Upgrade and Further Development of SAUNA Field Report 3

Prototype design

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Sammanfattning

Rapporten innehåller prototypdesignen för uppgradering av SAUNA Field systemet. Designen är baserad på resultaten från rapport 1 och 2 i samma projekt samt diskussioner under och efter koordinationsmöte 2 i Wien. Rapporten inkluderar den slutgiltiga designen för uppgradering av SAUNA Field systemet och omfattar punkterna 3.4.1–3.4.3 i offerten. Detaljer för detta uppdrag beskrivs i CTBTO kontraktet nummer 2017-1505 (FOI 2017-1283).

Nyckelord: Radioxenon, SAUNA Field, OSI, ädelgas

Summary

This report covers the prototype design for the upgraded SAUNA Field system. The design is based upon the findings in report 1 and 2 as well as discussion during and after coordination meeting 2. The prototype design covers solutions for items 3.4.1—3.4.3 in the technical offer. This work is described in detail in CTBTO contract number 2017-1505 (FOI 2017-1283).

Keywords: Radioxenon, SAUNA Field, OSI, noble gas

Table of contents

1 Introduction

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) allows for on-site inspection (OSI) in order to collect data, for the sole purpose of clarifying whether a treaty violation has occurred or not and to assist in the identification of a possible violator. During such an inspection a wide range of techniques and equipment for collecting facts are available to the inspection team, among others the collection and analysis of radioactive noble gases from both atmosphere and sub-surface.

In the past 20 years several different systems have been developed for collecting and analyzing radioactive noble gases (primary radioxenon and radioargon), both for the international monitoring system (IMS) and for the OSI-regime.

As a capability building and to test the concept of the noble gas collection and analyzing capability in field, several noble gas analyzing systems were developed (xenon systems according to Terms of References in (RFP 2011-0060/ALIMDJANOVA, 2011)). These systems where then tested in the field during the integrated field exercise for the OSI regime in Jordan 2014 (IFE14). One of these systems was SAUNA Field, which was previously known as OSI-SAUNA, but will henceforth be referred to as SAUNA Field (or SAUNA-F).

This project is a continuation of this capability building and examines, based upon lessons learned from the IFE14 and other exercises, what needs to be modified and improved on the radioactive xenon field laboratory systems in order to enhance the performance during an OSI. Both in general, and then specifically for SAUNA Field in accordance to the terms-of-reference of the contract number 2017-1505.

This report covers the prototype design for an upgraded version of the SAUNA Field system.

2 Prototype design

Three different parts of the SAUNA Field system has been re-designed to addressed items 3.4.1—3.4.3 in the technical offer: “3.4.1 Design of a new lead-shield a new detector stand”, “3.4.2 Re-design the β-γ detector to make it more robust for shipment” and ” 3.4.3 Adaption of gas sampling, separation and control unit into rack(s) or a frame”. Care has been taken to adapt the system for installation into flight pods, currently under designed by VRR (www.vrr-aviation.com), but it should be noted that the flight pod design is not finalised. In the final adaption, either the dimensions and requirements for securing points in the container floor will have to be adapted to the SAUNA-F or the design of the SAUNA-F bottom frame needs to be altered to match the container interface. See details in the coming sections. The new base frame of the SAUNA-F is very simple and can easily be adjusted to fit the securing points of a container.

The four detectors are located in the bottom of the rack to lower the centre of gravity, the detectors and their lead-shields make up for about half of the systems weight. To protect the system from shocks and vibrations during shipping the system will be placed upon dampers. The results of simulating the response of the dampers showed that the dampers in the floor should be sufficient and that no dampers at the top of the system, as earlier envisaged, should be required.

Figure 1. Overview of the new design for the SAUNA Field system. The four detectors are located at the bottom right of the system and an UPS is integrated into the custom-built frame, located above the detector units.

2.1 Design of a new lead-shield and a new detector stand

The detector and the lead shield has been completely re-designed to fit into the frame and make the construction more robust to handle the shipping conditions, see section 2.2. The decision was made to make four individual lead-shields, this will facilitate the handling of the detectors during both installation and repair. It will also allow for individual quality check (QC) measurements without cross-talk between the detectors. Each individual detector unit weighs about 100 kg, the drawing is shown in Figure 2. The lead shield is constructed out of several smaller sections to reduce the weight of each individual part. The new QC mechanism, developed for SAUNA II/III, is seen on the right side of the lead-shield in Figure 2. This model allows for better precision of the source location within the detector, which allows for a good accuracy for the automatic gain correction software. This software and hardware have been tested with good results on SAUNA systems and is implemented in the SAUNA III system. With the new QC mechanism, it will be possible to integrate the gain correction software on the SAUNA Field system. This will improve the detector stability and simplify the setup of the system in the field.

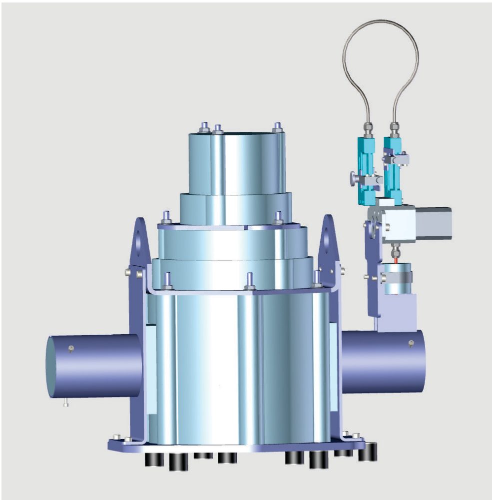


Figure 2. The new individual lead shield for one β-γ detector including the QC mechanism.

All detector electronics, *e.g.* high voltage, amplifiers, and PXI crate, together with the sample transfer unit (STU) are integrated into the frame nearby the detectors. In Figure 3 the four detectors are shown, note that they are mounted on rails to allow for easy access. The rails are split so that the two foremost detectors can be slid out in the front and the two other towards the back of the frame. This will facilitate installation as well as troubleshooting/repairs of the detectors.

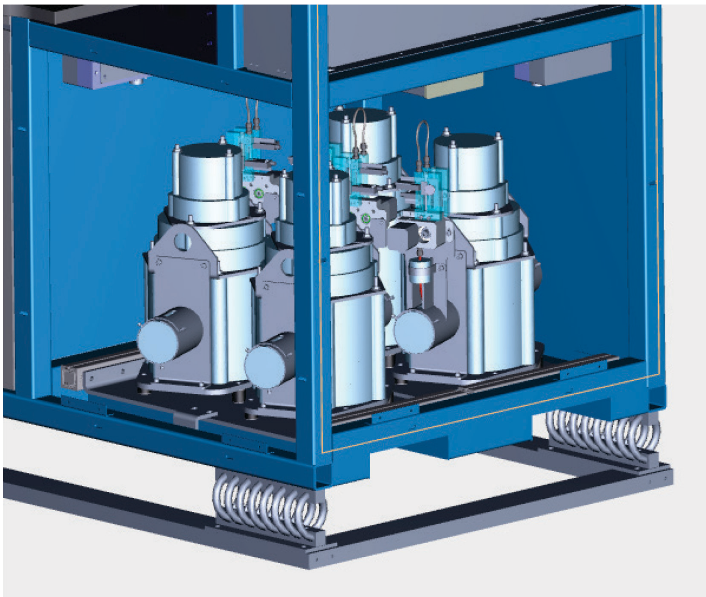


Figure 3. The detectors are placed on sliding rails in the bottom of the rack to allow for easy access.

