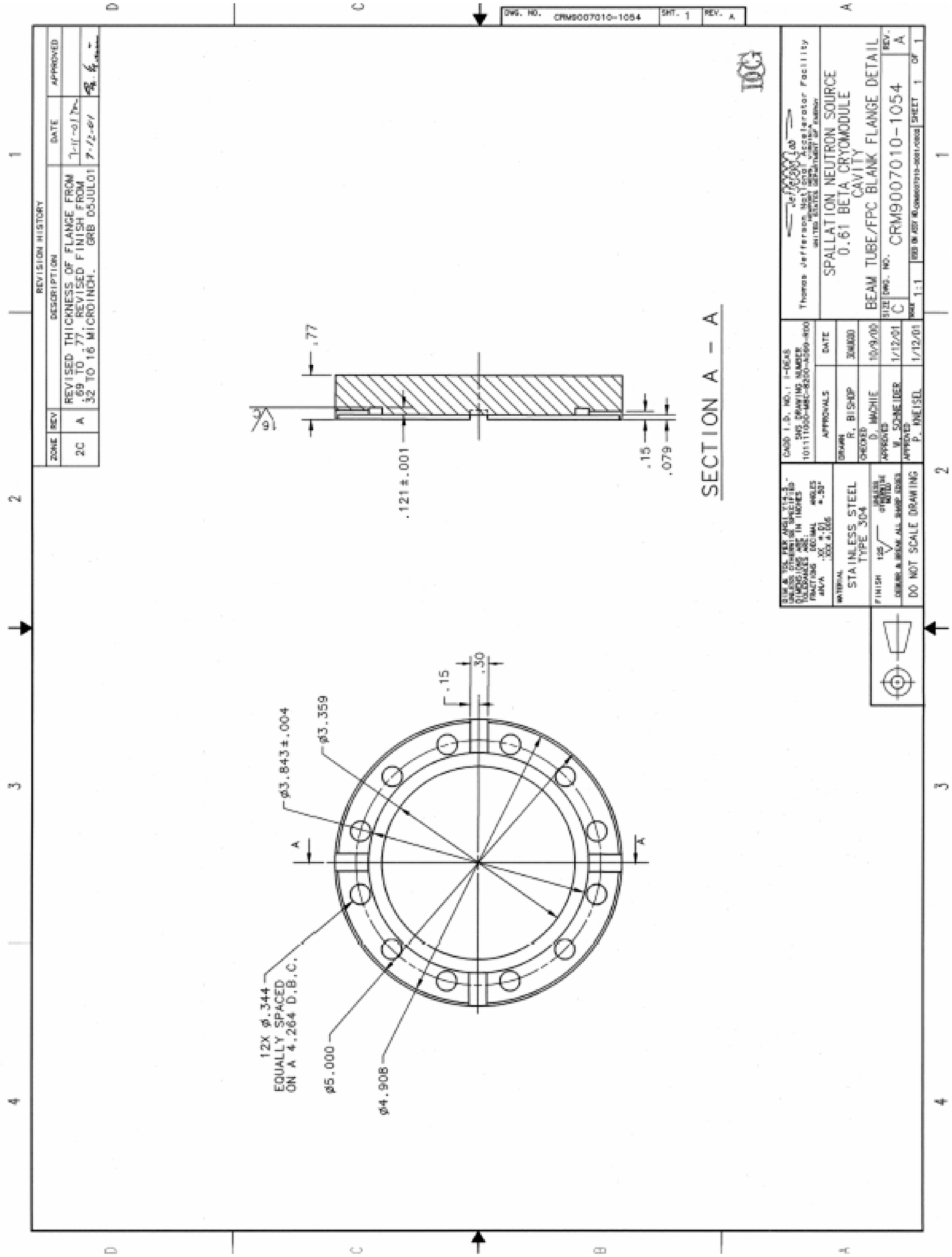
4.2 SNS

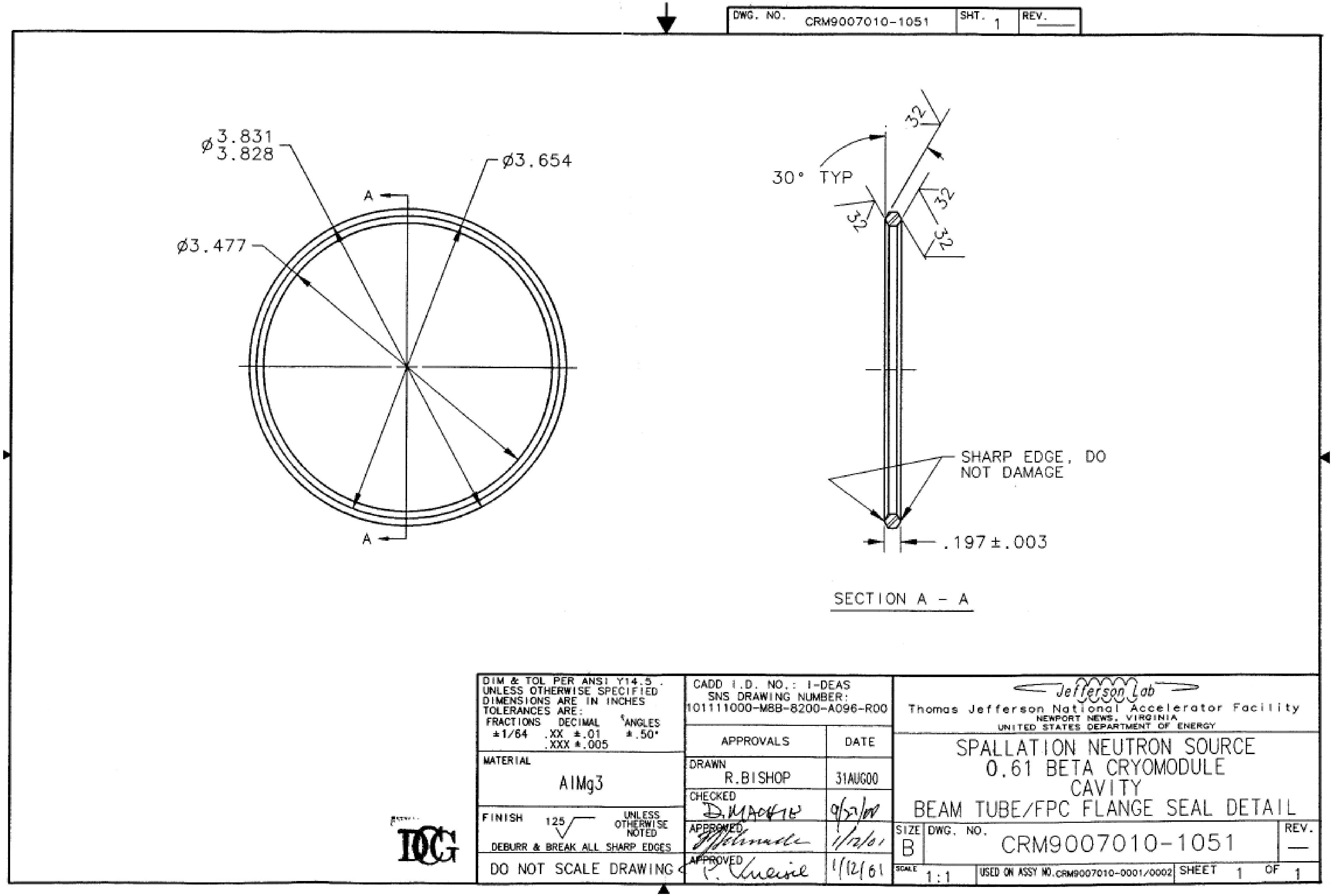
SNS Beam flange

SNS Beam flange male	
Material	NbTi
O.D.	124.2 mm (4.889”)
Thickness	25.4 mm (1.0”)
Number of holes	12
Bolt circle diameter	108.3 mm (4.264”)
Groove depth	1.0 mm (0.041”)
External groove diameter	97.6 mm (3.843”)
Screw	A286 (A66286 UNS INCOLOY) 5/16” – 24 [33]
Nut	Si Br [33]
Washer	Yes + Belleville [33]
Closing torque	49.5 Nm (348 inch lbs.) [33]
Seal	AlMg3 Diamond shape (DIN 1746)
Pipe connection	Electron beam welding


REVISION HISTORY
ZONE
REV
DESCRIPTION
DATE
APPROVED
SECTION A-A
DETAIL B
(ENLARGED)
NOTES:
1. ALL DIMENSIONS APPLY AFTER WELDING
CAVITY FLANGE
NIOBIUM-TITANIUM
FPC END-CAVITY FLANGE TUBE
NIOBIUM-REACTOR GRADE SPEC: CRM9000000-1001
SEE PARTS LIST
DO NOT SCALE DRAWING
Thomas Jefferson National Accelerator Facility
SPALLATION NEUTRON SOURCE
0.61 BETA CRYOMODULE
CAVITY
FPC END-CAVITY FLANGE - DETAIL
CRM9007010-1029
SHEET 1 OF 1
E.B. WELD
TOOL RADIUS
SHARP CORNER
2X .020 X 45° CHAMFER
.10 MIN PENETRATION
12X ⌀.344 ON A ⌀4.264 B.C.
11X 30°
⌀4.889
⌀3.643±.004
⌀2.982
(⌀3.182)
⌀3.232
⌀3.39±.030
1.12±.03
.041±.002
(2.618)
1.00 MIN
CL CAVITY
R.25
.062
.145

