

Nucleonic gauges for production processes: Non-invasive quality control

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International Atomic Energy Agency Scientific Forum

ATOMS IN INDUSTRY

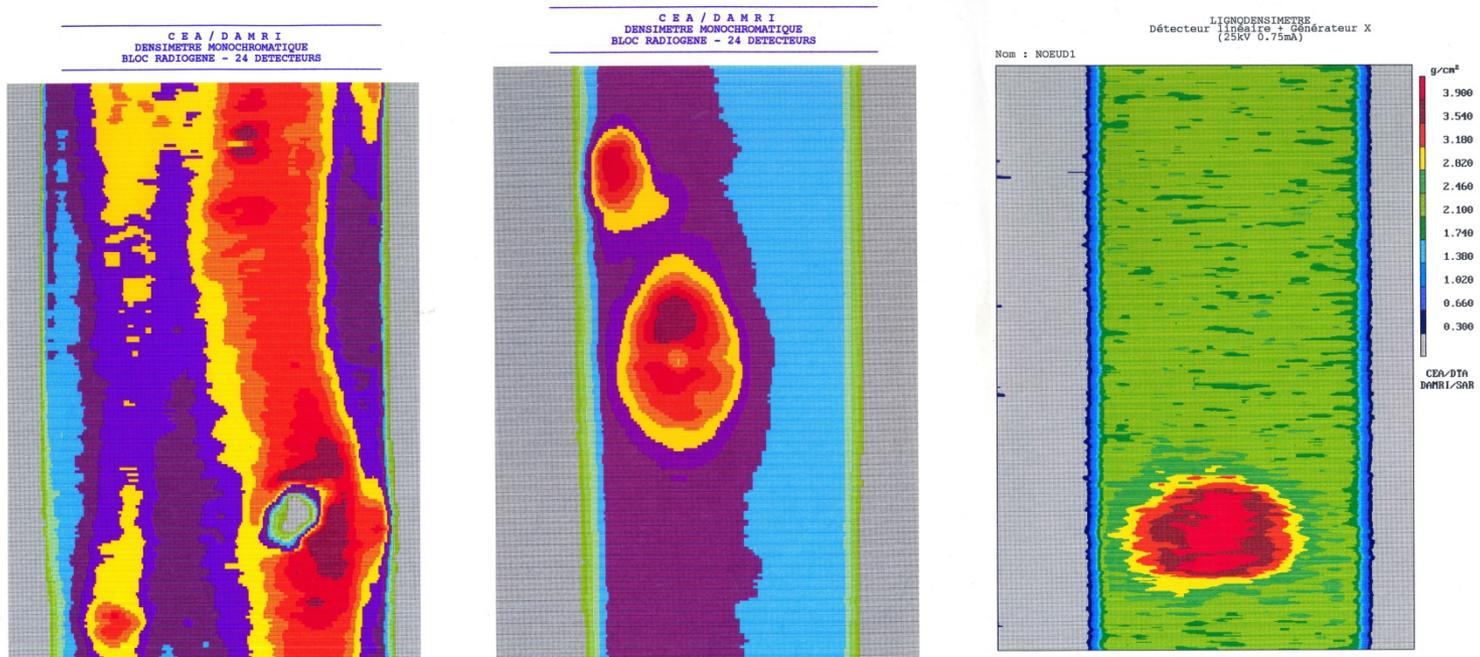
Radiation Technology for Development

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An attempt of definition of “nucleonic gauges”

