

NIOBIUM TECHNICAL SPECIFICATION FOR ESS MEDIUM BETA CAVITIES

REVISION E / 20 Jan 2017

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1 AREA OF VALIDITY

These specifications establish the requirements on the Nb material and semi-finished products fabricated according to ASTM B 393-05 to be used to produce medium beta cavities for ESS project.

2 NIOBIUM 300

2.1 ELECTRICAL PROPERTIES (RRR VALUE)

Nb 300: min RRR 300, aim: RRR > 300 *)

*) The Residual Resistivity Ratio, RRR, is defined as the ratio of electrical resistivity at 295 K to electrical resistivity at 4.2 K (in the case of Niobium: electrical resistivity at 4.2 K is obtained by extrapolation from value when the material is in a non-superconducting state e.g. 10 K or obtained due to suppressing the superconducting state of Nb at 4.2 K by application of high magnetic field).

2.2 CHEMICAL COMPOSITION

Limit in weight of the content of substitutional elements		
Ta		≤ 0.05 %
W		≤ 0.007 %
Ti		≤ 0.005 %
Fe		≤ 0.003 %
Si		≤ 0.003 %
Mo		≤ 0.005 %
Ni		≤ 0.003 %

Limit in weight of the content of interstitial elements		
H ₂		≤ 2 weight ppm
N ₂		≤ 10 weight ppm
O ₂		≤ 10 weight ppm
C		≤ 10 weight ppm

2.3 SHEET (ALTERNATIVELY DISC) MATERIAL FOR HALF CELLS

The preferred forms are the sheets but the company might offer also discs. All geometrical tolerances are reported in the technical drawings.

Product	Dimension [mm]	Drawing number
Nb-sheet Type A	460x460x4.3	DWG-MB-Halfcell-Rev01 Pos. 2
<i>Alternatively</i> Nb-disc Type A	Φ=465x4.3	DWG-MB-Halfcell-Rev01 Pos. 1

2.3.1 MICROSTRUCTURE

- 100% recrystallized and exhibit uniform size and equal-axed grains
- Predominantly grain size ASTM 5 (0.064 mm) or finer
- No grains larger than ASTM 3 (0.127 mm)

2.3.2 MECHANICAL PROPERTIES (DIN 50125, DIN EN 10002, DIN EN ISO 6507)

RRR 300 mechanical properties

Tensile strength, R_m	$> 140 \text{ N/mm}^2$ *
Yield strength, $R_p 0.2$	$50 < R_p 0.2 < 100 \text{ N/mm}^2$ *
Elongation, AL 30	$\geq 30 \%$ *
Hardness, HV (min. load 10 N)	≤ 60

*measured both perpendicular and parallel to the main rolling direction, using a strain rate of about 10^{-3} sec^{-1} . The difference in mechanical properties (R_m , $R_p 0.2$, AL 30) measured perpendicular and parallel to the main rolling direction should not exceed 20%.

2.3.3 DEEP-DRAWING QUALITY

If requested, the deep-drawing quality and avoidance of orange skin must be demonstrated on samples (for example, by bending with $r = 10 \text{ mm}$, small radius at iris).

2.3.4 QUALITY OF FINAL SHEET (DISC)

Clean conditions during manufacturing, especially during rolling, are crucial. Therefore, the vendor should verify all manufacturing steps concerning cleanliness.

Sheets (discs) must meet the following specifications after final annealing and cleaning (global removal of about $10 \mu\text{m}$ by grinding, followed by a chemical surface treatment of about $10 \mu\text{m}$):

Surface:

- Free from defects according to 2.3.8 of this specification.
- Surface roughness (acc. to DIN EN ISO 4287): arithmetic average of absolute values $R_a \leq 1.6$; maximum height of the profile $R_t \leq 15 \mu\text{m}$.
- Scratches and hollows are acceptable for $R_t \leq 15 \mu\text{m}$ if free from non-niobium material.

Bulk:

Sheets should be free of defects in the niobium according 2.3.8 of this specification.

2.3.5 DIMENSIONS AND TOLERANCES

Dimension and tolerances of the sheets (discs) are specified in the drawings.

2.3.7 ACCEPTANCE AND PACKAGING

The orderer reserves the right to have its technical or procurement representatives witness manufacturing steps, tests and inspections established under the manufacturer's quality assurance system to demonstrate compliance with the specifications.

The orderer will scan all Type A sheets (disks) in a qualified laboratory to detect eventual inclusions present below the surface. The orderer will accept up to 3 %, with respect to the total number of ordered Type A sheets, of unusable Type A sheets (defects present on both side of the sheet or disk). The orderer will inform the producer of all unusable sheets identification number and of the reasons for rejection. Above the 3 %, the producer has to replace the defective Type A sheets with new ones within 60 days from the notification of the threshold overcome.