SNS Beam flange female (blank flange)	
Material	Stainless steel type 304
O.D.	124.7 mm (4.908”)
Thickness	15.5 mm (0.611”)
Groove depth	3.1 mm (0.121”)
Internal groove diameter	85.3 mm (3.359”)
External groove diameter	97.6 mm (3.843”)
Number of holes	12
Bolt circle diameter	108.3 mm (4.264”)
Screw	A286 (A66286 UNS INCOLOY) 5/16” – 24 [33]
Nut	Si Br [33]
Washer	Yes + Belleville [33]
Closing torque	49.5 Nm (348 inch lbs.) [33]
Seal	AlMg3 Diamond shape (DIN 1746)

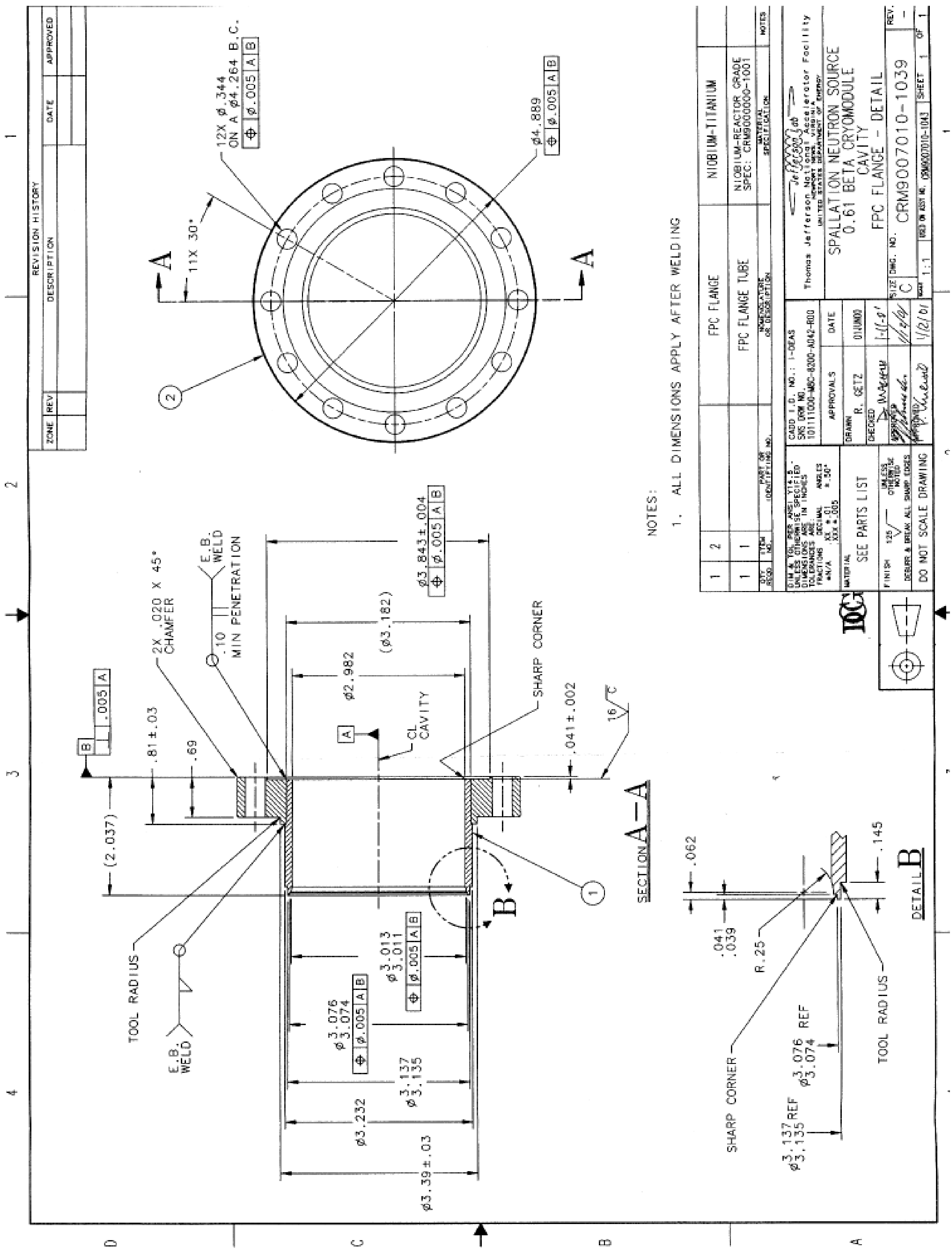

SECTION A – A
SPALLATION NEUTRON SOURCE
0.61 BETA CRYOMODULE
CAVITY
BEAM TUBE/FPC BLANK FLANGE DETAIL
CRM9007010-1054
Thomas Jefferson National Accelerator Facility
STAINLESS STEEL
TYPE 304
DO NOT SCALE DRAWING
REVISION HISTORY
REVISED THICKNESS OF FLANGE FROM .69 TO .77. REVISED FINISH FROM 32 TO 16 MICROINCH. GRB 05JUL01
R. BISHOP
D. MACHIE
W. SCHNEIDER
P. KNEISEL
12X ø.344 EQUALLY SPACED ON A 4.264 D.B.C.
ø5.000
ø4.908
ø3.843±.004
ø3.359
.121±.001
.77
.15
.079
.30



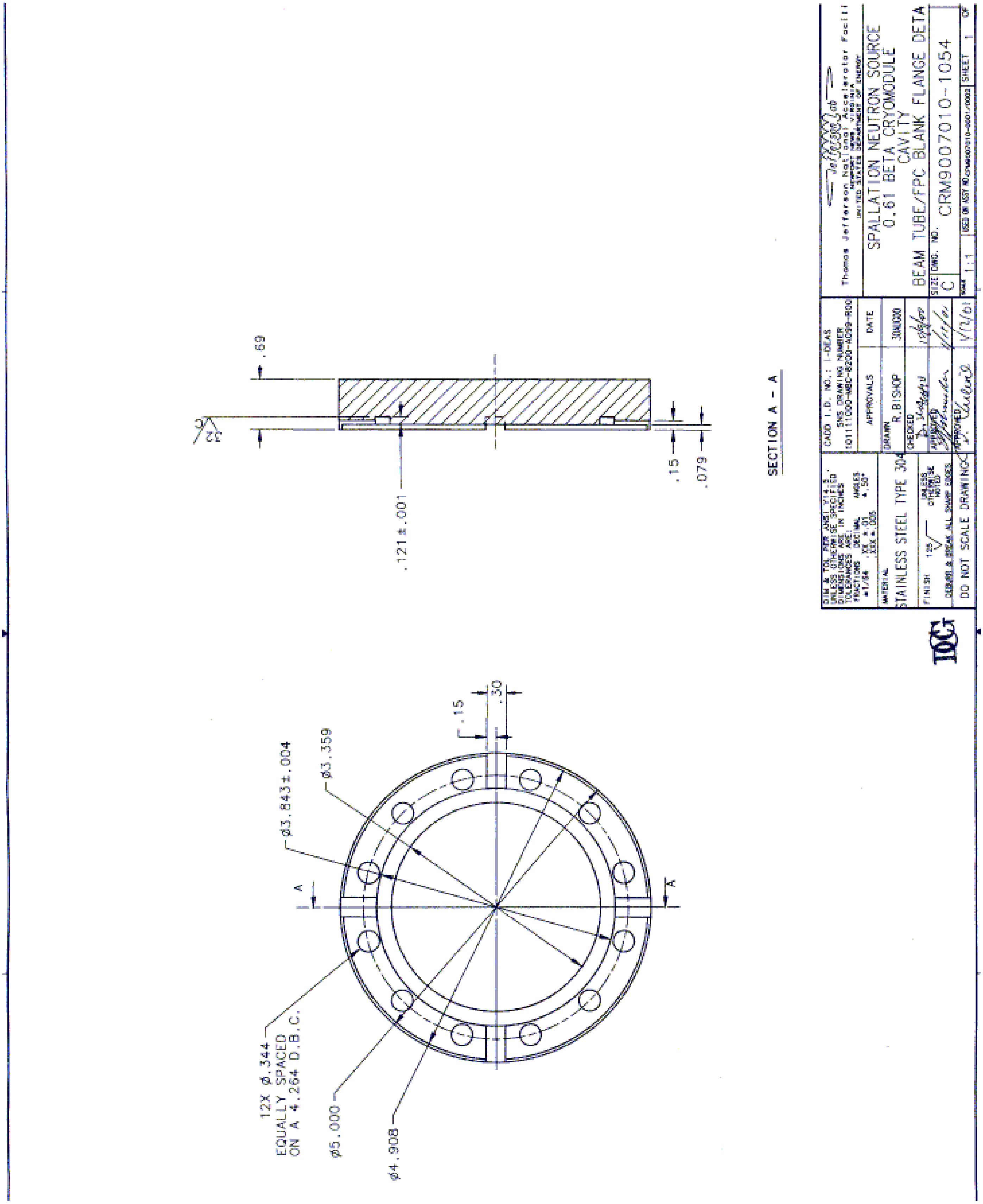
DWG. NO. CRM9007010-1051
SHT. 1
REV.
Ø3.831
3.828
Ø3.654
Ø3.477
A
A
30° TYP
32
32
32
32
SHARP EDGE, DO NOT DAMAGE
.197±.003
SECTION A - A
DIM & TOL PER ANSI Y14.5 . UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:
FRACTIONS ±1/64
DECIMAL .XX ±.01 .XXX ±.005
ANGLES ±.50°
MATERIAL
AIMg3
FINISH 125
UNLESS OTHERWISE NOTED
DEBURR & BREAK ALL SHARP EDGES
DO NOT SCALE DRAWING
CADD I.D. NO.: I-DEAS
SNS DRAWING NUMBER: 101111000-M8B-8200-A096-R00
APPROVALS
DATE
DRAWN R.BISHOP
31AUG00
CHECKED
APPROVED
APPROVED
Jefferson Lab
Thomas Jefferson National Accelerator Facility
NEWPORT NEWS, VIRGINIA
UNITED STATES DEPARTMENT OF ENERGY
SPALLATION NEUTRON SOURCE
0.61 BETA CRYOMODULE
CAVITY
BEAM TUBE/FPC FLANGE SEAL DETAIL
SIZE B
DWG. NO. CRM9007010-1051
REV. —
SCALE 1:1
USED ON ASSY NO. CRM9007010-0001/0002
SHEET 1 OF 1

