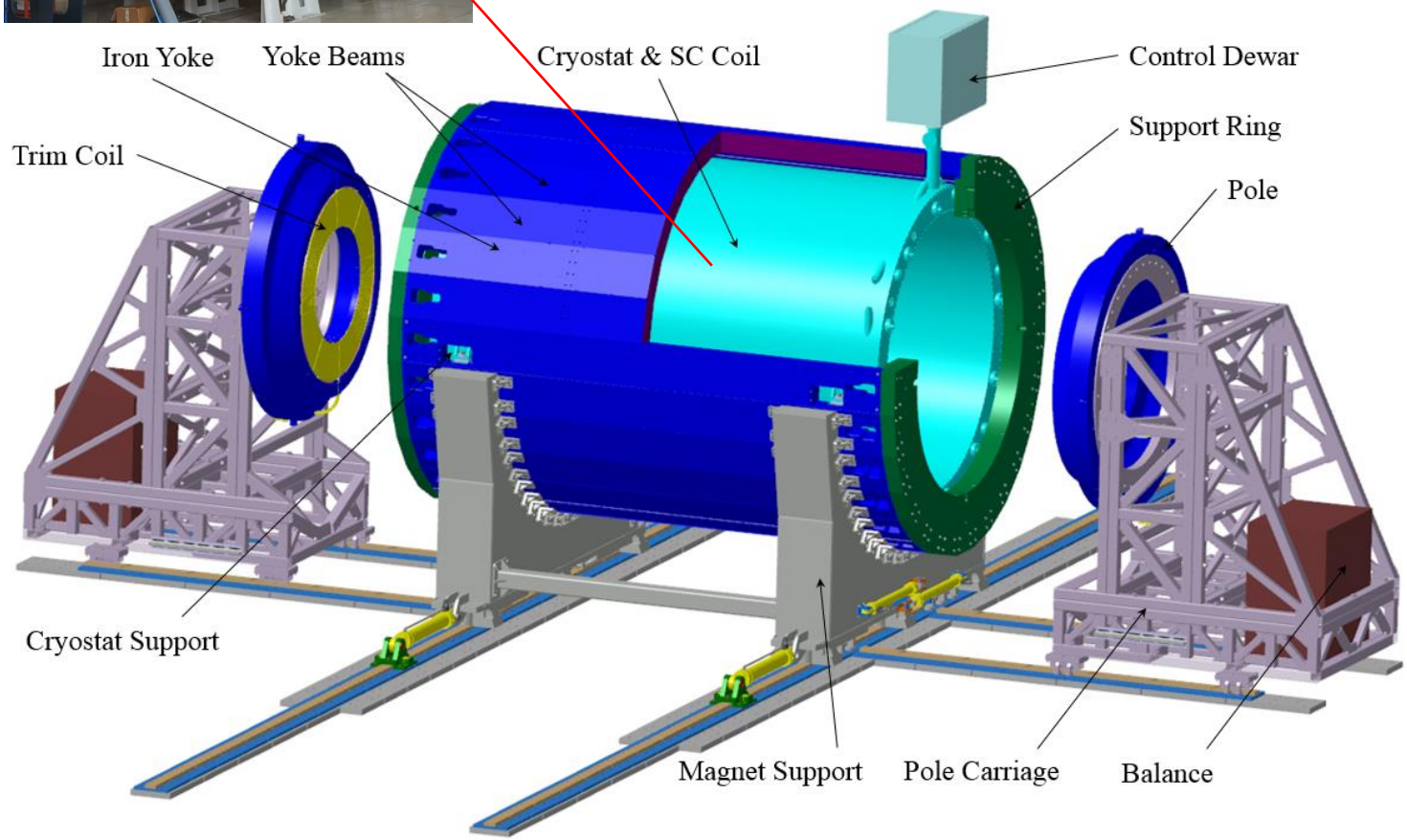
MPD Yoke production status

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)

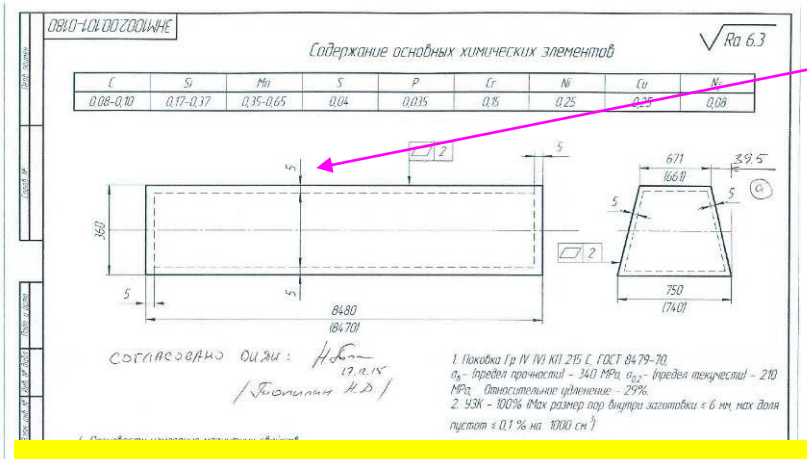
June – July 2019 – total transportation (AET Trans, St.Peterburg)

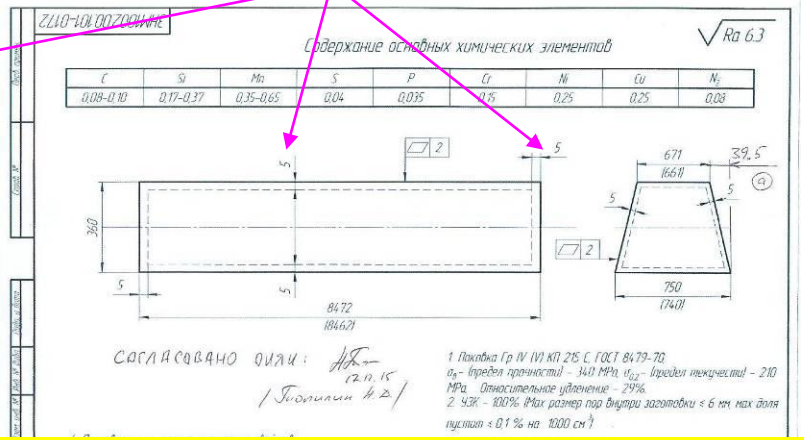
July - August 2019 – MPD rails installation (Pelcom, Dubna)

April 2020 – start to assembly in Dubna

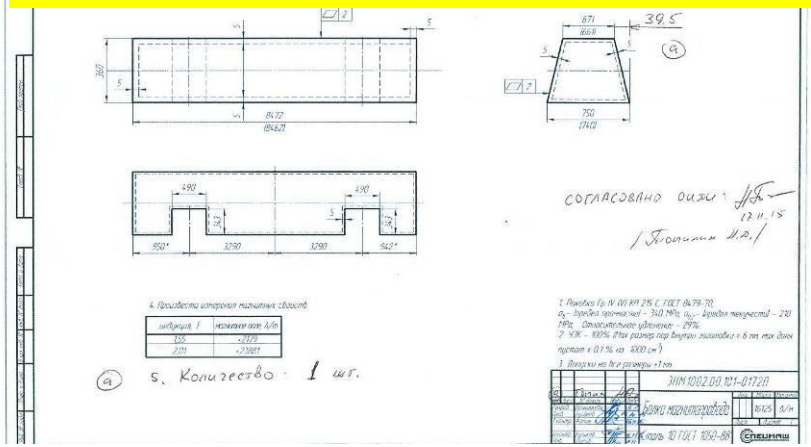
Plates

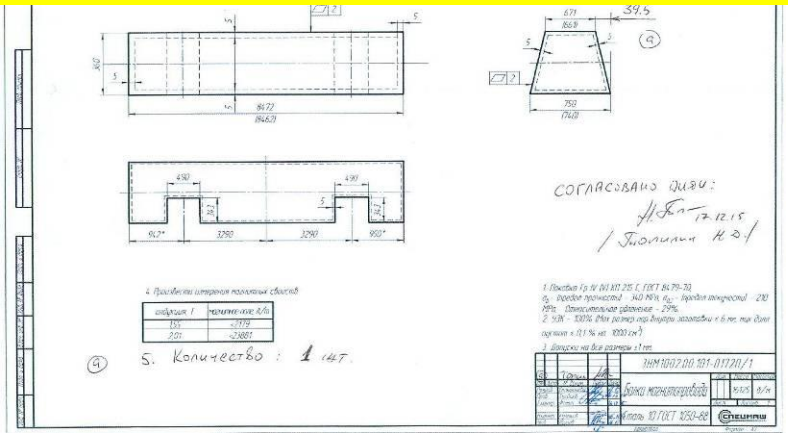
+ 5 mm





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	3НМ1002.00.101-0180	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_2< 0,008
2	Балка магнитопровода			2164521	
3	Балка магнитопровода		613160153	2164522	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_2< 0,008
4	Балка магнитопровода			2164523	
5	Балка магнитопровода		613160158	2164524	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_2< 0,008
6	Балка магнитопровода			2164525	
7	Балка магнитопровода		613160174	2164563	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_2< 0,008
8	Балка магнитопровода			2164564	
9	Балка магнитопровода		613160184	2164574	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_2< 0,008
10	Балка магнитопровода			2164575	
11	Балка магнитопровода		613160187	2164576	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_2< 0,008
12	Балка магнитопровода			2164577	
13	Балка магнитопровода		613160179	2164573	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_2< 0,008
14	Балка магнитопровода	3НМ1002.00.101-0172		2164570-1	
15	Прокладка	3НМ1002.00.101-0110		2164570-2	
16	Балка магнитопровода	3НМ1002.00.101-0172	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_2< 0,008
17	Прокладка	3НМ1002.00.101-0110		2164935-2	
18	Балка магнитопровода	3НМ1002.00.101-0172		2164936-1	
19	Прокладка	3НМ1002.00.101-0110		2164936-2	
20	Балка магнитопровода	3НМ1002.00.101-0172	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_2< 0,008
21	Прокладка	3НМ1002.00.101-0110		2164589-2	
22	Балка магнитопровода	3НМ1002.00.101-0172		2164590-1	
23	Прокладка	3НМ1002.00.101-0110		2164590-2	
24	Балка магнитопровода	3НМ1002.00.101-0172	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_2< 0,008
25	Прокладка	3НМ1002.00.101-0110		2164593-2	
26	Балка магнитопровода	3НМ1002.00.101-0172		2164594-1	
27	Прокладка	3НМ1002.00.101-0110		2164594-2	
28	Балка магнитопровода	3НМ1002.00.101-0172		2164602-1	C= 0,08 Mn= 0,56 Si= 0,26 S= 0,005
29	Прокладка	3НМ1002.00.101-0110	613160207	2164602-2	P= 0,012 Cr= 0,15 Ni= 0,24 Cu= 0,16 N_2< 0,008
30	Балка магнитопровода	3НМ1002.00.101-0172		2164603-1	
31	Прокладка	3НМ1002.00.101-0110		2164603-2	
32	Балка магнитопровода	3НМ1002.00.101-0172	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_2< 0,008
33	Прокладка	3НМ1002.00.101-0110		2164604-2	
34	Балка магнитопровода	3НМ1002.00.101-0172		2164605-1	
35	Прокладка	3НМ1002.00.101-0110		2164605-2	
36	Балка магнитопровода	3НМ1002.00.101-0172	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_2< 0,008
37	Прокладка	3НМ1002.00.101-0110		2164596-2	
38	Балка магнитопровода	3НМ1002.00.101-0172		2164597-1	
39	Прокладка	3НМ1002.00.101-0110		2164597-2	
40	Балка магнитопровода	3НМ1002.00.101-172П	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_2< 0,008
41	Прокладка	3НМ1002.00.101-0110		2164606-2	
42	Балка магнитопровода	3НМ1002.00.101-172П/1		2164607-1	
43	Прокладка	3НМ1002.00.101-0110		2164607-1	
44	Плита	СПМ370.420.3500	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_2< 0,008

