

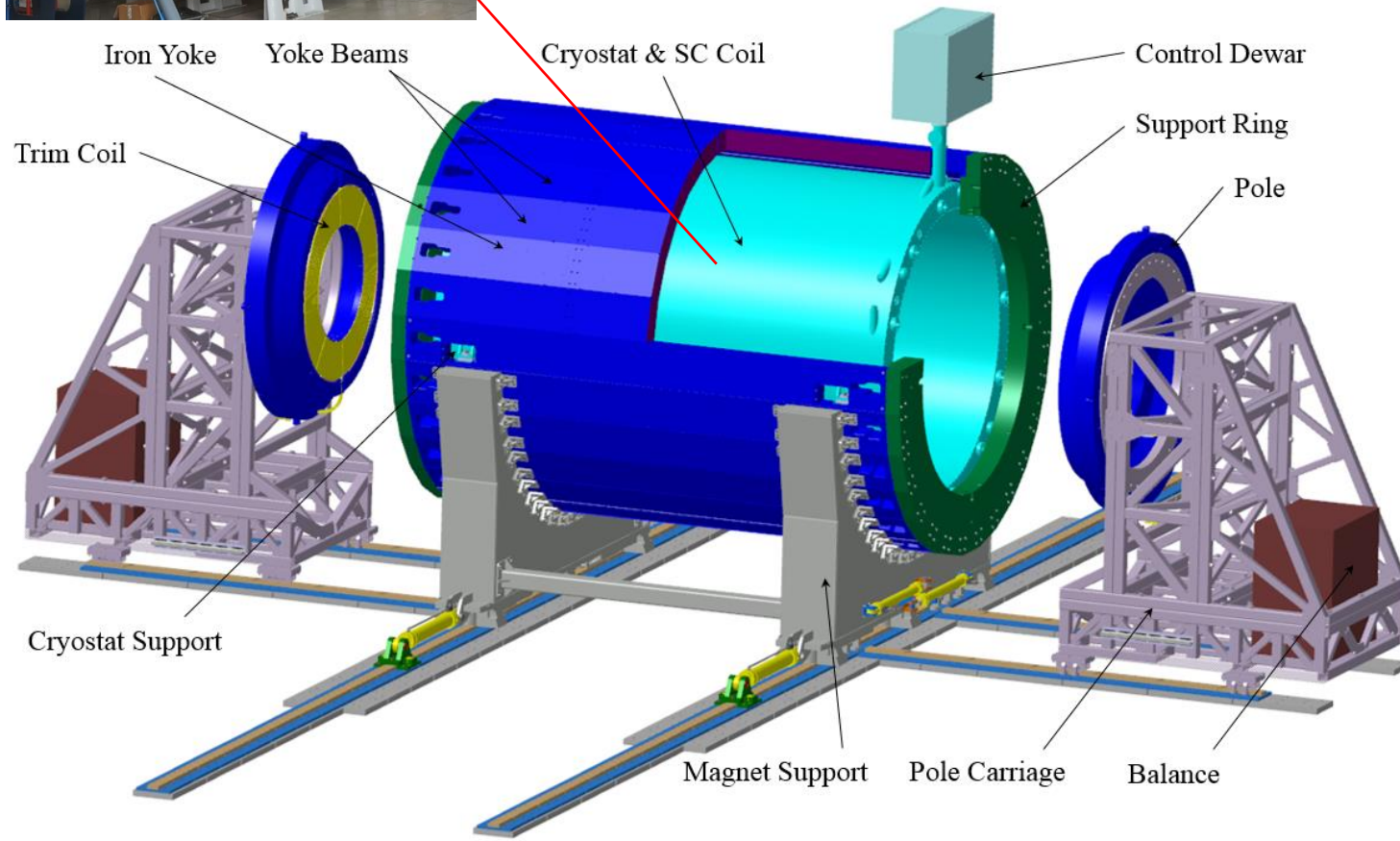
## MPD Yoke production status

[N.Topilin](#), E.Belyaeva, E.Gerasimov

JINR, Dubna



# MPD Yoke (L=8970 mm, Ø6625 mm)



28 plates  
16 t each

2 support rings  
42.5 t each

2 poles  
44 t each

Total: 621 t

Material:  
Steel 10  
(AISI 1010)  
forging

Lodgement (Yoke support) – 74 tons, ordinary steel St.3 (Fe 360)

2 Pole transport support – 15 tons each, ordinary steel St.3 (Fe 360)

## Global scenario:

December 2015 - signing contracts:

1 – JINR – SPETSMASH (St.Peterburg) – Forging production

2 – JINR – VHM (Vitkovice, Czech Republic) – Yoke and auxillary equipment production

June 2016 – forging production finishing (4 rings - Italy, 28 beams (plates) - Ukraine)

2016 – mid. 2017 – machining at VHM

2017 - the VHM plant went bankrupt (t was very dramatic situation)

March 2018 – resumption of work

June-July 2018 – Yoke preassembly

July 2018 – Yoke test

2018 – MPD movement system production

December 2018 – Yoke finish of production at VHM

Feb – March 2019 – rings transportation (AET Trans, St.Peterburg)

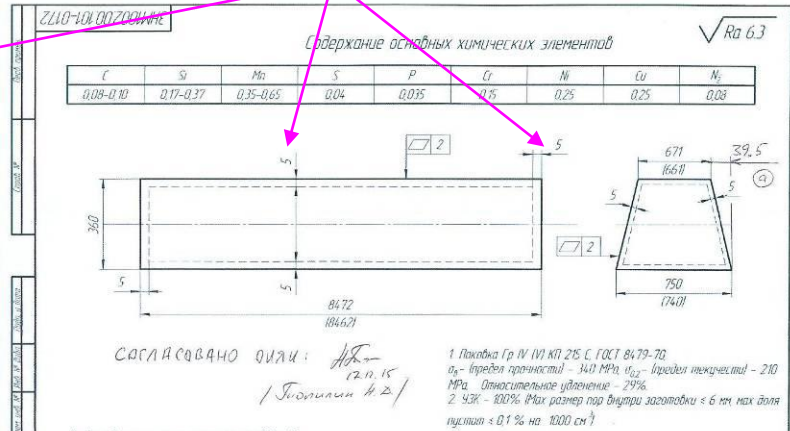
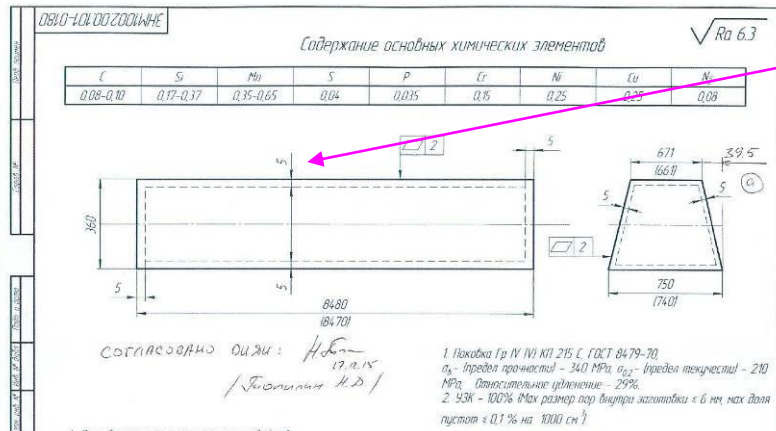
June – July 2019 – total transportation (AET Trans, St.Peterburg)

July - August 2019 – MPD rails installation (Pelcom, Dubna)

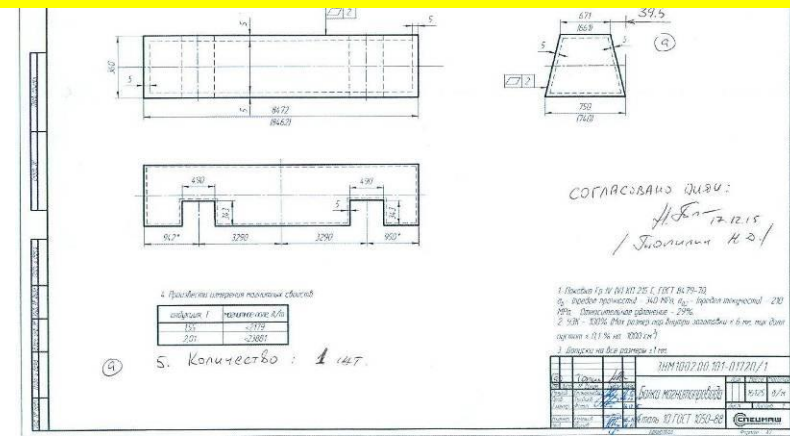
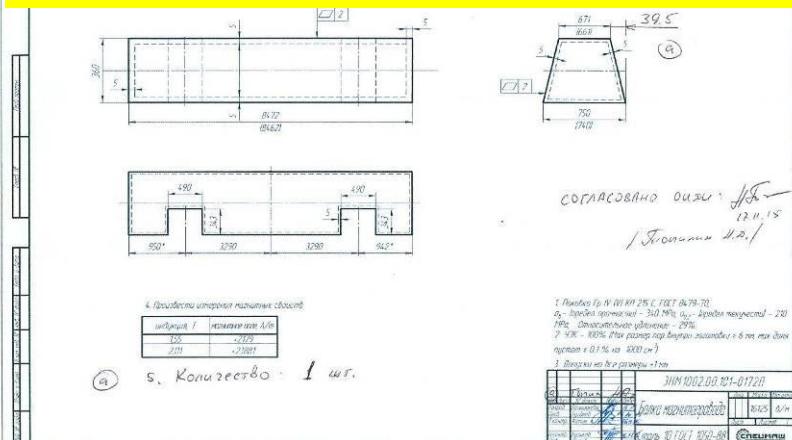
April 2020 – start to assembly in Dubna

# Plates

## + 5 mm



# Rad line of MPD Yoke production is Quality





# Plates production on NKMZ (Kramatorsk, Ukraine)



# Plates chemical composition

№	Наименование	№ черт.	Номер плавки	Фиксация НКМЗ	Химсостав стали, %
1	Балка магнитопровода	ЗНМ1002.00.101-0180	613160147	2164520	C= 0,10 Mn=0,59 Si= 0,27 S= 0,005 P= 0,012 Cr= 0,15 Ni= 0,20 Cu= 0,15 N <sub>2</sub> < 0,008
2	Балка магнитопровода			2164521	
3	Балка магнитопровода			2164522	
4	Балка магнитопровода		613160153	2164523	C= 0,10 Mn= 0,55 Si= 0,27 S= 0,003 P= 0,014 Cr= 0,08 Ni= 0,22 Cu= 0,14 N <sub>2</sub> < 0,008
5	Балка магнитопровода			2164524	
6	Балка магнитопровода		613160158	2164525	C= 0,10 Mn= 0,55 Si= 0,27 S= 0,008 P= 0,015 Cr= 0,12 Ni= 0,18 Cu= 0,17 N <sub>2</sub> < 0,008
7	Балка магнитопровода			2164563	
8	Балка магнитопровода		613160174	2164564	C= 0,09 Mn= 0,59 Si= 0,27 S= 0,002 P= 0,011 Cr= 0,09 Ni= 0,23 Cu= 0,12 N <sub>2</sub> < 0,008
9	Балка магнитопровода			2164574	
10	Балка магнитопровода		613160184	2164575	C= 0,10 Mn= 0,55 Si= 0,24 S= 0,002 P= 0,010 Cr= 0,11 Ni= 0,22 Cu= 0,18 N <sub>2</sub> < 0,008
11	Балка магнитопровода			2164576	
12	Балка магнитопровода		613160187	2164577	C= 0,10 Mn= 0,55 Si= 0,23 S= 0,003 P= 0,010 Cr= 0,09 Ni= 0,17 Cu= 0,20 N <sub>2</sub> < 0,008
13	Балка магнитопровода			2164573	
14	Балка магнитопровода		613160179	2164570-1	C= 0,09 Mn= 0,55 Si= 0,30 S= 0,002 P= 0,011 Cr= 0,13 Ni= 0,19 Cu= 0,16 N <sub>2</sub> < 0,008
15	Прокладка			2164570-2	
16	Балка магнитопровода		613160414	2164935-1	C= 0,09 Mn= 0,55 Si= 0,27 S= 0,003 P= 0,012 Cr= 0,12 Ni= 0,12 Cu= 0,24 N <sub>2</sub> < 0,008
17	Прокладка			2164935-2	
18	Балка магнитопровода			2164936-1	
19	Прокладка			2164936-2	
20	Балка магнитопровода		613160190	2164589-1	C= 0,09 Mn= 0,56 Si= 0,26 S= 0,005 P= 0,012 Cr= 0,10 Ni= 0,16 Cu= 0,27 N <sub>2</sub> < 0,008
21	Прокладка			2164589-2	
22	Балка магнитопровода			2164590-1	
23	Прокладка			2164590-2	
24	Балка магнитопровода		613160203	2164593-1	C= 0,09 Mn= 0,57 Si= 0,30 S= 0,005 P= 0,015 Cr= 0,13 Ni= 0,16 Cu= 0,27 N <sub>2</sub> < 0,008
25	Прокладка			2164593-2	
26	Балка магнитопровода			2164594-1	
27	Прокладка			2164594-2	
28	Балка магнитопровода			2164602-1	C= 0,08 Mn= 0,56 Si= 0,26 S= 0,005