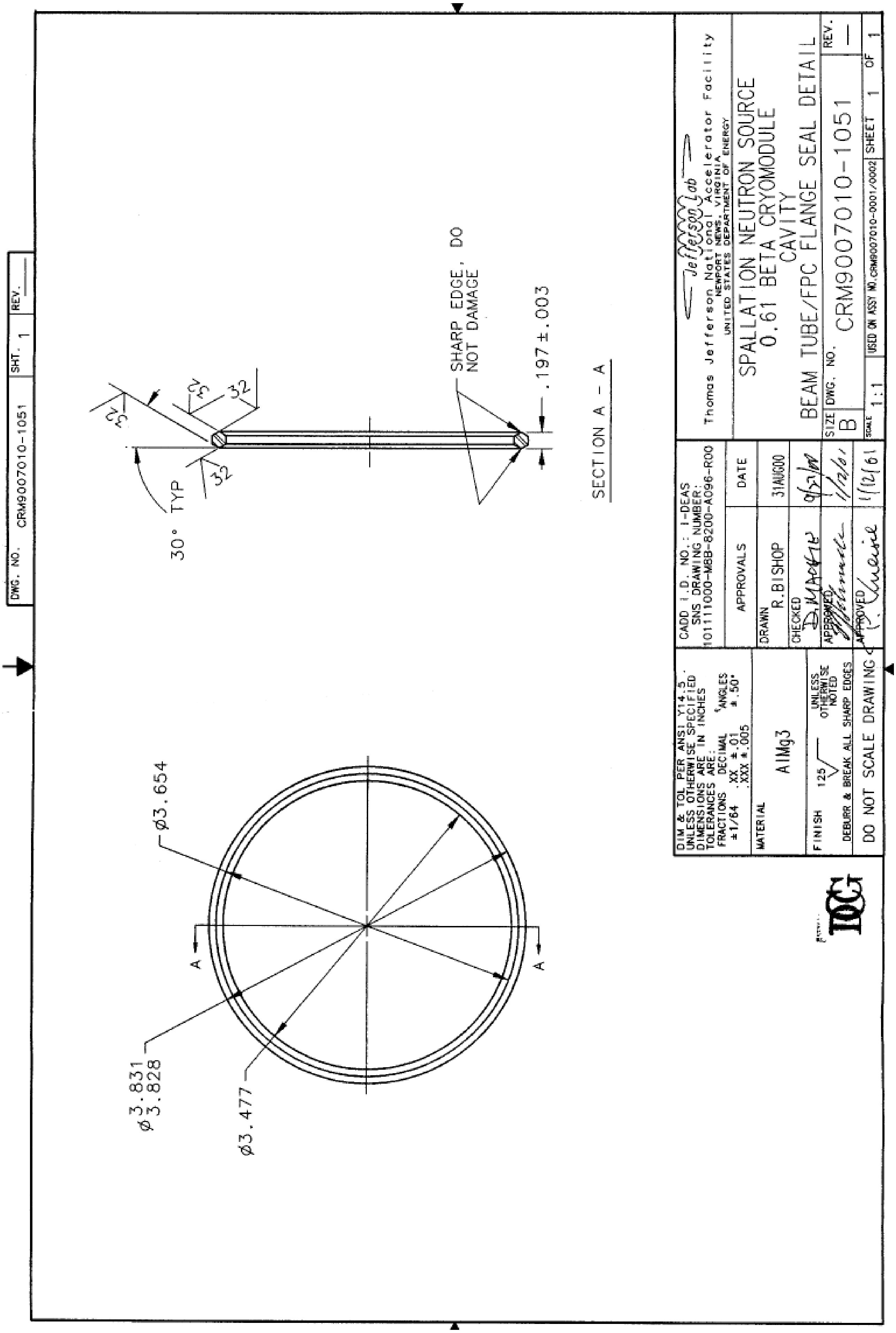
SNS Coupler flange

SNS Coupler flange male	
Material	NbTi
O.D.	124.2 mm (4.889”)
Thickness	17.5 mm (0.69”)
Number of holes	12
Bolt circle diameter	108.3 mm (4.264”)
Groove depth	1.0 mm (0.041”)
External groove diameter	97.6 mm (3.843”)
Screw	A286 (A66286 UNS INCOLOY) 5/16” – 24 [33]
Nut	Si Br [33]
Washer	Yes [33]
Closing torque	49.5 Nm (348 inch lbs.) [33]
Seal	AlMg3 Diamond shape (DIN 1746)
Pipe connection	Electron beam welding


REVISION HISTORY
ZONE
REV
DESCRIPTION
DATE
APPROVED
12X ø.344
ON A ø4.264 B.C.
ø4.889
11X 30°
SECTION A-A
DETAIL B
TOOL RADIUS
E.B. WELD
2X .020 X 45° CHAMFER
.10 MIN PENETRATION
SHARP CORNER
CL CAVITY
ø2.982
(ø3.182)
ø3.843±.004
ø3.013
ø3.011
ø3.076
ø3.074
ø3.137
ø3.135
ø3.232
ø3.39±.03
(2.037)
.81±.03
.69
.041±.002
.062
.145
R.25
NOTES:
1. ALL DIMENSIONS APPLY AFTER WELDING
FPC FLANGE
FPC FLANGE TUBE
NIOBIUM-TITANIUM
NIOBIUM-REACTOR GRADE
SEE PARTS LIST
DRAWN R. GETZ
DO NOT SCALE DRAWING
Thomas Jefferson National Accelerator Facility
SPALLATION NEUTRON SOURCE
0.61 BETA CRYOMODULE
CAVITY
FPC FLANGE - DETAIL
CRM9007010-1039

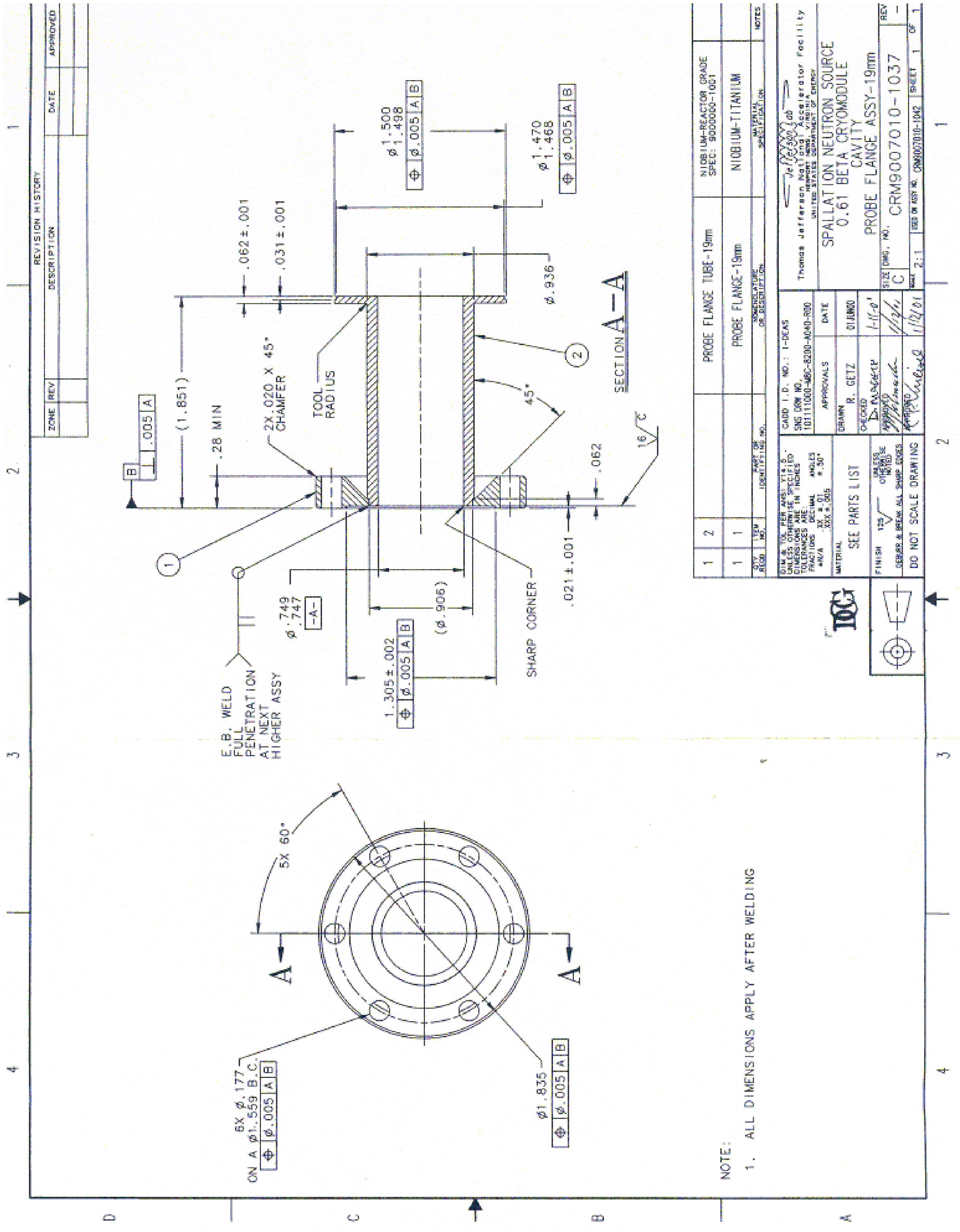
SNS Coupler flange female (blank flange)	
Material	Stainless steel type 304
O.D.	124.7 mm (4.908”)
Thickness	15.5 mm (0.611”)
Groove depth	3.1 mm (0.121”)
Internal groove diameter	85.3 mm (3.359”)
External groove diameter	97.6 mm (3.843”)
Number of holes	12
Bolt circle diameter	108.3 mm (4.264”)
Screw	A286 (A66286 UNS INCOLOY) 5/16” – 24 [33]
Nut	Si Br [33]
Washer	Yes [33]
Closing torque	49.5 Nm (348 inch lbs.) [33]
Seal	AlMg3 Diamond shape (DIN 1746)