А.И. Крутых 31.03.2016

Carbon C

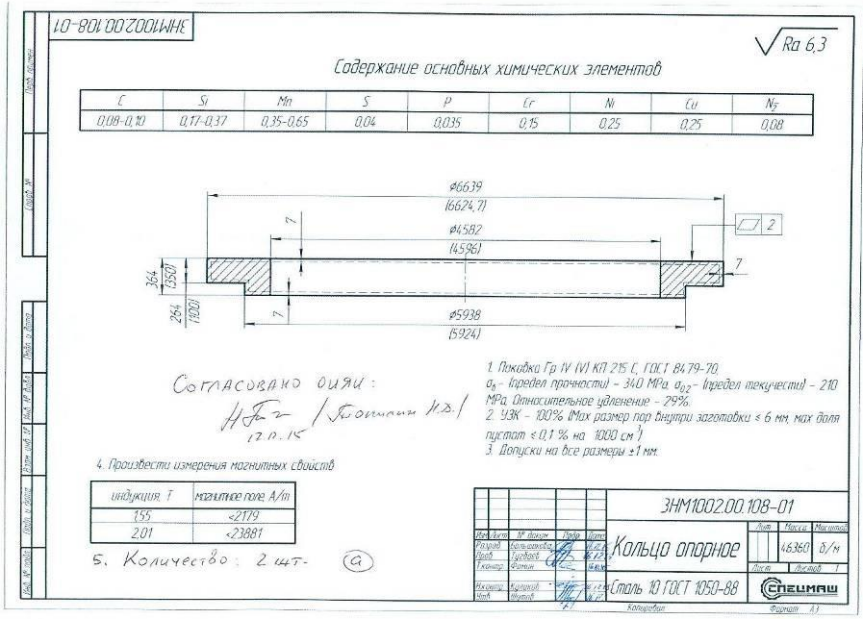
GOST on steel 10 0.07 - 0.14 %
Technical Order 0.08 - 0.10 %
Forging (really) 0.08 - 0.10 %
All other elements are inside tolerances

Mechanical properties:

Sigma **0.2** = 225 - 354 N/mm²
Average = 241 N/mm²
Technical Order = 210 N/mm²

Ultrasonic control: good

Support rings (Forgiatura Morandini)



ЗНМ1002.00.108-01

Ra 6,3

Содержание основных химических элементов

C	Si	Mn	S	P	Cr	Ni	Cu	N_2
0,08-0,10	0,17-0,37	0,35-0,65	0,04	0,035	0,15	0,25	0,25	0,08

Согласовано ОИЯИ:
12.11.15

1. Поковка Гр IV (V) КП 215 С, ГОСТ 8479-70. $\sigma_в$ - (предел прочности) - 340 МПа, $\sigma_{0,2}$ - (предел текучести) - 210 МПа. Относительное удлинение - 29%.
2. УЗК - 100% (Max размер пор внутри заготовки ≤ 6 мм, max доля пустот ≤ 0,1 % на 1000 см³)
3. Допуски на все размеры ±1 мм.
4. Произвести измерения магнитных свойств

индукция, T	магнитное поле A/m
1,55	<2179
2,01	<23881

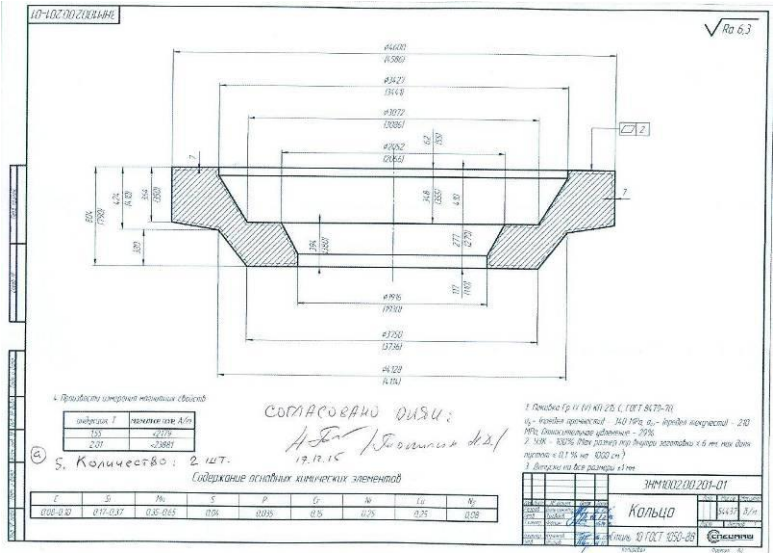
5. Количество: 2 шт.

ЗНМ1002.00.108-01
Кольцо опорное
Сталь 10 ГОСТ 1050-88
СПецМАШ
Масса 46360
Масштаб б/н
Лист 1
Листов 1
Формат А1

4 May 2016

14 June 2016

Poles



4 May 2016

14 June 2016

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 %

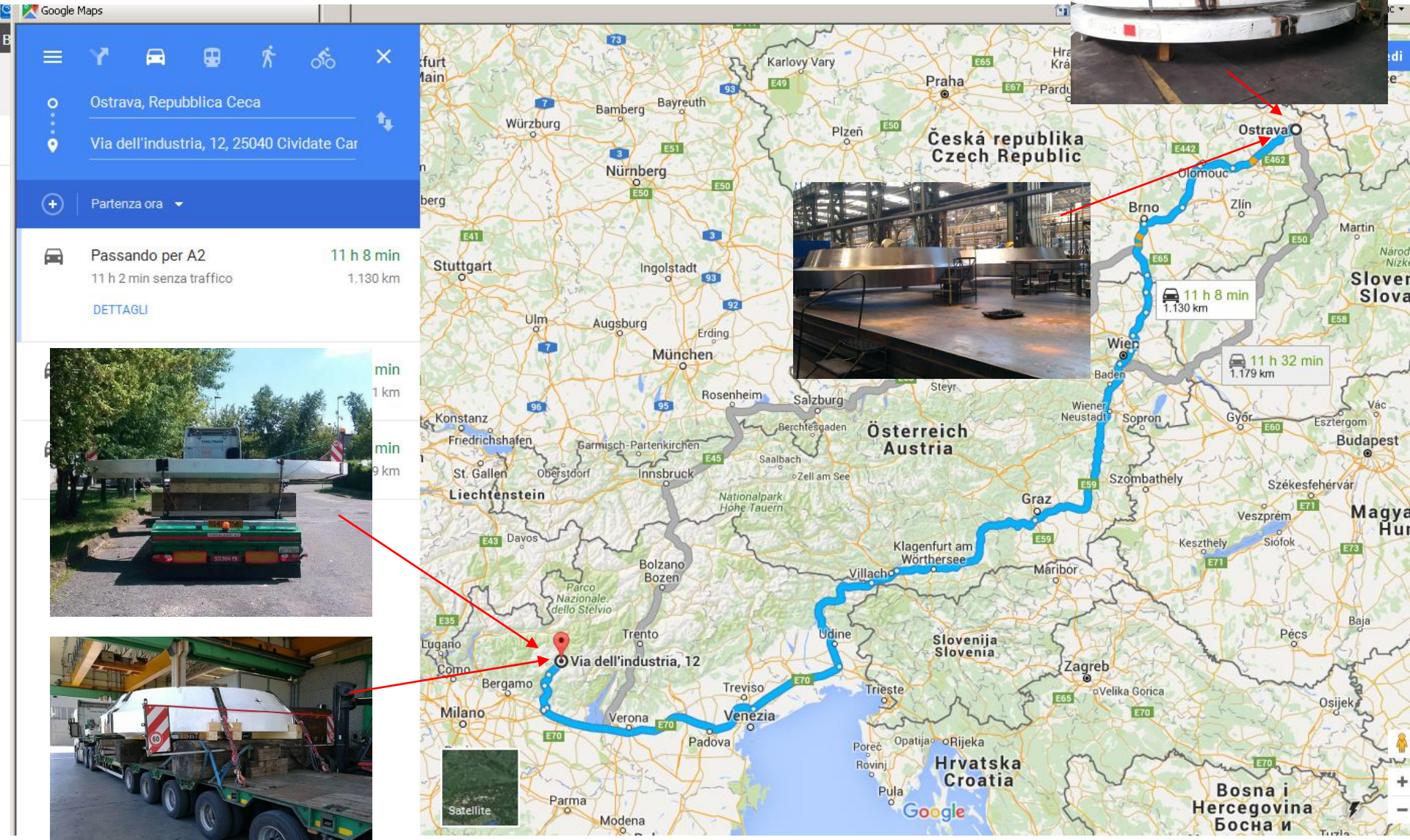
All other elements are inside tolerances

Ultrasonic control: good

Mechanical properties:

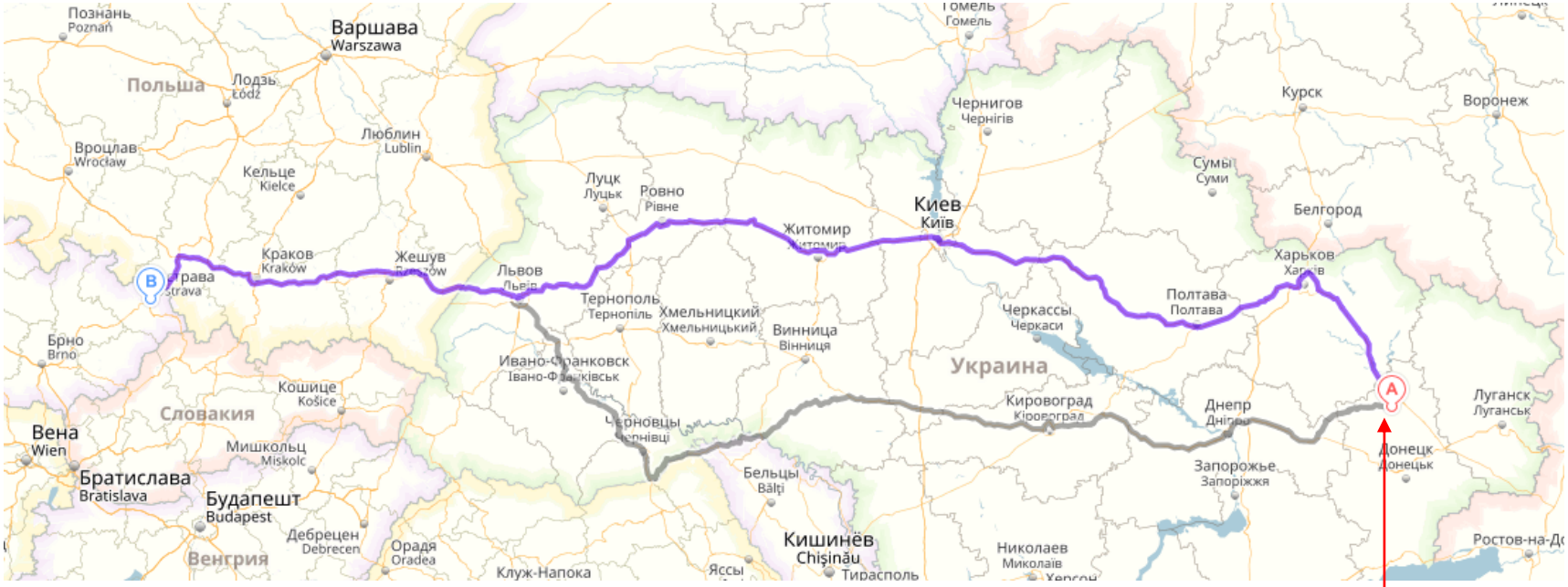
Sigma **0.2** = 231-292 N/mm²
Average = 255 N/mm²
Technical Order = 210 N/mm²

