FRAMATOME ANP

Ref. (Department/Year/Language/Serial No.) Rev.

Intermediate Report

NGPS3/2003/en/0005

Subject/Title
Continuous horizontal hot gas duct
Detailed design for GM-HTR reactor design

Place	Date
Erlangen	2003-02-25

Prepared by	Department	Tel.	Signature
D. Vanvor	NGPS3	94380	gez. Vanvor

Reviewed by

Project

HTR-E

Handling Instructions

restricted

Export Classification (Reports with techn. content)

AL: ECCN:

Dr. Brinkmann	Dr. Brinkmann
gez. Brinkmann	gez. Brinkmann
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Proj.-Code	UA	DCC	Contents Code	Doc. Ident. No.
ZFY116	BE		1123, 1435, 1436	**0600191597**

Summary

Pages of Text: 5 Appendices 6 Pages total: 11

This report serves as information for the members of WP1 of the HTR-E (EC Project: FIKI-CT-2001-00177) and is intended as an input for the SINTER network. It is the contribution of Framatom ANP GmbH to Deliverable 7b of the HTR-E.

The information is especially needed for the FEM-analysis for the hot gas duct to be prfotmed by EMPRESARIOS AGRUPADOS (EA), Mr. Arturo Buenaventura Pouyfaucon.

Distribution

Dr. Brinkmann, NGPS3
Mr. Ebert, NGPS3
Members of WP1 of HTR-E
Mr. Ballot, TH, f.i.o.
Mr. Bogusch, RGR, f.i.o.
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List of revisions

Rev.	Date	Scope of revision	Section/Page
0	2003-02-25	First issue	All

Table of Contents

1 Introduction

This report describes the design for a continuous horizontal hot gas duct in detail. The design is based on the data from Mr. Alain Gerber from NFEVES (see attachment 1) for the hot gas duct for the GT-MHR reactor design.

The continuous horizontal hot gas duct is split in several sections. Each normal section is 1620 mm long. For connecting to the upper core structure or the helium turbine inlet we need shorter sections, but for the FEM-analyses made by EA the longest section should by calculate.

In the attachments 3 to 5 the detailed construction for the continuous hot gas duct is shown.

2 Normal working conditions

Normal working conditions are fixed by NFEVES (see attachment 1). Therefore we have the following data:

Hot gas side:

Helium inlet temperature:	850 °C
Helium outlet temperature:	848,4 °C
Helium pressure:	70,8 bar
Helium mass flow:	316,19 kg/s

Cold gas side:

Helium inlet temperature:	487,9 °C
Helium outlet temperature:	487,8 °C
Helium pressure:	71,6 bar
Helium mass flow:	318,2 kg/s

3 Materials

The materials chosen are specified in our e-mail dated 13. January 2003 (see attachment 2).

For the fibre insulation you must calculate with a thermal conductivity of 0.55 W/mK at the temperature of 850 °C.

4 Special data

In completion we specified following data:

- Each insulation fibre area is filled with 90 Vol% helium.
- The shown depressurisation gaps in the positions 1, 5 and 6 are only pre designed. This design must be confirmed by the FEM-calculations.
- The shown depressurisation gap between position 5 / 6 and 7 (15 mm) and the ring outlet inside the liner (100 mm) are only pre designed. This design must be confirmed by the FEM-calculations.

VANVOR Dieter NGES3

Von: GERBER Alain NFEVES
Gesendet: Montag, 10. Februar 2003 17:23
An: Arturo Buenaventura Pouyfaucon (E-mail)
Cc: VANVOR Dieter NGES3; Laurent BRIOTTET (E-mail); BREUIL Eric NFEVEI; HAMY Jean Marie NFEVEK
Betreff: GT-MHR : nominal working conditions

Dear Arturo,
In your E-mail to M. Vanvor dated January the 9th about "HTR-E, WP1, Task D7b, Hot gas duct", you ask nominal working conditions data. These are the following (GT-MHR data) :

1 - NOMINAL OPERATING CONDITIONS

Hot gas size :

Helium inlet temperature : 850°C (= core outlet)
Helium outlet temperature : 848,4°C (=turbine inlet)
Helium pressure : 7,08 MPa
Helium mass flow : 316,19 kg/s

Cold gas side :

Helium inlet temperature : 487,9°C (=recuperator outlet)
Helium outlet temperature : 487,8°C (=core inlet)
Helium pressure : 7,16 MPa
Helium mass flow : 318,2 kg/s

2 - NORMAL OPERATION, LOAD CYCLING

The reactor load can be decreased from 100% to 30% (and inversely) at two load changes levels :
- low load change : 0,6% per minute
- rapid load change : within the range of 6% to 10% per minute.