12X ø.344
EQUALLY SPACED
ON A 4.264 D.B.C.
ø5.000
ø4.908
ø3.843±.004
ø3.359
.15
.30
A
A
.69
32
.121±.001
.15
.079
SECTION A - A
Thomas Jefferson National Accelerator Facility
SPALLATION NEUTRON SOURCE
0.61 BETA CRYOMODULE
CAVITY
BEAM TUBE/FPC BLANK FLANGE DETA
CRM9007010-1054
SIZE C
SCALE 1:1
SHEET 1 OF
MATERIAL
STAINLESS STEEL TYPE 304
DRAWN R.BISHOP
APPROVALS
DATE
CHECKED
APPROVED
DO NOT SCALE DRAWING


DWG. NO. CRM9007010-1051
SHT. 1
REV. —
30° TYP
32
32
32
32
SHARP EDGE, DO NOT DAMAGE
.197±.003
SECTION A - A
ϕ3.654
ϕ3.831
ϕ3.828
ϕ3.477
A
A
DIM & TOL PER ANSI Y14.5
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS ±1/64
DECIMAL .XX ±.01 .XXX ±.005
ANGLES ±.50°
MATERIAL
AlMg3
FINISH 125
UNLESS OTHERWISE NOTED
DEBURR & BREAK ALL SHARP EDGES
DO NOT SCALE DRAWING
CADD I.D. NO.: I-DEAS
SNS DRAWING NUMBER:
101111000-M8B-8200-A096-R00
APPROVALS
DATE
DRAWN R.BISHOP
31AUG00
CHECKED
APPROVED
APPROVED
Jefferson Lab
Thomas Jefferson National Accelerator Facility
NEWPORT NEWS, VIRGINIA
UNITED STATES DEPARTMENT OF ENERGY
SPALLATION NEUTRON SOURCE
0.61 BETA CRYOMODULE
CAVITY
BEAM TUBE/FPC FLANGE SEAL DETAIL
SIZE B
DWG. NO. CRM9007010-1051
REV. —
SCALE 1:1
USED ON ASSY NO. CRM9007010-0001/0002
SHEET 1 OF 1

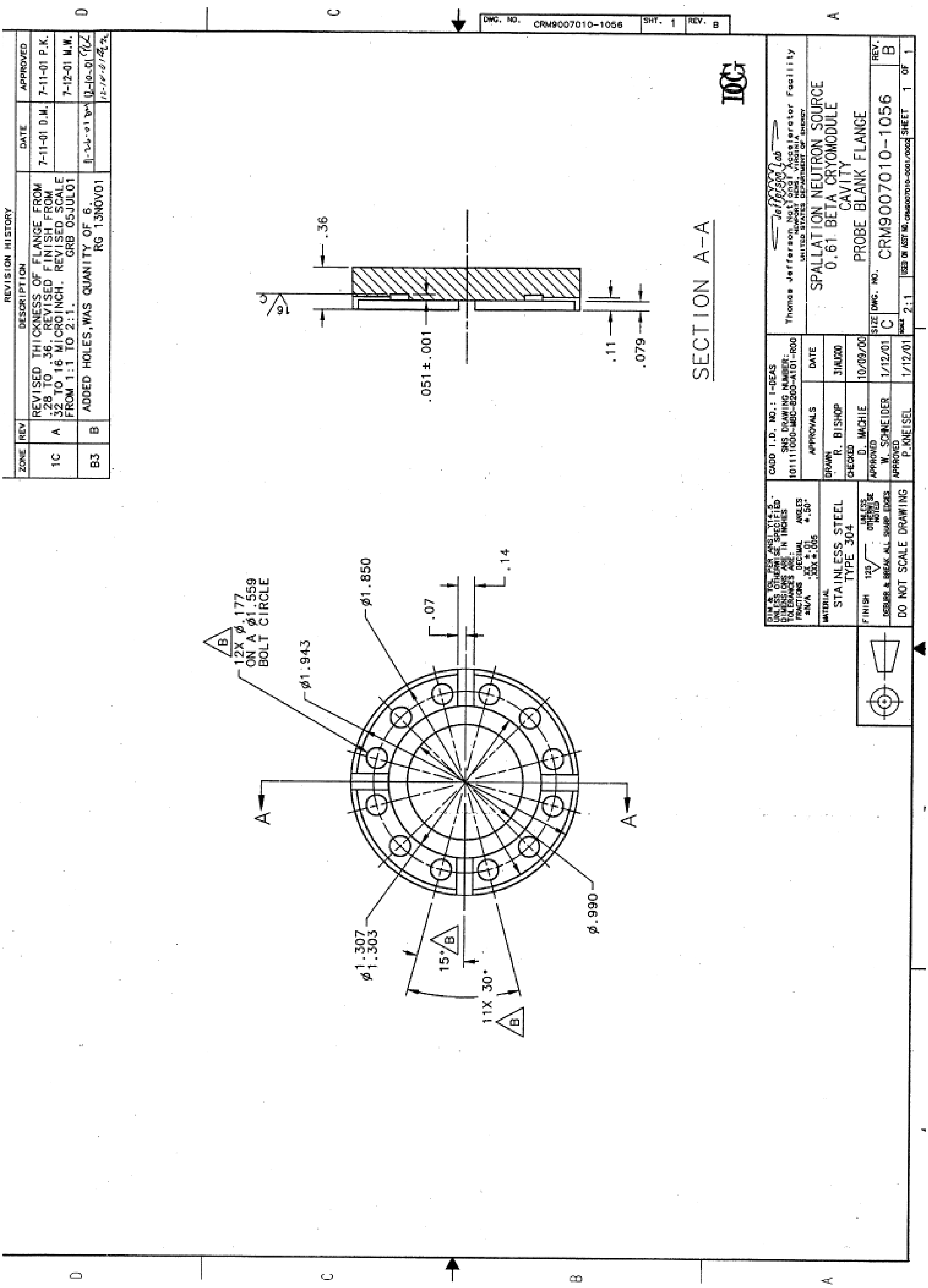
SNS Pick up

SNS Pick up flange male	
Material	NbTi
O.D.	46.6 mm (1.835”)
Thickness	7.1 mm (0.28”)
Number of holes	12
Bolt circle diameter	39.6 mm (1.559”)
Groove depth	0.5 mm (0.021”)
External groove diameter	33.1 mm (1.305”)
Screw	A286 (A66286 UNS INCOLOY) 8-32 [33]
Nut	Backer ring Al Ni Br [33]
Washer	Yes + Belleville [33]
Closing torque	5 Nm (40 inch lbs.) [33]
Seal	AlMg3 Diamond shape (DIN 1746)
Pipe connection	Electron beam welding

