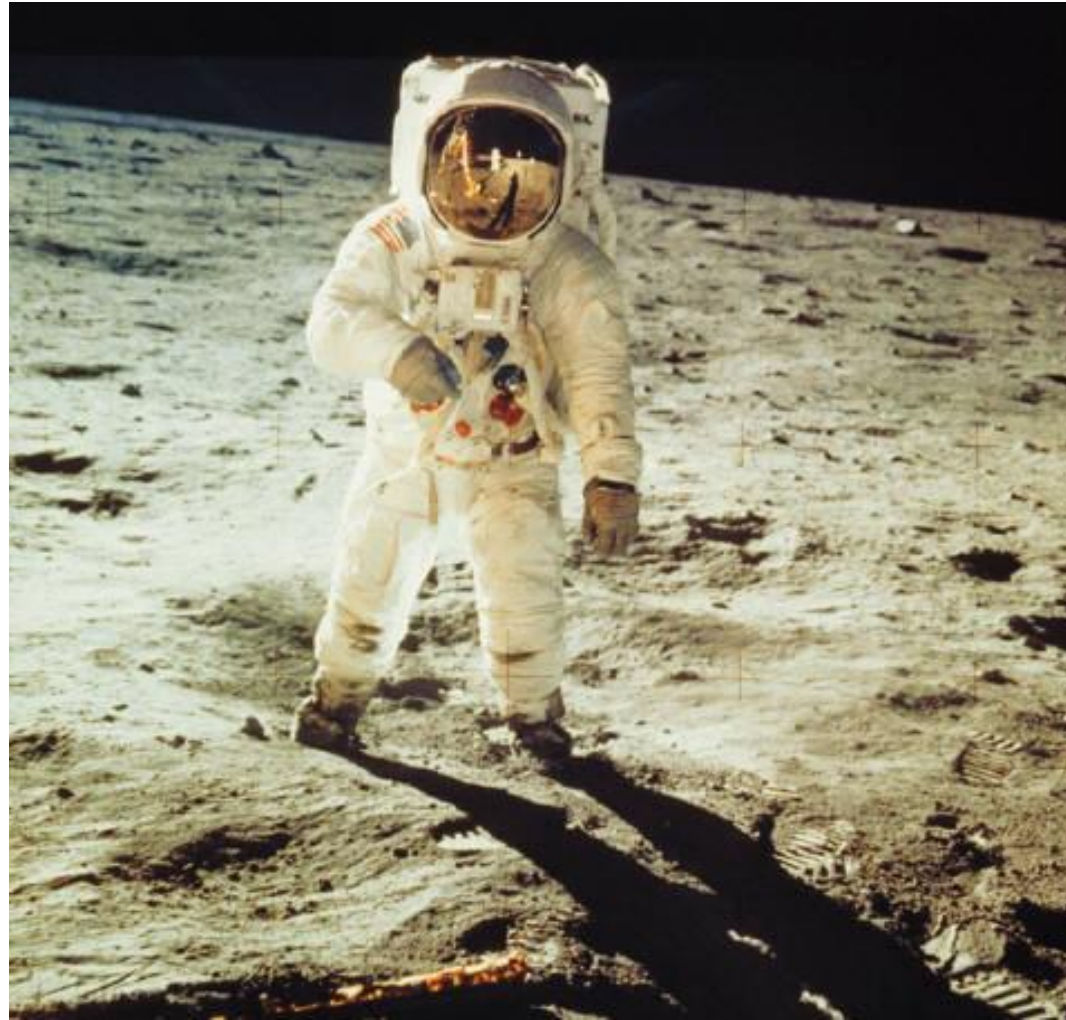


# The Future of Contamination Control

- Anne Marie Dixon-Heathman
- Cleanroom Management Associates, Inc.
- October 2023

# Contamination Control is...

Personal mastery – a lifelong journey of learning, changing, evolving, and improving



# Agenda

The past

The present

Things to consider  
for the future

*The Past –*  
a SHELL game





## WHY?

- We did not have the tools for continuous monitoring
- We did not have the tools for investigations
- Standards and training were not sufficient to solve problems
- ETC.

