

## UPGRADE OF THE JET KN3 GAMMA-RAY CAMERAS DIAGNOSTICS

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### **1.1. Overview**

The main research topics for 2009 year have been organized in three milestones with strong experimental relevance:

13. KN3-NA Test Stand (non-nuclear option) detailed design
14. KN3-NA Manufacture of the main components
15. KN3-NA Assembly and test stand manufacture

The main aim of the first milestone of the project is to provide a detailed design for the KN3-NA test stand (non nuclear option) which replicates on a 1/1 scale the JET installation configuration for neutron attenuators. The KN3-NA test stand will be used for the in-house (non-nuclear) tests: mechanical, electrical, hydraulic and pneumatic tests. The main components of the KN3-NA test stand are the following: horizontal camera neutron attenuator frame, vertical camera neutron attenuator support, and steering and control system.

The following activities have been carried out for this milestone of the KN3-NA project:

- conceptual design of the KN3-NA test stand (non –nuclear option)
- analysis and evaluation of the conceptual design within a JET technical meeting
- detailed design of KN3-NA test stand
- test procedure for KN3-NA test stand

The components above mentioned are settled on a mechanic structure with the purpose to simulate the same dimensions like JET tokamak.

Within the second milestone all the main components of the neutron attenuator assembly (attenuator casings, attenuator support frames and steering and control system) for the KN3 gamma-ray cameras (KN3-NA) have been manufactured.

The manufacturing has been carried out in accordance with the KN3-NA Quality Plan. The preliminary tests have shown that the main components satisfy the mechanical design specifications.

The main aim of the third milestone was to assemble all components of the KN3-NA on the test stand the entire assembly reproducing at 1/1 scale the JET installation configuration for neutron attenuators.

### **Publications**

[1] V. Zoita, M. Anghel, T. Craciunescu, M. Curuia, T. Edlington, M. Gherendi, V. Kiptily, K. Kneupner, I. Lengar, A. Murari, A. Pantea, P. Prior, S. Soare, S. Sanders, B. Syme, I. Tiseanu "Upgrade of the JET gamma-ray camera" Fusion Engineering and Design vol. 84, issue 7-11, pages 2052-2057, published June 2009

[2] M. Curuia, M. Anghel, P. Blanchard, T. Craciunescu, T. Edlington, M. Gherendi, V. Kiptily, K. Kneupner, I. Lengar, A. Murari, A. Pantea, P. Prior, S. Soare, S. Sanders, B. Syme, I. Tiseanu V. Zoita "Fast neutron filters for the JET upgraded gamma-ray cameras" Progress in Cryogenics and Isotope Separation 28-30 Oct 2009 Calimanesti Caciulata Romania

[3] M. Curuia, V. Zoita, S. Soare, M. Anghel, P. Blanchard, T. Craciunescu, T. Edlington, M. Gherendi, V. Kiptily, K. Kneupner, I. Lengar, A. Murari, P. Prior, S. Sanders, B. Syme, I. Tiseanu, "Upgrade of the JET gamma-ray camera" Zilele Asociatiei Euratom -MEDC, Bucuresti 26-27 Noiembrie 2009

[4] V. Zoita, T. Craciunescu, M. Curuia, M. Gherendi, S. Soare, M. Anghel, P. Blanchard, T. Edlington, V. Kiptily, K. Kneupner, I. Lengar, A. Murari, P. Prior, S. Sanders, B. Syme, I. Tiseanu, "Nuclear techniques for fusion plasma measurements on the JET Tokamak" Progress in Cryogenics and Isotope Separation 28-30 Oct 2009 Calimanesti Caciulata Romania