- At 0,6% per minute, on both hot and cold gas sides :
  * Transient induced temperatures variations are not significant.
  * Transient induced pressure variations is about 0.042MPa per minute
  * Transient induced flowrate variations is 1,9 kg/s per minute

- We have performed some calculations in the past concerning load change from 100% to 30% at 10% load change level. It can be retained in a conservative approach :
  * Outlet core temperature is regulated, so there is no variation of hot gas side temperatures
  * Cold gas side temperature variation is -9K per minute at transient beginning, +1,14 K per minute at end.
  * For both hot and cold gas sides, transient induced flowrate variation is -12,23 kg/s per minute in transient beginning, then -1,74 kg/s per minute at the end.

- No data available for 30% to 100% transient, our fisrt calculations are not correct (code problems). Moreover it depends of Helium Service System capacity to fill the helium inventory. In a first approach, inverse data of transient from 100% to 30% should be retained.

3 - GEOMETRICAL DATA
- Cold gas duct inner diameter : 2300 mm
- Hot gas duct outer diameter : 1700 mm
- Hot gas duct inner diameter : 1450 mm
- Hot gas duct wall thickness : 25 mm

4 - NEXT DATA
As promised in the november meeting in Juelich, we will produce envelope operation data for transient conditions in March 2003.

****
FRAMATOME-ANP PVES
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E-mail : alain.gerber@framatome-anp.com
****

Attachment 2-1

VANVOR Dieter NGES3

Von: VANVOR Dieter NGES3
Gesendet: Montag, 13. Januar 2003 14:44
An: 'abp@empre.es'
Cc: BREUIL Eric NFEVEI; 'laurent.briottet@cea.fr'; BRINKMANN Gerd NGES3
Betreff: AW: HTR-E, WP1, Task D7b, Hot Gas Duct

Dear Arturo Buenaventura,

To your E-Mail we take position as follows:

Objective and scope of the analysis
We need a FEM analysis of all construction units of the hot gas duct. This meens for detail:

- for the liner and the perforated pipe with a boil pressure of about 10 bars at 900 °C
- for the Vee-shaped spacers for a temperature differenz of about 600 K
- for the support pipe for a boil pressure af about 10 bars at 540 °C

But this data must be spezifide by NFEVEI!

Detailed geometry of the Hot Gas Duct:
This data and design specifications have to be fixed bei NFEVEI !

Materials:
Metal alloy 1.4876 for the liner, perforated pipe and the hot side of the vee-shaped sacer
Basis for the material parameters are the standards indicated according to German "Stahlschlüssel, 2001). In this steel key as basis standard the EN 1009-1 indicates. In Germany also the material sheet SEW 470 is permissible.

The material is classified as follows:
1.4876 X10NiCrAlTi32-21 / X10NiCrAlTi32-20
in USA: Type B 163, UNS No. N 08800 or N 08810 (AISI/SAE)
France: AFNOR Z 10 NC 32-21
Spain: UNE F.3314 - X 10 NiCrAlTi 32-20
GB: B.S. NA 15 (XH)
Japan: JIS NCF 800 (TP)

Metal alloy 1.4571 for the cold side of the vee-shaped spacer an the support pipe
Basis for the material parameters are the standards indicated according to German "Stahlschlüssel, 2001). In this steel key as basis standard the EN 10028-7 and EN 10088-1 one indicates.

The material is classified as follows:
1.4471 X6CrNiMoTi17-12-2
in USA: Type 316TI, UNS No. S 31635 (AISI/SAE)
France: AFNOR Z 6 CNDT 17-12
Spain: UNE F.3535 - X 6 CrNiMoTi 17 12 2
GB: B.S. 320 S 31
Japan: JIS SUS 316 Ti

The boundary conditions and Nominal working conditions:
This data and design specifications have to be fixed bei NFEVEI !