29	Прокладка	ЗНМ1002.00.101-0110	613160207	2164602-2	P= 0,012 Cr= 0,15 Ni= 0,24 Cu= 0,16 N <sub>2</sub> < 0,008
30	Балка магнитопровода	ЗНМ1002.00.101-0172		2164603-1	
31	Прокладка	ЗНМ1002.00.101-0110		2164603-2	
32	Балка магнитопровода	ЗНМ1002.00.101-0172	613160216	2164604-1	C= 0,08 Mn= 0,56 Si= 0,22 S= 0,005 P= 0,014 Cr= 0,12 Ni= 0,21 Cu= 0,24 N <sub>2</sub> < 0,008
33	Прокладка	ЗНМ1002.00.101-0110		2164604-2	
34	Балка магнитопровода	ЗНМ1002.00.101-0172		2164605-1	
35	Прокладка	ЗНМ1002.00.101-0110		2164605-2	
36	Балка магнитопровода	ЗНМ1002.00.101-0172	613160195	2164596-1	C= 0,08 Mn= 0,58 Si= 0,25 S= 0,004 P= 0,014 Cr= 0,13 Ni= 0,17 Cu= 0,26 N <sub>2</sub> < 0,008
37	Прокладка	ЗНМ1002.00.101-0110		2164596-2	
38	Балка магнитопровода	ЗНМ1002.00.101-0172		2164597-1	
39	Прокладка	ЗНМ1002.00.101-0110		2164597-2	
40	Балка магнитопровода	ЗНМ1002.00.101-1721/1	613160219	2164606-1	C= 0,10 Mn= 0,56 Si= 0,26 S= 0,002 P= 0,015 Cr= 0,12 Ni= 0,21 Cu= 0,25 N <sub>2</sub> < 0,008
41	Прокладка	ЗНМ1002.00.101-0110		2164606-2	
42	Балка магнитопровода	ЗНМ1002.00.101-1721/1		2164607-1	
43	Прокладка	ЗНМ1002.00.101-0110		2164607-1	
44	Плита	СПМБ70.420.3500	613160174	2164566	C= 0,09 Mn= 0,59 Si= 0,27 S= 0,002 P= 0,011 Cr= 0,09 Ni= 0,23 Cu= 0,12 N <sub>2</sub> < 0,008



А.И. Крутых

31.03.2016

## Carbon C

GOST on steel 10

0.07 - 0.14 %

Technical Order

0.08 - 0.10 %

Forging (really)

0.08 - 0.10 %

All other elements are inside tolerances

## Mechanical properties:

Sigma **0.2** = 225 - 354 N/mm<sup>2</sup>

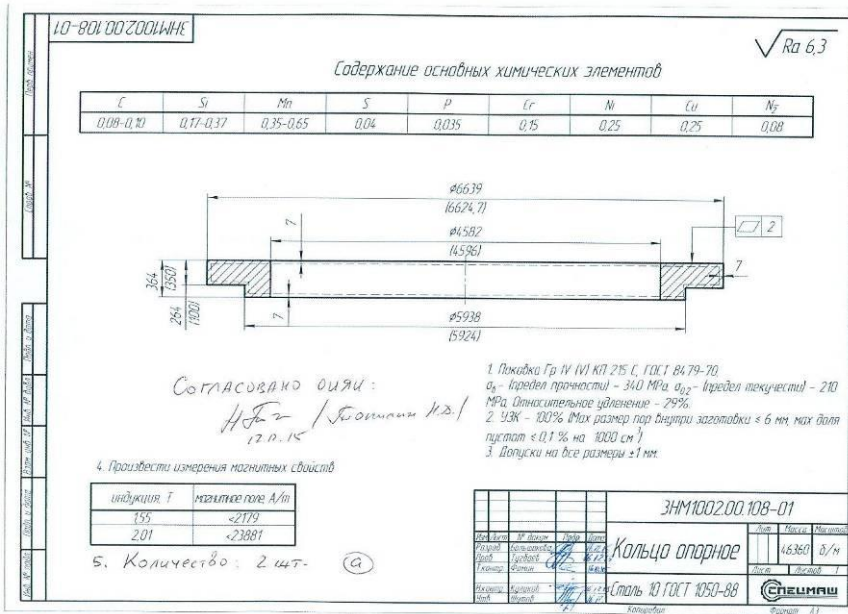
Average = 241 N/mm<sup>2</sup>

Technical Order = 210 N/mm<sup>2</sup>

Ultrasonic control: good



# Support rings (Forgiatura Morandini)

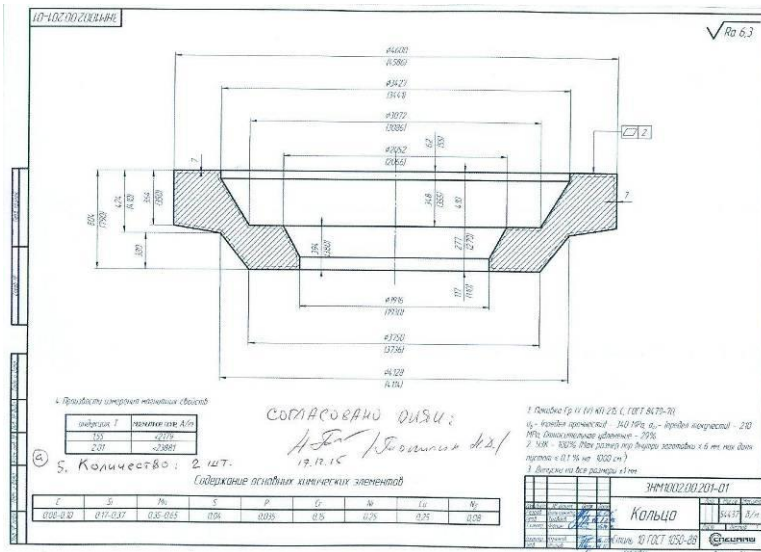


4 May 2016



14 June 2016

# Poles





# Rings chemical composition

Carbon C

GOST on steel 10	0.07 - 0.14 %
Technical Order	0.08 - 0.10 %
Forging (really)	0.08 - 0.09 %

All other elements are inside tolerances

Ultrasonic control: good

Mechanical properties:

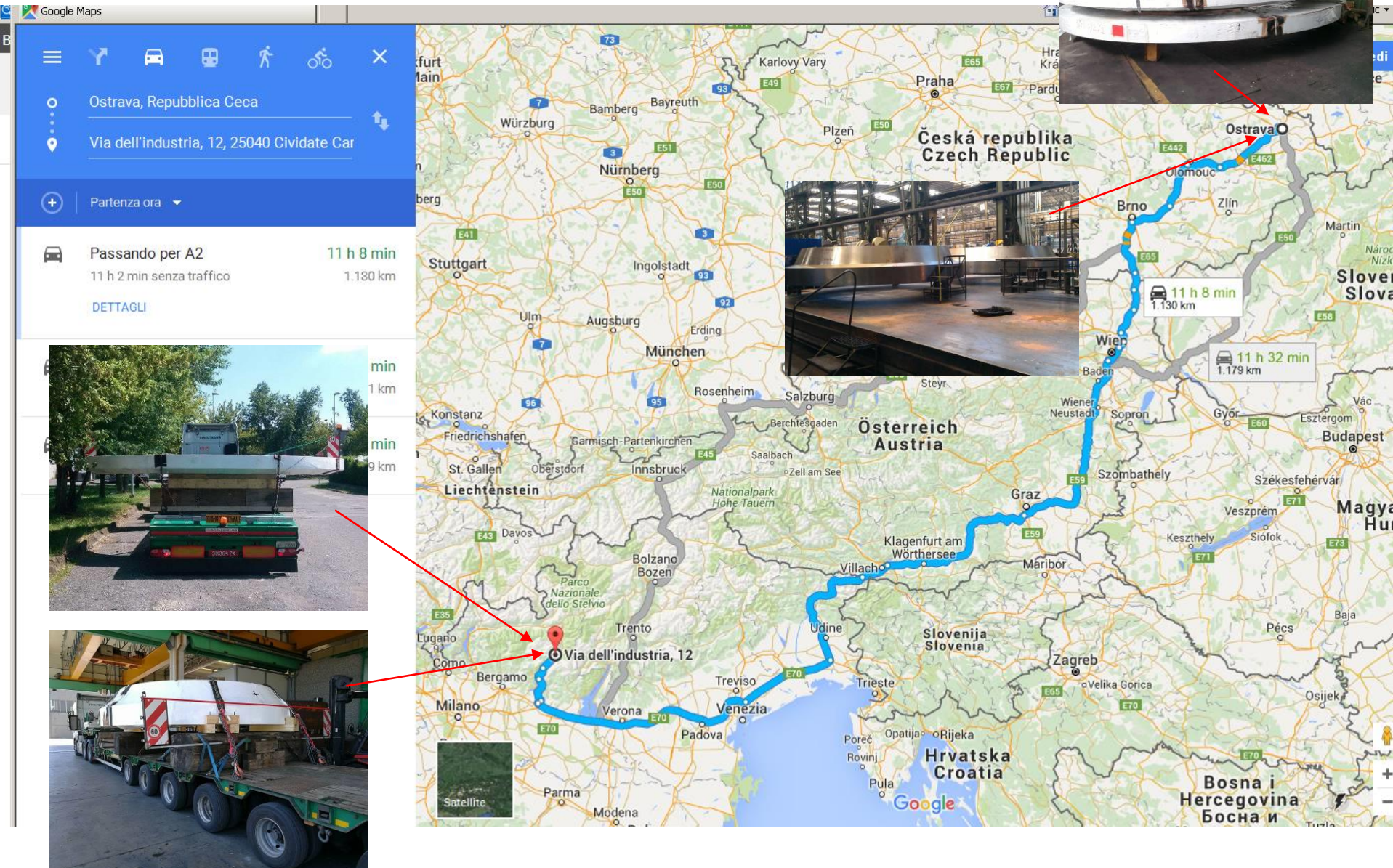
Sigma 0.2 = 231-292 N/mm<sup>2</sup>

Average = 255 N/mm<sup>2</sup>

Technical Order = 210 N/mm<sup>2</sup>



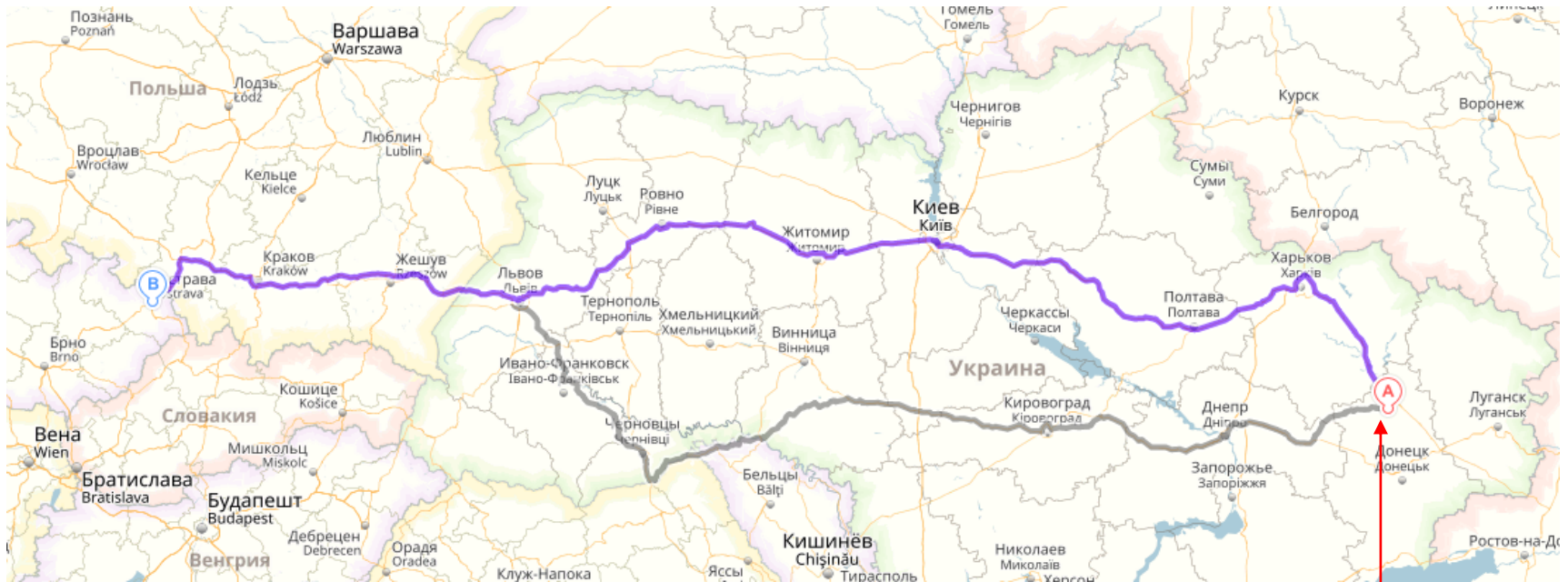
Forging transportation from Italy to VHM (Vitkovice, Czech Republic)  
1130 km





