EQUIPMENT SPECIFICATION DOCUMENT:

INTERNAL STRUCTURES - CASSETTE

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1 Introduction

Neutron spallation sources are devices designed to produce neutrons from spallation nuclear reactions. In order to produce this kind of reactions it is necessary to accelerate protons (H+ particles) using electromagnetic fields up to they get a huge amount of kinetic energy or speed close to light velocity. In that moment, protons are led to impact on a nucleus of a heavy atom (generally mercury, lead or tungsten) producing what it is known as spallation reaction.

The place where the reaction is produced it is known as spallation Target and it is considered the neutron source. This Targets are complex devices, from an engineering point of view, where a huge amount of heat is deposited on the spallation material. In some cases, it is note that the heat density in the spallation target can be higher than fuel bars inside a nuclear power reactor, as a consequence the design of spallation Target is a real engineering challenge. The ESS target is one of these cases.

The European spallation Source (ESS) is an ambitious European project with a budget higher to 1800 M €. The aim of the project is to design, build and operate the most important and the bright spallation neutron source in the world. The ESS will use a proton beam with final power deposited on the target of 5 MW (five times higher than SNS and JPARC), which will impact on a tungsten Target cooled by helium gas.

The Target will be designed with a set of tungsten blocks placed inside of a wheel of 2.5-2.6 meter of diameter. Protons will impact at high speed on the wheel in a radial direction. Inside the wheel, helium flows at high velocity, cooling the tungsten blocks dissipating the heat produced by the nuclear reactions. The wheel rotates at a speed of 0.2-0.5 Hz, so the proton beam impacts on a different region of the wheel at a repetition rate of 14Hz, distributing the heat over the whole perimeter of the wheel.

The aim of this document is to describe the following aspects that justify the technical decisions associated to the design of the Target internal structures:

- Loads and requirements
- Radiation damage conditions
- Thermomechanical conditions on normal operations (SF1 and SF2)

It should be remark that the internal structures are not a pressurized equipment and due to that, these elements are not under $RCC - MR_x$ design rules. However, the classification of the operational events, loads and mechanical design limits will be done according to these design rules in order to be consistent with other elements of the Target.

2 Loads scenarios

The operational conditions that the component have to withstand along its life time are defined as "load scenarios". The load scenarios are classified based on SF levels[2]:

- SF 1 and 2 are operating conditions associated with Normal operation, start and stop, and normal operational incidents.
- SF 3 Conditions are Operating Conditions which are rare and leads to shutdown and inspection, limit to 10 times in the lifetime.
- SF 4 Conditions are highly improbable but relevant for safety.

Based on the inspection conditions and actions after the scenario, a protection level is associated with the component (Level A, C or D). For the internal structures, inspection is not possible so, events are classified on Levels A (restart is possible after the event) or D (restart is not possible after the event).

Regarding the different operational scenarios [3], Table 1 shows the target events classification of the events considered for the internal structures (cassettes) design and its protection level. It should be remarked that the cassettes structures are not an equipment under pressure so, the level criteria is only included as indication. Moreover, it should be notice that additional accidental conditions will be consider for licensing purposes, but they are not in the scope of this document.

Table 1 shows several accidental cases in which the engineering solution for the cassette will no play a significant role for the behaviors of the system. These load conditions will be evaluated on safety analysis documents [1], but they are not in the scope of this document. The following load cases will not be considered:

- Unsynchronized wheel: The lost of synchronization between rotation of the wheel and proton beam can produced a significant amount of heat in the lateral areas of the cassette. Nevertheless, the cassette is not an structural element of the vessel and it is perfectly cooled due to the helium flow so, the increase of temperature will not produce any relevant effect for the design. This accident will be consider in detail in the design of the Target Vessel.

Requirement	**Loads**	**Level**	**Prot.**
Operating Conditions	Nominal Beam [4] Operating pressure (10 bar) Operational cooling conditions (3 kg s^{-1}) Wheel rotation	SF1	A
Vertically displaced beam	Vertically displaced beam Operating pressure (10 bar) Operational cooling conditions (3 kg s^{-1}) Wheel rotation	SF2	A
Unsynchronized wheel	Horizontally displaced beam Operating pressure (10 bar) Operational cooling conditions (3 kg s^{-1}) Wheel rotation	SF2	A
Loss of coolant flow and pressure	Nominal beam Operating pressure (< 10 bar) Operational cooling conditions (< 3 kg s^{-1}) Wheel rotation	SF3	D
Shut-down	No beam Operating pressure (10 bar) No coolant flow Wheel stopped	SF3	D

Table 1: Operational Scenarios identified for the Cassette[3]

3 ESS Target configuration

The configuration of a 5 MW spallation target is a complex process and there is no an unique solution. Also it should be remark that most of the activated material produced in the spallation reactions will be confine in the target. For that reason the target design is close related to ESS safety issues. In order to guide the selection of the target concept, ESS organized a working group in order to explore several Target options (Target Selection Concept Phase, TSCP). This working group explored several target options from 2010 to 2012[1].

After this process, ESS selected as final solution a solid rotating target cooled by helium. This solution was developed further by ESS and KIT along 2012-2013 and its final concept is summarized on the TDR proposal.

On November 2014, ESS-Bilbao was choose as in-kind partner for Target Wheel, shaft and drive unit. The redesign works started on January 2015. Along this period, ESS-Bilbao has follow and optimization process summarized on the Report [7] that arrives to a new base line proposal in June 2015. The previous configurations analysis is not in the scope of this document.

The proposed new target configuration is based on 10x30x80 mm^3 tungsten bricks. These tungsten bricks are placed on an steel support (the cassette), in a cross flow configuration as it is shown on Figure 1. The coolant will move in the gap between bricks removing the heat deposited by the proton beam, Figure 3.

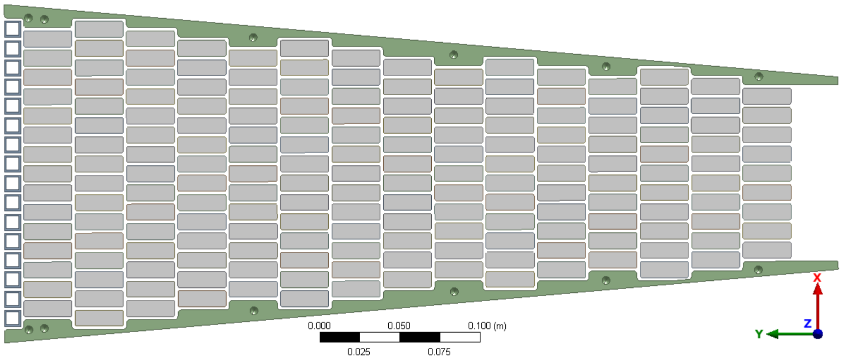


Figure 1: Tungsten bricks(grey) and turbulence generators final (blue) configuration on a Target Wheel sector.

The cassette withstand tungsten bricks and configures the inlet helium channels in the gap between ribs and target vessel (Figure 3). Finally, 36 of these cassettes will be assembled in a sectored wheel as it is shown on Figure 2.

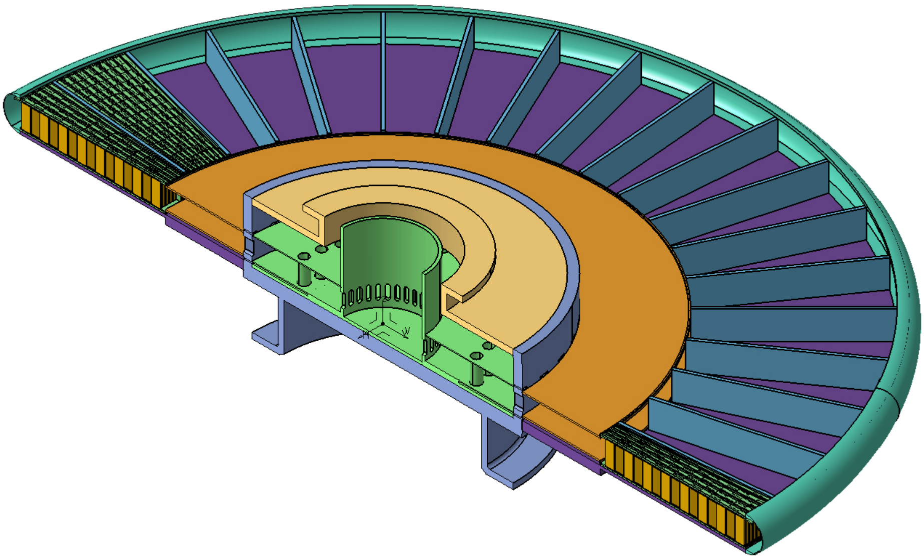


Figure 2: Target wheel configuration

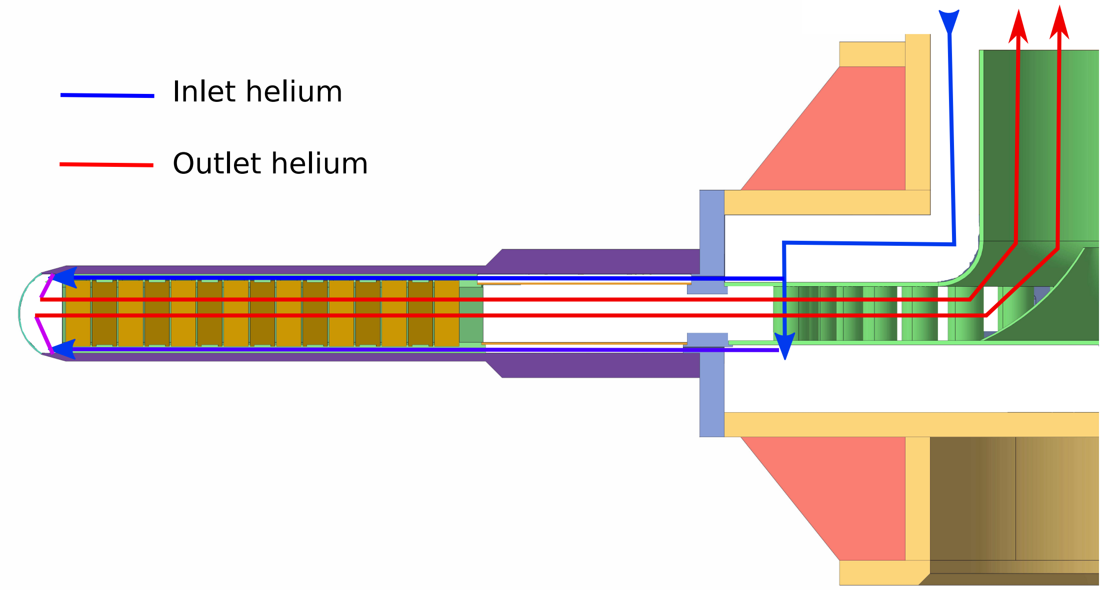


Figure 3: Target wheel helium flow

The relative position between bricks is defined by grooves machined in the top and bottom covers of the cassette. The adjustment between the groves and spallation material produces a gap between 20-100 μm at room temperature. On operational conditions, the gap increases up to 200 μm due to the differential thermal expansion. The vibration experiments [9] do not shown significant tungsten powder production due to the bricks vibration.

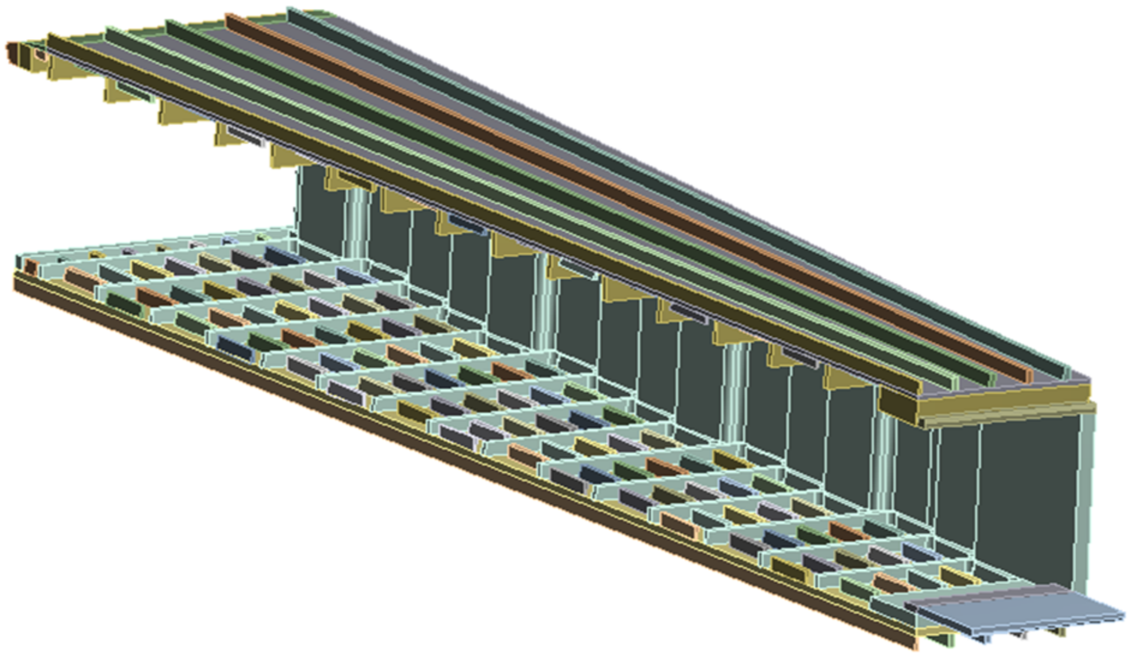


Figure 4: Internal structure geometry

The cassette also includes the lateral steel elements shown on Figure 5. These elements together with the tungsten bricks configure the helium channel closer to the lateral of the cassette. Finally, the from of the lateral regions introduces the holders for the wheel dismantlement process. These holders are consider an interface with the Remote Handling [20].

From the thermomechanical point of view, the holders in the cassette do not introduce any effect thus, they are not included in the scope of this document.

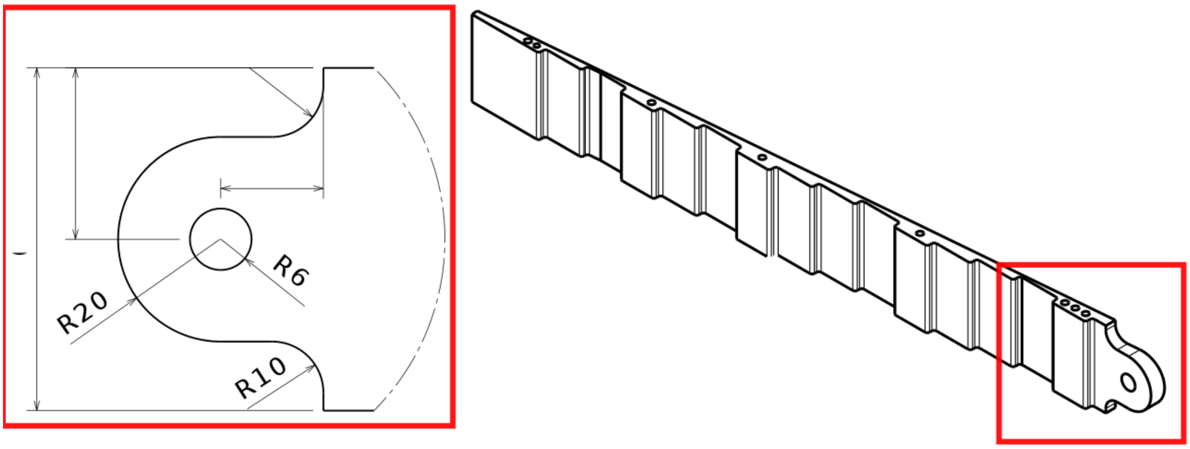


Figure 5: Interface between Remote handling and Cassette

4 Materials properties and operational limits

The internal structures (Figure 4), will be manufactured on austenitic stainless Steel (SS-316L). This alloy its frequently used on nuclear industry due to is good corrosion resistance properties and moderate radiation resistance. Also, this alloy can be welded with standard TIG/MIG techniques, even in thickness above 10 cm with very high quality. Finally, due to its frequent use on non-nuclear industry all the manufacturing technologies required for this material are widely available.

Mechanical properties for lineal model analysis have been taken from ESS Material's Handbook[5], which is completely consistent with $RCC - MR_x$ Appendix A[2].

Based on the scenario under analysis, the device has to be protected against different types of damage. This protection criteria are categorized in several levels. The nominal conditions (SF1,SF2) analyzed in this report are included in the Level A. Accidental conditions (SF3) are included on Level D.

Tables 2 and 3 show the Mechanical Stress limits for primary and secondary loads for both protection levels.

