Boiler Troubles

Acids from dissolved salts

- Water containing dissolved magnesium salts liberate acids on hydrolysis

$$MgCl_2 + 2\,H_2O \rightarrow Mg(OH)_2 + 2\,HCl$$

- The liberated acid reacts with iron of the boiler in chain-like reactions producing HCl.

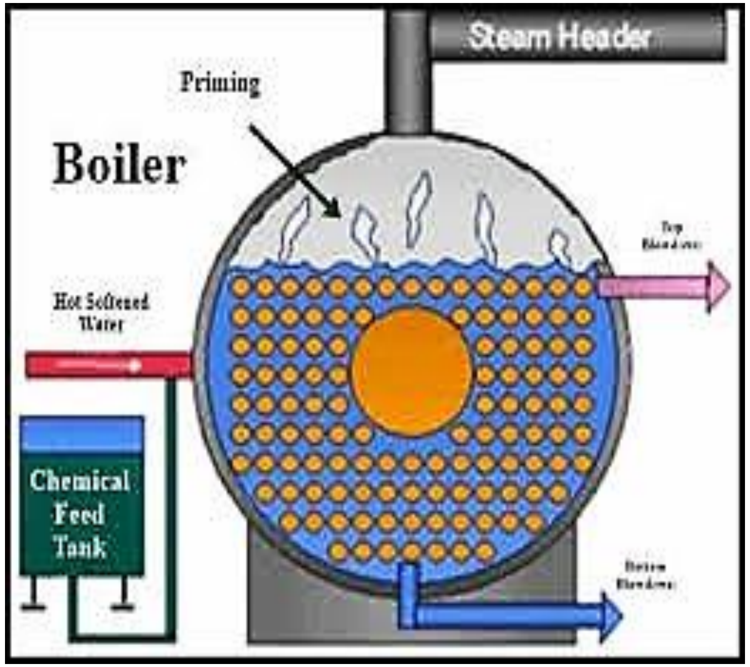
$$Fe + 2\,HCl \rightarrow FeCl_2 + H_2$$

$$FeCl_2 + 2\,H_2O \rightarrow Fe(OH)_2 + 2\,HCl$$

- As a result presence of even a small amount of $MgCl_2$ will cause corrosion of iron to a large extent

Priming

- When a boiler is producing steam rapidly, some particles of the liquid water are carried along-with the steam. This process of 'wet steam' formation is called priming.



- **Priming is caused by:**
  - Presence of a large amount of dissolved solids
  - high steam velocities
  - sudden boiling
  - improper boiler design
  - sudden increase in steam-production rate

Boiler Troubles: Priming & Foaming

- Priming can be avoided by:
  - fitting mechanical steam purifiers
  - avoiding rapid changing steaming rate
  - maintaining low water levels in boilers, and
  - efficient softening and filtration of the boiler-feed water.

Foaming

- Production of persistent foam or bubbles in boilers, which do not break easily. Foaming is due to presence of substances like oils (which greatly reduce the surface tension of water)
- Priming and foaming, usually, occur together

- Foaming can be avoided by:
  - adding anti-foaming chemicals like castor oil
  - removing oil from boiler water by adding compounds like sodium aluminates.