Best regards

==========

-----Ursprüngliche Nachricht-----
Von: Arturo Buenaventura Pouyfaucon [mailto:abp@empre.es]
Gesendet am: Donnerstag, 9. Januar 2003 18:08

Attachment 2-2

An: VANVOR Dieter NGES3; BREUIL Eric NFEVEI
Cc: 'Briottet Laurent (E-mail)'; Alfredo Orden (E-mail); Maite Dominguez (E-mail)
Betreff: HTR-E, WP1, Task D7b, Hot Gas Duct

Ref: 092-110-CE-EA-SV-03/0001

Dear Mr Vanvor,

As discussed during last HTR-E Meeting held in FZJ (Nov. 2002), we will carry out the themo-mechanical analysis of the horizontal Hot Gas Duct between the reactor and the PCU.

We are willing to start working as soon as possible, so we request from you the required input data for the analysis:

Objective and scope of the analysis (different types of analysis you require us to perform, results you need, etc..)
Detailed geometry of the Hot Gas Duct (Diameter, etc..)
Materials (if German reference, the equivalence or directly the list of characteristics)
The boundary conditions (fixing of reactor side and PCU side Hot Gas Duct extremities)
Nominal working conditions

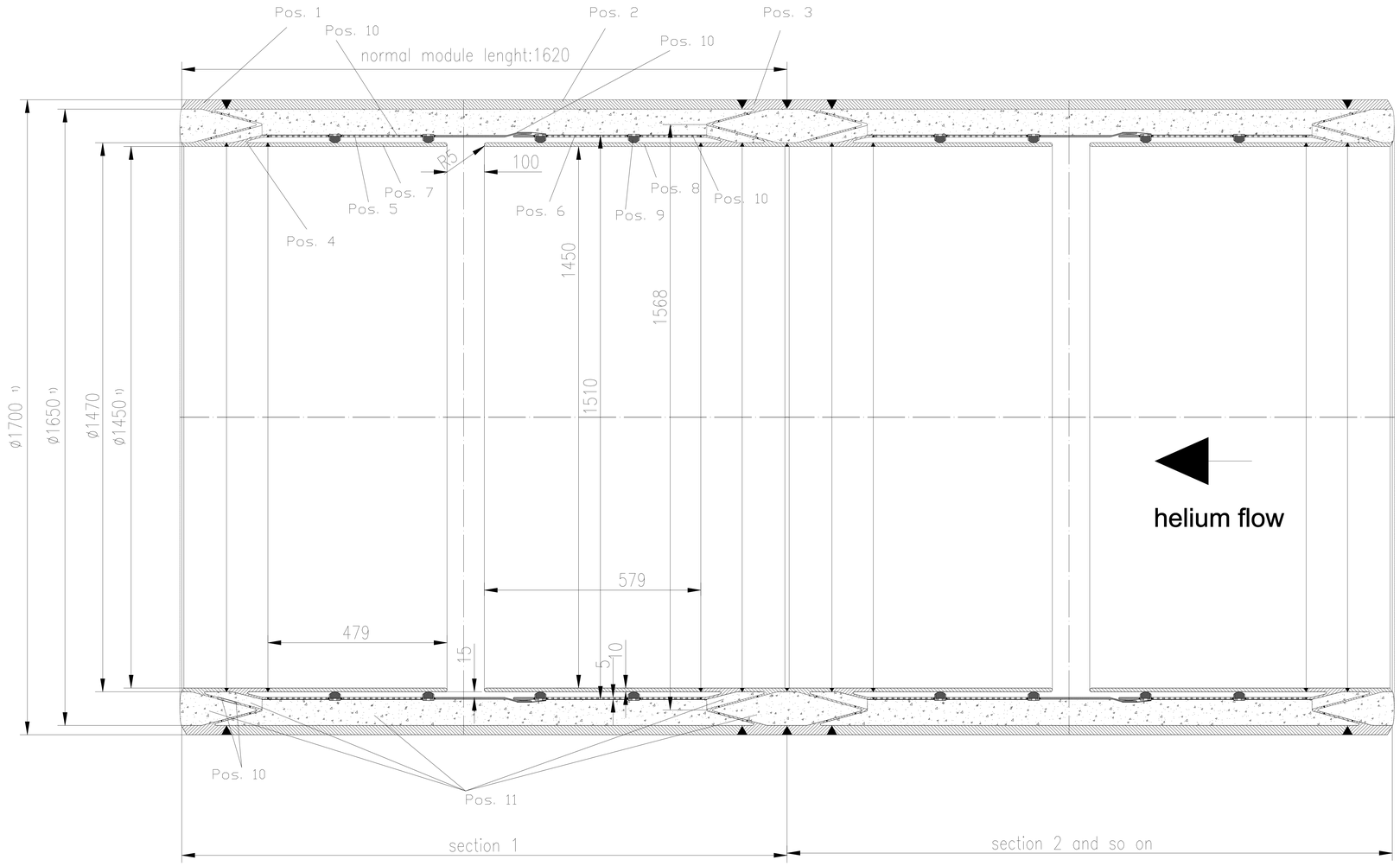
We are aiming to have the FE Model and calculations for nominal working conditions by March 2003.