All documentation should be submitted to orderer either prior to or with shipment. The inspection certificate 3.1 of the delivered sheets must be part of the package.

Packaging must be made in such a way that no defects as described in point in 2.3.8 of this specification will occur during transportation. The wooden boxes has to be delivered on euro-pallet according to DIN EN 13698-1 (dimensions 1200x800 mm) for efficient handling and storage. The maximum weight of each box should not exceed 300 kg.

Details of the packaging have to be agreed with the orderer.

2.3.8 DEFECTS

Standard defects

These defects are to be removed from the surface:

- Non-niobium material.
- Visible clusters of niobium oxides, segregation, cracks, and blisters.
- Scratches and marks of more than $R_t \geq 15 \mu\text{m}$, even if free from non-niobium material.
- Grease and fingerprints on the surface.

Other internal defects

- Shrink holes, laminations, and cracks.
- Niobium oxide and non-niobium clusters.

2.4 OTHER SEMI-FINISHED PRODUCTS

Other semi-finished products with RRR300 quality are:

Component	Dimension [mm]	Drawing number
Main Coupler Beam Tube	460x525x3.2	DWG-MB-FG-Materials-WOC Pos.6
Pick Up Beam Tube	400x460x3.2	DWG-MB-FG-Materials-WOC Pos. 4
Main Coupler Tube	270x350x3.2	DWG-MB-FG-Materials-WOC Pos. 5
Pick Up	Φ=30x700	DWG-MB-FG-Materials-WOC Pos. 2
Ring for tube	Φ _{ext} =160- Φ _{int} =130x40	DWG-MB-FG-Materials-WOC Pos. 1

2.4.1 MICROSTRUCTURE

- 100% recrystallized and exhibit uniform size and equal-axed grains
- Sheets
 - Predominantly grain size ASTM 5 (0.064 mm) or finer
 - No grains larger than ASTM 3 (0.127 mm)
- Tubes and rods
 - Predominantly grain size ASTM 0 (0.359 mm) or finer

2.4.2 MECHANICAL PROPERTIES (DIN EN ISO 6507)

- Hardness, HV (min. load 10 N) ≤ 60

2.4.3 INSPECTION CERTIFICATE

Inspection certificates 3.1 (according DIN EN 10204) should include the following results of measurements and checks of the properties specified above:

- Unique certificate number and the signature of inspection representative
- Material
- Product serial numbers
- Used testing principles, technical rules and specifications
- Dimension and tolerances as specified in the drawings
- Ingot number. Chemical analysis and RRR of the ingot.
- Annealing charge
- RRR value
- Recrystallization degree
- HV (min. load 10 N)
- Grain size
- Gas content

RRR, grain size, HV, gas content has to be measured on two samples of the annealing charge.

The orderer has to be provided with the dimension values for all semi finished products of the charge, with images of the microstructure and annealing protocols on

request.

2.4.4 ACCEPTANCE AND PACKAGING

The orderer reserves the right to have its technical or procurement representatives witness manufacturing steps, tests and inspections established under the manufacturer's quality assurance system to demonstrate compliance with the specifications.

All documentation should be submitted to orderer either prior to or with shipment. The inspection certificate 3.1 of the delivered products must be part of the package.

Packaging must be made in such a way that no defects as described in 2.4.5 of this specification will occur during transportation. The wooden boxes should not be larger than a euro-pallet according to DIN EN 13698-1 (dimensions 1200x800 mm) for efficient handling and storage. The maximum weight of each box should not exceed 300 kg.

Details of the packaging have to be agreed with the orderer.

2.4.5 DEFECTS

Surface:

- a) Free from defects according to 2.3.8 of this specification.
- b) The surface roughness quality is specified in the related drawings; maximum height of the profile $R_t \leq 15 \mu\text{m}$.
- c) Scratches and hollows are acceptable for $R_t \leq 15 \mu\text{m}$ if free from non-niobium material.

Bulk:

- a) Free of defects in the niobium according 2.3.8 of this specification.

3 NIOBIUM 40

3.1 ELECTRICAL PROPERTY (RRR VALUE)

RRR value: min RRR = 40

3.2 CHEMICAL COMPOSITION

Chemical analysis of the ingot

Limit in weight of the content of substitutional elements

Ta	$\leq 0.1 \%$
W	$\leq 0.01 \%$
Ti	$\leq 0.005 \%$
Fe	$\leq 0.005 \%$

Si	≤ 0.005 %
Mo	≤ 0.005 %
Ni	≤ 0.005 %

Limit in weight of the content of interstitial elements

H ₂	≤ 0.0015 %
N ₂	≤ 0.005 %
O ₂	≤ 0.01 %
C	≤ 0.005 %

3.3 MICROSTRUCTURE

Recrystallized: min. 95%

3.4 MECHANICAL PROPERTIES (DIN EN 10002, DIN EN ISO 6507)

RRR 40 mechanical properties

Elongation, AL 30	≥ 20 % *
Hardness, HV (min. load 10 N)	≤ 100

* Measured perpendicular to the main rolling direction, using a strain rate of about 10⁻³ sec⁻¹.