Temp (^oC)	**100**	150	**200**	250	300
S_m (MPa)	127	127	123	114	106
S (MPa)	119	114	108	106	106
$R^t_{p0.2}min$ (MPa)	165	150	137	127	118
(R_m)min (MPa)	430	–	390	–	380
<u>*Peak*</u> $1.5 * S_m = S^A_m$ (MPa)	190.5	190.5	184.5	171	159
<u>*Welding*</u> S_m * 0.85 (MPa) S_m * 0.70 (MPa)	107.95 88.9	107.95 88.9	104.55 86.1	96.9 79.8	90.1 74.2

Table 2: Primary load maximum stress values for SS 316L annealed alloy under Level A. Level D criteria: minimum value between [2.4∗ S_m] or [0.7∗ (R_m)min]

100 ^oC			
D (dpa)	2.75	5	10
S_{em}^A (MPa)	3711	2038	552
S_{et}^A (MPa)	6371	3680	1275
S_{em}^D (MPa)	6872	3775	1022
S_{et}^D (MPa)	11798	6816	2361
200 ^oC			
D (dpa)	2.75	5	10
S_{em}^A (MPa)	3257	1817	536
S_{et}^A (MPa)	5600	3295	1231
S_{em}^D (MPa)	6032	3364	993
S_{et}^D (MPa)	10371	6102	2279
300-350 ^oC			
D (dpa)	2.75	5	10
S_{em}^A (MPa)	2827	1447	294
S_{et}^A (MPa)	4849	2626	472
S_{em}^D (MPa)	5235	2680	544
S_{et}^D (MPa)	8980	4863	874

Table 3: Secondary load maximum stress values for SS 316L annealed alloy under Level A and Level D criterias

5 Methodology

5.1 Particle transport analysis

The radiation transport analysis in complex geometries needs several codes, software and tools to be implemented. This study combine the software *SuperMCAM or MCAD* [11], the codes *MCNPX/6* [14] and *ACAB 2008* [13], and the tool developed by the ESS Bilbao Team *GIGANT* [12]:

- *SuperMCAM or MCAD:* software to convert CAD geometries to MCNP format and other codes.
- *MCNPX/6:* general-purpose Monte Carlo N-Particle code that can be used for particles transport.
- *ACAB 2008:* computer program designed to perform activation and transmutation calculations for nuclear applications.
- *GIGANT:* (General Implemented Geometry Activation Neutron Tool) developed to implement complex geometries for activation calculations.

The methodology used to reach the results is shown in Figure 6, which summarizes the followed process.

The first step is to transform the CAD geometry into the format used in the code for particles transport, MCNP. The software that does the transformation is SuperMCAM.

The initial geometry has to be modified and simplified in order to make it easily to transform and simulate with the Monte Carlo code. In a general way, the simplification consists on remove or change the elements that are dispensable, from the neutron transport point of view. Some of these elements are bolts, nuts or chamfers. Moreover, several types of geometries are not able to be transformed to MCNP format, like spirals or surfaces defined with sketches.

The target model transformed by SuperMCAM has been implemented in the ESS Target Station model for MCNP. This model includes a detailed geometry of the target and the shaft with the final helix shape, which are the most important components for the analysis.

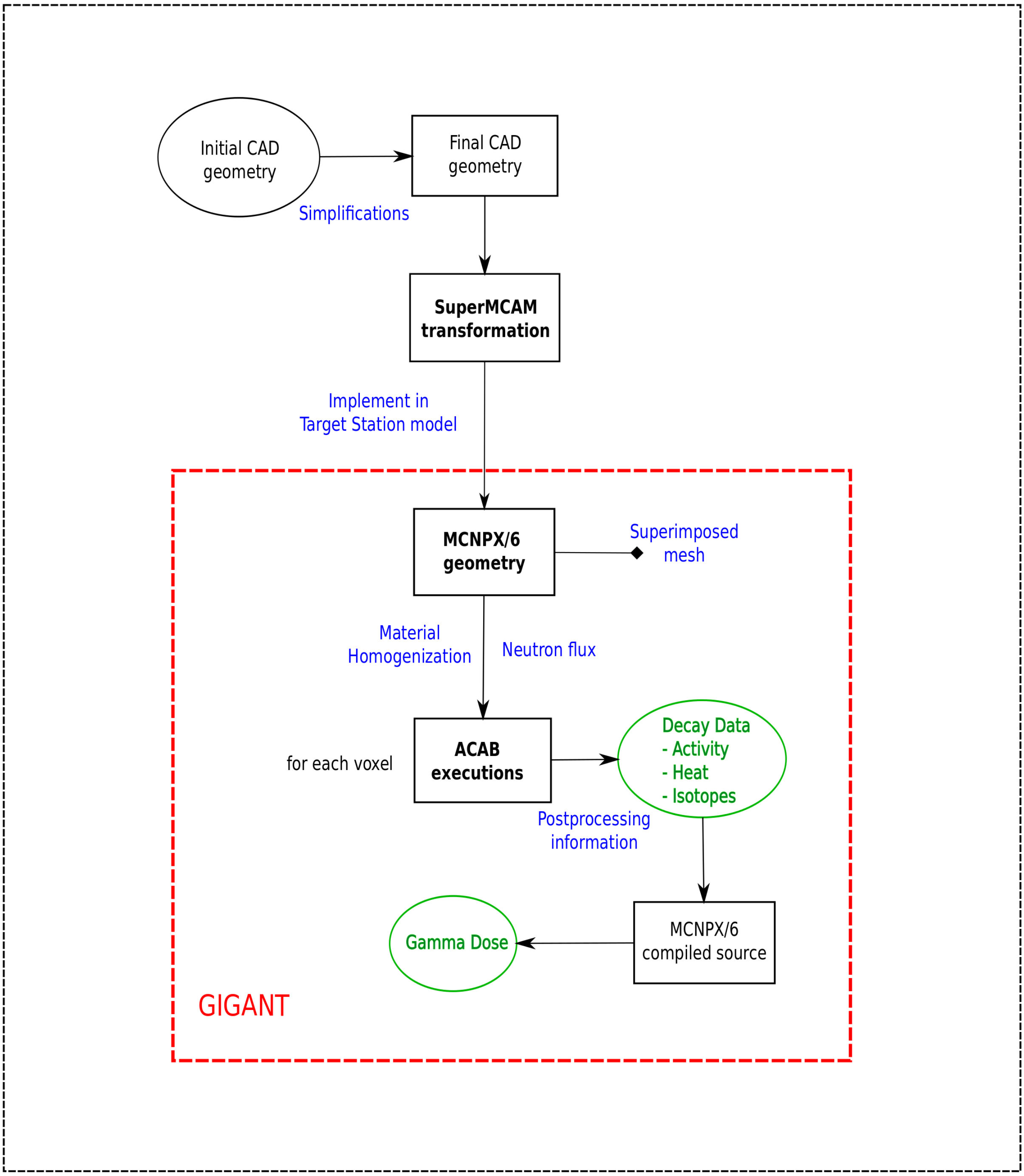


Figure 6: Scheme followed in the calculations from the initial CAD model to the final results.

Figure 7 shows the MCNPX model for the target spallation material. A detailed geometry for one sector has been included, in order to produce high accuracy results for heat load, irradiation damage and streaming proton paths along the wheel. The remaining 35 sectors has been simplify as an homogeneous mixture of helium and tungsten keeping the average density.

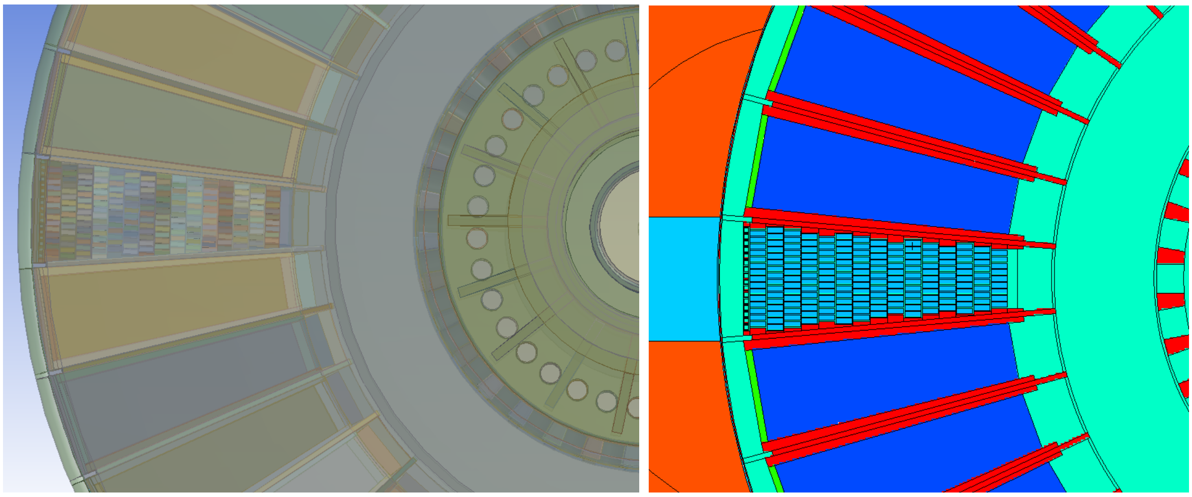


Figure 7: Geometry transformation from CAD model to MCNP format for ESS Target.

5.2 FEM-Thermal model

As shown in Spallation material analysis [19] the thermal profile of the cassette and the tungsten bricks can be solved with a FEM thermal solid, where only solids are taken into account and the cooling effect of the helium is reproduced by a convective boundary condition which is no time dependent. The aim of this section is to describe the thermal transient FEM model used to calculate the temperature evolution during the proton pulse and the subsequent cooling. The results of the simulations performed with this model are presented in the section 7.1 .

The following boundary conditions and assumptions have been considered to solve the thermal transient problem:

- The employed heat source is based on the Design Beam Footprint (REF). The heat source is activated in the simulation during the pulse ($t_{pulse} = 2.86 \cdot 10^{-3}$ ms) and disabled during the cooling ($t_{cooling} = 2.56857$ s).
- On the faces of the tungsten bricks, the turbulence generators an the side wall of the cassette, which are in contact with the helium, it has been applied the convection boundary condition that was described on CFD model for the Spallation Material analysis[19]. For the cassette this convection boundary condition was applied only on the internal face of the side wall.

- The heat transfer between internal plates faces to the helium is not considered, which is a conservative approach.
- It was defined a convection boundary condition to consider the cooling effect of the helium on the inlet channel of the cassette plates. The increase of temperature of the helium flowing trough these channels is considered linear and was obtained from a CFD model. To obtain the heat transfer coefficient the Dittus-Boelter equation was used:

$$Nu_D = 0.023 \cdot Re_D^{0.8} \cdot Pr^{0.4}$$

- Between the tungsten bricks and the cassette is assumed a perfect thermal contact.
- All other surfaces are considered adiabatic
- One half symmetry is considered, YZ is the symmetry plane.

Unlike the CFD problem the required mesh to accurately solve the thermo-mechanical problem is coarser. A non conformal mesh composed by 466,000 elements was employed, most are hexahedrons but some complex bodies were meshed with tetrahedrons (Figure 8).

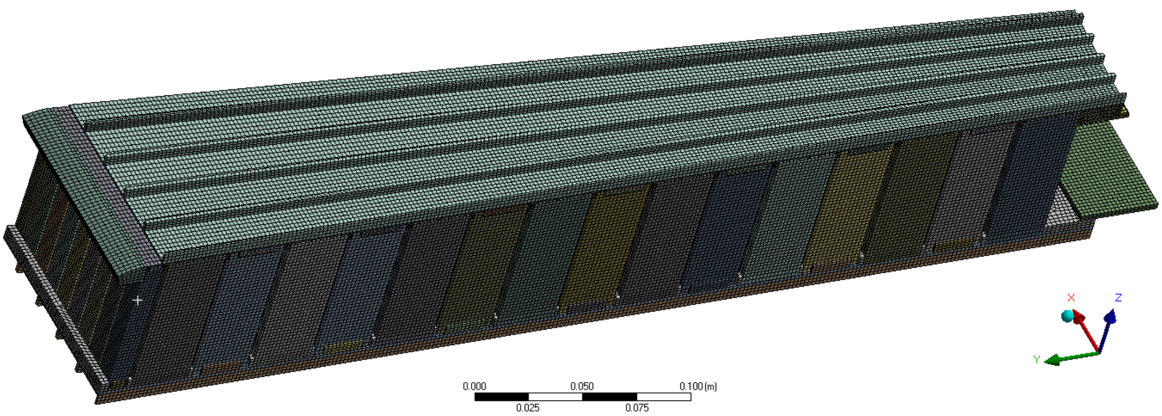


Figure 8: Mesh used to solve the FEM thermal problem of the spallation material and cassette

5.3 FEM-Mechanical model

The peak temperature distributions evaluated by means of the FEM-Thermal model(See section 5.2) are considered as thermal loads for the mechanical analysis. This section describes the mechanical model in order to calculate the stress profile evolution in the Cassette.

The evaluation of the stress conditions is performed by means of an steady state linear analysis considering the temperature distribution in the peak of the pulse. The geometry includes 219 bodies, and 218 lineal bounded contacts. Additionally, the following boundary conditions are considered:

- Frictionless support in the symmetry axis;
- No displacement is allowed along X and Y direction, but Z displacement is free for "B" point.
- No displacement is allowed along Z, but X and Y displacement are free for D.
- Δ Pressure between inlet and outlet helium path (0.14 Bar).

Figure 9 summarized the primary loads taken into account for the mechanical analysis. Regarding secondary loads, the temperature loads are evaluated with FEM-Thermal model described on section 5.2.

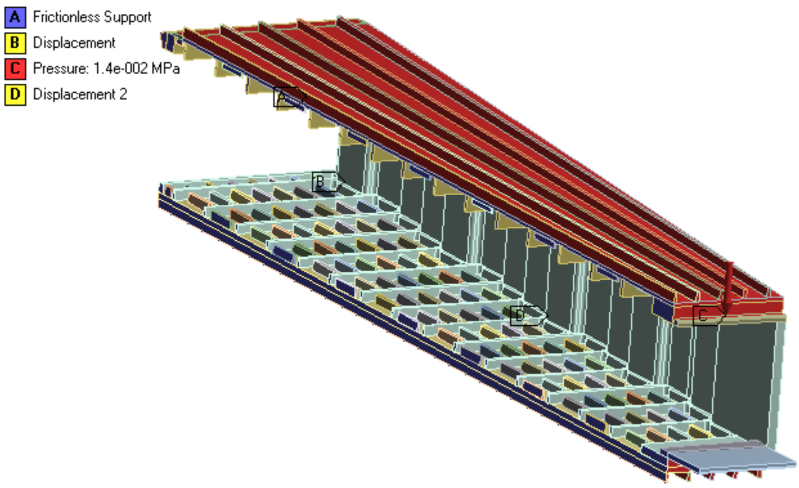


Figure 9: Primary loads in the internal structure

In regard to the mesh, a non conformal mesh composed by 32.964 hexahedral elements was employed. Figure 10 shows the mechanical analysis mesh. More than the 95% of the bodies have been deal with as sweepable.

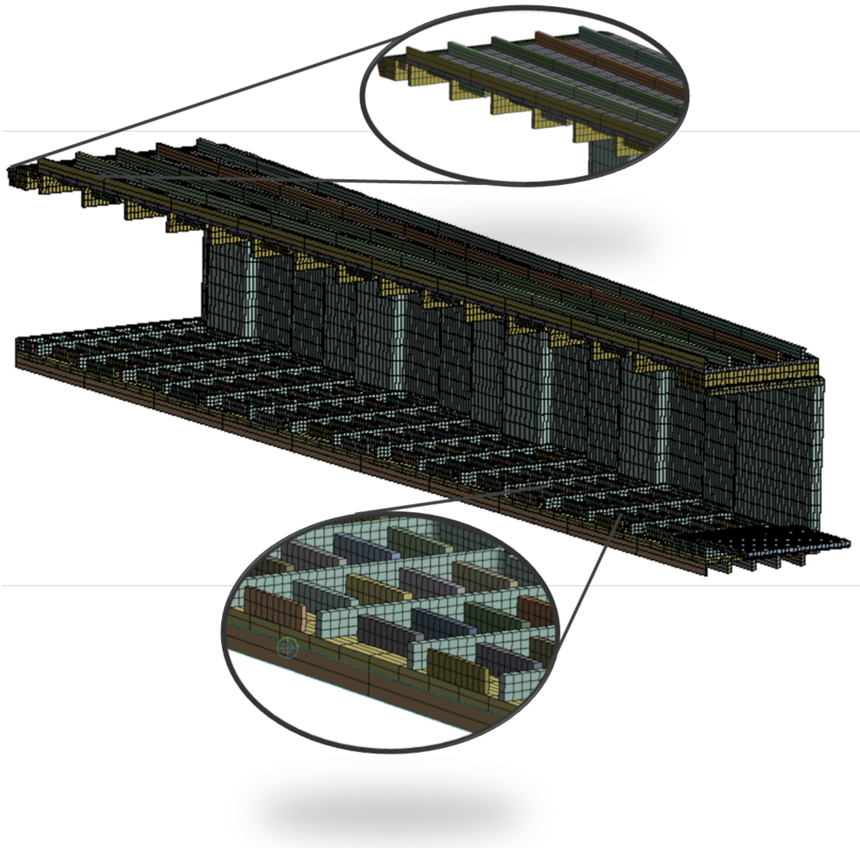


Figure 10: Mesh used to solve mechanical problem of the internal structure

6 Radiation damage conditions

The nuclear reactions produced on the spallation material will produce a large amount of neutrons. These neutrons has enough energy to produce displacements in the metallic meshes of the elements close to the source. The accumulation of this displacements degrades the mechanical properties of the material.

The cassette is one of the closest elements to the spallation material hence, the damage produced by neutrons play a role in its mechanical behavior. The methodology proposed for the evaluation of the radiation damage is described in not in the scope of this document, however several conclusions based on previous analysis are remarkable[15]:

- High energy neutrons will produce nuclear cascades similar to neutrons considered on $RCC - MR_x$ damage analysis methodology
- Ratio Helio/DPA in the elements not in contact with the proton beam are comparable with fission reactors
- Helium and hydrogen production are far below values that can produce mechanical effects.
- The faction of disperse protons that produces damage in the cassette is negligible compared with neutron damage.