Best regards,

Arturo Buenaventura
Empresarios Agrupados
Mechanical Department
Tf: +34 91 309 80 00
Fax: +34 91 591 26 55

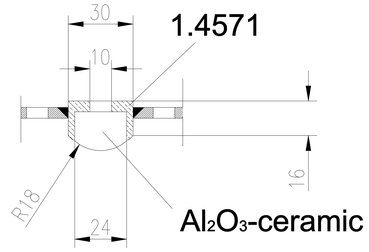
25.02.03

Continuous horizontal hot gas duct
vertical cross section, scale 1:5

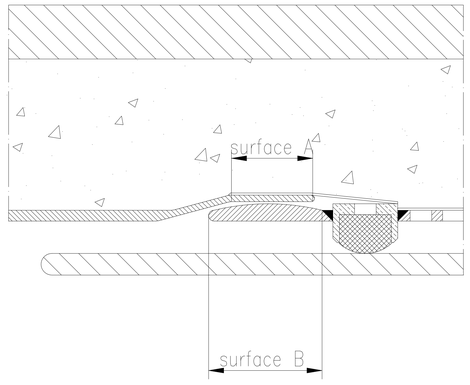


1) Basis Data:
Basis Date from E-Mail from 10. february 2003,
Alain Gerber, NFEVES
"GT-MHR: normal working conditions"

Pos. 9, scale 1:1



Detail: sliding system, scale 1:1



Coating for surface A and B:

dublex coating as NiCrAlY and $ZrO_2 + Y_2O_3$

ground surface with R_t= 50 µm,
NiCrAlY with 78,4/16,4/5,1 and 0,15 %
coating thickness 140 µm

cover coating as $ZrO_2 + Y_2O_3$, with >13 % Y_2O_3
ground surface with R_t= 25 - 50 µm
coating thickness 80 µm

--	fibre insulation	--	Al2O3	P 11	--
--	mesh cover	--	1.4876	P 10	--
64	ceramic spacer	ø30	--	P 9	see detail
1	liner	ø1450; th:10	1.4876	P 8	--
1	liner	ø1450; th:10	1.4876	P 7	--
1	perforated pipe	ø1510; th:5	1.4876	P 6	--
1	perforated pipe	ø1510; th:5	1.4876	P 5	--
2	depressurization spacer	ø1510; th:5	1.4876	P 4	see detail
1	Vee-shaped spacers	ø1700/ø1450; L:120	1.4876	P 3	see detail
1	support pipe	ø1700; Th: 25	1.4571	P 2	--
1	Vee-shaped spacers	ø1700/ø1450; L:120	1.4876	P 1	see detail

Sl. qt.	Benenng. Title	Fertig-/Abmessgs. Finished dim.	Norm-Nr./Zeichnl.-Nr. Stdrd.-No./Dwg.-No.	Werkstoff Material	LSE/Nr. Pos.	Bemerkungen Remarks

Ursprung/Original | Ursprung-Nr./Original-No. | Ursprr.-PKZ-Nr./Orig.-PC

Projekt/Project: HTR-E | PKZ/PC: ZFY116

	Datum Date	Name
gezeich. Drawn	24.02.03	Vanvor
Kontr. Check	24.02.03	Vanvor
gepr./f. Checked		
Abtlg. Dept.	NGPS3	

Maßstab Scale: 1 : 5 (1:1) | Le./ISO Type of Doc: AN39

Benennung/Title: Continuous Horizontal Hot Gas Duct
For GT-MHR Reactor Design
Deliverable 7b of WP1
Outline And Detail Drawing

