Q1/Q3 Cold Mass at CERN

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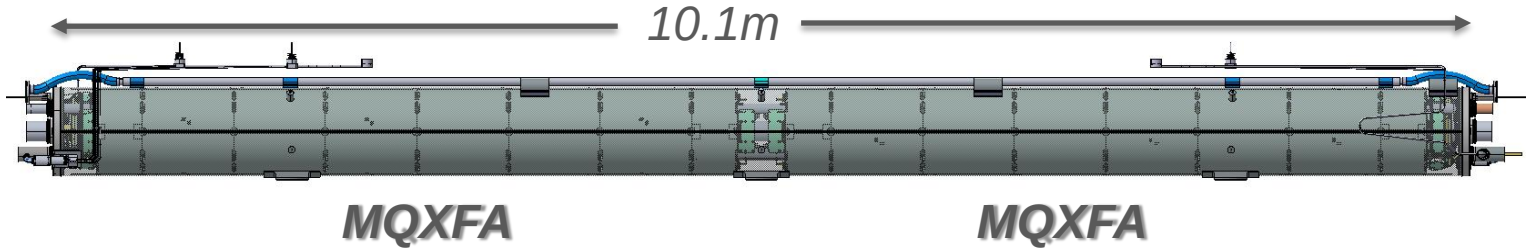
Outline

Following the CERN cold mass assembly workflow, what is the tooling needed to assemble a LMQXFA cold mass? Mainly in terms of:

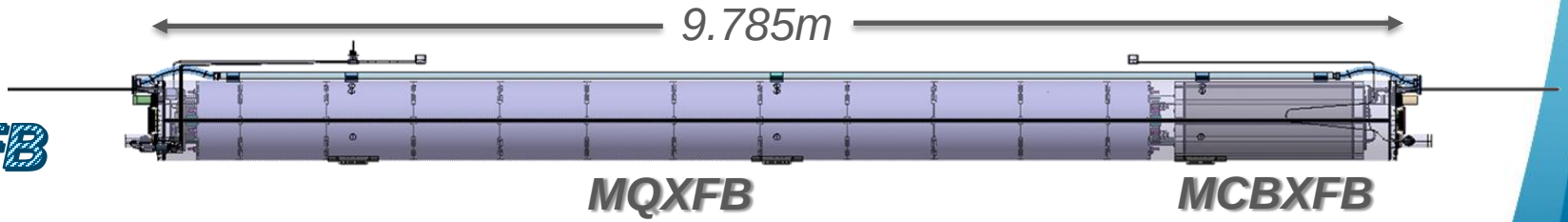
- Handling
- Alignment
- Splicing
- Fixed point anchoring
- Welding
- …

LMQXFA / LMQXFB

Q1-Q3
LMQXFA



Q2
LMQXFB



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YACA PROCESS DIAGRAM

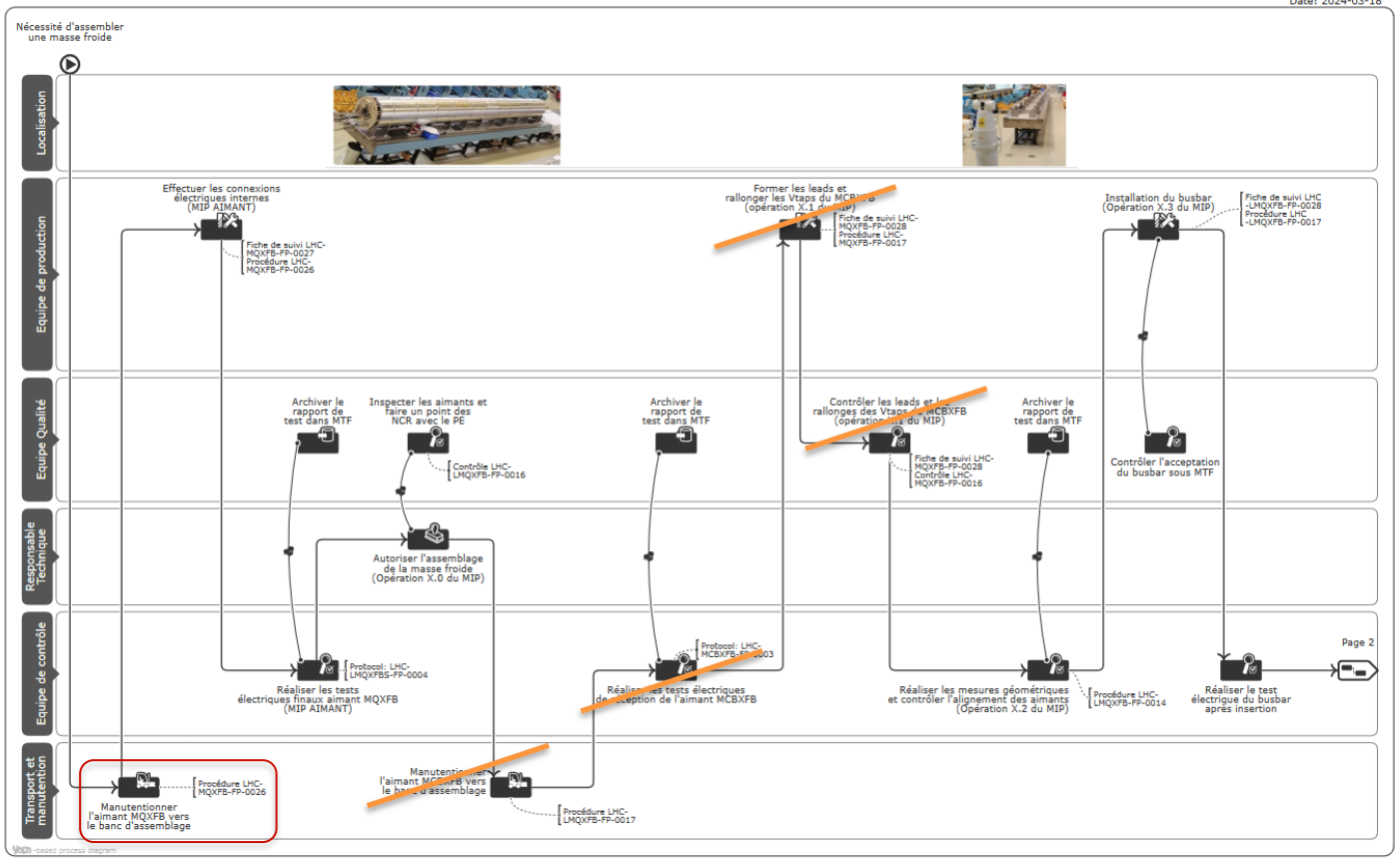
EDMS NO.	REV.	VALIDITY
2366861	2.0	VALID