2.2 Re-design of the β-γ detector

Each detector lead shield is placed on four dampers, seen in the bottom part of Figure 4, to protect the detectors from vibrations. Foam material will be placed between the lead and the NaI and β-cell to protect them from shock and rapid temperature changes and to allow for the detector to be mounted in the system during shipping. It should be noted that the detector, especially the NaI crystal, is sensitive to both shock and temperature variations, specifications are given in report 2 (Upgrade and Further Developments of SAUNA Field Report 2 - Definition of infrastructure requirements), and this should be taken into account when shipping the system inside the container. It is recommended to test this design for vibration and shock before the design is finalized. Due to the restrictions in temperature variation for the detector crystals it might not always be feasible to leave the detectors in the system during shipping and storing.

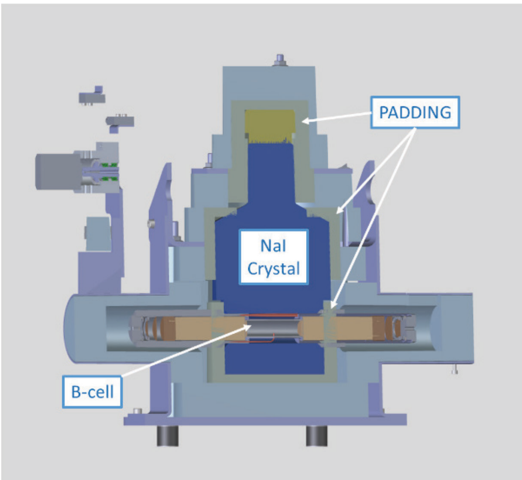


Figure 4. Cross section view of the detector. The insulating foam can be seen surrounding the NaI- and β-detectors.

2.3 Adaption of gas sampling, separation and control unit into a frame

The design has been altered to make the system suitable for integration into a flight container. No internal changes has been made in the modules nor to the connections between the modules, except for the detector unit which is described in the sections above. All units will be mounted on rails, to allow for serviceability, in a welded custom frame, shown in Figure 5, which is mounted on dampers on a simple and light base-frame. The suggested base-frame can easily be modified to fit with the securing points in the container. Once the container design is finalized holes for connectors can be made in the frame matching the floor railings. The proposed solution is to make the connector frame out of double aluminium profiles (see Figure 6).

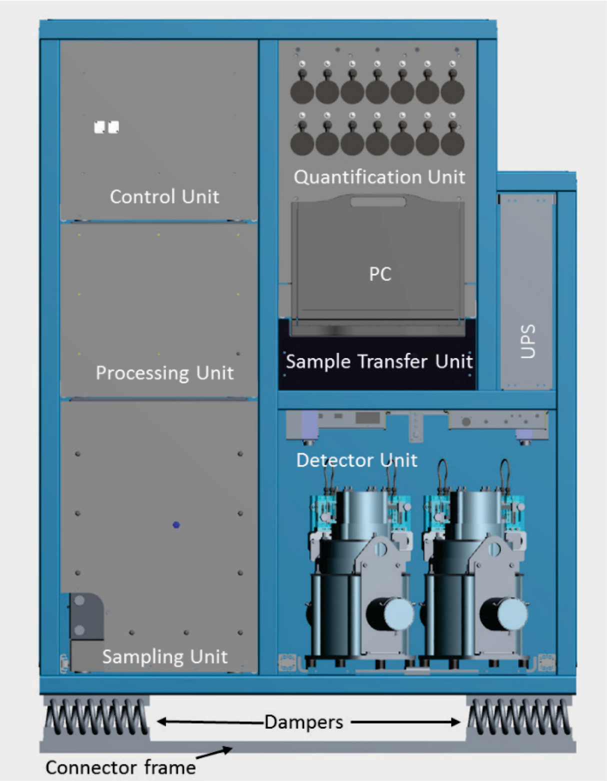


Figure 5. SAUNA-F system from the front with the system modules labelled.

The dampers for the rack are designed to handle shocks during shipment for an assumed weight of the system of 1000—1100 kg. The calculations show that two different models of ENIDINE WR20 wire rope dampers are suitable for the system. Since the centre of mass of the system is quite low, side stabilizers are not considered necessary. Without side stabilizer a recommended buffer zone on each side of at least 100 mm, at the top of the system, is recommended to allow for the expected displacement of the system. This displacement is expected to be less than 30 mm in all lateral directions for a 5G side load. If extreme tilt angles, above 10°, are to be expected side stabilizers could be used. If the final weight of the built system changes, the calculations should be updated since this might result in another model of the dampers. The space above the system is also needed to allow for the vertical movement during shipping.

All sides of the system will be covered by panels and no internal part will be accessible without removing one of these panels. This makes it possible to place tamper seals on the system.

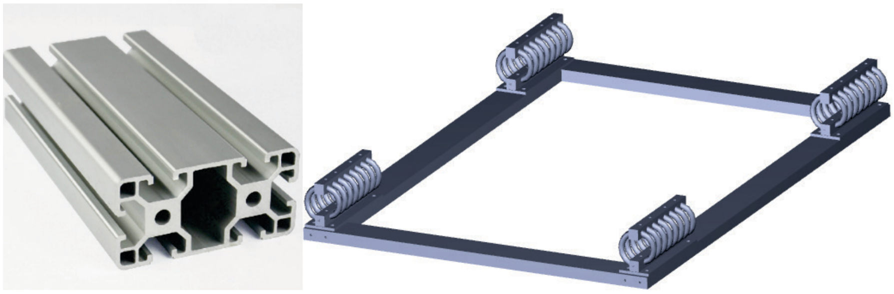


Figure 6. Suggested profile of the base frame to the left and the frame with dampers to the right.

2.4 Interfaces

The system will need three different external gas connections, shown in Figure 6, as well as electrical and network connections. The air inlet is only required if the system is used to sample ambient air, which is recommended during the set-up phase. These gas lines, as well as the electrical connections, should be placed on a flexible mount in the roof/back wall of the container to allow moving the system inside the container without disconnecting it. We recommend making a recessed panel, similar to the 32A power inlet that VRR suggest for the container, located in the back wall of the container with three quick connectors to simplify installation. During transport and storage these connectors are protected by caps that has to be removed before the system is used.