Inhaltsverzeichnis Contents No.: OS1600

Dienststl./Dept.: NGPS3 | UNID: 0600191634

Zykl.-Nr./Pkg.No.: -- | Index/Rev.: -- | Version: --

FRAMATOME ANP

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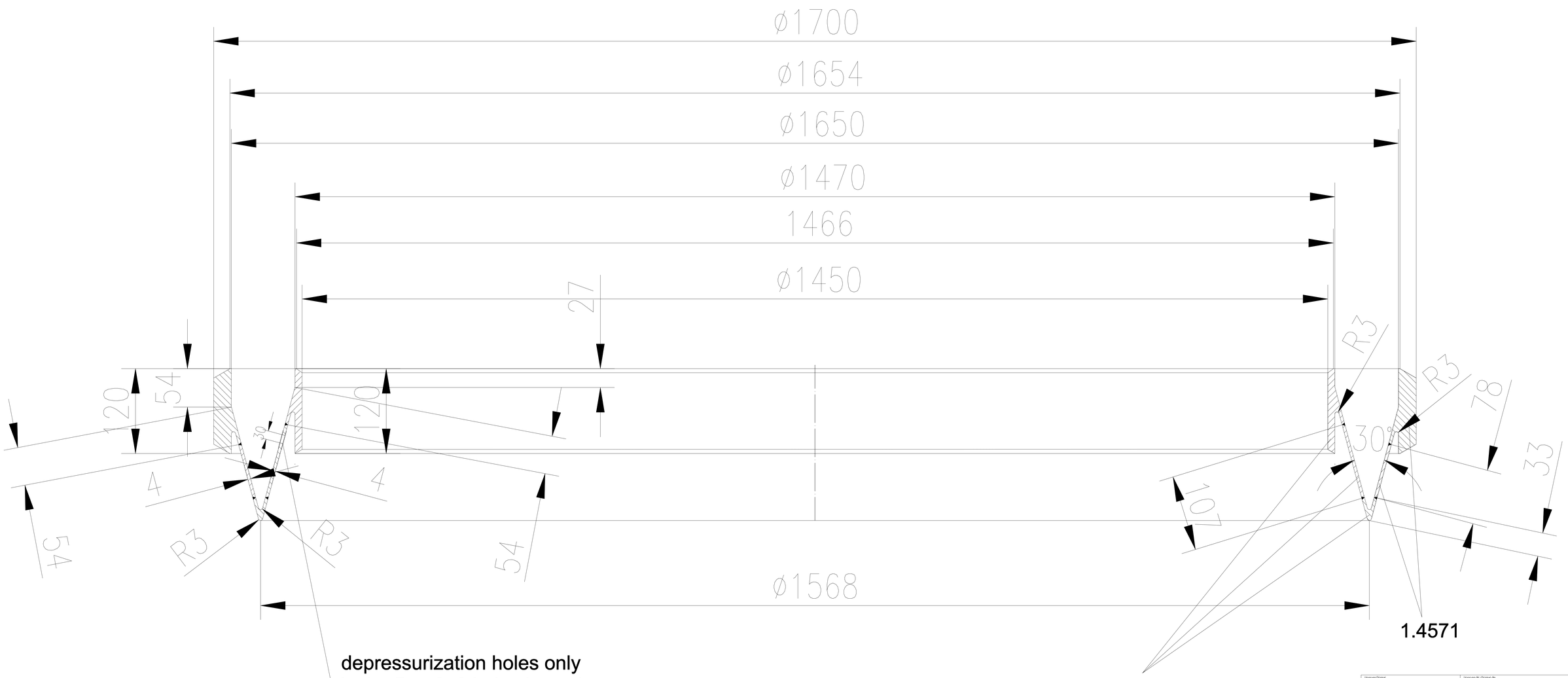
Pos. 1
scale 1:2