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

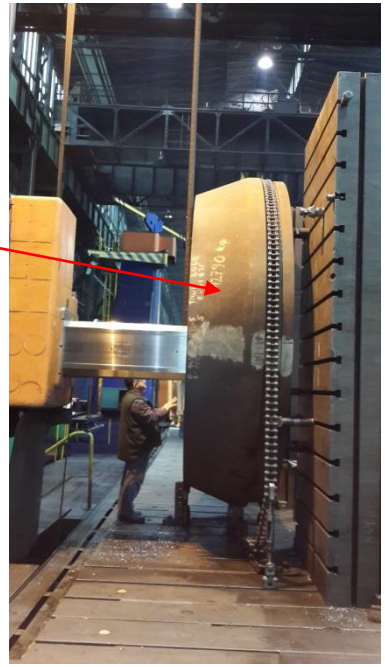


VHM equipment checking

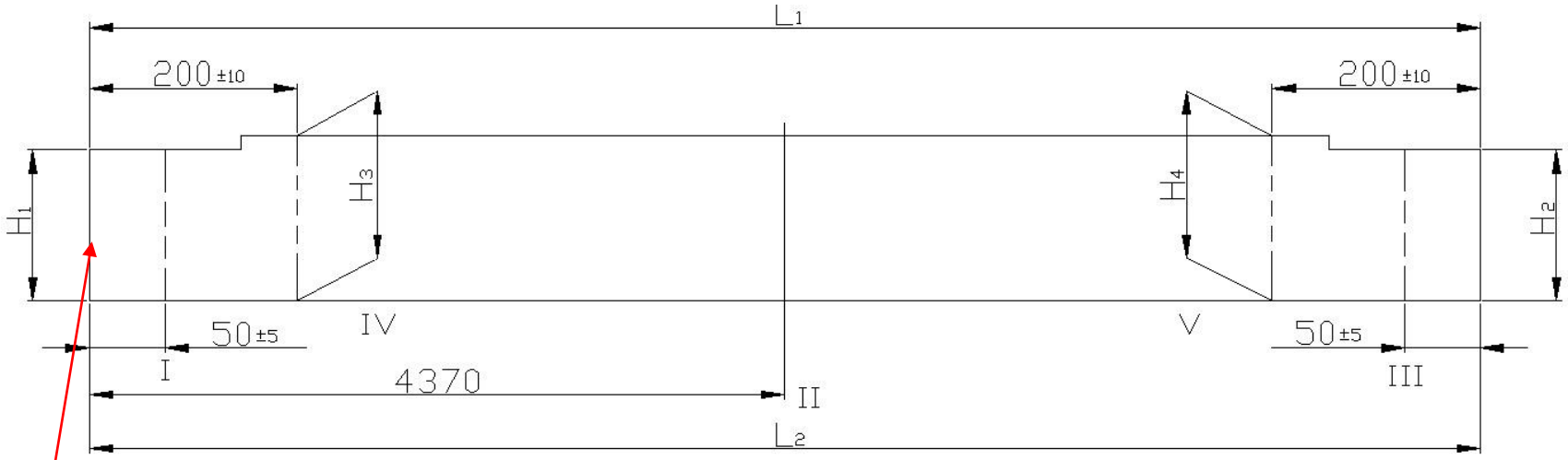
Milling machine for plates

A simple

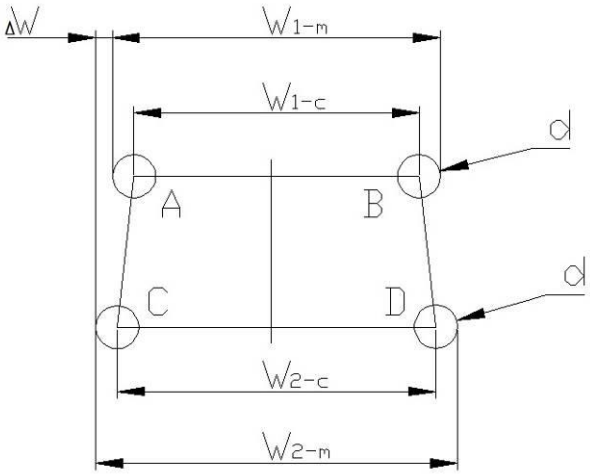
Boring machine for rings



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

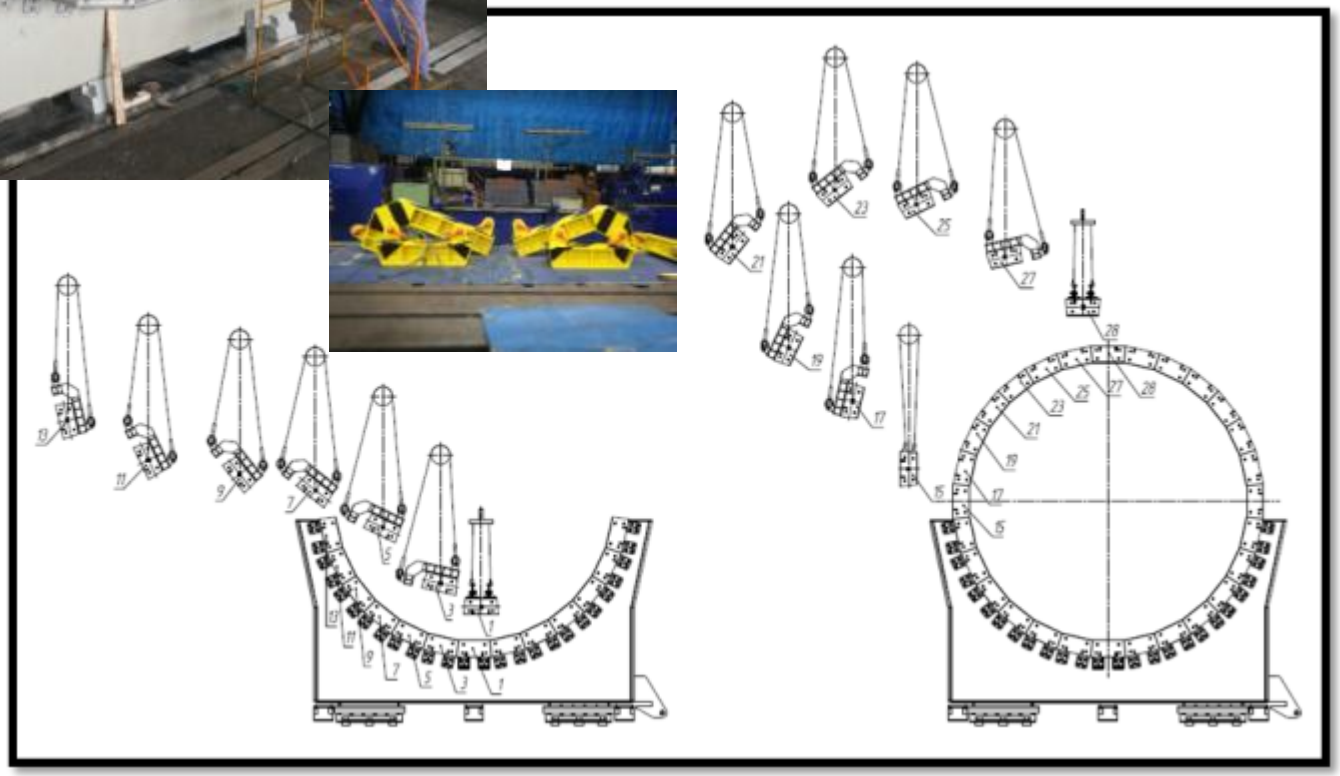
Pole machining

Cradles parts:

6 cradle support

Spacer plates between bottom surface of cradle and Roller Skates

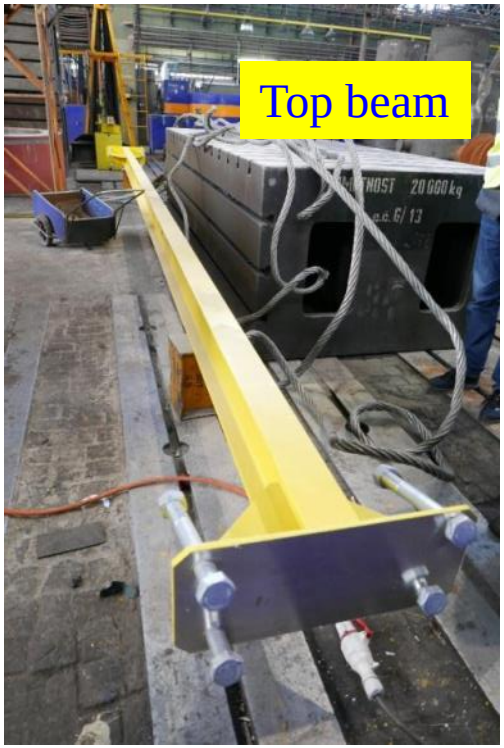
Predicted very useful tool !

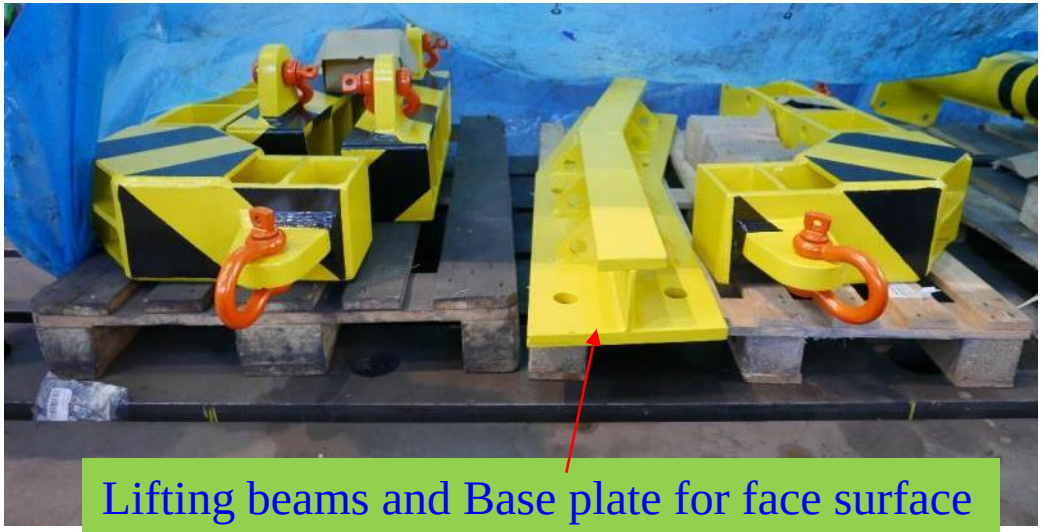


Poles transport supports (2 ps)