**NOW!!!**



# Contamination

**Contamination** is defined as any material substance or energy that is unwanted or adversely affects the product or process.

A diagram consisting of two circles connected by a right-pointing arrow. The left circle is blue and contains text about contamination. The right circle is green and contains text about high-level product technologies. The arrow points from the blue circle to the green circle.

CONTAMINATION is  
a major and  
increasing factor in  
manufacturing  
affecting yield, cost,  
quality, reliability  
and productivity.



All present and new  
high-level product  
technologies will be  
driven by the  
technology of  
*CONTAMINATION  
CONTROL..*



# Examples of current information and research –not followed

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Gowning materials – expiration times (pub 2021)

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Autoclave wrapping – a major source of wipers (pub 2022)

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Smoke studies unacceptable – warning letters

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EM deficient- warning letters

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Investigations incomplete – warning letters

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ETC.

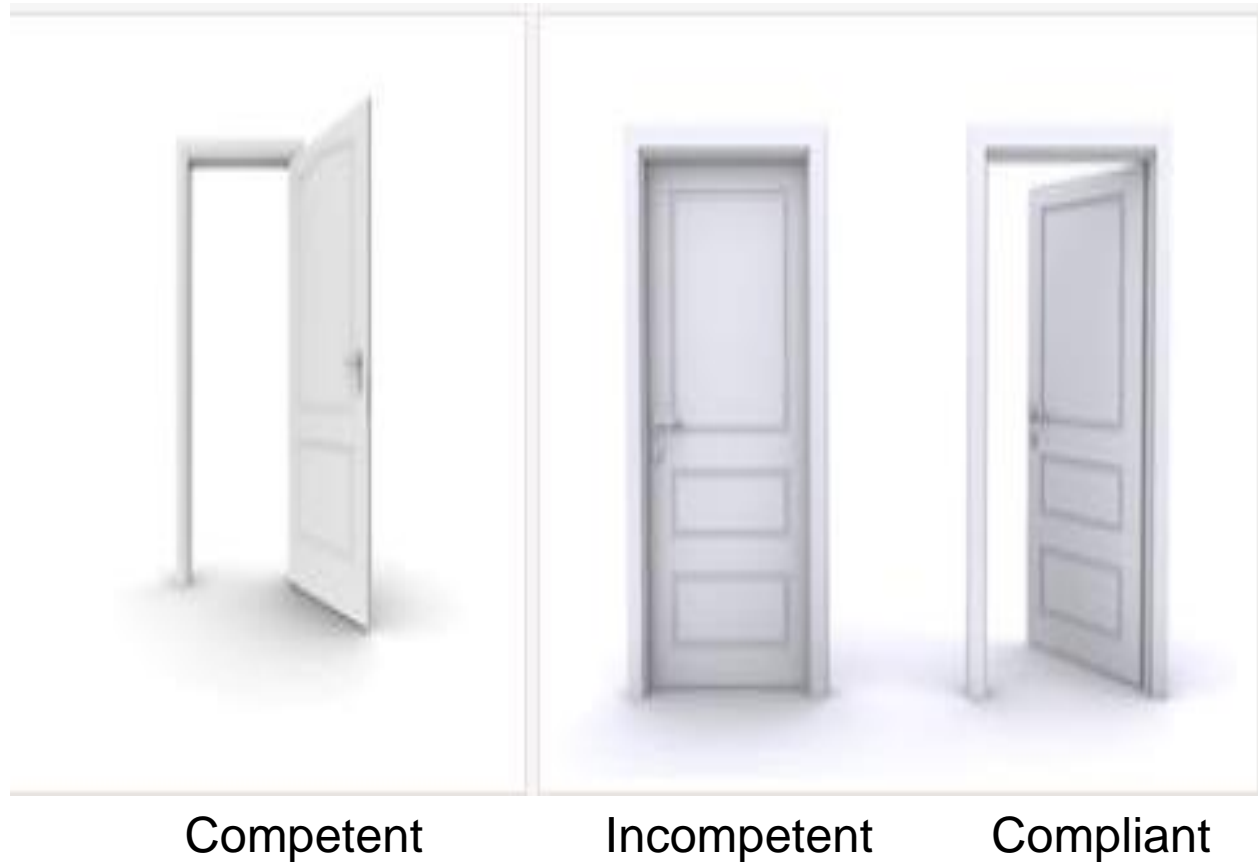
# Frequently used excuses –

- Drug shortage
- Only drug on the market
- We pass all inspections
- Never cited before
- Where is that written? What “c” in GMP?



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**For many  
companies -  
Today's  
Solution!**





# Bridge to the future

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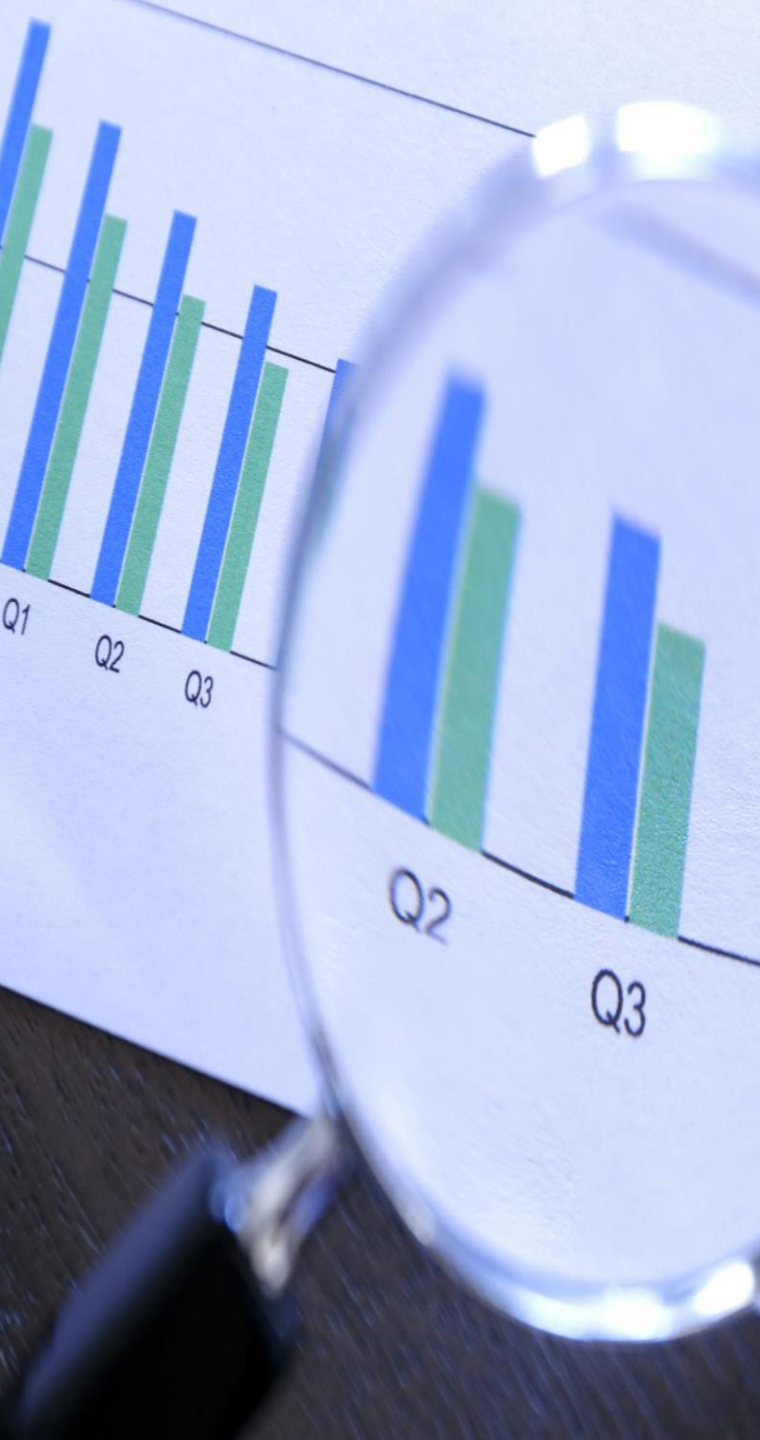




