



# Vacuum Science and Technology in Accelerators

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# Session 8

## Basic Vacuum Design of Accelerators II



## Aims

- To consider how a paper vacuum design can be turned into a working machine
- To see some of the common pitfalls in this process
- To consider some of the aspects of Quality Assurance pertinent to vacuum



## Design to machine

In the previous lecture we saw that there were two basic approaches to turning design into reality

- Build to print  
or
- Design and manufacture



## Design to machine

In build to print, the customer accepts all the risk of the design as far as meeting performance is concerned

As the vacuum designer you will be responsible for understanding the vacuum performance of all the materials and construction techniques involved

e.g. outgassing

desorption

temperature limitations



## Design to machine

In design and manufacture, the manufacturer will be responsible for ensuring the performance and therefore must understand these aspects.

In reality, it is unlikely that either of these extreme approaches will be undertaken. It is more likely that a “shared expertise” method of working will be undertaken.



## Some common pitfalls (Basic Design)

Underestimating internal surface areas and “gassy” items.

Forgetting about conductance limitations.

Forgetting about pumping speeds being pressure, species and history dependent.

Failing to appreciate the extent and implications of dynamic processes.



## Some common pitfalls (Manufacturing Design)

Failure to check vessel and component manufacturing drawings for

- Materials used
- Trapped volumes (solvent traps)
- Cleanability
- Temperature limitations
- Impedance problems
- Handling



# Basic Vacuum Design of Accelerators

## Some common pitfalls (Process)

Over specifying

Under specifying



## Some common pitfalls (Manufacturing)

Assuming manufacturers know what they are doing (management and shop floor).

Failing to think through the implications of concessions and design changes.

Failing to specify (or agree) a rigorous enough test programme, including methods.

Incorrect sequencing of inspection and test procedures.

Insufficient documentation.



## The main criterion

Remember - a good design is one which

- meets its specification
- allows for later improvements
- is economical
- is reliable
- is maintainable



## Quality Control

Accelerator builders are, in general, always building high precision prototypes which must work to a stringent specification.

To achieve this, good quality control or quality assurance is essential.

QA systems such as those set up under standards like ISO 9001 are well established and the mechanical aspects of vessel and component manufacture (e.g. materials, dimensions, tolerances) will fall under their aegis.



## Quality Control

Vacuum aspects of quality control are much more nebulous

The system builder needs to specify exactly what is wanted, how it is to be measured and how it is to be assessed.

There are no “standard” standards.

It is also likely that contractors will need to be educated and vacuum equipment may need to be supplied.

Trained vacuum inspectors will also need to be available.



## Quality Control

First define your standards.





## Quality Control

### General vacuum specification

- Materials
- Techniques
- Processes
- Handling
- Inspection

(In addition to vessel drawings, mechanical specification, etc.)



