Remote handling of ultra-high vacuum beam pipe connections in high-radiation zones

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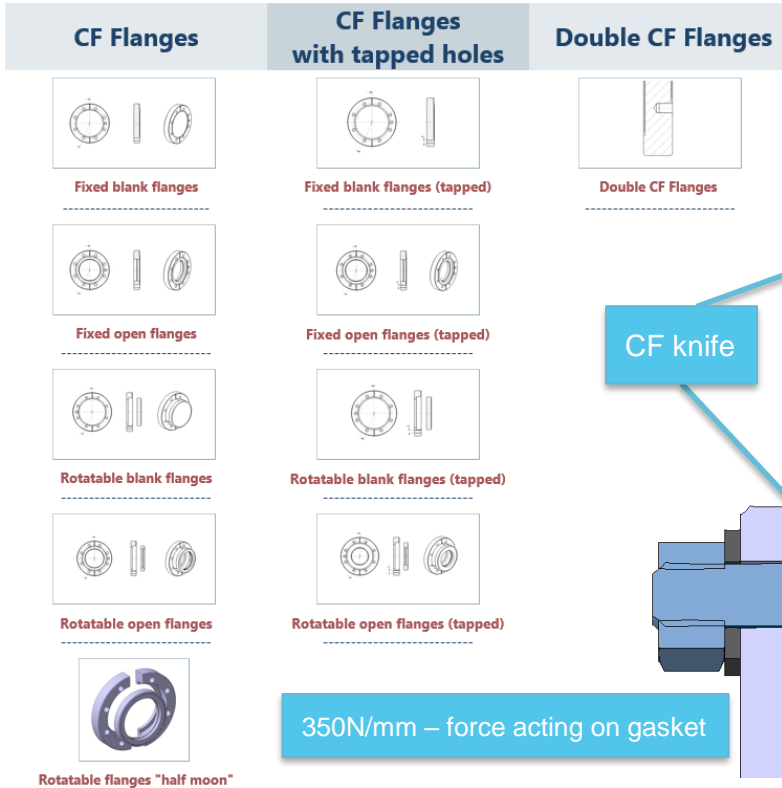
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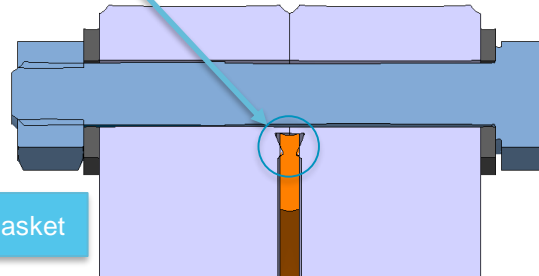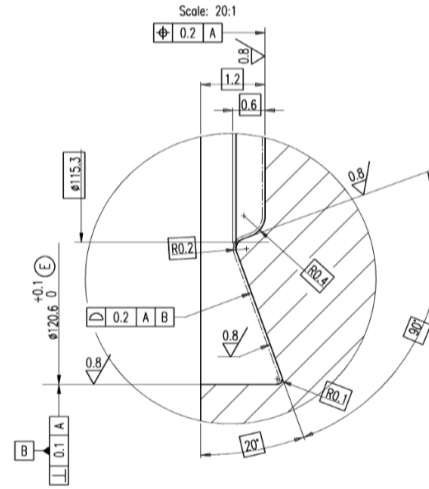
Outline

- Introduction to flanges with knife for ultra-high vacuum applications;

- Present applications of 'Quick chain clamps';

- HL-LHC connection concept for VAX;

- Summary.

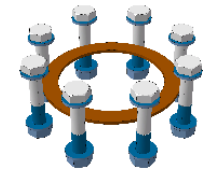# ConFlat (CF) flanges for Ultra High Vacuum (UHV)

CF Flanges	CF Flanges with tapped holes	Double CF Flanges
Fixed blank flanges	Fixed blank flanges (tapped)	Double CF Flanges
Fixed open flanges	Fixed open flanges (tapped)	
Rotatable blank flanges	Rotatable blank flanges (tapped)	
Rotatable open flanges	Rotatable open flanges (tapped)	
Rotatable flanges "half moon"		

CF knife

350N/mm – force acting on gasket

Cross section of a typical assembly

Bolts + silver coated gasket OFS
- Accelerators (LHC, LEIR,…)
- Compatible with bake out