REFERENCE
LHC-LMQXFB-FP-0002

WP03 - Assemblage d'une masse froide LMQXFB page 1

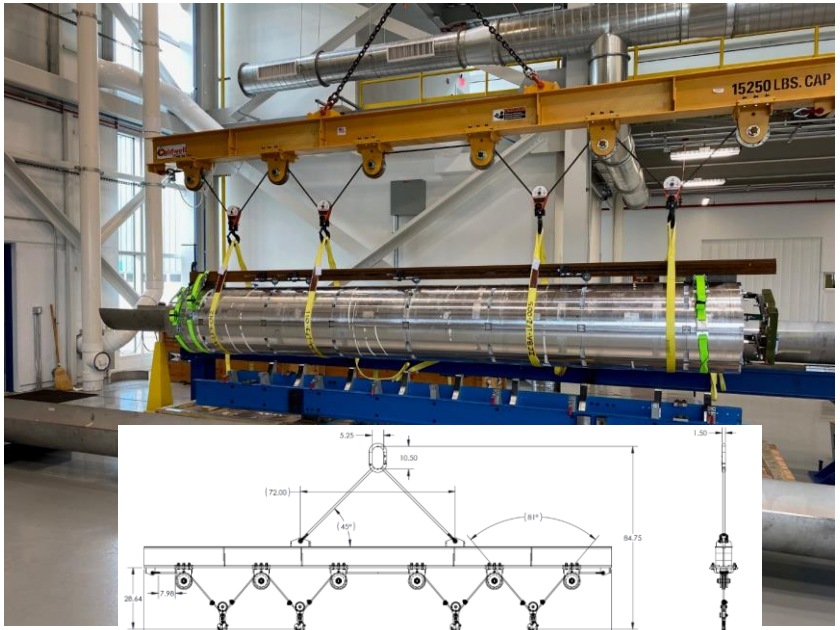
DIAGRAMME DE PROCESSUS ASSOCIÉ AU MIP réf. LHC-LMQXFB-FP-0001

Date: 2024-03-18



MQXFA Magnet handling

Lifting beam @Fermilab



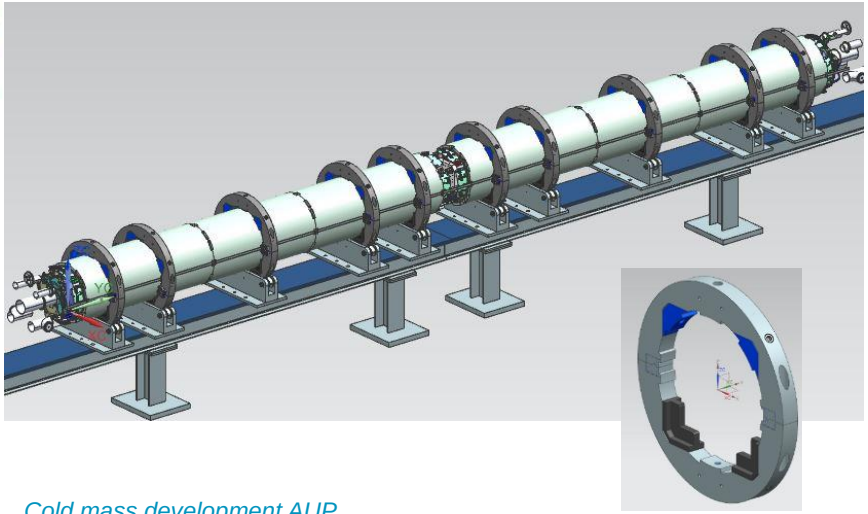
Lifting beam @CERN

Only for MQXFB!

Possibility to recover from LBNL or Fermilab after the last MQXFA has been sent?

MQXFA Magnets Alignment

Tooling @Fermilab



[Cold mass development AUP]

Presented by S. Feher during the 9th LH-LHC Collaboration meeting at Fermilab

Tooling that could be used @CERN

Aluminum storage bench:

- ☺ *Full length available*
- ☺ *Easy and cheep, additional supporting system already available*
- ☺ *Does not interfere with MQXFB assembly and loading*
- ☹ ***Too soft and not stable*** *(Al+plastic feet)*

MQXFB loading bench:

- ☺ *Robust alignment*
- 😐 *Existing supports could be adapted*
- ☹ ***Strong interference with MQXFB assembly***

Cold mass assembly bench:

- ☺ *Robust alignment*
- ☺ *Alignment features at the largest width*
- ☺ *Adaptative longitudinal position of the supports and the magnets*
- 😐 *Extension needed on the MCBXFB side (~2m)*
- ☹ ***Interference with LMQXFB assembly***

MQXFA magnets
new alignment bench in the LMF

Transform the 8m preparation bench used for the CCT magnets, adding the 2m extension of the cold mass assembly bench:

- ☺ *Full length available*
- 😐 *Realignment needed*
- ☺ *Robust alignment*
- ☺ *Adaptative longitudinal position of the supports and the magnets if the system is copied from the cold mass assembly bench.*
- ☺ *Cheaper solution can be designed reusing the additional supporting system already available.*
- ☺ ***No interference with the other HL-LHC cold masses production***

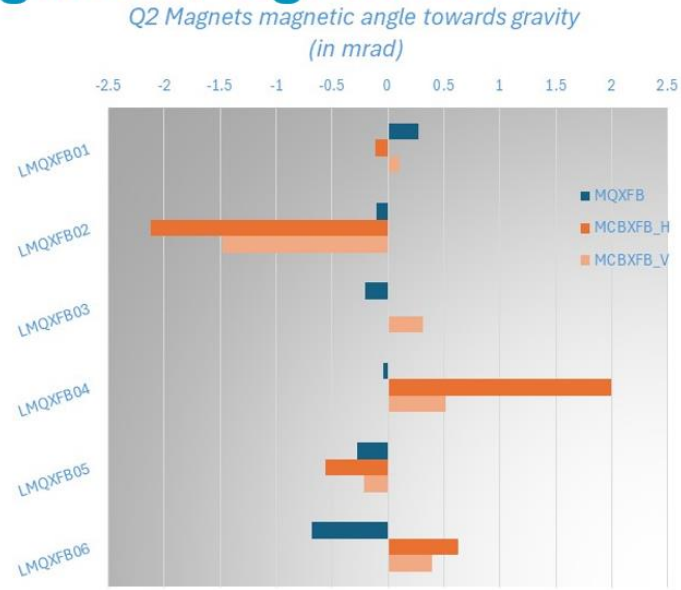
Alignment based on the magnet mechanics and the bench alignment precision.
No possibility to realign the magnets roll contrary to the bench in Fermilab.