# Forging transportation from NKMZ (Kramatorsk, Ukraine) to VHM (Vitkovice, Czech Republic) -1700 km, 29 trucks

Summer 2016



# VHM equipment checking



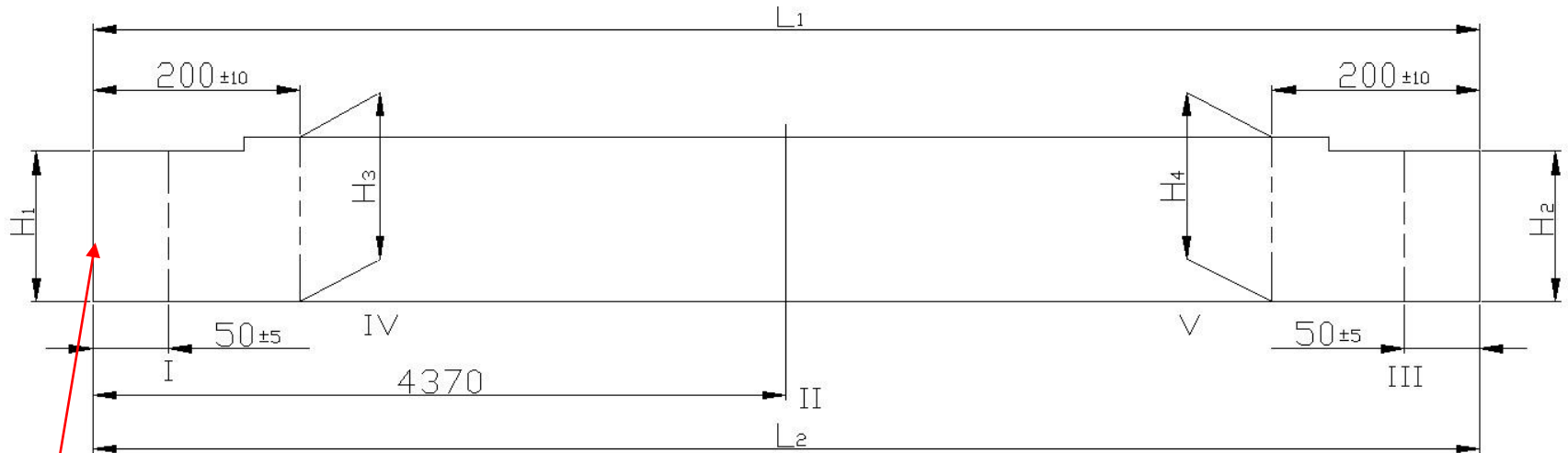
A simple

Milling machine for plates

Boring machine for rings



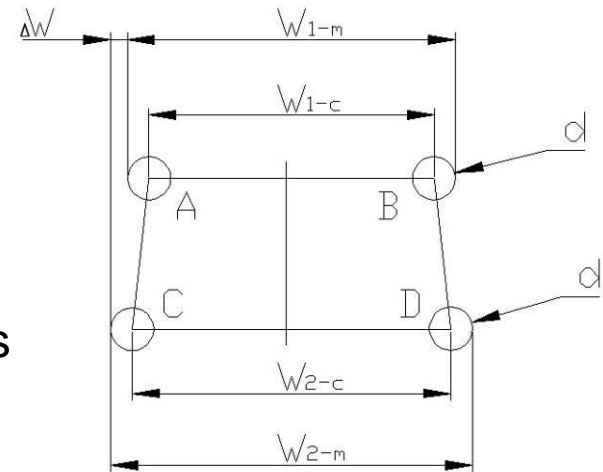
## Control measurements scheme



W side (marking)

QC documents were done  
for all plates, rings, lodgement contact surfaces

All deviations from nominal dimensions  
(length, wide, shape) are  
less than 0.05 mm





## Yoke production status, March - 2018



Support rings: need to have holes machining, sandblasting, painting



Yoke plates: 25 from 28 are ready



Pole machining





# Cradles parts:

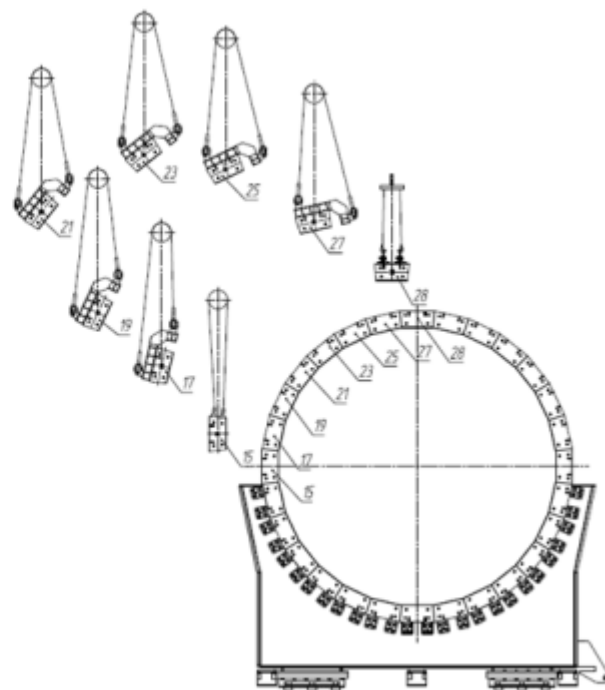
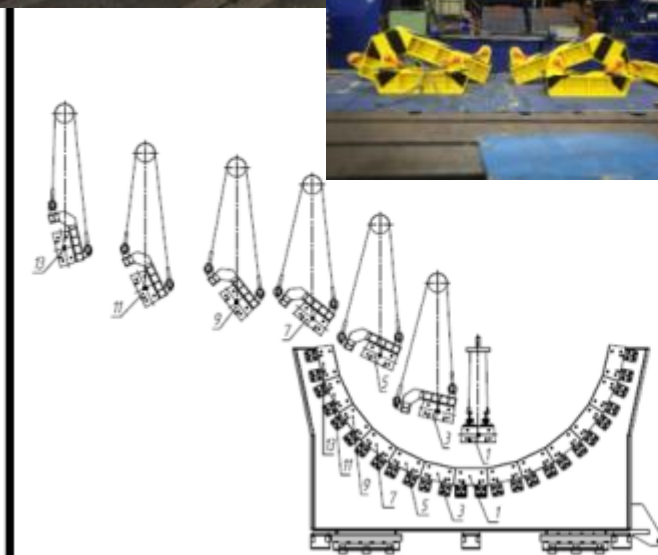
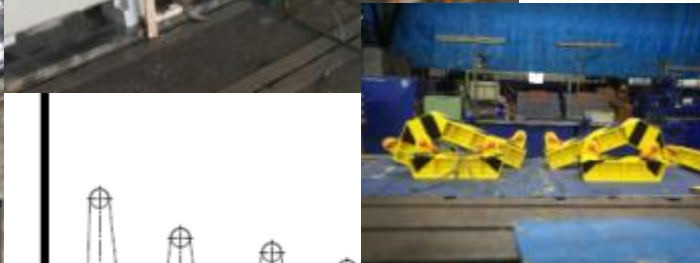


6 cradle support



Spacer plates between bottom surface of cradle and Roller Skates

**Predicted very useful tool !**





## Poles transport supports (2 ps)



Front stand



Bottom base parts



Back stand

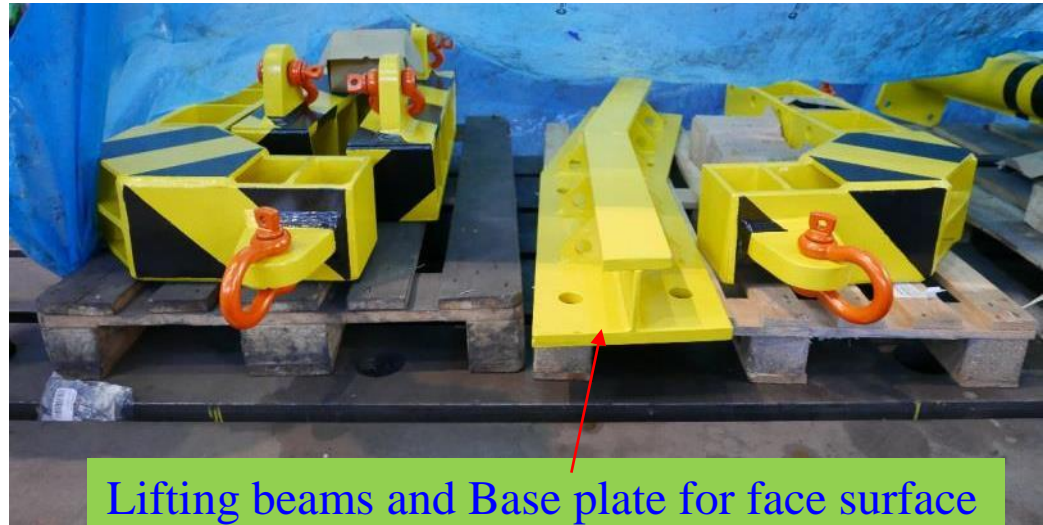


Bottom base parts



Rings billets

## Technological tool





## Preassembly experience at VHM

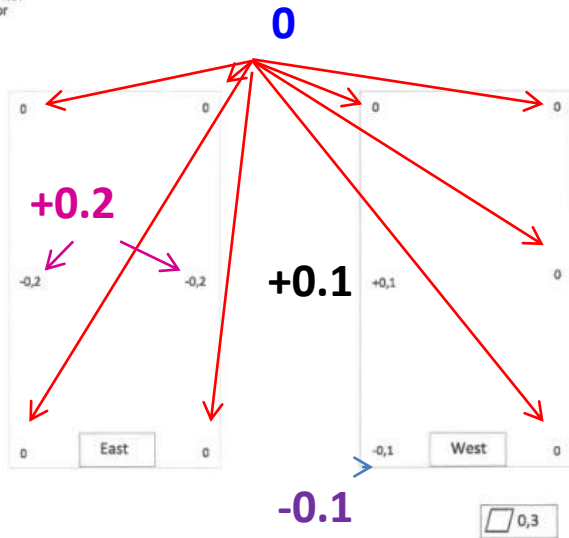
### Floor flatness on area 7x7 m<sup>2</sup>

Rozměrový protokol č. 392/370/18 .1

Размерный протокол No.  
Dimension report No.

JINR Dubna  
č. zák. 0-761-8917-5  
č. obj. 2-042-8915-5

Podlaha  
Настил  
Floor



Kontroloval, контроль, check-up: Větr. T.  
Datum, data, date: 20/6-06-13.  
Podpis, podpis, sign:

URJ  
376



Common non-flatness is 0.3 mm

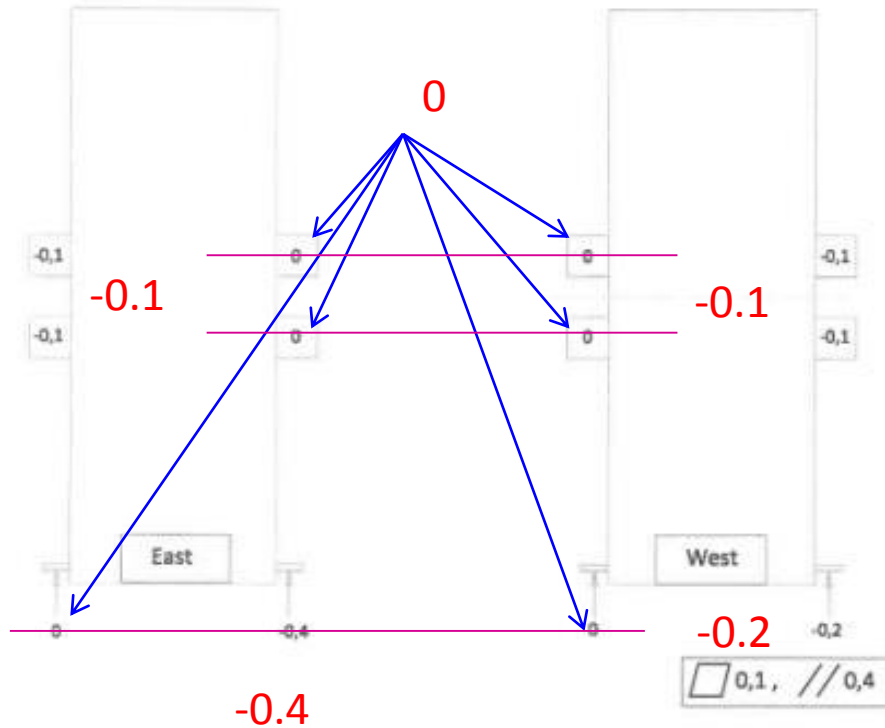


# Rozměrový protokol č. 392/370/18 .2

Размерный протокол No.  
Dimension report No.