Bolts + standard gasket OFHC
- Leak tests
- Laboratory use
- Not compatible with bake out

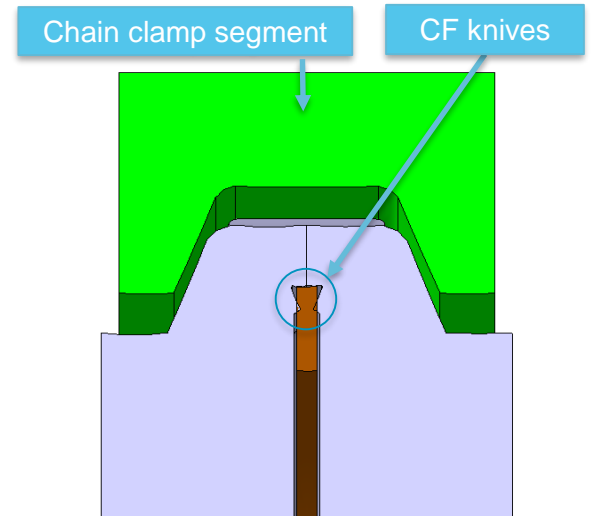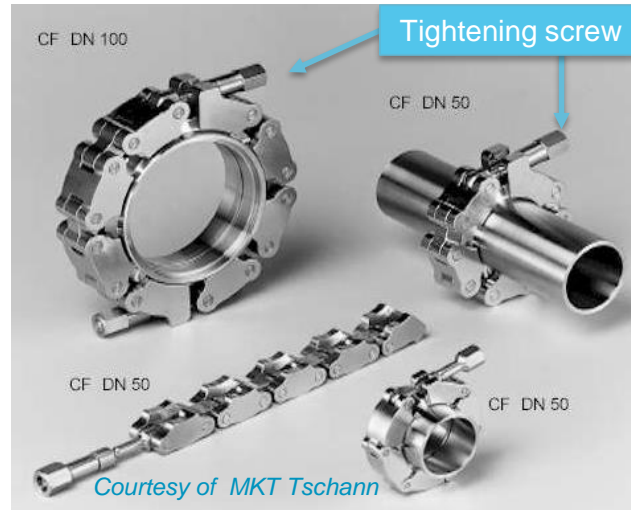Typical tightening torque – 33Nm (M8 screws for DN100)

ConFlat (CF) quick flanges for Ultra High Vacuum (UHV)
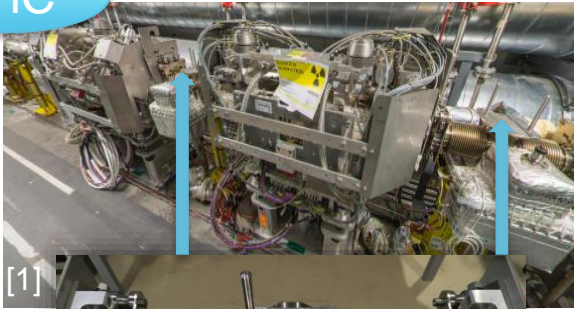
Quick CF Flanges (conical)

Quick CF Flanges

Tightening screw

CF DN 100

CF DN 50

CF DN 50

CF DN 50

Courtesy of MKT Tschann

Chain clamp segment

CF knives

Cross section of a typical chain clamp assembly

Overview chain clamps CF	
Material	Stainless steel 1.4435
Temperature range	-200 to +350°C
Tightening torque	Depends on clamp size (30Nm for DN100 chain clamp) and coating conditions
UHV	10^{-12} mbar
Available sizes	DN16 – DN250

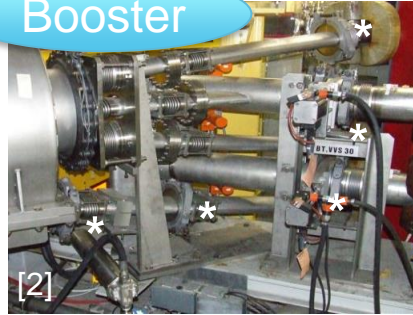# Examples of present applications – chain clamps and chain clamp assemblies

LHC

[1]

Combination of chain clamp and bellows compression tool

Horizontal actuation of tightening screws

Booster
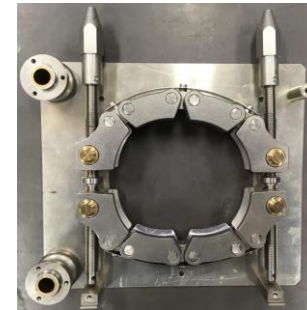
[2]