CERN experience using mechanics to align the MQXFB rolling angle toward gravity

LMQXFB Q2 Magnetic Alignment

	MQXFB	MCBXFB_H	MCBXFB_V
LMQXFB01	0.27	-0.11	0.10
LMQXFB02	-0.10	-2.12	-1.48
LMQXFB03	-0.20	0.00	0.31
LMQXFB04	-0.04	2.00	0.52
LMQXFB05	-0.28	-0.56	-0.21
LMQXFB06	-0.68	0.63	0.39

Courtesy of M. Pentella



- *Excellent correlation between the MQXFB magnetic axis and the yoke geometry.*
- *The quadrupole geometry can be used to orient the cold mass tilt towards gravity better than within ±1 mrad.*

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WP03 - Assemblage d'une masse froide LMQXFB page 2

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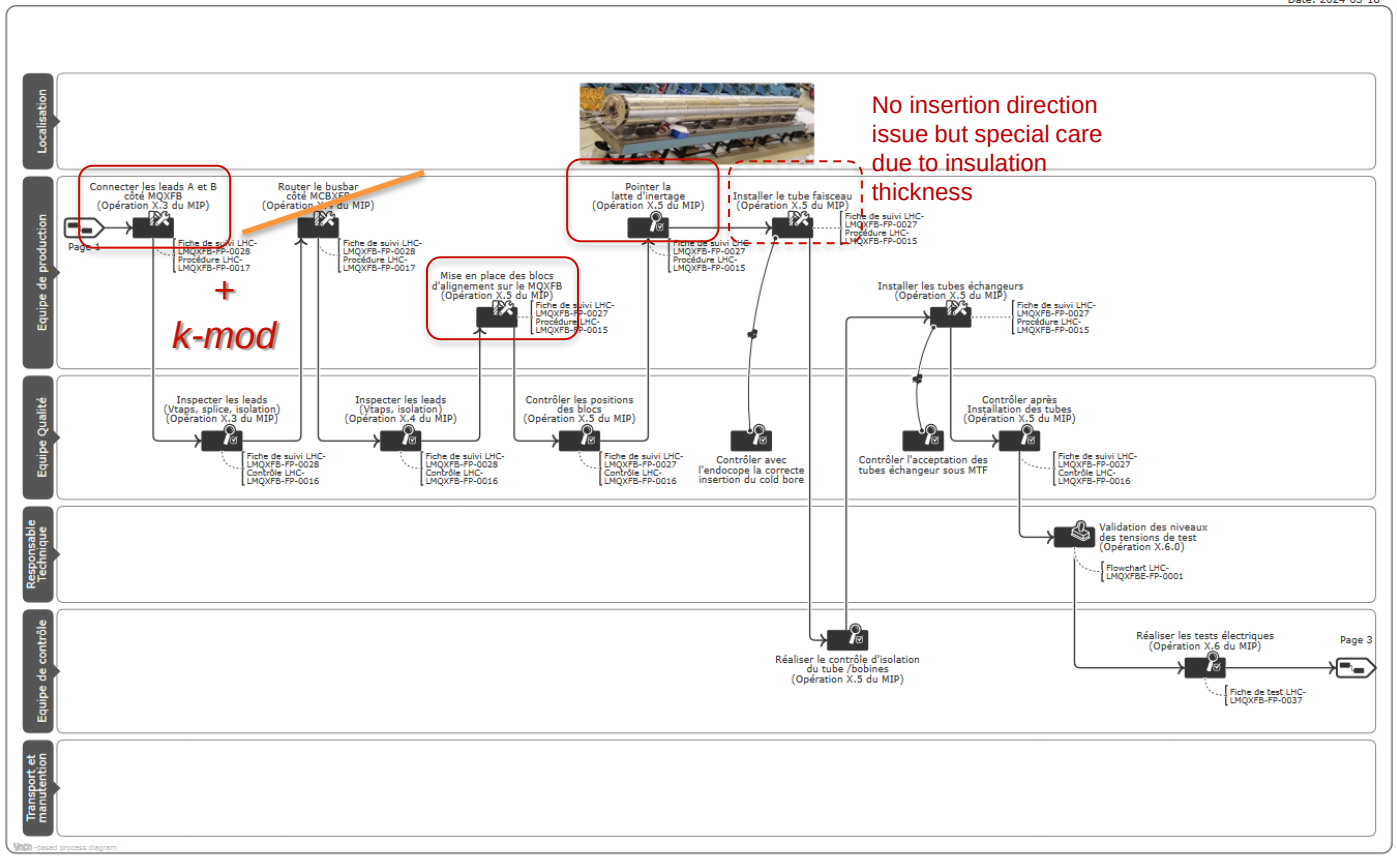
Date: 2024-03-18



13kA circuit and k-mod leads splicing

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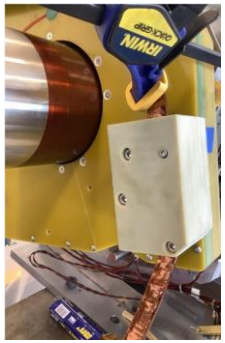

LMQXFA coldmass production experience and plan
Presented by T. Strauss during the 11th LH-LHC Collaboration meeting at CERN

Proposal @CERN

Assuming that the MQXFA magnets are delivered to CERN with their coil leads already spliced.

- Copy and used Fermilab tooling design to connect the busbars

OR

- Adapt CERN tooling reusing the CLIQ cable splicing for the k-mod leads and redesign the busbar fixed point(s)

Tack welding blocks and fixed points

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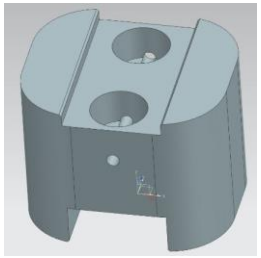
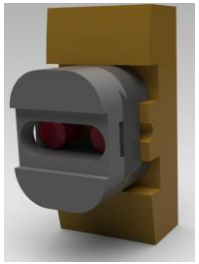
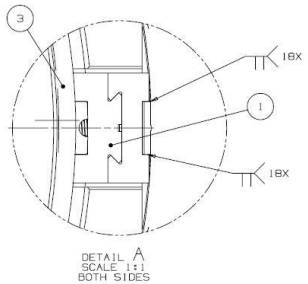


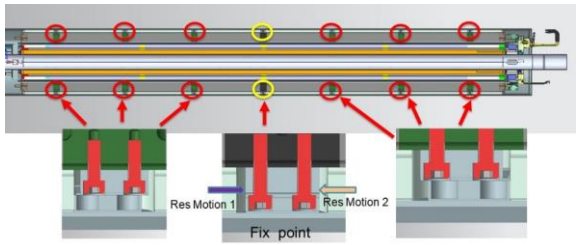
Fixed



Wide Slidding

Narrow Slidding



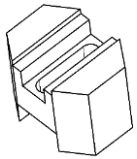


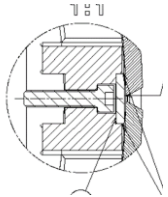
LMQXFA design modification due to requirements change

Presented by A. Vouris during the 11th LH-LHC Collaboration meeting at CERN

Proposal @CERN

- Sliding blocks: use LHCMQXFBS0030 standard MQXFB alignment block



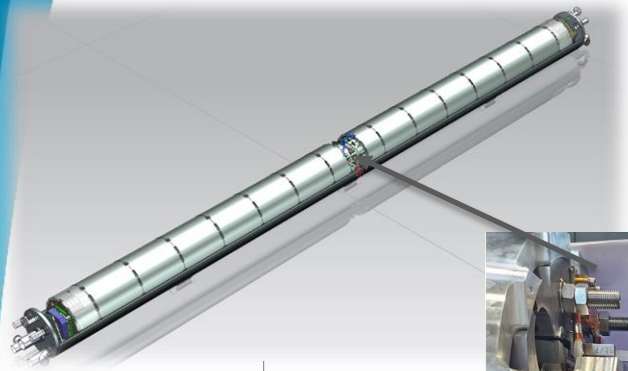


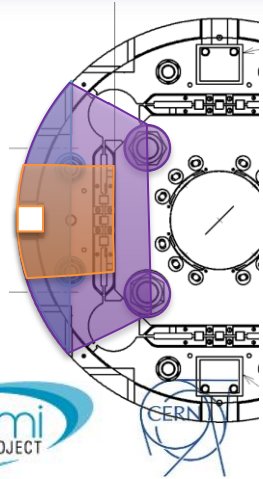
- Fixed point: see Susana's presentation to use LHC standard MQXFB alignment block standard MQXFB fixed point inside a machined yoke plate like for P2 and P3.