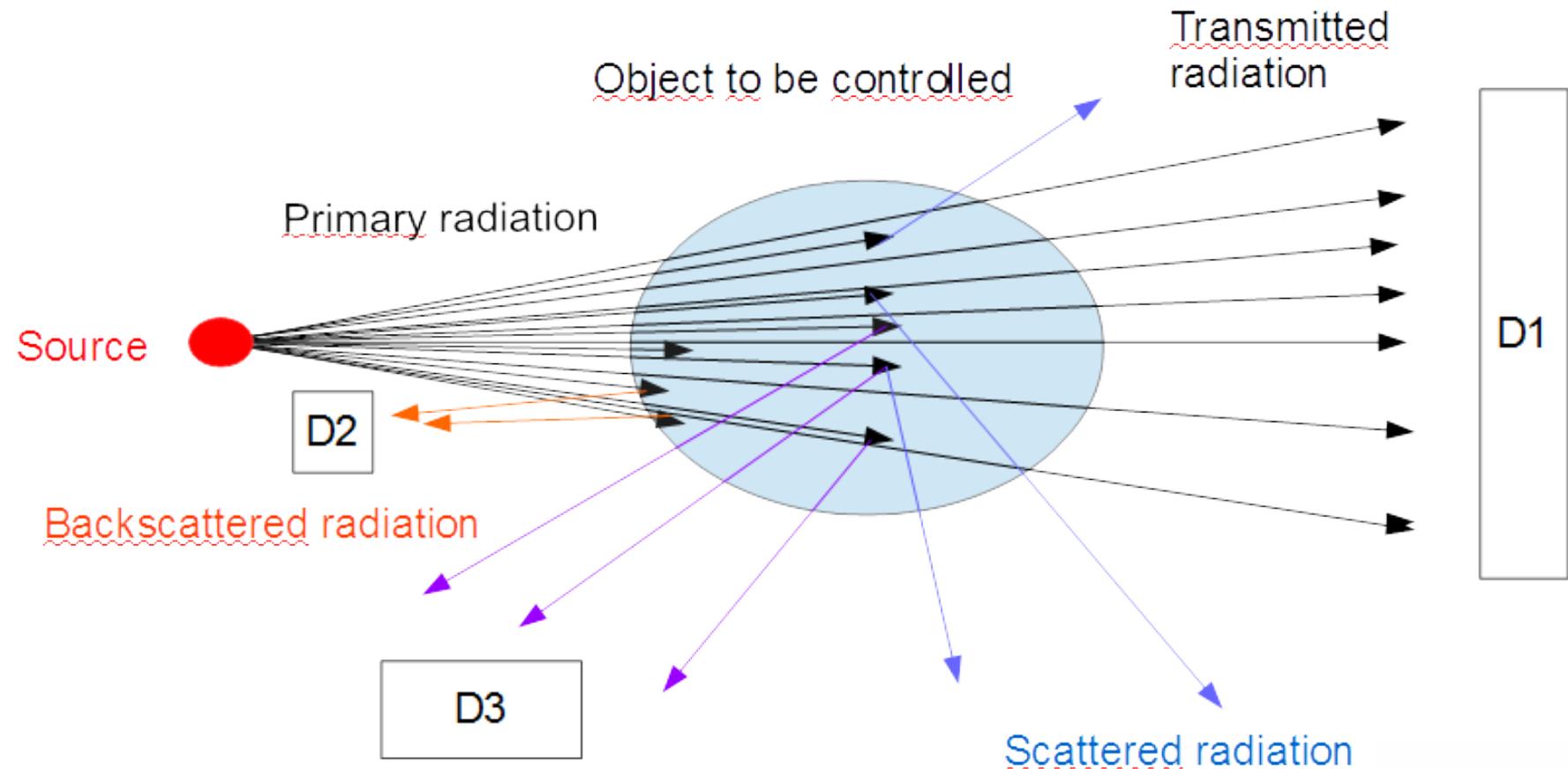
Other equivalent terms: “radioisotopic gauges”, “radionuclide gauges”, “nuclear gauges”, “nucleonic instrumentation”, “NCS – nucleonic control systems” or “radioisotope based measuring instruments”

- Any instrument permitting to **control, measure or analyse** a product or an object, by the mean of the interaction of a beam of ionising radiation emitted by a sealed radioactive source with the components of this product or object, followed by the detection of the transmitted radiation or an eventual secondary radiation.
- Any kind of ionising radiation can be used: beta particles. X or gamma rays, neutrons...