3.5 SEMIFINISHED PRODUCTS

Semi-finished products with RRR 40 quality are:

Product	Dimension [mm]	Drawing number
Stiffeners	200x300x4	DWG-MB-FG-Materials-WOC Pos. 3

3.6 INSPECTION CERTIFICATE

Inspection certificates 3.1 (according to DIN EN 10204) should include the following:

- Unique certificate number and the signature of inspection representative
- Symbol which represents the producer
- Material
- Product serial numbers
- Used testing principles, technical rules and specifications
- Dimension and tolerances as specified in the drawings
- Ingot number. Chemical analysis of ingot
- Annealing charge.
- RRR value
- Recrystallization degree
- HV (min. load 10 N)
- AL 30

RRR, Recrystallization degree, HV, gas content has to be measured on one sample of the annealing charge. The orderer has to be provided with images of the microstructure and annealing protocols on request.

3.7 ACCEPTANCE AND PACKAGING

Orderer reserves the right to have its technical or procurement representatives witness manufacturing steps, tests and inspections established under the manufacturer's quality assurance system to demonstrate compliance with the specifications.

All documentation should be submitted to orderer either prior to or with shipment. The inspection certificate 3.1 of the delivered products must be part of the package.

Packaging must to be made in such a way that no surface damage will occur during transportation. Boxes should not be larger than an Euro-pallet according to DIN EN 13698-1 (dimensions 1200x800mm) for efficient handling and storage. The maximum weight of each box should not exceed 300 kg.

Details of the packaging have to be agreed with the orderer

4 BATCHES

The present supply is divided in two batches of equal size, each one described below:

- Single batch contents
 - 241 RRR 300 sheets Type A (alternatively disks)
 - 11 RRR 300 "Main Coupler Beam Tube" Sheets
 - 11 RRR 300 "Pick Up Beam Tube" Sheets
 - 6 RRR 300 "Main Coupler Tube" Sheets
 - 21 RRR 300 "Ring for Tube"
 - 1 RRR 300 "Pick Up" Rod
 - 20 RRR 40 "Stiffeners" Sheets

We request the offerer to indicate in the offer which and how many batches are of interest.

5 DELIVERY

We expect the delivery of the Niobium parts divided in three steps with the following milestones:

M1, within 120 days from the order assignment:

- 30% Nb RRR 300 Type A Sheets (alternatively disks)

- All Nb RRR 300 Semi Finished Products
- All Nb RRR 40 Semi Finished Products

M2 M1 + 60 days from the order assignment:

- 40% Nb RRR 300 Type A Sheets (alternatively disks)

M3 M2 + 60 days from the order assignment:

- 30% Nb RRR 300 Type A Sheets (alternatively disks)

6 OPTION

We ask the offer to price the cost for this option:

A One set composed by the following components

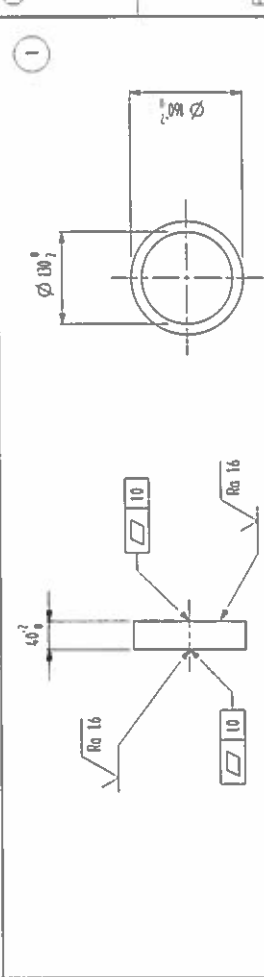
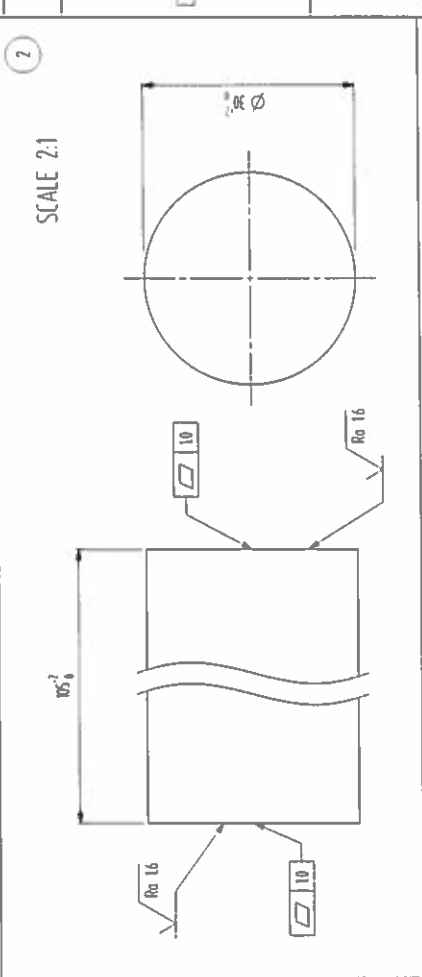
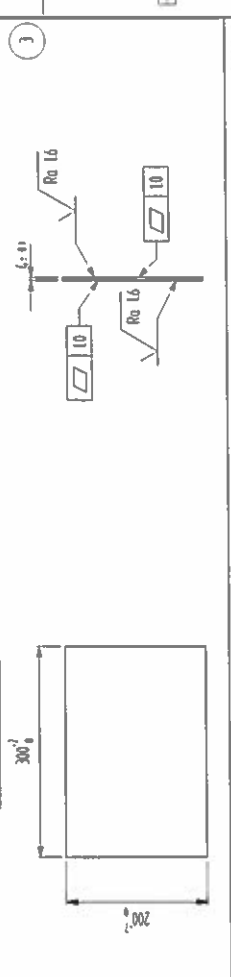
- a. 24 (twenty four) RRR 300 Type A sheets (alternatively disc) as drawing
DWG-MB-Halfcell-Rev01 Pos. 1 or Pos. 2
- b. 1 (one) RRR 300 "Main Coupler Beam Tube" Sheets as drawing
DWG-MB-FG-Materials2xWOC Pos. 6
- c. 1 (one) RRR 300 "Pick Up Beam Tube" Sheets as drawing
DWG-MB-FG-Materials2xWOC Pos. 4
- d. 1 (one) RRR 300 "Main Coupler Tube" Sheet as drawing