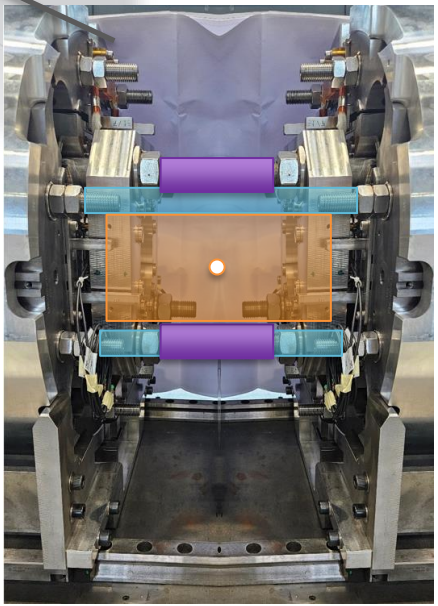
OR

- See next slide

LMQXFA magnets fixing to the cold mass







Additional proposals:

Create an anchoring between the two magnets and the backing strips using either:

- *A junction between the **yoke tie rods***
  - ☺ *One unique fixed point for both magnet aligned with the cold mass fixed point to the cryostat*
  - ☺ *No transmission of force through the end plates to the coils*
  - 😐 *M24 tie rods might imply multiple junctions*

- *A junction between the **collar packs tie rods***
  - ☺ *One unique fixed point for both magnet aligned with the cold mass fixed point to the cryostat*
  - ☺ *M36 tie rods stiffness*
  - ? *Transmission of force through the end plates to the coils*

- *A junction between the **magnet end plates on the NCS***
  - ☺ *One unique fixed point for both magnet aligned with the cold mass fixed point to the cryostat*
  - ☺ *Single piece, easiest to put in place*
  - 😐 *Keys must be shorten*
  - ? *Transmission of force through the end plates to the coils*

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YACA PROCESS DIAGRAM

WP03 - Assemblage d'une masse froide LMQXFB page 3

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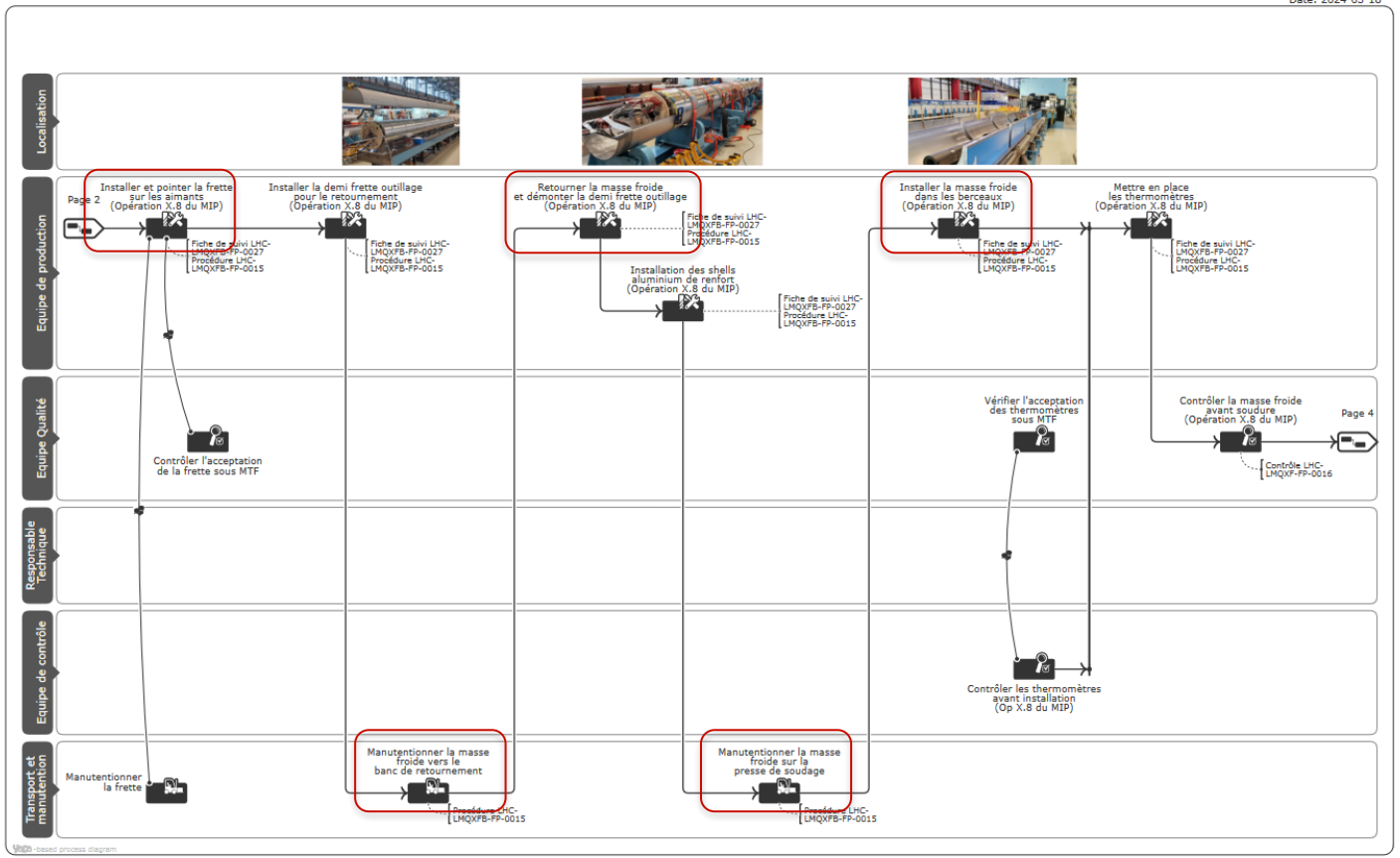
EDMS NO.	REV.	VALIDITY
2366861	2.0	VALID