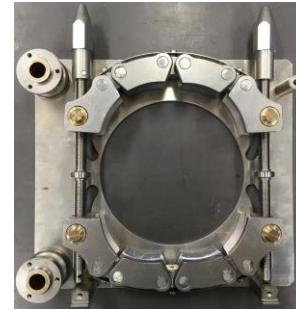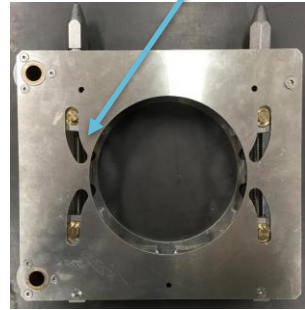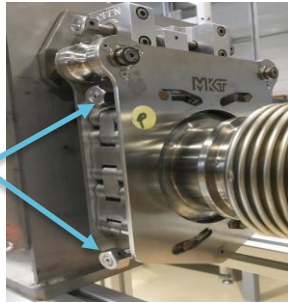Manual handling with optimized intervention tooling

- Preparation (drawings, pictures, simulations)
- Dose mapping;
- Work planning (where and how long);
- Mock-ups and training;
- Tooling (electrical wrenches, extension rods, etc.)

Guiding grooves
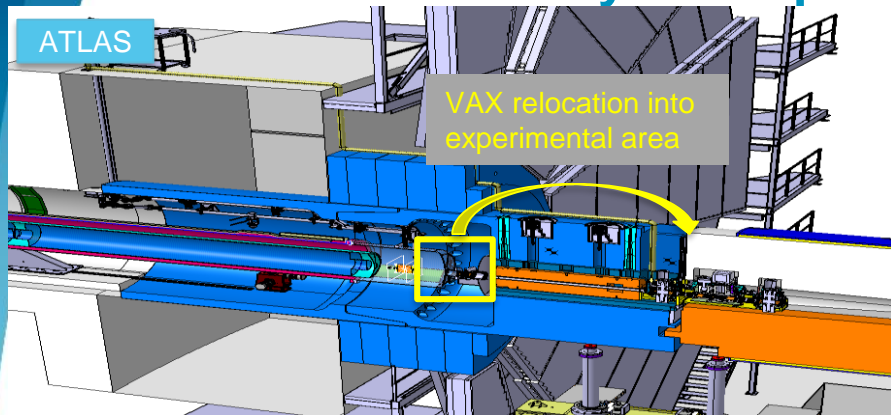
Chain clamp in open position

Chain clamp in close position

Vacuum Assembly for eXperimental areas (VAX) in HL-LHC phase

ATLAS

VAX relocation into experimental area

CMS

VAX relocation into experimental area
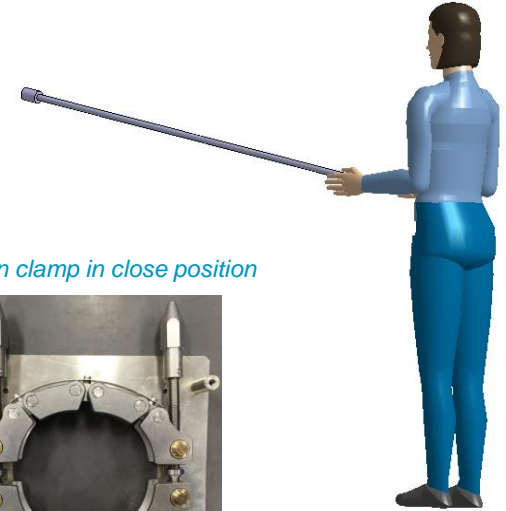
Access to VAX equipment at Point 1 (on the left) and Point 5 (on the right)
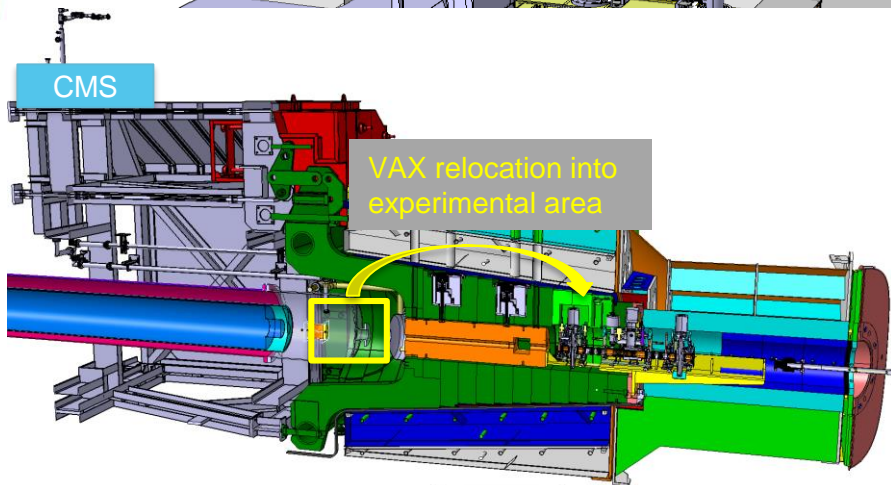
- Priority to radiation transparent aluminium;
- Transparent to a strong external magnetic field;
- Robust equipment ensuring long term system reliability;
- **Quick, standard and unified connection between the VAX components;**
- **Vertical remote handling maintenance.**