JINR Dubna  
č. zák. 0-761-8917-5  
č. obj. 2-042-8915-5

Stojany ☐ . //  
Стойки  
Stands



Kontroloval, контроль, check-up: Viček T.  
Datum, data, date: 2018-06-13  
Podpis, подпись, sign: *[Signature]*



Status on 04 June 2018

Stands shape



 <b>VITKOVICE</b> VITKOVICE HEAVY MACHINERY s.r.o.		<b>ROZMĚROVÝ PROTOKOL</b> <b>DIMENSION DRAWING</b> <b>РАЗМЕРОВЫЙ ПРОТОКОЛ</b>		Strana: / Page: / Страница: <b>1 / 5</b> Č.: / No.: / №.: <b>0258/370/18</b>	
Zákazník: / Customer: / Заказчик: <b>JINR Dubna</b> <b>Россия</b>		Název: / Name: / Название: <b>STOJAN</b> <b>СТОЙКА</b> <i>STAND</i>		Tabulka/bč.: / Worksheet No./ Листов/т. №.: <b>/</b> Zkuš.: / Test No.: / Проба №.: <b>/</b>	
Smlouva č.: / Contract No.: / Контракт / №.: <b>2-042-8915-5</b>		Výkres č.: / Drawing No.: / Чертёж / №.: <b>0-ZP-01022503 Rev.6</b> <b>0-ЗП-01022503 Rev.6</b>		Podmínky č.: / Conditions No./ Условия / №.: <b>-</b>	
				Zakázka/p.č.: / Order No./ Заказ / nos. / №.: <b>0-781-8990-6 / 2002</b>	
Šum.	Jmenovitý rozměr Nominal Dimension Номинальный Размер	Skutečný rozměr Actual Dimension Актуальный Размер	Poznámky Notes Заметка	OK	AC
	3555 ± 0,05	3555,00		X	
	3555 ± 0,05	3555,00		X	
	3291,5 ± 0,05	3291,50		X	
	3291,5 ± 0,05	3291,50		X	
	3291,5 ± 0,05	3291,50		X	
	± 1,0   H	0,10		X	
	± 1,0   H	0,10		X	
	4x Ø 33 H7 + 0,025 / 0	KALIBR / КАЛИБР	2x	X	
	480	480,00		X	
	2x Ø 30 H7 + 0,021 / 0	KALIBR / КАЛИБР		X	
	3900 ± 0,5	3900,00		X	
	Ø 125 H7 + 0,04 / 0	125,01 ± 125,04		X	
	4405 ± 0,5	4405,00		X	
	3555 ± 0,05	3555,00		X	
	280 ± 0,05	280,00		X	
	480	480,00		X	
	350 ± 0,05	350,00		X	
	3555 ± 0,05	3555,00		X	
	3918 ± 0,5	3918,00		X	
Kontroloval (Over, datum, jméno, podpis) Inspected: (Department, Date, Signature) Контрольровал (Отделение, Дата, Подпись)			Schválil (Over, datum, jméno, podpis) Approved by: (Department, Date, Signature) Одобрил (Отделение, Дата, Подпись)		
402.3, 2018-04-26, Jiří Fukna  Miloslav Mrázek <i>Miloslav Mrázek</i>			VITKOVICE HEAVY MACHINERY 402.3 - VEZDOPERAČNÍ A VÝSTRAŽNÍ KONTROLA <i>Daniel Konečný</i>		

Measurement Protocol  
(page 1/5) of  
Stand #1

Drawing tolerances are +/- 0.05 mm  
on the R=3655 mm and others

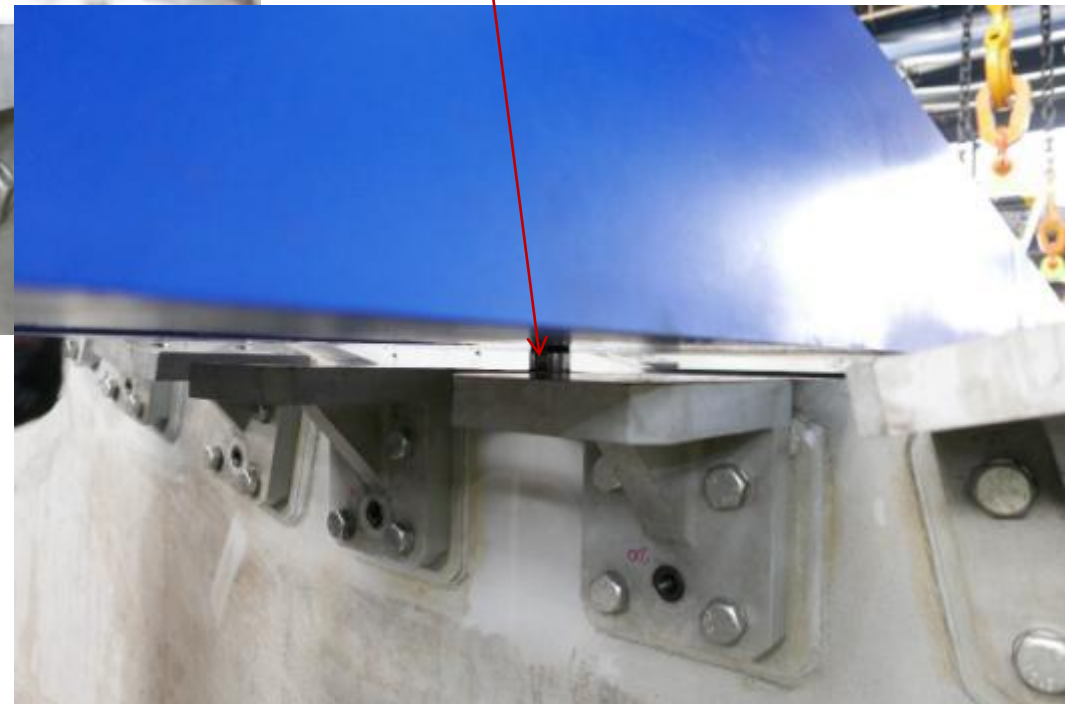
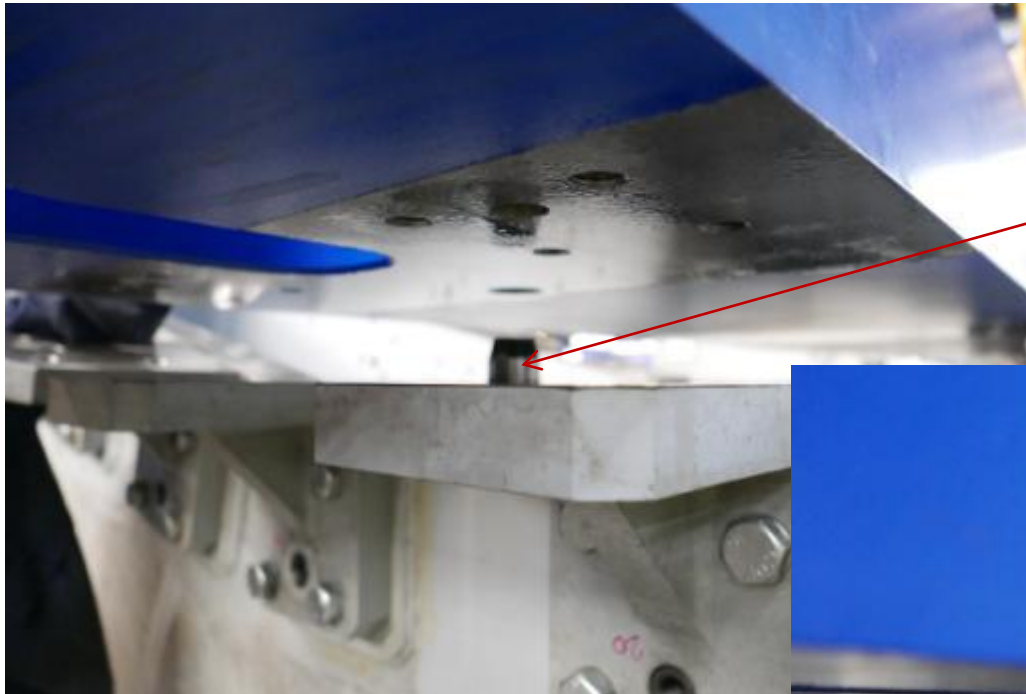
Main deviations are  
“zero” !

## Plate #1 installation (5 June 2018)





## Plate #1 installation (5 June 2018)



Position pins Ø 50 mm

## Plate #1 installation (5 June 2018)





## Plate #2 installation (5 June 2018)

Manipulator from  
Tile Calorimeter  
(ATLAS, CERN)  
It was used in 2002-2006

Second life in 2018-2019  
(NICA-MPD, VHM-JINR)



## Plate #2 installation





2 plates in place

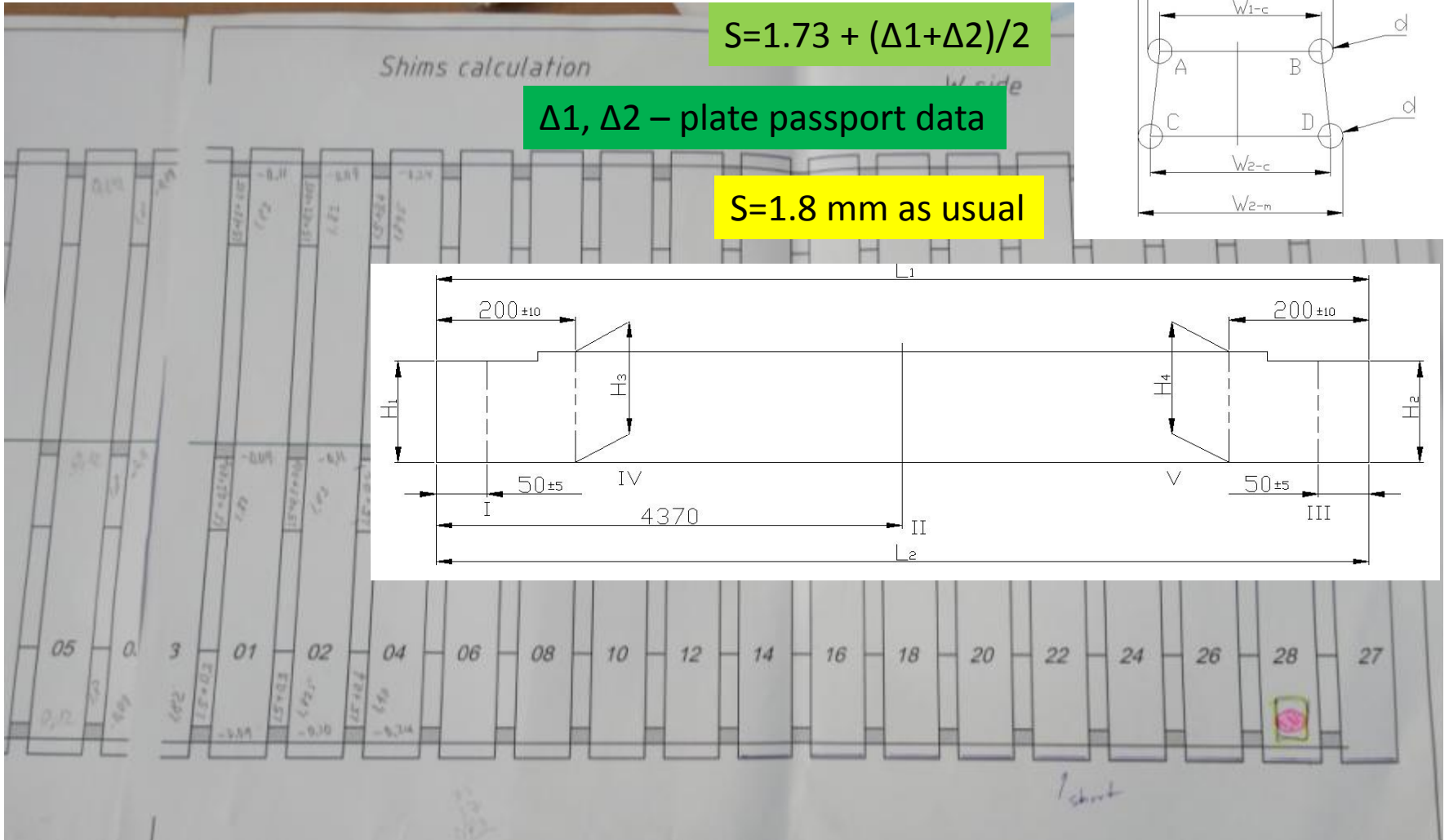
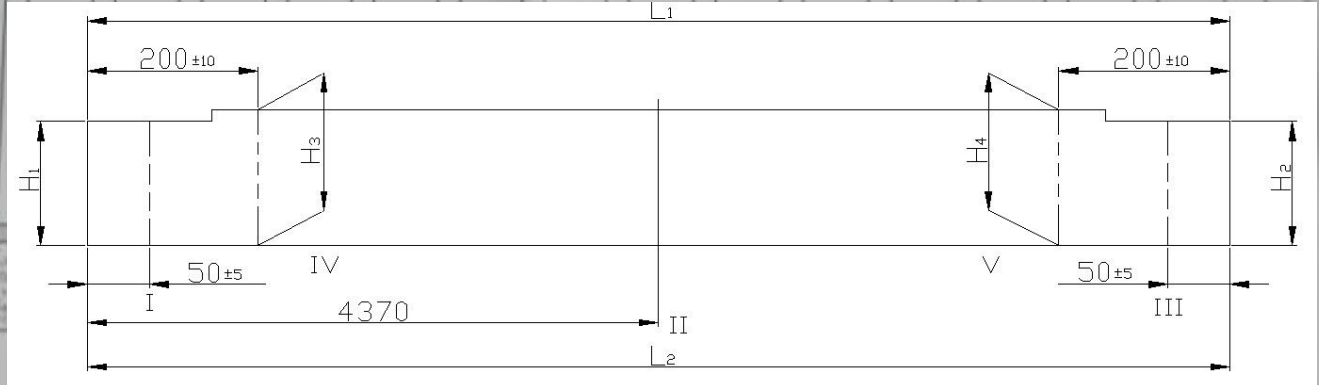
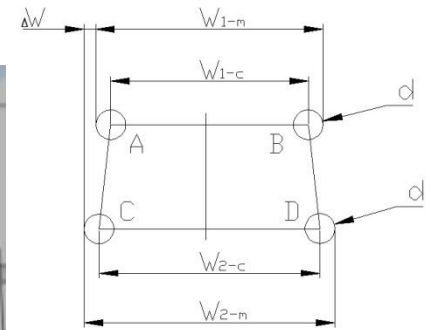