Pos. 3:
manufatured in a reflected image



depressurization holes only
in the Pos.3, 6 holes in each
vee-shaped spacer

Ursprung/Original			Ursprung-Nr./Original-Nr.		Ursprr.-PHZ-Nr./Orig.-PE
Projekt/Project			HTR-E		PHZ/PC ZFY116
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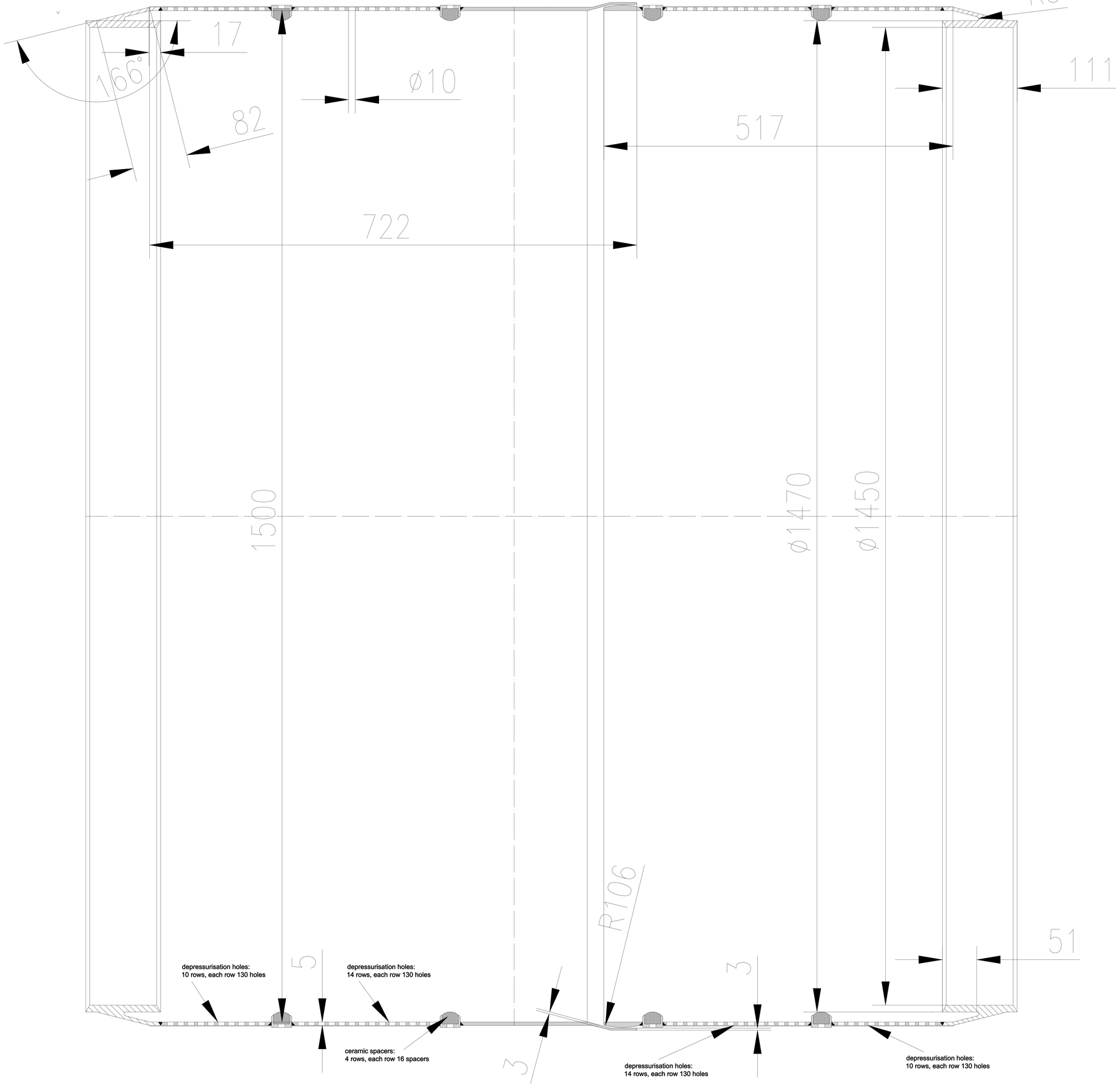

Pos. 4, 5, 6
scale 1:2

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Projekt/Project				PHZ/PC ZFY116
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gezeich./Drawn	24.02.03	Vanvor	Benennung/Title	Inhaltsverzeichnis/Contents-List OS1600
Kontr./Coord.	24.02.03	Vanvor	Continuous Horizontal Hot Gas Duct For GT-MHR Reactor Design Deliverable 7b of WP1 Detail Drawing	
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