Based on this assumptions, the model described on section 5.1 has been evaluated with KIT damage cross sections for steel [18]. The damage values shown on Figures 11 to 13 show areas of the lateral section of the cassette with stresses in the range of 7 dpa after 5 years of operation. However these areas have low stress values (See sections 7.1) so the material is far from its mechanical limits. In the areas with high stress conditions (top and bottom covers) the damage value is in the range between 3-4 dpa.

Regarding the gas production for both cases, hydrogen and helium, the values are far form any significant degradation of mechanical properties(swelling, embrittlement ...).

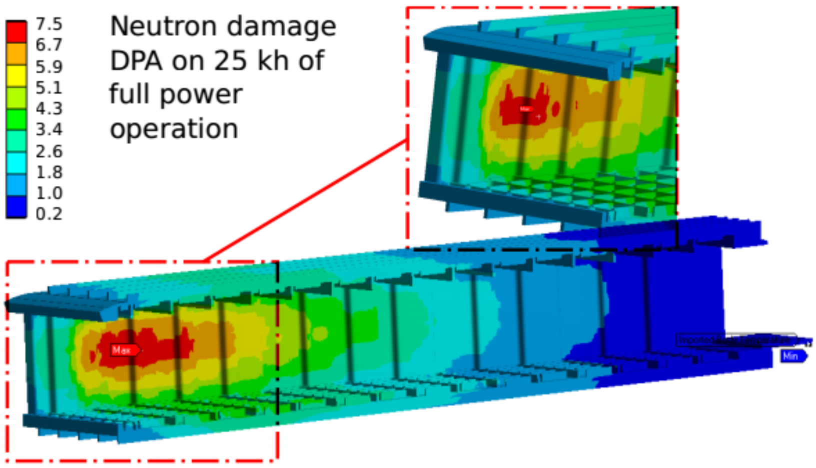


Figure 11: DPA produced on the cassettes for 25 kh of operation at nominal beam conditions [dpa]

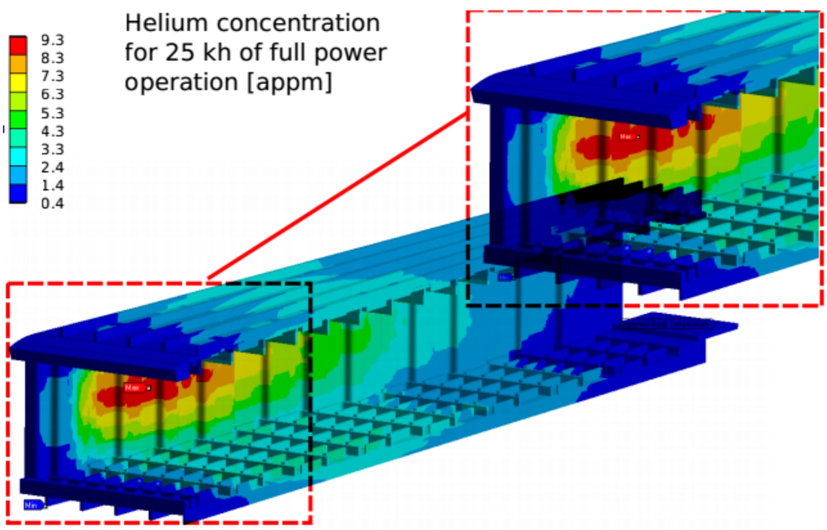


Figure 12: Helium produced on the cassettes for 25 kh of operation at nominal beam conditions [appm]

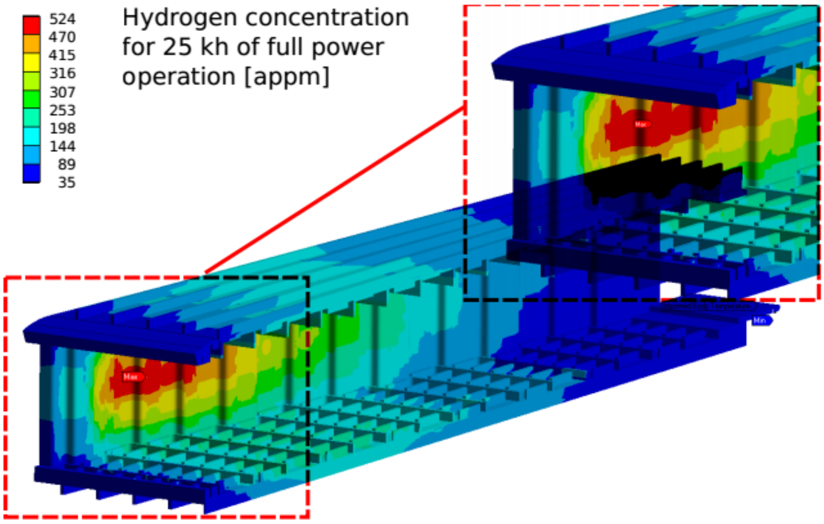


Figure 13: Hydrogen produced on the cassettes for 25 kh of operation at nominal beam conditions [appm]

7 Load scenarios thermomechanical analysis

7.1 SF1: Normal operational conditions

Based on the description shown in Section 2, loads on nominal conditions are produced by the design beam under nominal frequency for the repetition rate, with the wheel at his nominal rotation speed. Also the beam is considered synchronized with the wheel and hitting in the center of the cassette. The cooling system is working at nominal conditions, so helium mass flow trough the wheel is 3.0 kg/s which means 0.0833 kg/s in each cassette. Figures 14 and 15 show the beam on nominal conditions. Design beam includes the uncertainty on beam instrumentation, which means 20% more concentrated beam than nominal one.

Table 4 shows the main beam parameters for the load case.

Parameter	**Units**	**Value**
Beam Energy	GeV	2.0
Maximum Beam Energy	GeV	2.2
Pulse Repetition Rate	Hz	14
Beam energy per pulse	kJ	357
Maximum Energy per pulse	kJ	371

Table 4: Main beam parameters[4]

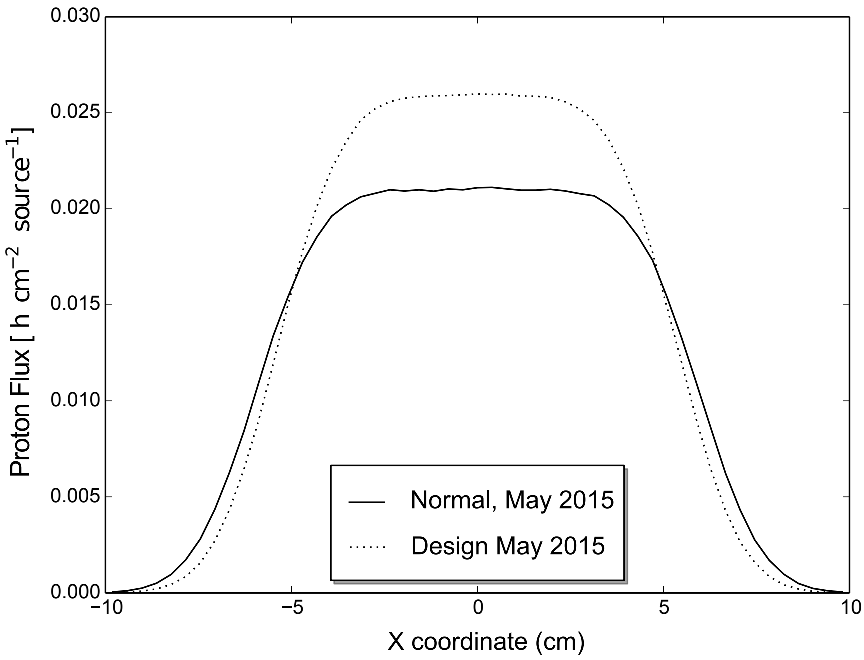


Figure 14: Nominal Beam and design beam[4]. Profile on longer dimension.

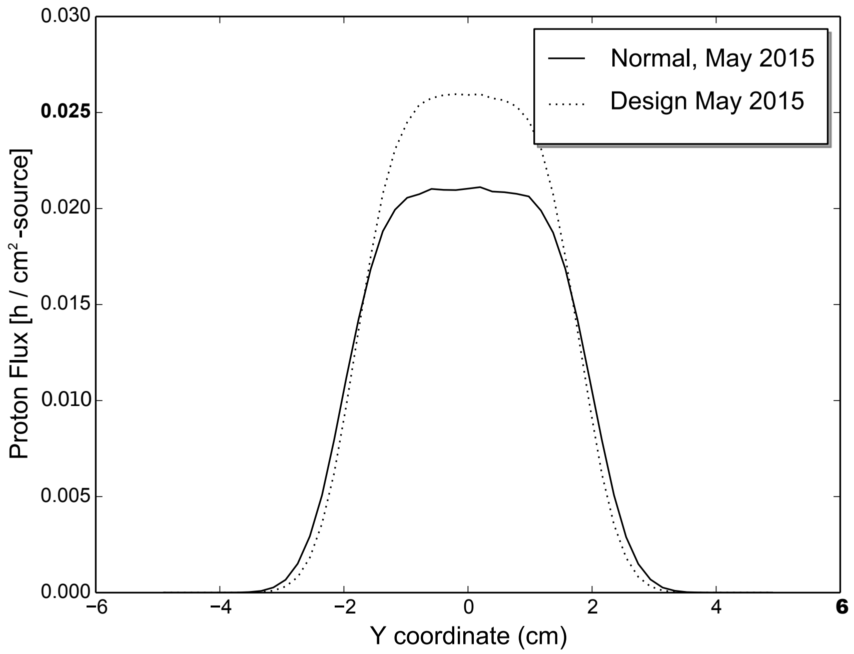


Figure 15: Nominal Beam and design beam[4]. Profile on shorter dimension

Following the $RCC - MR_x$ mechanical design rules, the loads has been classified as Primary (Pressure and dead weights) and Secondary (thermal stresses). Next sections will describe the analysis of the component to prevent th P and S damages.

P damage analysis

The primary loads on nominal conditions are the dead weights and the difference pressure between inlet and outlet of the helium flow. The CFD analysis shows a linear increase of the pressure difference along the cassette from 0 bar at the entrance to 0.14 at the outlet. However in order to introduce conservative conditions the pressure has been introduced as an homogeneous value at 0.14 bar.

Figure 16 shows the Equivalent Von-Misses stress for primary loads. This value (less than 37 MPa) is below the $RCC - MR_x$ proposed limit for membrane stress at 300^o ($S_m = 106$ MPa) hence, no additional analysis is needed.

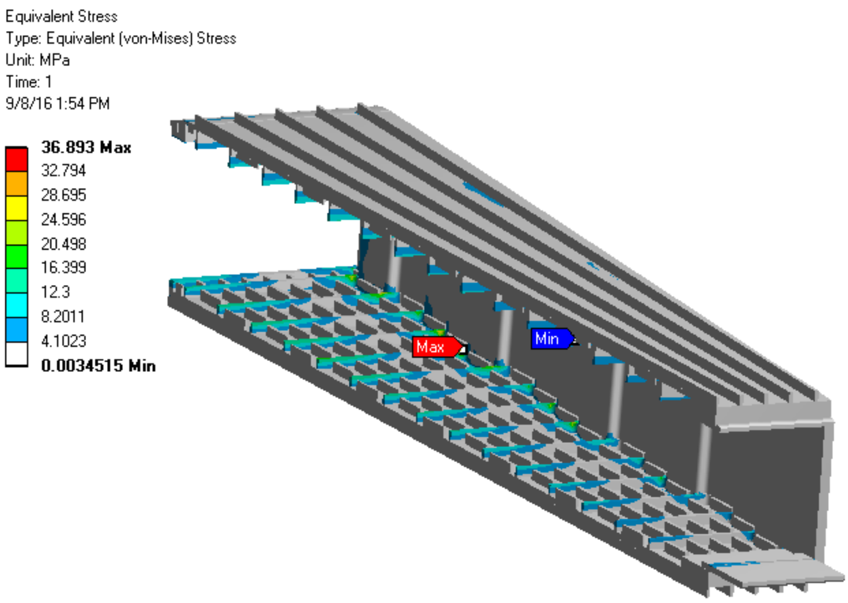


Figure 16: Equivalent Von Mises stress for primary loads

Regarding secondary loads, only temperature distribution at the peak of the pulse has been considered. The profile is shown on Figure 17.

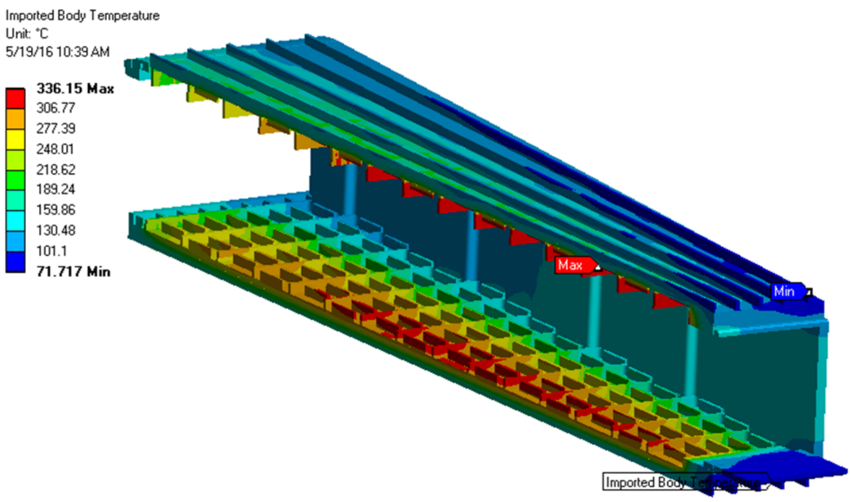


Figure 17: Temperature distribution in the internal structure

Figure 18 shows the Von-Misses stress for primary and secondary loads. The maximum stress value is located in an area at low temperature ($\sim 150^o$) and low irradiation level ($\sim$ 3-4 dpa) hence we can consider a limit to $S_m^{et} = 1817MPa$. The maximum equivalent stress in the FEM analysis is 729 MPa, far below the acceptable delves for membrane stress thus, no additional analysis is needed regarding secondary loads.

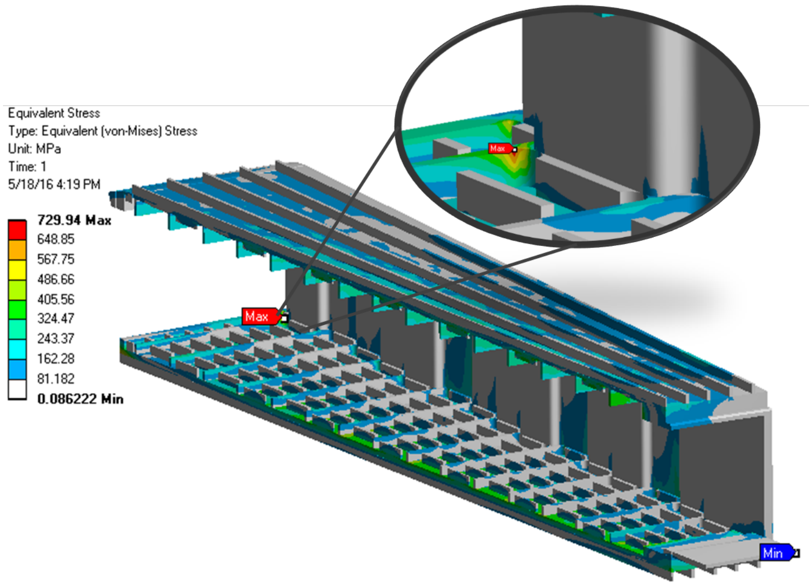


Figure 18: Equivalent Von Mises stress for primary and secondary loads

Finally, the deformation of the cassette is considered. Deformation produced on Z direction is shown on Figure 19. The maximum value is 0.30 mm, mainly produced by ΔP between the inlet and outlet helium paths. In the spallation material area the is a 1 mm in between cassette and tungsten bricks hence, there is no risk of collision between them.

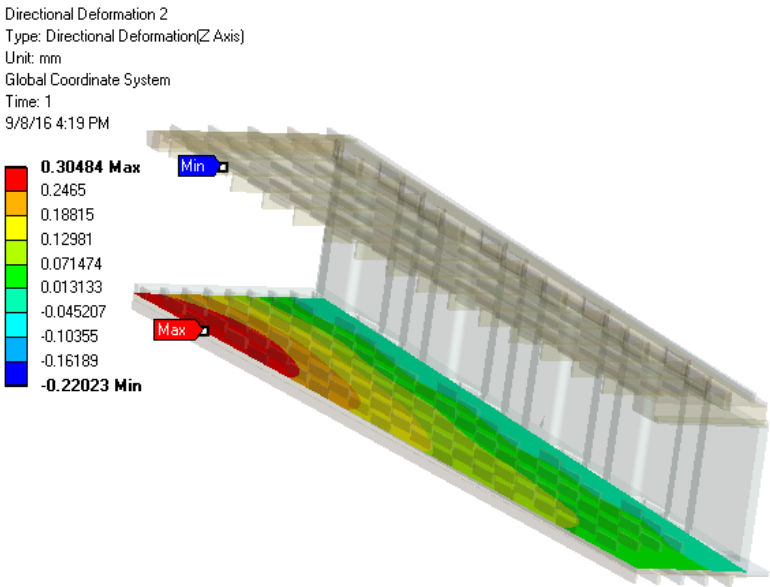


Figure 19: Directional Z deformation for secondary loads

Based on this analysis, the component clearly fulfill the $RCC - MR_x$ mechanical design criteria an no P damage is expected for this operational scenario.