## 1.2. Detailed results

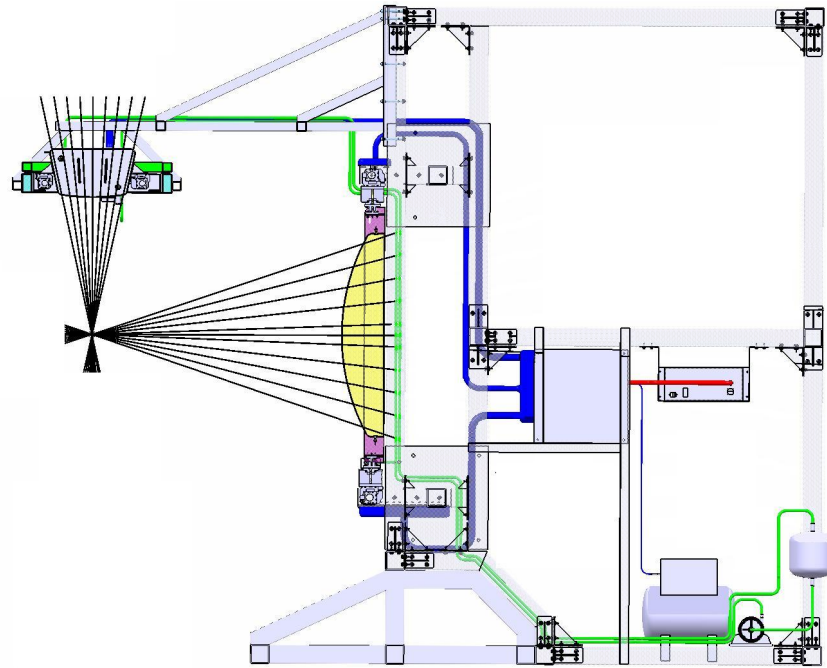
### 1.2.1. KN3-NA Test Stand (non-nuclear option) detailed design

Taking into account the brief overview given in Chapter 1.1, the GRC\_KN3\_NA project is rather complex in terms of assembling and testing. Therefore, a full system operation must be conducted to insure a proper operation. The main check points of the tests are:

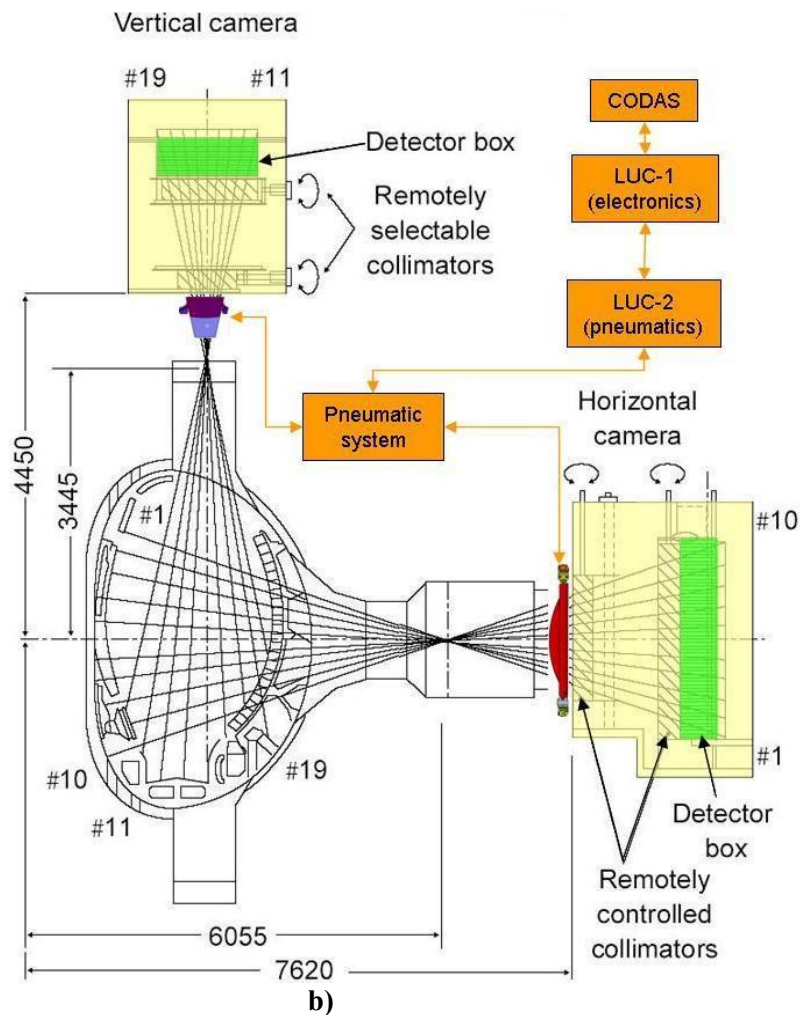
- Leak test (pure water and air circuits). There are two closed water circuits, one for each neutron attenuator, independently operated although served by one pump that provides 5 bar of pressure. This involves up to 15 connections (valves, pressure gauge, up to 25 m of hoses, junctions). The actuators are driven by compressed air (5-7 bars). There are two sets of actuators, one for each neutron attenuator (linear actuators & linear and rotating actuators), that include up to 40 connections, junction, pressure gauge and up to 40 m of hoses.
- Synchronization and timing. The neutron attenuators are designed to work either together or independently. There are no synchronization requirements, although the attenuators will work together. The estimated time interval to complete the action is a couple of minutes. Cushions and silencer have to be adjusted for a smooth manoeuvre. Pneumatic Limit Switches (PLS) and blocking devices have to be finely tuned and their position adjusted.
- Remote command and control. The system can be operated either by a computer (via Ethernet) or locally. The PLC software monitors air pressure, end-stroke position, position time-out and blocking devices status. It also issues warnings for events such as air pressure drops and timing errors (parameters initially defined). Beside the routine actions, the system response will be monitored for malfunction-induced events such pressure loss, jamming, etc.
- Pure water. The KN3-NA will be connected at JET demineralised water system.