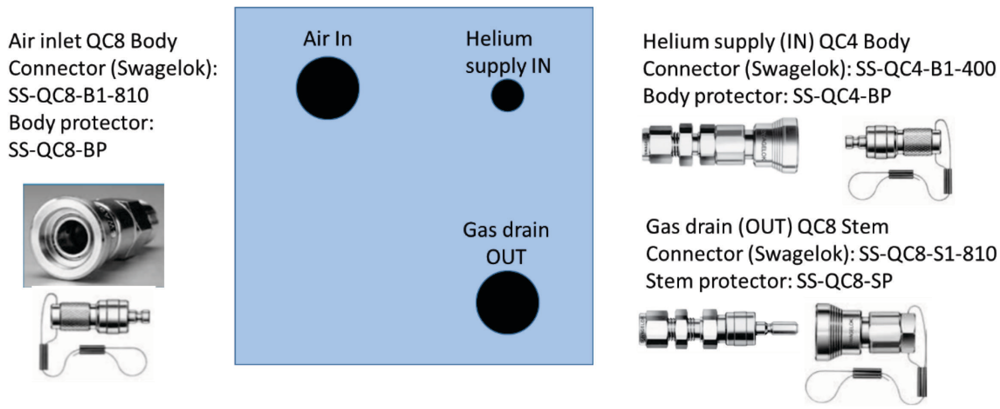


Figure 7. Connector panel for external connections, to be located on the outside of the container.

2.5 Integration into flight container

Depending on how the containers are placed or connected to each other, the SAUNA-F system can be orientated differently. The suggested placement, which is shown in Figure 7, allows for enough space on the back for exhaust and connections as well as a workspace on the front where most work are performed, *e.g.* adding new samples.

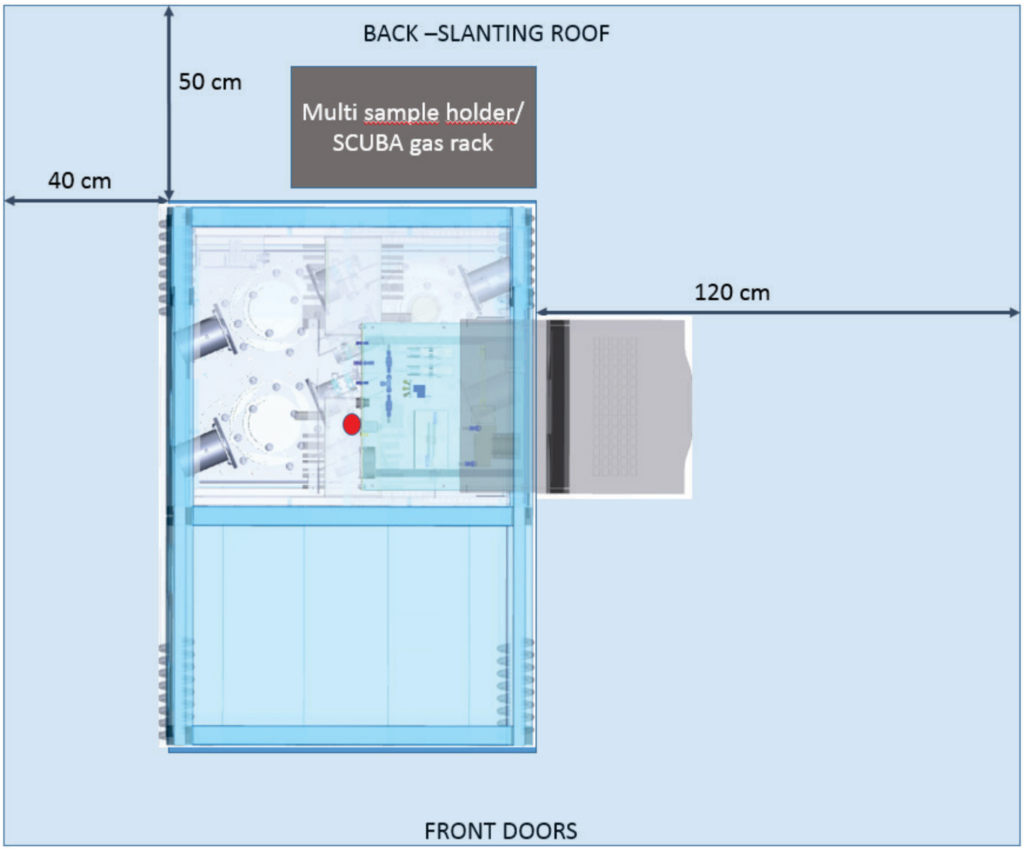


Figure 8. Suggested placement of the system inside the container (from above) with the keyboard extracted and the roof transparent to reveal the position of the detectors. The estimated centre of mass indicated by the red dot.

The system is designed to be installed using of a fork lift, for which the connector pane is designed, lifting from the shorter side of the system. Care should be taken when lifting the system since the centre of gravity is located near the detectors, on the opposite side from the lift.

2.6 Specifications

The dimensions of the system are presented in Table 1, all other system specifications were specified in report 2 (Upgrade and Further Developments of SAUNA Field Report 2- Definition of infrastructure requirements) of this project. These numbers should be reviewed once an upgraded SAUNA Field system is built and tested.

Table 1. System physical dimensions and electrical connection

Est. weight	1000—1100 kg
Dimension WxDxH	135x90x185 cm
Power connection	Fixed connection 1-phase 230 V 50 Hz
UPS model	APC SRT5KRMXLI
UPS max power	4500 W

Figure 9. The estimated centre of mass measures 0.8 m from the right, 0.7 m up from the floor and in the centre, as seen in Figure 8.

3 SAUNA Field (potential) upgrades

This section describes further changes that could be made to the SAUNA Field system to further improve the functionality and operation.

3.1 System capacity

The system was designed to handle samples of 2 m^3 in volume with a maximal CO_2 concentration of 0.3 %. The field prototype, which was used in IFE14 had the capacity to process samples with up to 2 % CO_2. Experience from other field campaigns show that these levels can exceed 10 %. The current operational method to handle this is to use external CO_2 filters (“scrubbers”). This method requires more equipment and more manual labour, hence an inspection would benefit from a system that could handle higher levels of CO_2 in the samples. By re-design of the sampling traps in the SAUNA-F and optimization of the process the system could be altered to handle higher levels of CO_2 in the samples which should, under most circumstances, remove the need of the external scrubbers and their regeneration equipment.

3.2 Operating

The SAUNA-F system only has one port to connect samples, which means that the operator need to visit the system multiple times per day to switch samples. The use of the system would be much improved if a multiple sample inlet were developed. This inlet should have the capacity of processing a full days of samples without interaction of the operator. The multiple sample input could be connected, via a flexible hose, to the single input of the current system and be controlled via the same software and hardware as today with some minor upgrades.

The operation of the SAUNA-F system would benefit from further development of the software, mainly with the aim on improving the stability and flexibility of the operation. The operator’s main interface with the system is the software and making it more user friendly and stabile will improve the usage of the system.

An automatic chain of custody integrated with the system hard- and soft-ware would facilitate the handling of samples for the operators. This could be utilized using RFID-tags integrated with the sample containers. These tags could store information such as; sampling ID, location, sample type and volume.