Examples of density mapping of three different wood species board - Gamma attenuation (showing knots or resin pockets)

Scheme of the useful interactions between ionising radiation & matter



Nucleonic gauges

- **How ?** Such measurements can be done through **online** process instrumentation
- **What ? Many physical or chemical parameters** can be measured: level, interface, thickness, mass per unit area, weight, density, void ratio, phase ratio, coating weight, moisture, elemental chemical composition...
- **Why ?** Measurements are **without contact, non-destructive, non-invasive**. They can be done through pipes, high pressure vessel walls, thermal insulations...
- **Where ?** Many **major industrial branches** are routine users of these tools : oil, natural gas, chemistry, mining, metallurgy, wood, paper, plastics, rubber, textiles, cement & building materials, glass...
- **Which benefits ?** Improvement of the **production quality**, optimisation of the production processes, **safety** improvement, **saving of raw materials**...



Reminder of the advantages & drawbacks of nucleonic gauges

Main advantages

- Penetration power in matter
- Stability of the source emission (in energy & flux)
- No need of electrical feed
- Palette of usable interactions with matter

Drawbacks

- Radioactivity by itself
- Real health risks during the “non use” periods: transportation, maintenance, dismantling of installations, storage of disused sources
- Increasing pressure from safety concerns: societal attitude, complexity & harshness of legal & regulatory authorisation (licensing) files
- Sometimes, lack of common standards or recommended practices (including in the 28 E.U. countries!)
- Some difficulty to get from suppliers certain types of radioactive sources



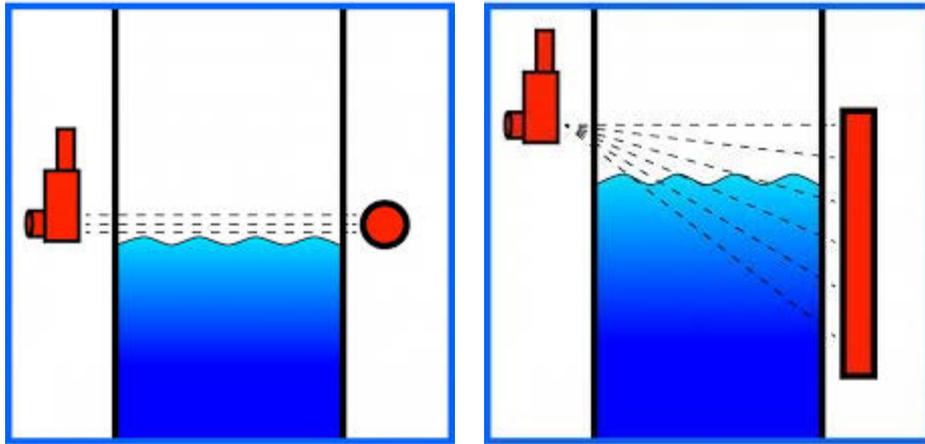
The world market of radioisotopic instrumentation

| Manufacturers of radioisotopic instrumentation (web survey November 2012) | |
|--|---------------|
| Type of equipment | Number |
| Gamma radiography apparatus | 8 |
| X-ray fluorescence analysers | 26 |
| Other analysers | 2 |
| On-line gauges (level, density, weight, thickness, coating weight, fraction ratio, imaging gauges...) | 40 |
| Field gauges (moisture and/or density) | 6 |
| Borehole logging tools | 10 |
| Total | 92 |