REFERENCE: LHC-LMQXFB-FP-0002

Date: 2024-03-18



Shell bevel design

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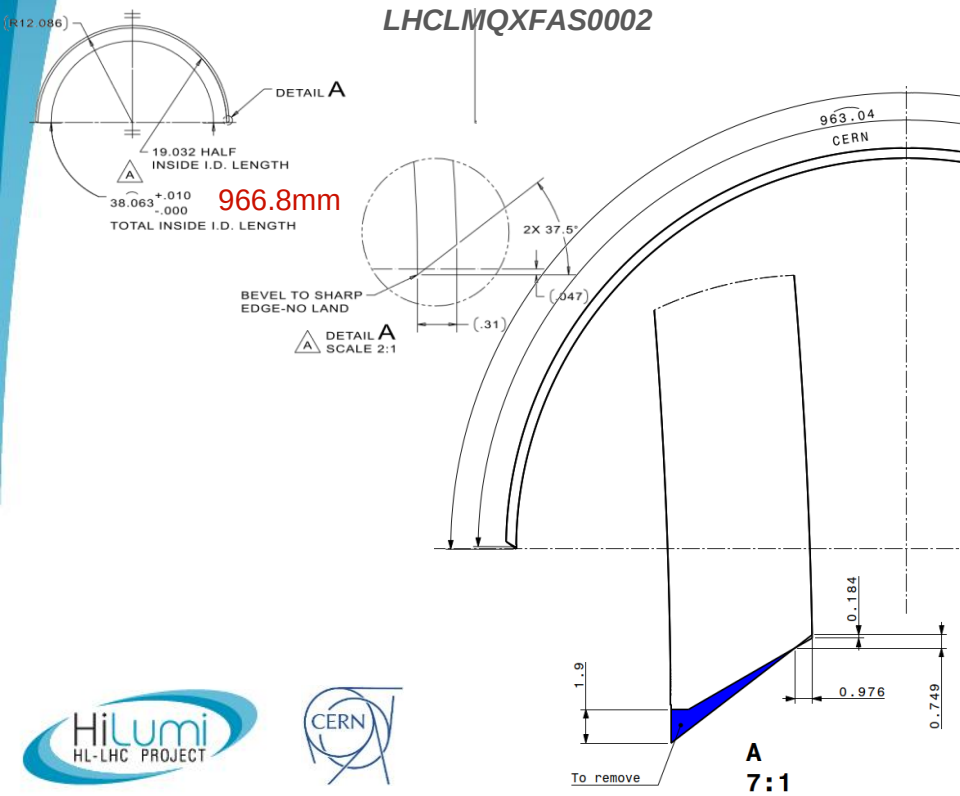
LHCLMQXFAS0002



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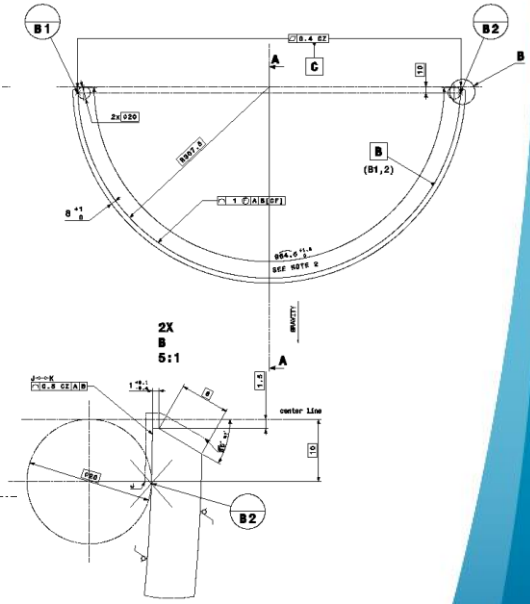

Backing strip design

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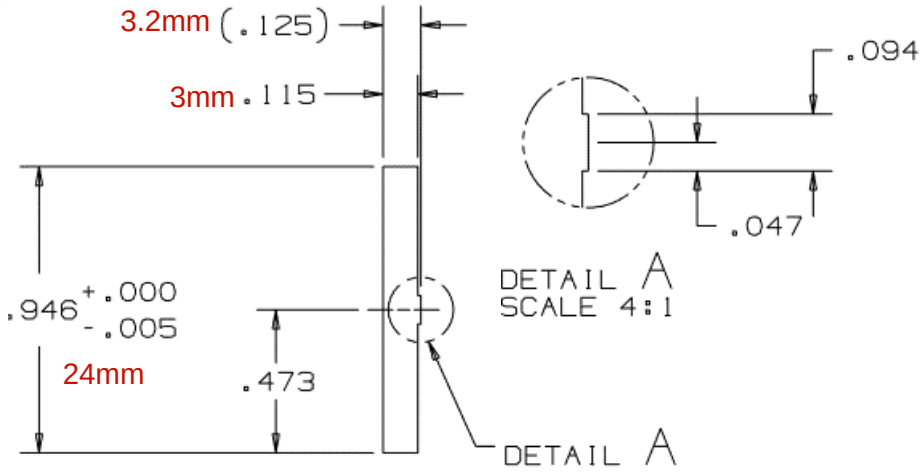

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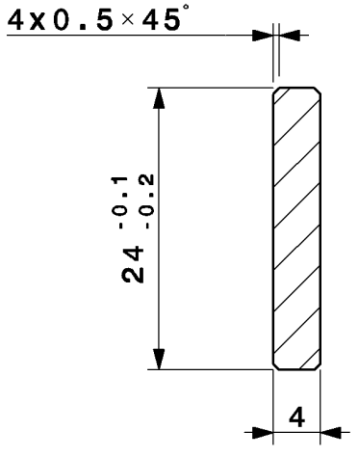