# Shims calculation

$$S = 1.73 + (\Delta 1 + \Delta 2) / 2$$

$\Delta 1, \Delta 2$  – plate passport data

$S = 1.8$  mm as usual





## Shims preparing



## Plates preparing for assembly





## Plates preparing for assembly



## Plate #5 installation (7 June 2018)





# Top points flatness measurement of 7 plates



# Rozměrový protokol č. 392/370/18 .3

Размерный протокол No.

Dimension report No.

JINR Dubna

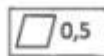
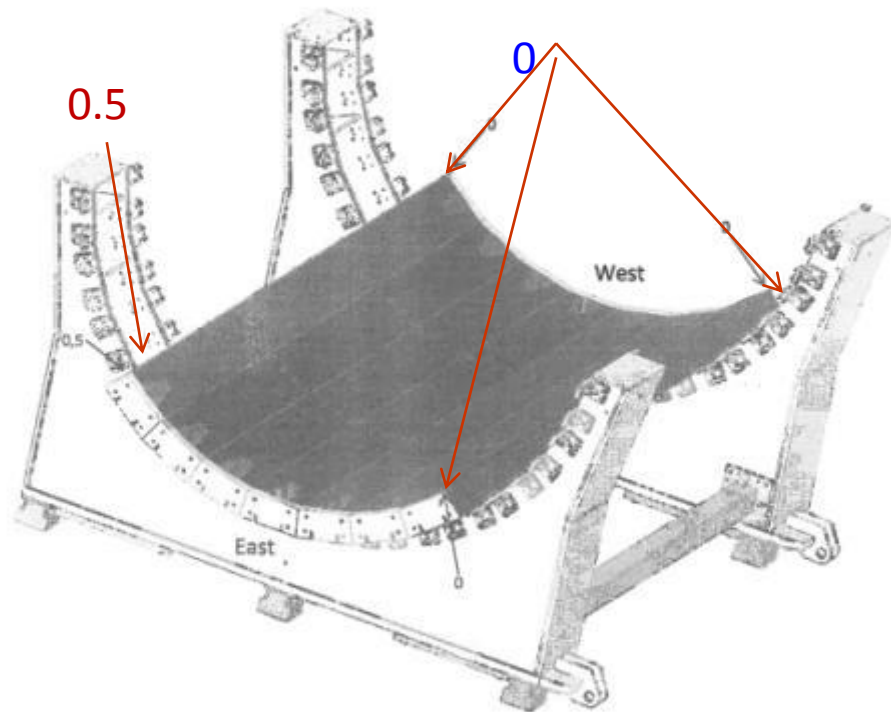
č. zák. 0-761-8917-5

č. obj. 2-042-8915-5

Stojany + 7 nosníků

Стойки + 7 балек

Stands + 7 beams



Kontroloval, контроль, check-up: Viček T.

Datum, data, date: 2018-06-13

Podpis, подпись, sign:

UŘJ  
376

7 plates in assembly





## Assembly step





## Plate #13 installation (9 June 2018)





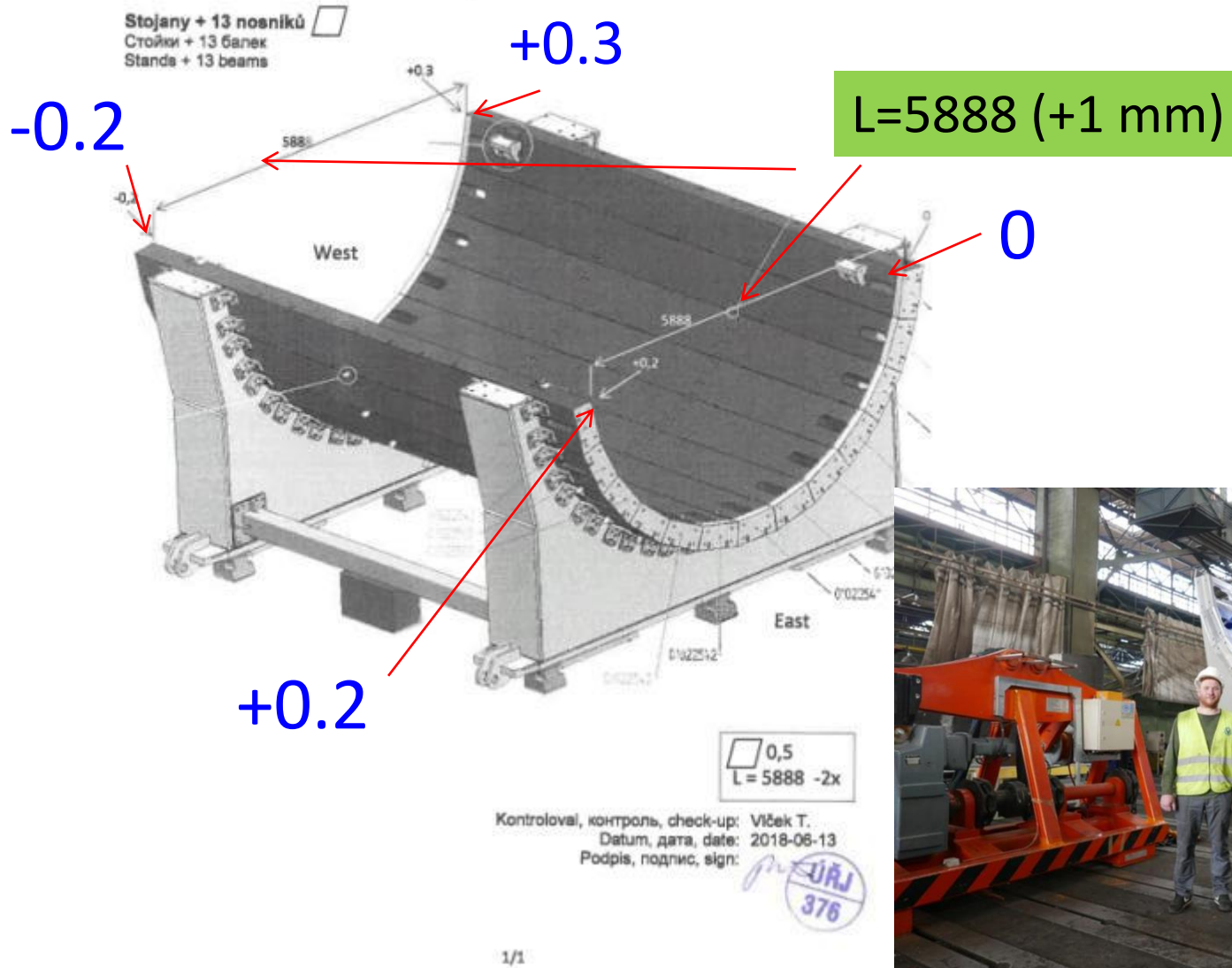
13 plates in place



Rozměrový protokol č. 392/370/18 .4  
Размерный протокол No.  
Dimension report No.