DWG-MB-FG-Materials2xWOC Pos. 5
- e. 1 (one) RRR 300 "Pick Up" Rod as drawing
DWG-MB-FG-Materials2xWOC Pos. 2
- f. 2 (two) RRR300 "Ring for Tube" as drawing
DWG-MB-FG-Materials2xWOC Pos. 1
- g. 2 (two) RRR 40 "Stiffeners" Sheets as drawing
DWG-MB-FG-Materials2xWOC Pos. 3

This option and the related quantity will be set within M3.

PROCEDURE MANAGER
(Dr. Paolo Michelato)

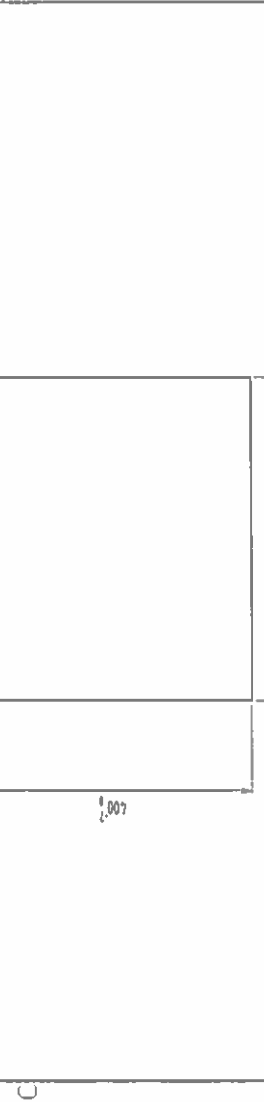
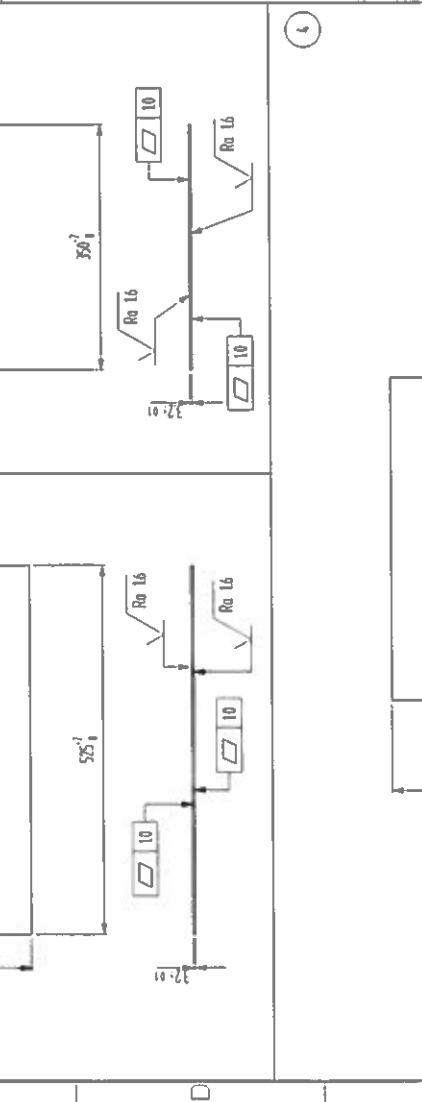
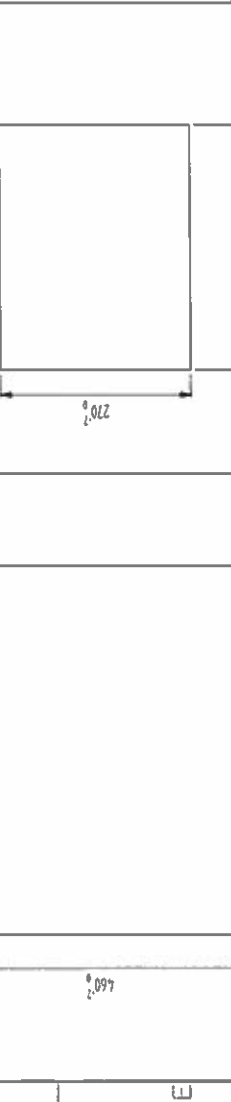