Lifting beam and cold mass rotation

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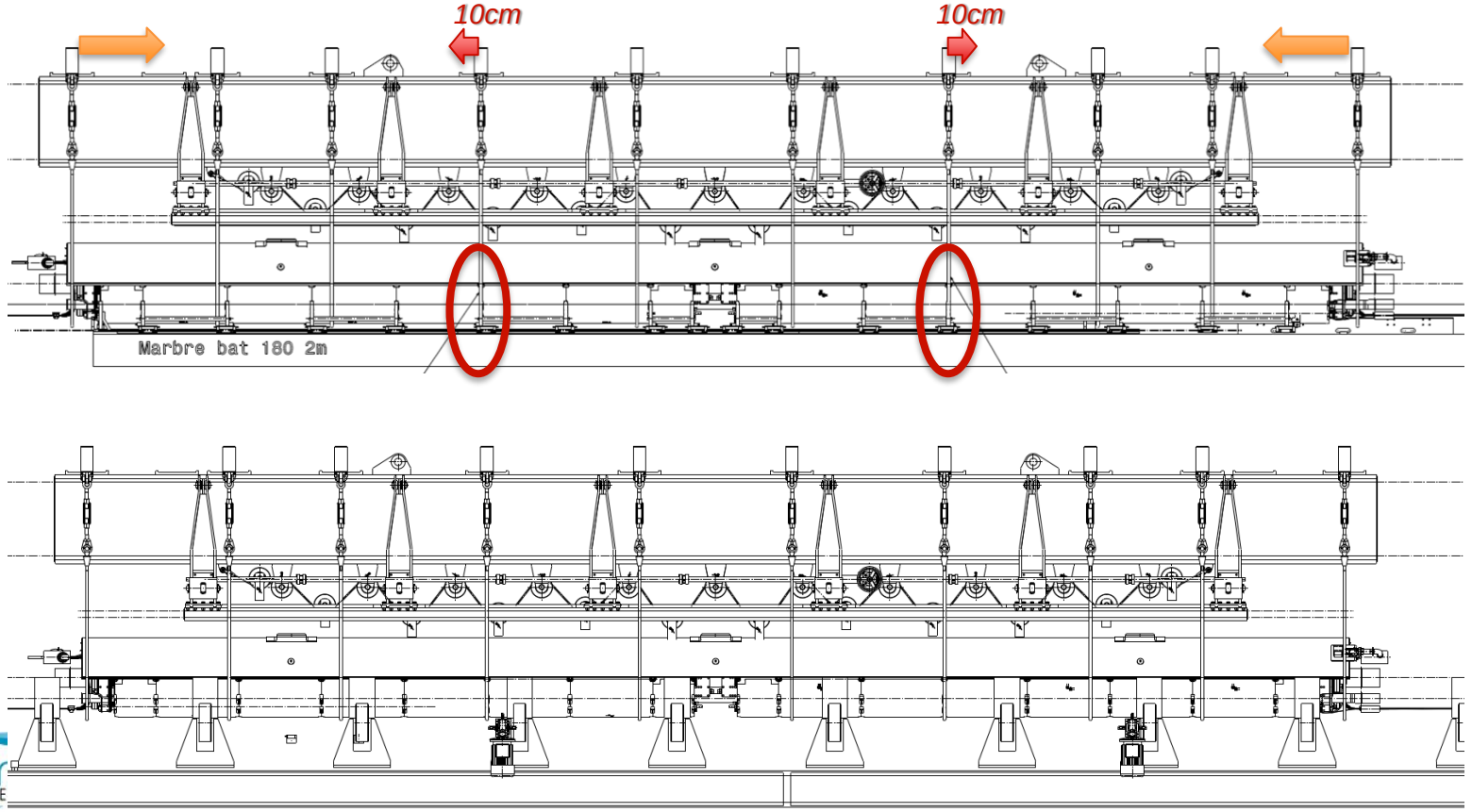
Transfer from the cold mass preparation bench to the rotation one



Lifting beam for transfer to the welding press conveyor

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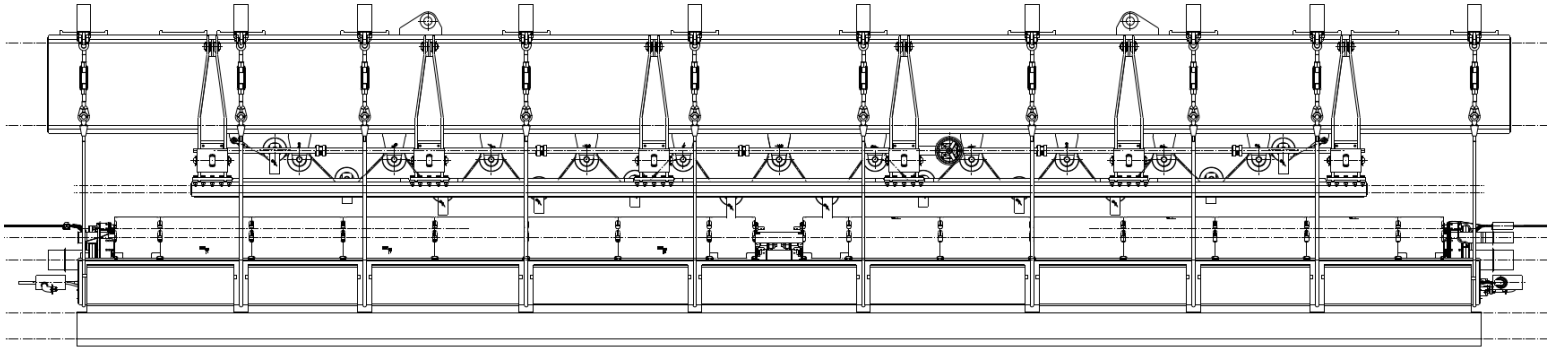
Transfer from the rotation bench to the press conveyor



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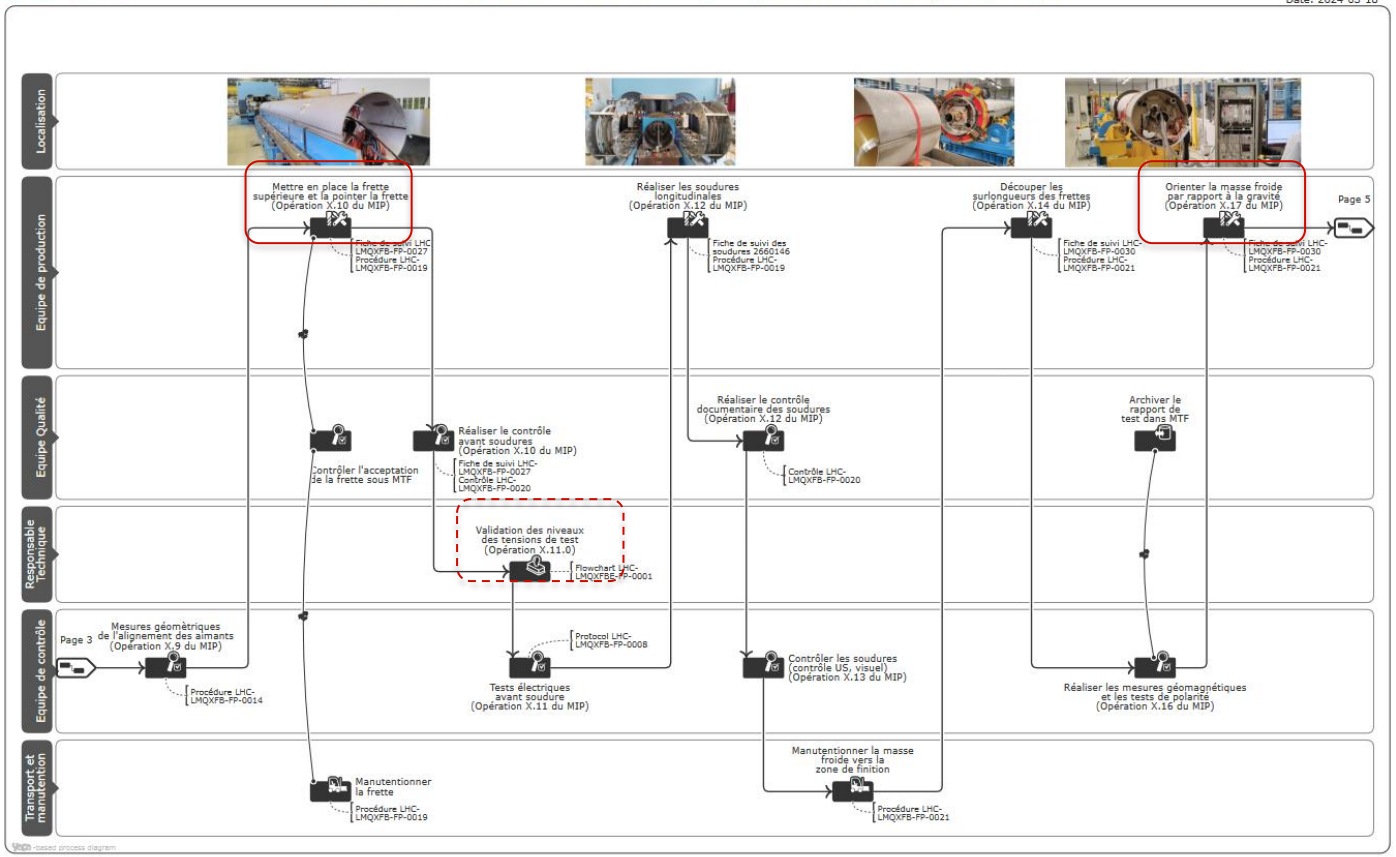
WP03 - Assemblage d'une masse froide LMQXFB page 4