## Quality Control

### Assessment (Tests)

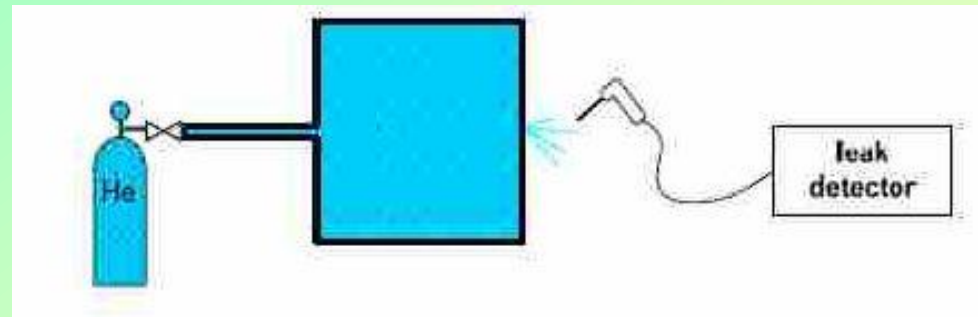
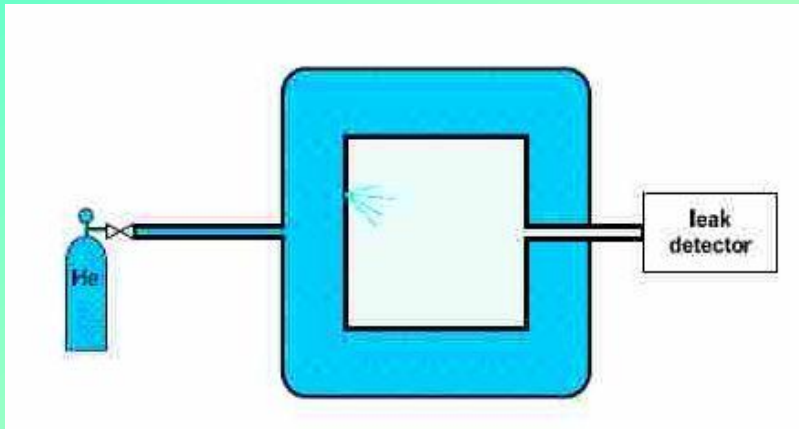
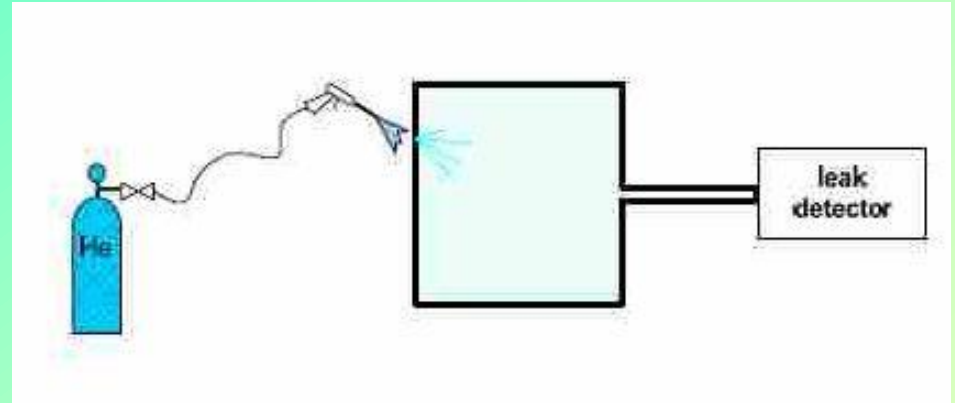
- Leak test
- Performance test
  - Base pressure
  - Outgassing rate
  - Cleanliness