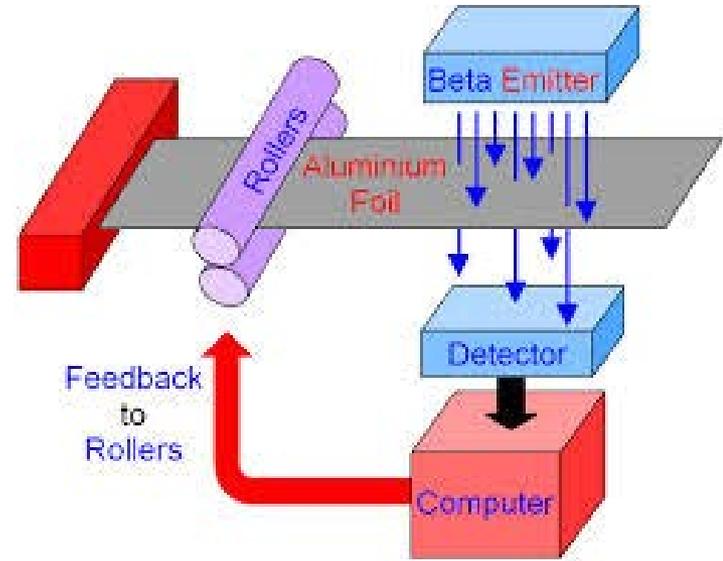
NB - Draft based on a survey mainly in Canada, France, Germany, India, Japan, South Africa, United Kingdom & United States



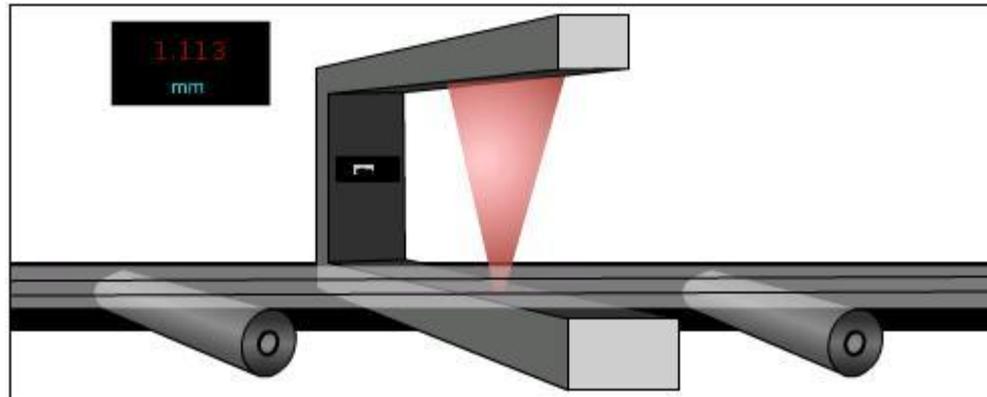
Some nucleonic gauge principles



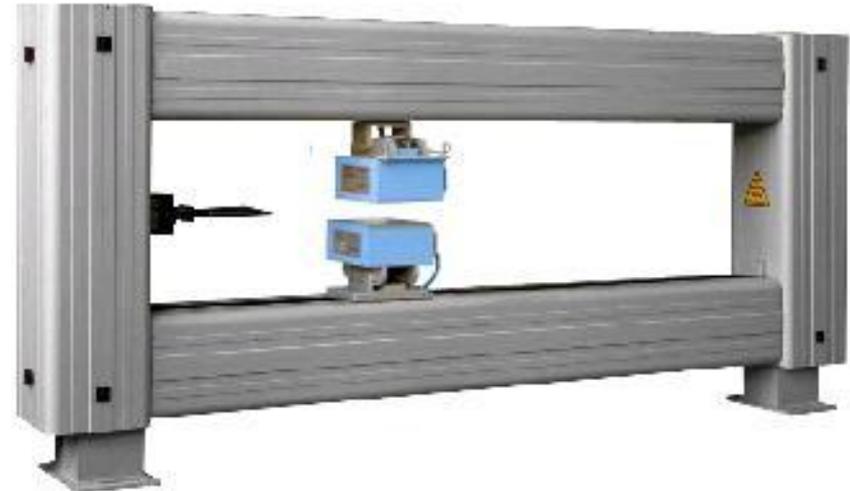
Level indicators



Thickness gauge



Global measurement (on belt conveyor)