DIAGRAMME DE PROCESSUS ASSOCIÉ AU MIP réf. LHC-LMQXFB-FP-0001

Date: 2024-03-18



Longitudinal welding preparation

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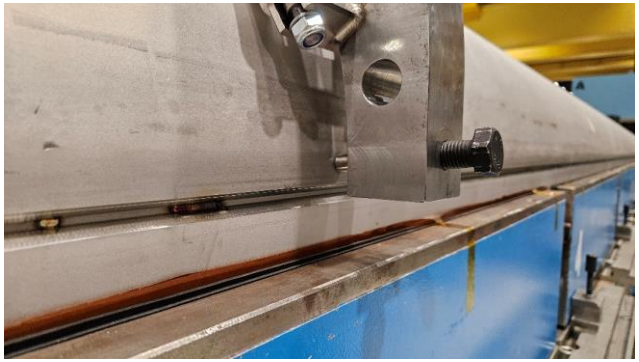
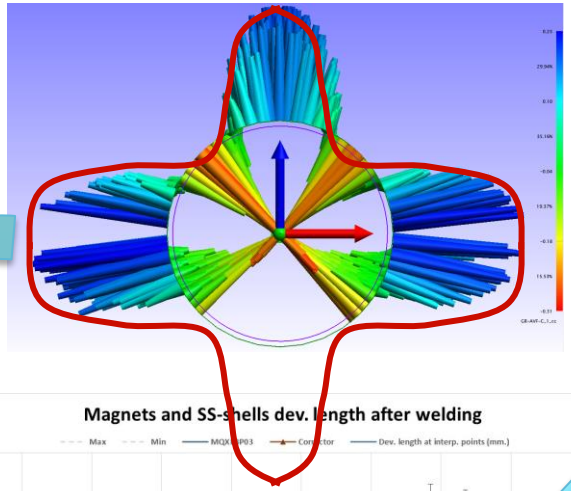
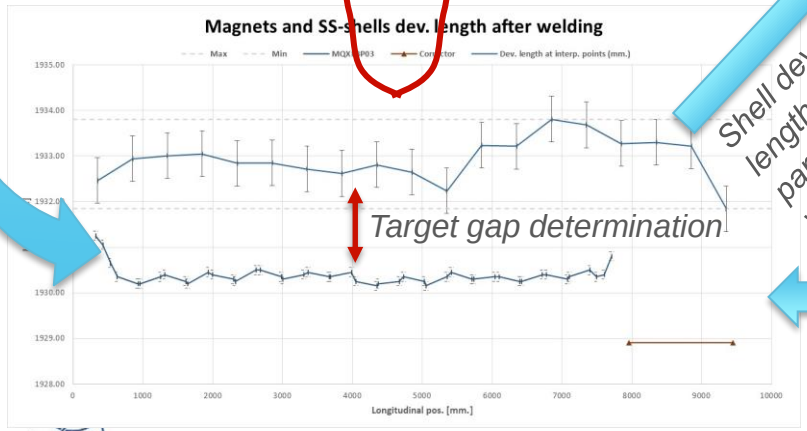


Developed length and welding shrinkage measurements



Measurements of the MQXFA magnets developed length at reception (after cold test)

Shell developed length control before assembly



Shell developed length adjustment in parallel to beveler welding preparation adjustment

Cold mass orientation to align the magnetic field to gravity

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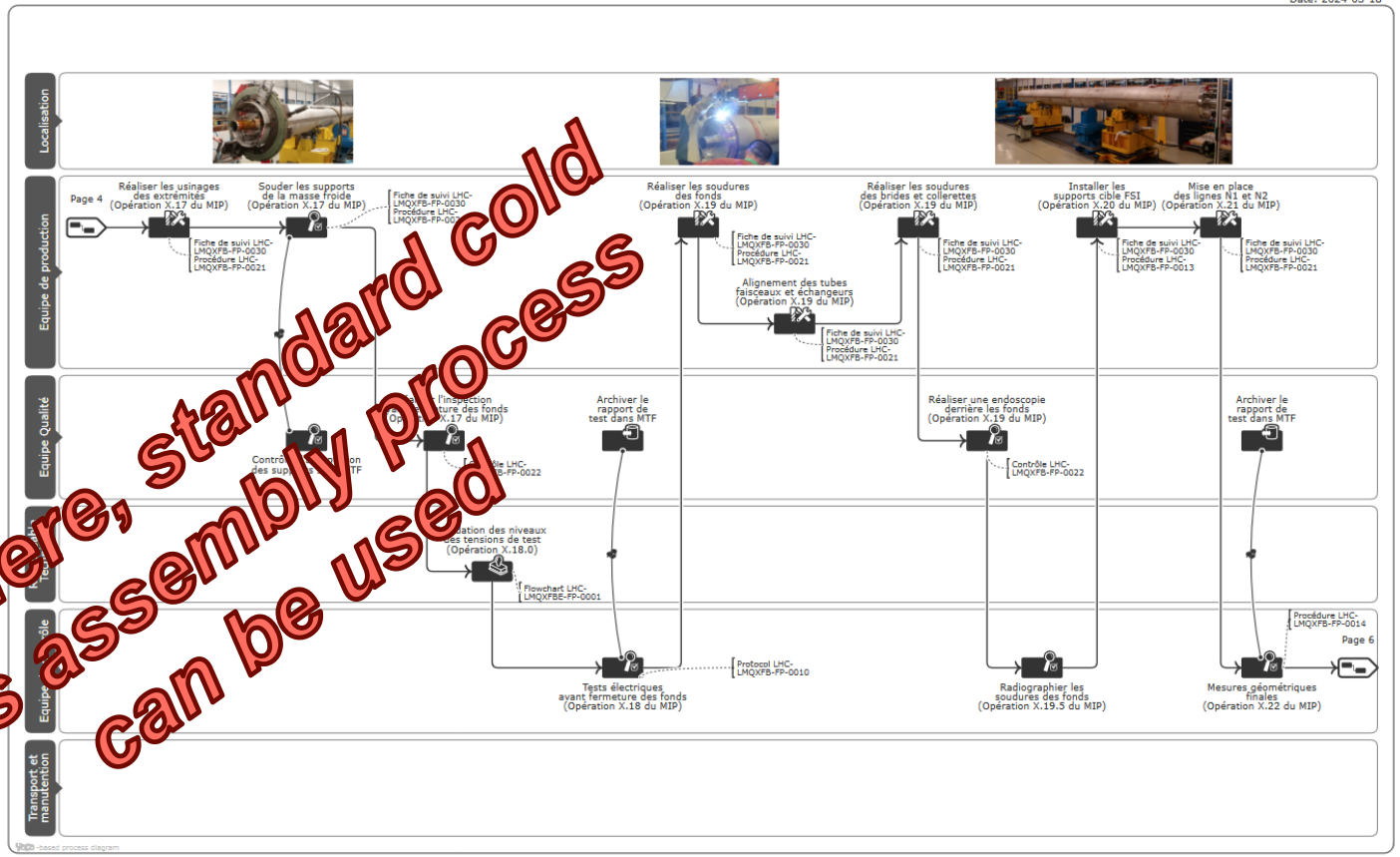
WP03 - Assemblage d'une masse froide LMQXFB page 5