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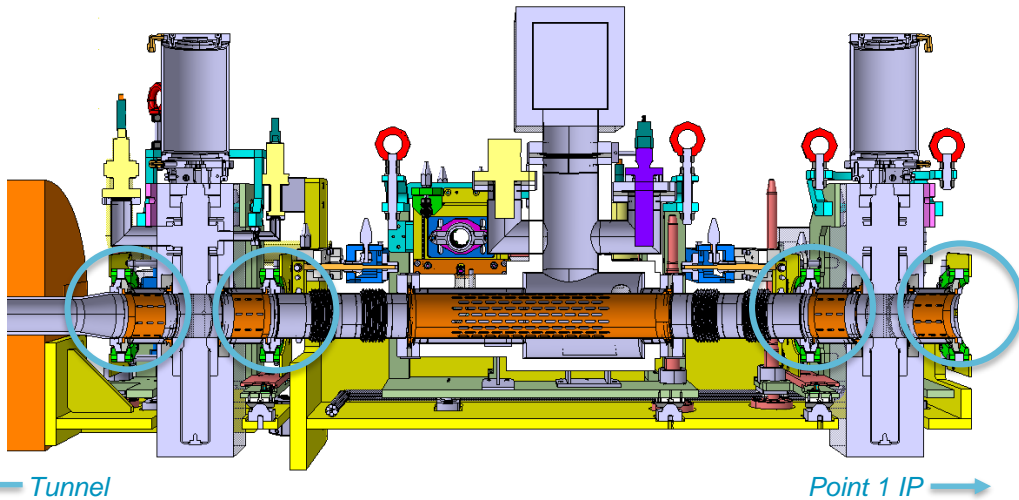# Vacuum Assembly for eXperimental areas (VAX) in HL-LHC phase

MODULE 1:
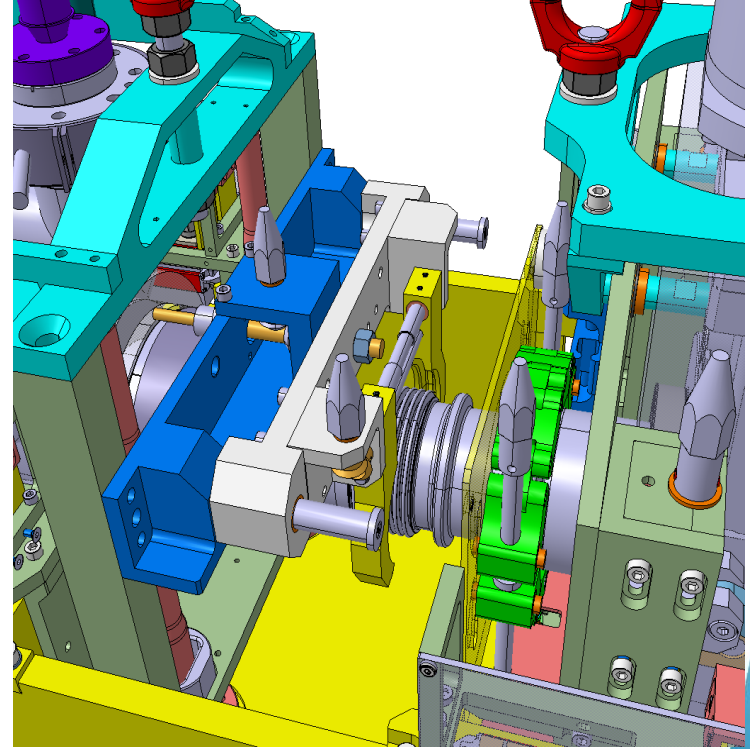• Vacuum sector valve
• DN100 chain clamp assemblies