JINR Dubna  
č. zák. 0-761-8917-5  
č. obj. 2-042-8915-5

# 13 plates in assembly



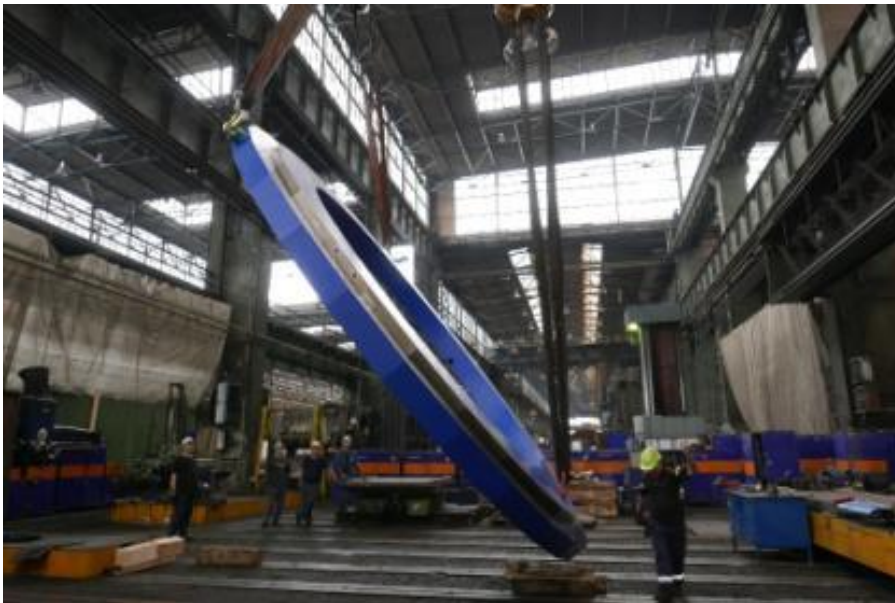


# Scaffolding erection





# Support ring manipulation



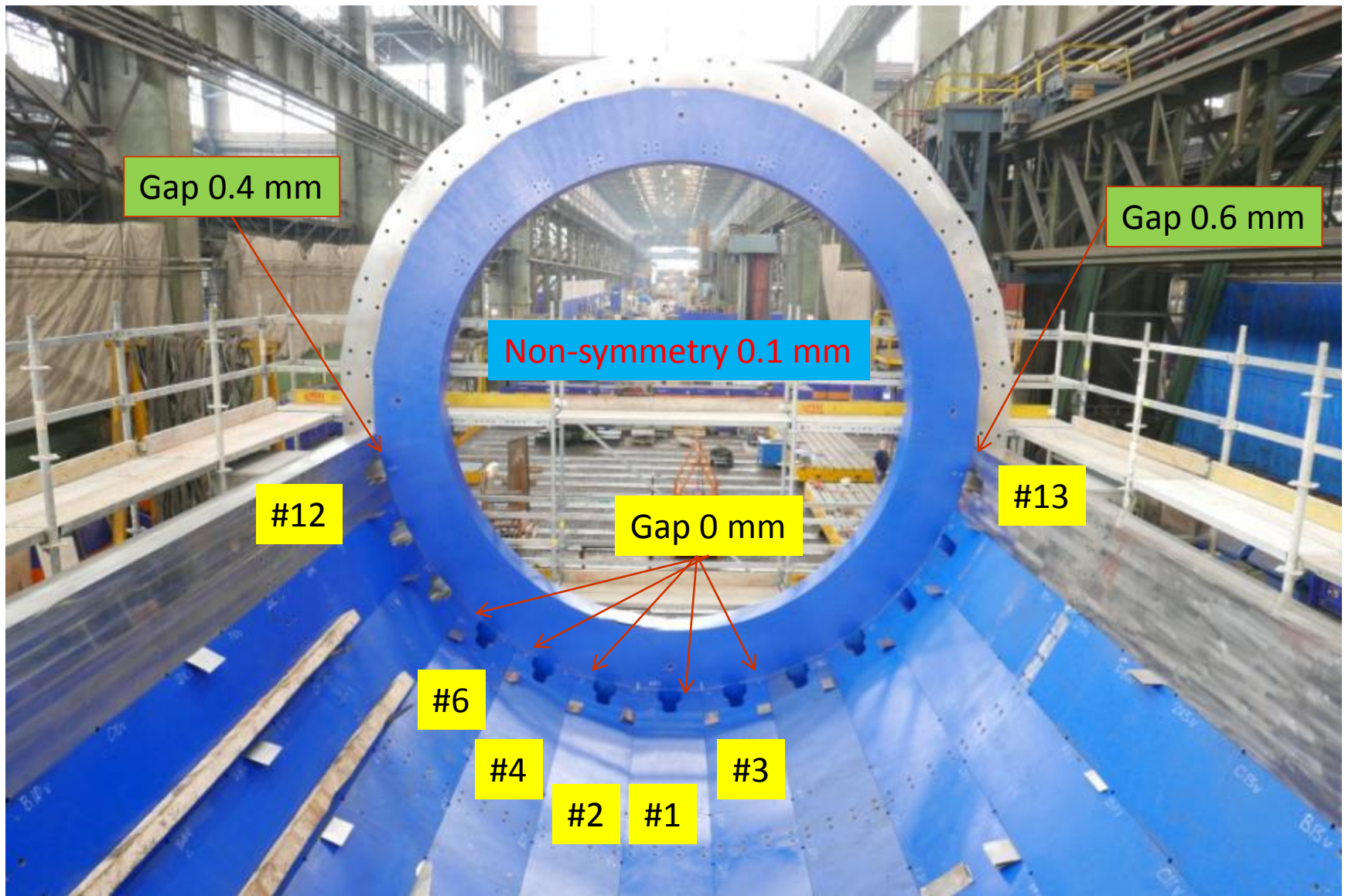


## Support ring #1 installation (12 June 2018)





## Support ring #1 on side W





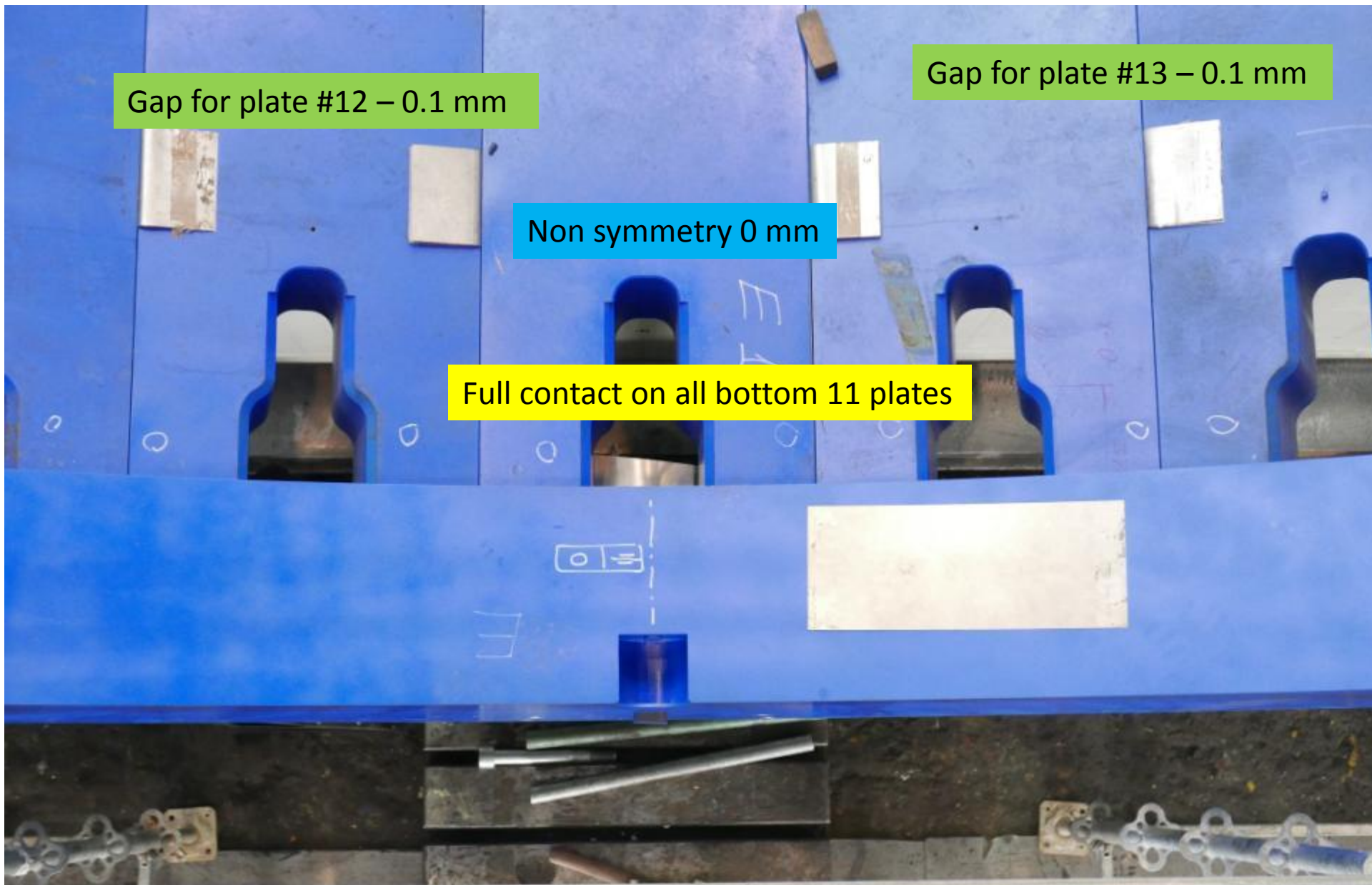
# Support ring #2 installation (13 June 2018)

Gap for plate #12 – 0.1 mm

Gap for plate #13 – 0.1 mm

Non symmetry 0 mm

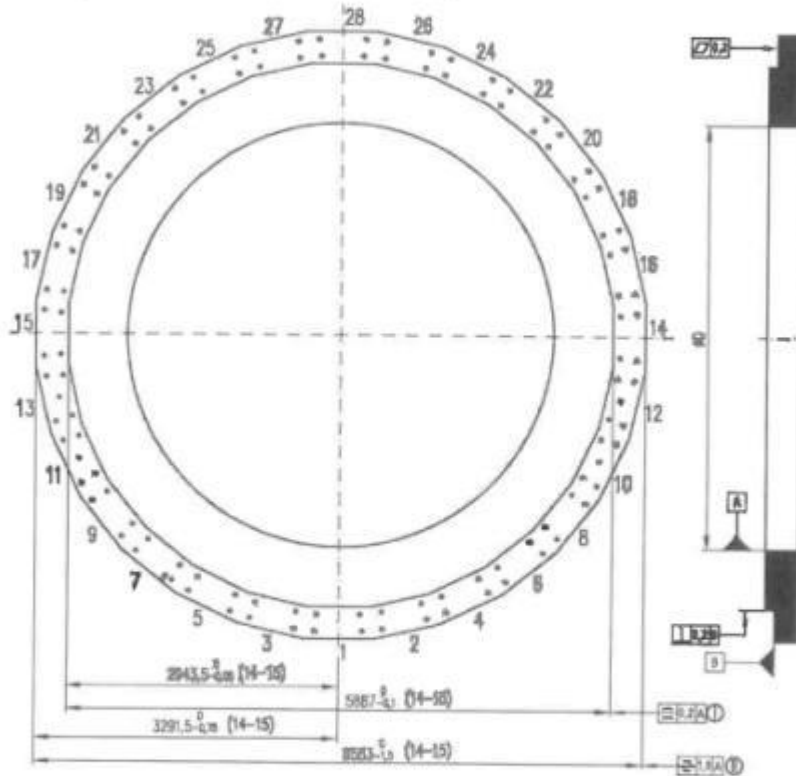
Full contact on all bottom 11 plates



0364/370/17

# Pasport Паспорт

Geometrické rozměry opracovaných opěrných kol v mm  
 Геометрические размеры обработанных опорных колес в мм  
 Geometric dimensions of machined supporting wheel in mm  
 Opěrné kolo č. 1, dle výkresu č. 1-ZP-01022548  
 Опорное кольцо № 1, по чертежу № 1-ZP-01022548  
 Supporting wheel No. acc. to dwg



Obr. 7 – Schéma proměření geometrie opěrných kol  
 Рис. 7 – Схема измерения геометрии опорных колес

Scheme of measuring of supporting wheel geometry

4-ZP-68 100 rev.2

Dimension Rozměr Размер	Dimension acc. to dwg Rozměr dle výkresu Размер по чертежу	Measured dimension Změřené rozměry Измеренные размеры	Calculated value Vypočítaná hodnota Вычисленное значение	Deviation from dwg Odhledy od výkresu Отклонения по чертежу	Real deviation Reálné odchylky Реальные отклонения	Note Poznámka Примечание
0	04898 H8	4596.37	4596.50	+ 0.5	+ 0.37	OK
1-28	2943,6 L <sub>28</sub>	2943,48	2943,45	- 0,05	- 0,02	OK
	5887,0 L <sub>1</sub>	5886,95			- 0,05	OK
	3291,5 L <sub>28</sub>	3291,08	3290,75	- 0,33	- 0,42	OK
	6582,0 L <sub>1</sub>	6582,21	6581,50	- 1,5	- 0,79	OK
I	0.02	0.02		0.2	0.02	OK
	1.0	0.03		1.0	0.03	OK
2-27	2943,6 L <sub>27</sub>	2943,47	2943,45	- 0,5	- 0,03	OK
	5887,0 L <sub>1</sub>	5886,96			- 0,04	OK
	3291,5 L <sub>27</sub>	3291,12	3290,75	- 0,75	- 0,38	OK
	6582,0 L <sub>1</sub>	6582,32	6581,50	- 1,5	- 0,88	OK
I	0.02	0.02		0.2	0.02	OK
	1.0	0.04				
4-26	2943,6 L <sub>26</sub>	2943,47	2943,45	- 0,05	- 0,03	OK
	5887,0 L <sub>1</sub>	5886,96	5886,90	- 0,1	- 0,05	OK
	3291,5 L <sub>26</sub>	3291,17	3290,75	- 0,75	- 0,33	OK
	6582,0 L <sub>1</sub>	6582,42	6581,50	- 1,5	- 0,58	OK
I	0.02	0.02		0.2	0.02	OK
	1.0	0.04				
8-23	2943,6 L <sub>23</sub>	2943,48	2943,45	- 0,05	- 0,03	OK
	5887,0 L <sub>1</sub>	5886,95	5886,90	- 0,1	- 0,05	OK
	3291,5 L <sub>23</sub>	3291,12	3290,75	- 0,75	- 0,38	OK
	6582,0 L <sub>1</sub>	6582,30	6581,50	- 1,5	- 0,70	OK
I	0.02	0.02		0.2	0.02	OK
	1.0	0.03				
9-21	2943,6 L <sub>21</sub>	2943,48	2943,45	- 0,05	- 0,04	OK
	5887,0 L <sub>1</sub>	5886,97	5886,90	- 0,1	- 0,03	OK
	3291,5 L <sub>21</sub>	3291,07	3290,75	- 0,75	- 0,43	OK
	6582,0 L <sub>1</sub>	6582,20	6581,50	- 1,5	- 0,80	OK
I	0.03	0.03		0.2	0.02	OK
	1.0	0.03				
10-19	2943,6 L <sub>19</sub>	2943,47	2943,45	- 0,05	- 0,03	OK
	5887,0 L <sub>1</sub>	5886,95	5886,90	- 0,1	- 0,05	OK
	3291,5 L <sub>19</sub>	3291,15	3290,75	- 0,75	- 0,35	OK
	6582,0 L <sub>1</sub>	6582,38	6581,50	- 1,5	- 0,82	OK
I	0.02	0.02		0.2	0.02	OK
	1.0	0.04				
12-17	2943,6 L <sub>17</sub>	2943,48	2943,45	- 0,05	- 0,02	OK
	5887,0 L <sub>1</sub>	5886,95	5886,90	- 0,1	- 0,05	OK
	3291,5 L <sub>17</sub>	3291,10	3290,75	- 0,75	- 0,40	OK
	6582,0 L <sub>1</sub>	6582,26	6581,50	- 1,5	- 0,74	OK
I	0.02	0.02		0.2	0.02	OK
	1.0	0.03				