### KN3-NA Test Stand Non-nuclear option

The stand was designed to test the functionality of the whole system in terms of replicating [1] as much as possible the actual operating configuration, fig. 1. However, the design had to take into account other constraints as well as future tests. The non-nuclear tests have to be performed in-house, at the manufacturer's site. Other tests (especially the nuclear radiation test) have to be carried out elsewhere, at a site licensed to operate with intense neutron sources.



a)



b)

Figure 1  
 a) KN3-NA Test Stand b) Vertical cross-section of Octant 1 Actual configuration of the KN3-NA system (to be installed on the JET fusion reactor)

The complete KN3-NA Test Stand is shown in fig. 2 along with a side view, fig. 2. The main components of the whole system are:

- Electro-pneumatic circuit (water pump, water tank, neutron attenuators, hoses, fittings, connectors and valves)
- Air circuit (air compressor, actuators, pneumatic limit switches, blocking devices, electro-pneumatic cubicle, fittings and connectors)
- Control unit (programmable logic controller and electrical connection to electro-pneumatic cubicle)
- HC and VC frames, HC lower support frame.

The draft below shows the detectors lines of sight and the overall dimensions of the whole setup.

**Conclusions**

The test stand is an exact replica of the KN3 HC and partially replicates KS3 optical box and will be used for all in-house tests (mechanical, electrical, pneumatic and hydraulic).