MODULE 2:
• Instrumentation to pump down and control vacuum

MODULE 3:
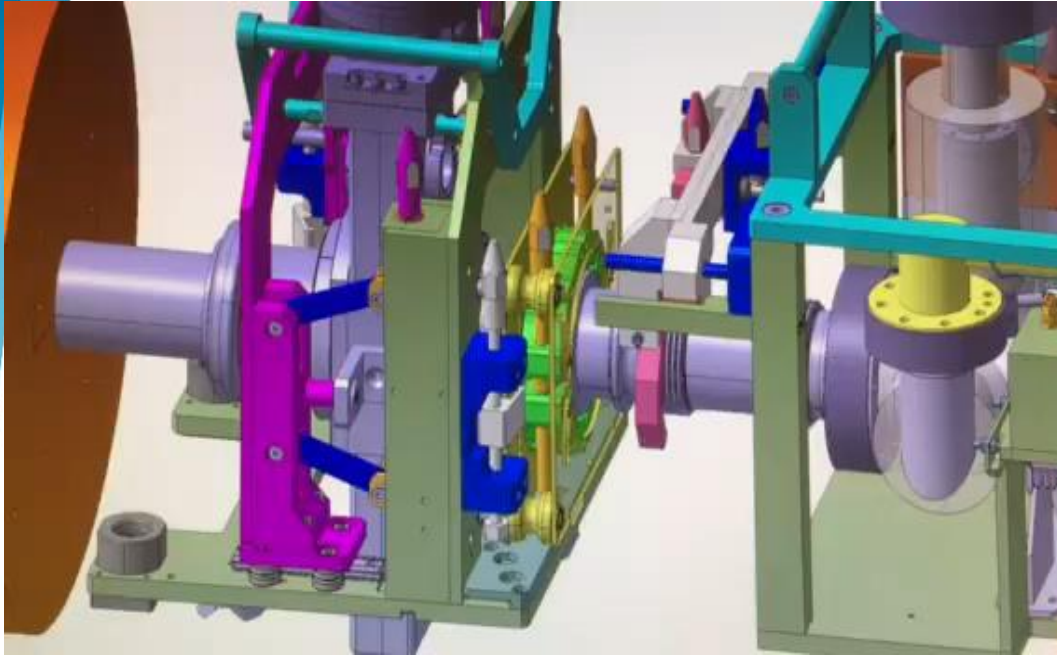• Vacuum sector valve
• DN100 chain clamp assemblies