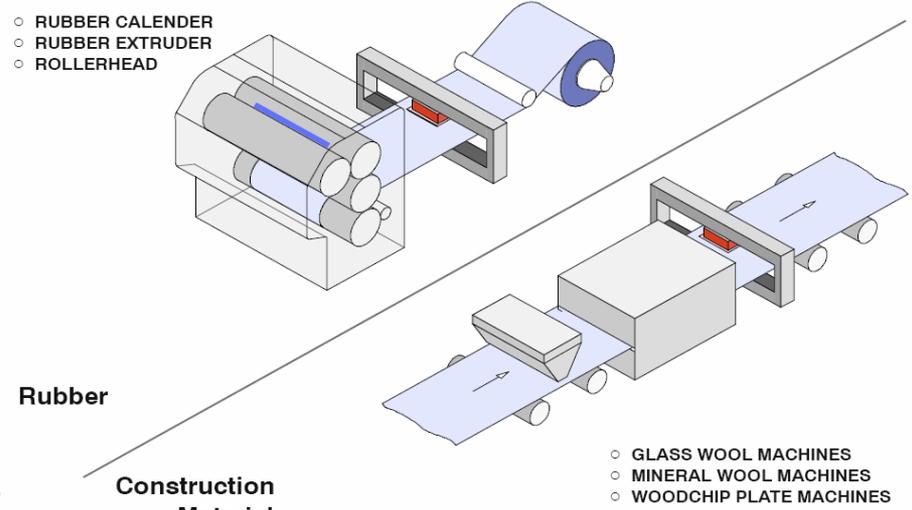
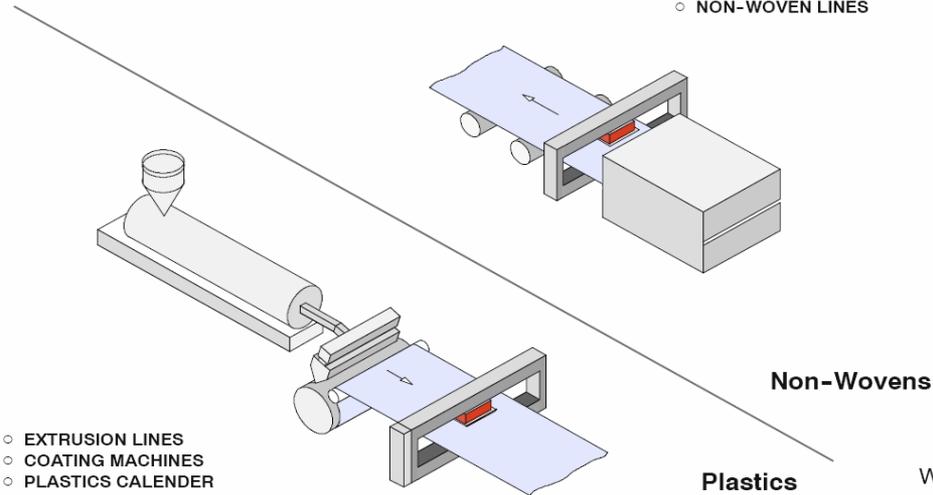
Profile (transverse scanning)