The latest version of the SOH software used on other types of SAUNA systems should be adopted to be used with the SAUNA–F which currently operates with a very basic SOH version.

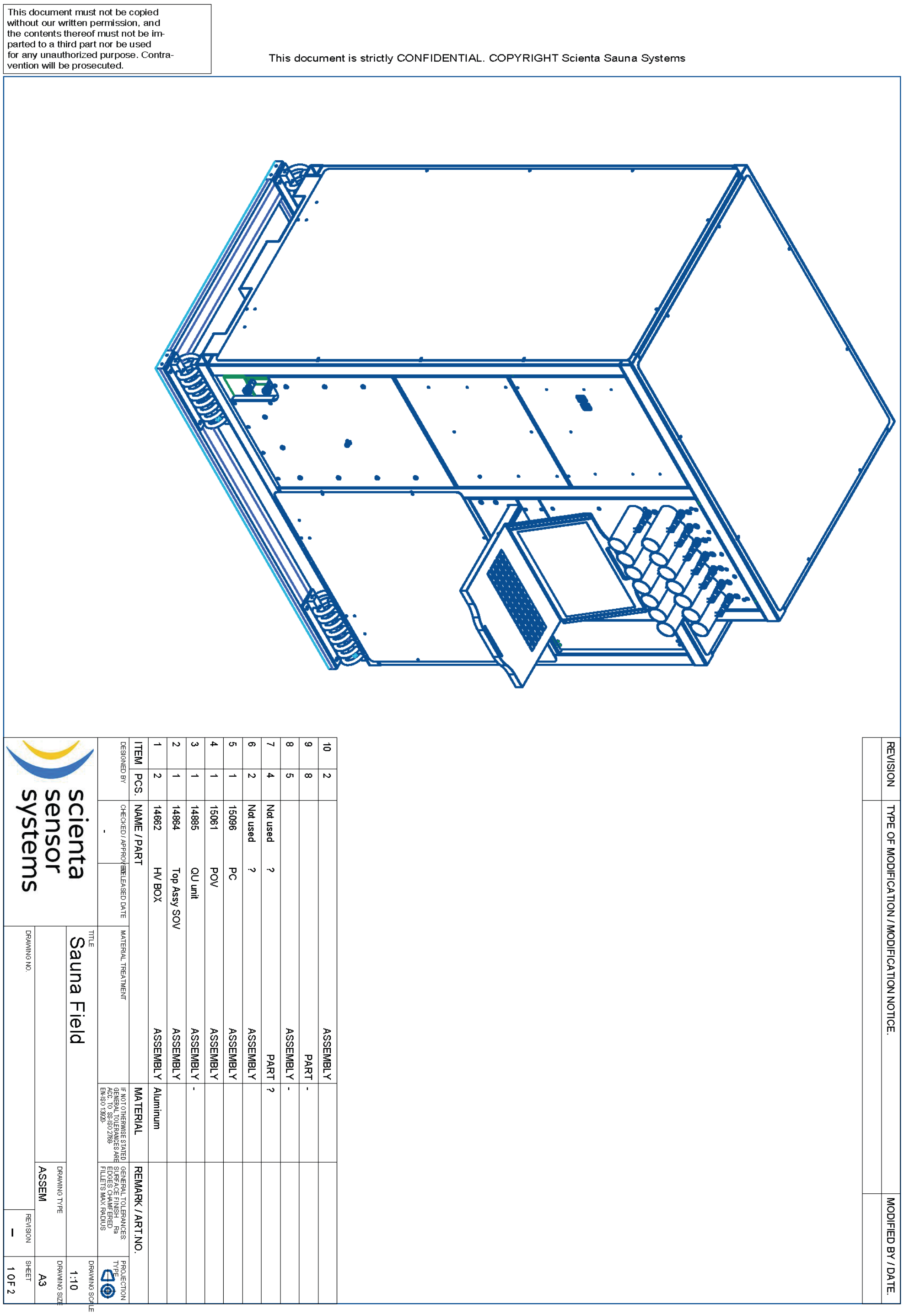
3.3 Deployment

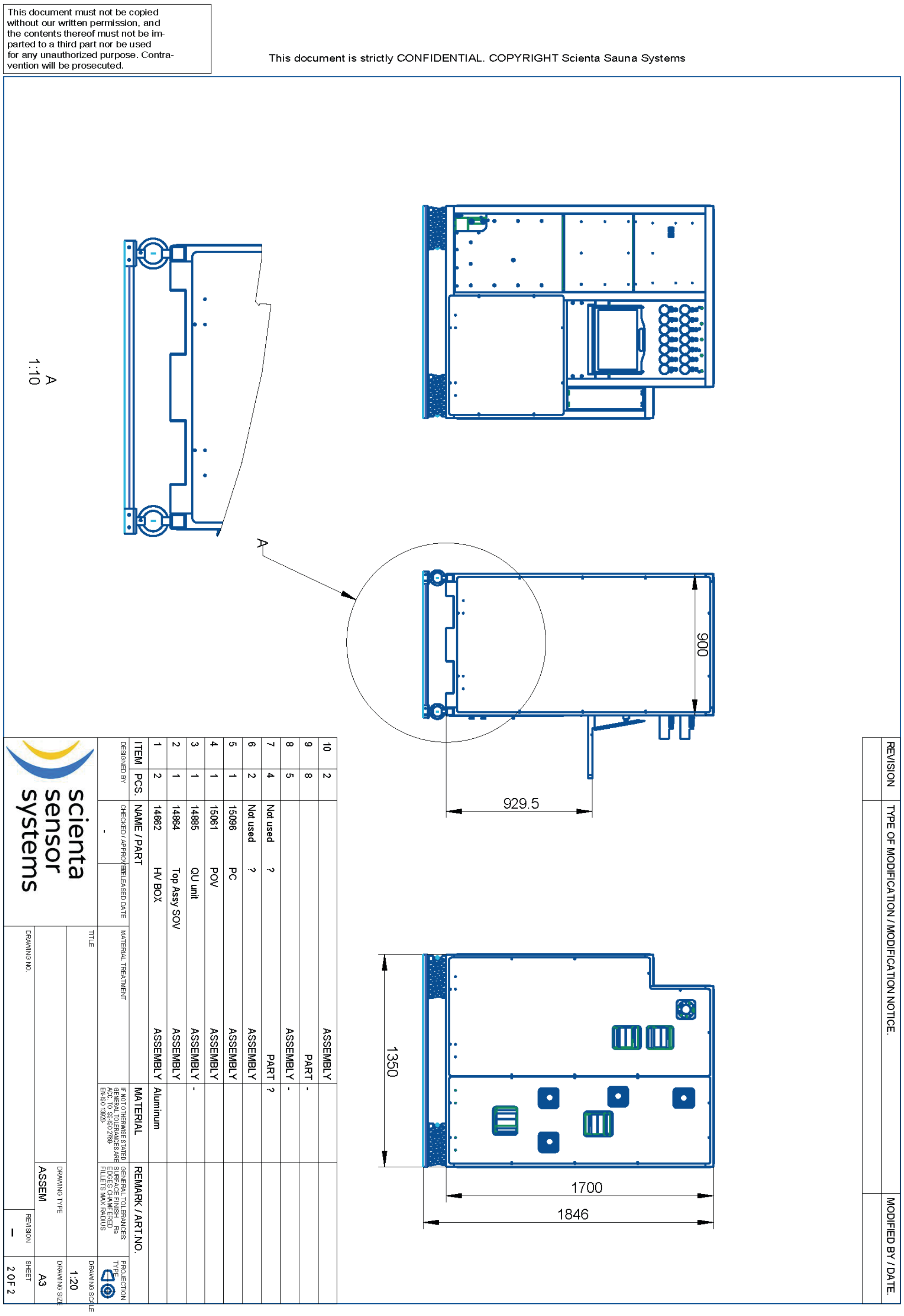
Once the system and the container are constructed, the set-up and shipping procedures should be tested, especially in respect to the detectors performance and sensitivity to shock. One suggestions is to install the system into the flight pod and transport it on a truck while monitoring, with the use of accelerometers, the function of the dampers. The electrical and gas connections should be revised to optimize the installation and simplify the set-up in the field.