GENERAL TOLERANCES FOR PLATES WORKING		30	30-50	50-75	75-100	100-150	150-200	200-300	300-400	400-500	500-700	700-1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-5000	5000-7000	7000-10000
± 1	± 2	± 2	± 2	± 2	± 3	± 4	± 4	± 5	± 6	± 8	± 10	± 12	± 15	± 20	± 25	± 30	± 40	± 50	± 60
FUP. MECHANICAL FINISHING OF SIZE WITHOUT CLEARANCE																			
TOLERANCES NOT SPECIFIED																			
± 0.1 ± 0.3 ± 0.5 ± 0.8 ± 1.2 ± 2 ± 3																			
WORKING SURFACES ROUNDPNESS																			
Rz 150 Rz 100 Rz 80 Rz 60 Rz 40 Rz 30 Rz 20 Rz 10 Rz 5 Rz 3 Rz 2 Rz 1.5 Rz 1 Rz 0.5																			



Pos.	Part Name	Qty.	Material	Finishing	Height
6	Main Coupler-Beam Tube		St37	minimum 300	
5	Main-Coupler- Tube		St37	minimum 300	
4	Pick-up-Beam- Tube		St37	minimum 300	
3	Stiffeners		St37	minimum 13	
2	Pick-up		St37	minimum 300	
1	Rep. Jar- Tube		St37	minimum 300	

GENERAL TOLERANCES FOR PLATES WORKING		30	30-50	50-75	75-100	100-150	150-200	200-300	300-400	400-500	500-700	700-1000	1000-1500	1500-2000	2000-3000	3000-4000	4000-5000	5000-7000	7000-10000
± 1	± 2	± 2	± 2	± 2	± 3	± 4	± 4	± 5	± 6	± 8	± 10	± 12	± 15	± 20	± 25	± 30	± 40	± 50	± 60
FUP. MECHANICAL FINISHING OF SIZE WITHOUT CLEARANCE																			
TOLERANCES NOT SPECIFIED																			
± 0.1 ± 0.3 ± 0.5 ± 0.8 ± 1.2 ± 2 ± 3																			
WORKING SURFACES ROUNDPNESS																			
Rz 150 Rz 100 Rz 80 Rz 60 Rz 40 Rz 30 Rz 20 Rz 10 Rz 5 Rz 3 Rz 2 Rz 1.5 Rz 1 Rz 0.5																			



Pos.	Part Name	Qty.	Material	Finishing	Height
6	Main Coupler-Beam Tube		St37	minimum 300	
5	Main-Coupler- Tube		St37	minimum 300	
4	Pick-up-Beam- Tube		St37	minimum 300	
3	Stiffeners		St37	minimum 13	
2	Pick-up		St37	minimum 300	
1	Rep. Jar- Tube		St37	minimum 300	