Applications overview - web processing industries

○ NON-WOVEN LINES

○ RUBBER CALENDER
○ RUBBER EXTRUDER
○ ROLLERHEAD



○ GLASS WOOL MACHINES
○ MINERAL WOOL MACHINES
○ WOODCHIP PLATE MACHINES

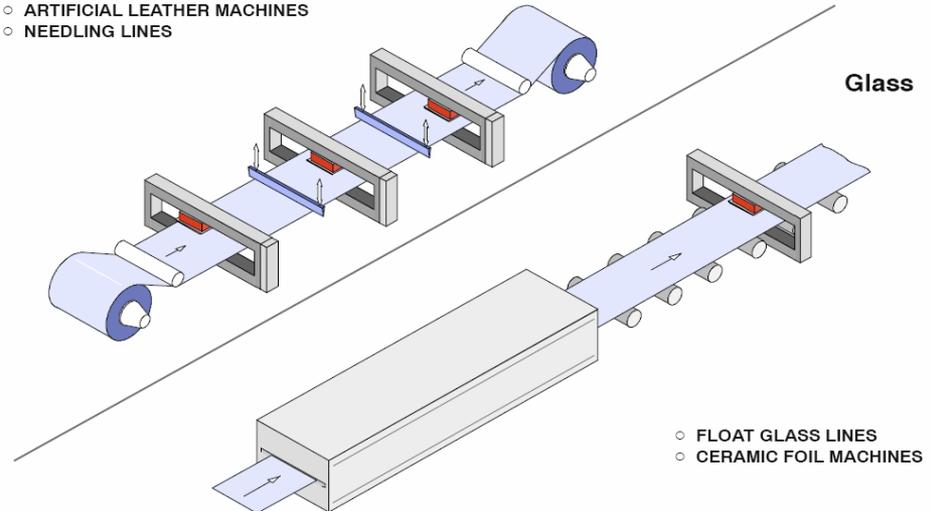
○ EXTRUSION LINES
○ COATING MACHINES
○ PLASTICS CALENDER

○ TEXTILE COATING MACHINES
○ ARTIFICIAL LEATHER MACHINES
○ NEEDLING LINES

Textile

Chemistry

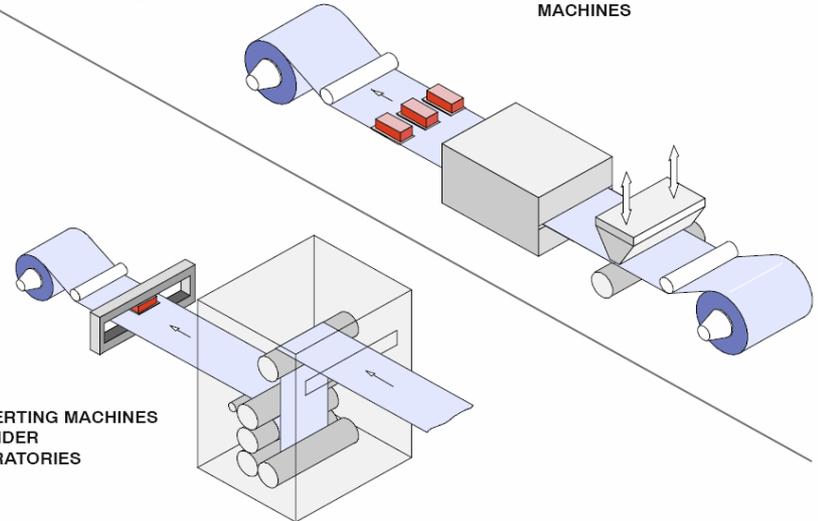
○ MAGNETIC TAPE COATING MACHINES

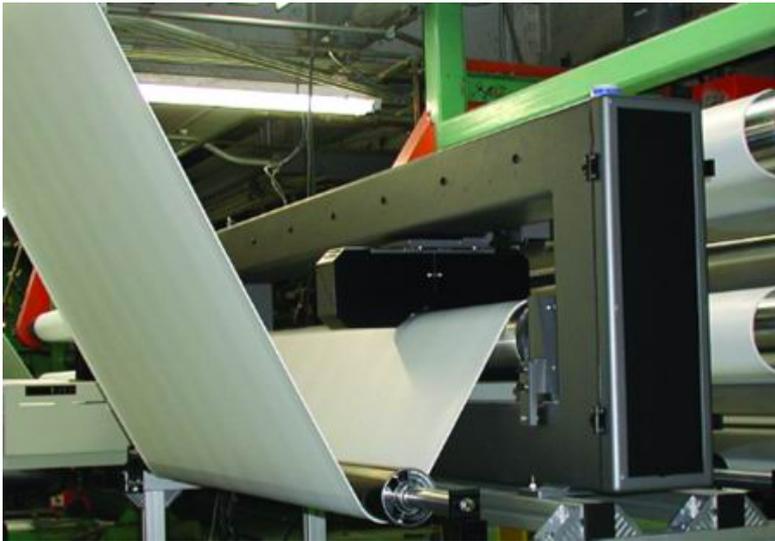


○ FLOAT GLASS LINES
○ CERAMIC FOIL MACHINES

Paper

○ CONVERTING MACHINES
○ CALENDER
○ LABORATORIES





Weight gauge (non woven)