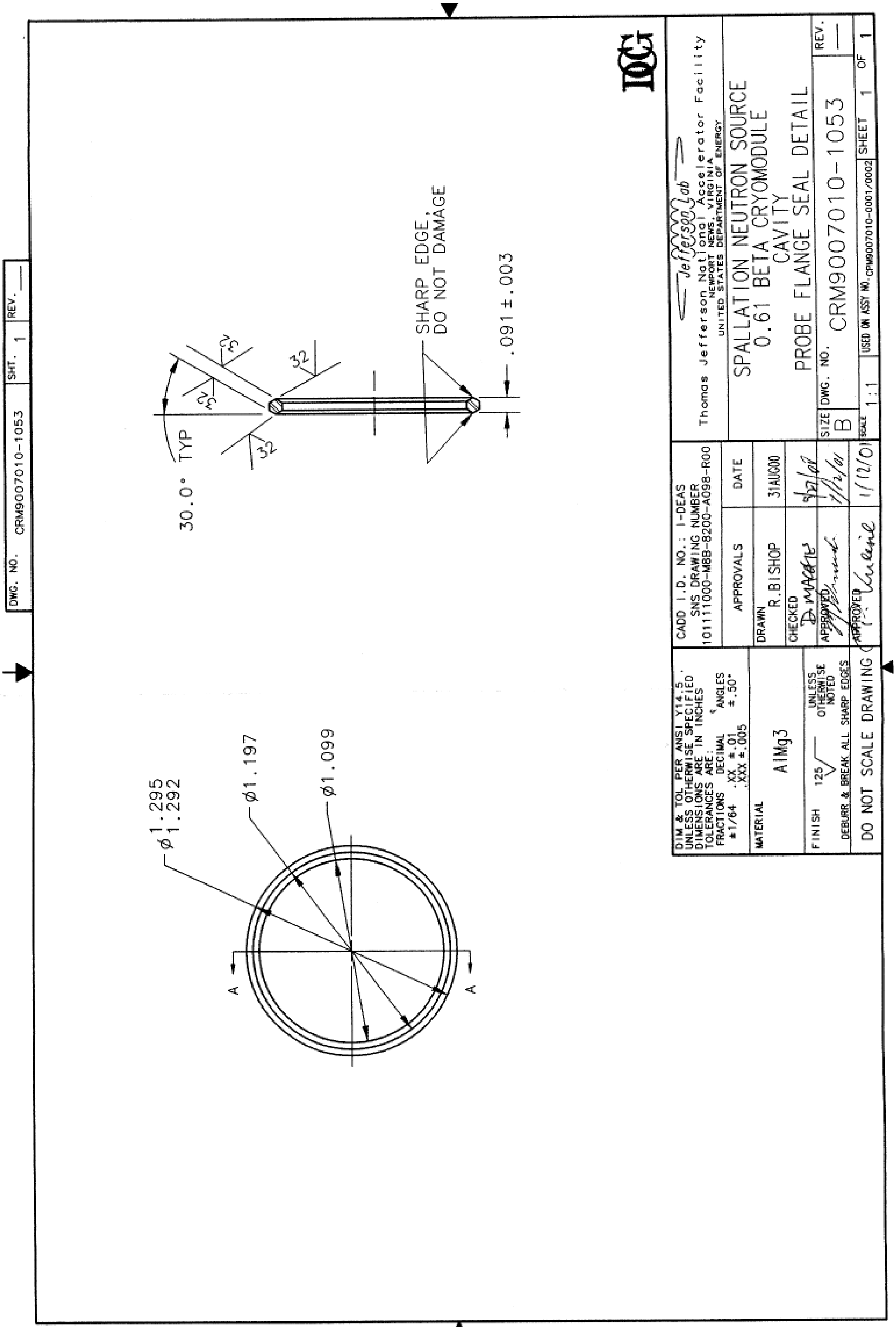


This is the old version of the pick up flange. The current design foreseen a change for the number of screw holes, from 6 to 12. See technical draw of the blank flange of page 75.

SNS Pick up flange female (blank flange)	
Material	Stainless steel type 304
O.D.	47.0 mm (1.85”)
Thickness	7.1 mm (0.281”)
Groove depth	1.3 mm (0.051”)
Internal groove diameter	25.1 mm (0.99”)
External groove diameter	33.1 mm (1.305”)
Number of holes	12
Bolt circle diameter	39.6 mm (1.559”)
Screw	A286 (A66286 UNS INCOLOY) 8-32 [33]
Nut	Backer ring Al Ni Br [33]
Washer	Yes + Belleville [33]
Closing torque	5 Nm (40 inch lbs.) [33]
Seal	AlMg3 Diamond shape (DIN 1746)



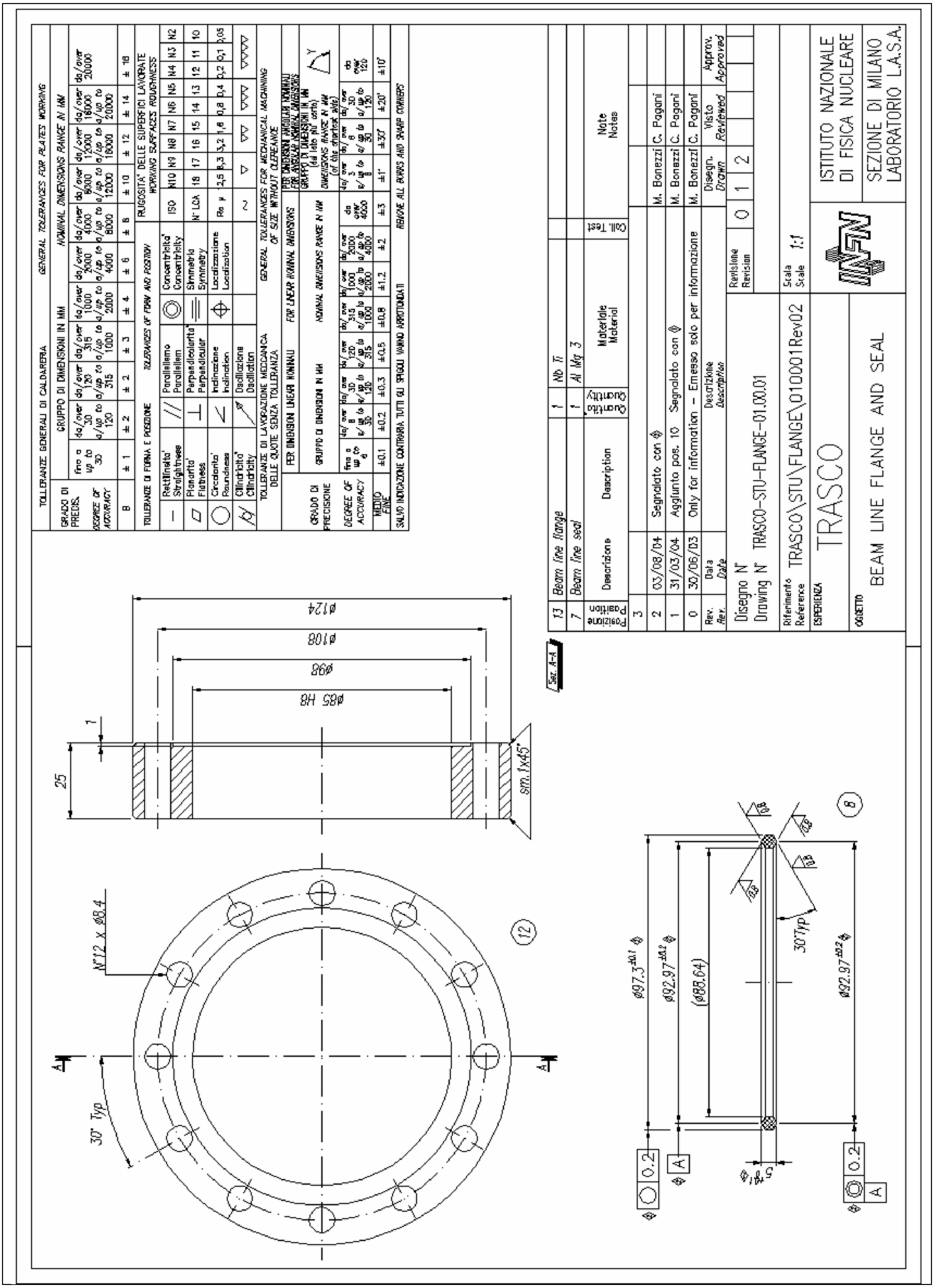
REVISION HISTORY
ZONE REV DESCRIPTION DATE APPROVED
1C A REVISED THICKNESS OF FLANGE FROM .28 TO .36. REVISED FINISH FROM 32 TO 16 MICROINCH. REVISED SCALE FROM 1:1 TO 2:1. GRB 05JUL01 7-11-01 D.M. 7-11-01 P.K. 7-12-01 M.M.
B3 B ADDED HOLES, WAS QUANITY OF 6. RG 13NOV01
DWG. NO. CRM9007010-1056 SHT. 1 REV. B
SECTION A-A
.36
.051 ±.001
.11
.079
12X ø.177 ON A ø1.559 BOLT CIRCLE
ø1.943
ø1.850
.07
.14
ø.990
ø1.307 1.303
15°
11X 30°
A
A
Thomas Jefferson National Accelerator Facility
UNITED STATES DEPARTMENT OF ENERGY
SPALLATION NEUTRON SOURCE
0.61 BETA CRYOMODULE
CAVITY
PROBE BLANK FLANGE
CADD I.D. NO.: I-DEAS
SNS DRAWING NUMBER: 101111000-M8C-8200-A101-R30
APPROVALS DATE
DRAWN R. BISHOP 31AUG00
CHECKED D. MACHIE 10/09/00
APPROVED W. SCHNEIDER 1/12/01
APPROVED P. KNEISEL 1/12/01
MATERIAL STAINLESS STEEL TYPE 304
DO NOT SCALE DRAWING
SIZE C DWG. NO. CRM9007010-1056 REV. B
SCALE 2:1 SHEET 1 OF 1


DWG. NO. CRM9007010-1053
SHT. 1
REV. —
30.0° TYP
32
32
SHARP EDGE; DO NOT DAMAGE
.091 ± .003
Ø1.295 1.292
Ø1.197
Ø1.099
A
A
DIM & TOL PER ANSI Y14.5. UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE: FRACTIONS ±1/64 DECIMAL .XX ±.01 .XXX ±.005 ANGLES ±.50°
MATERIAL
AlMg3
FINISH 125 UNLESS OTHERWISE NOTED
DEBURR & BREAK ALL SHARP EDGES
DO NOT SCALE DRAWING
CADD I.D. NO.: I-DEAS
SNS DRAWING NUMBER
101111000-M8B-8200-A098-R00
APPROVALS
DATE
DRAWN R.BISHOP
31AUG00
CHECKED
APPROVED
APPROVED
Thomas Jefferson National Accelerator Facility
NEWPORT NEWS, VIRGINIA
UNITED STATES DEPARTMENT OF ENERGY
SPALLATION NEUTRON SOURCE
0.61 BETA CRYOMODULE
CAVITY
PROBE FLANGE SEAL DETAIL
SIZE B
DWG. NO. CRM9007010-1053
REV. —
SCALE 1:1
USED ON ASSY NO. CRM9007010-0001/0002
SHEET 1 OF 1