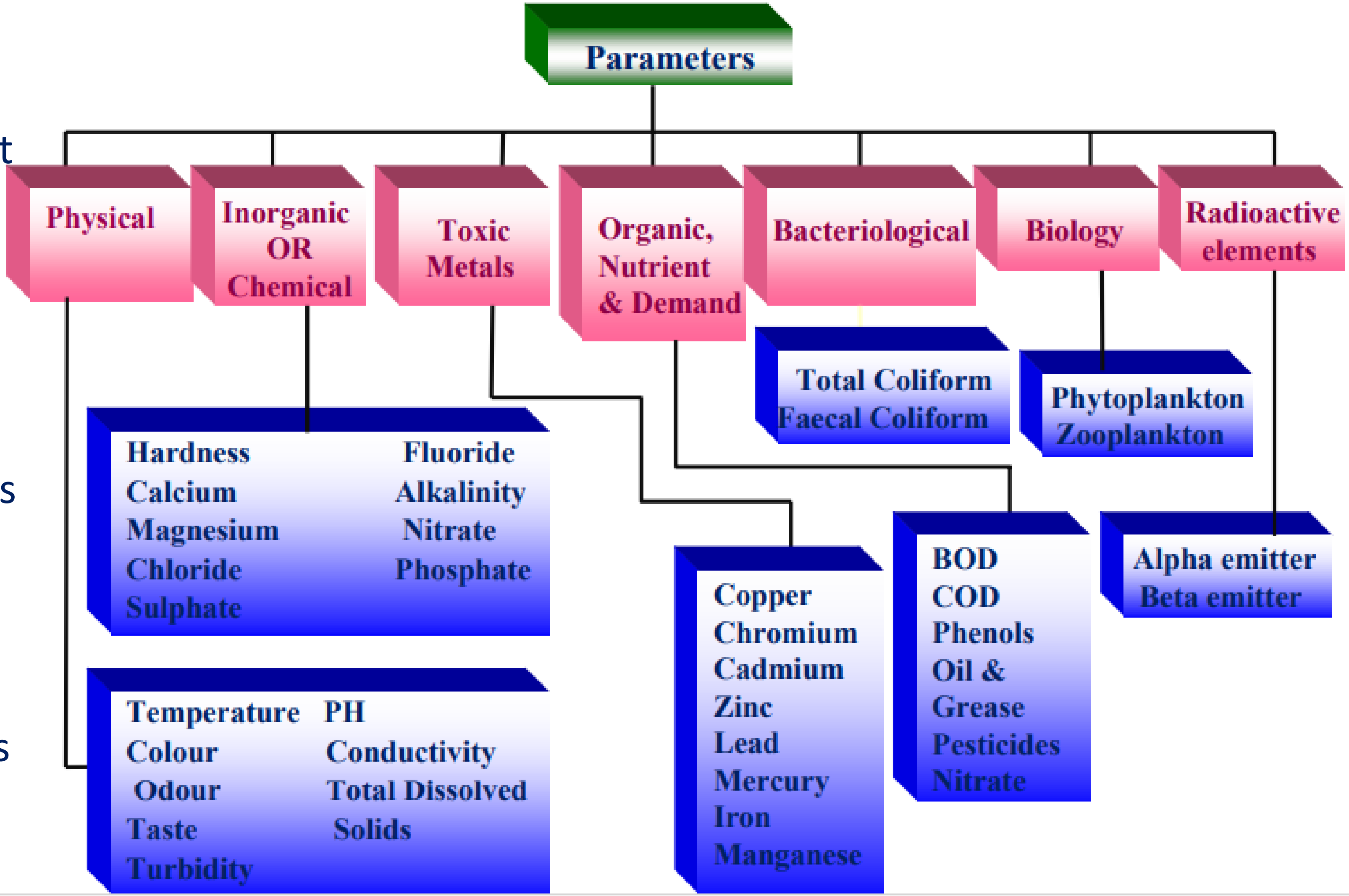
Priming and Foaming are objectionable because:

- Dissolved salts in boiler water are carried by the wet steam to super-heater and turbine blades, where they get deposited and the deposit reduces their efficiency
- Dissolved salts may enter the parts of other machinery, where steam is being used and decrease the life of the machinery
- Actual height of the water column cannot be judged properly, thereby making the maintenance of the boiler pressure becomes difficult.

Modern Methods of Water Analysis

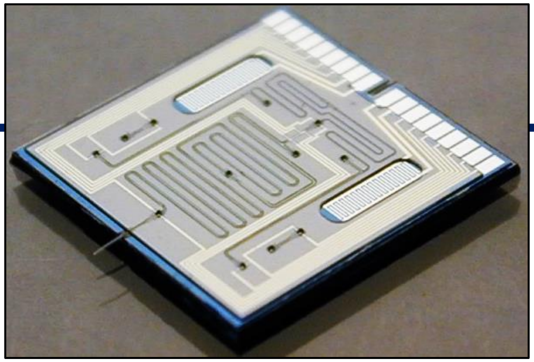
- **Importance of Water Analysis:**
  - **to ensure its quality/to detect pollutants that should be removed by water treatment.**
  - For example, drinking water must be fit for human consumption, while industrial water should be free from any contaminants that may corrode/damage equipment.
- **Limitations of Traditional Methods of Water Analysis:** The traditional analysis includes **chemical analysis, colorimetry, spectrometry, chromatography, and atomic absorption**. Although these techniques differ in sensitivity and accuracy, most of them are highly accurate.