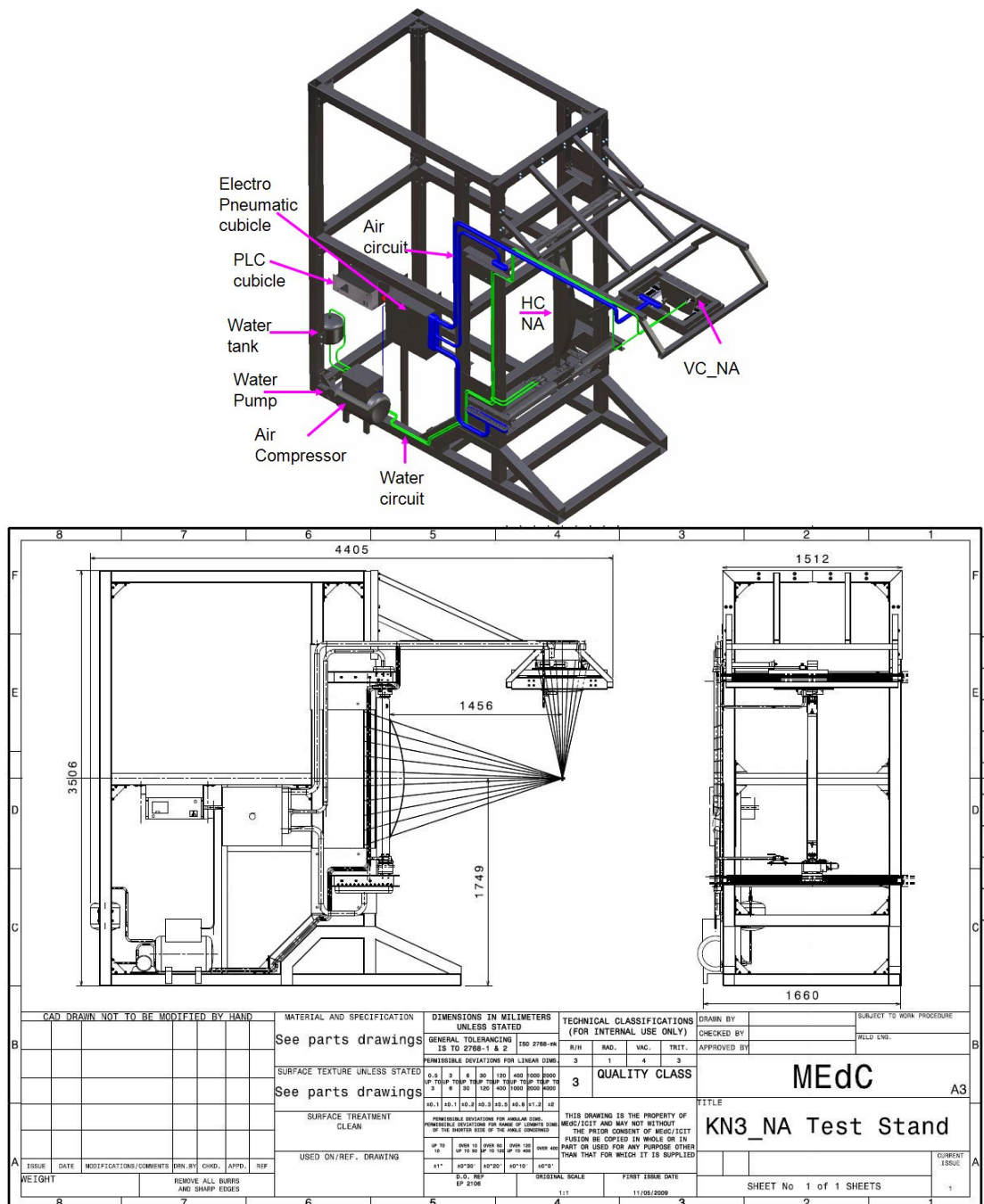


Figure 2 KN3-NA Test Stand 3D CATIA model; drafting

## Reference

[1] M. Curuia, M. Anghel, P. Blanchard, T. Craciunescu, T. Edlington, M. Gherendi, V. Kiptily, K. Kneupner, I. Lengar, A. Murari, A. Pantea P. Prior, S. Soare, S. Sanders, B. Syme, I. Tiseanu V. Zoita "Fast neutron filters for the JET upgraded gamma-ray cameras" Progress in Cryogenics and Isotope Separation 28-30 Oct 2009 Calimanesti Caciulata Romania

## 1.2.2. KN3-NA Manufacture of the main components

### 1.2.2.1 Manufacture of the KN3-NA casings

The material used for the neutron attenuator casings was INCONEL 600 sheet 3mm thick, cut to the required geometry, bent and welded. The final objects were assembled by long, continuous weld and thus being leaked tight.

The casings (fig. 3) were produced at the Titan Nuclear Equipment (TEN), Bucharest, Romania, according to the ICIT (overall) Quality Plan and TEN Quality Plan, checked and approved by the Romanian National Commission for Control of Nuclear Activity (CNCAN) [1].

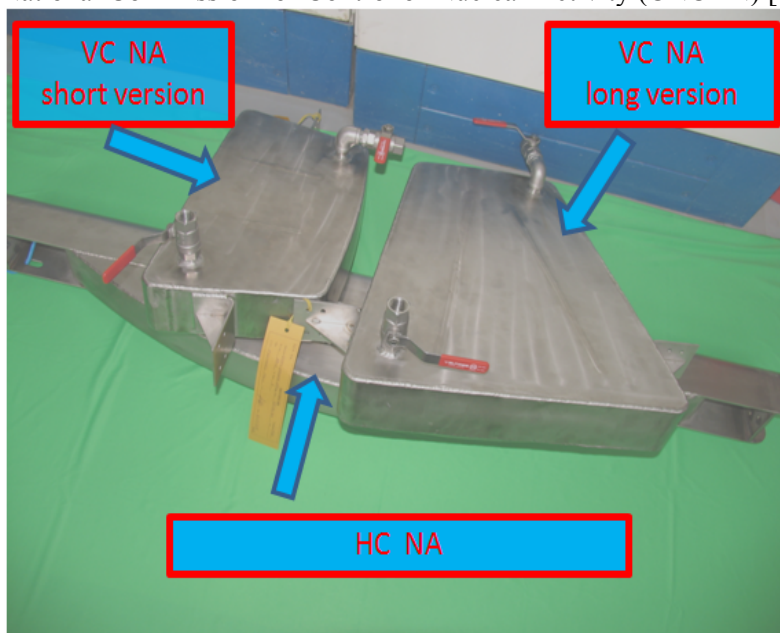


Figure 3 Attenuator casings

VC NA: Vertical camera neutron attenuator  
 HC NA: Horizontal camera neutron attenuator

### 1.2.2.2 Manufacture of the KN3-NA support frames

The support frames for both horizontal camera neutron attenuator and vertical camera neutron attenuators are presented in fig.4.