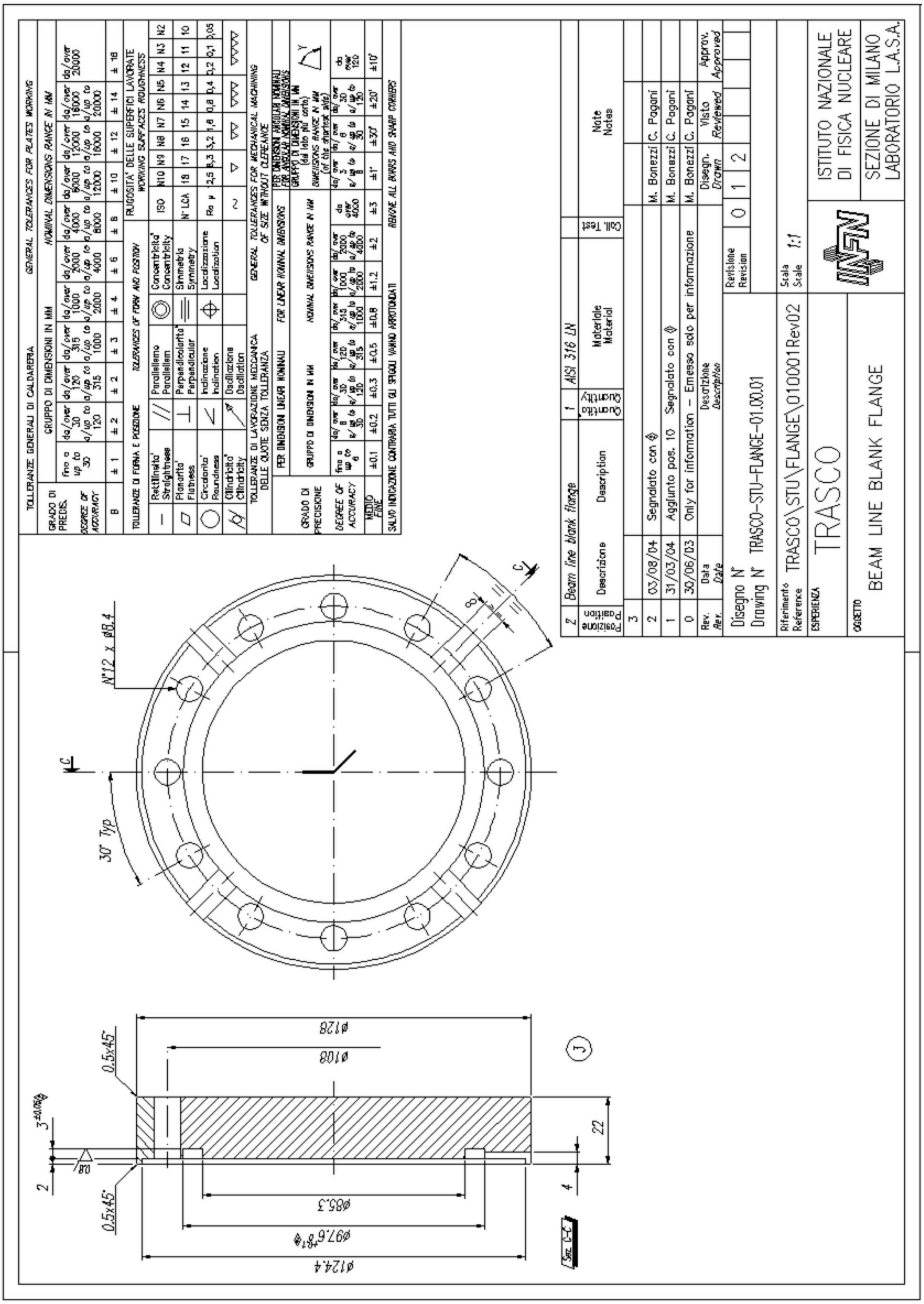
4.3 TRASCO/XADS

TRASCO Beam flange

TRASCO Beam flange male	
Material	NbTi
O.D.	124.0 mm
Thickness	25.0 mm
Number of Holes	12
Bolt circle diameter	108.0 mm
Groove depth	1.0 mm
External groove diameter	98.0 mm
Screw	M8 A4-80 (UNI EN ISO 3506-1)
Nut	M8 A4-80 (UNI EN ISO 3506-1)
Washer	A4 (UNI 5962)
Closing torque	30 Nm
Seal	AlMg3 Diamond shape (DIN 1746)
Pipe connection	Electron beam welding


BEAM LINE FLANGE AND SEAL
TRASCO
ISTITUTO NAZIONALE DI FISICA NUCLEARE
SEZIONE DI MILANO LABORATORIO L.A.S.A.
Disegno N° Drawing N° TRASCO-STU-FLANGE-01.00.01
Riferimento Reference TRASCO\STU\FLANGE\010001Rev02
Scala Scale 1:1
13 Beam line flange 1 Nb Ti
7 Beam line seal 1 Al Mg 3
0 30/06/03 Only for information - Emesso solo per informazione M. Bonezzi C. Pagani
1 31/03/04 Aggiunto pos. 10 Segnalato con M. Bonezzi C. Pagani
2 03/08/04 Segnalato con M. Bonezzi C. Pagani
ø124
ø108
ø98
ø85 H8
25
N°12 x ø8.4
30° Typ
Sez. A-A
sm.1x45°
ø97.3
ø92.97
(ø88.64)
30°Typ

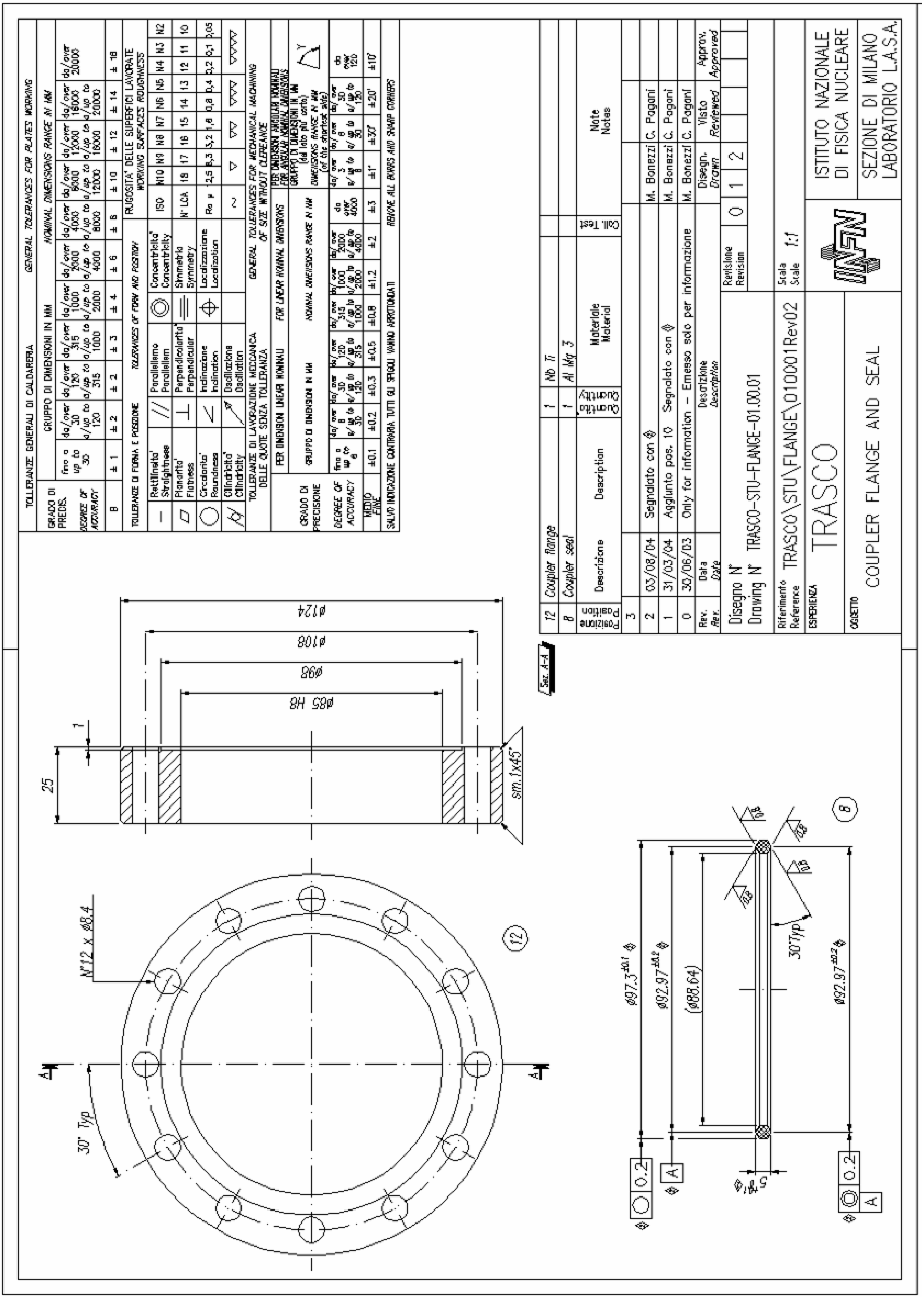
TRASCO Beam flange female (blank flange)	
Material	AISI 316 LN
O.D.	124.4 mm
Thickness	20.0 mm
Groove depth	3.0 mm
Internal groove diameter	85.3 mm
External groove diameter	97.6 mm
Number of holes	12
Bolt circle diameter	108.0 mm
Screw	M8 A4-80 (UNI EN ISO 3506-1)
Nut	M8 A4-80 (UNI EN ISO 3506-1)
Washer	A4 (UNI 5962)
Closing torque	30 Nm
Seal	AlMg3 Diamond shape (DIN 1746)