7.1.1 S damage analysis

S damages are associated with progressive degradation of the material under cyclic loads (fatigue and similar processes). For internal structures the only time dependence load is the temperature distribution. Figure 20 shows the temperature evaluation. The maximum ΔT is less than 2.5^{o}C so, it can not produce significant stresses. Based on that, no S damage analysis is needed.

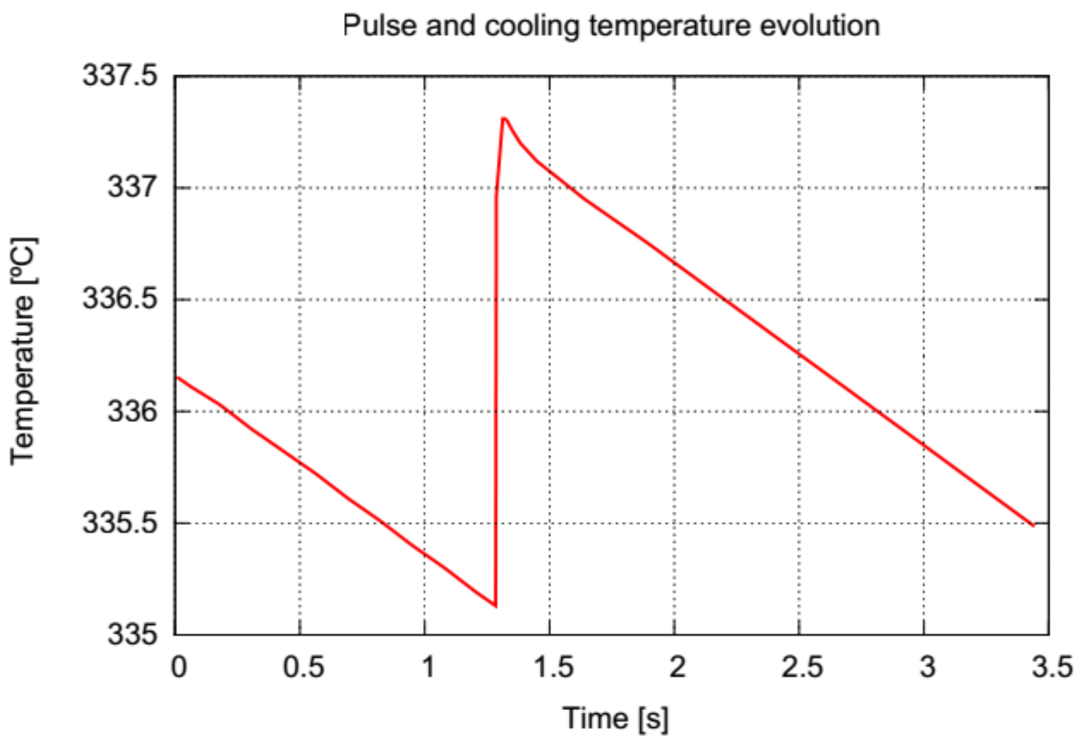


Figure 20: Maximum temperature evolution along the pulse on internal structures

7.2 SF2: Vertical displacement beam

Based on the description shown on Section 2, loads on this scenario are produced by the design beam under nominal frequency, with the wheel at his nominal rotation speed. Also the beam is considered synchronized with the wheel and hitting tungsten with a positive vertical displacement of 10 mm from the center of the cassette, as indicated in Figure 21. The cooling system is working at nominal conditions, so helium mass flow trough the wheel is 3.0 kg/s which means 0.0833 kg/s in each cassette.

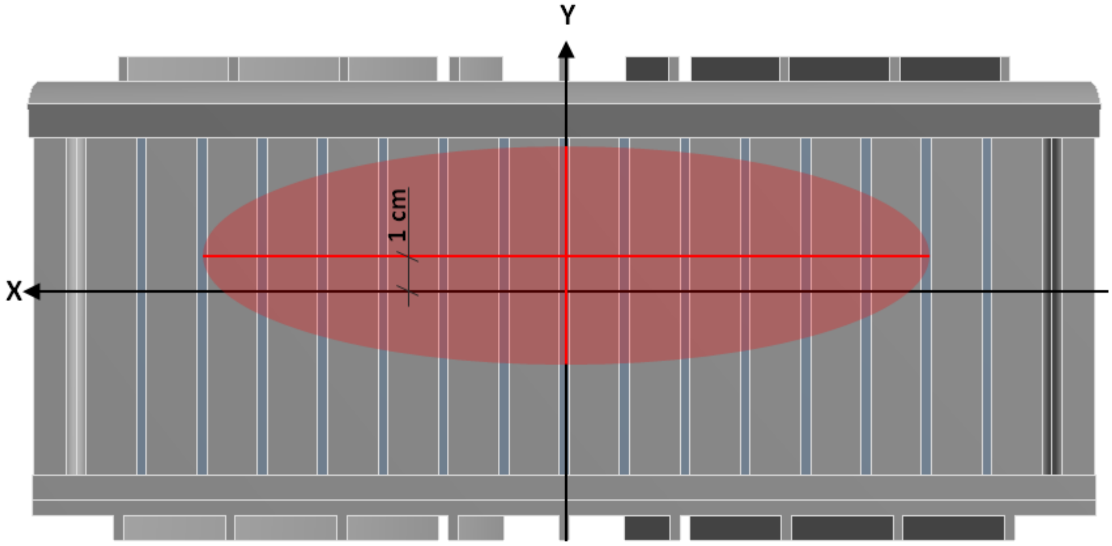


Figure 21: Beam vertical displacement

Figure 22 shows the temperature distribution in after the pulse. This accidental conditions produces, in the top plate of the cassette, an increase of 42^oC compared with the nominal case (Figure 17). Thus, a new analysis is needed taking into account the new secondary loads profile. It should be remark that primary loads do not change so a new analysis is not needed.

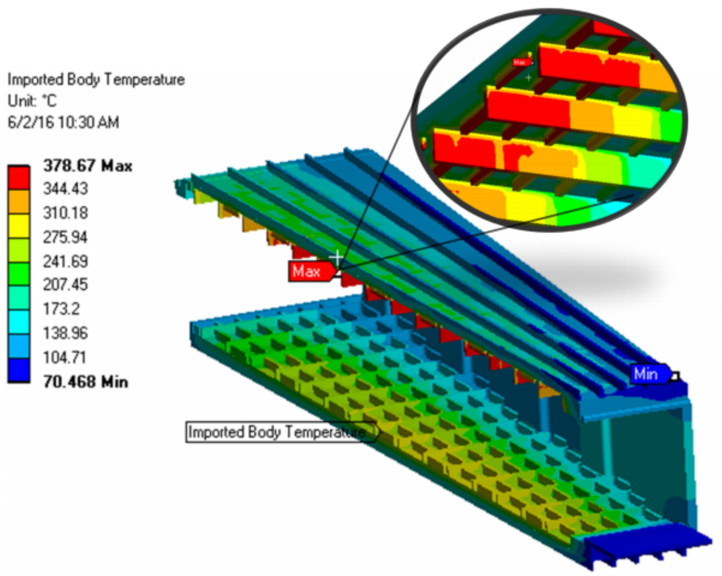


Figure 22: Temperature distribution in the internal structure with vertical displacement beam

Figure 23 shows the Von Mises equivalent stress for primary and secondary loads associated with the new temperature profile. The maximum stress level far below the S_m^{et} limit so the component clearly fulfill the Level A requirements.

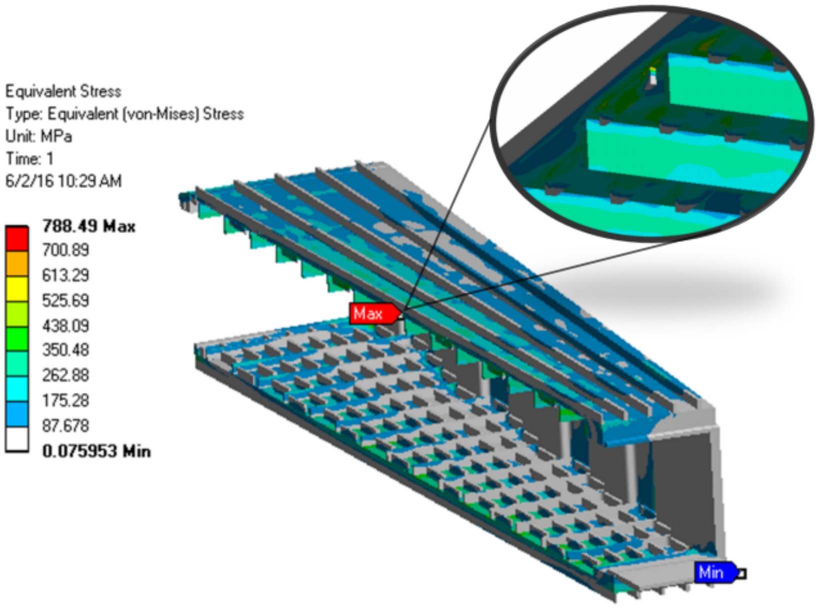


Figure 23: Equivalent Von-Mises stress in the internal structure with vertical displacement beam

7.3 SF3: Shutdown

The shutdown is described in Section 10.7 on Spallation Material Equipment Specification document [19]. Along the accident, the helium flow and beam are stop. On this conditions, the target remove the heat by radiation from its external surfaces so, the temperature evolves slowly up to the equilibrium value after 10^4 s. Figure 24 shows the temperature distribution into the internal structures. The profile is relative smooth due to the low decay heat generation ($\sim$ 30 kW).

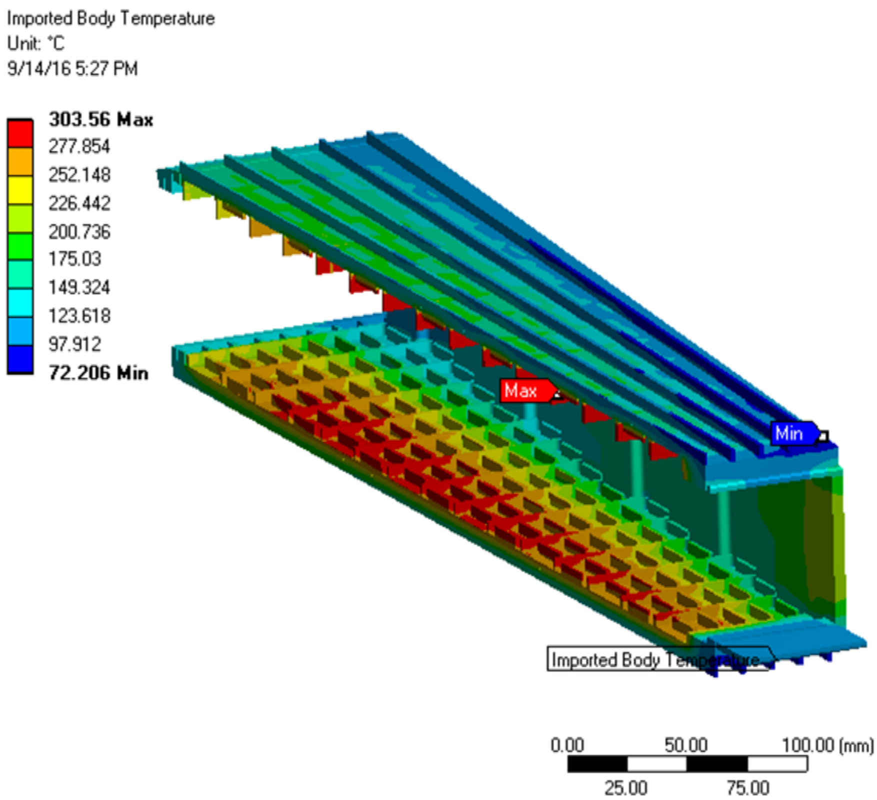


Figure 24: Temperature profile in the internal structures, 10^4 s after the shutdown

The primary loads in this scenario are not considered because the helium is not flowing so, all the faces of the cassette are under the same pressure. Regarding secondary loads, Figure 25 shows the equivalent stress. The maximum value is far below the S_m^{et} limit for the material thus, no additional study is needed.

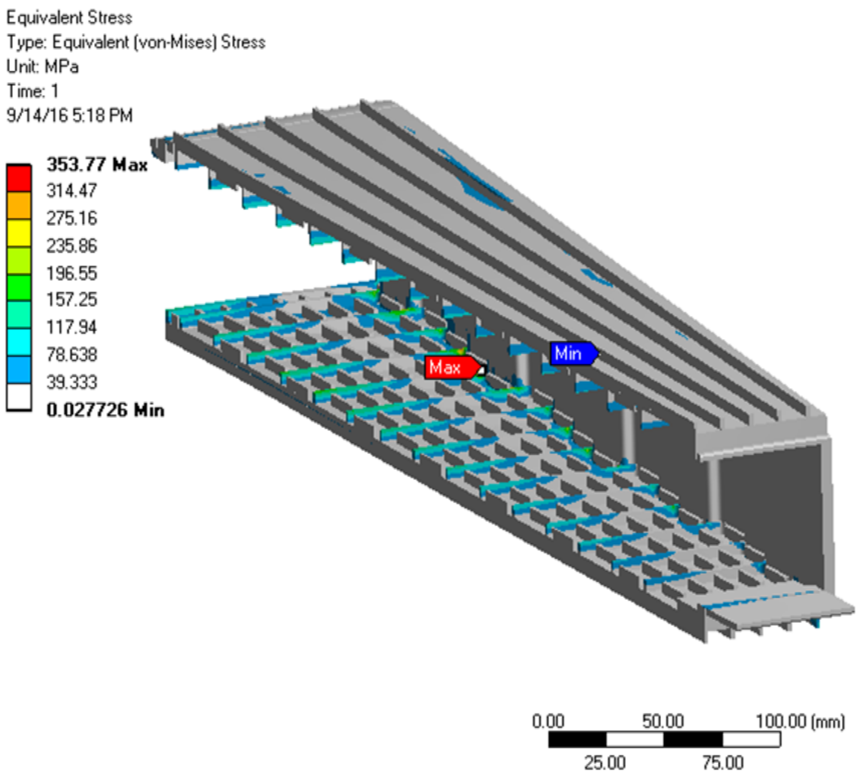


Figure 25: Equivalent Von-Mises stress in the internal structures, 10^4 s after the shutdown

7.4 SF1: Nominal beam

Figures 14 and 15 show the Design and Nominal beams considered for the analysis. It should be notice that design beam will produce a higher energy deposition in the spallation material so, from its point of view it is a conservative approach. However, if the heat load is concentrated in the center of the spallation material (Design beam) the fraction of the heat removed by the helium flow will be large and based on that the heat flux in the cassette is reduced. Thus, the design beam scenario could be not enough conservative for the cassette.

Based on this considerations, this section analyses the stress conditions for the cassette under nominal conditions. Primary loads are not related with temperature profile so, there is no modification compared with the study showed on section 7.1. Regarding secondary loads, the temperature profile shown in Figure 26 (end of the pulse) is considered.

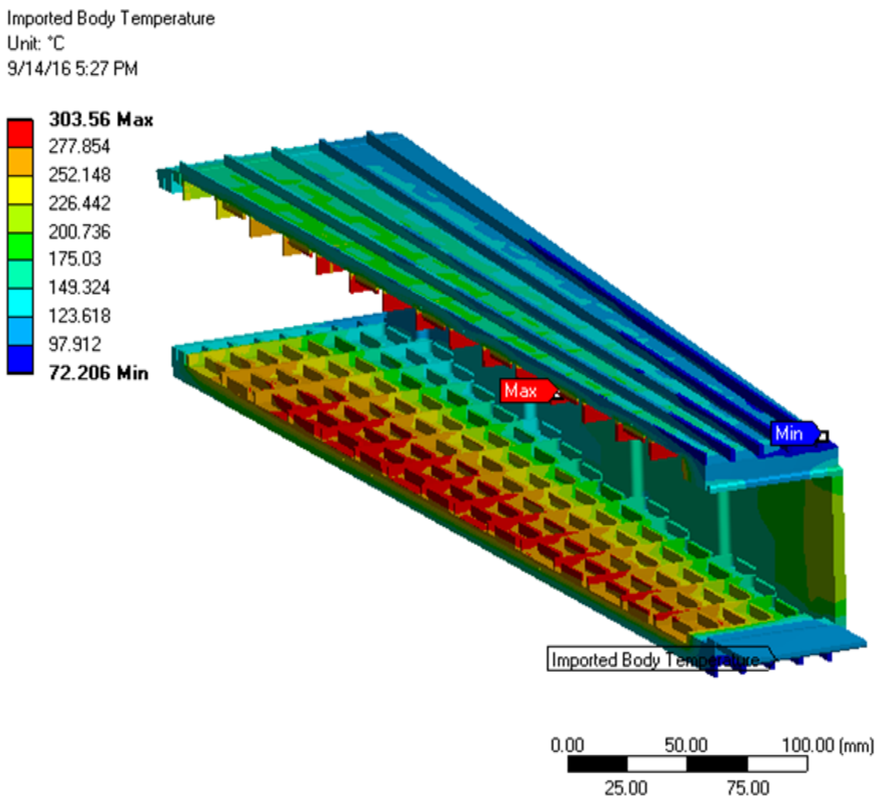


Figure 26: Temperature profile of the tungsten at the end of the pulse for nominal beam

Figure 27 shows the Equivalent Von-Misses stress for primary and secondary loads. The maximum value is far below the S_m^{et} limits so, no additional analysis is considered.