4-ZP-68 100 rev.2

5887 -0.1, really it is < 0.05 mm



# Support rings on both sides





## Technology beam (8470 mm) installation



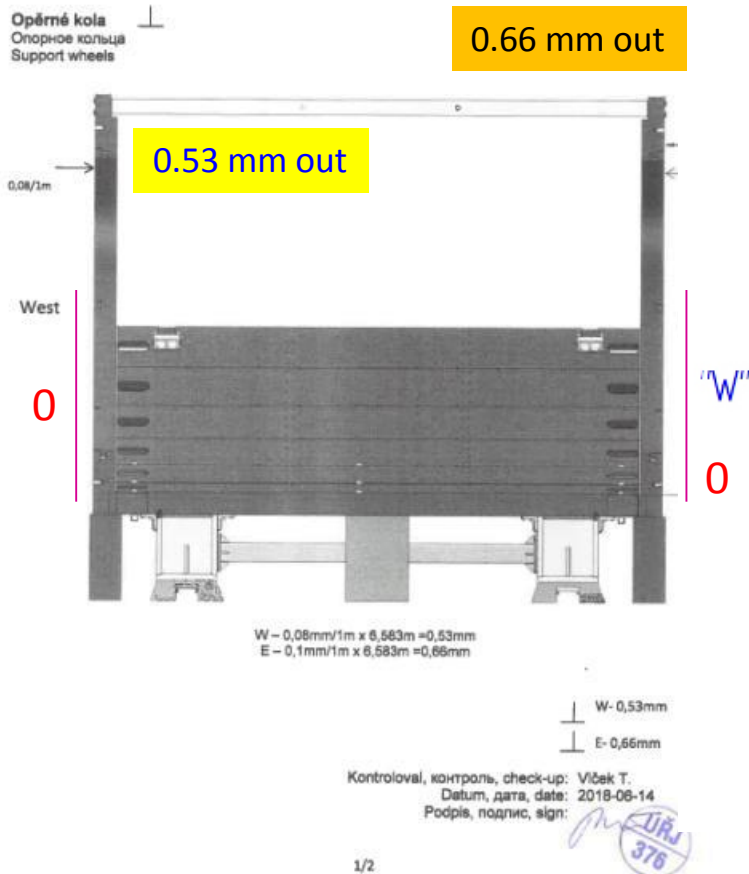


# Plate installation

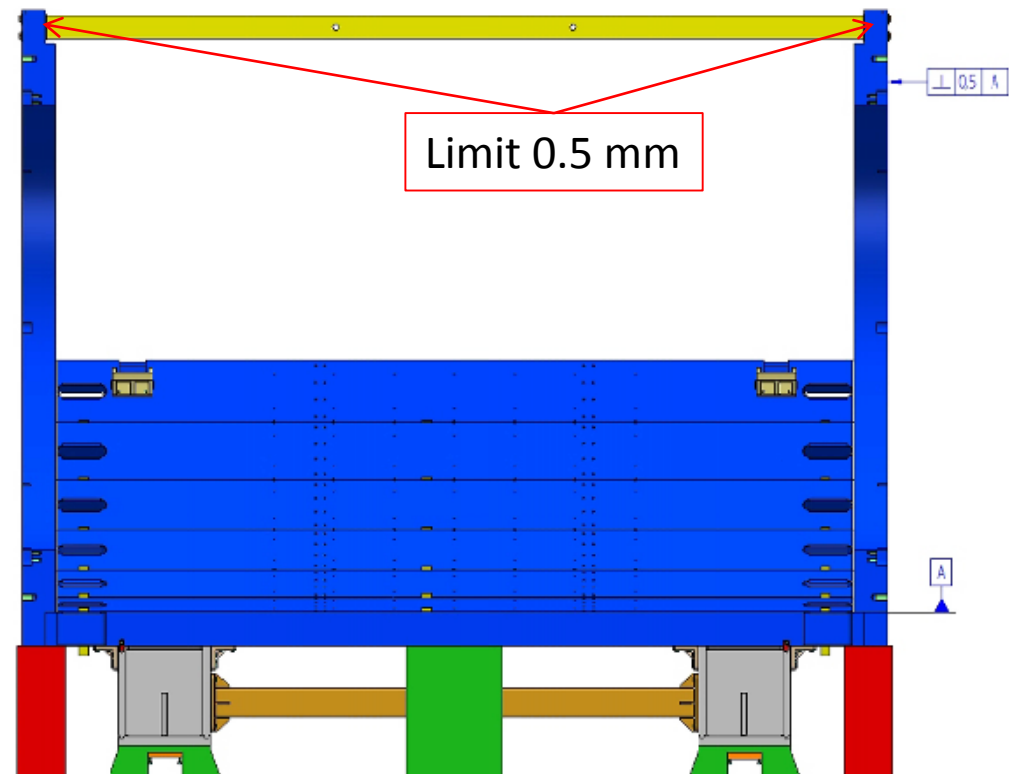


Rozměrový protokol č. 392/370/18 .5  
Размерный протокол No.  
Dimension report No.

JINR Dubna  
č. zák. 0-761-8917-5  
č. obj. 2-042-8915-5



## 2 support ring in assembly

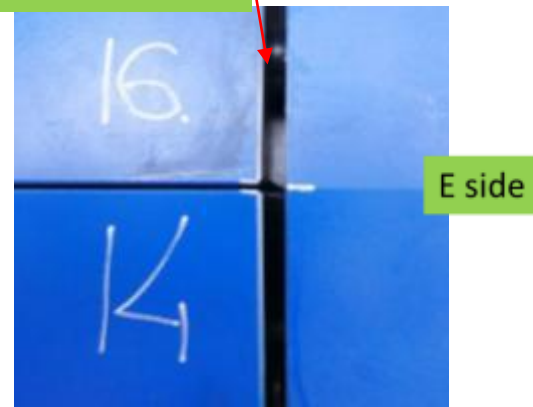
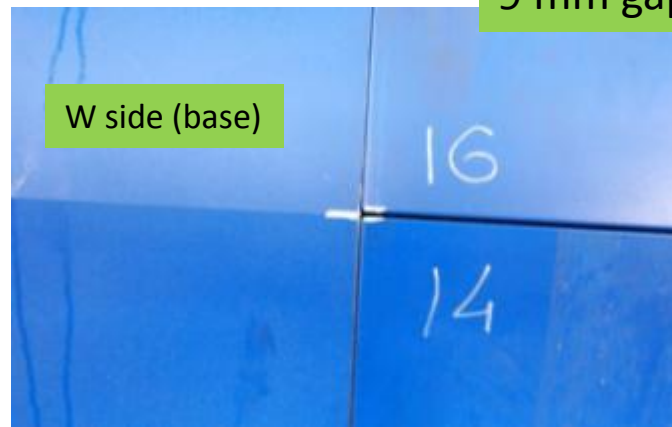




# Plates position on support rings (the similar situation for all bottom ones)



9 mm gaps for 8.5 mm shims



# Plates position on support rings (the similar situation for all bottom ones)

W side (base)



E side



E side

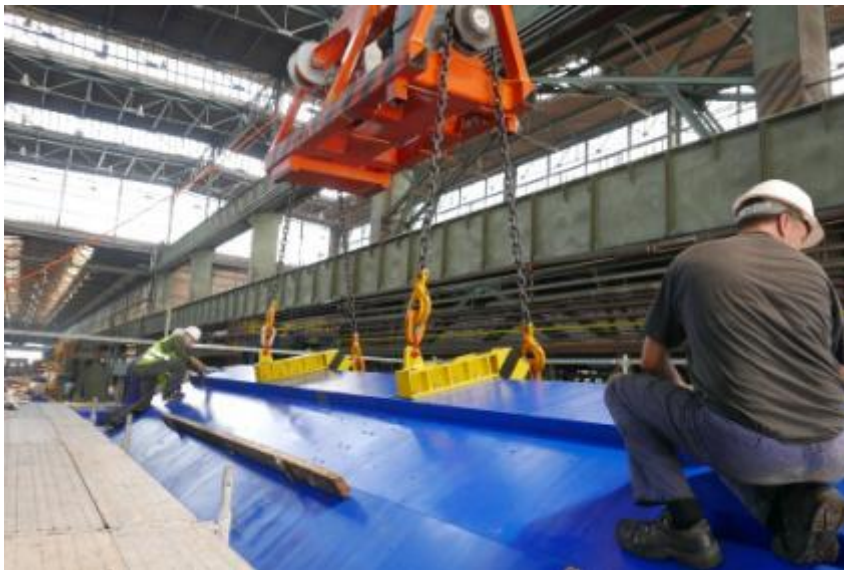


W side (base)





## Plate #26 installation



27 plates in place (20 June 2018)



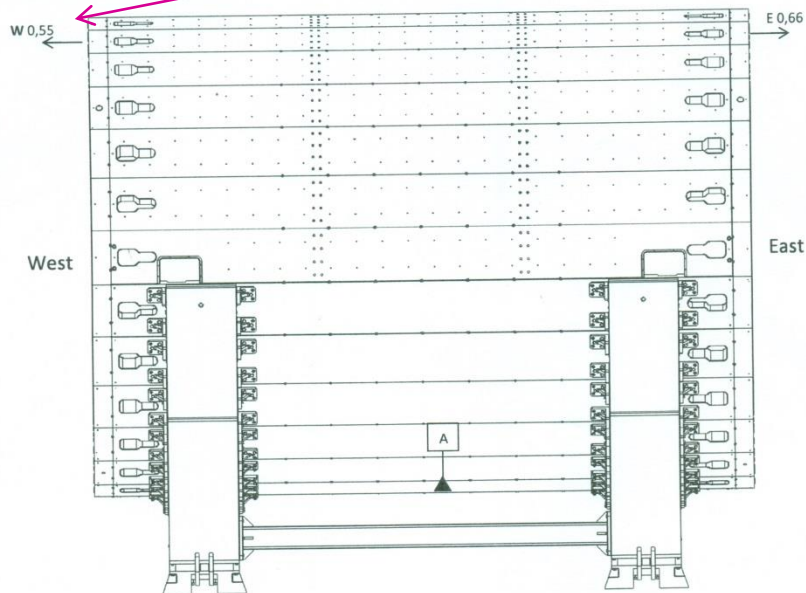


# “Final” measurements report (27 plates in assembly)

Rozměrový protokol č. 425/370/18  
Размерный протокол No.  
Dimension report No.

JINR Dubna  
č. zák. 0-761-8917-5  
č. obj. 2-042-8915-5

Opěrné kola + 27 nosníků  
Опорные кольца + 27 балок  
Support wheels + 27 beams

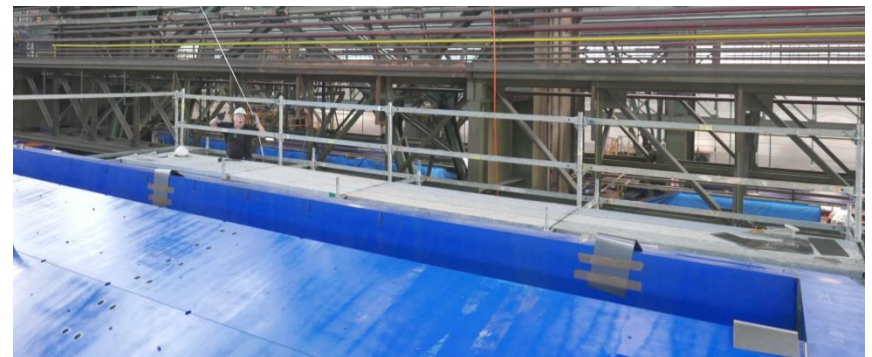


W 0,55 mm
E 0,66 mm

Kontroloval, контроль, check-up: Mrázek Miloslav  
Datum, дата, date: 21.6.2018  
Podpis, подпис, sign: *Mrázek*

