Best Practices on Vacuum Components

V. Baglin (TE-VSC)
on behalf of WP12

HL-LHC Standards and Best Practice Workshop
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The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

Outline

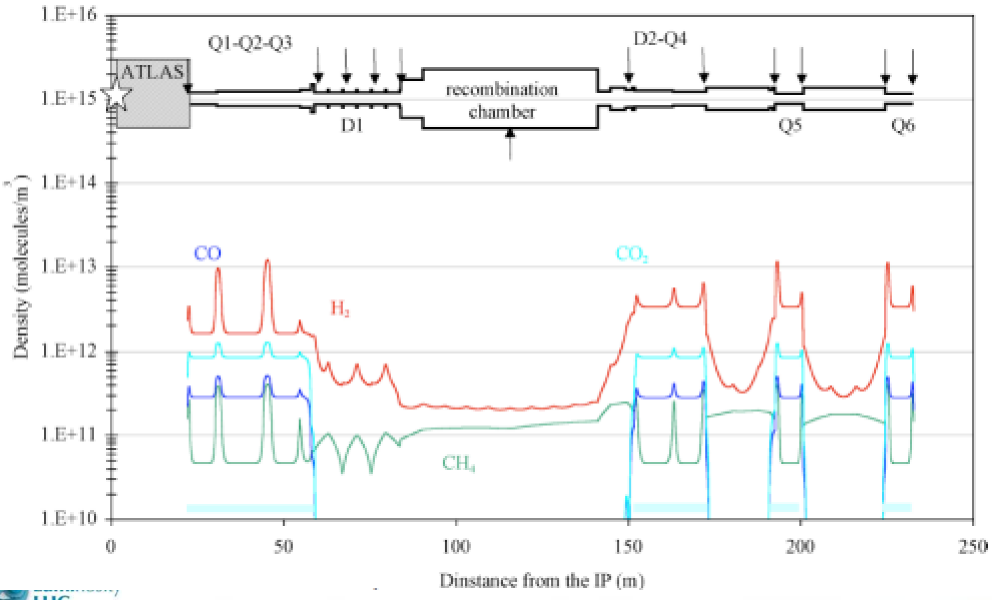
- Performances
- Component's life
- Operation
- Conclusion

Design Performances

- The vacuum system encompass vacuum components and other equipments (magnets, collimators, crab cavities, hollow lenses, LRBB compensator etc.)
- The system must ensure vacuum performances complying HL-LHC beam parameters and High Luminosity experiments reach

LHC Case:

- Ring : 100 h beam life time, also valid for HL-LHC
- Experiments: acceptable background, to be defined by experiments if different from LHC



	H2_eq / m3	mbar
<$LSS_{1\ or\ 5}$>	~ 5 10^{12}	10^{-10}
<ATLAS>	~ 10^{11}	10^{-11}
<CMS>	~ 5 10^{12}	10^{-10}

A. Rossi, CERN LHC PR 783, 2004.

Operation Performances

- Meet design specification
- Robustness
- Maintainability
- Spare policy
- Radiation compatibility:
    - with material & hardware
    - with personnel intervention on the field

How to reach these performances ?

- Using the “vacuum components best practices” applied for LHC but …

- In a better way !

Assembly & Components : Design

- Design review recommended (conceptual, detailed, production readiness …)
- During LHC procurement, the LHC-VAC group internally reviewed all technical specifications and drawings :
  - Ensure compatibility across the vacuum system
  - Allows optimisiation across components and performance
  - Use quality class (class A, approval circuit after control 1&2)

- Same policy must be applied for HL-LHC
- TE-VSC will reject components, including in-kind, which do not meet VSC DESIGN APPROVAL

High Luminosity LHC

Assembly & Components : Design

- Do’s and don’ts (just a few important ones from LHC)
  - No halogenated fluxes
  - No cold demountable joints
  - Helium envelopes are all-metal
  - Joining techniques need to be validated (materials, welding, DT)
  - No dye penetrant testing
  - Minimise thin wall components.
  - Combine RT leak and pressure test of components
  - Decide a policy for cold testing of critical components
  - Keep non-vacuum group manufacturing under control – assign a vac link person
  - Don’t allow deliveries until tightness certification is approved
  - Minimise number of welds to be tested in the tunnel
  - Many, many more
  - …