# Concept of Impact Assessment

- The impact assessment is a mandatory requirement in ISO 14644-5:2024. (Cleanrooms and Associated Controlled Environments: Operations)
- IA Identifies factors that could prevent the cleanroom from attaining or maintaining the required air cleanliness concerning contaminants of interest.
- It is developed at the start of routine operations (as built or design data) and revisited with major modifications and changes.
- Why IA?
  - Global relevance
  - Not subjected to the formal requirements of a risk assessment
  - Flexible and can easily be updated





# Impact Assessment

Includes the following:

- Operations
- Cleaning and sanitization
- Gowning and selection of consumables
- Facility and equipment maintenance
- Transfer of items
- Monitoring



# Operations Control Program (OCP)

ISO 14644-5:2024 states:

Management shall establish, implement, and maintain an OCP. It shall address how the cleanroom shall be operated within specified limits while manufacturing or handling products.

The OCP shall include considerations for sustainability, *e.g.*, water consumption, energy management (14644-16), efficient use of consumables (14644-18).



# OCP

At a minimum, the OCP shall address and include the following:

- Impact assessment
- Documents showing the flow of products and raw materials, equipment, personnel and waste
- Standard operating procedures or work instructions for all aspects of cleanroom setup and operations, including procedures that pertain to entry and exit of materials, equipment and personnel; shutdown and restart; and unplanned incidences
- Personnel Management Programme (requirements, gowning, training)
- Cleaning Programme
- Maintenance Programme (cleanroom installation, equipment)
- Monitoring Programme