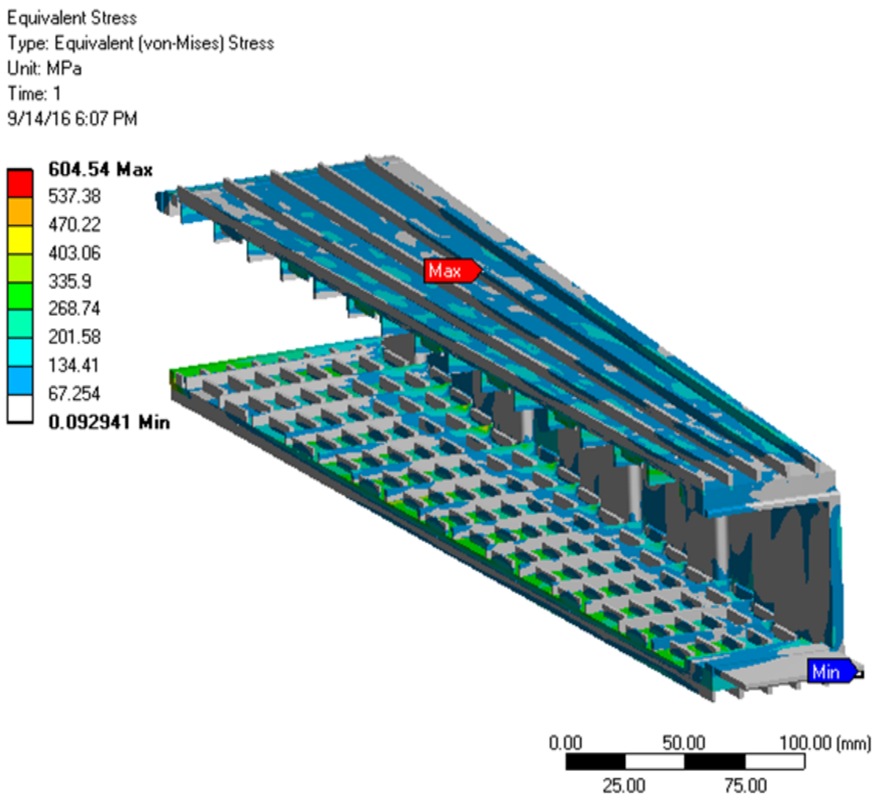


Figure 27: Equivalent Von-Mises stress in the internal structure with nominal beam

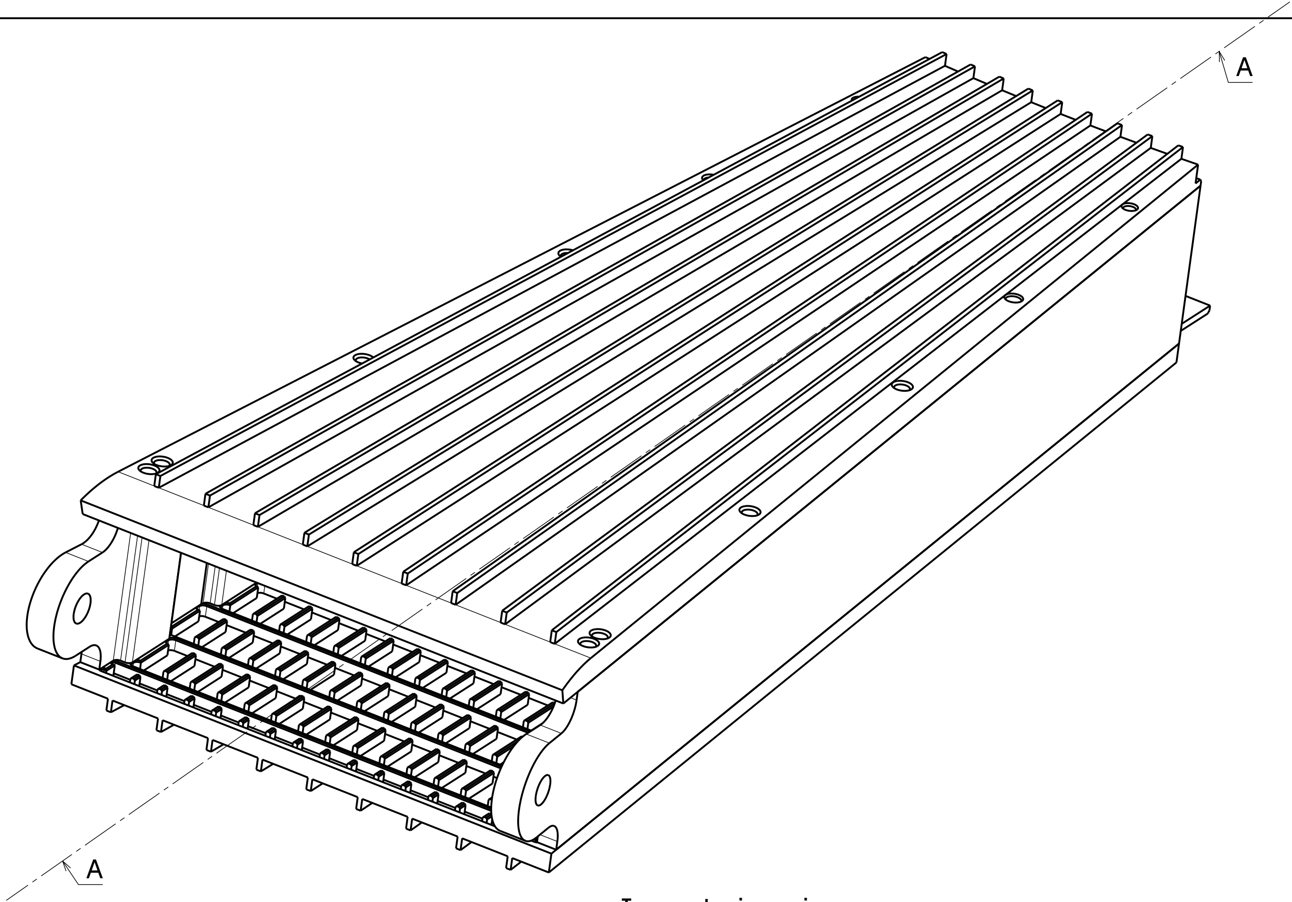
8 Conclusions

The analysis described in the previous sections can be summarized in the following points:

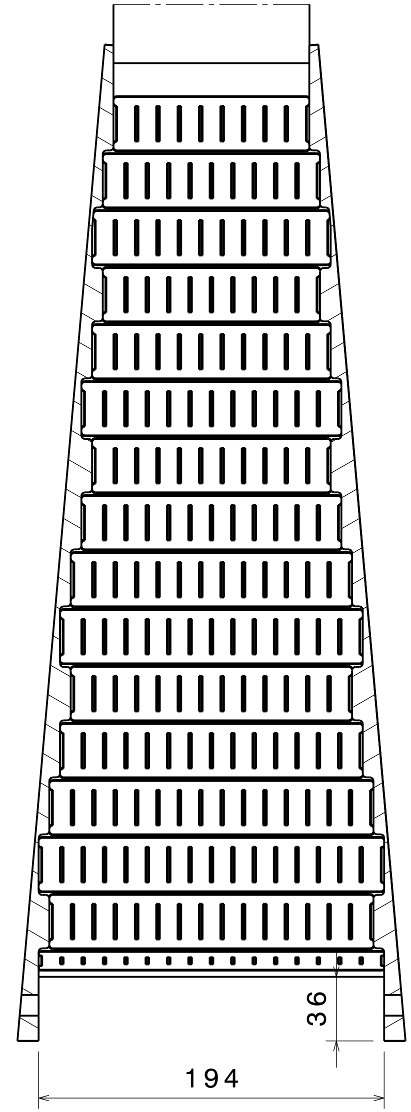
- The complete analysis of the component (radiation damage, temperature distribution and mechanical stress analysis) has been completed.
- The radiation damage for the component is in an acceptable level for 5 year operation.
- Temperature distributions will not produce significant deformations that change its functionality.
- In all the scenarios considered in the design process fulfill $RCC - MR_x$ requirement with significant safety margin.

9 Drawings

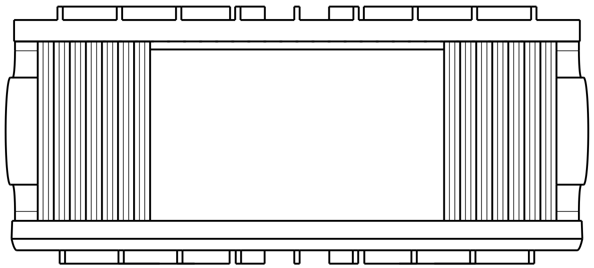
- TRGT-ESS-0106
- TRGT-ESS-0106-01-01
- TRGT-ESS-0106-01-02
- TRGT-ESS-0106-01-03
- TRGT-ESS-0106-01-04
- TRGT-ESS-0106-02-01
- TRGT-ESS-0106-02-02
- TRGT-ESS-0106-02-03
- TRGT-ESS-0106-02-04
- TRGT-ESS-0106-03
- TRGT-ESS-0106-04



Isometric view
Scale: 1:2



Section view A-A
Scale: 1:3



Front view
Scale: 1:2

NOTA: una vez montados, distancia entre cassette y rigidizadores < 100 µm
NOTA: redondeos encuentros R = 2

Acabado		rebarbar y romper aristas	
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Verificado	I. Rueda	24-6-16	
Aprobado	F. Sordo	24-6-16	

REVISADO

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

>	0.5	6	30	120	400	1000	2000
≤	6	30	120	400	1000	2000	4000
tol	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2

radio/chaflán

>	0.5	3	6
≤	3	6	-
tol	±0.2	±0.5	±1

ángulo

>	0	10	50	120	400
≤	10	50	120	400	-
tol	±1°	±30´	±20´	±10´	±5´

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽		▽▽▽			

ESS bilbao
P.T. Zamudio
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48170 ZAMUDIO (Bizkaia)
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www.essbilbao.org

MATERIAL: X2CrNiMo17-12-2

PESO (g): 2172

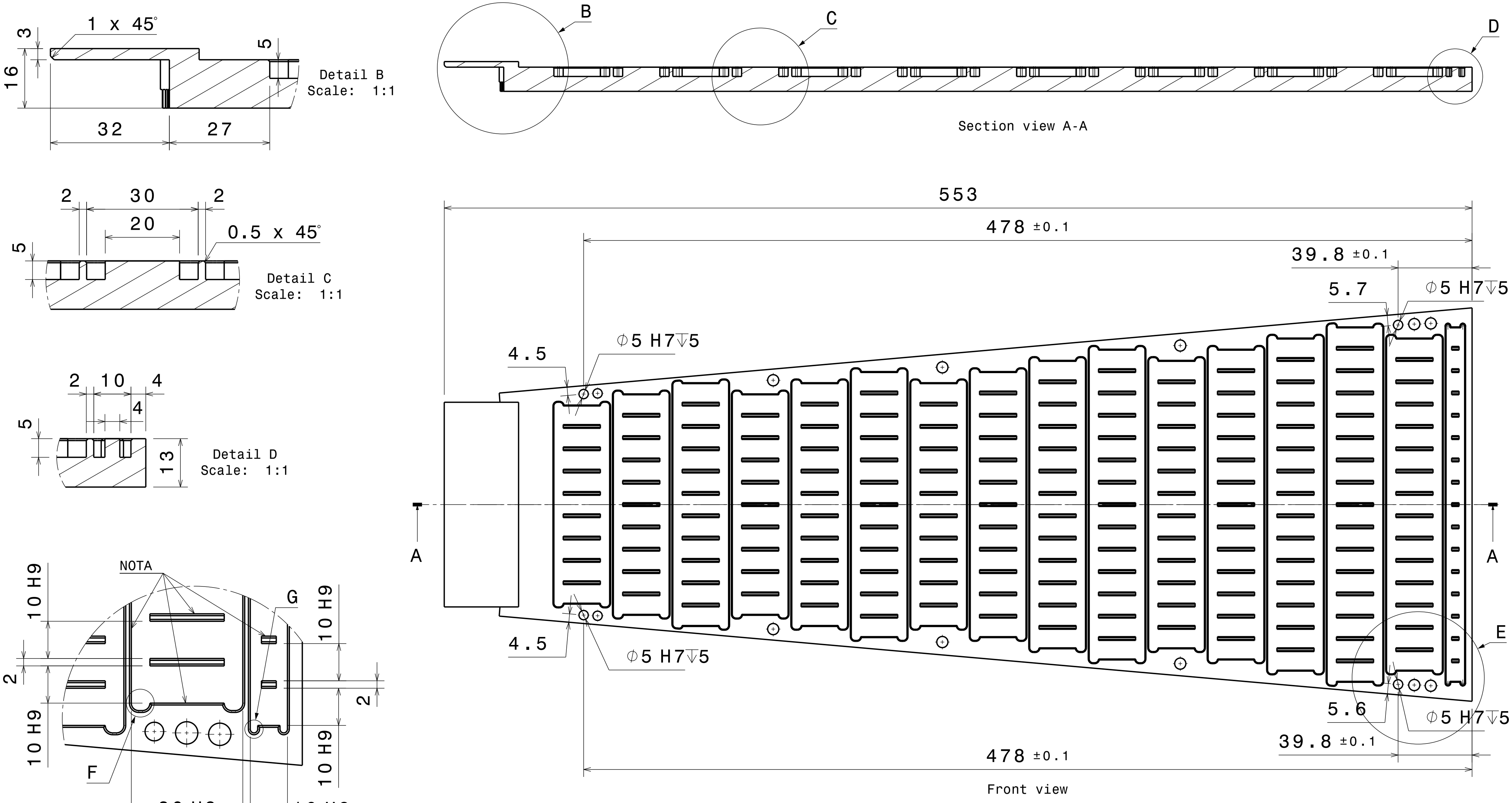
TÍTULO: Cassette Conjunto

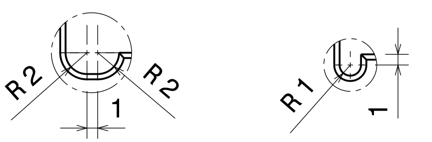
N.º DE DIBUJO: TRGT-ESS-0106

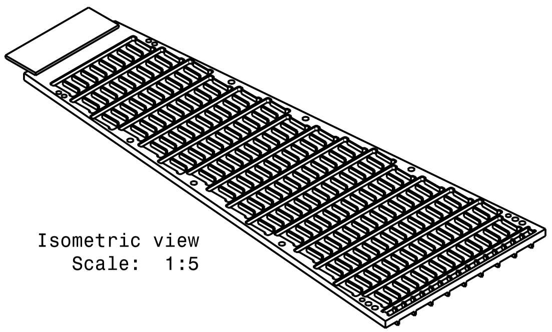
A3

ESCALA: 1:2

HOJA 1 DE 1







NOTA: chaflán 1 x 45° en ambos lados de tabiques y nervios, así como en paredes laterales (ver dibujo); chaflanes en zonas de salida de herramienta/radios de acuerdo no necesarios

Acabado	rebarbar y romper aristas
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Dibujado	A. Ortega	24-2-16
Verificado	I. Rueda	24-2-16
Aprobado	F. Sordo	24-6-16

REVISADO

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m) Lineales

>	0.5	6	30	120	400	1000	2000
≤	6	30	120	400	1000	2000	4000
tol	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2

radio/chaflán

>	0.5	3	6
≤	3	6	-
tol	±0.2	±0.5	±1

ángulo

>	0	10	50	120	400
≤	10	50	120	400	-
tol	±1°	±30'	±20'	±10'	±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽			▽▽▽		

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tel: 946076855
www.essbilbao.org