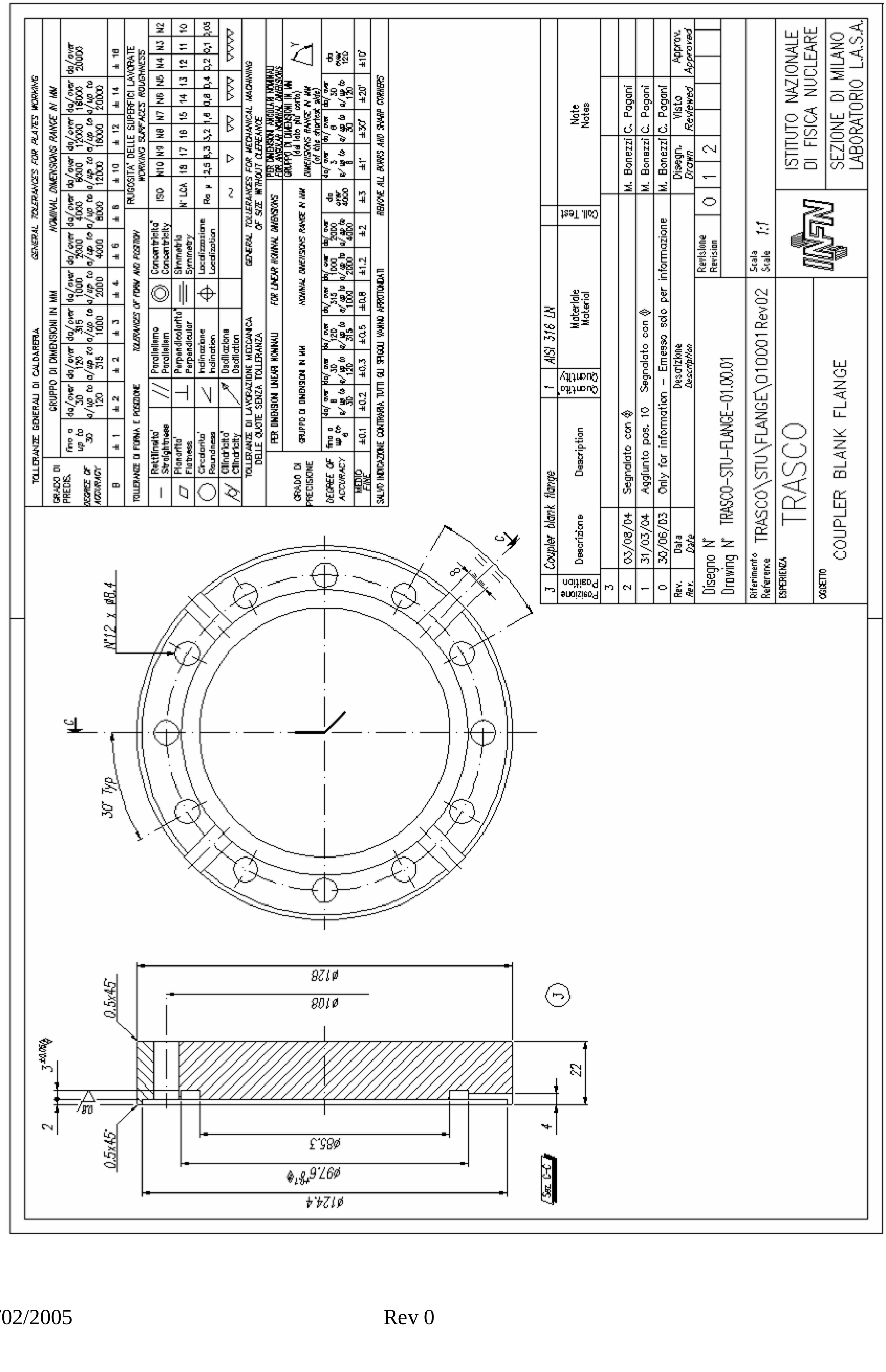
TOLLERANZE GENERALI DI CALDARERIA
GENERAL TOLERANCES FOR PLATES WORKING
TOLLERANZE DI FORMA E POSIZIONE
TOLERANCES OF FORM AND POSITION
RUGOSITA' DELLE SUPERFICI LAVORATE
WORKING SURFACES ROUGHNESS
TOLLERANZE DI LAVORAZIONE MECCANICA DELLE QUOTE SENZA TOLLERANZA
GENERAL TOLERANCES FOR MECHANICAL MACHINING OF SIZE WITHOUT CLEREANCE
SALVO INDICAZIONE CONTRARIA TUTTI GLI SPIGOLI VANNO ARROTONDATI
REMOVE ALL BURRS AND SHARP CORNERS
N°12 x ø8.4
30° Typ
C
C
8
0.5x45°
0.5x45°
3
2
22
4
ø128
ø108
ø85.3
ø97.6
ø124.4
Sez. C-C
2
Beam line blank flange
1
AISI 316 LN
Posizione Position
Descrizione Description
Quantità Quantity
Materiale Material
Note Notes
Coll. Test
3
2 03/08/04 Segnalato con ◈ M. Bonezzi C. Pagani
1 31/03/04 Aggiunto pos. 10 Segnalato con ◈ M. Bonezzi C. Pagani
0 30/06/03 Only for information - Emesso solo per informazione M. Bonezzi C. Pagani
Rev. Data Date Descrizione Description Disegn. Drawn Visto Reviewed Approv. Approved
Revisione Revision 0 1 2
Disegno N° Drawing N° TRASCO-STU-FLANGE-01.00.01
Riferimento Reference TRASCO\STU\FLANGE\010001Rev02
Scala Scale 1:1
ESPERIENZA TRASCO
OGGETTO BEAM LINE BLANK FLANGE
ISTITUTO NAZIONALE DI FISICA NUCLEARE
SEZIONE DI MILANO LABORATORIO L.A.S.A.

TRASCO Main coupler

TRASCO Main coupler male	
Material	NbTi
O.D.	124.0 mm
Thickness	25.0 mm
Number of Holes	12
Bolt circle diameter	108.0 mm
Groove depth	1.0 mm
External groove diameter	98.0 mm
Screw	M8 A4-80 (UNI EN ISO 3506-1)
Nut	M8 A4-80 (UNI EN ISO 3506-1)
Washer	A4 (UNI 5962)
Closing torque	30 Nm
Seal	AlMg3 Diamond shape (DIN 1746)
Pipe connection	Electron beam welding


ISTITUTO NAZIONALE
DI FISICA NUCLEARE
SEZIONE DI MILANO
LABORATORIO L.A.S.A.
COUPLER FLANGE AND SEAL
TRASCO
TRASCO\STU\FLANGE\010001Rev02
TRASCO-STU-FLANGE-01.00.01
Coupler flange
Coupler seal
Nb Ti
Al lég 3
Scala 1:1
M. Bonezzi
C. Pagani
30/06/03
Only for information - Emesso solo per informazione
31/03/04
Aggiunto pos. 10 Segnalato con
03/08/04
Segnalato con
Ø124
Ø108
Ø98
Ø85 H8
25
N°12 x Ø8.4
30° Typ
Sez. A-A
sm.1x45°
Ø97.3
Ø92.97
(Ø88.64)
30°Typ

TRASCO Coupler flange female (blank flange)	
Material	AISI 316 LN
O.D.	124.4 mm
Thickness	20.0 mm
Groove depth	3.0 mm
Internal groove diameter	85.3 mm
External groove diameter	97.6 mm
Number of holes	12
Bolt circle diameter	108.0 mm
Screw	M8 A4-80 (UNI EN ISO 3506-1)
Nut	M8 A4-80 (UNI EN ISO 3506-1)
Washer	A4 (UNI 5962)
Closing torque	30 Nm
Seal	AlMg3 Diamond shape (DIN 1746)