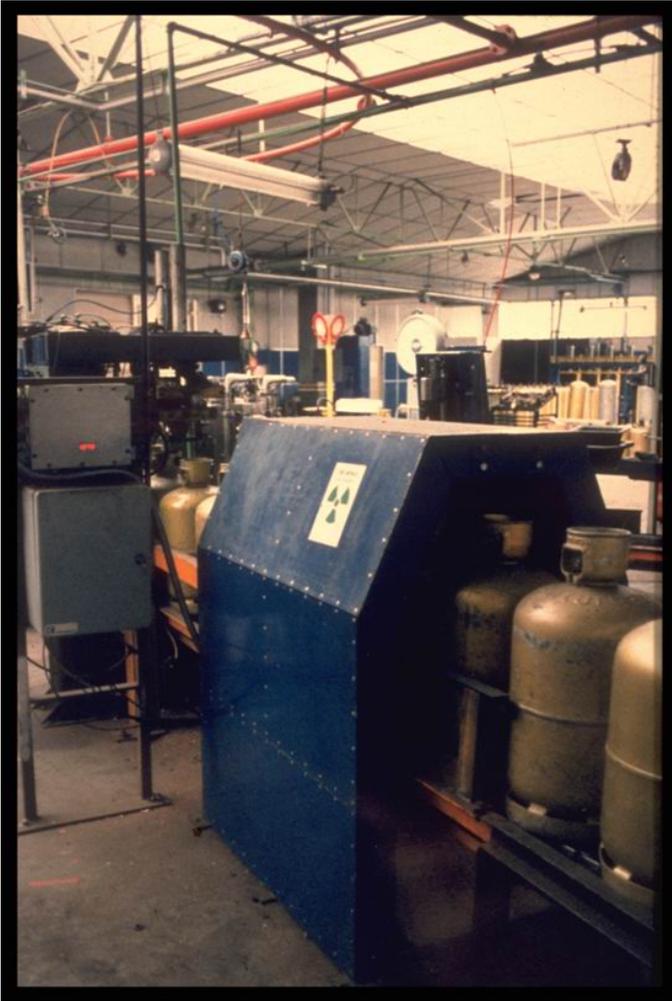
Weight gauge (paper)



Online cement analyser (neutron induced prompt gammas - n, γ)



Coating weight gauge (zinc on steel)



Level gauge - Online measurement of residue liquid butane weight in butane cylinders on LNG bottling carrousel (neutron backscattering - $^{241}\text{Am-Be}$)



Measurement of atmospheric dust concentration (β absorption - ^{14}C)



As a conclusion

Areas where the use of nucleonic gauges will remain a major technical choice

- **Online gauges** (level, density, weight, thickness, interface, analysis...) in **heavy industries** (petroleum, chemistry, coal, steel, aluminium, non ferrous metals, cement, glass, ores, nuclear fuel cycle...) because of harsh and/or severe, aggressive working conditions
- **Online weight measurement of sheet materials** (paper, plastics foils, rubber, web, non woven, foam boards, wood, steel, aluminium, co-laminates...)
- **Borehole logging tools** in oil, natural gas, uranium, metallic ores prospecting & exploitation, hydrogeology
- **Density & moisture field gauges** (civil engineering, agronomy soil studies...)

Related techniques

- Detection of narcotics & explosives
- Tomography (or tomodensimetry)
- Potentially: “dual instruments” associating nucleonic & non nucleonic measurements



Thank you!