MATERIAL: X2CrNiMo17-12-2

PESO (g): 3533

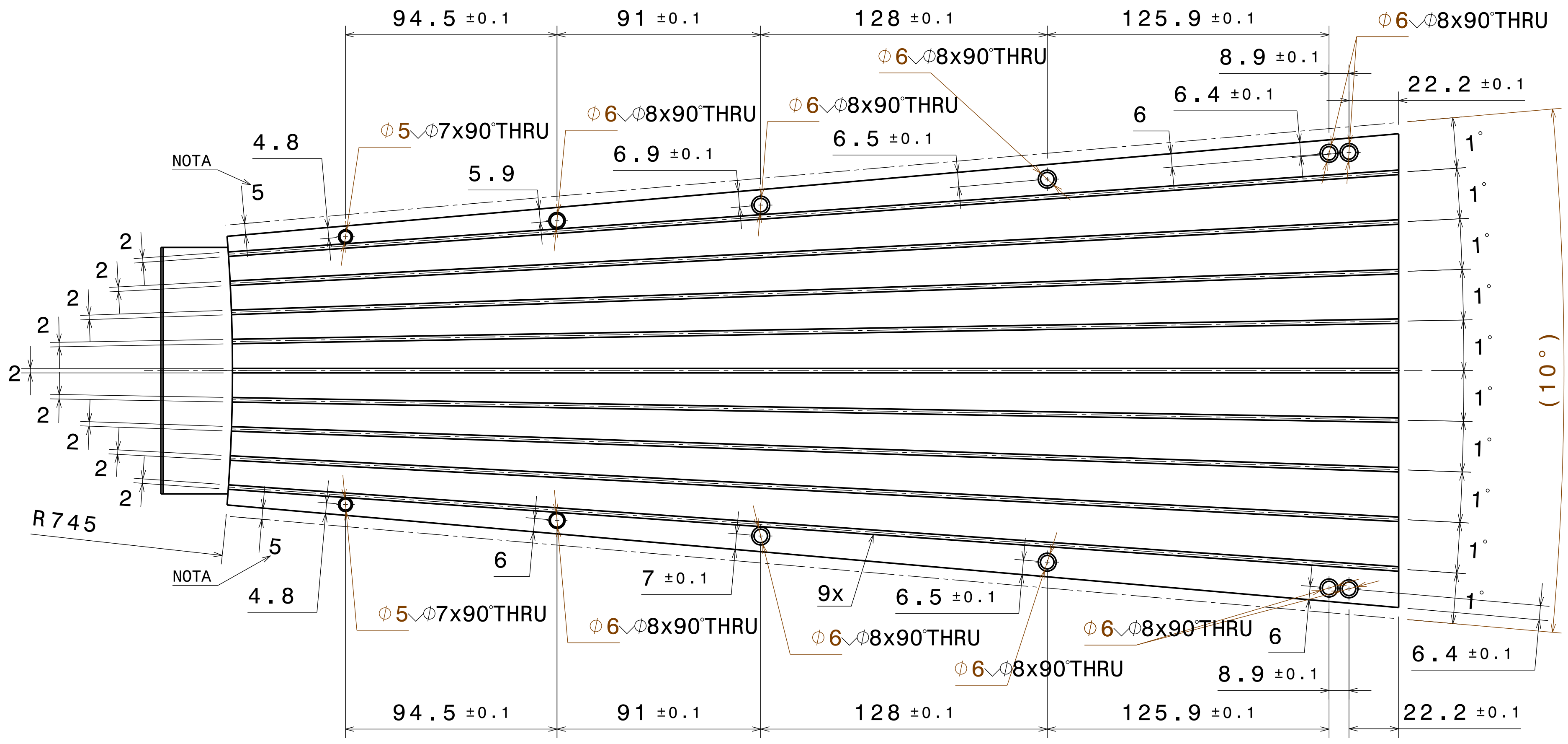
TÍTULO: Placa Inferior (Cassette)

N.º DE DIBUJO: TRGT-ESS-0106.01.01

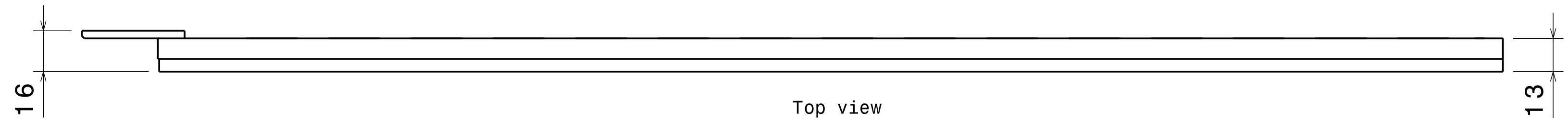
A3

ESCALA: 1:2

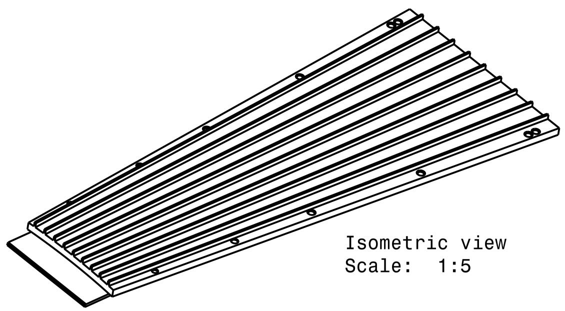
HOJA 1 DE 4



Front view



Top view



Isometric view
Scale: 1:5

NOTA: las aristas del contorno de la placa no convergen en el centro de los radios, sino que están desfasadas 5 mm a cada lado para dejar espacio a los rigidizadores (e = 10 mm)

NOTA: una vez montados, **distancia entre casette y rigidizadores < 100 µm**

Acabado: rebarbar y romper aristas

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Diseñado	M. Mancisidor	18-2-16
Dibujado	A. Ortega	24-2-16
Verificado	I. Rueda	24-2-16
Aprobado	F. Sordo	24-2-16

REVISADO

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

>	0.5	6	30	120	400	1000	2000
≤	6	30	120	400	1000	2000	4000
tol	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2

radio/chaflán

>	0.5	3	6
≤	3	6	-
tol	±0.2	±0.5	±1

ángulo

>	0	10	50	120	400
≤	10	50	120	400	-
tol	±1°	±30'	±20'	±10'	±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽		▽▽▽			

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tel: 946076855
www.essbilbao.org

MATERIAL: X2CrNiMo17-12-2

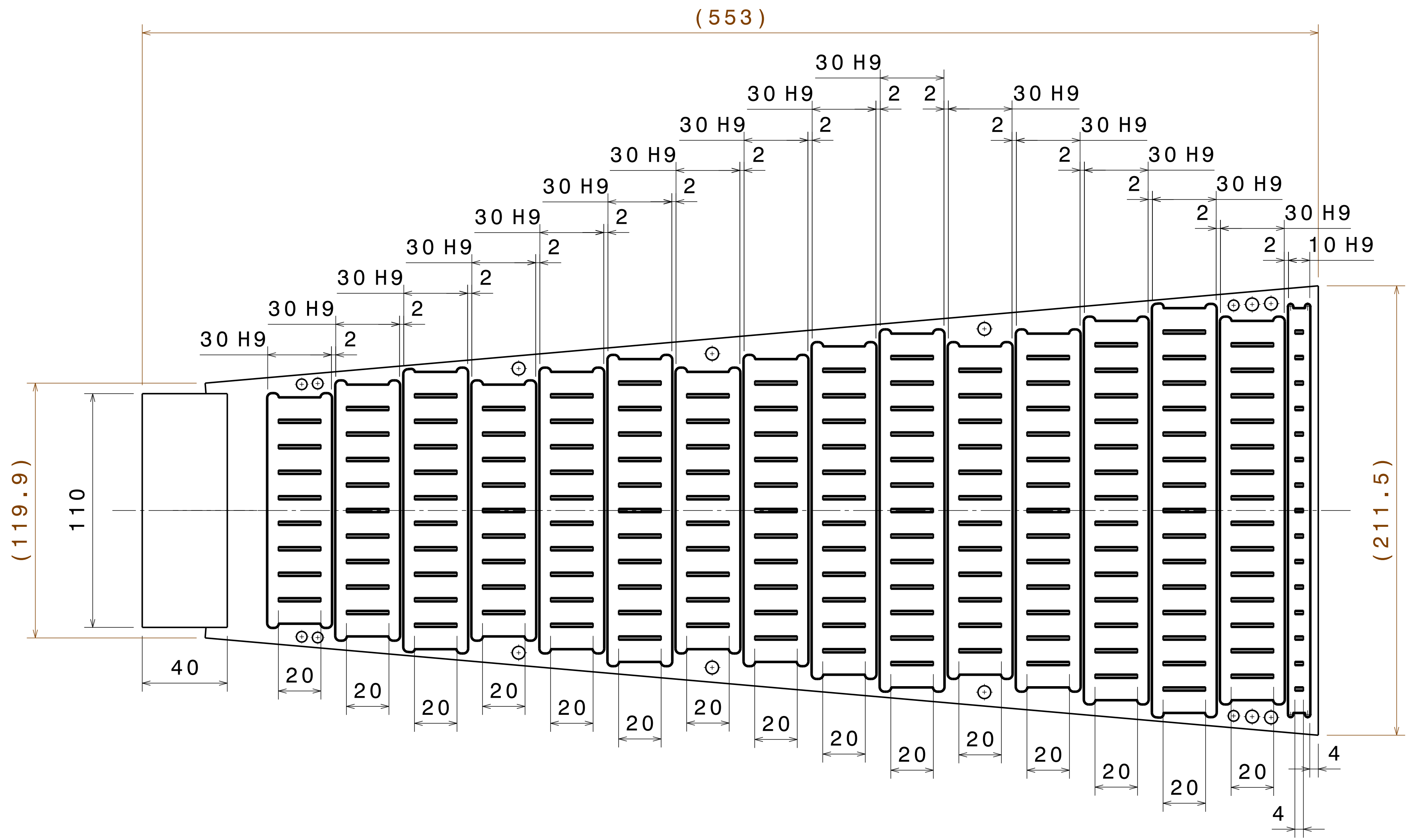
PESO (g): 3533

TÍTULO: Placa Inferior (Cassette)

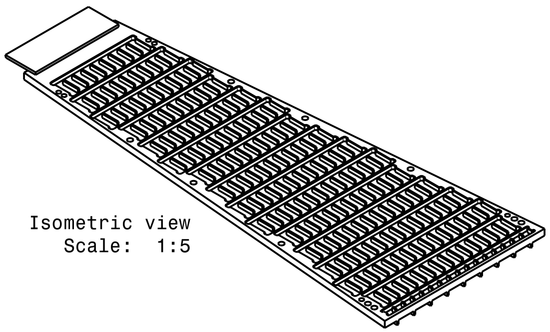
N.º DE DIBUJO: TRGT-ESS-0106.01.02

A3

ESCALA: 1:2



Front view



Isometric view
Scale: 1:5

Acabado	rebarbar y romper aristas

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Verificado	I. Rueda	24-2-16
Aprobado	F. Sordo	24-2-16

REVISADO

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

> ≤	0.5 6	6 30	30 120	120 400	400 1000	1000 2000	2000 4000
tol	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2

radio/chaflán

> ≤	0.5 3	3 6	6 -
tol	±0.2	±0.5	±1

ángulo

> ≤	0 10	10 50	50 120	120 400	400 -
tol	±1°	±30'	±20'	±10'	±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽			▽▽▽		

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MATERIAL: X2CrNiMo17-12-2

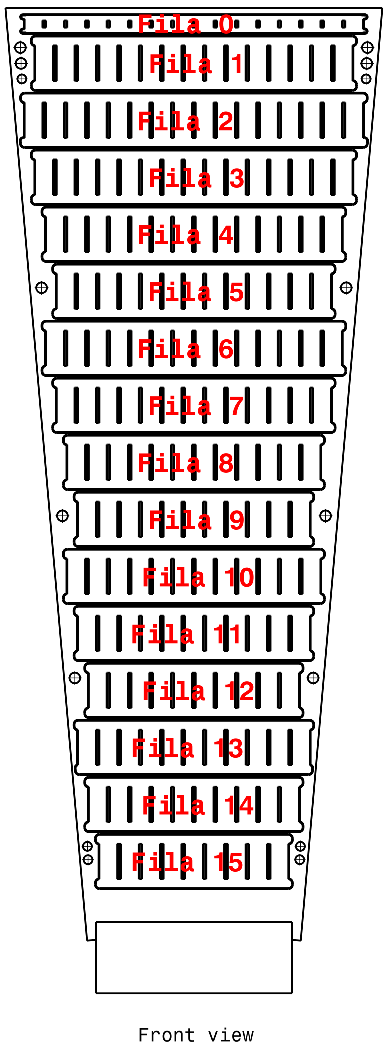
PESO (g): 3533

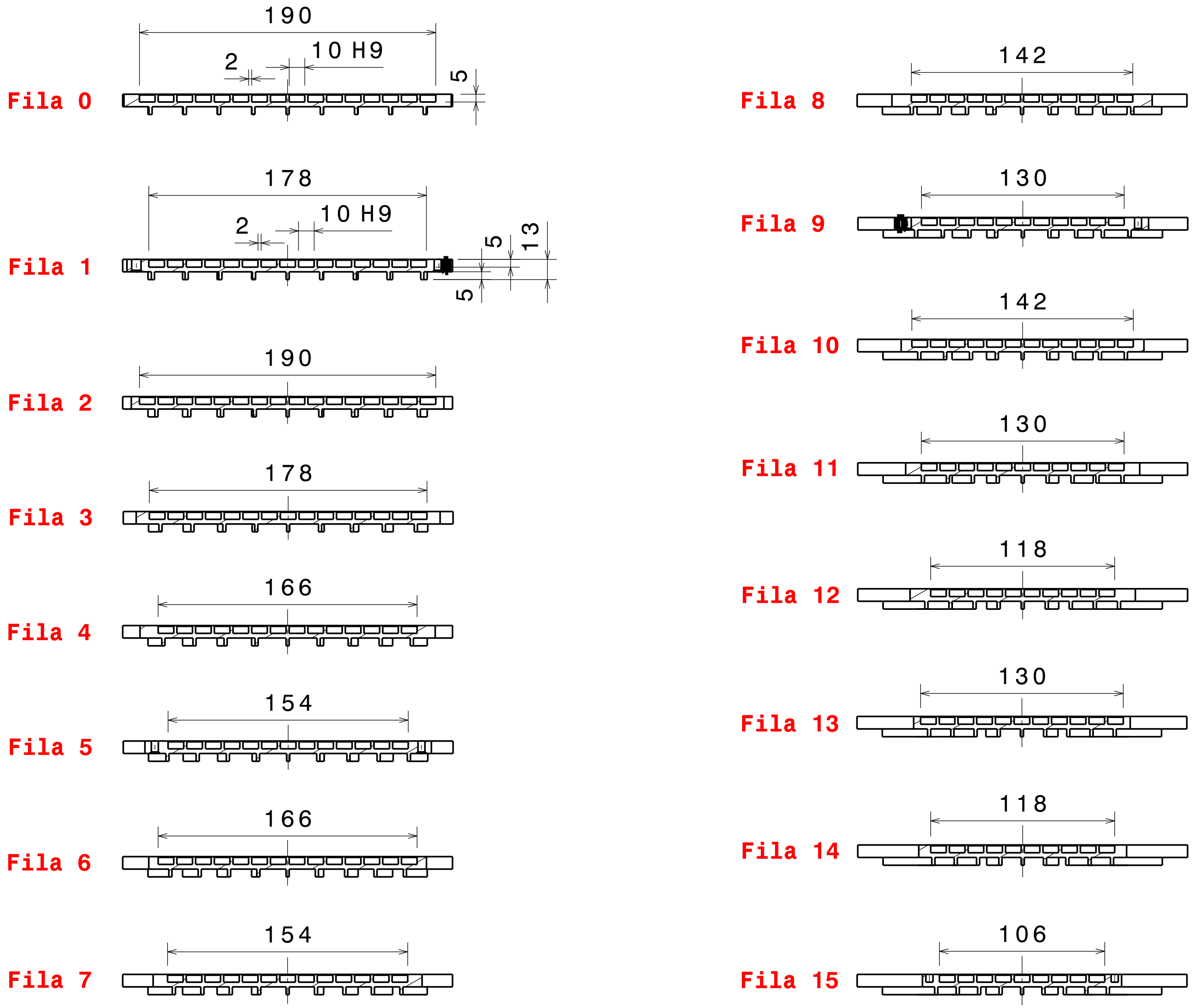
TÍTULO: Placa Inferior (Cassette)

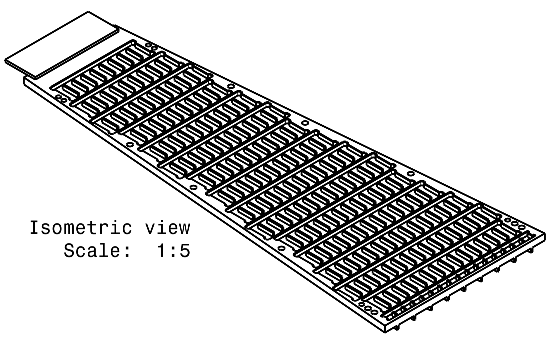
N.º DE DIBUJO: TRGT-ESS-0106.01.03

A3

ESCALA: 1:2







Acabado	rebarbar y romper aristas

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Diseñado	M. Mancisidor	18-2-16
Dibujado	A. Ortega	24-2-16
Verificado	I. Rueda	24-2-16
Aprobado	F. Sordo	24-6-16

REVISADO

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

>	0.5	6	30	120	400	1000	2000
≤	6	30	120	400	1000	2000	4000
tol	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2

radio/chaflán

>	0.5	3	6
≤	3	6	-
tol	±0.2	±0.5	±1

ángulo

>	0	10	50	120	400
≤	10	50	120	400	-
tol	±1°	±30'	±20'	±10'	±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽			▽▽▽		

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tel: 946076855
www.essbilbao.org