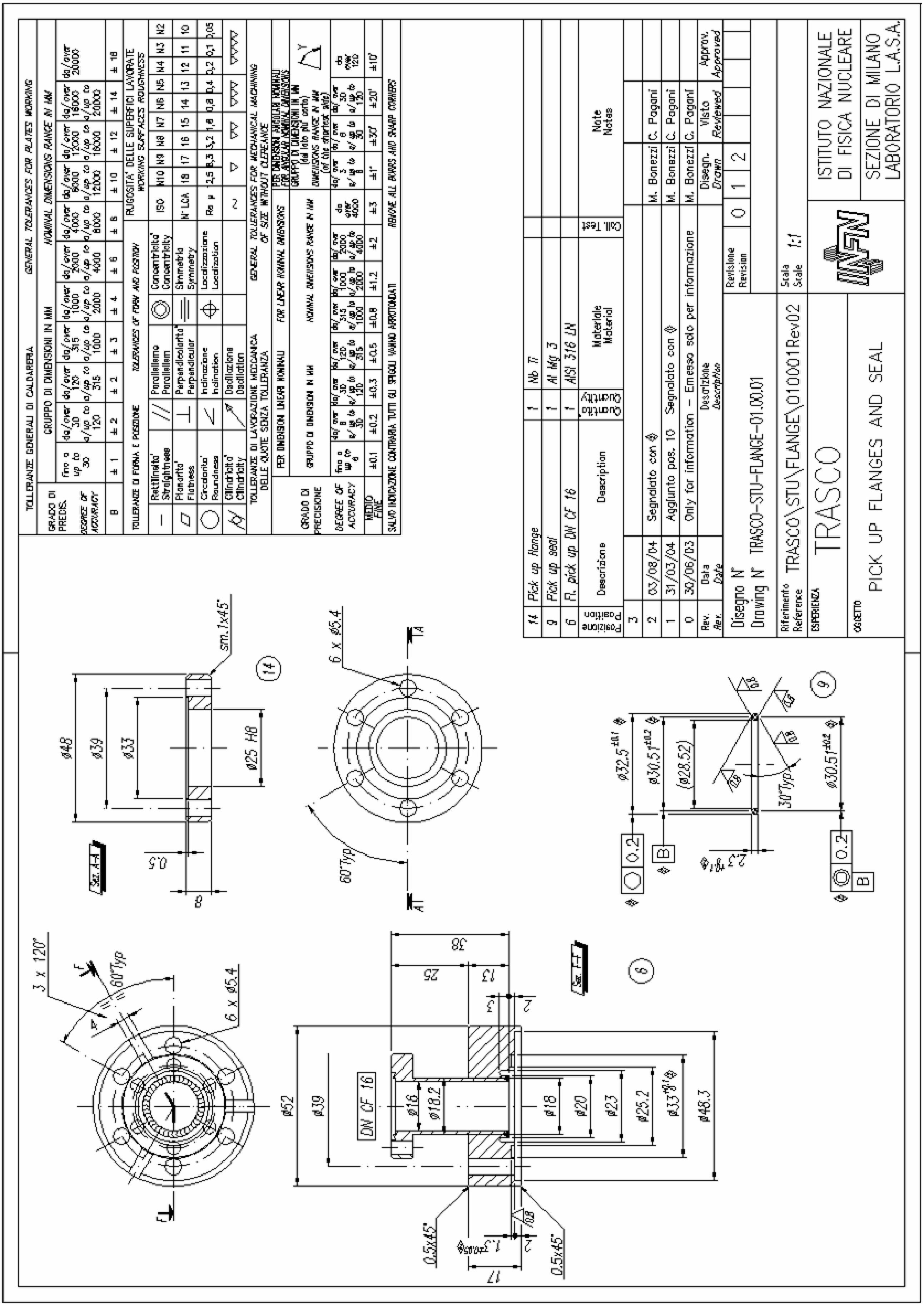


COUPLER BLANK FLANGE
TRASCO
ISTITUTO NAZIONALE DI FISICA NUCLEARE
SEZIONE DI MILANO LABORATORIO L.A.S.A.
Disegno N° Drawing N° TRASCO-STU-FLANGE-01.00.01
Riferimento Reference TRASCO\STU\FLANGE\010001Rev02
Scala Scale 1:1
Coupler blank flange
AISI 316 LN
03/08/04 Segnalato con
31/03/04 Aggiunto pos. 10 Segnalato con
30/06/03 Only for information – Emesso solo per informazione
M. Bonezzi C. Pagani
N°12 x ø8.4
30° Typ
ø128
ø108
ø85.3
ø124.4
0.5x45°
22

TRASCO Pick up flange

TRASCO Pick up flange male	
Material	NbTi
O.D.	48.0 mm
Thickness	8.0 mm
Number of Holes	6
Bolt circle diameter	39.0 mm
Groove depth	0.5 mm
External groove diameter	33.0 mm
Screw	M4 A4-80 M8 (UNI EN ISO 3506-1)
Nut	M4 A4-80 M8 (UNI EN ISO 3506-1)
Washer	A4 (UNI 5962)
Closing torque	5 Nm
Seal	AlMg3 Diamond shape (DIN 1746)
Pipe connection	Electron beam welding

TRASCO Pick up flange female (blank flange)	
Material	AISI 316 LN
O.D.	48.3 mm
Thickness	15.0 mm
Groove depth	1.3 mm
Internal groove diameter	25.2 mm
External groove diameter	33.0 mm
Number of holes	6
Bolt circle diameter	39.0 mm
Screw	M4 A4-80 M8 (UNI EN ISO 3506-1)
Nut	M4 A4-80 M8 (UNI EN ISO 3506-1)
Washer	A4 (UNI 5962)
Closing torque	5 Nm
Seal	AlMg3 Diamond shape (DIN 1746)


ISTITUTO NAZIONALE DI FISICA NUCLEARE
SEZIONE DI MILANO LABORATORIO L.A.S.A.
PICK UP FLANGES AND SEAL
TRASCO
TRASCO\STU\FLANGE\010001Rev02
Disegno N° Drawing N° TRASCO-STU-FLANGE-01.00.01
Scala Scale 1:1
14 Pick up flange 1 Nb Ti
9 Pick up seal 1 Al Mg 3
6 Fl. pick up DN CF 16 1 AISI 316 LN
2 03/08/04 Segnalato con
1 31/03/04 Aggiunto pos. 10 Segnalato con
0 30/06/03 Only for information – Emesso solo per informazione
M. Bonezzi C. Pagani
DN CF 16
TOLLERANZE GENERALI DI CALDARERIA
GENERAL TOLERANCES FOR PLATES WORKING

4.4 *Commercial cold connection*

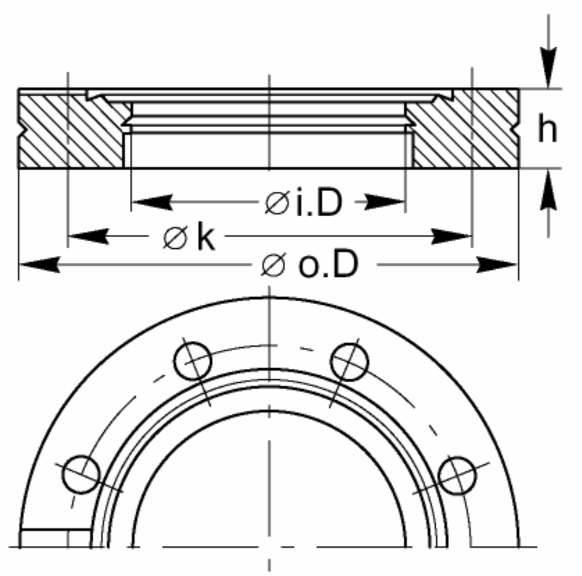
In the retrieving of information two kinds of commercial flanges and seals are been taken in account: Conflat CF flanges and Helicoflex.

CONFLAT® (CF FLANGES, ISO DIS 3669)

Usual CF flanges can be used also at cryogenic temperature (see for instance the Varian catalogue).

CF flanges			
	CF 16	**CF 40**	**CF 100**
Material	316 LN	316 LN	316 LN
O.D.	34.0 mm	69.5 mm	152.0 mm
Bolt circle diameter K	27.0 mm	58.7 mm	130.3 mm
h	7.5 mm	13.0 mm	20.0 mm
Number of holes	6	6	16
Bolt	M4 X 20	M6 X 35	M8 X 50
Suggested closing torque	4 Nm	10 Nm	20 Nm
Seal	copper gasket	copper gasket	copper gasket
Connection to Nb pipe	brazing	brazing	brazing

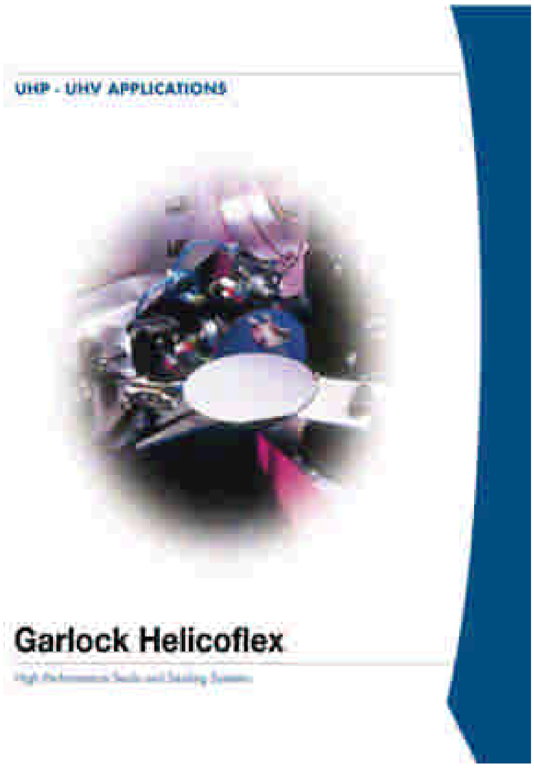
LEYBOLD catalogue 2003-04 page C15.03

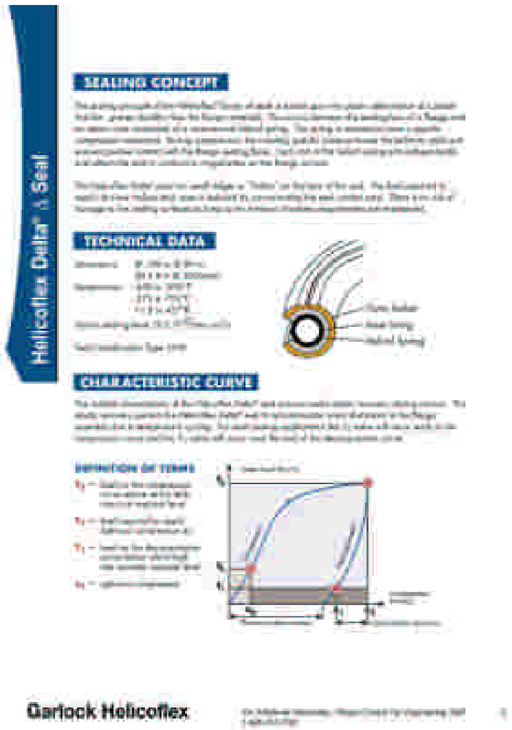


Helicoflex

Helicoflex are special metal gaskets, produced by Garlok, which can be used for UHV connections, also operating al cryogenic temperatures. The same company produce also special quick disconnect systems. Helicoflex gaskets were used in SC cavities but, in some cases, they had shown some drawback like difficulties in cleaning the internal spring. [34]

Detailed information of the Helicoflex seals characteristics and suggestions for the correct use can be found on the web: www.**helicoflex**.com/.





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