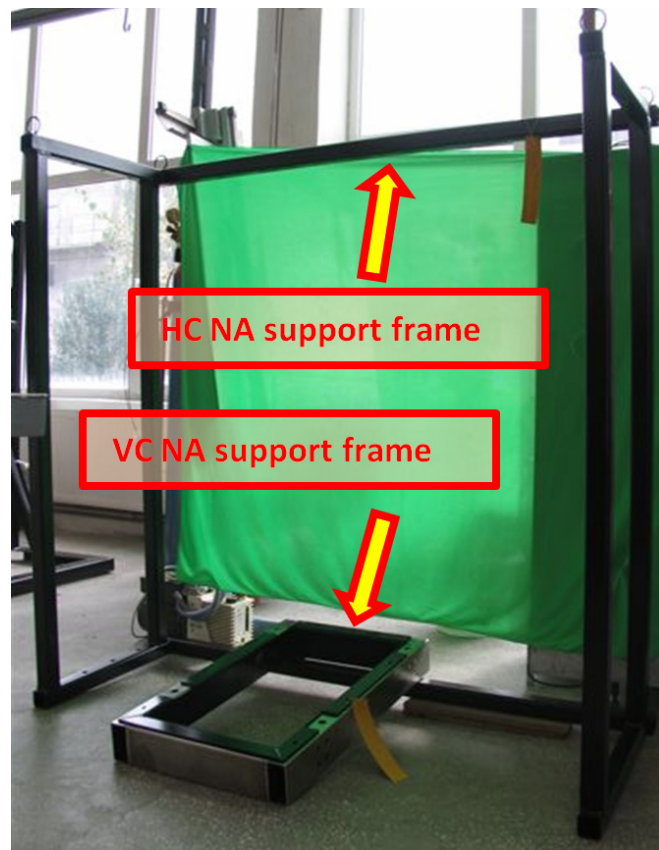


Figure 4 Support frames

VC NA: Vertical camera neutron attenuator HC NA: Horizontal camera neutron attenuator

### 1.2.2.3 Manufacture of the KN3-NA Steering and Control System

In fig. 5 are presented the components of the steering and control system:

- Two linear drives DGPL 40, 1500 mm stroke, for horizontal camera neutron attenuator, both equipped with clamping unit;
- Two rotating drives DGPL 40, 90°, for horizontal camera neutron attenuator;
- Two linear drives DGPL 32, 130 mm stroke, for vertical camera neutron attenuator, one being equipped with clamping unit;
- PLC Cubicle/Case in a standard rack 19'4U;
- EP Cubicle in an industrial RITTAL case;
- PLC-EP 50m/32 wires cable

All these components were manufactured by Festo.

The Programmable Logic Controller (PLC) together with the power supply, the main switch, the emergency stop switch, the main fuse, the push-buttons are placed into a standard 19"x4U rack case (fig.5). The electrical connection between PLC Cubicle and Electro-Pneumatic Cubicle was done using two 32 ways plug-in cable connectors and 50m/32 wires automation cable.

All the pneumatic components are placed into a 500x500x210 (mm) RITTAL industrial case. The air pressure is measured by means a manometer placed on the front panel of the cubicle.

The pneumatic linear drives are to be fixed either on the jig (Vertical Camera) or on the mounting frame (Horizontal Camera). To lock the attenuator casings into working/parking locations are used clamping units (for linear drives) or compact cylinder for rotating drive. The pneumatic limit switches will be fixed by means of "L" shape elements and captive nuts on the linear drive.