MATERIAL: X2CrNiMo17-12-2

PESO (g): 3533

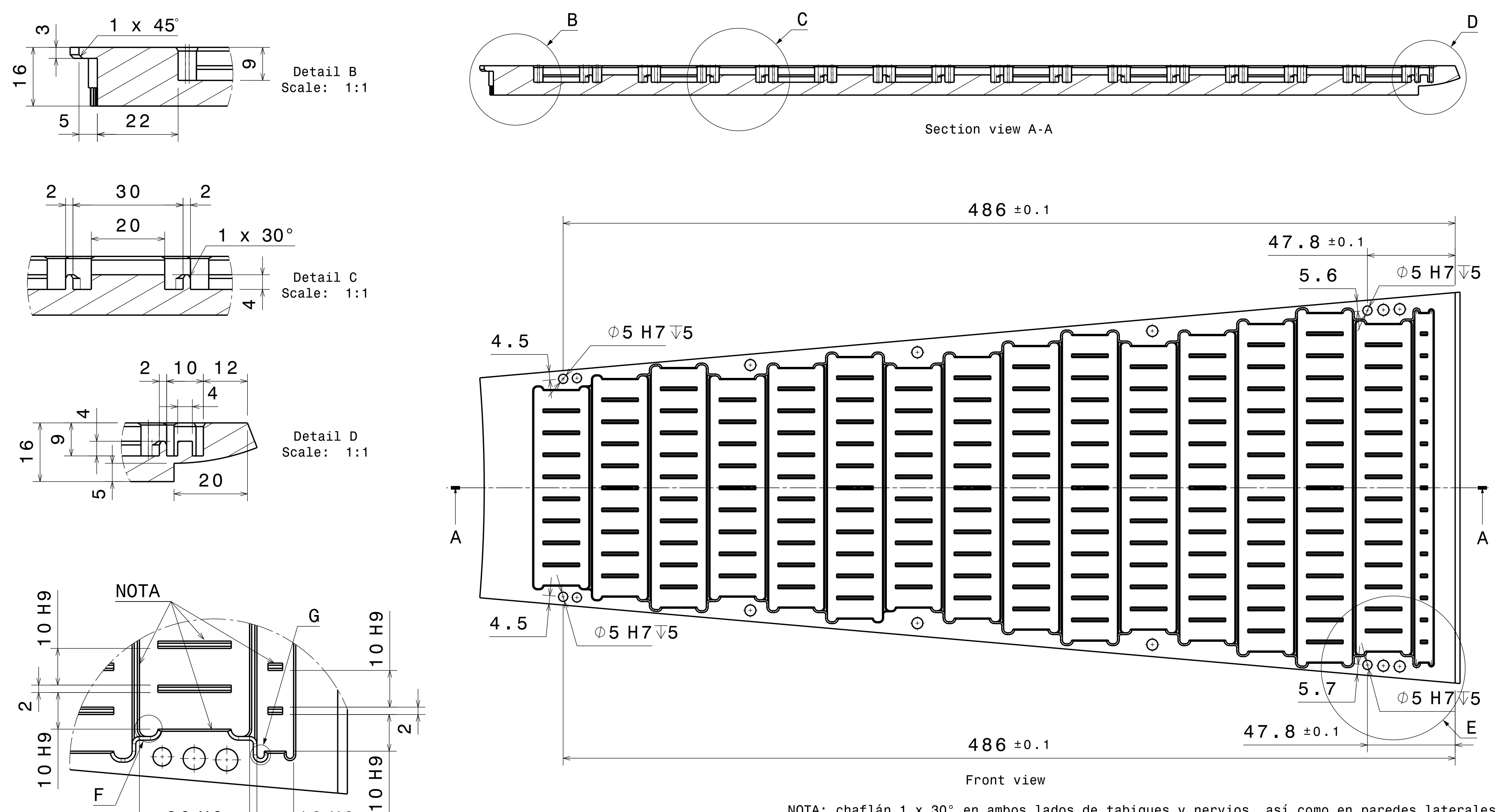
TÍTULO: Placa Inferior (Cassette)

N.º DE DIBUJO: TRGT-ESS-0106.01.04

A3

ESCALA: 1:3

HOJA 4 DE 4



NOTA: chaflán 1 x 30° en ambos lados de tabiques y nervios, así como en paredes laterales (ver dibujo); chaflanes en zonas de salida de herramienta/radios de acuerdo no necesarios

Acabado	rebarbar y romper aristas

	Nombre	Fecha
Diseñado	M. Mancisidor	18-2-16
Dibujado	A. Ortega	24-2-16
Verificado	I. Rueda	24-2-16
Aprobado	F. Sordo	24-6-16

REVISADO

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

> ≤ tol	0.5 6 ±0.1	6 30 ±0.2	30 120 ±0.3	120 400 ±0.5	400 1000 ±0.8	1000 2000 ±1.2	2000 4000 ±2

radio/chaflán

> ≤ tol	0.5 3 ±0.2	3 6 ±0.5	6 - ±1

ángulo

> ≤ tol	0 10 ±1°	10 50 ±30'	50 120 ±20'	120 400 ±10'	400 - ±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽			▽▽▽		

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tel: 946076855
www.essbilbao.org

MATERIAL: X2CrNiMo17-12-2

PESO (g): 3131

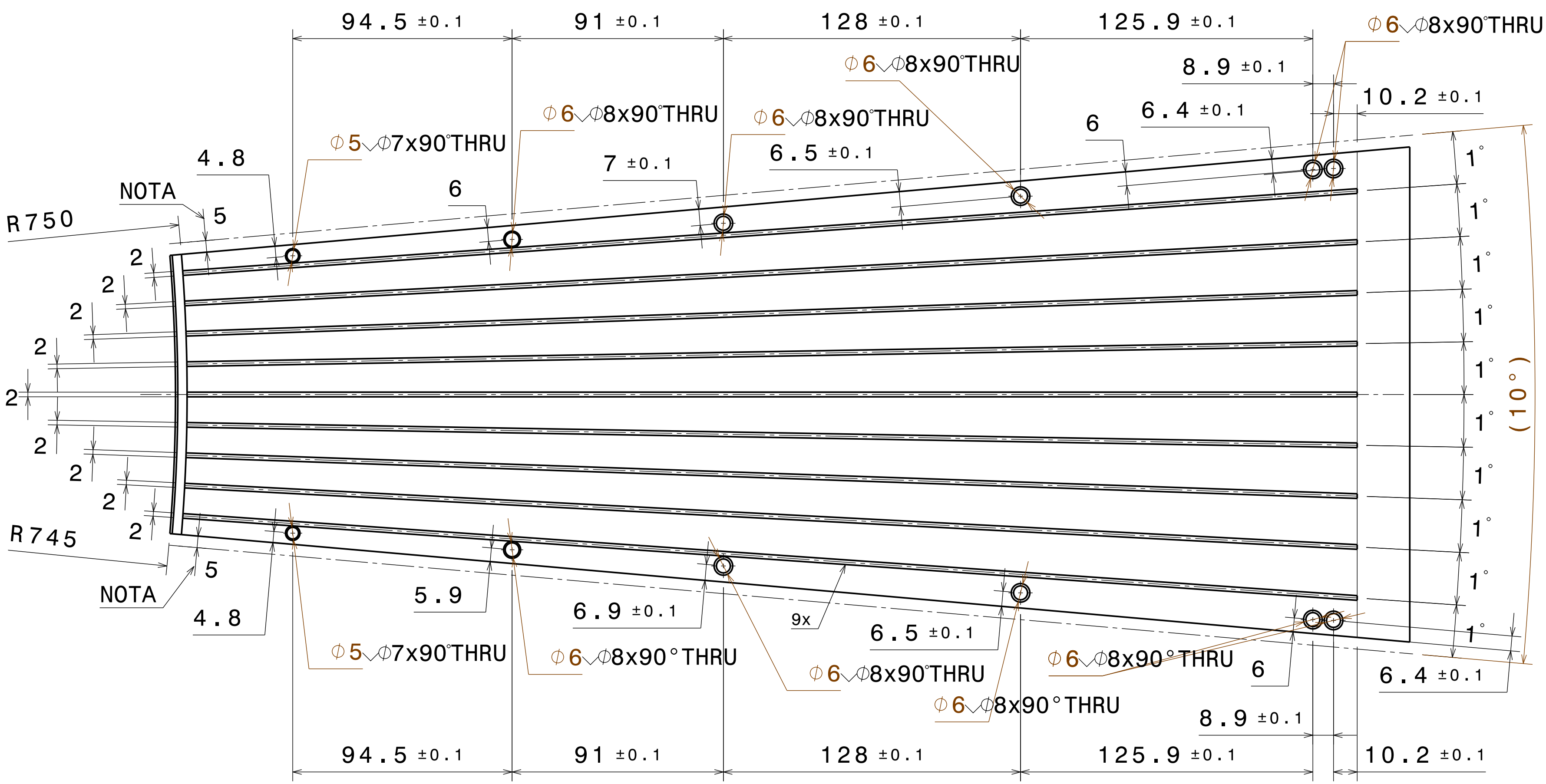
TÍTULO: Placa Superior (Cassette)

N.º DE DIBUJO: TRGT-ESS-0106.02.01

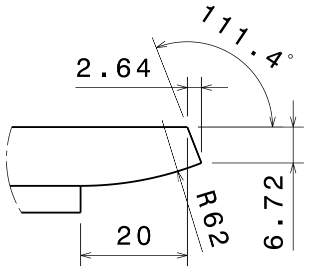
A3

ESCALA: 1:2

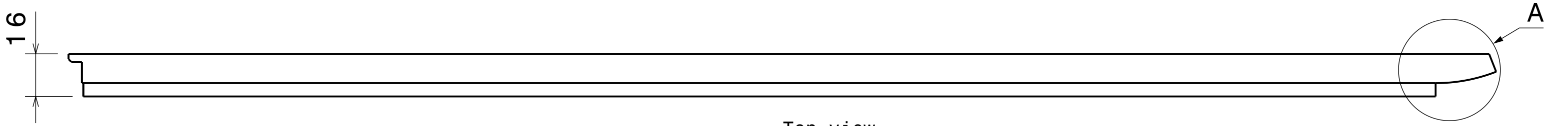
HOJA 1 DE 4



Front view

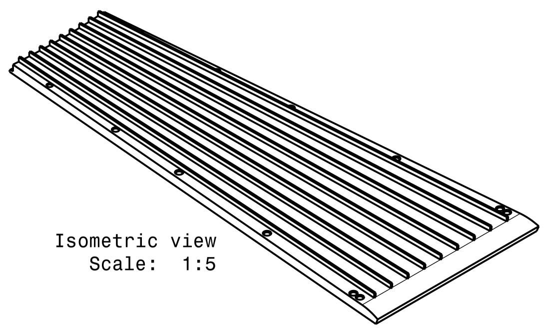


Detail A
Scale: 1:1



Top view

NOTA: las aristas del contorno de la placa no convergen en el centro de los radios, sino que están desfasadas 5 mm a cada lado para dejar espacio a los rigidizadores (e = 10 mm)
NOTA: una vez montados, **distancia entre casette y rigidizadores < 100 μm**



Isometric view
Scale: 1:5

Acabado	rebarbar y romper aristas

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Dibujado	A. Ortega	24-2-16
Verificado	I. Rueda	24-2-16
Aprobado	F. Sordo	24-6-16

REVISADO

Tolerancias generales en roscas DIN 13: 6H - 6g
Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

>	0.5	6	30	120	400	1000	2000
≤	6	30	120	400	1000	2000	4000
tol	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2

radio/chaflán

>	0.5	3	6
≤	3	6	-
tol	±0.2	±0.5	±1

ángulo

>	0	10	50	120	400
≤	10	50	120	400	-
tol	±1°	±30'	±20'	±10'	±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽		▽▽▽			

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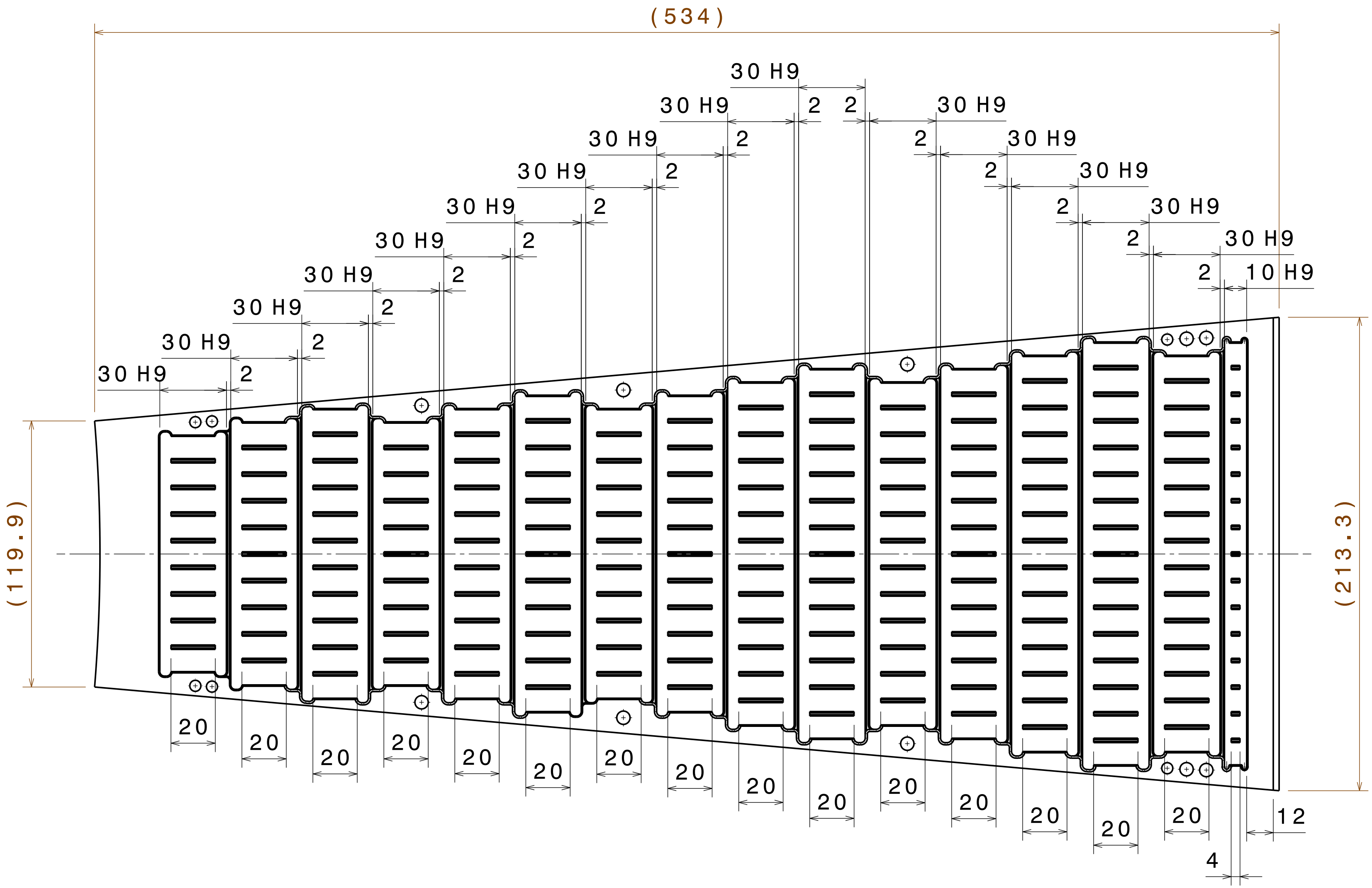
48170 ZAMUDIO (Bizkaia)
tel: 946076855
www.essbilbao.org

MATERIAL: X2CrNiMo17-12-2
PESO (g): 3131

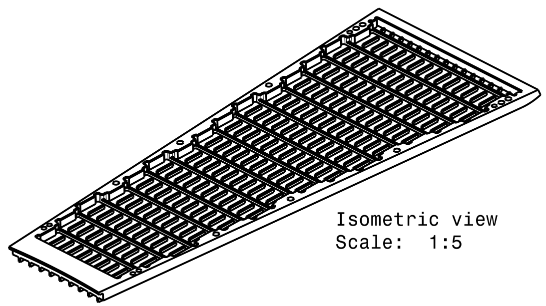
TÍTULO: Placa Superior (Cassette)

N.º DE DIBUJO: TRGT-ESS-0106.02.02
A3

ESCALA: 1:2
HOJA 2 DE 4



Front view



Isometric view
Scale: 1:5

Acabado	rebarbar y romper aristas	
ESS BILBAO Este plano, su formato y su contenido es propiedad de ESSbilbao y para uso estrictamente confidencial. No debe copiarse o distribuirse a terceros sin el permiso escrito de ESSbilbao		
	Nombre	Fecha
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Verificado	I. Rueda	24-2-16
Aprobado	F. Sordo	24-6-16

REVISADO

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

>	0.5	6	30	120	400	1000	2000
≤	6	30	120	400	1000	2000	4000
tol	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2

radio/chaflán

>	0.5	3	6
≤	3	6	-
tol	±0.2	±0.5	±1

ángulo

>	0	10	50	120	400
≤	10	50	120	400	-
tol	±1°	±30'	±20'	±10'	±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽			▽▽▽		

ESS bilbao
P.T. Zamudio
c/ Laida Bidea 201, Pab 4
48170 ZAMUDIO (Bizkaia)
tel: 946076855
www.essbilbao.org