Components : procurement

- Equipments owners are responsible for the procurement of their equipments:
    - Specification committee aproval
    - Appraisal of tender offers
    - Contract execution
    - Involvement of TE-VSC for vacuum issues at all these stages (link person)

- CERN TE-VSC is responsible for the procurement of all “V” named components:
    - VC: vacuum chambers, circular apertures 80, 212 (100, 130) and racetrack apertures (beam screens)
    - VM: warm modules
    - …
- For HL-LHC, VSC plans to reuse the maximum of LHC components

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Components : Interfaces

- Standard interfaces are already defined for LHC:
  - Racetracks
  - Circulars
  - Ellipticals

- They are too numerous => will be reduced for HL-LHC

Components : material type

- Material compatibility endorsed by EN-MME-MM
  - 304L, 316LN, ESR, #D forged etc.
- Material qualification by
  - Outgassing measurements
  - Gas composition
  - Surface analysis, AES, XPS
  - Dedicated set-up:
    - Secondary electron yields, photon electron yields
    - Photon reflectivities
    - Stimulated molecular desorption (photons, electrons, ions, protons)
- Performed by TE-VSC groups and collaborators
- Material properties also available in literature

Components : cleanliness

- Several standards developed at CERN matching machines performances.

- Available in EDMS: Cu, stainless steels, Aluminum, Ferrites…

- Expertise and approval by TE-VSC-SCC

- External companies can be qualified by SCC

Components : coating

- NEG, a-C coating
- Silver, gold, rhodium coating, Cu electroplating …..
- Can be executed in house
- Expertise and approval by TE-VSC-SCC
- External companies can be qualified by SCC

Components : leak tightness

- Building parts must be leak tight:
  - No measurable leak with sensitivity $<10^{-10}$ mbar.l/s
  - Responsibilities must be defined & approved in conceptual design phase

- Assemblies might allow larger leak rates:
  - Insulation vacuum: defined by the He pumping system (molecular turbo pumps in the LHC case)
  - Beam vacuum:
    - Cryogenic system : beam induced quench limit
    - Room temperature system : NEG saturation speed

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Components : qualification

- All vacuum systems components/assemblies, including in-kind contribution, must be qualified at surface
- Foresee time, space, ressources
- Results are documented in EDMS and attached to the MTF
- In fact a few LHC vacuum components are in MTF, but, this will be consolidated !

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Components : management

- No formal strategy for spares, nor component management !

- Need to define a clear and sector wide spare strategy

- Need to provide/use tool for component management

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Components : Installation

- All vacuum components are in LHC layout database, children included !

- This generates installation drawings

- Dedicated integration studies were performed during LHC design

Installation: where are we today ?

- End of LS1 BUT:
  - Still generating ECRs
  - Still missing some integrations studies
  - Still installing systems with drawings “not valid for installation”

- We have room for improvement

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Operation: radiation to personnel

- Partially taken into account for LHC:
  - Collimators with “quick flanges”
  - Remote tooling at some positions
  - Intervention procedures and tools

- Must be widely deployed for HL:
  - Be ready to accept that ALARA might mean longer interventions, impossibility to push the machine to its limit or even reduced performances
  - Review “hot” areas
  - Define remote tooling
  - Use redundancy to avoid personnel intervention on the field
  - Layouts must be optimised with TE-VSC

Conclusions

- Best practices ? …. difficult question !
- TE-VSC experience of it, which is of course not universal
- Best practices means time, discussion and agreements between colleagues (specs, reviews …)
- It means also “resources” to reach the targets

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Thank you for your attention

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High
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HL-LHC Standards and Best Practices Workshop

The purpose of the HL-LHC Standards and Best Practices Workshop is to share, and when possible reach an agreement on:

- Standards to be used for the HL-LHC Project in the different technical domains and equivalence between standards;
- - Best practices and engineering methods applicable for the design of HL-LHC components;
- - Requirements, tools and means for sharing data, technical parameters and documents.

The Workshop is intended for the “main drivers” of the design and integration of HL-LHC equipment.

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HL-LHC Standards and Best Practices Workshop

Our objective for these 3 days:

Get a common background and learn and discuss the Procedures/Best practices necessary for the HL project