



Estimation of connection bellows deformation for FRAS safety system

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Outline

- Introduction;
- Movement of connection bellows of collimators;
- FRAS safety system: bellows deformation treatment;
- Conclusions.

Introduction

- Connection bellows = hydroformed bellows;
- Connection bellows movements limits will be implemented within FRAS safety functions (WP15.4);



- **Limit strokes** (transversal, torsional, longitudinal) shall be defined to be implemented in protection functions.

Movement of connection bellows

■ Strokes of Collimators bellows

Bellow type	LHCTCLPX__0060	LHCTCLPX__0067
Operational stroke*	+5.5/-14	+5.5/-14
Axial stroke (<u>as per spec</u>)	± 15 mm	± 15 mm
Lateral stroke (<u>as per spec</u>)	± 2.5 mm	± 2.5 mm
Angular stroke (<u>as per spec</u>)	± 5°	± 5°
Lifetime [cycles] (<u>as per spec</u>)	500	500
Total length [mm]	172.5	173
Convolutions length [mm]	132	132.5

From EDMS 2428906:

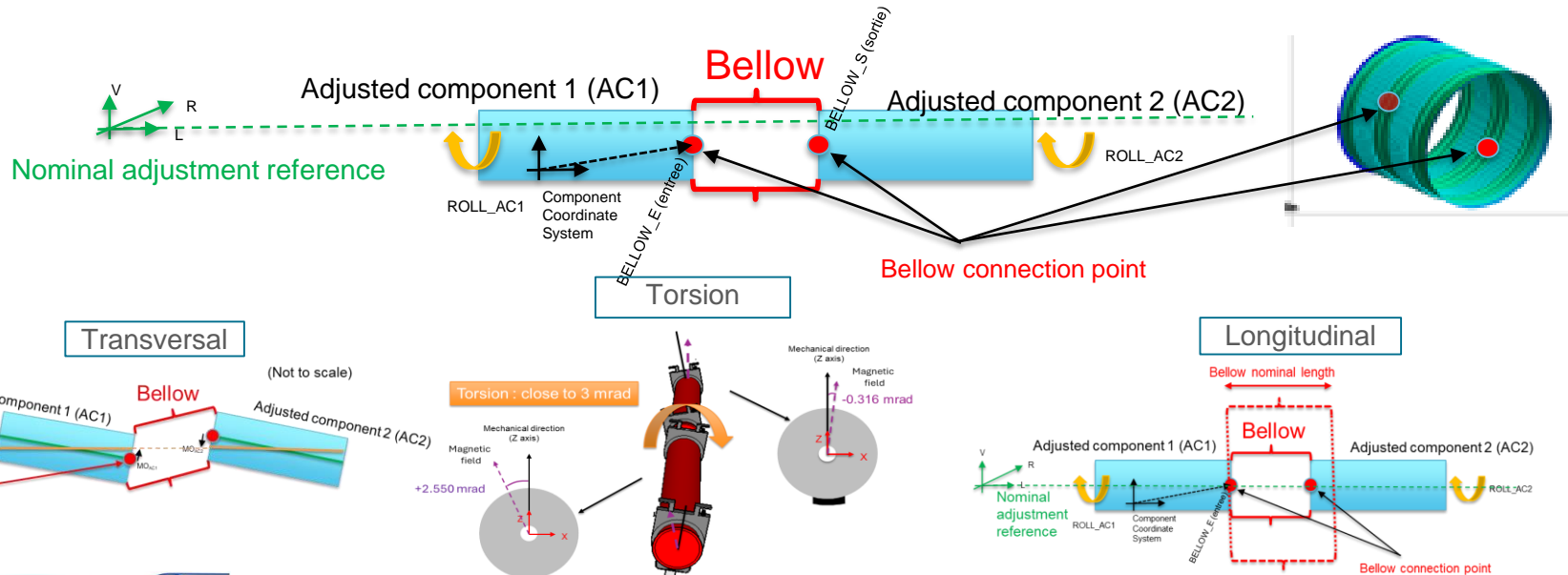
- The nominal stroke is **18.5 mm**. It means that when the tool will be in parking position (flanges opened, bellow compressed), it can compress the bellows up to 18.5 mm (from extended position – 163 mm – to compressed position – 144.5 mm).
- During this bake-out**, the bellows will absorb, by compression, the dilatation of the equipment in the longitudinal direction. For this reason, the bellows are installed at their nominal length **+ 5mm**.
- Maximum axial error (mm): +/-0.25 mm**

$$\rightarrow 18.5+0.25-5=13.75 \rightarrow \sim -14 \text{ mm}$$

$$\rightarrow 5+0.25=5.25 \rightarrow \sim \mathbf{+5.5}$$

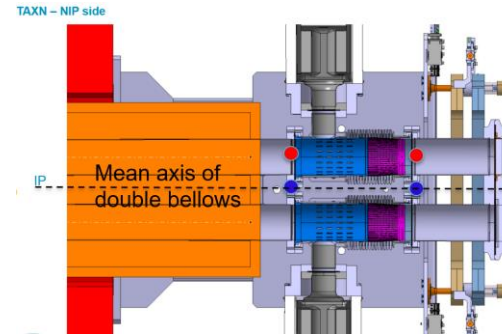
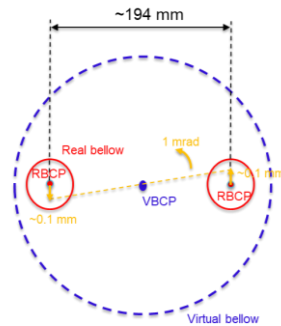
FRAS safety system

- Bellows movements limits will be implemented within FRAS safety functions
→ further details in: <https://indico.cern.ch/event/1473294/>
- Bellows deformation treatment:



Longitudinal deformation will be measured, but will not be protected by safety functions

Double-bellow deformation treatment



For **double bellow configuration** (as per collimators) → Bellow connection point approach:

- Virtual Bellow Connections Point (**VBCP**) in the mid-distance between Real Bellow Connection Points (**RBCP**) for bellows deformation follow-up
- Considering the LHC beams spacing at ~194mm, the maximum vertical offset of +/-0.1 mm is expected at RBCP, when ultimate FRAS rotation (+/-1 mrad) is applied. Rotation of component has negligible impact on radial offset.

According to that:

- The vertical and radial **transversal** deformation determination will be based on VBCP geometry, with vertical offset threshold limit reduced by 0.1 mm to achieve always RBCP position in its deformation range
- The **torsional** deformation will be determined in same way as for single bellow configuration, basing on components roll measurement.

Conclusions

- Virtual Bellow Connections Point approach will be used for collimators bellows;
- **Limit movement** (transversal, torsional, longitudinal) of **VBCP** shall be defined to be implemented in protection functions → shall be communicated to WP15.4



- **Need to identify max values of the secondary movements** from cantilever effect on RBCP (torsion under rotation, expansion under drift, shear under translation, etc) -based of allowable stroke of bellows (RBCP)- to evaluate the limit for VBCP;



- Need of kinematics study

Thank you for your attention!