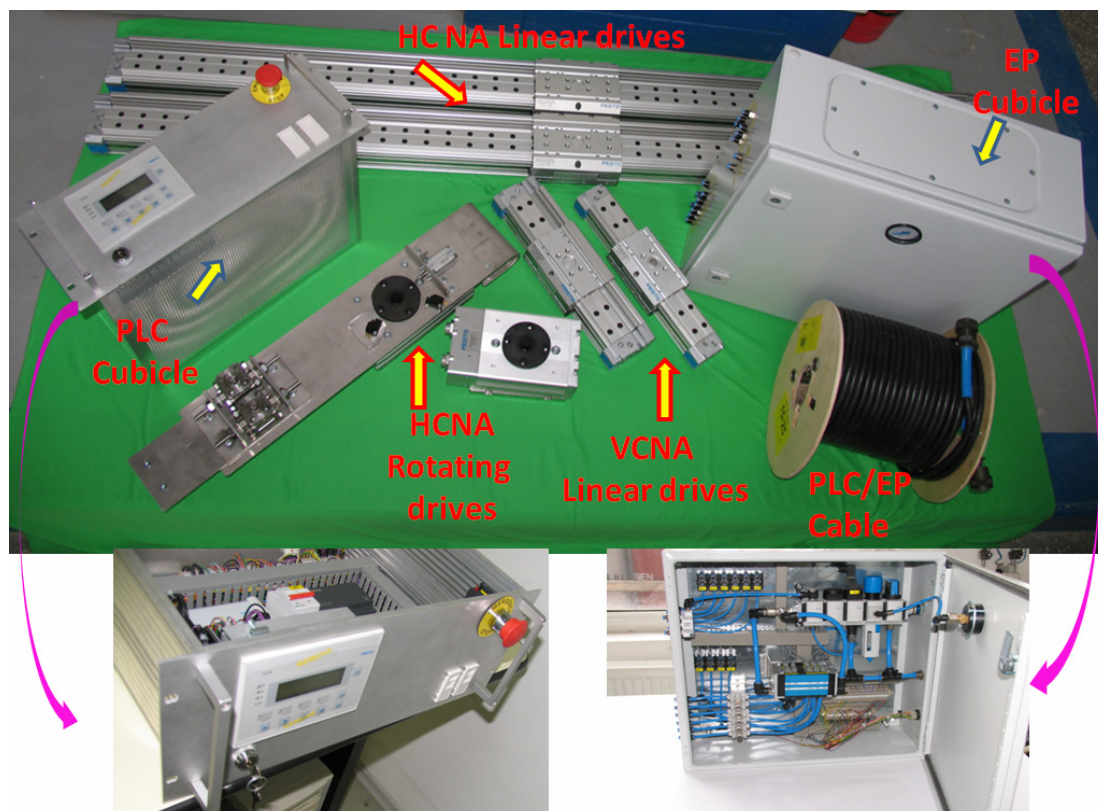


Figure 5 Steering and control system

## Conclusions

In accordance with the Quality Plan all manufactured components went through a dimensionality check and a series of tests (hydrostatic pressure test, penetrating liquid test and helium leak test, were applied. The results have shown that all the main KN3-NA components have met the specified requirements [1]. All testing reports are stored in the History File of the KN3-NA documentation archive.

## Reference

[1] M. Curuia, M. Anghel, P. Blanchard, T. Edlington, V. Kiptily, K. Kneupner, P. Prior, S. Sanders, S. Soare, V. Zoita Manufacture of the KN3-NA main components, Report October 2010

### 1.2.3 KN3-NA Assembly and test stand manufacture

#### 1.2.3.1 Manufacture of the KN3-NA Test Stand

KN3-NA Test Stand consists of three main parts:

- Horizontal Camera test stand frame
- Vertical Camera test stand frame
- Steering and control system

Horizontal Camera test stand frame is made by rectangular steel beams EN8, 100 X 100 X 5 mm, with different lengths. The structure is bolted (by M10x20 screws) and strengthened, at corners, with welded reinforcements. The lower support, which is a welded structure based on rectangular beams 100x100x5 mm, support provides balance for the whole system.

Vertical Camera test stand frame is made by rectangular steel beam EN8, 50x50x3 mm, bolted onto the HC by seven pairs of M12x24 screws and L-shaped steel profile EN8, 100x50x5 mm. The Vertical Camera neutron attenuator (with the KS3 middle frame replica) will be bolted to it.

The complete KN3-NA Test Stand is shown in fig. 6.