4 Conclusions

This report describes the necessary changes made to the SAUNA Field system to integrate it into flight pods, as well as a full re-design of the detector and lead shields to allow for a more robust design. None of these changes have been tested on a physical system and the full system characteristics as well as the integration into the flight container, including shock damping, should be tested once a new system is built.

System drawings





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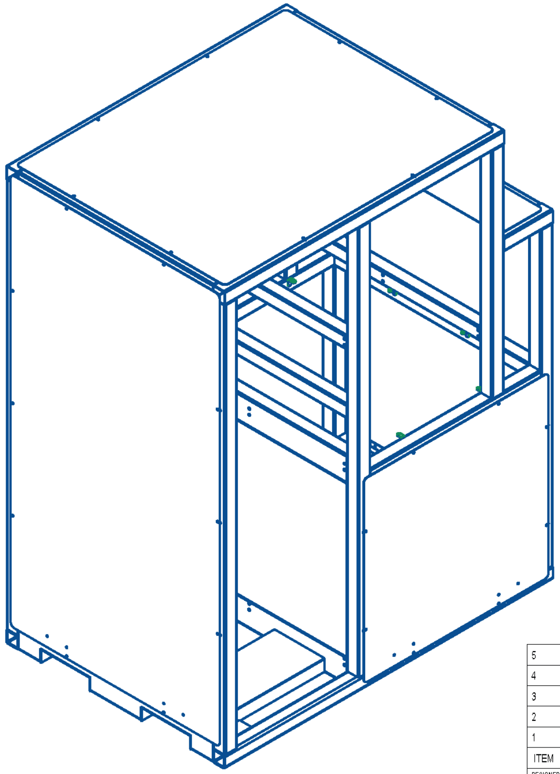

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scienta sensor systems

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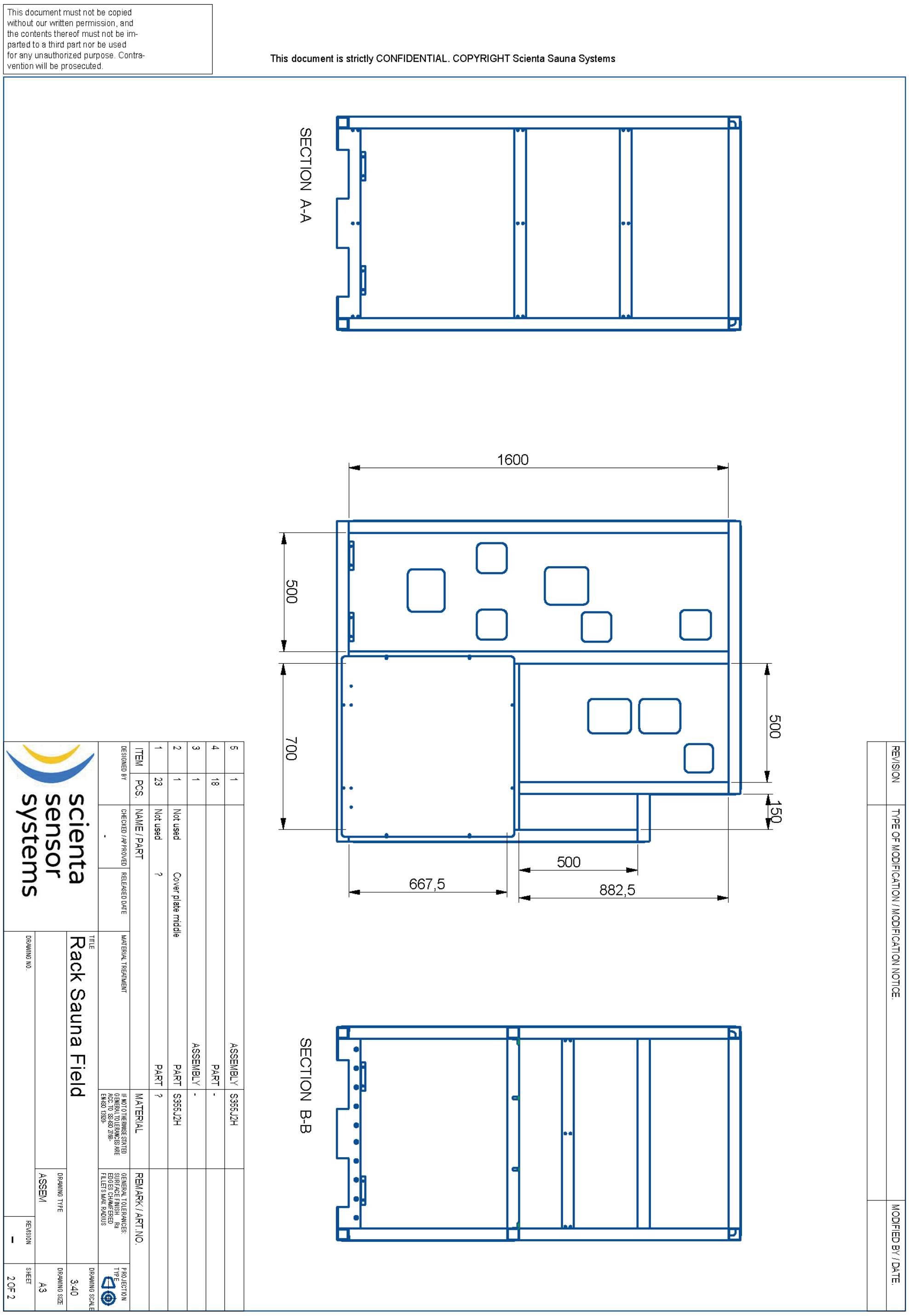
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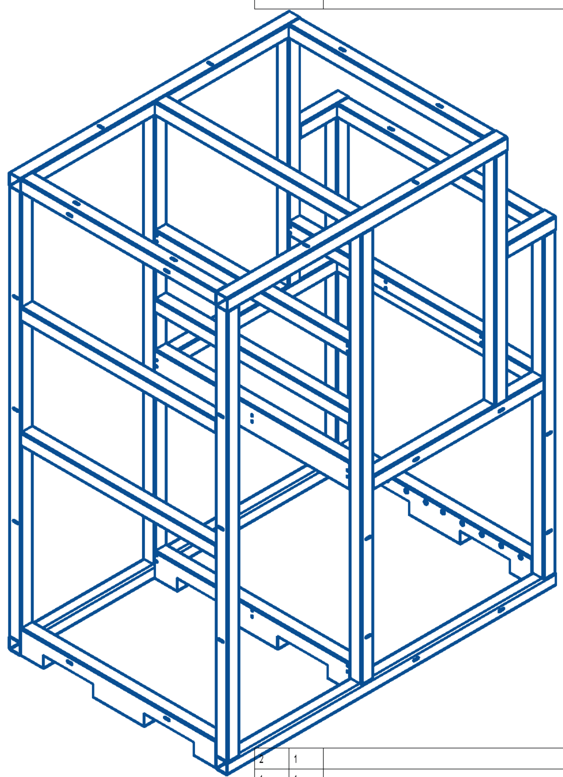