Ra 6.3

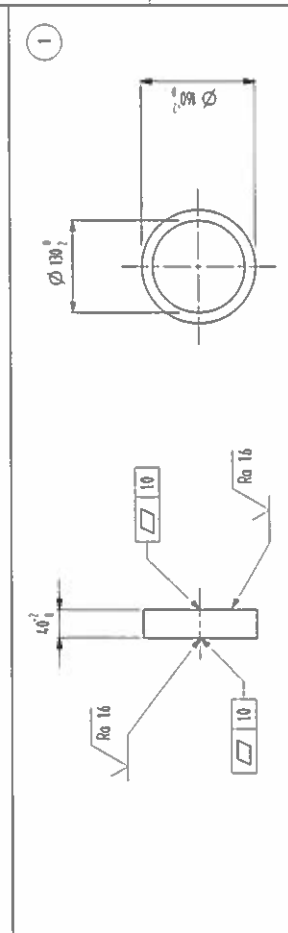
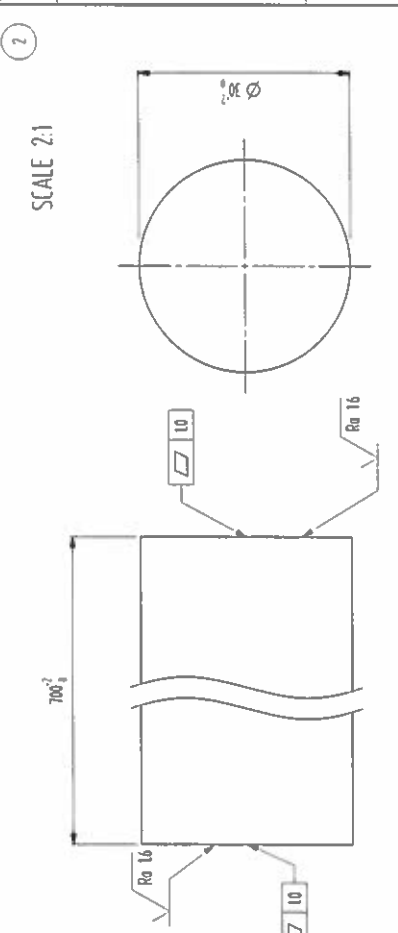
IN N
 with the trademark of P. Michelato

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 Drawn by: **I. Sufrianto**
 Checked by: **P. Michelato**
 Approved by: **P. Michelato**
 Date: **2016/09/21**
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 Units: **mm**

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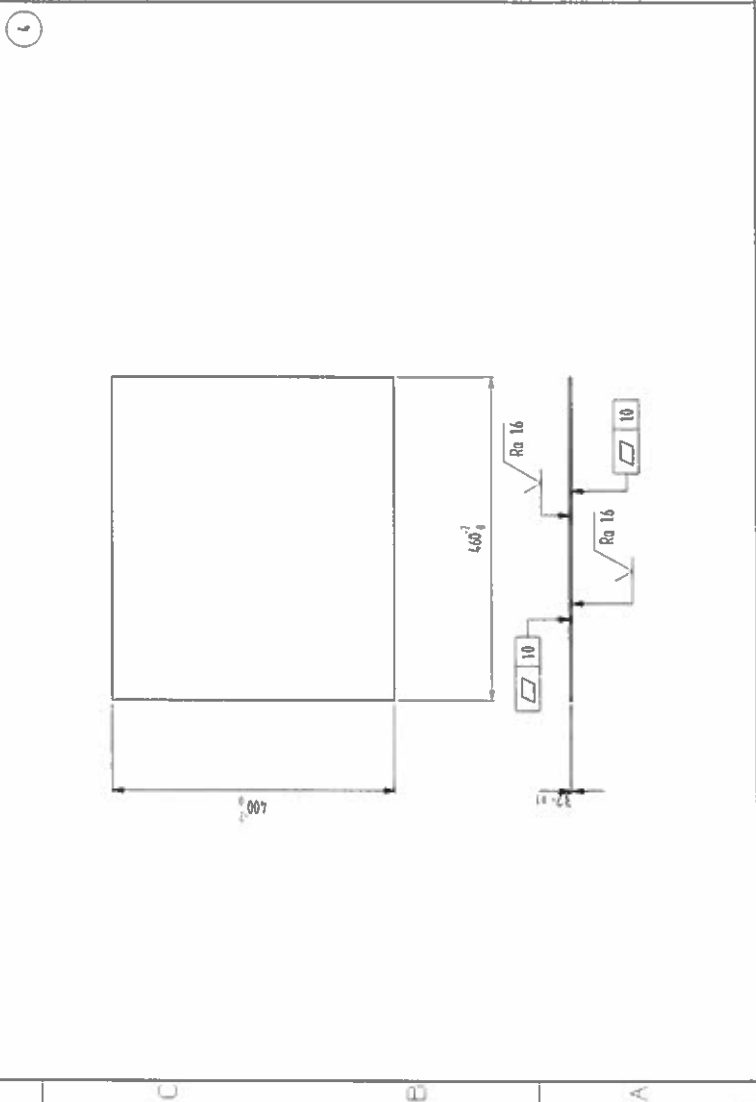
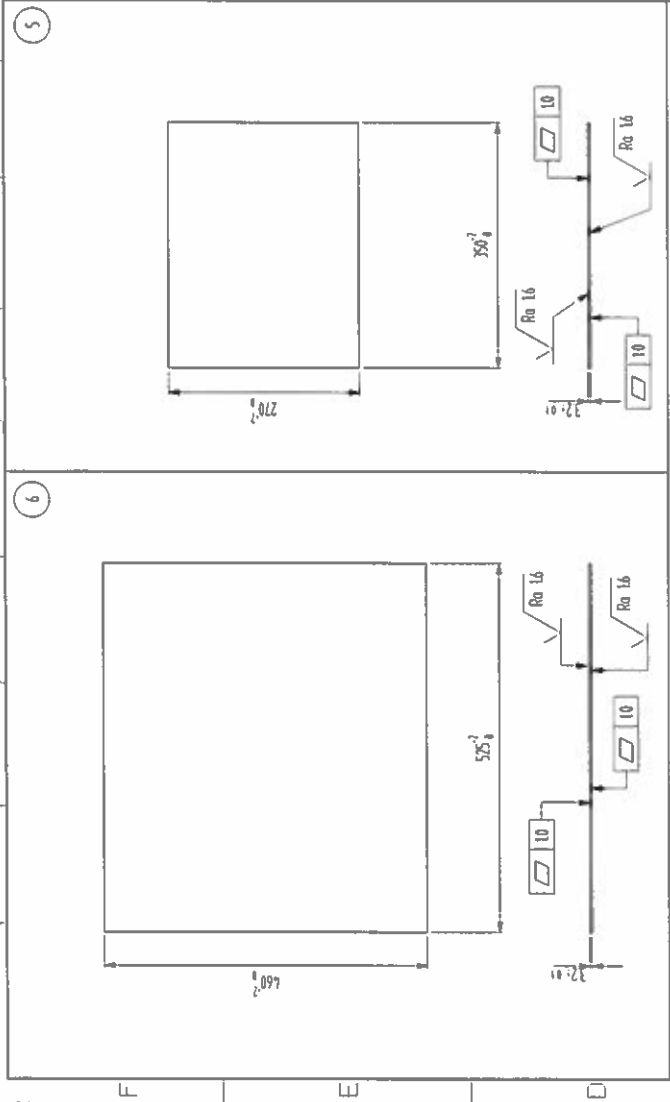
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 Sheet: **1 of 1**