## Leak tests

Specify a realistic leak rate

Specify testing method





## Leak Detection





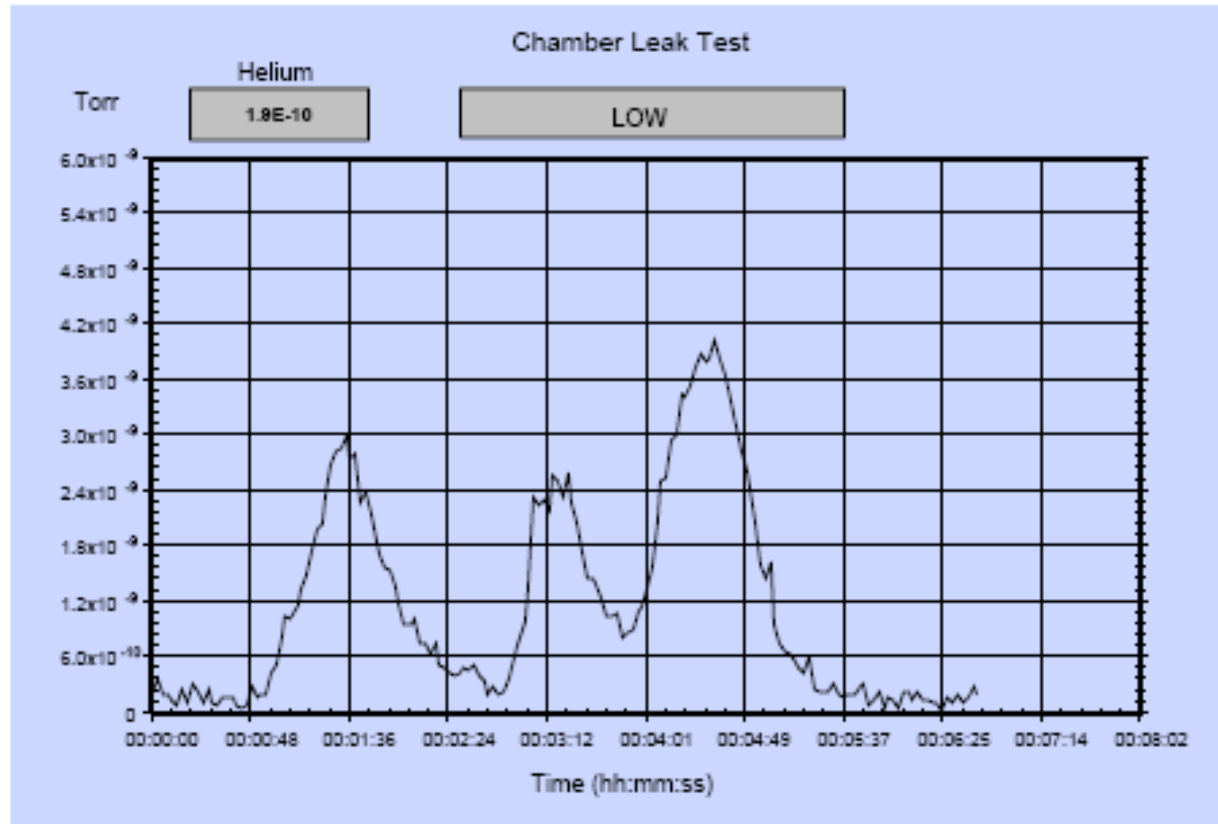
## Leak Detection with an RGA

If an rga is fitted to the system, it can be used for leak detection.

Modern rga systems will include a leak test mode where the analyser is tuned to He and the sensitivity is increased. The helium peak is displayed as a trend.



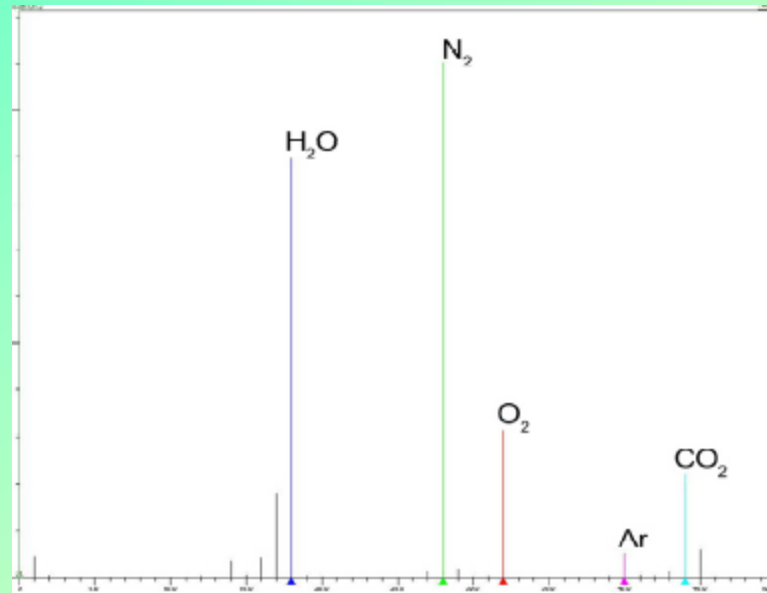
## Leak Detection with an RGA





## Leak Detection with an RGA

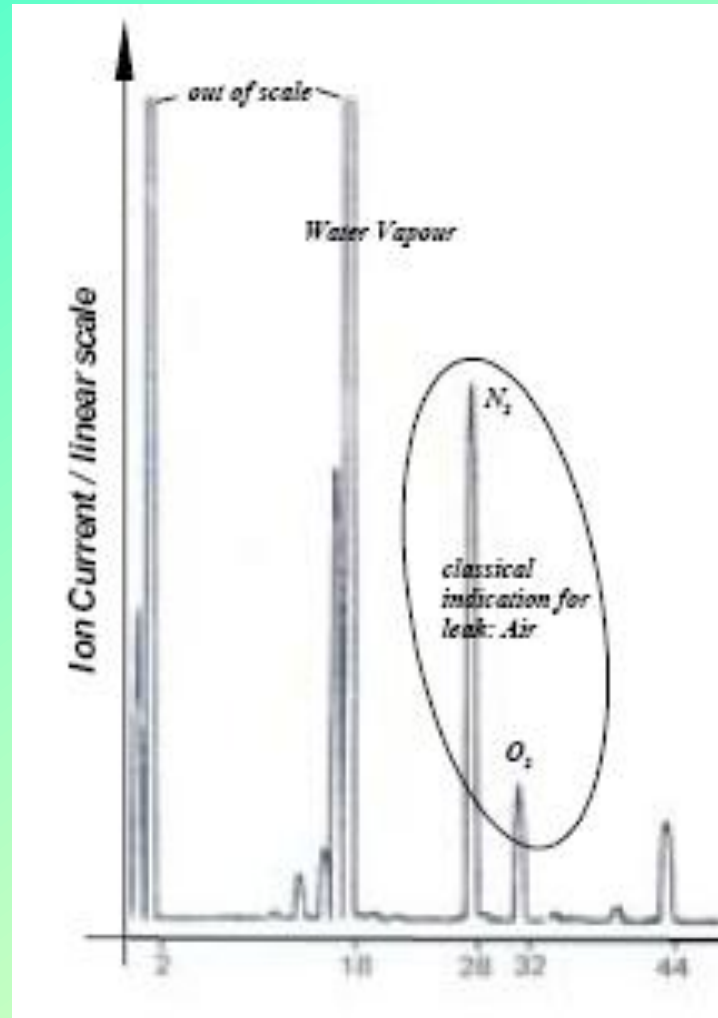
But it is more intelligent to ensure that a leak is present before chasing it