Water Quality Assessment : Potable & Industrial Uses



- They require **sampling, expensive devices, manpower** & they are time-consuming and difficult to conduct onsite

Lab-on-a-chip



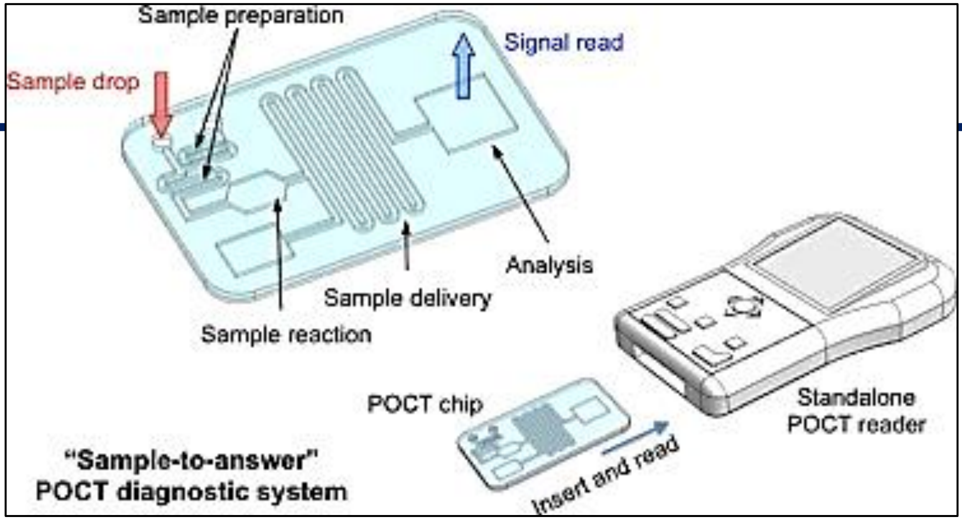
- A lab-on-a-chip (LOC) is a **device that integrates one or several laboratory functions on a single integrated circuit** (commonly called a "chip") of only millimeters to a few square centimeters to achieve **automation and high-throughput screening**
- Lab-on-a-chip devices are a subset of microelectromechanical systems (MEMS) devices and sometimes called **"micro total analysis systems" (µTAS)**
- Lab-on-a-chip technology employs microfluidics, which deals with very minute amounts of fluids in microchannels, to perform the analysis. **The lab-on-a-chip device is a chip that resembles electronic chips, but with micro-channels instead of electrical circuits.** It shrinks the lab to the chip size and can perform complete analysis or even series of analysis.

Advantages of LOC

- **low fluid volumes consumption** (less waste, lower reagents costs, and fewer sample volumes)
- **faster analysis and response time** due to short diffusion distance & high surface to volume ratio. **Reduce manpower** in the sampling process.
- **better process control** because of compactness of the systems due to the integration of much functionality and small volumes
- **safer platform** for chemical, radioactive or biological studies
- **much less expensive and offers higher accuracy** because of the small volume analysis and the possibility of eliminating the sampling process, which reduces the human error

Lab-on-a-chip

- The main components of a lab-on-a-chip system for water analysis are – **a liquid delivery system** (injector and fluidic transporter), mixer, reactor, separator, and power supply.



- **The Injector –** to deliver precise volumes into the chip. (syringe pumps or robotic pipets); **Transporters –** to control all aspects of the flow. They can be active (need an energy source) or passive (require manipulation the geometries of the channels). The most preferred is electrochemical pumping systems, such as microsyringe pumps.
- **Mixers:** to mix different fluids into the channels. It also could be passive (require design manipulation) and active (require power).
- **The Reactor:** reaction takes place here. 3 types of reactors – gas phase, liquid phase, and packed-bed reactors.
- **Controllers:** used for controlling all types of activities in the chip as well as data acquisition and signal processing.
- **Power supplies:** essential to run the lab-on-a-chip systems.

- ✓ LoC technology is rapidly developing and being used in **different industrial and research fields**
- ✓ Most biological LoC devices are commercialized, while More advanced LoCs for water analysis are still developing.
- ✓ Some LoC applications in water analysis are already established; such as pH testing, detection of various chemicals (e.g., NO_3^-/NO_2^-, Mn^{+2}, phosphates, and silicates).

- For example: the microfluidic pH analysis uses sulfonaphthalein as the main indicator. It includes the absorption cell, a static mixer, a syringe pump and four valves attached to the chip to regulate the flow.