Figure 6 the manufactured KN3-NA Test Stand

### 1.2.3.2 Manufacture of the KN3-NA Assembly

KN3-NA system consists of three main parts: KN3-NA for horizontal camera (HC NA) assembly, KN3-NA for vertical camera assembly (VC NA) and steering and control system [1].

The horizontal camera neutron attenuator, fig. 7, functions as a neutron filter when is in working position (in the plane determined by the gamma-ray detectors lines of sight). To move the attenuator casing in and out the detector line of sight a steering and control system is used. The structure of the steering and control system is the same both for HC NA and VC NA assembly.

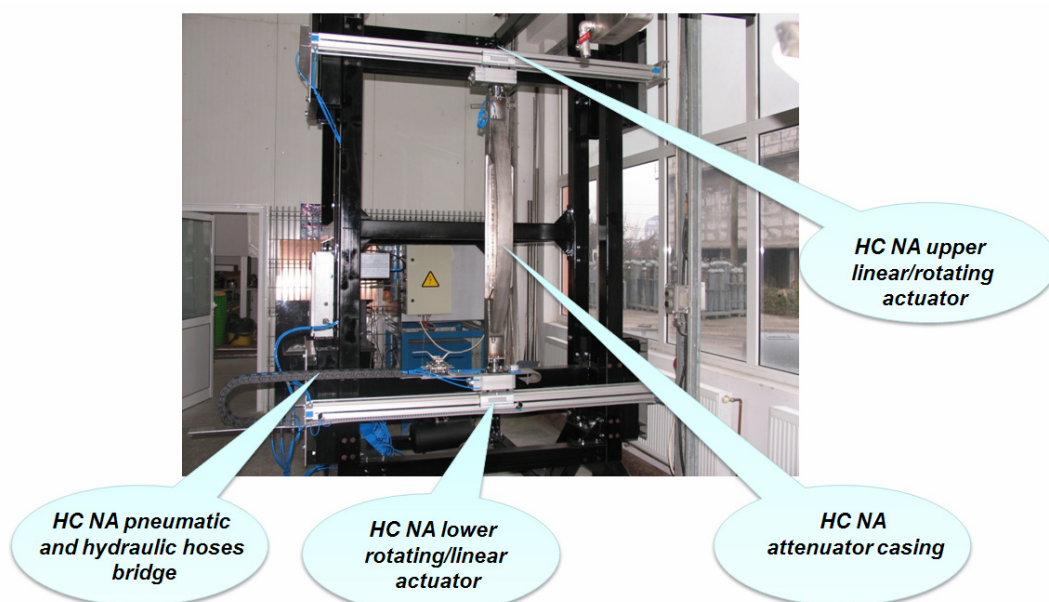


Figure 7 KN3-NA horizontal camera installed

A pneumatic system consisting of two linear and two rotating actuator is used to move the attenuator casing between the two fixed positions: working and parking positions. The components required for actuators command: flow control valves, pneumatic-electric convertors and block valves are placed into a cubical (called Electro-Pneumatic Cubicle). Between pneumatic system and (Electro-pneumatic Cubicle) there are 25 m pneumatic hoses. The electrical parts are placed into a 19" 4U rack cubicle (called PLC Cubicle). Between PLC Cubicle and Electro-Pneumatic Cubicle is a 50 m length electrical connection. The pneumatic part is supplied with pressurized air by means an air compressor. In fig. 7 is presented the installed HC NA.



The vertical camera neutron attenuator (VC NA) is also mounted on the KN3-NA Test Stand by means of the KS3 middle frame replica. To move in and out of the working location (100 mm translation) a steering and control electro-pneumatic system is used. Pneumatic linear drives perform the required action while pneumatic limit switches confirm their completion. The pneumatics is fed from the pressurized air compressor. KN3-NA vertical camera assembly is shown in fig. 8.