Rings billets

Technological tool





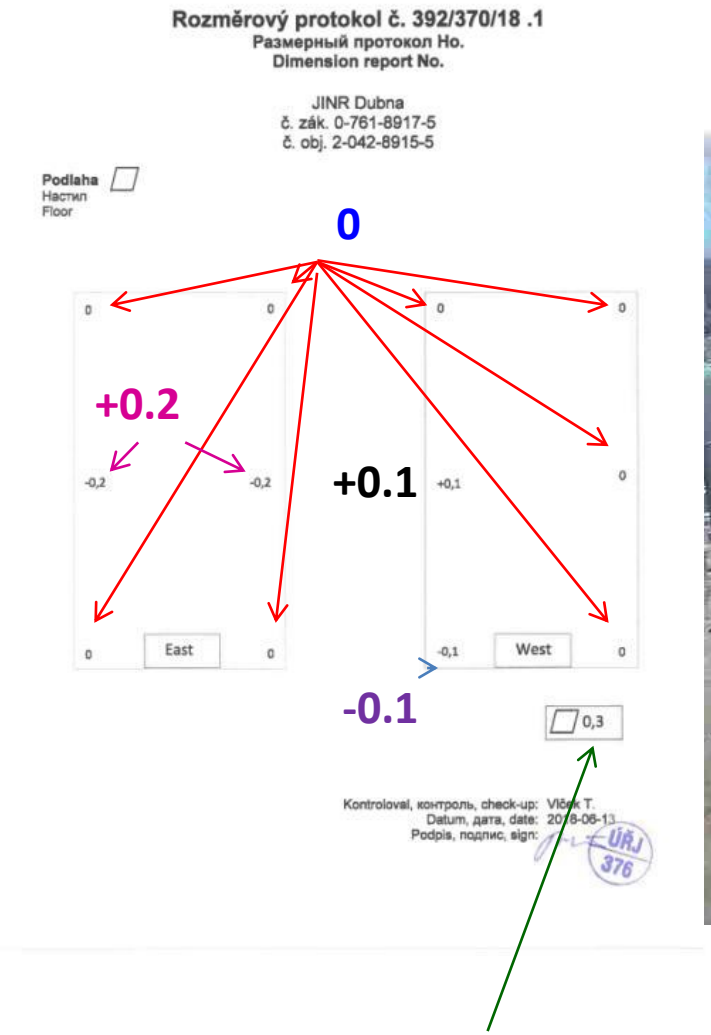
Lifting beams and Base plate for face surface

Lifting beam for plugs inserting-removing in vertical plates

Plugs

Preassembly experience at VHM

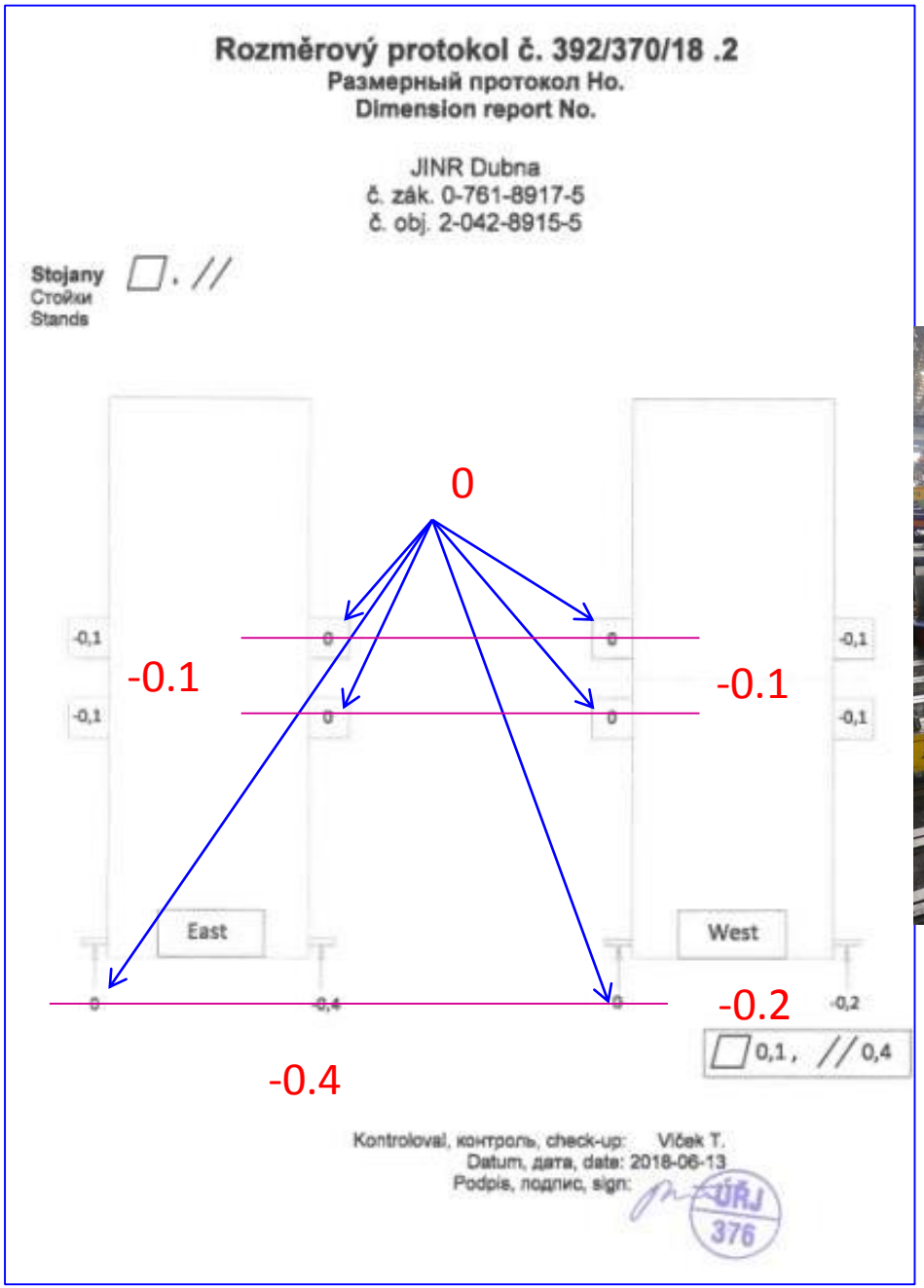
Floor flatness on area 7x7 m²



Common non-flatness is 0.3 mm

Status on 04 June 2018

Stands shape



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" !

VÍTKOVICE
VÍTKOVICE HEAVY MACHINERY a.s.

ROZMĚROVÝ PROTOKOL
DIMENSION DRAWING
РАЗМЕРОВЫЙ ПРОТОКОЛ

Strana: / Page: / Страница: 1 / 5
Č.: / No.: / №.: 0258/370/18

Zákazník: / Customer: / Заказчик:	Název: / Name: / Название:	Tavba/Č.: / Heat/current No.:/ Плавка/ т. №:
JINR Dubna Россия	STOJAN СТОЙКА STAND	/ Zk.č.: / Test No.: / Проба №: /

Smlouva č.: / Contract No.: / Контракт / № :	Výkres č.: / Drawing No.: / Чертёж / №.:	Podmínky č.: / Conditions No./ Условия / №.:	Zakázka/p.č. / Order No./ Заказа / поз. / №.:
2-042-8915-5	0-ZP-01022503 Rev.6 0-ЗП-01022503 Рев.6	-	0-761-8990-6 / 2002

Sym.	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 ± 0,8	3900,00		X	
	Ø 125 H7 + 0,04 / 0	125,01 ÷ 125,04		X	
	4405 + 0,2	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 + 0,3	3918,00		X	

Kontroloval (útvar, datum, jméno, podpis)
Inspected: (Department, Date , Signature)
Контролировал (Отделение, Дата, Подпись)

402.3, 2018-04-26, Jiří Fukna
Miloslav Mrázek

Schválil (útvar, datum, jméno, podpis)
Approved by(Department , Date , Signature)
Одобрил (Отделение, Дата, Подпись)

VÍTKOVICE HEAVY MACHINERY
402.3, 2018-04-26, Daniel Konečný 402.3 - MEZIOPERAČNÍ A VÝSTUPNÍ KONTROLA

Plate #1 installation (5 June 2018)

Plate #1 installation (5 June 2018)

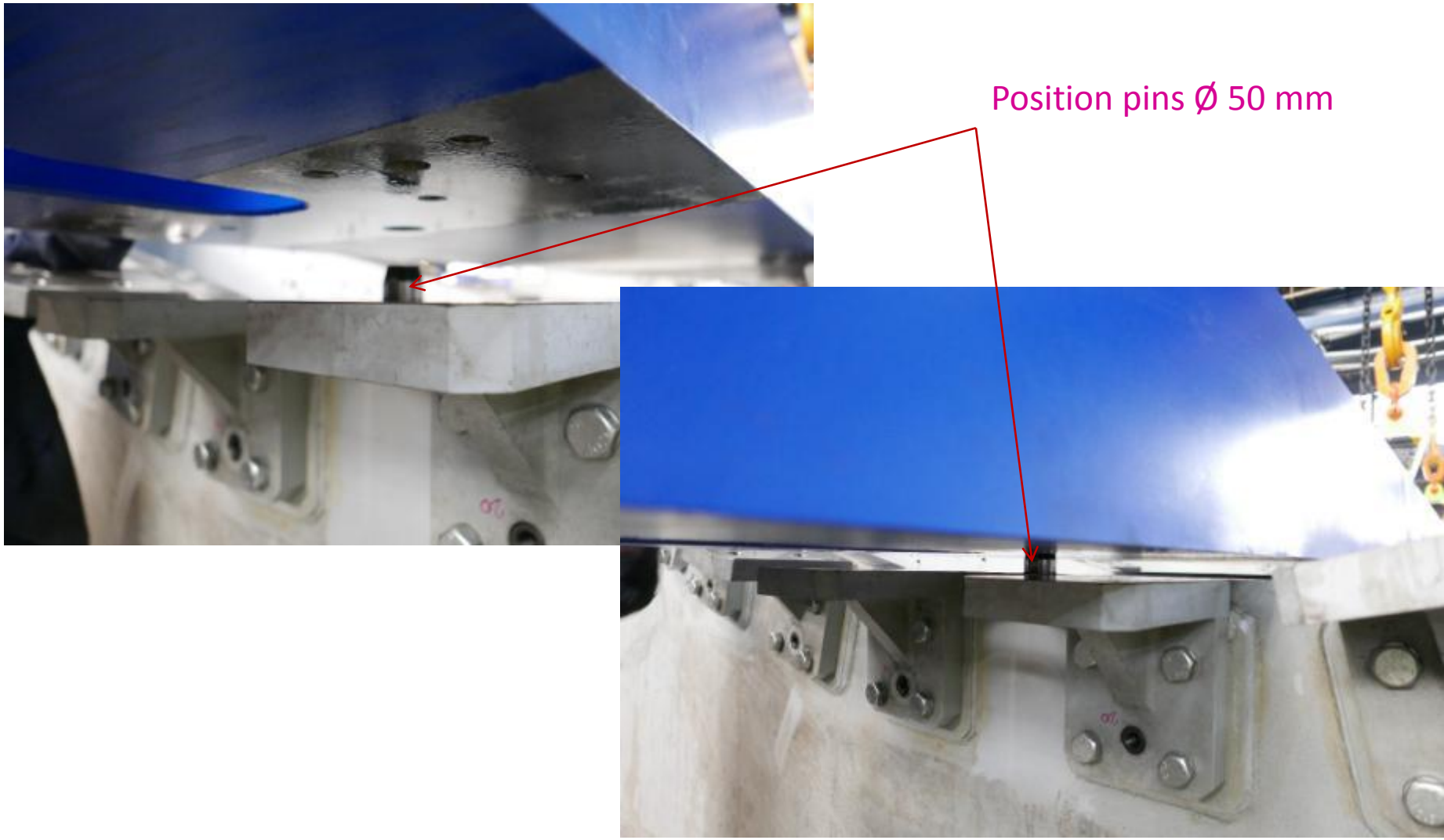


Plate #1 installation (5 June 2018)