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FOR PLATES WORKING		1	2	3	4	5	6	7	8	9	10	12
FOR MECHANICAL WORKING OF SIZE WITHOUT LEISURE		4	3	2	1	0	0	0	0	0	0	0
TOLERANCES NOT SPECIFIED		±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2.0	±3.0	±4.0	±5.0	±7.0
WORKING SURFACES ADDRESS		ISO N 10	ISO N 8	ISO N 7	ISO N 6	ISO N 5	ISO N 4	ISO N 3	ISO N 2	ISO N 1	ISO N 0	ISO N -1
Roughness		Ra 0.25	Ra 0.5	Ra 1.0	Ra 1.6	Ra 3.2	Ra 6.3	Ra 12.5	Ra 25	Ra 50	Ra 100	Ra 200



No.	Description	Material	Quantity	Unit
6	Main-Connector-Beam-tube	SS304	1	piece
5	Main-Connector-tube	SS304	1	piece
4	Pre-ty-Beam-tube	SS304	1	piece
3	Stiffeners	SS304	1	piece
2	Pre-ty	SS304	1	piece
1	Ring-ty-tube	SS304	1	piece
Pos.	Part Name	Qty	Material	Quantity

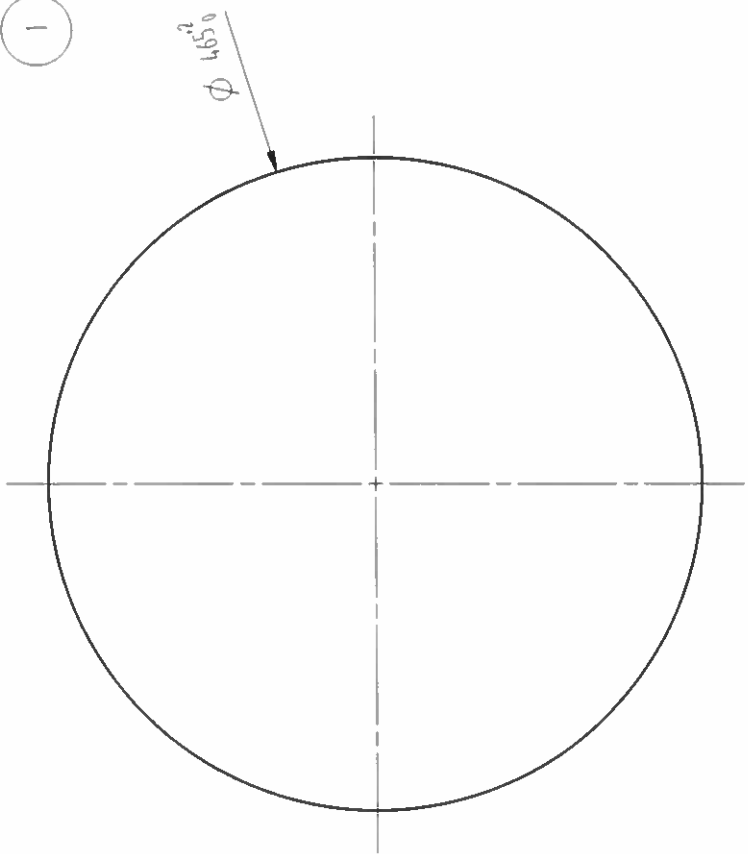
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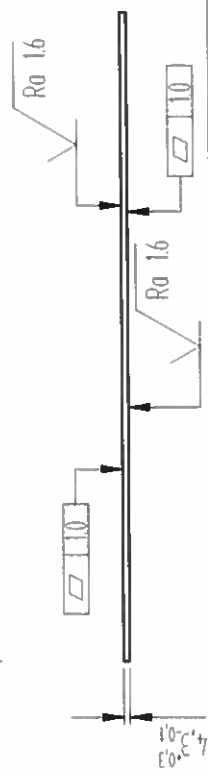
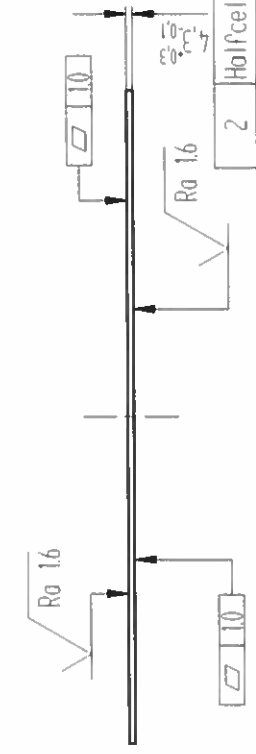
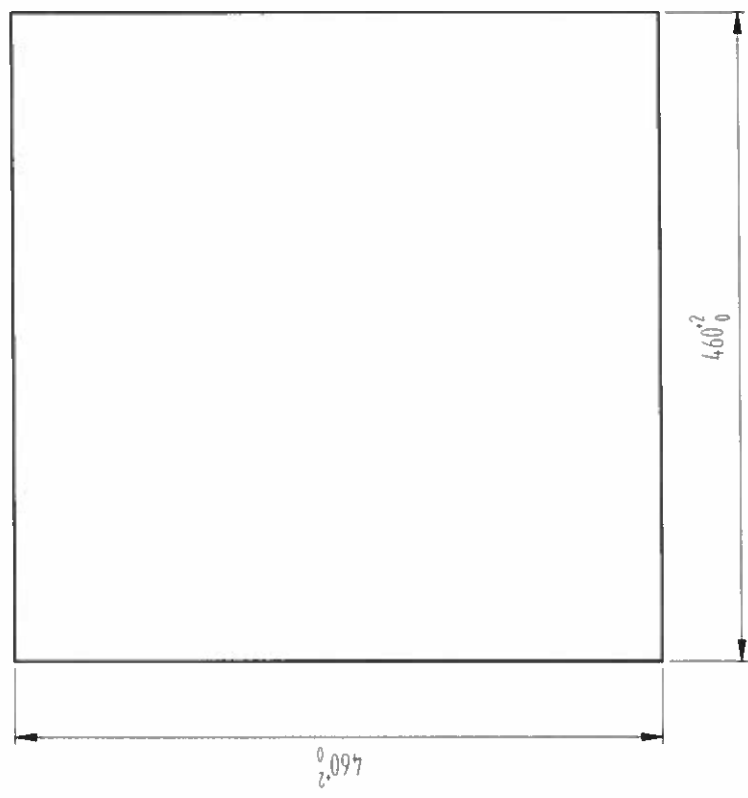
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Size: A2
 MB-FG-Materials-WOC
 Drawn by: I. Suparno
 Date: 2016/09/13
 Sheet 1 of 1

1



2



2	Halfcell-2			Niobium				RRR minimum 300		
1	Halfcell-1			Niobium				RRR minimum 300		
Pos.	Part Name		Qty	Material	Drawing	Note	Weight			
 INFN Istituto Nazionale di Fisica Nucleare		INFN Milano - LASA via Fratelli Cervi, 201 20090 Segrate (MI)		Size: <i>DWG: DWG-Halfcell</i> A4 Halfcell		Revision: 1				
Experience: ESS		Drawn by: L. Saghiano		Date: 2016/10/07						
Object: DWG_DESC		Checked by: P. Michelato		Scale: 1 : 5						
3D part:		Approved by:		Units: mm						
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