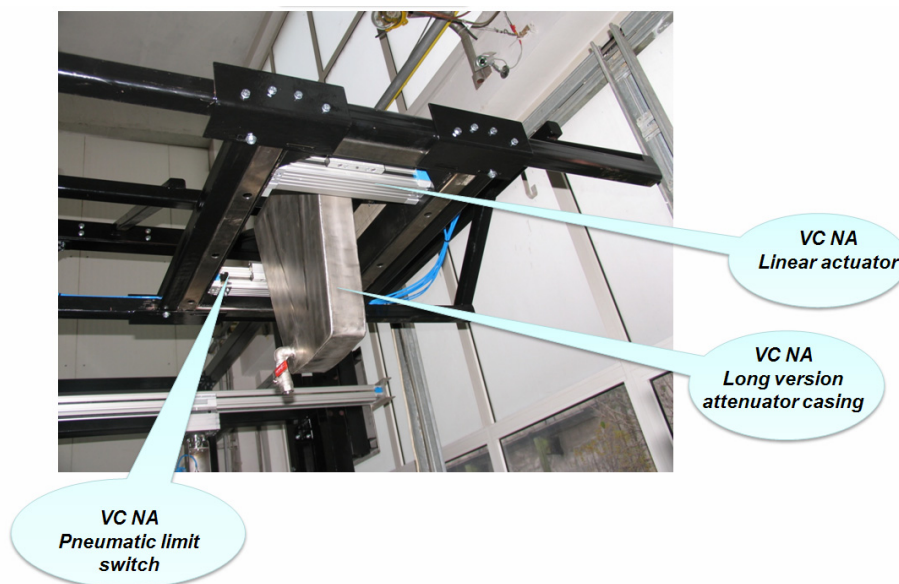


Figure 8 KN3-NA Vertical Camera assembled

In the fig. 9 are presented PLC Cubicle and Electro-Pneumatic Cubicle, main parts of the steering and control system.

The Programmable Logic Controller (PLC) together with the power supply, the main switch, the emergency stop switch, the main fuse, the push-buttons are placed into a standard 19”x4U rack case called LUC-1/PLC Cubicle. The electrical connection between PLC Cubicle and Electro-Pneumatic Cubicle was done using two 32 ways plug-in cable connectors and 50m/32 wires automation cable.

All the pneumatic components are placed into a 500x500x210 (mm) RITTAL industrial case, called LUC-2/Electro-Pneumatic Cubicle.

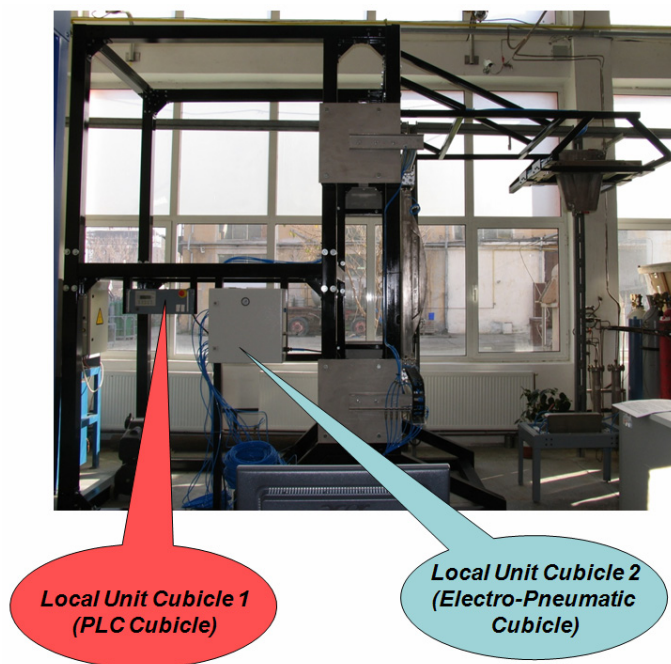


Figure 9 KN3-NA Assembly general views.

## Conclusions

All the components of the KN3-NA assembly have been manufactured and installed on test stand. The test stand is an exact replica of the KN3 horizontal camera neutron attenuator assembly and partially replicates the installation configuration for the KN3 vertical attenuator installation configuration (inside the KS3 optical diagnostics box). Using the KN3-NA Test Stand as an installation structure and the main components previously manufactured the whole KN3-NA system was assembled. All in-house tests (mechanical, electrical, pneumatic and hydraulic) will be done using KN3-NA test stand.

## Acknowledgements

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## Reference

- [1] M. Curuia, V. Zoita, S. Soare, M. Anghel, P. Blanchard, T. Craciunescu, T. Edlington, M. Gherendi, V. Kiptily, K. Kneupner, I. Lengar, A. Murari, P. Prior, S. Sanders, B. Syme, I. Tiseanu, "Upgrade of the JET gamma-ray camera" Zilele Asociatiei Euratom –MEDC, Bucuresti 26-27 Noiembrie 2009