MATERIAL: X2CrNiMo17-12-2

PESO (g): 3131

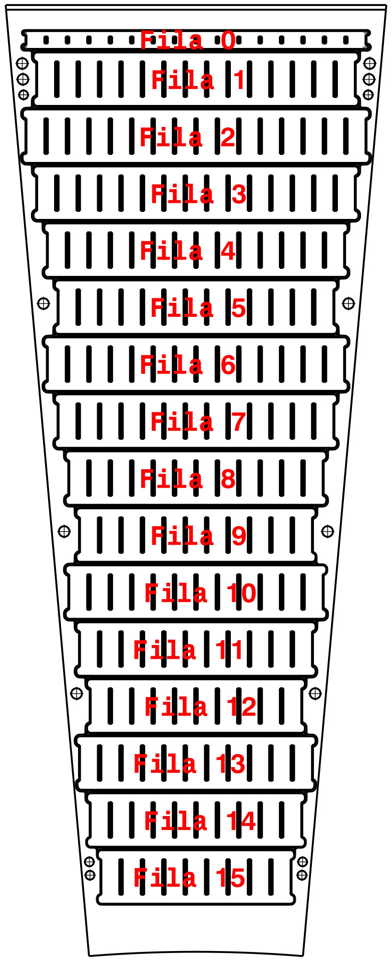
TÍTULO: Placa Superior (Cassette)

N.º DE DIBUJO: TRGT-ESS-0106.02.03

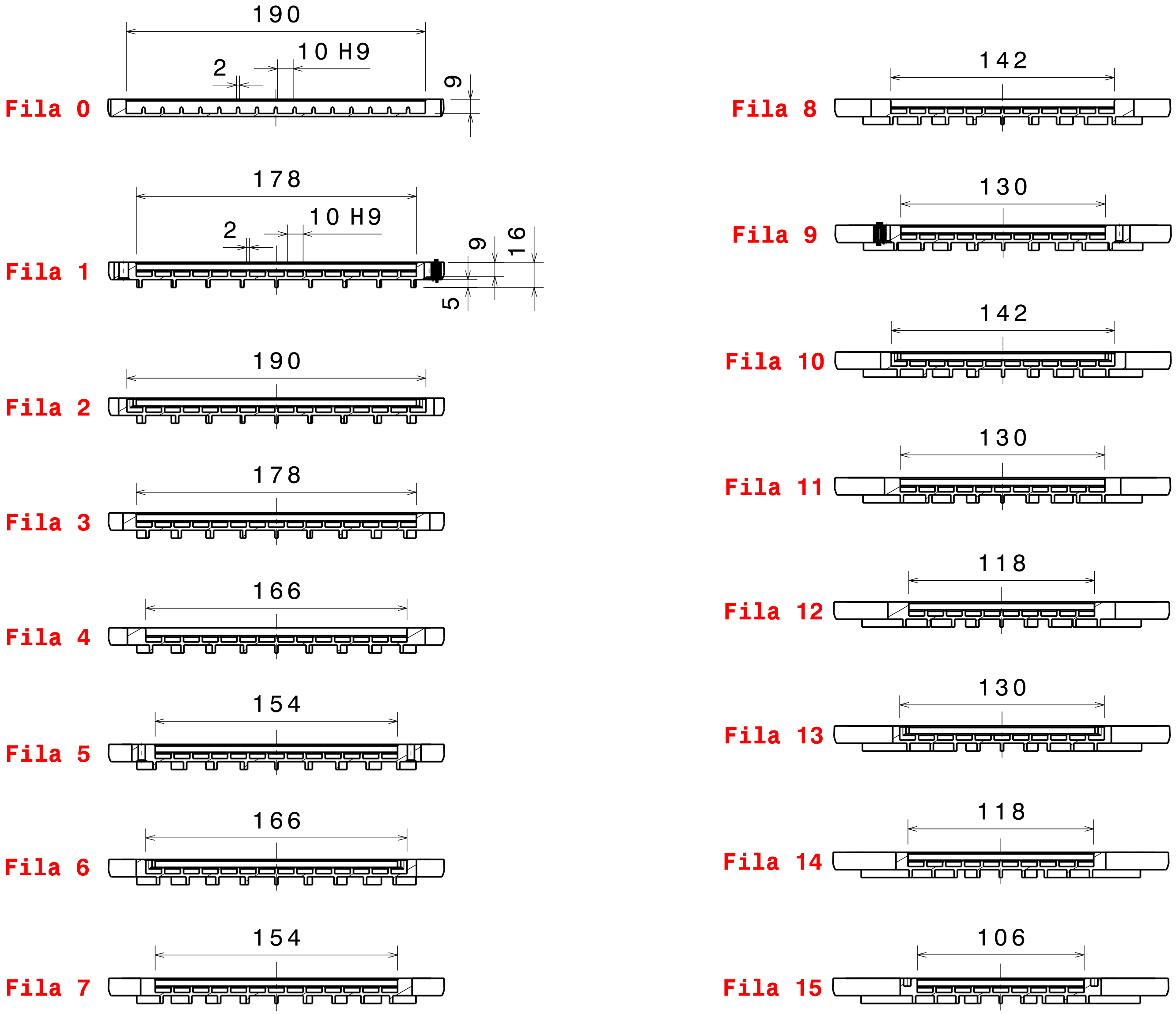
A3

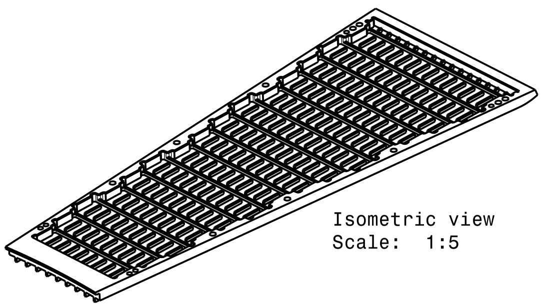
ESCALA: 1:2

HOJA 3 DE 4



Front view





Isometric view
Scale: 1:5

Acabado | rebarbar y romper aristas

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	Nombre	Fecha
Diseñado	M. Mancisidor	18-2-16
Dibujado	A. Ortega	24-2-16
Verificado	I. Rueda	24-2-16
Aprobado	F. Sordo	24-6-16

REVISADO

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

> ≤ tol	0.5 6 ±0.1	6 30 ±0.2	30 120 ±0.3	120 400 ±0.5	400 1000 ±0.8	1000 2000 ±1.2	2000 4000 ±2

radio/chaflán

> ≤ tol	0.5 3 ±0.2	3 6 ±0.5	6 - ±1

ángulo

> ≤ tol	0 10 ±1°	10 50 ±30'	50 120 ±20'	120 400 ±10'	400 - ±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽			▽▽▽		

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MATERIAL: X2CrNiMo17-12-2

PESO (g): 3131

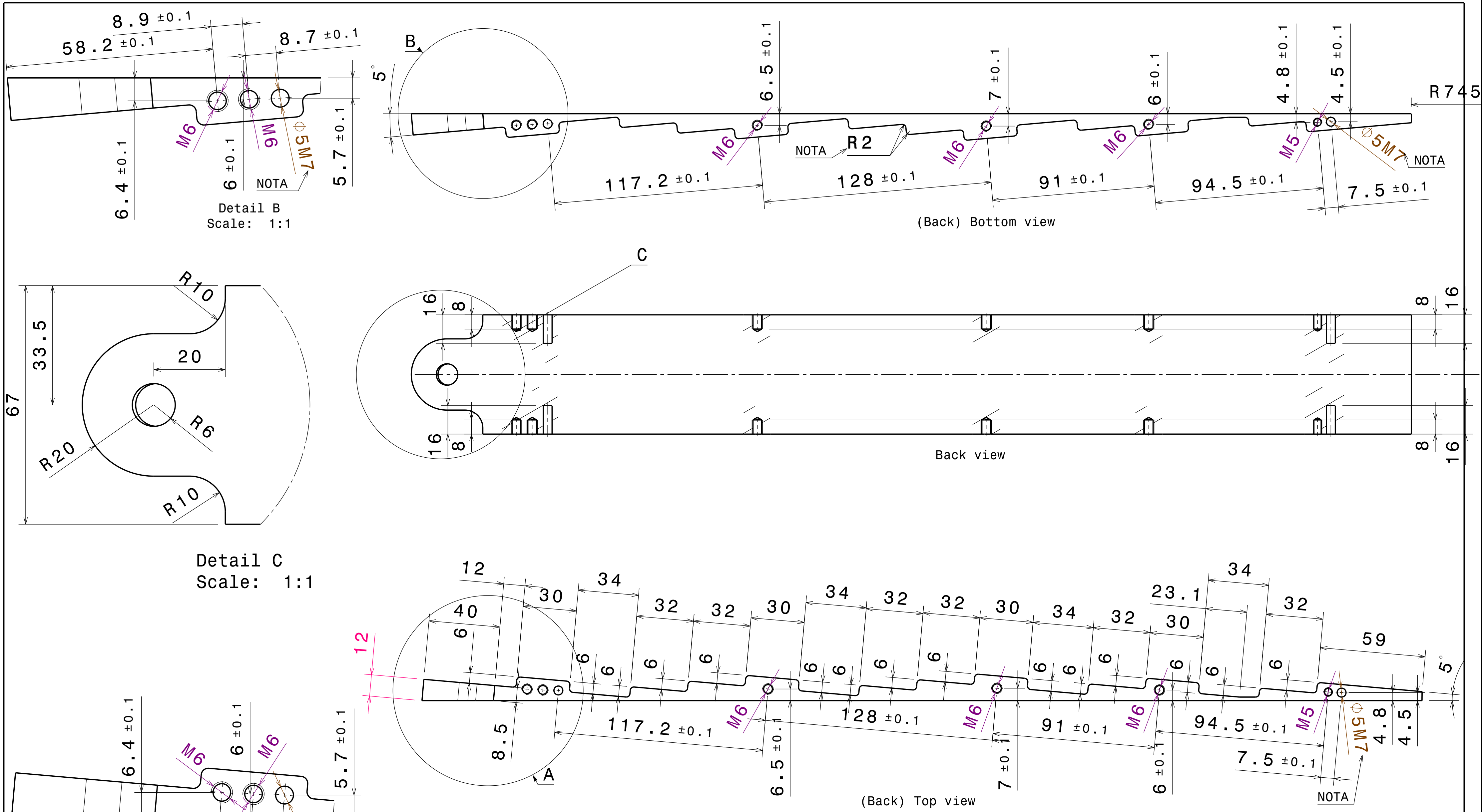
TÍTULO: Placa Superior (Cassette)

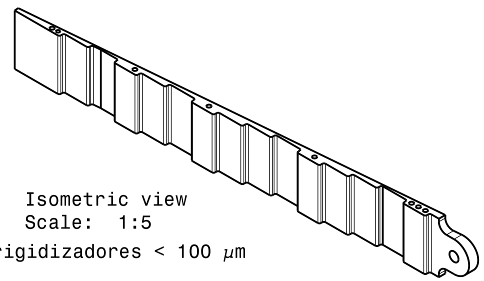
N.º DE DIBUJO: TRGT-ESS-0106.01.01

A3

ESCALA: 1:3

HOJA 4 DE 4





NOTA: una vez montados, distancia entre cassette y rigidizadores < 100 μm
NOTA: redondeos encuentros R = 2

Acabado	rebarbar y romper aristas		
ESS BILBAO Este plano, su formato y su contenido es propiedad de ESSbilbao y para uso estrictamente confidencial. No debe copiarse o distribuirse a terceros sin el permiso escrito de ESSbilbao			
	Nombre	Fecha	
Diseñado	M. Mancisidor	18-2-16	
Dibujado	A. Ortega	24-2-16	
Verificado	I. Rueda	24-2-16	
Aprobado	F. Sordo	24-6-16	
REVISADO			

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

>	0.5	6	30	120	400	1000	2000
≤	6	30	120	400	1000	2000	4000
tol	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2

radio/chaflán

>	0.5	3	6
≤	3	6	-
tol	±0.2	±0.5	±1

ángulo

>	0	10	50	120	400
≤	10	50	120	400	-
tol	±1°	±30'	±20'	±10'	±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽			▽▽▽		

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MATERIAL: X2CrNiMo17-12-2

PESO (g): 2256

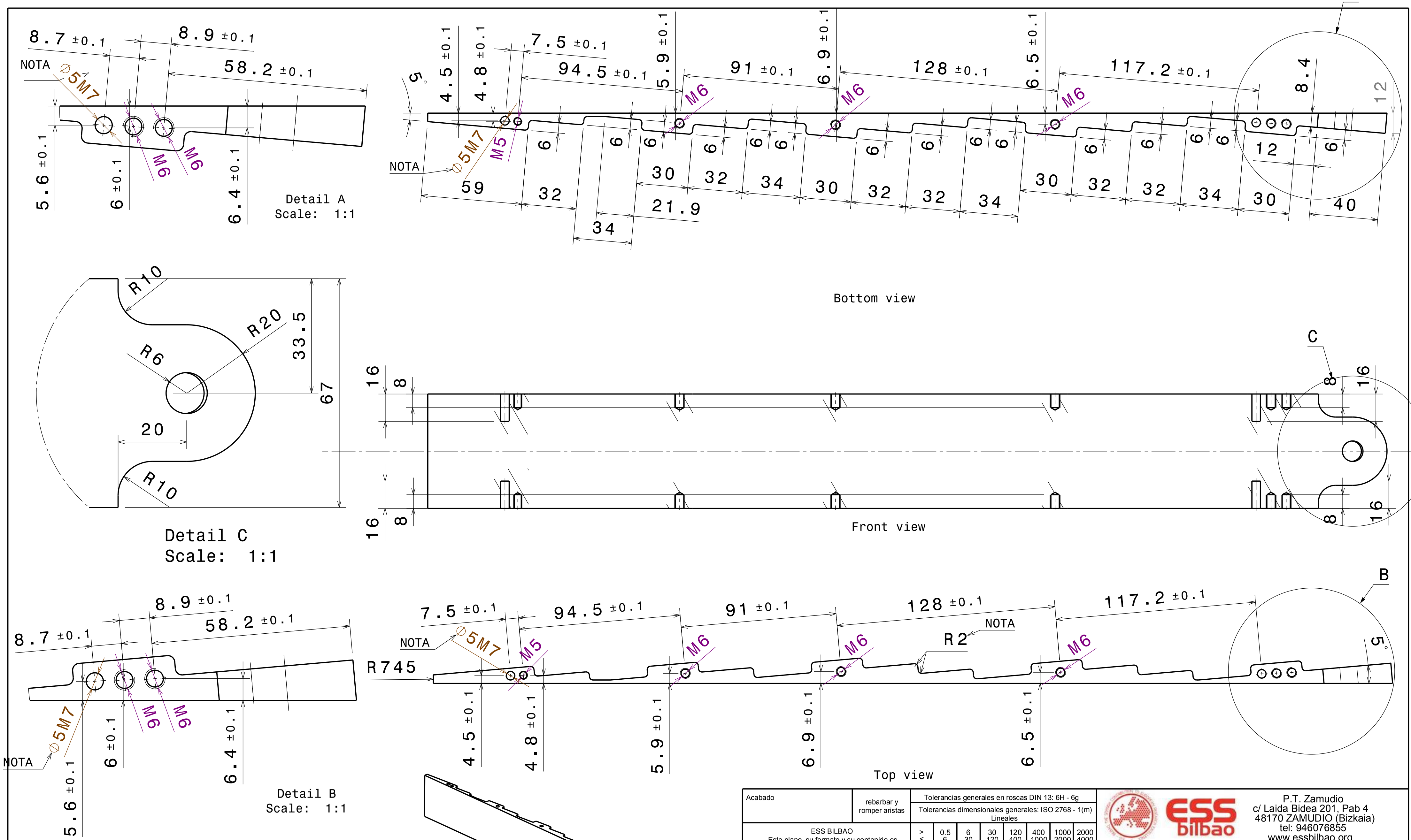
TÍTULO: Pared Derecha (Cassette)

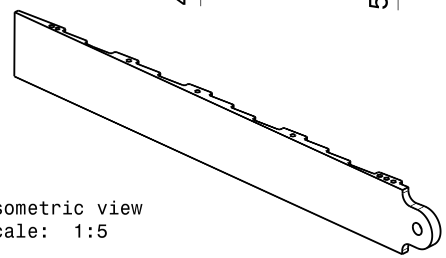
N.º DE DIBUJO: TRGT-ESS-0106.03

A3

ESCALA: 1:2

HOJA 1 DE 1





Isometric view
Scale: 1:5

NOTA: una vez montados, distancia entre casete y rigidizadores < 100 µm
NOTA: redondeos encuentros R = 2
NOTA: 4x agujeros (ø5 mm, tolerancia M7) para alojar pines de posicionamiento con apriete

Acabado	rebarbar y romper aristas	
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	Nombre	Fecha
Diseñado	M. Mancisidor	18-2-16
Dibujado	A. Ortega	24-2-16
Verificado	I. Rueda	24-2-16
Aprobado	F. Sordo	24-6-16
REVISADO		

Tolerancias generales en roscas DIN 13: 6H - 6g

Tolerancias dimensionales generales: ISO 2768 - 1(m)

Lineales

>	0.5	6	30	120	400	1000	2000
≤	6	30	120	400	1000	2000	4000
tol	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2

radio/chaflán

>	0.5	3	6
≤	3	6	-
tol	±0.2	±0.5	±1

ángulo

>	0	10	50	120	400
≤	10	50	120	400	-
tol	±1'	±30'	±20'	±10'	±5'

Tolerancias geométricas generales: ISO 2768-2(K)

Medidas en milímetros

Rugosidad

Ra	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2
DIN	~	▽	▽▽		▽▽▽			

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MATERIAL: X2CrNiMo17-12-2	PESO (g): 2143
TÍTULO: Pared Izquierda (Cassette)	
N.º DE DIBUJO: TRGT-ESS-0106.04	A3
ESCALA: 1:2	HOJA 1 DE 1

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