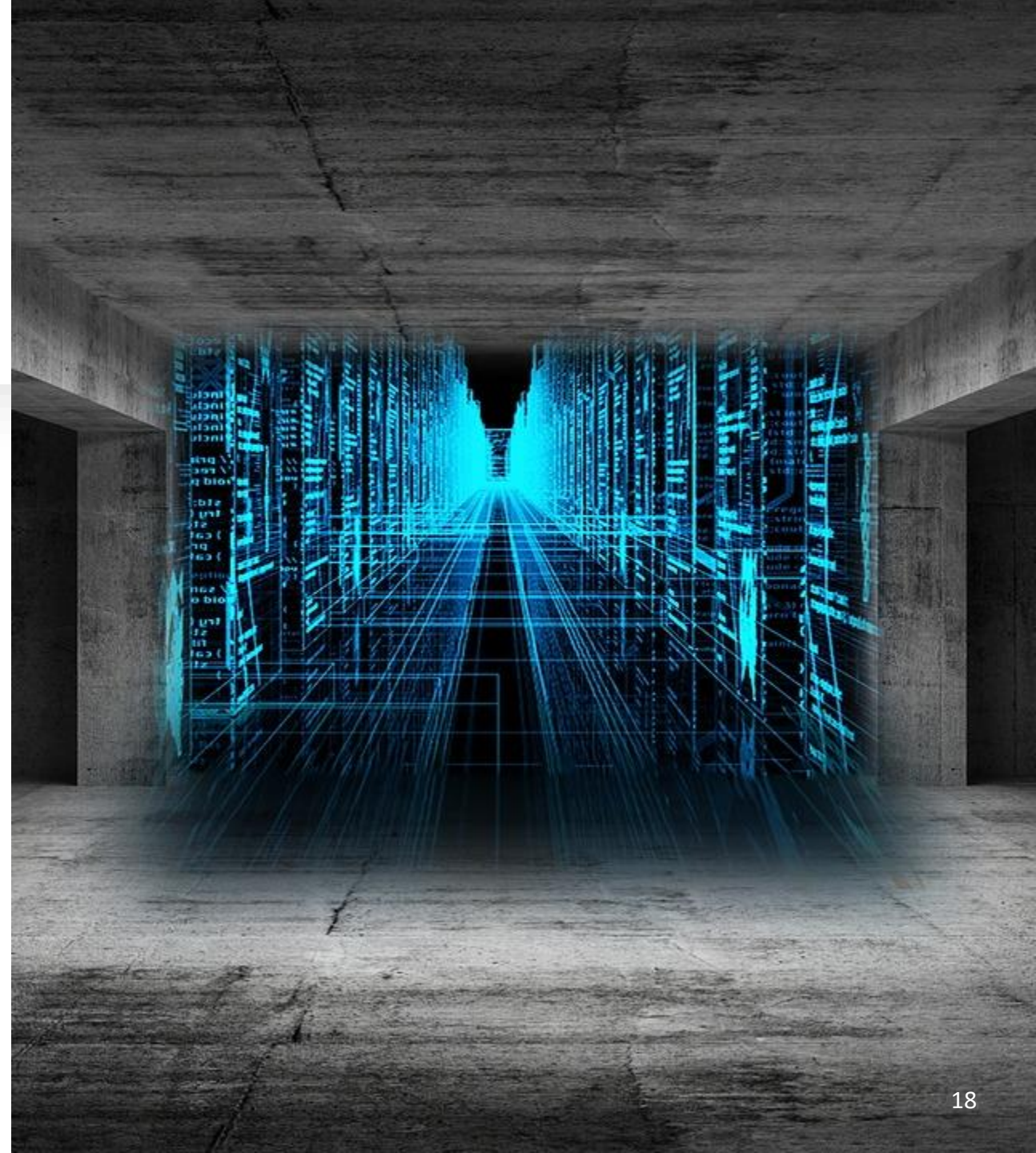
# Role of frequent and continuous monitoring

- Particles
- Active air
- Passive air
- Surfaces

How to analyze the data becomes challenging – too much data!!!

# AI

- **Artificial intelligence (AI)** enables computer systems to perform tasks normally requiring human intelligence.
- [National AI Initiative Act of 2020](#) (DIVISION E, SEC. 5001) became law on January 1, 2021, providing for a coordinated program across the entire Federal government.







## The Role of AI in Contamination Control

- Direction, guidance, and control should be in a Global Master Quality Document
- Need for AI ---
  - Investigations
  - EM excursions
  - Rejected product
  - Monitoring history data handling
  - Component variations – glass, stopper, syringes, etc.
  - Data handling and trending
  - ETC.

# Why now???

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Manpower turnover

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Lack of senior personnel

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Loss of corporate memory

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Cost of research and analysis for investigations, excursions, defects, rejected product, and many others

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Mandatory time-line for completion

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Requirement for objective evidence

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Operational demands

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CAPAs - PAs are not generally completed

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Etc. etc. etc.

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# Examples of the Application for AI

- Determine if this result has occurred in the past – when, why, how
- Maintain an internal library of defects and events
- Research current library of articles, 483's, journals for similar issues
- Database of all consumables and construction materials for chemistries, particles, fibers, microbial, porosity, cleaning compatibility, etc.
- Re-create portions of a process with history of EM data, and all operational conditions



# Fully Automated Filling and Packaging

- Improvement in design compatibility
  - Airflow dynamics
  - Particulate
  - Materials of construction
  - Microbial compatible
  - Sanitization vs. sterilization
- Advances in technology and data
  - Notifications
  - Controls
  - Data trend references





Beyond 2024



THANK YOU