# Basic Vacuum Design of Accelerators

## Leak Detection with an RGA

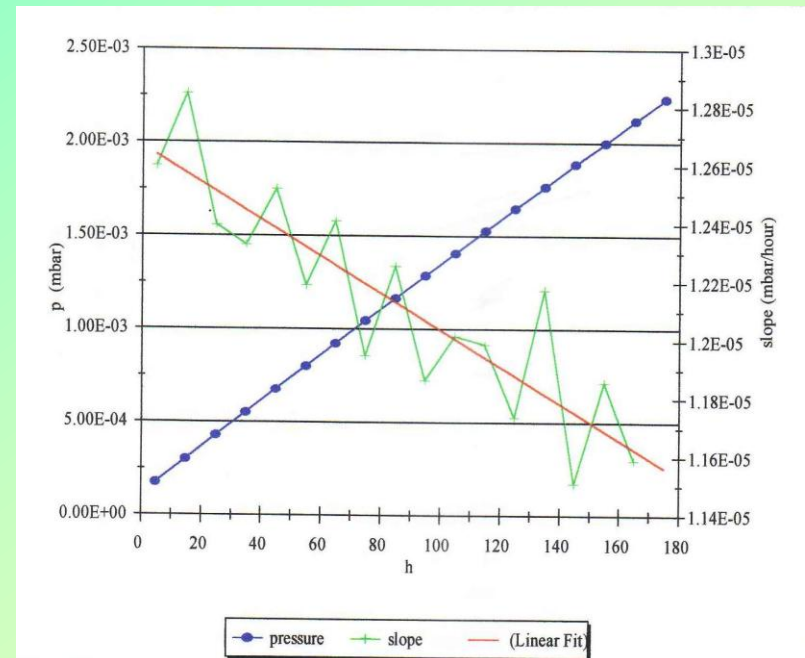
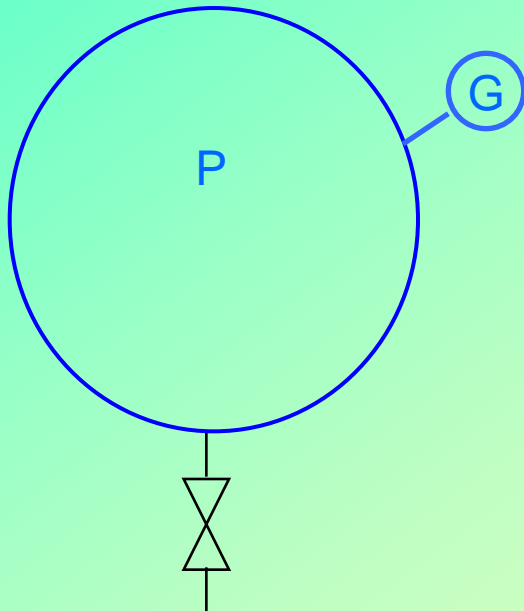




## Outgassing test

Rate of Rise (gas accumulation)

In a sealed chamber, 
$$Q = \frac{dP}{dt}_{t=0} \cdot \frac{V}{A}$$



Nemanic & Setina



## Cleanliness Test

Usually specified in terms of an rga spectrum. For example

Pressure Region	General Contaminants	Perfluoropolyphenyl ethers (Sum of peaks at 69 and 77 amu)	Chlorinated species (Sum of peaks at 35 and 37 amu)	Comment
High Vacuum	1	0.1	0.1	If unbaked, excluding water
UHV	0.1	0.01	0.01	

### Notes

The residual gas spectrum shall have been recorded over 1 –200 amu

The spectrum shall have been corrected for sampling error, mass discrimination and species relative sensitivities

These limits are expressed in terms of percentages of the total pressure in the system, The definition of “general contaminants” is the sum of the partial pressures of all peaks present in the residual gas spectrum of mass to charge ratio (amu) equal to 39, 41-43 and 45 and above

Also to be excluded from this summation are any peaks related to the rare gases xenon (i.e. 132, 129, 131) and krypton (i.e. 84, 86, 83)