DIAGRAMME DE PROCESSUS ASSOCIÉ AU MIP réf. LHC-LMQXFB-FP-0001

Date: 2024-03-18



From here, standard cold mass assembly process can be used

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WP03 - Assemblage d'une masse froide LMQXFB page 6

DIAGRAMME DE PROCESSUS ASSOCIÉ AU MIP réf. LHC-LMQXFB-FP-0001

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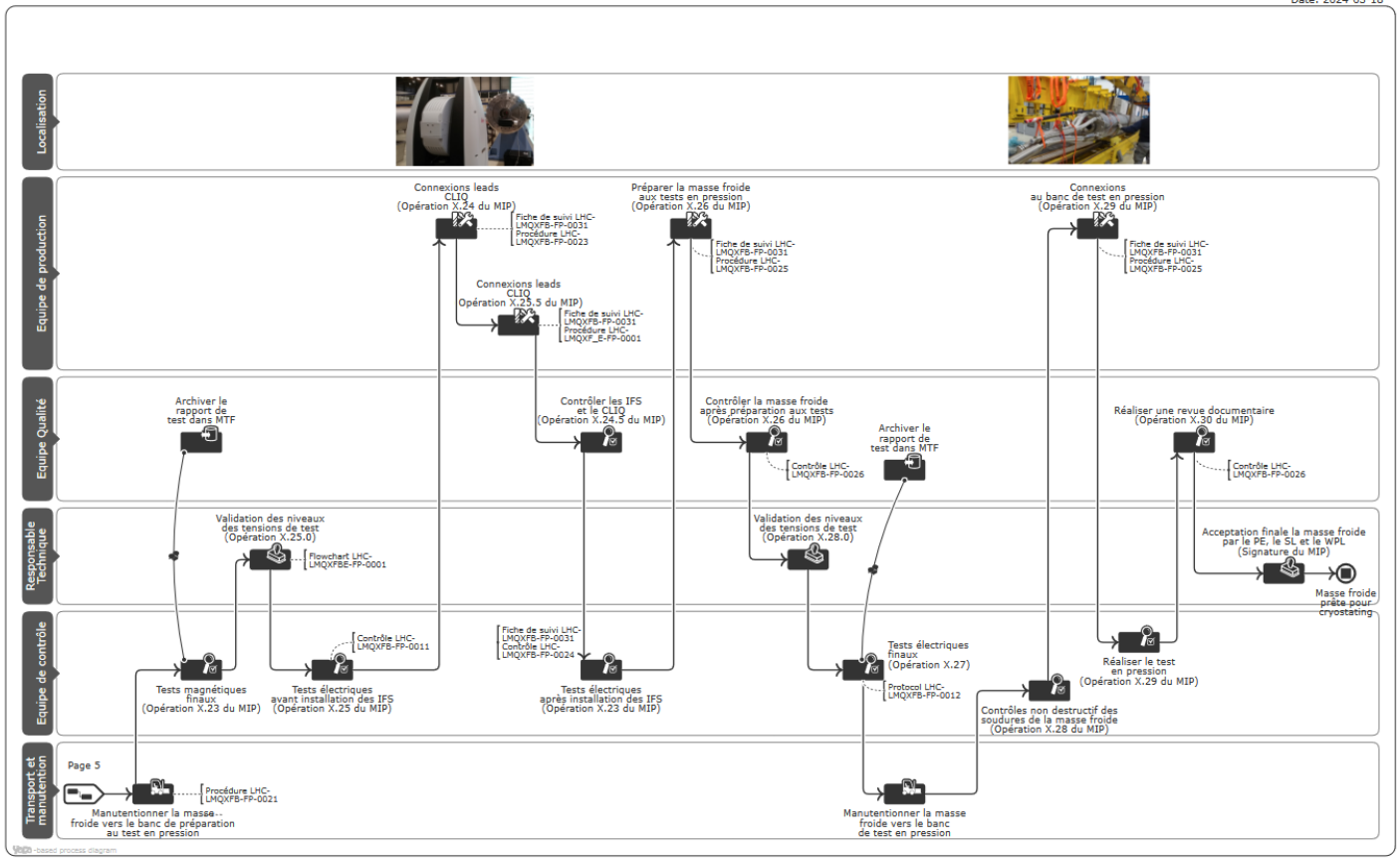

Conclusion

The study shows that it is possible to assemble a LMQXFA cold mass at CERN with the following tooling:

- **A lifting beam to handle MQXFA magnets.**
- Some modification to create a **cold mass assembly bench** or a new dedicated one to prevent disruption to the assembly of other types. Most of the material is available, orders can be passed for the rails and the supporting frames.
- The accuracy using **mechanical alignment to orient the magnetic field has been proven** on the MQXFB magnets. Measurements within [-0.68,+0.27] mrad were obtained without major efforts. Alignment of the two MQXFA magnets is expected to be better using a rigid pre-aligned structure.
- **Splicing tooling** could be copied, adapted or even redesigned to fit with CERN procedures.
- Proposals related to fixed points have been elaborated. **To be developed**.
- US shells could be machined at CERN to our standard developed length and bevel design. **CERN configuration backing strips to be ordered**.
- Orientation to gravity of the cold mass (combining both MQXFA magnetic field) can be done according to the proven LMQXFB procedure.

Additional work to be considered

- Reception tests and procedures to be written.
- Assembly and control procedures to be written.
- Preparation of subcomponents preparation has to be considered.
- Fabrication drawings to be updated?

- Duration of assembly is estimated to be 3 months as for the LMQXFB, except for the first cold mass that might require a few additional weeks.