Combination of chain clamp and bellows compression tool

Tunnel

Point 1 IP

VAX Module 1 maintenance - DN100 chain clamp

1. Bellow compression tool arrive to its position;
2. Jaws grab the collar of bellows;
3. First tightening screw of chain clamp DN100 is wound out to its maximum;
4. Second tightening screw of chain clamp DN100 is wound out to its maximum;
5. Chain clamp DN100 assembly is pivoted backwards to free some space;
6. Bellows is compressed by compression tool;
7. (Chain clamp DN100 assembly on the opposite side of Module 1 is opened by the same 3 screws (2x tightening screw and 1x pivoting screw). However, the chain clamp is hidden for the purpose of this video);
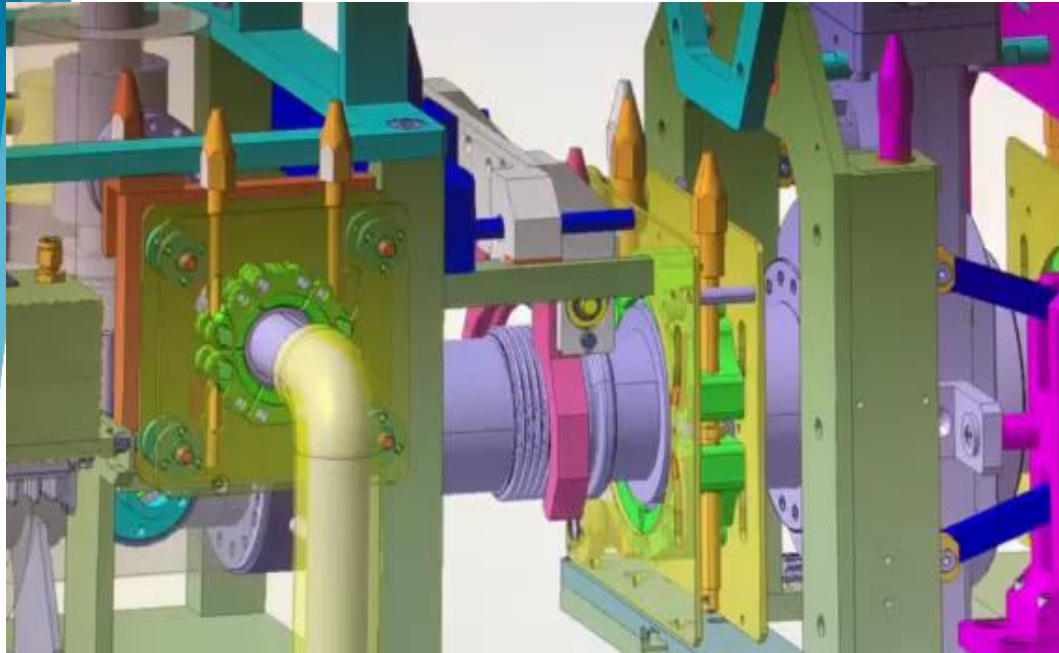8. The equipment in VAX Module 1 is shifted backwards and Module 1 is ready for transport.

VAX maintenance – DN40 chain clamp

1. Bellow compression tool arrive to its position;
2. Jaws grab the collar of bellows;
3. First tightening screw of chain clamp DN100 is wound out to its maximum;
4. Second tightening screw of chain clamp DN100 is wound out to its maximum;
5. Chain clamp DN100 assembly is pivoted backwards to free some space;
6. Bellows is compressed by compression tool;
7. (Chain clamp DN100 on the opposite side of Module 2 is opened in the same sequence. It is skipped for the purpose of this video)
8. First tightening screw of DN40 chain clamp is wound out to its maximum;
9. Second tightening screw of DN40 chain clamp is wound out to its maximum;
10. Chain clamp DN40 assembly is shifted backwards to free some space and Module 2 is ready for transport.

VAX prototype and tests

VAX chain clamps:

- Torque control;
- Tightening screw's turns control;
- Robot friendly interface;
- Minimum number of steps for the robot to operate the tightening (locking) screws;
- Chain clamp size determines number of segments (chain links) so that working conditions potentially could be affected by the gravity.
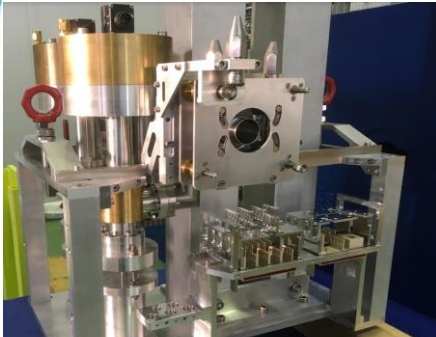
VAX Module 2 – chain clamp DN40

VAX Module interconnection – chain clamp DN100 in b.112

VAX Module 3 – chain clamp DN100 in b.186

VAX Module 1 – remote handling in b.186

VAX remote operation:

- intervention of robot (gripper or gripper with extension tool);
- Intervention of personnel from 'safe' area using extension tool.

Summary

Chain clamp connection assembly:

- Quick solution to 'bolted' connections in terms of remote handling;

- Simple and robust solution;

- Design depends on:
  - maintenance scenario;
  - available space (space required for the surrounding mechanical system);
  - Accessibility;

- Disadvantage to grease the clamp.

Remote handling:

- Cost;

- Accessibility;

- Time consuming;
  To remove 1 chain clamp at 5mSv/h [3]
  - Robot: 15-30 min (0μS);
  - Torque wrench: 3 minutes (250μS);

- No dose to personnel;

- Robot vs. human leverage to be always considered.

Thank you

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CERN 112/1-015

References

[1] J. Chauré - Intégration de blindages mobiles en LSS7 pour YETS et Long Shutdown *10th October 2018*;

[2] J. Hansen – LIU PSB Work package description&Project status *18th June 2012*;

[3] J. A. Ferreira – CERN experience: Vacuum design, interventions and operation in radioactive environment *22nd-24th November 2017*