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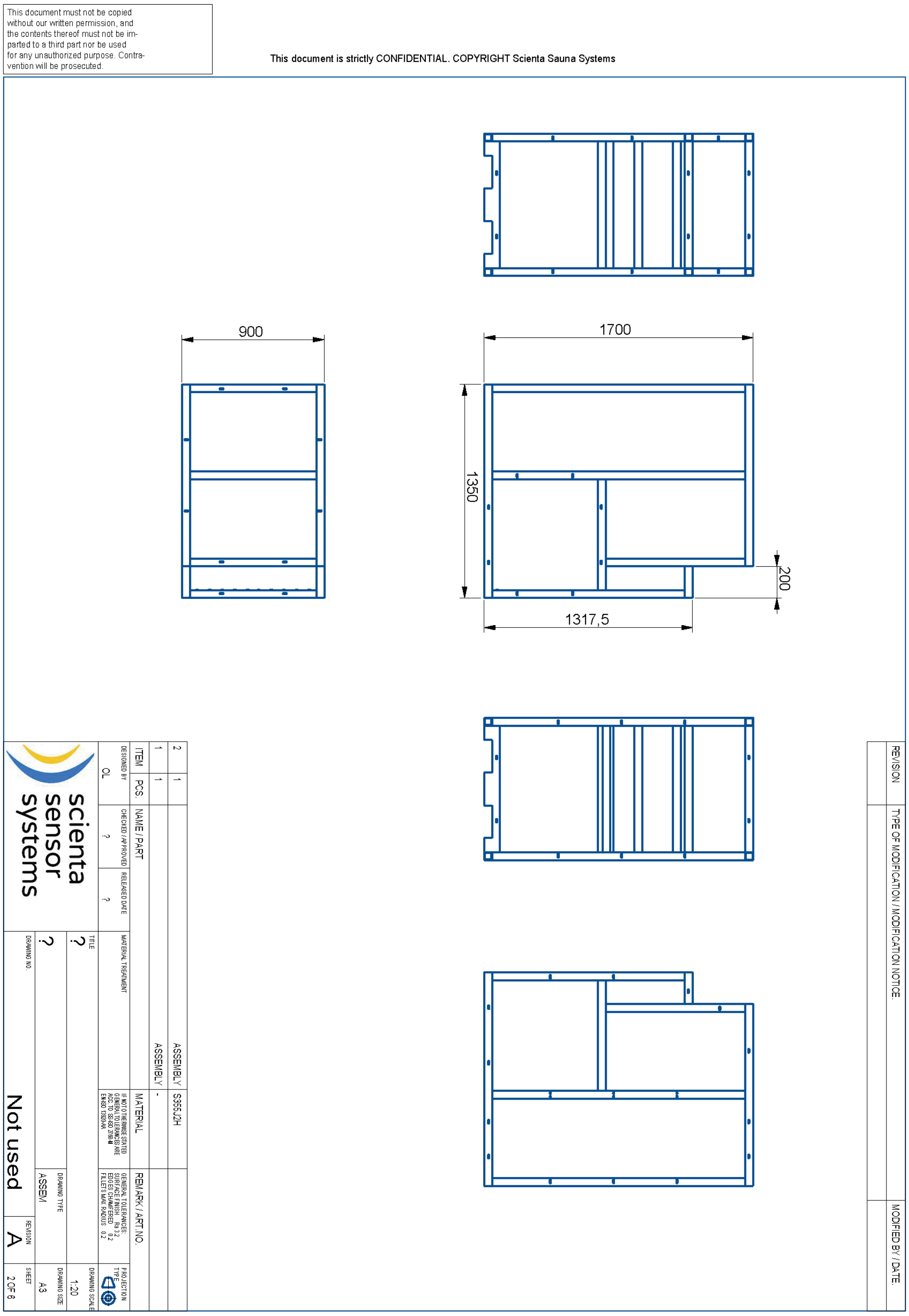
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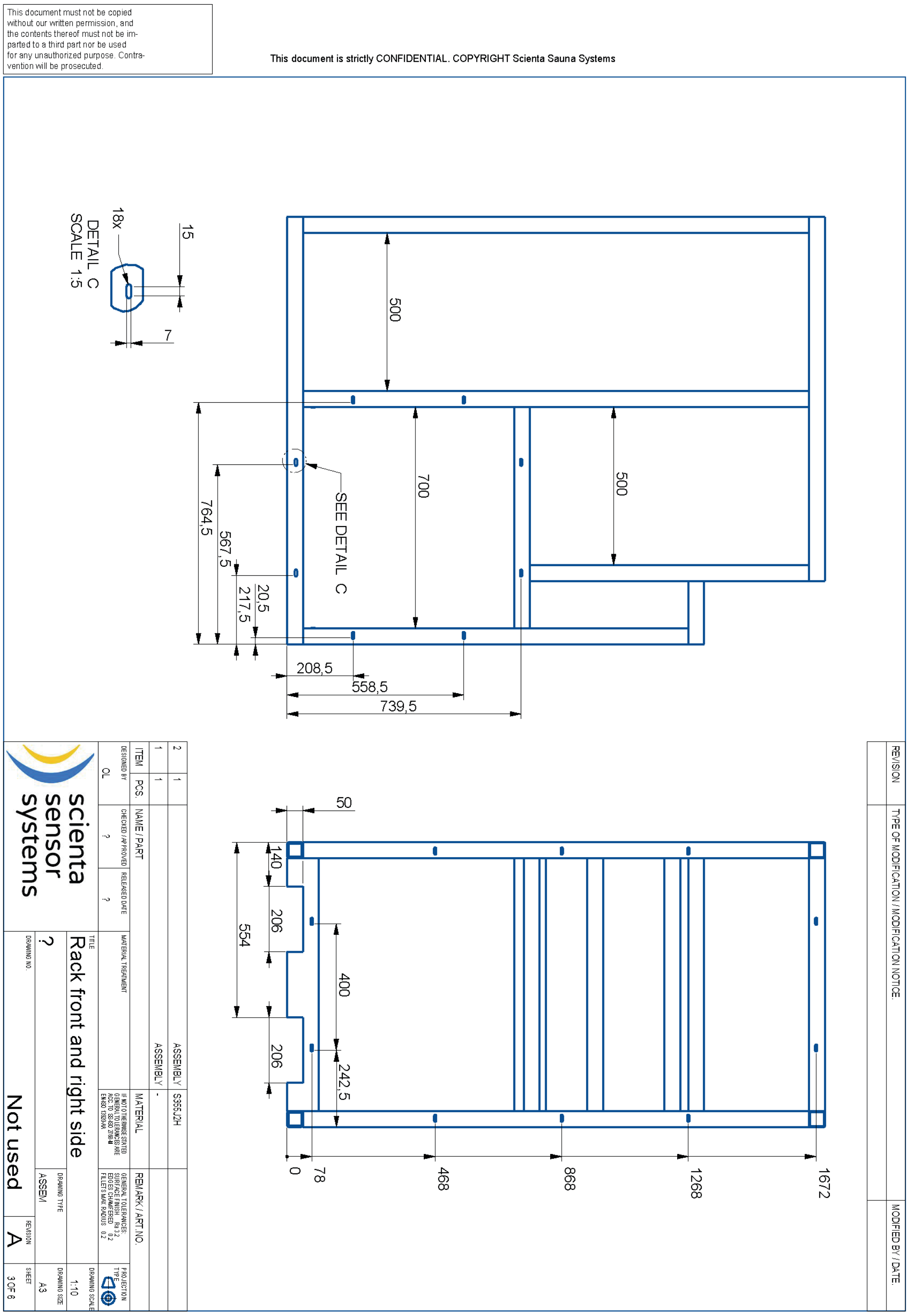
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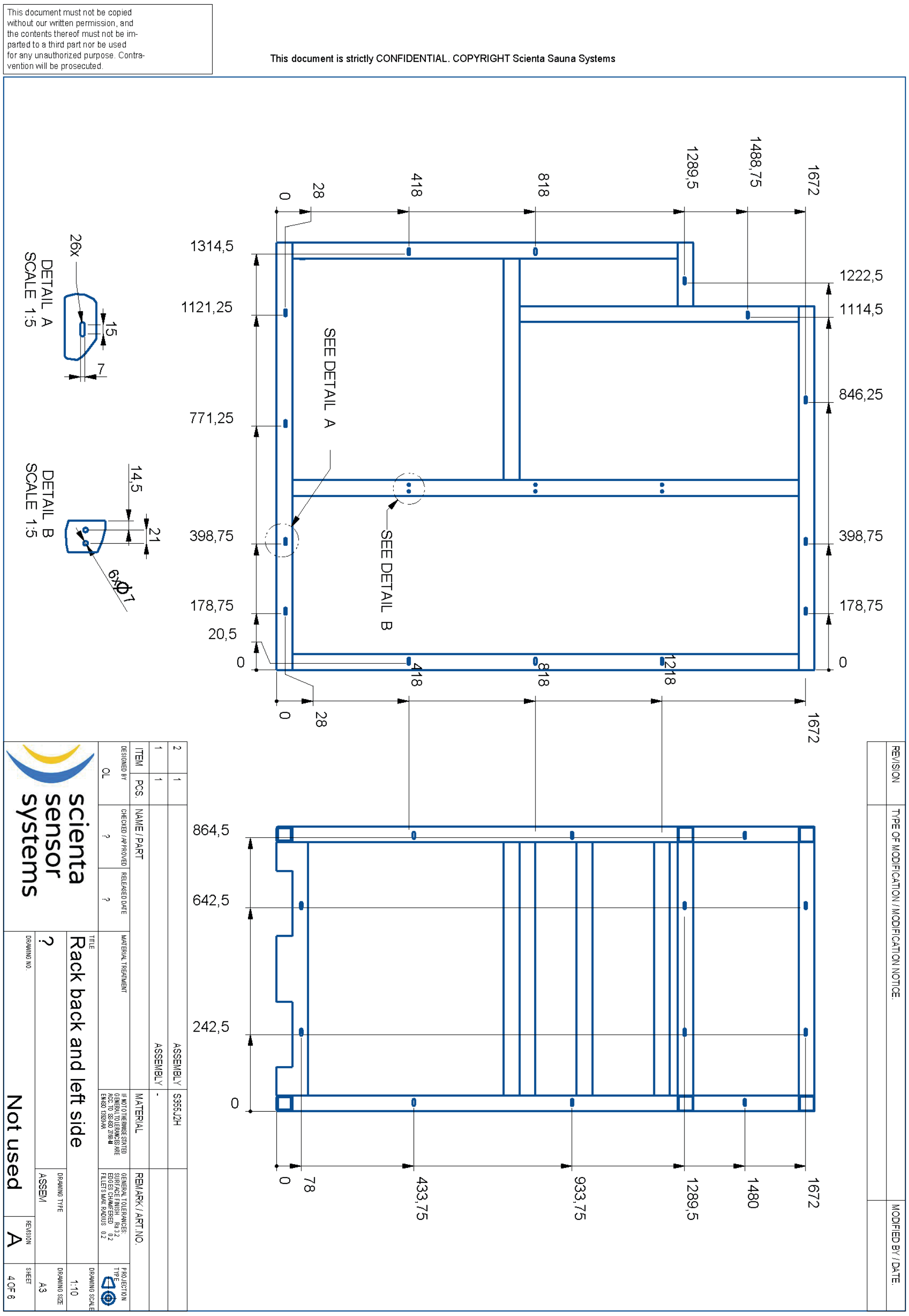