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

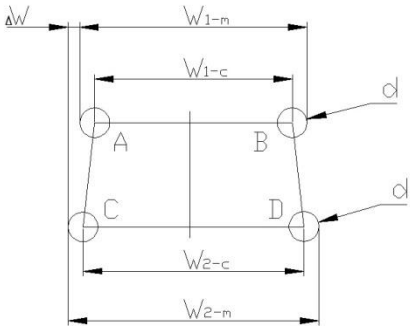
2 plates in place

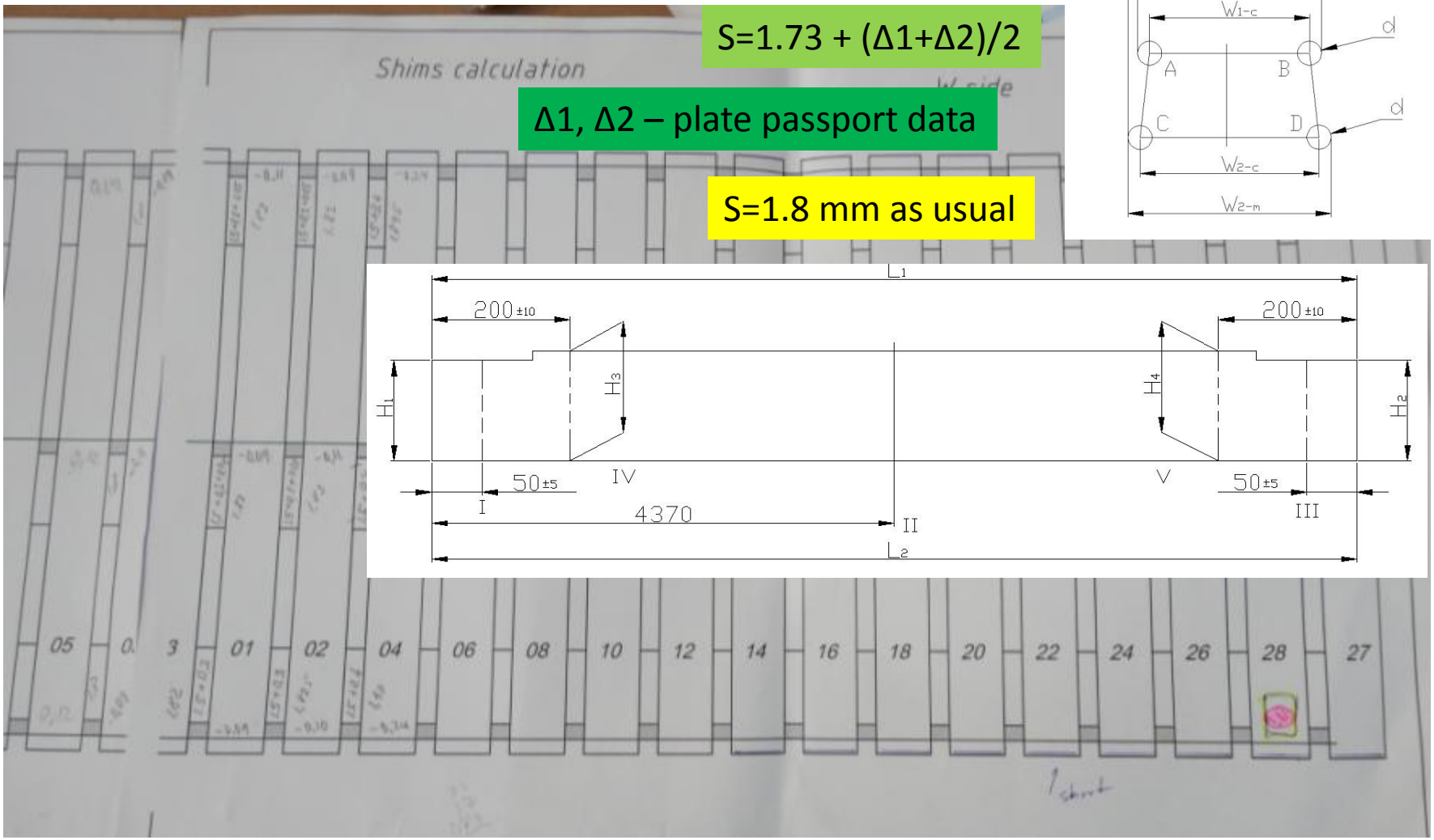
Shims calculation

S=1.73 + (Δ1+Δ2)/2

Δ1, Δ2 – 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)

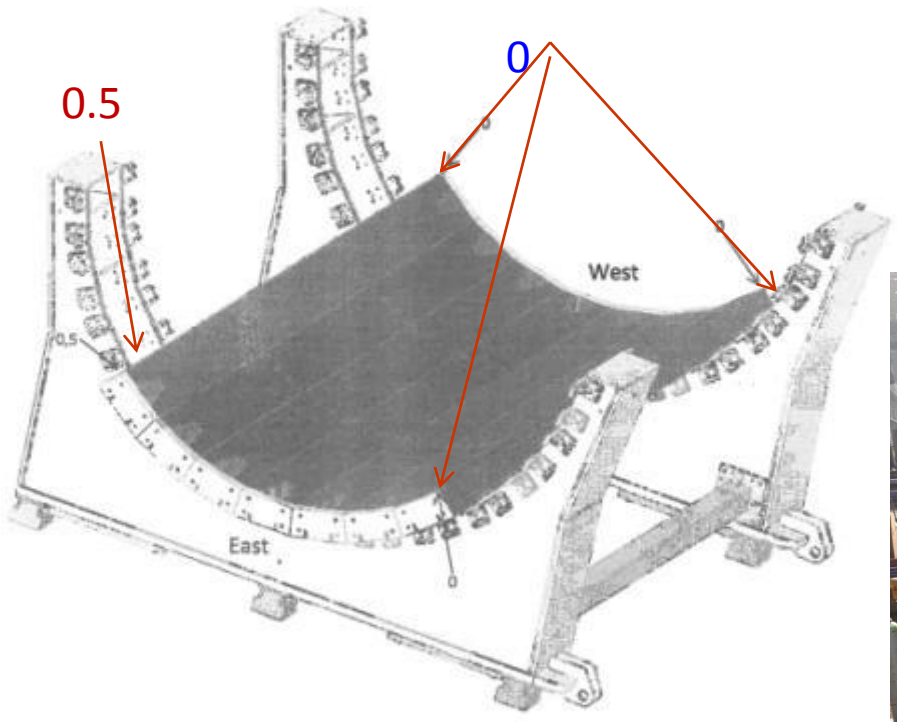
Top points flatness measurement of 7 plates

7 plates in assembly

Rozměrový protokol č. 392/370/18 .3
Размерный протокол Но.
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



0,5

Kontroloval, контроль, check-up: Vlček T.
Datum, дата, date: 2018-06-13
Podpis, подпис, sign:

ÚŘJ 376

1/1

Assembly step

Plate #13 installation (9 June 2018)

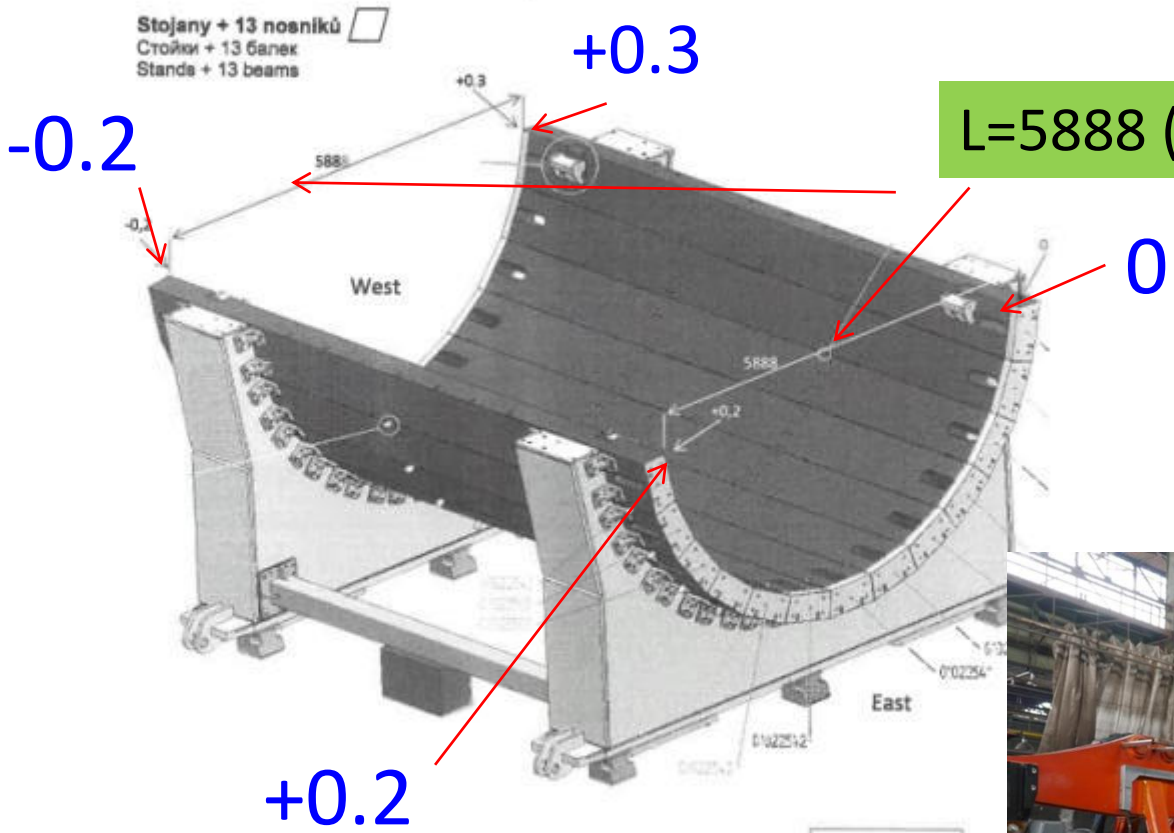
13 plates in place

13 plates in assembly

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

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

Stojany + 13 nosníků
Стойки + 13 балек
Stands + 13 beams



0,5
L = 5888 -2x

Kontroloval, контроль, check-up: Vlček T.
Datum, дата, date: 2018-06-13
Podpis, подпис, sign:

ÚŘJ 376

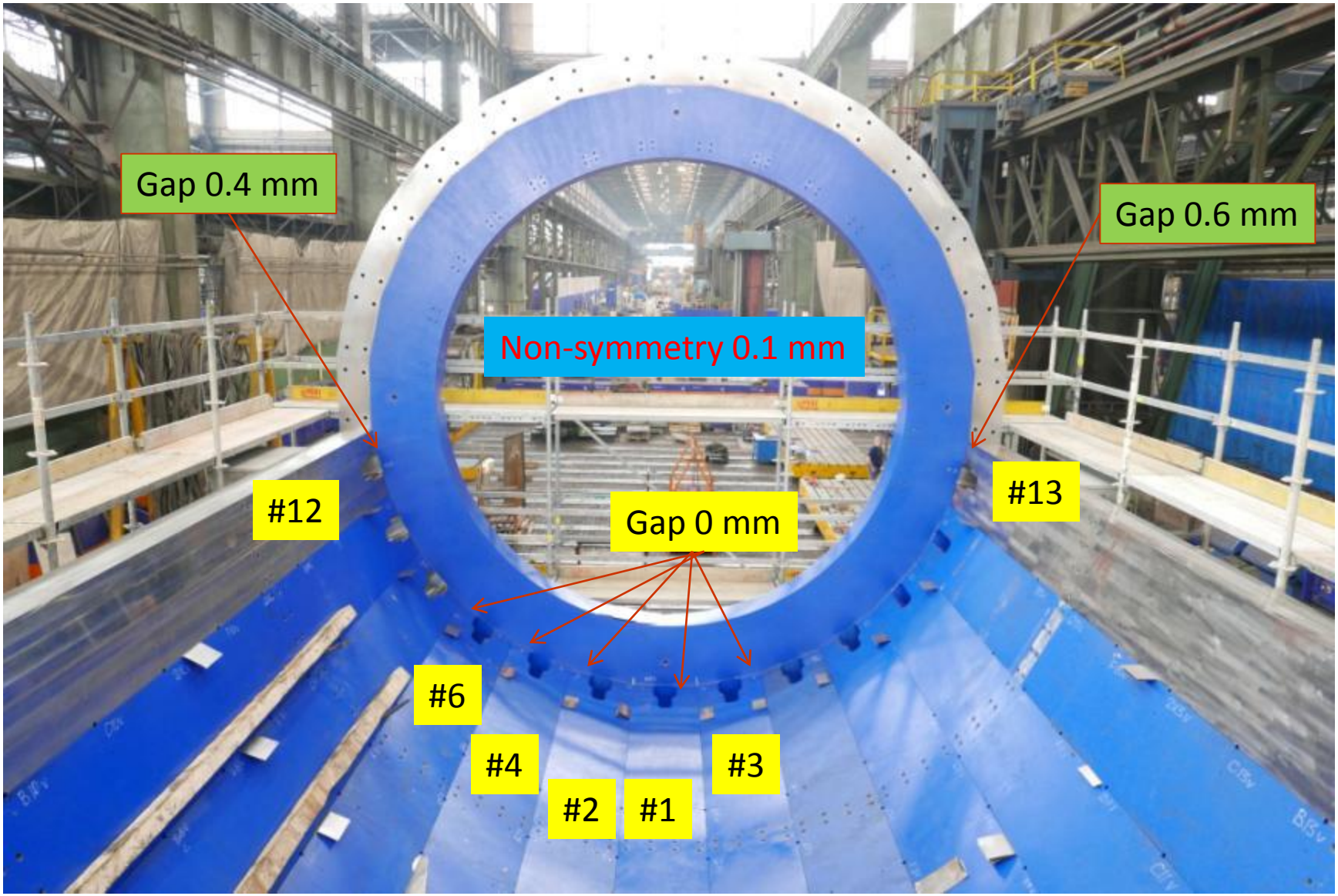
1/1

Scaffolding erection

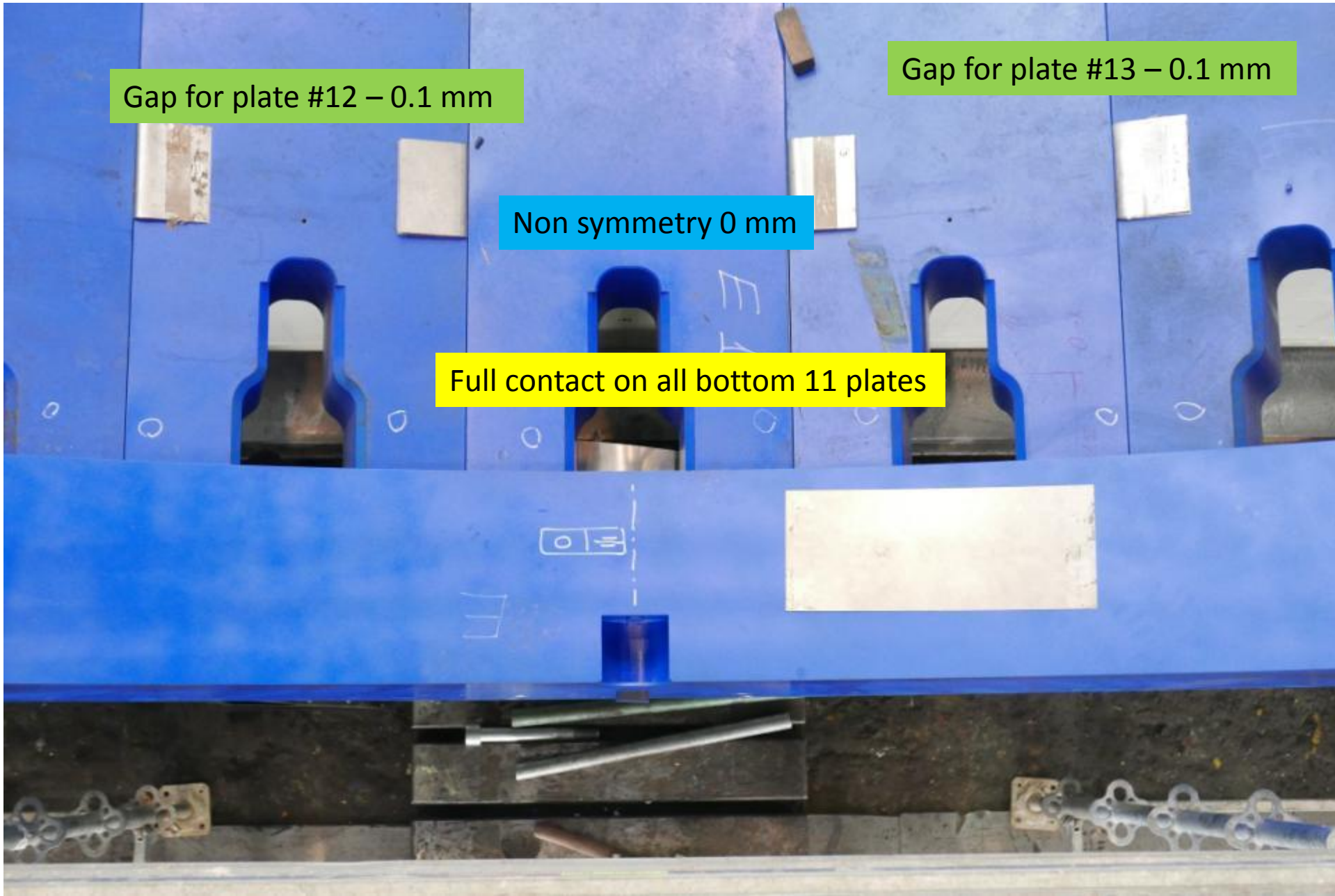
Support ring manipulation

Support ring #1 installation (12 June 2018)

Support ring #1 on side W



Support ring #2 installation (13 June 2018)

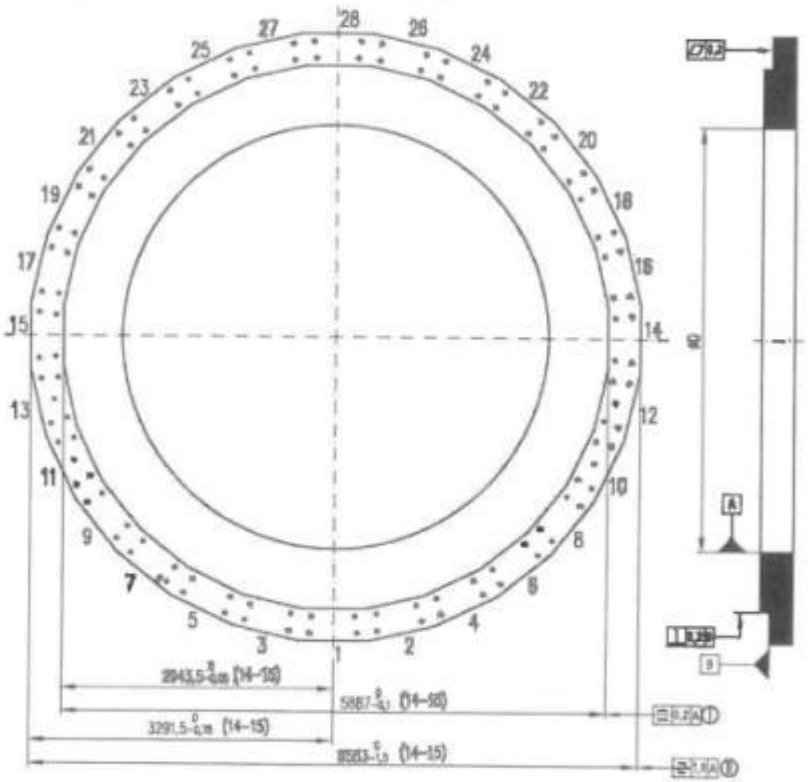


0364/370/17

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. / Опорное кольцо № / Supporting wheel No. 1 , dle výkresu č. / по чертежу № / acc. to dwg 1-ZP-01022548



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	Dimension acc. to dwg	Measured dimension	Calculated value	Deviation from dwg	Real deviation	Note
D	4596 H8	4596,37	4596,50	+ 0,5	+ 0,37	OK
1-25	2943,5	2943,48	2943,45	- 0,05	- 0,02	OK
	5887,0	5886,95			- 0,05	OK
	3291,5	3291,08	3290,75	- 0,75	- 0,42	OK
	6583,0	6582,21	6581,50	- 1,5	- 0,79	OK
	I 0,2	0,02		0,2	0,02	OK
	II 1,0	0,03		1,0	0,03	OK
2-27	2943,5	2943,47	2943,45	- 0,05	- 0,03	OK
	5887,0	5886,96			- 0,04	OK
	3291,5	3291,12	3290,75	- 0,75	- 0,38	OK
	6583,0	6582,32	6581,50	- 1,5	- 0,68	OK
	I 0,2	0,02		0,2	0,02	OK
	II 1,0	0,04				
4-25	2943,5	2943,47	2943,45	- 0,05	- 0,03	OK
	5887,0	5886,95	5886,90	- 0,1	- 0,05	OK
	3291,5	3291,17	3290,75	- 0,75	- 0,33	OK
	6583,0	6582,42	6581,50	- 1,5	- 0,58	OK
	I 0,2	0,02		0,2	0,02	OK
	II 1,0	0,04				
6-23	2943,5	2943,48	2943,45	- 0,05	- 0,03	OK
	5887,0	5886,95	5886,90	- 0,1	- 0,05	OK
	3291,5	3291,12	3290,75	- 0,75	- 0,38	OK
	6583,0	6582,30	6581,50	- 1,5	- 0,70	OK
	I 0,2	0,02		0,2	0,02	OK
	II 1,0	0,03				
8-21	2943,5	2943,46	2943,45	- 0,05	- 0,04	OK
	5887,0	5886,97	5886,90	- 0,1	- 0,03	OK
	3291,5	3291,07	3290,75	- 0,75	- 0,43	OK
	6583,0	6582,20	6581,50	- 1,5	- 0,80	OK
	I 0,2	0,03		0,2	0,02	OK
	II 1,0	0,03				
10-19	2943,5	2943,47	2943,45	- 0,05	- 0,03	OK
	5887,0	5886,95	5886,90	- 0,1	- 0,05	OK
	3291,5	3291,15	3290,75	- 0,75	- 0,35	OK
	6583,0	6582,38	6581,50	- 1,5	- 0,62	OK
	I 0,2	0,02		0,2	0,02	OK
	II 1,0	0,04				
12-17	2943,5	2943,48	2943,45	- 0,05	- 0,02	OK
	5887,0	5886,95	5886,90	- 0,1	- 0,05	OK
	3291,5	3291,10	3290,75	- 0,75	- 0,40	OK
	6583,0	6582,26	6581,50	- 1,5	- 0,74	OK
	I 0,2	0,02		0,2	0,02	OK
	II 1,0	0,03				