VÍTKOVICE HEAVY MACHINERY a.s.  
402.3 - MEZIOPERAČNÍ  
A VÝSTUPNÍ KONTROLA  
4-Z000034  
-3-

Side W – 0.55 mm out  
Side E – 0.66 mm out

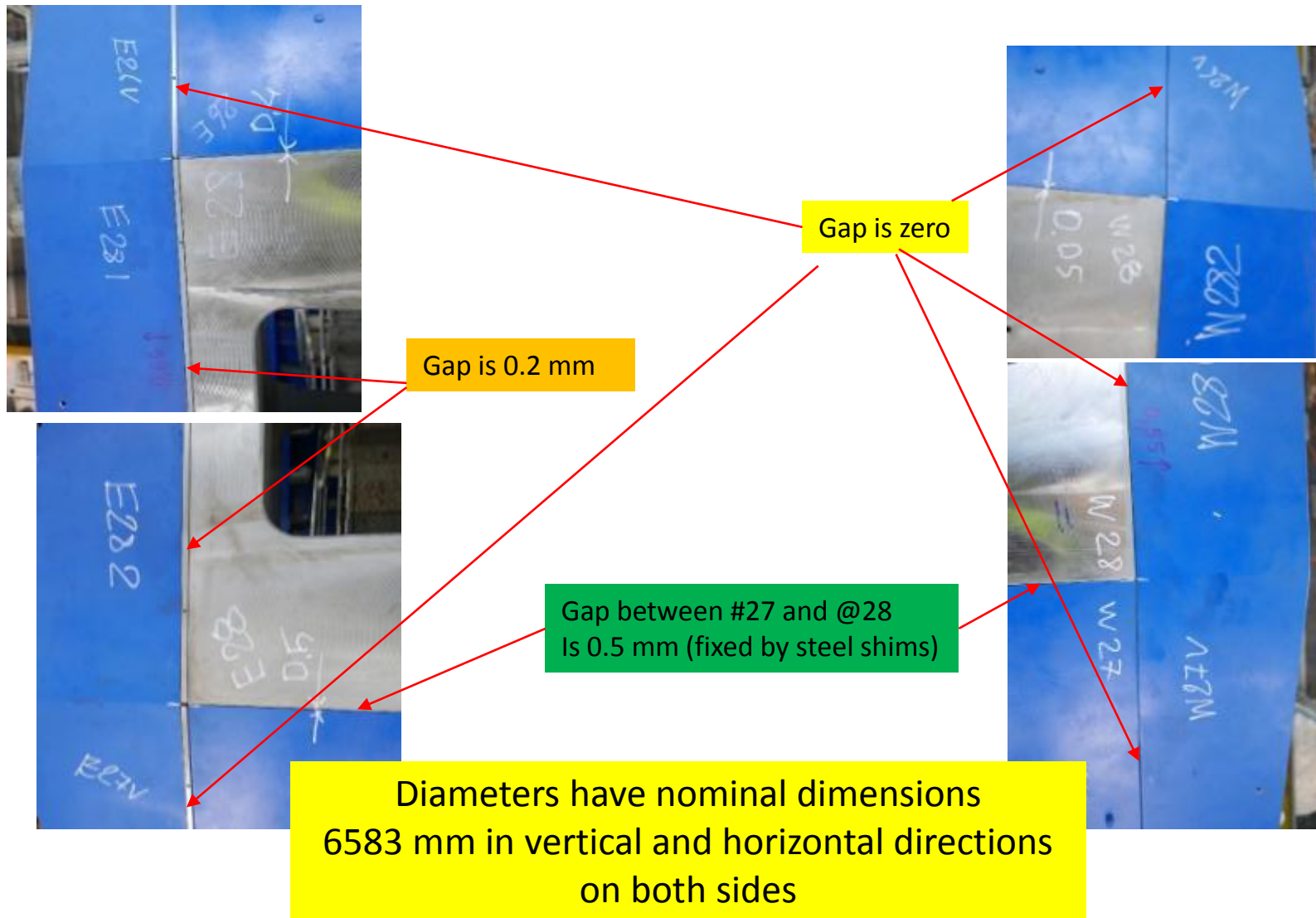


# Plate #28

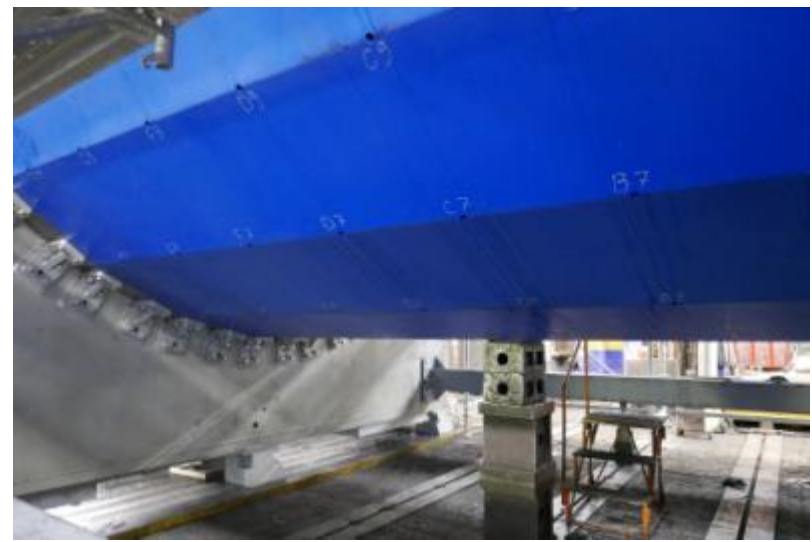




# Top plates positions



It is half way of preassembly.  
Next step is drilling of 544 holes  
33H7 for pins 33p6.



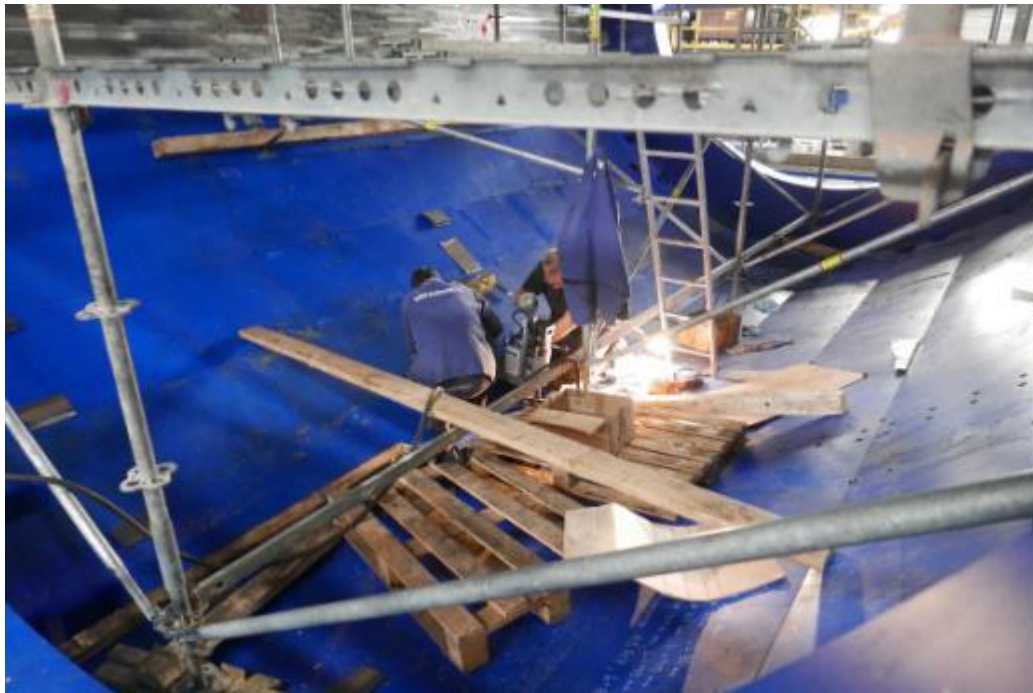




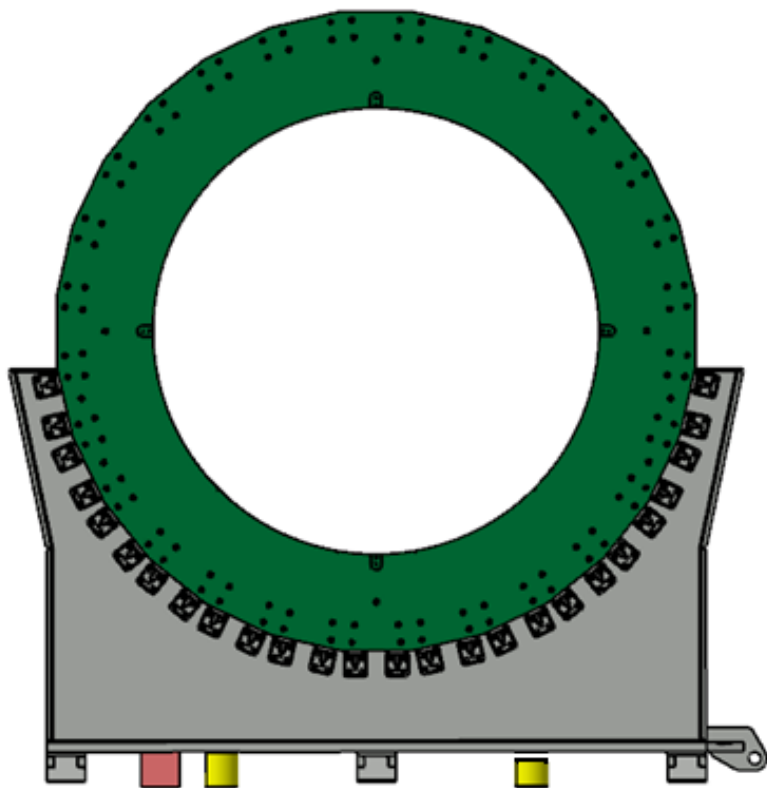
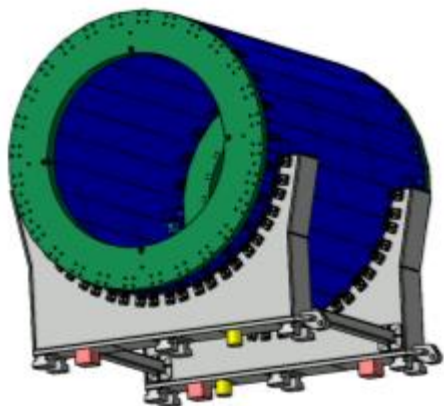
## 712 Holes drilling (in 5 steps):

- 1 – drill 28 mm
- 2 – mill 30 mm,  $h = 90$  mm
- 3 – mill 32 mm,  $h = 90$  mm
- 4 – mill 32.6 mm,  $h = 90$  mm
- 5 – rimmer 33H7 ( $0+0.025$ ),  $h = 80-85$  mm

279 from 712 are ready (on 23 June)



# TEST on 24 July 2018 at VHM



Shrinking calculation estimation, mm		Test result
Neva-Magnit	Progresstech-Dubna	VHM
10,2	9,0	10,4



# What does that mean? (Conclusions)

- **We are on the right way:**

- 1 - there is no mechanical hysteresis
- 2 - All 4 support trolleys accept half of the standard load
- 3 - Local load on the concrete is 50% of the design: increases the durability of the foundation and reduces the chance of subsidence of rail tracks in the process of exploitation  
(локальные нагрузки на бетон составляют 50% от расчетных: повышается долговечность фундамента и уменьшается шанс просадки рельсовых путей в процессе эксплуатации)

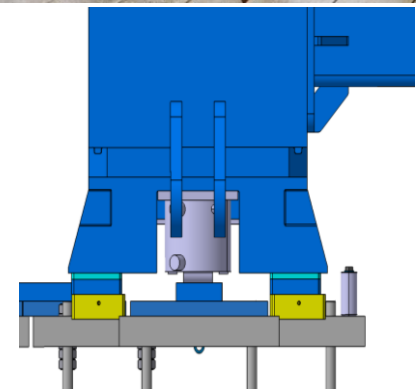
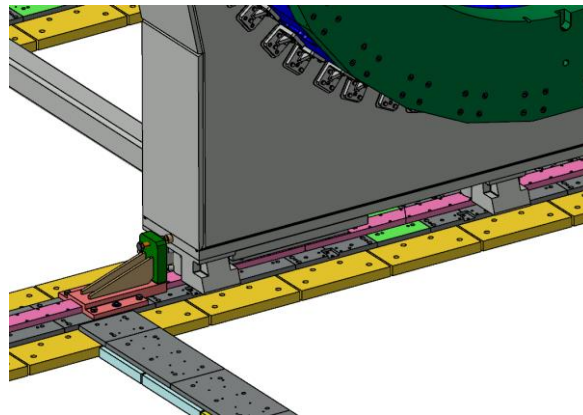
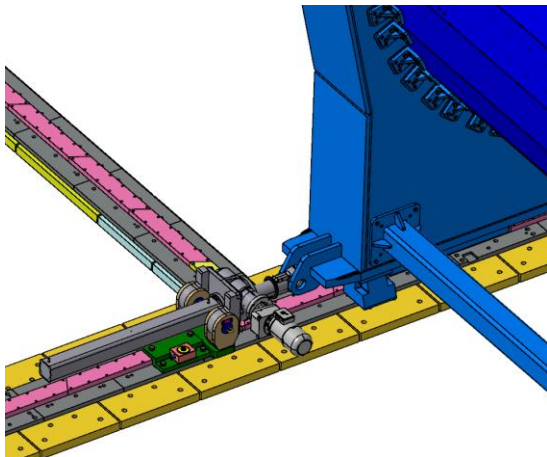
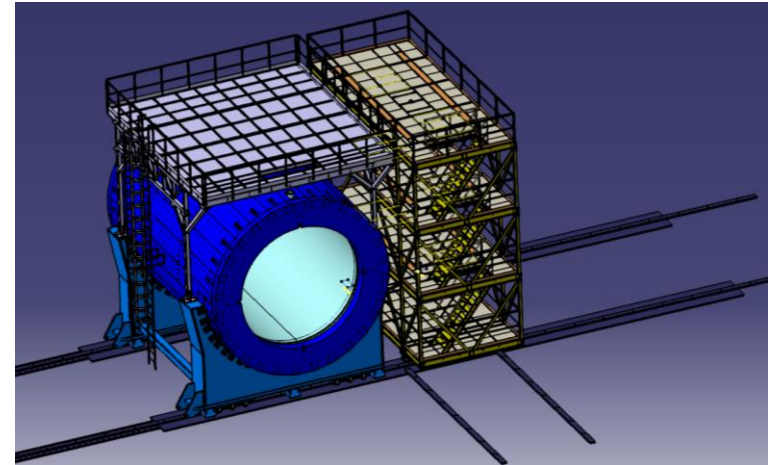
# Many thanks to “AET Trans”

All rings was delivered in time without any extra tax on the roads





# MPD movement system



## Plans for nearest future

October 2019 – April 2020 - installation of sandwich panels on the walls of the pavilion, creation of main and finishing floors, installation of gates, provision of heat and electricity in the pavilion

January – March 2020 – Top platform production

April – June 2020 – Yoke preassembly, movement system installation and test

May-July 2020 – Cryostat transportation

August 2020 – Cryostat installation

November 2020 – Magnetic field measurements

AOB



Thank you for your attention