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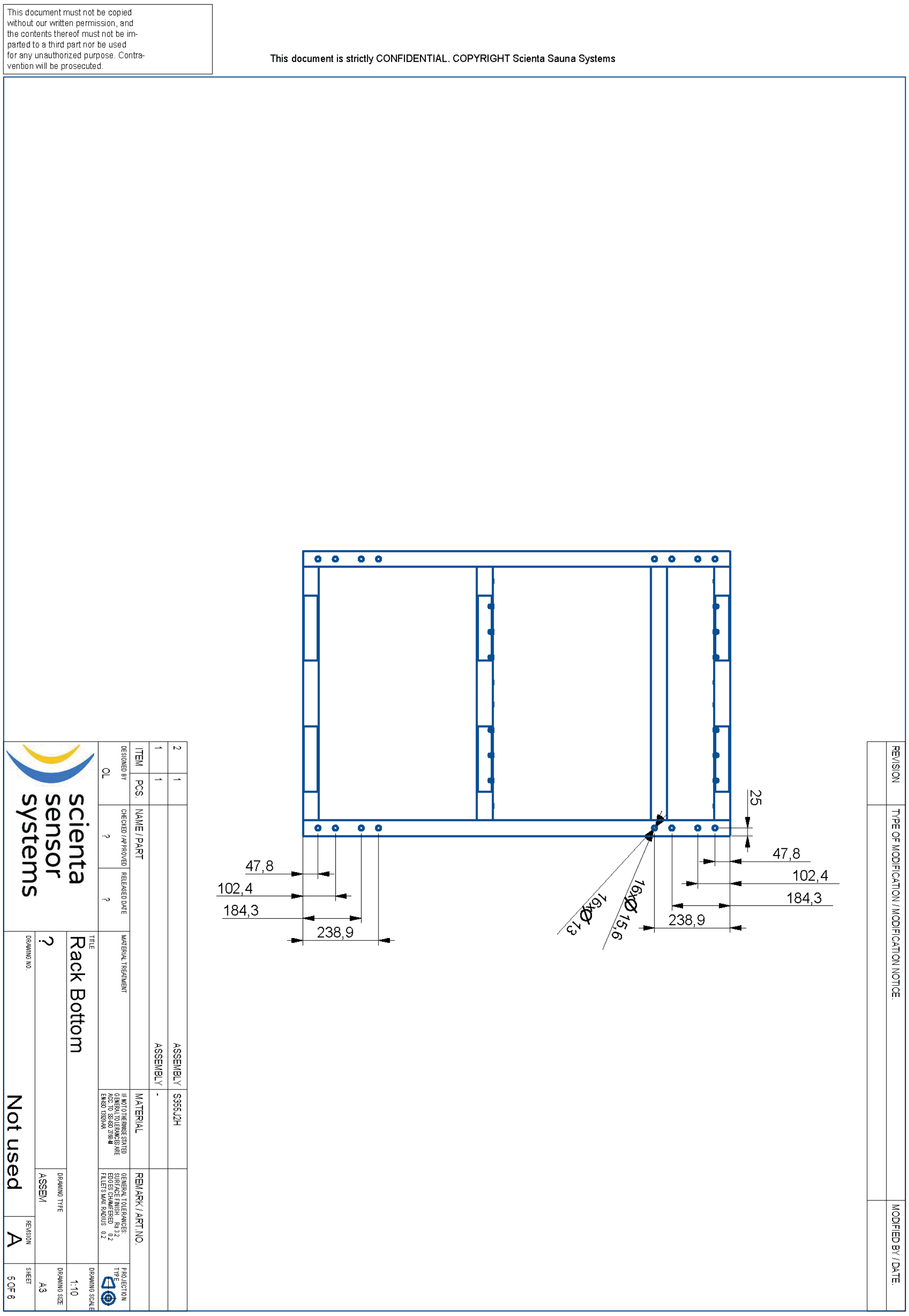
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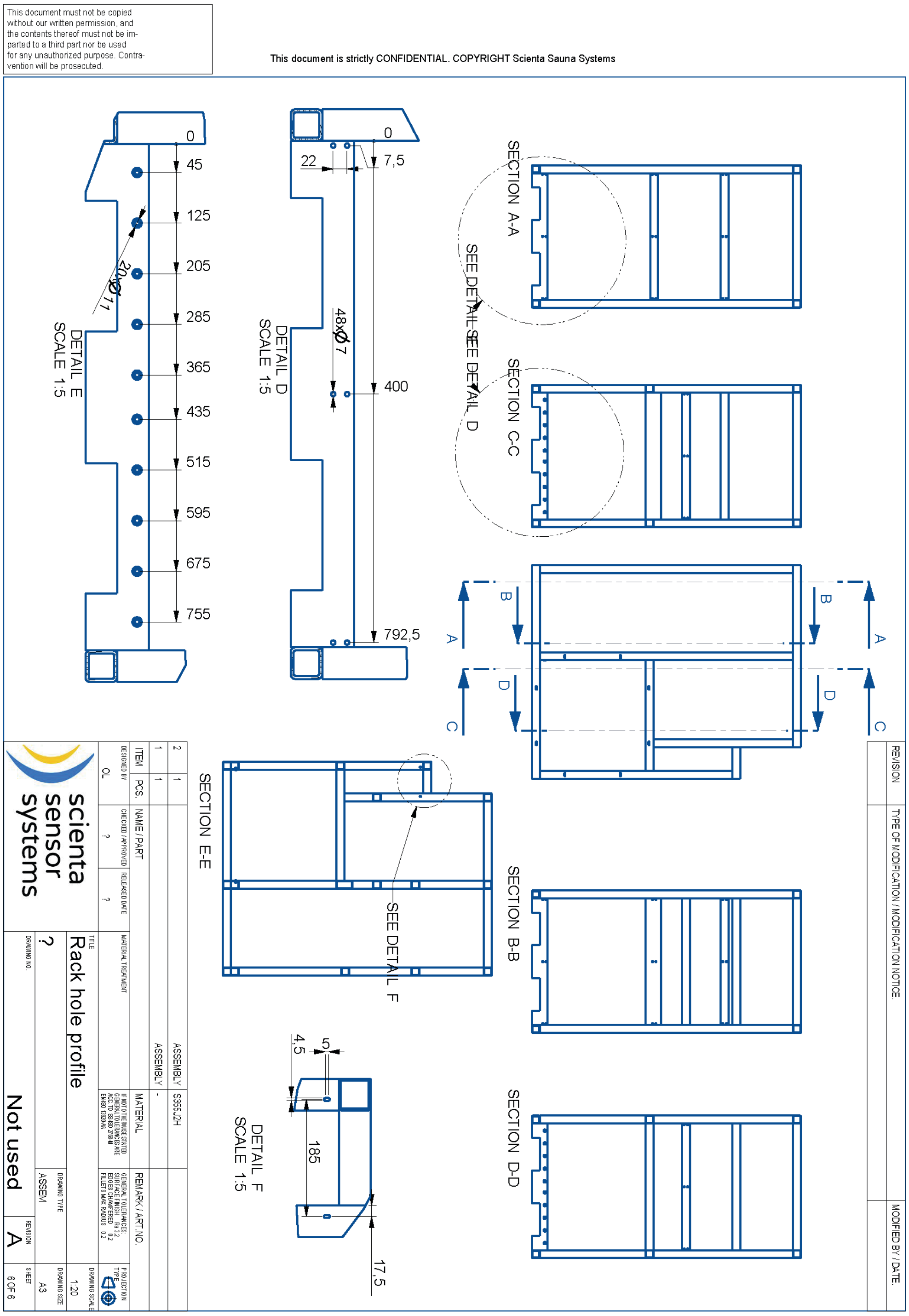
MATERIAL TREATMENT
scienta sensor systems
TITLE
Rack Bottom
?
DRAWING NO.
Not used
DRAWING TYPE
ASSEM
REVISION
A
DRAWING SCALE
1:10
DRAWING SIZE
A3
SHEET
5 OF 6



References

Aldener, M., & Fritioff, T. (2018). *Upgrade and Further Developments of SAUNA Field Report 2- Definition of infrastructure requirements.* FOI.

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