4-ZP-68 100 rev.2

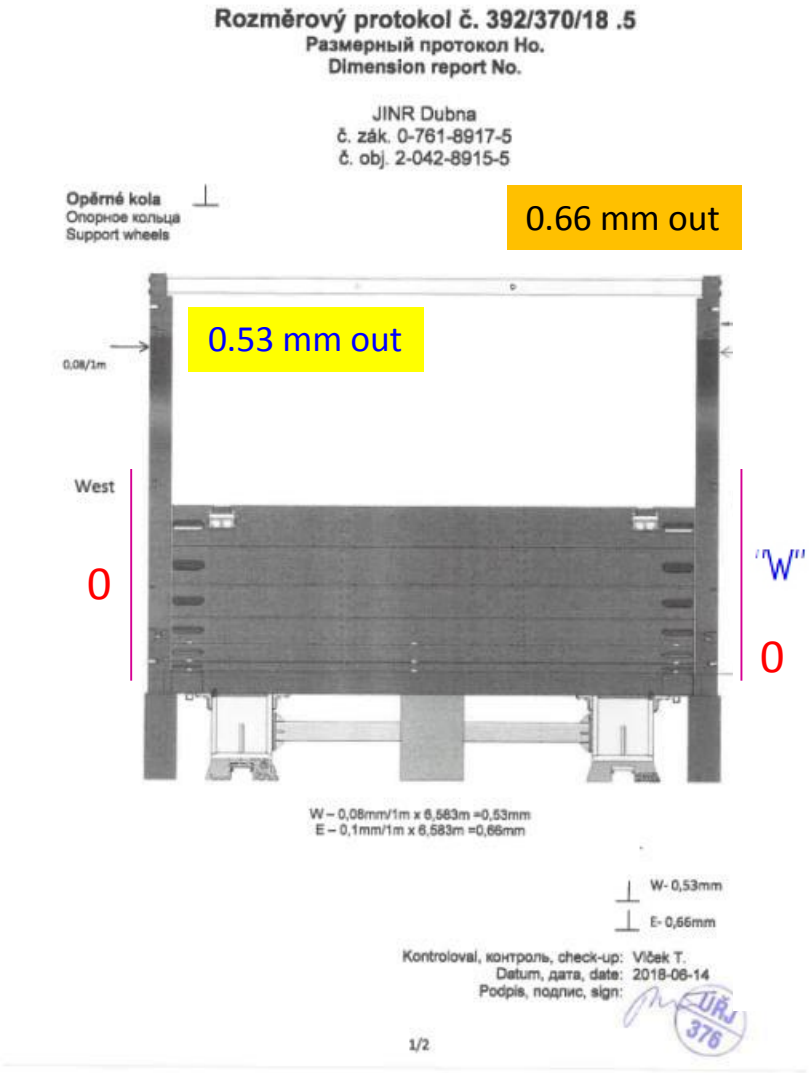
5887 -0.1 , really it is < 0.05 mm

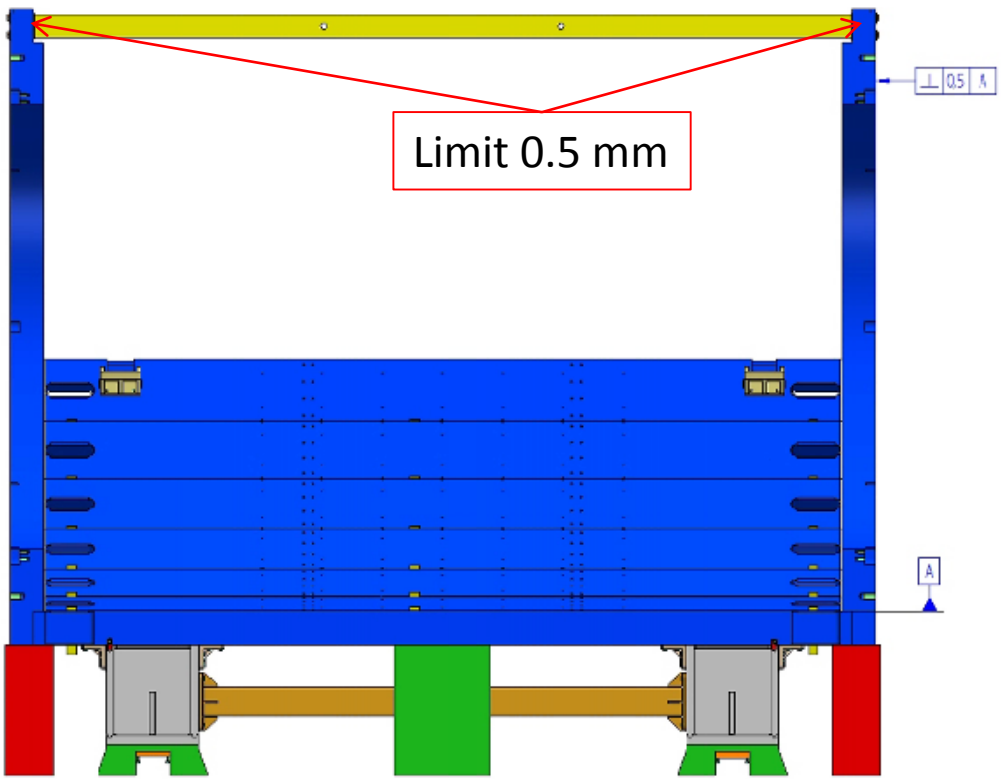
Support rings on both sides

Technology beam (8470 mm) installation

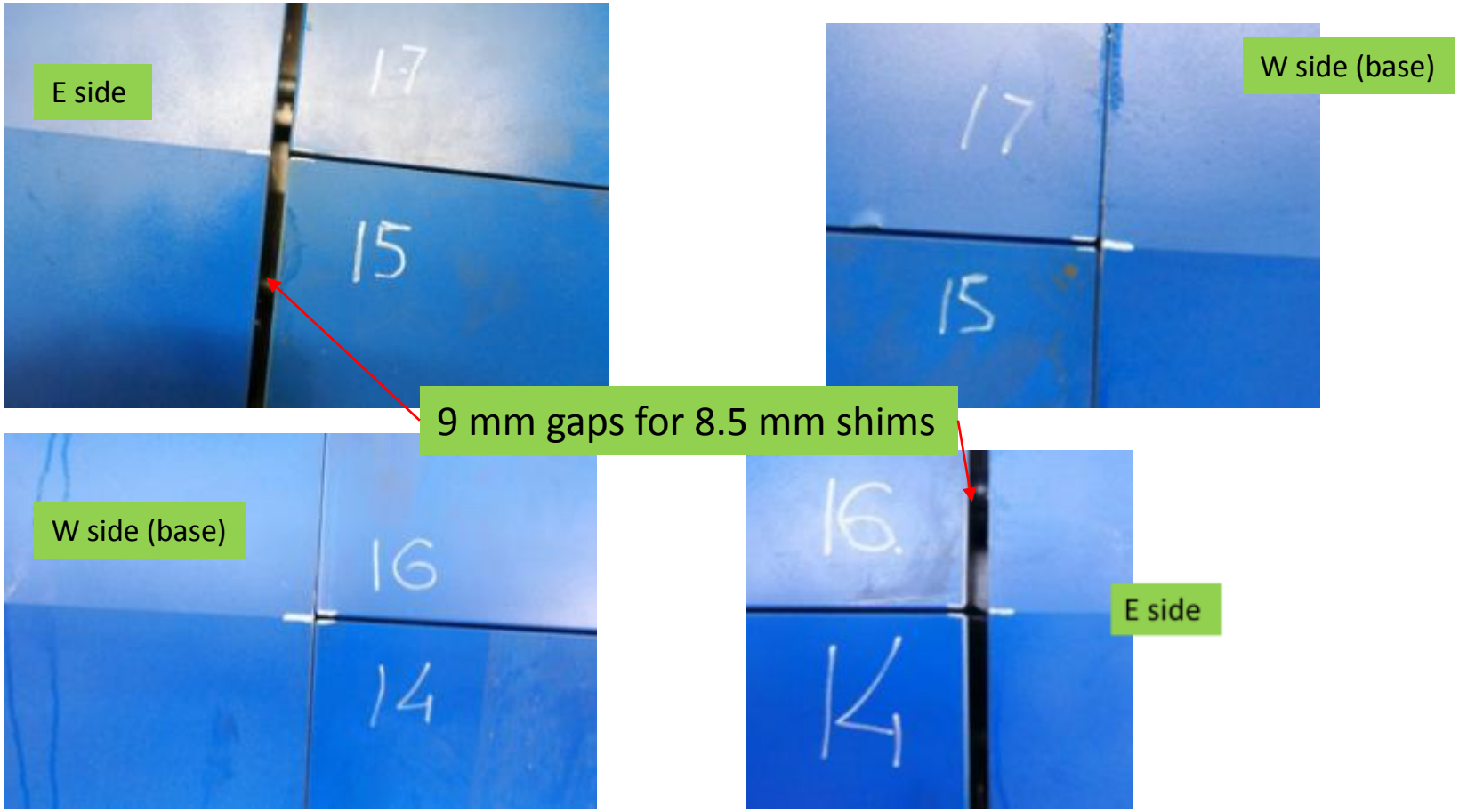
Plate installation

2 support ring in assembly





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



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

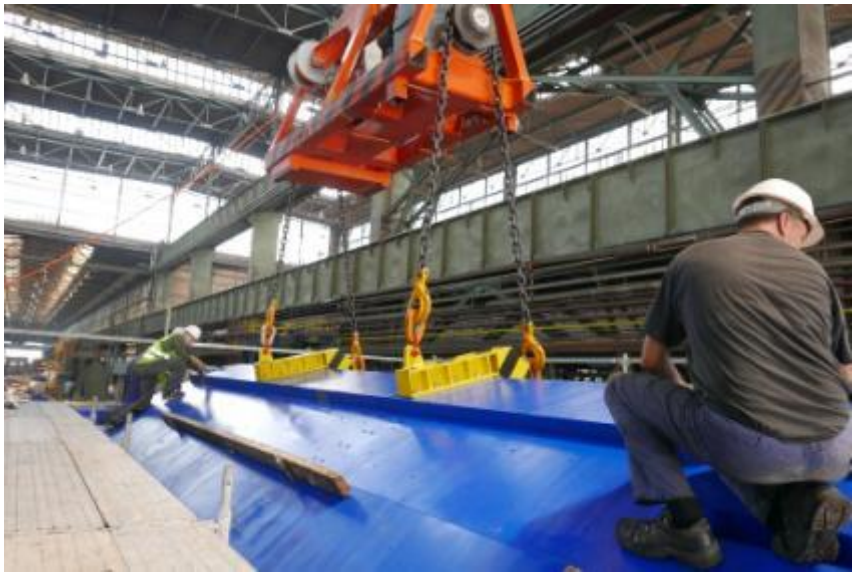
W side (base)

E side

E side

W side (base)

Plate #26 installation



27 plates in place (20 June 2018)

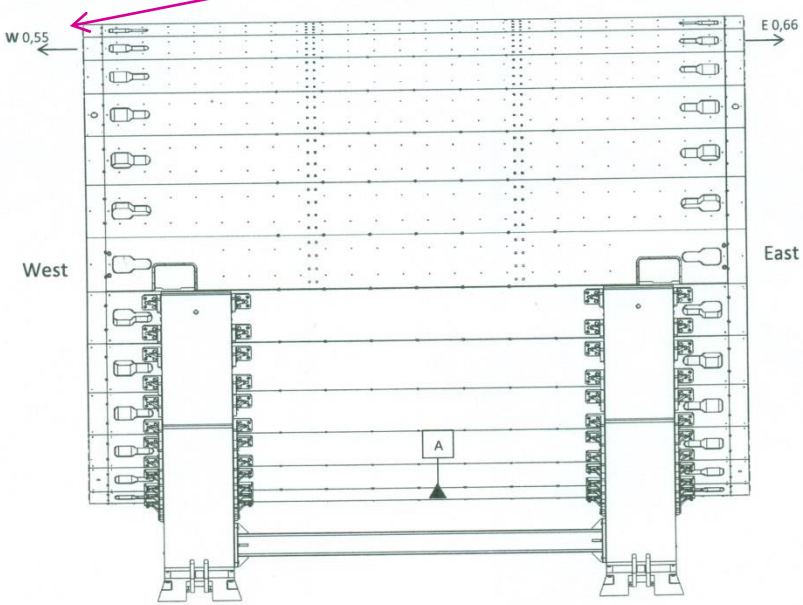
“Final” measurements report (27 plates in assembly)

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

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

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

Opěrné kola + 27 hosníků
Опорное 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:

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

4-Z000034

-3-

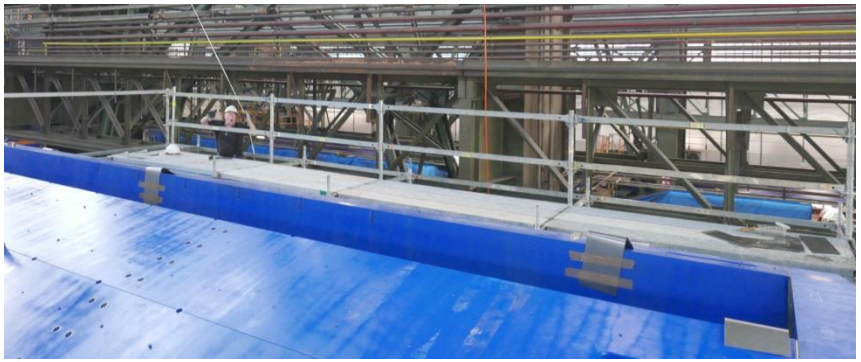
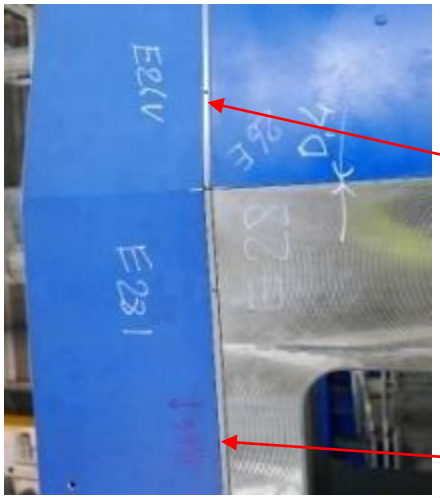


Plate #28

Top plates positions



Gap is zero

Gap is 0.2 mm

Gap between #27 and @28
Is 0.5 mm (fixed by steel shims)

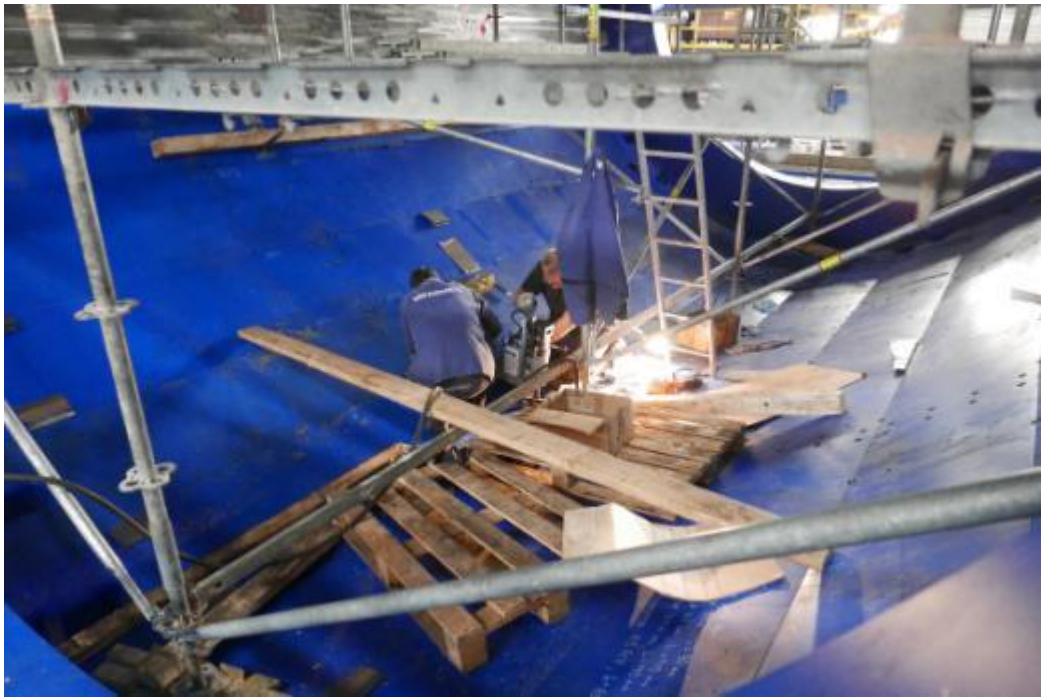
Diameters have nominal dimensions
6583 mm in vertical and horizontal directions
on both sides

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

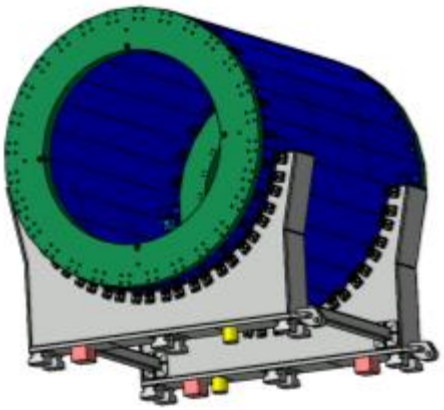
712 Holes drilling (in 5 steps):

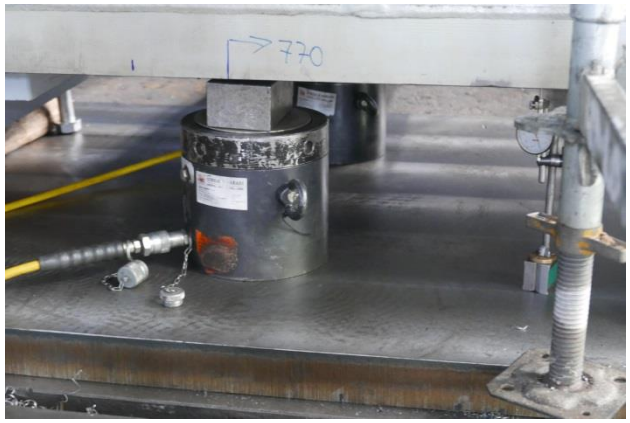
1 – drill 28 mm
2 – mill 30 mm, h = 90 mm
3 – mill 32 mm, h = 90 mm
4 – mill 32.6 mm, h = 90 mm
5 – rimmer 33H7 (0+0.025), h = 80-85 mm

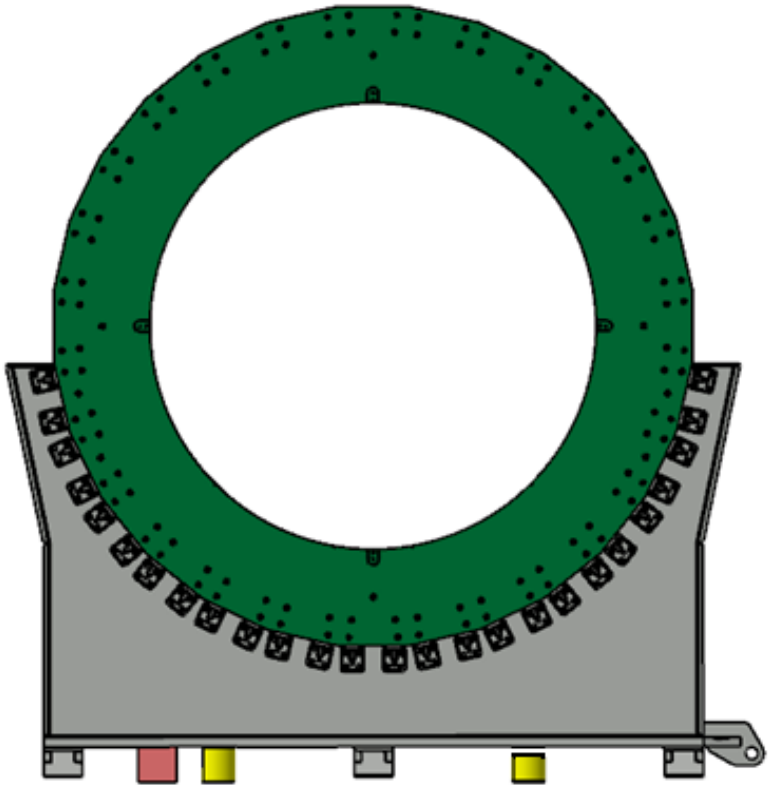
279 from 712 are ready (on 23 June)



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)

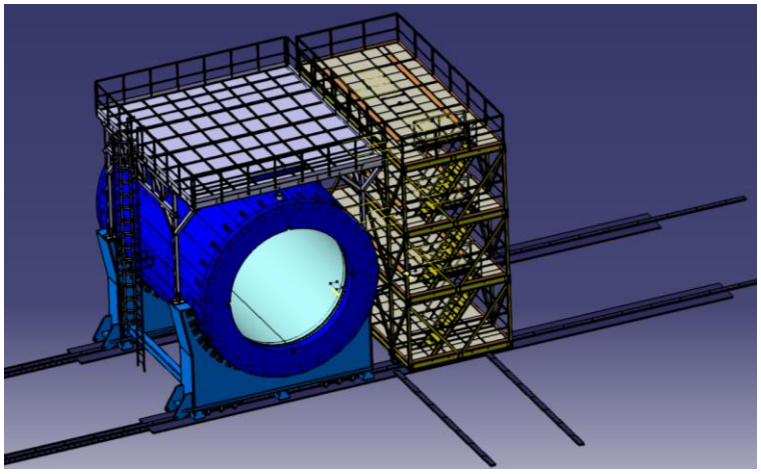
- **We are on the right way:**

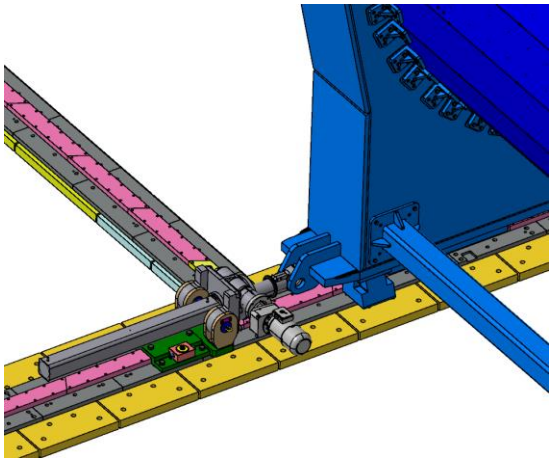
- 1 - there is no mechanical hysteresis
- 2 - All 4 support trolleys accept half of the standard load
- 3 - Local load on the concrete is 50% of the design: increases the durability of the foundation and reduces the chance of subsidence of rail tracks in the process of exploitation (локальные нагрузки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

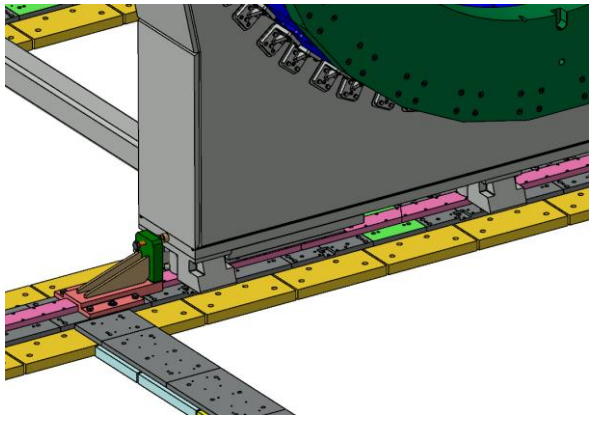
Many thanks to “AET Trans”

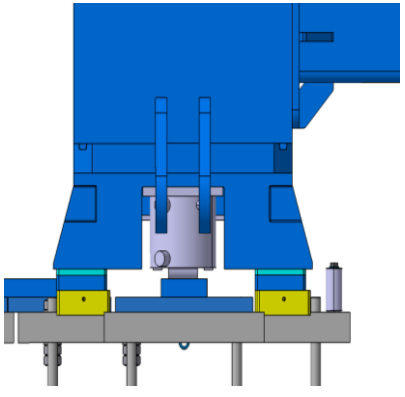
All rings was delivered in time without any extra tax on the roads

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